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PETROGENY OF THE MAJOR ACID INTRUSIVES OF THE ROUYN-BELL RIVER AREA, NORTHWESTERN QUEBEC

BY

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Signature of Professor
in Charge of Research...................................

Signature of Chairman of Department
Committee on Graduate Students..........................

PREFACE

This paper co-ordinates the results of a study of the average composition and variations in composition of the major acid intrusives of the Rouyn-Bell River area.

The work was made possible through a fellowship from the Royal Society of Canada and was undertaken during the field season of 1936, with research work carried on in the winter session of 1936-37 at the Massachusetts Institute of Technology, Cambridge, Massachusetts, U.S.A.

In part, the accumulated information corroborates previous work, but some changes of viewpoint are necessary. Therefore a full restatement of all facts obtained has been attempted.

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ABSTRACT

The various phases of the major plutonic masses have been differentiated and mapped. Petrographic examination and chemical analyses indicate that few are true granite and that several are differentiates of a common magma. The Bourlamaque mass, originally a quartz-gabbro, was first injected, and was followed by the tonalites and granodiorites of the other masses. Magmatic solutions, presumably from the same source, locally altered the Bourlamaque quartz-gabbro to an albite-tonalite.

As definite relations between the Syenite Porphyry and the major acid intrusives have never been found before, a detailed description of a dyke of syenite porphyry cutting the Flavrian mass is appended.

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CHAPTER I

INTRODUCTION

GENERAL STATEMENT

In reading over geological literature one will note that at nearly every gold occurrence in the Canadian Shield, the close relation of the deposits to acid igneous intrusives is well established. In most cases, the occurrence of minor sodic dykes and sills has been noted and in many instances commented on*.

* Gunning, H.C., M.Sc. Thesis on the Aldermac Syenite Porphyry, describes it as predominantly albite and containing sodic amphiboles pyroxenes.
Hawley, J.E., Siscoe Gold Deposits, C.I.M.M. Vol. 38, 1932, p.368, mineralization by sodic granodiorite series of intrusives.
Graton, L.C., Hollinger Mine, C.I.M.M. Vol. 36, p.7, 1930, notes occurrence of albitite dykes at the Hollinger and McIntyre Mines.
Ringsleben, W., in the Hollinger Number, Can. Min. Jour., 1935, referring to the albitite dykes states, "further developments may show some relationship".
Bruce and Hawley, Red Lake Area, O.B.M., Vol. 36, pt.3, 1927, say, "The porphyry is characterized by the high content of soda feldspars".
Todd, Kirkland Lake Gold Area, O.B.M., Vol. 37, pt.2, 1928, p.64, "source of the ores appears to have been an underlying granite mass". (The exposed intrusives are K-rich in which deposition is localized by faulting. However alterations indicate an increase of soda relative to potash.)

O'Neill, J.J., Geology of the Beattie Gold Mine, C.I.M.M., 1934, p. 299, Bostonite porphyry 70% oligoclase.
Wright, J.F., Beresford Lake Area, Mem. 169, p.58, "Deposits may have originated from a younger acid magma as yet unexposed". (The later differentiates are rich in soda, and albite pegmatites and granites are also found).

Where chemical analyses of the major intrusives are available, it appears that those to which the gold deposits are related have a high soda content, and those unaccompanied by gold deposits are potash intrusives.

A search of the literature was made and similar relations were found to exist in other Precambrian areas#.

#In Venezuela, Newhouse and Zuloaga (Ec. Geol. Vol. 24, p.797, 1929) have observed the genetic relation of a sodic rhyolite-granite porphyry to the gold deposits. In Southern Rhodesia, A.M. Macgregor, (G.S.S.R., Bull. 17, 1930) draws attention to the association of "grey soda-granites" with the gold deposits. Memoir 1 of the Gold Coast Survey, 1927, gives chemical analyses of associated intrusives which indicate a remarkable high soda content. In the Mysore deposit of India, Smeeth describes the association of soda rich intrusives. F.R. Feldtmann (West Australia G.S., 1927) states that albite porphyries caused mineralization at Kalgoorlie, and the same observations have been made by P.M. Zamiatin and others in the Siberian Precambrian areas. The association of gold with dykes consisting mainly of albite rock has been described by H.W. Turner and John A. Reed, "The East County of the Mother Lode", Min. and Sci. Press, March 2nd, 1907.

If it be recalled that, as Horace Freeman[x] and J.E. Spurr[e] pointed out, sodium sulphide in dilute

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[x] Freeman, Horace; "The Genesis of Sulphide Ores", E. & M.J., Vol. 120, 1925, p.973.
[e] Spurr, J.E., "Alkaline Sulphides as Collectors of Metals", E. & M.J., Vol. 120, 1925, p.975.

solutions is a strong solvent of metallics and silicates; that in primary gold deposits all over the world sulphides are invariably associated with gold; and further as Gilluly[x] points out in a study of an albite granite at Sparta, Oregon, how each later differentiate increases in soda content; The evidence strongly suggests that the sodic intrusives bear an important relation to the deposition of gold.

The widespread relations of minor sodic intrusives to gold-sulphide deposits in the Canadian Shield and other Precambrian areas has been indicated. Some important differences exist in the major intrusives, and might be found to bear some significant relation to the location of mineral deposits. Thus it is apparent that we need to know a great deal more about the average composition and variations in these major igneous masses. The problem is to supply this information and to attempt to draw conclusions as to differences in source, origin, and age, i.e., to establish the source of differentiation.

This is the first point that needs study, and the Rouyn-Bell River area of Northwestern Quebec was chosen for the purpose. In this area there has been

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x Gilluly, James; "Replacement Origin of the Albite Granite Near Sparta, Oregon", U.S.G.S. Prof. Pap. 175-c, 1933, pp. 65-81.

extensive mapping and recent revision so that the whole region has now been mapped in detail showing all the large batholithic masses and many of the minor intrusives. A wealth of material is available, and ideal sections could be selected and studied.

There are numerous batholithic exposures of different relative ages as well as minor intrusive sills and dykes. Distribution of the gold-sulphide ore deposits in the area indicates a definite relationship to certain of these and a study of available information suggests that they are the sodic masses in the area, the others being K-rich. This however could not be accepted as proved.

LOCATION AND ACCESSIBILITY

The area under discussion lies between north latitudes 48° and 49°, and extends from the interprovincial boundary to west longitude 76°45'. The area includes approximately 6,000 square miles and is covered by a four mile to an inch geological map*, (in pocket) and several detailed outcrop maps on a scale of one mile to an inch.

Excellent water routes provide ready access to within a few miles of almost any locality. New roads and railways are rapidly providing a better means of travel from point to point.

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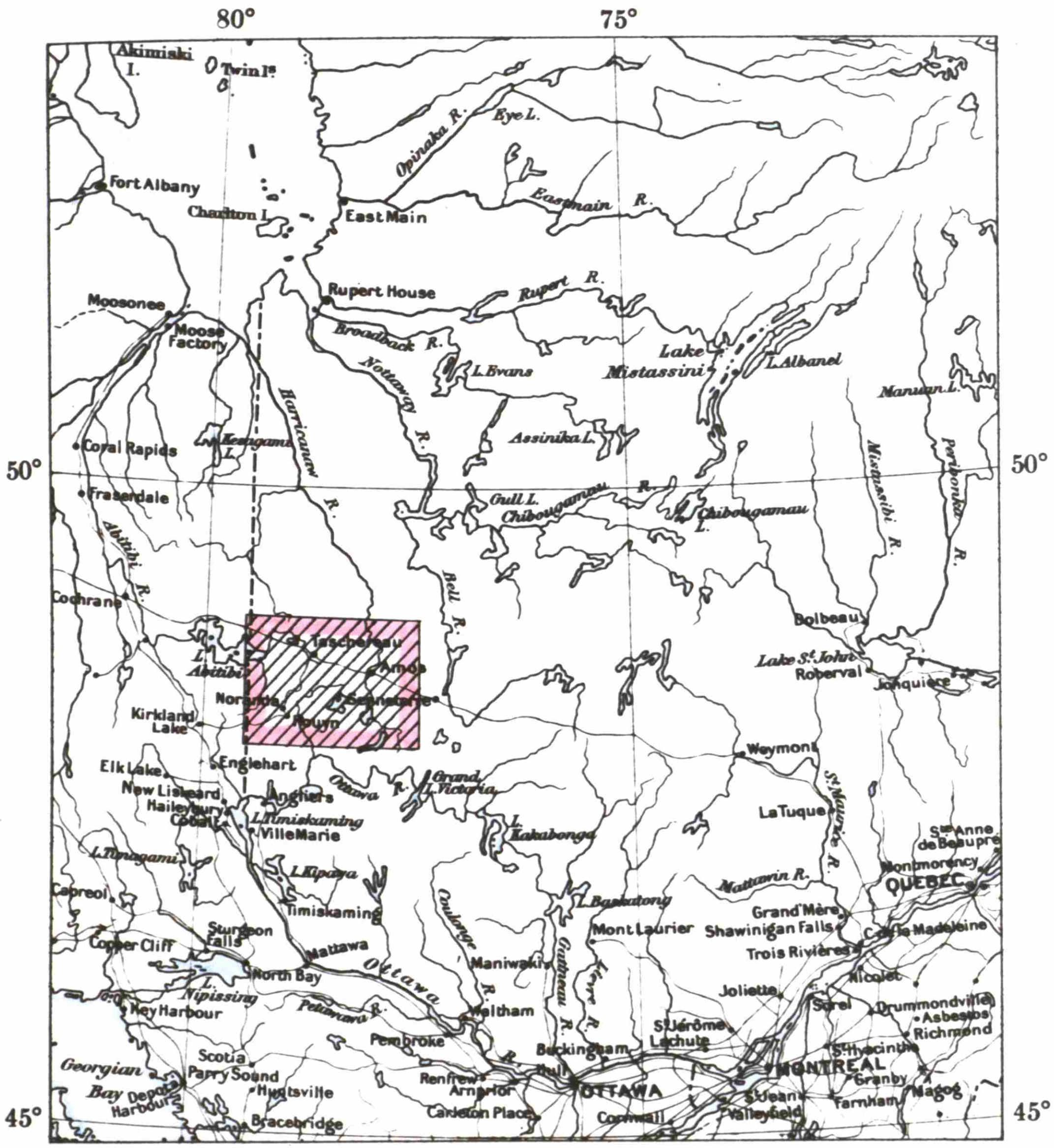
* Rouyn-Bell River Area, Quebec, G.S.C. Map 328A, 1936.



MAP SHOWING LOCATION

ACKNOWLEDGMENTS

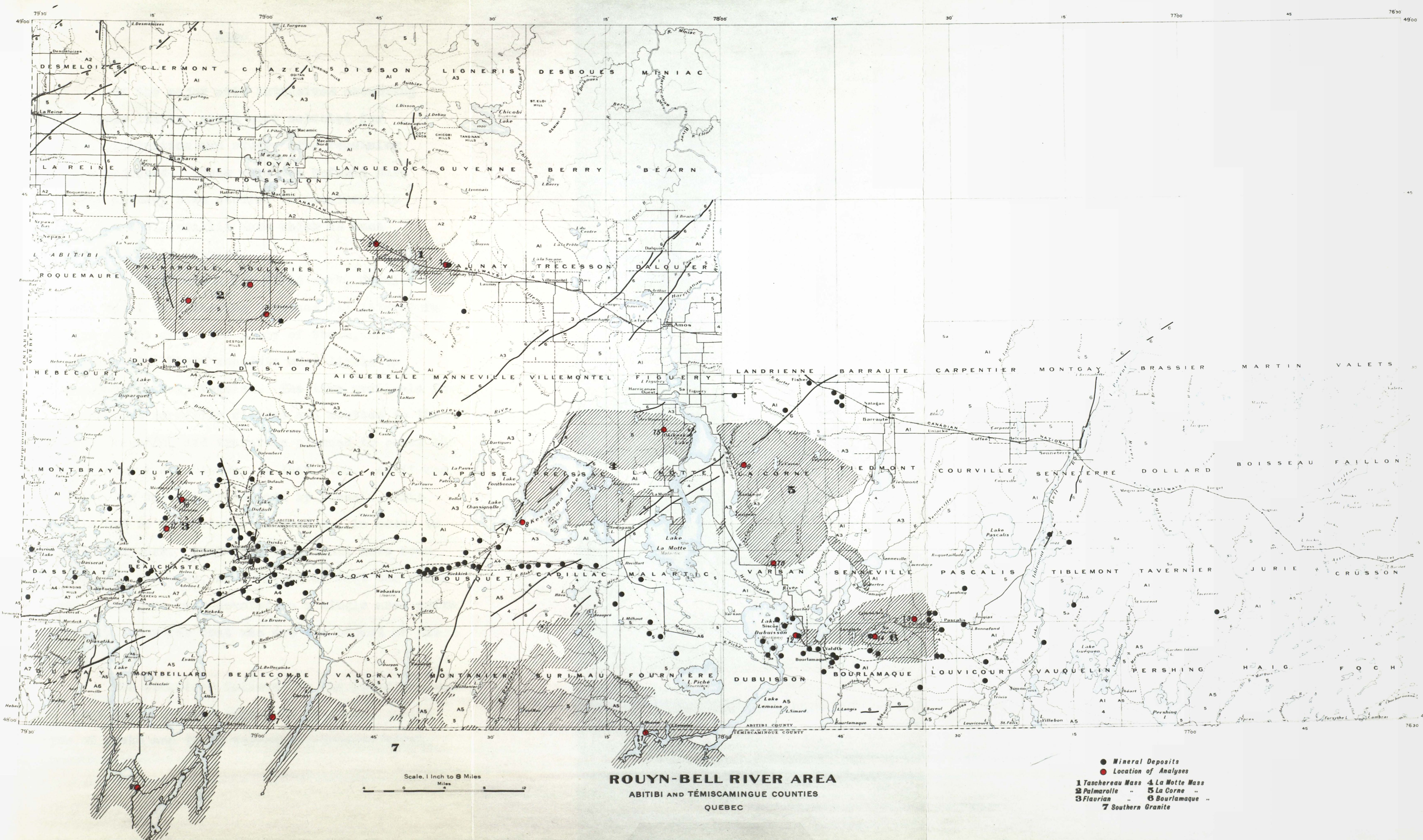
The author is greatly indebted to the Geological Survey of Canada and the Quebec Bureau of Mines without whose adequate geological maps this work could not have been carried out in so short a time. The Canadian Survey further aided in providing a complete field equipment for the summer.

To the Massachusetts Institute of Technology the author is indebted for assistance received during the winter sessions, and grateful acknowledgments are also made to Dr. H.C. Gunning who suggested the problem and supervised the work, and to the staff of the Department of Geology, Massachusetts Institute of Technology, for valuable suggestions and criticisms.

Thanks are also due to Dr. J.E. Hawley of Queen's University, for the loan of thin sections and unpublished manuscripts; to Dr. A.F. Buddington of Princeton University; and to Dr. E.S. Larsen of Harvard University.

FIELD WORK

The region studied was further limited to that lying south of the Canadian National Railway, and between the Ontario boundary on the West and the Bell River on the East. This was made necessary in order to complete the field work in one season.


ROUYN-BELL RIVER AREA
ABITIBI AND TÉMISCAMINGUE COUNTIES
QUEBEC
Scale, 1 Inch to 8 Miles
Mineral Deposits
Location of Analyses
1 Taschereau Mass
2 Palmarolle "
3 Flavrian "
4 La Motte Mass
5 La Corne "
6 Bourlamaque "
7 Southern Granite
DESMELOIZES
CLERMONT
CHAZEL
DISSON
LIGNERIS
DESBOUES
MINIAC
LA REINE
LA SARRE
ROUSSILLON
LANGUEDOC
GUYENNE
BERRY
BÉARN
PALMAROLLE
POULARIES
PRIVAT
LAUNAY
TRECESSON
DALQUIER
ROQUEMAURE
HÉBÉCOURT
DUPARQUET
DESTOR
AIGUEBELLE
MANNEVILLE
VILLEMONTEL
FIGUERY
LANDRIENNE
BARRAUTE
CARPENTIER
MONTGAY
BRASSIER
MARTIN
VALETS
MONTBRAY
DUPRAT
DUFRESNOY
CLÉRICY
LA PAUSE
PREISSAC
LA MOTTE
LA CORNE
FIEDMONT
COURVILLE
SENNETERRE
DOLLARD
BOISSEAU
FAILLON
DASSERAT
BEAUCHASTEL
ROUYN
JOANNES
BOUSQUET
CADILLAC
MALARTIC
VARSAN
SENNEVILLE
PASCALIS
TIBLEMONT
TAVERNIER
JURIE
CRUSSON
DUFAY
MONTBEILLARD
BELLECOMBE
VAUDRAY
MONTANIER
SURIMAU
FOURNIÈRE
DUBUISSON
BOURLAMAQUE
LOUVICOURT
VAUQUELIN
PERSHING
HAIG
FOCH
ABITIBI COUNTY
TÉMISCAMINGUE COUNTY

Of the major acid intrusives occurring within these limits, seven were selected for detailed examination and study: The remaining two were rejected. These were the Dufault Mass which has already been studied in considerable detail, and the Pascallis Mass which is much altered and poorly exposed.

In preparation for field work, considerable time was spent in gathering together all literature and maps on the area, the study of these, and the preparation of a field schedule most likely to produce satisfactory results. The time available for field work was carefully divided and allotted to the different massifs, and traverses planned to cover the greatest number of outcrops in that time. As it was necessary for the writer to work by himself, this schedule had to be strictly adhered to, in order to complete the work. Much more time could have been spent on any one mass, as a matter of fact the whole summer could have been devoted to a single area quite profitably. However that was not the object of the problem.

The procedure followed in the field was, on the first day a general survey of the area, noting types of rocks and their relations, contact zones, degree of metamorphism, etc. This was followed on succeeding days by carefully planned traverses to the outcrops indicated by the published maps of the surveys, in order to define the distribution of the various phases. Sometimes hours would be spent on a single outcrop studying significant features or peculiarities, or some variations in a rock type: At other times the rocks would be monotonously the same and traverses would average twenty miles or more. Suites of rock specimens were collected to show the point-to-point variations in the rock, and finally from a megascopic study of these, representative localities were selected for sampling the various phases. Where possible, samples were taken in rock cuts or from exploratory drilling. Where this was not possible, they were obtained by blasting away the weathered surface.

Because of the coarse granitic texture, five-pound samples were collected for chemical analysis. These were obtained by quartering down some twelve cubic feet of fresh rock, broken into fragments from the size of hen's eggs to dust particles. In each case, hand specimens and chips were taken for laboratory study. At least one sample was collected of each phase represented in each individual massif.

CHAPTER II

GENERAL GEOLOGY

GENERAL STATEMENT

As given in Memoirs and Reports of the Geological Survey and the Quebec Bureau of Mines, and supplemented by more recent work and personal observations during the past summer, the regional geology is as follows:-

The Rouyn-Harricanaw Area is a belt of Keewatin volcanics and younger sedimentary rocks, broken here and there by irregular areas of granitic rocks, and traversed by a series of parallel dykes. It is bounded to the north, south and east by regional granite batholiths and gneisses extending for several hundreds of miles.

Most of the belt is composed of the Keewatin Series, largely lavas with minor amounts of sedimentary material. Next in age are the Timiskaming sediments, extending in a broad east-west belt along the southern margin of the Keewatin volcanics.

Following deposition of the Timiskaming there was a great period of folding and igneous intrusion. The intrusives are of considerable variety but are chiefly plutonic.

A great period of erosion followed, a lapse of time so great that thicknesses of older rocks estimated at three to five miles were removed exposing the plutonic rocks. On the resultant peneplain was deposited the Cobalt series, only a small remnant of which now occurs in the southwest corner of the area. Here it is in direct contact with the intruded Timiskaming and the Truncated Southern granite batholith.

The youngest intrusives in the area are olivine diabase and quartz diabase dykes. The former are known to cut the Cobalt Series, and age determinations by the Helium-Thorium method have established their age as early Keweenawan*. As these are the youngest rocks of the region, they naturally limit all the older rock to the Precambrian.

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* Lane, A.C. and Urry, W.D., Ages by the Helium Method, Bull. G.S.A., Vol. 46, P.1115.

TABLE OF FORMATIONS

Quaternary	Post Glacial	Clays, sills, sands.
	Glacial	Boulder clay, morrain.
	Pre-Glacial	Ferruginous conglomerate.
Keweenawan	Dykes	Olivine and quartz diabase.
Huronian	Cobalt Series	Conglomerate, greywacke, arkose.
Pre-Huronian	Intrusives	Basaltic dykes.
		Altered peridotites.
		Syenite porphyry.
		GRANITIC INTRUSIVES.
		Quartz diorite (Older gabbro).
		(Post Timiskaming Folding).
		Diorite porphyry.
		Amphibolite.
	Timiskaming Series	Conglomerate, greywacke, lavas.
	Keewatin Series	Basalts, andesites, rhyolites, tuffs and metamorphosed sediments.

THE MAJOR ACID INTRUSIVES

The seven masses selected for study are, the Taschereau Mass, located on the Canadian National Railway at Taschereau; the Palmarolle Mass, located east of Lake Abitibi; the Southern Granite Mass, along the full length of the southern boundary and extending over a hundred miles to the south; the La Motte Mass and the La Corne Mass, lying on either side of the Harricanaw River south of Amos; the Bourlamaque Mass, lying east of Blouin Lake in Bourlamaque township; and the Flavrian Mass, northwest of Rouyn.

Previous to this investigation, analyses had only been published of the Dufault, La Corne and Bourlamaque masses. These are tabulared below.

TABLE I

PUBLISHED ANALYSES

	I	II	III	IV	V	VI
SiO_2	69.10	69.00	69.15	67.30	58.30	73.13
Al_2O_3	17.90	17.35	16.10	15.95	17.65	15.87
Fe_2O_3	0.72	1.28	1.30	1.75	2.00	0.04
FeO	1.38	1.22	1.50	1.30	3.98	0.96
MgO	1.14	0.75	1.18	0.70	3.60	0.43
CaO	3.44	3.40	2.95	3.68	6.24	2.11
Na_2O	1.16	1.33	1.88	2.88	3.22	4.57
K_2O	5.00	5.48	5.10	4.08	4.54	1.80
H_2O-	....	....	....	....	....	0.19
H_2O+	....	....	....	....	....	0.70
TiO_2	....	....	....	....	....	0.42
P_2O_5	....	....	....	....	....	0.20
Total	99.84	99.81	99.16	97.64	99.53	100.42

	VII	VIII	IX	X	XI
SiO_2	70.41	67.02	57.37	57.00	58.98
Al_2O_3	15.41	16.41	14.48	16.44	15.80
Fe_2O_3	1.01	0.23	1.58	0.86	1.60
FeO	2.60	3.36	8.98	6.33	4.73
MgO	0.99	1.06	1.96	1.73	1.25
CaO	1.29	4.68	3.49	5.36	6.75
Na_2O	6.87	4.02	7.13	6.40	6.28
K_2O	1.48	1.79	0.32	0.90	0.71
TiO_2	....	....	tr.	tr.	tr.
P_2O_5	....	....	0.03	0.08	0.35
FeS_2	....	....	0.26	0.43	0.35
CO_2+H_2O	0.97	2.77	4.52	4.76	3.92
Total	101.03	101.34	100.12	100.29	100.22

I (a) Granite from small sill on range I, lot 1, La Corne township, analyst William Gerrie*.

II (b) Granite from small mass, range I, lot 2, La Corne township, analyst William Gerrie.

*Gerrie, William; (analyses I-V), "Molybdenite in La Corne and Malartic Townships, Quebec." University of Toronto Studies, Geol. Series, No. 24, p.38.

Table I (continued)

III(c) Granite from range X, lot 64, northeast corner of Malartic township, analyst William Gerrie.

IV (d) Granite from range II, lot 11, La Corne township, analyst William Gerrie.

V (e) Hornblende syenite from range III, lot 44, La Corne township, analyst William Gerrie.

VI Granite dyke cutting sediments north of Lake La Motte and cut by basalt dykes, analyst G.W. Bain[e].

VII Normal grey granite, Dufault granodiorite, Quebec, J.F. Henderson[*].

VIII Siliceous granite, Dufault granodiorite, Quebec analyst J.F. Henderson.

IX Granodiorite from Siscoe dump, Bourlamaque Mass, Quebec Provincial Government Assay Laboratory[#].

X Granodiorite from Sullivan dump, Bourlamaque Mass, Quebec Provincial Government Assay Laboratory.

XI Granodiorite from drill core at Herbin Lake property, Bourlamaque Mass, Quebec Government Assay Laboratory.

Analyses I to VI are of the La Corne Mass. Gerrie's five analyses show an extraordinary similarity and all indicate a rather high potash to soda ratio. The single analysis by Bain seemed to be an exception. Published petrographic description supported Gerrie's analyses and hence it was concluded that the La Corne Mass was on the whole a potassic intrusive.

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[e] Bain, G.W.; "Pre-Keewatin Sediments of the Upper Harricana Basin, Quebec." Jour. Geol. Vol. 33, 1925, p.738.

[*] ________(Analyses VII & VIII) G.S.C. Mem. 166, 1931, p.123-125.

[#] Hawley, J.E.; (Analyses IX-XI) "Gold and Copper Deposits of Dubuisson and Bourlamaque Townships." Quebec B.M., Ann. Rept. 1930, Pt.C, p.24.

On the other hand the analyses and petrographic descriptions of the Bourlamaque and Dufault Masses (analyses VII to XI) indicate an extremely low potash-soda ratio, and these have been termed sodic intrusives.

Similarly, published petrographic descriptions of the other major acid plutonic masses in the area indicated that they fall into two distinct classes based on the potash-soda ratio. Thus the Bourlamaque, Dufault, and Flavrian masses appeared to be of high sodic composition and the others all highly potassic.

A glance at the accompanying map showing the areal distribution of gold sulphide deposits. (See page 13) indicates a definite grouping about the sodic masses (Dufault, Flavrian, and Bourlamaque). None seem to be related to the potassic masses.

The detailed petrographic descriptions on the following pages are the results of an intensive study of this phenomenon carried out both in the field and in the laboratory.

C h e m i c a l   A n a l y s e s: As stated before, extreme care was exercised in collecting material for chemical analyses. The final five-pound samples were treated in the chemical laboratories of the Geological Survey of Canada, where they were further reduced to -80 mesh, quartered, and ground in a mechanical agate mortar.

The residue of the -80 mesh material was set aside for heavy solution separation of the heavy accessories.

Thirty grams of the pulp were sent to W.H. Herdsman, Chemical and Metallurgical Laboratories, Glasgow, Scotland, for chemical analysis.

R o s i w a l   A n a l y s e s: Owing to the very coarse texture of these plutonic rocks, it was impossible to make Rosiwal analyses from thin sections. As pointed out by Washington*, a representative cross section area should be at least one hundred times the average grain size. It was therefore necessary to polish hand specimens to obtain a large enough area that would give accurate results. The polished surface was etched by hydrofluoric acid fumes. This formed a thin film of silica gel on the feldspars and left quartz unattacked. The potash and sodic feldspars were differentiated by staining with a solution of sodium cobaltinitrite which is a very delicate indicator for potash. When the specimen is finally dried the result is;- potash feldspars are stained a brilliant yellow, plagioclases are milky white, and quartz is glassy and unchanged. Now by means of a grid, very accurate determinations of the proportions of potash feldspar, plagioclase, and the dark constituents were readily made. The thin sections were used to identify the mineral species, and to determine their mutual relations. Where the original constituents were

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* Washington, H.S.; Jour. Geol. Vol. 10, 1902, p.660.

still recognizable, alteration products were ignored. This procedure proved to be very accurate as shown by modes recast from chemical analyses in terms of primary constituents.

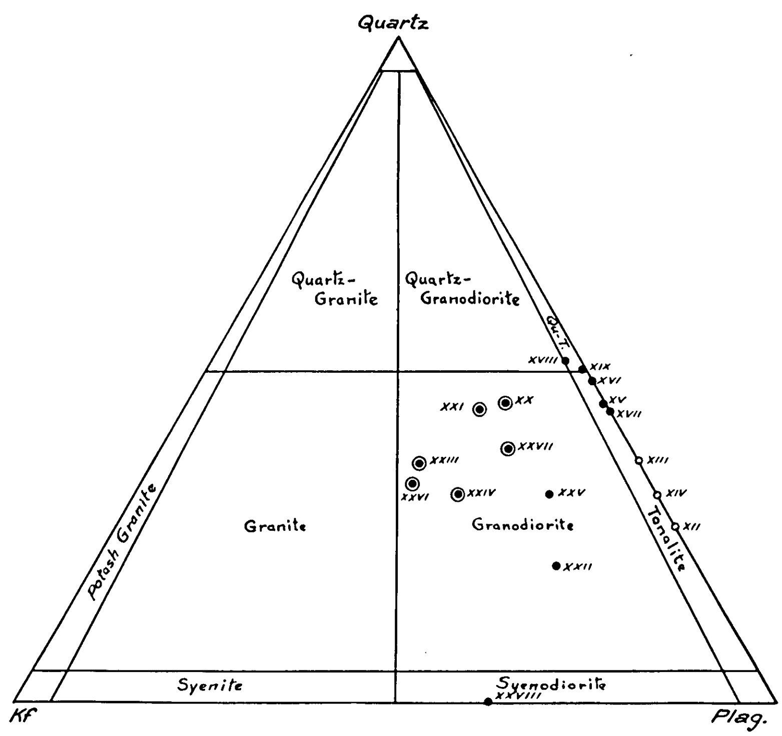

Figure 1. The major acid intrusives of the Rouyn-Bell River Area plotted according to Johannsen's classification.

C l a s s i f i c a t i o n: It is the writer's opinion that the broader field classification should never be discarded. However, in a work of this kind where more detailed petrographic determinations have been made, a more precise classification is essential to bring out the finer distinctions in rock types. Johannsen's classification* is unexcelled in this respect and has been used throughout with minor changes.

Figure 1 illustrates the limits of the various sub-divisions and the corresponding names for rocks falling into Class 2 (50%-95% leucocrates) and having plagioclase ranging from andesine (Ab50-Ab70) to oligoclase (Ab70-Ab90).

If the plagioclase is albite (Ab90-Ab100), the rock falls in Order 1, and if it is labradorite (Ab30-Ab50) or bytownite (Ab10-Ab30) into Order 3. Rocks in which the dark constituents are less than 5% belong to Class 1.

