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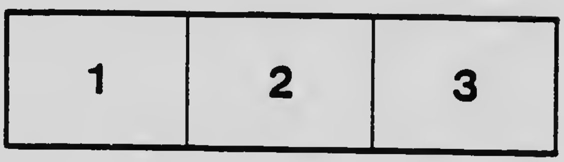

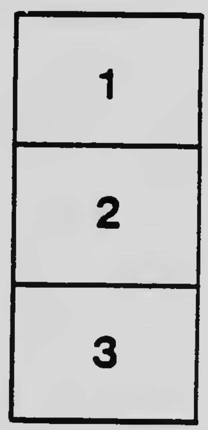

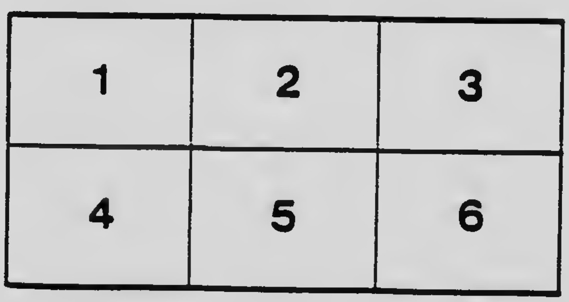

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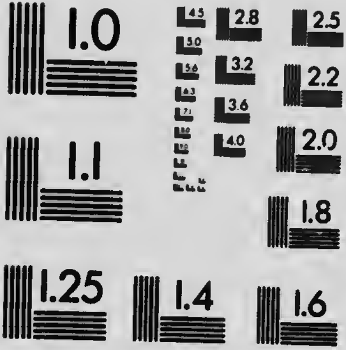

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GEOLOGICAL SURVEY OF CANADA

ROBERT BELL, I.S.O., M.D., D.Sc. (CANTAB.), LL.D., F.R.S.

REPORT

ON THE

GEOLOGY OF BROME MOUNTAIN

QUEBEC

BY

JOHN A. DRESSER, M.A.

OTTAWA
PRINTED BY S. E. DAWSON, PRINTER TO THE KING'S MOST EXCELLENT MAJESTY
1906

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No. 902

To Dr. ROBERT BELL,

Acting Director, Geological Survey of Canada.

SIR,—I have the honour to submit the inclosed report on the geology of Brome mountain, Quebec, together with a map to illustrate the same.

I have the honour to be, sir,

Your obedient servant,

JOHN A. DRESSER.

OTTAWA, Jany., 1904.

CONTENTS.

THE GEOLOGY OF BROME MOUNTAIN, QUE.

JOHN A DRESSER, M.A.

On the western part of the province of Quebec, the basin between the Appalachian hills and the Laurentian highlands is occupied by rocks of Palaeozoic age, which represent the geological scale from Cambrain to the Lower Devonian, both inclusive. The breadth of this basin in the vicinity of Montreal is about eighty miles. Its surface is almost uniformly level, except for the presence of a series of eight hills which rise from 700 to more than 1,000 feet above the plain. Six of these, viz. : Mount Royal, Montarville, Beloeil, Rougemont, Yamaska and Shefford, rise at somewhat regular intervals of about ten miles, and stand in a nearly east and west line. They thus extend for a distance of fifty miles eastward from Mount Royal, and from the city of Montreal, which is situated at its base. Brome mountain and Mount Johnson are respectively two and a half and six miles south of Shefford and Belœil.

Considered physiographically, these hills are of residual origin, having been etched into their present relief by the extensive denudation which the region has suffered. Evidently, the composition and texture of the rocks composing them have offered a much greater resistance to denuding agencies than was afforded by the surrounding strata. They are thus hills of the butte type. Mount Johnson of this series has been selected by Prof. Davis (5) as a subject for illustration of this class of hills.

Geologically considered, these hills have long been known to be of igneous origin, and intrusive in their relation to the palaeozoic sediments of the plain.

For this series Dr. F. D. Adams (1) has recently proposed the aptly-chosen title "Monteregian,"—Mons-Regnis (Mount Royal) being the best known of the group, and this name is likely to obtain permanent currency.

The hills of this series have already received considerable attention from the Geological Survey and reference may be made to reports by D. T. Sterry Hunt (2), Sir William Logan (3) and R. W. Ells (4).

(1) Journal of Geology, Vol. II. No. 3, April-May, 1903.
(2) Geol. Surv, of Can., 1858, pp. 171-187.
(3) Geology of Can., 1863, pp. 656-659.
Geol. Surv. of Can., 1894, pt. J.
(5) Physical Geography, Ginn & Co., Boston, 1898.

In 1901 the present writer completed a brief report on Shefford mountain, which appeared in the 13th Annual Report of the Geological Survey. In addition to the preliminary notices in various reports of the Directors of the Geological Survey a resume of the report was published in the American Geologist for October 1901. The main features of the Shefford mountain, the resemblance of Shefford to Brome and also their probable connexion will be discussed later.

