A STUDY OF THE SICKLE CONGLOMERATE WITH SPECIAL REFERENCE TO THE ZIRCON CONTENT

A Thesis

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Master of Science

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by

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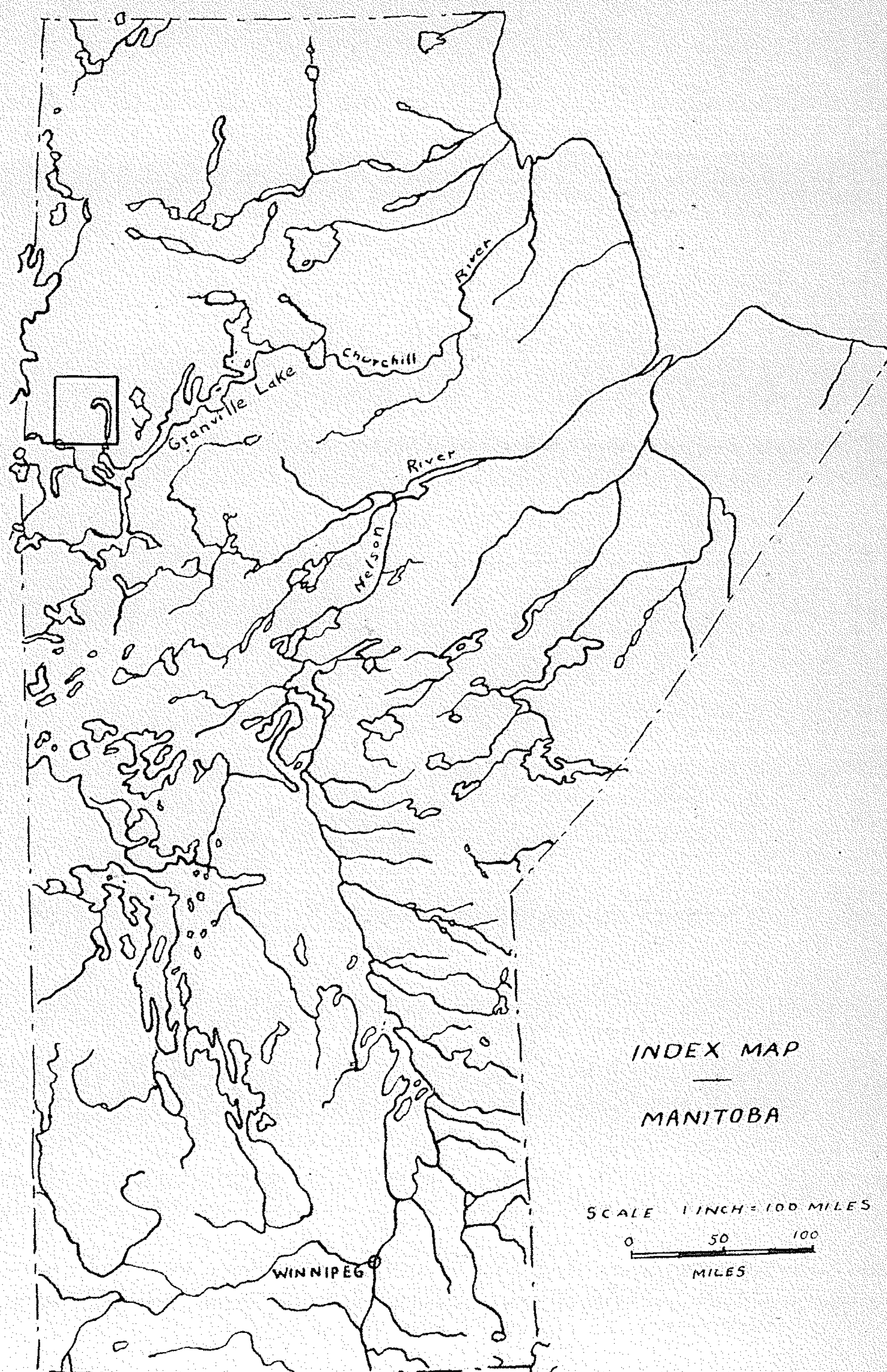


INDEX MAP

MANITOBA

SCALE 1 INCH = 100 MILES
0 50 100
MILES

CHAPTER I

INTRODUCTION

<u>Geographical Location:</u> The area dealt with in this thesis lies in the north central part of the Granville Lake Sheet. The Granville Lake Sheet is bounded by longitudes 100°00' and 102°00' west, and latitudes 56°00' and 57°00' north.

The closest rail approaches to the area are the northern termini of the Canadian National Railways at Sherridon and at Flin Flon. The float aircraft base for Sherridon is situated one mile west at the village of Kississing on Kississing Lake. The float aircraft base for Flin Flon is located on the northwest arm of Schist Lake, near the village of Channing, three miles southeast of Flin Flon. The area may also be reached by a canoe trip of approximately 180 miles with 23 portages. A description of this route is given by Norman (1934).

<u>Character of the Area:</u> The topography of the area is similar to much of the Precambrian Shield in that it is rugged in detail with rounded hills and steep ridges. The local relief is seldom greater than 100 feet. Much of the area is low, and occupied by swamps and muskegs. The three main rivers, the Keewatin, the Hughes, and the Laurie, are not easily navigated because of numerous rapids and falls. However, most parts of the area are accessible from lakes large enough for float aircraft to land.

Glacial drift is extensive in the area and outcrops are generally small and scattered. Hence much of the geology is obscure, and the relations between many rock types are unknown.

Underbrush is thick in many parts, hindering field work and in many places fires have produced thick deadfall.

Statement of Problem: The main problem in this investigation is the correlation of pebbles from the Sickle conglomerate with the older rocks in the area. The investigation involved a detail study of the zircon content in both the Sickle conglomerate and some of the acidic igneous and sedimentary rocks of the area. All specimens studied for zircon content were also examined in thin section.

As the conglomerate pebbles are highly stretched and altered, thin section study does not reveal much information that could be used in correlation with less altered rocks. Consequently this investigation has been concentrated mainly on a study of the heavy accessory mineral zircon. Zircon is used because it is a very stable mineral and is not easily altered. It was hoped that the same type of zircon found in the older rocks might be recognized in the conglomerate pebbles.

Previous Work: The Granville Lake sheet was mapped by J. F. Henderson in 1932, G. W. Norman in 1933, and by D. L. Downie in 1935. The results of this work are contained in Part C, Summary Report 1933, Geological Survey of Canada. During the past four summers geologists employed by the Manitoba Mines Branch have mapped several 15 minute sheets in the Granville Lake area on a scale of one inch to half a mile.

Those included in the area with which this thesis is concerned are the Lynn Lake, Hughes Lake and Sickle Lake sheets published as Preliminary Reports 46-2, 47-3, and 48-6 respectively. Also mapped, but as yet unpublished, are the Cockeram Lake, Lasthope Lake, and Counsell Lake sheets. Outcrops of Sickle conglomerate are present in all these areas except the Cockeram Lake sheet. The distribution and macroscopic appearance of the conglomerate in the several areas has been briefly dealt with in each report, but no attempt has been made to study the petrography of the matrix and pebbles or to ascertain the source material for the pebbles. Heavy accessory mineral study has not been attempted before in this locality. However in 1941 M. S. Stanton submitted a master's thesis at Queen's University in which heavy accessory minerals were used as a basis for correlation of Manitoba Precambrian rocks. This was done in the Manigotagan Lake area which lies some 400 miles to the south east of the Granville Lake area in the Central Manitoba mining district.

CHAPTER II

GEOLOGY OF THE LYNN-BARRINGTON LAKES AREA

Table of Formations[1]

Precambrian	Intrusives	Basic dykes, pegmatites, and aplite; quartz-feldspar porphyry and felsite.
		Granite, diorite, quartz diorite; gneissic and sheared equivalents.
		Diorite, quartz diorite, granodiorite; gabbro, amphibolite.
	Sickle Series	Arkose, greywacke, quartzite, conglomerate; derived schists.
	Unconformity	
	Granitic intrusives	
	Wasekwan Series	Volcanics: basic to acid lavas; breccia, tuff; derived hornblende schist and gneiss.
		Sediments: quartzite, impure quartzite, greywacke, iron formation; derived mica schist and gneiss.

(1) After Allan (1949).

Geological History

<u>General Statement:</u> The outline of events following is the probable sequence and is based on field observations of Allan (1948, 1949) and Fawley (1949).

The earliest event of which there is any record was the formation of the Wasekwan series. This series is predominantly volcanic but during Wasekwan times volcanism was interrupted by periods of sedimentation. Subsequently this series was highly folded, sheared, and intruded by granitic material.

A long period of erosion followed this period of Wasekwan activity. Bateman has estimated that 12,000 feet of Wasekwan rocks were removed at this time. Subsequently, the Sickle sediments were deposited. As these sediments consist chiefly of quartz and feldspar, large areas of granitic rock must also have been undergoing erosion. After the Sickle rocks were formed, folding again occurred. This folding, however, was not so intense as that which followed the Wasekwan period as they were altered to only a low grade of metamorphism. The Sickle sediments were, however, locally highly contorted, and conglomerate pebbles greatly elongated.

Following this second period of folding was a widespread period of intrusion accompanied by regional metamorphism. There may have been some overlapping of the periods of folding and intrusion, but some folding preceded intrusion as is shown by the presence of inclusion of Sickle sediments in the granite. Basic intrusives preceded granitic intrusives, possibly after the initial folding of the Sickle sediments. Cutting all earlier rocks are felsite, aplite and pegmatite dykes. They represent a late stage of the igneous activity. A lesser number of basic dykes are later than the acidic ones.

Extensive faulting and shearing took place following the granitic intrusions. Some of the faults form pronounced lineaments in the district, but few offsets have been measured.

The introduction of quartz into some of the shear zones and the deposition of carbonates, sulphides and gold in them, is the last geologic event of which there is any record. Finally glaciation removed all weathered material and left the area much in its present form.

Rocks Of The Area

General Statement: All the rocks in the area are of Precambrian age and may be divided into three major groups:

(1) An assemblage of volcanica and sedimentary rocks, the Wasekwan series.

(2) A younger series of sediments, the Sickle series, overlying the Wasekwan series.

(3) Intrusives ranging in composition from gabbro to granite.

The Wasekwan series resembles the complex of volcanics and sediments which have, in many other parts of the Shield, been found to be the oldest, presumably of Archaean age. Some intrusions cut both Wasekwan and Sickle series and some are pre-Sickle in age.

Wasekwan Series

General Statement: The Wasekwan series is a thick succession of pyroclastics, and sediments with intercalated lavas. Because most formations are steeply dipping, and few top determinations are possible, the sequence of formations in the Wasekwan series is not clear.

The predominant rock type in the Wasekwan series is a dark grey to green, fine-grained, containing small hornblende needles which give the fresh surface a spa rkling appearance. The rock was probably originally a basalt. It is porphyritic, amygdaloidal, and ellipsoidal in many places and flows of different phases are often interlayered. Volcanic breccia occurs sporadically in the area. Finely laminated tuffs and tuffaceous agglomerate are also found in many parts of the area. The tuffaceous agglomerate is not always easy to distinguish from volcanic breccia. Where the tuffs are abundant they are interbedded with and not readily separated from sediments. Flows and sediments are also intercalated.

A minor type of flow, fine-grained, light-grey, green and buff rhyolite and trachyte, is formed in many parts of the series.

Thin-bedded, dark-grey to brown, impure quartzites form the sedimentary rocks associated with the flows. In one place east of Frances Lake a thick succession of light-grey, impure quartzite occurs interbedded with a minor amount of tuff.

The iron formation is a distinctive member of the

Wasekwan series. It consists of light-grey, cherty material, high in magnetite, finely disseminated, or in crystals as much as an eighth of an inch across. Typically, the iron formation consists of banded chert, most bands measuring only a few inches across. Some of the bands are rich in magnetite so that magnetic anomolies are common in their vicinity. Narrow massive flows and a garnet-rich gneiss are commonly associated with the iron formation. Although the iron formation is exposed in only a few places it can be traced for great distances by its effect on a compass. In some places there appears to be two or three distinct bands but this effect may be caused by tight folding.

Sickle Series

General Statement: As this thesis deals mainly with the Sickle series, a more detailed discussion of this series will be given than of the other rock types of the area.

The Sickle conglomerate lies at the base of the series of rocks designated "Sickle" by Norman (1934). Outcrops of the conglomerate are common. It contains a great variety of pebbles including quartzite, chert, diorite, granite, quartz, rare greenstone, pegmatite, iron formation and arkose. The conglomerate rests unconformably on the Wasekwan complex and the whole series is cut by large igneous masses.

This conglomerate has been compared macroscopically by Norman with that of the Missi series between Amisk and Wekusko Lakes. The Missi conglomerate rests unconform-

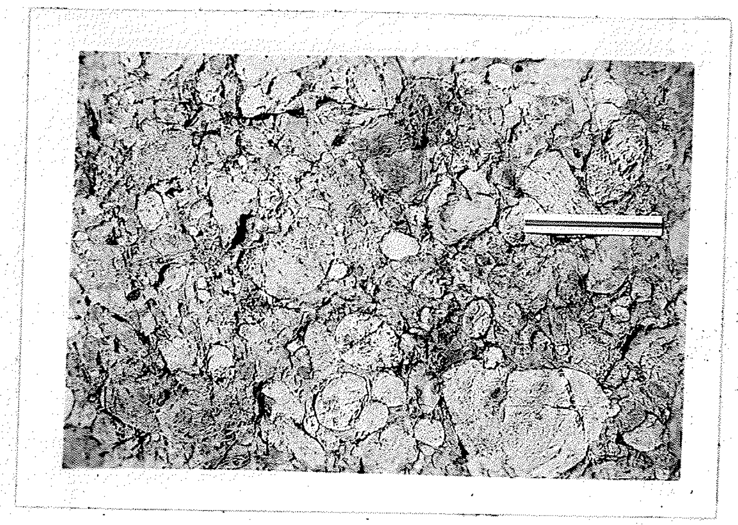


Fig. 1 Photograph of conglomerate outcrop. The six inch ruler shows the scale.

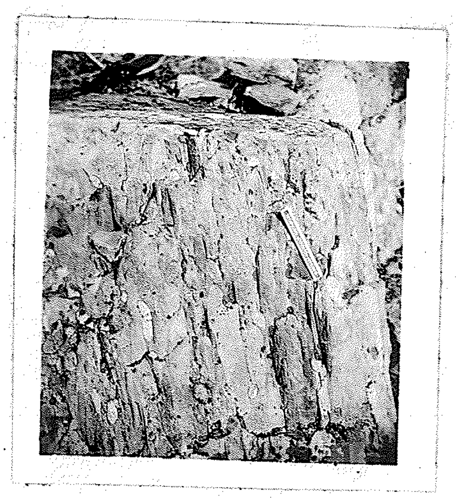


Fig. 2 Photograph of conglomerate outcrop. The six inch ruler shows the scale.

ably on a volcanic complex which, as in the case of the Sickle locality, is the oldest rock in the area. Norman (1934) states that the two are lithologically similar, the pebbles of the Missi conglomerate consisting of granite, quartz porphyry, quartz, basic lava, cherty quartzite, jasper and grey gneiss. Here also, the sediments are cut by large igneous masses. In both localities the conglomerate is basal and occurs in other horizons in the series.

An exact correlation of the two series is difficult as they are widely separated and the rock types represented by the pebbles differ to some extent. However, as stated by Norman (1934, p. 27c), "their lithological similarities, together with the unconformity that occurs immediately below them, suggests that they are of the same general age".