Thus a TONALITE (Quartz-diorite), 50% to 95% leucocrates, has potash feldspar less than 5% of and quartz between 5% and 50% of the quarfeloids, and has plagioclase ranging from andesine to oligoclase. If the plagioclase is

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* Johannsen, Albert: "A Quantitative Mineralogical Classification of Igneous Rocks, Revised," Jour. Geol., Vol. XXVIII (1920), 38-60, 159-77, 210-32, figs. 7.

albite, the rock becomes an ALBITE-TONALITE, and if the plagioclase is labradorite or andesine, the rock is a QUARTZ-GABBRO.

In a QUARTZ-TONALITE (Quartz-rich quartz-diorite) quartz makes up 50% to 95% of the quarfeloids. If the quartz is less than 5%, the tonalite becomes a DIORITE.

The corresponding rocks in Class 1 (less than 5% dark constituents) become LEUCOTONALITES, LEUCO-ALBITE-TONALITES, leuco-quartz-gabbros or QUARTZ-ANORTHOSITES, and leuco-quartz-tonalites or TONALITE-GREISENS.

A GRANODIORITE differs from a tonalite only in having more potash feldspar (5% to 50% of the quarfeloids), and similarly, depending on the kind of plagioclase, is an ALBITE-GRANODIORITE or a GRANOGABBRO. With increase in quartz it becomes a QUARTZ-GRANODIORITE.

The other families behave similarly. ALASKITE corresponds to leuco-albite-granite, and ANORTHOSITE corresponds to leuco-gabbro.

In figure 1 are also plotted the so-called "granites" and "granodiorites" that make up the various phases of the major acid intrusives. It is evident that there are no true granites among them, and that the majority lie in the tonalite and granodiorite families.

Rocks shown by open circles are quartz-gabbros (Order 3) having a more basic plagioclase (labradorite), while those with the double circle belong to Class 1 having less than 5% dark constituents and in this case are leucogranodiorites.

manuscript entitled "Notes on the Lamaque Intrusives".

In the accompanying map of the Bourlamaque mass, the northern contact with the Keewatin has been newly defined by additional information obtained during the field study.

DISTRIBUTION

The Bourlamaque intrusive is pear-shaped in area, extending some fifteen miles east-west and is about seven miles wide at the eastern end. Its areal extent is therefore roughly 55 square miles. However, less than 20 percent of this projects from beneath the lacustrine clays. The outcrops are fairly well distributed and are well glaciated. Generally they rise abruptly out of the flat swampy muskeg, but many small low outcrops occur that may easily be missed on a traverse.

The contact indicated on the accompanying map is in reality an interpolation between the outcrops, and where these are absent it has been located by geophysical and dip-needle surveys and by diamond drilling. No actual contacts with the Keewatin were seen in surface exposures, but its intrusive relation can be inferred by the numerous small dykelets of similar material out in the Keewatin lavas, and by the abundant inclusions.

CHAPTER III

THE BOURLAMAQUE MASS

GENERAL

The Bourlamaque mass has been studied in greater detail than the other igneous bodies due to the close association of some of the major gold producers of northwestern Quebec. In 1923, H.C. Cooke[*] visited the area to study the mineral discoveries and described some phases of the intrusive associated with the ore veins. He also pointed out the abnormally high sodic composition. The stock was first mapped in detail in 1926 by W.F. James and J.B. Mawdsley[e], and a one mile to an inch outcrop map was published by the Geological Survey of Canada (Map 224A). In 1930 a revised map was made by J.E. Hawley[#], in which newer work was added to the Canadian Survey map, especially in locating contacts, and its extention to the west. The following year, Memoir 166 was published by the Survey co-ordinating the results of a study of the whole region. The most detailed petrographic work is that by Hawley in a paper on the "Siscoe Gold Deposit"[=], and in an unpublished

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[*] Cooke, H.C., "Some Gold Deposits of Western Quebec"; G.S.C., Summary Report 1923, Pt. CI, p.98.

[e] James, W.F., and Mawdsley J.B.; "Fiedmont and Dubuisson Map Areas, Abitibi County, Quebec"; G.S.C., Sum. Rept. 1926, Pt. C, pp.56-72.

[#] Hawley, J.E.; "Gold and Copper Deposits of Dubuisson and Bourlamaque Townships, Abitibi County" Quebec Bureau of Mines, Ann. Rept. 1930, Pt. C, p.3.

[=] Hawley, J.E.; "The Siscoe Gold Deposit", C.I.M.M., Trans. for 1932, p.368.

Structural determinations of the Keewatin series indicate that south of the Bourlamaque mass they occupy the north limb of a syncline and strike S.80°E. No other information is available. The exceptionally low relief across the mass and the presence of abundant chloritic inclusions of Keewatin schist, even in the very centre of the intrusive area, seem to indicate that the present surface is very close to the original roof.

The Lamaque intrusive[*] is a small satellitic mass two miles south of Blouin lake, and is chemically and genetically related to the main body. The mass exposed on Siscoe island may also be a satellitic body as dip-needle surveys carried out on the ice of Lake de Montigny failed to show any connection[e]. However, the discovery of a northeast fault on the Greene Stabell property, which probably accounts for the topographic feature now occupied by Blouin lake to the northeast and Lake Lemoine to the southwest, suggests the possibility of other parallel faults between Siscoe island and the mainland. In that case the Siscoe intrusive may represent the faulted nose of the Bourlamaque mass.

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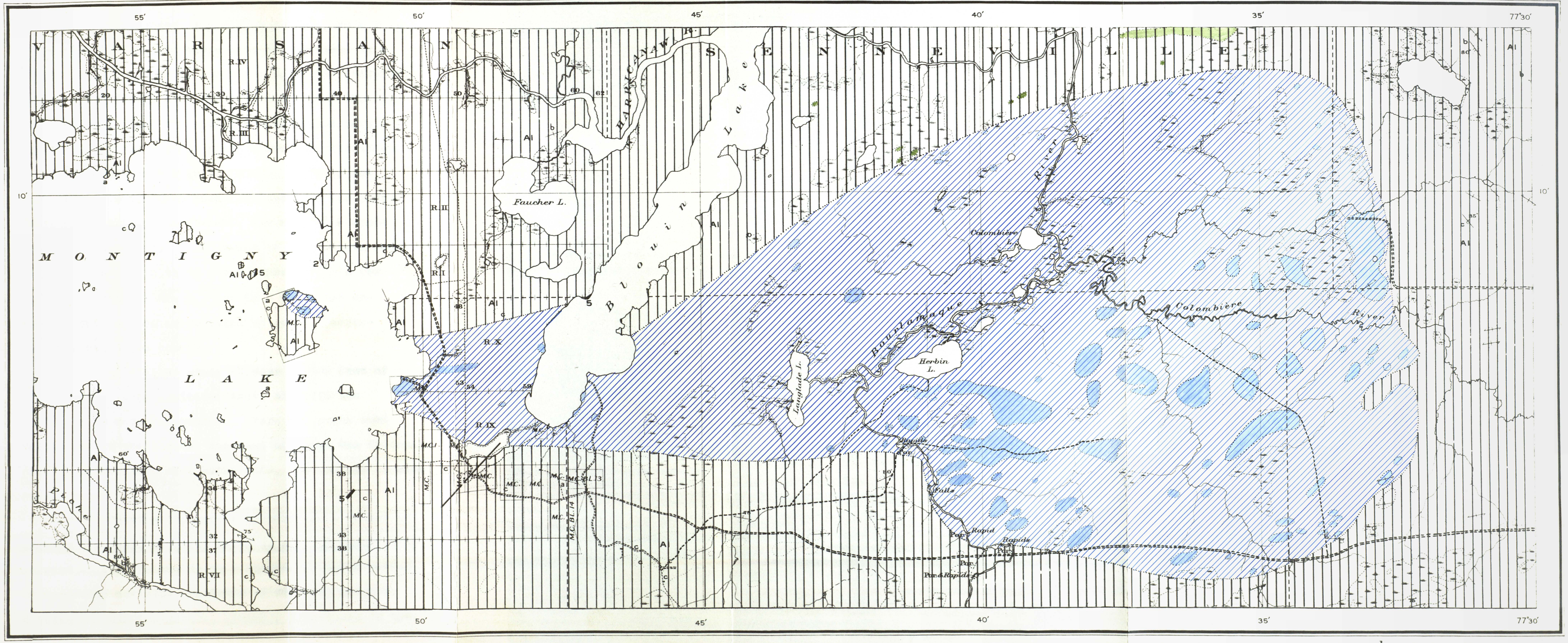
[*] Bell, L.V.: Quebec Bureau of Mines Annual Report, 1934, Pt. B, p.3.

[e] Hawley, 1930; Op. cit., p.12.

BOURLAMAQUE



Scale, $\frac{1}{63,360}$ or 1 Inch to 1 Mile

Miles

The general impression gained from a casual inspection is that the whole area is underlain by a single, apparently quite homogeneous, coarse textured, gabbroic intrusive, more or less chloritized locally. It is sheared along the southern borders and more especially in the western prong where chloritization and saussuritization are quite intense. Within the main body, shearing has been confined to a few narrow shear zones trending east-west, the rock as a whole being quite massive. Large veins of blue quartz and tourmaline occur in these shear zones and in a few places the same minerals occur in a very flat en-echelon vein system accompanied by gold. Quartz-chlorite veins are common.

A detailed study of some 30,000 feet of diamond drill core indicated that, although the intrusive is very homogeneous, there are quite some variations in grain size, and that although the feldspars usually predominate over hornblende, the reverse is also true.

Cutting the main intrusive are a number of porphyritic rocks slightly later in age and genetically related to it. Belonging to a distinctly later period of intrusive activity are dykes of diabase, and both quartz- and olivine-gabbro, probably Keweenawan in age.

The only apparent relation to the more acidic intrusives of the Rouyn-Bell River Area was seen at the south end of Blouin lake where altered gabbro is cut by pegmatite dykes and quartz veins. The pegmatites are chiefly quartz and pink microcline and are similar to those cutting the La Motte-La Corne Mass. The nearest potassic intrusive is the small boss in the vicinity of Dutertre lake.

LITHOLOGICAL CHARACTER

In the past, the Bourlamaque intrusive has been studied only in the vicinity of the economic deposits. The term "granodiorite" has been applied to it for more than fifteen years and it has generally been recognized as a highly altered mass. Hawley[*] has tried to determine its original composition by subtracting the amount of silica and soda occurring in secondary micrographic intergrowths from analyses of the altered phase, and arrived at the conclusion that it was at least a quartz-diorite. In a thin section from Louvicourt township, Hawley[e] was able to determine that the altered plagioclase was at least as basic as andesine (Ab54An46).

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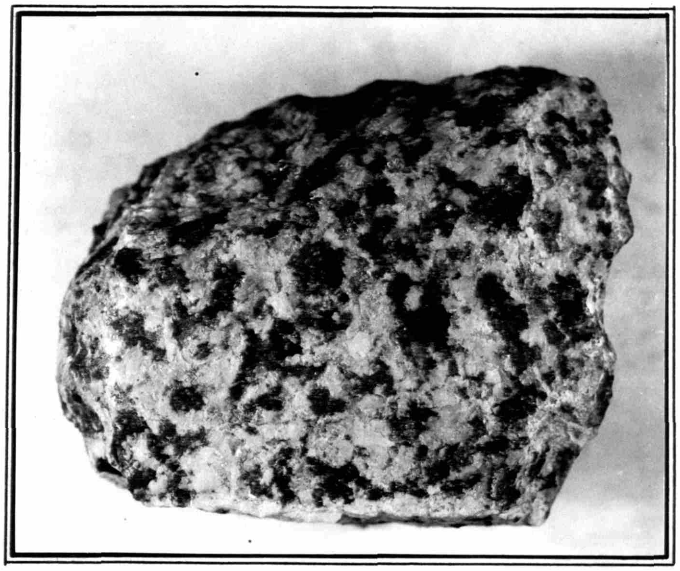
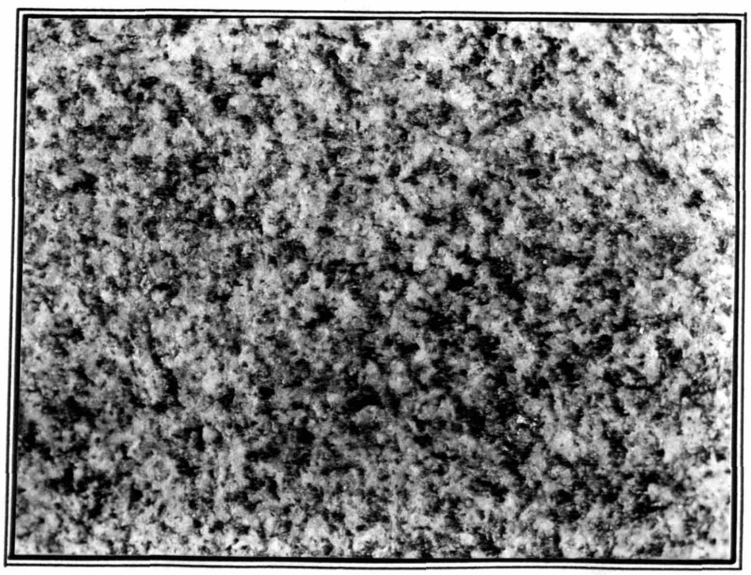
[*] Op. cit., 1932, p.6, and 1930, p.23.

[e] Op. cit., 1930, p.21.

PLATE I.



A. Typical Quartz-gabbro from the Bourlamaque Mass. About natural size.



B. Biotite bearing hornblende-tonalite, from the Taschereau border phase. About natural size.

THE BOURLAMAQUE QUARTZ-GABBRO AND TONALITE OF THE TASCHEREAU BORDER PHASE

The fresh unaltered phase has never been described, chiefly because it is never found in the vicinity of economic deposits to which previous studies have been confined, and because there is very little that has not undergone some alteration. Fresh, little-altered material has now been collected and studied by the writer and will be described separately below. It is a quartz-gabbro (See Fig. 1, p.23). Following a detailed description of the altered phase, evidence will be cited which has been interpreted to prove that the so-called "granodiorite" is the albitized, silicified and chloritized equivalent of the quartz-gabbro.

Quartz-Gabbro

Megascopic Features

Fresh unaltered quartz-gabbro is a dark grey colour and is coarse textured. The grain size averages about one centimeter with hornblende grains often up to 1.5 cm. Plagioclase and hornblende are conspicuous; clear, colourless quartz, brown biotite and an occasional crystal of sphene are visible in some specimens. The plagiocalse is white and striated and occasionally Carlsbad twins are recognizable. The hornblende is black and glistening, and the characteristic amphibole cleavage is readily distinguished.

In somewhat altered specimens the plagioclase takes on a pale greenish cast and hornblende loses its lustre and becomes dark green. An important observation is the appearance of small eyes of bluish opalescent quartz which is so characteristic in the completely altered phase.

Microscopic Features.

Under the microscope the texture is of a hypidiomorphic nature having euhedral and subhedral plagioclases, and subhedral hornblende with the interstices filled by quartz (See Plate IIB). The minerals identified were plagioclase, hornblende, biotite, and pyroxene. Subordinate constituents are quartz, titanite, apatite, ilmenite, and slight alteration products. Microchemical tests check the complete absence of potash feldspar.

Plagioclase was determined to be as calcic as acid labradorite (See Plate IIIA). Polysynthetic albite twinning is usually well developed, occasionally in combination with pericline twinning. Some untwinned grains and also combination albite and Carlsbad twins occur, though less commonly. Maximum extinction angles in the zone normal to (010) measured from albite twinning lamellae to 'a' gave 30^{o}, corresponding to basic andesine (Ab53An47), but extinction angles in well oriented sections

PLATE II.

A. Quartz-gabbro, showing the fresh nature of hornblende and of plagioclase. x15

B. Quartz-gabbro, showing unaltered plagioclase and entirely interstitial quartz. x15

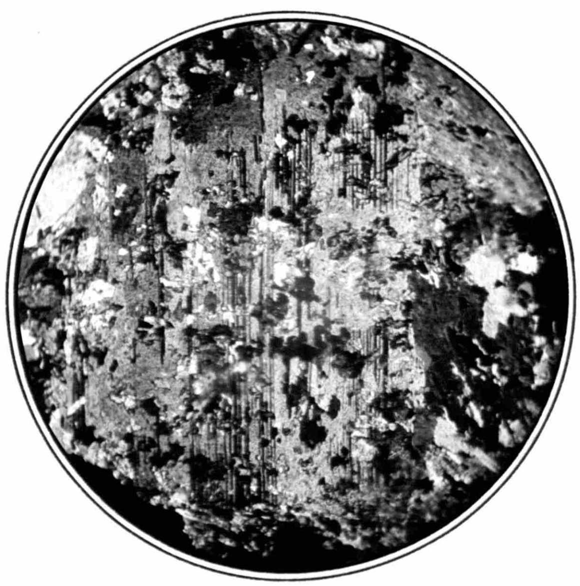
C. Quartz-gabbro, showing fresh hornblende with poikilitic inclusions of labradorite and slight embayment by primary quartz. The lower part of the field is uralitized pyroxene. x17

D. Pyroxene fringed by hornblende. x70.

MICROPHOTOGRAPHS OF THE BOURLAMAQUE QUARTZ-GABBRO

PLATE III.

A. Fresh combination carlsbad-albite penetration twin of labradorite (Ab47An53) in quartz-gabbro. x33



B. Slightly saussuritized andesine, being the initial stage of alteration. x17

FRESH AND SLIGHTLY ALTERED FELDSPARS IN THE BOURLAMAQUE QUARTZ-GABBRO from the zone normal to (010), where albite twinning is combined with Carlsbad twinning, indicated a slightly more calcic composition corresponding to acid labradorite (Ab48An52). It is optically positive and the indices are definitely greater than quartz. It is therefore undoubtedly labradorite.

Hornblende is the common green variety; pleochroism x-pale yellow y-olive green z-dark green. Absorption is $x < y < z$. The optic angle is medium and the sign negative. Extinction ($z \wedge c$) is 29°. Large units form around the plagioclases and poikilitically enclose smaller prisms (See Plate IIC).

Hornblende also occurs as uralite fringes on altered pyroxene (See Plate IID). Partially altered remnants of pyroxene gave the following properties,- colourless to pale green pleochroism, excellent rectangular cleavage, optically positive, extinction angles up to 42°, altering to antigorite and green biotite - probably augite.

Quartz generally occurs in wedge shaped areas interstitial to the other minerals (See Plates IIB, IIIA). It has a slight undulatory extinction and locally has attacked some of the earlier minerals.

Subordinate constituents are,- appreciable ilmenite, titanite in wedge shaped crystals, and a few apatite prisms.

In the fresh phase, alteration products are in very small amounts except in the pyroxene. Traces of clinozoisite and carbonates were noted along small fractures in some of the plagioclases. Somewhat more altered specimens show the gradual saussuritization of plagioclase (See Plate IIIB) with small grains of clinozoisite and epidote, and locally a little paragonite, set in an albitic base. There has been but little migration of material so that the bulk composition of the original feldspar is essentially duplicated by that of the mineral aggregate replacing it.

Albite-Tonalite*

Megascopic Features

The altered phase is usually considerably crushed and somewhat sheared locally. It is highly chloritized and contains eyes of bluish opalescent quartz, has a medium grey colour with a greenish cast on wet surfaces, and is equigranular. Plagioclase, bluish quartz and a chloritic ferromagnesian are the only recognizable constituents. The grain size varies

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* So-called sodic granodiorite, see p.23, figure 1.

considerably depending on the degree of shearing and alteration - average 2-4 mm. Some phases exhibit a pseudoporphyritic texture with plagioclase metacrysts and large irregular aggregates of bluish quartz in a greenish chloritic groundmass. The amount of quartz varies from 2% to 30% locally.

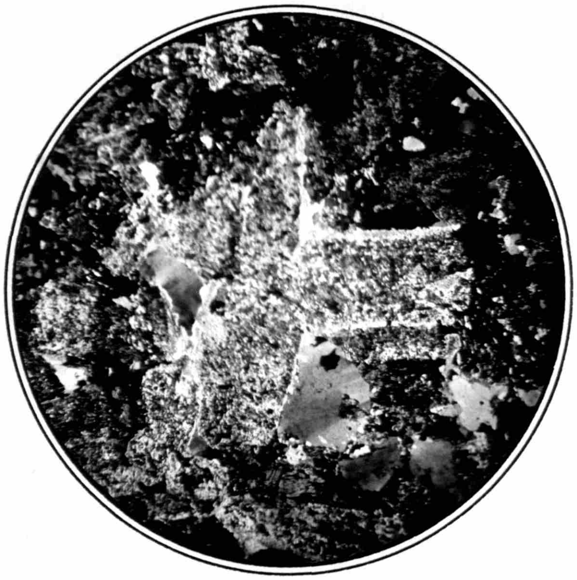
Microscopic Features.

In thin sections there is a great diversity both texturally and mineralogically.

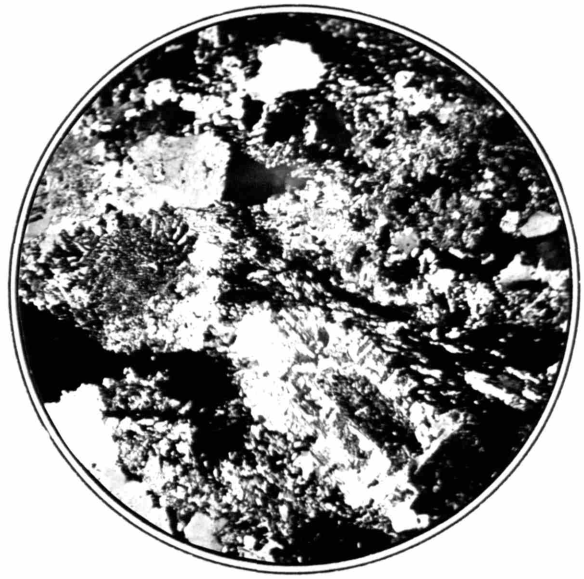
T e x t u r e: Textural varieties are gabbroic, pseudographic, and crystalloblastic with gradation throughout. Some slides are superficially identical to those of the quartz-gabbro (See Plate IVA). Feldspar and hornblende are of about the same grain size (1-1.5 cm.) and exhibit similar mutual relations. Some of the quartz is still entirely interstitial, however it is noticeably more abundant, and much of it is not confined to the wedge shaped interstices between the feldspar grains, but occurs in irregular masses and vermicular forms, replacing the other constituents.

As secondary quartz becomes more appreciable a typical crystalloblastic texture is taken on (See Plate IVD), and locally a more organized texture is developed.

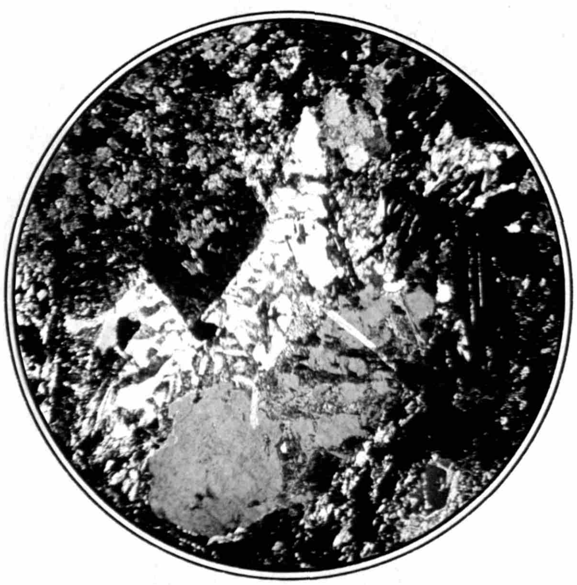
PLATE IV



A. Superficially identical primary texture of quartz-gabbro with interstitial quartz and saussuritized plagioclase rimmed by albite. x15



B. Cataclastic texture showing pseudographic replacement of plagioclase by quartz. x17

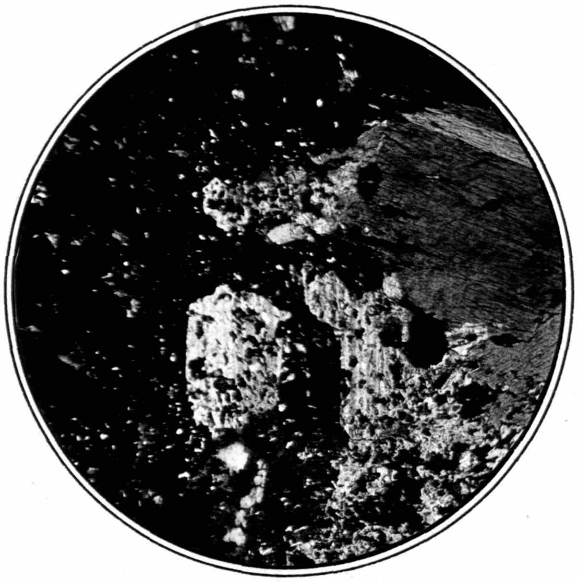


C. Pseudographic replacement of groundmass by quartz. At the right is a pseudomorph of leucoxene after ilmenite. x15

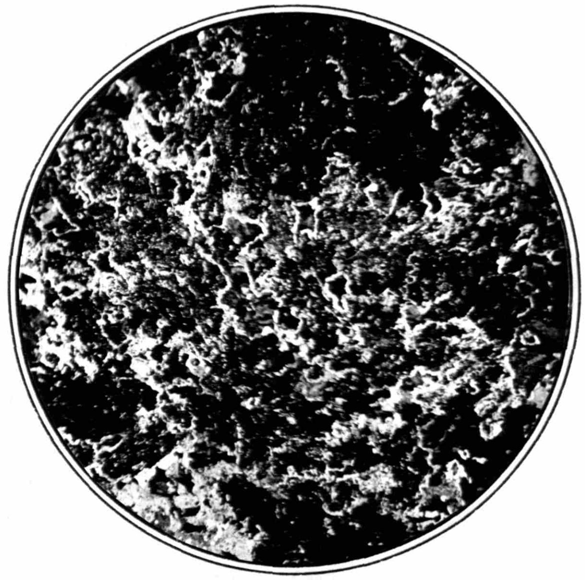
D. Albite-tonalite having a crystalloblastic texture. x14

VARIOUS TEXTURES EXHIBITED BY THE ALBITE-TONALITE

PLATE V

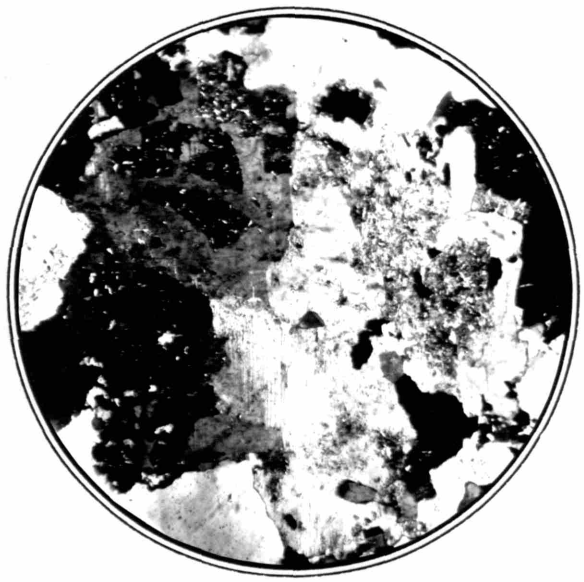


A. Three oriented remnants of a crystal of somewhat saussuritized andesine replaced by a mass of albite and saussuritic products. x42



B. A more advanced stage of albitization showing the development of clear albite rims on highly saussuritized plagioclases composed of saussuritic products in an albite base. x17

C. A veinlet of clear albite cutting a saussuritized plagioclase crystal. x45



D. Plagioclase carlsbad twin rimmed and veined by clear albite. x35

EVIDENCE OF ALBITIZATION

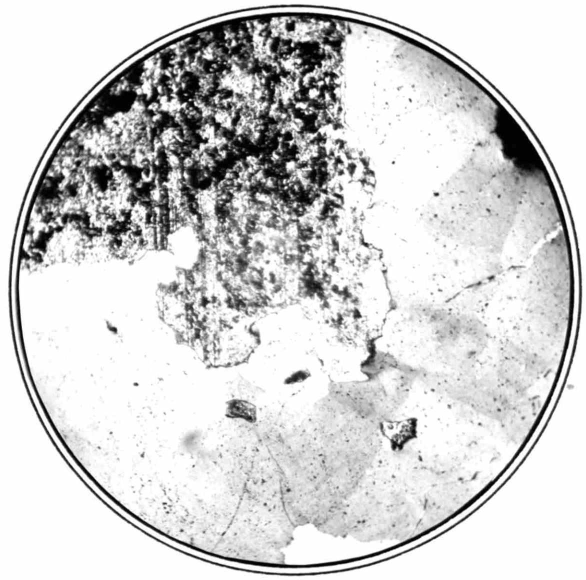
Quartz assumes crude graphic forms which gradually develop into pseudographic textures in which the quartz is all more or less oriented and replaces both individual plagioclases (See Plate VII), and the pseudocataclastic groundmass (See Plate IVB & C).

<u>Mineralogy and Mineral Habits:</u> The minerals in the altered phase are quartz and much altered remnants of the original plagioclase, hornblende, and biotite. It consists chiefly of an aggregate of secondary minerals, - albite, quartz, chlorite, penninite, clinozoisite, epidote, paragonite, carbonate, etc.

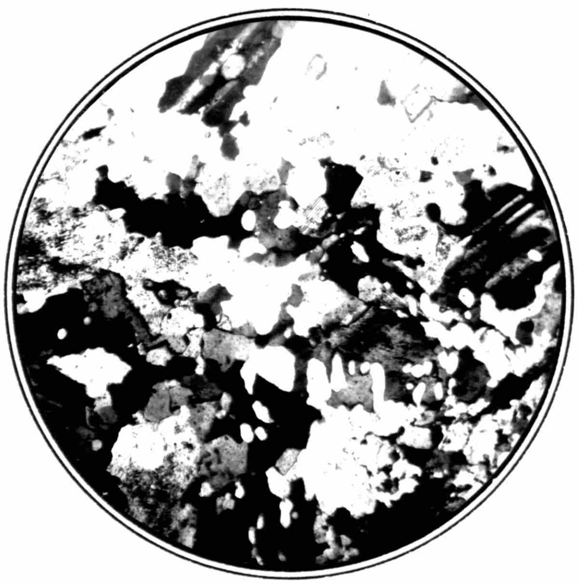
P l a g i o c l a s e: The plagioclase superficially resembles that of the quartz-gabbro. Except for a few remnants of the original andesine-labradorite (See Plate VA), it is entirely albite, forming clear, narrow borders or rims around highly saussuritized grains of plagioclase (See Plate IVA, VB). The core of these is usually an aggregate of clinozoisite, epidote and some paragonite in an albite base, cut by veinlets and tongues of clear albite (See Plate VC & D). Plagioclases, nearly cleared of saussuritic products, occur in the more advanced phases of replacement in which the rock is almost entirely composed of quartz and albite (See Plate VIC & D).

