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ARCHEAN GRANITOID INTRUSIONS INTO
THE PONTIAC GROUP, LAC REMIGNY AREA,
NORTHWESTERN QUEBEC

by

■ CLAUDE LAROUCHE, B. Sc.

A thesis submitted to the Faculty of
Graduate Studies in partial fulfilment
of the requirements for the degree of
Master of Science

Carleton University

Ottawa, Ontario

August, 1979

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ABSTRACT

In the Lac Rémigny area of the Superior Province in northwestern Quebec, an Archean granitoid batholith has intruded the metasedimentary rocks of the Pontiac Group.

Two complexes are distinguished within the batholith. The Lac Fréchette Complex, the smaller and earlier of the two, consists of quartz-poor alkalic rocks ranging from monzonite to quartz monzonite. The Lac Rémigny Complex is more siliceous and varies from monzodiorite to granodiorite. Associated dykes of pegmatite, granite and aplite intruded most of the region studied. Primary mineral foliation and lineation, and orientation of small mafic xenoliths indicate upward flow of magma and suggest diapiric emplacement; stoping was also locally involved. Contact relationships of dykes suggest dilational emplacement during several phases of magma injection.

One hundred and nineteen samples of the main intrusions and the related dykes were studied petrographically and fifty samples were analysed for major, minor and trace-elements.

The batholith consists of several chemically distinct units that intruded in an evolutionary sequence, the younger units generally being more felsic. The variations are primarily caused by crystal fractionation at depth; differentiation did not occur in situ.

The general absence of contact metamorphic effects indicates synkinematic emplacement under pressure-temperature conditions of the amphibolite facies of regional metamorphism; well developed flow structure and evidence of strain in mineral grains suggest a high proportion of crystals to liquid in the intruding material.

Potassic feldspar megacrysts, abundant in the quartz monzodiorite and the granodiorite of the Lac Rémigny Complex, are concluded to be primary precipitates, oriented by magma flow.

Information concerning the origin of the Lac Fréchette Complex is consistent with several mechanisms: late stage differentiation of initially basaltic magma, or early accumulation of precipitates from granitic to quartz syenitic magma, or varying degrees of partial melting of quartzofeldspathic or feldspathic rocks. The Lac Rémigny Complex magma may have evolved however by anatexis and mobilization of mainly igneous basement rocks forming the floor of the metasedimentary rocks at deeper levels in the crust. Water was concentrated in the Lac Rémigny magma during crystallization leading to repeated intrusion of a large volume of associated pegmatite, granite and aplite dykes.

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The Lac Rémigny area, northwestern Quebec, offers an excellent opportunity to study the field relationships, petrography and petrogenesis of the Archean intrusive rocks found in the southern part of the Superior Province (Figure 1-1). This region is underlain by a large composite batholith intruding, at the present level of erosion, meta-sedimentary rocks of the Pontiac Group, located south of the Abitibi volcanic belt.

A map (Figure 1-2 in pocket) was completed by the author during the field seasons of 1975 and 1976, while employed by the Quebec Department of Natural Resources. The map represents a detailed section through part of the batholith, which is bounded by metasediments to the north, the Grenville front to the south and southeast and a cover of Huronian sedimentary rocks to the west (Figure 1-3).

There has been little information available on the composition and structural organisation of this batholith. This lack can be explained in part by the large extent of the unit and the fact that it is commonly believed to be of no economic interest.

Chagnon (1968) related the characteristics of the intrusive complex to those of synkinematic batholiths located between the mesozone and the catazone of Buddington's (1959) classification. He also described their origin and emplacement as being complex and obscure.

Figure 1.1 Map of the Province of Quebec, showing Precambrian structural provinces and the location of the study area.

LEGEND

STUDY AREA

METAMORPHIC ZONES

Chlorite

Biotite

Staurolite

Alumino-silicate

PROTEROZOIC

COBALT GROUP

ARCHEAN

INTRUSIVE ROCKS

1. Granite, monzonite, granodiorite, syenite
2. Trondjemite, tonalite
3. Diorite, gabbro
4. Foliated granitoids more or less hybrid, undifferentiated
5. Tonalitic gneiss

METASEDIMENTARY ROCKS (may include pyroclastic rocks)

1. Lac Caste Group
2. Kewagama Group
3. Duparquet Group
4. Temiskaming and Cadillac Groups
5. Undifferentiated

PONTIAC GROUP

METAVOLCANIC ROCKS

1. Malartic Group
2. Kinojevis Group
3. Blake River Group
4. Undifferentiated

Figure 1-3: Geological setting of the Lac Réminy area (modified after the geological map of the Province of Quebec). The legend appears on the facing page.

2

Dimroth (1973) proposed for the same rocks a different interpretation and defined a new mechanism of batholithic emplacement characterized by the slow opening and filling of a complex system of fractures forming swarms of dykes which collectively attain batholithic dimensions.

The objectives of this study are:

- to present the distribution, internal composition and structure of the Archean intrusive rocks along cross sections from Cloutier to Rémigny (Figure 1-2)

- to establish the sequence of intrusion

- to infer emplacement mechanisms

- to graphically analyse chemical and modal data from which a differentiation and/or assimilation model can be derived

- to document and interpret the presence of potassic feldspar megacrysts occurring in some units

- to examine the possible origin of the magma and compare this region with other Archean granitoid complexes.

Chapter 2 is concerned with the geological setting of the study area. Previous work is briefly noted and the regional geology given in stratigraphic succession. Metamorphic and tectonic events are summarized on a regional scale.

The geology of the map area is discussed in Chapter 3. The megascopic and microscopic description of the different facies is given along with their distribution and field relationships. Well-preserved ultramafic flows are of special interest as they are described for the first time

in the Lac Rémigny area. The effects of metamorphism affecting the thesis area are complicated by successive events of deformation.

The relations of the intrusions to the wall-rock, and the internal structure of the batholith, help to suggest some emplacement mechanisms which will be examined in Chapter 4. Dykes are given careful attention as they underlie the largest part of the granitoid region. Their textures and structures give evidence of the history of dyke filling. This subject will be treated in detail.

Petrological and geochemical data are presented in Chapter 5. Graphical treatment of 119 modal analyses and 50 chemical analyses illustrates mineralogical and chemical relationships suggesting a differentiation and/or an assimilation model for the origin of the various rock types.

Chapter 6 deals with the genesis of the intrusions. The potassic feldspar megacrysts important in many Precambrian granitoids are documented. By comparing the petrography and geochemistry of the study area to that of other Archean suites possible sources for the magma are suggested.

CHAPTER 2:

REGIONAL GEOLOGY

2.1 Introduction

Granitoid rocks of various compositions were intruded into large volumes of Archean volcanic and sedimentary rocks throughout the Superior Province during the Kenoran Orogeny (Goodwin, 1972). This period of folding and metamorphism could have been the last of a series of orogenies, effects of which have been destroyed by the final one (Kalliokoski, 1968; Stockwell et al, 1970). The thermal event was dated at 2740 m.y. by Dallmeyer, Maybin and Durocher (1975) in the eastern Abitibi greenstone belt, Quebec and at about 2,600 m.y. by Baragar and McGlynn (1976) in a review of early Archean basement in the Canadian Shield. In general the widespread emplacement of the granitoid bodies left only isolated remnants and belts of older supracrustal rocks present in a number of synformal units (Stockwell et al, 1970; Goodwin, 1972). This characteristic is also visible in other Archean terrains throughout the world.

Detailed studies in the Abitibi belt have generally been confined to small plutons (Dawson, 1966; Wolhuter, 1971; Campiglio and Darling, 1976; Goldie, 1976) and large batholithic complexes are still poorly understood. The Lac Rémigny area offers an excellent opportunity to study part of such a complex with special emphasis on the evolution of magmatic intrusions, emplacement mechanisms and origin of the magma.

2.2 Previous Work

McOuat, in 1873, did the original reconnaissance mapping of the area. The canoe route he followed passes from the western arm of the Lac des Quinze through Lac Rémigny and Rivière Solitaire (Figure 1-2). He described gneissoid strata in the Lac des Quinze area and fine grained, grey granitic material, actually metasedimentary, closely associated with a hornblende rich rock which appears to cut the former. Wilson (1913) mapping the region of Lac Kewagama included the northern part of the study area and defined as Pontiac Series the metagreywacke and schist now known as the Pontiac Group. The complexity and the heterogeneous character of the rocks intruding the Pontiac Group were noted. He also described the contact between the batholith and the metasediments as being marked by a large zone where dykes and irregular masses of pegmatite, granite and aplite increase in size and number towards the batholith. The orientation of the Pontiac Group was seen to be uniform throughout the dyke zone even where it is only present in small bodies between the dykes. Chagnon (1968) gave a good description of the intrusive rocks and also extended mapping of the Pontiac Group further to the south. He recognized a hornblende-pyroxene syenite body to the north, around Lac Fréchette and Lac Barrière, which is separated from a southern intrusion by a belt of metasediments. Hornblende granite, including a porphyritic variety, intimately mixed with oligoclase-microcline granite was shown to compose the southern intrusion.

Biotite-pyroxene rock, nodular syenite, hornblende syenite and plagioclase-hornblende gneiss were also described, as well as a large number of pegmatite, granite and aplite dykes which cut all other facies except the diabase.

Dimroth's (1973) detailed studies referred to the oligoclase-microcline granite as an heterogeneous granodiorite and his interpretation differed slightly from that of Chagnon. The heterogeneous granodiorite was believed to form a sheet of dykes capping the earlier intrusions (hornblende-pyroxene syenite and hornblende granite) referred to as the homogeneous member. According to Dimroth, the contact between the homogeneous member and the country rock is invaded by the heterogeneous member and at one place up to seven generations of dykes are present. The texture and the structure of the dykes suggest that there was only a small amount of magma available at any time for their production.

Mapping of parts of the same batholith has been carried out in regions adjacent to the thesis area by Wilson (1918), Cooke (1923), James (1924), Denis (1937), Freeman (1957a, 1957b), Winter (1972), Lestra (1972), Rive (1975) and Van de Walle (1978).

2.3 Geological Setting of the Study Area

The Lac Rémigny area is located within the Pontiac meta-sedimentary belt, which extends from the Abitibi volcanic belt to the north, to the Grenville Front to the south and southeast (Figure 1-3). A few ribbons of volcanic belt are present also

to the southwest, in the metasedimentary belt. The stratigraphy of the region was described by Dimroth et al (1973, 1974, 1975, 1976) in the Rouyn-Noranda - Val d'Or area, and by Imren (1974a, 1974b) in the Val d'Or area. Figure 2-1 presents a tentative stratigraphy of the different groups from Dimroth (1976). The Malartic Group consists of a basal unit of ultramafic flows overlain by formations of alternating mafic and acidic composition. The Lac Caste Group is a very strongly deformed unit composed of greywacke with minor conglomerate and chert. The Kinojevis Group was erupted in deep water and forms an extensive, thick sheet of tholeiitic basalt. Contact relations between the Malartic Group, the Lac Caste Group and the Kinojevis Group are unclear. After the cessation of volcanic activity, a fan of turbidites of unknown extent, the Kewagama Group, covered part the area. Later the Blake River Group erupted to the south of the Kinojevis Group as a thin sheet of tholeiitic basalt. Upon this basaltic base grew a number of complex shield volcanoes belonging to a calcalkaline suite, which form the main part of the Blake River Group. Some of the shield volcanoes were nearly emergent at the end of their development and were a source for the volcanic fragments included into the basal conglomeratic sandstone of the Cadillac Group. A second suite of tholeiitic basalts overlies the shield volcanoes to form the third phase of the Blake River Group. This volcanic chain can be interpreted as built southward in

Figure 2-1: Tentative stratigraphic interpretation of the Rouyn-Val d'Or area (Dimroth, 1976)

successive steps (Dimroth, 1976) and is adjoined to the south by a marine sedimentary basin occupied by the Pontiac Group, a large turbidite fan cut by channels filled with turbidite conglomerates containing only greywacke pebbles (Dimroth, 1975). The Pontiac Group is older than the Cadillac Group and thus, because part of the Cadillac Group interfingers with the Blake River andesites, the Pontiac Group must be at least equivalent to the early phase of the Blake River Group and perhaps even to the older Kinojevis Group (Dimroth, 1975). Paleocurrents in the marine sedimentary basin indicate provenance from the northwest, north and northeast.

The Temiskaming and Cadillac Groups are also composed of turbidite fans (conglomerate and greywacke). They were derived from a mixed volcanic and granitic terrain and the deposition of these suites may correlate with the last stage of Pontiac deposition. The Duparquet Group is made up of fluvial deposits grading to the southwest into turbidites.

Imreh (1976) determined the stratigraphic relation between volcanism and sedimentation in the Val d'Or area. The volcanic rocks of the La Motte-Vassan Belt (Malartic Group) appear to pass into the Pontiac metasedimentary rocks along strike through a transition zone of interfingering sediments and volcanics. Serpentinic flows present in the Pontiac and having the same characteristics as those forming the volcanic basement to the north have been described by Imreh. There seems to be a gradual transition from volcanism to sedimentation without any significant time break and it is highly

possible that, at a certain moment, sedimentation and volcanism were proceeding simultaneously in different parts of the basin. The base of the Pontiac Group is then the roof and the lateral equivalent of the Malartic Group.

Imren (1973) defined the stratigraphic relations of the Pontiac metasediments and the metavolcanics of the Baby structure located approximately twenty (20) kilometers north-east of Ville-Marie in Témiscamingue county (Figure 1-3). He concluded that the metasediments form the stratigraphic base of the metavolcanic rocks but the correlation of the metavolcanic material with the volcanic units of the Abitibi belt to the north is not clear. Another metavolcanic belt lies thirty (30) kilometers east of Ville-Marie and possesses the same character and direction as the Baby structure. They are separated by granodioritic-trondjemitic intrusions.

Various types of plutons are present in the region. They range in size from small stocks to large batholiths and are in places responsible for deformation as well as contact metamorphism (Dawson, 1966). The volume of exposed intrusive material is low in metavolcanics (Figure 2-2) and abundant supracrustal material characterises a high level terrain. Small, marginally foliated intrusive plutons are closely associated with felsic volcanics; they probably represent coeval intrusive equivalents. Jolly (1977) documented the relationship between Archean lavas and intrusive bodies of the Abitibi belt.

Figure 2-2: Distribution of granitoid rocks in the southern part of the Superior Province. The limits of the granitoid bodies are undefined along the Grenville Structural Front.

Granitoid bodies ranging in size from narrow dykes to immense batholithic complexes underlie a large volume of the Pontiac gneiss belt. The foliated granitoid rocks form a large core set in the metasediments with a few roof pendants left as large inclusions (Figure 2-2). The volume of intrusive material indicates a deeper level terrain than the volcanic belt. Rare tonalitic gneisses of pre-kinematic origin are present in the region and contain amphibolitic inclusions with sharp contacts, denoting the intrusive character of the tonalite. The composition of the numerous facies of the batholith varies but monzodiorite, quartz-monzodiorite, granodiorite and monzonite appear to be most abundant and commonly in a given complex, the potash-rich rocks are generally younger than the sodic ones. Pegmatite, granite and aplite are common constituents of the gneiss belt and form either dykes concentrated around the related intrusions or large scattered masses. After the Kenoran orogeny, the rocks were deeply eroded and Aphebian sediments were deposited in a basin covering the western part of the region. Numerous swarms of diabase dykes were emplaced over a large span of time in the early Aphebian to possible Helikian Eras.

Regional Metamorphism

The low grade (greenschist facies) metamorphic belt of volcanic rocks located to the north of the region is in structural contact with the metasedimentary gneiss belt to the south, which underwent a higher grade of metamorphism

(amphibolite facies). The variation at the contact is sharp along a boundary fault and indicates uplift of the gneiss belt compared to the volcanic belt (Kalliokoski, 1968).

Chagnon (1968) concluded that a uniform grade of metamorphism prevailed throughout the study area, equivalent to the staurolite-quartz subfacies of the almandine-amphibolite facies as defined by Fyfe, Turner and Verhoogen (1958). The volcanic rocks to the southwest show a slightly lower grade of metamorphism, upper greenschist to lower almandine amphibolite (Chagnon, 1968; Rive, 1974). Chagnon interpreted these lower grade rocks as retrograde resulting from intrusions, or as a block more resistant to the effects of metamorphism.

Isograds parallel to the Grenville Front have been drawn by Van de Walle (1978) and Goulet (1978) who mapped adjacent areas north of the present study. They are illustrated on Figure 1-3. The grade of metamorphism increases in a southeasterly direction towards the Grenville Front from a chlorite zone to a biotite zone, to a staurolite zone, to a wide alumino-silicate zone covering most of the granitoid area. The intensity of metamorphism is locally difficult to identify because the minerals have been retrograded.

Regional structure

The structural pattern of the metasedimentary belt is quite different from that of the volcanic belt (Dimroth et al, 1973)

The metasedimentary belt is characterized by a nearly horizontal schistosity and small-scale recumbent folds, re-folded in part under the action of rising granitoid batholiths. Large scale isoclinal folds with nearly vertical axial planes distinguish the volcanic belt. Also generally two, rarely one or three, sub-vertical schistositities are superposed upon the isoclinal folds, and the intensity of deformation varies greatly. Many sets of faults cut the Archean rocks. Their orientation varies and their relative age is commonly unknown. They may be related to diabase intrusions and to sedimentation in the Aphebian sedimentary basins. (Stockwell et al, 1970.)

2.4 Age of the Intrusive Rocks

In the Superior Province, the intrusive activity reached a peak during the Kenoran orogeny when the batholithic complexes and many of the smaller plutons were emplaced. Those post sedimentation plutons are related to the Algoman group (Goodwin, 1972) as opposed to the presedimentation Laurentian granites generally inferred from the presence of granitic clasts in metaconglomerates.

No specific dates are available for the granitoid rocks of the study area. However dating of the Kenoran orogeny places limits on the time of intrusion. A range of 2,460 m.y. (Snelling, 1962) to 2,740 m.y. (Dallmeyer, Maybin and Durocher, 1975) has been determined and corresponds roughly to the major period of intrusions proposed by Goodwin (1972) for the

Superior province. Age determinations published for rocks of adjacent regions place further restrictions on the time of emplacement of specific bodies. K-Ar dates ranging from 2,545 m.y. (G.S.C. sample #61-168, Lowdon et al, 1963) to 2,600 m.y. (G.S.C. sample #64-129, Wanless et al, 1966) are generally obtained for granodiorites, quartz monzonites and syenites intruding the volcanic belt. Snelling (1962) investigated the ages of metamorphism of the volcanics and the time of intrusive emplacement in the Val d'Or area. He obtained an average K-Ar age of 2,635 m.y. on muscovites for the Preissac-Lacorne batholith and this age would represent the lower age limit of metamorphism for the Abitibi volcanic belt, the muscovite pegmatites not being metamorphosed.

Two Pontiac intrusions located about 30 kilometers south of Cadillac have also been dated and found to be younger than the Preissac-Lacorne batholith. Biotite from a biotite-granodiorite (G.S.C. sample #59-78) of the Béraud township gave a K-Ar age of 2,285 m.y. Chloritized biotite from a biotite-quartz monzonite (G.S.C. sample #59-76) was dated at 2,600 m.y. but this latter age is not reliable. Fresh biotite from the Pontiac schist shows that the metamorphism occurred more than 2,460 m.y. ago. Snelling also obtained decreasing ages of metamorphism for the sedimentary rocks toward the Grenville Front. Wynne-Edwards (1972) explained these younger ages and the fact that the isograds are nearly parallel to the Front as a result of the passive uplift of a narrow zone of the Archean

basement during the Grenvillian orogeny. The later erosion is considered to have exposed deeper levels of pre-existing metamorphic "isograds" without major deformation or mineralogical changes.

CHAPTER 3

GEOLOGY OF THE MAP AREA

3.1 Access, Topography and Field Methods

The northern limit of the region investigated lies about 30 kilometers southwest of the towns of Rouyn-Noranda. The area extends over 30 kilometers to the south and is bounded by latitudes $47^{\circ}40'$ and $48^{\circ}00'$ N and longitudes $79^{\circ}03'$ and $79^{\circ}15'$ W. It can be reached by the major highway 101 joining Rouyn-Noranda to Ville-Marie (Figure 1-3). Secondary roads cut across most of the area and lead to major lakes. The isolated areas can be easily reached by waterways.

Some minor work has also been carried out on Lac Caron which is accessible through secondary roads from Rouyn-Noranda.

The relief is moderate, elevations ranging from 260 m in the northeast corner to about 365 m east of the village of Rémigny. The streams flow into the Ottawa River through a series of long and narrow lakes which are characteristic of the region. No visible correlation exists between the rock types and the topography. It is not unusual to find metasediments as a dominating facies on top of ridges.

The present study began with detailed remapping of two sections through the batholith taking advantage of the good exposure along the shore of the lakes and the road-cuts. Chagnon's (1968) map and stratigraphy were used as a guide. The results are plotted on Figure 1-2 (geological map, in pocket) at the scale of 1:50,000. The correlation between the different sections is based on published data, geophysical

survey and the writer's interpretation. Representative samples of the rock units were collected for modal and bulk chemical analysis.

The field work carried out during the present study led to a slightly different interpretation than that of Chagnon. Some of the units have been further subdivided and dyke intrusions constitute a unit of major importance. One hundred and forty (140) thin sections of selected rocks were studied by standard petrographic methods. The author has used Streckeisen's classification (1973) and a few changes have been made to the rock names published by Chagnon (1968). In such cases the name used by Chagnon follows in parentheses.

3.2 Lithology

The batholith presents a complex petrographic picture consisting of a mosaic of individual bodies mainly elongated parallel to the regional structure. They are generally distinguished by their location, mineralogical composition, sharp contacts and the arrangement of flow structures. Mapping confirmed the existence of two separate complexes, both comprising several units, in addition to pegmatitic, granitic and aplitic dykes.

The Lac Fréchette complex covers a small territory in the north of the map area and is composed mostly of quartz-poor rocks. The Lac Rémigny complex, richer in quartz, crops out over most of the region and is separated from the former by an area of Pontiac metasediments. No contact has

been observed between the two complexes but based on indirect relationships the Lac Fréchette Complex seems to be older. The time interval between the emplacement of the different units of each complex is not known but they were intruded in a sequence of increasing silica content. Granite, sensu stricto, is rare and is generally restricted to late dykes. The proposed stratigraphy for the study area is reported in Table 3-1.

-Pontiac Group

Only a relatively small part of the total area of exposure of the Pontiac Group lies within the Lac Rémigny area. This part has been subdivided into three distinctive rock units. The most widespread of these is a greywacke with minor argillite (map unit 3) that is more or less metamorphosed to biotite quartzo-feldspathic gneiss and biotite schist respectively. A distinctive unit representing ultramafic volcanism (map unit 1) occurs in the lower part of the Pontiac Group. The third rock unit consists of small lenses and sills of amphibolites (map unit 2).

Ultramafic flows (1)

On the northeast shore of Lac Barrière, ultramafic flows occur in a few outcrops and locally their well preserved textures are typical of ultramafic volcanism in the Archean.

Numerous such occurrences have been described in the Abitibi volcanic belt, (Eckstrand, 1972; Pyke et al, 1973; Dimroth et al, 1973, 1974, 1975; Imreh, 1974a, b). They have also been

Table 3-1

Table of Formations

Cenozoic	Pleistocene and Recent	Sand, gravel and clay (21)
		Unconformity
Proterozoic		Olivine diabase (20) Diabase
		Intrusive contact
	Lac Rémigny Complex	Lamprophyre (19) Pegmatite, granite and aplite dykes (18) Porphyritic biotite granodiorite (17) Pegmatite, granite and aplite dykes Biotite granodiorite (16) Porphyritic granodiorite (15) Porphyritic quartz mon- zodiorite (14) Quartz monzodiorite (13) Hornblende monzonite (12) Monzodiorite (11) Biotite pyroxenite (10)
Archean		???
	Lac Fréchette Complex	Quartz monzonite (9) Coarse grained monzonite (8) Porphyritic monzonite (7) Leuco-quartz diorite (6) Lusitanite (5) Hornblendite, hornblende pyroxenite (4)
		Intrusive contact
	Pontiac Group	Biotite quartzo-feldspa- thic gneiss and biotite schists (3) Amphibolites (2) Ultramafic flows (1)

found in contact with and within the Pontiac metasediments by Winter (1972), Imreh (1976), Rive (1975) and Van de Walle (1978) but have not previously been described in the map-area.

Well-preserved flows are represented in only one outcrop on Lac Barrière. There are eight flows in all. The flows are overturned and two thicker flows (2 m) to the north are below a succession of at least six flows with an average thickness of one meter each. A typical flow has from the bottom upward a cumulate zone (10 cm), a massive zone (50 cm), and a spinifex zone (about 40 cm). The spinifex decrease in size toward the top and the central part of the spinifex zone is weathered out. The bottom of the flow is lighter in colour than the top and the contact between flows is sinuous presenting no evidence of interflow material. Elsewhere the ultramafic lavas are closely associated with peridotitic intrusions and it is probable that the intrusions represent the parental magma of these bodies. In the Lac Barrière area, rare dark grey serpentinites veined with fibrous minerals are present in the vicinity of the ultramafic flows. They seem to cut the metasediments and may well represent intrusive material.