Brome mountain comprises an area of about thirty square miles in the townships of Brome, East Farnham and Shefford, the first and second of which are in the county of Brome, the third in the county of Shefford. Brome, the largest of the Monteregian hills, lies two and a half miles south of Shefford, which comes next in size, the two mountains being the most easterly of the group. In form Brome is rudely circular. The central portion, in the vicinity of Brome pond, which is three-quarters of a mile in length and half as broad, is a nearly level basin about two by two and one half miles in extent, and is generally overlain by heavy beds of clay. This is surrounded by a nearly continuous rim of hills which rise from 600 to 1,000 feet above the altitude of the basin, which is itself about fifty feet above the level of the country surrounding the mountain, or five hundred feet above sea level. Pine Mountain, the highest point in the Brome mass, was found by simultaneous aneroid readings at the base and summit to be 1,500 feet above mean sea level.

The main inlet of Brome pond, which drains the entire central portion of the mountain, is a stream that has settled up a considerable area at the head of the pond.

The source of the lake is, therefore, largely surface drainage. The other ponds, judging from their relatively smaller basins, and from the character of their banks, owe their origin, mainly to subterranean inflow.

Brome has already been shown to be like the other hills of the Monteregian series, an igneous mass intrusive through the Palaeozoic strata. The latter as demonstrated by Dr. Ells belongs to the Sillery division of the Cambrian system on the northeast and south sides of Brome mountain, and on the west to the Mystic series D 2b, of the Upper Chazy. The intrusion of the mountain, therefore, took place subsequently to the Chazy period. The latest time at which it could have been formed is less definitely indicated, by the fact that the igneous rocks of the mountain are somewhat foliated and have in places an incipient, schistose structure. This, though less schistose, is parallel in direction with the foliation of the surrounding sediments, and represents a late stage in the folding of the Appalachian uplift.

This foliation does not occur in the Permo-Carboniferous of the maritime provinces; Brome Mountain must therefore have been formed after the deposition of the upper Chazy sediments and before the close of the Carboniferous period. This age-limit virtually agrees with that of the adjacent intrusion of Shefford Mountain, which shows similar dynamic metamorphism, but cuts slightly later strata, viz: the Farnham black slates, (D 3a,) a division of the lower Trenton. The slates however, do not occur at Brome. The igneous rock of Brome Mountain is concealed in many places by outliers of sedimentary rocks, which agree in character, as far as could be ascertained, with the stratified rocks of the surrounding district. The outliers are generally of small extent, and occur at places where they are protected from glaciation, or where, for other reasons, denudation has not been severe. Their altered character, as well as other evidences, prove the igneous part to be intrusive, and their position indicates that the igneous rock of the mountain formed a laccolith, rather than an actual volcano.

The writer's researches at Shefford Mountain have shown that mass, also, to be laccolithic. There, the strata shows an arched position, and the highest part of the igneous portion of the Mountain is overlain by a cap of sedimentary rock, the Trenton slates, having an area of about a quarter of a square mile which is invaded by dikes from the underlying intrusives, which are themselves of two different ages of intrusion.

Dr. Adams has demonstrated that Mount Johnson (*Op. cit.*) is a true volcanic neck; Mount Royal has been shown to have in all probability a similar origin (Canadian Record of Science). In regard to Mount Royal, Mr. J. S. Buchan has recently (Canadian Record of Science) raised the question of the possible laccolithic structure but did not pronounce decisively upon it.

The field evidence of the relations of these rocks is not altogether conclusive. Though the district is hilly, exposures, owing to the thick covering of drift, are infrequent and the country is often heavily wooded. In the only contact found between the first and second intrusions the syenite was evidently intruded later than the essexite, fragments of which it contains and into which it sends off apophyses. This contact exposed at intervals for about a quarter of a mile can be seen in crossing the eastern ridge of the mountain through the notch nearest West Shefford station. Except in one small exposure on what is locally known as Collier's hill, there were no evidences of a transition from one rock to the other.

At the top of some of the highest hills, as at Iron hill for instance, the syenite becomes finer in texture, in others, as on the northwest side of Collier's it becomes porphyritic. No such variation was detected in the essexite. These facts, together with the relative positions occupied by the two rocks, lead to the deduction that the syenite has been injected largely between the previously formed essexite and the overlying sedimentary rock, and consequently, that the essexite is covered in many portions of the present surface by syenite. In further support of these views, hornstone and other sedimentary fragments were frequently found resting on the syenite, but not on the essexite.

The relations of the tinguaite to the surrounding syenite are very obscure. The contact is everywhere covered, and no traces of transition could be discerned towards the margin of the mass, or in the surrounding rock. It might represent the pipe of a volcano, if the mountain were once an active one, but on other grounds, this does not seem likely. Moreover no evidences of flow structure could be found in the tinguaite, which should, on the hypothesis of its being a volcanic vent, show an upward movement in the cooling lava. A dike of trachytic type, which cuts the syenite near the foot of Brome pond, could, conceivably, be a differentiated off-shoot from the tinguaite mass. It should also be added that the corresponding rocks in Shefford mountain, which is scarcely three miles distant, and probably connected with Brome at no great depth, are undoubtedly separate intrusions.