PLATE VI.

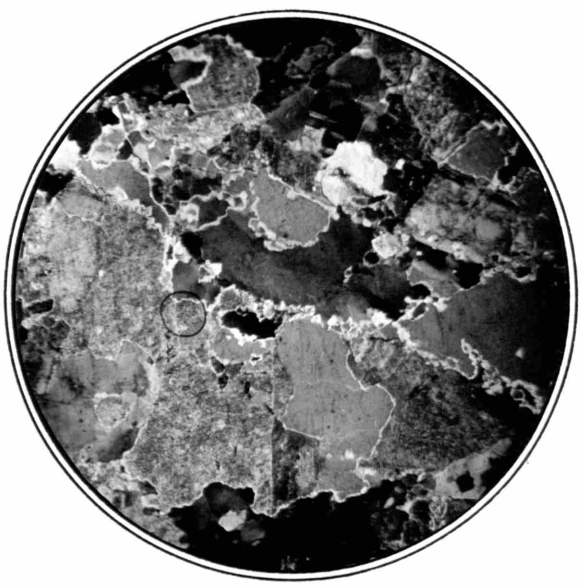
A. Leucoxene, pseudomorphous after a skeletal crystal of ilmenite. x25



B. Saussuritized plagioclase embayed by quartz containing oriented remnants of the same crystal. x52



C. Vermicular quartz replacing a groundmass of albite and quartz. x17



D. Albite-tonalite cleared of saussuritic products and having no ferromagnesians. Note combination carlsbad-albite twin of albite (Ab96An4) and the quartz veinlet. x17

LEUCOXENE PSEUDOMORPH, SILICIFICATION, AND ALBITE-TONALITE CLEARED OF SAUSSURITIC PRODUCTS.

In the few specimens containing both albite and labradorite, it is quite evident that the albite is replacing an original plagioclase crystal and is not the result of zoning (See Plate VA & D).

The albite in these rocks varies from acid oligoclase to pure albite. Where it was possible to obtain the optic sign, it is invariably positive. Extinction angles measured, vary from 6^{o} to 18^{o} in the zone normal to (010), and $N < 1.544$ of quartz. One specific example gave the following results:- optic axis section: sign positive, Nm slightly < 1.544 of quartz and much less than 1.55, ext. $\perp$ x $z \wedge 010$ 18^{o}, hence albite; untwinned section $\perp(010)$: ext. $\perp$ z $x \wedge 001$ 21^{o}, N distinctly < 1.544 of quartz, therefore positively albite.

It is accordingly evident that some of the albite is at least as sodic as (Ab99An1), and that in some specimens it may be as calcic as (Ab90An10). Locally, twin lamellae are bent and have a wavy extinction.

Q u a r t z: Quartz is both primary and secondary. The former is in wedge shaped areas interstitial to the feldspars as in the quartz-gabbro (See Plate IVA), and contains minute contraction cracks typical of inversion. By far the greater portion is secondary, replacing the other minerals. Large patches occur, replacing plagioclase and containing oriented wisp-like remnants of the plagioclase (See Plate VIB).

Some is vermicular in plagioclase (See Plate VIC), and also in veinlets cutting all other minerals (See Plate VID). Locally it occurs in graphic replacement textures as rosettes on plagioclase crystals (See Plate IVB & C), and as pseudographic replacements of plagioclase (See Plate VII).

Plate VII.- The pseudographic replacement of a saussuritized plagioclase crystal by quartz. x42

H o r n b l e n d e: Where not too badly altered it is the same as that in the quartz-gabbro:- Pleochrism x-pale yellow y-olive green z-dark green; absorption is $x < y < z$; optic angle medium and sign negative; extinction $(z \wedge c)$ is 29°. Twinning is common and apatite and titanite occur as inclusions. It is later than the plagioclase and earlier than quartz. Locally it has gone over to biotite.

Generally the ferromagnesians are completely replaced by an aggregate of secondary minerals,- carbonate, quartz, chlorite epidote, and usually penninite after biotite.

B i o t i t e: Primary biotite is nearly always completely replaced by penninite. Thus, it occurs in large grains but is always later than hornblende. Some biotite is secondary after hornblende. It generally occurs in subordinate amounts but is more abundant than in the quartz-gabbro.

E p i d o t e: Epidote is a secondary product in saussuritized plagioclases and an alteration product of hornblende. Locally it was observed in veinlets in the rock and is usually more extreme in mineralized zones. It occurs as euhedral crystals and as irregular grains, is optically negative, and has a pale yellow to colourless pleochroism. The plane of the optic axis is normal to the elongation of crystals.

P a r a g o n i t e: Paragonite occurs as a subordinate alteration product of plagioclase. It was distinguished from sericite by microchemical tests for potash which gave a negative result.

A c c e s s o r i e s: The chief accessory constituents are: ilmenite, apatite, titanite, and probably some magnetite. Ilmenite occurs as irregular grains surrounded by a reaction rim of titanite, and as skeletal crystals now completely altered to leucoxene (See Plate VIA). Apatite occurs in small prisms, locally as large as 1 mm. in cross section. Titanite is present as primary wedge shaped crystals and as reaction rims around ilmenite.

The degree of alteration, especially chloritization, seems to depend to a large extent on the grain size. That is, it varies directly as the degree of mylonitization. The Bourlamaque intrusive is finer grained and more sheared in the vicinity of Siscoe island and locally along the southern contact, and here it is correspondingly more chloritized and saussuritized. Epidote is usually more abundant in specimens having a high content of blue quartz.

CHEMICAL FEATURES

The intimate genetic relations of the quartz-gabbro and its altered equivalent are further illustrated by the chemical analyses tabulated below. These consist of three new analyses of the quartz-gabbro, and three analyses of the altered "granodiorite" first published by Hawley* in the Quebec Bureau of Mines Report.

*Op. cit., p.24.

TABLE II

ANALYSES OF THE BOURLAMAQUE INTRUSIVE

	Quartz-gabbro			"Sodic Granodiorite"		
	XII	XIII	XIV	IX	X	XI
SiO_2	55.82	63.85	57.00	57.37	57.00	58.98
Al_2O_3..........	15.38	14.44	15.04	14.48	16.44	15.80
Fe_2O_3..........	1.61	1.01	1.76	1.58	0.86	1.60
FeO	6.40	5.96	6.57	8.98^x	6.33^x	4.73^x
MgO	3.38	2.88	4.34	1.96	1.73	1.25
CaO	7.44	5.94	7.54	3.49	5.36	6.75
Na_2O	2.57	2.62	2.61	7.13	6.40	6.28
K_2O	0.49	0.39	1.93	0.32	0.90	0.71
H_2O+	2.65	1.80	1.90	(		
H_2O-	0.25	0.20	0.40	(4.52$^\theta$	4.76$^\theta$	3.92$^\theta$
CO_2	2.60	nil	nil	(		
TiO_2	0.64	0.74	0.68	tr	tr	tr
P_2O_5	0.48	0.21	0.21	0.03	0.08	0.05
MnO	0.09	0.07	0.09	x	x	x
F*	0.04	0.02	0.02			
S	0.08	tr	tr			
FeS_2				0.26	0.43	0.35
Total	99.92	100.13	100.09	100.12	100.29	100.22

^{x}MnO included in FeO
$^\theta$Loss on ignition
*Determined by the writer.

XII. Quartz-gabbro from exploratory drill core, Sullivan Mine, lot 49, R X, Dubuisson township, Analyst W.H. Herdsman.

XIII. Quartz-gabbro from pit, southeast corner of Senneville township, Analyst, W.H. Herdsman.

XIV. Quartz-gabbro from exploratory drill core, Payore Mine, south of Herbin lake, Bourlamaque township. Analyst, W.H. Herdsman.

IX. 'Altered diorite' from Siscoe Mine, Repeated from Table I, p.19.

X. 'Granodiorite' from Sullivan Mine. Repeated from Table I, p.19.

XI. 'Granodiorite' from Herbin lake. Repeated from Table 1, p. 19.

The norms for the three new analyses (XII, XIII, XIV) are given in Table III below, and are calculated according to the classification of Cross, Iddings, Pirsson, and Washington.

TABLE III

NORMS OF THE QUARTZ-GABBRO

	XIIa	XIIIa	XIVa
Quartz	16.03	26.92	10.71
Orthoclase	2.89	2.30	11.40
Albite	21.76	22.19	22.10
Anorthite	28.92	26.39	23.50
Diopside	4.17	1.41	10.34
Hypersthene..........	15.87	15.54	15.40
Magnetite	2.33	1.46	2.55
Ilmenite	1.22	1.41	1.29
Apatite	1.15	0.51	0.51
Not used	5.58	2.00	2.29
Total	99.92	100.13	100.09
Symbol	II.4.4.3	II.4.4.3	II.4.(4)3.3
Name	Bandose	Bandose	Harzose near Bandose

Table IV gives the modes of the same three analyses recast as primary constituents based on the microscopical examination of the rocks, together with a Rosiwal analysis of the typical fresh quartz-gabbro, and one of a less siliceous phase. These indicate the remarkable uniformity of the Bourlamaque intrusive in mineral composition. According to

Johannsen's[x] classification, it is a quartz-gabbro (238). See figure 1, page 23. In addition, the modes of the saussuritized phases of the Siscoe and Sullivan analyses (IXb, Xb) are added for comparison. These would be classed as albite-tonalites (218). The term "granodiorite" is not used because it implies the presence of potash-feldspar in excess of 5% of the quarfeloids whereas, actually , none occurs.

TABLE IV

APPROXIMATE MINERAL PERCENTAGES OF BOURLAMAQUE PHASES

	XIIb	XIIIb	XIVb	x	e	IXb#	Xb#
Quartz..........	18	28	21	16	2	7.98	9.90
Albite(Ab95An5).						63.13	59.64
Labradorite (Ab48An52)	49	48	45	47	57		
Potash feldspar.	0	0	0	0	0		
Hornblende......	21	15	28	20	35	7.93	4.44
Biotite.........	8	6.5	2.5	2			
Pyroxene........	.	.	.	12			
Carbonates......	.	.	.	.	.	9.39	12.40
Muscovite (?)...	.	.	.	.	.	2.71	7.61
Chlorite........	.	.	.	.	.	3.68	5.84
Epidote.........	.	.	.	.	5	1.82	
Magnetite.......	1.6	0.5	1.8	1.5	0.4	2.29	1.24
Ilmenite........	1	1.1	1	0.7			
Titanite........	0.2	0.3	0.2	0.1	0.2		
Apatite.........	1.2	0.5	0.5	0.7	0.4	0.08	0.19
Pyrite..........	tr	0.1	tr			0.26	0.43
Total	100	100	100	100	100	99.27	101.59

x Typical fresh quartz-gabbro
e Less siliceous phase of quartz-gabbro
Recast by Hawley in an unpublished paper

x Ibid.

As pointed out by Hawley, the analyses of the albite-tonalites show a surprising similarity in the content of silica alumina, ferric iron, and magnesia, and are characterized by an exceptionally high-soda low-potash content. The only main points of difference are in the higher ferrous iron and soda content, and in the lower lime content of analysis IX from the Siscoe mine. Thin sections, however, indicate a higher degree of alteration in the Siscoe vicinity.

Material of the quartz-gabbro, submitted for chemical analysis was, unfortunately, not entirely unaltered. This was unavoidable as it was necessary to send the samples for analysis before they could be thoroughly examined petrographically. The microscopic study indicated small amounts of saussuritic products in the plagioclases and some secondary quartz. However, modes calculated from the analyses show that there has been little if any migration of material so that the bulk composition of the original feldspar is essentially duplicated by that of the mineral aggregate replacing it. A comparison of the modes with the Rosiwal analysis of the typical fresh quartz-gabbro indicates a possible addition of secondary quartz varying from 2 to 10%.

The three new analyses are therefore a rather good representation of the fresh quartz-gabbro and a comparison indicates a marked uniformity in chemical composition especially when the 10% of secondary quartz is allowed for in analysis XIII.

Comparison of the analyses of the quartz-gabbro with those of the albite-tonalite ('Sodic Granodiorite') show that while there are only slight changes in most of the major oxides, there is a remarkable increase in soda and a slightly less prominent decrease in both lime and magnesia.

ORIGIN OF THE ALBITE-TONALITE

There must have been a vague dissatisfied feeling in Hawley's mind regarding the origin of the Bourlamaque intrusive, when, in his study of the Lamaque intrusive, and based on the striking similarity in chemical composition, he suggested* that it might be a differentiate of a larger dioritic magma.

It has now been definitely established that the fresh unaltered rock of the Bourlamaque intrusive is a quartz-gabbro and, as will be shown in the final chapter, that as such it forms an early member of the magmatic stem from which most of the major acid intrusives of the Rouyn-Bell River Area were derived. Similarly, field relations, microscopic studies, and chemical

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* Unpublished Manuscript.

analyses indicate that the albite-tonalite or so-called 'granodiorite' is the altered equivalent of the quartz-gabbro.

Gilluly[*] in his very able treatise on the origin of the albite granite of Sparta, Oregon, has led the way to a solution of this phenomenon and most of his evidence has been duplicated to the last detail. He has postulated late and post-magmatic replacements of an almost completely solidified quartz diorite, by solutions derived by filter press from lower portions of the same mass and guided in part at least, by brecciated and sheared zones within it, as the origin of an albite granite. This hypothesis is also in complete agreement with Bowen's[θ] thesis that albite granites are of hydrothermal origin.

As was noted by Gilluly, the common features of the albitic phase are, - its association with zones of weakness; the unusual amount of replacement, and widespread occurrence of epidote, clinozoisite, chlorite, and bluish opalescent quartz; and the development of pseudographic textures.

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[*] Gilluly, James: "Replacement Origin of the Albite Granite near Sparta, Oregon", U.S.G.S. Prof. Pap. 175-C, 1933, p.65-81.

[θ] Bowen, N.L.: "The Evolution of the Igneous Rocks", Princeton, 1928, p.132.

The quartz in the fresh quartz-gabbro is colourless and entirely interstitial, occupying small triangular areas. In the albitic phase, in addition to the primary colourless quartz bluish opalescent quartz occurs in irregular blotches and veinlets, penetrating the rock in many directions.

Myrmekitic and micrographic textures are common in the albitized phase though entirely absent from the unaltered quartz-gabbro. That these graphic textures can be of replacement origin is illustrated in the graphic replacements of andesitic inclusions in the Flavrian mass. (See Plate XII).

Evidence of Late Magmatic or Hydrothermal Mineral Formation

That the albite-tonalite is the result of late magmatic or hydrothermal origin is evident when the following facts are considered: Shearing and development of a cataclastic texture must have occurred after more or less consolidation of the intrusive, and these appear to have localized the more intense alteration. The texture of the fresh quartz-gabbro and the saussuritized phase are identical. This has been interpreted as due to the saussuritization of the already solidified quartz-gabbro especially as all stages have been observed from the first appearance of saussuritic products along the minute fractures in labradorite, the occurrence of saussuritized but still recognizable plagioclase, and finally, superficially identical crystals composed of an aggregate of saussuritic products in an albite base.

The potash content in both the quartz-gabbro and the albite-tonalite is almost identical. Not only that, but in both it is abnormally low. In contrast to this there has been a remarkable increase in soda. It is impossible to account for this selective enrichment of soda over potash by a process of crystallization from a magma. The only reasonable explanation seems to be replacement or albitization by sodic solutions.

This conclusion is adequately supported by abundant evidence of replacement in thin sections: The formation of clear rims of albite on saussuritized labradorite, the occurrence of veinlets and stringers of albite cutting crystals of plagioclase, the embayment of plagioclase by albite and its gradual replacement till only oriented remnants of the original feldspar remain in a groundmass of albite, and finally, the occurrence of albite, pseudomorphous after labradorite, - all suggest attack by sodic solutions and the gradual replacement of labradorite by albite.

Paralleling the development of albite there was much replacement by quartz. Vermicular replacements and graphic textures, and the occurrence of wisp-like remnants of plagioclase in large masses of quartz embaying the other minerals testify to this, and together with the opalescent nature of the secondary quartz, are further evidence of attack by hydrothermal solutions.

Albitization is also indicated by the dominance of albite in the adjacent Keewatin lavas although residual andesine and labradorite are not unknown. They are also sheared and altered to chlorite and epidote.

It is interesting to note that in a detailed study of the wallrock alteration of the Siscoe deposit Cooke[*] observed the following change,-

TABLE V

WALLROCK ALTERATION OF THE SISCOE DEPOSIT

	Country Rock	Intermediate Rock	Wall rock immediately adjacent to vein.
Quartz	4[e]	5	2.5
Albite	35-40 (Ab90An10)	80	95 (Ab100An0)
Calcite	2[e]	11[e]	2.5
Chlorite	50	2	0
Epidote	2[e]	0	0

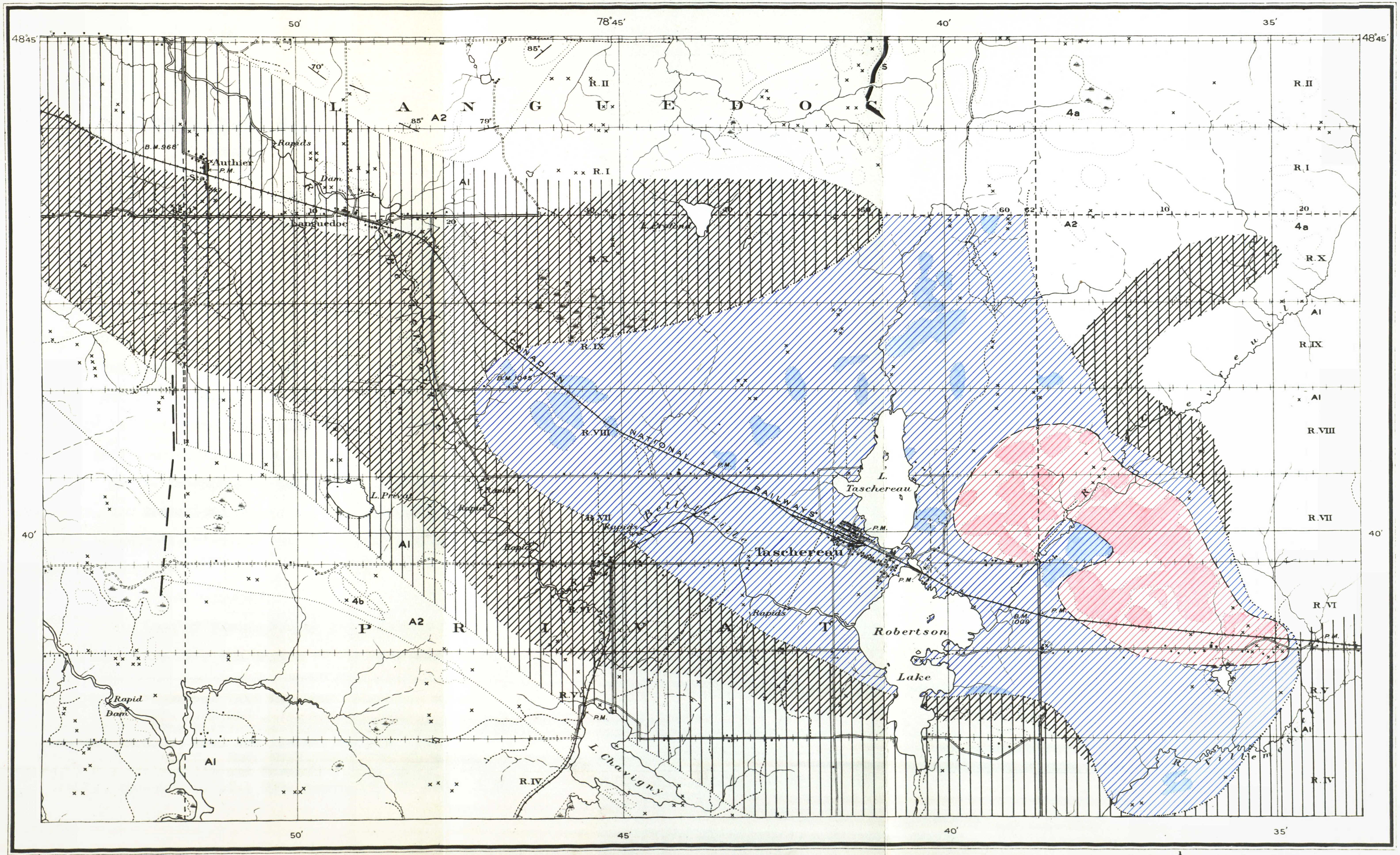
[e] Actual Figures not given by Cooke.

[*] Ibid., p.94.

This indicates, that at least in the vicinity of the ore deposits, there was a considerable introduction of soda, silica, and alumina with, at first, rearrangement and then removal of lime and ferrous iron. In addition to this there was also introduction of tourmaline, sulphides, and gold as is indicated by the vein material.

Conclusions

It is postulated that the Bourlamaque mass was originally a quartz-gabbro, possibly having a slightly more basic border facies (somewhat richer in ferromagnesians and having a more basic labradorite) and that sodic hydrothermal solutions guided in part at least by zones of shear and crushing, brought about the present rock types by replacement.



Scale, $\frac{1}{63,360}$ or 1 Inch to 1 Mile

Miles

CHAPTER IV

THE TASCHEREAU MASS

GENERAL

The Taschereau mass, also known as the Lake Robertson "granite", has received the attention of several geologists because it lies right on the transcontinental railway. It was first mapped in exploratory work by M.E. Wilson*, and later by T.L. Tanton°, in conjunction with the building of the railway. The detailed mapping of the area was made by B.S.W. Buffam[x] in 1926, with slight revision by A.H. Lang[#] in 1932. The final mile to the inch outcrop map, No. 285A, was published in 1934.

In the accompanying map of the Taschereau intrusive, the Geological Survey map was used as a base on which to show the distribution of the various phases mapped in the field.

DISTRIBUTION

The town of Taschereau on the Canadian National Railway, lies very near the centre of the intrusive mass

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* Wilson, M.E.: "Kewagama Lake Map-Area, Quebec", G.S.C. Mem. 39 (1913), p.38 and p.76, and Map 93A.

°-Tanton, T.L.: "The Harricanaw-Turgeon Basin, Northwestern Quebec", G.S.C., Mem. 109 (1919), and Map 183A.

x Buffam, B.S.W.: G.S.C., Sum. Rept., 1926, Pt. C, p.133.

\# Lang, A.H.: "Palmarolle and Taschereau Map Areas, Abitibi County, Quebec", G.S.C., Sum. Rept., Pt. D, 1932, p.28

which is roughly elliptical in shape. The major diameter parallels the railway, striking north 60° west, and conforms with the folding in the country rocks. It is about ten miles long with a maximum width of four miles at Taschereau.

It has an areal extent of some thirty square miles and is fairly well exposed, especially in the eastern half where it is almost barren of vegetation and soil. Elsewhere, the well glaciated

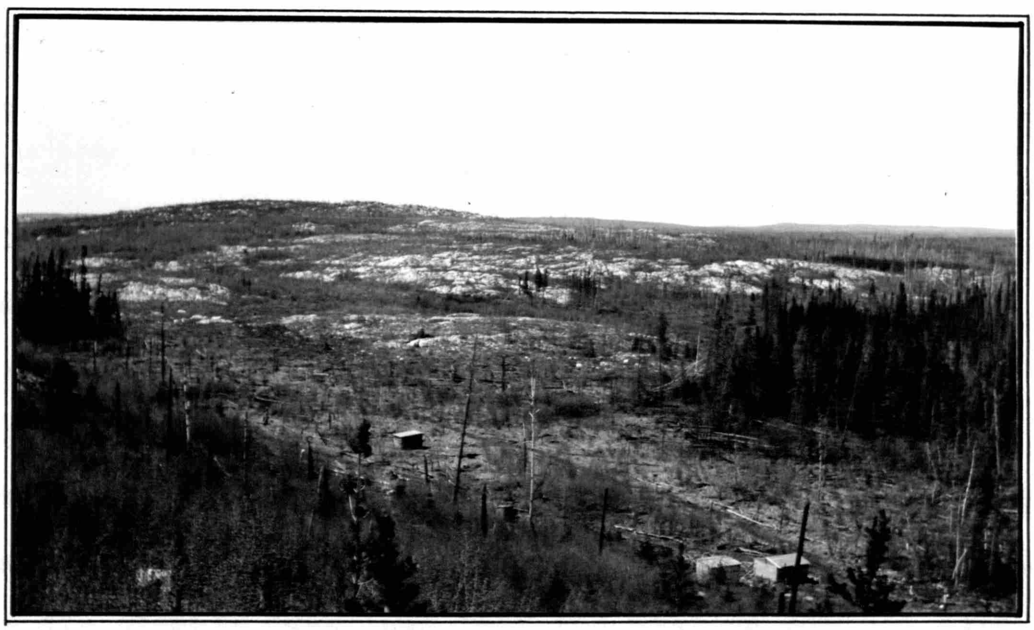


Plate VIII. The Taschereau intrusive-devoid of soil and vegetation.

outcrops appear at intervals of not more than a mile and generally much closer.

The distribution of the synclinal Keewatin sedimentary bands to the northeast and southwest, suggests that the igneous body lies along the axis of an anticlinal structure, the limbs of which dip steeply to the northeast and southwest at from 70° to 85°.

The intrusive is surrounded by a wide transition zone of highly metamorphosed basic lavas injected by igneous material of a dioritic composition. Around the eastern end this zone is very narrow or absent. Along the southern edge it gradually widens from about 1,000 feet in the east to over two miles at the western end of the intrusive. Here joined by the transition zone from the northern edge a belt of metamorphosed lavas two miles wide extends northwestwards for at least seven miles where plutonic rocks are again exposed. This phenomenon strongly suggests that the eastern wall is vertical or inclined to the northwest, that the northern and southern contacts are either vertical or dip steeply away, and that the western contact dips to the northwest. In other words, the igneous mass is roughly elliptical and plunges to the northwest.

The lavas in this zone are so completely recrystallized that they resemble igneous rocks varying from hornblende syenite to coarse amphibolite with little or no feldspar. In places they are brecciated and are injected by igneous material. Near the inner edge, the presence of interstitial feldspar in the amphibolite suggests addition of material from the intrusive, just as contamination, due to slight assimilation, has rendered the igneous border phase quite basic locally.

Chloritic inclusions are quite abundant along the margins of the intrusive, and occasional large fragments occur very near the central part of the area. It appears therefore, that the boss has not been incised very deeply. However a thickness of half a mile or so was probably removed, explaining the paucity of fragments in the central part of the area, and probably exposing the more acid core.

There are two distinct facies,- a grey border phase, and a highly siliceous, pinkish core phase, very low in ferromagnesians. The latter is confined to a small area in the eastern part of the intrusive, roughly four miles long and having an area of five and a half square miles. It is monotonously homogeneous, yet interest is maintained by the extraordinary high content of quartz. Locally, as in the southern part of lot 62 R. VII, Privat township, the quartz is so abundant as to appear porphyritic and occurs in aggregates three quarters of an inch and more across.

The rest of the intrusive appears to be a grey granitic rock consisting of white feldspar, quartz, and black biotite. It is more variable and has a narrow outer marginal facies of dioritic composition containing hornblende. Toward the centre it becomes more siliceous and seems to grade into the core phase over a short distance.

The major joint set is nearly horizontal at intervals of from three to five feet. Aplite stringers, and a few pegmatite dykes up to three feet wide cut both the border phase and the core phase. They are almost entirely microcline and quartz corresponding to the basis of the core phase.

LITHOLOGICAL CHARACTER

In previous reports the Taschereau intrusive has been erroneously termed a "granite" as potash feldspar never exceeds a maximum of 15 to 20 percent, which is rather low even for a granodiorite (See Figure 1, page 23).

Thin sections and staining reveal that in the border phase, potash feldspar is absent or only in slight traces, and that the rock is a tonalite (quartz-diorite). Similarly the core phase is a leucogranodiorite, and locally by increase of quartz becomes a granodiorite-greisen.

The Tonalite Border Phase

Megascopic Features

On a fresh surface the tonalite is a medium to light grey colour depending on the amount of ferromagnesians. It has an even grained granitic texture and the grain size averages 2-4mm.; some biotite flakes 6mm. in diameter were observed.

Black biotite, white feldspar, and clear colourless quartz are recognizable in hand specimens. Near the outer margin, greenish hornblende is the dominant ferromagnesian.

Microscopic Features

In thin sections the rock has a hypidiomorphic texture having large euhedral plagioclase crystals in a basis of anhedral quartz grains (See Plate IXA). The chief constituents are plagioclase, quartz, and one or two dark minerals. Accessories are magnetite, apatite, zircon, and titanite. Microchemical tests check the total lack of potash feldspars except in one case where it is a minor accessory.

Plagioclase occurs as strongly resorbed or corroded crystals which in places show their original crystal form.. They are zoned - grading from a core of (Ab66An34) to a narrow rim of (Ab70An30) - that is acid andesine. The plagioclase is polysynthetically twinned

PLATE IX.

A. Typical tonalite of the border phases, showing euhedral altered plagioclase and a euhedral crystal of hornblende enclosed in biotite. x14

B. Typical granodiorite of the core phases having euhedral to subhedral plagioclases and abundant interstitial quartz. x14

C. A section of the core phase showing the abundant nature of the quartz and four separate areas of microcline that extinguish together. x10

D. A section of the core phase from the Taschereau mass showing a large unit of microcline enclosing quartz and plagioclase. x20

MICROPHOTOGRAPHS TYPICAL OF THE BORDER AND CORE PHASES on the albite law with occasionally some pericline twinning. Combination carlsbad and albite twins are common. Optical determinations of composition were made chiefly on these combination twins and according to Wright's modification of Michel-Levy's diagram. The zoning is indicated by a shadow that moves out radially on rotation, and is emphasized by alteration of the core to white mica (paragonite). Rarely, some undulatory extinction was observed in the plagioclase crystals.

The ferromagnesian constituents are hornblende and biotite with either one predominating although commonly hornblende is most abundant near the outer edge and biotite near the core. Biotite is the common brown pleochroic variety occasionally having undulatory extinction. In places, parallel intergrowths occur with muscovite. Inclusions of apatite are common; titanite and zircon less so. Hornblende is the common green variety; pleochroism x=pale yellow y= olive green z=dark green, absorption $x < y < z$. It is optically negative. Extinction ($z \wedge c$) is 26° and twinning common.