The cumulate zone is made up of a granular peridotite consisting of serpentine pseudomorphs after olivine, with a few grains of chlorite, in a matrix of actinolite and chlorite. The spinifex zone is easily distinguished in the field

by a "bird track" structure in which black lamellae intersect each other in a typical way as described by Dirmoth et al., (1974) in the Rouyn-Noranda area. The contact between the massive zone and the spinifex zone is irregular and may possibly be explained by the downward growth of the olivine blades against the underlying subunit (Pyke et al., 1973). In thin-sections the spinifex texture is visible as elongated aggregates of serpentine crystals fringed by magnetite. The matrix is composed of actinolite, Mg-rich chlorite, talc, opaques and possibly epidote and carbonates.

Chlorite-talc schists with large idiomorphic pyrite are probably related to tectonic movements which took place near the contact of the ultramafics and the Pontiac metasediments. The introduction of water, SiO_2 , CO_2 and other dissolved material altered the chemical composition of the rock and resulted in the present mineralogy. Polygonal fractures are locally seen in this rock unit.

Two chemical analyses (Appendix I, Table 1A, 1 and 2) have been obtained for the ultramafic formation from the cumulate zone of a flow and the spinifex zone of the underlying flow respectively. Figure 3-1 is a $\text{MgO-CaO-Al}_2\text{O}_3$ diagram illustrating the major compositions of the Archean ultramafic formations of the world. Analyses from Lac Barrière plot on the magnesian side of the diagram and their composition corresponds to known peridotite classes. The bottom of the flow is slightly richer in MgO than the top and their Al_2O_3 content is similar. They also plot in the elongated field defined by

Figure 3-1 Chemical comparison of Archean mafic and ultramafic flows of the world, modified after Gélinas, Lajoie and Brooks (1977).

Peridotitic Komatiites

- 1 Komati formation
- 2 Sandspruit formation

Basaltic Komatiites

- 3 Geluk type
- 4 Badplass type
- 5 Barberton type

Serpentinities

- 6 Val d'Or area; Imreh 1976
Spinifex Ridge, Lamothe township; Gélinas et al., 1977
(Archean ultramafic volcanoclastics included in that field)
- X Lac Barrière area (this study)

the ultramafic rocks of the Abitibi belt, characterized by a $\text{Al}_2\text{O}_3/\text{CaO}$ ratio greater than 1.

A zone between the Pontiac metagreywacke and the ultramafic flows is occupied by mineralized metasediments of unique composition. They are of variable thickness, generally one meter and are composed mostly of recrystallized quartz, with lesser amount of biotite, chlorite and epidote. They locally display well-developed graded bedding. Mineralization of copper and zinc is most abundant along fractures but is also disseminated. A rock sample of this zone was analysed by Chagnon (1968) and gave the following concentrations: Cu 0.10%, Fe 35.65%, Zn 0.04% and Au 0.004 ons/ton. Northwest of the present study area a similar mineralized zone has also been recognized at the contact of metasediments with ultramafic material by Winter (1972) and Van de Walle (1978). An exhalative character may be assigned to this type of mineralization (Van de Walle, 1978).

Amphibolites (2)

The amphibolites represent a minor portion of the Pontiac Group. They are found as small sills or lenses interlayered with the metasediments and commonly do not underlie a large enough area to be represented on the map. Many rock types composed mostly of hornblende and plagioclase are found within the granitoid rocks and it is not always possible to make a distinction between the Pontiac amphibolites, probably

derived from volcanic material, and the amphibolite-like material associated with the intrusions. Generally the Pontiac amphibolites are medium grained, dark green to black and composed of variable amounts of nematoblastic hornblende and plagioclase. Apatite, sphene and locally sulphides are present in minor quantities and biotite, sericite and epidote are developed as alteration products.

Several large blocks of amphibolite found within the intrusions have undergone metasomatism; large poikiloblastic plagioclase feldspars have developed, enclosing the hornblende. A good example is found 3.5 kilometers northwest of the village of Rémigny ($70^{\circ}14'30''$, $47^{\circ}46'30''$) and it is not rare to find quartz and microcline developed in a similar way.

Recrystallization of medium grained amphibolite to a very coarse, almost pegmatitic material occurred locally at the contact with the intrusions. This coarse grained amphibolite can easily be mistaken for the hornblendite found within the Lac Fréchette Complex and certain igneous diorite of the Lac Rémigny Complex.

Biotite quartzo-feldspathic gneiss,
and biotite schist (3)

The Archean metasediments occur as extensive outcrops and as inclusions ranging in size from mappable units to mesoscopic clots within the batholith. They are composed of alternating beds of greywacke and pelitic material, varying from

20 cm up to several meters in thickness. No stratigraphic subdivision is yet possible on a large scale because of the monotonous character of the metasediments. Holubec (1972) proposed a thickness of 2130 to 2140 m and also noted their homogeneous composition and lack of conspicuous lateral changes. Bedding can be recognized in many places by a slight difference in composition.

Biotite quartzo-feldspathic gneiss and biotite schist are the main facies encountered; meta-arkose layers or granitoid sills are found locally. The metasediments are dark grey on fresh surface and brownish-grey on the weathered surface. The fine to medium grain size is fairly consistent throughout the area adjacent to the intrusions and even at the immediate contact with the plutons.

In thin section, the gneiss is seen to be a generally well foliated rock consisting mainly of quartz, oligoclase and biotite. The quartz crystals are elongated and display an undulatory extinction; they make up 25-35% of the volume (Appendix I, Table 1D, analyses 1 to 3). Oligoclase is anhedral, rarely twinned and slightly altered to sericite; it accounts for 40 to 50%.

The biotite grains (15 to 30%) reveal a preferred orientation; an undulatory extinction is common. At least two, commonly parallel, generations of biotite define a strong schistosity. Poikiloblastic muscovite is found as large porphyroblasts cutting across the main foliation. In places,

their form suggests that muscovite is a pseudomorphic mineral after some alumino-silicates. Hornblende crystallized in some layers; microcline is generally absent except at the southern limit of the area where migmatitic structure indicates that melting took place. The leucosome consists essentially of varying portions of quartz, plagioclase and microcline. The accumulation of biotite along the margins of the leucosome suggests that the migmatites were formed in situ by local segregation. Small patches of fibrous sillimanite are seen in most of the thin sections of metasediments studied except the migmatites. Sillimanite also occurs as inclusions into the quartz grains. Garnet is restricted to some rare beds and no staurolite was observed. Zircon, apatite, opaques and sphene are present as accessory minerals; alteration minerals are sericite, epidote and chlorite.

The Pontiac metasediments exhibit numerous structures complicated by more than one period of deformation. Commonly on a regional scale, they display a complex migmatitic structure composed of various, mostly discordant, interpenetrating dykes. Yet even where dykes account for more than 80% of the rock by volume the fragments always keep their original orientation which can be used to trace the regional structure. Graded bedding structures typical of Pontiac Group elsewhere were not observed and may clearly have been destroyed by recrystallization. A postmetamorphic period of silicification along fracture zones locally affected the metasediments and resulted

in differential weathering.

-Lac Fréchette Complex

Introduction

Field data indicate the existence of a discrete quartz-poor petrogenetic unit which can be separated from the far more abundant quartz-bearing rocks that characterize most of the map area. This petrogenetic unit lies mainly north of the map area and has been referred to as the Lac Fréchette Complex (Van de Walle, 1978) in the course of this study. Van de Walle assigned an alkaline character to those rocks. Similar rocks have been described in the eastern part of La Motte township by Brett et al (1976). They concluded them to be an abnormal rock type for the area.

Large variations in composition, texture and grain size are distinctive properties of this granitoid complex, located west of Lac Barrière and surrounding Lac Fréchette. The units are mainly quartz-poor and can be readily indentified by their mineralogy and their textural characteristics. The aeromagnetic map shows a strong anomaly over Lac Fréchette Complex. Magnetite is present in minor amounts in many samples of the stock and suggests that substantial amounts of this mineral may be fairly widespread in the area of the major positive anomaly.

Based on Currie's definition (1976, page 1): "An alkaline

rock is one that contains a feldspathoidal mineral either in the rock itself or in the chemical analysis recalculated into the CIPW norm".

The different units can be classified as alkaline, having nepheline in the norm (Appendix I, Table 13, analyses no. 3, 4, 5, 8, 10). No modal feldspathoidal mineral has been observed in thin section.

The more mafic rocks are commonly found in the southern part of the complex whereas the felsic units, intruded in order of increasing silica content, have no simple distribution pattern. The earlier units are in sharp contact with the later ones and are locally contained as angular inclusions. The majority of these rocks have been considerably amphibolized and saussuritized and the earlier leuco-quartz diorite in contact with the porphyritic monzonite has been affected by potassic metasomatism. The blocky plagioclases which composed mineralogically the large part of the leuco-quartz diorite have been gradually replaced by potassic feldspar over a wide zone. Near the contact with the porphyritic monzonite, the replacement is important, resulting in the formation of a monzonite-like rock.

No pegmatitic material that can possibly be related to the intrusion was found. This absence indicates a relatively dry magma and also suggests emplacement at high crustal levels. Nevertheless rare dykes of aplitic monzonite have been found cutting through the country rocks in the vicinity of the intrusions.

Hornblendite, hornblende pyroxenite (4)

The hornblendite and hornblende pyroxenite form an elongated body north-east of Rollet ($75^{\circ}10'$ - $47^{\circ}57'$) and represent the earliest unit of the Lac Fréchette Complex. An approximate outline has been drawn for the unit and no direct contact has been observed between the two rock types. The hornblende pyroxenite crops out to the southeast of the body and is believed to grade into the hornblendite which is the dominating facies.

These dark to brownish green rocks consist essentially of hornblende, some of which is biotitized and chloritized. Rare feldspar, pyroxene, apatite and sphene are also recognized. The outstanding feature is the roughness of the fresh and weathered surfaces of the outcrop due to the large size of the hornblende crystals. In hand specimen the size is fairly constant but over large areas the hornblende may vary from 1 to 15 mm in length. The feldspar is interstitial and varies in abundance even on the same outcrop.

Thin sections reveal the amphibole crystals to be prismatic, up to 1 cm across, rarely elongated and to constitute in most specimens more than 80% of the rock. They are characterized by a strong pleochroism from bluish green (X), to dark olive green (Y) to almost black (Z). Commonly the larger grains have irregular and ragged outlines. Of special interest is the fact that they alter to brown biotite and that any one crystal is composed of two distinct parts: a core of altered and

bleached hornblende set in a rim entirely free of alteration products (see plate IA); the central part is dusty as a result of the presence of fine grains of iron oxide. The secondary brown biotite is further altered to chlorite with the development of sphene. Pyroxene (augite) forms small grains scattered around the large grains of hornblende and mixed with the smaller grains of hornblende into a matrix. It is fresh, has a light green colour, and commonly accounts for less than 15% of the rock. There is no pyroxene present as inclusions in the hornblende thus indicating an early crystallization of the amphibole. The plagioclase is calcic oligoclase and is generally interstitial to the hornblende. Polysynthetic twinning is rare and the plagioclase usually shows an alteration to sericite. Apatite is locally abundant with a well defined outline suggesting a magmatic origin.

The hornblende pyroxenite is composed largely of fresh anhedral pyroxenes (augite) and hornblende having the same characteristics as those found in the hornblendite. The amphiboles appear as large anhedral crystals surrounded by the grains of clinopyroxene. Both are surrounded by magnetite which gives the impression of cumulus pyroxene and hornblende in a matrix of magnetite. Magnetite is also localized in veins. Feldspars are absent and apatite is the only colourless mineral of the rock.

Chagnon (1968) presented an analysis of the amphibole from

the hornblendite and the chemical composition is that of hastingsite, a sodi-calcic hornblende commonly found in alkali rocks. Two whole rocks chemical analyses have been obtained for the hornblendite (Appendix I, Table 1A, analyses 3 and 4) and the norm has been calculated (Appendix I, Table 1B).

The calculated norm indicates that the facies is undersaturated, containing leucite and up to 10.8% of nepheline. The low Ni and Cr content and the high Ba, V and TiO_2 content differentiate this facies from the Pontiac amphibolites analyzed by Van de Walle (1978, samples 74-4 and 74-31). From the petrographic study, it seems that the hornblendite and the hornblende pyroxenite represent a mafic cumulate resulting from an early precipitation of hornblende and clinopyroxene from the magma. Nevertheless the composite aspect of the hornblende and the freshness of the pyroxenes suggest that the hornblende crystals may be xenocrysts carried out in suspension before settling with the pyroxenes. The clear inclusion-free rim would represent adcumulus material.

Some hornblendites have also been described in the region as basic differentiates from a hornblende monzonite. Tremblay (1950), mapping the Lacorne intrusion, recognized their plutonic origin and Brett (1960), in the same area concluded that the hornblende-rich facies is the result of crystal settling in the magmatic material.

Lusitanite (5)

Rocks described under this name are not abundant. They are found mostly to the northeast of the village of Rollet where they cut through the hornblendite and contain it as inclusions. The rock is poor enough in silica and sufficiently rich in mafic minerals to be included in the alkali gabbro class. In hand specimen it is coarse grained (average 6 mm) dark grey to black, and possesses an heterogeneous mineralogical composition. Locally the feldspar (36% of the volume of the rock) is composed almost exclusively of phenocrysts of potassic feldspar ranging in size from 1-5 cm in a matrix of hornblendes and clinopyroxenes (augite). Some phenocrysts exhibit a glomeroporphyritic texture but generally their parallel alignment defines a strong lineation. This facies grades into one of monzonite composition in which plagioclase may account for as much as 50% of the total feldspars. The colour index is more than 60 and the low percentage of silica (Appendix I, Table 1A, analysis 5) distinguishes this facies from normal monzonite.

Study of thin sections reveals that the phenocrysts of potassic feldspar are microperthitic. Potassic feldspar in the matrix is replacing plagioclase and is accompanied by fresh anhedral albite. Epidote is abundant and may also result from the replacement of plagioclase by potassic feldspar, the calcium being redistributed into epidote. The remaining plagioclase is subhedral with the composition of oligoclase

(An 22). Augite with a strongly coloured rim of aegerine is the most abundant of the mafic minerals. Of less importance is an amphibole showing the same characteristics as that in the hornblendite. Actinolite is locally developed at the expense of the hornblende and is associated with spene. Spene, allanite and apatite are accessory minerals.

Leuco-quartz diorite (6)

The leuco-quartz diorite crops out over a small area immediately to the west of the hornblendite. The facies is in sharp contact with Pontiac metasediments which are also cut by dykes of the quartz diorite. Rare angular blocks of ultramafic rocks, composed mostly of actinolite appear as xenoliths in addition to small inclusions of metasediments.

Dykes of pegmatite, granite and mafic composition cut the facies. In hand specimen the rock is greyish white on fresh surfaces and brownish grey on the weathered surface. Blocky feldspars generally 1cm long, sometimes as long as 2 cm, constitute 60 to 80%, the rest being made up by interstitial quartz and mafics.

Thin sections show a great deal of deformation: the subhedral to anhedral plagioclase exhibits undulatory extinction and albite twins are locally bent. The composition varies from calcic oligoclase to sodic andesine. Augite is interstitial to the plagioclase and displays a yellow to pale green

pleochroism. Hornblende, pleochroic from light yellow to green, partly replaces the clinopyroxene and contains inclusions of apatite, zircon and opaque. Quartz is found associated with the mafics and can constitute up to 7%. The accessory minerals are opaques, sphene, apatite and zircon. A gradual replacement of the plagioclase feldspars by potassic feldspars occurred throughout the facies. To the southwest of the rock body very little replacement took place. In a northeasterly direction towards the porphyritic monzonite, the replacement is more advanced and even developed megacrysts of potassic feldspar, thus transforming locally the leuco-quartz diorite into a monzonite. The relationship between the leuco-quartz diorite and the hornblendite is not known but it seems possible that the leuco-quartz diorite represents an accumulation of plagioclase which is contemporaneous with the mafic differentiate. A chemical analysis is given in Appendix I, Table 1A, no. 6.

Porphyritic monzonite (7)

The porphyritic monzonite (porphyritic hornblende-pyroxene-syenite of Chagnon) underlies two small areas: one west of Lac Barrière, the other west of Lac Fréchette. It is a medium to coarse grained (2-6 mm) pink rock which weathers to a pinkish grey. The facies is porphyritic with megacrysts of potassic feldspar up to 2.5 cm long. They are locally oriented parallel to the contact and define a

flow orientation. In hand specimen they appear to be fractured and rounded. Within a single megacryst, there may be variation in colour from pink at the center to grey at the margins which probably reflects a change in composition. Fine grained mafic inclusions and xenoliths composed of recrystallized amphiboles are elongated parallel to the megacrysts.

Plagioclase, perthite, augite and biotite are the major constituents seen in thin section; amphibole, biotite, epidote and chlorite are mostly of secondary origin. The accessory minerals are zircon, sphene, apatite and magnetite. The anhedral plagioclase is a slightly altered oligoclase. The potassic feldspar is relatively fresh, xenomorphic and makes up the majority of the megacrysts. Perthite is abundant and in many cases there are numerous zones of perthite, without any optic continuity, in the same megacryst of microcline. The oval shape of the feldspars and the local mortar texture around megacrysts suggest a late- or post-crystallization deformation. The pyroxenes are subhedral to anhedral, twinned, slightly altered and exhibit the optic properties of augite. Typically they alter to a bluish-green hornblende and biotite. Magnetite is closely associated with the pyroxenes. Biotite is also present as individual crystals and quartz in trace amount.

The contacts between the porphyritic monzonite and the country rock are rarely preserved, having been invaded by younger facies. A few inclusions of metasediments are present

within the monzonite which in turn is cut by foliated mafic dykes intersecting the primary flow orientation. One chemical analysis (Appendix I, Table 1A, no. 7) has been obtained for the porphyritic monzonite.

Coarse-grained monzonite (8)

The coarse monzonite (pyroxene-hornblende-syenite) covers a small area west and north of Lac Barrière but it is thought to be more extensive to the north, outside the study area. The facies is homogeneous, coarse grained (average 7 mm), white to pink, and weathers grey. Throughout the unit hornblende and laths of plagioclase define a good lineation; inclusions of Pontiac metasediments are rare and commonly weathered out; elongated xenoliths of mafic material are common at the margin and are useful in the determination of flow structure. Locally the volume of ferromagnesian minerals increases considerably, indicating the probable assimilation of mafic material such as amphibolite, and the composition changes to diorite.

As revealed in thin section, quartz is generally absent; feldspars are present along with mafic minerals: pyroxene, hornblende and biotite. Calcic oligoclase is anhedral and displays undulatory extinction; bent albite twins are occasionally seen. Microcline, in the form of interstitial grains, is equally abundant and shows evidence of growth at the expense of plagioclase. Light green augite forms the cores of hornblende crystals, pleochroic from yellow green to blue green.

Magnetite is found mostly within the pyroxene. The amount of biotite varies from 5-12%. Replacement is common among various minerals: augite is replaced by hornblende, hornblende is altered to biotite and biotite to chlorite and sphene. Apatite, epidote, sphene, opaques and allanite are present as accessories. In one thin section, calcite is associated with the alteration of hornblende.

The relationship between the coarse-grained monzonite and the porphyritic monzonite is not clear, in one place, it seems that inclusions of porphyritic monzonite are contained in the coarse monzonite. The latter is cut by the quartz monzonite and rare dykes of pegmatite. Locally a secondary schistosity is developed. The chemical composition of the coarse grained monzonite is given in Appendix I, Table 1A, analysis 8.

Quartz monzonite (9)

Because of their similarities and their limited distribution over small areas around Lac Fréchette and Lac Barrière, slightly different rock types which in places cut one another have been grouped under this heading. They are pink with pinkish grey weathering. Quartz is locally present; the grain size is fine to medium (0.8-5 mm). The quartz monzonite is subporphyritic in places as a result of the development of minor euhedral pink potassic feldspar megacrysts; it cuts the earlier facies of the Lac Fréchette Complex. The megacrysts are sometimes difficult to observe and are visible only by the

reflection of the light at certain angles. The leucocratic character, (less than 15% ferromagnesian), the relatively fine grain size, the presence of small mafic inclusions and the relation to other facies are good criteria for the recognition of the quartz monzonite. Inclusions of Pontiac metasediments and mafic material are in places partly or completely digested, leaving small clots rich in mafic minerals. A secondary schistosity can be observed locally.

Thin sections show that plagioclase is anhedral, altered at the center, deformed and slightly coarser than the other constituents. The potassic feldspar is fresh, anhedral and interstitial. Microperthite is common and forms megacrysts which in some facies have irregular margins resulting from the partial replacement of the matrix. Quartz is present mostly in porphyritic rocks, as anhedral grains accounting for up to 20%. The type of mafic mineral encountered is related to the amount of quartz included in the rock. Light green clinopyroxenes are found in quartz poor facies containing hornblende but only in rare cases is pyroxene found associated with green hornblende where quartz is abundant. Biotite is altered to chlorite and sphene and small holes may indicate the former occurrence of carbonates. Apatite, sphene, opaques, zircon, allanite and epidote constitute the accessory minerals. The mafic minerals are clustered

and locally a mortar texture may be developed where plagioclase and mafics are surrounded by small grains of potassic feldspar, plagioclase and hornblende.

The quartz monzonite is in sharp contact with the leuco-quartz diorite, the porphyritic monzonite and the coarse monzonite; it cuts these rocks and is cut only by pegmatitic, granitic and mafic dykes.

Chemical analyses are given in Appendix 1, Table 1A, 9 and 10.

The Lac Fréchette Complex is typically hypidiomorphic-granular and exhibits an homogeneous igneous fabric in most thin sections. Variations include mosaic textures formed where local comminution and recrystallization have taken place. Other altered fabrics are those suggestive of fracturing or rupturing.

-Lac Rémigny Complex

Introduction

The Lac Rémigny Complex occupies most of the map area. The different facies of the pluton are elongated roughly parallel to the regional structural trend. The relative ages of the rocks were determined in the field on the basis of cross-cutting relationships and presence of included fragments. The complex is constituted of quartz bearing rocks ranging mainly in composition from monzodiorite to granodiorite. Dioritic members are relatively rare. Most of the

true granites occur as dykes and stockworks which cut the earlier intrusions. Porphyritic facies are dominant and contain large blocks of non porphyritic rocks.

Biotite pyroxenite (10)

The rock is dark green on fresh surfaces and weathers to a brownish grey; it is commonly medium to coarse grained (3-6 mm) and becomes pegmatitic in certain veins and pockets. It contains ultramafic inclusions of green actinolite and carbonates are present yielding numerous pits seen on a weathered surface. Differential weathering occurs along silica-rich fractures; locally, small fractures are also enriched in potassic feldspar. The unit is generally massive and the different mineral constituents are present in variable amount.

In thin section pyroxene is the dominant mafic mineral (50%); it is subhedral to anhedral, twinned in part and displays variable extinction which reflects a concentric variation in composition. The characteristics are those of diopside augite. A slight alteration to hornblende and biotite along cleavages is visible.

Biotite is second in volume (up to 40%). It is subhedral to anhedral and grains are interstitial and locally deformed; pleochroism varies from brownish yellow to green olive. Poikilitic hornblende, about 5%, fills the interstices. Altered plagioclase in places replaced the other constituents;

the accessories are quartz, apatite and iron oxides. Sphene, epidote, chlorite and white micas represent the secondary minerals.

The biotite pyroxenite is present in contact with a facies having the same composition, but in which nodular structures have been developed. The size of the nodules is about 2.5 cm, decreasing to 6 mm at the contact. The structure is well defined on weathered surfaces where patches apparently richer in felsic material are isolated in a mafic matrix. The nodules are elongated, of ovoid cylindrical shape, and define a strong linear orientation. They are distinct from ultramafic inclusions also contained in the rock.

The structure is difficult to recognize in thin section because of its large scale and similar mineralogy to that of the matrix. Larger grain size and higher percentage of feldspars are distinctive of the nodules. The matrix is composed of pyroxene, biotite, hornblende and plagioclase. Pyroxene is subhedral to anhedral, rarely zoned and slightly altered. The characteristics are those of augite and it is closely associated with biotite. The biotite is subhedral to anhedral, pleochroic from yellow brown to green and appears to be primary. It forms small clusters in places but is generally interstitial. Locally it shows signs of deformation: undulatory extinction and bending. The accessory minerals are light green hornblende, either mantling some pyroxene or as

independent grains. Small anhedral grains of oligoclase, rarely twinned, bent in places, are slightly altered at their center. They replace biotite and show zoned and complex extinction. Poikilitic oligoclase is also present; it is localized in thin section and defines the nodular texture observed in the pyroxenite. Sphene is present along fractures in biotite grains; zircon and apatite are also represented.