In all places where the conglomerate was studied by the writer it forms the basal member for the overlying sediments. However, the conglomerate is not necessarily present wherever outcrops of Sickle sediments are found. Following are descriptions of the conglomerate in the various localities studied.

<u>Rodmac Lake Conglomerate:</u> Outcrops of conglomerate occur along the north-west shore of Rodmac Lake, striking approximately north 80 degrees east and dipping from 75 to 80 degrees north. It lies at the base of approximately 10,000 feet of Sickle sediments. Since these sediments lie to the south of the conglomerate, its base is assumed to be the north, the rocks being overturned.

The conglomerate here varies in thickness from 2500 feet at the east end to 4500 feet at the west end although the most westerly outcrops are scattered. This thick section may be due to folding or faulting.

A pronounced graduation in pebble size was noted from bottom to top. Pebbles at the base of the conglomerate are as long as 24 inches although these are rare. Pebbles 10 to 12 inches in length are common at the base and the average length is about six to eight inches. They constitute 60 to 70 per cent of the outcrop (as seen on the weathered surface). The pebbles increase both in number and size towards the top of the conglomerate. The largest ones here are three inches to four inches long and comprise 20 to 25 per cent of the outcrop. The majority of the pebbles are elliptically shaped, their length being from one and a half to three times their width. Some pebbles, particularly those of white vein quartz and some of the larger ones of other types, are almost circular in outline. It has been suggested by Fawley (1949) that, when the other pebbles were stretched, there was insufficient heat to make the quartz plastic.

Uniformly small pebbles, one inch to two inches long and having a width equal to half their length, are present throughout the entire width of the conglomerate. Macroscopically they consist of white to light-grey felsite.

The matrix weathers dark grey to greenish grey in color, is uniform and has a highly sheared appearance. The planes of shearing pass around the pebbles and strike in the direction of their elongation. Mineralogically, the matrix is a quartz feldspar muscovite schist which has altered to phyllite in many places, particularly near the pebbles.

Sickle Lake Conglomerate: The conglomerate rimming the north and east sides of Sickle Lake forms the basal member of the Sickle series at its type locality. Its thickness here ranges from 300 feet to 2400 feet. Here again, as Fawley (1949) states, "it is highly probable that the thicker sections are due to folding and faulting. The true thickness probably varies between 300 feet and 1000 feet."

The conglomerate here is part of a simple plunging syncline. It strikes north along the shore of Sickle Lake and bends around to the west at the north end of the lake. The dips are to the west and south respectively.

The conglomerate occurs as prominent ridges, more resistant than the overlying sediments. The rock is a light-buff weathering quartz-feldspar-mica schist, arkosic in appearance and altered to phyllite. It contains stretched pebbles ranging from one to 15 inches in length. The matrix has been highly sheared and the majority of the pebbles are stretched, their length being two to ten times their width. The white quartz pebbles and some of the more granitic-appearing types are more rounded than the rest. Here again as Fawley (1949) suggests a possible reason for this is lack of sufficient heat to make the quartz plastic. The elongation of the pebbles can be seen particularly well on vertical surfaces.

The different rock types comprising the pebbles have been divided on a macroscopic basis into the following: pink and light grey quartzite, chert, diorite, granite, quartz, rare greenstone, pegmatite, iron formation, arkose and feldspar porphyry (rhyolite).

The concentration of pebbles in the matrix varies from as high as 80 per cent to as low as five per cent. A few beds of arkose are interbedded with the conglomerate. Most of these are from two to ten feet wide but in one place a width of 30 feet of arkose containing only three or four pebbles was observed.

No observed gradation in pebble size or in concentration of pebbles was noted across the width of the conglomerate although the few large pebbles that were found (ten inches to 12 inches in length) occurred much closer to the bottom of the conglomerate than to the top.

The matrix usually weathers to a neutral or buff color with an orange tint in places. It is highly sheared, the lines of shearing passing around the elliptical pebbles. The rock breaks easily along the planes of shearing exposing a dark-grey to greenish grey fresh surface. The fresh surface shows the rock to be fine-grained, compact and uniform. It is predominantly a silicious rock but a considerable amount of pink to grey feldspar is present. Megascopically it appears to be arkosic in composition. Alteration to phyllite occurs frequently, particularly around the pebbles. Here the matrix is dark gray with a schistose appearance.

Irregular spots of a reddish mineral are scattered throughout the matrix. A permanent magnet suspended on a string is very weakly attracted to a specimen of the matrix containing this mineral that is assumed to be red iron oxide.

Hughes Lake Conglomerate: A massive conglomerate representing the basal member of the Sickle series occurs at the north and west sides of Hughes Lake and on the west side of Stan Lake. Here, as at Sickle Lake, the conglomerate is resistant to weathering and often occurs as prominent ridges.

The pebbles consist of quartz, felsite, chert, granite porphyry, pegmatite and rarely diorite, sediments and volcanics. They average two inches to three inches in length. Pebbles of quartz and granite are, in general, larger than the others. The pebbles are often slightly elongated and constitute 80 per cent of the outcrop.

The matrix is a pink to grey to greenish arkose and contains visible grains of quartz and feldspar. In places it is schistose with biotite and chlorite; in other places it is fine-grained grey and sericitic. Scattered irregular spots of red iron oxide occur as at Sickle Lake. Here thin bands of black hematite appear to indicate the bedding. Some lenses of sand a few feet in length occur in the conglomerate.

At Hughes Lake, unlike the other localities, the conglomerate is gradational with the overlying sediments. At the base the pebbles are of quartz, granite, chert and felsite. Across the strike and up the section the pebbles become light and dark chert and felsite with some quartz and finally some pink felsite. Near the top of the conglomerate scattered beds of arkose occur. They become more abundant until the rock finally becomes an arkose with an occasional pebble bed.

Ralph Lake Conglomerate: The Ralph Lake conglomerate is limited to a belt on the west side of Ralph Lake. It is well exposed near the shore of Ralph Lake, on the south side of Betty Lake, and a mile and a half north of Evelyn Lake. Typically the rock is a light-weathering fine-grained quartz-mica schist in places containing coarse clastic grains of quartz. In this matrix lie fragments of many types and sizes. A weathered surface reveals the character of the rock to better advantage than a fresh surface. Most of the fragments are lenticular with sharp points, light grey, fine grained, silicious, and range from half an inch to three inches in length. On a vertical surface the fragments are seen to be greatly elongated, some measuring as much as 14 inches. Fragments of different rock types were noted including quartzite, cherty material, fine grained amphibolite, feldspar-hornblende gneiss, granite gneiss, diorite, granite and quartz. The granite and quartz pebbles are nearly round and one to four inches in diameter. Southwest of Betty Lake, quartz mica schist is interbedded with the conglomerate, and to the north the schist becomes more prevalent and finally makes up the whole formation.

Conglomerate at other Localities: Outcrops of basal conglomerate also occur south and west of Lasthope Lake. The area has been mapped by A. P. Fawley but the results are not published as yet. From personal communication with Fawley (1950) it would seem that the conglomerate here does not vary greatly in appearance from that at Sickle Lake.

Outcrops of conglomerate of the Sickle series are present in the vicinity of Dunphy Lakes but these are not believed to be basal and will not be dealt with here.

Upper Members of the Sickle Series: Sickle arkose and some greywacke overlie the conglomerate in all the localities described. It is exceptionally uniform in appearange through a thickness of several thousand feet although in some localities there are scattered pebble beds. Some scattered pebbles of quartz (half an inch across) are found in it, particularly near the base.

The arkose is grey, buff or pinkish weathering with grains of quartz and feldspar an eighth of an inch across showing on the weathered surface. The fresh surface is light to dark grey, much with a reddish tinge owing to iron oxide.

The beds tend to become finer grained and more argillaceous toward the top. In one locality at Sickle Lake a few beds of intraformational breccia of very fine-grained arkose or argillite occur in the upper sections.

Cross bedding, scour-and-fill, and, in many localities, ripple marks indicate the tops of beds. Though the arkose is generally massive, a close search will usually reveal thin laminations showing bedding.

Intrusive Bodies

Basic and Intermediate Types: Numerous irregular intrusive bodies composed of rocks termed gabbro and diorite occur throughout the area. Several of them appear to be composite intrusives of several rock types. Recognizable rock types are peridotite, norite, quartz norite, fine and coarse-grained hornblendite, hornblende gabbro, diorite, anorthosite, and quartz diorite. Within the composite intrusions some contacts are well marked whereas others, owing to metamorphism, are gradational.

All the bodies mapped show intrusion by pegmatite, felsite and porphyry dykes and masses. Some are intruded by granite on their margins. Several areas of fine-grained quartz diorite occur throughout the area. These are not the same as the quartz diorite of the basic bodies.

A noticeable feature in this area is the absence of diabase dykes.

Granitic Types: A large part of the area is occupied by intrusive rocks ranging in composition from diorite to granite. In mapping, an attempt was made by Manitoba Government geologists to distinguish diorite and quartz diorite of a granitic type from rocks of the same composition of a basic type. Thus in the published government maps much of the area shown as granite is really diorite or quartz diorite.

As the Sickle conglomerate appears to lie on an eroded granite surface in some localities and contains granite pebbles, and as granite intrudes the conglomerate, two different ages of granite are indicated.

Structural Geology

General Statement: The structure of the whole area has not yet been satisfactorily determined. Few top determinations from pillow lavas are obtainable and almost all indicate the tops of the volcanic flows to be to the north. There was probably much folding in these belts but it is likely that it is minor to the main structure.

Iron formations are good horizon markers but the number of these bands present has not been ascertained, nor have they been traced continuously across the area. Where there are no outcrops care must be taken not to confuse magnetic anomolies such as pyrrhotite-bearing dykes for iron formation.

Faulting is widespread on minor and major scales. The map shows many lineaments along which is evidence of shearing and faulting.

The Sickle conglomerate forms part of a plunging syncline at both Sickle and Hughes Lake. The structure is especially obvious at Sickle Lake where the configuration of the lake is controlled by the strike of the sediments.

An unconformable contact of the Sickle conglomerate with the older rocks is present only on the east side of Black Trout Lake which lies just east of the south end of Sickle Lake. At this contact the conglomérate strikes north and south and is overturned to the west. The pre-Sickle rocks strike north 80 degrees east and dip steeply north. The schists are highly contorted and are sharply truncated by overlying conglomerate. These relations indicate a definite structural unconformity between Sickle and older rocks.

At Sickle Lake this series unconformably overlies the Wasekwan series. The contact between the two series is often covered by overburden and in some places the strike and dip of the two is similar. However, even when the two series are in contact with one another, the Wasekwan sediments have undergone a higher grade of metamorphism than have the Sickle sediments.

MAP LEGEND

Purple: Wasekwan series - volcanic flows and sediments.

Blue: Altered equivalents of the Wasekwan series.

Green: Basal conglomerate of the Sickle series.

Yellow: Sickle series - sediments.

Orange: Diorite,gabbro.

Pink: Granitic bodies.

MAP SHOWING GENERAL GEOLOGY AND SPECIMEN LOCATION

A PORTION OF GRANVILLE LAKE SHEET

TAKEN FROM MAPS 343A AND 344A
GEOLOGICAL SURVEY OF CANADA

MILES
4 0 4 8 12

Fig. 3

CHAPTER III

PETROLOGY OF THE SICKLE CONGLOMERATE

Methods Of Sampling In The Field

General Statement: Field work for this investigation was carried out by the writer while acting as a student assistant to Mr. T. A. Oliver of the Manitoba Mines Branch Geological Survey during the field season of 1949.

Rock samples of the conglomerate pebbles up to one pound in weight were collected at closely spaced intervals of approximately 25' across the strike of the outcrops. Several specimens of the matrix were also taken. Care was taken to see that the pebble specimens were not contaminated with fragments of the matrix. Specimens were collected by the writer from the conglomerate outcrops at Rodmac and Sickle Lakes and specimens of the conglomerate from Ralph and Lasthope Lakes were provided by Manitoba Mines Branch geologists. The pebbles were very difficult to chip out with a geological hammer and pebbles representing some rock types could not be obtained.

The accompanying map shows the location of the conglomerate specimens collected.

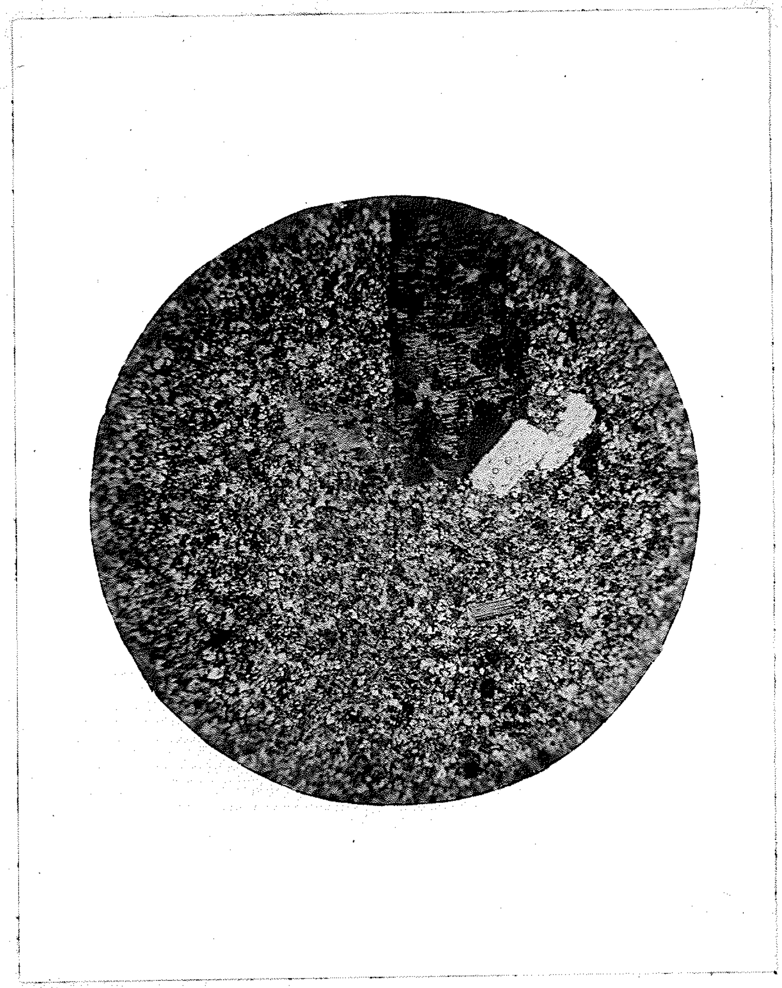
Lithology Of The Pebbles

Quartz: One of the most common rock types represented by pebbles in the conglomerate is light-grey to white quartz. These pebbles are found in all localities where the conglomerate is exposed, and are always small, their diameters ranging from one to three inches. They are roughly circular, although a few are slightly elliptical. They were found throughout the conglomerate, and comprise from ten to twenty per cent of the pebbles in the various localities studied.

A thin section of this rock type reveals little information that could not be gathered from a macroscopic examination. It shows the rock to consist almost entirely of intergrown quartz grains. They vary greatly in size but are predominantly from 0.1 to 0.5 mm. in diameter. Rarely are strain shadows present, and these are not pronounced. A trace of muscovite is present. It occurs as small colourless flakes scattered over the entire slide with apparent random orientation.

Quartzites: Quartzite pebbles are abundant in the conglomerate in all localities forming approximately thirty-five per cent of all the pebbles. They vary greatly in size. At Rodmac Lake quartzite pebbles 24 inches long and 20 inches wide were observed at the base of the conglomerate. Higher in the stratigraphic section they become smaller, and at the top are about two inches long and one inch wide. The average length of the Rodmac Lake quartzite pebbles is four to six inches. At Sickle Lake they are of the same size, and were found throughout the section. The larger quartzite pebbles are only slightly elliptical, their length being one and a half times their width but many of the smaller ones appear to be highly stretched so that their length is often six to eight times their width.

