A PETROGRAPHIC STUDY

OF ADMIRALTY SEDIMENTS AND VASHON TILL

by

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and

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P R E F A C E

The surface deposits about the Puget Sound Region have been a source of great interest to many observers. As a result a number of papers have appeared from time to time, the oldest work being that of Charles Wilkes of the United States Exploring Expedition, in 1845. In 1913 J. Harlan Bretz, in his "Glaciation of the Puget Sound Region", published as Bulletin No. 8 of the Washington Geological Survey, gave us our first complete history of this region.

The history of the Puget Sound region, as given in this article, is, to a certain extent, a short summary of Mr. Bretz's work.

In conclusion we want to thank Professors Goodspeed and Saunders for their invaluable assistance and advice; also Mr. McLellan and Mr. Fuller whose recent collections of San Juan and Cascade rocks enabled us to correlate the gravels under observation.

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OUTLINE OF PUGET SOUND HISTORY

Most of the formations outcropping in the Puget Sound Basin are of Tertiary Age, and all of them south of the strait belong to this division of geological history. Eocene and Miocene sedimentary beds record a shallow sea with changing depths and shore lines. Marine sediments are interbedded with the terrestrial, and it is in this formation that some of our coal seams are found. The tertiary period was one of constant shifting and movement.

The Pliocene was a period of great movement and erosion, the earlier beds being folded and domed with a general rising of area. This was followed by a period of great erosion with occasional lava flows.

The Pleistocene, or the great ice period, was divided by Willis into three main epochs, Admiralty (glacial intrusion), Puyallup (interglacial period), and Vashon (second glacial intrusion). Since this division was made there has been noticed slight evidence of a third glacial intrusion, but as yet of not sufficient character to warrant a definite statement as to its having existed.

ADMIRALTY EPOCH

The Admiralty Till is not exposed to any great extent anywhere in the Puget Sound Basin. This is due to the covering of Vashon Till and outwash. Drifts older than the Vashon are exposed only in excavations, in stream bluffs and in the sea cliffs along the shores of the Sound. One of the best sections under observation is found in the Denny Hill regrade of the City of Seattle.

The Admiralty Till is nowhere deeply weathered, though in some places stained by percolating waters.

There is very little difference between the Vashon and Admiralty Tills, except that the Vashon is weathered to a greater extent and is more gravelly. The Admiralty Till in general consists of a blue to gray clay interspersed with rounded pebbles and boulders grading from two feet to a few inches. The till itself has no definite form throughout but varies in character due to the stratigraphic relations.

The base of the Admiralty Till was found in the diggings of the Bell Street sluiceway tunnel of the Denny Hill regrade. Dark quicksands were reported to lie under it. The Admiralty Till, at Port Washington Narrows, is found to be lying on decomposed sediments which, observed at various points, have given rise to the statement that there must have been a third or older glacial intrusion.

Due to the fact that there are only one or two exposures of the base of the Admiralty Till, no true estimate of its thickness

can be made, although it has been reported to be from twenty to twenty-five feet.

PUYALLUP EPOCH

The Puyallup Epoch, as named by Willis, is that period which elapsed between the Admiralty and Vashon glacial epochs. The beds laid down in this period are known as the Admiralty Sediments and are exposed in nearly all the sea cliffs and excavations throughout the Sound.

The material of the deposits ranges from clay to coarse gravel, with pebbles up to six and eight inches in diameter.

The beds have a reported thickness of from ten to three hundred feet, and rarely retain the same character for any great distance, lens structure, abrupt transition, or gradual change in character being the rule. In many places are found lignitic seams, and at the base of the series clay beds containing marine molluscan and crustacean remains. Stream bedding is very common in the gravels, with occasional delta bedding.

Following the laying down of these beds a general uplift occurred, and a long period of stream and atmospheric erosion ensued. The gravels and sands became stained and cemented, and near the surface somewhat decomposed.

Stream erosion advanced to submaturity and the area became deeply incised by broad valleys with a general north and south

trend due to the original slope of the Admiralty drift plain.

VASHON EPOCH

The latest glacier of the Puget Sound advanced from the north, similar to the Admiralty. At its maximum it extended over a greater area than the Admiralty, for in no place is the Admiralty drift found beyond the Vashon Till.

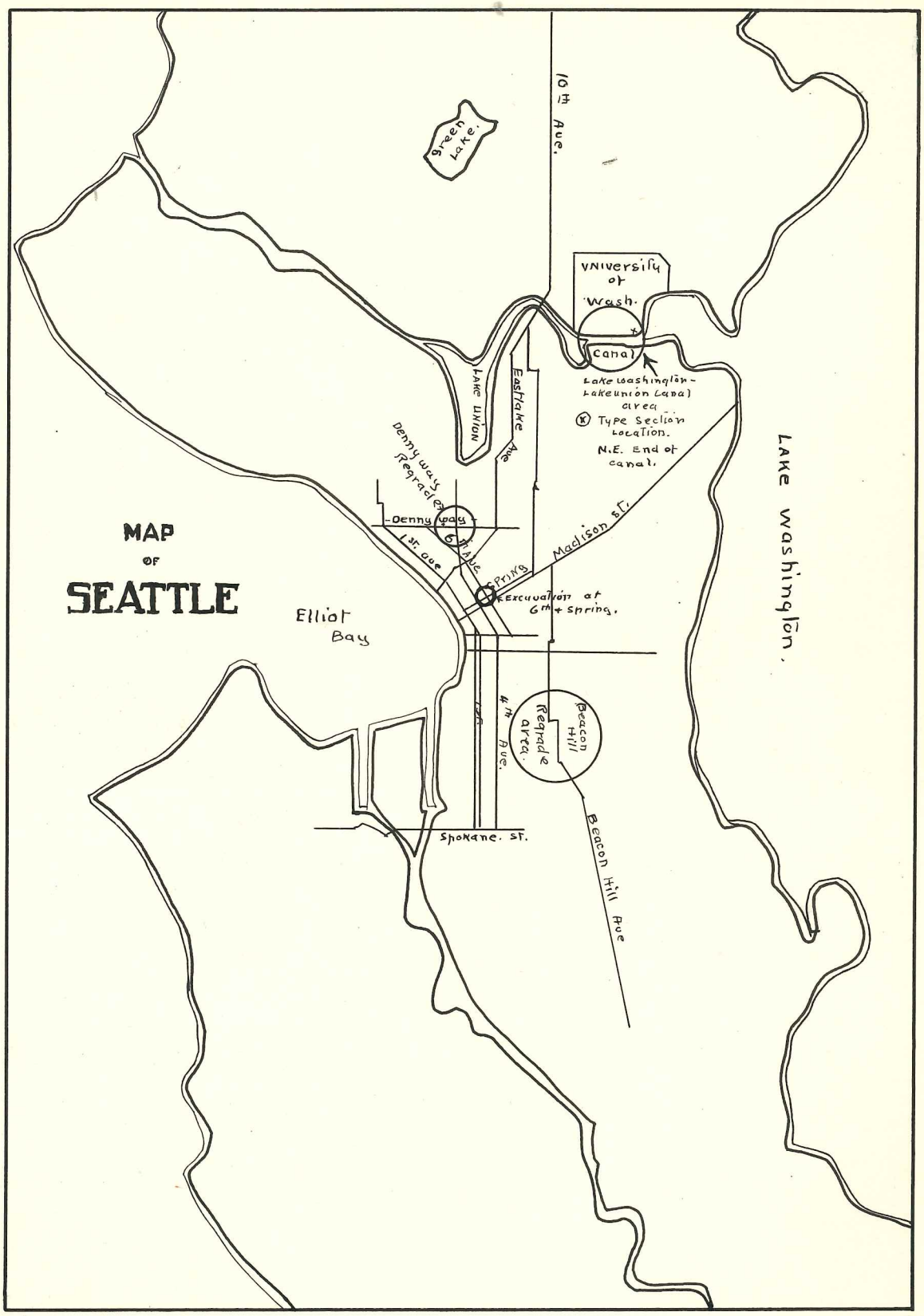
The most noteworthy landmark of the Vashon epoch was the development of thousands of symmetrical gravel mounds of fairly uniform size, closely spaced, and of varying structure.

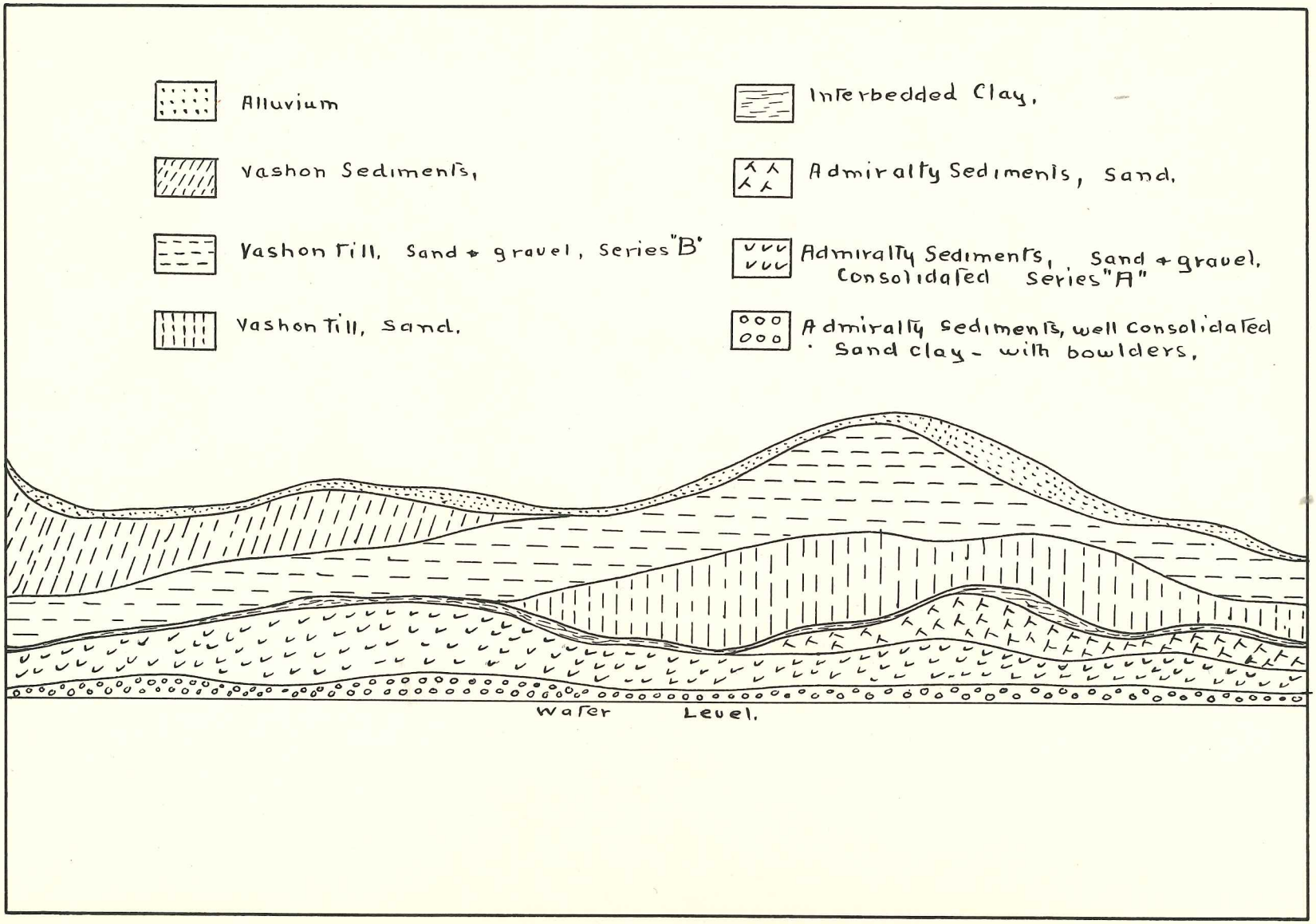
The moraine and outwash deposits laid down by the early retreat have completely obliterated the interglacially eroded valleys in the southern part of the Sound Basin, while further north the Vashon Till sheet acts as a veneer of fresh material on the slopes and summits of the interglacial hills, and in many places on the floors of the interglacial valleys.