The precise time of emplacement of the biotite pyroxenite is uncertain because of contradictory observations but it appears to be the earliest intrusion of the Lac Rémigny Complex. A dyke with a composition similar to that of the biotite pyroxenite was observed to cut the quartz monzonite, south of the village of Cloutier thus indicating a younger age than the Lac Fréchette Complex. The chemical composition of the biotite pyroxenite appears in Appendix I, Table 1A, analyses 11 and 12. (12 is a nodular biotite pyroxenite).

Monzodiorite (11)

This map unit comprises several rock types, which are not easily distinguished as separate entities in the field, and units of mixed character. Generally, the different facies form small masses randomly distributed inside the porphyritic intrusions and locally cut the Pontiac metasediments as dykes. They are distinctly different in texture and composition and more than one period of intrusions is represented. Locally, they grade into another over short distances. Nevertheless

the principal characteristics of each facies will be described individually in the text.

-monzodiorite

It commonly occurs in the vicinity of the country rock and has also sent dykes into the contact zone between the Lac Fréchette Complex and the country rock, north of Lac Barrière. Rare dykes are also found cutting the Pontiac metasediments. The monzodiorite is grey, medium grained (2-3 mm) and contains numerous small mafic inclusions. Anhedra clinopyroxene is the dominant mafic mineral. The plagioclase, oligoclase with complex extinction patterns, is subhedral to anhedral, highly altered and contains inclusions of hornblende, biotite and apatite. The potassic feldspar is interstitial, anhedral microcline, commonly fresh with poikilitic inclusions of hornblende, apatite and sphene. Quartz is present in trace amount and biotite is largely altered to chlorite. Apatite, sphene and opaques are the accessory minerals. The replacement of plagioclase by microcline is not uniform; the potassic feldspar typically surrounds the inclusions present in the plagioclase and, locally, quartz haloes develop in the plagioclase at the contact with microcline. Chemical analyses are given in Appendix I, Table 1A, no 13, 14, 19 and 20.

-nodular monzonite

Small bodies and dykes varying in composition from diorite through monzodiorite, to monzonite (nodular syenite) are dispersed throughout the area. The percentage of the

different constituents and the structure are highly variable, even on the same outcrop, and differentiate this unit from the monzodiorite described above. Exposures situated four (4) kilometers south of the Rivière Solitaire ($79^{\circ}11'30''$ and $47^{\circ}53'30''$) on the western shoreline of Lac Rémigny, show a good example of these variations: a fine nodular monzonite is intruded between a diorite and a coarse nodular monzonite. The diorite is characterized by variation in grain size from fine to medium (0.6-4 mm) and by the tendency for feldspar to form clots. The nodular texture of the monzonite (plate IB) consists of felsic patches surrounded by mafic material. Locally fine nodules are present in the contact zone and increase in size away from it (plate IC). In other cases, nodule size is constant but their distribution is always homogeneous. A massive grey hornblende monzonite generally crops out close to the diorite and occasionally a chilled margin is present in the diorite in contact with the monzonite. Pegmatitic phases of monzonitic composition and lenses of hornblendite are also present in contact with or within the nodular monzonite. The different facies described as nodular monzonite often alternate in a few zones and define an irregular layering.

In thin section, plagioclase, pyroxene, hornblende and potassic feldspar are the major minerals observed. Oligoclase is slightly coarser than the other constituents and contains inclusions of amphibole and pyroxene. Subhedral to anhedral augite, partly altered to hornblende is

the dominant mafic mineral. Megacrysts of primary hornblende are present in a few units; they are altered to chlorite and account for a minor portion of the total mafic minerals. Interstitial grains of potassic feldspar (microcline) replace the plagioclase. Apatite, sphene and magnetite are accessory minerals. Chemical analysis is given in Appendix I, Table 1A, no. 15. The nodular texture is similar to that observed in the biotite pyroxenite. Patches apparently richer in felsic material are difficult to observe under the microscope and do not differ much from the mafic matrix. Locally, it may be a result of incomplete digestion of mafic material, but the homogeneous size and distribution of the nodules over small area suggests a magmatic segregation of the felsic minerals. Metasomatism would not explain the decreasing size of the nodules toward the contact.

The relationships of the various facies included in the monzodiorite unit is not well defined. The monzodiorite cuts the quartz monzonite of the Lac Fréchette Complex, contains inclusions of biotite pyroxenite and is cut by porphyritic quartz monzodiorite and granodiorite.

Rare dykes cutting the porphyritic quartz monzodiorite and granodiorite present a gradual textural and compositional change from the margin inward. Diorite constitutes the marginal facies and the potassic feldspar content increases rapidly inward to characterize a monzonite. A nodular texture similar

to the one described before appears locally. The main difference between this dyke material and the nodular monzonite is the nature of the mafic mineral, pyroxene being absent in the former. Chemical analyses of these dykes are given in Appendix I, Table 1A, no. 35-36-37.

Hornblende monzonite (12)

Two distinct bodies of hornblende monzonite (hornblende syenite) have been distinguished from the monzodiorite. One body lies just south of Lac Chabot, central part of the map area, and the other one occupies the southeastern limit of the region studied. They form homogeneous units of medium to coarse grained (average 5 mm) pink material, weathering to a rusty brown and displaying a well developed lineation. Rare xenoliths of metasediments are present. It is not known if the hornblende monzonite can be correlated with the coarse monzonite of the Lac Fréchette Complex or if it simply represents a facies of the Lac Rémigny Complex. The latter hypothesis is favoured because of the location of the hornblende monzonite, far from the Lac Fréchette area, and the fact that some facies of the Lac Rémigny Complex seem to grade into a facies similar in composition to that of the hornblende monzonite: for example, the grey hornblende monzonite associated with the nodular monzonite.

Thin sections show clusters of prismatic hornblende to be the dominant mafic mineral, slightly altered to biotite

and chlorite. Inclusions of quartz and opaques in some of the amphiboles may indicate a secondary origin. In places, cores of clinopyroxene can be seen in the hornblende. Biotite is subordinate to hornblende and is highly altered to chlorite and sphene. Xenomorphic grains of oligoclase are slightly coarser than the hornblende. It is commonly sericitized at the center indicating a relict zoning. Fresh potassic feldspar grains are mostly interstitial and partly replace the plagioclase. They contain inclusions of hornblende, chlorite, plagioclase, and apatite. A sodic rim commonly surrounds the plagioclases in contact with potassic feldspar and locally myrmekite penetrates these plagioclases. Primary quartz is rare. The accessory minerals are apatite, iron ore, sphene and allanite. The lineation is the result of the parallel orientation of the hornblende.

Chemical analyses are given in Appendix I, Table 1A, no. 16 and 17. The hornblende monzonite does not carry nepheline in the norm, as does the coarse grained monzonite, which may be another indication of their different origin.

Quartz monzodiorite (13)

Rocks of quartz monzodiorite composition (hornblende granite) are commonly located at the margin of the Lac Rémigny Complex; they also form large blocks within the younger porphyritic units. The facies is mainly pink to grey and weathers grey; it is medium to coarse grained (4-8 mm) and slightly

porphyritic. It contains rare Pontiac metasediment blocks, numerous small mafic inclusions and fragments of material composed of coarse grained hornblende and plagioclase. Small mafic inclusions are locally folded near the margin of the quartz monzodiorite and a weak foliation can be measured locally. Abundant pegmatites and granites cut this facies.

In thin section hornblende and plagioclase are abundant, followed by lesser amounts of quartz and microcline. Accessory minerals are represented by sphene, zircon, apatite and opaque. Chlorite, epidote and biotite constitute the secondary minerals. Hornblende is present in every thin section and locally contains poikilitic inclusions of biotite, sphene and apatite. Its pleochroism varies from light green (X) to yellowish green (Y) to deep green (Z). Plagioclase is the dominating mineral. It is slightly altered and the composition is that of oligoclase. Quartz and microcline are interstitial. Chemical analyses are given in Appendix I, Table 1A, no. 21 and 22.

Small areas of pronounced layering occur within the border zone of the monzodiorite in which the composition changes to that of highly foliated diorite (plagioclase-hornblende gneiss). The dioritic facies crops out mainly north of Lac Pian and at the southwestern limit of the map area. These two areas are believed to represent the northeastern and southwestern borders of the main intrusion of the lac Rémigny Complex. The rock is composed exclusively of medium to coarse (3-10 mm) hornblende and plagioclase. Large sheets of metasediments are isolated within the diorite and small ultramafic inclusions are abundant.

The foliation is defined by a strong orientation of the elongated ~~minerals~~ and a segregation of minerals in alternating layers of feldspar and hornblende.

Examination ~~in thin~~ section reveals a yellow green to dark green pleochroic hornblende slightly altered to biotite which occurs with a xenomorphic oligoclase. The plagioclase is highly altered. Minor quantities of potassic feldspar, quartz, chlorite, epidote, biotite, apatite, zircon and sphene are present. The chemical composition of the diorite is given in Appendix I, Table 1A, no. 18.

Porphyritic quartz monzodiorite (14)

and porphyritic granodiorite (15)

In the field, the porphyritic quartz monzodiorite and the porphyritic granodiorite (porphyritic hornblende granite) differ only in the amount of quartz they contain, therefore they will be described together. On the map, the contact separating the two units is arbitrarily drawn on the basis of visual estimation of the percentage of quartz present into the rock. They represent the largest part of the Lac Rémigny Complex.

The hand specimen is a white to pinkish grey, medium to coarse grained rock (5-10 mm) which weathers grey. Megacrysts of potassic feldspar are well developed and range in size from 5 mm to 2 cm. These are zoned as a result of the concentric arrangement of mafic minerals. They also exhibit a variable composition, indicated by a pink core surrounded by a pale grey rim. The distribution of the megacrysts is not

homogeneous and the composition of the matrix varies from a diorite to a tonalite. Small elongated mafic inclusions are locally partly digested, but generally they define a marked foliation. The weak parallelism of plagioclase and mafic minerals can also be measured as a lineation.

In thin section anhedral quartz is present as interstitial grains or as small clots in the plagioclase. Elongated and prismatic crystals of hornblende are slightly altered and contain poikilitic inclusions of biotite, epidote, sphene and apatite. They are twinned and have a tendency to form clusters. Plagioclase is abundant; the composition varies from sodic to calcic oligoclase with complex extinction patterns, and albite twins are locally bent. The plagioclase feldspars are usually larger than the other constituents and alteration is developed at the center and at the margins of the crystals indicating compositional variations within the oligoclase. Fresh anhedral plagioclase is also present. Potassic feldspar appears as interstitial crystals and as megacrysts; it is characterized by well developed, sharp multiple twinning. A complete description of the potassic feldspar is given in Chapter 6 along with a discussion on the origin of the megacrysts. Opaques, apatite and sphene are present as accessory minerals. Secondary chlorite, epidote and biotite were also recognized. Chemical analyses are given in Appendix I, Table 1A, no. 23 to 32.

Biotite granodiorite (16)

The biotite granodiorite crops out over small areas just east of the village of Rémigny, west of Baie du Tigre and between Lac Beaumesnil and Lac Lebret. No sharp contact has been observed with the porphyritic granodiorite, but its location in the field may imply a progressive transition between the two units. The relationship is supported by the correlation between the decreasing size of the potassic feldspar, enrichment in biotite at the expense of hornblende and the increasing amount of quartz present when moving from the porphyritic to the non-porphyritic facies.

The rock is pink to white and weathers to a brownish grey. Rare megacrysts of potassic feldspar (microcline) are locally observed and the unit tends to be homogeneous. Small mafic inclusions are present and biotite is the dominant mafic constituent. Chemical analyses are given in Appendix I; Table 1A, No. 38-39.

Porphyritic biotite granodiorite (17)

Toward the end of the plutonic activity the porphyritic granodiorite (oligoclase microcline granite) was intruded. It constitutes one of the most extensive units of the area. It intersects a few generations of pegmatite dykes, but it is also cut by numerous younger generations of pegmatites. The unit can not be referred to as a large dyke because its mechanism of intrusion is different from that of the dykes. The outline is irregular and breccias are developed locally.

Most of the unit is located at the center of the study area; but dykes and bodies, too small to be represented on the map, are intruded into all the earlier facies of the Lac Rémigny Complex. No porphyritic biotite granodiorite has been found cutting the Lac Fréchette Complex, but a few dykes are present in the country rock adjacent to it.

The hand specimen is greyish white and grey on weathered surfaces. It is porphyritic with a medium to coarse (3-6 mm) grained matrix. Examination of the thin sections indicates that biotite and hornblende make up the mafic minerals. The biotite dominates; it is subhedral and contains inclusions of zircon and apatite. Slight alteration of the biotite to chlorite with the development of sphene is noted. Local deformation is present within the biotite. Subhedral hornblende, pleochroic from yellow brown to dark green, contains iron oxide along fracture zones and is slightly altered to biotite. The plagioclase displays a complex extinction pattern and also shows signs of deformation, such as bent and fractured albite twins. Inclusions of biotite and apatite are common. Relict normal zoning is revealed by the concentration of alteration products in the cores of some crystals. Quartz is interstitial and locally contains inclusions of biotite, apatite and hornblende. It replaces the plagioclase and displays undulatory extinction. The potassic feldspar is fresh, anhedral microcline, either interstitial or else occurring as large zoned megacrysts. The megacrysts have diffuse margins replacing the matrix. Myrmekite is found in plagioclase grains associated with the megacrysts.

Epidote is usually present and is probably derived from the replacement of plagioclase by potassic feldspar. Sphene, opaques and chlorite occur in trace quantities.

The porphyritic biotite granodiorite contains numerous inclusions of the earlier intrusions. Small mafic xenoliths are rare, but rounded blocks of the immediate country-rock are locally abundant. Chemical analyses of the porphyritic biotite granodiorite are given in Appendix I, Table 1A, nos. 40 to 42. Analyses nos. 33 and 34 are from monzodiorite inclusions.

Pegmatite, granite and aplite dykes (18)

Injections of pegmatitic, granitic and aplitic material are prevalent in all rock types, but dominant at the northern contact of the batholith with the country-rock where they display very complex patterns. Some pegmatites may be related to the regional migmatization, but most postdate the main magmatic event and represent the late manifestation of the batholithic activity.

Generally this material falls into three (3) categories:

1. medium to coarse grained generally conformable veins and sills restricted to the metasediments. They are rimmed by mafic selvages, folded, cut by pegmatites which are not visibly deformed and generally they weather white.
2. fine to very coarse-grained sills and dykes which cross-cut the porphyritic quartz monzodiorite and porphyritic granodiorite but are intersected by the porphyritic biotite granodiorite. They are commonly zoned and vary in color from white and grey to pink.

3. fine to very coarse grained dykes and sills intersecting the porphyritic biotite granodiorite. Pink pegmatite material exhibiting a complex textural zoning and white muscovite pegmatite are well represented in that class. The distinction between early (type 2) and late (type 3) dykes is based purely on age relations, the earlier set being cut off by the porphyritic biotite granodiorite.

Type 1 (dykes) are derived by anatexis of the Pontiac metasediments and will not be discussed any further in this chapter.

Type 2 (dykes) represent periods of magmatic injection associated with and post-dating the porphyritic quartz monzodiorite and the porphyritic granodiorite, but they are intersected by the porphyritic biotite granodiorite. These pegmatites can be easily recognized where they are cut by the porphyritic biotite granodiorite otherwise the distinction from certain units of type 3 becomes difficult the colour being not characteristic.

Type 3 (dykes) represent a long and complex period of magmatic injection post-dating the porphyritic biotite granodiorite. They are most abundant in the Lac Caron area where they form an important unit invading the contacts between the major intrusions and the Pontiac metasediments.

There are several pieces of evidence confirming the magmatic emplacement of material along fractures for both type 2 and 3: dykes are in sharp contact with the country-rock; many small inclusions are rotated, and are discordant with the main

foliation of the country-rock; layers are offset across the dyke and more recent dykes are seen to slightly displace earlier ones. These late siliceous additions vary in width from a few centimeters to several meters and several stages of pegmatitic activity are recognized. They form large zones in which dykes are the only material present, such as seen at the northern contact of the batholith. The structure of the intruded rock can be described as agmatitic (Mehnert, 1968). The continuous addition of material on a regular scale over a certain period of time was sufficient to produce an heterogeneous, but mappable unit. Bell (1971) referred to a similar unit in the upper Nelson River area (Manitoba and northwestern Ontario) as granitization by displacement. Dimroth (1973) in a detailed study of small areas at Lac Caron and 6.5 km northwest of the village of Rémigny, along the highway, proposed a new class of batholithic emplacement mechanism characterized by the opening and filling of a complex system of fractures.

The many rock types displayed in the dykes are too varied to be treated in detail; the main points common to both types are summarized below:

- complete absence of flow orientation;
- rare angular inclusions of the immediate country-rocks;
- locally a biotite sheet is developed between the metasediments and the pegmatite;
- in places very fine felsic layers branched from a main dyke;
- pegmatites have a massive igneous microfabric;

- graphic intergrowths are particularly common within the pegmatites;
- mineralogical zonation is common in narrow pegmatites; the variation is commonly symmetrical with quartz at the center and feldspars at the margin;
- symmetric and non-symmetric textural zonations in which aplites border pegmatites and pegmatites border aplites are locally abundant;
- dykes cutting the batholith tend to be less heterogeneous than those in the contact zone;
- comb layering is locally well developed. This term was proposed by Moore and Lockwood (1973) to describe layers of oriented minerals perpendicular to the wall. They suggest that the layers have been deposited by large volumes of aqueous fluids that migrated upward along the contact between the magma and the wall rock or along the interface between the magma and the previously solidified melt. The growth direction in comb layers can be determined by the branching and widening of feldspars and quartz and is invariably toward the center of the dyke.
- pegmatitic, granitic and aplitic dykes are composed mainly of quartz (in places ferruginous, in others smoky), albite or oligoclase and microcline. Biotite and/or muscovite are variable in volume when present. Hornblende is rare. Irregular distribution of garnet along elongated zones in pegmatites gives the impression of layering. Magnetite is

locally present;

- in rare places at Lac Caron, boron metasomatism produced tourmaline in the metasediments in contact with some dykes.
- occurrence of quartz veins cutting pegmatitic dykes suggests that some quartz was emplaced during the latest stage of fracture filling in the batholith. Quartz veins are commonly oriented in the same direction as the shear zones.

In a narrow granitic dyke at Lac Caron nodules of sillimanite are present. The main features of the nodular sillimanitic rock are:

- the irregular distribution of the nodules, which form about 20% of the volume of the rock;
- the dimension of nodules; which are usually 1 cm in diameter;
- their composition which consists exclusively of fibrolite rimmed by a narrow zone of quartz;
- quartz, plagioclase, rare garnets and flakes of muscovite compose the matrix;
- no dispersed sillimanite occurs in the matrix and garnets are in places enclosed within the nodules.

Two facies of type 3 (dykes) can be identified from well defined characteristics. Interlayering of pink pegmatitic, granitic and aplitic material within the same fracture represents one facies; the other is a coarse-grained muscovite pegmatite.

The pink layered pegmatite is widespread in the area, but

is most prominent in the northwest corner of the map. Its main characteristic is the complete variations from layers of pegmatite to granite and aplite within the same dyke. The facies is cut by the muscovite pegmatite. Thin section reveals that quartz, oligoclase, orthoclase and microcline are the main constituents. The micas (biotite and/or muscovite) are generally absent.

Muscovite pegmatite forms both large dykes and pockets within the metasediments and the batholithic units. They are fairly homogeneous in composition, white in colour and chilled contacts are common. Deformation is present at the contact of some dykes where the schistosity of the metasediments is bent over a zone of a few centimeters. Muscovite pegmatites are locally folded with the Pontiac metasediments. They are found all through the study area, but are most prominent at Lac Caron, and around Lac Pian where they cut through all the other dyke intrusions. Quartz, albite, muscovite and variable volume of microcline are the major minerals encountered in the rock. Graphic intergrowth of quartz and feldspar is common. Sillimanite has been found associated with the muscovite pegmatite of the Lac Caron area.

Some evidence of mineralization has been observed within the coarse pegmatite mainly of type 3. Most of these occurrences were previously known and have already been investigated. Beryl is associated with quartz in a pegmatite cutting the porphyritic biotite granodiorite between Lac Barrière and Lac Caire. A

mineral of the columbite-tantalite series was also recognized from the same dyke. A few grains of molybdenite were observed locally throughout the area. Economic investigations were conducted in an area north of Lac Chabot and west of Lac Pian in search of radioactive minerals in pegmatites. A few holes were drilled along the road west of Lac Pian. High radioactivity readings were also obtained with a scintillometer on rocks located south-east of Lac Beaumesnil.

Morin (1977) proposed that in some of the granitoid rocks of northwestern Ontario, the aqueous fluids of the late stages of magmatic crystallization scavenged the rare earth elements, uranium and thorium, from the allanite included in these rocks and redeposited them in greater concentration in genetically related pegmatites. This mechanism is believed to have been responsible for the formation of radioactive pegmatites in the study area. The epidote rim commonly surrounding the allanite contained in the granitoid rocks is probably related to the leaching process.

Lamprophyre (19)

The plutonic rocks are cut in many places by dark dykes of various compositions. They were intruded before the final emplacement of the late granitic dykes, but it is not known whether or not they are genetically related to the plutonic rocks they intrude. They are classified as lamprophyres and many of them carry mafic phenocrysts. Feldspar is almost

invariably restricted to the groundmass. Lamprophyres are locally abundant cutting the Lac Fréchette Complex and Van de Walle (1978) described a progressive change from a syenodiorite of the Lac Fréchette Complex to a lamprophyre by the gradual development of blue green amphibole around the pyroxene and the decomposition of perthitic feldspar into microcline and plagioclase.

Pyroxene, hornblende, biotite and plagioclase are the common minerals of the dykes. Quartz and microcline are generally absent. The accessory minerals are apatite, sphene and magnetite. Pyroxene (diopside or augite) or hornblende or biotite are found as phenocrysts within different dykes and also constitute the matrix with interstitial oligoclase altered to sericite. Pyroxene phenocrysts exhibit locally concentric zoning and biotite tends to form elongated clusters. Chemical variations of some mafic dykes are given in Appendix I, Table 1A, no. 43 to 46 and show an alkaline tendency.

-Diabase (20)

Hypabyssal rocks occurring mainly as dykes confirm the widespread stability of the early Aphebian crust. Throughout the Precambrian, they frequently intruded rocks of the Superior Province. They are unmetamorphosed, relatively uniform and have small variations in chemical and mineralogical composition. They are mostly subvertical and generally conform to definite strike directions with the most prominent trend being approximately north-south. A second direction strikes roughly 030° ; these are the Abitibi dykes. A third direction is possibly represented by rare dykes oriented 120° . Lestra (1972) and Winter (1972) northwest of the study area described the displacement of the N-S swarm by the younger 030° set. Huronian conglomerates overlies the N-S dykes (Cooke et al, 1931) demonstrating their early Aphebian age.

North-South diabase dykes

This northerly striking swarm probably corresponds to Matatchewan type dykes of Fahrig et al, (1965) for which the greatest potassium-argon date reported is 2485 m.y. (Fahrig and Wanless, 1964). It is the most important swarm with dykes up to 30 meters wide. They display intermittent breaks, have chilled contacts and commonly exhibit offsets.

The diabase has a medium to fine grained, ophitic to subophitic texture. The composition is gabbroic with large zoned plagioclase feldspar phenocrysts up to 3 cm long. The altered phenocrysts (An 70) are often grouped, resulting in a glomeroporphyritic texture; they lie in a relatively fresh matrix

of euhedral to subhedral plagioclases (An 66) enveloped in pyroxenes. The clinopyroxenes (pigeonite, augite) slightly altered to hornblende, dominate over orthopyroxenes (hypersthene). Biotite is rare but magnetite is widespread as an accessory mineral. A groundmass of micrographic quartz-feldspar intergrowth characterizes this diabase. Chemical analyses no. 48-49 and 50 (Appendix I, Table 1A) are from the diabase dykes with a N-S direction.

030° diabase dykes

This northeasterly trending swarm, referred to as olivine diabase by Wilson (1962) and locally as the "black granite" by Van de Walle (1978) probably corresponds to the Abitibi type dykes of Fahrig et al., (1965). The swarm is estimated to be 1230 m.y. old by potassium-argon dating of biotite by Fahrig and Wanless (1964).

This diabase has a fine to medium grained ophitic to subophitic texture. It is highly altered locally; the clinopyroxenes are purplish (titano-augite) and the plagioclases have the composition of labradorite. Olivine is present as small rounded crystals in the pyroxenes and the plagioclases. Biotite and long crystals of apatite are the accessory minerals. The rock is slightly magnetic and can be distinguished on the aeromagnetic map.