The colour of these quartzite pebbles is distinctive at different localities. At Rodmac Lake they are predominantly light to medium grey whereas the specimens from Sickle



X 30

Fig. 4 Photomicrograph of a thin section of a typical quartzite pebble. (X Nicols)

Lake are nearly all light pink to pinkish grey.

These quartzites have a typical aphanitic, siliceous appearance in hand specimen. About half of them contain larger grains of quartz that appear in hand specimens to be porphyroblasts or phenocrysts and are up to one sixteenth of an inch across. One specimen contained much epidote. Rarely, minute flakes of biotite are present. These usually have a preferred orientation giving the specimen a banded or aligned appearance. Microscopically the quartzite are found to consist of roughly 90 to 95 per cent quartz with minor amounts of orthoclase, oligoclse, biotite, muscovite, chlorite, magnetite, epidote and a carbonate mineral.

The thin sections show typical granoblastic textures with finely intergrown quartz grains ranging in size from 0.01 to .07 mm. The groundmass consists entirely of quartz, and the other minerals occur as larger grains in this groundmass. The intergrown quartz rarely shows strain shadows, but the larger quartz grains usually show pronounced strain shadows and are often broken into several fragments that have optical continuity.

Some magnetite was observed in all the sections examined. It is scattered throughout the thin section with random orientation and occurs as subhedral to anhedral grains.

About 50 per cent of the quartzites studied were found to contain some orthoclase and oligoclase grains. As these never exceed six to eight per cent of thin section, and usually constitute much less, the rocks are termed quartzites rather than feldspathic quartzites or arkoses. The feldspar grains are usually subhedral, sometimes euhedral and rarely anhedral in form. They show no preferred orientation. The crystals often have slightly irregular borders and may contain rounded inclusions of quartz completely within the feldspar grain. Sericite and kaolin are invariably present as alteration products.

The presence of much epidote in one hand specimen was confirmed microscopically. The epidote, although granular in occurrence, shows a rough alignment.

The majority of the thin sections examined contain a trace of green biotite which occurs as minute rods and flakes. When a sufficient amount of biotite is present it shows a distinct alignment. This lineation, as indicated by the biotite, is influenced by the larger quartz and feldspar grains. Some of the biotite is slightly altered to chlorite.

Muscovite is common to all the quartzites and some sections contain as much as ten per cent. It forms small flakes and is also distinctly aligned where there is a sufficient amount of the mineral present for this feature to be seen.

A minor amount of a carbonate mineral occurs interstitially around the quartz grains in most sections. The exact composition of this mineral could not be determined as there was an insufficient amount present for a chemical test.

Mylonites: Pebbles classed as mylonites can be recognized as such by microscopic means only. Macroscopically

X 30

Fig. 5 Photomicrograph of a thin section of a typical mylonite pebble. (X Nicols) they cannot be distinguished from quartzites. They are found in all localities where quartzite pebbles are present and are of the same general size, shape, appearance, and distribution as the quartzite pebbles. The percentage of this type of pebble is much lower than that of the quartzite type. It never exceeds ten per cent, although this approximation is necessarily very rough because the rock type could not be recognized in the field.

Microscopically the mylonites prove to have a mineralogical composition similar to the quartzites. They are estimated to contain 90 to 95 per cent quartz with minor amounts of orthoclase, oligoclose, magnetite, sericite, kaolin, biotite, a carbonate mineral, and some iron oxide stain. Muscovite is always present in larger amounts than are these other accessory minerals.

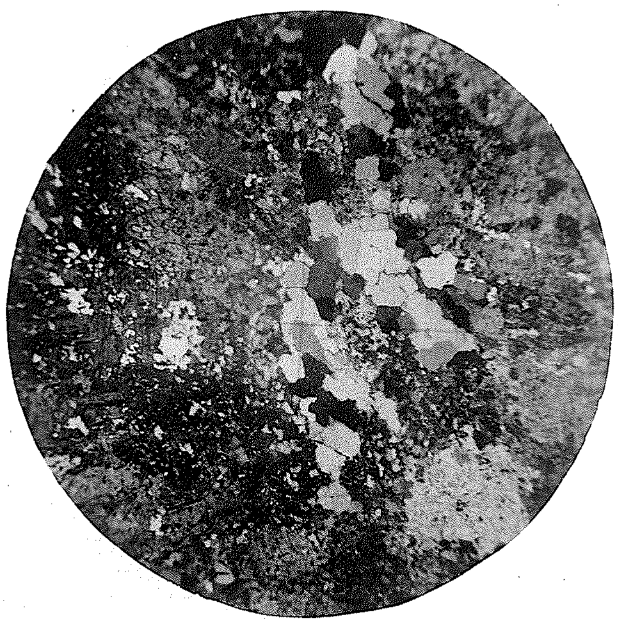
The occurrence of these accessory minerals in both the mylonites are quartzites is similar. The diagnostic characteristic of the mylonites is their texture. According to Waters and Campbell (1935) a mylonite is a microbreccia that maintained coherence during deformation, the brecciated character being apparent only from microscope study. It is essentially unrecrystallized, possesses a flow structure as a result of steaking out of the pulverized groundmass, and contains uncrushed fragments in a dusty, siliceous, and kaolinitic paste. If no uncrushed fragments are present it is called an ultramylonite, but this type is difficult to recognize where there is found no transition from a mylonite. The pulverization takes place under conditions such that the rock maintains its coherence.

The mylonites here discussed consist of broken fragments of strained quartz, often lens-like in appearance, in a fragmental groundmass comprised chiefly of quartz and minor amounts of the other minerals. Rarely larger fragments of feldspar are present. The carbonate mineral occurs interstitially with the quartz and often exhibits good cleavage. From its interstitial distribution it is inferred to be younger than the movement which caused the mylonitization.

Two thin section with a mylonitic groundmass but containing no larger fragments were studied. From their general appearance the writer has classed these as ultramylonites. However the name is open to some question for, as has been mentioned earlier, this rock type is difficult to recognize if no transition type from mylonites are present.

The term mylonite does not imply whether the rock was an igneus or sedimentary type before the mylonitization took place and in this case the origin is difficult to ascertain with certainty. Being now very high in quartz and calc-alkalic feldspars, it is assumed that they were originally quartzites or very acidic igneous rocks. It is possible that the final crushing necessary to transform the rock into a mylonite took place during that period when the conglomerate was stretched.

Granites: Pebbles of granite are common in the conglomerate in all localities, constituting 20 to 25 per cent of



X 30

Fig. 6 Photomicrograph of a thin section of a typical granite pebble. (X Nicols) all pebbles at Rodmac Lake and 10 to 15 per cent at Sickle Lake. They follow the same size gradation as do the quartzite pebbles. Hence, at Rodmac Lake there is a distinct gradation across the section. They vary from 18 inches across at the base to three inches across at the top, with the average diameter being from four to six inches. This average size is uniform across the section at Sickle Lake. The granitic type pebbles, like the quartz pebbles, tend to be more rounded than most other types. They are sometimes slightly elliptical, but this characteristic is not widespread. The colour of these pebbles is predominantly grey although at Sickle Lake pink ones were seen rarely.

Macroscopically the granites are very fine-grained, often almost aplitic in appearance. They are composed chiefly of light-grey, and rarely pink, feldspar and quartz. A few quartz phenocrysts are usually present. Most of the specimens show about five per cent biotite which has no preferred orientation in hand specimen. No other minerals can be seen macroscopically. One specimen from Ralph Lake has a medium to coarse-grained texture. It contains grey feldspar crystals, slightly coarser than the rest of the minerals, that give the rock a porphyritic appearance. Biotite forms five per cent of the specimen.

Microscopically the rocks consist of roughly equal amounts of quartz, orthoclase, and oligoclase feldspar. Minor amounts of several other minerals are present. Quartz and feldspars are estimated to constitute 80 to 85 per cent of the rock specimens.

The quartz and feldspars are enhedral in form and occur together with sutured of "feathery" contacts. Some large quartz grains are present but most of these have been granulated. The larger quartz grains show prominant strain shadows. Small areas of fine-grained intergrown quartz occur throughout the sections and are almost completely free from strain shadows. Small blebs of this strain-free quartz embays the feldspar grains in some places. The plagioclase feldspar is polysynthetically twinned and all the feldspars are highly kaolinized and slightly sericitized.

Green to brownish-green biotite occurs as small flakes with random orientation and forms an estimated five per cent of the slide. Pleochroic halos, often present in the biotite, probably indicate the presence of zircons as this mineral was later proved to be present. In many places the biotite shows alteration to chlorite.

Muscovite occurs in nearly all specimens in small plates but shows no orientation.

Minute granular aggregates of epidote rarely occur closely associated with the biotite. This mineral is present in ten per cent of the specimens and constitutes only a trace when present. Small rod-like crystals that resemble apatite are present as inclusions of the quartz in one section. One to two per cent anhedral magnetite is present in most specimens. A carbonate mineral, having the same occurrence as that in the quartzites, was observed in nearly all the granite thin sections. It constitutes about one per cent of the rock and occurs interstitially in small masses, often showing prominant 120 degree cleavage traces. Here again the exact carbonate mineral could not be determined owing to the small amount present.

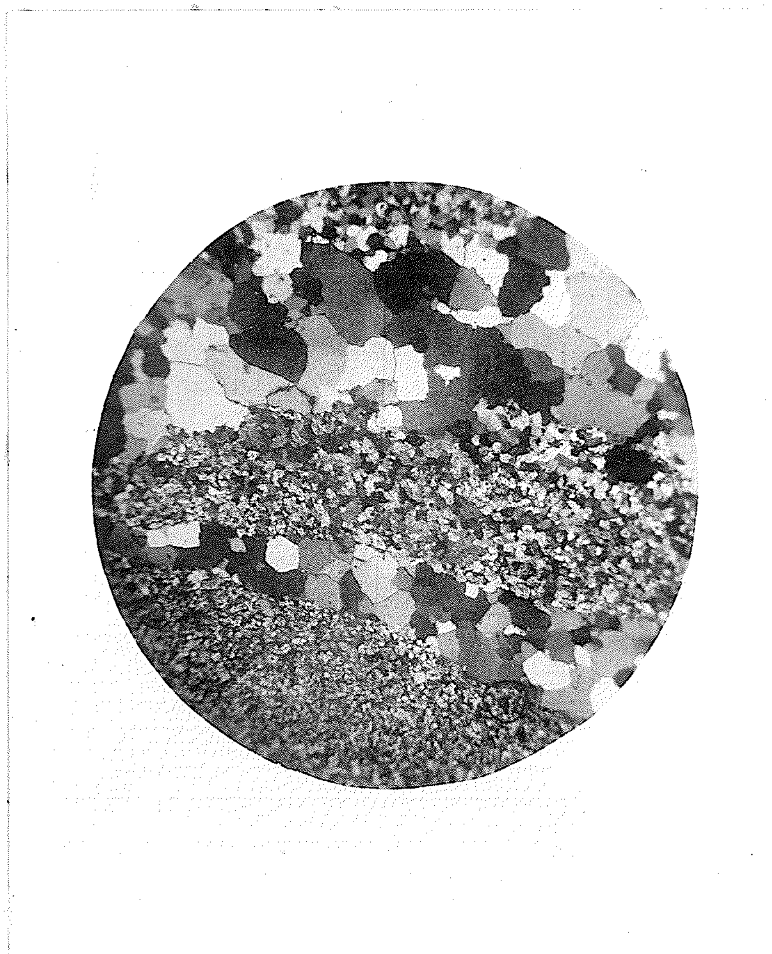
A noteable feature of the granitic type pebbles is their lack of mafic minerals. A small amount of biotite is the only mafic mineral present in all the specimens.

The rock types described thus far comprise most of the pebbles in the conglomerate. The remaining 10 to 20 per cent consist of seven different rock types. Owing to their scarcity, the exact percentage of each type could not be estimated.

Iron Formation: Pebbles of iron formation were found in the conglomerate at Sickle Lake but are extremely rare. They vary from one to two inches in length and are up to one inch wide. There is no gradation in size from the top to the bottom of the conglomerate and pebbles of iron formation are present throughout the stratigraphic section.

Macroscopically the pebbles consist of alternate bands of dark red hematite, and light and dark chert. The bands are irregular and indefinite and never exceed an eighth of an inch in width. The specimens present an over-all dark appearance. They are very magnetic as indicated by their strong influence on a compass needle.

Microscopically the rock was found to consist of alternating irregular bands of fine-grained and medium-grain-



X 30

Fig. 7 Photomicrograph of a thin section of a typical iron formation pebble. (X Nicols) ed intergrown quartz. The fine-grained or cherty quartz contains much interstitial iron oxide. All the quartz, and especially the coarser-grained variety, has a very fresh appearance and is completely free from strain shadows.

<u>Chert:</u> Rarely pebbles of light and dark chert occur. These pebbles are smaller than most other types, varying from one to two inches wide. They are extremely fine grained, uniform in texture, and black or light grey to white in colour. When broken they usually exhibit a sub-conchoidal fracture.

Microscopically the rocks are found to consist chiefly of quartz and a minor amount of magnetite and sericite. The quartz is extremely fine grained and has a typical intergrown appearance. Unoriented sericite or very fine-grained muscovite occurs throughout the thin sections. Anhedral magnetite is present usually as a trace but may constitute up to 15 per cent of the darker specimens.

<u>Arkose:</u> Pebbles termed arkose have been classified as such from microscopic evidence only. Many of the slides show minor amounts of oligoclase and orthoclase in large grains. In two of the sections examined the amount of feldspar present, being about 20 per cent, was considered large enough to term the rock arkose. Aside from this difference the rock type is identical with the more feldspathic quartzites.

It is possible that the arkoses are essentially the same rock type as these quartzites. They have been sub-divided in order to present a uniform and consistent classification.

<u>Other Types:</u> Pebbles of three other rock types were recognized in the conglomerate at Sickle Lake. As it was impossible to obtain specimens of these they have been studied and classified only on a macroscopic basis.

A few pebbles of a rock type believed to be andesite were observed. They were about three inches long and one inch wide, extremely fine grained, uniform in texture and dark green in colour. Pebbles of pegmatite six to eight inches across and slightly elliptical in shape are rarely present. They consist of quartz and pink feldspar crystals up to three quarters of an inch in length. No mica was observed.

One pebble believed to be diorite was found, but only its weathered surface could be seen. It weathers to the black and white shades that are typical of diorites, and appears to be medium grained. It is roughly circular in outline and has a diameter of about four inches.

<u>Conclusions:</u> From a petrographic study of the pebbles it is evident that the conglomerate, and consequently its pebbles, have been highly stretched or sheared but not otherwise altered. The larger quartz grains all exhibit strong strain shadows and are often granulated. The biotite flakes in most specimens have been oriented in the direction of elongation of the pebbles and they flow around the larger grains. The fine-grained quartz, being free from strain shadows, may have re-crystallized under pressure subsequent to or at the time of shearing. This would account for the small grains of quartz embaying the feldspar grains. The muscovite present

in most specimens as small flakes is scattered throughout most sections, often oriented in the direction of pebble elongation, and is therefore assumed to be of secondary origin, possibly also developed at the time of shearing.

It was noted that the colour of the pebble specimens from Rodmac Lake and from Sickle Lake is distinctive. As these localities are 20 miles apart it is assumed that the pebbles came from different source rocks. The pebbles have been so crushed by stretching of the conglomerate that no microscopic difference between the pink and grey is evident.

