GEOLOGY OF VIEWMOUNT AVENUE, WESTMOUNT

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The Geology and Petrography of

Viewmount Avenue,

Westmount.

by

George Shaw

Submitted in partial fulfillment for

the requirements for the degree of Master of

Science.

McGill University

1934.

CONTENTS

Introduction and Acknowledgements

This thesis comprises two parts, the first being a general description of the Monteregian province with a consideration as to the origin of the nepheline syenites, and the second, a description of the rocks of a small area on the southwest side of Mount Royal. A geological map of the thesis area accompanies this thesis. The topography of the area was deduced from a plane table survey.

The writer was assisted in the field by Mr. H.I.Williams. The field and laboratory investigation and the writing of this thesis were under the supervision of Dr. F.F.Osborne.

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A B S T R A C T

The Monteregian hills are composed principally of plutonic igneous rocks of alkaline character including such rocks as nordmarkite, nepheline syenite, tawite, pulaskite, essexite, yamaskite, montrealite, rougemontite and olivine essexite. A study of the analyses of the various rock types indicates an average composition approximating that of essexite. It is reasonable to assume, then, that the stem type magma had the composition approximating essexite. The variation diagram plotted from the analyses of the various rock types suggests that the nepheline syenite, nordmarkite, tawite, pulaskite and laurdalite on the one hand, and yamaskite, rougemontite, montrealite and olivine essexite on the other, are acid and basic differentiates respectively of the original essexite magma. The diagram suggests differentiation by deformation.

In the thesis area are exposed essexite, nepheline syenite, camptonite, fourchite and tinguite intrusives penetrating the Trenton limestone. The nepheline syenite, camptonite and tinguaite form igneous breccias which give an excellent indication in the order of intrusion of the various rock types. The sequence of intrusions established for the thesis area compares very well for that established for other parts of the mountain.

PART ONE

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The Monteregian Hills

The Monteregian Hills are eight in number and extend in a line fifty miles long cutting diagonally across the St. Lawrence lowlands between the Laurentian area of Precambrian highly crystalline rocks on the northwest and the Appalachian front on the southeast. Five of the hills are intruded through the slightly disturbed rocks of the foreland but three of the largest are within the fault slices of the Appalachian zone (Fig 1.)

Table I gives the area of intrusive rock comprising the hills together with the heights of the respective hills above sea level and above the surrounding plain.

Table I

Name - from west to east	Area of igneous rock in sq. mi.	Height above plain	Height above S.L.
Mount Royal	3.03	650 feet	759 feet
Mount St. Bruno	1.76	620 "	715 "
Mount St. Hilaire	3.37	1230 "	1350 "
Mount Johnson	0.24	685 "	876 "
Rougemont Mountain	5.02	1140 "	1260 "
Mount Yamaska	3.11	1300 "	1460 "
Shefford Mountain	5.40	1300 "	1500 "
Brome Mountain	23.60	1100 "	1500 "

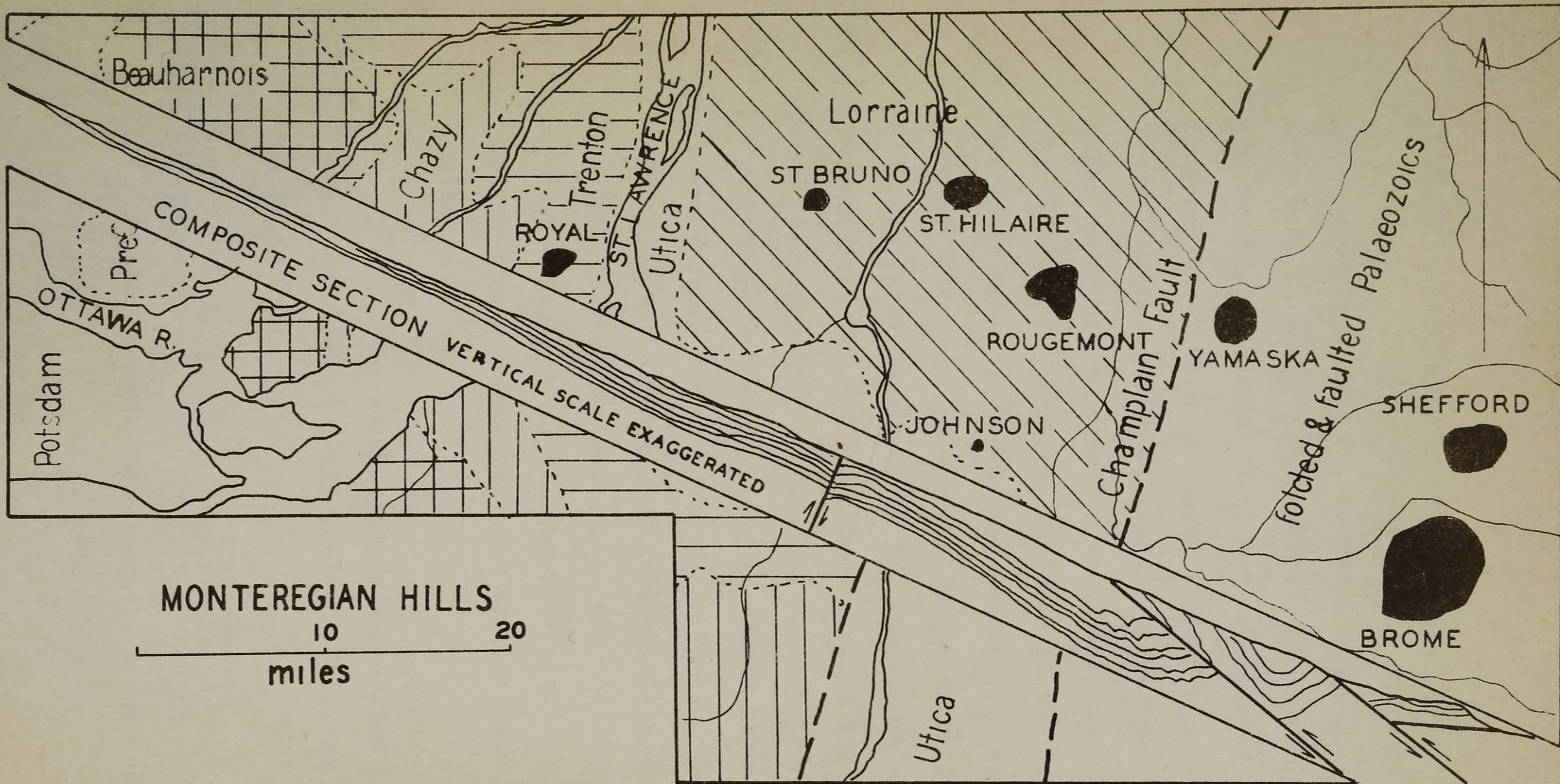
Beauharnois
Chazy
Trenton
ST LAWRENCE
Utica
Lorraine
ST BRUNO
ST. HILAIRE
ROYAL
ROUGEMONT
YAMASKA
JOHNSON
SHEFFORD
BROME
Champlain Fault
folded & faulted Palaeozoics
Pre€
OTTAWA R.
Potsdam
COMPOSITE SECTION VERTICAL SCALE EXAGGERATED
Utica
MONTEREGIAN HILLS
10
20
miles

FIG. 1

Thickness of Palaeozoic Sedimentary Rocks

The thickness of the early Palaeozoic rocks underlying the St. Lawrence lowlands increases from west to east. At Montreal the known thickness of the sediments is 2000 feet, but on crossing the St. Lawrence River this thickness increases rapidly. The log of a deep well at St. Angele about two and a half miles northeast of Mount Johnson, indicates that, in that particular locality, the base of the Trenton formation is 5000 feet below the surface of the ground. Another well at St. Gerard, 45 miles north of Mount Yamaska, cuts the basal sandstone of the Trenton at a depth of approximately 6000 feet. Some samples from these wells show slickensiding thus indicating that there has been a certain amount of faulting at depth although there is no evidence of movement at the surface. The eastward increasing thickness of the sedimentary rocks may be due not only to the inequalities in sedimentation, but also to movement along gently dipping faults at depth. Fig.1 shows a simple composite cross section of the St. Lawrence lowlands.

The stratigraphic succession of the Palaeozoic formations underlying the lowlands is given in the following table(6)

Ordovician	Lorraine shales Utica shales Trenton limestone Chazy limestone Beauharnois sandstone
Cambrian	Potsdam sandstone

It can be estimated then that approximately 7000 feet of sediments are to be found immediately west of the Champlain Fault, which separates the front thrust of the Appalachians from the foreland. The Tracy Brook normal fault crops out fifteen miles west of the Champlain fault and tends to increase the thickness of the sediment--ary rocks to the east, which is the downthrow side.

Near the easternmost hills it is not unreasonable to assume a thickness of 10,000 feet of strata above the Precambrian.

As seen in Fig. 1 Yamaska, Shefford and Brome are intruded into fault slices of the Appalachian zone: Yamaska is in the most westerly or Phillipsburg slice whereas the two latter are in the Oak Hill slice (6).

The Palaeozoic rocks of this part of the Appalachian region were folded not by the late Palaeozoic Appalachian revolution but by the Taconic orogeny at the close of the Ordovician (15). As will be seen later (page 5) the Monteregian hills were intruded in post Devonian times so the cores of Brome, Shefford and Yamaska were introduced into folded rather than flat lying rocks.

Former Cover

Lower Devonian rocks once covered at least part of the area, but only fragments included within igneous rocks indicate their former presence. It is not unreasonable to assume, therefore, that at least 1000 feet more Palaeozoic strata was once present in the section.

By analogy with other localities a former cover of from 2000 to 3000 feet of rock above the plutonics is not improbable (13).