120° diabase dykes

A third swarm of dykes strikes in a west-northwesterly

direction across the study area. They are generally fine grained with phenocrysts of plagioclase feldspar about 1 cm long, and may correspond to Sudbury type dykes of Fahrig et al, (1965). Fahrig and Wanless (1964) suggest a K-Ar age of about 1285 m.y. for that swarm. No cutting relation has been observed between the 030° and the 120° dykes.

Zones of faulting and jointing appear to have been the major influences controlling the occurrence and trend of the dykes. It is interesting to note the parallelism of the dyke swarms and the major linear structures defined by elongated lakes.

-Pleistocene and Recent Deposits (21)

Unconsolidated glacial and post-glacial deposits overlies the Precambrian rocks and cover most of the map area. The local relief is generally low and the main physiographic feature is a rather flat plain interrupted locally by hilly terrains. The rugged pre-Pleistocene terrain was filled by debris during the glacial period. Clays overlies the debris and are part of the clay belt of northwestern Quebec and northeastern Ontario which lies in the basin previously occupied by the glacial Lake Barlow-Ojibway.

Glacial striae and friction cracks indicate that the direction of the Pleistocene ice movement was 200° . An east-west trending ridge covers the central part of the study area. It is approximately 20 meters high and 1 kilometer wide. The width increases considerably west of Lac Rémigny. It is constituted mostly of gravel and blocks up to 0.5 meter in diameter. The ridge is possibly the result of re-working of

the glacial deposits by the Lake Barlow-Ojibway (Chagnon, 1968).

3.3 Metamorphism

The greywackes characteristic of the metasedimentary Belt bear the evidence of a long and complex history of metamorphism and deformation.

North of the map area, zones of chlorite, biotite, staurolite and alumino-silicate based on the first occurrence of the respective minerals have been traced by Van de Walle (1978). Goulet (1978) east of that region, mapped two regional metamorphic isograds on the basis of specific metamorphic reactions: a biotite-epidote isograd and a staurolite-biotite isograd to the south. These isograds can be regarded as the trace of surfaces that bound masses of rocks in which the highest level attained by the prograde metamorphism can be defined in terms of the reactants and products of a specific metamorphic reaction, rather than just the first appearance of an index mineral (Carmichael, 1970). The distribution of the metamorphic zones shows a gradual increase in grade of metamorphism in the direction of the batholith; these are drawn on Figure 1-3.

The grade of metamorphism is rather uniform over the region covered by this study and may be assigned to the sillimanite-muscovite zone of the upper amphibolite facies as discussed by Hyndman (1974). Its presence is established by the following characteristic assemblages contained in the metasedimentary rocks.

Hornblende - plagioclase - quartz - (biotite)

Quartz - plagioclase - biotite - muscovite - sillimanite - (garnet)

The homogeneous bulk composition of the metasediments limits the number of assemblages observed. Two parallel generations of biotite are aligned in an axial plane, schistosity and cut by unoriented muscovite and muscovitized alumino-silicate. One generation is represented by small (0.2 mm) biotite the other consists of large (1 mm) tablets. These observations are similar to the ones made by Dimroth (1974). The sillimanite occurs mostly in small nests of fibrolite and as small needles within the quartz. The composition of the plagioclase is constant over a small area. On a regional scale, a slight tendency for plagioclase to become more calcic toward the south was observed by Chagnon (1968). Nevertheless, the composition is invariably oligoclase and may reflect the low calcium content of the Pontiac metasediments.

Referring to a PH_2O -T diagram for the stability limits of common minerals in quartz-bearing non-calcareous rocks presented by Hyndman (1974, page 313), temperatures of 500° to 700°C . and pressure from 2 to 5 kilobars may be estimated. The mineral assemblages are those of low to medium pressure and are thus typical of a relatively steep geothermal gradient.

Migmatites were developed from metasediments in the southern part of the area. They show an alternation of leucosome (quartz, potassic feldspar, plagioclase) and melanosome (mainly biotite).

This indicates that temperature sufficient to initiate melting was reached. Only certain beds have been affected, suggesting a slight variation in the melting ranges of the different layers. The migmatites may also indicate the participation of a metasedimentary component in the production of intrusive magma. They are believed to be formed before the emplacement of the main granitoid bodies. Subsequently, they were extensively invaded by intrusive pegmatitic veins which led to the development of complex pegmatoid migmatites.

Plutonic rocks are particularly insensitive to thermal metamorphism and the main effects are the destruction of the original igneous texture and the replacement of anhydrous by hydrous silicates (Spry, 1969). Recrystallization is evident in many facies of the batholith and resulted in an apparent reduction of the grain size. The best evidence of metamorphism affecting the intrusions is observed at Lac Caron where pegmatites intruded during the latest part of deformation contain patches of muscovitized sillimanite; another granitoid dyke contains nodules of fibrous sillimanite. It is believed that the growth of the nodules took place in a relatively static environment after the crystallization of the dyke. The breakdown of certain minerals and their replacement by sillimanite are required to account for the formation of the sillimanite aggregates. In the pegmatites, these may originally have formed from muscovite in the pegmatite; but this mineral is not present in the granite. Also the absence of potassic feldspar

in the matrix of the granitoid dyke may be taken as an indication that this feldspar was the most liable to breakdown and that it was therefore the first mineral to be completely decomposed and replaced. The excess of potassium and silica, being highly mobile, was removed.

Different authors offer various explanations to account for the origin of this nodular texture: primary magmatic differentiation and segregation from a magma of special composition (Read, 1973); metamorphic distribution of quartz and sillimanite (Losert and Fisera, 1964); and a dealcalization process (Losert, 1968; Eugster, 1970). In this study, the last hypothesis is favoured.

Textural evidence of post-crystalline deformation and retrograde metamorphism has been observed throughout the area. Kinked biotite crystals and bent plagioclase crystals are common. Sillimanite is encapsulated by biotite which defines the main foliation in the rocks. Partial replacement of biotite by chlorite, plagioclase and aluminosilicates by sericite and muscovite is widespread.

Commonly an amphibolite facies metamorphism is found adjacent to major granitoid batholiths such as the Coast Range batholith (Hutchison, 1970); the Sierra Nevada batholith (Kistler, 1966) and the Idaho batholith (Hietanen, 1969). Generally the batholiths are slightly younger than the regional metamorphism. In the case of the Lac Rémigny area, the felsic

differentiates present as dykes have been affected by metamorphism and the amphibolite facies conditions are a very late tectonic phenomenon. The same conclusions were reached by Dimroth (1973, 1974) who stated that the growth of muscovitized alumino-silicate (kyanite ?) in metasediments of the region probably was correlated with the growth of partly muscovitized sillimanite in the heterogeneous granodiorite which intruded during the latest part of the deformation. Thus, the amphibolite facies metamorphism in the southern part of the Pontiac Group is likely a very late tectonic phenomenon, and probably is related to the intrusion of large granodiorite and trondhjemite-tonalite massifs. The large massifs such as the Lac Réminy Complex supplied the heat, which continued to affect the rocks after they had crystallized.

3.4 Structure

- Folds

Metamorphism in the Pontiac Group occurred in conjunction with complex superposed polyphase folding (Goulet, 1978). In the adjacent region to the north of the present study, Goulet also described two main sets of superposed folds; essentially isoclinal with almost vertical axial planes. The older set, generally north-south striking and upright, was deformed about east-west axial surfaces. In the study area, the solution of the structural geometry is complicated by the lack of significant stratigraphic horizons and possibly by the modification

of the earlier structures by the emplacement of intrusive masses.

The prominent alignment of biotite flakes in a matrix of quartz and feldspar has developed a strong schistosity. In many places, the bedding dips at the same angle as the schistosity, but in other places it dips more steeply and the schistosity crosses the bedding. In the northern part of the map area, dips to the north and to the south, commonly greater than 60° , and the generally northeast-southwest regional structure trend indicate that the rocks have been folded strongly along northeast-southwest axes defining tight to isoclinal folds. Locally some units (ultramafic flows east of Lac Barrière) are slightly overturned. Van de Walle (1978) on the eastern shoreline of Lac Opasatica also described the axial planes of tight folds within metagreywacke and talc schists as being clearly overturned to the south. The northeast-southwest set of folds is responsible for the main structural grain discernible on the map of the area and roughly corresponds to the second generation schistosity (S_2) of Goulet (1978).

Generally, the schistosity tends to conform to the margin of the intrusive masses. In the northern part of the area, the foliation in the metasediments strikes northeast with steep dips varying between the northwest or the southeast (Figure 1-2, map in pocket). Southwest of Lac Fréchette, the schistosity becomes east-west and swings to a northwestern strike west of Lac Fréchette. In the central and southern part of the study area, the strike of the schistosity is southeast.

The most common type of lineation observed in the meta-sediments is defined by the axes of small folds involving the bedding and, locally, small amphibolite layers. Intersection of the bedding with the schistosity has in places been measured. The lineations are variable in orientation and plunge; it is commonly difficult to determine the plunge of the large scale folds.

It is also apparent from the field data that more than one period of deformation is represented, and structural superposition has been observed. Northeast of Rollet ($79^{\circ} 09'$, $47^{\circ} 56'30''$) the main northeastern schistosity is folded around axes oriented toward the southeast. The axial plane of those folds is parallel to a post-intrusive schistosity superimposed on the batholith and will be described in Chapter 4, as secondary foliation. These small folds locally involve intrusive material.

The relation of folding to plutonic emplacement is well demonstrated by the variations in strike of the main schistosity from the northern to the southern part of the study area. The porphyritic biotite granodiorite seems to deflect the metasediments in the southern part of the Lac Barrière area, thus indicating that the major period of folding was completed before the emplacement of the porphyritic biotite granodiorite. The main schistosity within the metasediments is also cut by the dyke intrusions and even the small isolated blocks of Pontiac material maintained an orientation parallel to the

regional structure. The post intrusive penetrative foliation strikes roughly northwest-southeast and no ~~major~~ folds are known to be associated with it.

- Faults

Several faults are inferred to penetrate the batholith, largely on the basis of topographic evidence such as elongated bays, straight shorelines and aligned valleys. Unfortunately, it is difficult to obtain information regarding the movement and other characteristics of these inferred faults.

A major fault oriented north-northeast has been mapped within Lac Barrière, based on the occurrence of a talc-chlorite schist unit. Minor shear zones are numerous within the batholith. They are oriented mostly northeast in the northern part of the study area and in the central and southern part, three orientations predominate; north-south, northwest-southeast and northeast-southwest. Those directions correspond roughly to the elongation of the lakes and the orientation of the bays and even to the three main sets of diabase dykes.

- Joints

Fractures in the granitoid rocks are commonly planar to gently curved, with variable dips. They can be grouped into two sets: an earlier set occupied by dyke material related to the batholith and a later set of barren fractures crossing the boundaries between the different facies of the batholith,

including the dykes. This later set was formed after the consolidation of the batholith, cutting it into blocks and is of regional extent. The joints are a few centimeters to several meters apart and can easily be traced across large outcrop. Mineralization with epidote, biotite, quartz and hematite is locally present along the fractures. They are generally steeply dipping but horizontal fractures are also developed. The joints are related to a regional system of stress and unloading during erosion.

Stereographic plotting of poles of the joints for three parts of the region studied shows the existence of at least four systems throughout the area. In the northern part of the map area, over the Lac Fréchette Complex, joints with an orientation of 350° dominate, followed by secondary sets at 157° , 128° and 285° . In the central part of the map area, the dominating set is 120° followed by secondary sets at 010° , 095° and horizontal. In the southern part of the region, 006° dominates with less important directions being 035° , 050° , 090° and horizontal.

CHAPTER 4

STRUCTURES OF THE INTRUSIONS

4.1 Relations to the wall-rock

The strike of the metasedimentary rocks of the wall-rock generally conforms rather closely with the outline of the pluton on a regional scale, but the contact is characterized by marked variations from outcrop to outcrop. The contacts are commonly sharp, but slight gradation over a zone of 10 cm to a few meters where migmatites are developed is locally encountered. The walls may also be brecciated or completely invaded by a wide zone of dyke material.

Lack of chilling at the contacts between the intrusions and the sedimentary rocks indicates that the latter were heated to the temperature of the intrusive rocks prior to the actual penetration of the gneiss by the intrusive rocks. Contacts are steep and the supracrustal rocks stand almost vertically.

The Lac Fréchette Complex is surrounded by mostly sub-vertical metasediments except to the north, where the meta-greywackes were found to dip gently towards the intrusions. The schistosity of the metasediments is disrupted and large blocks of slightly different orientation are present side by side, no igneous matrix being present. The over all picture is that of a large breccia. Intrusive breccia is also present as small dykes cutting the country rock or within the margin of

the intrusion itself, pointing to the importance of brecciation in the emplacement of this complex.

A unique feature is developed in a dyke of leuco-quartz diorite cutting the metasediments north of the village of Rollet ($79^{\circ} 13'45''$, $47^{\circ} 57'20''$) 100 meters west of the igneous contact. Several circular mafic patterns (Plate ID) are visible in the dyke. The rings are about 2 cm thick and have an average diameter of 45 cm. Some of the rings form complete circles set one within the other and others are truncated. The author believes that they represent layers of mafic material derived from the magma as a result of successive injections therefore defining a feeder tube for the dyke itself or a mass of leuco-quartz diorite now eroded. The plate presents an overall view looking down the axis of the tube which is oriented 145° , plunging 55° . The tube migrated from the southwest towards the north-east with time as shown by older mafic circles cut and destroyed by more recent ones. Plate IIA is a close-up showing details of the mafic layers grading rapidly into felsic material toward the center of the tube. Renewed injection of material resulted in repetition of the mafic layers.

Where the Lac Rémigny Complex is adjacent to the Pontiac metasediments along its southwestern border, a strong foliation is developed in the quartz monzodiorite, but no direct contact has been observed. To the north in the Lac Caron area, dykes

of pegmatitic, granitic and aplitic material occur over a large area and constitute a complex zone several thousand of meters wide which masks the relationships between the major intrusions and the country rock.

Wedging is locally evident where the hornblende monzonite and the porphyritic quartz monzodiorite are interlayered with long strips of metamorphic rocks (metasediments and minor fine grained amphibolites). The schistosity and the layering within the strips are truncated by the injected rocks but they remain sub-parallel to the contact. This arrangement corresponds to the flow phenomenon described by Mehnert (1968, p. 215, Fig. 82) and represents relative movement at the contact of the pluton.

The contact of the porphyritic biotite granodiorite are generally marked by an abrupt change from coarse grained granitoid rocks to medium grained gneissic metasedimentary country rock. Locally, plutonic migmatites are developed over a zone of few meters wide, in which there is no definite distinction between the leucosome and the melanosome. Instead, the rock is characterized by diffuse patches, a few centimeters wide, that differ only slightly in composition and fabric. The texture is xenomorphic-granular and garnet is relatively abundant. Shreds of biotite schist are contained within the rock. Nevertheless the amount of assimilation is insignificant on a regional scale. The contact can also take the form of an igneous breccia cutting the metasediments. An example is seen

on a small island in the southern part of Lac Barrière (79°07', 47°54'). The breccia dyke (Plate IIB) has variable orientation and thickness. The size of the fragments ranges from a few centimeters to a few decimeters. Angular blocks of meta~~volcanics~~, medium grained igneous material composed exclusively of plagioclase and hornblende in variable percentage and metasediments are contained in a matrix of slightly porphyritic biotite granodiorite. The blocks constitute 75 to 90% of the outcrop. It is also obvious that many of these blocks were moved a certain distance by the intruding magma, having no equivalent in the immediate surrounding. Large patches of biotite granodiorite are visible in the breccia and look like rounded fragments but careful observation (Plate IIC) shows that the biotite granodiorite extends around the mafic fragments.

4.2 Internal Organization

- Relations between the different facies of each complex

The different facies of each complex are typically separated by sharp contacts without visible change in grain size or mineralogy as the contact is approached. An exception is the porphyritic quartz monzodiorite and the porphyritic granodiorite, which are distinguished only by the estimated volume of quartz (greater than 20% in the granodiorite). Also the biotite granodiorite is believed to be gradational into the porphyritic granodiorite. The transition from porphyritic to non-porphyritic units is sharp, generally marked by the sudden

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appearance of potassic feldspar megacrysts. Less commonly, a gneissic fabric is present within the non-porphyrific facies over a zone of a few centimeters; a good example of that type of contact is present on small island north of Lac Beaumesnil ($79^{\circ}02'45''$, $47^{\circ}47'30''$).

Locally the contact between the porphyritic biotite granodiorite and the monzodiorite is represented by an agmatitic (breccia) structure (Mehnert, 1968) in which large fragments of monzodiorite are surrounded by relatively narrow veins of porphyritic biotite granodiorite; such is the case south-east of Rollet on the eastern shoreline of Lac Rémigny ($79^{\circ}11'45''$, $47^{\circ}52'$). This veining shows evidence of pronounced mobility of the granodiorite relative to the monzodiorite. The absence of reaction between the granodiorite and the xenoliths of monzodiorite may indicate a high temperature for the monzodiorite during the emplacement of the granodiorite or the unreactive character of the xenoliths.

At one place, a breccia of intrusive origin occurs over a small area in the leuco-quartz diorite north of the village of Rollet ($79^{\circ}13'40''$, $47^{\circ}47'20''$). The sharp edges of the fragments of leuco-quartz diorite roughly match one another and the space in between is filled with biotite lamprophyre (Plate IID).

The various facies demonstrate the composite nature of the batholith. Inclusions of earlier facies in the younger

units are common and laboratory studies show that modal amounts of the felsic materials and rock chemistry change abruptly at the contacts and confirm that the contacts are not a gradational continuity, but of discontinuity. Therefore, if the different facies are related by some kind of differentiation process, their relationships then clearly indicate differentiation outside their present location.

Primary foliation

The most common type of foliation is that produced by the planar parallelism of ragged clusters of mafic minerals. Tabular orientation of feldspar grains and country-rock screens occur on many outcrops and small areas of pronounced banding are locally present within the quartz monzodiorite. The origin of these foliated structures is of great significance regarding the mode of emplacement of the batholith. The marginal zones of the plutons are always foliated approximately parallel to the contacts which show considerable variations in trend across the area. The foliation is thus associated with the emplacement of a magma capable of flow and is primary in origin.

The marginal foliation decreases in intensity inward, along with the content of elongated mafic xenoliths which become the only reliable basis of measurement. The primary foliation is useful in the determination of the shape and attitude of the contacts of the different bodies where three-dimensional exposures are missing. The rocks are strongly

foliated near the southwestern limit of the Lac Rémigny Complex and the steep outward dip indicates that the body probably widens with depth. North of Lac Plan pronounced banding within the quartz monzodiorite dips steeply to the north and may represent the northern limit of an early facies of the Lac Rémigny Complex.

Some variations in the attitude of the foliation in the interior of the batholith suggest that the magma flow was affected by irregularities in the roof or by lateral and/or vertical movement during emplacement. Finally the foliation is truncated at borders of transgressive dykes and veins genetically related to the emplacement of the younger rock units within the batholith.

- Lineation

A marked tendency for plagioclase and elongated minerals such as hornblende to be aligned, with their major axes more or less parallel, is observed within some units of the batholith. They form a distinct lineation. The attitude of the lineation may suggest the direction in which the magma flowed before consolidation of high level plutons, but in deep seated plutons the fabric can be produced by the combined effects of magmatic flow and deformation.

Evidence shows that the lineation is related to deformation also affecting the immediate country-rock and it is not mainly due to magmatic flow. In the hornblende monzonite, the

lineation is concordant with the structure of the adjacent country-rock. There is also a tendency for the axes of small folds from granitic veins into the sediments to be parallel to the hornblende lineation present within the monzodiorite southeast of Rollet ($79^{\circ}11'30''$, $47^{\circ}53'30''$). The potassic feldspar phenocrysts of the lusitanite northeast of Rollet are also elongated parallel to the axes of minor folds affecting the country-rock. Lineations within the coarse monzonite north of the study area plunge westward at a moderate to steep angle and may well represent the direction the magma flowed but generally the lineated fabric in the study area is believed to be due mostly to deformation during or after the emplacement of a specific body.

- Inclusions

A small number of xenoliths and roof pendants of sedimentary rock are present in the Lac Rémigny Complex. These remnants may indicate that the Pontiac sediments once covered most of the map-area.

Mafic inclusions are abundant in hornblende-bearing granitoid rocks, especially near their margins. They are present as isolated rafts ranging in length from a few centimeters to several meters; they are sharply bounded and have the form of discs and filaments. The flattening of the inclusions suggests the shaping of soft inclusions by movement of the magma. They are a source of foliation even where the enclosing rock becomes essentially massive.

The inclusions may represent remnants of premagmatic material that have been recrystallized by the magma (Moore, 1963) and indicate assimilation of the country-rock. Clearly the function of the reaction was not to change the chemical composition of the xenoliths to conform with that of the magma, but to produce solid phases that were stable under the conditions of the magma at the time of incorporation.

Metasedimentary rocks, which are the dominating facies of the country-rock are rarely represented as small xenoliths. If contamination has occurred at the present level of erosion, Pontiac metasediments would be the dominant fragments. It is also possible that greywacke fragments were completely digested by the intrusive material, but the good state of preservation of rare fragments clearly indicates that digestion was not effective on a large scale. Thus the compositions of the mafic to ultramafic inclusions, not matching the immediate country-rock tends to indicate assimilation below the present level of exposure and may even represent relict material from the source region of the magmas.

Another possibility still exists for the origin of those small mafic to ultramafic xenoliths; they may well be autoliths resulting from segregation of early formed minerals. The fact that metasedimentary inclusions are rare even where the Pontiac Group is the dominating country-rock suggests that most xenoliths may have originated as segregations.

Within the batholith where earlier units are present as inclusions into the younger ones, no reaction is evident in the former. Only locally, granitic material appears to have been added to the inclusions, producing secondary quartz and feldspar; this is the case within the monzodiorite present as inclusions in the porphyritic biotite granodiorite.

- Secondary fabric

It is important to establish whether or not the structures of the country-rock are completely terminated at the contacts. Locally in the study area, a fracture cleavage is seen to cut the intrusive contacts and this type of secondary fabric is interpreted as a product of stress which deformed granitoid rocks after their emplacement. The first stages of deformation within the batholith are evident by undulatory extinction in quartz, bending of feldspar twins and granulation. Folding and "boudinage" of dyke material confirm a late deformation.

North of Lac Pian, in the dioritic gneiss, the primary foliation is cut by a dyke of pegmatite which is in turn folded. The axial plane in this case is parallel to the primary foliation. The secondary fabric is also seen within the late mafic dykes present in the northern part of the study area, but it is difficult to follow the cleavage into the main intrusive material. The best evidence of post-crystallization deformation is present in the northwest corner of the study area where dykes of leuco-quartz diorite are folded with the metasediments and an axial plane cleavage is developed.

passing from the metasediments through the dyke material without any disturbance. The cleavage is also well defined in an adjacent pink granite, but is difficult to follow through dykes of pegmatite because of their coarse grain. The secondary fabric affecting the late differentiate dykes proves that the deformation was still acting at the end of the emplacement of the intrusive material.

4.3 Zone of Emplacement

The batholith is intrusive into the metasedimentary unit which is metamorphosed to the amphibolite facies. The absence of variation of the grain size at the contact and the lack of contact metamorphism indicate low thermal gradient between the intrusion and the country-rock. Transgression of primary layering is present, but generally the batholith is concordant and commonly elongated in a direction parallel to the country-rock structure. The batholith on a regional scale occupies an antiformal position.

Pegmatites and aplites are developed on an extensive scale and constitute a major area of migmatite. Zoned megacrysts of potassic feldspar are developed and replacement features are common. The broad structural picture suggests that the rock was undergoing deformation and metamorphism while the granitoids were being emplaced. Batholiths with these characteristics have been classified by Buddington (1959) as belonging to the catazone and have all the characteristics of

synkinematic granites. Their mineralogy also corresponds to the mineralogy of Marmo's (1968) synkinematic granite. The dykes may be emplaced at a late kinematic stage but still bear the evidence of continued deformation and metamorphism.

4.4 Mechanism of Intrusion

For the Lac Fréchette Complex, the structural trends in the country-rocks, mostly parallel to the margins of the intrusions, the absence of large xenoliths of the country-rock, the mortar texture around oval megacrysts, the strong lineation in many facies of the composite complex and the importance of brecciation at the margins are consistent with a forceful emplacement of that complex.

In the case of the Lac Rémigny Complex, a composite nature has been recognized and inclusions of metasedimentary rocks are too scarce to account for the missing country-rock. The numerous small mafic to ultramafic inclusions do not have any equivalent in the immediate country-rock and whatever their origin, they must have been carried up with the magma. The rate of emplacement and the viscosity of the intrusion were probably sufficiently high to prevent these xenoliths from sinking. Structural trends in the country-rock seem to have been dragged into parallellism with the margins of the intrusions and a weak lineation is visible in many facies of the batholith. The intrusion mechanism consistent with these processes is forceful injection as a diapir; the roof of the plutons must have been

displaced upward and removed by erosion. A similar process has been discussed by White, Chappell and Cleary (1974) for some Australian Paleozoic batholiths.