The igneous rocks of which Brome mountain is essentially composed are of three principal types, each of which is probably the product of a separate irruption. There are also several different facies of two of these types, which are the results of magmatic differentiation in the individual masses. The rock of the first intrusion ranges from essexite to theralite. The rock of the second is of a syenitic character and passes, by the loss of accessory quartz and the addilum of nepheline, from nordmarkite to nepheline-syenite. The third and latest irruption seems to have been much smaller in volume, shows very little variation and has the characteristics of a tinguaite. The structure is that of an effusive rock and, from its microscopical and chemical properties is classed as a phyro-laurdalose. The distribution of these rocks is best shown by the accompanying plate.

The essexite is a massive rock, gray in colour and weathering to a dull brown. Its structure is granitoid and its texture medium. Feldspar and small amounts of dark minerals, chiefly hornblende, mica, and iron ore can be seen by the unaided eye.

In the thin section feldspar is found to constitute fully 90 per cent of the rocks in parts that are considered typical, the remaining constituents being pyroxene, olivine, and biotite with accessory magnetite, and apatite. Hornblende enters into the composition of many parts of the rock in amounts quite equal to pyroxene, but in some cases is altogether wanting.

The structure in general is hypidiomorphic granular. Plagioclase feldspar is by far the most abundant constituent of this rock. It is twinned according to the albite law in broad lamellae which extinguish symmetrically at an angle of 40 degrees, or more. Hence it is bytownite or a basic labradorite. A few rather large crystals with rhombic outlines are banded by the coarse microperthitic intergrowths and so form a separate feldspathic constituent.

The hornblende is trichroic, the scheme of absorption being $\mathfrak{C} < \mathfrak{B} > \mathfrak{A}$ with $\mathfrak{B}$ nearly equal to $\mathfrak{C}$. The colour ranges from chestnut to yellowish brown. The maximum angle of extinction observed $\mathfrak{C} > \mathfrak{C}$ 20°.

The principal augitic constituent is slightly dichroic. Sections having $\mathfrak{C}$ or $\mathfrak{B}$ parallel to the plane of the polarizer are gray, or grayish green, while those having $\mathfrak{A}$ in a similar position are flesh-coloured. Much of the mineral, however, shows no pleochroism whatever. The angle of extinction, was found to be as high as 45 degrees. The augite is commonly intergrown with hornblende in a very intricate manner. These zones are distinguished by slight differences in their angles of extinction, due, apparently, to minute variations in the chemical composition in the mineral. In a few sections, small grains are seen which seem to belong to another variety of augite. They show a difference from the last in their polarization colours, which can hardly be accounted for by mere difference of orientation. They are, however, too small to admit of satisfactory determination and are quite unimportant in amount.

Biotite is present in irregular areas having imperfect crystallographic outlines.

Sphene is prominent, its idiomorphic outlines indicating a comparatively early crystallization.

The olivine is nearly colourless, and is serpentinized along cracks of the primary mineral. It crystallized earlier than the pyroxene.

Nepheline is represented by a few areas of secondary material occupying interstices amongst the other minerals.

Apatite occurs in needles, and, with magnetite, was the earliest constituent of the rock.

The order of crystallization of the minerals has been approximately as follows:—magnetite, apatite, sphene, olivine, pyroxene, hornblende, biotite, plagioclase, orthoclase, nepheline.

From the foregoing description the rock is, therefore, best classed with the essexite group in the Rosenbusch classification. Chemically considered it differs from the type of that group, as the following analysis by Mr. M. F. Connor, shows, in possessing less silica and greater amounts of alumina and lime. This follows naturally from the preponderance of lime-soda feldspar which characterizes the rock. Its varietal determination is, therefore, a lime-feldspar rich essexite.

For purposes of comparison the related rocks of Shefford and Mount Johnson are also quoted.

An analysis of the essexite from Brome is given under I in the following table—II is an analysis of essexite from Shefford mountain,—III, of essexite from Mount Johnson and IV, of essexite from Salem, Mass., which is the type occurence of essexite.

—	I	II	III	IV
$Si\ O_2$	44·00	53·15	48·85	47·94
$Al_2\ O_3$	27·73	17·64	19·38	17·44
$Fe_2\ O_3$	2·36	3·10	4·29	6·84
$Fe\ O$	3·90	4·65	4·94	6·51
$Mg\ O$	2·30	2·94	2·00	2·02
$Ca\ O$	13·94	5·66	7·98	7·47
$Na_2\ O$	2·36	5·00	5·44	5·63
$K_2\ O$	·45	3·10	1·91	2·79
$C\ O$	—	·39	—	—
$Ti\ O_2$	1·90	1 52	2·47	·20
$P_2\ O_5$	·20	·65	1·23	1·04
$S\ O_3$	—	·28	—	—
Cl	—	·07	—	—
$Mn\ O$	0·08	·46	·19	—
$Ba\ O$	—	·13	—	—
$H_2\ O$	·80	1·10	·68	2·04
	100·02	99·84	99·36	99·92

Nordmarkite is a plutonic rock generally of uniform texture, of medium or coarse grain, and gray or reddish gray in colour. It is one of the "Trachytes" of Hunt. In the hand specimen it is seen to be highly feldspathic, the only dark mineral discernible being an occasional speck of biotite.

