RG 2002-03

GEOLOGY OF THE FERME-NEUVE AREA (31J/11)

Pierre Lacoste

Accompanies map
SI-31J11-C3G-00K

View looking north at the Rock of Ages quarry in the Guénette granitic Suite.

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Québec

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Abstract

This geological mapping project at a scale of 1:50,000 in the Ferme-Neuve area (31J/11) forms the westward extension of a program encompassing map sheets 31J/10, 31J/14 and 31J/15.

The rocks belong to the "*Central Metasedimentary Belt*" of the Grenville Province. Several previously defined lithodemes extend from east to west, and a few new lithodemes were also introduced. The *Curières supracrustal Sequence*, which is part of the *L'Ascension metamorphic Suite*, constitutes the most important lithodeme in the map area. This sequence is formed of alternating layers of feldspar-biotite paragneiss, quartzite, paragneiss with sillimanite nodules, calcitic marble and graphite-rich paragneiss. This assemblage is intruded by m-scale gabbro sills (*Tic-Tac-Toc mafic intrusive Suite*) and white granite injections (*Lanthier Granite*) locally occurring as sills and dykes. Rocks of the *Lacoste intrusive Suite* were subsequently emplaced. The intrusive bodies that make up the *Chute-Saint-Philippe granitic Suite*, the *Lac-Saguay intrusive Suite*, the *Mont-Laurier monzonitic Suite* and the *Guénette granitic Suite* represent newly defined lithodemes in the area. The southeast corner of the map area is underlain by the *Sainte-Véronique Ring Complex*. Other minor intrusive bodies of variable composition and smaller size are also present.

The area is characterized by the presence of three structural fabrics. The ENE part of the map area contains large open folds with a shallow dip. In the west, the structural trend is essentially determined by the emplacement of intrusions and deformation zones.

The immediate vicinity of Guénette is well known for its quarries of pink granite used as monument stone, and of Val-Barrette, for its very white dolomitic and calcitic marbles used as aggregates. A few marble horizons appear pure enough in certain locations to form a source of agricultural lime to meet local needs, and a SEDEX-type zinc mineralization is associated with dolomitic marble, at the contact with commonly rusty diopsidite, especially in the eastern part of the map area. Furthermore, our work has revealed the presence of gabbro intrusions hosting traces of disseminated pyrite and pyrrhotite, as well as vast expanses of paragneiss outcrops containing at least 5% graphite. Finally, several zones offer potential for nepheline syenite.

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Director
Alain Simard

Head of the Service géologique de Québec
Pierre Verpaelst

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Robert Marquis

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Critical review
Claude Hébert, Kamal N.M. Sharma, Joanne Nadeau

Translation
Michelle Mainville

Editing and Page Layout
Jean-Pierre Lalonde
Kamal N.M. Sharma

Computer assisted drawing
Nathalie Drolet
Charlotte Grenier
Patrick Olivier
Katy Tremblay

Technical supervision
André Beaulé

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INTRODUCTION

Objectives

This geological report is based on mapping carried out in the Ferme-Neuve area (Mont-Laurier sector) at 1:50,000 scale, along the westward extension of mapping performed in 1996 (Hébert *et al.*, 1996 and 1997; Hébert and Nantel, 1999) in NTS sheet 31J/10. The project will eventually extend northward to cover map sheets 31J/14 and 31J/15 (Figure 1).

This project forms part of a larger program to map and update the central part of map sheet 31J. This area was selected based on the favourable setting for SEDEX-type zinc mineralization in dolomitic marbles. Stream sediment and lake sediment geochemistry surveys yielded anomalous zinc values (Choinière, 1990). A study of the heavy mineral component of certain sediment samples revealed the presence of gahnite, an indicator mineral for zinc.

The objective of the 1997 summer field program was to update the geological map. Furthermore, the map area is mostly known for its industrial mineral potential.