The writer believes that most of the large grains of feldspar are prophyroblasts. They usually have good crystal form despite the fact that the quartz is strained and granulated. Also, these crystals often contain inclusions of fine-grained quartz. The inclusions are rounded and have irregular distribution. When the feldspars crystallized under pressure the quartz present in the vicinity may have been included in the crystals formed around it.

As the carbonate mineral is present in nearly all the pebbles, regardless of their rock type, the writer believes that it was introduced after the pebbles were emplaced in the conglomerate. Supporting this conclusion is the fact that the carbonate occurs interstitially in all specimens and appears to have been introduced after the shearing and stretching of the conglomerate.

Zircons are very scarce in the pebbles and the only indication of them in thin section is the presence of pleochroic halos in the biotite.

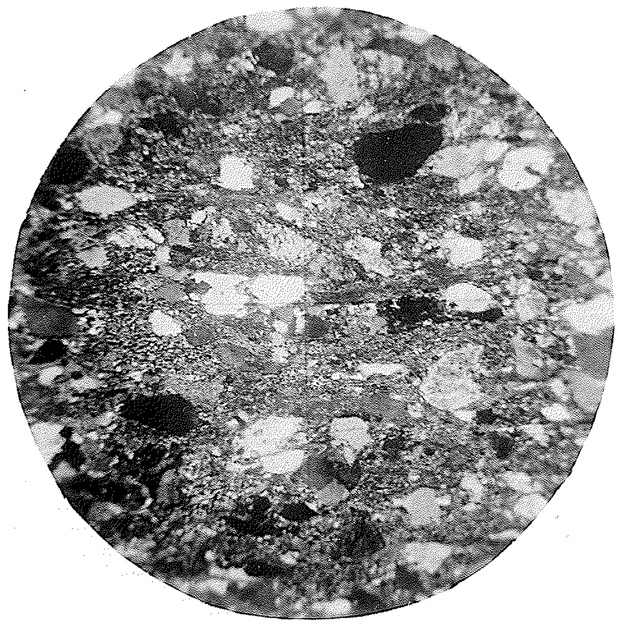
The quartzite pebbles weather to a uniform grey or pink colour and in places the larger grains of feldspar and quartz weather out and resemble phenocrysts. Hence it is believed by the writer that the pebble types described macroscopically by Allan (1948) and Fawley (1949) as felsites, rhyolite porphyry and many arkoses may actually be classed together with the quartzites. In any case none of the sections of specimens gathered by the writer or provided by the Manitoba Mines Branch have the composition of an acidic extrusive rock.

Lithology Of The Matrix

General Statement: The weathered surface of the matrix has been described under the general description of the Sickle series in Chapter II. Its general appearance will therefore not be dealt with in this section.

A macroscopic examination of the fresh surface reveals little information. It is dark grey in colour and very fine grained. A few medium-sized quartz grains can be identified and the whole surface presents a siliceous appearance, but no other minerals can be recognized. The rock is schistose in a direction corresponding with the strike of the conglomerate and breaks easily along the planes of schistosity. In some places, particularly around the pebbles, the matrix has altered to phyllite that is extremely fine-grained and has a dull lustre.

One specimen was collected near the top of the con-



X 30

Fig. 8 Photomicrograph of a thin section of the conglomerate matrix. (X Nicols) glomerate where pebbles were relatively rare. Some quartz appears to be re-crystallized but it is otherwise the same as the other matrix specimens.

Microscopically the rock consists essentially of rounded and fragmental grains of quartz and, less commonly, oligoclase in a groundmass of sericite. The sericite is estimated to comprise 38 per cent, the quartz 48 per cent, and the oligoclase 10 per cent. The sericite is extremely fine grained and can only be resolved under a magnification of 450 diameters. The quartz and feldspar grains vary greatly in size over the entire slide. In some places fractures in the quartz grains are filled with sericite. All the quartz grains show moderate strain shadows. Anhedral magnetite is present in the groundmass and forms about one per cent of the matrix. Greenish brown biotite occurs rarely in small flakes in the groundmass. It is found particularly around the larger fragments but forms no more than a trace.

A trace of granular epidote is present in a few places in the groundmass. A reddish opaque stain appears in the quartz and mica. This was observed on the weathered surface and, as mentioned above, is believed to be iron oxide.

Lineation in the slides is not pronounced but the long axes of the quartz in the plane of the thin sections tend to have a common orientation which is apparent under a low power lens.

A specimen collected near the top of the conglomerate is similar to the others except that the lineation of the quartz and mica is slightly more pronounced and a few more quartz grains are evident. The rock has the composition of an arkose but the writer believes that it could be more accurately named on a mineralogical basis and has given it the term quartz-sericite-oligoclase schist.

Conclusions: The sericite-filled fractures in the strained quartz indicate that the sericite may have developed as a result of stretching of the conglomerate.

Heavy Accessory Minerals

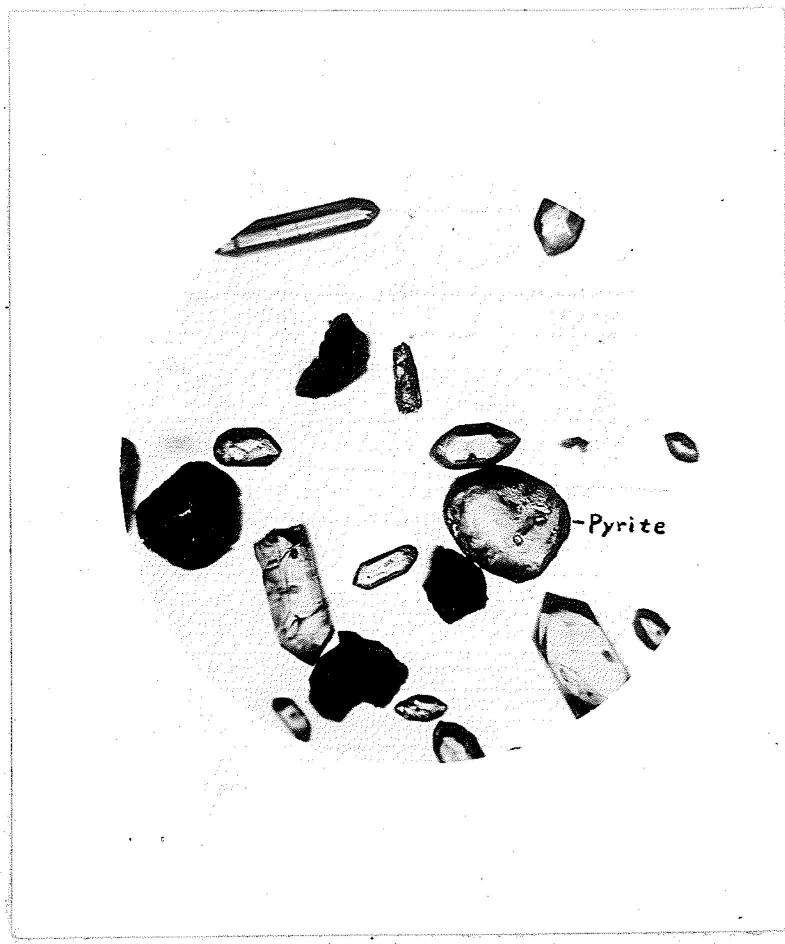
Laboratory Methods Of Separation

Crushing, Screening, Panning: The size of the sample taken for crushing ranged from 150 to 200 grams in weight. Each sample was broken to about a quarter inch size in a jaw crusher and finer crushing was done in the Mines Branch pulverizer. This machine consists of two circular disks which may be set so that they are only a fraction of a millimeter apart. One of the disks has a shallow hollow in the centre and rotates at a high speed; the other is solid and stationary. The crushed rock fragments are dropped into the hollow in the disk through a funnel arrangement. Centrifugal force throws the material out of the hollow and the rotating motion of one disk against the other pulls the fragments apart. The setting of the distance between the disks may be adjusted thus varying the resulting particle size. The material was put through the pulverizer four or five times and screened after each time. No attempt was made to crush the sample to an equal fineness at once for such a process would result in an unnecessarily high amount of rock flour.

It was thought that the pulverizer might possibly destroy euhedral crystals which might be present so an experiment was carried out to determine any rounding effect the pulverizer might have. A 500 gram specimen of granite was crushed in a jaw crusher and then split into two equal parts. One part was ground in the pulverizer to pass an 80 mesh screen; the other was crushed in a diamond mortar to avoid any grinding motion. The zircons were then separated and mounted in a manner described below. A study of the zircons obtained by these two methods showed no differences in their crystal form. Figs. 9 and 10 show the zircons that have been obtained by the two different methods.

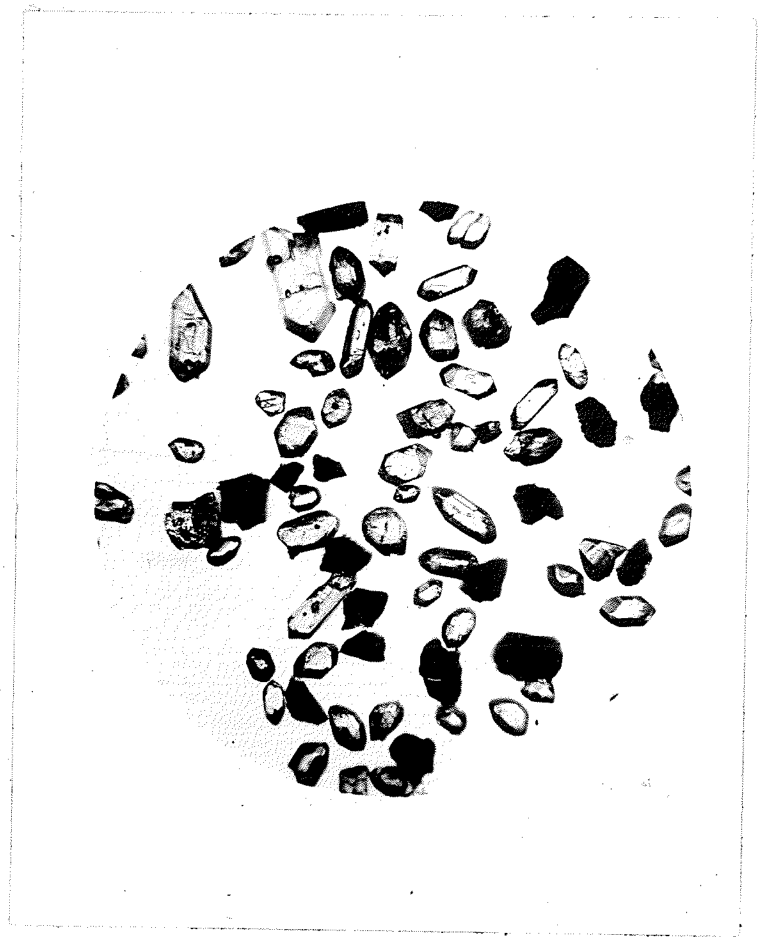
The fineness to which the sample must be crushed depends, of course, on the grain size of the rock. The specimens dealt with in this problem appear to be mono-mineral when crushed to pass through an 80-mesh screen. This size was consequently used throughout the work. The samples were repeatedly crushed until they would completely pass an 80-mesh screen. This involved, however, the production of some rock flour.

The rock flour, and the greatest part of the lighter minerals such as quartz and feldspar, were removed by panning. A Brazilian-type miner's pan was constructed by the laboratory technician for this purpose. This pan has a conical shape, 12 inches across at the top, with the angle at the apex being 120 degrees. It was constructed of copper



X 45

Fig. 9 Photomicrograph of zircon grains isolated by crushing in the pulverizer.



X 45

Fig. 10 Photomicrograph of zircon grains isolated by crushing in the diamond mortar.

sheeting and, as the circular motion of the water on the inside must be unrestricted, it was chromium-plated on the inside to give a perfectly smooth surface.

When water was added to the crushed specimen most of the rock flour went into suspension and could be poured off by a process of decantation. This was repeated three or four times until the decanted water was clear. A slow swirling motion was then applied with fresh water causing the heavier minerals to settle at the apex of the cone with the lighter ones on top. These lighter minerals were then scooped off and the process repeated several times until only a few grams remained in the apex. This portion then consisted of the heavy minerals and a minor part of the light ones. This sample was then carefully poured into a filter funnel, allowed to drain, and dried over a hot plate at a temperature not exceeding 100 degrees C.

The samples studied in this investigation contain very little biotite or chlorite so it was not considered necessary to baueritize them before running through the heavy liquid. Baueritization consists of boiling in concentrated HCl for half an hour to bleach the biotite to "bauerite", thus lowering its specific gravity so that it will float in a heavy liquid. This process is only necessary when biotite or chlorite is abundant and the heavy liquid used does not have specific gravity higher than 3.1.

<u>Magnetic Separation:</u> The grains obtained as a result of panning were divided into three portions; highly magnetic, moderately to weakly-magnetic, and non-magnetic. This was

done with the use of a permanent magnet and a strong electromagnet.

All the grains were spread into a mono-mineral layer on a large sheet of paper. A permanent magnet covered by a piece of paper was then passed slowly over all parts of the sheet about half an inch above the grains. The strongly magnetic grains attached themselves to the paper on the magnet and were then easily removed. This portion consists chiefly of magnetite which is common in thin sections. Steel filings from the pulverizer were also removed here. This portion was bottled and labelled.

The moderately to weakly-magnetic grains were then separated from the remainder by bringing the sample within a quarter of an inch of the poles of the electromagnet with a sheet of paper inserted between the poles and the sample. All other minerals with any magnetic properties were drawn off in this portion and also bottled and labelled.

The remaining portion was then put through the heavy liquid to separate the zircons from the other non-magnetic minerals.

<u>Heavy Liquid Separation</u>: Two heavy liquids commonly used as media for specific gravity separation of minerals were obtainable in the laboratory where this work was carried out; bromoform ($CHBr_3$) whose specific gravity ranges up to 2.89, and clerici solution (thallium mallonate and thallium formate) whose specific gravity ranges up to 4.1. As the writer wished to isolate zircons (specific gravity 4.68 to 4.70) clerici solution was used for all samples.

No centrifuge separator being available, gravity separation was used. About 135 c.c.'s of clerici solution with a specific gravity of 3.75 were poured into a separatory funnel with a total capacity of about 185 c.c.'s. The funnel consisted of one main chamber which tapered to a point at the bottom and had one stop cock below this chamber. The non-magnetic grains were poured into this funnel, shaken thoroughly, and allowed to stand for 15 minutes. This process was repeated four times. After the fourth time the clerici solution was allowed to stand until the solution in the main chamber was clear, the grains being concentrated at the top and bottom of the liquid. The heavy grains which sank to the bottom were then carefully drained off into a suction filter by opening the stop cock. Care was taken in closing the stop cock as lighter grains tend to be pulled down through the liquid when it begins to drain out the bottom.

The clerici solution was collected in a suction filter bottle in its pure form. This bottle was replaced by another when the grains and the filter paper were washed with distilled water, and the diluted clerici solution was later reconcentrated.

The grains were then washed thoroughly in a conical filter paper and concentrated at its apex. The filter paper with the grains was then carefully dried on a hot plate at a temperature not exceeding 100 degrees C. The grains were then bottled and labelled.

The same procedure was carried out for the lighter fraction which remained on the top of the heavy liquid and they were similarly bottled and labelled.