Form of the Intrusives

The form of the intrusives of the Monteregian hills is only partly known. As Mount Royal is known to have vertical contacts from the position of the contacts found on the surface and in the railway tunnel passing through the mountain, it has been considered a plug or a stock. At Mount Johnson the fluidal structure of the rocks is vertical, and the intrusive is thus a plug or possibly a neck (1). At St. Bruno the vertical fluidal arrangement of the minerals is to be noted at a few places showing that the magma was moving vertically at the time of consolidation (8). LeRoy has suggested that St. Bruno may have reached the laccolithic level and the magma extruded laterally. The evidences for this view, however, are scanty. St. Hilaire and Rougemont have been considered plugs (13). Dresser is of the opinion that Brome (9) and Shefford (10) mountains are denuded laccoliths. The form of Yamaska is not rightly known although Young (17) considers it to be a plug. It is possible that the bodies described as plugs may be stocks with very steep but slightly in-dipping sides. The area of the exposed surface might depend on the thickness of the sedimentary rocks traversed.

Age of the Intrusions

The Monteregian hills are known to be younger than early Devonian from fragments of that age included in the igneous rocks. The upper limit of age is uncertain although several lines of evidence seem to indicate that the intrusions may be younger than the Triassic:

(1) Camptonite dikes in Connecticut, which are possibly comagmatic with the Monteregian intrusives, are known to cut Triassic rocks.

(2) The rocks of the Monteregian province resemble some alkaline intrusives of Tertiary age in the United States such as those of Magnet Cove, Arkansas.

(3) The most cogent argument for the youth of these intrusives is the absence of pleochroic haloes around the accessory minerals. Eve and McIntosh (11) have shown that the rocks of the Monteregian province are richer than the average in radium. Nevertheless, pleochroic haloes are lacking or are very immature. The absence of the haloes might be due to heating, but the surrounding rocks show no evidence of heating to a temperature sufficient to destroy the haloes.

Dresser (9) claims to have found evidence of the Appalachian folding in the rocks of Shefford and Brome. If such is the case the intrusives are undoubtedly of late Palaeozoic age. This evidence is, however, not very conclusive.

Composition of the Intrusives

The Monteregian hills constitute a Canadian petrographic province (1) typified by rocks of alkaline

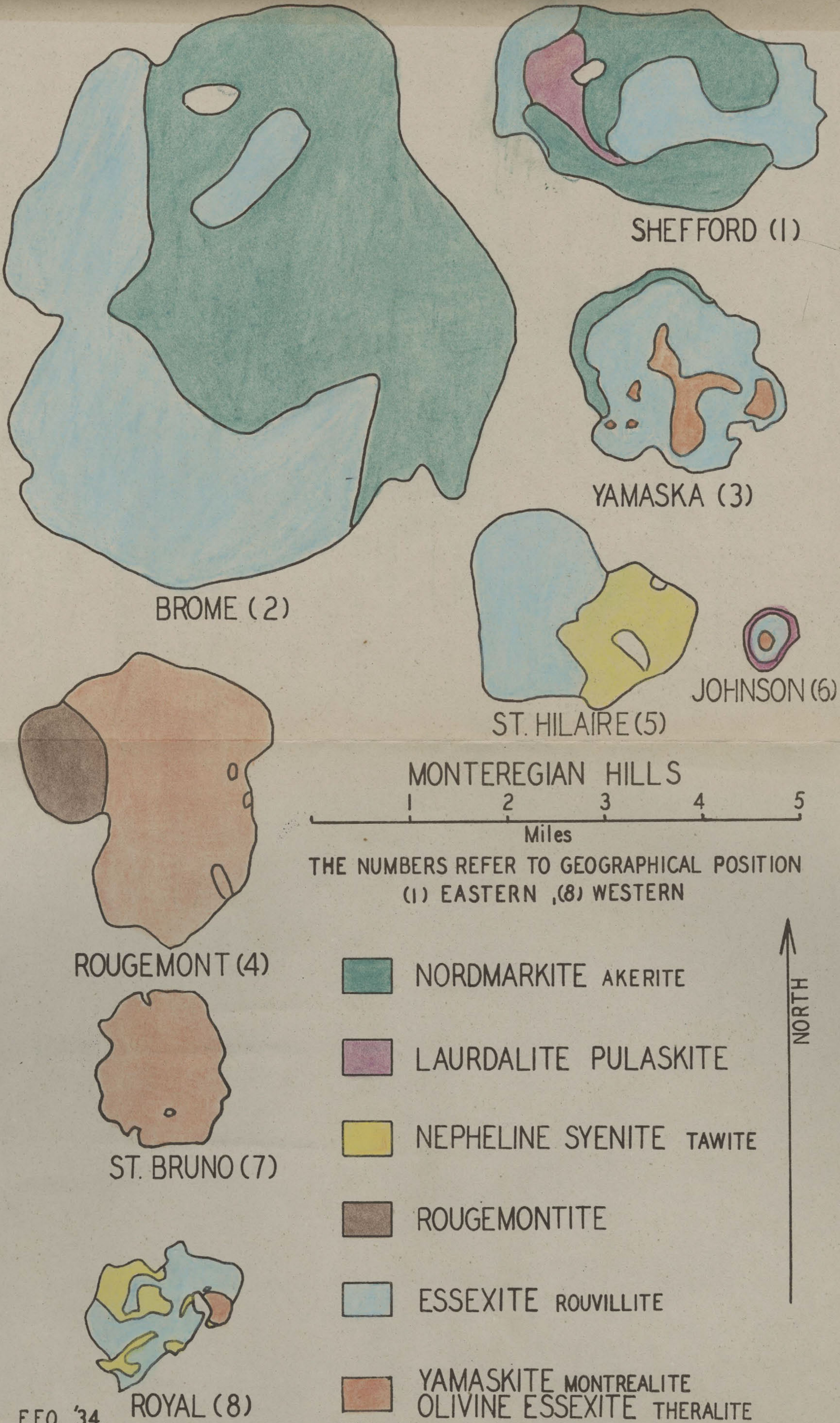
SHEFFORD (1)
BROME (2)
YAMASKA (3)
ST. HILAIRE (5)
JOHNSON (6)
ROUGEMONT (4)
ST. BRUNO (7)
ROYAL (8)
MONTEREGIAN HILLS
1 2 3 4 5
Miles
THE NUMBERS REFER TO GEOGRAPHICAL POSITION
(1) EASTERN ,(8) WESTERN
NORDMARKITE AKERITE
LAURDALITE PULASKITE
NEPHELINE SYENITE TAWITE
ROUGEMONTITE
ESSEXITE ROUVILLITE
YAMASKITE MONTREALITE
OLIVINE ESSEXITE THERALITE
NORTH
F.F.O. '34.

FIG. 2

character the chief of which is essexite as is seen in Table II which gives the results of planimetric measurements of all the geological maps of the intrusives.

Table II

Rock Type	Area in sq. mi.	% of total area of Monteregian plutonic intrusives
Essexite, Rouvillite	19.06	41.87
Nordmarkite, Akerite	16.18	35.54
Yamaskite, Montrealite, Olivine Essexite	6.06	14.49
Nepheline Syenite, Tawite	2.28	5.01
Rougemontite	0.82	1.80
Pulaskite, Laurdalite	0.59	1.29
Total	45.53	100.00

The distribution of the above rocks, the respective size of the various hills, and their orientation with respect to north is seen in Fig. 2. The figure does not indicate the ralative positions of the hills with respect to one another.

Tables III to X inclusive give the analyses of the types of rock comprising the Monteregian hills, the area of each mountain underlain by each rock type, the percent of each rock in each mountain and the average composition of the individual mountains.

It is to be noted that the average composit- -ion of all of the hills with the exception of Brome and Shefford, is in the Essexite or Theralite class.

The analyses used in the following tables were taken from the geological reports on the various hills, and the analyses are considered to be of specimens representative of that particular type of rock. This proceedure is open to errors but the errors should be compensating. The papers from which the analyses were taken are cited in the bibliography at the end of this paper.

The average composition of all of the hills in the foreland is given in Table XI and that of the hills in the faulted zone in Table XII. Table XIII gives the average composition of all of the essexites of the hills in the foreland. If Tables XI and XIII be compared it will be seen that the composition of the hills in the foreland is very close to that of the average essexite of the same hills.

It is probable that the primary magma from which the rocks of the Monteregian hills were formed was not more basic than an essexite and that the Yamaskites etc., are basic segregations from such a magma whereas the more acidic nepheline syenites and related rocks crystallized from rest magma derived by deformation from essexite. This suggestion is substantiated somewhat by a study of the variation diagrams shown in Fig. 3.

Table III

Mount Royal

3.03 sq. mi.

Rock	Essexite	Olivine Essexite	Nepheline Syenite	Average
Area	2.00	0.10	0.93	3.03
%	66.00	3.30	30.70	
SiO_2	43.10	44.66	55.90	47.05
TiO_2	2.80	2.27	0.70	2.13
Al_2O_3	13 94	9.64	19.75	15.58
Fe_2O_3	4.92	4.98	1.00	3.72
FeO	6.93	6.65	2.05	5.42
MgO	8.86	12.83	0.59	6.45
CaO	14.65	13.11	3.10	11.05
Na_2O	2.50	2.07	7.25	3.94
K_2O	0.89	1.17	5.61	2.34
MnO	0.14	0.19	0.10	0.13
H_2O	0.70	0.90	2.00	1.10
CO_2	0.64	0.37	1.85	1.00
BaO	0.03	-	0.09	0.05
P_2O_5	0.27	0.24	-	0.18
	100.37	99.08	99.99	100.14

Table IV

Mount Bruno

1.76 sq. mi.