In the thin section, feldspar is found to make up probably 90 per cent of the entire rock. The remaining constituents in order of relative abundance are,—biotite, pyroxene, hornblende, sphene and apatite. Biotite and pyroxene, and rarely hornblende, may be ranked as essential constituents. Biotite is more than equal in amount to all the other constituents together except feldspar. Occasionally a little nepheline appears, and in other parts a few grains of quartz. Logan gives the specific gravity of the rock as 2.632—2.638 (Geology of Canada 1863 p. 656).

The feldspar has a mottled appearance and generally resembles orthoclase, but on closer examination proves to have a finely laminated perthitic intergrowth in the spotted areas. These areas appear to be more numerous in proportion to the magnifying powers employed.

Consequently, it seems that their number is limited only by the power of the microscope. The feldspar is therefore regarded as kryptoperthite. Logan reported its specific gravity to be 2·575, and gave the following analysis (V) of selected grains:—

—	V	VI
$Si O_2$	65·70	65·90
$Al_2 O_3$	20·80	19·46
$Pe_2 O_3$	—	·44
$Ca O$	·84	·28
$Na_2 O$	6 52	6·14
$K_2 O$	6·43	6·55
$H_2 O$	·50	·12
	100 79	98·89

The biotite is strongly pleochroic in shades of brown. The pyroxene is nearly or quite colourless. The extinction angle in the principal plane rises to 45 degrees.

The hornblende is green in ordinary light, and shows pleochroism, but occurs in amounts so small that its scheme of absorption could not be satisfactorily determined. The other minerals present no features worthy of note. This rock agrees very closely in its essential features with the laurvikite, of Norway, described by Prof. W. C. Brögger. In portions where quartz enters into its composition, it passes into nordmarkite and in many parts is indistinguishable from the rock of that variety in Shefford Mountain. Its resemblance to both of these in chemical composition is shown in the following analysis:—

	VII	VIII	IX	X
$S_1 O_2$	61·77	58·88	65·43	59 96
$Al_2 O_3$	18·05	20·30	16·96	19·12
$Fe_2 O_3$	1·77	3·63	1·55	1·85
$Fe O$	1·75	2·58	1·53	1·73
$Mg O$	·89	·79	·22	·65
$Ca O$	1·54	3·03	1·36	2·24
$Na_2 O$	6·83	5·73	5·95	6·98
$K_2 O$	5·21	4·50	5·36	4·91
$Ti O_2$	·74	—	·16	·66
$P_2 O_5$	·15	·54	·02	·14
$S O_3$	—	—	·06	·08
Cl	—	—	·04	·14
$Mn O$	·08	—	·40	·49
$Ba O$	—	—	—	·12
$H_2 O$	1·10	1·01	·82	1·10
	99·88	100·99	99·86	100 17

Analysis. VI. is of kryptoperthite, from Laurvik, Norway, by Gmelin, described by Brogger (Syenite pegmatitgange" p 524). The kryptoperthite of Brome indicates a mixture having nearly the composition $Ab_3\ Or_2$.

VII. Nordmarkite, Brome, analysis by M. F. Connor.

VIII. Laurvikite, Byskoven, near Laurvik, Norway. Analysis, cited by Rosenbusch in "Elemente der Gesteinslehre."

IX. Nordmarkite, Shefford, analysis by M. F. Connor.

X. Laurvikite " " "

The norm of VII is as follows :

Orthoclase	31·14
Albite	57·11
Anorthite	2·78
Nepheline	0·28
Olivine	0·62
Diopside	3·16
Apatite	0·34
Ilmenite	1·37
Magnetite	2·55
	99·35

The place of the rock in the quantitative classification is as follows :

Class 1, Persalane.

Order 5, Canadare.

Rang. 1, Nordmarkase.

Subrang 4, Nordmarkose.

In structure it is megascopically granitic, and therefore becomes a grano-nordmarkose. It, too, is approximately normative. The chief departure of the norm from the mode is in the alkali feldspars, which in the rock are in the form of microperthite.

(Laurdalose). This rock forms a low rounded hill, chiefly in lot 25 of range 11 of Brome, and occupies an area scarcely one-third of a mile in length, and of nearly equal width. It is a porphyritic rock having a green matrix and a few phenocrysts of light gray colour.

In the microscopic section the rock is seen to be porphyritic and with a felsitic base. The phenocrysts are found to be feldspar, generally of the character of that mineral in the nordmarkose. Typical plagioclase was seen. Some of the phenocrysts appeared to be pure orthoclase, but more possessed the mottled character of kryptoperthite. Areas of granular, feldspathic-looking material are also numerous and are prominent in the cryptocrystalline portion of the rock. Granular ferro-magnesian minerals are also found in some of these aggregates with small amounts of magnetite, apatite, chlorite and a few individuals of biotite.

Sodalite appears in bluish individuals having rounded or polygonal outlines. It is isotropic showing no pleochroism even with a gypsum plate producing red of the first order, yields no interference figure in convergent light and the characteristic dust-like inclusions are noticeable.