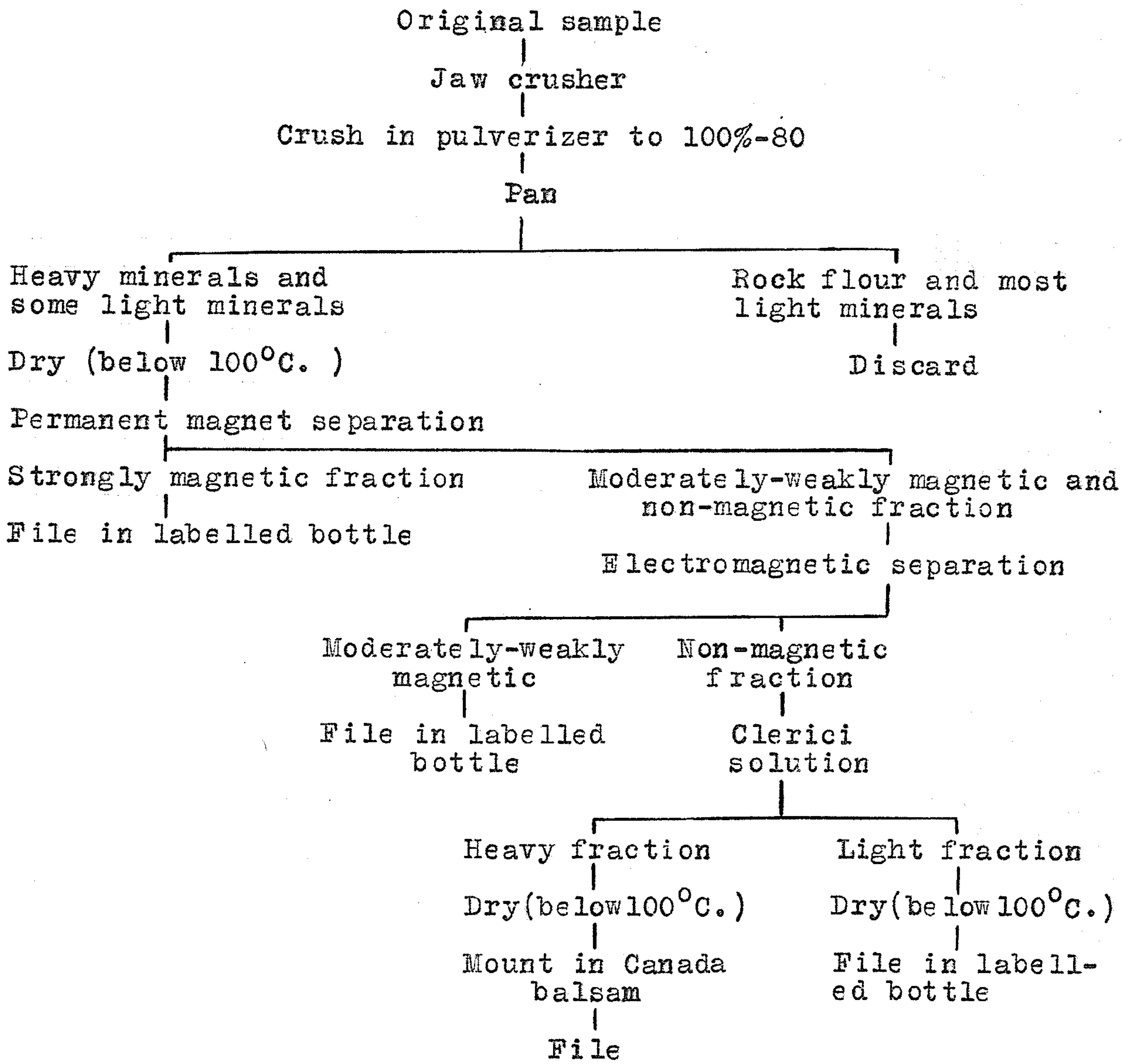
Gravitational separation is inefficient compared with centrifuging. Tyler and Marsden (1937, p.8) estimate that 66 per cent of the heavy minerals are lost in the light fraction, thus making gravitational separation only 34 per cent efficient.

Permanent Mounting: The zircons were mounted along with other minerals that came down in the clerici solution. The value of hand picking the zircons was not considered sufficient to warrant the time it would require.

The heavy grains were mounted on glass slides in Canada balsam. This was accomplished as follows: A moderate layer of balsam was spread on a glass slide and heated on a hot plate at 150 degrees C. until it became "tacky". The slide was then removed from the hot plate and allowed to cool. When the balsam hardened the grains were poured onto the slide and carefully spread on the balsam so that no grains were superimposed on others. The slide was then placed on the hot plate and, as the balsam melted, the grains sank into it. The cover glass was immediately applied. The slide was then removed from the hot plate and excess balsam removed from the slide with xylol. It was labelled and filed.

Reconcentration of Heavy Liquid: The diluted clerici solution was reconcentrated by heating very gently to drive off the water. The solution decomposes if boiled and should not be heated over 80 degrees C. The water is driven off very easily and to change the gravity by .1 or .2 the solution should never be heated more than ten to fifteen minutes without running a specific gravity test.

The following is a "flow sheet" of the procedure used in this investigation for the concentration of heavy minerals.



Zircon Types From The Conglomerate

<u>General Statement</u>: The following section is devoted to a description of the zircons found in the various conglomerate pebbles and matrix.

The term "malacon" will be used in accordance with the usage of Tyler, Marsden, Grout, and Thiel (1940, p.1441). It is characterized by abnormally weak birefringence, dull lustre and a cloudy altered appearance. The low birefringence (first order grey to yellow) is especially diagnostic as all other zircons have a birefringence ranging from second to fourth order. They are colourless to pale dirty yellow and many contain dust-like inclusions.

If heated properly malacon may change to zircon with typical characteristics. Therefore it may be a hydrated form of normal zircon. However it has been found in dykes cutting metamorphosed sediments that contain only zircons of normal birefringence (see Tyler, Marsden, Grout, and Thiel, 1940, p.1442). This suggests that there must be a difference in chemical composition. They may occur as borders on zircons of normal birefringence. This is the most common occurrence of malacon found in this investigation.

As no pleochroism was noted in any of the zircons, no hyacinth type is believed to be present. However the birefringence of nearly all grains varies from third to fourth order.

Most of the grains are colourless and some show a faint yellowish tint. This yellow colour may be due to iron oxide stain on the crystal or to the thickness of the grain.

The zircons are extremely clouded under ordinary transmitted light and the condenser lens must be inserted in the microscope in order to see such things as colour, zoning and inclusions. This cloudiness may be due to fractures, zoning, or minute inclusions. Many of the fractures may have formed during the crushing of the rock sample.

The dark, clouded, fuzzy appearance of the zircons has made it impossible to take photomicrographs which would show the desired characteristics. Instead, a series of 92 camera lucida drawings (X 100) have been prepared. They are included in fig. 15 (in pocket). The characteristics of the zircons from each sample studied are also summarized here, along with the petrographic classification of the specimen. Characteristica that are present in a specimen but are extremely rare are not considered diagnostic and have not been included in the summary for the specimen. Such characteristics will, however, be mentioned in the written description.

The crystal form of all zircons, except as otherwise mentioned, is characteristically simple and consists of a simple prism usually terminated by a pyramind.

A description of the zircons from each rock examined is given below. No attempt was made to crush all the rocks examined in thin section. Only those which bore a macroscopic similarity to some acidic rock type in the Lynn-Barrington Lakes area and for which a sufficient weight of sample could be obtained were crushed. The zircons from pebble types of similar lithology and locality are identical. Hence zircons from each rock type, rather than those from individual specimens will be described.

Quartzite Pebbles (Rodmac Lake): Zircons from this rock type are rare but those present are typically moderately elongate with an average length-width ratio of about 2:1. They are extremely clouded and almost opaque under ordinary transmitted light. With a condenser lens in the microscope they are colourless but may have a slight yellowish tint that appears to be an external stain, possibly Fe_2O_3. By reflected light the zircons are honey yellow. No euhedral crystals are present. The general crystal outline is usually recognizable but the interfacial edges are rounded. Some grains are almost oval in shape. Most of the zircons are zoned with zonal angles being sharp and angular in contrast to the rounded crystal edges. The entire zircon may be zoned or a central unzoned core may be present. Inclusions are rare but the following types occur: (1) rounded to irregular, opaque inclusions; (2) colourless, acicular crystals in random arrangemant. The faces of the zircon crystals are usually slightly corroded and fractured. It is possible that much of this fracturing is due to crushing in the preparation of the sample. Interference colours are of the third order. Rims of malacon found on three of the grains examined (Fig. 15) are characterized by birefringence of low first order. These rims are found on slightly rounded, zoned grains and completely enclose some grains. The rounding of the core is interpretted as evidence that the malacon has formed as a result of secondary growth.

Quartzite Pebbles (Sickle Lake): The zircon content from these pebbles is low. They are moderately elongate with a length-width ratio ($2\frac{1}{4}$: 1) slightly higher than that of the zircons from the Rodmac Lake quartzite pebbles. Here again they are extremely clouded and almost opaque under ordinary transmitted light. Most grains are colourless when viewed with a condenser lens in the microscope but some show a slight yellowish tint. By reflected light the zircons are honey yellow. No euhedral crystals are present and many of the grains are completely rounded and oval-shaped. A few were seen to have a rough crystal outline with well rouded interfacial edges. No distinct zones were observed in any of the zircons,and although it is possible that the cloudiness may have obscured the zoning,it is considered that the distinct variety found in the Rodmac Lake quartzite pebbles is not present. Inclusions are rare but,where present,the following types are found: (1) colourless,acicular,unoriented inclusions; (2) opaque,irregularly shaped inclusions. Crystal faces on some grains are slightly corroded and most grains are fractured. Interference colours are of the middle third order,but two zircon grains were observed to be completely surrounded by malacon rims having a low first order birefringence (Fig.15). Because the inner portions of the grains are rounded more than the rims,it is inferred that the rims are a result of secondary growth.

Mylonite Pebbles (Sickle Lake): Zircons are common in this rock type and are moderately elongate with an average length-width ratio of 2:1. Some of the euhedral types have a ratio of 3:1 but these are uncommon. Nearly all are clouded and the condenser lens of the microscope must be used to examine them. They are colouless or very pale yellowish when viewed with transmitted light. By reflected light the zircons are pale yellow. Euhedral crystals are extremely rare and are mainly the simple pyramid and prism type (Fig. 15) but some crystals are terminated by a straight line which may represent a basal pinacoid. The majority of the zircons present are of subhedral form. The general crystal shape is present but the crystal edges are rounded and crystal faces are slightly irregular. Completely rounded grains are rarely present. Zoning is characteristic in nearly all zircons. The zones follow the external crystal form and exhibit sharp angles. Inclusions are common and are of the following types: (1) colourless to reddish, small, acicular inclusions. often roughly aligned with their long axis parallel to the c-axis of the zircon; (2) opaque, rounded to irregular inclusions showing no preferred orientation. The crystal faces are usually smooth and show little fracturing. Interference colours are of the third order. Many crystals have a dark cloudy core surrounded by a narrow malacon rim (Fig. 15). These rims, although forming distinct external faces and angles, often enclose a rounded darker core. The cores may have formed and been rounded prior to the formation of the malacon which is considered by the writer to be secondary.

Granite Pebbles (Rodmac Lake): Zircons are abundant in these pebbles. Most are moderately elongate with an average length-width ratio slightly in excess of 2:1. In one sample two very elongate zircons were noted. Their length-width ratio is 4½:1. The zircons are so clouded as to appear almost opaque under ordinary transmitted light; the condenser lens must be used in the microscope. The grains are commonly colourless, but the faint yellowish tint noted in those from the quartzite pebbles is often present. By reflected light the zircons are pale yellow. Zircons of euhedral form are present but rare. The majority are subhedral in form and crystals show a slight rounding of interfacial edges. A few completely rounded grains are present. Slightly rounded crystal edges may indicate a slight amount of resorption if the grains were crystallized from a magma. The crystal form is a simple prism and pyramid with a basal pinacoid being rarely present. About half the grains are zoned. When present, this characteristic is very distinct even though the crystals may be rounded. Those grains that are euhedral have zones following the external crystal form. Zircons from several specimens were observed to contain darker central cores, although the whole crystal is still optically continuous and otherwise uniform. These are illustrated in Fig.15 (specimens P-3-49 and P-14-49). Some zircons from specimen P-15-49 have a zones exterior around a central unzoned core (Fig.15). Inclusions are common in most zircons. The types are: (1) small, transparent, acicular inclusions, some of which are oriented with their long direction parallel to the c-axis of the zircon. (2) rounded inclusions, some colourless and some opaque. Some of these may be gas bubbles. Faces of zircon crystals are generally smooth but many grains are fractured. Interference colours are of the third order in most grains but some zircons of low first order birefringence were observed in three specimens. These have a simple crystal form that appears clouded and corroded; they are malacon grains. Several of the normal zircon crystals are surrounded by malacon rims that have low first order interference colours and are more clouded than the interior of the crystal. They completely envelope the clearer interior of the grains but occur only around the ends of the others. The zones conform with the crystalline outline of the interiors and are illustrated in Fig.15 under specimen P-2-49.

Granite Pebbles (Sickle Lake): Zircons are common in Sickle Lake granite pebbles. They are moderately elongate but are slightly longer than those from the granite pebbles of Rodmac Lake. The average length-width ratio of these is 3:1. One crystal with a ratio of 5:1 was observed. This grain is illustrated in Fig.15. Most of the zircons are cloudy and dark but some clear ones are present. The darkness of the grains is believed by the writer to be due, at least in part, to the high degree of zoning found in most crystals. Most of the grains are colourless viewed by transmitted light but a faint irregular yellowish tint is present in some. By reflected light the grains are pale yellowish.

The crystal form is euhedral to very slightly rounded and the crystals consist of simple prisms and pyramids, som of which are terminated by basal pinacoids. Zoned crystals are common and unzoned zircons are rarely present. The entire crystals are usually sharply zoned but in some grains an unzoned interior is surrounded by a zoned rim. Inclusions are common and the following types are present: (1) colourless, acicular crystals, some of which are oriented with their long axis parallel to the c-axis of the zircon; (2) opaque, unoriented, rectangular to irregularly shaped inclusions. Crystal faces are usually smooth but some appear slightly corroded. Most of the grains are slightly fractured. The interference colours of the zircons are middle third order with the exception of some extremely rare malacon grains that are anhedral in form. Rarely a normal zircon is enclosed by a thin border of malacon completely encircling the grain. All such grains have a crystalline core and a conformable border and it has not been found possible to ascertain whether or not the border is a secondary growth.

Granite Pebble (Ralph Lake): Only a few zircons were observed in this specimen. They are moderately elongate with an average length-width ratio of slightly over 2:1. Viewed by transmitted light they are extremely clouded but colourless. By reflected light they are pale yellowish. No euhedral grains are present. Most zircons are subhedral with rounded interfacial edges and slightly irregular faces. Some completely rounded grains are present. No crystals are zoned and no cores are present. Inclusions are common and are of the following types: (1) colourless, acicular, unoriented crystals; (2) opaque, irregularly shaped inclusions. Crystal faces are slightly corroded and fractured. The interference colours of the zircons are middle third order. No borders or secondary growths were observed.

Matrix (Sickle Lake): Zircons are common in the matrix. Most are moderately elongate with a length-width ratio of about 2:1. Stubby crystals (length-width ratio $1\frac{1}{2}$:1) are rarely present. They are highly clouded but, viewed with the condenser lens in the microscope, are usually colourless. Rarely a yellow-orange tint was observed. By reflected light the zircons are pale yellow. No euhedral crystals are present, and although the general crystal outline may be recognized, the interfacial edges are rounded and the faces are often slightly irregular. Zones are common and distinct, and occur throughout the entire zircon in some instances but form only a border around a central unzoned core in others. Inclusions are rare but the following types occur: (1) small, colourless, acicular, unoriented crystals; (2) irregular, opaque inclusions. Faces of zircons are slightly corroded and fracturing is uncommon. Interference colours are of the third order. Small malacon rims are often present on the ends of zircon crystals. Small secondary outgrowths occur on most grains. They are usually in the form of pyramids growing out from the zircon at right angles to the principal axis of the parent crystals, but they may grow out from any face. These are illustrated in Fig.15. Zoned rims around slightly rounded interiors are interpretted as having formed as a result of later or secondary growth.