Location and Access

The study area covers a surface of 1,065 km², and corresponds to NTS sheet 31J/11 – latitudes 46° 30' to 46° 45' and longitudes 75° 00' to 75° 30'. It is located about 250 km northwest of Montréal (Figure 1). Highway 117, between

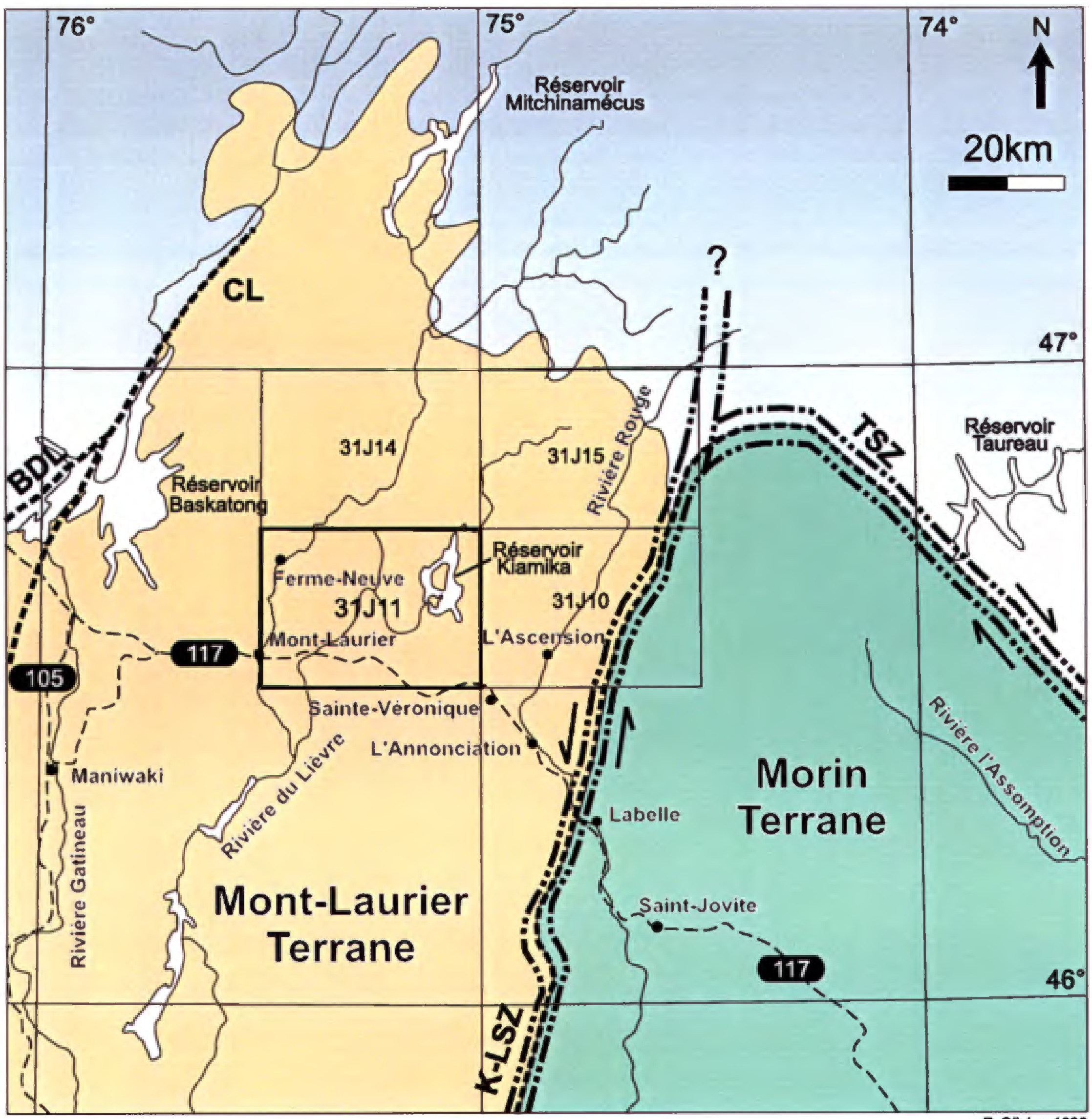


FIGURE 1 - Location of the Ferme-Neuve area (NTS sheet 31J/11) and its regional geological setting showing the Kinonge-Labelle shear zone (K-LSZ), the Taureau shear zone (TSZ), the Baskatong-Désert lineament (BDL) and the Cayament lineament (CL) (modified after Martignole and Friedman, 1998; Sharma *et al.*, 1998, 1999).