The structure is that of a typical effusive rock. Whether it represents a separate irruption through nordmarkose, which entirely surrounds it, or is a sharp differentiation from it, has been impossible satisfactorily to determine. The contact with the adjacent rock is everywhere drift-covered and no dikes of it are found in the surrounding rock, which is also generally drift-covered in the immediate vicinity. As far as could be ascertained in the field it seemed most likely that it was the differentiation product of the nordmarkose magma, and there appears little reason to abandon this view, which however, must at present, remain an inconclusive one.

The character of the rock is shown in the following analysis XI, made by Mr. Connor. The rock is, chemically, closely related to the laurvikose *(pulaskite)* of Shefford, differing chiefly in its degree of crystallization, and it may be the equivalent of that rock in Brome.

—	XI	XII	XIII
$Si\,O_2$	55·68	59·96	56·85
$Al_2\,O_3$	20·39	19·12	21·56
$Fe_2\,O_3$	2·10	1·85	3·44
$Fe\,O$	1·95	1·73	1·14
$Mg\,O$	·80	·65	·85
$Ca\,O$	1·92	2·24	5·26
$Na_2\,O$	9·18	6·98	6·07
$K_2\,O$	5·34	4·91	3·66
$Ti\,O_2$	·60	·66	
$P_2\,O_5$	·06	·14	
$Mn\,O$	·31	·49	
$H_2\,O$	1·50	1·16	·52
	99·83	99·83	99·35

XI, Laurdalose, Brome.
XII. Pulaskite, Shefford, Quebec.
XIII. Lauvrikite, red, Tonsberg, Norway.

The norm calculated from analysis XI is as follows :—

Orthoclase	31·69
Albite	27·77
Nepheline	25·56
Acmite	2·31
Diopside	7·85
Olivine	·24
Ilmenite	1·06
Magnetite	1·86
	98·34
Add H_2O	1·50
	99·84

It is therefore classed as follows :—

Class II	Dosalane.
Order 6	Norgare.
Rang 1	Laurdalase
Subrang 4	Laurdalose.

The structure of this rock is both macroscopically and microscopically, porphyritic, the ground-mass being microcrystalline.

As sodalite is one of the few distinguishable minerals in it, and is indicative of its alkaline character, it may best be designated as a sodalite-bearing felsophyro-laurdalose.

DIKES.

Dikes later than the principal intrusions of the mountains which contain them, are very abundant in some of the Monteregian hills, and, in others, they are almost entirely wanting. Mount Royal and Shefford seem to have been, subsequent to their solidification, shattered by disturbances—which gave rise to the many fissures represented by the dikes, but Mount Johnson does not appear to have similarly suffered.

In Shefford, the dikes are of the camptonite and bostonite varieties, the latter being the later in age. Only five dikes were observed in the Brome mountain, and two of these, at least, being nordmarkite cutting essexite, do not properly come under the category of the later dikes. Of the remainder, two belong to the camptonite class and consist of hornblende and plagioclase feldspar, a few grains of magnetite and, in one case, a little augite. One of these two is marked by a tendency towards idiomorphic structure; the other by a distinct fluidal arrangement of the crystals. One is seen to cut nordmarkite; the other is found in essexite. The remaining dike is allied to the bostonite type. It occurs in nordmarkite, having been intruded later than the body of that rock. No evidence of its age relative to that of the camponite could be obtained.

The scarcity of dikes at Brome, as well as the contact of the igneous with the sedimentary rocks, points to the intrusions of this mountain as having been of no very violent character. The general absence of dikes within the igneous mass of the mountain also indicates since its intrusion, there has been little disturbance.

RELATION OF SHEFFORD AND BROME MOUNTAINS.

The similarity of Brome and Shefford mountains, both in the rocks which compose them, and in their laccolithic structure, combined with their close proximity, seems to point to their being parts of one laccolith. The evidence upon the point is not, however, such as to be wholly conclusive. The greater part of the area between the two mountains is mantled by a heavy bed of post glacial clay, admitting of a few rocks exposures in the intervening distance. The bed of the Yamaska river, which is the lowest depression between the mountains, was carefully examined, but no exposure of igneous rock was found.

In a hill a quarter of a mile distant from Brome and west of the West Shefford Station of the Canadian Pacific Railway, the chief additional evidence is gained. The hill itself which is 1,200 feet long and rises nearly 150 feet above the surrounding land maintains fairly uniform level on the tops and is not over five hundred feet in width. Its sides are quite steep.

The rocks are chiefly bl ck slates and a quartzose sandstone, both characteristic of the Trenton formation in the vicinity. But these are often rusty, as though near an igneous contact, and in several places are cut by narrow dikes, less than half an inch in width, of the nordmarkite or some closely allied rocks. The hill is evidently a lightly covered boss of igneous rock forming a spur of the mountain. The hardening of the sedimentaries by the contact with the underlying igneous mass has probably given it its superior resisting power to the unaltered Trenton, the removal of which has formed the hill.

A smaller though very similar hill oc urs a short distance west of the Shefford mountain, but the most areful examination failed to find any evidence, other than its occur ace, that it is due to intrusive agency.