Sickle Sediments (Sickle Lake): One specimen of the Sickle sediments taken just above the conglomerate has a high zircon content. These zircons are typically moderately elongate with a length-width ratio of $2\frac{1}{2}$:1. Most of them are clouded and colourless when viewed by transmitted light but some have a slight yellowish tint. All grains are pale yellow in reflected light. Euhedral crystals are extremely rare, most grains being subhedral to rounded in form. Completely zoned crystals are absent but some grains possess a zoned border enclosing an unzoned interior. Some zircons were observed to have a darker central core surrounded by an unzoned rim. These are illustrated in Fig.15. All grains are slightly corroded and fractured. Birefringence is of the third order in all the zircons. None of the grains contain inclusions.

Conclusions: The most noteable fact to result from the study thus far is the difference in the zircons from pebbles from Rodmac Lake and from Sickle Lake. The exact differences can readily be seen by examining the camera lucida drawings (Fig.15) and refering to the zircon descriptiond. Briefly, the zircons from the quartzite pebbles from Rodmac Lake are characteristically zoned whereas those from the Sickle Lake quartzite pebbles are unzoned or show hazy, ill-defined zones. The zircons from the Rodmac Lake granite pebbles are, in general, subhedral to anhedral and some possess darker central cores. Those from the Sickle Lake granite pebbles are euhedral to subhedral in form and tend to possess more distinct zones. This fact supports the conclusion made earlier, based on the difference in the colour of the pebbles from the two localities, that the pebbles in the conglomerate at the two localities are not derived from the same rock.

This is the only conclusion that the writer draws from the work thus far but a further examination of the zircon characteristics is made under "Discussion of Resulte". This includes a study of all the zircons examined from all pebbles and other acidic rocks in the area.

CHAPTER IV

PETROLOGY OF SOME ACIDIC ROCKS OF THE AREA

Methods Of Sampling In The Field

General Statement: As was stated in the introduction it was hoped that this study might show some correlation between the conglomerate pebbles and some of the older acidic rocks in the area. Most of the area has been mapped by Manitoba Government geologists and samples of most of the rock types are on file in the Manitoba Mines Branch offices. The writer was given access to these files and all specimens bearing any macroscopic resemblance to pebble types in the conglomerate were removed for further study. The specimen numbers were placed on a map showing the rock body from which they came and any specimens which were known to be definitely younger than the Sickle series were discarded. The remainder were filed for thin section and heavy mineral study. The accomphying map (Fig.3) shows the location of the specimens studied.

Lithology

General Statement: As each specimen represents an entire rock type it is obvious that a detailed discussion of the petrography of the various rock types is impossible. Also, it was not considered necessary as this thesis chiefly concerns the petrography of the Sickle conglomerate. The petrography of the other acidic rocks of the area is examined only for correlative purposes. This correlation was approached chiefly by a study of zircon grains rather than thin section methods. Consequently the thin sections were studied with two objectives in mind: (1) to determine the minerals present rather than to accurately determine their relationships; (2) to determine whether the specimens are of igneous or sedimentary origin.

Granites: Four of the specimens whose locations are shown on the map are from acidic igneous bodies : B-63-48, C-238-49, A-129-48, and B-72-48.

Specimen B-63-48 is a fine-grained pink biotite granite bearing some macroscopic resemblance to the pinkish grabitic type pebbles found at Sickle Lake. A microscopic examination of this type shows the rock to be hypautomorphic granular in texture and to contain roughly 55 per cent microcline,25 per cent quartz,15 per cent orthoclase,and minor amounts of kaolin,biotite and magnetite. As no trace of microcline feldspar is present in any of the conglomerate pebbles,a correlation with this type is improbable and hence the thin section was not studied in any detail. Suffice it to say for purposes of later zircon classification,that the rock is typically granitic in both texture and mineral composition.

Specimen C-238-48 occurs as an inclusion in a basic intrusive body. Microscopically it shows a marked resemblance to the granitic pebble from Ralph Lake. It is a medium-grained rock showing 20 to 30 per cent quartz. Some larger grey feldspar crystals give the rock a slightly porphyritic appearance. About five per cent biotite and hornblende can be seen.

Microscopically this specimen has a hypautomorphic granular texture. A Rosiwal analysis shows it to consist of andesine 25 per cent, orthoclase 47 per cent, quartz 17 per cent, biotite 6 per cent, hornblende 4 per cent and a minor amount of magnetite. The feldspars are moderately kaolinized. Some of the biotite occurs as rims around the hornblende and may be secondary. Most of the biotite, for lack of evidence to the contrary, is considered primary. The biotite and hornblende occur in the interstices of the quartz and feldspar grains. No zircons were seen in this section. According to Grout (1932, p.50) this rock is a quartz monzonite.

Specimens A-129-48 and B-72-48 were both examined for their macroscopic similarity to grey biotite granite pebbles found at Rodmac Lake. Both are light grey, fine grained and contain some biotite although the biotite content here is slightly higher than in the pebbles. An estimation of amount is given in the microscopic description following. Individual quartz grains are more evident in these specimens than in the pebbles.

Specimen B-72-48 has a hypautomorphic granular texture and its composition is estimated to be: oligoclase 50 per cent, quartz 20 per cent, orthoclase 15 per cent, biotite 4 per cent, hornblende 4 per cent and minor amounts of magnetite, apatite, epidote, and a carbonate mineral. Feldspars are moderately kaolinized. Quartz and feldspar form the main part of the rock with the other minerals occurring in their interstices. According to Grout (1932, p.50) this rock is a granodiorite.

Specimen A-129-48 is also hypautomorphic granular in texture and its mineral composition is estimated to be: orthoclase 48 per cent,oligoclase 20 per cent,quartz 20 per cent, microcline 5 per cent and biotite 5 per cent. The feldspars are slightly kaolinized. A trace of chlorite occurs ae rims around the biotite flakes and is therefore believed to have altered from the biotite. Pleochroic halos may indicate the presence of zircons. The quartz and feldspars form the main part of the rock with the other minerals occurring in their interstices. According to Grout (1932,p;50) this rock is a granite.

Quartzites: The quartzite pebbles whose location is shown on the accompanying map (Fig.3) are all similar in appearance and are all members of the Wasekwan series. They resemble the greyish quartzite conglomerate pebbles except that the porphyroblasts or phenocrysts found in the pebbles are lacking here. They are medium to dark grey in colour,siliceous in appearance and aphanitic but with a trace of biotite which gives the rock a suggestion of banding.

Microscopically the rocks consist of roughly 85 per cent quartz and 10 to 15 per cent biotite. Muscovite is sometimes present. The quartz is fine grained,has a typical intergrown texture,and shows minor strain shadows. Biotite forms small green plates and is usually concentrated in narrow bands. Muscovite,when present,occurs dispersed throughout the entire section in small,aligned flakes. There are no particularly distinctive features about these quartzites.

Mylonites: This term is again used in conformance with the ideas of Waters and Campbell (1935) and is a textural classification that does not indicate whether the rock was originally igneous or sedimentary. Rocks classed here resemble the mylonites and the finer-grained crushed granites found as pebbles in the conglomerate. Their occurrence, however, indicates that they were emplaced as igneous rocks.

Specimen F-347-49 is from a body of rock which occurs in the Wasekwan series near Wasekwan Lake. It forms a narrow band, conformable with the other members of the series, and is believed by Fawley (1950) to be a sill-like body. It was termed "felsite" in the field. The rock is grey in colour with a purplish caste and resembles the quartzites and mylonites found as pebbles in the conglomerate. It is extremely fine grained, siliceous in appearance and shows no lineation.

Microscopically the rock is estimated to contain 50 per cent quartz, 15 per cent microcline, 15 per cent oligoclase, 10 per cent orthoclase and minor amounts of biotite, sericite and a carbonate mineral. The texture is well illustrated in Fig.11. The larger quartz fragments are often markedly fractured. The muscovite forms long bands of small flakes and occurs throughout the entire section. The carbonate mineral occurs interstitially and does not appear to have been affected by the movement so may have been introduced subsequent to the mylonitization.

The other mylonite specimens, A-23-48 and A-16-48, show more resemblance to the finer-grained granite pebbles.

X 30

Fig. 11 Photomicrograph of a thin section of mylonite specimen F-347-49. (X Nicols)

They are medium to light grey in colour, fine grained, and are composed chiefly of quartz, feldspar, and a minor amount of aligned biotite. They have been described by Bateman (1945) as a sheared granite gneiss. Allan (1948) believes them to be sills of granitic rock of pre-Sickle age. Their areal extent is small.

Microscopically they have typical mylonitic textures. Specimen A-23-48 is estimated to contain 45 per cent quartz, 45 per cent orthoclase, 4 per cent biotite, 4 per cent muscovite, and a trace of oligoclase and kaolin. The rock consists of fragmental quartz and feldspar grains in a fine-grained paste or groundmass of quartz and mica. The quartz often occurs as crushed lenses. Specimen A-16-48 is estimated to contain 40 per cent quartz, 40 per cent muscovite, 10 per cent biotite and chlorite, and small amounts of magnetite, zircon, and a carbonate mineral. The quartz occurs as fragments or elongated lenses in a groundmass of fine-grained quartz and muscovite. No feldspars are present. The carbonate mineral shows good cleavage and does not appear to have been affected by the force which produced the mylonite.

<u>Eruptive Breccia</u>: An eruptive breccia lies unconformably below the conglomerate on the east shore of Sickle Lake. Fig.12 shows the contact of these two rocks. This breccia is mentioned by Bateman (1942, p.791) in a footnote to an article. He states that in a personal communication J.D.Bateman described to him what appears to be a pre-Sickle

Fig. 12 Photograph of the conglomerate-granitic rock contact. The geological hammer shows the scale.

granite that passes upwards into a talus-like mass of angular blocks with a sandy filling. This material then grades upwards into basal Sickle conglomerate containing boulders of the granite.

The locality described was visited by the writer and mapped in detail. The writer does not agree with the above description. The granitic type rock mentioned is present but is more basic than a granite. Macroscopically it consists of roughly equal amounts of quartz and madium-grey feldspar and 15 per cent biotite. The rock has a pronounced gneissosity. This rock grades upwards into an eruptive breccia that consists of angular blocks of the granitic rock in a groundmass of dark-green trap material. The trap material shows intrusive relationships with the granitic rock.

Lying on this breccia is the basal Sickle conglomerate but no gradation between the two is present. Fig.12 confirms this fact. No granitic conglomerate pebbles bear any strking resemblance to the granitic rock below.

Microscopically this gneiss is estimated to consist of quartz 20 per cent,andesine 40 per cent,biotite 15 per cent,orthoclase 20 per cent and minor amounts of magnetite, sericite,chlorite,and epidote. It has a hypautomorphic granular texture but the quartz grains have all been granulated. All other minerals occur in the interstices between the quartz and feldspar grains; the biotite has a rough alignment which produces a gneissic appearance in the rock. According to Grout (1932,p.50) this rock falls at the division between quartz monzonite and granodiorite.

A thin section of the intruded trap material was studied. This rock is extremely fine grained and seems to be composed chiefly of sericite or fine-grained muscovite and greenish brown biotite. A minor amount of chlorite, magnetite, and quartz is present. From Grout's (1932, pp. 122-123) description this rock appears to be a lamprophyr.

Conclusions: Few conclusions can be drawn from such a brief outline of petrography. A point of interest is the large number of specimens from various localities which contain the introduced carbonate mineral. In all instances it appears to have been introduced after the consolidated rock was formed.

The mylonite specimens from Anson Lake appear very similar in thin section to some of the pebbles. As these mylonites are believed to be pre-Sickle in age it is possible that they represent a rock type from which some of the conglomerate pebbles may have come.

The thin section of the mylonite from the sill near Wasekwan Lake shows a similarity to thin sections of mylonite pebbles from the conglomerate.

Microscopic study showed no striking similarities between any other rock type in the area and the conglomerate pebbles. Quartzites from the area and quartzite pebbles are similar, but as neither have any distinguishing features this, in itself, is not diagnostic.

Zircon Types From The Acidic Rocks

General Statement: Following is a description of the zircons from the acidic rocks of the area described above. A summary of their characteristics and camera lucida drawings of typical grains is found in Fig.15.

Granites: As the granitic type rocks come from widely separated areas their zircon content will be described separately

Specimen C-238-49 contains a few moderately elongate zircons with an average length-width ratio of 2½:1. They are extremely clouded but appear colourless to faintly yellowish when examined with the condenser lens in the microscope. By reflected light they are pale yellow. Some euhedral crystals are present but most grains are subhedral to rounded. The crystal form is usually a simple prism and pyramid but a basal pinacoid terminates some grains. Their form is illustrated in Fig.15. Some crystals are zoned but this feature is rather indistinct owing to the clouded appearance of the grains. No cores were observed in any of the zircons. Acicular, colourless, unoriented inclusions are present but rare. Faces of the crystals are smooth and only slightly fractured. Interference colours of all grains are of the third order.

Specimen A-129-48 has a low zircon content. It contains mainly stubby zircons with a length-width ratio of 1½:1. Moderately elongate grains (ratio 2:1) are rarely present. The grains are colourless when viewed by transmitted light. Clear crystals predominate but some clouded ones are present. By reflected light the grains are pale yellowish. No euhedral crystals occur but all zircon grains show rough crystal outlines with rounded interfacial edges. No zones were observed but one grain has a darker central core (Fig.15). Inclusions are present and are irregular in shape, colourless, and may be gas bubbles. Crystal faces are smooth but cloudy and grains are often fractured. The interference colours of all grains are of third order.

Specimen B-72-48 contains numerous moderately elongate zircons with an average length-width ratio of $2\frac{1}{2}$:1. One very elongate crystal, length-width ratio 5:1, was observed. Transmitted light shows the grains to be colourless, although some have a clouded appearance. This cloudiness appears to be due to the zoning. The grains are pale yellow by reflected light. Some euhedral crystals occur, but the majority of the grains have slightly rounded to well rounded interfacial edges. Zoning is usually evident in the clouded variety but is never present in the clear type. Inclusions are rare but the following types were observed: (1) colourless, acicular crystals with random orientation; (2) opaque, irregularly shaped inclusions. Crystal faces are smooth and show no evidence of fracturing. Interference colours are of the third order in all grains.

Most zircons from specimen B-63-48 are moderately elongate (average length-width ratio $2\frac{1}{2}$:1) but several well rounded grains (ratio $1\frac{1}{2}$:1) were observed. The zircon content is low. All grains are extremely clouded and colourless to faintly yellowish in transmitted light. They are orange-yellow in reflected light. Euhedral crystals are absent in this sample but most grains show a rough crystal outline. Some are completely rounded and have no crystal faces. No completely zoned zircons occur but one well rounded grain is enveloped by a zoned rim (Fig.15). The rounding of the inner core is interpretted as evidence that the outer zoned rim has formed as a result of secondary growth. No inclusions occur in the zircons. Crystal faces are slightly corroded and usually fractured. Interference colours are of the third order.

Mylonites: As specimen F-347-49 is the only one of its kind, its zircon content will be described separately. Zircons are rare in this specimen. Those present are typically moderately elongate with an average length-width ratio of $2\frac{1}{2}$:1. They are extremely clouded and, with a condenser lens in the microscope, are colourless to faintly yellowish. By reflected light the zircons are pale yellow. All the grains are slightly rounded to well rounded and few crystal faces are present. Indistinct zoning occurs in some grains but is partially obscured by the cloudiness. No cores are present. A few colourless, irregularly shaped inclusions were noted and the writer believes them to be gas bubbles. The faces of most zircon crystals have undergone some corrosion and are usually fractured. All interference colours are of the third order.