After the withdrawal of the frontal margin of the glacier it seems to have melted back more rapidly thus having no great outwash or recessional moraine deposits. It was during this period that a lake known as Lake Russell was formed, this being due to the rapid retreat of the ice in a basin with mountains flanking both sides and ice blocking its only outlet to the north. The southern outlet to the Chehalis was blocked by the extensive moraine which was laid down with the early retreat.

Lake Russell remained until the Strait of Juan de Fuca was opened, when it was destroyed and marine water replaced it in a number of the valleys.

Following the Vashon ice came a period of crustal movements with a general uplift of the district. Although the evidence is not as clear as could be wished, the sea appears to have stood at least fifty feet above its present level.


MAP
OF
SEATTLE
Elliot
Bay
Green Lake.
10th Ave.
University of Wash.
Canal
Lake Washington - Lake Union Canal) area
Type Section location.
N.E. End of canal.
LAKE UNION
Eastlake Ave
Denny Way Regrade area
Denny Way
1st. Ave
6th Ave.
Spring
Excavation at 6th + Spring.
Madison St.
LAKE WASHINGTON.
Beacon Hill Regrade area.
4th Ave.
12th
Spokane. St.
Beacon Hill Ave



The North East Bank of the Canal.

LOCATION AND DESCRIPTION

The area under observation lies wholly within the limits of the City of Seattle, which is situated on Elliot Bay, an arm of Puget Sound.

The area was divided into three sections: the first is known as the Lake Washington-Lake Union Canal; the second, Denny Hill regrade and an excavation at Spring Street and Sixth Avenue; the third, regrade operations at Beacon Hill.

The first district was studied in detail, while the other two were observed for their structure and formation and as a means for correlating the various gravels found in the canal district.

Between Lake Washington and Lake Union lies a small till ridge a quarter mile in length with an elevation above the lake level of about fifty or eighty feet above sea level. Through this has been cut a ship canal, which, on completion, lowered the elevation of Lake Washington some eight feet. This neck of land has an elevation some two hundred feet lower than the areas to the north or south of it. McKnight, in his "Origin of Lake Washington", states that this was the original outlet for Lake Washington and surrounding country immediately following and during the retreat of the Vashon glacier, as well as during the interglacial period.

The major portion of the canal is lined with cement but

at either end the terrain is such that it maintains a natural bank with little or no sloughing. The north bank of the eastern end of the canal was taken as the representative section, and it was from this section that the pebbles were chosen for our Petrographic Analysis.

The bank can be divided into three main sections, the first, or lower bed, Admiralty sediments, the middle bed of Vashon till, overlain by a thin layer of Vashon sediments.

The Admiralty sediments are composed of two main stratas, the lower, which just shows above the water level, being in the form of hard, well consolidated sandy gray clay, showing in some places a slight banding. Interspersed in this are pebbles and small boulders ranging in size from a fraction of an inch to about one foot. These pebbles are oval in form and some are rugged in outline. Very few are subangular or display facets. This deposit dips slightly to the south.

Lying directly above this is a rather thick deposit of sediments composed chiefly of sand and pebbles of varying size, well consolidated. Both the sand and the pebbles display water-worn features and are typical products of stream action. The deposit consists of a series of lenses of various sizes lying with a slight dip towards the west. No evidence of bedding is to be found anywhere in this series.

Above this latter bed lies the relatively thin deposit of

Vashon Till. There is no evidence of conformity between the two beds. This deposit is typically glacial in nature, consisting of sands, gravels and intermixed pebbles and boulders, the large majority of which display subangular features and distinct facets.

From the physical shape and construction of this deposit it, no doubt, was originally of a greater thickness but subsequent erosion has reduced it to a lesser.

The Vashon sediments, which lie directly above, are of no great importance. They consist chiefly of an extremely thin layer of very badly altered sand and gravel covered with a coating of alluvium.

Of the remaining two districts little need be said, as the description of the first applies equally to the other two, with a few exceptions. The chief one is the greater thickness of the various deposits, and also the greater depth of Admiralty sediments uncovered. Another noticable exception is the fact that the material is not as well consolidated as is that of the canal district.

PETROGRAPHIC ANALYSIS

Specimen Number: A.1.

Rock Name: Radiating Granophyre.

Field Name: Quartz Porphyry.

Location: Admiralty Sediments.

Megascopic Description

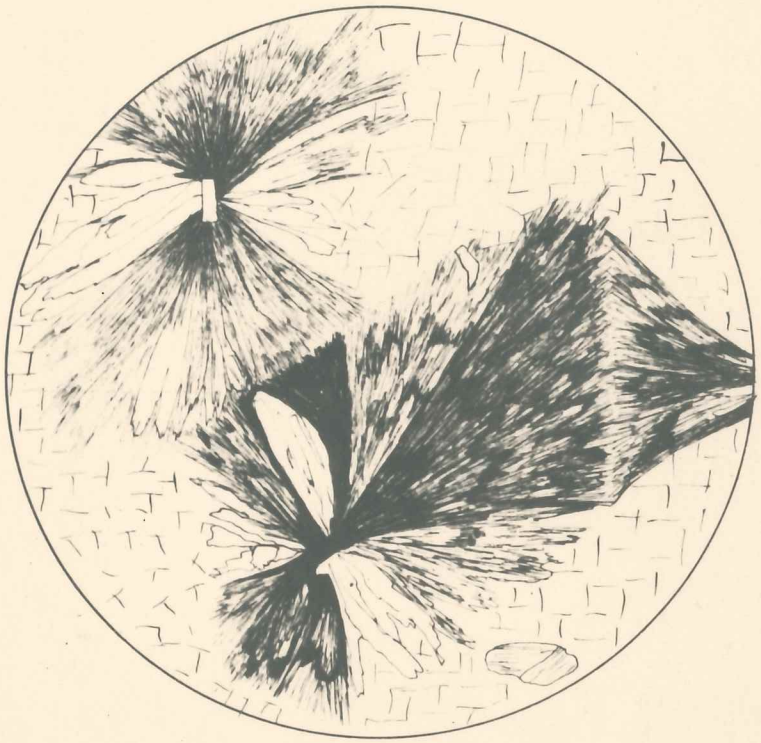
A porphyritic rock containing crystals of quartz and feldspar, groundmass lithoidal and light colored containing crystals of epidote of yellowish green color.

The Visible Minerals are: Quartz, Orthoclase, Epidote.

Microscopic Analysis

A holocrystalline groundmass, very fine grained with granophyric fabric, showing a graphic intergrowth of quartz and feldspar, with radial crystallization of orthoclase.

The Mineralogic Composition is: Quartz, Orthoclase, Oligoclase, Epidote.



Radiating Felspar

PETROGRAPHIC ANALYSIS

Specimen Number: A.2.

Rock Name: Hornblende Granite.

Field Name: Granite.

Location: Admiralty Sediments.

Megascopic Description

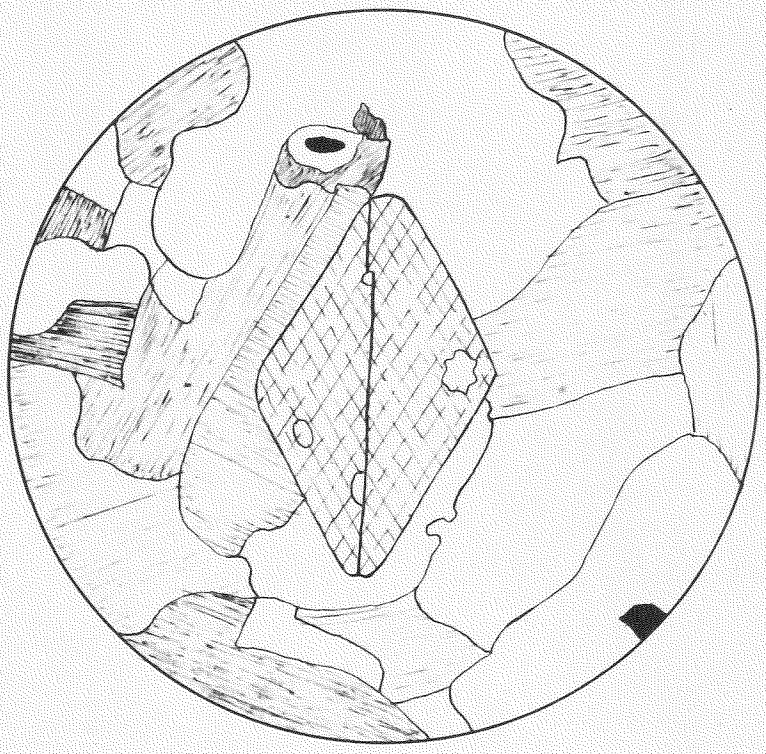
Medium grained - crystalline rock

The Visible Minerals are: Quartz, Orthoclase, Plagioclase, Hornblende.

Microscopic Analysis

A holocrystalline groundmass, granularity phanerocrystaline, of regular fabric, showing intergrowth of fedlspar, alteration of feldspar and hornblende.

The Mineralogic Composition is: Quartz, Orthoclase, Plagioclase, Hornblende, Biotite, Magnitite, Chlorite.



Hornblende Twinning

PETROGRAPHIC ANALYSIS

Specimen Number: A.3.

Rock Name: Hornblende Lamprophyre.

Field Name: Lamprophyre.

Location: Admiralty Sediments.

Megascopic Description

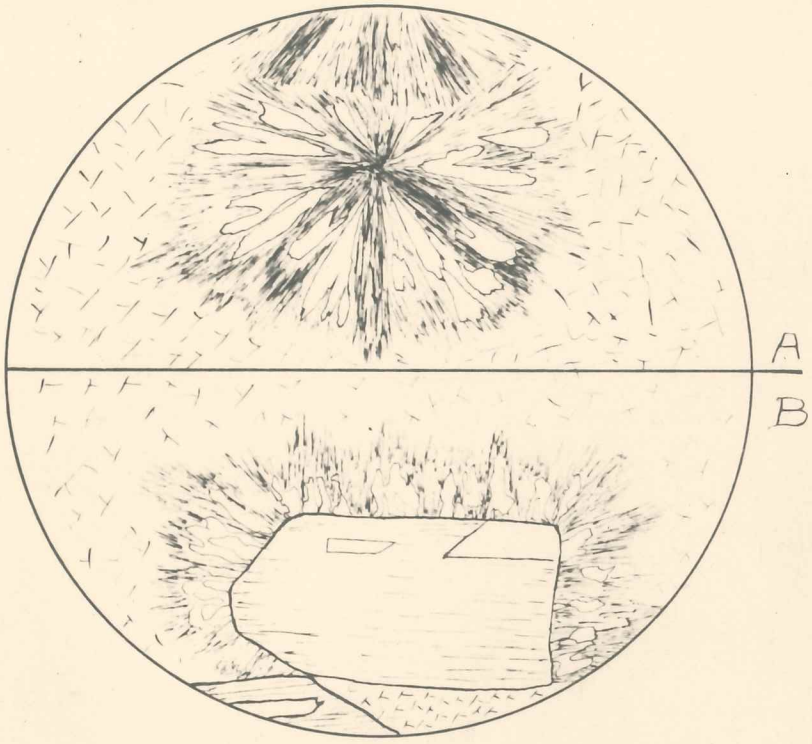
A fine grained groundmass with corroded phenocrysts of feldspar holocrystalline.

