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KAZABAZUA RIVER SUB-AREA

R. Kretz

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PRELIMINARY REPORT
OF
GEOLOGY OF THE KAZABAZUA RIVER SUB-AREA
PONTIAC COUNTY, QUEBEC
by
RALPH KRETZ

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Geology of the Kazabazua River Sub-area
of the Otter Lake Area,
Pontiac County, Quebec

by Ralph Kretz

March 1971

Introduction

A preliminary report on the geology of the Otter Lake area was previously published (Kretz, 1957a), together with a map on the scale of 1 inch to 1 mile. The area lies about 60 miles north-west of Ottawa and Hull, and is bounded by latitudes $45^{\circ} 45'$ and $46^{\circ} 00'$ north, and by longitudes $76^{\circ} 15'$ and $76^{\circ} 30'$ west. A small portion of the Otter Lake area, lying 4 miles south-east of Otter Lake village, was observed to contain a variety of rock types and some noteworthy structural features, and was considered worthy of detailed study. This sub-area, which measures about 3 miles square, is here referred to as the Kazabazua River sub-area, and is described in the present report.

Field work was carried out for short periods during the summers of 1968, 1969, and 1970. The accompanying geological map (fig. 1) was prepared by use of an enlarged air photograph as a base map, on the scale of 1 inch to 820 feet. Points on the ground will be referred to in the text by two numbers, the first being the minutes of latitude and the second the minutes of longitude. The degrees of latitude and longitude are everywhere 45° and 76° respectively, and are omitted from the co-ordinate numbers.

Topography

The Kazabazua River sub-area lies in the Laurentien uplands, north of the Ottawa River valley, at an elevation of about 750 feet above sea level. The Kazabazua river, which here is near its head waters, flows through the area as shown in fig. 1. To the north and east of the river, the land surface forms a number of north-easterly trending ridges, about 200 feet high. These are parallel to the strike of the layering in the underlying rock. To the south of the Kazabazua river, the topography is more irregular, reflecting a greater variation in the strike of the underlying rocks.

The north-eastern portion of the sub-area is wooded but the remainder is mainly open farm land, well suited for detailed geological study. Plate 1 shows a typical view of the area.

General Geology

The rocks of the Otter Lake area (Kretz, 1957a) and the Fort Coulonge area (Kretz, 1957b) to the west have been divided into 6 principal rock groups and numerous rock units, as shown in table 1. Those rock units that occur in the Kazabazua River sub-area are indicated in table 1 by an asterisk. Here, the most abundant rock units are calcite-rich marble, various plagioclase gneisses containing garnet, biotite, hornblende, and calcic pyroxene, and a mafic rock referred to as metagabbro. These rocks are interlayered with each other.

In the northern half of the map-area the layers dip easterly, but in the southern half, the attitude is more variable, and a northerly plunging anticline is present. The northern and southern portions of the map-area are evidently separated by a major fault.

Marbles and Skarns (1)

The marbles and skarns of the Kazabazua River sub-area have been divided into a number of rock units, as shown in table 1. Marbles occur much more abundantly than skarns, and the calcite-rich marble (a) is much more abundant than the other marble units.

Marble occurs as layers and lenses ranging in thickness from a few cm. to 180 m. The interlayering of marble and plagioclase gneisses on a large scale is clearly shown on the geological map (fig. 1). On a smaller scale, the individual layers are locally about 6 m thick (at co-ordinates 50.2, 19.7) or a few cm thick (at 48.33, 20.45). South of the Kazabazua river, in the vicinity of (48.8, 20.0), calcite-rich marble is found to be intermixed with a gray granitic rock, the latter forming irregularly-shaped bodies, a few m in dimension, within the marble.

The marbles commonly contain inclusions of foreign rock. These may be irregularly-shaped fragments, or layers that may be folded. These rocks include diopside and amphibole skarn, amphibolite, biotite gneiss, and pegmatite. Inclusions of skarn and amphibolite may be rimmed by phlogopite, and inclusions of pegmatite may be rimmed by pyroxene. Mineral foliation and lineation may be present in apparently isolated fragments of gneiss and amphibolite.

Calcite-rich Marble (1a)

The calcite-rich marble is a white rock that is composed mainly of calcite, and commonly contains small proportions of dolomite, phlogopite, graphite, pyroxene, and amphibole. Very small proportions of other minerals may be present, as shown

in table 2. Locally, hydrogen sulphide is liberated when the rock is broken.

Fine exposures of calcite-rich marble may be examined near (49.9, 21.0), where the marble contains thin layers relatively rich in dolomite, in dolomite and phlogopite, and in amphibole. The crystals in these layers may be larger in size than the crystals in the adjacent calcite-rich rock. Layers of nearly pure dolomite, up to $\frac{1}{3}$ m thick may also be present, as shown in plate 2. All of the layers within the marble are, for the most part, conformable.

The rock also contains tabular mylonite zones, darker in colour, and composed mainly of fine-grained calcite and graphite. These zones are approximately parallel to the layering described above.

Although calcite and dolomite occur as discrete grains, calcite grains may contain tiny inclusions of dolomite. This appears to be an exsolution texture.

Calcic pyroxene and amphibole are commonly present in the calcite-rich marbles in small amounts. The amphibole may occur as discrete grains, but it commonly forms rims about grains of calcic pyroxene. The texture is well displayed in specimen G103-69 (table 2), where the crystallographic axes of the amphibole mantle are parallel to those of the pyroxene core. Locally, tiny grains of quartz are present within the amphibole mantle. It is evident that a hydration reaction occurred such that pyroxene was altered to amphibole plus quartz. This reaction may have taken place during the closing stages of metamorphism, not necessarily at a lower temperature than that which prevailed during the crystallization of pyroxene.

Tabular crystals of graphite and phlogopite are very common in the marbles, and these may have a parallel or a random orientation. Where the orientation is parallel, the resulting foliation plane lies parallel to the layering.

Other Marble Units

Dolomite-rich marble (1b), which consists entirely or almost entirely of dolomite, was found at a few localities, where it occurs as layers and lenses, a few mm to about $\frac{1}{3}$ m thick in calcite-rich marble. It is a white rock that weathers to a dark gray colour (plate 2), and on some rock surfaces can be readily distinguished from calcite-rich marble. Exposures may be seen at (49.96, 21.0), where the photograph of plate 2 was taken, and at (48.35, 21.1) and (48.4, 20.1).

Humite-group marble (1d) was found only at one place (49.8, 21.0) where clinohumite, $\text{Mg}(\text{OH},\text{F})_2 \cdot 4\text{Mg}_2\text{SiO}_4$, is locally present in a thick layer of calcite-rich marble. The minerals present in two specimens collected from this locality are listed in table 2.

Serpentine marble (1e) is essentially a calcite-rich marble which contains 5 to 30 per cent serpentine. It may contain minor dolomite and phlogopite (table 2). This rock was encountered at numerous places in the sub-area, for example at (48.4, 21.5), where calcite-rich marble and serpentine marble are interlayered, at (48.4, 20.7), where serpentine marble forms layers and lenses in calcite-rich marble, and at (49.2, 20.1), where serpentine marble contains pods of serpentine and inclusions of diopside rock rimmed by serpentine.

The serpentine occurs as granules, about 1 mm in diameter,

and appears to be, for the most part, an alteration of olivine. In some rocks of the Otter Lake area, various stages in the alteration of olivine to serpentine have been preserved. In addition; some serpentine may have formed from diopside, as shown for example by the presence of serpentine rims about inclusions of diopside rock.

Pink calcite marble with calcic pyroxene (lf) was found at only two localities. At (20.2, 19.7), where marble and plagioclase gneiss are interlayered, some of the marble is pink in colour and contains green pyroxene, as well as some quartz and potassium feldspar. At (48.25, 20.0), a minor amount of pink marble, containing green pyroxene and black phlogopite, is exposed on a cliff, which is composed mainly of white, calcite-rich marble and plagioclase gneisses.