Rock Area	Essexite 1.76	Umptekite 0.006	Average 1.76
SiO_2	45.37	50.56	45.37
TiO_2	1.50	2.25	1.50
Al_2O_3	6.21	18.28	6.21
Fe_2O_3	2.40	3.57	2.40
FeO	8.09	4.62	8.09
MgO	18 67	3.38	18.67
CaO	14.47	7.10	14.47
Na_2O	0.85	4.30	0.85
K_2O	0.37	3.31	0.37
MnO	-	0.13	-
H_2O	0.88	1.40	0.88
CO_2	0.62	0.76	0.62
	99.43	99.66	99.43

Table V

Mount Johnson

0.24 sq.mi.

Rock	Pulaskite	Essexite Andose	Essexite Essexose	Average
Area	0.07	0.13	0.04	0.24
%	29.17	54.16	16.67	
SiO_2	59.45	48.85	48.69	51.87
TiO_2	0.80	2.47	2.71	1.58
Al_2O_3	19.97	19.85	17.91	19.54
Fe_2O_3	1.61	4.29	3.09	3.25
FeO	3.15	4.94	6.41	4.62
MgO	1.12	2.00	3.06	1.92
CaO	1.87	7.98	7.30	6.04
Na_2O	6.33	5.44	5.95	5.75
K_2O	3.93	1.91	2.56	2.58
MnO	-	0.19	0.15	0.08
H_2O	0.74	0.68	0.95	0.75
P_2O_5	0.45	1.23	1.11	0.91
	99.45	98.83	98.89	98.89

Table VI

Mount St. Hilaire

3.37 sq.mi.

Rock	Essexite	Sod.Neph. Syen.	Rouvillite	Tawite	Average
Area	2.01	1.31	0.01	0.04	3.37
%	59.65	38.87	0.29	1.19	
SiO_2	49.96	54.74	51.26	41.84	51.84
TiO_2	2.40	Tr	1.66	-	1.45
Al_2O_3	18.83	21.53	23.78	28.42	19.90
Fe_2O_3	2.52	4.06	1.81	3.29	3.12
FeO	6.64	0.94	2.70	0.40	4.41
MgO	3.52	0.18	1.96	0.25	2.21
CaO	7.42	0.90	8.00	0.66	4.85
Na_2O	5.25	12.84	6.72	19.48	8.42
K_2O	2.58	4.18	2.16	2.06	3.08
MnO	0.20	0.14	0.10	0.15	0.17
H_2O	0.60	0.35	0.65	0.76	0.50
P_2O_5	0.25	-	-	0.04	0.15
	100.17	99.86	100.00	97.35	99.92

Tawite also contains 3.37% Cl

Table VII

Rougemont Mountain

5.02 sq. mi.

Rock	Essexite	Yamaskite	Rougemontite	Average
Area	4.00	0.20	0.82	5.02
%	79.68	3.98	16.34	
SiO_2	44.62	45.44	40.68	44.00
TiO_2	1.87	1.50	2.04	1.88
Al_2O_3	7.90	5.85	19.83	9.77
Fe_2O_3	4.22	2.84	4.68	4.24
FeO	5.67	6.49	6.49	5.83
MgO	14.00	16.24	7.67	13.05
CaO	19.44	18.16	17.64	19.09
Na_2O	1.20	1.03	1.10	1.18
K_2O	0.31	0.38	0.27	0.32
MnO	0.10	0.24	0.10	0.10
H_2O	0.82	1.28	0.35	0.76
CO_2	0.60	-	-	0.45
	100.75	99.42	100.85	100.67

Table VIII

Mount Yamaska

3.11 sq.mi.

Rock	Essexite	Yamaskite	Akerite	Average
Area	2.26	0.54	0.31	3.11
%	72.67	17.36	9.97	
SiO_2	43.91	39.97	57.75	44.59
TiO_2	3.80	4.05	1.53	3.62
Al_2O_3	19.63	8.68	17.50	17.52
Fe_2O_3	4.16	8.63	2.92	4.80
FeO	5.55	7.99	2.94	5.70
MgO	5.20	10.32	1.70	5.80
CaO	9.49	15.18	3.86	9.90
Na_2O	4.49	1.19	5.08	3.97
K_2O	1.51	0.74	3.51	1.58
MnO	0.07	0.19	0.19	0.08
H_2O	0.53	0.57	0.37	0.51
CO_2	0.51	1.15	0.55	0.61
P_2O_5	0.32	-	1.05	0.33
	99.17	98.65	98.77	99.03

Table IX

Shefford Mountain

5.40 sq. mi.

Rock	Essexite	Nordmarkite	Pulaskite	Average
Area	2.31	2.67	0.42	5.40
%	42.77	49.45	7.28	
SiO_2	53.15	65.43	59.96	59.74
TiO_2	1.52	0.16	0.66	0.77
Al_2O_3	17.64	16.96	19.12	17.41
Fe_2O_3	3.10	1.55	1.85	2.23
FeO	4.65	1.53	1.73	2.88
MgO	2.94	0.22	0.65	1.51
CaO	5.66	1.36	2.24	3.26
Na_2O	5.00	5.95	6.98	5.62
K_2O	3.10	5.36	4.91	4.36
MnO	0.46	0.40	0.49	0.43
H_2O	1.10	0.82	1.10	0.95
CO_2	0.39	-	-	0.16
P_2O_5	0.65	-	0.14	0.28
	99.36	99.74	99.83	99.50

Table X

Brome Mountain

23.60 sq.mi.

Rock	Nordmarkite	Essexite	Laurdalite	Average
Area	13.20	10.30	0.10	23.60
%	55.93	43.65	0.42	
SiO_2	61.77	44.00	55.68	53.98
TiO_2	0.74	1.90	0.60	1.25
Al_2O_3	18.05	27.73	20.39	22.29
Fe_2O_3	1.77	2.36	2.10	2.03
FeO	1.75	3.90	1.95	2.69
MgO	0.89	2.30	0.80	1.51
CaO	1.54	13.94	1.92	6.97
Na_2O	6.83	2.36	9.18	4.87
K_2O	5.21	0.45	5.34	3.12
MnO	0.08	0.08	0.31	0.08
H_2O	1.10	0.80	1.50	0.97
P_2O_5	0.15	0.20	0.06	0.17
	99.87	100.02	99.83	99.93

Table XI

Average composition of the hills in the foreland

	Average Royal	Average Johnson	Average Bruno	Average Hilaire	Average Rougemont	Average
Area	3.03	0.24	1.76	3.37	5.02	16.53
SiO_2	47.05	51.87	45.37	51.84	44.00	46.53
TiO_2	2.13	1.58	1.50	1.45	1.88	1.96
Al_2O_3	15.58	19.54	6.21	19.90	9.77	14.12
Fe_2O_3	3.72	3.25	2.40	3.12	4.24	3.81
FeO	5.42	4.62	8.09	4.41	5.83	5.68
MgO	6.45	1.92	18.67	2.21	13.05	8.86
CaO	11.05	6.04	14.47	4.85	19.09	12.30
Na_2O	3.94	5.75	0.85	8.24	1.18	3.68
K_2O	2.34	2.58	0.37	3.08	0.32	1.52
MnO	0.13	0.08	-	0.17	0.10	0.10
H_2O	1.10	0.75	0.88	0.50	0.76	0.73
CO_2	1.00	-	0.62	-	0.45	0.60

Table XII

Average composition of the hills in the faulted zone

	Average Yamaska	Average Shefford	Average Brome	Average
Area	3.11	5.40	23.60	32.11
SiO_2	44.59	59.74	53.98	54.87
TiO_2	3.62	0.77	1.25	1.36
Al_2O_3	17.52	17.41	22.29	21.40
Fe_2O_3	4.80	2.23	2.03	2.41
FeO	5.70	2.88	2.69	2.81
MgO	5.86	1.41	1.51	1.68
CaO	9.90	3.26	6.97	6.36
Na_2O	4.49	5.62	4.87	4.98
K_2O	1.51	4.36	3.12	3.24
MnO	0.07	0.43	0.08	0.13
H_2O	0.53	0.95	0.97	0.94
CO_2	0.51	0.16	-	0.02

Table XIII

Average Essexite, Rouvillite

Mountain	Johnson		Royal	St. Hilaire		
Rock	Andose	Essexose	Essexite	Essexite	Rouvillite	Average
Area	0.13	0.04	2.00	2.01	0.01	4.19
SiO_2	48.85	48.69	45.44	49.96	51.26	47.63
TiO_2	2.47	2.71	2.69	2.40	1.66	2.51
Al_2O_3	19.85	17.91	16.12	18.83	23.78	17.52
Fe_2O_3	4.29	3.09	4.23	2.52	1.81	3.38
FeO	4.94	6.41	5.59	6.64	2.70	6.05
MgO	2.00	3.06	5.76	3.52	1.96	4.52
CaO	7.98	7.30	10.77	7.42	8.00	9.01
Na_2O	5.44	5.95	4.48	5.25	6.72	4.88
K_2O	1.91	2.56	2.30	2.58	2.16	2.41
MnO	0.19	0.15	0.14	0.20	0.10	0.16
H_2O	0.69	0.95	0.87	0.60	0.65	0.73
CO_2	-	-	1.17	-	-	0.55
P_2O_5	1.23	1.11	0.26	0.25	-	0.28