Nevertheless stoping was effective on a local scale in the Lac Barrière area. On a regional scale the porphyritic biotite granodiorite seems to have wedged its way into the metasediments, changing their main orientation from northeast to southeast. Large amounts of xenoliths from the immediate country-rock (including earlier intrusions) near its margins and dykes of granodiorite within the metasediments indicate that the intrusion was also permissive and not the only result of thrusting aside of the wall rocks. As seen in the field the melt was introduced along cracks into the monzodiorite and gradually surrounded pieces of the "roof", which then fell into the melt and either sank or floated; little assimilation took place.

The variability and complexity of the structures seen in the dyke complex can give important clues on the emplacement mechanism of this unit. On every outcrop, many generations of dykes intersect each other and up to seven generations of dykes have been observed in a few square meters by Dimroth (1974). Every generation is the product of repeated opening and filling. Most dykes show one or several types of zonation. Comb layering, screen layering, mineral and grain size zonation and symmetrical, asymmetrical and complex dyke filling have been described by Dimroth. It is clear that the dyke complex was formed as a result of simple "brecciation" by mechanical splitting of the country-rock and simultaneous filling of the fractures by

injection of magma. The volume of the dykes attaining batholith dimension led Dimroth to define a new class of batholithic emplacement mechanism which is assumed to have consisted of the dilation of the walls along fissures and filling to space with injected magma.

If the present width of the dykes is equal to the space created by dilation, it resulted in an increase in volume directly proportional to the volume of dykes and doming must have occurred in the same way as for forceful intrusion.

The orientations of dykes from the contact zone at Lac Caron and within the batholith about 6.5 km north of the village of Rémigny were measured and plotted on a diagram to check the possibility of grouping those dykes into families. The dykes cutting the batholith tend to form a concentric pattern with four (4) major orientations, 005, 045, 105 and 135° (Figure 4-1). The orientation of the dykes in the contact zone at Lac Caron appears to be largely controlled by the structure of the wallrocks; the dykes are mostly oriented within 45° of the strike of the Pontiac metasediments.

Figure 4-1: a) Orientations of dykes cutting the batholith 6.5 km north-west of the village of Rémigny (96 measurements; b) Orientations of dykes from the contact zone at Lac Caron (155 measurements). Dashed line represents the strike of the Pontiac metasediments. N: number of measurements

PLATE I

- A Photomicrograph of an amphibole crystal (hastingsite) from hornblende of the Lac Fréchet Complex. Note the ragged outline and the two distinct parts: a core of altered and bleached hornblende set in a rim entirely free of alteration products. The central part is dusty as a result of the presence of fine grains of iron oxide. Field of view 0.3 mm long.
- B Nodular texture within the monzonite. Leucocratic minerals tend to cluster together and give felsic patches surrounded by more mafic material. The monzonite crops out on a small island in Lac Rémigny, 4.9 km southeast of Rollet. Pick handle is 30 cm long.
- C View looking west, of the contact between the monzodiorite and the nodular monzonite. Contact near the right hand side of the photograph is oriented 080° . The size of the nodules increases southward, away from the contact. Cap of beer (southwest corner of the picture) is 3 cm in diameter.
- D Feeder tube in a leuco-quartz diorite dyke cutting the Pontiac metasediments 4.4 km north-northeast of the village of Rollet ($79^{\circ}13'45''$, $47^{\circ}57'20''$). View looking down the axis of the tube $145^{\circ}/55^{\circ}$. The scale is represented by the lens cap (55 mm).

PLATE II

- A Close-up of the feeder tube showing details of the mafic layers grading rapidly into felsic material toward the center of the tube. (View looking south) The scale is represented by the lens cap (55 mm).
- B Igneous breccia dyke cutting the Pontiac metasediments. Numerous fragments of metavolcanic, intrusive and metasedimentary rocks are cemented by the porphyritic biotite granodiorite which also formed large patches within the dyke. Located on a small island in the southern part of Lac Barrière (79°07', 47°54') View looking southwest. Pick handle 30 cm long.
- C Photograph showing a close-up of the patch of porphyritic biotite granodiorite present in the northeastern quadrant of Plate IIB. The granodiorite can be followed around the various fragments and clearly represents the matrix of the breccia dyke.
- D Intrusive breccia within the leuco-quartz diorite. The sharp edges of the fragments roughly match one another and the space in between is filled with biotite lamprophyre. The field of view is about 1 m wide. Located north of Rollet (79°13'40", 47°57'20").

CHAPTER 5

GEOCHEMISTRY OF THE INTRUSIONS

5.1 Introduction

When studying a closely associated group of igneous rocks it is important to discover whether these rocks were derived from one another, or from a common parent magma, or else completely unrelated. Field observations and petrographic studies are suggestive but the use of chemical data in variation diagrams provides additional evidence in the determination of these relationships. The mineralogical and chemical compositions of the Lac Rémigny area intrusive rocks were investigated by modal and chemical analyses. The results of the analysed rocks form the basis of the diagrams. The location and distribution of the specimens used in this study are given in Figure 5-1 (in pocket).

5.2 Method of Analysis

Over four hundred rock samples were collected during field work of which 150 have been studied in thin section. The hand specimens were collected from the most representative part of each unit distinguished in the pluton.

One hundred and nineteen rock slabs were stained for potassic feldspar using sodium cobaltinitrite. The procedure adopted for modal analysis was to count 400 points, on a 1.2 mm grid, from a stained slab. Modes are presented in Table 1D, Appendix I.

Chemical analyses of fifty selected rocks were performed, some by Dr. G.H. Holland of Durham, England, and others by the laboratory of the Quebec Department of Natural Resources. Large rock samples averaging 1.5 kg were collected and split. A small part of each sample was used to prepare a thin section and a rock slab, the balance was crushed. A representative portion of each crushed sample was sent for chemical analysis. Analytical techniques used by the laboratory of the Quebec Department of Natural Resources included the following methods: Si, Al, Fe, Mg, Ca, Na, K, Ti, Mn, Zn, Ni, Cu, Pb, Co, Cr, V, Cd, Mo, As, Li, Ag and Hg were analysed by atomic absorption; U, Th, Ba and Sr by X-ray fluorescence; Sn by spectrography; F by specific ion electrode; S and C by infra-red; H_2O , H_2O by gravimetry and P by colorimetry. Dr. Holland used X-ray fluorescence; his analyses are volatile-free and re-calculated to 100%. Fe_2O_3 is a calculated value so that $Fe^{III}/Fe^{II} = 0.32$. The results of the chemical analyses for major, minor and trace elements are given in Appendix I, Table 1A and 1C. Normative compositions were calculated from the chemical analyses by the LEMNORM⁽¹⁾ program. The norm of the rocks is given in Appendix I, Table 1B.

In some cases within the porphyritic material, two slabs from the same sample or two slabs from the same outcrop were cut, stained and compared to estimate the error attributed to both the method used for point counting and the coarse grain size of the rocks studied. This method gave modal variations

(1) Computer program available from the department of geology, Carleton University

up to 5.7% for two slabs of the same sample (Appendix I, Table 1D, Analyses #94 and #95) and up to 7.5% for two slabs of different samples from the same outcrop (Appendix I, Table 1D, Analyses #86 and #87). A minor variation in composition may also exist at the scale of the outcrop, nevertheless the estimated modal mineralogy can be used with confidence to determine the existence of a possible compositional trend within the various rock types represented in the Lac Rémigny area.

The homogeneity in chemical composition of the porphyritic quartz monzodiorite has been checked using three megascopically identical samples from the same outcrop where mafic inclusions are rare; felsic dykes, which account for about 25% of the outcrop, were avoided in the samples. The material sampled was believed to be the most homogeneous part of the body. The chemical compositions of the analyses #29, #30 and #31 (Appendix I, Table 1A) show a slight variation in many constituents particularly in K_2O which constitutes 1.40 to 2.57 weight percent. Trace-element values are consistent. The calculated norm from these chemical analyses (Appendix I, Table 1B) is summarized in Table 5-1.

The calculated norm shows a slight variation in quartz, plagioclase and potassic feldspar content between the three samples. These data also indicate that the porphyritic quartz-monzodiorite and the porphyritic granodiorite are intergradational on a local scale.

Normative mineralogy (recalculated to 100%)

Analysis #	29	30	31
Quartz	16.95	12.27	13.54
Plagioclase	72.39	68.00	68.26
K-feldspar	10.66	19.73	18.20

Modal mineralogy (recalculated to 100%)

Analysis #	79	75	78
Quartz	25.00	19.54	19.74
Plagioclase	60.96	54.30	56.25
K-feldspar	14.04	26.16	24.01

Table 5-1:

Variations between the calculated and the modal mineralogy within the porphyritic rocks of the Lac Rémigny Complex. Analyses #79, #75 and #78 correspond respectively to #29, #30 and #31.

Modal analyses on the same rocks (Appendix I, Table 1D, analyses #79, #75 and #78 respectively) are also presented on Table 5-1. The modal compositions display noticeable variations from the normative compositions. The quartz and the potassic feldspar are more abundant in the modal analyses. Nevertheless, the variations in the modal analyses match those encountered in the norm.

5.3 Graphical Treatment of Modal Analysis

The results of modal analyses are presented on the standard quartz-feldspar-mafic minerals and quartz-plagioclase-potassic feldspar diagrams. The intrusions have been divided into two complexes based on field and petrographic evidence. Because of the mineralogical overlap that exists between the two complexes, they were plotted on separate diagrams in order to obtain a clear picture of their evolution.

Figure 5-2: Modal quartz-feldspar-mafic minerals diagram for the Lac Fréchette Complex. (percentage by volume) Δ : hornblendite; $\diamond$: leuco-quartz diorite; $\circ$: porphyritic monzonite; $\square$: lusitanite; $\bullet$: aplittic monzonite; ∇ : coarse monzonite; $\blacktriangle$: quartz monzonite.

Figure 5-3: Modal quartz-feldspar-mafic minerals diagram for the Lac Rémigny Complex. (percentage by volume) Δ : quartz monzodiorite; $\square$: porphyritic quartz monzodiorite, porphyritic granodiorite and biotite granodiorite; $\circ$: porphyritic biotite granodiorite; $\bullet$: dyke material.

The petrographic terminology and rock classification used in this study are those followed by Streckeisen (1973). The different facies within the batholith have been classified on the basis of quartz content and ratio of alkali feldspar to total feldspar. Values for plagioclase include sericite and saussurite, and microcline counts include free microcline and microperthite.

The quartz-feldspar-mafic minerals (Q-F-M) diagram for rocks of the Lac Fréchette Complex (Figure 5-2) reveals two definite populations; the compositional gap between the mafic and the more felsic material is thought to be real and not a function of sampling. The mafic rocks probably represent cumulates from the magma. The felsic units are generally quartz-poor except for the last intrusion which shows a gradual enrichment in quartz parallel to the quartz-feldspar side of the diagram. This situation indicates that the volume of mafic constituent stayed more or less constant during the quartz enrichment which occurred at the expense of feldspar.

The Lac Rémigny Complex shows a gradual shift on the Q-F-M diagram (Figure 5-3). It varies from a mafic-rich, quartz-poor unit to a quartz-rich, mafic-poor unit. The other facies fall somewhere in between those two end members. The trend is more or less parallel to the quartz-mafic side of the diagram and points out to a constant volume of feldspar. The evolution toward a quartz-rich, mafic-poor facies is well represented by pegmatite, granite and aplite dykes in which mafic minerals are in places non-existent.

Figure 5-4: Q-A-P modal mineralogy of rocks of the Lac Fréchette Complex (percentage by volume) with classes after Streckeisen (1973). Felsic minerals: Q: quartz, A: alkali feldspars (potash feldspar+albite), P: plagioclase (An 5-100), F: feldspathoids. Data normalized to (Q or F + A + P) 100. Δ: hornblendite; ◻: lusitanite; ◇: leuco-quartz diorite; ○: porphyritic monzonite; ▽: coarse monzonite; ●: aplitic monzonite; ▲: quartz monzonite; ■: normative equivalents

Figure 5-5: Q-A-P modal mineralogy of rocks of the Lac Rémigny Complex (percentage by volume) with classes after Streckeisen (1973). Q: quartz, A: alkali feldspars (potash feldspar+albite), P: plagioclase (An 5-100). Data normalized to (Q + A + P) 100. Δ: monzodiorite, quartz monzodiorite; ◻: porphyritic quartz monzodiorite, porphyritic granodiorite, biotite granodiorite; ○: porphyritic biotite granodiorite; ●: dyke material.

The quartz-plagioclase-potassic feldspar diagram of the modal analyses for the Lac Fréchette Complex (Figure 5-4) shows a concentration of the compositions in the saturated monzonite field with an enrichment in quartz for the younger unit. This enrichment is parallel to the potassic feldspar-quartz side of the diagram and indicates a decrease in the volume of potassic feldspar at the expense of quartz, the volume of plagioclase remaining constant. A gap occurs between dioritic and monzonitic compositions and some samples of lusitanite plot in the potassium-rich corner of the diagram. Their composition is unique, the mineralogy being composed mainly of pyroxene, hornblende and potassic feldspar.

On the quartz-plagioclase-potassic feldspar diagram (Figure 5-5) a general trend away from the plagioclase corner and toward a more potassium and quartz-rich material is characteristic of the Lac Rémigny Complex. This trend is similar to the one obtained in the Q-F-M diagram. It can be noted that the dyke material varies in composition from tonalite to true granite and that the pegmatites poor in potassic feldspar are in fact rich in muscovite.

5.4 Graphical Treatment of Chemical Data

The chemical analyses carried out in this study and selected chemical analyses for parts of the northern section of the batholith published by Van de Walle (1978) have been used to examine in more detail the chemical evolution of these two closely associated complexes. The presentation of analytical data is best achieved graphically.

To illustrate the variations displayed by the different oxides, they have been plotted against the differentiation index (D.I.) of Thornton and Tuttle (1960).

"...fractional crystallization of complex magmas produces liquids which move toward and, for all practical purposes, eventually reach the system SiO_2 - NaAlSiO_4 - KAlSiO_4 , petrogeny's residua system. In a volcanic rock series the distance a given magma has travelled toward this goal can be quantitatively measured by calculating the norm and summing the constituents of petrogeny's residua system; the value is called the differentiation index". (Thornton and Tuttle, 1960, page 664).

It is also an inverse measure of the basicity of the rock. The D.I. of Thornton and Tuttle seems not to have been widely accepted by petrologists; certainly it is very little used. In this limited study of about 50 samples plots of D.I. versus the content of the various oxides and trace elements give significant and characteristic trends.

The diagram of D.I. versus oxides has first been used to determine whether or not it is possible to show distinct trends between the components of the Lac Fréchette Complex and those of the Lac Rémigny Complex: Alkaline rocks have a relatively low silica content compared with other rocks of the same D.I.

Seventeen analyses of rocks from the Lac Fréchette Complex and thirty-four from the Lac Rémigny Complex have been plotted (Figure 5-6 and 5-7 respectively); the diagrams show no marked differences nevertheless the monzonitic rocks share characteristics that distinguish them from those of the Lac Rémigny Complex. SiO_2 is slightly higher within the rocks of the Lac Rémigny Complex and based on the limits drawn by Thornton and Tuttle, the rocks are mostly oversaturated. The

Figure 5-6: Variation diagram for analysed samples of the Lac Fréchette Complex (in wt%). Major, minor, trace elements and geochemical ratios are plotted against the differentiation index of Thornton and Tuttle.

○ : data from this study; ● : data from Van de Walle, 1978.* (See text for details on the analyses)

*which are not complete for the trace-elements.

Figure 5-7: Variation diagram for analysed samples of the Lac Réminy Complex (in wt %). Major, minor, trace elements and geochemical ratio are plotted against the differentiation index of Thornton and Tuttle.

△: quartz monzodiorite, porphyritic quartz monzodiorite, porphyritic granodiorite and biotite granodiorite; □: porphyritic biotite granodiorite; ○: pegmatite, granite and aplite dykes; ●: pink pegmatite dykes. Data for dyke material are from Van de Walle (1978). (See text for details on the analyses)

Lac Fréchette rocks only become slightly oversaturated in the late quartz monzonite. Al_2O_3 shows a steady increase toward the more felsic facies of the Lac Fréchette Complex. This point differs from the Lac Rémigny Complex which shows a slight increase followed by a weak decrease toward the more felsic facies. Trends for CaO , TiO_2 , FeO , Fe_2O_3 and MgO are similar in both complexes. K_2O and Na_2O are slightly higher in the Lac Fréchette Complex than in the Lac Rémigny Complex. The difference becomes more apparent when the sum of $\text{Na}_2\text{O} + \text{K}_2\text{O}$ is plotted versus the D.I. Higher strontium abundances are also noted within the monzonites. Really these diagrams support the existence of two genetic associations, thus the distinction made in the field was valid.

The compositional trends for the entire intrusion of the Lac Fréchette Complex (Figure 5-6) are toward increasing SiO_2 , Al_2O_3 , K_2O , Na_2O , $\text{Na}_2\text{O} + \text{K}_2\text{O}$ and decreasing Fe_2O_3 , FeO , MgO , CaO , TiO_2 with higher D.I. Concentrations of Co, V and Zn generally decrease with increasing D.I. and Ba, Sr, Li, Cu, Cr and Ni do not show any particular relation to the D.I. The interruption in the trends is not a function of poor sampling. It is believed that the rocks with intermediate composition are not exposed or completely absent.

Chemical constituents of the Lac Rémigny Complex (Figure 5-7) exhibit systematic variations from one rock type to the next. The order of emplacement of the rock units as inferred from field relationships agrees with their arrangement on the

basis of chemical variations. Values for SiO_2 and K_2O increase in the more felsic facies; Al_2O_3 increases slightly with the D.I. and suddenly decreases at high D.I. Fe_2O_3 , FeO , MgO , CaO and TiO_2 show a steady decrease as they evolve toward the more felsic members. K_2O and Na_2O display a weak increase when going from the mafic to the felsic facies, but become scattered at high D.I. when the chemical data from the dykes are plotted. The CaO value of the dykes fits exactly the trend defined by the other facies but locally Na_2O and K_2O diverge significantly from the main trends. The dispersion is not completely random, a lower weight percent of Na_2O value fits a high K_2O percentage. This variation from the main linear trend may well indicate that some of the dykes are not comagmatic with the main intrusions. This will be discussed in Chapter 6, section 3.

Trace elements such as Cr and Ni show a steep decrease in the mafic facies corresponding to a slight increase of the D.I., but the slope of the linear trend becomes nil toward the less mafic facies. Cu, Zn, V and Sr exhibit generally trends with positive slopes. Co also decreases slightly toward the more felsic facies and an important divergence from the main trend occurs in the late differentiate. Li values are rather dispersed and the Ba distribution varies from 500 to 3700 ppm in the mafic facies; it tends to be less variable at higher D.I.

The distribution of the trace elements in this study with the exception of Li and Ba is related to the proportions of mafic minerals in the various rock units and they increase as modal amounts of these minerals increase.

Figure 5-8: Quartz (Q)-plagioclase (albite + anorthite) (P)-alkali feldspar (A) diagram from normative analyses for rocks of the Lac Rémigny Complex. Symbols as defined in figure 5-5. Arrow points the composition of the rock used for microprobe feldspar analyses in chapter 6.

The variation of the Ba/Sr ratio is of interest, as these elements show comparable crystallochemical properties. These allow Ba to replace Ca in plagioclase, but also to concentrate in K-minerals, while Sr is enriched in plagioclase, but substitutes for K in potassic feldspar to a large extent. Therefore, a good coherence between these two trace elements is to be expected in series of rocks related by differentiation. The values of the Ba/Sr ratio with rare exception tend to increase gently toward the felsic end of the series in the rocks of the Lac Rémigny area.

The normative equivalents for the units of the Lac Fréchet Complex appear on Figure 5-4 along with the modal analyses. The arrows indicate the shift from the modal to the normative compositions.

The different facies of the Lac Rémigny Complex have also been plotted on a diagram constructed from the molecular proportions of C.I.P.W. normative quartz, orthoclase and plagioclase (albite + anorthite) recalculated to 100% (Figure 5-8). All rocks are quartz normative. The normative classification provides some analogy with the field classification. The trends obtained either by mineralogical or normative analyses are similar in direction but the calculated mineralogy contains lower potassic feldspar than observed in the modal analysis. The quartz content is also slightly lower in the calculated norm and a general displacement of the compositions toward the plagioclase pole occurs in the calculated mineralogy. Nevertheless both trend can be related to a fractionation path according to

Figure 5-9: Normative quartz-albite-orthoclase and albite-orthoclase-anorthite ternary plots.
 □: Lac Fréchette Complex; ○: main intrusions of the Lac Rémigny Complex (monzodiorite, quartz monzodiorite and granodiorite); ■: dykes (biotite-muscovite); △: pink layered pegmatite; ●: muscovite pegmatite; +: ternary minimum for confining pressures (500, 1000, 3,000, 5000 bars) from Tuttle and Bowen, 1958 and Winkler, 1967.

Tuttle and Bowen, 1958 and Winkler, 1967. The difference between the modal and the normative mineralogy can be explained by the normative Ab dissolved in the real alkali feldspar crystals.

Figure 5-9 shows the distribution of rocks of the Lac Rémigny area in terms of the normative Q-Ab-Or and An-Ab-Or diagrams. Ternary minimum for confining pressures (500, 1000, 3000 and 5000 bars) from Tuttle and Bowen (1958) and Winkler (1967) are also plotted. The position of the ternary minimum is shifted toward the Ab corner in response to an increase of pressure. The same is true of "minimum melt" compositions in An-bearing systems (Winkler, 1967). The systematic distribution of the rocks in terms of the normative ratios on the Q-Ab-Or diagram appears to suggest a magmatic origin of the pluton. The fractionation path evolves toward the ternary minimum. Normative Ab-Or-An diagram also shows a progressive enrichment in Ab and Or with late differentiates.

5.5 Chemical Relationships with Respect to a Differentiation and/or Assimilation Model

Variation diagrams of the major and minor oxides plotted against the differentiation index show a fairly good linear relation. Element behavior is compatible with variation patterns characteristic of magmatic differentiation. We also see that many trace elements show a high degree of variability within each complex but are related to the type and especially the volume of mafic minerals present.

For the Lac Fréchet Complex a strong chemical differentiation is evident, with SiO_2 from 40% in the ultramafic facies to 68% in the more felsic ones. ($\text{Na}_2\text{O} + \text{K}_2\text{O}$ also presents important variations from 2.65 to 11.65%). These facts, along with the compositional gap that exists between the mafic and more felsic units and the scattering of plotted values on the basic side of the diagram, suggest a crystal-liquid fractionation of the magma for the formation of some units of the Lac Fréchet Complex. Strontium, being either rejected by the mafic minerals or only admitted in the plagioclases, would have been depleted in the mafic cumulate from which the hornblende crystallized. A low strontium concentration in the hornblende can be seen on Figure 5-6. Note also the Sr concentration (4000 ppm) corresponding to high Ba concentration (13400 ppm) of the lusitanite which cuts the hornblende. Strontium and barium entered the potassic feldspar (dominating feldspar) in higher amounts, being depleted in the mafic cumulate.

The more felsic facies of the Lac Fréchet Complex evolved toward a progressive silica increase in the sequence from monzonite to quartz monzonite, with a particularly marked increase in the quartz monzonite. Trends of modal and normative mineralogy (Figure 5-4) also show an enrichment in quartz and depletion in mafic percentage. Igneous differentiation is then suggested for the derivation of the more felsic units of the Lac Fréchet Complex.

Interfacies mineralogical trends for the Lac Rémigny Complex (Figure 5-3) demonstrate maximum abundance in the granite for quartz, microcline and plagioclase, and minimum abundance

for the total mafic mineral content (mafic + accessory minerals). This compares favourably with Bowen's "Reaction Series" in that the characteristic minerals hornblende and biotite give way to biotite and muscovite, and the anorthite content of the plagioclase decreases from oligoclase to albite. The distribution of rocks of the Lac Rémigny Complex on the quartz-albite-orthoclase ternary diagram (Figure 5-9) is characterized by a trend in the direction of quartz enrichment toward the "minimum melt" composition. The quartz-rich end of the trend is represented by rock compositions that are the last to crystallize in the sequence of intrusion. The granite may thus have resulted from the normal crystallization by differentiation of a magma.

The interfacies chemical trends demonstrate enrichment in silicon and potassium and impoverishment in ferric and ferrous iron, calcium and magnesium from intermediate to acidic facies. This evidence is supported by the maximum abundance of quartz and the minimum content of mafic minerals in the dyke material.

The role of assimilation during emplacement of the porphyritic biotite granodiorite has been discussed in Chapter 4.1 and is considered to be of little importance.