Brucite marble was observed at only one locality (48.1, 20.7), where a white marble contains about 15 per cent of gray granules of brucite, and minor serpentine.

Rocks rich in minerals such as calcic pyroxene, calcic amphibole, scapolite, and phlogopite are here referred to as skarn. They are commonly associated with marble, and commonly occur as inclusions in marble, and they may contain a small proportion of calcite.

White diopside skarn (lp), which occurs abundantly on Calumet Island to the south-west, is not common in the Kazabazua River sub-area. It may be examined at (49.6, 20.6), where an outcropping 10 x 30 m consists almost entirely of white diopside, with some phlogopite and a trace of calcite. The skarn is cut by quartz veins.

Green diposide skarn (lq) was found at several localities,

where it occurs as small bodies associated with marble and pegmatite. It consists mainly of green diopside but usually contains also some black phlogopite and green amphibole. Exposures of pyroxene-rich skarn and amphibole-rich skarn associated with serpentine marble and granitic rock may be examined at (48.36, 21.04). At (49.33, 21.35) a zone of skarn, about 1 cm thick has developed at the contact between calcite-rich marble and biotite gneiss.

The occurrence of skarn as inclusions in marble is well shown in the vicinity of (49.9, 21.0), (48.68, 20.0), and (48.4, 20.1). Some of the inclusions contain graphite. A zoned inclusion, about 20 cm in diameter, was found to contain a core rich in scapolite, followed by zones rich in pyroxene, then amphibole, and finally, phlogopite.

Diopside-scapolite-sphene skarn (1r) was observed at 2 or 3 localities. At (49.93, 20.35), in and about a pit of disintegrated marble, numerous blocks of scapolite skarn have been found by local residents; the scapolite is highly fluorescent.

Plagioclase gneisses and amphibolites (2)

Approximately one-half of the Kazabazua River sub-area is underlain by a variety of plagioclase-bearing gneisses and amphibolites, similar to rocks that elsewhere have been referred to as Grenville-type gneisses. The rocks have been subdivided as shown in table 1. They are gray rocks composed of plagioclase and certain combinations of garnet, biotite, hornblende, and calcic pyroxene. Quartz is commonly present but potassium feldspar is absent or present in only small amounts. Varieties with sillimanite or with orthopyroxene

were not found in the Kazabazua River sub-area. Representative mineral assemblages are listed in table 3.

Apart from biotite-graphite gneiss (2d), which is a distinctive, rusty-weathering rock, all of the rock units are gradational one to the other, and are best described together; they will be referred to as the common plagioclase gneisses and amphibolites.

The common plagioclase gneisses and amphibolites occur interlayered with each other and with marble. Most exposures show the presence of some gray quartz-feldspar (pegmatitic) material in the form of veins or layers, usually parallel to the layering, or as more irregularly-shaped bodies. The proportion of this material varies greatly, and when present in proportions greater than about 10 per cent, its presence is indicated on the geological map by the appropriate symbol.

Biotite-garnet gneiss (2b) and biotite gneiss (2c) form a small proportion of the total plagioclase gneiss and amphibolite of the map-area. Representative mineral assemblages are given in table 3. The rock is well exposed near the northern boundary (50.56, 20.4), where it is a sandy-weathering rock with about 10 per cent of biotite. At this locality, the rock contains a very small proportion of gray quartz-feldspar material as layers parallel to a foliation defined by the parallel orientation of biotite crystals. A few small amphibolite lenses and layers, a few cm thick, are also present, parallel to the foliation. A small amount of pegmatite is present, occurring as small cross-cutting, folded dikes and as larger pink pegmatite dikes. Small quartz veins of variable attitude are also to be found here.

Hornblende-biotite-garnet gneiss and hornblende-garnet gneiss (2e) are common in the map-area, and some mineral assemblages are given in table 3. The rock is very well exposed in the vicinity of (49.9, 20.8), where some biotite gneiss (2c) and biotite-garnet gneiss (2b) are also present. The rock here is gray-weathering, relatively homogeneous, and relatively fine-grained, with grain size about $\frac{1}{2}$ mm. A foliation, marked by the parallel orientation of biotite and hornblende crystals is well developed, and a gneissic texture or lamination, formed by the segregation of quartz and plagioclase, is also present. The proportion of quartz and plagioclase in the lamellae varies greatly; some consist almost entirely of quartz.

Occasional amphibolite layers, a few cm to about 1 m thick are interlayered with the gneisses at the above-mentioned locality. These consist of hornblende, biotite, and plagioclase, with local calcic pyroxene, and themselves possess a layering, best revealed on weathered surfaces. A very small proportion of pegmatite is associated with the amphibolite, occurring as layers and pods which for the most part lie parallel to the foliation. These consist of quartz, plagioclase, potassium feldspar, hornblende, and biotite, and possess an erratic mineral distribution and an apparently random crystal orientation. Some quartz veins are also present at the above locality; they are a few cm thick and are both cross-cutting and parallel to the foliation.

Another fine exposure of hornblende-biotite-garnet gneiss (2e) is found at (50.03, 19.62), where locally the rock possesses a very well developed mineral foliation and mineral lineation.

Even some of the small quartz-feldspar veins possess a lineation, defined by elongate quartz grains.

Hornblende-biotite gneiss and amphibolite, and hornblende gneiss and amphibolite (2f) form the most common varieties of plagioclase gneisses in the Kazabazua River, map-area, as well as in the Otter Lake area as a whole. Typically, the rock is dark gray to black, and contains 20 to 40 per cent of hornblende, with a smaller proportion of biotite. Quartz may or may not be present. The rock almost invariably possesses a mineral foliation defined by the parallel orientation of hornblende and biotite crystals, but this foliation is at times difficult to detect in the field. Gneissic texture and lamination may be present, or the rock may be nearly homogeneous. Typical mineral assemblages are listed in table 3.

Fine exposures of rock unit 2f are found in a cliff beside the Cawood road, at (48.4, 21.35). The rock here consists principally of hornblende-biotite gneiss (G72-69, table 3), which possesses a well-developed foliation involving all minerals, and a faint gneissic texture. The mean grain size is about 1 mm. A small amount of biotite-garnet gneiss (G13-69, table 3) is interlayered with the hornblende-biotite gneiss, and some quartz-feldspar material is present as layers and lenses. The latter rock varies from fine to coarse-grained (1 to 5 mm), and consists of quartz, plagioclase (An 10) and potassium feldspar which occurs as discrete grains or as inclusions in plagioclase; erratically distributed crystals of garnet may be present.

Additional exposures of hornblende gneiss may be examined at (48.55, 21.26), near the above locality. Here the rock may contain about 20 per cent of gray pegmatitic material, occurring as veins and dikes passing through the rock in various

directions (plate 3). Some of the pegmatite bodies contain hornblende while others contain some potassium feldspar. Concentrations of biotite are locally found in the gneiss, along the margins.

Noteworthy exposures of hornblende-biotite gneiss are also found at (48.37, 19.95), where the rock (G92-69, table 3), displays foliation, lineation, and gneissic texture. The rock appears to be homogeneous, but slight variation in mineral proportion evidently exists from layer to layer, for incipient boudinage structures have developed locally.

Hornblende gneiss or amphibolite in which the grain size varies conspicuously, was found at (49.26, 20.0). Specimens of fine-grained amphibolite (G118-69) and medium-grained amphibolite (G119-69) are included in table 3.

A very patchy hornblende gneiss occurs in an erosion gully at (48.43, 20.15). Immediately beside the Cawood road, south of the gully, there is an outcropping of hornblende gneiss with prismatic clusters of plagioclase grains. This may have been a prophyritic igneous rock.