MONTEREGIAN PLUTONIC ROCKS

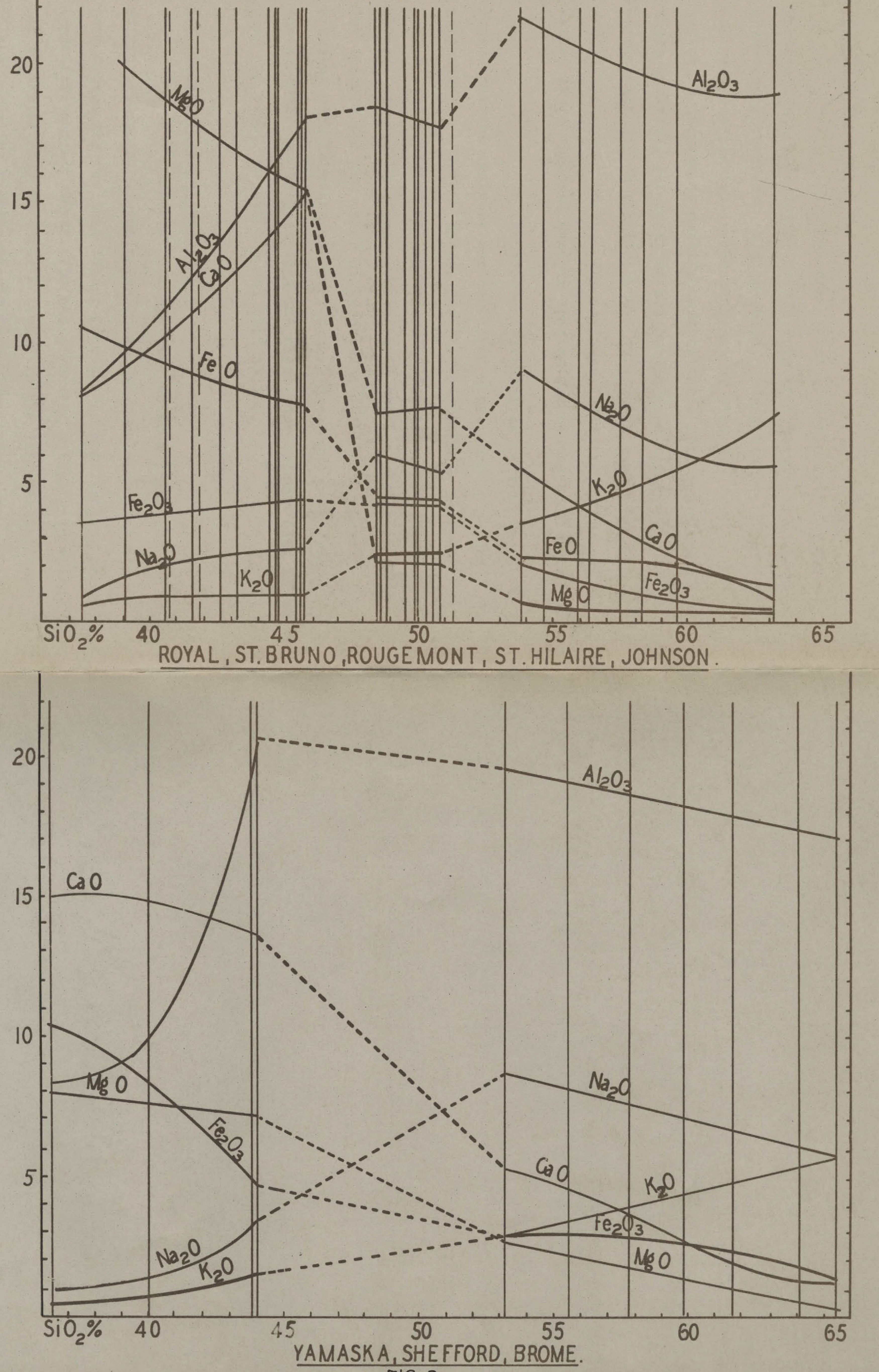

FIG. 3

Variation Diagrams

The analyses of the plutonic rocks of the Monteregian hills plotted in the form of a variation diagram show very interesting relationships. In all forty three analyses are plotted in the diagrams of Fig. 3. The variation diagram is not the most suitable form for plotting these analyses, but as it is ordinarily used and is serviceable for subalkaline rocks it is used here to facilitate comparisons. The analyses indicated by the dashed lines were not used in tracing the course of the curves.

In the diagrams themselves it will be noted that the analyses are clustered about certain silica percentages. In the Brome, Shefford and Yamaska diagram five of the analyses fall between 36% and 44% silica, none between 44% and 53%, and seven between 53% and 66% silica. The diagram for the other hills shows a still more marked grouping with fourteen analyses from 37% to 46%, none from 46% to 48½%, ten between 48½% and 51½%, none between 51½% and 53½% and eight between 53½ and 63½% silica.

The Origin of Nepheline Syenite

Several authors have written regarding the origin of nepheline syenite. Bowen (4) considers that it is formed from the residual liquor from the crystallization of a granitic magma. Smyth (16) has advocated a theory in which the volatiles play an important part in the differentiation of the nepheline syenite liquid from a granitic magma. Osborne (14) has shown that the nepheline syenite of the

Haliburton Bancroft area shows no evidence for a greater concentration of volatiles than in the granites of the same district. Daly (7) has propounded a theory whereby a sub--alkaline magma assimilates limestone by the formation of dense silicates thus removing the silica and increasing the percentage of soda permitting the formation of feldspathoidal minerals. This hypothesis has been modified somewhat by Shand by assuming that the limestone is assimilated after differentiation of the subalkaline magma has proceeded as far as the alkaline granite stage.

Inasmuch as it is believed that alkaline ultrabasic rocks and nepheline syenite are differentiates from the medio-silicic, alkaline, essexite, the problem of the origin of nepheline syenite is less important than the origin of essexite which has not been discussed here.

Relationship of Essexite and Nepheline Syenite

The distribution of the analyses in the variation diagrams under consideration is suggestive of differentiation by deformation, especially for the analyses on the right hand side of the diagram. It would seem that the nepheline syenite and other siliceous rocks were the restmagma from the essexite and the more basic rocks which are represented on the diagram below 51% silica.

If the diagrams are examined in detail it will be noted that in the break on the right hand side of the diagram the curve for Al_2O_3 rises sharply to the right, lime drops rapidly to the right and soda rises. This may be explained by the assumption that the plagioclase crystallizing in the essexite at a certain time was in solidus relationship with the plagioclase liquid in the restmagma. The calculation of the ratio of the plagioclase in the norm, however, is not of value in indicating the liquidus-solidus relationship in more than a qualitative way because:

(1) The 'minerals' of a calculated norm are few and are of simple composition. A set of standard minerals id used and other important rock forming minerals such as amphiboles, pyroxenes, micas, etc. of complex composition are omitted and the molecules which go into their composition are distributed between the minerals of the norm. In a rock such as an essexite, in which the percentage of complex minerals is high, the plagioclase ratio of the norm would not show the average composition of the plagioclase in the rock.

(2) It is known that some of the anorthite molecule enters into the formation of the pyroxenes. The norm calculation of the plagioclase ratio then, would indicate a much more calcic plagioclase than is really present.

(3) The norm ratio of the plagioclase would be affected by the fact that $NaAlSiO_4$ and $KAlSi_3O_8$ are to some extent soluble in plagioclase (2).

(4) The plagioclase of the essexite is zoned and it is the equilibrium between the outermost shell of the crystals and the restliquid that is important in determining the liquidus-solidus composition.

Table XIV gives seven analyses of plagioclase taken from various rocks of the Monteregian hills.

Table XIV

	I	II	III	IV	V	VI	VII
SiO_2	46.90	49.06	53.10	53.60	61.10	62.05	63.53
TiO_2	-	0.14	-	-	-	-	-
Al_2O_3	31.10	30.96	26.80	25.40	20.10	22.60	23.38
Fe_2O_3	1.35	0.55	1.35	4.60	2.90	-	-
FeO	-	-	-	-	-	-	-
MgO	0.65	0.15	0.72	0.86	0.79	-	0.94
CaO	16.09	13.05	11.48	13.62	3.65	3.96	3.37
Na_2O	1.77	4.79	4.24	-	5.93	7.95	8.87
K_2O	0.58	0.50	0.71	-	3.56	1.80	0.94
MnO	-	0.04	-	-	-	-	-
Ign.	1.00	0.76	0.60	0.80	0.40	0.80	-

I. Plagioclase from diorite, Mount Yamaska. T.Sterry Hunt, Geology of Canada, 1863, p.469.

II. " An66 from diabase gabbro, Sta. 204 85, Mount Royal Tunnel. Bancroft and Howard (2). M.F.Connor analyst.

III. " from yellowish olivine diorite, St.Bruno Mt. Geology of Canada 1863

IV. " with augite from olivine rock Mount Royal. Geology of Canada, 1863

V. " from micaceous trachyte. Mount Yamaska, Geology of Canada, 1863

VI. " Andesine from essexite, Mount Johnson. Geology of Canada, 1863.

VII. " Andesine from Monnoirite, Mount Johnson. Treated with conc. HCl. Analyst N.L.Wilson.

Of the above analyses two are dependable viz. II and VII. Analyses II shows a deficiency of SiO_2 below the theoretical composition of such a plagioclase. This is taken to indicate that the plagioclase contains considerable dissolved carnegieite $Na_2Al_2Si_2O_8$. The more sodic feldspar of analysis VII shows no carnegieite and this may ne due to treatment with HCl which would decompose zeolites and nepheline which may have been present in analysis II.

The nepheline syenite is taken to be the restmagma fraction derived from the crystallization of essexite for the following reasons:

(1) Field evidence shows that, in all cases, the intrusion of the nepheline syenite follows that of the essexite.

(2) The average composition of the differentiates approximates the composition of an essexite.