Quartz was the last mineral to crystallize. Irregular grains with sutured boundaries fill all the remaining space. It contains abundant minute contraction cracks typical of inversion and invariably has an undulatory extinction. In sections from the hornblende border phase the quartz contains innumerable very long needles of rutile. The rutile is generally confined to the central parts of individual quartz grains. Magnetite and apatite prisms and more rarely zircon and titanite are generally associated with the ferromagnesian minerals and the plagioclase aggregates. The zircons may be minute crystals surrounded by pleochroic haloes, or large stubby zoned prisms with inclusions.

In one slide, a very small amount of microperthite was identified. This may be secondary but is probably a final product of crystallization.

Alteration products are paragonite and a little clinozoisite emphasizing the zoning in the andesine, penninite replacing biotite, and some chloritization of hornblende. A secondary mineral that has been identified as epidote with a fair degree of certainty, locally occurs as large crystals and angular grains replacing plagioclase and ferromagnesians. It is nearly colourless: Some grains suggest a pale yellow pleochroism. It has excellent cleavage and is commonly twinned. There is some undulatory extinction: Angles measured to the cleavage gave 37° as a maximum. In some sections it is optically positive. However the high dispersion and high birefringence, and the very large optic angle are characteristic of epidote. Calcite and Kaolin are usually found only in badly weathered specimens. Evidence of some deuteric alteration is the occurence of a little vermicular quartz at the contact of quartz and plagioclase.

Chemical Features

In Table VI below, is an analysis of the tonalite which is typical of the border phase, together with the calculated norm and the mode. The rock is, accordingly, a biotite bearing hornblende-tonalite according to Johannsen's classification (See Figure 1 page 23).

TABLE VI

CHEMICAL ANALYSIS, CALCULATED NORM, AND MODE OF THE TASCHEREAU BORDER PHASE

Analysis No.	XV#	Norm		Mode	
SiO_2..........	66.40	Quartz......	29.69	Quartz.......	36
Al_2O_3.........	15.66	Orthoclase..	4.44	K-feldspar...	0
Fe_2O_3.........	0.94	Albite......	24.63	Andesine	
FeO...........	4.55	Anorthite...	24.85	(Ab67An33)..	41.5
MgO...........	1.92	Corundum,,,,.	.91	Hornblende...	13.5
CaO...........	5.22	Hypersthene.	12.13	Biotite......	7
Na_2O..........	2.91	Magnetite...	1.36	Magnetite....	1.1
K_2O...........	0.75	Ilmenite....	.36	Apatite......	.4
H_2O+..........	0.85	Apatite.....	.41	Titanite.....	.5
H_2O-..........	0.20	Total	98.78	Zircon.......	tr
CO_2...........	nil			Total	100
TiO_2..........	0.19	Symbol: II.4.4.3.			
P_2O_5.........	0.17	Name: Bandose		Symbol: (228)	
MnO...........	0.04			Name: Biotite bearing	
F^x^...........	0.02			Hornblende-tonalite.	
S.............	tr				
Total	99.82				

Biotite bearing hornblende-tonalite, from rock cut C.N.R., lot 32, R. VIII, Privat township. Analyst, W.H. Herdsman.
[x] Determined by the writer.

A study of the point-to-point variations of the border phase shows that, although not uniform, it presents no startling quantitative differences. Table VII gives Rosiwal analyses illustrating the changes in the border phase from the outer margin towards the core. Examination of these shows a rather limited range in

TABLE VII

APPROXIMATE MINERAL PERCENTAGES
OF THE TASCHEREAU BORDER PHASE

	a	b	c	d
Quartz................	26	36	35	39
K-feldspar............	0	0	1.5	0
Andesine (Ab67An33)...	46	41.5	53	49
Hornblende............	16	13.5	3	3
Biotite...............	10	7	6	8
Magnetite.............	1	1.1	.7	.4
Apatite...............	.5	.4	.3	.6
Titanite..............	.5*	.5	.2	...
Zircon................	...	tr	.3	...
Total	100	100	100	100

* Partly rutile in quartz.

a. Outer marginal phase. Biotite bearing hornblende-tonalite. (228)
b. Mode of analysis XV, Biotite bearing hornblende-tonalite. (228)
c. Intermediate phase. Hornblende bearing biotite-tonalite. (228)
d. Siliceous phase adjacent to inner margin. Hornblende bearing biotite-tonalite. (228)

the variations. There is a gradual increase of quartz toward the centre of the mass and correspondingly, biotite-proxies hornblende more and more although the total ferromagnesians decrease.

The Granodiorite Core Phase

Megascopic features.

Specimens of the core phase are characterized by the abnormally high quartz content (See Plate IXC) and the small amount of dark constituents. It usually has a pale pink colour but near the margins pink and light grey varieties occur in close proximity. Its texure is dominantly even grained granitic, with medium to coarse grain size - average 3-6mm. Locally it has a pseudoporphyritic texture with water clear quartz aggregates nearly three-quarters of an inch in diameter. In the field, rocks of the core phase were unhesitatingly classified as siliceous granites but the colour of the feldspars was most misleading as shown by petrographic examinations and staining checks made in the laboratory. Quartz and small black flakes of biotite are always readily recognizable.. The difficulty lies in the field determination of the feldspar which is white to pale pink.

Microscopic Features.

In thin sections the texure is hypidiomorphic having plagioclase almost entirely in euhedral forms occurring in a basis or "oxymesostasis" of anhedral quartz and potash feldspar (See Plate IX B,C, & D). The minerals are chiefly quartz and plagioclase with some microcline or microperthite. Biotite is the only dark constituent, and is never more than five percent. Magnetite, apatite, titanite, zircon, and pyrite occur sparingly as accessories.

In the core phase, plagioclase occurs as much corroded, blocky crystals, scattered uniformly throughout the basis. Only locally were they in sufficient numbers to interfere with their euhedral form. As in the border phase albite twinning is well developed and combination carlsbad and albite twins are common: Pericline twinning is rare. Optical determinations gave acid andesine (Ab68An32) as the most basic core material with the most acid periphery up to basic oligoclase (Ab72An28) in composition. The average composition of the plagioclase is (Ab71An29) or basic oligoclase. This was checked exactly by recasting the chemical analysis of this phase.

Quartz is with few exceptions, the most abundant mineral of the core phase (See Plate IXC). It occurs in large irregular grains having sutured contacts. There is but little undulatory extinction and it was the last mineral to crystallize. It has corroded and embayed the euhedral plagioclases and replaced microcline to a considerable extent.

The potash feldspar which forms the basis along with quartz is chiefly microcline: Microcline-microperthite, and microperthite intergrowths make up the balance. The mineral orthoclase was never found present in any of the plutonic rocks of the Rouyn area. The microcline occurs in large irregular units (See Plate IXD)and as wisps in areas of quartz (See Plate IXC), all of them extinguishing together. They are probably parts of one crystal unit, that has been embayed and corroded by quartz. The occurrence of wisps of polysynthetically twinned oligoclase in microcline suggests that the microcline replaced plagioclase to some extent. On the other hand some may represent an intergrowth developed by exsolution.

Biotite occurs as small irregular flakes and is the common brown pleochroic variety. It is chloritized and replaced by penninite, and contains minute inclusions of zircon and titanite.

Alteration products are, penninite replacing biotite, small amounts of paragonite and clinozoisite in plagioclase, and epidote replacing both biotite and plagioclase.

Chemical Features

An analysis representative of the core phase is given in Table VIII along with its norm and mode. The name biotite-leucogranodiorite is in accordance with Johannsen's classification (See figure 1, page 23).

The Rosiwal analyses shown in Table IX indicate the local variations in the Taschereau core phase. The greatest change is in the quartz content, which is sometimes so great that the rock must be classed as a greisen. Biotite, the only dark mineral is a very minor accessory.

TABLE VIII

CHEMICAL ANALYSIS, CALCULATED NORM, AND MODE OF THE TASCHEREAU CORE PHASE

ANALYSIS NO. XVI#		NORM		MODE	
SiO_2........	75.95	Quartz.......	39.10	Quartz.......	42
Al_2O_3.......	12.88	Orthoclase...	18.17	K-feldspar...	16
Fe_2O_3.......	0.47	Albite.......	30.51	Oligoclase	
FeO.........	1.60	Anorthite....	6.66	(Ab71An29)..	37
MgO.........	0.09	Corundum.....	1.12	Biotite......	4
CaO.........	1.34	Hypersthene..	2.77	Magnetite....	.6
Na_2O........	3.61	Magnetite....	.68	Apatite......	tr
K_2O.........	3.08	Ilmenite.....	tr	Titanite.....	tr
H_2O+........	0.65	Apatite......	tr	Zircon.......	tr
H_2O-........	0.20	Total	99.01	Muscovite....	tr
CO_2.........	nil			Pyrite.......	.4
TiO_2........	tr	Symbol: I.3.2.4.		Total	100
P_2O_5........	tr	Name: Alsbachose			
MnO.........	tr				
S...........	0.06				
Total	99.93				

#Biotite-leucogranodiorite, from diamond drill core, lot 11, R. VII, Launay township. Analyst, W.H. Herdsman.

TABLE IX

APPROXIMATE MINERAL VARIATIONS OF THE TASCHEREAU CORE PHASE

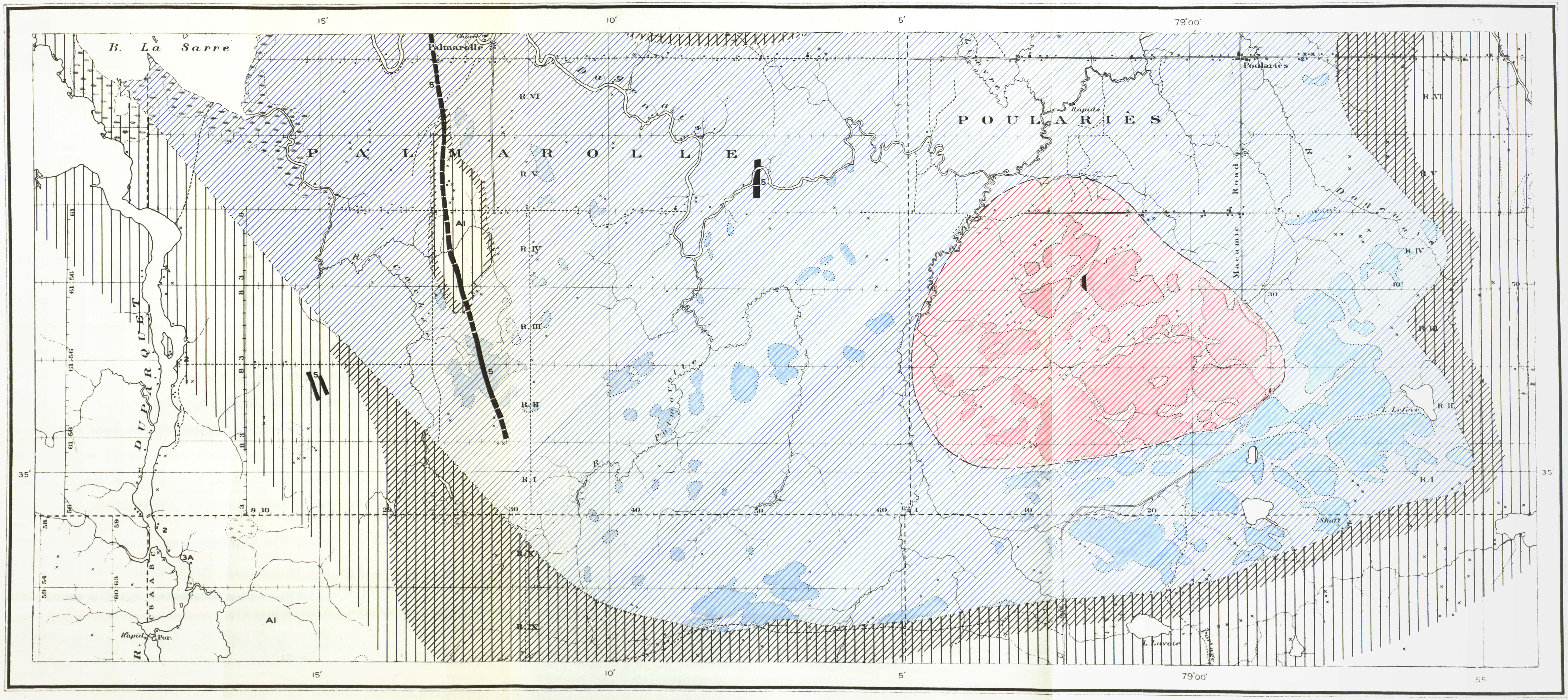
	a	b	c	d
Quartz..................	42	41	50	53
K-feldspar..............	16	7	5	5
Oligoclase (Ab71An29)...	37	48	44	40
Hornblende..............	0	0	0	0
Biotite.................	4	4	0.8	1.5
Magnetite...............	0.6	tr	tr	0.2
Apatite.................	tr	tr	tr	0.3
Titanite................	tr	tr	0.2	tr
Zircon..................	tr	tr	...	tr
Muscovite...............	tr	..	...	..
Pyrite..................	0.4	..	...	..
Total	100	100	100	100

a. Mode of analysisXVI,normal core phase from centre of mass: Biotite-leucogranodiorite (127).
b. Normal core phase from margin of core phase: Biotite-leucogranodiorite (127).
c. More siliceous core phase. Biotite-granodiorite-greisen (123).
d. More siliceous core phase. Biotite-granodiorite-greisen (123).

GENESIS

A discussion of the origin of these phases has been deferred until after the descriptions of the Palmarolle and Flavrian masses. Field relations, petrographic studies, and chemical analyses indicate a marked genetic similarity and the writer is of the opinion that all are related to a common source magma, and as is shown in a later chapter, are similarly related to other major acid intrusives of the Rouyn-Bell River area.

PALMAROLLE



Scale $\frac{1}{63,360}$ or 1 Inch to 1 Mile

Miles

CHAPTER V

THE PALMAROLLE MASS

GENERAL

Very little was known of the Palmarolle mass until the detailed study of the Rouyn-Bell River Area was undertaken by the Geological Survey. Due to inaccessibility, the early surveys[x] show only a few outcrops on the eastern shore of Lake Abitibi, and a few miles up the Dagenais river.

The intrusive was first mapped in its entirety by Buffam[e] for the Survey in 1925, with slight adjustments by Lang[x] in 1932, following which detailed mile to the inch outcrop maps of the area were issued: See both the Palmarolle and Taschereau sheets (Maps 293A and 285A, respectively).

Using these as a base, the accompanying map of the Palmarolle mass was prepared to show the distribution of the various rock types. The southeast quarter of Palmarolle township, and the adjacent part of Poularies were remapped with the aid of photographs, loaned by the Topographical Surveys.

DISTRIBUTION

The recent four mile map of the Rouyn-Bell river area shows a large horseshoe-shaped mass of plutonic rocks

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[x] Wilson, M.E., and later Tanton, T.L.: Ibid.

[e] Buffam, B.S.W., "Destor Area, Abitibi County, Quebec", G.S.C., Sum. Rept. 1925, Pt. C, p.99.

[x] Ibid.

directly east of Lake Abitibi and south of the Canadian National Railway. Distribution of synclinal bands of Keewatin sediments in its proximity, indicates that both arms occupy anticlinal structures trending south-east, and are separated in the western half by a narrow synclinal tongue of the older rocks. Due to the heavy overburden and lack of outcrops in the eastern part, it is impossible to determine whether the two arms actually join across the intervening synclinal area or remain separate.

The name "Palmarolle mass" has been restricted to the plutonic rocks of the southern arm which occupies most of Palmarolle and Poulariès townships, and the adjacent parts of Duparquet and Destor townships on the south.

The Palmarolle mass is roughly 125 square miles in area extending east from Lake Abitibi for 17 miles, and having an average width of 7 miles.

In Palmarolle township the topography is low and thickly wooded, and only scattered outcrops project from beneath the heavy overburden of lacustrine clays. However, these are evenly distributed and are a good representation of the underlying rocks. In the southern part of Poulariès township, the rocks appear to have been more resistant, and form a rugged range of hills that are completely denuded of soil and vegetation. The Rouyn-Macamic highway threads its way through the centre of this rocky upland and is an excellent means of access. Both rock types of the Palmarolle mass occur in this vicinity, which not only lends itself to very critical examination of the various phases but gives a very complete picture of the bed rock.

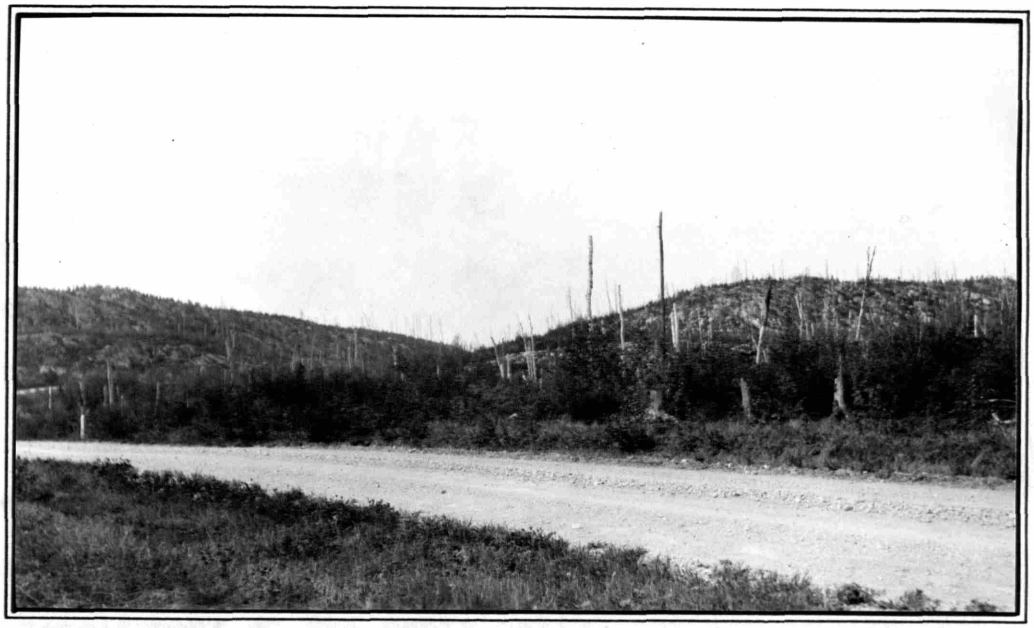

Plate X. The Rouyn-Macamic highway takes advantage of the valley along the contact between the granodiorite core phase (right) and the tonalite border phase (left).

Where the country rock is rhyolite, the actual limits of the intrusive are hard to show because in the vicinity of the contact, inclusions of the country rock are so abundant in the intrusive phase, and the adjacent volcanics are brecciated and highly injected by dykes and masses of the intrusive. Most of these inclusions have well defined edges, and show no reaction with the granite,- the only change being a recrystallization and coarsening of grain. Where basic rocks were intruded, a transition zone of highly metamorphosed rocks is developed as described surrounding the Taschereau mass. Inclusions are still common several miles from the contact. In the western part, a large mass of country rock over two miles long is indicated.

Along the southern edge of the Palmarolle mass, a zone of extreme shearing three-quarters of a mile wide is developed parallel to the contact. This is cut by quartz veins subsequent to the shearing. Along the eastern edge the schistosity is east-west and does not parallel the contact. It is also not as intense. It therefore is evident that the batholith was intruded into the Keewatin lavas subsequent to folding and development of the schistosity, cutting across the pre-existing schistosity to the east, and paralleled it in the south where it was greatly intensified.

As in the Taschereau mass, the igneous rocks composing the Palmarolle mass are divisible into a pink siliceous core phase, and a more basic grey border phase. The core phase forms the greater part of the rocky upland, and being a more resistant rock, probably accounts for the relief. It is almost circular in area, having a diameter of four to five miles and an area of 14 square miles.

The greater part of the Palmarolle mass is underlain by the grey border phase which in contrast to the core phase abounds in inclusions and is cut by a plexus of basic dykes of varying composition. Aplite and pegmatite dykes were found cutting the border phase and although virtually every square yard of the surface was examined in the vicinity of the two phases, no intrusive relations could be definitely established between them. Outcrops of both phases occur within two hundred feet, separated by an area of muskeg, and both phases remain unchanged in texture or composition to the very edge of the outcrop. The greatest difference in the two phases, aside from composition is the abundance of inclusions and the great number of basic dykes in the border phase. Time and again the writer was impressed by this during the field work. The plexus of dykes vary greatly in direction, size, texture, and composition. Buffam[*] noted a marked radial arrangement of the basic dykes in the southeast part of the Palmarolle mass. The strike of the majority of the dykes here is approximately at right angles to the contact of the nose. West of the Macamic highway, the strike varies from north-south to N 10° W, and if the contact is followed around the nose, the strike gradually becomes N 45° W, then N 70°W, and finally N 80°W in R. IV, lot 35 of Poularièes township.

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[*] Buffam, B.S.W.: G.S.C., Unpublished manuscript No. 10

Both phases of the stock are cut by a north-south set of Keweenawan diabase dykes.

LITHOLOGICAL CHARACTER

A study of thin sections and chemical analyses shows an almost complete absence of potash feldspar in the border phase, and that its mineral composition corresponds to that of a tonalite. Potash feldspar is present up to 30 percent in the core phase and the mineral composition corresponds to that of a very siliceous to normal granodiorite.

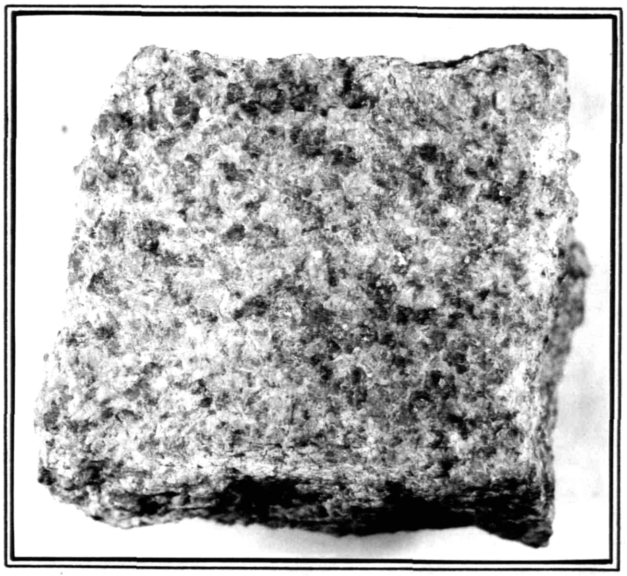
The Tonalite Border Phase

Megascopic Features.

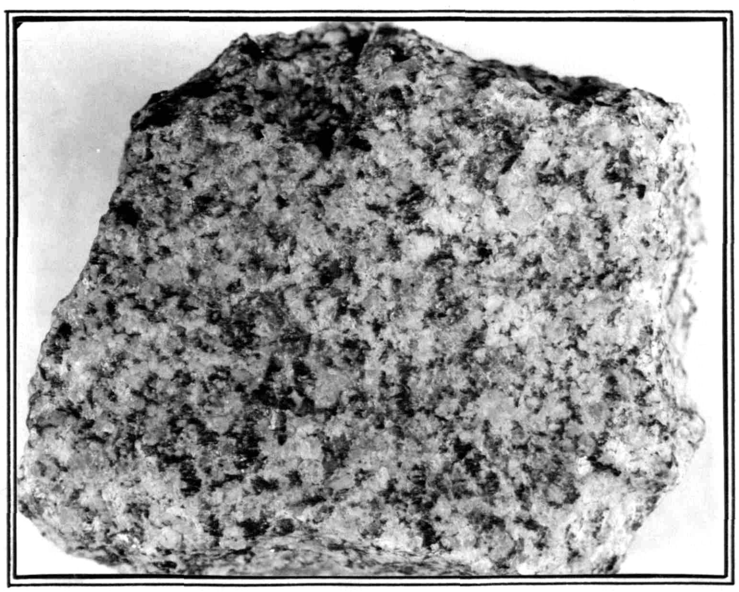
In hand specimens the border phase is an even grained greyish granitic rock made up of white feldspars, colourless quartz, and black ferromagnesians. A closer inspection shows the presence of both hornblende and biotite in nearly equal amounts, and in some specimens the plagioclase has a greenish cast. Nearer the centre of the mass there is a decided increase in quartz content and the feldspars have a pinkish tinge.

The grain size averages 4-6mm. with occasional blocky feldspar crystals up to 9mm. in which both carlsbad and albite twinning are recognizable.

PLATE XI.



A. The biotite-leucogranodiorite core phase of the Palmarolle mass. About natural size.



B. Biotite bearing hornblende-tonalite of the Palmarolle border phase - A more silicious facies from the inner margin. About natural size.

TYPICAL SPECIMENS OF THE PALMAROLLE INTRUSIVE

Microscopic Features

Thin sections of the tonalite are very similar to those described for the Taschereau mass. The rock has a hypidiomorphic texture in which euhedral and subhedral plagioclase crystals occur in a ground mass of quartz and ferromagnesians. Plagioclase and quartz are the most abundant constituents with hornblende and biotite together making up about twenty percent of the rock. Accessories are magnetite, titanite, apatite, and traces of zircon. Only traces of potash feldspar were identified.

The plagioclase occurs as blocky, much embayed and corroded crystals. Polysynthetic twinning on the albite law is almost always present, occasionally in combination with pericline and carlsbad twinning. The composition of the plagioclase was determined optically using the combination carlsbad-albite twins where possible. It is acid andesine (Ab68An32) and is locally as calcic as (Ab65An35). Slight development of clinozoisite and paragonite emphasize the zoning.

Biotite is the common brown pleochroic variety and is locally altered to penninite. In some sections it occurs in parallel intergrowths with muscovite. Hornblende is usually quite fresh and is often twinned. It is the common green pleochroic kind. In most sections hornblende is in excess of the biotite, though locally the reverse is the case. Biotite began to crystallize late and included euhedral crystals of both plagioclase and hornblende (See Plate IXA).

Quartz occurs in irregular grains having sutured contacts and is interstitial to the other minerals. It is fractured and has an undulatory extinction. Liquid inclusions are common, generally arranged along linear directions.

Other accessories are magnetite, titanite, apatite, and locally zircon, microcline-microperthite, and microperthite. The potash feldspar intergrowths were seen only in two sections of the phase and traces were revealed in polished handspecimens by staining.

Alteration products are clinozoisite and paragonite in the cores of the plagioclases, penninite replacing biotite, and a little epidote. The rock is usually little altered except near the weathered surface. In extreme cases calcite is also found.

Chemical Features.

Two chemical analyses have been made of the tonalite border phase. These are shown in Table X, together with the calculated norm and mode. Analysis XVII is representative of the typical tonalite of the border phase, while No. XVIII is of the more siliceous central part. A comparison of the two indicates a

TABLE X

CHEMICAL ANALYSES, CALCULATED NORM, AND MODE OF THE PALMAROLLE BORDER PHASE

ANALYSIS NO. XVII[x]		NORM		MODE	
SiO_2......	67.20	Quartz......	31.24	Quartz......	35
Al_2O_3.....	12.62	Orthoclase..	2.89	K-feldspar..	tr
Fe_2O_3.....	1.07	Albite......	25.72	Andesine	
FeO.......	5.34	Anorthite...	19.28	(Ab68An32).	42
MgO.......	2.64	Diopside....	1.86	Hornblende..	12
CaO.......	4.56	Hypersthene.	13.74	Biotite.....	9
Na_2O......	3.04	Magnetite...	1.55	Magnetite...	1.1
K_2O.......	0.49	Ilmenite....	1.10	Apatite.....	.4
H_2O+......	1.90	Apatite.....	.43	Titanite....	.5
H_2O-......	0.40	Total	97.81	Total	100
CO_2.......	nil				
TiO_2......	0.58	Symbol: II.3.3.5.		Symbol: (228)	
P_2O_5......	0.18	Name: -----------		Name: Biotite bearing	
MnO.......	0.07	(near Placerose)		hornblende-tonalite	
F*........	0.02				
S.........	tr				
	100.11				

ANALYSIS NO. XVIII[e]		NORM		MODE	
SiO_2......	68.47	Quartz......	32.92	Quartz......	38
Al_2O_3......	12.98	Orthoclase..	3.78	K-feldspar..	tr
Fe_2O_3.....	1.19	Albite......	26.48	Andesine....	
FeO.......	4.69	Anorthite...	19.39	(Ab68An32).	40
MgO.......	2.06	Diopside....	1.43	Hornblende..	11
CaO.......	4.51	Hypersthene.	11.23	Biotite.....	9
Na_2O......	3.13	Magnetite...	1.73	Magnetite...	1.5
K_2O.......	0.64	Ilmenite....	1.01	Apatite.....	.5
H_2O+......	1.30	Apatite	.43	Titanite....	tr
H_2O-......	0.40	Total	98.40	Total	100
CO_2.......	nil				
TiO_2......	0.53	Symbol: II.3.3.5		Symbol: (228)	
P_2O_5......	0.18	Name: ----------		Name: Biotite bearing	
MnO.......	tr	(near Placerose)		hornblende-tonalite	
F*........	0.02				
S.........	tr				
Total	100.10				

[x] Biotite bearing hornblende-tonalite from rock-cut on Macamic highway, lot 27, R.II, Poulariès township. Analyst, W.H. Herdsman.

* Determined by the writer.

[e] Biotite bearing hornblende-tonalite from pit, lot 38, R.II, Palmarolle township. Analyst, W.H. Herdsman.

remarkable uniformity in both chemical and mineral composition, and shows that there is very little change from the border of the mass to the central part.

This uniformity in mineral composition is still further illustrated by a point-to-point study of the border phase by means of Rosiwal analyses. In Table XI four Rosiwal analyses are shown along with the modes of the two analyses.

TABLE XI

APPROXIMATE MINERAL PERCENTAGES OF THE PALMAROLLE BORDER PHASE

	a	b	c	d	e	f
Quartz...............	18	35	36	35	25	38
K-feldspar...........	0	1	0	tr	0	tr
Andesine (Ab68An32)..	60	46	41	42	52	40
Hornblende...........	15	7	12	12	20	11
Biotite..............	6	10	8	9	.4	9
Magnetite............	.5	.2	1.5	1.1	1.8	1.5
Apatite..............	.4	.3	1.2	.4	.8	.5
Titanite.............	.1	.5	.3	.5	tr	tr
Zircon...............	tr	-	tr	-	tr	-
Total	100	100	100	100	100	100

a. Marginal facies, eastern edge, Biotite bearing hornblende-tonalite.
b. Intermediate facies, west of Poulariēs, Hornblende bearing biotite-tonalite.
c. Intermediate facies, Biotite bearing hornblende-tonalite.
d. Mode of analysis XVII.
e. Adjacent to core phase. Biotite bearing hornblende-tonalite.
f. Mode of analysis XVIII.