The other mylonite specimens are from the sheared granite gneiss near Anson Lake and their zircons will be described together. Zircons are common in all specimens.

The average length-width ratio of these grains ranges from $2\frac{1}{2}$:1 to 3:1. Stubby crystals (ratio $1\frac{1}{2}$:1) and elongate ones (ratio $4\frac{1}{2}$:1) are rarely present. Viewed by transmitted light they are colourless to faintly yellowish and some are clouded. By reflected light the zircons are pale yellow. Euhedral crystals are uncommon but most grains possess a rough crystal outline with rounded interfacial edges. Some zones were observed but they are hazy and indefinite and often appear to form external rims on the grains. Inclusions are rare but the following types occur: (1) colourless,acicular,unoriented crystals; (2) opaque, irregularly shaped inclusions. The clouded zircon grains are often highly fractured,possibly causing their clouded appearance. Interference colours are of the third order.

<u>Quartzites</u>: The quartzite specimens are from the Wasekwan series and were taken from localities only one mile apart. Hence their zircon content will be described together.

Zircons are rare in these rocks. Most grains are moderately elongate with an average length-width ratio of $2\frac{1}{2}$:1. Some stubby crystals (ratio $1\frac{1}{2}$:1) were observed in one specimen but they are more rounded than the more elongate grains. Most of the grains are clouded when viewed without the condenser lens in the microscope. Viewed by transmitted light they are colourless to pale yellow,and by reflected light they are slightly yellowish. No euhedral zircon crystals occur and all grains are slightly rounded to well rounded with crystal faces rarely present. Zoning is extremely rare and, where observed, is hazy and indefinite. Some acicular, unoriented inclusions occur. Most of these are colourless but one is pleochroic from greenish blue to brownish red. Most grains are highly fractured. The writer believes this to be one reason for their clouded appearance. All the zircons have third order interference colours.

Eruptive Breccia: The zircons of the lamprophyr matrix will first be described. Only a few are present. The average length-width ratio of these grains is $2\frac{1}{2}$:1 although stubby crystals (ratio 1:1) rarely occur. Most grains are clouded and colourless by transmitted light. Some clear grains were observed. A few grains have a faint yellowish tint. By reflected light the zircons are pale yellow. Euhedral crystals are extremely rare, most grains being slightly rounded to well rounded. The majority of the zircons show some zoning although it is hazy and indefinite in appearance. Inclusions are rare but the following types occur: (1) colourless, acicular, unoriented crystals; (2) opaque, irregularly shaped inclusions. The crystal faces are usually smooth and free from fractures. Thin rims of malacon occur on the ends of some grains but they are rare. The interference colours of all zircons other than the malacon are of third order.

The other specimens in this group form the fragments of this breccia. Zircons are common in this rock type and have an average length-width ratio of $2\frac{1}{2}$:1. Some stubby crystals (ratio $1\frac{1}{2}$:1) and elongate crystals (ratio 5:1) are also present. Most of the zircons are clear but a few clouded ones were observed. All grains are colourless by transmitted light and pale yellow by reflected light. Most crystals consist of a simple prism and pyramid but some grains are terminated by a basal pinacoid. Perfect euhedral crystals are uncommon but most of the grains have a rough crystal outline with slightly rounded interfacial edges. Some hazy,ill-defined zones occur in one grain but this is not diagnostic. Inclusions are rare but the following types occur: (1) colourless,irregularly shaped,unoriented inclusions believed by the writer to be gas bubbles; (2) colourless,acicular, unoriented crystals. Crystal faces are usually smooth and individual crystal faces are often visible in the clear grains (see Fig.15). Fractures are uncommon. Interference colours are of the third order and no malacons are present.

Conclusions: No immediate conclusions were gathered from a study of these zircons alone. A general discussion of the characteristics of all zircons studied and the conclusions from this study follows in the next chapter.

CHAPTER V

CONCLUSIONS

Discussion of Results: The writer presents a tentative correlation of the conglomerate pebbles with three of the rock types in the area.

The grey quartzite pebbles from Rodmac Lake may have come from the Wasekwan quartzites as typified in the region of Frances Lake. This correlation is suggested for the following reasons:

(1) The Wasekwan series is believed by Norman (1934,p.27c) to be older than the Sickle series. It is possible that pebbles of the older series would occur in the younger one.

(2) Wasekwan quartzites and quartzite pebbles from the Sickle conglomerate are almost identical macroscopically.

(3) Microscopically there is very little difference between the two types. This is evident from a study of the petrographic descriptions given in a previous chapter. This might, however,be expected from any two quartzites of the same grain size.

(4) The zircons are similar in all but minor respects although no particularly distinctive characteristics occur. They differ in that zones are well defined in the pebble zircons whereas the zones in the quartzite zircons are slightly irregular. This may be due to the clouded appearance of the grains. The zircons from the pebbles show some thin malacon rims but,as the writer believes them to be secondary outgrowths,they could have formed by authigenesis after the pebbles were emplaced.

These quartzites lie within a volcanic series and form a large percentage of the pebbles in the conglomerate, whereas andesite or other volcanic pebbles are rare. The writer assumes that the basic rock,being more easily decomposed by weathering,was completely broken down,and that the highly acidic rocks resisted weathering,were transported,and emplaced as pebbles.

Some of the fine-grained and crushed pebbles of grey granite may have come from rocks classed as mylonites found in the vicinity of Anson Lake. These are described by Bateman (1945) as sheared granite gneisses and believed by Allan (1948) to be sills of granitic rock of pre-Sickle age with a small areal extent. This correlation is suggested for the following reasons:

(1) As described above,the source rock is believed to be older than the Sickle series.

(2) It was noted in the petrographic descriptions that the two rock types were macroscopically similar.

(3) The pebbles classed as crushed granites and mylonites (sheared granite gneisses) are similar in thin section,both in texture and composition. The term mylonite has been applied to indicate their texture,but field relations show them to be originally igneous.

(4) As with the quartzites the zircons are similar but not diagnostic. Zones are of the same type,often forming only external rims on the grains but are more hazy in the mylonites (sheared granite gneisses). Minor secondary growths

are present only on the pebble zircons.

Sills of acidic mylonite,such as that found in the Wasekwan series (specimen F-349-49) near Wasekwan Lake, may have been the source for mylonite pebbles in the conglomerate. The reasons are similar to the above but will be briefly summarized:

(1) The Wasekwan series is older than the Sickle series.

(2) The hand specimen from the sill resembles the mylonites which are present as conglomerate pebbles.

(3) The two rocks are similar in thin section in both texture and mineral composition.

(4) Little work was done on the mylonite pebble zircons and only one specimen was available from the mylonite sill. However,as may be seen from the descriptions,the zircons are similar in most characteristics. The only major difference is the presence of some secondary growths on the pebble zircons.

There is no similarity in the zircons from the conglomerate pebble from Ralph Lake and those from specimen C-238-49 although these rocks show some macroscopic and microscopic similarities. Any correlation here is unlikely.

No other similarities between pebbles and older acidic rocks of the area were observed in either thin section or zircon content. Further correlation is unlikely along these lines of approach.

Tables I and II show the percentage of each rock type containing zircons that exhibit the various characteristics. Only properties which are commonly present

NUMERICAL TABULATION OF ZIRCON CHARACTERISTICS

Property	Pebbles		Conglom. matrix	Sickle seds.	Acidic rocks		Basic rocks
	Granite	Quartzite			Igneous	Quartzite	
Stubby crystals	0	0	0		22	0	x
Moderate crystals	100	100	100	x	100	100	x
Elongate crystals	0	0	0		0	0	
Euhedral crystals	50	0	0		33	0	
Rounded grains	80	100	100	x	77	100	x
Colour-less	100	100	100	x	100	100	x
High birefr.	100	100	100	x	100	100	x
Malacon	10	20	50		0	0	x
Secondary growth	0	40	100		11	0	
Zoned	50	70	50		33	0	x
Cored	30	20	50	x	0	0	
Inclusions present	80	60	0		33	50	

TABLE I

The numbers represent the percentage of specimens that possess each property. The "x" indicates that only one specimen is represented and that a property is present.

NUMERICAL TABULATION OF ZIRCON CHARACTERISTICS

Property	Pebbles			
	Rodmac Lake		Sickle Lake	
	Granite	Quartzite	Granite	Quartzite
Stubby crystals	0	0	0	0
Moderate crystals	100	100	100	100
Elongate crystals	0	0	0	0
Euhedral crystals	43	0	66	0
Rounded grains	71	100	66	100
Colour-less	100	100	100	100
High birefr.	100	100	100	100
Malacon	14	0	0	30
Secondary growth	0	50	0	33
Zoned	43	50	66	33
Cored	28	0	33	33
Inclusions present	57	50	100	100

TABLE II

The numbers represent the percentage of the specimens that possess each property.

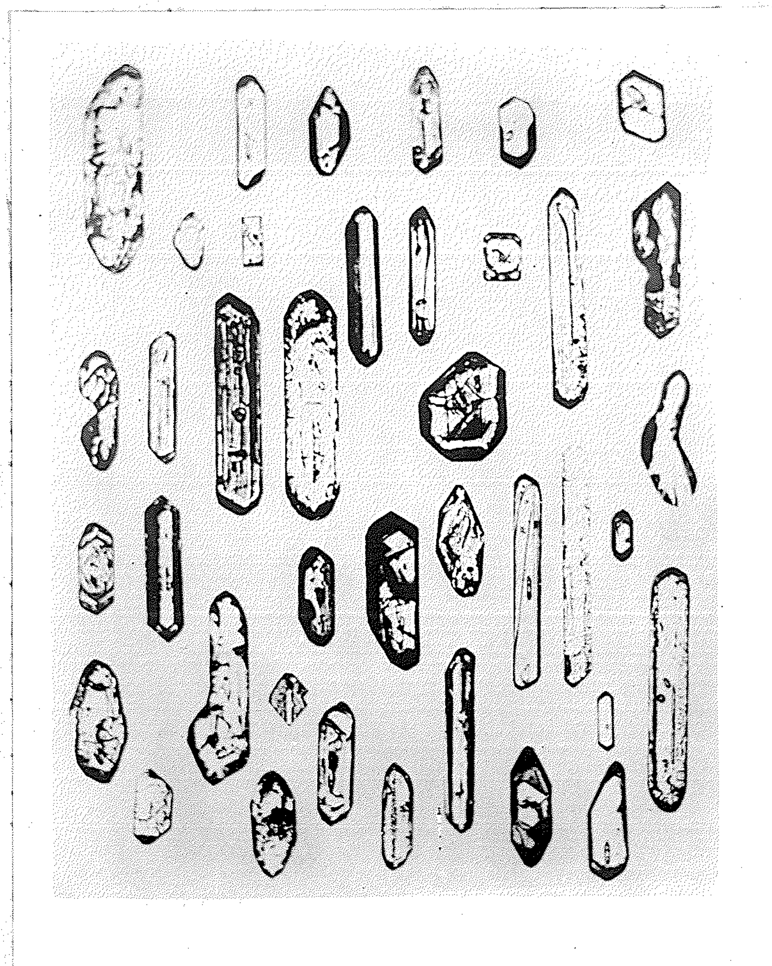
were used in compiling these tables as properties that are rare are not considered diagnostic.

An examination of Table I shows the moderately elongate crystals to predominate. A significant feature is the fact that most of the granites contain euhedral zircons and some rounded grains whereas only rounded grains are present in the quartzites. This rounding may possibly have occurred during transport of the grains prior to deposition.

Zircon grains may be useful in distinguishing granites from granitic-appearing sediments. Trueman (1912) emphasizes this fact. The presence of rounded grains is not diagnostic but euhedral crystals would be a good indication of igneous origin. In this way it might be possible to ascertain whether a mylonite was originally igneous or sedimentary before it was crushed. Similarly, granitized sediments could be recognized by the presence of well rounded zircon grains.

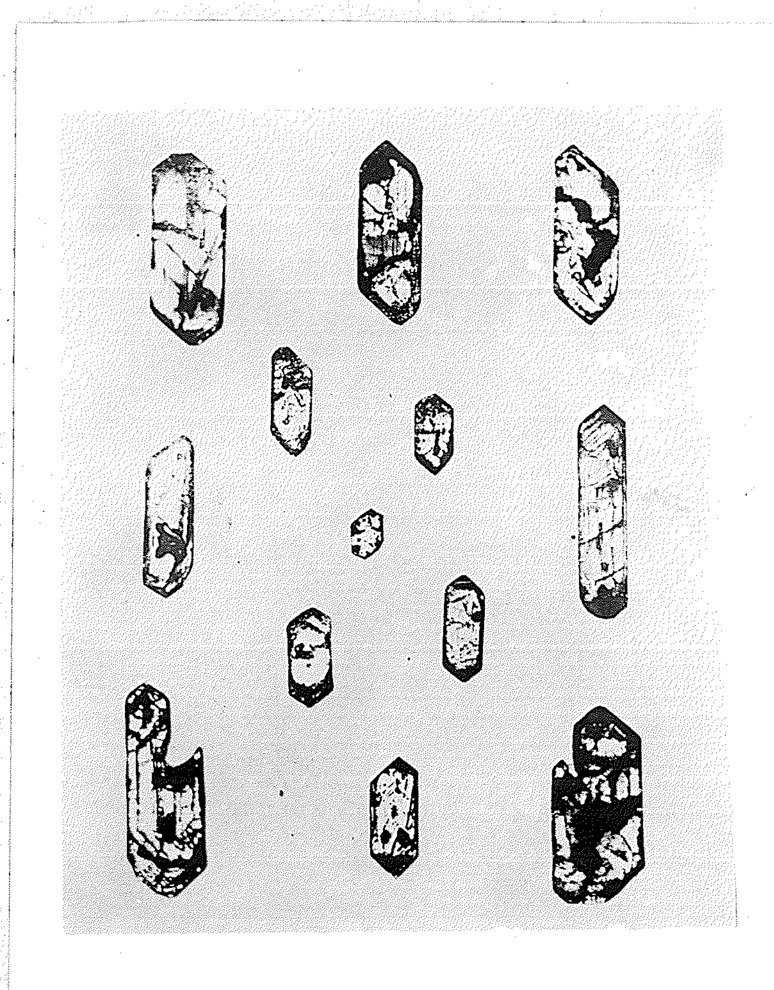
The presence of some rounded zircons in a rock does not preclude igneous origin for resorption may cause a rounding. Bruce and Jewitt (1936) illustrate many rounded grains from igneous rocks. Figs. 13 and 14 show many rounded zircons amongst the euhedral ones which were found in granites of supposedly igneous origin. These photos are after Zerndt (1927).

The presence of malacon or malacon rims does not appear to be limited with regard to rock type for they occur in both granite and quartzite pebbles in roughly equal amounts.



X 110

Fig. 13 Zircons from a granite. Photograph after Zerndt (1927).



X 110

Fig. 14 Zircons from a granite. Photograph after Zerndt (1927).

In the conglomerate pebbles secondary growths are present in 40 per cent of the zircons from quartzites but in none of the zircons from granites. However, in the rocks of the area, 11 per cent of the granites contain zircons with secondary growths and none of the quartzites contain zircons with this feature. Thus it would appear that, whereas secondary growths are not limited as to rock type, they form more commonly in sedimentary rocks.

The secondary growths commonly occur as small pyramidal faces growing out from the main crystal in a direction at right angles to the principal axis of the parent crystal. They are similar to those described by Butterfield (1930).