(3) Certain complex minerals of the essexite and nepheline syenite such as plagioclases, pyroxenes and amphiboles, are of such composition as to suggest a solidus-liquidus relationship between the two rocks. The average composition of the plagioclase of the nepheline syenite (providing there has been no differentiation from the syenite liquid) should be the liquidus composition of the plagioclase that crystallized in the essexite at the time of the explusion of the nepheline syenite. This would fix the solidus. In this case it might be safe to use the norm plagioclase ratio which is approximately Ab 75, An 25.

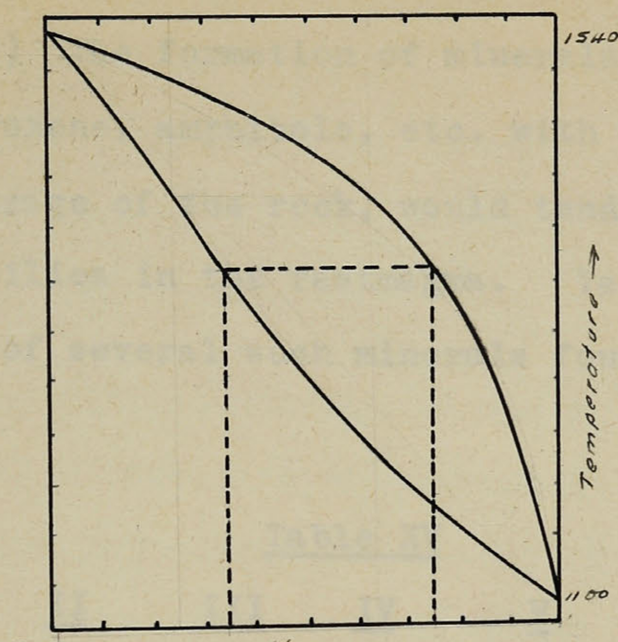

Fig.4

This indicates a filtration fairly early in the history of the essexite magma, possibly about the beginning of crystall--ization of the amphibole (Fig,4). Buckland (5) found that, in certain alkaline gabbros of Mount Royal, the amphibole commenced to crystallize at An 71.

The continued crystallization of the magma of the nepheline syenite would tend to give a magma rich in silica and alumina. This theory is supported by the fact that some of the end stage dikes of Mount Royal contain crystals of quartz, the dikes having the composition of a felsic nordmarkite. The enrichment of the residual magma in silica might be accounted for in several ways:

(1) Bowen (4) has advanced the theory that, in the presence of water, the polysilicate minerals tend to break up releasing silica and forming orthosilicates such as biotite. This explanation is, however, not feasible in this

case because the orthosilicate minerals are not sufficiently abundant in the rocks to account for the free quartz.

(2) The formation of minerals such as feldspathoids, olivine, pyroxene, amphibole, etc. with a lower silica content than the average of the rock, would tend to increase the content of silica in the restmagma. Table XV gives the composition of several such minerals found in the Monteregian plutonics.

Table XV

	I	II	III	IV	V	VI	VII	VIII
SiO_2	37.13	37.17	37.12	49.40	50.89	49.51	38.63	39.23
TiO_2	-	-	0.30	-	0.78	0.61	5.03	4.53
Al_2O_3	-	-	-	6.70	4.21	2.72	11.97	14.38
Fe_2O_3	-	-	1.72	7.83	1.43	22.26	3.90	2.92
FeO	22.57	22.54	25.66	-	4.19	5.82	11.52	8.56
MgO	39.36	39.68	33.78	13.06	15.97	1.09	10.20	13.01
CaO	-	-	2.10	21.88	22.38	7.16	12.81	11.70
Na_2O	-	-	-	0.74	-	8.63	3.14	3.05
K_2O	-	-	-	tr	-	0.38	1.49	0.98
H_2O	-	-	-	Ign.50	0.23	0.57	0.33	0.36
MnO	-	-	-	-	0.17	1.51	0.73	0.65

I. Olivine from olivine diorite, St. Bruno. T.Sterry Hunt, Geology of Canada, 1863.

II. Olivine from olivine diorite, St. Bruno

III. Olivine from essexite, Mount Royal. Analyst W.V.Howard. Essexites of Mount Royal (2)

IV. Augite from essexite, St. Bruno. Geol. of Can. 1863

V. Augite from montrealite, Mount Royal. Analyst J.B.Robertson

VI. Acmite, from nepheline syenite pegmatite, Mount Royal.
Analyst J.B.Harrington. Guide Book III

VII. Alkaline amphibole from essexite, Mount Johnson.
Analyst N.N.Evans. Guide Book III. (1)

VIII. Alkaline amphibole from essexite, Mount Royal.
Analyst J.B.Harrington. Essexites of Mount Royal (2)

The differentiation of the rocks belonging on the left hand side of the diagram is less easily accounted for. The curves have required a great deal of smoothing. Furthermore the rocks are characterized by minerals of similar silica content (Table XV) such as amphiboles, pyroxene, olivine and intermediate plagioclase thus leading to a very poor separation of the analyses on the diagram.

It may be concluded that the stem type magma had a silica content of about 50% and the composition of either essexite or theralite. The calcity of the plagioclase, however, would point to the former. This would imply that the rocks represented on the right and left hand sides of the diagram are the acid and basic differentiates respectively of an original essexite magma.

PART TWO

SIZE AND LOCATION OF AREA

The thesis area is situated on the southeast side of Mount Royal, north of Cote des Nieges Road and east of Shakespeare Road opposite the Westmount Reservoir as shown in Fig. 5. It includes all of Viewmount Avenue. The area is comparitively small being roughly 200 yards square.

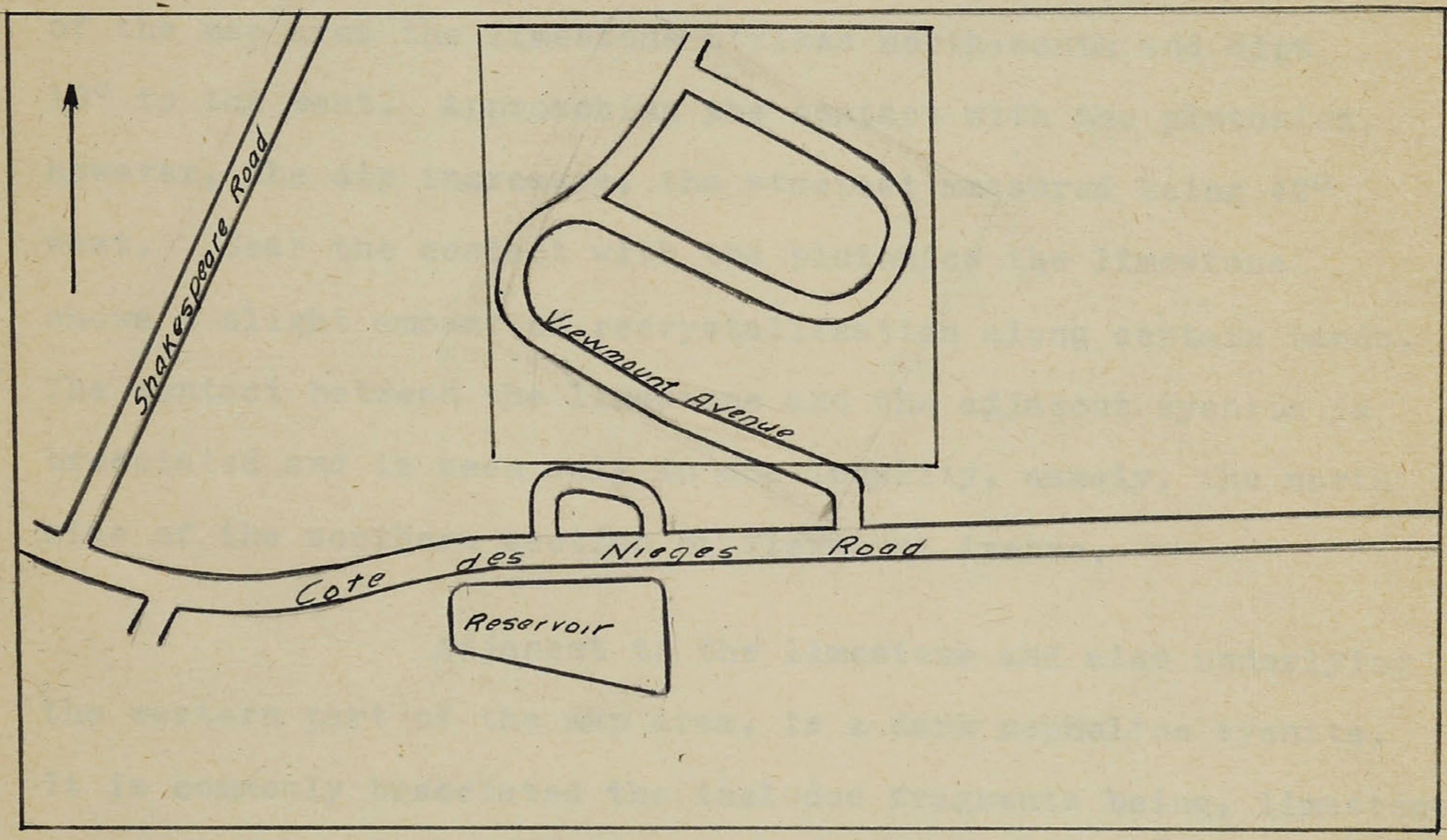

Fig 5

GENERAL DESCRIPTION OF AREA

Several distinct rock types characteristic of Mount Royal outcrop in the Viewmount area. These are Trenton limestone, essexite, nepheline syenite and various types of dikes consanguinous to the above mentioned plutonics. The outcrops in the area are few and drift covers most of the contacts. This together with the fact that the contacts are strongly brecciated makes it uncertain as to where lines dividing the various rock types are to be drawn. Breccias of igneous origin have been found on Mount Royal close to the thesis area. These localities, Littles Quarry and Westmount Quarry, are approximately due south of the thesis area at distances of approximately 500 yards and 300 yards respectively.