The Granodiorite Core Phase

Megascopic Features

Specimens of this phase are characterized by the unusually high quartz content and the small amount of dark constituents. It is a pink coloured, coarse grained, granitic rock. The grain size varies from 4mm. to 7mm., being coarsest in the centre. Quartz and plagioclase form the bulk of the rock and potash feldspar varies from 10 to 30 percent but is not recognizable in the field. The pinkish colour of the plagioclase has caused confusion in the field classification of the rocks, suggesting a higher content of potash feldspar than is actually the case. The dark constituents are biotite, up to 5 percent, and small amounts of magnetite and titanite. As in the Taschereau mass quartz aggregates up to a centimeter across give the rock a pseudoporphyritic appearance.

A few specimens contain long slender crystals of orthite which are commonly surrounded by a brown discolouration.

Microscopic Features.

Thin sections reveal that almost all the plagioclase occurs in euhedral forms enclosed in a basis of quartz and some potash feldspar. The rock thus has a hypidiomorphic texture. Accessories are biotite, magnetite, titanite, apatite, zircon, muscovite, and orthite.

The plagioclase is strongly zoned and polysynthetically twinned and the once blocky euhedral crystals are now much corroded. Albite twinning is invariably present, occasionally in combination with carlsbad twinning; pericline twinning is only rarely present. Determinations made on combination carlsbad-albite twins indicate it to be oligoclase with an average composition of Ab77An23. This is checked by recasting the chemical analyses. Plagioclase almost crystallized in complete suspension in the magma because only locally was there any interference in the formation of the outer zones.

Some potash feldspar was identified as microcline but most of it occurs as microperthite intergrowths which are locally so large as to poikilitically enclose the plagioclase. It is greatly replaced by quartz which was the last mineral to crystallize.

Quartz is generally the most abundant constituent having filled in all the remaining space and replacing all the other minerals to a considerable extent. It is only slightly strained with almost no undulatory extinction.

Biotite is the only ferromagnesian mineral. It usually occurs in small hexagonal flakes but locally it has developed excellent euhedral crystals. Some may be of a secondary nature after hornblende. The biotite began to crystallize toward the end of the formation of plagioclase and before the potash began. It is now of a greenish colour due to chloritization and in some sections is replaced by penninite.

One of the final products of crystallization was a little muscovite forming an outer border on biotite and shreds included in the quartz. Traces of magnetite, apatite, titanite, and some zircon are included in biotite and quartz. Some zircon crystals are zoned, pale yellow, and slightly pleochroic.

Orthite was not found in any of the thin sections studied but acicular crystals found in hand specimens were identified as orthite under the microscope.

Paragonite and some clinozoisite and epidote occur as alteration products in plagioclase, and biotite is altered to penninite. Potash feldspar is always fresh.

Chemical Features

Only one chemical analysis was considered necessary to represent the core phase as it is quite uniform in mineral composition and varies only slightly in grain size. The results of this analysis are given in Table XII together with its norm and mode.

TABLE XII

CHEMICAL ANALYSIS, CALCULATED NORM, AND MODE OF THE PALMAROLLE CORE PHASE

ANALYSIS NO. XIX*		NORM		MODE	
SiO_2......	73.20	Quartz......	36.05	Quartz......	42
Al_2O_3.....	13.07	Orthoclase..	13.78	K-feldspar..	12
Fe_2O_3.....	0.64	Albite......	30.71	Oligoclase..	
FeO.......	2.44	Anorthite...	10.47	(Ab77An23).	39
MgO.......	0.72	Corundum....	.71	Hornblende..	0
CaO.......	2.26	Hypersthene.	5.19	Biotite.....	5
Na_2O......	3.63	Magnetite...	.93	Magnetite...	.9
K_2O.......	2.33	Ilmenite....	.65	Apatite.....	.3
H_2O+......	0.80	Apatite.....	.29	Titanite....	.5
H_2O-......	0.50	Total	98.78	Zircon......	tr
CO_2.......	nil			Muscovite...	.3
TiO_2......	0.34	Symbol: I.3.2.4		Orthite.....	tr
P_2O_5......	0.12	Name: Alsbachose		Total	100
MnO.......	tr				
F^x........	0.01			Symbol: (127)	
S.........	tr			Name: Leucogranodiorite	
Total	100.06				

* Biotite-leucogranodiorite, from pit, lot 16, R.IV, Poulariès township. Analyst, W.H. Herdsman.
ˣDetermined by the writer.

Table XIII gives a set of Rosiwal analyses to show the most extreme variations in the core phase and even in these there is no marked difference. From an inspection of these it is evident that the Palmarolle core phase lies very near the boundary between Class 1 and 2 in Johanssen's classification, but as the lack of dark constituents is a strong characteristic, it is here placed entirely in class 1. It is a biotite-leucogranodiorite and locally with an increase of quartz, borders on a greisen.

TABLE XIII

APPROXIMATE MINERAL VARIATIONS OF THE PALMAROLLE CORE PHASE

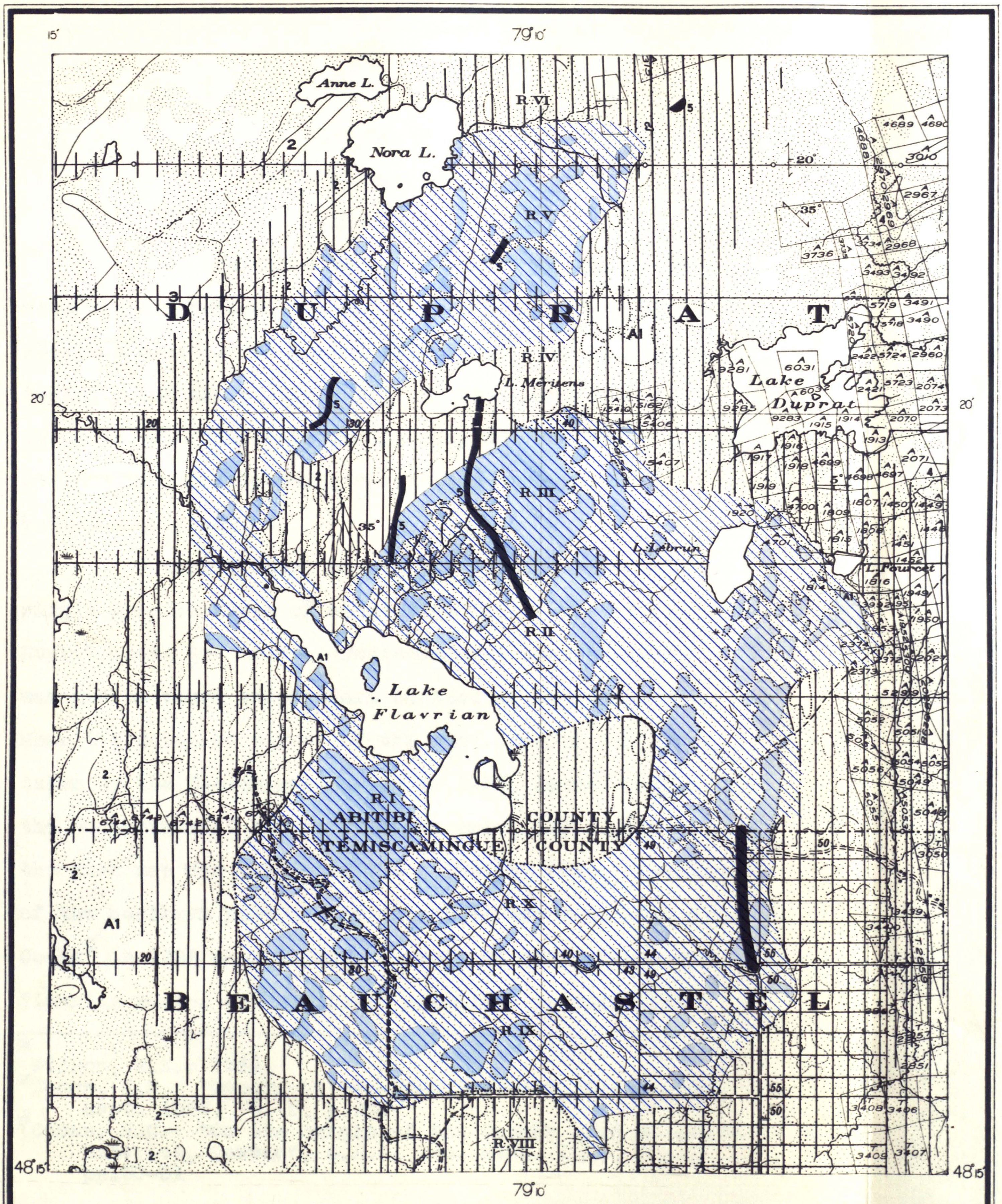
	a	b	c	d
Quartz................	25	42	41	48
K-feldspar............	30	12	13	10
Oligoclase (Ab77An23).	43	39	40	36
Hornblende............	tr	0	0	0
Biotite...............	1.5	5	4	5
Magnetite.............	tr	.9	.7	.5
Apatite...............	tr	.3	.4	.4
Titanite..............	tr	.5	.8	tr
Zircon................	.1	tr	-	tr
Muscovite.............	.4	.3	.1	.1
Orthite...............	-	tr	-	tr
Total	100	100	100	100

a. Marginal facies, Biotite-leucogranodiorite (127).
b. Average core phase, mode from analysisXIX(127).
c. Average composition of central part (127).
d. More siliceous central part. Biotite-granodiorite-greisen (123).

GENESIS

It will now be evident that a discussion of the origin of the Taschereau phases is equally applicable to those of the Palmarolle mass. A comparison of the chemical analyses and mineral composition of both the border phase and the core phase of each of these shows that they might well belong to one mass. Similarly it will be seen that the Flavrian mass is another member of this series, and hence all three are discussed after a description of this third mass.

FLAVRIAN



Scale, $\frac{1}{63,360}$ or 1 Inch to 1 Mile

Miles

CHAPTER VI

THE FLAVRIAN MASS

GENERAL

Of the three major intrusive masses in the northwestern part of the Rouyn-Bell River Area, the Flavrian mass is the most difficult of access. Duprat township and the northern half of Beauchastel, in which the Flavrian mass is located, have no water routes and are only now becoming accessible through the building of roads.

When Wilson[x] mapped the Abitibi region, one single long traverse of about five miles, west from Lake Duprat along the Abitibi-Temiscamingue county-line, managed to reach the eastern contact of the intrusive. When the detailed survey of the whole region was undertaken by the Geological Survey in 1922, James[x] mapped the southern half of the Flavrian mass, and a mile to the inch map was published the following year. Mapping of the northern part of the intrusive was completed by Cooke[#] in 1926 when he made a study of the Dufault and Flavrian masses and published excellent petrographic

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[x] Wilson, M.E.: Ibid.

[x] James, W.F.: "Duparquet Map-Area, Quebec", G.S.C. Sum. Rept. 1922, Pt. D, p.90.

[#] Cooke, H.C.: "On the Origin of the Copper Ores of Rouyn District, Quebec", G.S.C. Sum. Rept. 1926, Pt. C, pp.50-51 descriptions. Finally in 1933, a revised outcrop map of the area was issued by the Survey. (See Map 281A, Duparquet Sheet).

The accompanying map of the Flavrian mass was prepared using the new Survey map as a base. New roads and township subdivisions were added and locally, the contacts of the intrusive were redefined by additional information obtained in the field. As the area is now almost completely denuded by forest fires, many new outcrops were located and, with the aid of aerial photographs, a complete revision of the existing outcrop boundaries was made.

DISTRIBUTION

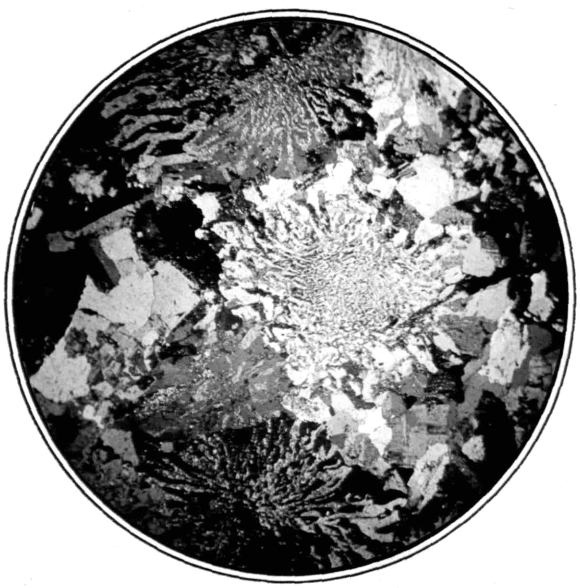
As shown in the general location map of the major acid intrusives, the Flavrian mass lies some six miles northwest of Noranda. It is roughly oval in shape, extending about eight miles north-south and has a maximum width of five miles. Two large areas of Keewatin rocks occur within the intrusive area and are probably roof pendants. Excluding these the plutonics outcrop over an area of 24 square miles and are everywhere well exposed, and lend themselves to a very critical examination.

Within the intrusive mass and away from the contacts, small andesitic inclusions are common and show

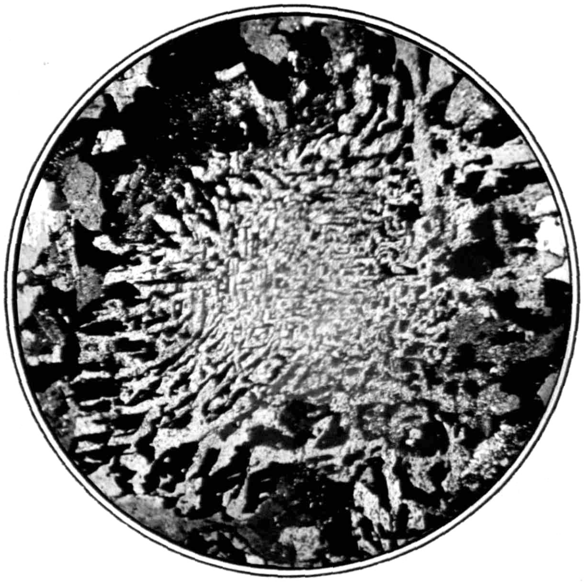
PLATE XII.

A. Andesite inclusion from the Flavrian mass in which the original trachytic texture and feldspar laths can still be seen, showing some replacement by quartz. x14

B. An inclusion still recognizable as andesite in which the quartz forms crude pseudographic replacement textures. x14



C. Lace like replacements of andesite by quartz, each individual extinguishing as a unit. x14



D. An enlargement of a single unit in C. x30

THE GRAPHIC REPLACEMENT OF INCLUSIONS

evidence of granitization and hydrothermal alteration by the development of eyes of quartz and albite metacrysts. Near the margins of these, long acicular crystals of hornblende are generally developed. Some inclusions are so greatly altered that they are light coloured and resemble rhyolite, having a "spherulitic" texture. In thin sections this is seen to be actually a pseudographic replacement texture in which quartz and albite form rosette-like replacements of the andesite (See Plate XII). In still other inclusions, a coarse texture is developed strongly resembling the plutonic rocks. However they are always recognizable as such by the development of long slender needle-like crystals of hornblende. Locally hornblende needles attain an acicular length of half an inch and more.

Approaching the contacts, inclusions become more numerous and larger until they form breccia blocks in an igneous matrix. Finally the blocks touch and the intrusive phase occurs as dykelets intruding the recrystallized greenstone. Everywhere along the contacts of the intrusive, igneous breccias are developed, and there is apparently little assimilation even where the country rocks are quite basic.

The contact is very well exposed on the west side of Flavrian lake in range II. Here the country rock is an amygdaloidal basalt. Near the contact it is cut by numerous granite and aplite dykes and the intrusive itself is an igneous breccia containing over 50 percent of its volume of sharp angular fragments of the amygdaloidal basalt. The intrusive is apparently quite normal and uncontaminated by assimilation. It is coarse grained and very siliceous just as that from the centre of the mass.

The degree of alteration and recrystallization of the large masses of Keewatin rocks within the oval area suggests that they are very thin remnants of the original roof of the body. Similarly the abundance of small inclusions and aplite dykes throughout the intrusive area, and, as will be shown later, the nature of the alteration of the intrusive, are all phenomena of the upper portion of a batholith. In addition to this, the degree of silicification of the surrounding Keewatin rocks, and the occurrence in them of granitic dykes, suggest that the plutonic rocks lie not very far beneath. In view of all these facts, it seems probable that the Flavrian mass has barely been unroofed by erosion.

Field work and later, laboratory work, show that the Flavrian intrusive is almost entirely composed of one single phase, the only variations being in the amount of quartz and ferromagnesians, and in the abundance of inclusions. It is made up of highly siliceous, coarse grained, pinkish rocks, that in the field were thought to resemble most closely the acidic core phase of the other masses already described. More basic phases are only found with difficulty. Petrographic and chemical analyses however, show that it has characteristics that correspond more nearly to those of the border phases of the above masses. A check back over the specimens collected revealed that although much more siliceous, the Flavrian intrusive strongly resembles the more highly differentiated facies of the Palmarolle border phase mentioned on page 82.

The intrusive is classed as a quartz-tonalite (See fig. 1, p. 23), and as will be shown below, evidence seems to indicate that it was probably once a tonalite in composition and is now a highly silicified equivalent.

In all probability, differentiation accounted for a considerable increase of quartz except in local border phases, so that the greater part of the intrusive was originally high in quartz corresponding to the composition of the inner part of the Palmarolle border phase (See Rosiwal analysis 'f', Table XI, p.87), and silicification rendered this magmatic product still more siliceous. There is also evidence of slight albitization.

The relative age of the plutonic rocks, and the Quartz Diorite (Older Gabbro), the Syenite Porphyry, and the Later Gabbro is also well illustrated in the Flavrian area. As described by Cooke[*], the granodiorite cuts across a sill of quartz diorite just north of Flavrian lake, and a breccia of large blocks of quartz diorite in a granitic matrix is developed at the contact. The Flavrian intrusive is therefore definitely younger than the Quartz diorite. In a good exposure on lot 28, Range X of Beauchastel township, a dyke of Syenite Porphyry was seen to definitely cut the Flavrian mass. The dyke is about a foot wide, has a vertical dip, and strikes N 30°E. Along the strike it was also seen to cut two aplite dykes. The Syenite Porphyry is therefore younger than the Flavrian intrusive. As definite relations between the Syenite Porphyry and the major acid intrusives have never been found before, a detailed description of the dyke is appended. As shown on the accompanying map, at least three dykes of the Later Gabbro are found cutting the Flavrian mass. Near the contact, small dykelets come off and extend unto the quartz-tonalite. These are very fine grained and have a dense glassy chilled edge suggesting intrusion into cold rocks.

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[*] Op. cit., p.53.

LITHOLOGICAL CHARACTER

Megascopic Features

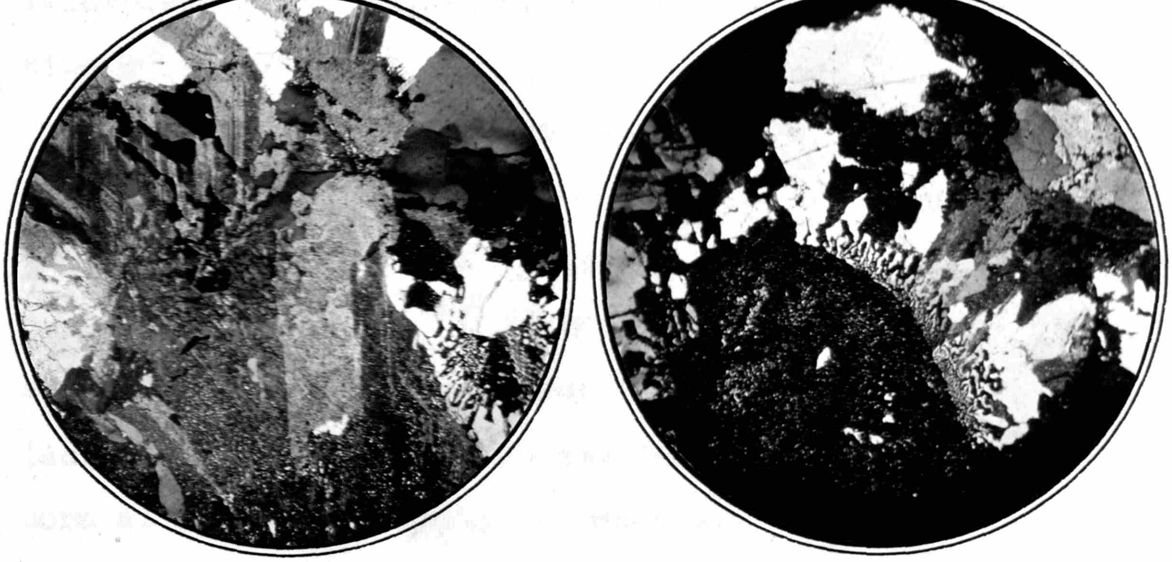
In hand specimens most of the rock types have a pinkish tinge and, depending on the amount of ferromagnesians, are light coloured or greyish green. Quartz and feldspar are very abundant, the former exceptionally so in some specimens. The grain size averages 2mm. to 4mm.

Only locally, near the margins, basic varieties occur that are chiefly feldspar and hornblende. These are quite similar to the unaltered Bourlamaque intrusive but are considerably finer grained. The suite of specimens collected, show an almost complete gradation from this basic type to the dominant siliceous type, by an increase in quartz and a corresponding reduction in the ferromagnesian constituents. Finally the feldspars become decidedly pink. Thus in the predominating rocks, the ferromagnesian constituents have a peculiar silicified appearance and aggregates of them somewhat resemble remnants of partly digested fragments. A study of the exomorphic effects of the intrusive, however, shows that there was no assimilation of fragments and that they have been recrystallized, with the development of acicular hornblende crystals near their margins and pseudographic textures within. Their angular shape is still well preserved. The writer therefore suggests that this is further evidence of the silicification of a once more basic rock.

In some specimens considerable chlorite and epidote are developed replacing the ferromagnesian constituents. Veinlets of epidote were seen to cut the granitic rocks and some aplite dykes as well.

Microscopic Features.

Although the rocks of the Flavrian intrusive generally exhibit the characteristic hypidiomorphic texture of the other intrusives, there is abundant evidence of deuteric alteration, with the development of micrographic textures. In some specimens the ferromagnesians are almost entirely altered to chlorite, penninite, and epidote, and the feldspars contain considerable zoisite and paragonite, and are surrounded by a rosette of micrographically intergrown quartz and plagioclase near albite in composition (See Plate XIIIB).



A. Pseudographic replacements of a plagioclase crystal and the groundmass by orientated quartz units. x17

B. A pseudographic intergrowth of quartz and acid plagioclase forming a corona on a crystal of plagioclase. x17

PLATE XIII. MICROGRAPHIC REPLACEMENTS OF THE FLAVRIAN INTRUSIVE ITSELF SIMILAR TO THOSE BROUGHT ABOUT IN THE INCLUSIONS.

In other specimens quartz is much more abundant and is oriented throughout the slide, giving the rock a pseudomicrographic texture (See Plate XIIIA). In the most siliceous types, the original ferromagnesians are no longer in evidence, having been completely altered, and removed to a considerable extent. Quartz occurs in large areas embaying the earlier minerals, and is bounded by curving lobed edges against the feldspars.

The chief minerals are therefore quartz and plagioclase with minor amounts of biotite and hornblende.

Traces of microcline and intergrowths of soda and potash feldspars, magnetite, titanite, and apatite occur as minor constituents.

Plagioclase forms euhedral and subhedral grains that are well zoned and twinned. It is generally so saussuritized that its original composition is hard to determine. However, determinations made on somewhat altered crystals gave a composition of basic oligoclase ($Ab_{70}An_{30}$) and this corresponds fairly well with the norm as recast from analyses, when the small amount of albite, occurring in microperthitic intergrowths is allowed for.

The unoriented primary quartz has considerable undulatory extinction and is much fractured. The quartz occurring in micrographic replacements, however, shows no effects of straining.

The ferromagnesians are so badly altered that several sections are necessary before it is possible to identify their original composition. Biotite was definitely one of the primary minerals formed and was probably the common brown pleochroic kind. It is now altered to green pleochroic chlorite and to penninite having the peculiar ultra-blue birefringence. Green pleochroic hornblende was also a primary mineral but probably in small amounts. It also appears to have been earlier than biotite. It is now replaced by pale green chlorite, and epidote.

In addition to the alteration products already mentioned calcite occurs in small irregular stringers to a minor extent and albite replaces the plagioclase crystals locally along the margins and forms small amounts of microperthitic intergrowths.

Chemical Features.

Two analyses were made of specimens representative of the dominant rock type of the Flavrian mass. These are tabulated in Table XIV, together with the calculated norm and the mode. Both are very similar throughout and indicate a high silica content and very low potash content. A comparison with analyses of the Taschereau and Palmarolle phases indicates that they resemble a silicified equivalent of the border phases, as they have the characteristic low potash content of these. They resemble the analyses of the core phase in the amount of silica, but there is not the corresponding increase in potash, and the ferrous iron content is much greater.

A comparison of the modes also shows the paucity of potash feldspar characteristic of the tonalite border phases of the other masses.

Four additional Rosiwal analyses were made to show some of the variations in the dominant rock type. These

TABLE XIV

CHEMICAL ANALYSES, CALCULATED NORM, AND MODE OF THE FLAVRIAN INTRUSIVE

ANALYSIS NO. XX*		NORM		MODE	
SiO_2.......	73.79	Quartz......	39.26	Quartz.......	46
Al_2O_3......	11.83	Orthoclase..	5.03	K-feldspar...	2.5
Fe_2O_3......	0.72	Albite......	33.30	Oligoclase	
FeO........	4.18	Anorthite...	10.41	(Ab70An30)..	41
MgO........	0.62	Diopside....	.59	Biotite......	8
CaO........	2.21	Hypersthene.	8.12	Hornblende...	-
Na_2O.......	3.94	Magnetite...	1.04	Magnetite....	.7
K_2O........	0.85	Ilmenite....	.74	Titanite.....	1.0
H_2O+.......	0.90	Apatite.....	.22	Apatite......	.2
H_2O-.......	0.40	Total	98.71	Epidote......	.6
CO_2........	nil			Total	100
TiO_2........	0.39	Symbol: I.3.2.4		Symbol: (224)	
P_2O_5.......	0.09	Name: Alsbachose		Name: Biotite-	
MnO........	0.07	(near Yukonose).		quartz-tonalite.	
F^x.........	0.01				
S..........	tr				
Total	100.00				

ANALYSIS NO. XXI#		NORM		MODE	
SiO_2.......	72.06	Quartz......	36.87	Quartz.......	43
Al_2O_3......	12.03	Orthoclase..	3.42	K-feldspar...	.6
Fe_2O_3......	1.59	Albite......	35.45	Oligoclase...	
FeO........	4.08	Anorthite...	11.46	(Ab70An30)..	42
MgO........	0.73	Diopside....	.27	Biotite......	11
CaO........	2.47	Hypersthene.	7.53	Hornblende...	-
Na_2O.......	4.19	Magnetite...	2.31	Magnetite....	1.8
K_2O........	0.58	Ilmenite....	.72	Titanite.....	.9
H_2O+.......	1.30	Apatite.....	.31	Apatite......	.3
H_2O-.......	0.20	Total	98.34	Epidote......	.4
CO_2........	nil			Total	100
TiO_2........	0.38	Symbol: I.3.2.5			
P_2O_5.......	0.13	Name: Yukonose		Symbol: (224)	
MnO........	0.08			Name: Biotite-	
F^x.........	0.01			quartz-tonalite.	
S..........	tr				
Total	99.83				

*Biotite-quartz-tonalite, from pit, lot 37, R. II, Duprat township. Analyst, W.H. Herdsman.

xDetermined by the writer.

#Biotite-quartz-tonalite, from pit, lot 28, R. X, Beauchastel township. Analyst, W.H. Herdsman.

indicate the high quartz content of some phases, while a fifth indicates some of the more basic border material. All lack potash feldspar and are more or less silicified tonalites. According to Johannsen's classification, they now range in composition from tonalite to quartz-tonalite and even to a tonalite-greisen. (See Figure 1, p.23).

TABLE XV

MINERAL VARIATIONS IN THE FLAVRIAN MASS

	a	b	c	d	e	f	g
Quartz..........	35	32	43	46	48	50	60
K-feldspar......	0	0	.6	2.5	2	1.2	tr
Oligoclase...... (Ab70An30).....	25	58	42	41	41	35	35
Ferromagnesians.	40	9	11	8	7	13	4
Magnetite.......	2	.4	1.8	.7	1.3	.3	tr
Titanite........	.5	.3	.9	1.0	.2	.4	..
Apatite.........	.5	.1	.3	.2	.1	.1	..
Total	100	100	100	100	100	100	100

a. Tonalite (228). A local border facies.
b. Tonalite (228). A local border facies.
c. Quartz-tonalite (224). Mode of analysis XXI.
d. Quartz-tonalite (224). Mode of analysis XX.
e. Quartz-tonalite (224). Average from large point, Flavrian L.
f. Quartz-tonalite (224). Average from large island, Flavrian.
g. Tonalite-greisen (124). From just east of the southern roof pendant.

CHAPTER VII

GENESIS OF THE TASCHEREAU, PALMAROLLE, AND FLAVRIAN PHASES

An attempt is here made to explain the observed phenomena in accordance with the facts available, and to rule out theories which are not in agreement with these observed facts. Any final decision in regard to this important problem must be deferred pending the accumulation of more data, and till similar rock series have been studied, not to mention the much-needed increase in our knowledge of the physico-chemical principles controlling the phenomena of magmatic differentiation.

Field relations, petrographic studies, and chemical analyses indicate a distinct genetic relationship between the core phase and the surrounding border phase. In fact the two are unique in having such a low potash content. All the phases comprising these intrusives show similar chemical characteristics. Comparisons with the averages of rocks of their silica content (See Figure 6, page 164) indicate that all are characterized by an exceedingly low potash content which is 2 to 3 percent below the average. Soda, on the other hand, is about normal in the core phases but is low in the border phases. With regard to the two Flavrian analyses, the variation diagrams strongly suggest an increase in soda in these rocks probably due to slight albitization as substantiated by the petrographic studies.

Similarly ferrous iron, magnesia, and lime are considerably above the average in all the phases.