The Visible Minerals are: Orthoclase, Quartz, Plagioclase, Hornblende, Epidote, Magnetite.

Microscopic Analysis

A very fine holocrystalline groundmass with small phenocrysts of orthoclase, porphyritic fabric, the feldspar showing numerous carlsbad twinning and radial crystallization. The hornblende partially converted to chlorite.

The Mineralogic Composition is: Orthoclase, Plagioclase, Quartz, Hornblende, Magnetite, Apatite, Epidote, Pyrite.



Radiating Epidote and Felspar

PETROGRAPHIC ANALYSIS

Specimen Number: A.4.

Rock Name: Quartz Porphyry Type of Rhyolite.

Field Name: Rhyolite.

Location: Admiralty Sediments.

Megascopic Description

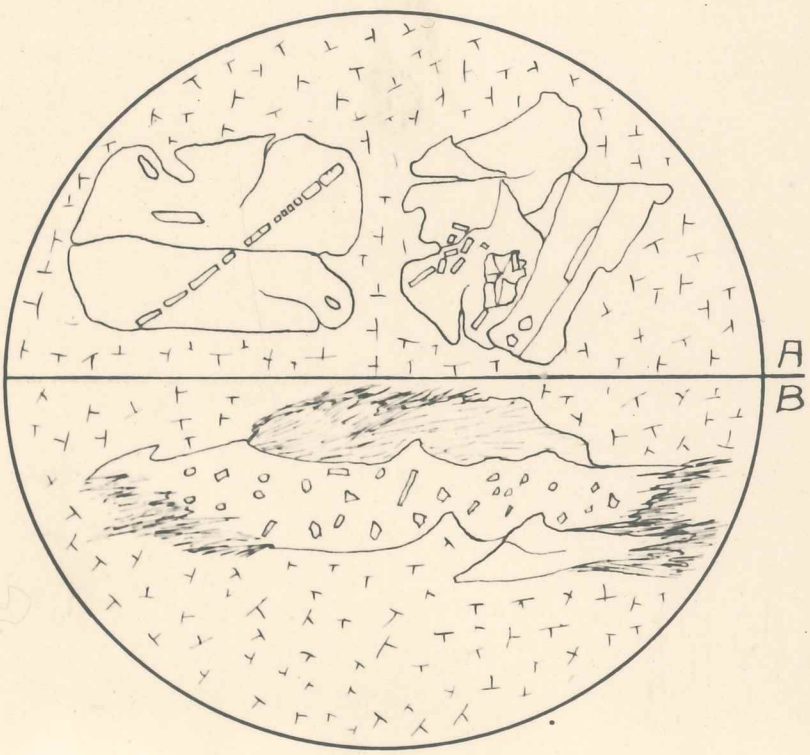
Extremely fine groundmass containing smallphenocrysts of feldspar; dull red colored volcanic rock.

The Visible Minerals are: Feldspar, Quartz.

Microscopic Analysis

Slightly porphyritic phenocrysts of orthoclase, smaller ones of quartz in a microcrystalline groundmass, some phenocrysts of orthoclase showing carlsbad twinning.

The Mineralogic Composition is: Orthoclase, Quartz, Plagioclase.



Inclusions in Quartz

PETROGRAPHIC ANALYSIS

Specimen Number: A.5.

Rock Name: Pyroxene-Hornblende Andesite.

Field Name: Andesite.

Location: Admiralty Sediments

Megascopic Description

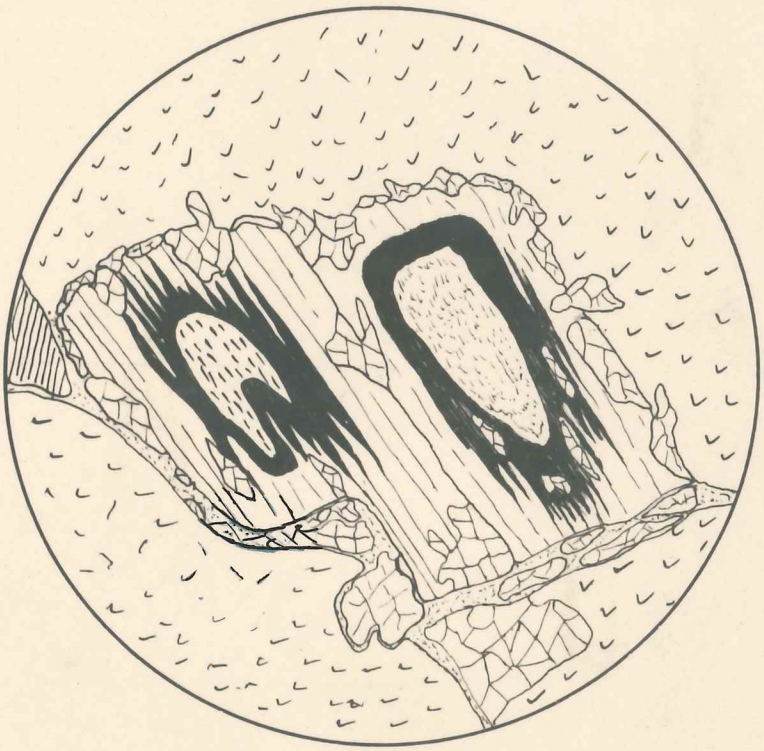
A very fine holocrystalline rock of green color.

The Visible Minerals are: Felspar, Magnetite, Chlorite.

Microscopic Analysis

Fine holocrystalline groundmass, minophyric fabric, phenocrysts of plagioclase and occasional orthoclase felspar highly altered.

The Mineralogic Composition is: Plagioclase, Orthoclase, Hornblende, Apatite, Magnetite, Kaolin, Serpentine, Chlorite, Epidote.



Felspar Altering to Epidote

PETROGRAPHIC ANALYSIS

Specimen Number: A.6.

Rock Name: Hornblende Gneiss.

Field Name: Gneiss.

Location: Admiralty Sediments.

Megascopic Description

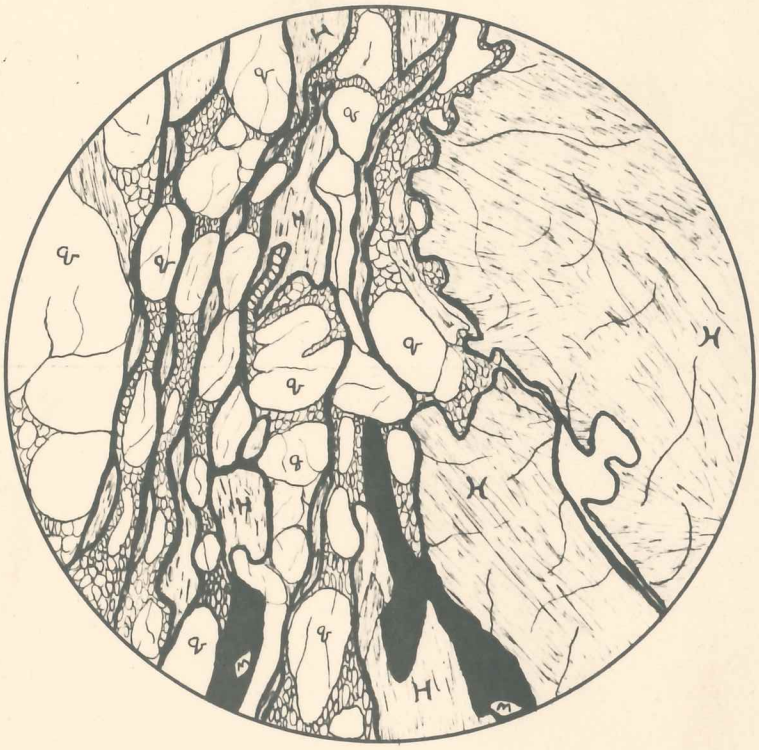
Banded crystalline rock. Excellent example of gneissic structure, the banding being formed by inclusions or alternate layers of pyroxene.

The Visible Minerals are: Feldspar, Quartz, Hornblende.

Microscopic Analysis

A holocrystalline rock, showing gneissic structure both in the groundmass and the inclusions -- chiefly feldspar cemented with quartz.

The Mineralogic Composition is: Orthoclase, Plagioclase, Oligoclase, Quartz, Hornblende, Biotite, Apatite, Magnetite, Limonite.



H. - Hornblende
Q. - Quartz
M. - Magnetite

Gneissic Structure

PETROGRAPHIC ANALYSIS

Specimen Number: A.7.

Rock Name: Gneiss.

Field Name: Gneiss.

Location: Admiralty Sediments.

Megascopic Description

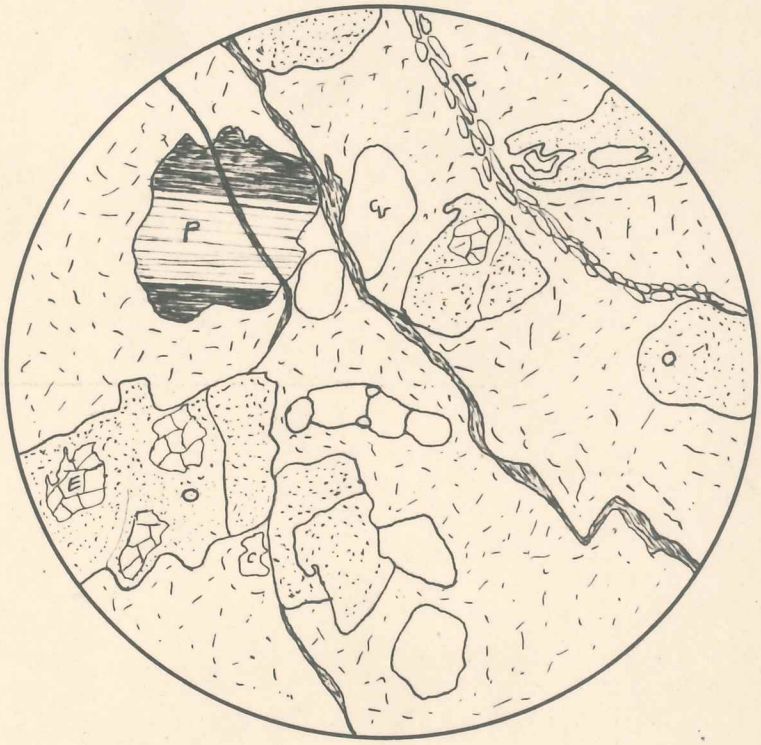
Holocrystalline rock with gneissic structure.

The Visible Minerals are: Felspar, Quartz, Hornblende, Epidote.

Microscopic Analysis

Holocrystalline groundmass, showing crushing, resulting in a slight gneissic structure with bands of chlorite and epidote. Felspars badly altered. Orthoclase crystals containing apatite.

The Mineralogic Composition is: Orthoclase, Plagioclase, Quartz, Chlorite, Epidote, Magnetite, Hornblende.