Calcic pyroxene gneiss and granulite (2g) occurs rarely in the Kazabazua River sub-area. It is found for example at (48.38, 20.54), 100 m north of the road (specimen G85-69, table 3), where it is associated with granitic rocks.

A peculiar body of fine-grained, homogeneous rock containing garnet and calcic pyroxene but no hornblende or biotite (specimen G59-68, table 3) occurs at the Kazabazua river (49.15, 20.10). The rock is faintly gneissic. Some pegmatite is present, as dikes and apparently as inclusions. This rock is classed as pyroxene gneiss but differs greatly

from other pyroxene gneisses of the Otter Lake area.

Biotite-graphite gneiss and schist (2d) was found in the south-west corner of the map area (at 48.15, 21.32) where it forms a layer associated with other plagioclase gneisses and with marble. The rock weathers yellow, rusty, or black, due to the presence of pyrite. One sample was found to consist mainly of quartz, plagioclase (about An 20), red biotite, and about 10 per cent graphite. Minor amounts of muscovite, potassium feldspar, pyrite, and apatite are present.

Mafic and Ultramafic Rocks (3)

The mafic and ultramafic rocks of the Kazabazua River sub-area have been sub-divided as shown in table 1. In some of these rocks an igneous (sub-ophitic) texture is partly preserved, but most of them are essentially metamorphic rocks with foliation and gneissic texture developed in varying degrees. There appears to be little doubt that most or all of the rocks here referred to as mafic and ultramafic rocks were initially igneous rocks of gabbro or diorite composition, which were emplaced before or during the most recent metamorphism.

Gabbro and Altered Gabbro; Igneous Texture Preserved (3a)

Two small bodies of gabbroic rock in which sub-ophitic texture is partly preserved were found in the Kazabazua River sub-area. One of these, near (49.62, 21.55) appears to be a dike, while the other, at (48.66, 20.87) is a small pluton.

The gabbro body at (49.62, 21.55) as exposed is about 240 m long and 30 m wide, and consists of a dark, fine-grained, homogeneous rock. Two specimens were collected from the southern end of the dike, these being separated by a distance of about

5 m. One (G35-68, table 4) is composed of plagioclase, orthopyroxene, calcic, pyroxene, hornblende, biotite, and minor amounts of other minerals. The texture is subophitic, but the presence of irregular surfaces on the long-prismatic plagioclase crystals, and the presence of hornblende rims about pyroxene crystals suggests that the rock was somewhat affected by metamorphism. In the other specimen (G36-68, table 4), orthopyroxene and calcic pyroxene are not present and have apparently completely altered to hornblende, the ophitic texture being partly destroyed. This rock has evidently been more intensely affected by metamorphism. A third specimen, collected approximately mid-way along the length of the exposed dike appears to be intermediate to the above two specimens regarding degree of metamorphism.

The gabbro body at (48.66, 20.87), as exposed, forms a small pluton about 75 m in diameter, surrounded on three sides by hornblende gneiss. The rock is medium-grained and its texture is highly variable. Portions of the body are homogeneous, with no apparent foliation or gneissic texture. A sample of this rock (G53-68, table 4) was found to consist of calcic plagioclase crystals, which show a slight tendency toward 'lath shape', and of hornblende with relicts of calcic pyroxene. The rock appears to have initially possessed a gabbroic texture, which has been largely destroyed by metamorphism.

Portions of the body are composed of a gneissic to laminated, heterogeneous rock. One large sample of this rock was obtained, and the minerals found in two thin-sections cut therefrom (G54-68A, G54-68B) are listed in table 4. In this rock, the plagioclase is more sodic, pyroxene is absent, and hornblende is

more abundant. Garnet is locally present. The rock appears to represent a portion of the pluton that was intensely deformed and affected by metamorphism. Some of the differences between the two specimens collected from the pluton (for instance the composition of plagioclase and the amount of apatite) may be attributed to initial differences in bulk composition.

Metagabbro (3b)

One large layer and several smaller bodies of a distinctive mafic rock, composed mainly of hornblende and plagioclase, occur in the map-area. Typically, hornblende forms gneissic segregations which are normally about 1 cm in dimension, but may be as large as 7 cm, giving the rock a striking appearance. Calcic pyroxene and biotite are commonly also present, while anthophyllite and scapolite are rare. The rock will here be referred to as metagabbro, although the contained plagioclase is usually less calcic than An 50.

North of the Kazabazua river, a layer of metagabbro can be traced for a horizontal distance of nearly 3 km. The thickness is somewhat variable, as shown on the geological map, and reaches a maximum of about 150 m. The body appears to terminate in the south, near the Kazabazua river. The layer is underlain by hornblende gneiss and amphibolite (2f) and overlain, for the most part, by marble (1a).

Locally, the rock shows considerable variation. For example, at (50.03, 19.14) the hornblende content is variable, in places attaining nearly 100 per cent, while the gneissic texture varies from fine to coarse. The crystal size is also variable, and in places the hornblende crystals are 2 cm long while the plagioclase grains are only about 1 mm in diameter.

At (49.56, 19.4) a faint layering was detected within the layer of metagabbro. This structure consists of four layers, a few mm thick, relatively rich in hornblende, occurring within a 'section' of metagabbro, 0.6 m thick.

The minerals present in four samples of the large metagabbro layer are listed in table 4. Calcic pyroxene is only locally present. In some rocks, aggregates of chlorite grains are found, surrounded by hornblende, and these appear to be products of a late-stage alteration of relict grains of calcic pyroxene, left over from the metamorphic conversion of pyroxene to amphibole. Magnetite is commonly present in relatively large amounts (up to about 5 per cent) and small amounts of pyrite are usually present.

Numerous smaller bodies of metagabbro were encountered, but only two of these are large enough to be shown on the geological map. The smaller bodies appear to exist mainly as layers, and occur interlayered with gneisses (2) and marbles (1). Locally (50.25, 19.65) a rock very similar to metagabbro occurs as pods and lenses, only a few cm in dimension, within hornblende gneiss.

Some samples of the smaller bodies of metagabbro are listed in table 4. Calcic pyroxene is locally abundant, and biotite may be present. Not all of the rocks contain magnetite. Scapolite and potassium feldspar are present in the small pluton near the north border (50.5, 20.75), in a rock that appears to have been affected by metasomatism (G30-68, table 4).

Hornblende-plagioclase amphibolite (3c)

Metagabbro as described above commonly occurs elsewhere in the Otter Lake-Fort Coulonge area, and associated with it one may find bodies of amphibolite that in many respects resemble the amphibolite (2f) of the plagioclase gneisses and amphibolites (2). Amphibolite associated with metagabbro is in general more homogeneous, darker in colour, and richer in magnetite.

In the Kazabazua River sub-area, a body of amphibolite (3c) was found near the western margin (at 49.8, 21.3), where it locally grades into or contains bodies of metagabbro (3b) and ultramafic rock (3d). A specimen from this locality has been examined microscopically (G31068, table 4), and was found to contain about 10 per cent magnetite.

A similar rock occurs to the south of the above locality, between a layer of marble (1a) to the east and interlayered marble (1a) and gneiss (2fc) to the west. However, this rock contains only a very small amount of magnetite, and in addition the plagioclase is more sodic (An 25) than that normally found in the mafic amphibolite (3c); the rock has therefore been grouped with the plagioclase gneisses and amphibolites (2).

Ultramafic rock (3d)

Three occurrences of ultramafic rock (3d) were found in the Kazabazua River sub-area. The outcroppings are very small, and the bodies of rock are possibly no more than a few m in dimension. The rock may be homogeneous or heterogeneous, and they may or may not show a slight foliation.

Within the body of mafic amphibolite (3c) described above (at 49.73, 21.47), the ultramafic rock consists almost entirely of calcic pyroxene and hornblende (specimen G38-68, table 4). These minerals are rich in magnesium relative to iron, and no magnetite or other iron minerals are present, the rock must be rich in magnesium.