These characteristics are best illustrated by the use of ternary diagrams. In Figure 2, the modal mineral

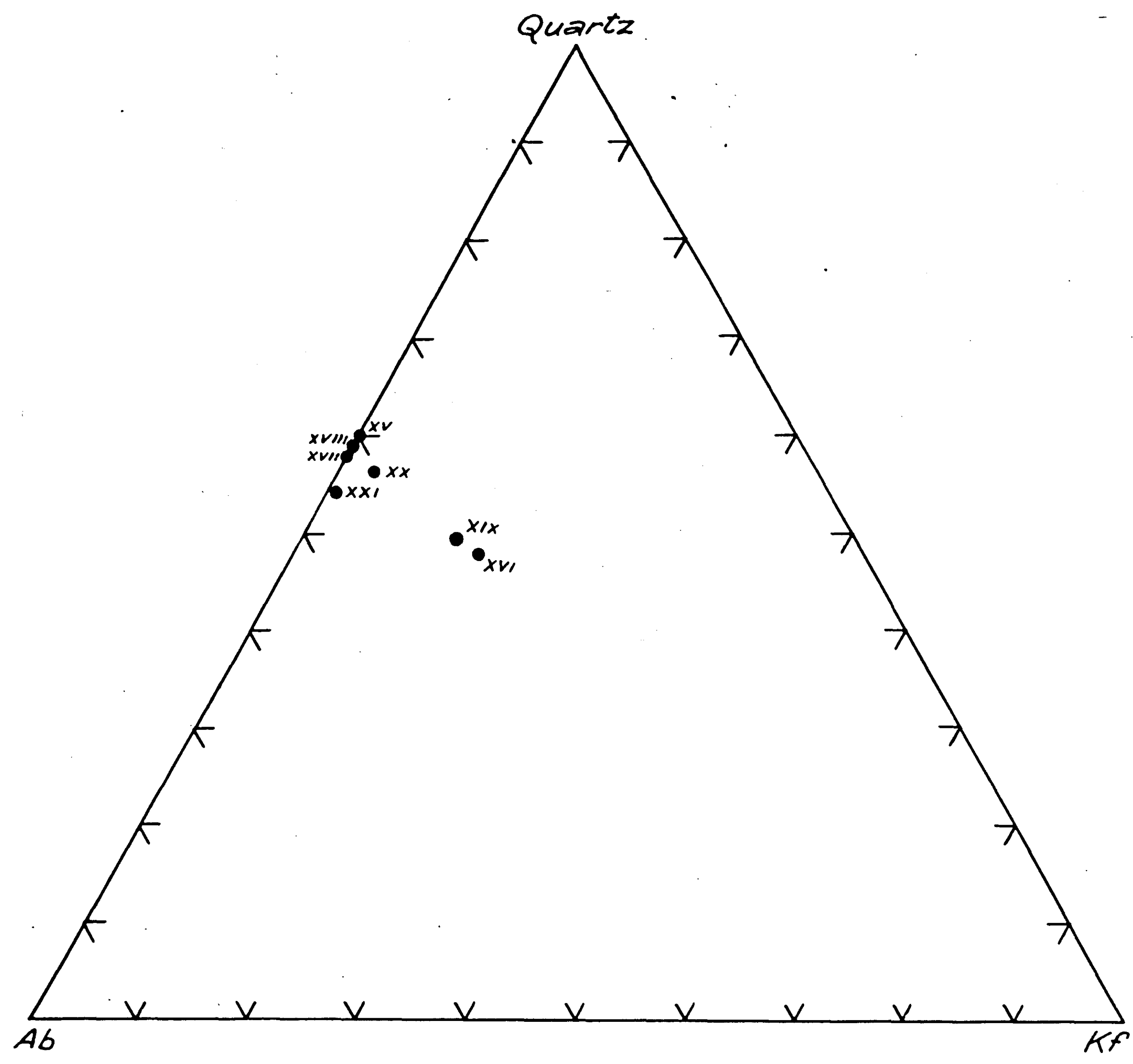


Figure 2. A plot of the modal proportions of SiO_2 NaAlSil, and KAlSil for all analyses of the Taschereau, Palmarolle, and Flavrian phases.

percentages have been plotted. The results strongly support the division of the rock types into two distinct phases, and show the similarity of the individuals in each. Plotting normative mineral percentages shows even less variation of the components of the two groups. Analyses XV, XVII, and XVIII of the border phases show very slight variations, and the Flavrian analyses definitely belong to the same group. According to Bowen's* residua system, Analyses XVI and XIX lie very near the composition of the residual liquid produced by differentiation. Therefore, in view of this and the unique genetic similarities in composition, it seems unquestionable that all are differentiates of a common source, the core phases being very near the end products.

Figure 3 shows the rock subdivisions according to Shand's classification[⊖] and also the norms of the same analyses. The only difference in plotting modes would be to slightly displace the points away from 'orthoclase' since the norm shows all the potash as this mineral. The results show complete agreement with the classification

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*- Bowen, N.L.: "Recent High Temperature Research on Silicates", Am. Jour. of Sci., Vol. XXXIII, 1937, p.12.

⊖ Shand, S.J.: "Eruptive Rocks", 1927.

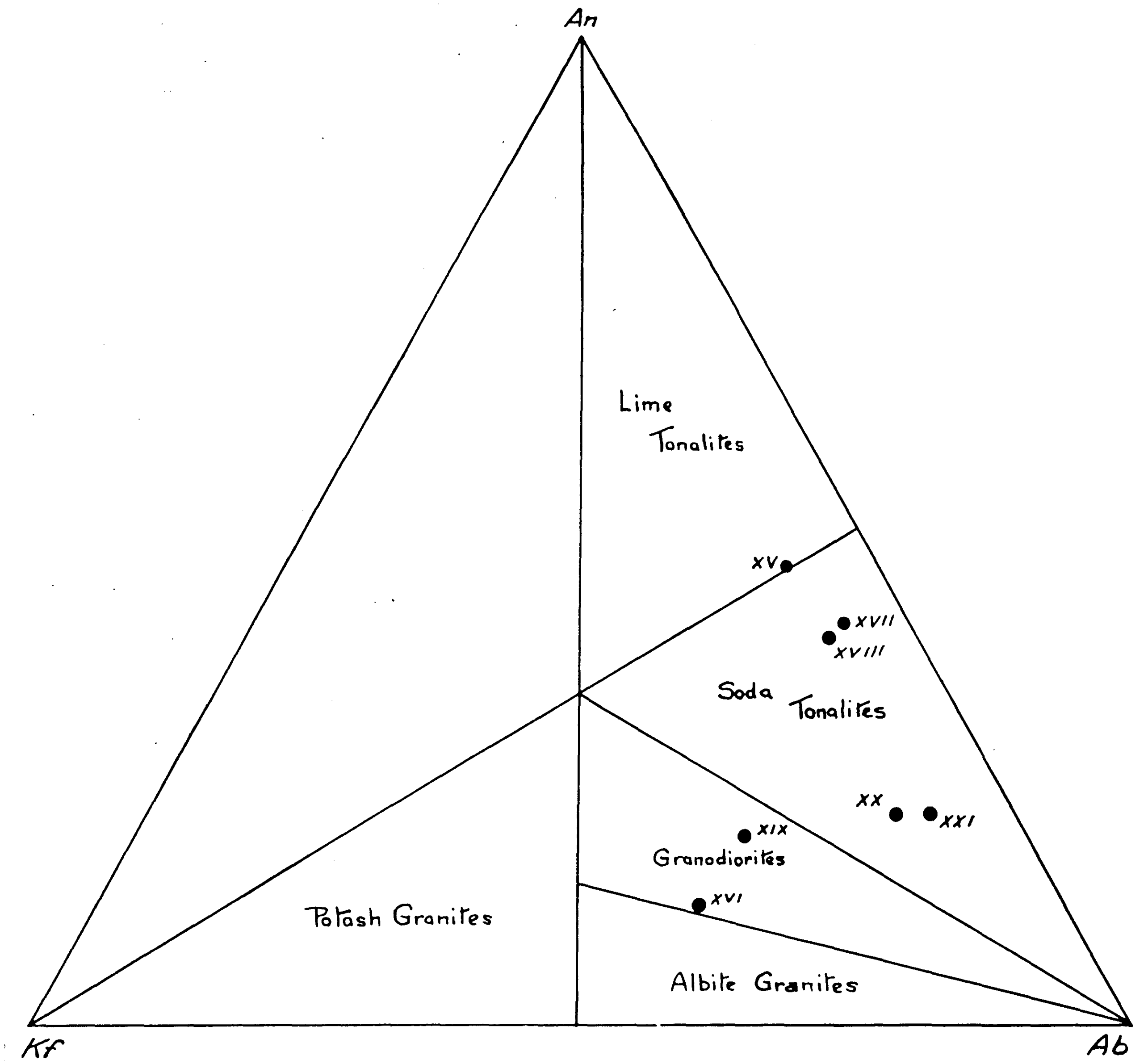

Figure 3. A plot of the normative feldspars of all analyses of the Taschereau, Palmarolle, and Flavrian phases showing rock subdivisions according to Shand's classification.

adopted. In addition the slight enrichment of soda in the Flavrian mass is brought out.

The occurrence of the basic dykes cutting the border phase of the Palmarolle mass and their absence in the core phase, would probably suggest that the core is younger than the dykes and that it belongs to a much later period of igneous activity. However there is no evidence of stoping or brecciation at the contacts nor are there any dykes of the core phase cutting the border rocks and, in the face of the strong genetic similarities of the two plutonics, the writer feels confident that the dykes cutting the border phase are also younger than the core. The observed facts are probably best explained by the development of a joint set in the outer border and not in the core phase due to a difference in their physical properties.

If it is assumed that the border phase is the result of quick cooling of a basic magma, and that the more siliceous core is due to further differentiation with contemporaneous movements of the magma, we are met by the fact that the border phases are not fine grained, but are as coarse as if not coarser than, the more siliceous core phases. Also the tonalites are not confined to the margins, but are quite extensive and too widespread to represent a chilled border phase.

In addition there is considerable evidence that is indicative of slow cooling. The rocks are coarse textured and the presence of euhedral plagioclases necessitates very gradual cooling to account for the centres of crystallization being far enough a part in the beginning so that euhedral crystals could form. The radial sweep of extinction across the field indicates a very gradual change in composition of the plagioclase series and implies more or less continuous reaction. This also requires a long time of slow cooling, with long suspension of the crystals in a liquid. Finally the complete absence of orthoclase, might also be interpreted to signify very slow cooling of the magma to permit conversion to the low temperature form of microcline (below 650°). However, the great lapse of geologic time since the Algoman may be sufficient to account for the inversion.

The possibility that the core and border phases represent a mass which was intruded as an already differentiated magma has been ruled out because it involves serious theoretical and structural difficulties.

Laboratory researches have fairly well established that liquid immiscibility is untenable at the low temperatures at which these rocks must have crystallized. Similarly, diffusion during crystallization (Soret effect) is inadequate to account for more than very local border varieties, and, since the rate of diffusion is extremely slow, such varieties should be characterized by gigantic crystals.

The hypothesis, that we are dealing with an example of "multiple intrusion", seems to best fit the facts of structure and distribution in the field as now known, and is in agreement with microscopical and chemical evidence. No serious difficulties are involved, and the writer finds that this is in accordance with the views held by Anderson[*] and others, ".......that the advance of magma takes place in a series of movements, separated by pauses (some, perhaps, prolonged) during which partial solidification occurs, especially in the marginal portions". Also, the evidence sustains the latest theories[θ] that the order of solidification of a batholith is, the hood first and the core last.

From the study of thin sections it was seen that andesine was the earliest essential constituent to crystallize in the border phases, and that, under the existing conditions of temperature and pressure in the magma, pyroxenes were unstable so that hornblende was the first ferromagnesian formed.

These facts strongly suggest that the source magma had already differentiated to some extent with the settling out of the more basic constituents, and that the border phases were emplaced at a time of evolution in

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[*] Anderson, G.H.: "Granitization, Albitization, and Related Phenomena in the Northern Inyo Range of California-Nevada", G.S.A. Bull., Vol. 48, 1937, p.20.

[θ] Emmons, W.H.: "The Basal Regions of Granite Batholiths", Jour. Geol., Vol. XLI, 1933, pp. 1-11.

crystallization when pyroxenes were no longer stable and when andesine was being deposited. Thus the magma, from which the border phases crystallized, may have contained some andesine and some of the early accessory constituents as apatite and zircon in addition to breccia blocks of the intruded rocks.

Chemical and Rosiwal analyses indicate that there is very little change in composition from the outer contact to the inner margin of the border phase. It is therefore probable that the whole magma chamber was originally occupied by a magma of more or less one composition.

In this medium, andesine crystallized as excellent euhedral crystals, and, as the magma became more impoverished in lime, the plagioclase changed in composition from a core of andesine (Ab66An34) to a periphery of acid andesine bordering on oligoclase (Ab70An30). This change must have been very gradual as there is no evidence of abrupt zoning.

Not till the final stages of crystallization of the plagioclase crystals did some segregation of these occur, so that interference of crystal form occurred locally in the outer zones of the crystal.

Hornblende and biotite began crystallizing toward the end of the formation of the plagioclase and, where free to grow formed large units. Biotite was slightly later than hornblende as euhedral crystals of both plagioclase and hornblende are enclosed in biotite.

Finally, the residual liquid crystallized filling in the interspace with pure quartz and locally with traces of microperthite or microcline. Thus, beginning at the roof or contact of the reservoir, complete solidification gradually moved in towards the centre of the mass and, due to changes in the physical conditions, hornblende gradually gave way to biotite. Probably, due to slight differentiation, there was a small increase in quartz.

When solidification of the border phase or hood had reached the vicinity of the present contact with the core phase, the core was probably occupied by a magma swimming with euhedral crystals of plagioclase and various other minerals, and of about the same bulk composition as the already solidified portion. The abrupt change in composition of the core material necessitates a similar change in the composition of the magma occupying the core. The plagioclase in the core is more abruptly zoned and might be interpreted to indicate that there was some crystal sorting or more rapid cooling. However, the plagioclases still have an excellent euhedral character and show less synneusis than in the border phase, and the basis is quite coarse and often poikilitically encloses the earlier minerals. The more likely explanation seems to be a change in composition of the residual liquid as substantiated by its corrosive action.

This could have been brought about either by tapping off the original magma in the core and replacing it with new material from the source reservoir which has itself differentiated further, so that the residual magma is now more siliceous and richer in potash, or instead of replacing the unsolidified core phase by an entirely new magma, it may have been diluted by the addition of liquid rich in silica and potash, and probably richer in soda. In other words, by the residual magma from progressive crystallization squeezed out of a crystalline mush by filter pressing. In this system plagioclase would now be somewhat unstable and would be corroded by the residual liquid.

In the core the final crystallization was the formation of the quartz-microcline basis, Locally, the microcline units are so large as to poikilitically enclose the corroded oligoclase crystals. Due to convection currents or some kind of crystal sorting, the core was locally enriched in silica.

That deforming stresses were active is shown by the cataclastic phenomena in the border phases. The fact that the core phase is never found cutting the rocks of the border phase, suggests that it was injected before fracturing occurred in the tonalite.

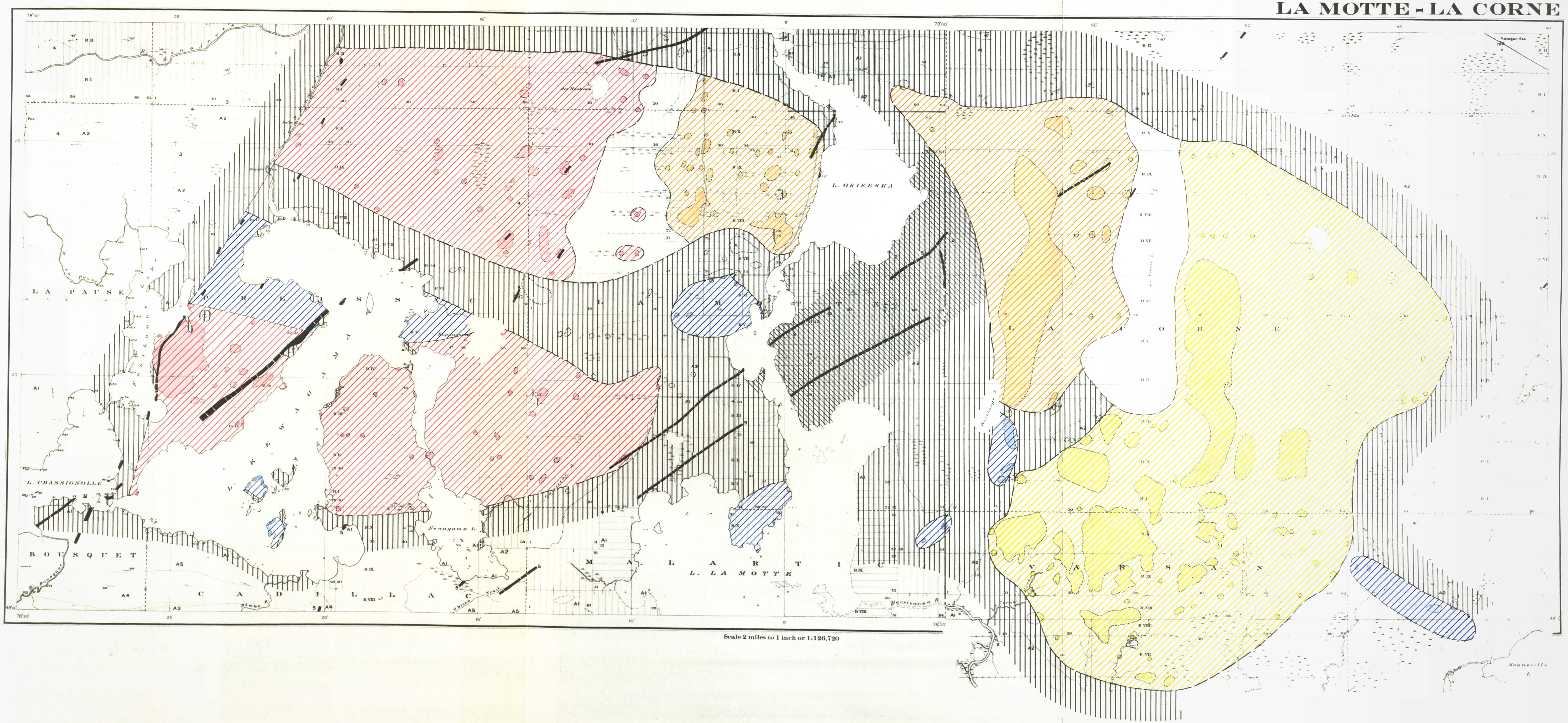
The fact that the quartz of the core phase is only very little strained suggests that the diastrophic movements had practically ceased.

Towards the end of the final consolidation, quartz greatly corroded the early minerals and locally formed graphic replacements in both the upper portions of the batholith and in the overlying roof.

Igneous activity was brought to a close by the development of aplites and pegmatites cutting both phases. These are chiefly quartz and microcline corresponding to the final product of consolidation in the core phases.

These are in turn cut by the plexus of basic dykes which are dense and fine grained and have chilled margins. Hence the evidence seems to indicate beyond a doubt that the core phase is decidedly older than these basic dykes even though they do not interest it.

LA MOTTE - LA CORNE



CHAPTER VIII

THE LA MOTTE-LA CORNE MASSES

GENERAL

Due to the discovery of molybdenite associated with the La Motte-La Corne batholith, it has received the attention of several geologists*, Most of the studies were confined to the molybdenum occurrences and, due to the lack of outcrops and difficulty of access of the north-east part of the La Corne mass, the areal maps are more of an exploratory nature.

The chief sources of information were the one mile outcrop maps[e] issued by the Geological Survey and mapped

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* Johnston, J.F.E.: "The Eastern Part of the Abitibi Region", G.S.C. Sum. Rept., 1901, pp. 128-141.
Walker, T.L.: "Report on the Molybdenum Ores of Canada", Dept. of Mines, Canada, Mines Branch, (1911).
Wilson, M.E.: "Kewagama Lake Map-Area, Pontiac-Abitibi, Quebec", G.S.C. Sum Rept., 1911, pp. 273-279.
"Kewagama Lake Region, Quebec, 1911", G.S.C., Mem. 39.
Bancroft, J.A.: "Report on the Geology and Mineral Resources of Keekeek and Kewagama Lakes Region", Rept. of Mining Operations in the Province of Quebec (1911), Q.B.M. Ann Rept. 1912, pp. 160-207.
Tanton, T.L.: "Harricanaw-Turgeon Basin, Northwestern Quebec", G.S.C. Mem. 109, 1919.
Bain, G.W.: Can. Min. and Met. Bull. No. 178, 1927, pp. 201-247; Jour. Geol., Vol. XXXIII, 1925, pp. 728-743.
James, W.F., and Mawdsley, J.B.: "La Motte and Fourniere Map Areas, Abitibi County, Quebec", G.S.C. Sum. Rept. 1925, Pt. C, pp. 64-67.
"Fiedmont and Dubuisson Map Areas, Abitibi County, Quebec", G.S.C., Sum. Rept., 1926, Pt. C, pp. 56-72
Gerrie, William: "Molybdenite in La Corne and Malartic townships, Quebec", Univ. of Toronto Studies, Geol. Sr. No. 24, 1927, p.38.

e La Motte Sheet, G.S.C. Map No. 189A, and Fiedmont Sheet, G.S.C. Map No. 206A.

by James and Mawdsley in 1925 and 1926 as part of the detailed study of the Rouyn area, and the more recent examination of the La Corne molybdenite deposits by Hawley in 1930*.

Field work indicated that the batholith is much more complex than any of the other masses in the Rouyn area, and that the outcrops are too scattered and the mass too large to attempt more than a preliminary examination in the time available.

The accompanying map is based on the two Survey maps. The amount of work and information only justifies a small diagram but in order to be able to indicate the location of outcrops which are generally small and hard to find, the two mile to an inch scale was decided on. It represents the broadest generalization and interpretation of the facts available, and the geological boundaries should not be regarded as contacts but as the general limits of the various phases.

The results of the laboratory work indicate that a much more detailed study and mapping must be undertaken before it is possible to give an accurate interpretation of the sequence of differentiation. Also

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* Hawley, J.E.: "Molybdenite Deposits of La Corne Township, Abitibi County", Q.B.M., Ann. Rept., 1930, Pt. C, pp. 99-122.

the petrographical and chemical analyses are so much at variance with previous publications that it will be necessary to form an entirely new picture.

DISTRIBUTION

The La Motte-La Corne mass occupies almost the entire area of Preissac, La Motte, and La Corne townships and adjacent parts of Varsan, Fiedmont, Villemontel, and Figuery. It extends over thirty miles east-west, and averages twelve to fourteen miles in width.

A belt of highly recrystallized and partly granitized Keewatin rocks - biotite schists, chlorite schists, amphibolites, etc.- occupies a broad strip along the valley of the Harricanaw and separates the plutonic rocks of the La Corne mass from those of La Motte. The La Motte mass is itself bisected by an east-west belt of similar Keewatin rocks, and the evidence available suggests that another belt underlies the low north-south valley occupied by La Corne lake.

As described by Hawley*, the intruded rocks are a sedimentary complex the exact age of which is not known. They are definitely older than the volcanic flows, and may represent an early sedimentary member of the Keewatin or may even be pre-Keewatin in age.

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* Ibid., p.104

Two distinct and entirely new rock types were recognized in the La Corne area: A dark grey hornblende-granodiorite, characterized by the occurrence of abundant crystals of titanite in handspecimens, and a white garnetiferous muscovite-leucogranodiorite. Both types are rather well exposed but are separated by a wide drift-filled valley so that no intrusive relations could be established between them.

The garnetiferous rocks occupy the northwest corner of the La Corne intrusive area and the same phase is again exposed in the northeastern corner of the La Motte mass on the opposite side of the Harricanaw valley, suggesting a connection beneath Lake Okikeska.

The rest and greater part of the La Motte area is apparently underlain by a homogeneous, pink, biotite-granodiorite. Outcrops are poorly exposed and widely scattered except on Indian Point, the large peninsula in the southwest corner of the area.

Those areas shown in blue on the accompanying map represent uncorrelated, fine to medium grained grey rocks. Some may be fine grained differentiates of the larger intrusive areas and others may represent border phases.

Abundant fragments and large blocks of biotite schist occur scattered throughout the various igneous phases.

In contrast to the other batholithic masses of the Rouyn area, the La Motte-La Corne intrusives are characterized by the abundant development of aplitic and pegmatitic phases and by the close association of molybdenite. In the biotite and muscovite granodiorites, pegmatites may represent as much as 50 percent of the outcrop.

The plutonic rocks are cut by two sets of parallel Keweenawan diabase dykes. One set strikes N 55°E and has been traced for a length of forty miles; the other strikes N 30°E and has been traced for over fifty miles.

THE LA CORNE HORNBLENDE-GRANODIORITE

This phase has the greatest areal distribution, occupying about two-thirds of the La Corne mass. It has an area of eighty seven square miles, and except for slight marginal phenomena is very homogeneous throughout.

It contains more inclusions of biotite schist than the other phases. They range in size from a few inches to feet and occasionally several hundreds of feet in diameter. In the southern part of the intrusive area, two and a half miles from the border, a pronounced parallel arrangement of the inclusions was noticed trending N 20°W. All are greatly recrystallized and contain abundant metacrysts. A detailed examination showed that the fragments have well defined angular boundaries, and that the adjacent igneous rock is unchanged in texture and composition. Slight endogenous deposition of hornblende occurred on the surfaces of the fragments. Within the inclusions, plagioclase metacrysts and some large hornblende prisms are developed in a completely recrystallized groundmass.

Megascopic Features.

The hornblende-granodiorite is a dark grey rock with locally a pinkish tinge. Generally, handspecimens are even grained having a grain size of from 2mm. to 3mm. However, a close inspection reveals the occurrence of very occasional phenocrysts of feldspar 5mm. to 10mm. in diameter. In one specimen a hornblende crystal one inch long was observed.

Plagioclase and hornblende are always conspicuous and readily identified. The former is white to greyish, locally pinkish, and occurs as rectangular, blocky crystals in which cleavage, zoning, and striations are easily recognizable. The hornblende is jet black and very fresh. It occurs as stubby to elongated prisms and, except for an occasional black flake of biotite, is the only dark constituent. In some specimens it is somewhat epidotized. Near the periphery of the mass, the hornblende prisms have a slight parallelism and there is a tendency to a linear arrangement of both feldspar and hornblende.

Quartz, although not conspicuous, is always visible and in some localities is quite noticeable. It would therefore be quite wrong to class these rocks as syenites even though the quartz is almost negligible in comparison to the very siliceous garnetiferous phase described in the following chapter.

Staining of polished surfaces indicated the presence of considerable interstitial potash feldspar and emphasizes the abrupt zoning in some of the plagioclases. It also shows that although the hornblende is well formed, it and all the other constituents are interstitial to the plagioclase.

The rocks of this phase are all readily distinguished from all the other rock types in the Rouyn area by the elongated euhedral developments of the hornblende and by the auxiliary constituent titanite, which is an omnipresent accessory occurring in rather large, light brown, euhedral, wedge-shaped crystals.

Microscopic Features.

In thin sections the rock has a hypidiomorphic texture. Considerable myrmekite is developed in the outer margins of plagioclase where adjacent to potash feldspar.

Euhedral to subhedral crystals of plagioclase, hornblende, and titanite occur in a medium grained equigranular aggregate of microcline, microperthite, and quartz. Acid plagioclase, hornblende, microcline, and quartz are the chief constituents in their order of abundance. Titanite is unusually well developed while biotite, apatite, magnetite, and zircon occur in subordinate amounts.

The euhedral to subhedral plagioclase crystals are abruptly zoned and considerably embayed. Carlsbad twinning is quite common often in combination with albite twinning: Pericline twinning is less common. The central parts are optically positive and extinction angles on combination twins correspond to acid oligoclase ($Ab_{84}An_{16}$). The indices are greater than that of Canada balsam. Embayed crystals of plagioclase are bordered by a rim of clear albite that is probably of replacement origin. In nearly every slide more or less myrmekite is developed at the margins in contact with potash feldspar and in some slides has penetrated to the very core of the plagioclase crystals. Alteration products of plagioclase are epidote and paragonite. They are generally only in minor amounts or even lacking.

Hornblende occurs as slender elongated prismatic crystals, commonly twinned. Its maximum extinction is 23° and pleochroism is marked - green to yellow.

Biotite is the common brown to greenish pleochroic variety. It is usually quite fresh but locally is completely altered to penninite.

Titanite occurs as unusually large wedge-shaped crystals, commonly poikilitically enclosing small apatite prisms. It is strongly pleochroic in dark brown to greyish yellow colours.

Quartz and potash feldspars belong to a later stage of solidification. They are irregular anhedral grains filling in the interspaces between the earlier more or less euhedral minerals. Much of the quartz is confined to wedge-shaped areas between the plagioclase, but in some slides it has replaced both potassic and sodic feldspars. Undulatory extinction is not very marked. Microcline is the common potash feldspar and is always absolutely fresh. Apatite, zircon, and magnetite were identified in thin sections in insignificant amounts.

Although alteration is usually very slight, epidote is fairly well developed where there is a myrmekitic texture. It has attacked hornblende, plagioclase, and biotite, has a strong yellowish-green pleochroism, and strong birefringence: in some grains it is twinned.

Chemical Features.

A chemical analysis of the hornblende-granodiorite is given in Table XVI, along with its calculated norm and the mode. The material collected for analysis was very fresh and was considered representative of this whole phase. This is justified by Rosiwal analyses of specimens collected from widely separated points.

TABLE XVI

CHEMICAL ANALYSIS, CALCULATED NORM, AND MODE OF THE LA CORNE HORNBLENDE-GRANODIORITE

ANALYSIS NO. XXII#		NORM		MODE	
SiO_2.......	63.04	Quartz.......	15.12	Quartz.......	16
Al_2O_3......	16.06	Orthoclase...	13.66	K-feldspar...	14
Fe_2O_3......	1.26	Albite.......	34.41	Oligoclase	
FeO........	3.55	Anorthite....	18.58	(Ab80An20)..	46
MgO........	2.68	Diopside.....	4.52	Hornblende...	20
CaO........	5.23	Hypersthene..	9.42	Biotite......	2
Na_2O.......	4.07	Magnetite....	1.83	Magnetite....	tr
K_2O........	2.31	Ilmenite.....	.80	Titanite.....	1.3
H_2O+.......	0.55	Apatite......	.70	Apatite......	7
H_2O-.......	0.35	Total	99.04	Zircon.......	tr
CO_2........	nil			Total	100
TiO_2.......	0.42	Symbol: II.4.3.4			
P_2O_5.......	0.29	Name: Tonalose		Symbol: (227)	
MnO........	0.08			Name: Hornblende-	
F*.........	0.03			granodiorite.	
S..........	tr				
Total	99.92				

#Hornblende-granodiorite from rock cut on Amos-Val d'Or highway, lot 32, R. VI, Varsan township. Analyst, W.H. Herdsman.
*Determined by the writer.