The Trenton limestone outcrops in the southeast part of the map area. It is bluish grey in color and shows a distinct banding. In the extreme southeast corner of the map area the limestone strikes north-south and dips 10° to the west. Approaching the contact with the plutonics, however, the dip increases, the steepest measured being 42° west. Near the contact with the plutonics the limestone shows a slight amount of recrystallization along certain bands. The contact between the limestone and the adjacent syenite is brecciated and is seen only in one locality, namely, the north side of the southern section of Viewmount Avenue.

Adjacent to the limestone and also underlying the western part of the map area, is a dark nepheline syenite. It is commonly brecciated the included fragments being, limestone, essexite and an almost black camptonite. The fragments are not numerous. West of the syenite a black, rusty-weathering camptonite is exposed. This camptonite completely surrounds the essexite and the younger nepheline syenite. Its contacts with the older, dark syenite and with the essexite are strongly brecciated.

The essexite is exposed on the south section of Viewmount Avenue and in the extreme northeast corner of the map area. In the latter exposure the essexite is very coarse grained and shows a pronounced banding due to the segregation of the light and dark minerals. The banding is vertical and strikes N 40° W. Crystals of dark minerals up to one and one quarter inches in length are found in the coarse essexite. Both varieties of essexite break up easily under the action of weathering.

The younger nepheline syenite is much lighter in color than the older variety and ismin the form of a dike like intrusion in the camptonite.

Most of the dikes cut the limestone although two dikes of nepheline syenite were found cutting the essexite and one tinguaite dikes cuts the younger nepheline syenite.

DESCRIPTION OF ROCK TYPES

(1) Essexite

The essexite exposed in the thesis area is typically of the Mount Royal variety described by Adams (1). It is a mesocratic to melanocratic rock composed essentially of amphibole, pyroxene and plagioclase with minor amounts of felsic minerals which cannot be recognozed in the hand specimen. In the normal phase of the essexite the granularity varies from medium to coarse, the crystals of amphibole locally attaining a length of three quarters of an inch. The granularity varies from place to place throughout the essexite mass but there is a tendency for the coarser grained material to form around the margins.

The amphibole occurs as euhedral crystals up to three quarters of an inch in length showing the typical hornblende cleavage. The crystals have no specific orientation. The pyroxene crystals can be recognozed in the hand specimen by their stumpy habit and characteristic cleavage. Polysynthetic twinning can be seen on the plagioclase individuals which have a bluish color very similar to the laboratory specimens of labradorite.

Under the microscope the essexite shows a hypidiomorphic texture. The amphiboles and pyroxenes tend to be euhedral but the former show a greater degree of idiomorphism. The plagioclase individuals are sunhedral, the terminal faces of the crystals being absent. Small amounts of accessory constituents are present in the interstices between the amphiboles, pyroxenes and feldspars. The composition of the rock is approximately plagioclase 50%, amphibole 25%, pyroxene 15%, others 10%.

The amphibole occurs as euhedral crystals, many of which show a marked zoning which is in evidence in plane polarized light as well as between crossed nicols. The zoning characterizes a change in composition of the amphibole from a magnesia rich variety at the centre to a ferrous iron rich variety at the outside. The minerals belong to the hastingsite group of amphiboles. Billings (3) distinguishes between the various members of the hastingsite group by the ratio of FeO : MgO in the mineral. If the ratio is greater than 2 the mineral is ferrohastingsite, if less than 2 and greater than $\frac{1}{2}$, femahastingsite, and if less than $\frac{1}{2}$, magnesiohastingsite. Billings also gives the optical properties of the various types. No chemical analyses of the amphibole from the essexite of the Viewmount area were made and the minerals have been identified optically.

The outermost part of the crystals has absorption Y > Z > X with pleochroism Y dark green, Z pale green, X pale yellow. The optic axial plane is transverse to the elongation of the crystal and normal to (010). Y is in the direction of elongation and the extinction $Y \wedge \underline{c}$ is 17°. The optic axial angle is small, approaching uniaxial, and has a negative acute bisectrix. The inclined dispersion is strong. This part of the amphibole compares very well optically with the ferrohastingsite from Almunge, Sweden as described by Billings.

The ferrohastingsite gives place to femahastingsite towards the centre of the crystal. The mineral has absorption X<Y=Z giving pleochroism X pale yellow, Y and Z green. The optic plane is parallel to (010) and Z is in the direction of elongation giving an extinction $Z \wedge \underline{c}$, 15^{o}. The optic axial angle is approximately 70^{o} and the sign of the birefringence is negative. Dispersion is not noticeable.

The innermost zone of the crystals differs from the femahastingsite in its pleochroism. The absorption is X<Y=Z with pleochroism X pale yellow, Y and Z deep brown. The optic axial plane is parallel (010) and the extinction, $Z \wedge \underline{c}$, is 20^{o}. The optic axial angle is about 80^{o} and has a negative acute bisectrix. As noted by Billings, the increase in the content of magnesia tends to lessen the dispersion, increase the extinction angle and increase 2V. Such being the case the centre of the amphibole crystals is either a magnesiohastingsite or a variety of basaltic hornblende rich in ferrous iron.

Table XVI gives the composition of several amphiboles.

The <u>pyroxene</u> - Under the microscope the idiomorphism of the pyroxene is not so apparent as in the hand specimen, although some individuals show good crystal outline. The mineral shows two good cleavages at right angles and is colorless. The interference figure shows the mineral to biaxial positive with strong inclined dispersion on optic axis B which emerges near (001). The extinction angle, $Z \wedge \underline{c}$ is 41°. The optic axial angle is about 60°. The mineral is common augite with some titanium causing the strong dispersion. Hourglass zoning is noticeable in some crystals.

Table XVI

	I	II	III	IV
SiO_2	34.184	37.49	38.633	39.29
TiO_2	n.d.	0.86	5.053	4.53
Al_2O_3	11.527	10.81	11.974	14.38
Fe_2O_3	12.621	7.52	3.903	2.92
FeO	21.979	25.14	11.523	8.56
MgO	1.353	1.35	10.200	13.01
CaO	9.867	9.77	12.807	11.70
Na_2O	3.290	2.06	3.139	3.05
K_2O	2.286	1.91	1.489	0.98
H_2O	0.348	2.01	0.330	0.36
MnO	0.629	0.95	0,729	0.65
	98.084	99.87	99.762	99.37

I. Ferrohastingsite from nepheline syenite, Dungannon township, Hastings County, Ontario.

II. Ferrohastingsite from nepheline syenite, Almunge, Sweden

III. Femahastingsite from essexite, Mount Johnson, P.Q.

IV. Femahastingsite from Mount Royal, P.Q.

The above analyses are taken from the paper by Billings cited in the bibliography.

The plagioclase is commonly twinned after the albite law but rarely after the carlsbad law. Zoning of the crystals is pronounced and the calcity of the central part is An_{55} while that of the outer rim is An_{33}. The crystals are subhedral, the terminal faces being absent.

Orthoclase is present in small amounts and is interstitial to the euhedral minerals. The indices of refraction are slightly lower tnan canada balsam and the sign of the birefringence is negative. The cleavage of the orthoclase is very poorly developed.

Titanite is an abundant accessory constituent of the essexite. It occurs in crystals showing good wedge--shaped outline in thin section. The indices and birefringence are high and the mineral appears grey between crossed nicols. The optic axial angle is small and has a positive acute bisectrix. The inclined dispersion $\rho > v$ is strong.

Sodalite or Nosean - This mineral has allortiomorphic outlines and is seen as rounded patches. It is isotropic and has low indices of refraction. It may be included in the plagioclase and shows some alteration to sericite along fracture planes.

Apatite occurs in well formed crystals and can be easily recognozed by its low birefringence and high refractive index.

A few small flakes of Biotite showing normal pleochroism are present in the essexite. The biotite is commonly associated with the hornblende and has the same orientation and is probably a product of paulopost alteration.

Magnetite is associated with the dark minerals and occurs either as irregular grains or as euhedral octahedra.

A few small irregular grains of calcite are present in the essexite.

(2) Nepheline Syenite

The nepheline syenite exposed in the thesis area occurs in two generations; the older or dark syenite and the younger or light syenite. Megascopically the two rocks differ greatly in color the older variety being a dark bluish grey whereas the younger rock weathers to a very light grey color. Microscopically the two varieties cannot be differentiated. The rocks are medium to fine grained composed essentially of plagioclase, orthoclase, amphibole, nepheline and biotite with garnet, apatite, sphene iron ores and nosean as accessory constituents. The content of feldspathoidal minerals lends a bluish tint to the color of the fresh rock. Both varieties of the syenite will gelatinize slightly when powdered and treated with dilute HCl and heated. The content of feldapsthoids of the Viewmount syenites is probably not as high as in the syenites from other parts of the mountain for Adams (1) describes them as gelatinizing readily when treated in the same manner.

The exposures at Viewmount have a perceptible vertical fluidal arrangement of the component crystals indicating that, in this place at least, the magma was largely crystalline when magmatic movement ceased.

The older syenite completely surrounds the younger variety and was apparently intruded along the contact of the essexite and limestone. The lighter syenite was intruded in the form of a dike penetrating the older camptonite.

The composition of the rock determined

microscopically is as follows: plagioclase 50%, orthoclase 20%, feldspathoids 10%, amphiboles 10%, others 10%.