Q. - Quartz
P. - Plagioclase
O. - Orthoclase
E. - Epidote
C. - Chlorite

PETROGRAPHIC ANALYSIS

Specimen Number: A.8.

Rock Name: Porphyrite.

Field Name: Melaphyre.

Location: Admiralty Sediments.

Megascopic Description

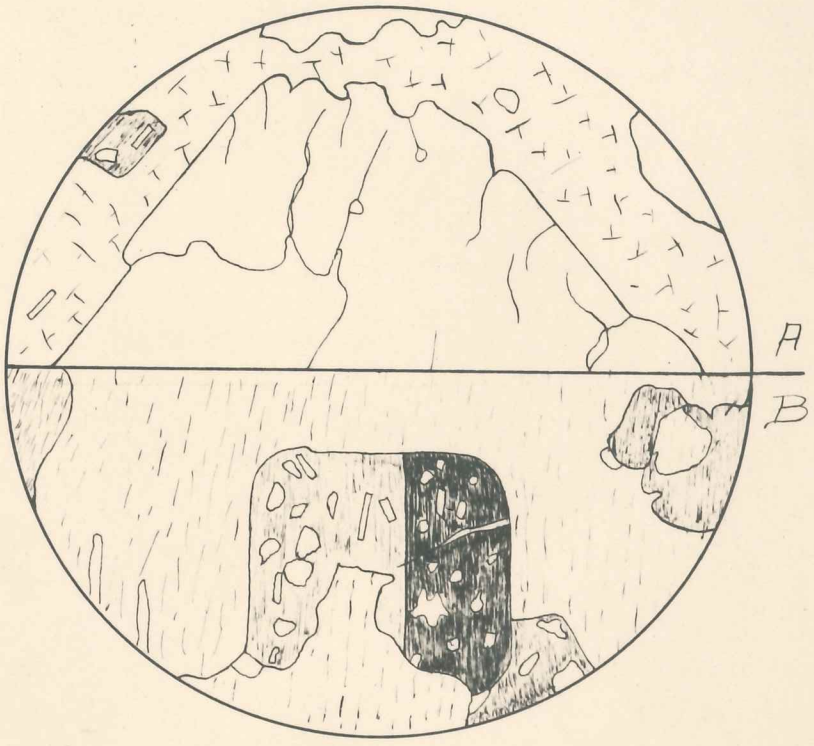
A dark colored porphyritic rock, with very fine groundmass containing phenocrysts of plagioclase, felspar, orthoclase and quartz -- quartz rounded.

The Visible Minerals are: Plagioclase, Orthoclase, Quartz.

Microscopic Analysis

A holocrystalline, very fine grained groundmass, containing both orthoclase and plagioclase with quartz. Some idiomorphic augite. Felspar badly altered, with inclusions of epidote. Augite partially altered to chlorite.

The Mineralogic Composition is: Plagioclase, Orthoclase, Quartz; Groundmass of Orthoclase, Plagioclase, Quartz; Magnetite, Augite, Limonite, Kaolin, Chlorite, Epidote.



Secondary Quartz and Felspar

PETROGRAPHIC ANALYSIS

Specimen Number: A.9.

Rock Name: Quartzite.

Field Name: Quartzite.

Location: Admiralty Sediments.

Megascopic Description

A felsitic holocrystalline rock, containing a small quartz vein.

The Visible Minerals are: Quartz, Pyrite.

Microscopic Analysis

A fine grained holocrystalline rock containing recrystallized felspar and quartz, with small quartz veins with inclusions of actinolite. Felspar altered to some extent.

The Mineralogic Composition is: Quartz, Plagioclase, Orthoclase, Altinolite, Epidote, Chlorite, Hemitite, Limonite, Pyrite.

Actinolite Needles

PETROGRAPHIC ANALYSIS

Specimen Number: A.10.

Rock Name: Garnet - Granulite.

Field Name: Gneiss.

Location: Admiralty Sediments.

Megascopic Description

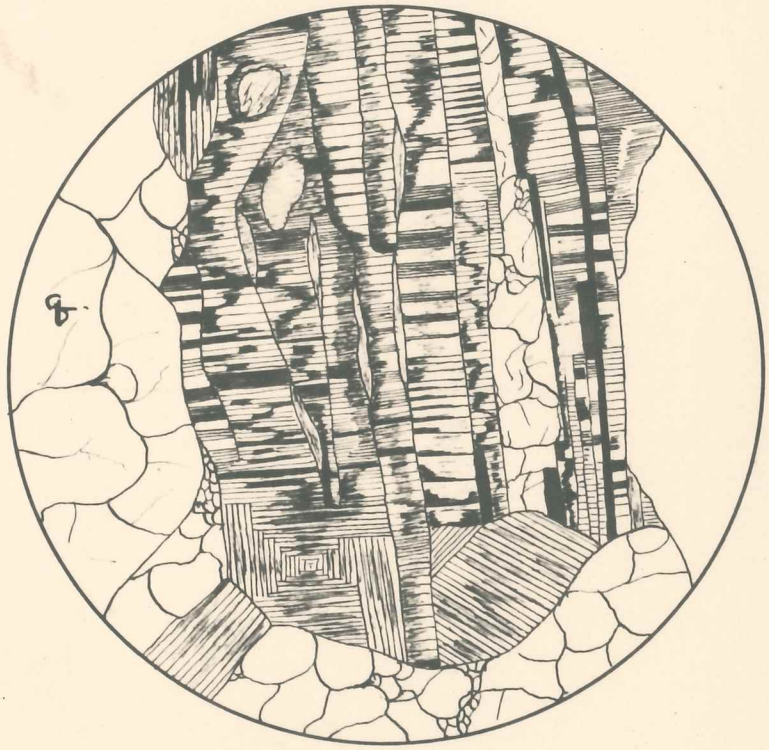
Fine grained banded gneiss.

The Visible Minerals are: Quartz, Felspar, Hornblende.

Microscopic Analysis

A fine grained holocrystalline rock containing phenocrysts of felspar, slightly banded structure. Some felspar in form of microperthite. Numerous crystals of garnet.

The Mineralogic Composition is: Quartz, Orthoclase, Plagioclase, Albite, Microperthite, Grossular, Hornblende, Magnetite.



Microperthite Twinning

PETROGRAPHIC ANALYSIS

Specimen Number: A.11.

Rock Name: Andesite.

Field Name: Andesite.

Location: Admiralty Sediments.

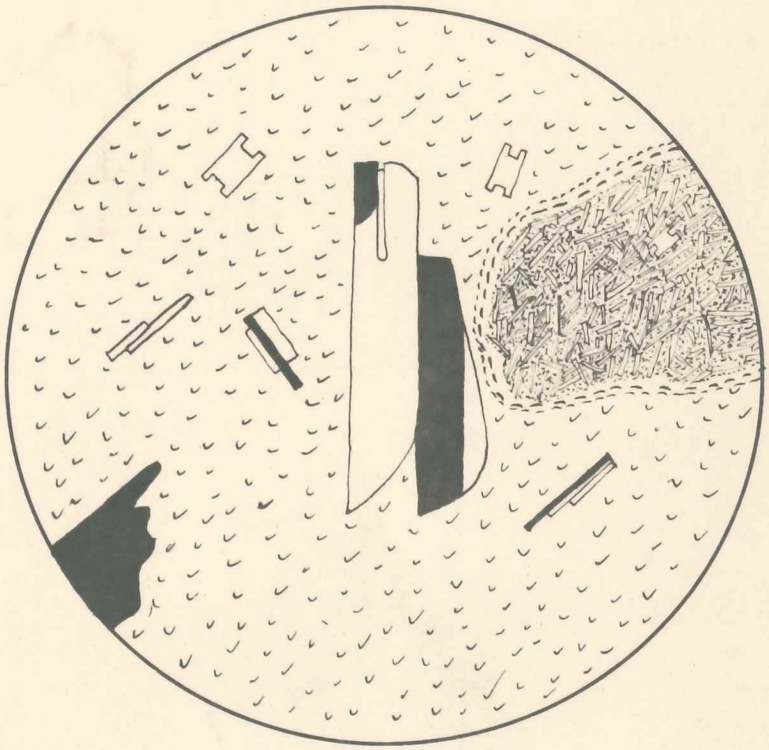
Megascopic Description

Fine glossy groundmass with small phenocrysts of felspar and pyroxene. A dark rock shading to red.

Microscopic Analysis

A dense glossy groundmass. Phenocrysts of crystal, felspar and magnetite dust. The magnetite replacing the felspars with some zoisite. Entire groundmass spotted with magnetite dust.

The Mineralogic Composition is: Sanidine, Anorthite, and Glossy Felspars underterminable; Zoisite, Magnetite.



Glassy Felspar in Ophitic Structure

PETROGRAPHIC ANALYSIS

Specimen Number: A. 12.

Rock Name: (Probably) Andesite.

Field Name: Green Stone.

Location: Admiralty Sediments.

Megascopic Description

Medium grained rock of green color, with numerous quartz veins.

The Visible Minerals: Quartz, Felspar.

Microscopic Analysis

A fine grained porphyritic rock, groundmass cryptocrystalline containing phenocrysts of quartz. Also finer grained quartz veins. A few badly altered felspar crystals.

The Mineralogic Composition is: Quartz, (Orthoclase), Felspar and Quartz, Limonite, Chlorite, Epidote, Kaolin.

PETROGRAPHIC ANALYSIS

Specimen Number: A.13.

Rock Name: Biotite - Granite - Gneiss.

Field Name: Gneiss.

Location: Admiralty Sediments.

Megascopic Description

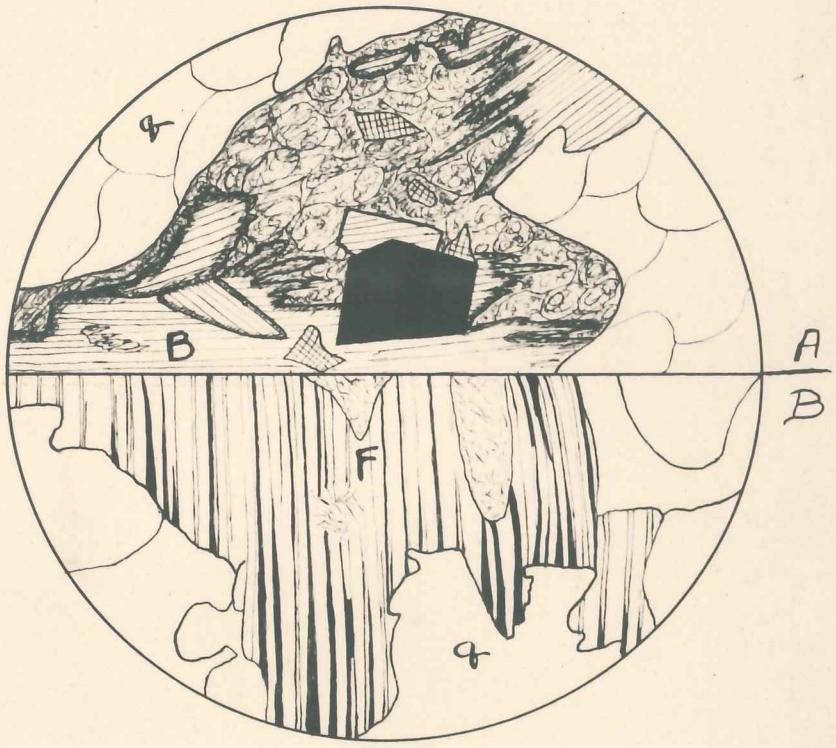
Granitoid slightly banded structure.