The body of metagabbro that is situated near the south border of the map-area, contains a small body of ultramafic rock (at 48.25, 20.74). A specimen of this rock (G113-69) is composed principally of calcic pyroxene and hornblende, but contains small amounts of other minerals, as shown in table 4. The hornblende appears to have formed wholly or in part from calcic pyroxene, and most of the plagioclase has altered to white mica.

Numerous blocks of a spinel-bearing ultramafic rock were observed at (48.58, 20.75); the mineral assemblage found in one sample (G62-68) is given in table 4.

Near the above locality, at (48.6, 20.73), a hornblende-rich layer may be examined; the layer is more than 1 m thick, and in addition to hornblende, contains some orthopyroxene, calcic pyroxene, biotite, and plagioclase (G63-68, table 4). The rock is associated with a variety of rocks, including hornblende gneiss, metagabbro, veined gneiss, and pegmatite.

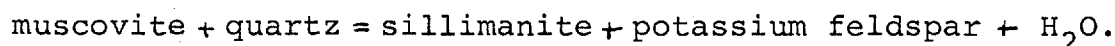
Potassium Feldspar Gneisses (4)

In the Otter Lake-Fort Coulonge area, potassium feldspar gneisses occur in great abundance and variety, but in the Kazabazua River sub-area, only veined gneiss (4a) is present. The main occurrence of this rock lies near the western margin of the map-area, in the vicinity of (49.8, 21.6), which forms the eastern edge of a broad belt of northerly-trending veined

gneiss. Apart from this locality, veined gneiss was found at three other places in the Kazabazua River sub-area, where it forms small outcroppings.

Veined gneiss (4a) is a distinctive, pink coloured rock. It normally consists of two parts, a gray or gray-pink biotite gneiss, and coarse-grained pink quartz-feldspar material, present as numerous small veins lying parallel to the foliation. The proportion of quartz-feldspar material varies, but is normally 10 to 30 per cent of the total rock volume. Larger (about 1 m thick) pink pegmatite layers are commonly also present.

The minerals found in 3 specimens of veined gneiss are listed in table 5. Muscovite is present, and in one specimen it is associated with sillimanite, potassium feldspar, and quartz, i.e. all of the minerals of the following equation are present:



The sillimanite within this rock occurs only locally and invariably near muscovite. Evidently it formed from muscovite by the above reaction, which however did not proceed to completion.

Granitic and Syenitic Rocks (5)

The granitic and syenitic rocks of the Otter Lake - Fort Coulonge area have been subdivided as shown in table 1. In the Kazabazua River sub-area, only heterogeneous granitic and syenitic rocks are present.

Gray Granite (5a) Layers in Marble (1a)

At several places in the map-area, the calcite-rich marble (1a) contains layers of gray granitic rock, ranging in thickness from a few cm to a few tens of cm. The layers generally lie parallel to the layering within the marble; in places, they are

somewhat folded. Exposures may be examined at (48.57, 20.42) and (48.35, 20.85).

Many of the layers possess a pronounced foliation or lamination, defined by parallel lenses and lamellae of quartz, but in the hinge areas of the folds, the foliation is often somewhat obscure. The foliation generally lies parallel to the layering, and in the hinge areas, it may either maintain parallelism with the layer or it may show a tendency to parallel the axial plane.

The granitic layers are composed mainly of quartz, plagioclase and potassium feldspar. Minor mica or pyroxene may be present, and garnet was found at one locality. The mineral proportions within one specimen (G136-70) obtained near Kazabazua River (49.05, 19.3) is given in table 6.

Gray Granite (5a) Bodies Associated with Marble (1a)

In the southern half of the map-area, in the vicinity of (48.7, 20.0), a volume of intermixed marble (1a) and gray granitic rock (5a) appears to form the hinge area of a northerly plunging anticline. The granitic rock occurs as irregularly-shaped bodies a few m to a few tens of m in dimension, embedded in marble, but locally the marble appears to have invaded the granite. The proportion of granitic rock to marble varies from place to place, and, taking into account the greater resistance that the granitic rock offers to erosion, the proportion may be approximately 1 to 1. The limbs of the anticline contain only a very small proportion of granite.

The granitic rock is always gray, but varies considerably in relation to mineral proportion and texture. The minerals present include quartz, plagioclase, potassium feldspar, biotite,

muscovite, and minor amounts of other minerals. The variation one may find in the plagioclase to potassium feldspar ratio and in the amount of biotite present is shown by two specimens (G55-68, G57-68) listed in table 6.

The grain diameter is normally about 1 mm, but locally the grain size may range from fine to coarse. Some rocks display alternate layers of slightly different grain size. The rock locally possesses a pronounced lineation, defined by elongate aggregates of biotite grains; a foliation, also defined by biotite grains, may or may not be present in the lineated rocks. In some rocks, foliation and lineation cannot be detected by macroscopic examination. The granitic rock may locally be very heterogeneous. Pods and veins of quartz may be present.

Granitic Rock (5ac) Associated with Plagioclase Gneisses and
Amphibolites (2)

Nearly all outcroppings of plagioclase gneiss and amphibolite (2) in the Kazabazua River sub-area show the presence of some quartz-feldspar bodies that may be referred to as granite or pegmatite. The bodies are mainly tabular sheets and veins, a few cm to a few tens of cm thick, that lie parallel to the foliation in the gneiss and amphibolite, but cross-cutting layers and veins may also be present. Some bodies are highly irregular in shape. An example of granitic veins in amphibolite is shown in plate 3, and fine exposures may be examined in the vicinity of (48.4, 21.35). The proportion of granitic material present ranges from a small fraction to about 50 per cent; an average value is about 10 per cent.

The granitic rock is mainly white or gray in colour (5a)

but some bodies of pink granite (5c) may be found. Small bodies of granitic rock a few cm in dimension are normally gray (5a) and poor in potassium feldspar; larger bodies, a few m in dimension may be either gray (5a) or pink (5c) and are rich in potassium feldspar. The mineral content of gray granite (5a) and pink granite (5c) is similar; dark minerals commonly present include hornblende and biotite, and locally calcic pyroxene, sphene, or garnet. Magnetite occurs locally as crystals up to 1 cm in diameter.

One specimen of pegmatite (G74-69) was examined in some detail. It was collected at (48.4, 21.35), where gray pegmatite forms layers in hornblende-biotite gneiss (G72-69, table 3) and biotite gneiss with traces of garnet (G73-69, table 3). The pegmatite consists mainly of plagioclase and quartz and contains only minor amounts of potassium feldspar (table 6), mainly as inclusions in plagioclase. The grain size is about 1 cm, and the rock possesses a conspicuous foliation, defined by the parallel arrangement of non-equidimensional quartz grains. Shreds of biotite aggregates or biotite and garnet are present, and may represent portions of gneiss that were incorporated in the pegmatite. The pegmatite here appears to have been metamorphosed.

Syenite (5e) Associated with Hornblende Gneiss (2f)

Syenite (5e) was found near the south-west corner of the area (48.25, 21.27), where the rock occurs as local layers and pods of gray-to-pink pyroxene syenite and hornblende syenite, in a mixture of hornblende gneiss (2f) and gray-to-pink granite and pegmatite. The syenitic rocks contain pods of green pyroxene, some of which have cores of black hornblende.

Pink Pegmatite (5c) Associated with Veined Gneiss (4a)

Pink pegmatite layers, about 1 m thick are commonly associated with the veined gneiss found in the vicinity of (49.8, 21.6). Specimen G34-68 (at 49.94, 21.6) consists principally of quartz, plagioclase, and potassium feldspar, and contains minor amounts of biotite, muscovite, and sillimanite. Biotite occurs as aggregates, about 1 cm in diameter. Sillimanite is only locally present; as in the adjacent veined gneiss (G33-68, table 5), it is associated with muscovite.