Feldspars

The plagioclase occurs in elongated subhedral crystals which are strongly zoned and vary in calcity from An 35 at the centre to An 12 at the outside. The crystals are twinned after the albite and carlsbad laws, the former being much more common. The crystals often lack terminal faces and are mantled by orthoclase in the direction of elongation. There is very little difference in refractive index between the sodic plagioclase and the orthoclase, although the former is slightly higher as determined by the Becke line. The line of separation between the two minerals is easily seen between crossed nicols, the orthoclase having no albite twinning and having slightly lower birefringence. A microperthitic intergrowth of sodic plagioclase and orthoclase is also present in a few crystals indicating that the orthoclase commenced to crystallize before the cessation of crystallization of the plagioclase. The plagioclase in the microperthite has a composition of An 20. The orthoclase may be distinguished from the nepheline by its biaxial character and (001) and (010) cleavage although the latter feature is not always well developed. It can be brought out by etching with dilute HCl.

Feldspathoids

Nepheline occurs in allotriomorphic grains interstitial to the crystals of plagioclase, orthoclase and amphibole. It can be distinguished from the feldspar by etching thus bringing out the cleavage in the latter which may be very porrly developed. An isotropic material with low refractive index and very similar in all respects as that described as sodalite or nosean under essexite, is also present in the nepheline syenite. It occurs as rounded grains and shows alteration to sericite along fracture planes. The nepheline shows similar alteration.

Amphibole

This mineral differs slightly from that of the essexite in that the crystals are composed essentially of the variety ferrohastingsite with a small core of femahastingsit In a few crystals a small core of magnesiahastingsite is noted. Many of the smaller crystals are composed entirely of ferro--hastingsite. The properties of the ferrohastingsite in the nepheline syenite are the same as those already described for that occurring in the essexite. The crystals are euhedral and occasionally show simple twinning parallel to (100).

Garnet is present in euhedral crystals. It is pale brown in color and is isotropic. It has no cleavage but is strongly fractures. Numerous small inclusions of biotite, amphibole, feldspar and apatite are seen in the garnet. The inclusions have no definite orientation. On the weathered surface of the syenite the garnets appear as small black spots.

Apatite is the most abundant accessory constituent of the nepheline syenite. It occurs in the form of euhedral crystals with negative elongation. It can be easily recognized by its moderate indices of refraction and low birefringence.

Titanite is a common accessory constituent of the syenite but is not as abundant as in the essexite. The crystals are smaller but show the same wedgeshaped outline in thin section.

Biotite is present in small amounts and is a product of paulopst alteration of the amphibole and is invariably associated with it having the same orientation. Sericite is a common alteration product of the feldspathoid minerals.

(3) The Breccias

All the igneous rocks of the Viewmount area with the exception of the essexite form breccias. Fragments of essexite are found in all later plutonic intrusives. Brecciation is most pronounced near the contacts but occasional fragments are found scattered throughout the intrusive masses. This is particularly noticeable in the rusty camptonite. The fragments of all the breccias are angular to subangular with sharp boundaries against the matrices showing little or no assimilation.

The Older syenite breccia

This is the most widespread breccia of the thesis area. Near the limestone contact fragments of limestone are numerous while near the contact with the coarse essexite, that rock forms the bulk of the inclusions together with fragments of yamaskite and camptonite. The limestone and essexite fragments in the breccia are very similar to those previously described, but the yamaskite is foreign to Mount Royal although Montrealite, a similar rock containing olivine, outcrops on Cote des Nieges Road 300 yards west of Viewmount Avenue. It is possible that the yamaskite fragments represent a local facies of the essexite for segregation of the dark minerals was noted in the coarse variety which outcrops in the northeast corner of the area. A thin section of the yamaskite was studied and the microscopic determination of the constituent minerals was as follows.

Amphibole

This mineral occurs in subhedral crystals with absorption $X < Y = Z$ giving pleochroism X pale yellow, Y and Z dark brown. Brown section with no pleochroism giving parallel extinction give a good acute bisectrix inter--ference figure indicating that $Y = \underline{b}$ and that the axial plane is parallel to (010). The interference figure shows medium dispersion $\upsilon > \rho$ with 2V 70^o to 80^o. The extinction, $Z \wedge \underline{c}$, is 24^o thus confirming the mineral as magnesiohastingsite. It differs from the amohibole of the essexite and syenite in that it shows no zoning.

The pyroxene is very similar to that occurring in the essexite and already described as augite. It is colorless, biaxial negative with strong inclined dispersion on optic axis B, and with extinction $Z \wedge \underline{c}$ 43^o. The strong dispersion may be accounted for by the high content of TiO_2.

Magnetite occurs in irregular grains scattered throughout the rock and apatite is present in euhedral crystals. The plagioclase is in very small irregular grains interstitial to the ferromagnesians and is recognozable only by its twinning and birefringence. The calcity could not be determined.

A Rosiwal analysis of the section gave amphibole 47.3%, pyroxene 46.9%, apatite 1.8%, magnetite 2.6%, plagioclase 1.5%.

Camptonite Breccia

This breccia is characterized by a matrix of rusty weathering camptonite. The fresh material is black and contains considerable pyrite. The included fragments are essexite, yamaskite, dark syenite and occasionally older camptonite which can be distinguished from the matrix by the absence of pyrite. Toward the centre of the intrusion the camptonite is massive with very few inclusions, but near the contacts with the syenite to the east and the essexite to the west there is strong brecciation. The camptonite was intruded along the contact with the older syenite and essexite because the included fragments at the eastern contact are chiefly syenite whereas at the western contact with the essexite the fragments are chiefly essexite.

A thin section of the camptonite matrix shows the following minerals: plagioclase 70%, biotite 15%, pyroxene 5%, iorn ores 5%, others 5%.

The plagioclase occurs in lathshaped individuals, strongly zoned and ranging in composition from An 55 to An 22. Twinning after the albite and carlsbad laws is common.

The pyroxene occurs in irregular grains totally lacking in crystal outline but showing the characteristic pyroxene cleavage. It is colorless, biaxial positive with inclined dispersion $\rho > v$. The extinction $Z \wedge \underline{c}$ is 38^{o}.

The biotite is present in small irregular flakes showing intense pale yellow to dark brown pleochroism It is commonly associated with the pyroxene.

The pyrite occurs in irregular grains scattered through the rock and apatite is present in small crystals. A few wedgeshaped crystals of shpene are also present. Calcite grains are scattered through the rock and are easily recognized by their strong double refraction. A small amount of sericite is present as an alteration of the plagioclase

Younger Syenite Breccia

The younger syenite is much lighter in color than the older syenite. The brecciation in the younger syenite is not pronounced but occasional fragments of essexite and older camptonite (rusty weathering variety) are found. The camptonite breccia already described is cut by numerous small veinlets of the younger syenite. Occasional fragments of the camptonite breccia are found in the syenite.

Tinguaite Breccia

Cutting the younger syenite is a tinguaite intrusion very strongly brecciated, the included fragments being essexite, yamaskite, camptonite and younger syenite. The tinguaite matrix weather to a greenish grey color in contrast to the rusty brown of the included camptonite. The fresh tinguaite is much darker in color. The contact of the tinguaite and syenite is very sharp.

(4) Dike Rocks

Two types of dike rocks are found in the thesis area : nepheline syenites and lamprophyres. Two dikes of nepheline syenite were found cutting the essexite. They are light grey in color and similar in all respects to the younger nepheline syenite already described. The lamprophyres all cut the limestone and therefore their age relationships with respect to the plutonics could not be determined. The dikes vary in width from 2 inches to 20 inches and are almost black in color. They are very fine grained and occasionally porphyritic, the phenocrysts being hornblende and pyroxene. No minerals with the exception of the phenocrysts can be recognized in the hand specimen. The dikes all strike in a general north-south direction but the dips vary from 75° east to 30° west and do not follow a definite system. Some of the dikes contain fragments of the adjacent limestone.

By a microscopic study it is possible to divide the lamprophyres into two major types: camptonite and fourchite. The former are by far the more numerous and of the eight thin sections examined seven were found to be varieties of camptonite and one fourchite. Three types of camptonite can be recognized.

<u>Camptonite variety #1</u>

Only one thin section of this type was examined and the rock was found to contain as essential constituents plagioclase 30%, amphibole 60% with accessory minerals titanite, apatite, iron ores and sodalite 10%.

The plagioclase occurs both as subhedral crystals and allotriomorphic grains, the latter being interstitial to the amphibole crystals. The plagioclase crystals are strongly zoned and range in composition from An 20 to An 48. The more sodic material is found as the allotriomorphic grains and also as margins of the crystals. The calcis plagioclase is found only in the centre of the zoned crystals.

The amphibole is present as elongated, subhedral crystals and as angular fragments ranging in composition from a magnesiohastingsite with absorption $X < Y = Z$ giving pleochroism X brownish yellow, Y and Z deep brown, to a green pleochrois amphibole vary similar to the femahastingsite described under essexite. The femahastings-ite occurs either as the small irregular grains or as narrow rims around the crystals of magnesiohastingsite.

The apatite and titanite occur as small euhedral crystals and the iron ores as small irregular grains scattered throughout the rock. The sodalite or nosean forms a few small irregular patches which have a low refractive index, are isotropic and are slightly altered to sericite.

Camptonite variety # 2

This camptonite is characterized by a higher content of feldspathic constituents than variety # 1, the percentage ranging from 40 to 65 in the various thin sections examined. Amphibole is presentbin varying amounts from 10% to 35%, and pyroxene may be present up to 30% but a lower content (20%) is more usual. Biotite varies in amount from 0% to 20% and titanite may be present up to 5% of the rock. Accessory constituents are titanitem apatite, calcite and iron ores. Under the microscope the rocks is similar to the essexite except that it is much finer in grain.