Montréal and the Abitibi region, crosses the south part of the map area from east to west. Several secondary roads provide easy access to the area, and numerous logging roads and farm lands provide access to outcropping areas. Several towns and villages are located on or near Hwy 117; Mont-Laurier sits at the western edge of the map area, whereas Sainte-Véronique is in the east, and Ferme-Neuve in the northwest. The other important communities are Lac-Saguay, Guénette and Val-Barrette. The main water bodies in the area are Lac des Écorces, Lac Gauvin, Lac Saint-Paul, Lac David, Lac des Cornes and the Réservoir Kiamika. The Rivière du Lièvre, which flows from the NE of Ferme-Neuve towards Mont-Laurier, and the Rivière Kiamika, which flows from the Réservoir Kiamika to the Lac des Écorces, are the two main waterways. Several other smaller lakes and rivers are scattered throughout the area. The topographic relief is moderate in the eastern half, but is much flatter towards the northwest.

Methodology

Field mapping, carried out during the summer 1997 at 1:50,000 scale, was greatly facilitated by the dense network of roads and various trails accessible with all-terrain vehicles. Furthermore, the shores of the Réservoir Kiamika offer vast outcropping sections accessible by boat. A few sectors, such as the centre and NW corner of the map area, are however devoid of outcrops, especially where sand and gravel deposits are dominant.

About twenty stream sediment samples were collected in the immediate vicinity of Sainte-Véronique, in the southeast partof the map area, in order to complete the geochemical inventory of the area.

Sodium cobaltinitrite staining (to identify feldspars) was systematically performed on all rock samples collected in the field in order to define the principal rock types.

Data from previous work (geochemistry, geophysics, satellite images, geology and geochronology) were integrated with newly collected data. All this geoscience information is contained in the SIGÉOM database of the Ministère des Ressources Naturelles du Québec. The geological map (31J/11) was also digitized and integrated to SIGÉOM.

Previous Work

The area was mapped by Wynne-Edwards *et al.* (1966) at 1:250,000 scale. The southeastern part of the map area (Sainte-Véronique sector) was mapped by Rive (1976). Furthermore, a thin band, located in the south part of map sheet 31J/11, is included in the work of Aubert De La Rue (1948) at a scale of 1:63,360. NTS sheets located to the south (respectively 31J/06 and 31J/03) were mapped by the Geological Survey of Canada (Corriveau and Jourdain, 1993; Corriveau and Madore, 1994), and several other studies were carried out to the southwest by the Ministère des Ressources Naturelles (in 31F and 31K) by Madore *et al.* (1994 and 1996). The immediate vicinity, near Highway 117 (Figure 1), contains road cuts that were examined many times over by several geologists during various studies, field trips or geological meetings (Laurin *et al.*, 1972; Laurin and Sharma, 1975; Indares and Martignole, 1985, 1989 and 1990; Sharma *et al.*, 1993; Corriveau *et al.*, 1995 and 1997; Easton, 1992; Hocq, 1994; Davidson, 1995). A stream sediment survey was conducted by Choinière (1990). In the immediate vicinity of Mont-Laurier, mineral exploration and prospecting work for industrial mineral substances has been ongoing, from the turn of the 20th century up until today.