Zoned borders often occur on rounded grains. This is interpretted as evidence that the border has grown after the crystal was rounded. If the inner unzoned core has a euhedral crystal outline it is impossible to tell whether or not the border is a secondary growth.

The type and number of inclusions in the zircons vary in the specimens studied with no apparent regard to rock type or geographic location.

The most striking feature of the zircons from the matrix is the fact that all specimens examined were found to contain some zircons with secondary growth. This supports the conclusion stated earlier that zircons in sedimentary rocks have a strong tendancy to form secondary growths.

Table II shows the characteristics of the zircons from the pebbles classified into geographic location. It is included to show the differences in zircon content depending on geographic location.

Summary of Conclusions: The writer has come to the following conclusions through a study of the petrography and zircon content of the rocks involved in this investigation:

1. The conglomerate contains pebbles of granite, quartzite,mylonite,iron formation,chert,arkose,andesite, diorite,and pegmatite.

2. Most conglomerate pebbles have been highly stretched. The writer believes that this may have caused the granulation and recrystallization of the quartz grains and also caused the formation of much muscovite in the pebbles. The feldspars occur as porphyroblasts. They may be mistaken for phenocrysts in hand specimen.

3. Microscopic study of the felsites,rhyolite porphyries,and most arkoses described by Allan (1948) and Fawley (1949) on a macroscopic basis shows them to be,at least in this locality,quartzites and feldspathic quartzites containing larger quartz grains or feldspar porphyroblasts.

4. Stretching of the conglomerate has caused the development, in the matrix,of phyllite. It occurs particularly around the pebbles. Much sericite has formed in the groundmass as a result of this movement.

5. A carbonate mineral occurs in minor amounts in nearly all the rocks of the area, including the conglomerate pebbles. It was introduced subsequent to the stretching of

the conglomerate.

6. The zircon content and hand specimen colour indicate that the pebbles at Rodmac Lake and at Sickle Lake come from different rocks or at least different phases of the same rock.

7. Three sources are possible for at least some of the conglomerate pebbles:

(a) Acidic sills in the Wasekwan series.

(b) The quartzites of the Wasekwan series.

(c) Sheared granite gneisses as typified by relatively small sills in the vicinity of Anson Lake.

8. Most of the granitic type rocks contain some euhedral crystals. Sedimentary rocks rarely, if ever, contain crystals that do not show at least some rounding. This fact could be useful in determining whether a rock is of igneous or sedimentary origin.

9. Secondary growths may occur on zircons in sedimentary or igneous rocks but are more common in sedimentary rocks.

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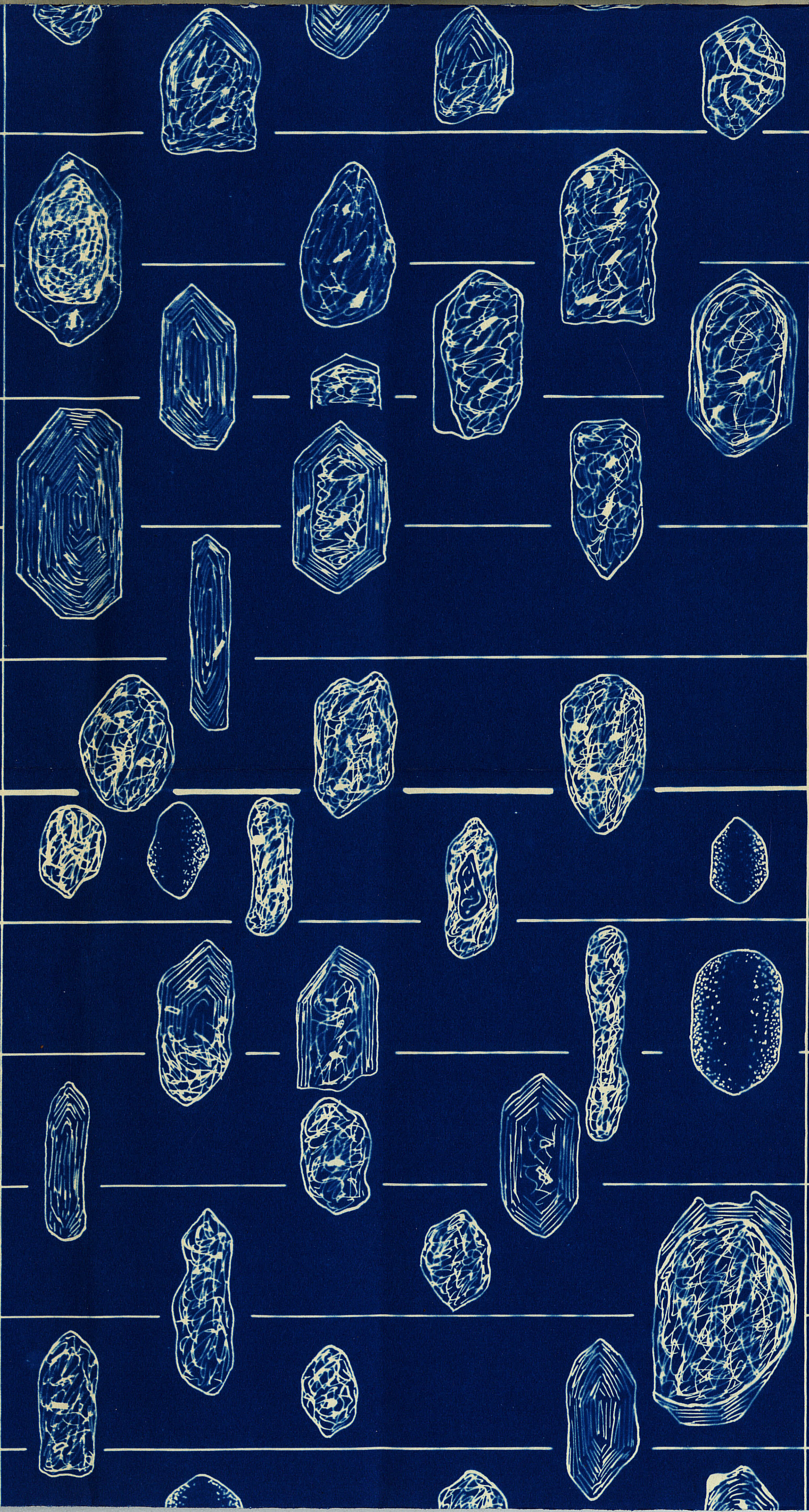
TABULATION OF ZIRC

SPECIMEN NUMBER	LOCATION	FIELD OCCURRENCE AND ROCK TYPE	CAMERA LUCIDA DRAWINGS OF ZIRCON GRAINS (X100)	LENGTH-WIDTH RATIO
P-1-49	RODMAC LAKE	CONGLOMERATE PEBBLE GRANITE (CRUSHED)		2 1/2:1
P-2-49	RODMAC LAKE	CONGLOMERATE PEBBLE GRANITE (CRUSHED)		3:1
P-3-49	RODMAC LAKE	CONGLOMERATE PEBBLE GRANITE (CRUSHED)		2:1
P-8-49	RODMAC LAKE	CONGLOMERATE PEBBLE GRANITE		2:1
P-12-49	RODMAC LAKE	CONGLOMERATE PEBBLE QUARTZITE (CRUSHED)		2:1
P-13-49	RODMAC LAKE	CONGLOMERATE PEBBLE QUARTZITE		2:1
P-14-49	RODMAC LAKE	CONGLOMERATE PEBBLE GRANITE		2:1
P-15-49	RODMAC LAKE	CONGLOMERATE PEBBLE GRANITE		2:1
P-19-49	RODMAC LAKE	CONGLOMERATE PEBBLE GRANITE		2:1

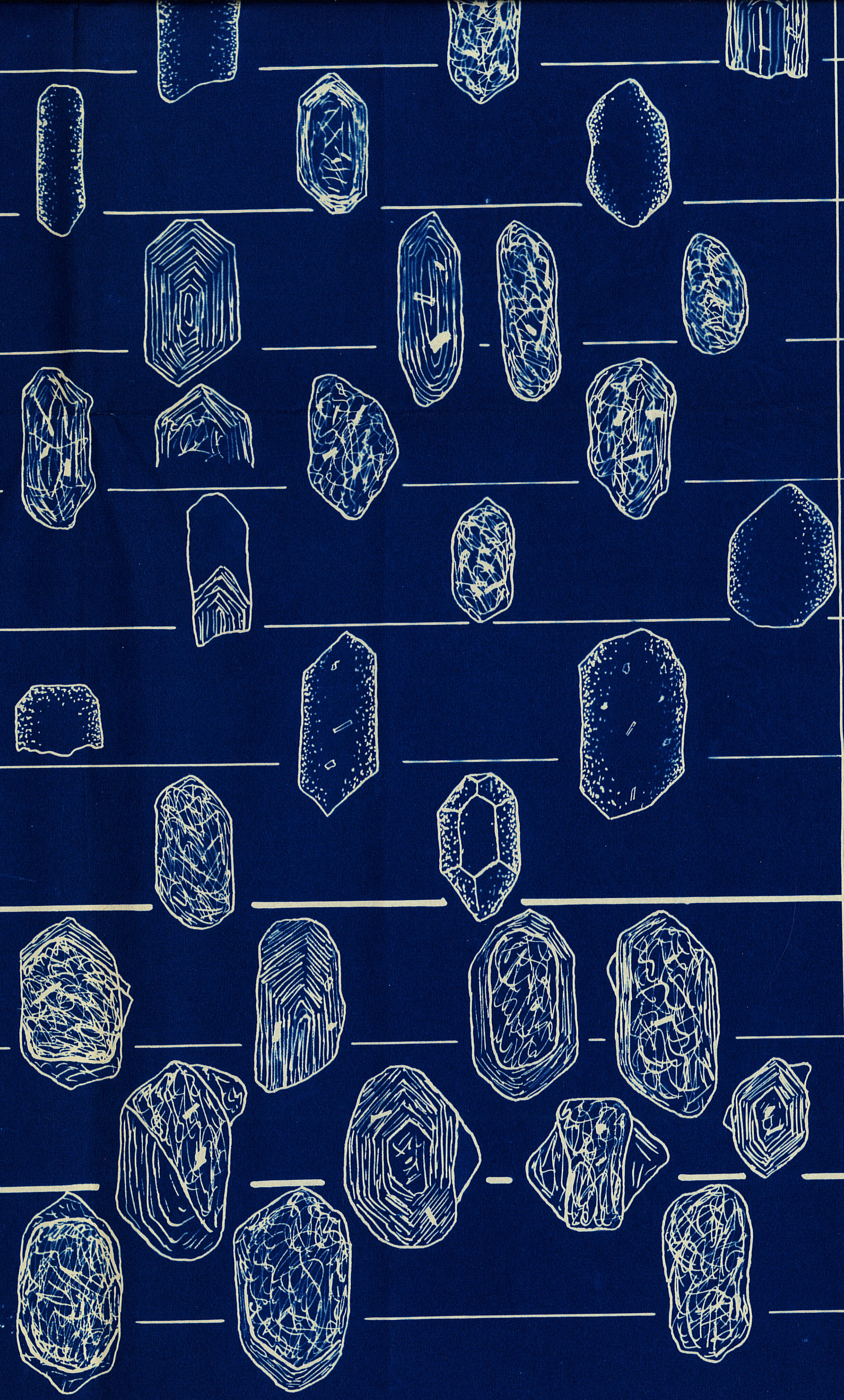
ON CHARACTERISTICS

STUBBY HABIT	MODERATELY ELONGATE	VERY ELONGATE	EUHEDRAL TO SLIGHTLY ROUNDED	ROUNDED TO WELL ROUNDED	COLOURLESS	HIGH BIREFR.	MALACON OR MALACON RIM	SECONDARY GROWTH	ZONED	CORED	INCLUSIONS PRESENT
-X-	X	-X-		X	X	X			X		X
	X		X	-X-	X	X	-X-		X	-X-	X
	X			X	X	X	X			-X-	X
	X			X	X	X					-X-
	X			X	X	X	-X-	X	-X-		-X-
-X-	X			X	X	X			X		X
	X			X	X	X			-X-	X	-X-
	X		X		X	X			X	X	-X-
	X		X	X	X	X	-X-		-X-		X

P-23-49	SICKLE LAKE	CONGLOMERATE PEBBLE QUARTZITE	2:1
P-24-49	SICKLE LAKE	CONGLOMERATE PEBBLE QUARTZITE	2:1
P-35-49	SICKLE LAKE	CONGLOMERATE PEBBLE MYLONITE	2:1
P-47-49	SICKLE LAKE	CONGLOMERATE PEBBLE GRANITE	3:1
P-48-49	SICKLE LAKE	CONGLOMERATE PEBBLE GRANITE	3:1
A-46-49	RALPH LAKE	CONGLOMERATE PEBBLE GRANITE	2:1
A-129-48	ARBOUR LAKE	INTRUSIVE BODY GRANITE	1 1/2:1
B-72-48	COCKERAM LAKE	INTRUSIVE BODY GRANODIORITE	2 1/2:1
A-23-48	ANSON LAKE	INTRUSIVE BODY MYLONITE	3:1
B-63-48	COCKERAM LAKE	INTRUSIVE BODY GRANITE	2 1/2:1 1 1/2:1
F-347-49	WASEKWAN LAKE	SILL ACID MYLONITE	2 1/2:1
	BAY	SEDIMENTARY BED	



	X		-X-	X	X	X			-X-		X
-X-	X			X	X	X	X			X	X
	X		-X-	X	X	X	-X-	X	X		X
	X	-X-	X	X	X	X	-X-		X	X	X
	X		X	X	X	X			X		X
	X			X	X	X					X
X	X			X	X	X				-X-	-X-
	X		-X-	X	X	X			-X-		X
	X	-X-	X		X	X			X		X
X	X			X	X	X		X	X		
	X			X	X	X			-X-		-X-



A-147-46	LAKE	QUARTZITE	2 1/2:1
A-16-48	ANSON LAKE	INTRUSIVE BODY **MYLONITE**	2 1/3:1
C-238-49	MYRNA LAKE	INCLUSION IN BASIC INTRUSION **QUARTZ MONZONITE**	2 1/2:1
A-227-46	W.LYNN LAKE	SEDIMENTARY BED **QUARTZITE**	2 1/3:1 1 1/2:1
B-2-49	SICKLE LAKE	ERUPTIVE BRECCIA MATRIX **LAMPROPHYR**	2 1/2:1 1:1
B-11-49	SICKLE LAKE	INTRUSIVE BODY **GRANODIORITE** (GNEISSIC)	2 1/2:1 1 1/2:1
B-10-49	SICKLE LAKE	INTRUSIVE BODY **GRANODIORITE** (GNEISSIC)	2 1/3:1
M-3-49	SICKLE LAKE	CONGLOMERATE MATRIX **ARKOSE**	2 1/2:1
M-4-49	SICKLE LAKE	CONGLOMERATE MATRIX **ARKOSE**	2 1/2:1
F-18-49	SICKLE LAKE	SEDIMENTARY BED **ARKOSE**	2 1/2:1

	X			X	X	X			-X-		
-X-	X	-X-	-X-	X	X	X					-X-
	X		X	X	X	X			X		X
-X-	X			X	X	X			-X-		X
X	X			X	X	X	X		X		-X-
-X-	X	-X-	X		X	X			-X-		-X-
	X			X	X	X					
-X-	X			X	X	X	X	X	-X-	X	-X-
	X			X	X	X		X	X		-X-
	X			X	X	X		-X-	-X-	X	

X PROPERTY ABUNDANT -X- PROPERTY RARE

FIG. 15