The Visible Minerals are: Quartz, Felspar, Biotite.

Microscopic Analysis

A holocrystalline rock, gneissic texture, showing slight bending of the biotite crystals. Quartz shows secondary embayments. Felspars in form of microperthite, in some cases altered to sericite, biotite to chlorite. Plagioclase also shows secondary twin lamellae due to strain.

The Mineralogic Composition is: Quartz, Albite, Labradorite, Oligoclase, Orthoclase, Biotite, Apatite, Magnetite, Chlorite, Lapentine, Sericite, Zoisite.



Q. - Quartz
B. - Biotite

A - Biotite altering to Chlorite
B - Felspar showing strain Lamellae

PETROGRAPHIC ANALYSIS

Specimen Number: A.14.

Rock Name: Hornblende Granite.

Field Name: Granite.

Location: Admiralty Sediments.

Megascopic Description

Granitoid-crystalline, light colored rock.

The Visible Minerals are: Quartz, Felspar, Biotite, Hornblende, Magnetite.

Microscopic Analysis

A holocrystalline rock of granular fabric. Felspar showing zonal structure. All minerals slightly altered.

The Mineralogic Composition is: Quartz, Orthoclase, Oligoclase, Albite, Hornblende, Biotite, Magnetite, Chlorite, Epidote, Sericite.

H. - Hornblende
Q. - Quartz

Zonal Structure in Felspar

PETROGRAPHIC ANALYSIS

Specimen Number: A.15.

Rock Name: Altered Biotite Granite.

Field Name: Granite.

Location: Admiralty Sediments.

Megascopic Description

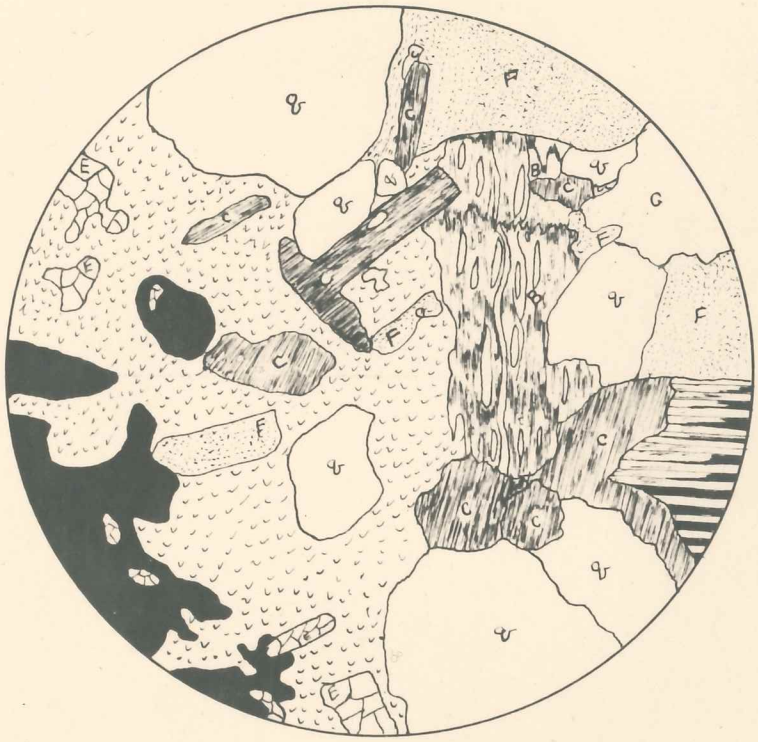
A granitoid crystalline rock of light color. Badly altered.

The Visible Minerals are: Quartz, Felspar, Biotite, Chlorite, Magnetite.

Microscopic Analysis

A holocrystalline rock, granular fabric, with all felspars badly altered to epidote. The biotite to chlorite.

The Mineralogic Composition is: Orthoclase, Oligoclase, Albite, Biotite, Magnetite, Hornblende, Epidote, Chlorite.



Q. - Quartz
F. - Altered Felspar
C. - Chlorite
B. - Biotite
E. - Epidote

Altered Biotite Granite

PETROGRAPHIC ANALYSIS

Specimen Number: A.16.

Rock Name: Malchite.

Field Name: Diorite.

Location: Admiralty Sediments.

Megascopic Description

A fine groundmass. Phenocrysts of feldspar, green in color. Secondary sulphides.

The Visible Minerals are: Felspar, Quartz, Pyroxene, Sulphides.

Microscopic Analysis

A porphyritic rock with very fine groundmass, badly altered, containing what appears to be secondary quartz, indicating a dyke type rock. In needlelike form. Phenocrysts of felspars. Augite and olivine. All felspars altered to epidote and koalin. Augite in part altered to ceralite.

The Mineralogic Composition is: Andesine, Oligoclase, Orthoclase, Quartz, Augite, Olivine, Magnetite, Ilmenite, Apatite, Hornblende, Epidote, Koalin, Uralite.

PETROGRAPHIC ANALYSIS

Specimen Number: A.17.

Rock Name: Granite.

Field Name: Granite.

Location: Admiralty Sediments.

Megascopic Description

A medium grained rock with pinkest color.

The Visible Minerals are: Quartz, Felspar, Muscovite, Chlorite, Magnetite.

Microscopic Analysis

A holocrystalline rock, granite texture, even fabric containing altered crystals of orthoclase biotite, also a graphic intergrowth of felspars is noted, with a small amount of structure.

The Mineralogic Composition is: Quartz, Orthoclase, Albite, Andesine, Labradorite, Biotite, Hornblende, Magnetite, Apatite, Chlorite, Epidote.

Q. - Quartz

Felspar Twinning

PETROGRAPHIC ANALYSIS

Specimen Number: A.18.

Rock Name: Basic Andesite.

Field Name: Green Stone.

Location: Admiralty Sediments.

Megascopic Description

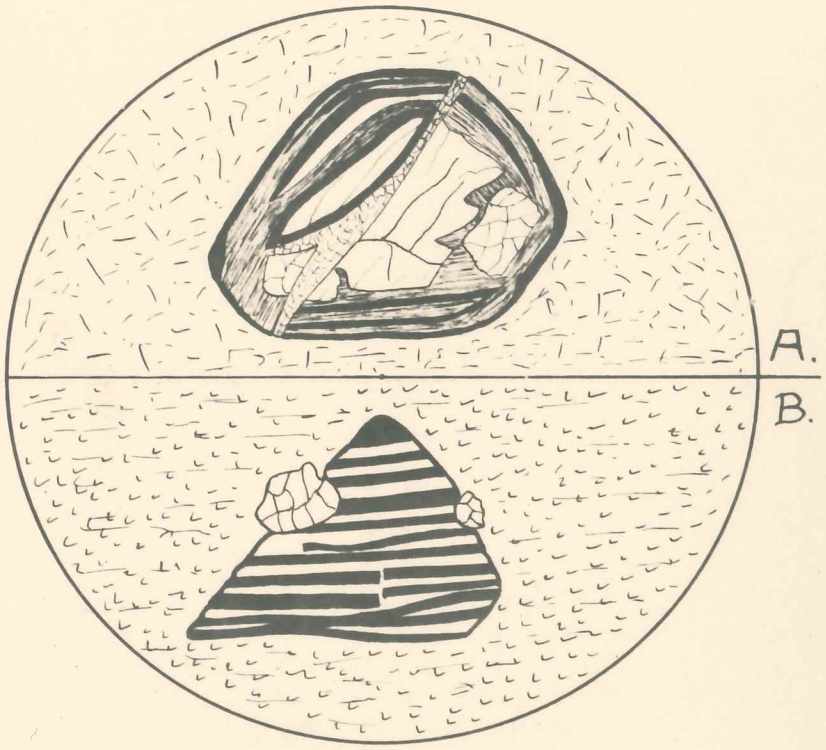
Fine grained crystalline, altered, green colored rock, with some phenocrysts of pyroxene.

The Visible Minerals are:

Microscopic Analysis

Extremely fine grained rock, badly altered, containing phenocrysts of probably labradorite, altered in part to epidote. Phenocrysts of augite. Partly altered groundmass quartz and kaolin originally glass. Illmenite showing partial decomposition to leucoxene.

The Mineralogic Composition is: Labradorite, Augite, Paragasite, Quartz, Epidote, Kaolin.



Illmenite Altering to Leucoxene

PETROGRAPHIC ANALYSIS

Specimen Number: A.19.

Rock Name: Pyroxene Andesite.

Field Name: Andesite, a Green Stone

Location: Admiralty Sediments.

Megascopic Description

Very fine grained, altered green colored rock, with pyroxene phenocrysts.

The Visible Minerals are:

Microscopic Analysis

Extremely fine grained crystalline rock, groundmass originally glass, Appears now to be quartz and kaolin with some chlorite. A few feldspar laths. Large masses of serpentine, replacing femic phenocrysts. No proof of original pyroxene. Probably some hornblende.

The Mineralogic Composition is: Labradorite, Feldspar, Kaolin, Chlorite, Serpentine, Epidote.

PETROGRAPHIC ANALYSIS

Specimen Number: A.20.

Rock Name: Quartzite.

Field Name: Quartzite.

Location: Admiralty Sediments.

Megascopic Description

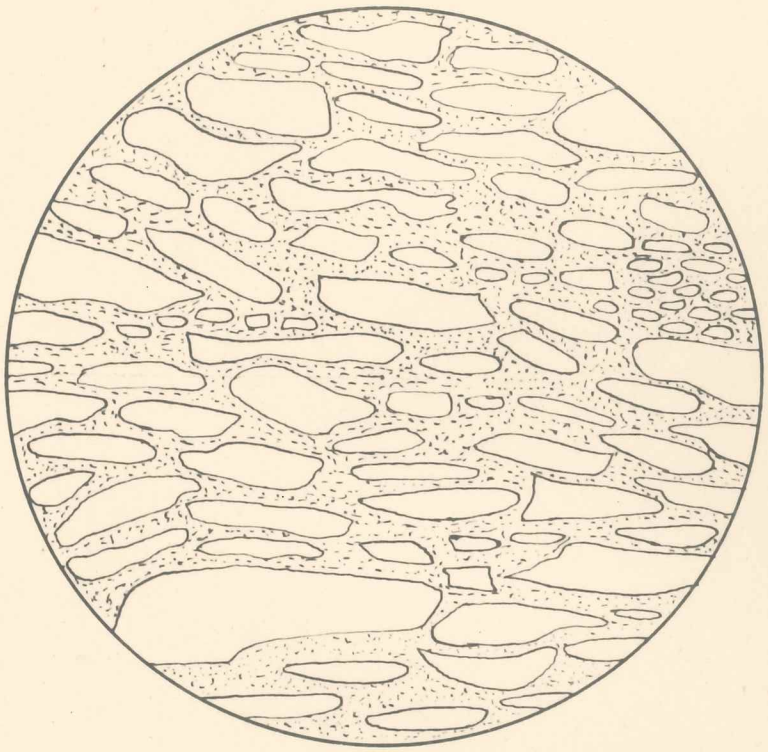
A very fine grained crystalline rock with creamish color.

The Visible Mineral is: Quartz.

Microscopic Analysis

Uneven grained recrystallized quartz grains in elongated formation, giving the appearance of parallel orientation. The cementing material seems to be fine grained secondary quartz containing a small amount of limonite.

The Mineralogic Composition is: Quartz, Limonite.



Parallel Orientation of Quartz

PETROGRAPHIC ANALYSIS

Specimen Number: A.21.