The Rosiwal analyses are tabulated in Table XVII and show a marked uniformity in the mineral composition of the intrusive. Gerrie's analysis of the hornblende "syenite" (See Analysis V, Table I, p. 19) is of this same phase. A comparison with the new analysis by Herdsman shows a considerable difference in the potash-soda ratio which is also contrary to the results of the Rosiwal analyses.

TABLE XVII

MINERAL VARIATIONS IN THE LA CORNE HORNBLENDE-GRANODIORITE

	a	b	c	d
Quartz.................	16	15	18	20
Potash feldspar.......	14	22	14	9
Oligoclase (Ab80An20).	46	45	49	46
Hornblende............	20	14	18	21
Biotite...............	2	2	tr	2
Titanite..............	1.3	1.5	1	1.6
Apatite...............	.7	.5	tr	.4
Magnetite.............	tr	tr	tr	-
Zircon................	tr	tr	-	tr
Total	100	100	100	100

a. Mode of Analysis XXII Table XVI.
b. A Rosiwal analysis to show the greatest local development of potash feldspar observed.
c. Average hornblende-granodiorite.
d. Average hornblende-granodiorite.

THE LA MOTTE-LA CORNE MUSCOVITE-GRANODIORITE

The rocks of this phase outcrop in two separate areas on either side of Lake Okikeska. That in the northwest corner of the La Corne body has an area of thirty square miles while that in the eastern part of the La Motte body has an area of fifteen square miles.

Megascopic Features.

In contrast to the other plutonic rocks, this phase is almost pure white, having large flakes of light to dark mica. In the field two distinguishing characteristics are the omnipresence of red garnet (.5mm.-1.2mm. in diameter), and muscovite, often in rather appreciable amounts.

Away from the margins the rocks are even grained, coarse, granitic and average 3 to 6mm. in grain size. The marginal phases are coarse pegmatitic to very fine grained. The fine grained rocks have an apparent grain size of less than 1mm. but reflection of light from cleavage planes often indicates a graphic texture in which large units of white microcline poikilitically enclose numerous crystals of plagioclase and muscovite. The coarse pegmatitic rocks of the marginal phase are poorly defined and occur in large irregular masses and dykes in the fine grained rocks. Away from the margins they are abundant and occur as well defined dykes in the normal coarse grained rocks. Together with occasional aplite dykes they cut these rocks in every direction and in some outcrops make up as much as 50 percent of the rock.

In the field, quartz, feldspar, iron-poor mica, and garnet are always recognizable. It is however impossible to distinguish between the potash and soda feldspars since both are pure white. In the normal phases, quartz generally makes up 30 to 40 percent of the composition. In some specimens, there is a very crude tendency to segregation of the mica flakes.

On the weathered surfaces mica is bleached a silvery white and the rock is weathered pure white. Near joints and beneath the leached weathered surface, the rocks are stained with limonite.

Microscopic Features.

In thin sections the texture of the normal rocks is granitic and, with the exception of the minor accessories, all the constituents lack crystal form of any kind. The plagioclases are all greatly corroded remnants that have been attacked by the still liquid part of the magma. Where irregular remnants are enclosed in microcline, abundant myrmekitic textures are developed in the outer margins and often penetrate to the very centre of the plagioclase fragments.

Quartz, acid plagioclase, microcline and microperthite are the chief constituents while muscovite, biotite, and almandite are rather abundant accessories. In some slides occasional small grains of apatite and zircon were identified. Titanite and magnetite are extremely rare.

As already stated, plagioclase occurs as very irregular, deeply embayed remnants. It is commonly quite fresh with locally slight alteration along twin lamellae. Albite twinning predominates, occasionally in combination with carlsbad twinning. Only very rarely are they twinned on the pericline law.

Since thin sections show that plagioclase is the only lime bearing mineral in appreciable amounts, the plagioclase must contain all the anorthite shown in the norm, and, depending on the presence of soda in microcline would be more basic than that calculated from the norm. A recast of the norms of the two analyses of this phase gives acid oligoclase - (Ab85An15) for that from the La Corne mass and (Ab89An11) for that from the La Motte mass. Optical determinations using combination carlsbad-albite twins where possible, gave extinction angles corresponding to acid oligoclase (Ab85An15). Practically all the plagioclase in thin sections of this phase shows no evidence of zoning and has simultaneous extinction throughout.

Quartz occurs in large irregular areas and as vermicular shapes replacing all the early minerals. It contains abundant liquid inclusions that occur scattered through the grains and also as linear segregations. In the fine grained phases much of the quartz occurs as vermicular shapes that are all oriented over large areas and give the rock a crude micrographic texture. On the whole the fine grained phases resemble aplites. Undulatory extinction is only of slight occurrence.

As shown by the chemical analyses and modes of these rocks, potash feldspar is quite appreciable in this phase and it approaches a granite in composition. In local varieties potash feldspar is actually in excess of the plagioclase feldspar so that in some places the rocks do grade into true granites. The potash feldspar is almost entirely microcline with smaller amounts of microperthite. The characteristic microcline twinning may be very coarse or very fine. The potash feldspars were one of the last minerals to crystallize and form large units enclosing severely corroded remnants of plagioclase.

Muscovite is the chief accessory. It is colourless to pale golden yellow indicating traces of iron. The yellow varieties are faintly pleochroic. It occurs as fairly thick tabular crystals scattered throughout the rock and around the edges, where in contact with quartz, there has been considerable reaction with the formation of myrmekitic intergrowths. Biotite is a pale brown iron-poor variety occurring as small shreds, and is often only a minor accessory. In some specimens, however, it predominates over muscovite. Biotite always formed later than plagioclase whereas in some sections muscovite may have begun to crystallize before plagioclase had completed its formation. This suggests that biotite may be the result of enrichment of the rest magma in iron.

Almandine garnet is present in all hand-specimens of this phase. It is a pale wine colour. Occasionally it is so abundant that it is a frequent accessory in thin sections while in other sections it is entirely absent. Excellent euhedral forms are poikilitically enclosed in the potash feldspar. It is always isotropic.

Minute inclusions of zircon in biotite and small needles of apatite occur sparingly in some slides.

Chemical Features.

Specimens for chemical analysis were collected from each of these areas and the results of these are shown in Table XVIII along with the calculated norms and modes. Analysis XXIV from the La Motte area contains slightly more garnet than the average, and there is a slight difference in the respective amounts of biotite and muscovite in both analyses. The two analyses however, are nearly identical.

To illustrate a point-to-point variation in this phase, four additional Rosiwal analyses were made and are shown in Table XIX along with the modes of the two analyses from Table XVIII. These indicate that there is very little difference in composition even between the normal facies and the finer grained aplitic border facies.

TABLE XVIII

CHEMICAL ANALYSES, CALCULATED NORMS, AND MODES OF THE LA MOTTE LA CORNE MUSCOVITE GRANODIORITE

ANALYSIS NO. XXIII#		NORM		MODE	
SiO_2	73.42	Quartz	29.98	Quartz	34
Al_2O_3	14.19	Orthoclase	28.36	K-feldspar	27
Fe_2O_3	0.04	Albite	30.72	Oligoclase (Ab85An15)	33
FeO	1.78	Anorthite	5.57	Muscovite	2
MgO	0.18	Corundum	.94	Biotite	4
CaO	1.12	Hypersthene	3.42	Almandite	tr
Na_2O	3.63	Magnetite	.06	Apatite	tr
K_2O	4.81	Ilmenite	.30	Titanite	tr
H_2O+	0.30	Apatite	tr	Magnetite	-
H_2O-	0.20	Total	99.35	Total	100
CO_2	nil				
TiO_2	0.16	Symbol: I.4.2.3.			
P_2O_5	tr	Name: Toscanose.		Symbol: (127)	
MnO	tr			Name: Garnetiferous muscovite-bearing biotite-leuco-granodiorite.	
F*	tr				
S	tr				
Total	99.83				

ANALYSIS NO. XXIV⊖		NORM		MODE	
SiO_2	73.64	Quartz	26.29	Quartz	29
Al_2O_3	14.48	Orthoclase	26.67	K-feldspar	24
Fe_2O_3	0.03	Albite	38.84	Oligoclase (Ab85An15)	39
FeO	1.52	Anorthite	4.77	Muscovite	5
MgO	0.08	Corundum	.24	Biotite	1
CaO	0.96	Hypersthene	2.96	Almandite	2
Na_2O	4.59	Magnetite	.04	Apatite	tr
K_2O	4.52	Ilmenite	tr	Titanite	tr
H_2O+	nil	Apatite	tr	Magnetite	tr
H_2O-	0.30	Total	99.81	Total	100
CO_2	nil				
TiO_2	tr	Symbol: I.4.1.3			
P_2O_5	tr	Name: Liparose (near Toscanose)		Symbol: (127)	
MnO	tr			Name: Garnetiferous muscovite-leuco-granodiorite.	
F*	tr				
S	tr				
Total	100.12				

#Garnetiferous muscovite-bearing biotite-leucogranodiorite, from pit, lot 12, R. VI, La Corne township. Analyst, W.H. Herdsman.

*Determined by the writer.

⊖Garnetiferous muscovite-leucogranodiorite, from rock-cut on Amos-Malartic highway, lot 28, R. X, La Motte township. Analyst, W.H. Herdsman.

Rosiwal analysis "f" was made on the most potassic phase observed in handspecimens and indicates that in some local phases the potash feldspar does exceed the plagioclase to a slight extent. Therefore true granites do occur but only as local differentiates.

TABLE XIX

MINERAL VARIATIONS IN THE GARNETIFEROUS MUSCOVITE-GRANODIORITE OF THE LA MOTTE-LA CORNE MASS

	a	b	c	d	e	f
Quartz...........	29	34	34	30	28	30
K-feldspar.......	24	27	23	25	30	35
Oligoclase....... (Ab83An17)......	39	33	37	40	38	32
Muscovite........	5	2	5	4	3	tr
Almandite........	2	tr	tr	tr	tr	-
Biotite..........	1	4	1	1	1	3
Apatite..........	tr	tr	-	tr	tr	tr
Zircon...........	-	-	-	tr	-	tr
Titanite.........	tr	tr	-	-	-	-
Magnetite........	tr	-	-	-	-	-
Total	100	100	100	100	100	100

a. Mode of Analysis XXIV, representing a more garnetiferous facies of the normal La Motte phase: Garnetiferous muscovite-leucogranodiorite.

b. Mode of Analysis XXIII, representative of the normal La Corne phase: Muscovite-bearing biotite-leucogranodiorite.

c. A Rosiwal analysis representing the normal La Motte phase: Garnetiferous muscovite-leucogranodiorite.

d. A Rosiwal analysis of the fine grained border facies of the La Motte phase: Garnetiferous muscovite-leucogranodiorite.

e. A Rosiwal analysis of the fine grained border facies of the La Corne phase: Garnetiferous muscovite-leucogranodiorite.

f. A Rosiwal analysis of a local potassic phase of the La Corne phase: Biotite-leucogranite.

THE SHEET LIKE INTRUSIVES ASSOCIATED WITH THE MOLYBDENUM DEPOSITS

The rocks described under this heading occur in the two areas, shown in blue on the accompanying map, that lie just south of Baillargé lake. Although only minor intrusives, they are associated with the only known mineral deposits in the La Corne area. It is therefore of interest to know which phase, if any, of the La Corne intrusive they are related to.

Hawley* and Gerrie* give brief petrographic descriptions of these intrusives in their reports on the molybdenum occurrences and analyses were made by Gerrie and are shown in Table I, page 19.

Dykes irregular masses and sheet-like injections occur in the highly schisted sediments that underlie the Keewatin volcanics. They were injected after the folding of the sediments and occur along bedding planes in anticlinal folds, and as dykelets along schistosity planes. They are cut by the molybdenite bearing pegmatites and by quartz veins, and contain abundant inclusions of the biotite schist.

In handspecimens these intrusives are fairly fine grained greyish rocks having a maximum grain size of 1mm. They are even textured and the chief constituents seem to be quartz and feldspar with minute flakes of black mica.

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* Ibid.

Thin sections indicate that the minerals have undergone considerable deuteric alteration so that the rock has a pseudocataclastic texture. Superimposed on this is a flow structure by which the mica shreds are all more or less oriented in a parallel direction. The minerals identified are plagioclase, quartz, microcline, microperthite, biotite, muscovite, and minor amounts of titanite, apatite, and zircon.

Plagioclase occurs as much corroded and embayed rectangular and rounded grains having fine albite twin lamellae, occasionally combined with carlsbad twinning. The outer margin of some grains is slightly more acid than the core giving a zoned extinction. The optic axes are nearly at 90° so that both positive and negative signs result. Determinations made on several sections from different sills and masses gave the following composition for the plagioclase.

1. Finely twinned grain $\perp X$: $Z \wedge 010 = 6^\circ$, acid oligoclase ($Ab_{88}An_{12}$).
2. Grain having combined carlsbad-albite twinning with 0° extinction in both halves, acid oligoclase ($Ab_{80}An_{20}$).
3. Untwinned section $\perp 010$: Sign +, $Np >$ balsam and $<$ o of quartz, oligoclase.
4. Section $\perp X$: $Z \wedge 010 = 20^\circ$, $Z \wedge 001 = 7.5^\circ$, acid oligoclase ($Ab_{87}An_{13}$).
5. Section $\perp X$: $Z \wedge 010 = 85^\circ$, $Z \wedge 001 = 5^\circ$, acid oligoclase ($Ab_{84}An_{16}$).

Quartz occurs in very irregular grains intersitial to plagioclase and as vermicular replacements within plagioclase. It has an undulatory extinction and in some sections produces a crystalloblastic texture due to replacement.

Both microcline and microperthite occur in small amounts in most sections but may be entirely absent in others. Orthoclase was not found in any of the sections of this phase. The potash feldspar is almost entirely interstitial and myrmekites are well developed in its vicinity. Some patches of microcline occur as replacements within grains of plagioclase.

Dark green pleochroic biotite is chiefly confined to the groundmass between the larger plagioclase grains, however, some small shreds occur enclosed in plagioclase. It occurs as small irregular corroded shreds having a subparallel arrangement. Titanite, apatite, and zircon inclusions are common and in some slides the biotite has been replaced to some extent by epidote and chlorite.

Although muscovite cannot be identified in any of the handspecimens it is quite common in all the thin sections as large flakes several times larger than the biotite, and often is the coarsest mineral in the slide. It is severely corroded and embayed and is usually bordered by peritectic reaction rims.

Apatite and titanite occur as rather abundant accessories scattered throughout the slides. Both occur as small to fairly large euhedral crystals. The titanite occurs as wedges having a dark brown pleochroism. They are quite characteristic of the rock and are apparently identical to those in the hornblende granodiorite to the east.

Epidote is the chief secondary mineral replacing both biotite and plagioclase. It is strongly pleochroic and occurs as irregular grains and as well developed crystals which are commonly twinned. In some sections, considerable white mica is developed in the plagioclase.

The order of crystallization of the accessories determined by poikilitic enclosure of early minerals in the later ones is,- apatite first, followed in order by zircon, titanite, and the micas.

A Rosiwal analysis of a representative specimen of this phase gave the following result.

Quartz.......	20
K-feldspar...	2
Oligoclase...	70
Biotite......	5
Muscovite....	2
Titanite.....	.7
Apatite......	.3
Zircon.......	tr
Total	100

The potash feldspar content was checked by staining. Therefore according to Johannsen's classification the rock is a muscovite-bearing biotite-leucotonalite. (See figure 1, page 23).

Unfortunately, the Rosiwal analysis and optical determinations failed to substantiate Gerrie's analyses. Except for titanite plagioclase is the only lime-bearing mineral. Therefore, if the analyses are correct, the plagioclase should correspond to labradorite. Also, if sufficient potash is allotted to all the magnesia for biotite and the surplus is calculated as orthoclase, the analyses represent about 25 percent potash feldspar. Neither was found to be the case and in addition norms of the analyses show a considerable surplus of alumina as corundum. It was therefore necessary to disregard the analyses.

The undulatory extinction in the quartz of the tonalites suggests that they are probably older than the muscovite-leucogranodiorite phase of the La Corne mass and are nearer that of the hornblende-granodiorite phase which also shows some cataclastic features. The presence of the large wedge-shaped titanite crystals that are so characteristic of the hornblende-granodiorite also seem to indicate a genetic relation between the tonalite sheet-like injections and the hornblende-granodiorite batholith to the east. On the other hand, the occurrence of muscovite and, according to Hawley[x], garnet, seems to link the sheet-like masses and the pegmatitic phases with that of the muscovite-leucogranodiorite or might indicate that their minerals formed under similar conditions.

The minor intrusives of the molybdenite deposits therefore seem to have characteristics more or less intermediate between the two major phases of the La Corne mass and might indicate a definite relation between them. One outstanding difference is the very low content of potash feldspar in the minor intrusives, but this is readily explained by filter pressing.

THE PINK GRANODIORITE PHASE OF THE LA MOTTE MASS

These rocks occupy the greater part of the La Motte area and are best exposed on Indian Point. Elsewhere, exposures are very small and widely scattered. It underlies an area of about 95 square miles. Pegmatitic phases are abundant and often make up 20 to 50 percent of an outcrop.

The rocks are coarse grained and fairly even textured with only local variations in grain size. Fine

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[x] Ibid. p.105.

aplitic to coarse pegmatitic phases occur without any definite boundaries. In hand specimens the rocks are pale pink. Pinkish feldspar and colourless quartz are the chief constituents, and biotite is the only dark mineral and is commonly altered to epidote.

Thin sections indicate abundant deutric alterations. Much quartz seems to be hydrothermal and myrmekite is everywhere strongly developed even penetrating to the very core of many of the feldspars.

The indices of some of the plagioclase are between that of quartz and balsam and give extinction angles corresponding to oligoclase ($Ab80An20$). Much of it is albite with indices less than balsam, and there is much evidence of albitization of the more calcic plagioclase.

Biotite occurs as dark green pleochroic shreds strongly replaced by epidote, and there are a few shreds of muscovite.

No clinozoisite was observed and there is apparently no zoning.

An analysis of this phase together with the calculated norm and the mode is shown in Table XX.

TABLE XX

CHEMICAL ANALYSIS, CALCULATED NORM, AND MODE OF THE LA MOTTE BIOTITE-GRANODIORITE

ANALYSIS NO. XXV[#]		NORM		MODE	
SiO_2	71.37	Quartz	27.04	Quartz	29
Al_2O_3	14.47	Orthoclase	14.05	K-feldspar	13
Fe_2O_3	tr	Albite	40.37	Plagioclase	50
FeO	2.31	Anorthite	10.22	Biotite	7
MgO	0.93	Corundum	.26	Muscovite	.1
CaO	2.26	Hypersthene	6.07	Titanite	.5
Na_2O	4.77	Magnetite	tr	Apatite	.4
K_2O	2.38	Ilmenite	.57	Magnetite	tr
H_2O+	0.50	Apatite	.38	Total	100
H_2O-	0.60	Total	98.96		
CO_2	nil			Symbol: (227)	
TiO_2	0.30	Symbol: I.4.2.4		Name: Biotite-granodiorite	
P_2O_5	0.16	Name: Lassenose			
MnO	tr				
F*	0.01				
S	0.08				
Total	100.14				

[#] Biotite-granodiorite from Indian Point, Kewagama Lake. Range I, La Pause township. Analyst, W.H. Herdsman.

*Determined by the writer.

THE MINOR INTRUSIVES OF SENNEVILLE TOWNSHIP

These are exposed in the area shown in blue in the southeast corner of the map of the La Motte-La Corne Masses. One of these in the vicinity of Dutertre Lake is apparently a small outlier of the large La Corne horneblende granodiorite batholith to the north. An outcrop of this body, just south of the mouth of the Bourlamaque river on Blouin lake, was described by Hawley[e]. New exposures were

[e] Op. Cit., 1930, p.31.

located during the past season on the Bourlamaque river south of Dutertre lake, and south of the river. It is a siliceous pink to grey biotite bearing hornblende-granodiorite with chloritic inclusions, and is cut by pegmatite dykes similar to those cutting the Bourlamaque mass and the La Motte-La Corne intrusives. In thin section it is identical to phases of the La Corne mass, having euhedral oligoclase and hornblende crystals in a base of microcline, microperthite, and quartz, and the typical large euhedral titanite crystals so common in the La Corne hornblende-granodiorite. Brown pleochroic biotite is a minor accessory.

Plate XIV. Corroded and saussuritized plagioclase rimmed by clear albite and poikilitically enclosed in perthitic feldspar. x14

The microphotograph in Plate XIV is from this phase and is a beautiful illustration of slightly saussuritized and corroded plagioclase rimmed by clear albite and poikilitically enclosed in perthite. Quartz is interstitial and replaces the earlier minerals slightly.

In lot 14, R. VIII of Senneville township, on the eastern border of the hornblende-granodiorite mass, sheet-like injections were observed similar to those on the molybdenite property. Irregular dykes and masses, and sheet-like bodies of a fine grained grey granitic rock cut sedimentary biotite schists. Handspecimens from both localities are identical and the only apparent difference in thin sections is the occurrence of brown pleochroic biotite instead of the green variety.

CHAPTER IX

THE SOUTHERN GRANITE COMPLEX

The Southern Granite batholith extends for over 100 miles south of the Rouyn-Bell river map area. It is far too large and much to complex to attempt more than a preliminary examination in the time available.

Hitherto it has been discussed by many writers* who examined it along some of the main water routes.

The northern fringe of the batholith which lies within the map area is in reality a mygmatite and

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*
Cooke, H.C.: "Opasatika Map-Area, Timiskaming County, Quebec"; G.S.C., Sum. Rept. 1922, Pt. D, pp. 19-74.
Denis, Bertrand D.: "Sabourin Map-Area, Temiscamingue County", Quebec Bureau of Mines Ann. Rept. 1934, p.14.
James, W.F.; and Mawdsley, J.B.: "Clericy and Kinojevis Map-Areas, Temiscamingue and Abitibi Counties, Quebec", G.S.C. Sum. Rept. 1924, Pt. C, pp. 99-125.
"La Motte and Fourniere Map-Areas Abitibi County, Quebec"; G.S.C. Sum. Rept. 1925, Pt. C, pp.52-77.
McOuat, W.: "Report of an examination of the Country between Lake Timiskaming and Abitibi; G.S.C. Rept. of Progress 1872-73, pp. 112-135.
Parks, W.A.: "The Geology of a District from Lake Timiskaming Northward"; G.S.C. Sum. Rept. 1904, pp. 198-225.
Wilson, M.E.: "Lake Opasatika and the Height of Land"; G.S.C. Sum. Rept. 1908, pp. 121-123.
"Larder Lake District"; G.S.C. Sum. Rept. 1909, pp. 173-179.
"Northwestern Quebec Adjacent to the Interprovincial Boundary and the National Transcontinental Railway"; G.S.C. Sum. Rept. 1910, pp. 203-207.
"Geology and Economic Resources of the Larder Lake District, Ontario and Adjoining Portions of Pontiac County, Quebec"; G.S.C. Mem. 17, 1912.
"Kewagama Lake Map-Area, Pontiac and Abitibi, Quebec"; G.S.C. Sum. Rept. 1911, pp. 273-279.
"Kewagama Lake Map-Area, Quebec"; G.S.C., Mem. 39, 1913, pp. 77-82.
"Timiskaming County, Quebec"; G.S.C. Mem. 103, 1918, pp. 35 & 98-101.

it is almost impossible to find even a small area in which the present rock can be assumed to be the solid equivalent of an original intrusive magma.

Plate XV. Lit-par-lit mygmatites on the south shore of Lonely Bay well within the Southern Granite area and still of undoubted sedimentary origin.

It was therefore necessary to penetrate far south into the heart of the body. As there are no outcrop maps available of this part and since the outcrops are generally small and hard to find, examination was chiefly confined to the canoe routes. Two north-south sections were made across the mass and three samples were collected for chemical analysis. Two of these are apparently of true magmatic origin while the third is of a gneissic rock which is shown on the survey maps as 'Augite Syenite'.

The greater part of the area is composed of highly granitized Timiskaming sediments with an over-abundance of pegmatitic phases. Small dykelets and sills intrude the sediments in an irregular and complex manner and blocks of greywacke both large and small are entirely cut off and surrounded by granitic and pegmatitic material. Everywhere there has been a profound metamorphic effect on the intruded rocks. The fragments exhibit all stages of digestion and recrystallization. In some the edges are sharp and unaffected; others exhibit a vague outline; and finally all that remains of an original mass of greywacke is a vaguely outlined dark patch of granitic material. This has been interpreted as assimilation by melting. However, a careful observation indicates that the strike of these sedimentary masses is invariably that of the intruded Timiskaming, showing that they have not been tilted from their original position. Hence they probably represent unreplaced remnants which are still oriented. It is highly improbable that such a magma would have sufficient heat to melt included fragments. Furthermore, there is no evidence of stoping or of the batholith having forced aside the overlying mantle. No schistosity has been developed parallel to the contacts, and in thin sections the gneissic types show no evidence of granulation, undulatory extinction, or other evidence of deformation.

The texure of the granitic rocks is generally coarse-grained to pegmatitic, though fine-grained facies are abundant. The mafic constituents are unevenly distributed and locally there is a tendency to be porphyritic.

All the evidence points to a molecular replacement brought about by percolating aqueous solutions. The widespread occurrence of lit-par-lit gneisses recalls the recent paper by Anderson* on "Granitization, albitization, and related phenomena in the Northern Inyo Range of California-Nevada", in which he cites much evidence to show that they are most likely the result of replacement by circulating hydrothermal solutions. The most conclusive argument in support of this is the fact that lit-par-lit injection of a magma along the schistosity and bedding planes necessitates the addition of material without there being any loss. This would require a great increase in volume or density and there is no evidence of either being the case.

Throughout the contact belt there are bands of hornblende schists and hornblendite. These probably represent basic recrystallized phases of the Timiskaming as similar masses occur in the sediments.

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* G.S.A. Bull., Vol. 48, No. 1, January, 1937.

The two granitic masses from which the analyses were taken may represent the true magma which paralleled the advance of the albitizing solutions.

The mass represented by analysis XXVI is a white muscovite-leucogranodiorite very similar to that occurring in the La Motte-La Corne batholith.

In handspecimens it is a white, medium grained rock, having an average grain size of 2mm. with large flakes of muscovite up to 7mm. across. Clear colourless quartz and white feldspar are abundant and are readily identified. Small flakes of biotite and almandite are minor accessories.

In thin sections the quartz is seen to occur in large areas having only slight undulatory extinction. The plagioclase is finely twinned and is stongly corroded and replaced by microcline. There is some development of myrmekite replacing the plagioclases. The original composition was probably as calcic as Ab88An12.

The other body represented by Analysis XXVII is pinkish coloured with an average grain size of 2mm. and is chiefly quartz and pink feldspar.

In thin sections there is much evidence of deuteric alteration. Biotite is altered to penninite, and muscovite is in large irregular shreds replacing plagioclase. The

TABLE XXI

CHEMICAL ANALYSES, CALCULATED NORMS, AND MODES OF THE MUSCOVITE-GRANODIORITE PHASES OF THE SOUTHERN GRANITE

ANALYSIS NO. XXVI#		NORM		MODE	
SiO_2......	73.60	Quartz......	31.72	Quartz......	33
Al_2O_3.....	14.57	Orthoclase..	28.81	K-feldspar..	28
Fe_2O_3.....	0.14	Albite......	28.50	Oligoclase..	
FeO.......	1.16	Anorthite...	4.58	(Ab88An12).	33
MgO.......	0.53	Corundum....	2.02	Muscovite...	5
CaO.......	0.92	Hypersthene.	3.34	Biotite.....	1
Na_2O......	3.37	Magnetite...	.20	Magnetite...	nil
K_2O.......	4.88	Ilmenite....	tr	Titanite....	tr
H_2O+......	0.25	Apatite.....	tr	Apatite.....	tr
H_2O-......	0.35	Total	99.17	Almandite...	tr
CO_2.......	nil			Total	100
TiO_2......	tr	Symbol: I.4.2.3.			
P_2O_5......	tr	Name: Toscanose		Symbol: (127)	
MnO.......	nil	(near Liparose)		Name: Muscovite-	
F*........	tr			leucogranodiorite	
S.........	tr				
Total	99.77				

ANALYSIS NO. XXVII⊖		NORM		MODE	
SiO_2......	73.54	Quartz......	29.20	Quartz......	34
Al_2O_3.....	14.48	Orthoclase..	25.33	K-feldspar..	20
Fe_2O_3.....	0.06	Albite......	35.90	Oligoclase..	
FeO.......	1.42	Anorthite...	4.08	(Ab88An12).	38
MgO.......	0.25	Corundum....	1.32	Muscovite...	6
CaO.......	0.82	Hypersthene.	3.18	Biotite.....	2
Na_2O......	4.24	Magnetite...	.09	Magnetite...	nil
K_2O.......	4.29	Ilmenite....	tr	Titanite....	tr
H_2O+......	0.40	Apatite	tr	Apatite.....	tr
H_2O-......	0.30	Total	99.10	Total	100
CO_2.......	nil				
TiO_2......	tr	Symbol: I.4.1.3.		Symbol: (127)	
P_2O_5......	tr	Name: Liparose		Name: Muscovite-	
MnO.......	tr	(near Toscanose)		leucogranodiorite.	
F*........	tr				
S.........	tr				
Total	99.80				

Muscovite-leucogranodiorite from pit, at outlet of Mourier Lake. Analyst, W.H. Herdsman.

*Determined by the writer.

⊖Muscovite-leucogranodiorite from pit, south side of Lonely River near highway, Lot 14, R. IV, Desandroins township. Analyst, W.H. Herdsman.

plagioclase is finely twinned and corresponds to acid oligoclase (Ab88An12) in composition. It is extremely corroded, albitized, and silicified. Microcline and microperthite are the potash feldspars.

The analyses of both these are shown in Table XXI, together with their calculated norms and modes. They indicate that the two are almost identical in composition and a comparison with the analyses of the La Motte-La Corne muscovite-granodiorite shows an equally strong similarity. In fact all four analyses might be from one and the same mass suggesting that the rocks are related in origin.

The so-called 'Augite Syenite' west of Caron lake is another phase of considerable extent.

It is a peculiar pinkish orthogneiss. Irregular black "hornblendes" form elongated aggregates 6-10mm. long having a pronounced linear direction. These occur in a fine even grained groundmass of pink and white feldspars, generally having a grain size averaging 0.5mm.

In thin sections the "hornblende" aggregates are seen to be made up of augite and hornblende. The augite is colourless to pale green having a maximum extinction angle of 55^{o}. It is considerably altered to and replaced by hornblende. The hornblende has a sap-green to bluish green pleochroism and has numerous inclusions of magnetite, titanite, and apatite. Biotite occurs in minor amounts and is completely replaced by penninite.