On the whole, however, it seems probable that Brome and Shefford are merely parts of one great laccolith and that the connecting part between is only lightly covered by palaeozoic sediments. The akerose essexite of Shefford and the hessose of Brome are, then, merely phases of the same mass. The nordmarkose of both form one mass, and the laurdalose of Brome, if a separate intrusion, corresponds to the laurvikose (pulaskite) of Shefford, which, like the former, is in parts also poorly crystallized.

THE CHEMICAL COMPOSITION OF THE MAGMA.

The chemical mean of the three intrusions at Shefford is practically identical with the composition of the laurvikose, while the order of intrusion is: 1st, the most basic differentiate, essexite akerose; 2nd, the acid extreme, nordmarkite nordmarkose; and 3rd, the pulaskite (laurvikose) of intermediate composition.

A comparison of the following tables of analyses of rocks from Shefford mountain shows the Brome specimens to have lower ratios of silica but higher of alumina and lime.

—	II Essexite (akerose).	IX Nordmarkite (nordmarkose)	X Pulaskite (laurvikose).	XIV Mean of II, IX and X.	XV Brome mtn.	XVI Mean of Shefford and Brome.
SiO_2	53·15	65·43	59·96	59·51	54·25	55·47
Al_2O	17·64	16·96	19·12	17·90	22·14	21·17
Fe_2O_3	3·10	1·55	1·85	2·17	2·03	2·07
FeO	4·65	1·53	1·73	2·64	2·66	2·66
MgO	2·94	·22	·65	1·27	1·48	1·44
CaO	5·66	1·36	2·24	3·09	6·77	5·93
Na_2O	5·00	5·95	6·98	5·98	4·95	5·19
K_2O	3·10	5·36	4·91	4·46	3·23	3·52
CO_2	·39	—	—	·13	—	—
TiO_2	1·52	·16	·66	·78	1·23	1·13
P_2O_5	·65	·02	·14	·27	·17	·12
SO_3	·28	·06	·08	·14	—	—
Cl	·07	·04	·14	·08	—	—
MnO	·46	·40	·49	·45	·12	·20
BaO	·13	—	·12	·08	—	—
H_2O	1·10	·82	1·10	1·00	·98	·99
	99·84	99·86	100·17	99·95	100·01	99·89

The akerose and nordmarkose areas of Shefford Mountain are practically equal in extent, and while the laurvikose is much smaller than these, its composition is virtually the mean between the akerose and nordmarkose. Therefore the calculated analysis XIII may be safely taken as representing the average composition of the Shefford mass, as indicated by the section afforded by the present surface.

A rock of the composition of the mean of Shefford would be classed as follows in the quantitative classification :—

Class II. .... Dosalane.
Order 5 .... Germanare.
Rang 3 .... Andase.
Subrang 4 .... Andose.

It stands nearly on the line between persalane and dosalane, the ratio of the salic to the femic minerals being as 85.33 : 12.40.

The mean composition of Brome Mountain, estimated from the areas of the present surface exposures (see col. XV), would be classed thus:—

Class	I	Persalane.
Order	5	Germanare.
Rang	3	(alkalicalcic)
Subrang	4	(dosodic).

The mean composition of Shefford and Brne mountains, similarly estimated, is given in col. XVI.

The position of such a rock in the Quantitative Classification would be as follows:—

Class	I	Persalane.
Order	5	Canadare.
Rang	3	(alkalicalcic).
Subrang	4	(dosodic).

This almost completely agrees with the mean of Brome mountain, and differs but slightly from that of Shefford, which stands almost exactly upon the dividing line between classes I and II.

The general mean of the two hills, as well as that of Brome, thus fall on a part of the Quantitative Classification that has not yet been occupied. Being hypothetical rocks they do not warrant he introduction of a new name, especially as their position can be otherwise definitely indicated.

ECONOMIC GEOLOGY.

The nordmarkose of Brome mountain like that of Shefford, is used for building and might be also employed for ornamental purpose. It is light gray rock, or sometimes fawn coloured, and has been used for the walls of a handsome Roman Catholic Church in West Shefford village. The rock has been quarried on the northern part of the mountain known locally as Gale mountain, and also at Hayes quarry, near the road to Sheffington. The latter quarry about two miles from the railway has furnished the stone used in the construction of the Canadian Pacific Railway bridge over the Yamaska river at Sheffington. Some excellent types of this rock suitable for finer work are to be seen near Iron hill, five or six miles from the railway. This rock disintegrates rapidly on exposed surfaces, where the gradient is steeper than the angle of repose for the detritus. This is due to the absence of any cementing mineral, and gives rise to large bodies of angular feldspathic talus. This is especially noticeable on the south side of Pine mountain, Iron hill. It forms a valuable road metal, and should be more generally used in the vicinity.

These are the chief economic uses of Brome mountain. Certain areas of Nordmarkose might, however, be found so free from dark mineral as to be of use for feldspar.

The name Iron hill is said to have been given on account of the presence of large bodies of that metal, which were supposed to exist in the vicinity and were said to cause a noticeable disturbance of the compass. I found no trace of such disturbance, however, nor any other evidence of the presence of iron in abundance. Joint planes in the nordmarkose on Pine mountain, as in several parts of Shefford, and Brome mountains, are coated with a thin incrustation of iron and have sometimes been mistaken for solid masses of iron as large as the blocks they enclose.