In both complexes, the sharp contacts between the different facies of each complex suggest that the differentiation did not occur in situ, except for the porphyritic quartz monzodiorite of the Lac Rémigny Complex which grades into the porphyritic granodiorite by increase of quartz. Two stages of intrusion are suggested by the composite nature of the batholith and the emplacement mechanism. The first stage involved the emplacement of a magma below the present exposure and the

second stage was the result of continued upward movement of the more differentiated part of the magma into the earlier crystallized units to assume the present field relationship of the batholith.

CHAPTER 6

PETROGENESIS OF THE INTRUSIONS

6.1 Potassic Feldspar Megacrysts

The potassic feldspar described in this section are characterized by an internal zonation of inclusions and occur in certain units of the Lac Rémigny Complex; phenocrysts of the Lac Fréchette Complex, being free of inclusions are not included in this description. The microcline megacrysts are mainly restricted to quartz monzodiorite and granodiorite compositions. The groundmass of such rocks is usually that of a quartz diorite with rare interstitial grains of potassic feldspar. Commonly the megacrysts display a well-developed crystal form in hand specimens, but irregular shapes are also found. They are elongated with a maximum size of 1.5 by 2.5 cm and show local dimensional orientation parallel to the contact. The megacrysts contain small inclusions of subhedral to euhedral plagioclase and hornblende which also occur as larger crystals in the groundmass. These inclusions are typically arranged with their long axes parallel to the megacryst faces and are disposed in a concentric zonal pattern. Typically the inclusions are more common toward the margin of the megacrysts than in the core. The mafic mineral inclusions, being parallel to the plagioclase orientation give textural evidence that the plagioclase was incorporated on the growth surfaces of the potassic feldspar, as was the hornblende, and does not represent an exsolved phase.

Although the megacrysts appear to be euhedral in hand specimen, the actual boundary between groundmass and megacryst is not well defined in thin section (Figure 6-1). Typical of Precambrian synkinematic acid rocks is the replacement of plagioclase by potassic feldspar. Commonly, the more advanced the replacement, the more sericitic is the plagioclase (Marmo, 1968). There seems to be a relation between myrmekite and the microcline; only around megacrysts is myrmekite found. Plagioclase inclusions within the megacrysts show a more albitic marginal zone reflecting a different composition probably related to a post-magmatic diffusion of sodium into the rim of the enclosed plagioclase (Higgins and Kawachi, 1977).

Relative time of growth of potassic feldspar megacrysts and groundmass minerals is difficult to establish. The three main hypothesis for the origin of the megacrysts are:

- megacrysts are a product of late stage magmatic crystallization, based on the parallel arrangement of megacrysts, the concentric zonation of inclusions in the megacrysts and the composition of included plagioclase (Hibbard, 1965);
- megacrysts have grown as porphyroblasts after solidification of the magma, by replacement of the granitoid material by late potassium metasomatism, based on cases where megacrysts exist in surrounding migmatites and hornfelses (Hyndman, 1969);

Figure 6-1:

Sketch showing the relationship at the margin of microcline megacryst (right) and plagioclase (left), within the porphyritic granodiorite. Replacement of plagioclase by microcline is evident and a more albitic rim borders the plagioclase. Note the development of quartz within the plagioclase (lower left corner). Small plagioclase and hornblende inclusions within the microcline. Field of view is 0.22 by 0.4 mm.

- megacrysts are an early feature of crystallization, based on the relative enrichment of barium at the center of the megacrysts with respect to the margin and the groundmass feldspar (Kerrick, 1969). Taylor et al, (1960) have shown that there is a tendency for Ba to be enriched in early formed potassium feldspar suggesting a primary magmatic origin.

Chagnon (1968) suggested a metasomatic origin for the potassic feldspar megacrysts found in the map area, but the present study reveals important features, concerning their origin, not previously taken into account. Because they contain inclusions of plagioclase and hornblende, the megacrysts are thought to have formed during the late stages of crystallization, but because of dimensional orientation near the external contacts, they are thought to have formed before complete consolidation of the magma. The rare presence of identical porphyroblasts of potassic feldspars in some inclusions indicates pressure and temperature conditions like those in the magma and probably metasomatism of the intruded rock, but it does not necessarily indicate a metasomatic origin for all megacrysts.

Four electron microprobe analyses were carried out on two microcline megacrysts and on two feldspars (one plagioclase and one microcline) from the groundmass of a porphyritic granodiorite. The results are presented in Appendix II, Tables 2A and 2B. Analyses were performed on a Cambridge Micro-scan 5 microprobe, at 15 kv accelerating potential. Standards consisted of natural analysed minerals: Si and K from phlogopite;

Ca from garnet; Na and Al from albite and Ba from synthetic barium-ferrite. The SiO_2 is not accurate and affects the totals, but the Na, Ca, K and Ba are comparable to analyses presented by Deer, Howie and Zussman (1975) (P. Mainwaring, personal communication). The thin section studied is composed of 14.5% microcline megacrysts in a groundmass of 17.5% quartz, 47.25% slightly altered plagioclase, 15% hornblende, 5% biotite (trace of alteration), 0.75% annedral microcline and accessories. A chemical analysis of the rock is also presented in Appendix I, Table 1A, #28.

The only difference observed between the composition of the microcline megacrysts and the microcline within the groundmass is the barium content. The cores of the megacrysts are richer in that element than the potassic feldspars of the matrix. It is assumed, based on a similar study (Kerrick, 1969; Higgins and Kawacki, 1977), that the rim of the megacrysts has a Ba value resembling that of the feldspar from the matrix, because the marginal zone of the megacrysts is believed to have crystallized around a preexisting core of potassic feldspars simultaneously with the crystallization of interstitial potassic feldspar in the groundmass.

No apparent relation exists between the Ba content and the Or/Ab ratio. The tendency ~~for~~ Ba to be enriched in early-formed potassic feldspar has been suggested by several workers: Taylor et al (1960); Oftedahl (1959, 1961) and Heier (1962). Boettcher et al (1967) have shown a zonation from

high Ba cores to low Ba rims in potassic feldspar megacrysts of trachyte dykes from the Rainy Creek Complex in Montana. Based on this information, Kerrick (1969) and Higgins and Kawacki (1977) have inferred an early crystallization of zoned potassic feldspar megacrysts in a porphyritic quartz monzonite from the Central Sierra Nevada, California and in a porphyritic granodiorite from New Zealand respectively.

In conclusion, at least two stages of crystallization can be distinguished: the early magmatic crystallization of the main part of the mineral, and the late magmatic crystallization of a rim characterized by the partial replacement of the adjacent minerals (mainly plagioclases) by microcline. Based on textural relationships, the inner idiomorphic part of the megacrysts would be contemporaneous with the generation of plagioclase and hornblende contained as oriented inclusions. The outer xenomorphic part is younger and visibly grew into the older granitic fabric partially replacing the earlier minerals.

The bulk composition of the rock on a normative Q-Or-Ab ternary diagram (Figure 5-8) does not plot in the field where potassium feldspar is the first to crystallize; rather the liquid composition must intersect the cotectic between the plagioclase and the potassic feldspar fields early in the crystallization path so as to permit the contemporaneous crystallization of potassic feldspar and plagioclase. Note also the fractionation path of the rocks of the Lac Rémigny Complex lying almost parallel to the quartz-plagioclase side of the diagram. If metasomatism was the major process in the formation of the megacrysts,

we should expect a trend toward the potassic feldspar apex, but it is not the case in this study.

It can also be suggested that the potassic feldspar tends to growth rapidly. It is likely that all minerals precipitated out over a fairly large time interval. If hornblende crystallizes to late stage, then rapid growth could permit potassic feldspar to crystallize late and form large crystals. The maximum percentage of megacrysts within the rock may provide a clue to the late crystallization of the potassic feldspar. Plagioclase is twice as abundant as the potassic feldspar.

6.2 Information from Pegmatites

Two important families of pegmatites have been described separately within the dyke complex: a muscovite pegmatite which is widespread in the contact zone and a pink layered pegmatite well-represented in the core of the batholith. The origin of the layered structure within the pink pegmatite and the conditions existing at the time of emplacement of the muscovite pegmatite will be examined.

It is well known that solution of volatiles in a silicate melt is favoured by high pressure. As the magma cools, the residual melt becomes rich in water and other volatiles and may crystallize as very coarse grained pegmatite. The volatiles inhibit nucleation of grains resulting in fewer grains and aid the rate of diffusion giving larger grains. If the

volatiles are absent (never being present) or lost, fine grained aplites crystallize. The concentration of volatiles can easily account for the natural grain size variations encountered but the repeated gradation of aplite to pegmatite layers within the same dyke of pink pegmatite is difficult to explain. Two possibilities discussed by Jahns and Burnham (1969) can be examined. The first one involves the development of a fracture in the cooling intrusion which is filled with a residual melt rich in volatiles. Subsequent fracturing causes a sudden drop in pressure, resulting in a loss of volatiles and in the crystallization of fine grained aplite. It is difficult to explain the subsequent fracturing of the same dyke along several planes parallel to the dyke walls, nevertheless, several acts of opening, filling and re-opening along the same fracture may give similar layering. The second possibility is concerned with the contemporaneous crystallization of aplite and pegmatite from the water-poor portion of the magma and from a coexisting water-rich fluid, respectively. During the emplacement of the volatile-rich melt the external pressure is not able to contain the volatiles, which start to separate just before the complete solidification of the melt. In this case, it is difficult to assume that the separation of volatiles will occur along numerous parallel zones but a gradation between aplite and pegmatite is expected.

The presence of primary muscovite in a granite limits its crystallization conditions to the region below the muscovite breakdown curve and above the water-saturated solidus (White, Chappell and Cleary, 1974). Muscovite granites must be nearly saturated with respect to water, crystallization conditions being located just above the water-saturated solidus. As it is impossible for a melt to cross the granite solidus, they cannot move far upward to lower pressure without crystallizing completely. Therefore, muscovite pegmatites are derived from material which originated near the area where they are now found.

The normative Qtz-Ab-Or plot (Figure 5-9) demonstrates that pegmatites are quartz-rich with respect to the associated granites. This is consistent with other studies of granite-pegmatite suites (Harris, 1974) and is ascribed to the relatively high silica content in the hydrous phase during late stages of crystallization (Luth and Tuttle, 1969).

6.3 Comparison with other Granitoid Suites

Chappell and White (1974) recognized, based on chemical, mineralogical and field criteria, two contrasting granitoid types in eastern Australia. They interpreted these granitoids as being derived from the partial melting of two different types of source material, one igneous and the other sedimentary and referred to them as I-type and S-type respectively. Differences in the derived granitoids are inherited from the source rock and each type presents distinctive characteristics.

Many of the features result from a high aluminum content relative to alkali and calcium in the S-type granitoids and a greater alkali and calcium content relative to aluminum in the I-type granitoids. Field relationships between the two types may be distinctive. Mafic hornblende-bearing xenoliths of igneous appearance are present in I-type whereas metasedimentary xenoliths are common in S-type. Where both types occur together in a composite batholith, the S-type is commonly early in the intrusive sequence and presents a strong secondary foliation truncated by the later I-type intrusions which are either massive or have a dominant primary foliation.

The early granitoids of the study area belong to the I-type. Hornblende is the chief mafic mineral even in felsic varieties, they are relatively rich in sodium and the molecular ratio ($\text{Al}_2\text{O}_3/\text{Na}_2\text{O} + \text{K}_2\text{O} + \text{CaO}$) is smaller than 1:1. Diopside appears in the norm and corundum is not represented.

Some late facies present as dykes of muscovite-garnet-pegmatite and muscovite pegmatite show many of the characteristics of S-type with a molecular ratio $\text{Al}_2\text{O}_3/\text{Na}_2\text{O} + \text{K}_2\text{O} + \text{CaO}$ greater than 1:1, no normative diopside and normative corundum < 1%. The only compositional difference from S-type is their relatively high Na_2O content. They should be classified as I-type because they are younger units cutting the I-type granitoids but it is possible that melting of sediments began after the main granitoid emplacement.

Modal and chemical data clearly show that the alkali intrusive rocks of the Lac Fréchette Complex are not petrogenetically compatible with the far more abundant quartz-rich, calc-alkalic rocks that characterize the Lac Rémigny Complex. Instead the older monzonitic rocks constitute part of a discrete petrogenic unit that is certainly comagmatic with the Lac Rémigny Complex.

Similar relationships have been described by Young (1978) in the Reading Prong province of northwestern New Jersey and southern New York. Slightly metamorphosed intrusive igneous rocks indicate the existence of two parallel intrusive rock belts during the Precambrian time in this region, a northwestern syenite-monzonitic belt and a southeastern granitic belt. In more recent batholiths such as the Inyo batholith, California, distinct, occasional monzonitic rocks are described by Sylvester, Miller and Nelson (1978) as a separate entity occurring within or in the vicinity of the more abundant calc-alkalic rocks forming the bulk of the Sierra Nevada batholith.

On an AFM diagram (Figure 6.2) the Lac Fréchette Complex shows a variation from iron-rich to alkali-rich rocks across the boundary limiting the calc-alkaline field and the tholeiite field. The data from the Lac Rémigny Complex define a trend toward alkali enrichment within the calc-alkaline field and are typical of a calc-alkaline variation trend (Nockolds and Allen, 1953, 1954 and 1956).

Figure 6.2:

AFM variation diagram (in wt %) for alkalis ($\text{Na}_2\text{O} + \text{K}_2\text{O}$), iron ($\text{FeO} + \text{Fe}_2\text{O}_3$) and magnesium (MgO) present within the intrusive rocks of the Lac Rémigny area. Dividing line between the tholeiitic and the calc-alkaline fields is from Irvine and Baragar (1971). Trends for tholeiitic suite (1) and primitive calc-alkaline suite (2) of Abitibi volcanic types are from Jolly (1977); Preissac-Lacorne trend (3) from Dawson (1966); Flora lake stock trend (4) from Heimlich (1965); Barnum lake pluton trend (5) from Kehlenbeck (1977); alkaline (6) and calc-alkaline (7) variation trends are from Nockolds and Allen (1953, 1954, 1956). ■ : Bourlamaque batholith (Campiglio and Darling, 1976); • : Lac Rémigny Complex; ○ : Lac Fréchette Complex

No evidence of an Fe enrichment trend is observed. It is also interesting to note that the porphyritic biotite granodiorite plots on the iron-rich side of the main trend defined by the Lac Rémigny Complex. Compared with other Archean igneous suites for which trends are also represented on the AFM diagram, the Lac Rémigny Complex is even more magnesium-rich with respect to $\text{FeO} + \text{Fe}_2\text{O}_3$ than the primitive calc-alkaline suite of Abitibi volcanic type from Jolly (1977). Its composition also differs considerably from certain batholiths and stocks present within typical Precambrian "greenstones". The Bourlamaque batholith (Campiglio and Darling, 1976) within the Abitibi volcanic belt and the Flora lake stock (Heimlich, 1965) in northern Ontario are good examples. Nevertheless, the Preissac-Lacorne batholith (Dawson, 1966) within the Abitibi volcanic belt and the Barnum Lake Pluton in the Thunder Bay area (Kehlenbeck, 1977) emplaced into pelitic to semipelitic metasedimentary schists and gneisses present trends similar to the Lac Rémigny Complex, in the calc-alkaline field of the AFM diagram.

6.4 Origin of the Magma

Differentiation processes for the Lac Fréchette and Lac Rémigny Complexes have been clearly indicated, nevertheless, it is difficult to establish if the magma originates by remelting of crustal rocks or represents addition of new crustal material from the mantle. The fact that granitoid batholiths appear to be restricted exclusively to areas underlain by continental crust (Fresnall and Bateman,

1973) may suggest a source material from the crust or at least contamination of some sort by the crust.

For the Lac Fréchette Complex, there are several mechanisms that could account for the development of rocks of quartz monzonitic and monzonitic compositions. Such rocks could develop:

- 1) as a refractory residuum left behind after extraction of eutectic granitic liquids formed by partial melting of deeply buried metasedimentary rocks (De Vore, 1975). The rocks of the Lac Fréchette Complex present a granular texture that might be expected to develop during removal of the partial melt fraction or during later remobilization of a solid monzonitic mush. There is however a lack of relict stratigraphy within the monzonitic rock which might be expected if they were originally metasediments.
- 2) by reaction of granitic magma with rocks of amphibolitic or gabbroic composition (Buddington, 1972). Amphibolitic horizons do occur in contact with monzonitic rocks but the intrusive material generally becomes more monzodioritic to dioritic in character close to the amphibolite. Remnants of incompletely digested amphibolite are expected to have been carried upward by the intruding magma. At the present level of erosion such amphibolite inclusions are restricted to near the contacts with amphibolitic horizons.

- 3) as late stage differentiates of initially basaltic magma (McDougall, 1962). In such cases however the volume of gabbroic or basaltic rocks should greatly exceed that of monzonitic material. At the present level of erosion mafic rocks are absent. Syenite and monzonite stocks of Archean age are present in the Kirkland Lake area where they are associated with alkalic volcanism (Cooke and Moorhouse, 1969).
 - 4) as early cumulates of fractionated granitic to quartz syenitic magma (Shaw, 1965). If a granitic magma exists at depth within the crust, syenitic material can develop by gravitative settling of early formed mafic minerals such as clinopyroxenes, ferro-hastingsite and moderately calcic-alkali feldspar. If this mechanism was valid the monzonite could have formed and differentiated at greater depths and been intruded to the present level.
 - 5) by varying degrees of partial melting of quartzofeldspathic or feldspathic rocks at considerable depth. Numerous experimental studies (Tuttle and Bowen, 1958; Winkler, 1974) indicate that initial partial melts in the "granitic" system become progressively more silica-deficient as the pressure during smelting is increased. Therefore, it could be argued that the quartz-poor rocks of the Lac Fréchette Complex were generated at a greater depth within the crust than the normal quartz-rich units of the Lac Rémigny Complex by means of partial melting of quartzofeldspathic and feldspathic rocks.
- C

It is not possible to assign a definite solution to the problem of origin of the Lac Fréchette Complex because many processes can be involved but evidence that these rocks are I-type, differentiated at depth, that little assimilation was involved and fractional crystallization was important, rule out the first two processes.

Many petrologic and structural characteristics indicate that the Lac Rémigny Complex is similar to many composite granitoid plutons. The consensus of opinion among experimental petrologists now appears to be that partial melting of the lower crust is responsible for the origin of such batholiths. Brown and Fyfe (1970), Cann (1970), Fyfe (1970, 1973), Hall (1971), Hietanen (1973), Brown (1973), Presnall and Bateman (1973), Glikson and Lambert (1976) have presented models for crustal magma generation in water-deficient systems which contain water only in the hydrous minerals. It seems probable that during metamorphism of metasediments and of the igneous rocks (extrusive or intrusive) forming the floor of the metasediments, temperatures appropriate to fusion have been obtained. Melting represents an unusual condition which can only occur as a result of thickening of the crust or, more likely, of a source of heat increasing the thermal gradient in the lower crust.

The sequence of intrusion in the Lac Rémigny Complex is from mafic to felsic. It is frequently argued that fractional fusion would produce the reverse sequence of intrusion (Hietanen, 1973) thus the wide range of composition results

from fractional crystallization of the derived magma. The fractionation path of the magma of the Lac Rémigny Complex across the granitic phase diagram Q-Ab-Or and Ab-Or-An (Figure 5-9) gives certain indications as to its nature. The original magma would have been of monzodiorite composition and a differentiation toward granodiorite occurred. The scattered distribution of bulk compositions, mainly in the dyke material, may reflect changing P_{H_2O} during crystallization (Winkler, 1974) or alkali exchange between solid and vapour phases during the final stages of crystallization (Orville, 1963). From the positions of the ternary minimum a pressure of 3 to 5 kilobars can be estimated during the crystallization of the pink layered pegmatite, which is within the range of 2 to 5 kilobars determined by metamorphic assemblages within the Pontiac metasediments.

SUMMARY AND CONCLUSION

Clearly established facts concerning the intrusive rocks of the Lac Rémigny area are as follows:

- The pluton consists of elongated bodies parallel to the regional trend of the country-rock;
- It is located within a metasedimentary belt represented by the Pontiac greywackes;
- The pluton is a composite body and consists of a sequence of rock units which constitute two natural series chemically and mineralogically;
- Each of the units is moderately uniform which is evident by the clustering of modal analyses;
- The units have been emplaced in an order corresponding to increasingly more felsic rocks;
- The field data indicates that the units wedged themselves between steeply dipping schistosity planes and shouldered the rocks aside;
- The presence of well developed, concentrically disposed xenoliths and mineral foliation, the generally outward dip of the steep foliation planes and the presence of displaced inclusions of the country-rock suggest that mobile material moved into its present location from below;
- A strong fabric can be seen in the plutons, especially in peripheral regions. The role of flow in producing such structure is clear;

- The large plutons cut and therefore postdate the main folding and foliation present in the Pontiac metasediments, nevertheless, post-crystallization deformation was also imposed on both intrusive and envelope and can be followed without deviation through contacts;
- Signs of deformation such as bent and fractured albite twins, bent biotite cleavage traces and deformed mafic inclusions are evident within the main intrusions;
- Late stage pegmatite, granite and aplite are common throughout the batholith, but they constitute a complex zone invading the contact of the main intrusion and the country-rock.
- Variation in composition and structure of the dykes suggests many episodes of openings, with emplacement of a small quantity of liquid each time;
- Certain mineralogic relationships and characteristics provide further evidence that the Lac Rémigny area has been affected by late-magmatic and possibly postmagmatic processes. These include sericitized and saussuritized plagioclase, uralitized pyroxene, alteration of iron ore to sphene, undulatory extinction of quartz and plagioclase, deformed plagioclase twin lamellae, bent biotite cleavage traces;
- The geochemical behavior of the chemically analysed elements can be explained mainly by magmatic differentiation. The latest intrusions are richest in Si, K, Li in contrast to the earliest intrusions which contain the largest amounts of Mg, Cr and Ni.

The available data suggest that the batholith was emplaced by multiple, forceful intrusion of magmas before the end of the period of intense deformation and metamorphism. It is possible that during this regional deformation, a zone of partial or complete melting developed at depth and caused monzodioritic material of the approximate chemical composition of the Lac Rémigny monzodiorite to become mobile and rise under the influence of its gravitative potential. Two stages of intrusion are suggested by the composite nature of the batholith and the emplacement mechanism. The first stage is represented by the emplacement of a magma below the present exposure and the second stage was the result of continued upward movement of the more differentiated part of the magma into the earlier crystallized units to assume the present field relationship of the batholith.

Flow structure, absence of chilled contacts, and strain indicate that the units arrived at their present locations in the form of rather viscous, crystal-liquid mushes. The general absence of contact metamorphic effects suggests that the pressure-temperature environment of the intrusion was essentially that of the upper amphibolite facies of regional metamorphism.

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Appendix I
Table 1A Whole rock chemical analysis of rocks from Lac Rémigny area in weight percent. Analyses by Q.D.N.R. (a) and Holland (b)

Analysis# Field#	1 L-72-1	2 L-72-3	3 L-204	4 L-206-1	5 L-206-9	6 L-237-2	7 L-96	8 CL-8
SiO ₂	39.80	40.00	40.30	39.00	43.75	64.60	61.20	58.80
Al ₂ O ₃	3.15	3.50	10.60	7.65	10.30	16.80	15.48	14.95
Fe ₂ O ₃	5.60	6.38	6.60	9.95	8.04	1.34	1.08	2.33
FeO	2.80	3.26	9.90	10.80	8.20	1.63	3.42	3.36
MgO	34.50	33.05	8.65	7.45	5.52	1.62	3.31	3.27
CaO	1.25	2.18	13.30	17.40	12.35	2.66	4.47	4.30
Na ₂ O	0.04	0.06	2.65	1.75	2.08	9.30	5.73	6.28
K ₂ O	0.01	0.01	1.20	0.90	3.42	0.63	4.21	3.45
H ₂ O-	0.30	0.20	0.11	0.09	0.07	0.06	-	0.09
H ₂ O	11.60	9.90	1.85	1.45	0.83	0.62	-	0.83
TiO ₂	0.01	0.21	2.70	1.65	1.25	0.42	0.64	0.52
P ₂ O ₅	0.02	0.02	0.88	1.35	0.58	0.11	0.34	0.14
MnO	0.09	0.11	0.37	0.37	0.28	0.05	0.09	0.10
CO ₂	0.01	0.09	0.01	0.56	0.21	0.01	-	0.20
S	0.18	0.11	0.02	0.05	0.05	0.03	0.03	0.01
F	0.01	0.02	0.15	0.08	0.09	0.02	-	0.05
Total	99.34	99.09	99.29	100.50	97.02	99.89	100.00	98.68

- not determined

NOTE: Chemical analyses were performed partly by the laboratory of the Québec Department of Natural Resources (Q.D.N.R.) and partly by Dr. G. Holland at the University of Durham, England. The methods used are described within the text and the locations of the samples appear on Figure 5-1 (map in pocket). Analyses (1-2) ultramafic flows; (3-4) hornblende; (5) lusitanite; (6) leuco-quartz diorite; (7) porphyritic monzonite; (8) coarse grained monzonite. The analyses are reproduced in the same form as quoted by the laboratory; not all figures are necessarily significant.