Rock Name: Quartzite.

Field Name: Quartzite.

Location: Admiralty Sediments

Megascopic Description

An extremely fine grained rock of dark color.

The Visible Minerals are: Quartz, Magnetite.

Microscopic Analysis

A coarse grained, metamorphosed quartzite, each element of the mosaic with irregular boundary fitting into the irregularities of the adjoining elements cementing material practically unrecognizable. A few grains of recrystallized felspar.

The Mineralogic Composition is: Quartz, Felspar, Limonite, Magnetite.

PETROGRAPHIC ANALYSIS

Specimen Number: A.22.

Rock Name: Chalcedonic Quartz.

Field Name: Vein Quartz.

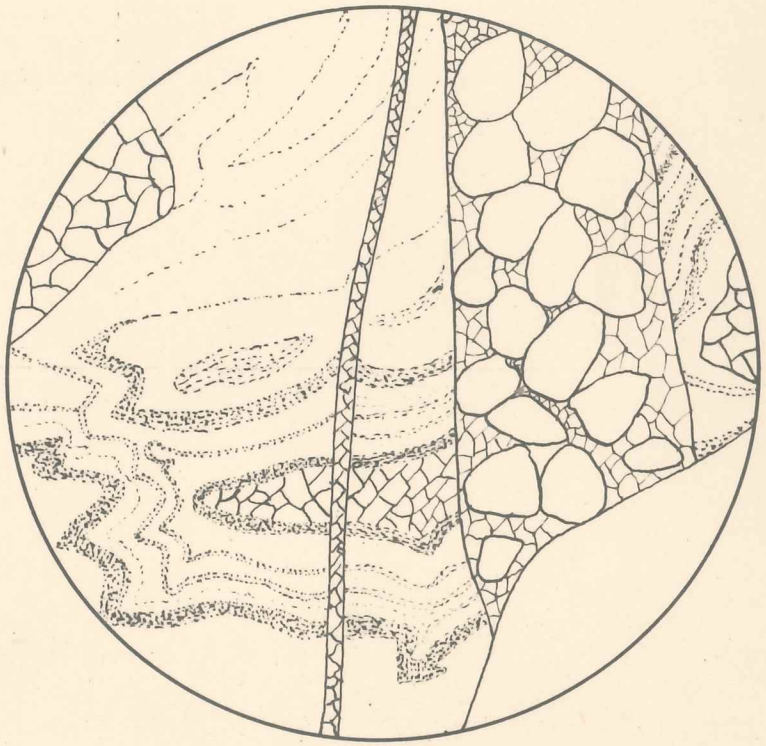
Location: Admiralty Sediments.

Megascopic Description

Drusy quartz containing later quartz veins.

Microscopic Analysis

Extremely fine grained rock of low temperature chert like quartz, with later coarser quartz filling veins, and patches of coarser grained quartz, probably druses. Opaque material probably kaolin. May originally have been vein or vein dike rock.



Vein Dike Quartz

PETROGRAPHIC ANALYSIS

Specimen Number: B.1.

Rock Name: Altered Andesite.

Field Name: Andesite.

Location: Vashon Till.

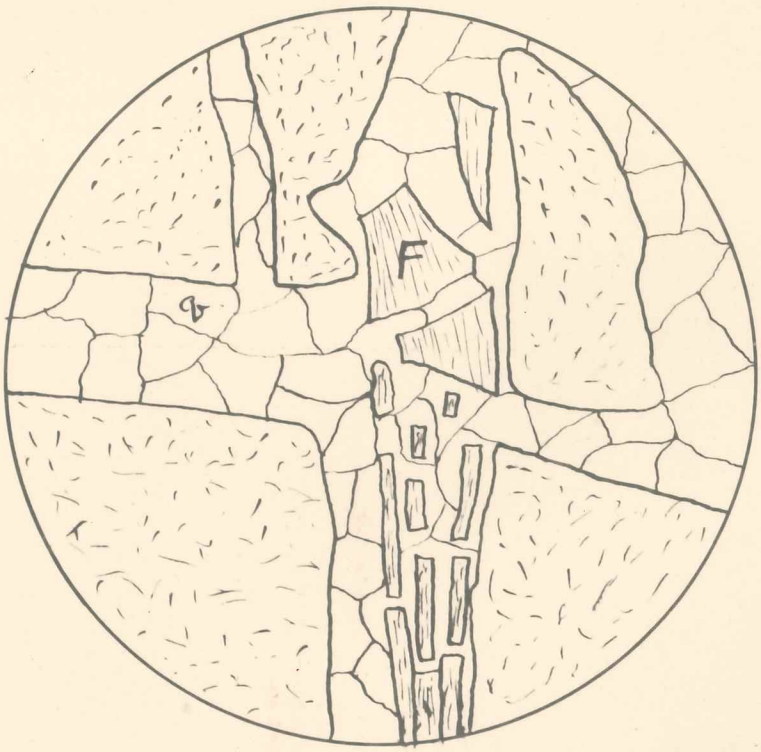
Megascopic Description

A glassy green colored rock slightly stained with iron containing phenocrysts of felspar.

Microscopic Analysis

Extremely fine grained grounmass of secondary chalcedonic quartz and kaolin. Color due to iron stained kaolin. Groundmass shows flow structure. Replacement has taken place along extensive network of fractures. Phenocrysts of clear labradorite, and some felspar laths.

The Mineralogic Composition is: Labradorite, Quartz, Magnetite, Kaolin, Epidote, Chlorite.



Q. - Quartz
F. - Felspar

Felspar fractured by Quartz

PETROGRAPHIC ANALYSIS

Specimen Number: B.2.

Rock Name: Mica Syenite.

Field Name: Syenite.

Location: Vashon Till.

Megascopic Description

A granitic rock, medium grained of light color, with biotite altered to chlorite.

The Visible Minerals are: Felspar, Chlorite.

Microscopic Analysis

A holocrystalline rock, granular fabric. Felspar badly altered. Small amount of quartz intergrown in the orthoclase. Large amounts of biotite altered to chlorite, more or less retaining its mica structure.

The Mineralogic Composition is: Orthoclase, Biotite, Quartz, Magnetite, Hornblende, Chlorite, Epidote.

PETROGRAPHIC ANALYSIS

Specimen Number: B.3.

Rock Name: Vein Dike Quartz.

Field Name: Vein Quartz.

Location: Vashon Till.

Megascopic Description

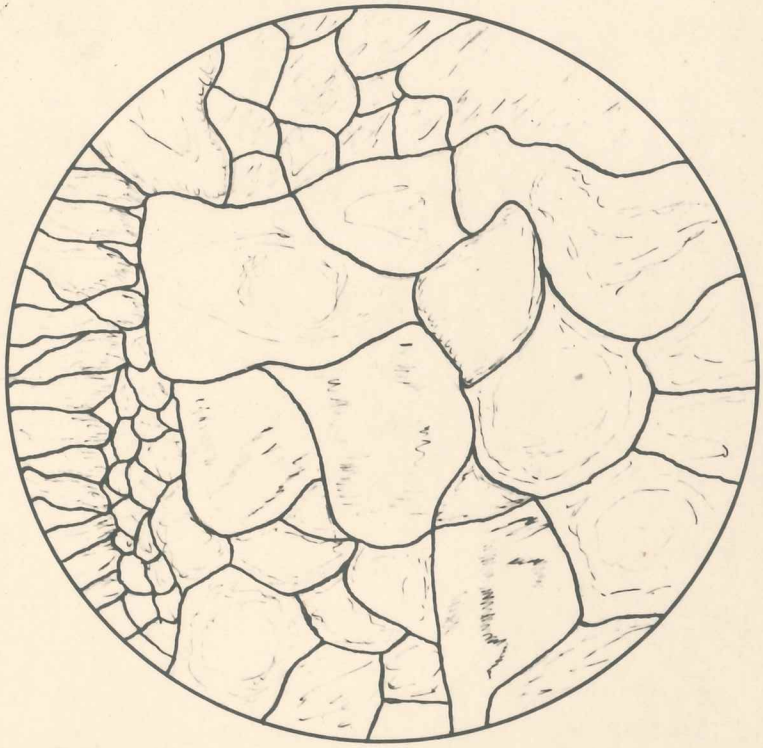
Medium grained rock, containing quartz veins. Slightly stained with iron.

The Visible Minerals are: Quartz, Limonite.

Microscopic Analysis

A medium to coarse grained rock of varying forms of quartz. The grains angular to subangular, showing typical vein dike formation. Perfect interlocking of crystals taking the place of cement.

The Mineralogic Composition is: Quartz, Felspar, Limonite.



Vein Dike Quartz

PETROGRAPHIC ANALYSIS

Specimen Number: B.4.

Rock Name: Actinolite Schist.

Field Name: Schist.

Location: Vashon Till.

Megascopic Description

Extremely fine grained, grey colored schistose rock, with fine quartz veins.

Microscopic Analysis

Groundmass of extremely fine grained quartz with actinolite needles forming a schistose structure. Veins of secondary quartz.

The Mineralogic Composition is: Actinolite, Quarts, Zoisite.

PETROGRAPHIC ANALYSIS

Specimen Number: B.5.

Rock Name: Quartzite.

Field Name: Quartzite.

Location: Vashon Till.

Megascopic Description

Fine grained microgranitic dark colored rock.

Microscopic Analysis

A holocrystalline microgranitic rock containing small grains of angular to subangular quartz, having the appearance of arkose. (The grains range from .03 m.m. to .1 m.m.).

The Mineralogic Composition is: Quartz, Felspar, Magnetite.

PETROGRAPHIC ANALYSIS

Specimen Number: B.6.

Rock Name: Olivine Basalt.

Field Name: Basalt.

Location: Vashon Till.

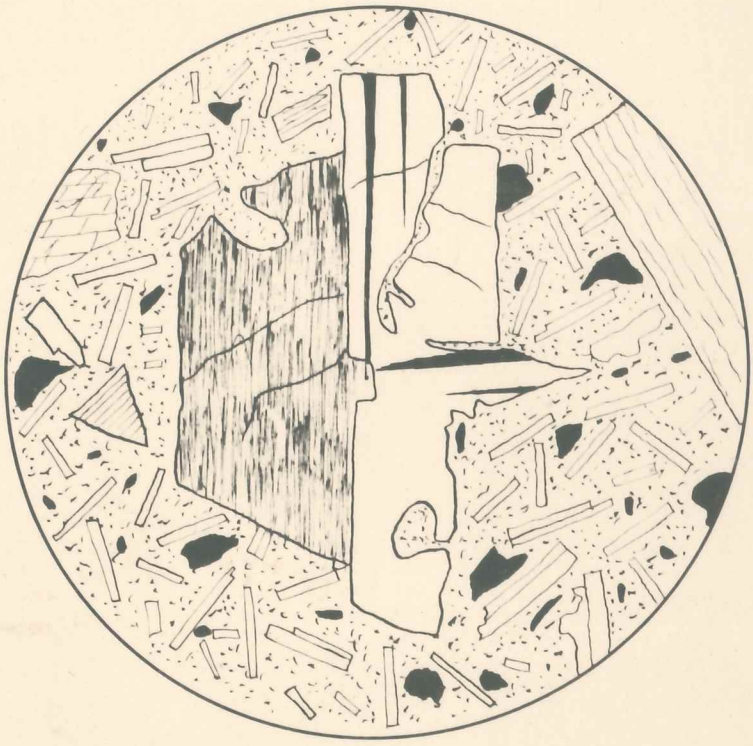
Megascopic Description

Fine grained crystalline dark colored rock, containing phenocrysts of felspar.