Pegmatite (5ac) associated with metagabbro (3b)

Pegmatite dikes locally cut metagabbro (3b), but they are not nearly as abundant as in the other rock units (1, 2, 4). In the vicinity of (49.7, 21.4) a slightly gneissic pegmatite dike in metagabbro was found to consist of plagioclase (An 20) and quartz, with minor amounts of potassium feldspar, biotite, chlorite, and magnetite. The pegmatite contains inclusions of the enclosing rock.

Diabase Dikes (6)

Only one diabase dike was found within the Kazabazua River sub-area, and this lies near the Kazabazua River, at (49.1, 20.1). The dike is about 45 m thick, and is exposed for only a short distance along its length. A well developed fracture set is present, with fractures approximately parallel to the dike and spaced at about $1/3$ m intervals; fractures in other directions are also present.

The rock is homogeneous, with random orientation of minerals, and sub-ophitic texture. It consists of plagioclase

(about An 58) and calcic pyroxene, the latter partly altered to mica, sphene, and chlorite. Small amounts of quartz, magnetite, and apatite are also present.

Structural Geology

Nearly all of the rock exposures of the Kazabazua River sub-area possess a planar element, and many possess a linear element as well. The planar elements are defined by 1) layering within marble and within plagioclase gneisses and amphibolites, and the interlayering of marbles, gneisses, and other rock units, 2) gneissic texture, and 3) mineral foliation, i.e. the parallel orientation of crystals of biotite and other minerals in the rocks. Where two or three planar elements are found in the same rock, they are almost invariably parallel. Linear elements are defined by 1) mineral lineation, i.e. the parallel orientation of elongate crystals of hornblende, quartz, or other minerals, or the occurrence of elongate clusters of crystals of biotite or other minerals, 2) fold axes of folded layers of plagioclase gneiss and amphibolite, and 3) fold axes of folded layers of quartz-feldspar rock in marble. More than one of these linear elements are rarely found in the same outcropping, but where found in adjacent outcroppings, they are almost invariably nearly parallel.

From a structural point of view, the Kazabazua River sub-area can be readily divided into a northern half and a southern half, separated by the east-west valley near latitude $45^{\circ} 49'$. In the northern half, the planar elements everywhere dip easterly and the linear elements plunge easterly. Some variation exists in the attitude of these elements. The strike appears to undulate, as shown especially by the shape of the

large layer of metagabbro. On a smaller scale, within an area 240 m by 900 m (at 49.8, 20.8), 17 measurements have revealed a variation in strike from Azimuth 358° to 35° and a variation in dip from 30° to 50° east. The mineral lineations in the northern half also show some variation in bearing and plunge angles; in general they are confined to the foliation plane. A stereographic plot of the poles to the planar elements, and of the linear elements from the northern part of the map-area is shown in fig. 2.

A noteworthy aspect of the structure of the northern part is that small-scale folds are practically absent.

Within the southern half of the map-area, the planar elements vary greatly in attitude, and the linear elements plunge north-easterly. The fold axes of small quartz-feldspar layers in marble may vary somewhat. For example, at (48.57, 20.42), 12 measurements produced a variation in bearing from Azimuth 15° to 39° , and in plunge from 9° to 33° north-east. A stereographic plot of the poles to the planar elements, and of the linear elements in the southern part of the map-area is shown in fig. 3. It is evident that the poles to planar elements define a girdle, which indicates that the rocks were folded about north-easterly plunging axes. All linear elements lie approximately parallel to the girdle axes, i.e. to the axes of large-scale folds.

In contrast to the northern part of the sub-area, small-scale folds are very common in the southern part. Large-scale folding is also seen in the anticlinal structure involving intermixed marble and gray granite (map unit II). The limbs of this fold dip easterly and the axis plunges north-easterly.

The boundary between the northern and southern halves of the map-area is marked by a topographic lineament, defined by an east-west valley. The rock near this lineament is commonly very much fractured, and two specimens of plagioclase gneiss near (49.1, 20.5) were found to be highly altered, with plagioclase altered to white mica and hornblende and biotite to chlorite. These specimens contain an unusually large amount of pyrite, suggesting that pyrite was introduced to the rocks. It appears likely therefore that this lineament marks the presence of a fault.

The lineament can be traced both eastward and westward for distances of about 14 miles, or a total distance of about 30 miles. If a fault is in fact present, the direction and magnitude of the displacement cannot be determined at present. The apparent 'drag' of the gneiss and marble layers north of the lineament (at 49, 19.2) may be the result of the north block moving west and perhaps down relative to the south block.

A southeasterly trending fault may be present in the southern part of the area, and may account for the apparent discontinuity, in a northeasterly direction, of the metagabbro and marble layers near (48.3, 20.0).

Geological Interpretation

The Kazabazua River sub-area forms only a small area, and elaborate interpretations concerning the origin and development of the rocks do not appear to be in order. Nevertheless, some preliminary interpretations can be offered, and a rough sketch can be drawn of the geological history of the area.

The rocks are principally metamorphic rocks, similar to

rocks that elsewhere in the Grenville province have been dated at about ^{1 billion} 10 years. The diabase dike is not affected by metamorphism, and must be younger in age.

The calcite and dolomite marbles of the map-area are considered to be metamorphosed limestone, and the layering found in the marbles may be preserved sedimentary bedding. Metamorphism has caused a recrystallization of carbonate minerals, and the local crystallization of forsterite, diopside, phlogopite, amphibole, and humite, which may have been produced from interaction of carbonate minerals with quartz. Some introduction of material may have taken place during metamorphism, for example fluorine to form humite and potassium to form phlogopite, while carbon dioxide certainly escaped from the rock. The presence of diopside crystals rimmed by amphibole is interpreted as the result of an introduction of water to the rock after metamorphism was already well advanced. The graphite, so commonly present in the marbles was produced from organic matter, or it was derived from the carbonate minerals. Serpentine has evidently formed from forsterite, and possibly also from diopside, due to the introduction of water at a later stage and lower temperature, i.e. during a period of retrograde metamorphism.

The plagioclase gneisses and amphibolites represent a wide range in chemical composition. Some of the biotite-garnet gneisses are possibly similar to graywacke or argillite in composition, while the hornblende and calcic pyroxene gneisses and amphibolites are possibly similar to andesite and basalt in composition. The layered aspect of these rocks, and their association with marble suggests that they are metamorphosed

sedimentary and volcanic rocks.

The mafic and ultramafic rocks of the area are interpreted as being igneous rocks, emplaced as sills and small dikes and plutons. Some of these have a partially preserved igneous texture, and were possibly emplaced during the period of metamorphism. But most of the rocks are definitely metamorphic, and must pre-date the metamorphism.

The origin of the veined gneisses in the sub-area is obscure, but elsewhere in the Otter Lake - Fort Coulonge area, gradations can be found along strike from plagioclase gneisses and amphibolites to veined gneiss, and they appear to be metasomatic rocks, derived from the plagioclase gneisses through an introduction of potassium and other elements.

The granitic rocks of the map-area are small bodies, occurring mainly as pegmatite layers and dikes, and as irregularly shaped bodies associated with marble. Most of these rocks were evidently emplaced from an external source, but little is known concerning the origin of the material and the method by which it invaded the other rocks. Most of the granitic bodies have a metamorphic texture and were evidently emplaced before or during metamorphism. Different ages of granitic rocks are no doubt present.

Hence the area is for the most part a metamorphic terrain. The intensity or grade of metamorphism may have varied slightly across the area, but the repeated occurrence of certain minerals and mineral assemblages indicates that no great variation existed. The rocks may be assigned to the upper part of the amphibolite facies, which corresponds to a temperature of approximately 500°C.