DISTRIBUTION AND EXTENT OF THE MONTEREGIAN SERIES.

It was Sir William Logan's opinion (1) that the distribution of these hills depends on a fold of the palaeozoic strata, which he described as "traceable all the way from Lac des Chats (on the Ottawa river) to the trap mountain of Rigaud."

Recent researches by Mr. O. E. Leroy (2) of this Survey, have, however shown that Mount Royal is probably the western limit of the Monteregian chain, and that Rigaud, like the intervening hill, Mont. Calvaire, does not as previously supposed belong to the series.

Dr. Ells, *loc. cit.*, also has pointed out that Shefford, Brome and Yamaska mountains occur along the contact of the Cambrian and Cambro-Silurian formation. He suggests that they are also on fault lines, which if they follow the direction of contact, must run transversely to the course of the Monteregian chain.

Of the general distribution of these hills Dr. Adams merely says:—"It is highly probable that these ancient volcanic mountains are, as is usual in such occurrences, arranged along some line or lines of weakness or deep-seated fracture."

Owing to the heavy beds of clay by which the region is covered, decisive evidences of disturbance of the strata are difficult, if not impossible, to obtain. Dynamical considerations, however, seem to be corroborative of the probability of a fracture in the direction of the Monteregian chain. For the successive uplifts of the Appalachian axis have crowded the palaeozoic rocks of the St. Lawrence valley against the escarpment of the Laurentian hills at the north. This crowding has been sufficient to crumble the palaeozoic measures along their south eastern border into a fissile mass for several miles from the edge and to tilt them frequently into vertical, if not overturned positions. Hence, it is easy to conceive that their force is sufficient to

(1) Geology of Canada, 1863, p. 9.
(2) Bulletin of the Geological Society of America, Vol. XII, 1901.
Marginal note to the southwestern quarter sheet of the Eastern Townships map of the Geological Survey, 1896.

cause a transverse fracture or, at least, a line of weakness along the line of greatest pressure which would be directly at right angles to the Appalachian axis. This would be especially the case were the elevation of the Appalachian axis slightly greater in the vicinity of Brome and Shefford mountains, than elsewhere. Such a fracture would be greatest at the eastern and least at the western end, which approximately denotes the variation in the size of these hills. Brome is the largest, Shefford the next in size and Montarville and Mount Royal the smallest of the series, except Mount Johnson, which is quite out of the main line and so may depend on a subordinate longitudinal fold. The compression of the sedimentary rocks, it should be mentioned, took place very largely before the intrusion of the Monteregian hills.

The possibility suggested by Dr. Ells, of the Monteregian chain extending across the Appalachian axis, was inferred f macroscopic resemblance of certain rocks of Orford to the syenitic rock (nordmarkose) of Shefford. The distance between Shefford and Brome mountains and Mount Orford—only twenty miles—is the nearest point of approach of the Monteregian chain to the series of hills to which Orford, Owls Head and the other hills of that range belong. Between them is the axis of the first Appalachian, itself an ancient volcanic ridge.

About a mile and a half west of Mount Orford, i. e. towards Shefford, four dikes are plainly exposed in a cutting of the Canadian Pacific Railway. Their proximity to Mount Orford naturally suggested that they were offshoots from that mass, but specimens taken from the dikes seemed to indicate that they more probably belonged to Shefford mountain. Thin sections of each were, therefore, examined under the microscope. The results as the following descriptions show, were negative, and the dikes should, accordingly, be regarded as offshoots from Mount Orford.

I. A mile and a half west of "Orford Crossing", the point from which the ascent of the mountain is usually begun, a dike some ten feet in width appears in the Pre-Cambrian sedimentary mica schists of the locality. It is a reddish brown porphyritic rock showing light grey phenocrysts and irregular rusty red areas somewhat larger than the phenocrysts.

By the aid of the microscope the phenocrysts, which form only a small portion of the rock, are found to be feldspar. Some of the less decomposed show the polysynthetic twinning of plagioclase, but all are too far altered to admit of more definite determination. The groundmass is composed chiefly of feldspathic and ferruginous material, the latter being ap[illegible]ntly ferric iron more or less hydrated and giving the prevail[illegible] to the rock, while the former is in small lathshaped crystals of a later generation than the phenocrysts. They show no flow structure, being arranged as in diabase and having the interstices filled with ferruginous material. There are also a few small grains of a brightly polarizing substance which has not been identified. They are probably the remnants of some decomposed bisilicate.

The rock is thus a much altered porphyrite, probably diabase porphyrite.

II. About half a mile west of this dike there occurs an intrusion of igneous rocks which is exposed for 225 feet along the railway. The greater portion, which is also presumably the older, is a coarsely porphyritic dark green rock which weathers to a brown or bluish-brown. Its most striking feature is the abundance of black hornblende phenocrysts, frequently an inch to an inch and a half in length. In the thin section these appear to be dichroic, the scheme of the absorption being $O = b < A$. The colour ranges from deep to yellowish brown. The angle of extinction in a section, approprimately parallel to the clinopinacoid, measures 18°. Pyroxene phenocrysts are also present in considerable numbers, some of which are of a pinkish shade, but the majority are colourless. Both hornblende and pyroxene phenocrysts show broad rims of biotite and magnetite, due to resorption.