Table 1A (cont'd)

Analysis#	(a)	(b)	(a)	(b)	(a)	(b)	(a)	(b)
Field#	18	19	20	21	22	23	24	25
	L-380-2	L-5-A	L-4-A	L-493-1	L-48-1	L-45-1	CL-5	LK-2
SiO ₂	56.60	58.75	54.12	59.70	56.75	63.12	58.70	59.47
Al ₂ O ₃	15.10	15.60	14.07	15.70	14.00	14.51	15.30	15.95
Fe ₂ O ₃	1.78	1.32	2.02	1.40	1.61	1.35	1.70	1.31
FeO	4.54	4.13	6.31	3.25	4.55	4.26	3.25	4.10
MgO	6.43	4.03	6.40	3.81	5.95	5.09	3.80	4.49
CaO	5.27	5.54	7.75	4.60	6.05	3.89	4.60	4.96
Na ₂ O	5.24	5.44	4.06	5.25	4.45	4.20	6.20	5.69
K ₂ O	2.17	3.87	3.22	2.75	2.65	2.58	3.05	2.97
H ₂ O-	0.10	-	-	0.09	0.08	-	0.15	-
H ₂ O	1.40	-	-	1.37	1.78	-	1.55	-
TiO ₂	0.63	0.68	0.97	0.42	0.63	0.56	0.50	0.61
P ₂ O ₅	0.32	0.53	0.93	0.26	0.35	0.30	0.36	0.39
MnO	0.08	0.10	0.14	0.08	0.11	0.11	0.08	0.03
CO ₂	0.12	-	-	0.01	0.07	-	0.10	-
S	0.01	0.03	0.02	0.01	0.00	0.04	0.01	0.03
F	0.11	-	-	0.08	0.06	-	0.01	-
Total	99.90	100.02	100.01	98.78	99.09	100.01	99.26	100.00

- Not determined

NOTE: (18) diorite; (19-20) monzodiorite; (21-22) quartz monzodiorite; (23-25) porphyritic quartz monzodiorite; (24) porphyritic monzodiorite

Table 1A (cont'd)

Analysis# Field#	(a) 26 L-484	(a) 27 L-489	(b) 28 L-R-2	(b) 29 L-46-5	(b) 30 L-45-10	(b) 31 L-47-1	(a) 32 L-223	(a) 33 L-142-2
SiO ₂	63.15	61.25	64.43	63.24	62.94	63.18	62.50	53.50
Al ₂ O ₃	14.65	14.90	15.31	15.33	15.61	14.99	15.10	15.90
Fe ₂ O ₃	1.13	1.46	1.02	1.21	1.18	1.18	1.34	4.75
FeO	3.88	2.94	3.23	3.80	3.70	3.72	2.86	5.80
MgO	3.43	3.47	3.92	4.53	4.22	4.17	3.32	3.35
CaO	4.16	4.44	3.48	4.91	4.71	4.70	4.23	7.00
Na ₂ O	4.80	5.32	4.83	4.65	4.78	4.76	4.95	4.35
K ₂ O	2.70	2.92	2.98	1.40	2.57	2.38	3.01	1.90
H ₂ O-	0.08	0.10	-	-	-	-	0.05	0.07
H ₂ O	1.50	1.20	-	-	-	-	0.91	1.17
TiO ₂	0.63	0.42	0.47	0.56	0.53	0.55	0.52	1.04
P ₂ O ₅	0.23	0.26	0.21	0.25	0.26	0.26	0.24	0.48
MnO	0.04	0.07	0.10	0.11	0.09	0.10	0.07	0.14
CO ₂	0.15	0.03	-	-	-	-	0.01	0.03
S	0.01	0.01	0.01	0.01	0.02	0.01	0.01	0.16
F	0.08	0.07	-	-	-	-	0.07	0.05
Total	99.65	98.86	99.99	100.00	100.01	100.00	99.18	99.69

- Not determined

NOTE: (26-27-31) porphyritic quartz monzodiorite; (28-29-30-32) porphyritic granodiorite; (33) inclusion of monzodiorite within the porphyritic biotite granodiorite

Table 1A (cont'd)

Analysis# Field#	34 (a) L-211-1	35 (b) L-45-3	36 (a) L-424-1	37 (b) L-46-1	38 (a) L-236	39 (a) L-333	40 (a) L-28	41 (a) L-142-1
SiO ₂	55.00	53.30	52.40	53.32	68.75	65.00	63.50	67.90
Al ₂ O ₃	13.90	17.46	13.40	13.14	14.40	14.75	16.10	14.75
Fe ₂ O ₃	2.05	2.13	2.85	2.27	0.60	1.21	1.55	1.12
FeO	5.40	6.70	6.30	7.08	1.85	2.65	2.30	1.40
MgO	5.95	4.26	7.50	8.08	1.85	2.87	1.50	0.90
CaO	7.80	6.58	7.20	7.55	2.55	4.10	3.50	2.40
Na ₂ O	3.47	4.63	3.30	2.63	4.90	5.00	4.96	4.80
K ₂ O	1.66	3.01	3.40	3.98	2.75	2.60	3.25	3.61
H ₂ O-	0.09	-	0.07	-	0.06	0.05	0.10	0.06
H ₂ O	1.81	-	1.70	-	1.15	1.05	0.95	0.92
TiO ₂	0.52	0.94	0.80	0.97	0.31	0.50	0.63	0.21
P ₂ O ₅	0.44	0.75	0.48	0.78	0.13	0.21	0.28	0.17
MnO	0.16	0.16	0.16	0.17	0.05	0.07	0.06	0.05
CO ₂	0.12	-	0.01	-	0.01	0.01	0.03	0.03
S	0.01	0.17	0.04	0.04	0.01	0.01	0.01	0.01
F	0.16	-	0.15	-	0.06	0.04	0.05	0.05
Total	98.54	100.09	99.76	100.01	98.43	100.12	98.77	98.38

- Not determined

NOTE: (34) inclusion of monzodiorite within the porphyritic biotite granodiorite; (35-36-37) mafic dykes cutting the porphyritic quartz monzodiorite; (38-39) biotite granodiorite; (40-41) porphyritic biotite granodiorite

Table 1A (cont'd)

Analysis#	(a)	(b)	(b)	(b)	(b)	(b)	(a)	(b)
Field#	L-211	L-63-1	43	44	45	46	47	49
	L-211	L-63-1	L-63-1	L-14-D	L-9A	L-5-D	L-46-2	L-57-1
SiO ₂	61.25	51.53	51.80	52.57	56.62	74.27	49.65	52.06
Al ₂ O ₃	16.90	12.24	12.07	13.79	13.64	14.70	17.50	14.59
Fe ₂ O ₃	1.69	2.44	2.30	2.18	1.62	0.15	1.60	2.54
FeO	3.15	7.60	7.19	6.82	5.05	0.47	8.45	7.91
MgO	1.96	10.35	11.39	8.34	7.87	0.19	6.00	9.67
CaO	4.21	9.14	9.65	8.79	5.93	1.20	10.70	9.42
Na ₂ O	4.95	2.09	3.20	4.23	5.24	4.80	2.20	1.78
K ₂ O	3.15	3.08	1.00	1.46	2.79	4.07	0.64	1.02
H ₂ O-	0.08	-	-	-	-	-	0.14	-
H ₂ O	1.16	-	-	-	-	-	1.70	-
TiO ₂	0.42	0.88	0.78	0.88	0.67	0.10	0.90	0.68
P ₂ O ₅	0.34	0.45	0.42	0.75	0.42	0.02	0.07	0.11
MnO	0.07	0.19	0.18	0.18	0.11	0.02	0.16	0.17
CO ₂	0.03	-	-	-	-	-	0.01	-
S	0.07	0.02	0.03	0.03	0.06	0.01	0.07	0.13
F	0.07	-	-	-	-	-	0.07	-
Total	99.50	100.01	100.01	100.02	100.02	100.00	99.85	100.08

- Not determined

NOTE: (42) porphyritic biotite granodiorite; (43-44-45-46) lamprophyres; (47) dyke of pink granite;
 (48-49) north-south striking diabase dyke

Table 1A (cont'd)
(b)

Analysis#	50
Field#	L-57-2
SiO ₂	51.75
Al ₂ O ₃	15.81
Fe ₂ O ₃	2.56
FeO	8.02
MgO	8.03
CaO	8.76
Na ₂ O	1.83
K ₂ O	2.13
H ₂ O-	-
H ₂ O	-
TiO ₂	0.74
P ₂ O ₅	0.12
MnO	0.17
CO ₂	-
S	0.14
F	-
Total	100.06

-: not determined

NOTE: (50) north-south striking diabase dyke

Appendix I
Table 1B CIPW normative mineralogy and Differentiation Index for rocks of Lac Rémigny

Analysis# Field#	1 L-72-1	2 L-72-3	3 L-204	4 L-206-1	5 L-206-9	6 L-237-2	7 L-96-A	8 CL-8
QUARTZ	0.0000	0.0000	0.0000	0.0000	0.0000	0.8663	0.0000	0.0000
CORUNDUM	0.8595	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
ORTHOCLASE	0.0000	0.0000	1.7333	0.0000	10.1789	3.7236	24.8832	20.8912
ALBITE	0.3384	0.5077	0.0000	0.0000	0.0000	78.6862	48.4809	49.0276
ANORTHITE	6.0710	9.2816	13.4876	10.3629	8.6695	2.2446	4.0900	2.4202
LEUCITE	0.0000	0.0000	4.2023	4.1710	7.8686	0.0000	0.0000	0.0000
NEPHELINE	0.0000	0.0000	12.1460	8.0210	9.5335	0.0000	0.0000	2.2247
DIOPSIDE	0.0000	1.1126	38.5120	37.3114	41.0642	8.4348	12.8728	14.8300
HYPERSTHENE	29.9319	24.2653	0.0000	0.0000	0.0000	3.4661	5.0066	0.0000
OLIVINE	51.0527	52.1415	15.7565	20.8507	11.5782	0.0000	1.0342	5.8825
MAGNETITE	4.0886	4.6830	6.5239	8.8438	6.9735	1.2323	1.5657	2.2907
ILMENITE	0.0000	0.3988	5.2272	3.1334	2.3738	0.7976	1.2153	0.9875
APATITE	0.0472	0.0472	2.0761	3.1849	4.3683	0.2595	0.8021	0.3303
PYRITE	0.3367	0.2058	0.0374	0.0935	0.0935	0.0561	0.0561	0.0187
CA-ORTHOSILICATE	0.0000	0.0000	0.0000	7.0221	0.0000	0.0000	0.0000	0.0000
DIFF. INDEX	0.3384	0.5077	18.0816	12.1920	27.5810	83.2761	73.3641	71.6435

NOTE: Normative mineralogy of both sets of analyses was calculated, free of volatile, using LEWORN program. Fe'''/Fe'' of QNOR analyses was converted to a ratio of 0.32 to conform to analyses of Holland. Analysis numbers and rocks names correspond respectively to those of Table 1A. The analyses are reproduced in the same form as quoted by the program; not all figures are necessarily significant.

Analysis# Field#	9 L-56-a	10 L-14	11 L-26	12 L-2	13 L-17-A	14 L-183-1	15 L-360	16 L-273
QUARTZ	9.0091	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.7519
CORUNDUM	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
ORTHOCLASE	22.2235	25.7107	11.6437	22.7554	15.1309	20.0957	19.5047	25.4152
ALBITE	61.0876	53.5747	0.9175	7.0180	20.4753	13.8685	27.5150	40.6122
ANORTHITE	2.9072	0.0000	13.5236	6.9668	9.4656	7.7555	11.2558	7.9161
LEUCITE	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
NEPHELINE	0.0000	2.8623	1.9322	7.4276	0.0000	0.6457	1.8241	0.0000
DIPOSIDE	1.4342	10.4572	45.1018	32.3295	25.8965	36.9101	16.4625	7.4822
HYPERSTHENE	2.2784	0.0000	0.0000	0.0000	3.7266	0.0000	0.0000	12.1901
OLIVINE	0.0000	2.9180	21.5729	17.1105	20.6408	9.8443	13.1443	0.0000
MAGNETITE	0.5509	0.0656	2.4936	2.7401	2.7401	2.5226	7.1174	2.0152
ILMENITE	0.3608	0.7596	1.5761	1.3293	1.4052	1.9749	1.5762	0.7976
APATITE	0.1180	0.3775	1.1088	0.5898	0.4954	2.8310	2.3592	0.7314
PYRITE	0.0374	0.0187	0.1496	0.0561	0.0374	0.0374	0.2058	0.0187
ACMITE	0.0000	2.5600	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
DIFF. INDEX	92.3201	82.1477	14.4934	37.2010	35.6062	34.6099	48.8437	66.7793

Analysis# Field#	17 L-343	18 L-380-2	19 L-5-A	20 L-4-A	21 L-493-1	22 L-481	23 L-45-1	24 CL-5
QUARTZ	5.3466	0.0000	0.0000	0.0000	3.5762	0.5783	11.9597	0.0000
CORUNDUM	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
ORTHOCLASE	19.0318	12.8258	22.8736	19.0318	16.2539	15.6628	15.2491	18.0270
ALBITE	44.3350	44.3350	45.0050	33.9725	44.4196	37.6509	35.5357	51.2313
ANORTHITE	9.8138	11.2780	6.7233	10.6617	11.1572	10.4040	13.1245	4.9159
LEUCITE	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
NEPHELINE	0.0000	0.0000	0.5537	0.2051	0.0000	0.0000	0.0000	0.6642
DIOPSIDE	7.3467	10.3058	14.0432	17.6141	8.0945	13.9879	3.4061	13.2002
HYPERSTHENE	8.7582	8.7571	0.0000	0.0000	10.8476	14.7397	16.9344	0.0000
OLIVINE	0.0000	6.6685	6.3246	11.5571	0.0000	0.0000	0.0000	6.4235
MEGNETITE	1.6673	2.2907	1.9137	2.9286	1.7397	2.1892	1.9572	1.8847
ILMENITE	0.7976	1.1964	1.2913	1.8420	0.7976	1.1964	1.0634	0.9495
APATITE	0.3775	0.7549	1.2504	2.1941	0.6134	0.8257	0.7078	0.6134
PYRITE	0.0374	0.0187	0.0561	0.0374	0.0187	0.0000	0.0748	0.0187
DIFF. INDEX	68.7134	57.1608	68.4324	53.2095	64.2497	53.8920	62.7445	69.9226

Analysis# Field#	25 L-K-2	26 L-484	27 L-489	28 L-R-2	29 L-46-5	30 L-45-10	31 L-47-1	32 L-223
QUARTZ	0.0000	11.4918	5.4677	11.1748	13.1546	9.4474	10.4679	8.7425
CORUNDUM	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
ORTHOCLASE	17.5542	16.0766	17.2587	17.6133	8.2747	15.1900	14.0670	17.7906
ALBITE	48.1424	40.6122	45.0119	40.8661	39.3431	40.4430	40.2738	41.8814
ANORTHITE	9.2148	10.4002	8.1578	11.2985	16.8281	11.9154	12.5118	10.0983
LEUCITE	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
NEPHELINE	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
DIOPSIDE	10.3923	7.0643	9.9042	3.7114	4.7662	7.8894	7.3710	7.5719
HYPERSTHENE	8.2681	9.1646	8.9513	12.4469	14.2154	11.7628	11.9298	9.2447
OLIVINE	2.4031	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
MAGNETITE	1.8993	1.4498	1.6673	1.4787	1.7542	1.7107	1.7107	1.5658
ILMENITE	1.1585	1.1964	0.7976	0.8925	1.0634	1.0065	1.0444	0.9875
APATITE	0.9201	0.5426	0.6134	0.4954	0.5898	0.6134	0.6134	0.5662
PYRITE	0.0561	0.0187	0.0187	0.0187	0.0187	0.0374	0.0187	0.0187
DIFF. INDEX	65.6966	68.1806	67.7382	69.6542	60.7724	65.0804	64.8087	68.4145

Analysis#	33	34	35	36	37	38	39	40
Field#	L-142-2	L-211-1	L-45-3	L-424-1	L-46-1	L-236	L-333	L-28
QUARTZ	0.0000	4.1558	0.0000	0.0000	0.0000	21.2923	13.4841	12.0243
CORUNDUM	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
ORTHOCLASE	11.2300	9.8114	17.7906	20.0952	23.5238	16.2539	15.3673	19.2091
ALBITE	36.8048	29.3593	36.3545	27.9209	22.2521	41.4583	42.3044	41.9660
ANORTHITE	18.2530	17.4537	17.9745	11.7125	12.2968	9.1806	10.1299	12.0733
LEUCITE	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
NEPHELINE	0.0000	0.0000	1.5273	0.0000	0.0000	0.0000	0.0000	0.0000
DIOPSIDE	11.2144	14.9390	8.0384	16.9609	16.2322	2.1276	7.1911	2.8794
HYPERSTHENE	12.4706	16.1806	0.0000	1.3498	9.9002	6.0810	7.8606	6.6647
OLIVINE	2.6624	0.0000	11.4335	14.2915	8.7799	0.0000	0.0000	0.0000
MAGNETITE	4.3785	2.6820	3.0880	3.3925	3.2910	0.8554	1.4353	1.5368
ILMENITE	1.9750	0.9874	1.7850	1.5192	1.8420	0.5887	0.9495	1.1964
APATITE	1.1324	1.0380	1.7694	1.1324	1.8402	0.3067	0.4954	0.6606
PYRITE	0.2993	0.0187	0.3180	0.0748	0.0748	0.0187	0.0187	0.0187
DIFF. INDEX	48.0348	43.3265	55.6724	48.0166	45.7759	79.0045	71.1558	73.1994

Analysis# Field#	41 L-142-1	42 L-211	43 L-63-1	44 L-14-D	45 L-9-A	46 L-5-D	47 L-46-2	48 L-237-1
QUARTZ	19.2411	7.7123	0.0000	0.0000	0.0000	0.0000	27.7045	1.8620
CORUNDUM	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.2661	0.0000
ORTHOCLASE	21.3369	18.6181	18.2043	5.9105	0.0000	16.4903	24.0557	3.7827
ALBITE	40.6122	41.8814	17.6832	27.0748	0.0000	41.6982	40.6122	18.6139
ANORTHITE	8.0441	14.5966	14.9229	15.6213	14.3334	5.4626	5.8229	35.9902
LEUCITE	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
NEPHELINE	0.0000	0.0000	0.0000	0.0000	19.3878	1.4284	0.0000	0.0000
DIOPSIDE	2.3077	3.3839	22.1471	23.6961	0.0000	17.0223	0.0000	13.5792
HYPERSTHENE	4.4002	8.8682	7.4090	7.9215	0.0000	0.0000	1.0637	18.0992
OLIVINE	0.0000	0.0000	13.3500	13.9334	21.9232	13.1969	0.0000	0.0000
MAGNETITE	1.0438	1.8558	3.5374	3.3345	3.1605	2.3486	0.2175	3.2330
ILMENITE	0.3988	0.7976	1.6711	1.4812	1.6711	1.2723	0.1899	1.7091
APATITE	0.4011	0.8026	1.0616	0.9909	1.7694	0.9909	0.0472	0.1651
PYRITE	0.0187	0.1309	0.0374	0.0561	0.0561	0.1122	0.0187	0.1309
KALIOPHILITE	0.0000	0.0000	0.0000	0.0000	4.9034	0.0000	0.0000	0.0000
CA-ORTHO-SILICATE	0.0000	0.0000	0.0000	0.0000	7.5458	0.0000	0.0000	0.0000
DIFF. INDEX	81.1903	68.2117	35.8876	32.9853	23.2912	59.6169	92.3725	24.2587

Analysis#	49	50
Field#	L-57-1	L-57-2
QUARTZ	2.0568	0.3802
CORUNDUM	0.0000	0.0000
ORTHOCLASE	6.0287	12.5894
ALBITE	15.0604	15.4834
ANORTHITE	28.8118	28.6378
LEUCITE	0.0000	0.0000
NEPHELINE	0.0000	0.0000
DIOPSIDE	13.9078	11.4106
HYPERSTHENE	28.7103	25.8671
OLIVINE	0.0000	0.0000
MAGNETITE	3.6824	3.7114
ILMENITE	1.2913	1.4053
APATITE	0.2595	0.2831
PYRITE	0.2432	0.2619
DIFF. INDEX	23.1459	28.4530

Appendix I
Table 1C Concentration in ppm (ppb for mercury) of trace-elements in rocks of Lac
Réminy

Analysis# Field#	1 L-72-1	2 L-72-3	3 L-204	4 L-206-1	5 L-206-9	6 L-237-2	7 L-96-A	8 CL-8
Cu	17	27	18	150	290	53	42	15
Zn	32	48	240	240	190	74	114	71
Pb	2	2	4	3	5	5	-	13
Ni	180	180	75	48	36	48	57	88
Co	78	84	40	44	37	7	-	15
Cr	1800	2000	300	46	34	22	147	165
V	63	66	360	560	450	38	-	100
Sr	3	2	7	6	5	2	-	2
As	0.2	0.2	0.4	0.9	0.7	0.3	-	0.5
Cd	0.2	0.2	0.2	0.2	0.2	0.2	-	0.2
Mo	2	2	2	2	2	2	-	2
U	2	2	2	2	2	2	-	2
Th	2	2	6	6	4	2	-	2
Ba	50	32	780	410	13400	3200	1537	2600
Li	6	4	10	12	9	34	-	14
Sr	18	26	770	890	3700	1900	1630	2300
Rb	-	-	-	-	-	-	69	-
Ag	0.2	0.2	0.2	0.2	0.2	0.2	-	0.2
Y	-	-	-	-	-	-	18	-
Zr	-	-	-	-	-	-	333	-
Nb	-	-	-	-	-	-	9	-
Hg	10	10	10	5	5	10	-	10
Ba/Sr			1.0	0.5	3.6	1.7	0.9	1.1

- Not determined

NOTE: analysis numbers correspond respectively to those of Table 1A. The analyses are reproduced in the form as quoted by the laboratory; not all figures are necessarily significant.