The layered rocks were obviously deformed to produce folds ranging in wave length from a few cm to perhaps 1 km or more. It appears clear from figs 2 and 3 and from the geological map that the rock structures in the northern and southern halves of the area are distinctly different. This difference is emphasized in Fig. 4, which represents a preliminary structural interpretation of the map-area.

The period of deformation coincided approximately with the period of metamorphism. It is possible that the rocks were affected by more than one period of metamorphism and deformation. In high-grade metamorphism and metasomatism of the type experienced by this terrain, earlier periods of metamorphism and deformation are usually largely or entirely obliterated.

Following metamorphism, some movement continued in the form of faulting, with one major fault and possibly some small ones. The diabase dike was emplaced, apparently along the major fault. The large fault is only one of numerous east-west faults in the region, some of which have played a major role in the development of the Eardley escarpment and the Ottawa River valley.

References

- Kretz, Ralph, 1957a. Preliminary report on Thorne-Leslie-
Clapham Area. Quebec Dept. Mines. P.R. No. 346.
- _____, 1957b. Preliminary report on Litchfield-
Huddersfield Area. ibid, No. 338.

Rock Units

- X 1. marbles and skarns
 - X 1a. calcite-rich marbles; may contain dolomite; commonly contain phlogopite, graphite, calcic amphibole, calcic pyroxene; layers of dolomite-rich marble may be present.
 - X 1b. dolomite-rich marble.
 - 1c. olivine marble; mainly calcite; some dolomite, olivine (partly altered to serpentine), phlogopite.
 - X 1d. humite-group marble; mainly calcite; some dolomite, phlogopite, and a humite group mineral.
 - X 1e. serpentine marble; mainly calcite and serpentine.
 - X 1f. pink-calcite marble with calcic pyroxene; commonly contains calcic amphibole, biotite.
 - 1g. pink-calcite marble with calcic pyroxene and potassic feldspar; commonly contains scapolite, sphene.
 - 1h. calcite marble with abundant silicates.
 - X 1p. white-diopside skarn; may contain calcic amphibole.
 - X 1q. green-diopside skarn; commonly contains biotite; may contain scapolite, calcic amphibole, calcite.
 - X 1r. diopside-scapolite-sphene skarn and granulite.
 - 1s. calcic pyroxene-garnet granulite.
- X 2. plagioclase gneisses and amphibolites
 - 2a. biotite-garnet-sillimanite gneiss.
 - X 2b. biotite-garnet gneiss.
 - X 2c. biotite gneiss and biotite schist, may contain hornblende
 - X 2d. biotite-graphite gneiss and schist (rusty-weathering); may contain garnet, sillimanite.
 - X 2e. hornblende-biotite-garnet gneiss and amphibolite; hornblende-garnet gneiss and amphibolite; may contain minor calcic pyroxene.
 - X 2f. hornblende-biotite, gneiss and amphibolite; hornblende gneiss and amphibolite; may contain calcic pyroxene.
 - X 2g. calcic pyroxene gneiss and granulite; may contain hornblende, biotite, garnet.
 - 2h. orthopyroxene gneiss and granulite; may contain hornblende, garnet, biotite.
 - X 2q. quartzite.

- X 3. mafic and ultramafic rocks
 - X 3a. gabbro and altered gabbro; igneous texture preserved.
metagabbro:
 - X 3b. hornblende-calcic plagioclase rock with conspicuous segregations of hornblende; may contain biotite, calcic pyroxene, rarely anthophyllite; commonly gneissic.
 - X 3c. mafic amphibolite; homogeneous;
commonly associated with 3b.
 - X 3d. ultramafic rock; commonly contains orthopyroxene (altered), calcic pyroxene, red biotite, rarely spinel;
commonly associated with 3b.

- X 4. potassium feldspar gneisses
 - X 4a. veined gneiss (biotite gneiss with parallel veins of quartz + pink potassium feldspar).
 - 4b. garnet-bearing veined gneiss.
 - 4c. hornblende-bearing veined gneiss.
 - 4d. potassium feldspar granulite with very minor biotite;
small pegmatite dykes commonly present.
 - 4e. biotite-potassium feldspar gneiss and hornblende-biotite-potassium feldspar gneiss.
 - 4f. interlayered amphibolite and pink granitic or syenitic rock (migmatite).

- X 5. granitic and syenitic rocks
predominantly gray, heterogeneous rocks
 - X 5a. leucogranite, biotite granite, pegmatite.
 - 5b. garnet-bearing granite.
predominantly pink, heterogeneous rocks
 - X 5c. leucogranite and pegmatite; may contain minor calcic pyroxene, hornblende, biotite.
 - 5d. calcic pyroxene granite and hornblende granite.
 - X 5e. leucosyenite, calcic pyroxene syenite, and hornblende syenite.
predominantly pink, homogeneous rocks.
 - 5f. granodiorite and associated rocks.
 - 5g. syenite and associated rocks.

- X 6. diabase dikes

Table 2. marbles, mineral assemblages and mineral proportions*

	1	2	3	4	5	6	7	8	9	10
calcite	98	98	90	98	98	80	70	80	90	60
dolomite			2		2	20	30	20	10	2
phlogopite	2		2	2	.1	.1	2	.1	2	10
amphibole	.1	2	2	2	2	2	.1	2	.1	
pyroxene		2	2	.1	.1				.1	
olivine							.1			
clinohumite								2	.1	
quartz	.1			.1						
K feldspar				.1 ⁿ						
tourmaline	.1			.1						
sphene	.1									
serpentine						2	2	.1	.1	30
apatite	.1	.1	.1	.1			.1	.1	.1	
graphite	2		.1	2	2	.1		.1		
magnetite	.1	.1 ⁿ	.1 ⁿ	.1		.1 ⁿ			.1 ⁿ	
spinel							2	.1		
pyrite	.1	.1 ⁿ								
pyrrhotite		.1 ⁿ						.1		

1. G 1-66 (48.4, 21.55) Calcite-rich marble (1a)
2. G 7-66 (48.33, 20.85)
3. G 26-68 (49.94, 20.9)
4. G 103-69 (49.95, 18.95)
5. G 131-69 (49.94, 20.9)
6. G 29-68 (50.48, 20.84)
7. G 46-68 (20.2, 19.7)

- | | | | |
|-----|----------|---------------|--------------------------|
| 8. | G 5-66 | (49.8, 20.0) | humite-group marble (1d) |
| 9. | G 132-69 | (49.94, 20.9) | |
| 10. | 120-55 | (48.4, 21.55) | serpentine marble (1e) |
-
-

*see table 2b

n not confirmed

Table 2b: notation used in the estimation of mineral proportions

<u>Symbol</u>	<u>Meaning</u>
.1	< 0.5 per cent by volume
2	0.5 - 5
10	5 - 15
20	15 - 25
30	25 - 35
40	35 - 45
50	45 - 55
60	55 - 65
70	65 - 75
80	75 - 85
90	85 - 95
98	95 - 100

Table 3: plagioclase gneisses and amphibolites.