The finer grained matrix is a complex of rounded and resorbed plagioclase grains and irregular grains of microcline. Apatite, titanite, and magnetite occur as large rounded grains. Quartz is entirely lacking.

The analysis of this rock type, along with its norm and mode is shown in Table XXII. It is quite different from any of the other rock encountered in the area as shown by the norm. According to Johannsen's classification it corresponds to a syenodiorite in composition.

TABLE XXII

CHEMICAL ANALYSIS, CALCULATED NORM, AND MODE OF THE ORTHOGNEISS

ANALYSIS NO. XXVIII#		NORM		MODE	
SiO_2......	57.12	Nephaline......	1.14	Quartz......	0
Al_2O_3.....	15.16	Orthoclase.....	27.26	Orthoclase..	27
Fe_2O_3.....	2.49	Albite.........	39.32	Oligoclase..	45
FeO.......	4.81	Anorthite......	5.63	Hornblende..	15
MgO.......	3.82	Diopside.......	13.59	Augite......	10
CaO.......	5.05	Olivine........	6.58	Biotite.....	1
Na_2O......	4.90	Magnetite......	3.62	Apatite.....	1
K_2O.......	4.62	Ilmenite.......	.91	Titanite....	1
H_2O+......	0.85	Apatite........	1.05	Total	100
H_2O-......	0.30	Total	99.10		
CO_2.......	nil				
TiO_2......	0.48	Symbol: II.5.2.3		Symbol: (2211)	
P_2O_5......	0.44	Name: Monzonose		Name: Augite-Syenodiorite. Orthogneiss.	
MnO.......	0.09				
F*........	0.04				
S.........	tr				
Total	100.17				

\# Augite-syenodiorite orthogneiss from west of Caron Lake, lot 33, R. I, Bellecombe township. Analyst, W.H. Herdsman.

* Determined by the writer.

CHAPTER X

AGE OF THE MAJOR ACID INTRUSIVES

In various areas of the Precambrian of the Canadian Shield, existence of at least two periods of granitic intrusion is indicated by the presence of closely folded and highly metamorposed granite-pebble-bearing conglomerate. In the southern part of the Shield, these oldest granite-pebble-bearing conglomerates are placed at the base of a sedimentary-volcanic group termed the Timiskaming Series. The granites which supplied the pebbles are called Laurentian, and the later intrusives accompanying the folding and causing the metamorphism have been called Algoman.

William D. Urry of the Massachusetts Institute of Technology, has made age determinations on three rock types of the Rouyn area by the Helium method. The material was submitted by the Horne Mine, Noranda, Quebec, and to date only that of the diabase has been published*. His results were as follows:

Intrusives		Age, Millions of Years.
Younger Diabase (North-south dyke)	chill	485 ± 20
	3' from chill	520 ± 25
	3' from chill	525 ± 25
	Average	510 (Early Keweenawan)
Quartz-Diorite (Older Gabbro)	centre	805 ± 70
	margin	785 ± 115
Extrusives		
Andesite (Keewatin)		1090 ± 90

*Lane, A.C., and Urry, W.D.: "Ages by the Helium Method".

All the rocks of the Rouyn-Bell River area are thus limited to pre-Keweenawan age by the early Keweenawan diabase dykes. The dense appearance of some of these dykes indicates that they cooled at no great depth below the surface, and the wide chilled borders which are glassy* in places, indicate that the country rocks were cold.

It is therefore evident that a long period of time must have elapsed following the intrusion of the plutonic masses which must have cooled at great depth below the present surface, probably near the boundary between the zone of fracture and the zone of flowage, and which have since been nearly unroofed by a long period of surface erosion preceding the intrusion of the diabase magma. Furthermore, the intensive peneplanation must have occurred before deposition of the Cobalt Series which would have been entirely removed in the process as it is of a continental glacial origin and has been tilted only to an angle of 10 to 15 degrees.

Near the Ontario border, the age of the Southern Granites is definitely fixed: It intrudes the Timiskaming and both are unconformably overlain by the Cobalt Series and it also furnished numerous pebbles to the basal conglomerate. It is therefore Algoman, and the rise of the magma probably followed closely the process of folding and uplift.

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* G.S.C. Memoir 166, p.108.

The other batholithic masses are known to intrude the folded Keewatin and are controlled by the folding. Some defintely cut across the folding and schistosity and are not fractured, crumpled, or rendered schistose. Hence they must be younger than the time of the folding of these rocks which appears to be post-Timiskaming in age. The fact that some of the inclusions in the roof are schists of a sedimentary nature also suggests that they may be post-Timiskaming.

The Flavrian mass was seen to be definitely younger than the Quartz-Diorite (Older Gabbro) which it cuts and included as an igneous breccia. This, in turn, cuts the Timiskaming*.

Urry's age determinations therefore limit these intrusives to from 510 to 800 million years in age and it is evident that they are not only much older than the Keweenawan dykes but are also pre-Cobalt. In other words they are all probably of Algoman age and may be products of one period of igneous activity.

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* G.S.C. Summary Report 1926, Pt. C, p.52.

CHAPTER XI

DIFFERENTIATION

As many of the intrusives showed strong genetic similarities both chemically and microscopically and also in their field occurrence, an attempt was made to determine whether they belong to a common magmatic stem. Accordingly, the analyses were plotted up in the conventional way as a variation diagram in which the major oxides were plotted as ordinates against the percentage of silica as the abscissa.

At first the points all appeared to be scattered about without rhyme or reason, but after a careful study it was found that analyses of the Taschereau, Palmarolle, and Bourlamaque Masses which had suffered little or no albitization or silicification, all more or less defined smooth curves.

The results are shown in Figure 4. The black dots represent the analyses used in drawing the curves, and it will be seen that only in the alumina, ferrous oxide, and magnesia curves do the points vary appreciably. These variations however seem to be quite legitimate in view of Grout's* findings: As a result of careful chemical analysis he finds that the probable error in the determination of the major constituents is less than ±0.3 percent. However,

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* Grout, F.F.: "The Use of Calculations in Petrology", Jour. Geol. Vol. 34, 1926, p.512.

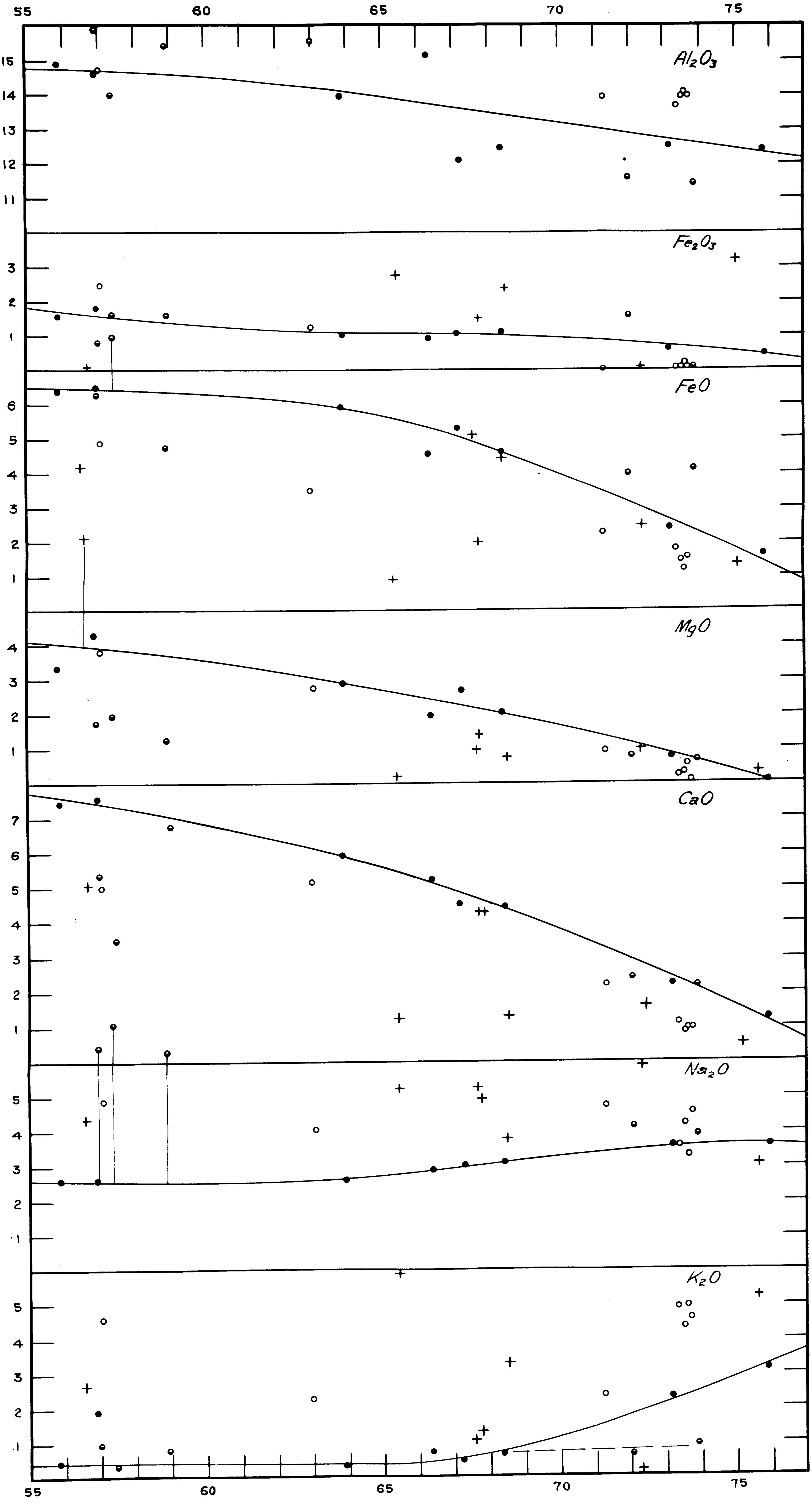

FIG. 4. Variation Diagram of the analyses of the Rouyn-Bell River Area.

magnesia and alumina may be in error as much as 3 percent. The difficulty in the determination of ferrous iron is well known and hence it seems that the variations for these analyses are all well within the limits of experimental error. It can thus be said that the various oxides of each of these analyses consistently fall on a smooth curve.

The analyses represented by the half shaded circles are those of the Bourlamaque and Flavrian rocks that have suffered albitization and silicification and which petrographical studies have shown belong to the same suite of rocks.

There seems to have been little change in the potash content of these altered rocks. In the Bourlamaque albite-tonalites, soda has been increased as much as 4 percent with a corresponding decrease in lime and magnesia. Little can be said regarding iron and alumina except that in all probability there was an increase in the latter. The gains and losses suffered by the Bourlamaque quartz-gabbro due to later hydrothermal alterations are adequately shown by the use of a straight-line variation diagram.

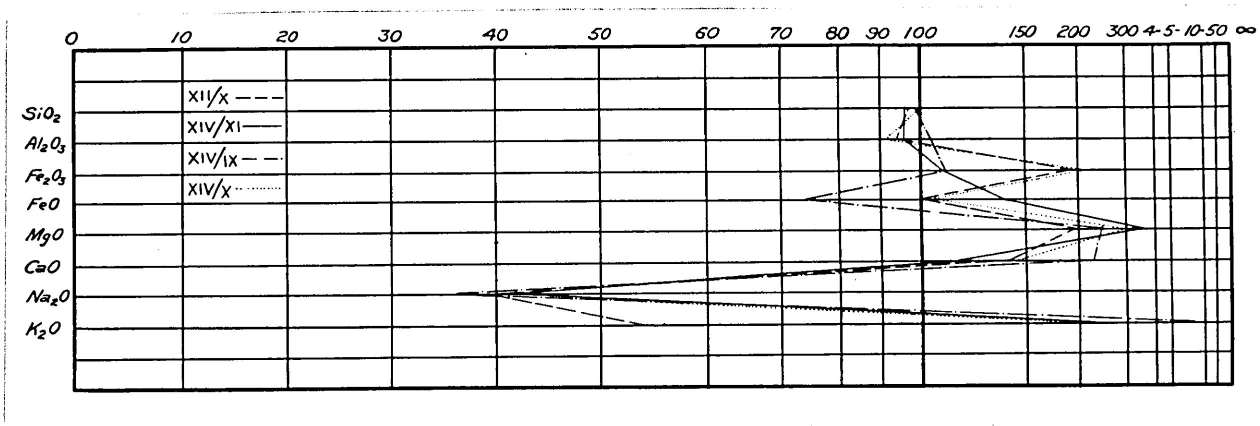

Figure 5. Straight-line diagram showing the probable gains and losses suffered by the Bourlamaque quartz-gabbro.

In Figure 5, the quotients obtained by dividing the percentage of the oxides in analyses of the quartz-gabbro by those in analyses of the albite-tonalites, have been multiplied by 100 and plotted on the logarithmic scale. Gains are represented by the points on the left and the losses by those on the right. Generally, with a slight increase in silica and alumina, there has been a decided increase in soda and locally an increase in ferrous iron.

Regarding the analyses of the Flavrian mass we have no analyses of the unsilicified rock, however, a comparison can be made with the rocks of the Taschereau and Palmarolle border phases using the variation diagram in Figure 4. If it is assumed that potash has been relatively unchanged, the potash curve would indicate a five percent increase in silica. This compares favourably with the excess of silica and quartz in the Flavrian analyses over those of the Taschereau and Palmarolle border phases. If the points for the other oxides of the Flavrian analyses are shifted to the left an equivalent distance, it is evident that, in addition to an increase of silica, there has been a slight increase in soda at the expense of lime, magnesia, and ferrous iron. This substantiates the conclusions drawn from microscopical evidence.

There still remain the analyses of the La Motte-La Corne Mass and the Southern batholith. These are shown by the open circles.

The four analyses of the muscovite-leuco-granodiorites of the La Motte-La Corne and Southern batholith are almost segregated in a single point near the upper end of the diagram. It seems likely, therefore, that they all belong to a common source. They vary considerably from the curve already defined. Similarly, beginning at the left, analyses XXVIII, XXII, and XXV vary widely from the curve.

Offhand, they seem to bear no relation to the suite of rocks already discussed, and might even represent a curve of their own. However, there still remains the possibility of crystal sorting or filter pressing to account for the discrepancies.

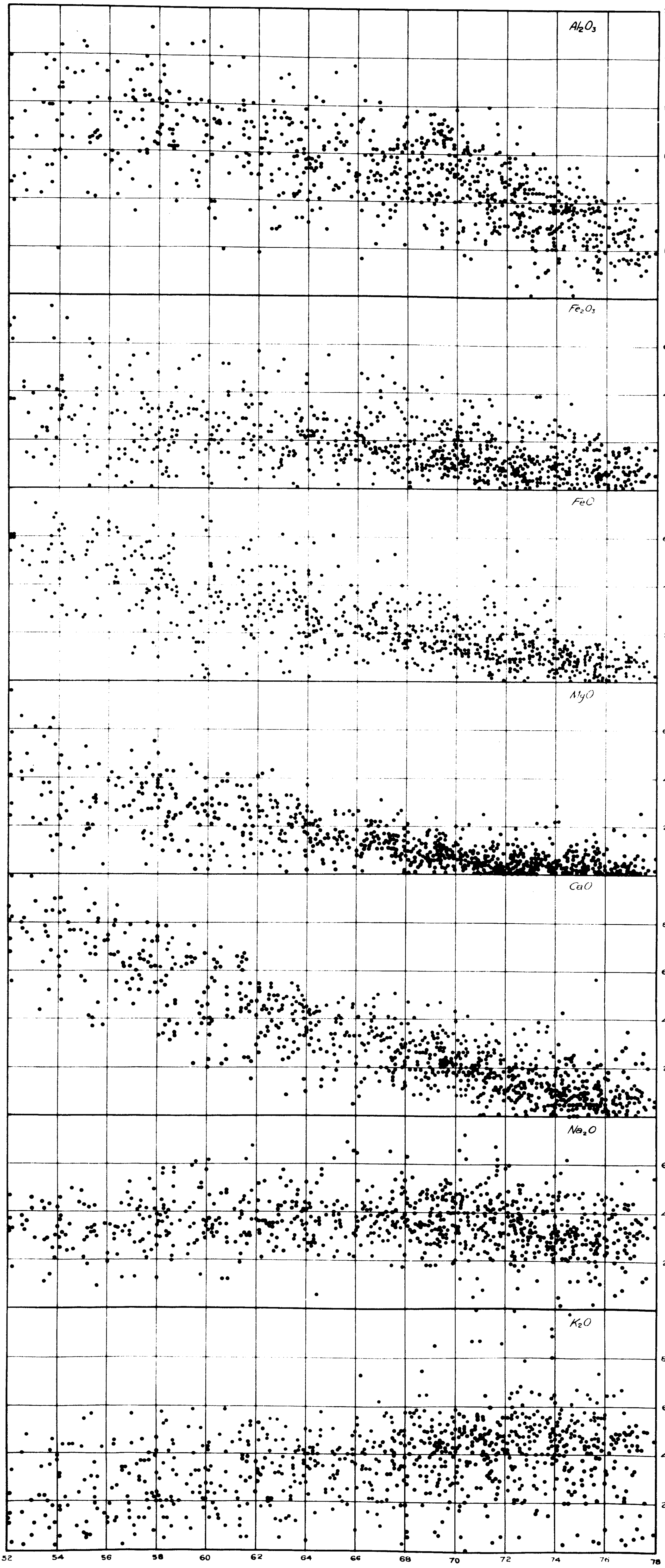

FIG. 6 Variation Diagram of Analyses from Washington's Tables

Can these analyses belong to the curves and the variations be attributed to crystal sorting or to filter pressing?

To test these possibilities, over 6,000 points, representing some 900 analyses from Washington's tables*, were plotted in a similar variation diagram as shown below. These represent rocks from widely separated areas all over the face of the globe.

The results were most amazing to the writer, for with few exceptions they do not vary more than four percent from a curve representing their averages. Generally, the deviations are less than one or two percent, especially near the upper end of the diagram where the analyses in question occur.

In other words, if the analyses of the La Motte-La Corne and the Southern batholiths, belong to the curves drawn for the other major acid intrusives of the Rouyn-Bell River area, it can also be argued on the basis of variation diagrams that intrusives in New Zealand and Iceland belong to the same stem.

The logical answer is inevitable, and the writer strongly urges that in future the use of variation diagrams for the purpose of defining a magmatic stem be restricted to those analyses which lie on or very near a smooth curve, unless adequately supported by other evidence.

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* U.S.G.S. Prof. Pap. 99.

In the face of this, the writer feels that the rocks of the La Motte-La Corne mass and the Southern batholith must be regarded as of a different source since evidence to the contrary is lacking.

The variation diagrams plotted from Washington's tables have a variety of uses. Among them, the averages of analyses for any percent of silica can be determined at a glance. Also, the range of an oxide for a specific silica content can be had.

A comparison of the variation diagrams of the Rouyn-Bell River analyses with those plotted from Washington's tables show the following characteristics:

Oxide	Analyses Related to the Curve	Other Analyses
K_2O	extremely low	normal
Na_2O	slightly below normal	slightly above normal
CaO	very high	normal
MgO	rather high	normal
FeO	rather high	normal
Fe_2O_3	low	low

Thus, in comparison with the average rocks of similar silica content, the suite of rocks defining the curve in the Rouyn-Bell River variation diagram is unique in its extremely low potash content and in the high content of lime, magnesia and ferrous iron.

For comparison, analyses of some other granitic masses in northern Ontario and Quebec are shown in Figure 4 by crosses. None of these appear to bear any relation to the curve.

CHAPTER XII

SUMMARY AND CONCLUSIONS

Although the results of this thesis do not support the division of the major acid intrusives of the Rouyn-Bell River area into sodic and potassic types, there appear to be two distinct series of rocks. The various phases of the Bourlamaque, Taschereau, Palmarolle, and Flavrian masses are characterized by an extremely low potash content, and the writer feels that the evidence strongly supports grouping them as differentiates of a common source. The sodic nature of the intrusives associated with the economic deposits are undoubtedly due to later hydrothermal alterations.

In Bowen's recent paper[*] he has very conclusively demonstrated the concentration of soda-alumina silicates in the residual liquids from magmatic differentiation.

As pointed out by Emmons[θ], it is also possible that the charge of molten rock which reached the region of emplacement to form a batholith, exhausted the supplying sources from which the magma rose.

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[*] "Recent High-Temperature Research on Silicates and its Significance in Igneous Geology", by N.L. Bowen, Am. Jour. Sci., Jan. 1937, Vol. 33.

[θ] Emmons, W.H.: "The Basal Regions of Granitic Batholiths", Jour. Geol. Vol. XLI, 1933, p.7.

This might explain the close relation of economic deposits and sodic rocks, since both the mineralizers and the soda-alumina silicates are concentrated in the residual liquids, and would also explain why later differentiates are barren.

Although there is no evidence relating the La Motte-La Corne and the southern batholithic rocks to the other plutonics of the Rouyn-Bell River area, our present knowledge of magmatic differentiation would indicate that if they are products of the same magmatic source, they must be later differentiates to account for the increase in potash. There appears to be no evidence contrary to this hypothesis and the writer offers it as a mere suggestion.

Regarding the Quartz-Diorite or "Older Gabbro" the writer suggests that it may represent the earliest product of this series of differentiates. It has already been demonstrated that it is closely related to the granitic differentiates in age[*].

In summary, therefore, the sequence of events may have been as follows:-

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[*] G.S.C. Mem. 166, p.128.

(1) Injection of sills and dykes of the Quartz-Diorite (Older Gabbro) during or closely following the post-Timiskaming folding.

(2) At about the same time as (1) emplacement of the Bourlamaque Quartz-Gabbro by stoping.

(3) Injection of the Taschereau, Palmarolle, and Flavrian,Tonalites as slightly later products of differentiation. These solifified from the hood down.

(4) Injection of the granodiorite core phases by dilution or tapping off the still unsolidified core of the Taschereau and Palmarolle masses, and the development of aplites and pegmatites.

(5) Intrusion of the Syenite Porphyry dyke complex, and -

(6) Albitization and silicification of the Bourlamaque Quartz-Gabbro and other rocks in the region of shear zones. This was probably accompanied by the ore solutions.

(7) Probably as a final event the Southern batholith and the La Motte-La Corne mass invaded the Timiskaming sediments and overlying rocks by metasomatic replacement.

APPENDIX

THE SYENITE PORPHYRY DYKE

As definite relations between the Syenite Porphyry and the major acid intrusives have never been found before, a detailed description of the dyke cutting the Flavrian mass is included herein. In a good exposure on lot 28, range X, of Beauchastel township, a dyke of Syenite Porphyry was seen to definitely cut the Flavrian tonalite. The dyke is about a foot wide, has a vertical dip, and strikes N 30°E. A long the strike it was also seen to cut two aplite dykes.

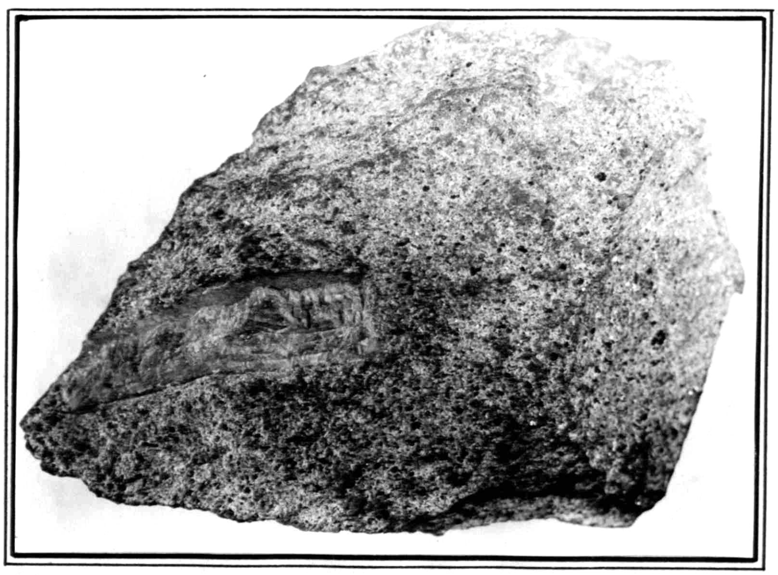

Plate XVI. Syenite Porphyry from a dyke cutting the Flavrian mass. About two-thirds natural size.

The dyke weathers to a brick red colour on the surface and, although only a foot wide, is characterized by gigantic booklike phenocrysts of feldspar. These are all orientated parallel to the walls of the dyke and give the rock a pronounced trachytic texture. One of the largest crystals removed, measured 3" x $1\frac{1}{4}$" x 3/8". They are distinctly zoned, are twinned on the Carlsbad law, and have a brownish, purplish, or pinkish-grey colour on a fresh surface.

The greyish groundmass is very fine grained having a slight purplish tinge, and appears to be chiefly feldspar. Scattered through this are black hexagonal plates of biotite averaging 1mm. in diameter, with an occasional one as much as 6mm., and clear yellow prisms of apatite, 3mm. to 4mm. long. The apatite was recognized by its characteristic hexagonal form terminated by pyramids, its hardness and its basal parting. In oils its indices were found to be $o=1.635$, $e=1.633 \pm 1$ which are within the range of common apatite. Only minor amounts of quartz are visible locally.

In thin sections the groundmass also exhibits a decidedly trachytic texture. More or less parallel shreds of biotite and crystals of feldspar and apatite lie in a holocrystalline felty swarm of fine lathlike crystals of feldspar that are parallel except where they swirl around the larger crystals.

Biotite is the common brown pleochroic variety and is locally altered to chlorite. It makes up about 20 percent of the groundmass. Apatite occurs as small prisms as well as in the large 'phenocrysts' visible in handspecimens. The large feldspar phenocrysts as well as the large crystals of feldspar in the groundmass are microperthite and microcline, now greatly replaced by albite and locally by quartz. Albite cuts across them in irregular veinlets and locally, replacements show a tendancy toward chessboard structure. The felty groundmass is almost pure albite. Magnetite, a very small amount of quartz and muscovite, and inclusions of titanite and zircon in biotite, occur as accessories.

Some sericite is developed in the potash feldspars, and calcite and chlorite occur as alteration products in the groundmass. Locally clusters of these may represent completely replaced amphibole.

Detailed descriptions of the various phases of the Aldermac Syenite Porphyry have been made by Gunning* and, although the dyke found cutting the Flavrian mass does not fit exactly his description of any one of the three types into which he has grouped them for convenience,

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* Gunning, H.C.: "Syenite Porphyry of Boischatel township, Quebec", G.S.C. Bull. No. 46, 1927, pp.31-41.

it has many of the characteristics of the group as a whole, and lies between his descriptions of the acid and intermediate types.

In 1926 Cooke* tentatively placed the Syenite Porphyry as immediately following the intrusion of the 'granodiorite'. However in the more recent publications of the Geological Survey, it has for some reason or other been placed in the geological table as preceding the intrusion of the major acid intrusives. The finding of this dyke seems to definitely establish the Syenite Porphyry as younger than the major acid intrusives.

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* Op. cit., p.49.

BIOGRAPHICAL NOTE

William Carruthers Güssow; son of H.T. Güssow, Dominion Botanist of Canada; Natural born, British subject; Born London, England, April 25, 1908. Came to Ottawa, Canada, July, 1909. Attended Devonshire Public School from 1917 to 1919, Woodroffe Public School, 1919, to 1921, and Nepean High School, 1921 to 1926. After matriculating obtained a position as student map draughtsman in the Geological Survey of Canada; resigned after three years in order to pursue a university education.

Attended Queen's University, Kingston, Ontario from 1929 to 1935, obtaining his B.Sc. in 1933 and M.Sc. in 1935. In his senior year he demonstrated in Qualitative Analysis and during his two graduate years instructed half-time in Geology. Came to the Massachusetts Institute of Technology in 1935 on a $250 graduate scholarship and returned the following year with one for $500 and in addition a $1500 Royal Society of Canada Fellowship. Married Margaret Blackett Robinson on September 24, 1936.

Field experience consists of two field seasons of detailed geological work in the Sudbury Area, Ontario, with Dr. W.H. Collins; one season of detailed mapping in the Sturgeon River Area for the Ontario Bureau of Mines; another two in geological examination of mining properties in Northern Ontario and Northwestern Quebec for private companies; and finally, two seasons of an exploratory nature in the Northwest Territories and west of Lake Nipigon, Ontario.

One paper has been published being "Contributions to the Knowledge of the Flora of Northern Manitoba and the Northwest Territories, Dominion of Canada", also an abstract of the present thesis.

Canada
Department of Mines
HON. T. A. CRERAR, MINISTER; CHARLES CAMSELL, DEPUTY MINISTER.

BUREAU OF ECONOMIC GEOLOGY
GEOLOGICAL SURVEY

Issued 1936

LEGEND

PROTEROZOIC (LATE PRECAMBRIAN)

COBALT SERIES

A7 — Conglomerate with some greywacke, arkose and slate

ARCHEAN (EARLY PRECAMBRIAN)

POST-TIMISKAMING

6 — Olivine gabbro, quartz gabbro (some dykes may be post-Cobalt)

5 — Granite, syenite, granodiorite (5a) and allied rocks; possibly not all of one age

4 — Serpentine, peridotite, amphibolite

3 — Quartz porphyry, syenite porphyry; some may be pre-Timiskaming

2 — Quartz diorite in places grading into granite

1 — Quartz diorite

TIMISKAMING

A6 — Altered basic lava

A5 — Mainly greywacke and quartzite, in part altered to mica schist; some conglomerate, lava, and small intrusive bodies

A4 — Conglomerate with some interbedded greywacke

KEEWATIN

A2 A3 — Tuff, breccia and other sediments; bodies marked A3 may be post-Keewatin

A1 — Basalt, andesite, dacite, and rhyolite variously altered and in part changed to schist, etc.; minor amounts of tuff and small intrusive bodies

Geological boundary
Fault (defined, approximate)
Synclinal axis
Road
Road not well travelled
Trail or portage
Power transmission line
Rapid or fall

SOURCES OF INFORMATION

Geology from surveys by the Geological Survey of Canada; *and the* Bureau of Mines, Quebec.

Base map from surveys by the Department of Lands and Forests, Quebec; *the* Geological Survey of Canada; *and the* Topographical and Air Survey Bureau, Department of the Interior.

MAP 328 A
(PUBLICATION No. 2404)

ROUYN-BELL RIVER AREA

ABITIBI AND TÉMISCAMINGUE COUNTIES

QUEBEC

Scale, $\frac{1}{253,440}$ or 1 Inch to 4 Miles

Miles
4 0 4 8 12

Kilometres
5 0 5 10 15 20