Microscopic Analysis

A holocrystalline groundmass, ophitic structure with laths of basic labradorite, and phenocrysts of bytownite and anorthite, both albite and pericline twinning shown. Also an occasional carlsbad twinning. Zonal structure is well represented in some of the felspars. Femics largely altered to fibrous hornblende. Olivine stained brown.

The Mineralogic Composition is: Labradorite, Bytownite, Anorthite, Magnetite, Fibrous Hornblende, Olivine, Chlorite.



Lath Structure of Basalt

PETROGRAPHIC ANALYSIS

Specimen Number: B.7.

Rock Name: Greywacke.

Field Name: Greywacke.

Location: Vashon Till.

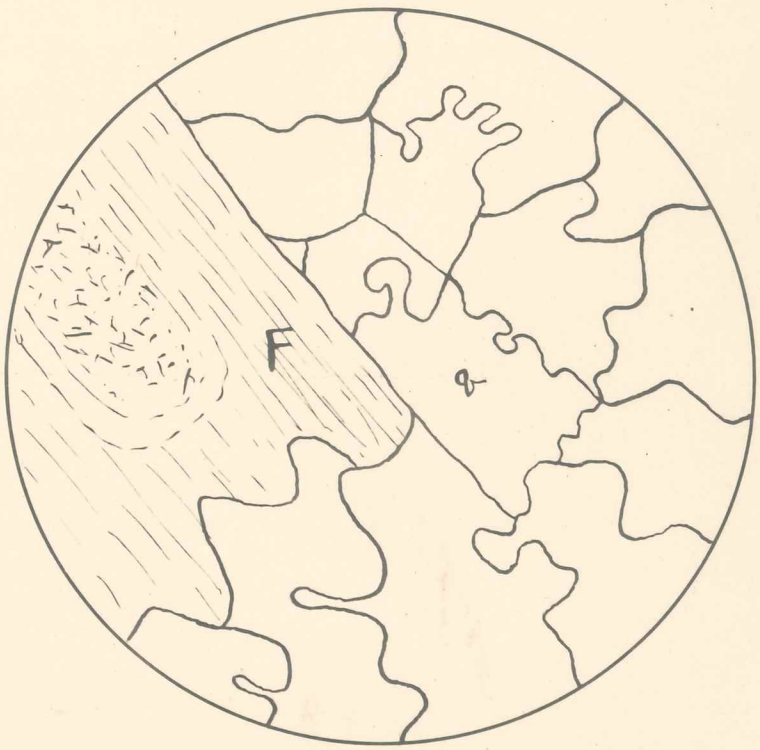
Megascopic Description

A fine grained gritty arenaceous rock containing nodules of coarser material, largely quartz.

Microscopic Analysis

Fine grained angular quartz cemented by a secondary quartz, which has in place broken down the outline of the original grains. Felspars also effected by secondary quartz, containing some biotite which has chiefly been altered to chlorite.

The Mineralogic Composition is: Quartz, Albite, Orthoclase, Biotite, Magnetite, Chlorite.



F. - Felspar
Q. - Quartz

Secondary Quartz

PETROGRAPHIC ANALYSIS

Specimen Number: B.8.

Rock Name: Schist.

Field Name: Schist.

Location: Vashon Till.

Megascopic Description

A fine grained schistose rock of dark color, containing bands of light colored rock.

Microscopic Analysis

A microcrystalline rock, with schistose or flow structure. Groundmass consists of quartz and felspar, with larger crystals of pyroxene and epidote. Magnetite scattered through entire portion of slide.

The Mineralogic Composition is: Quartz, Felspar, Magnetite, Pyroxene, Epidote, Chlorite.

PETROGRAPHIC ANALYSIS

Specimen Number: B. 9.

Rock Name: Biotite Hornblende Granite.

Field Name: Granite.

Location: Vashon Till

Megascopic Description

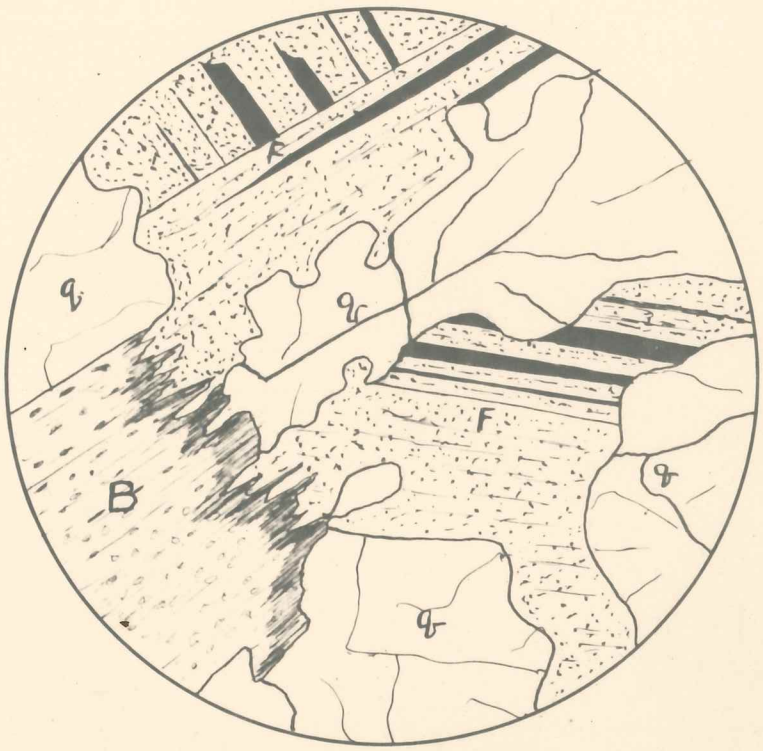
Coarse grained, granitic, altered granite.

The Visible Minerals are: Quartz, Felspar, Biotite, Hornblende.

Microscopic Analysis

A holocrystalline, coarse grained rock with even fabric with secondary quartz which has replaced both the felspar and femic mineral. Femics partly altered. Felspars altered in nearly all cases.

The Mineralogic Composition is: Quartz, Orthoclase, Oligoclase, Albite, Biotite, Hornblende, Augite, Apalite, Sericite, Epidote, Kaolin, Chlorite.



B. - Biotite
F. - Felspar
Q. - Quartz

Quartz Replacing Biotite and Felspar

PETROGRAPHIC ANALYSIS

Specimen Number: B.10.

Rock Name: Aplite.

Field Name: Aplitic Dike Rock.

Location: Vashon Till.

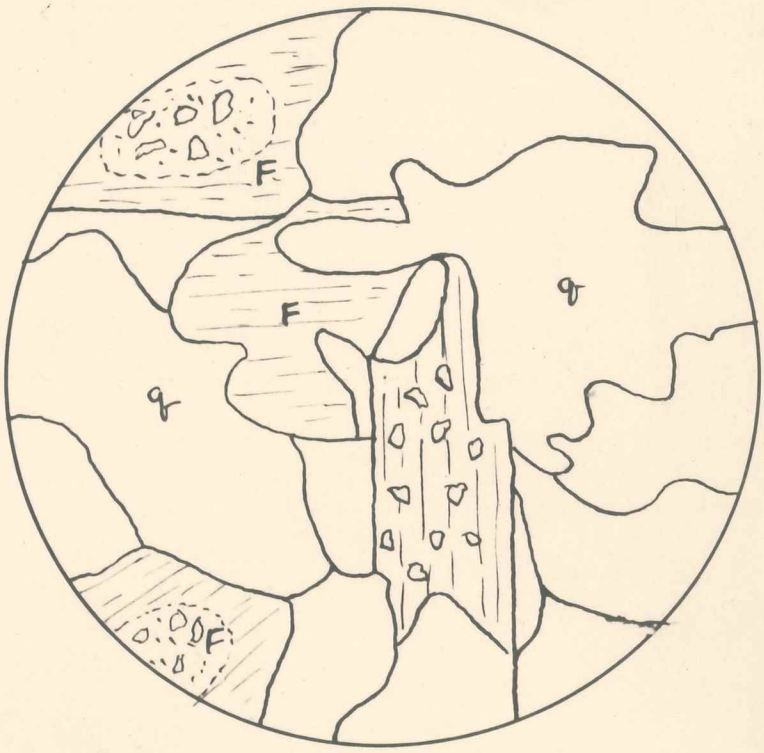
Megascopic Description

Fine grained holocrystalline rock with apalite structure, with a large amount of femics in the vein material.

Microscopic Analysis

A medium grained rock, grains of quartz fairly well rounded. Felspars badly altered in part showing radiating structure. All femics altered to chlorite. The chlorite in part acting as the cementing material.

The Mineralogic Composition is: Quartz, Orthoclase, Labradorite, Anorthite, Albite, Magnetite, Chlorite, Kaolin.



F. - Felspar
Q. - Quartz

Aplitic Dike Rock

PETROGRAPHIC ANALYSIS

Specimen Number: B.11.

Rock Name: Granaphyre.

Field Name: Porphyry.

Location: Vashon Till.

Megascopic Description

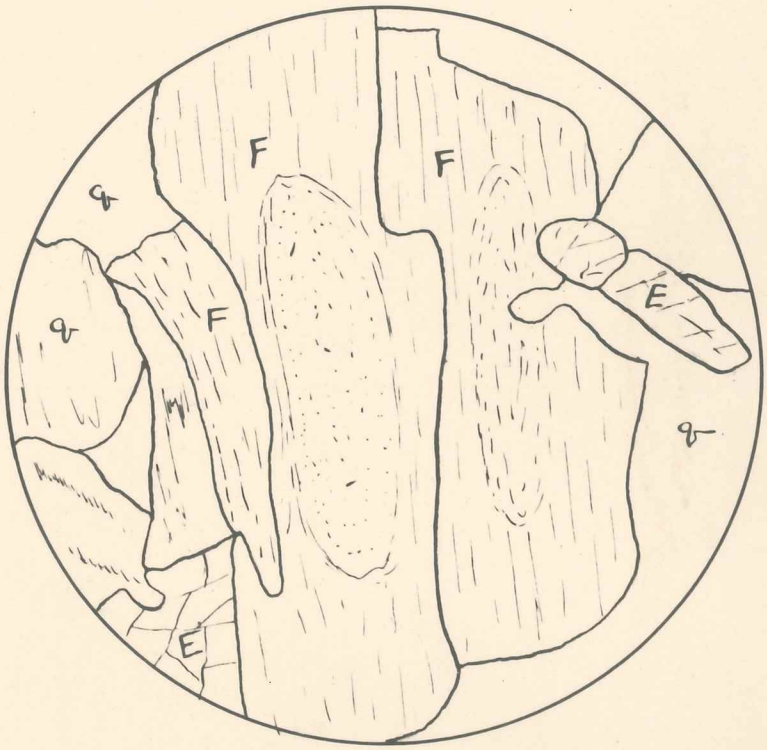
Medium grained porphyritic rock with phenocrysts of felspar. The whole badly altered.

The Visible Minerals are: Felspar, Quartz, Magnetite, Pyroxene.

Microscopic Analysis

A fine grained groundmass. Holocrystalline with micrographic intergrowth of quartz and felspars. Femics entirely altered. Felspars altered to Kaolin. The phenocrystic felspars contain crystals of sericite.

The Mineralogic Composition is: Quartz, Orthoclase, Labrodorite, Andesine, Magnetite, Augite, Chlorite, Kaolin, Sericite.