mineral assemblages and mineral proportions*

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	
biotite	10	10	10	10	2	2	.1	2	.1	2	.1	2	.1	10	10	10		.1	2	2		
garnet	2	.1			2	10	2	2	20	20	10											10
hornblende		2	.1		2	20	20	2	30	20	30	20	50	30	20	30	40	30	40	40		
Ca pyroxene						2			10								2	2		30	2	
plagioclase	70	50	60	50	60	40	60	80	50	60	60	70	50	40	60	60	50	70	60	20	70	
K feldspar		.1	.1	.1	2		.1	.1														.1
quartz	20	30	30	40	20	20	10	10		2		2		10	10	2				2		2
zircon	.1				.1		.1	.1					.1	.1								.1
sphene										.1							.1			2		
apatite	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1
magnetite					.1	.1 ⁿ	2	2		2		.1	2		.1 ⁿ		2	2	2			10
ilmenite	.1 ⁿ										2 ⁿ			2 ⁿ		2					.1 ⁿ	
pyrite	2		.1	.1 ⁿ		.1 ⁿ	.1 ⁿ			.1 ⁿ	2	.1			.1 ⁿ	.1 ⁿ	.1 ⁿ	.1 ⁿ	.1 ⁿ	.1 ⁿ		
pyrrhotite														.1 ⁿ								
graphite				10																		
allanite		.1 ⁿ	.1		.1 ⁿ		.1 ⁿ	.1														
chlorite	2		2	.1	.1			.1	.1													.1
muscovite + w. mica	2		.1	2	.1			.1			2	.1	.1									
carbonate								.1														

n not confirmed

* see table 2b

Table 3 (continued)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
An(plagioclase)		30	20	20	20	40	24	28	40	29	34	36	38	30	31	36	40	30	32	54	20
1. G 117-69	(49.15, 20.35)	biotite-garnet gneiss (2b)																			
2. G 73-69	(48.4, 21.3)	biotite gneiss (2c)																			
3. G 93-69	(48.75, 18.95)																				
4. G 68-69	(48.15, 21.32)	biotite-graphite gneiss (2d)																			
5. G 22-68	(49.92, 20.74)	hornblende-biotite-garnet gneiss																			
6. G 44-68	(49.7, 20.1)	and hornblende-garnet gneiss (2e)																			
7. G 45-68	(50.03, 19.62)																				
8. G 61-68	(48.64, 19-65)																				
9. G 96-69	(48.7, 20.35)																				
10. G 115-69	(49.3, 20.4)																				
11. G 116-69	(49.13, 20.45)																				
12. G 47-68	(50.0, 20.16)	hornblende-biotite gneiss and																			
13. G 56-68	(48.43, 20.15)	hornblende gneiss (2f)																			
14. G 72-69	(48.4, 21.3)																				
15. G 92-69	(48.37, 19.95)																				
16. G 95-69	(48.6, 20.5)																				
17. G 106-69	(49.67, 19.18)																				
18. G 118-69	(49.26, 20.0)																				
19. G 119-69	(49.26, 20.0)																				
20. G 85-69	(48.38, 20.54)	calcic pyroxene gneiss (2g)																			
21. G 59-69	(49.15, 20.10)																				

Table 4: mafic and ultramafic rocks:

mineral assemblages and mineral proportions*

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
orthopyroxene	2																	2
ca pyroxene	10		10		.1	20				50	2	30			40	50	50	10
hornblende	10	30	30	60	50	20	30	50	30	2	30	30	50	20	50	40	50	60
biotite	10	2	.1	.1	.1				.1	.1	10		.1	2				2
garnet					2													
spinel																		2
plagioclase	60	60	60	40	50	60	60	50	70	40	60	40	50	50		2		20
scapolite										2					2			
K feldspar										2								
quartz	2	2					.1 ⁿ			.1	2			2				
sphene					.1					.1		.1					2	
apatite	.1	.1			.1	.1		.1	.1	.1	.1	.1		.1		.1		
magnetite	2	2	.1 ⁿ		.1 ⁿ	2	2	2	2		2	2 ⁿ		10		2 ⁿ		
ilmenite													.1				.1 ⁿ	.1 ⁿ
pyrite			.1	.1 ⁿ	.1 ⁿ	.1	.1 ⁿ	2	.1		.1	2						
pyrrhotite													.1			2	.1	
chlorite				a 2	a .1	.1	a .1	a 2					.1		2 ⁿ			
muscovite + w. mica			.1		.1	.1				.1		.1		.1		10		
carbonate		.1	.1							.1	a .1	.1	.1			.1	.1	
talc											an .1							

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	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
An(plagioclase)	34	34	70	40 ²	29	50	50	44	52	38	34 ¹¹	46	40	42				44

1.	G 35-68	(49.62, 21.55)	gabbro and altered gabbro (3a), dike-like
2.	G 36-68	(49.62, 21.55)	body at (49.62, 21.55)
3.	G 53-68	(48.66, 20.87)	gabbro and altered gabbro (3a), small
4.	G 54-68 B	(48.66, 20.87)	pluton at (48.66, 20.87)
5.	G 54-68 A	(48.66, 20.87)	
6.	G 100-69	(50.03, 19.14)	metagabbro (3b) large layer
7.	G 109-69	(49.56, 19.4)	
8.	G 110-69	(49.56, 19.4)	
9.	G 137-69	(49.3, 19.6)	
10.	G 30-68	(50.48, 20.75)	metagabbro (3b) various occurrences
11.	G 41-68	(49.7, 21.4)	
12.	G 114-69	(48.1, 20.7)	
13.	326-55	(49.37, 20.4)	
14.	G 31-68	(49.85, 21.3)	mafic amphibolite (3c)
15.	G 38-68	(49.73, 21.47)	ultramafic rocks (3d)
16.	G 113-69	(48.25, 20.74)	
17.	G 62-68	(48.58, 20.75)	
18.	G 63-68	(48.6, 20.73)	

n not confirmed; a alteration of calcic pyroxene

* see table 2b.

Table 5: Veined gneiss:

Mineral assemblages and mineral proportions *

	<u>1</u>	<u>2</u>	<u>3</u>
biotite	20	20	10
muscovite	2	2	.1
sillimanite		.1	
plagioclase	50	50	50
K feldspar	10	10	10
quartz	20	20	20
zircon	.1	.1	.1
apatite		.1	.1
magnetite	.1 ⁿ	.1	.1
pyrrhotite	.1		
chlorite	2		.1
white mica			.1
An (plagioclase)	20 ⁿ	20	20

1. G 32-68 (49.84, 21.58)

2. G 33-68 (49.95, 21.58)

3. G 124-69 (49.7, 21.65)

n not confirmed

* see table 2b

Table 6: Granitic rocks
mineral assemblages and mineral proportions *

	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>
quartz	30	30	20	20
k feldspar	10	60	10	2
plagioclase	60	10	50	80
biotite		.1	10	.1
garnet				.1
muscovite	.1	.1	.1	
chlorite	.1	.1	.1	
zircon			.1	
apatite		.1	.1	
magnetite		.1		
pyrite	.1 ⁿ		.1	
rutile			.1 ⁿ	
sphene	.1			
carbonate			.1	
An (Plagioclase)	20	20	16	

1. G 136-70(49.05, 19.3) gray granite (5a) layer in marble
2. G 55-68 (48.7, 20.15) gray granite (5a) associated with marble.
3. G 57-68 (48.95, 19.95) gray granite (5a) associated with marble.
4. G 74-69 (48.4, 21.3) gray granite (5a) associated with hornblende-biotite gneiss and biotite gneiss.

n not confirmed

* see table 2b

Plates

1. View of a portion of the Kazabazua River sub-area.
2. Calcite-rich marble (light) with layers of dolomite-rich marble (dark). Location (49.97, 21.0).
3. Quartz-feldspar veins in amphibolite. Location (48.55, 21.26).

1.



2.