The feldspar crystals, which can be sometimes seen with the naked eye, are found, in the section, to be striated, and to extinguish at angles as high as 34° with the albite twinning plane, thus indicating approximately the composition of labradorite.

Biotite occurs in small individuals not usually well formed, while a large number of small idiomorphic augites make with it, and with the less perfectly crystallized feldspar, a rather finely crystalline groundmass. The rock is thus classed as an augite-diorite-porphyrite.

III. This consists of feldspar, either grey or flesh-coloured, with quartz, biotite, augite and hornblende. It has a granular texture and is somewhat foliated.

In the thin section the feldspar is found to consist of about equal parts of orthoclase and plagioclase. Quartz, which occurs quite abundantly, is often intergrown with feldspar, forming a beautiful granophyric structure.

Biotite is abundant in both basal and prismatic sections. It is sometimes intricately intergrown with hornblende.

Hornblende is less abundant than biotite. It generally has irregular outlines and sometimes enclosed grains of augite. It is probably mostly, but not entirely, uralitic.

The augite, colourless and much decomposed, occurs in less amount than hornblende. In some places scattered fragments extinguish simultaneously, and appear to be remnants of a larger original crystal. A few rather large grains of sphene are found, and calcite appears amongst the secondary constituents.

The rock is, therefore, intermediate between hornblende granitite and quartz-mica-diorite and belongs to the tonalite or grano-diorite type.

IV is a coarsely crystalline rock of a greenish, sometimes almost black colour. In the microscopic section it is found to be holocrystalline, and to have a granitic structure with a tendency towards idiomorphism on the part of the chief mineral constituents. These are essentially plagioclase, augite, biotite, olivine, hornblende and quartz. The accessary minerals are iron and apatite, with secondary calcite and serpentine.

The plagioclase was observed in several instances to extinguish symmetrically on the albite twinning lamellae, at an angle of 35°. Hence it is probably labradorite.

Augite occurs in well formed crystals which are flesh-coloured, or nearly colourless. It is often intergrown with brown hornblende, the latter sometimes forming a border or fringe around an augite crystal. The hornblende is brown and extinguishes at an angle of 14° with the longer axis. The scheme of absorption is $\mathfrak{c} > \mathfrak{b} > \mathfrak{a}$.

Olivine forms the largest individual crystals in the section. They show characteristic high single and double refraction and lines of parting. Along the latter, the mineral has altered to a yellowish green serpentinous decomposition product. In natural light a section is made quite dark by the presence of a vast number of minute, opaque, trichite-like inclusions which appear unchanged in completely serpentinized portions of the olivine and are probably some ore of iron. Alteration to serpentine is observed to have taken place in the centre of an otherwise fresh looking crystal of olivine. In others, the change begins along the lines of parting or around the margin. A little interstitial quartz is to be seen.

The rock is an olivine gabbro, and is essentially similar to the olivine gabbro of Mount Washington river, New Hampshire, contained in a series of typical rocks prepared by Dr. F. D. Adams, of which descriptions were published by the Geological Department of McGill University in 1896.

A comparison of these dikes with what is known of the Mount Orford series on the one hand, and with the rocks of the Monteregian chain on the other, shows them to be closely allied to the former, and quite dissimilar to the latter.

An examination of the copper bearing [1] traps of the Precambrian belt, which lies between the Orford series and the Monteregian chain is in progress at the time of writing. This belt, which forms the ridge of the Appalachian axis, has been examined for a distance of twenty miles southwest of Brome, and forty miles to the northeast without finding a single occurrence of any rocks related to the Monteregian series. In similar volcanics, presumably of the same age, a typical comptonite dike was, however, found by the writer at Lennoxville [2], fifty miles southeast of Brome. A similar dike has been observed by the writer at Richmond [3] about fifty miles east of Brome.

Mr. V. F. Marsters [4] has found typical comptonite on the shore of Lake Memphremagog, about the same distance south of Brome, while Prof. Kemp has recorded [5] the occurrence of a large number of comtonites and bostonites in the vicinity of Lake Champlain, some forty miles southwest of these mountains.

Prof. Kemp deduced from the frequent association of these dikes with alkaline magmas, the probability of a large area of rock of that character being found either in the vicinity or at no great depth within the earth.

A further examination of the area between these chains of hills, and along the line from Brompton lake to the Huntingdon mines, was made. In this distance of twenty miles along the Orford series no rocks of the Monteregian type were found, hence it seems safe to assume that rocks of the type which characterize that remarkable petrographical province do not occur to the eastward of the Sutton mountain, or main Appalachian, axis in this region.

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(1) Dr. F. D. Adams' Report Geological Survey, 1800-1 2.
(2) Am. Jour. Sci., July, 1902.
(3) Canadian Record of Science, Jan. 1901.
(4) American Geologist 1895.
(5) Bull, U. S. G. S., No. 107.