F. - Felspar
E. - Epidote
Q. - Quartz

PETROGRAPHIC ANALYSIS

Specimen Number: B.12.

Rock Name: Metamorphosed Dike Type Granite.

Field Name: Altered Granite.

Location: Vashon Till.

Megascopic Description

Medium grained rock granitic texture, containing large altered crystals of hornblende. Felspars altered.

Microscopic Analysis

Fine grained rock of micrographic structure with large phenocrysts of altered hornblende. The rock slightly metamorphosed with secondary felspar of porphyritic type. The felspars and femics badly altered.

The Mineralogic Composition is: Quartz, Felspar, Decomposed Hornblende, Serpentine, Epidote, Kaolin, Sericite, Chlorite.

PETROGRAPHIC ANALYSIS

Specimen Number: B.13.

Rock Name: Rhyolite.

Field Name: Rhyolite.

Location: Vashon Till.

Megascopic Description

Dark red colored rock of a dense stony texture, containing minute veins.

Microscopic Analysis

A cryptocrystalline groundmass, containing small quartz veins. Also some minute phenocrysts of glassy felspar. Some extremely fine grains of magnetite.

PETROGRAPHIC ANALYSIS

Specimen Number: B.14.

Rock Name: Rhyolite.

Field Name: Rhyolite.

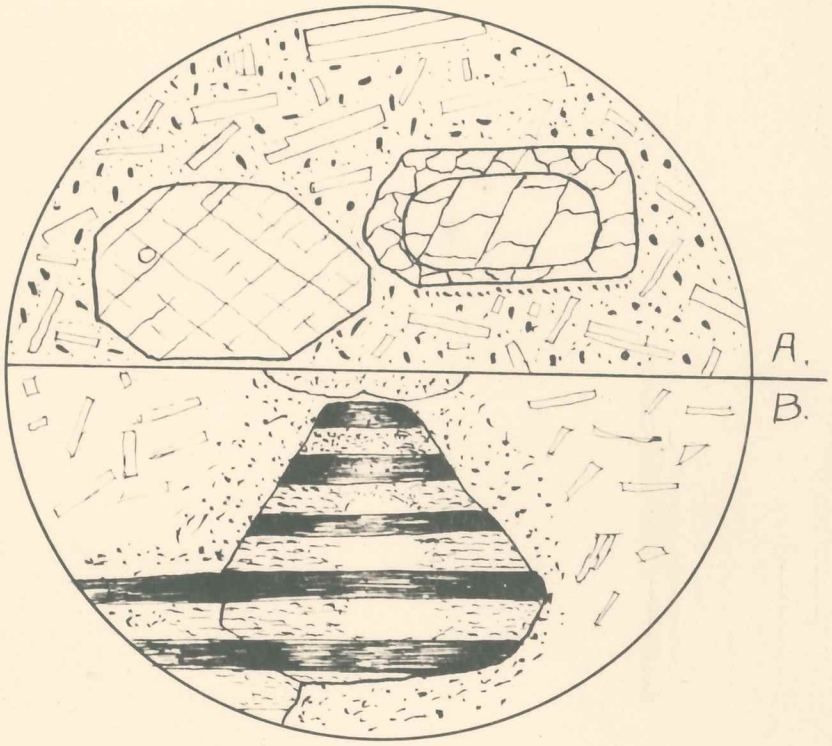
Location: Vashon Till.

Megascopic Description

Dense glassy red rock with small veins of quartz. Volcanic.

Microscopic Analysis

A microcrystalline groundmass with small phenocrysts of felspar. Numerous quartz veins.



Phenocrysts in Rhyolite

PETROGRAPHIC ANALYSIS

Specimen Number: B.15.

Rock Name: Lamprophyre.

Field Name: Lamprophyre.

Location: Vashon Till.

Megascopic Description

A fine grained crystalline rock of a granitic type.

The Visible Minerals are: Quartz, Felspar, Pyroxene.

Microscopic Analysis

A medium grained crystalline rock, with some quartz. Felspar intergrowth. Felspars badly altered. Some secondary quartz. Femics altered to chlorite. Zonal structure well developed in felspars.

The Mineralogic Composition is: Quartz, Orthoclase, Labradorite, Albite, Biotite, Hornblende, Magnetite, Epidote, Chlorite, Kaolin, Sericite.

PETROGRAPHIC ANALYSIS

Specimen Number: B.16.

Rock Name: Arkosic Quartzite.

Field Name: Quartzite.

Location: Vashon Till.

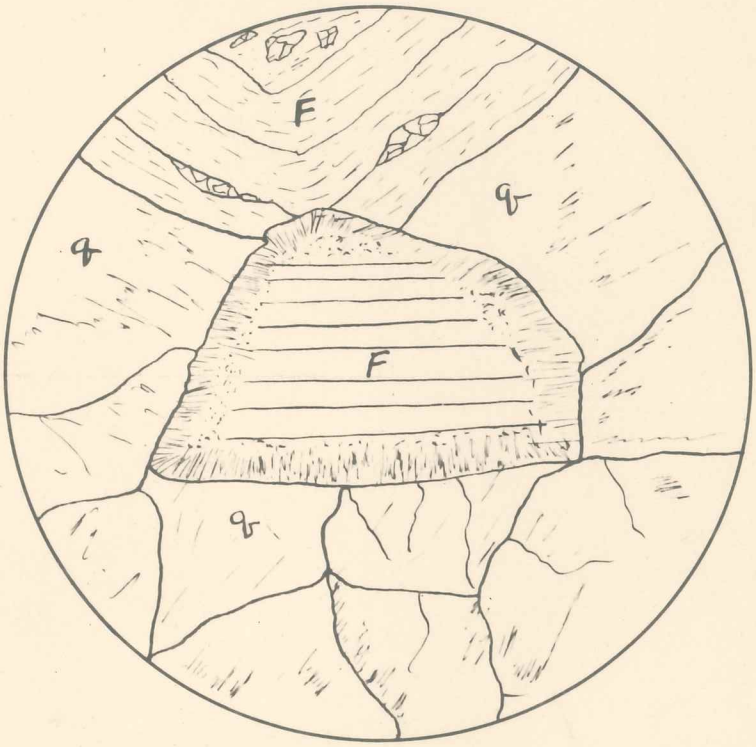
Megascopic Description

A very fine grained dark colored rock, containing quartz and felspar.

Microscopic Analysis

A fine grained rock of granulitic structure. The grains angular to subangular. Groundmass of extremely fine quartz and felspar. Felspars all badly altered, chiefly to epidote, though some kaolin.

The Mineralogic Composition is: Quartz, Orthoclase, Plagioclase, Biotite, Magnetite, Chlorite, Epidote.



F. - Felspar
Q. - Quartz

Arkosic Quartzite

PETROGRAPHIC ANALYSIS

Specimen Number: B.17.

Rock Name: Radiolarian Quartz.

Field Name: Quartzite.

Location: Vashon Till.

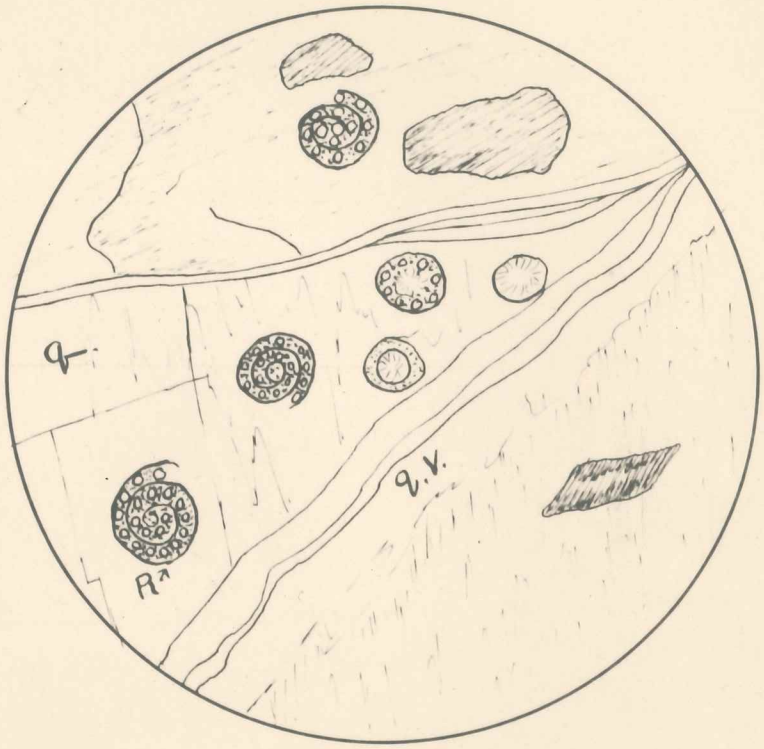
Megascopic Description

Fine grained, dense, dark rock, with quartz veins and stained with iron.

Microscopic Analysis

An extremely microscopic groundmass with quartz veins. Quartz of a cherty nature, containing radiolarians.

The Mineralogic Composition is: Quartz, Felspar, Magnetite.



R. - Radiolaria

Radiolarian Quartz

C O N C L U S I O N S

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Mr. Bretz, in his "Glaciation of the Puget Sound Region", so fully describes the Denny Hill regrade area that for this work it was taken as a type section. By correlating the various stratas in the different districts the age and formation of each could easily be determined.

The lower portion of the Admiralty Sediments, with its slightly stratified clay beds, containing scattered boulders and pebbles, was laid down during a period of fairly quiet water or sluggish streams. This can be seen from the fact that the deposits are superposed above each other in all parts of the region without regard to what kind of sediments lay beneath, and also an absence of delta bedded material.

These sediments were probably laid down immediately following the retreat of the glacier before any great amount of erosion took place, and also before the big Cascade streams entered the Sound. This is borne out by the fact that the rock material is foreign to the neighboring mountains.

The upper portion of the Admiralty Sediments, or the "A" series, which comprises a small section in relative thickness, has been laid down by swift streams. The top surface of the lower clay formation suffered erosion to a certain extent, and the gravel of the upper series brings out this erosion effect quite clearly. The deposit consists of a series of lenses of well consolidated

gravels and sands. Usually the gravels are bedded horizontally, but they possess stream cross-bedding in almost every section.

The gravel and sand of this series are almost everywhere stained by iron oxide. The sand is commonly buff colored, the gravel yellow to orange hue.

According to Mr. Bretz, the Cascades contributed to a small extent in the building up of the Admiralty Sediments. This extent has proven to be greater than at first thought. By means of a petrographic study of these sediments it was found that the upper portion, ranging in different localities from two to fifteen feet in thickness, belong to an entirely different series than that which lies directly below. This upper portion was correlated with the Fuller collection of Cascade rocks, and it was found that ninety-five percent of this series was of Cascade origin. By means of a megascopic correlation the same was found to be true in the other two areas studied.

Thus we have a fairly large area in the center of the Puget Sound Basin showing a stream deposited layer of considerable thickness of Cascade rocks.

The Vashon Till, or "B" series, advanced from the north, as did the Admiralty, the ice coming from the snow fields of British Columbia. Only a minor part of the ice came from the margining mountains. This fact has been borne out by this petrographic study.

In this case the pebbles of the Vashon Till were compared both microscopically and megascopically with McLellan's collection of rocks from San Juan and adjacent islands, thus not only giving us the kind of rock but also the general direction of the glacier.

It was found that the Vashon Till is composed entirely of rocks which had their origin directly to the north, and in no wise connected with either the Cascades or Olympic Mountains.