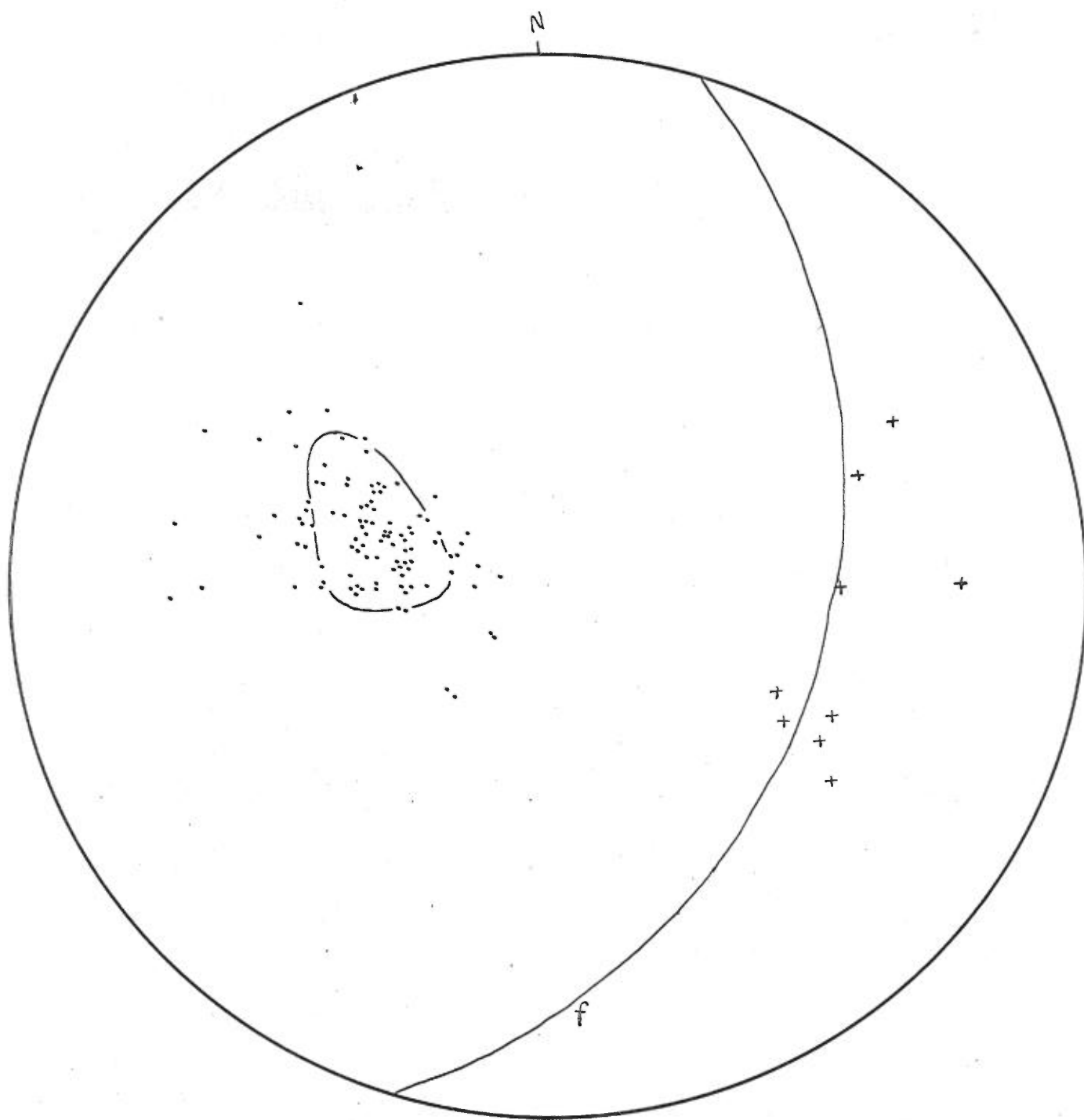


3.



Figures

2. Stereographic plot of structural elements in the northern half of the Kazabazua River sub-area.
3. Stereographic plot of structural elements in the southern half of the Kazabazua River sub-area.

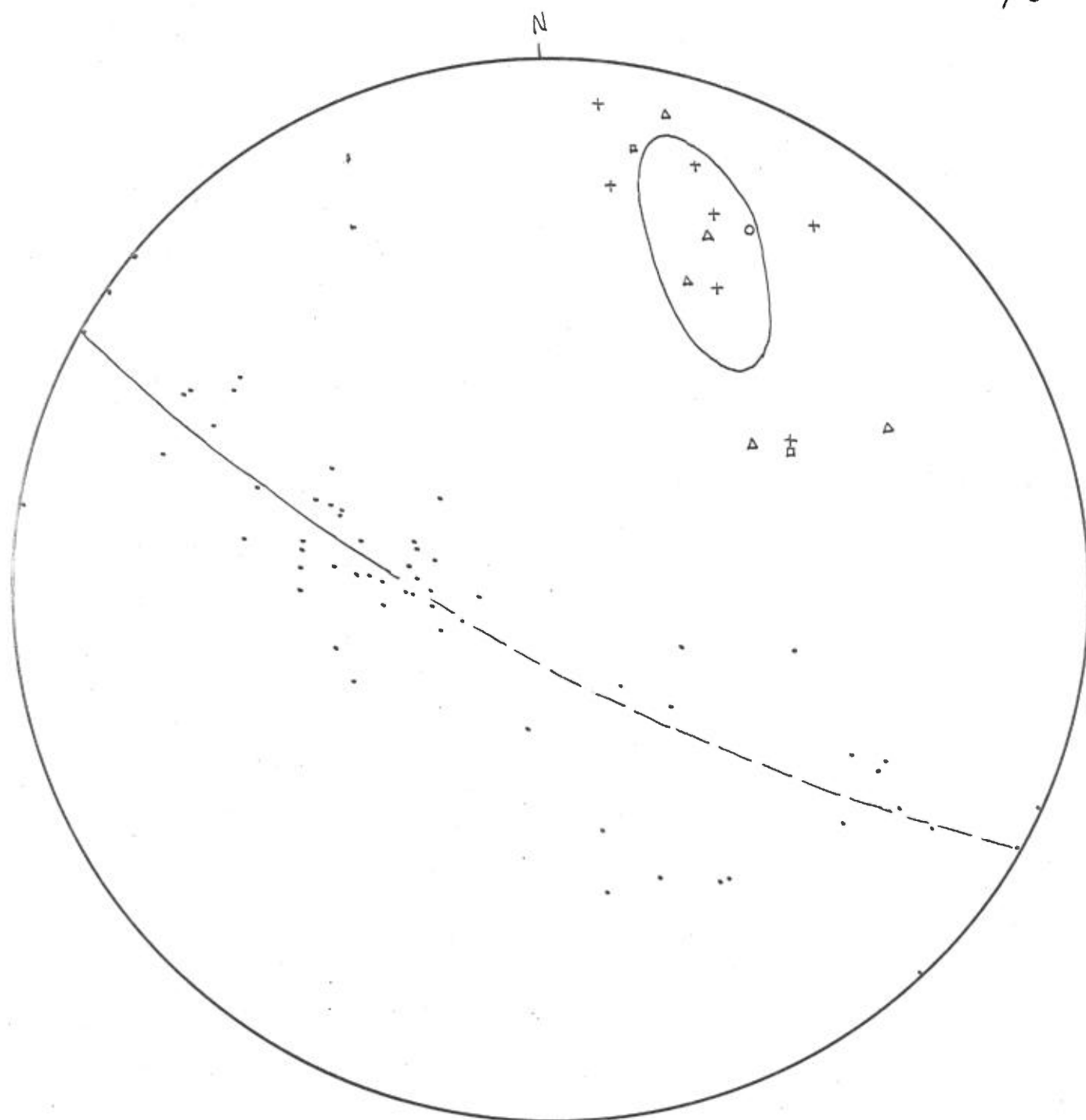


• poles to foliation and layering (103 measurements)

+ mineral lineation (9 measurements)

○ variation in poles to foliation planes (17 measurements) in
an area 240 m by 900 m (at 49.8, 20.8); only 4 poles indicated.

f mean foliation plane



- poles to foliation and layering (60 measurements)
- + mineral lineation (7 measurements)
- O variation in fold axes, quartz-feldspar layers in marble at (48.57, 20.42), (12 measurements)
- Δ fold axes, quartz-feldspar layers in marble
- fold axes, plagioclase gneiss
- girdle axis