Table 1C (cont'd)

Analysis# Field#	9 L-56-A	10 L-14	11 L-26	12 L-2	13 L-17-A	14 L-183-1	15 L-360	16 L-273
Cu	13	17	15	220	9	120	44	48
Zn	56	56	72	99	121	77	130	73
Pb	-	3	-	4	-	6	11	15
Ni	23	24	187	220	376	69	28	54
Co	-	8	-	42	-	32	26	15
Cr	48	23	1113	1000	1397	400	33	73
V	-	59	-	170	-	120	170	81
Sn	-	2	-	2	-	3	3	2
As	-	0.3	-	0.2	-	0.2	0.2	0.2
Cd	-	0.2	-	0.2	-	0.2	0.2	0.2
Mo	-	2	-	2	-	2	2	2
U	-	2	-	2	-	2	2	2
Th	-	3	-	2	-	2	2	10
Ba	1106	1300	1320	2800	1855	3100	1600	1600
Li	-	2	-	14	-	30	13	9
Sr	1092	790	522	890	705	1100	1300	1100
Rb	115	-	66	-	78	-	-	-
Ag	-	0.2	-	0.2	-	0.2	0.2	0.2
Y	5	-	14	-	13	-	-	-
Zr	357	-	67	-	97	-	-	-
Nb	8	-	3	-	5	-	-	-
Hg	-	-	-	-	-	-	-	-
Ba/Sr	1.0	1.6	2.5	3.1	2.6	2.8	1.2	1.5

- Not determined

Table 1C (cont'd)

Analysis# Field#	17 L-343	18 L-380-2	19 L-5-A	20 L-4-A	21 L-493-1	22 L-481	23 L-45-1	24 CL-5
Cu	18	690	13	16	88	53	29	45
Zn	71	84	94	143	73	95	126	80
Pb	13	10	-	-	11	14	-	16
Ni	55	120	65	75	83	120	108	65
Co	12	28	-	-	15	25	-	74
Cr	52	500	169	176	80	500	370	58
V	78	140	-	-	94	120	-	84
Sn	2	2	-	-	3	2	-	2
As	0.2	0.2	-	-	0.2	0.2	-	0.6
Cd	0.2	0.2	-	-	0.2	0.2	-	0.2
Mo	2	2	-	-	2	2	-	2
U	2	2	-	-	2	2	-	2
Th	2	3	-	-	2	2	-	4
Ba	1800	450	3721	3729	2200	1800	784	2700
Li	26	86	-	-	28	37	-	9
Sr	1200	1500	2951	3154	1400	1200	933	1700
Rb	-	-	60	75	-	-	148	-
Ag	0.2	0.2	-	-	0.2	0.2	-	0.2
Y	-	-	17	26	-	-	18	-
Zr	-	-	77	167	-	-	139	-
Nb	-	-	3	3	-	-	7	-
Hg	10	10	-	-	5	5	-	10
Ba/Sr	1.5	0.3	1.3	1.2	1.6	1.5	0.8	1.6

- Not determined

Table 1C (cont'd)

Analysis Field#	25 L-K-2	26 L-484	27 L-489	28 L-R-2	29 L-46-5	30 L-45-10	31 L-47-1	32 L-223
Cu	35	8	33	4	13	4	4	210
Zn	106	76	70	89	125	87	96	81
Pb	-	13	12	-	-	-	-	12
Ni	80	56	62	66	85	76	75	100
Co	-	13	15	-	-	-	-	17
Cr	217	69	64	222	265	255	247	53
V	-	72	81	-	-	-	-	84
Sn	-	2	2	-	-	-	-	2
As	-	0.2	0.2	-	-	-	-	0.2
Cd	-	0.2	0.2	-	-	-	-	0.2
Mo	-	2	2	-	-	-	-	2
U	-	2	2	-	-	-	-	2
Th	-	2	2	-	-	-	-	3
Ba	2612	1800	1800	1853	1458	1550	1576	1900
Li	-	27	24	-	-	-	-	35
Sr	1701	1300	1500	1179	1335	1251	1349	1500
Rb	53	-	-	64	63	89	68	-
Ag	-	0.2	0.2	-	-	-	-	0.2
Y	17	-	-	11	14	17	14	-
Zr	254	-	-	146	155	160	151	-
Nb	7	-	-	8	6	7	9	-
Hg	-	5	5	-	-	-	-	5
Ba/Sr	1.5	1.4	1.2	1.6	1.1	1.2	1.2	1.3

- Not determined

Table 1C (cont'd)

Analysis# Field#	33 L-142-2	34 L-211-1	35 L-45-3	36 L-424-1	37 L-46-1	38 L-236	39 L-333	40 L-28
Cu	67	40	49	48	55	30	15	30
Zn	150	100	127	120	120	49	68	79
Pb	10	9	-	17	-	15	15	11
Ni	30	75	21	70	83	41	58	33
Co	26	25	-	30	-	8	14	10
Cr	16	400	28	400	221	52	61	21
V	220	160	-	180	-	38	66	66
Sn	4	4	-	4	-	2	2	2
As	0.4	0.2	-	0.2	-	0.2	0.2	0.2
Cd	0.2	0.2	-	0.2	-	0.2	0.2	0.2
Mo	2	2	-	2	-	2	2	2
U	2	2	-	2	-	2	2	2
Th	2	6	-	10	-	2	2	2
Ba	900	2400	1991	1400	2651	1500	1700	1100
Li	31	53	-	27	-	29	27	33
Sr	940	760	1792	880	899	960	1400	1200
Rb	-	-	121	-	109	-	-	-
Ag	0.2	0.2	-	0.2	-	0.2	0.2	0.2
Y	-	-	31	-	36	-	-	-
Zr	-	-	273	-	203	-	-	-
Nb	-	-	7	-	8	-	-	-
Hg	20	5	-	10	-	5	10	10
Ba/Sr	1.0	3.2	1.1	1.6	2.9	1.6	1.2	0.9

- Not determined

Table 1C (cont'd)

Analysis# Field#	41 L-142-1	42 L-211	43 L-63-1	44 L-14-D	45 L-9-A	46 L-5-D	47 L-46-2	48 L-237-1
Cu	27	73	20	83	46	124	3	130
Zn	55	90	121	144	166	94	19	84
Pb	15	16	-	-	-	-	-	2
Ni	23	28	105	159	80	118	6	120
Co	6	10	-	-	-	-	-	38
Cr	11	27	417	848	216	554	17	76
V	44	69	-	-	-	-	-	220
Sn	2	2	-	-	-	-	-	3
As	0.2	0.2	-	-	-	-	-	0.3
Cd	0.2	0.2	-	-	-	-	-	0.2
Mo	2	2	-	-	-	-	-	2
U	2	2	-	-	-	-	-	2
Th	5	2	-	-	-	-	-	2
Ba	1300	3200	1675	419	746	1608	1318	140
Li	30	29	-	-	-	-	-	10
Sr	890	1200	780	1006	1458	1176	438	220
Rb	-	-	99	29	32	81	134	-
Ag	0.2	0.2	-	-	-	-	-	0.2
Y	-	-	24	18	30	17	4	-
Zr	-	-	123	82	1239	135	68	-
Nb	-	-	6	4	10	7	6	-
Hg	10	5	-	-	-	-	-	5

Ba/Sr 1.5 2.7 2.1 0.4 0.5 1.4 3.0 0.6

- Not determined

Table 1C (cont'd)

Analysis# Field#	49 L-57-1	50 L-57-2
Cu	85	97
Zn	84	86
Pb	-	-
Ni	166	165
Co	-	-
Cr	602	264
V	-	-
Sn	-	-
As	-	-
Cd	-	-
Mo	-	-
U	-	-
Th	-	-
Ba	221	609
Li	-	-
Sr	189	311
Rb	43	126
Ag	-	-
Y	20	21
Zn	73	80
Nb	2	3

Hg	-	-
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Ba/Sr	1.2	2.0
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- Not determined

Appendix I

Table 1D: Modal mineral content (measured in volume percent) of rocks from Lac Réminny area. Four hundred (400) counts per stained slab.

SAMPLE#	QUARTZ	PLAGIOCLASE	K-FELDSPAR	MAFIC AND RELATED MINERALS	ROCK NAME
PONTIAC METASEDIMENTS					
1 L-8	25.00	39.50	-	35.50 (bio- musco)	Biotite quartzo-feldspathic gneiss
2 L-274	27.50	44.75	-	27.75 (" - ")	" " "
3 L-178	34.75	48.25	-	17.00 (" - ")	" " "
LAC FRECHETTE COMPLEX					
4 L-204	-	1.50	-	98.50 (hrn- px)	Hornblendite
5 L-204a	-	11.25	-	88.75 (" - ")	"
6 L-206-1	-	4.75	-	95.25 (" - ")	"
7 L-208	-	-	-	100.00 (px- hrn)	Hornblende pyroxenite
8 L-17-2	-	-	14.25	85.75 (hrn- px)	Lusitanite
9 L-206-9	-	-	28.00	72.00 (" - ")	"
10 L-206-10	-	-	36.50	63.50 (" - ")	"
11 L-206-2	-	16.50	21.25	62.75 (" - ")	Mela-monzonite
12 L-237-2	7.25	79.75	0.25	12.75 (px- hrn- bio)	Leuco-quartz-diorite
13 CL-33	1.25	48.50	29.50	20.75 (px- hrn)	Monzonite
14 CL-21	1.25	30.75	28.25	39.75 (" - ")	"
15 CL-22	tr	28.25	47.50	24.25 (px- hrn- bio)	Porphyritic monzonite

NOTE: -: not observed, tr: trace, px: pyroxene, hrn: hornblende, bio: biotite, musco: muscovite

Location of the samples appear on Figure 5-1 (map in pocket) Names after Streckelsen 1973
Mafic and related minerals appear in order of decreasing importance.

Table 1D: (cont'd)

SAMPLE#	QUARTZ	PLAGIOCLASE	K-FELDSPAR	MAFIC AND RELATED MINERALS	ROCK NAME
16 L-96	tr	51.00	27.00	22.00 (px-hrn-bio)	Pyrophyritic monzodiorite
17 L-108	tr	49.50	41.25	9.25 (" - " - ")	Pyrophyritic leuco-monzonite
18 L-19	tr	38.00	45.75	16.25 (" - " - ")	Pyrophyritic monzonite
19 L-200	-	65.25	7.75	27.00 (" - " - ")	Monzodiorite
20 CL-99	3.75	73.75	4.50	18.00 (" - " - ")	Leuco-diorite
21 CL-6	tr	40.25	32.00	27.75 (" - " - ")	Monzonite
22 CL-8	0.50	54.00	26.00	19.50 (" - " - ")	Monzodiorite
23 CL-19	tr	43.50	41.25	15.25 (" - " - ")	Monzonite
24 CL-27	-	44.75	40.50	14.75 (" - " - ")	"
25 L-14	tr	46.25	38.25	15.50 (hrn-px-bio)	"
26 L-56A	12.00	43.00	35.00	10.00 (hrn-bio)	Quartz-monzonite
27 CL-45	5.00	44.25	41.25	9.50 (hrn-px-bio)	"
28 L-230	18.25	46.25	21.50	14.00 (hrn-bio)	Pyrophyritic granodiorite
29 CL-40-1	16.50	58.25	17.25	8.00 (" - ")	Leuco-quartz monzodiorite
30 CL-67	21.25	44.00	25.50	9.25 (" - ")	Granite
31 CL-16	9.25	44.00	31.50	15.25 (" - ")	Quartz monzonite
32 CL-132	tr	40.75	59.25	tr (hrn-px-bio)	Leuco-monzonite
33 CL-66	15.50	40.00	29.50	15.00 (hrn-bio)	Quartz monzonite

NOTE: -: not observed, tr: trace, px: pyroxene, hrn: hornblende, bio: biotite

Table 1D: (cont'd)

SAMPLE#	QUARTZ	PLAGIOCLASE	K-FELDSPAR	MAFIC AND RELATED MINERALS	ROCK NAME
LAC REMIGNY COMPLEX					
34	L-170-2	-	18.00	37.74 44.25 (hmn - b1o)	Mela-syenite
35	L-217	1.25	34.25	10.00 54.50 (hmn - px - b1o)	Mela-monzodiorite
36	L-17-3	0	23.75	15.75 60.50 (" - " - ")	Mela-monzonite
37	L-424-5	-	14.25	26.25 59.50 (hmn - b1o)	" "
38	L-424-6	-	33.75	24.75 41.50 (" - ")	Monzonite
39	L-487-1	-	49.50	tr 50.50 (" - ")	Diorite
40	L-142-2	2.00	54.25	tr 43.75 (" - ")	"
41	L-273	tr	33.25	36.00 30.75 (hmn)	Monzonite
42	L-283	tr	34.75	16.25 49.00 (")	Monzodiorite
43	CL-7	tr	39.25	33.75 27.00 (hmn - b1o)	Monzonite
44	L-5-A	tr	44.50	22.24 33.25 (px - hmn - b1o)	Monzodiorite
45	CL-43-4	-	37.25	19.50 43.25 (hmn - b1o)	"
46	L-442	14.25	37.00	17.00 31.75 (" - ")	Quartz monzodiorite
47	CL-53-1	10.75	45.00	15.75 28.50 (" - ")	" "
48	L-481	tr	56.50	tr 43.50 (" - ")	Diorite
49	L-380-2	tr	48.75	tr 51.25 (" - ")	"
50	CL-66-4	-	27.75	- 72.25 (" - ")	Mela-diorite

NOTE: -: not observed, tr: trace, px: pyroxene, hm: hornblende, bio: biotite

Table 1D: (cont'd)

SAMPLE#	QUARTZ	PLAGIOCLASE	K-FELDSPAR	MAFIC AND RELATED MINERALS	ROCK NAME
51 L-342-5	2.00	37.25	22.50	38.25 (hrn - bio)	Monzonite
52 L-4-A	0.50	48.25	10.00	41.25 (px - hrn - bio)	Monzodiorite
53 L-4-A	tr	46.50	9.25	44.25 (" - " - ")	"
54 CL-54	19.50	35.25	17.75	27.50 (hrn - bio)	Granodiorite
55 CL-84	15.00	44.75	10.25	30.00 (" - ")	Quartz monzodiorite
56 CL-5-2	-	32.75	27.50	39.75 (" - ")	Monzonite
57 L-485	14.75	40.25	9.25	35.75 (" - ")	Quartz monzodiorite
58 L-493-1	12.50	44.75	14.50	28.25 (" - ")	"
59 L-494-1	15.25	40.25	10.50	34.00 (" - ")	"
60 L-293	9.25	41.25	20.75	28.75 (" - ")	"
61 L-3	tr	33.75	24.00	42.25 (hrn - px - bio)	Monzonite
62 L-490-3	16.25	39.00	23.75	21.00 (hrn - bio)	Quartz monzonite
63 CL-50	tr	57.25	22.50	21.25 (" - ")	Monzodiorite
64 L-505	2.50	30.25	17.75	49.50 (" - ")	Mela-monzonite
65 L-424-3	19.75	50.75	-	29.50 (" - ")	Tonalite
66 L-K-2	3.00	49.25	22.00	25.75 (" - ")	Porphyritic monzodiorite
67 CL-62	tr	49.75	8.25	32.00 (" - ")	"
68 CL-5-1	tr	47.75	16.25	36.00 (" - ")	"

NOTE: -: not observed, tr: trace, px: pyroxene, hrn: hornblende, bio: biotite

Table 1D: (cont'd)

SAMPLE#	QUARTZ	PLAGIOCLASE	K-FELDSPAR	MAFIC AND RELATED MINERALS	ROCK NAME
69 L-484	11.50	43.25	19.00	26.25 (hrn - bio)	Porphyritic quartz monzodiorite
70 L-45-1	10.00	44.75	19.25	26.00 (" - ")	"
71 L-489	11.25	44.75	15.00	29.00 (" - ")	"
72 L-330-1	15.75	51.75	6.00	26.50 (" - ")	Porphyritic granodiorite
73 L-R-2	17.50	47.25	15.25	20.00 (" - ")	"
74 CL-55-2	11.00	51.75	16.75	20.50 (" - ")	Porphyritic quartz monzodiorite
75 L-45-10	14.75	41.00	19.75	24.50 (" - ")	Porphyritic granodiorite
76 L-223	17.50	39.50	20.25	22.75 (" - ")	"
77 CL-55-1	16.25	44.00	19.75	20.00 (" - ")	"
78 L-47-1	15.00	42.75	18.25	24.00 (" - ")	Porphyritic quartz monzodiorite
79 L-46-5	18.25	44.50	10.25	27.00 (" - ")	Porphyritic granodiorite
80 L-236	26.00	45.75	11.25	17.00 (bio - hrn)	Granodiorite
81 L-212	19.75	58.00	-	22.25 (bio)	Tonalite
82 CL-63	24.50	38.00	14.75	22.75 (bio - hrn)	Porphyritic biotite granodiorite
83 L-28	21.50	50.25	12.00	16.25 (" - ")	"
84 CL-78-1	25.25	42.25	23.75	8.75 (" - ")	"
85 L-167	18.75	52.25	17.50	11.50 (" - ")	"
86 L-142-1	14.00	43.50	21.00	21.50 (" - ")	Porphyritic quartz monzodiorite

NOTE: -: not observed, hrn: hornblende, bio: biotite

Table 1D (cont'd)

SAMPLE#	QUARTZ	PLAGIOCLASE	K-FELDSPAR	MAFIC AND RELATED MINERALS	ROCK NAME
87 L-142-1	15.25	42.00	24.25	18.50 (blo - hrm)	Porphyritic quartz monzodiorite
88 L-142-1A	24.50	35.50	29.50	10.50 (" - ")	Porphyritic biotite granite
89 L-180	21.50	45.75	28.25	4.50 (" - ")	" " "
90 L-476-2	18.00	53.50	14.25	14.25 (" - ")	Porphyritic biotite granodiorite
91 CL-53-2	17.00	39.50	32.25	11.25 (" - ")	Porphyritic biotite granite
92 CL-55-3	20.75	46.25	22.50	10.50 (" - ")	" " "
93 CL-53-3	35.75	35.50	27.25	1.50 (" - ")	" " "
94 L-211	18.50	44.00	16.50	21.00 (" - ")	Porphyritic biotite granodiorite
95 L-211	19.75	42.50	18.50	19.25 (" - ")	" " "
96 CL-55-2A	12.75	63.50	13.00	10.75 (" - ")	Porphyritic quartz monzodiorite
97 L-399-1	-	41.25	-	58.75 (blo)	Lamprophyre
98 L-399-1A	24.25	5.75	61.25	8.75 (")	Alkali-feldspar granite
99 LC-3	23.75	29.75	31.25	15.25 (musco)	White granite
100 LC-7	38.25	46.50	9.75	5.50 (")	" "
101 LC-8	29.25	49.75	-	21.00 (")	Muscovite pegmatite
102 CL-2	34.25	25.00	36.50	4.25 (blo)	Grey granite
103 CL-89-1	30.00	36.25	33.75	tr (")	" "
104 CL-34-4	31.75	26.00	42.25	tr (")	Pink granite

NOTE: -: not observed, tr: trace, hrm: hornblende, blo: biotite, musco: muscovite

Table 1D: (cont'd)

SAMPLE#	QUARTZ	PLAGIOCLASE	K-FELDSPAR	MAFIC AND RELATED MINERALS	ROCK NAME
105 L-137	35.25	24.00	39.50	1.25 (blo)	Grey granite
106 L-45-2	26.75	34.75	31.00	7.50 ("	" "
107 CL-1-5	41.25	19.50	28.75	10.50 ("	Pink granite
108 CL-32	33.25	31.75	32.00	3.00 ("	Grey granite
109 LC-1	31.25	50.75	-	18.00 (musco)	Muscovite pegmatite
110 CL-34-3	42.25	39.25	18.50	tr (blo)	Biotite pegmatite
111 CL-39	35.00	29.50	33.50	2.00 (blo - musco)	Granite
112 L-133-2	30.25	54.00	9.25	6.50 (blo)	Granodiorite
113 L-46-2	30.00	33.75	33.25	3.00 ("	Pink granite
114 L-396	30.50	58.25	2.25	9.00 ("	Tonalite
115 L-211-2	37.25	42.50	-	20.25 (musco)	Muscovite pegmatite
116 CL-78-2	32.00	40.50	23.75	3.75 (blo)	Grey granite
117 LC-2	52.25	47.75	-	-	Leuco tonalite
118 L-R-2	36.00	31.50	29.75	2.75 (blo)	Pink granite
119 L-356-C	35.75	30.50	31.25	2.50 ("	" "

NOTE: -: not observed, tr: trace, blo: biotite, musco: muscovite

APPENDIX 11

TABLE 2A: Results of microprobe analyses (wt%) showing the compositions of feldspars within a representative sample of the porphyritic granodiorite of the Lac Rémigny Complex (Sample # LR-2).

	#1	#2	#3	#4
SiO ₂	60.71	58.19	60.78	60.66
Al ₂ O ₃	19.08	19.36	18.98	21.95
BaO	2.08	2.63	1.41	0.20
CaO	0.00	0.00	0.00	2.78
Na ₂ O	0.85	0.74	0.29	8.62
K ₂ O	15.12	14.52	16.44	6.03
TOTAL	97.84	95.44	97.90	100.25

NOTE: Microprobe work performed by P. Mainwaring. Analytical conditions are given in the text. The cores of the crystals were analysed:

- #1 Microcline megacryst, #2: microcline megacryst,
- #3 interstitial microcline from the matrix,
- #4 subhedral oligoclase from the matrix.

APPENDIX II

TABLE 2B: Numbers of ions in the formula of feldspars on the basis of 32 (O) and recalculated molecular percentage of An, Ab, Or components.

	#1	#2	#3	#4
Si	11.67	11.52	11.69	11.07
Al	4.32	4.51	4.30	4.72
Na	0.16	0.14	0.05	1.53
Ca	0.00	0.00	0.00	0.54
K	1.85	1.83	2.02	0.70
Ba	0.16	0.20	0.10	0.01
Or	92.6*	93.5*	97.7*	25.5*
Ab	7.4	6.5	2.3	55.0
An	0.0	0.0	0.0	19.5

* Ba is considered to substitute for K

NOTE: analysis numbers correspond respectively to those of Table 2A.
The procedure followed for calculation is described by Deer,
Howie and Zussman (1971) p. 515-517.

3 3

OF/DE

ARC-374

3d

N

LAC
REMIGNY
AREA

figure 5-1

• Sample Localities

Sample Localities

ECHELLE 1:50000 SCALE

9/9

79°15'

79°10'

79°05'

79°00'

2

40

40

65

42

60

20

40

40

48°00'

Lac
Fréchette

Barrière

119

79°05'

79°00'

78°55'

40 65 60 20 40

20

Barrière

Lac Caron

48°00'

24

N

4755

4750

34

LEGEND

NECES PLISTOCÈNES ET RÉCENTS

Sable, gravier et argile

PROTÉROZOÏQUE

Diabase, diabase à olivine

ARCHAÏEN

Roches intrusives

(COMPLEX III)

Lamprophyre

Pyroxène, granite et gabbro

M: muscovite

B: biotite

Granodiorite porphyroïde à biotite

Granodiorite à biotite

Granodiorite porphyroïde

Monzonite porphyroïde à quartz

Monzonite à quartz

Monzonite à hornblende

Monzonite

Pyroxénite à biotite

(COMPLEX IV)

Monzonite à quartz

LEGEND

PLEISTOCÈNE AND RECENT DEPOSITS

Sand, gravel and clay

PROTÉROZOÏC

Diabase, olivine diabase

ARCHAÏAN

Intrusive rocks

(COMPLEX)

Lamprophyre

Pyroxene, granite and gabbro

M: muscovite

B: biotite

Porphyritic biotite granodiorite

Biotite granodiorite

Porphyritic granodiorite

Porphyritic quartz monzonite

Quartz monzonite

Hornblende monzonite

Monzonite

Biotite pyroxenite

(COMPLEX)

LAC FRECHETTE

44

47°50'

47°50'

47°45'

47°45'

47°50'

47°45'

Monzonite à quartz
Monzonite à amphibole
Monzonite
Biotite à quartz

(COMPLEX III)

Monzonite à quartz
Monzonite à amphibole
Monzonite à amphibole
Biotite à quartz
Biotite
Monzonite à quartz
Monzonite

Roches sédimentaires et volcaniques

(GROUP III)

Quartzite, gneiss, schistes
Schistes à biotite et quartz
Schistes

Amphibolite

Gneiss à quartz et amphibole

12

LAC PROCHETTE

Quartz monzonite
Gneiss monzonite
Porphyritic monzonite
Leuco-quartz diorite
Lunite
Monzonite, hornblende
pyroxénite

POSTAL (II)

Biotite quartz-feldspathic
gneiss and biotite schist

Amphibolite
Ultrabasic flows

Quartz monzonite
Hornblende monzonite
Monzonite
Biotite pyroxénite

(COMPLEX)

Quartz monzonite
Gneiss monzonite
Porphyritic monzonite
Leuco-quartz diorite
Lunite
Monzonite, hornblende
pyroxénite

Sedimentary and volcanic
rocks

(GROUP)

Biotite quartz-feldspathic
gneiss and biotite schist

Amphibolite

Ultrabasic flows

MINERALISATION

- 1. Copper, iron
- 2. Molybdenite
- 3. Chrysotile
- 4. Columbite-tantalite
- 5. Chrysotile
- 6. Columbite-tantalite

MINERALISATION

- 1. Copper, iron, or 2. Copper, iron, gold
- 3. Iron
- 4. Iron
- 5. Iron
- 6. Iron

SYMBOLES CONVENTIONNELS

- Affleurements isolés
- Vers d'affleurements
- Contours géologiques connus
- Contours géologiques probables
- Litage: sommet déterminé et renversé
- Litage: sommet non déterminé (incliné, vertical, pendage non déterminé)
- Schistosité, gneissification, foliation (incliné, vertical, pendage non déterminé)
- Direction et plongement de la linéation
- Roches intrusives: -foliation (incliné, vertical, pendage non déterminé)

SYMBOLS

- Isolated outcrops
- Group of outcrops
- Known geological contacts
- Assumed geological contacts
- Bedding: top known and overturned
- Bedding: top not known (inclined, vertical, dip not known)
- Schistosity, gneissosity, foliation (inclined, vertical, dip not known)
- Trend and plunge of lineation
- Intrusive rocks: -foliation (inclined, vertical, dip not known)

67

LAC REMIGNY AREA

74

SCALE 1:50,000 ECHELLE

déterminé)		(inclined, vertical, dip not known)
Schistosité, gneissification, foliation (incliné, verticale, pendage non déterminé)		Schistosity, gneissosity, foliation (inclined, vertical, dip not known)
Direction et plongement de la linéation		Trend and plunge of lineation
Rockes intrusives:		Intrusive rocks:
-foliation (incliné, verticale, pendage non déterminé)		-foliation (incliné, vertical, dip not known)
-clivage de fracture (incliné, vertical, pendage non déterminé)		-fracture cleavage (inclined, vertical, dip not known)
-direction et plongement de la linéation		-trend and plunge of lineation
Direction et plongement des diaclases (inclinaison, verticale, horizontales)		Strike and dip of jointing (inclined vertical, horizontal)
Zones de cisaillement ou failles (connues, présumées)		Shear zones or faults (known, assumed)
Stries glaciaires		Glacial striae
Routes carrossables, sentiers		Roads all weather, trails
Pont		Bridge
Ligne de transport d'énergie électrique		Electric power line
Tranchées		Trenching

(1) units 1, 2 and 3 interlayered

848

3 Mi
Km

END

09 01.81

FIN