The amphibole is present in strongly zoned crystals varying in composition from a magnesiohastingsite at the centre to a femahastingsite at the outside. The magnesiohastingsite has pleochroism X pale yellow, Y and Z deep brown. The extinction, $Z \wedge \underline{c}$ is 20^{o}. The fema--hastingsite has pleochroism X pale yellow, Y and Z deep green with extinction, $Z \wedge \underline{c}$ 17^{o}. The femahastingsite is present in much smaller amounts than the magnesium variety and is found either as a narrow rim around the crystals of magnesiohastingsite or as a rection product of the pyroxene.

The plagioclase may be present either as subhedral crystals or as allotriomorphic grains. The calcity ranges from An 25 to An 60. Albite twinning is common in some of the section examined but id totally absent in others.

The pyroxene is usually present as small grains showing two good cleavages at right angles. In the larger individuals a slight zoning is noticeable. The interference figure shows a positive birefringence and inclined dispersion, $\rho > v$

The biotite occurs as irregular flakes

The biotite occurs as irregular flakes showing good cleavage and straight extinction. It may or may not be associated with the dark minerals.

Titanite when present, shows the typical wedgeshaped outline in this section and the iron ores are in the form of irregular grains scattered through the rock. The apatite is invariably euhedral whereas the calcife is always found as irregular grains easily distinguished by their strong birefringence.

Camptonite variety # 3

This camptonite is a highly altered porphyritic rock, the phenocrysts of original hornblende being represented by aggregates of irregular flakes of biotite with magnetite. Other rounded aggregates of sericite, koalin and calcite probably represent original feldspar phenocrysts. The groundmass of the rock is composed essentially of 60% feldspathic material, 20% amphibole, 10% pyroxene, 5% biotite with apatite, titanite, calcite and iron ores as assessory constituents. The rock is very fine grained the average grains size of the ground mass being 0.03 mm.

The amphibole is pleochroic from light to dark brown with extinction up tom20^{o} on the cleavage. The pyroxene has medium indices of refraction, iscolorless and occasionally shows two cleavages at right angles. The biotite is in irregular flakes with stright extinction.

Apatite can be recognized by its moderate indices and low birefringence, calcite by its high birefringence, and titanite by its wedgeshaped outline. All the minerals with the exception of the apatite and titanite occur as irregular grains.

Fourchite

The fourchite is characterized by a high content of pyroxene with a small amount of analcite present in the groundmass. The average grain size of the rock is 0.05 mm. It is equigranular with the following constituents: feldspathic material 20%, amphibole, 10% pyroxene 60% with minor amounts of accessory constituents including apatite, calcite, iron ores and analcite.

The pyroxene shows two well developed cleavages at right angles, is colorless with moderate birefringence and high indices of refraction. The pyroxene occurs as rounded grains with extinction, $Z \wedge \underline{C}$, 40^{o}. The amphibole is a green pleochroic variety of hastingsite with extinction, $Z \wedge \underline{c}$ 15^{o}. It is present as irregular grains. The feldspar occassionally shows albite twinning and its refractive index is slightly greater than 1.54. The analcite is isotropic with index lower than 1.54. Apatite occurs as small crystals and biotite is present in very small amounts.

SEQUENCE OF INTRUSIONS

The igneous breccias of the thesis area give an excellent indication of the order of intrusion of the various igneous rocks in this section of Mount Royal. The essexite is included in all other igneous rocks with the exception of the small dikes, but contains no inclusions itself, indicating that it was the first rock to be intruded. This was followed by the intrusion of dikes, one variety of which was a black camptonite with little pyrite, for fragments of such a rock are found in the later dark syenite. The dark syenite was intruded along the contact of the essexite with the limestone as is shown by the fact that near the limestone contact fragments of limestone are numerous whereas near the essexite contact the fragments are mainly of essexite.

The older syenite intrusion was followed by that of the rusty weathering camptonite which was intruded along the contact of the older syenite ans essexite. The camptonite contains fragments of essexite, older camptonite and dark syenite. This camptonite was then intruded by a large dike of the younger nepheline syenite which conains occasional fragments of the camptonite breccia. The syenite was then cut by an intrusion of tinguaite for fragments of the younger syenite are found in the tinguaite breccia.

A comparison of the sequence established for the Viewmount area with that of Mount Royal by Bancroft (20) and for Corporation Quarry by Halet (12) is given in the following table.

Mount Royal	Corporation Quarry	Viewmount
Camptonite		
Nepheline syenite		
Camptonite	Camptonite	
Maenaite	Tinguaite	Tinguaite
	Pegmatite	
Nepheline syenite	Neph. Syenite	Neph. syenite
Monchiquite	Fourchite	
Camptonite	Camptonite	Camptonite
	Syenite breccia	Syenite breccia
Tinguaite	Tinguaite porph.	
	Camptonite	Camptonite
Essexite	Essexite	Essexite

Halet expresses some doubt as to the exact correlation of the nepheline syenites of Corporation Quarry with those from other parts of the mountain, but believes that the syenite breccia represents an earlier irruption of the syenite magma, thus making a total of three syenite intrusions for Mount Royal. If the tinguaite intrusions of Corporation Quarry and Viewmount are of the same age the correlation would be as above and the syenites of the thesis area would be the first two intrusions of nepheline syenite in Mount Royal.

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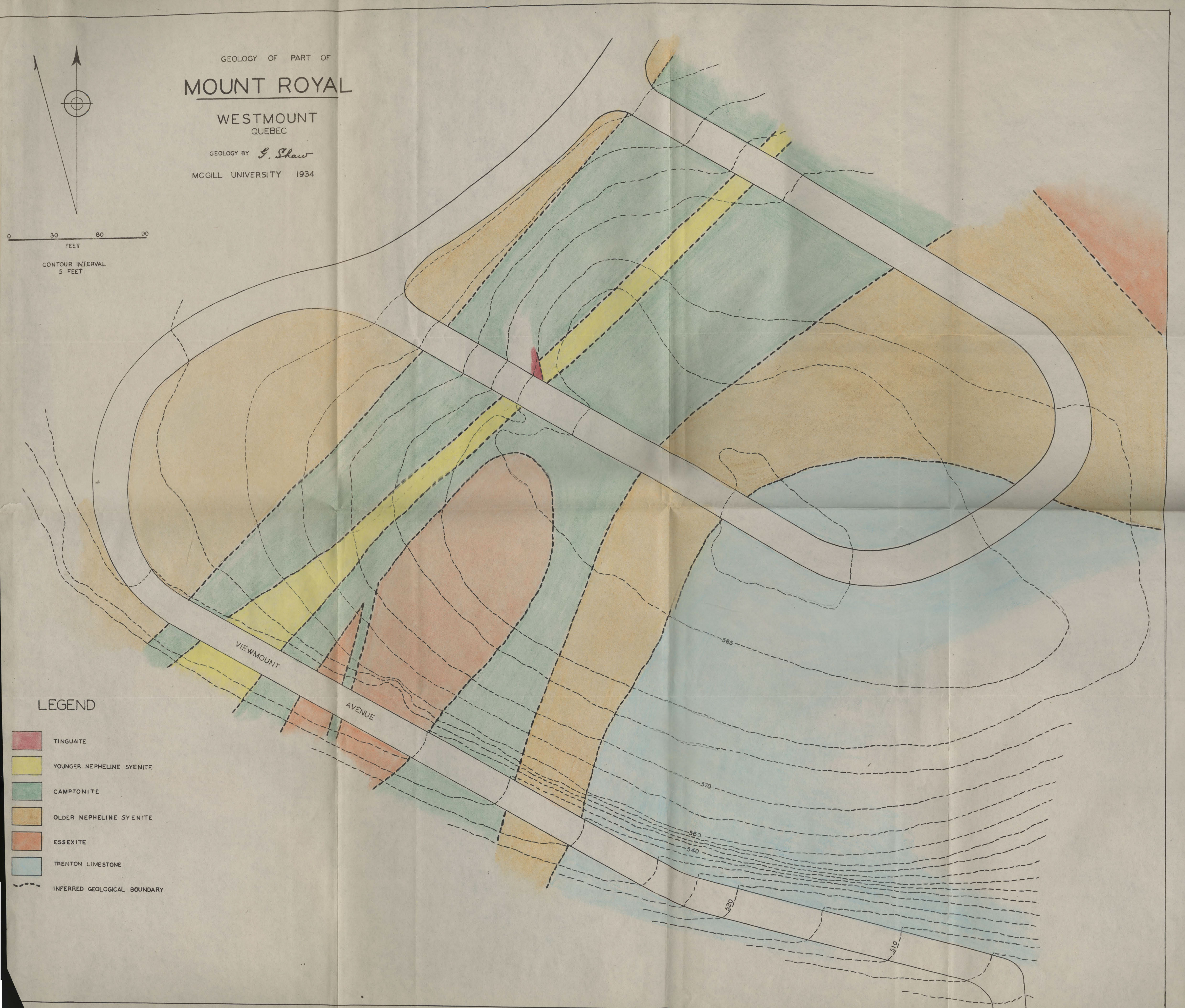
GEOLOGY OF PART OF
MOUNT ROYAL
WESTMOUNT
QUEBEC
GEOLOGY BY G. Shaw
MCGILL UNIVERSITY 1934
0 30 60 90
FEET
CONTOUR INTERVAL
5 FEET
VIEWMOUNT
AVENUE
585
570
540
520
510
LEGEND
TINGUAITE
YOUNGER NEPHELINE SYENITE
CAMPTONITE
OLDER NEPHELINE SYENITE
ESSEXITE
TRENTON LIMESTONE
INFERRED GEOLOGICAL BOUNDARY