Acknowledgements

We wish to thank the geologists of our 1997 field crew for their cooperation, namely Joanne Nadeau, Suzie Nantel and Robert Marquis. We also wish to thank the other members of the team, namely students Ian Chartrand (McGill), Patrice Lampron (UQAM) and Bernard Olivier Martel (UQAM), who showed a great spirit of cooperation in performing various tasks in the field, as well as our cook, Jean-Paul Delanay, who also carried out a few daily chores. We also wish to thank our colleague Claude Hébert for his input in various discussions about the map. We also extend our gratitude to our colleague Kamal N.M. Sharma, for lending us information concerning the lineament interpretations from the satellite images, as well as Michel Hocq, for the petrographic description of thin sections.

We would like to acknowledge the work of Patrick Olivier, of the Montréal office, for all the technical support and the production of figures.

GENERAL GEOLOGY

The rocks in the map area are part of the *Allochthonous Monocyclic Belt*, according to the Grenville geological Province subdivision proposed by Rivers *et al.* (1989).

The area is essentially included in the *Mont-Laurier Terrane* (Figure 1), which corresponds to the *Central Metasedimentary Belt* as defined by Wynne-Edwards (1972).

Supracrustal rocks occupy nearly half the surface area of the map area. They are mainly composed of paragneiss, quartzite, marble, calc-silicate rock and amphibolite. These rocks form different assemblages grouped under the heading "*L'Ascension metamorphic Suite*" (Hébert and Nantel, 1999). This suite is composed of two distinct sequences; the first outcrops east of the Rivière Rouge (NTS 31J/10) and is named the *Rouge-Mattawin supracrustal Sequence*. The second sequence, the only one outcropping in map sheet 31J/11, is located west of the Rivière Rouge, and bears the name *Curières supracrustal Sequence*.

Gabbro sills assigned to the *Tic-Tac-Toc mafic intrusive Suite* as well as to the *Lac-Saguay intrusive Suite* intrude rocks of the *Curières supracrustal Sequence*. Rocks of the *Lacoste intrusive Suite*, composed of orthogneisses and resembling grey gneisses, constitute a restricted lithological unit that essentially outcrops in the NE and SE corners of the map area. In the NE part of the area, more or less porphyritic granitic to monzonitic gneisses are observed; these rocks scarcely outcrop and were not grouped under a lithodemic unit. Other types of intrusive rocks were also identified in the area, listed here in chronological order regarding their emplacement: 1) an anorthosite-gabbro-norite-leuconorite-monzonite-porphyritic granite assemblage that we associate with the *Morin AMCG intrusive Suite* (31J/10); 2) the *Lanthier Granite*; 3) the *Chute-Saint-Philippe granitic Suite*, 4) syenitic rocks of the *Sainte-Véronique Ring Complex*, 5) the *Mont-Laurier monzonitic Suite* and 6) the *Guénette granitic Suite*. Other smaller intrusive units were also mapped but were not given a lithodemic name.

From a structural standpoint, the effects of the *Labelle shear zone* (LSZ) (Martignole and Corriveau, 1991 and 1993), also known as the *Kinonge-Labelle shear zone* (K-LSZ) (Sharma *et al.*, 1998 and 1999) are minor (Figure 1). The shear zone somewhat obliterates an earlier fabric associated with a previous thrusting episode. The orientation of the tectonic trend in map sheet 31J/11 is rather strongly influenced by the emplacement of the numerous intrusive units.

Known isotopic ages (U-Pb zircon ages) (Figure 2) for lithodemes or tectonic events present within NTS sheet 31J/11 are: 1346 Ma for grey gneisses of the *Lacoste intrusive Suite* (Hébert and Nantel, 1999), 1165 Ma to 1135 Ma for the *Morin AMCG Suite* (Emslie and Hunt, 1990; Doig, 1991; Friedman and Martignole, 1995), *ca.* 1081 Ma and 1076 Ma for the *Sainte-Véronique Ring Complex* (Corriveau *et al.*, 1990), 1063 to 1054 Ma for the *Guénette granitic Suite* (Friedman and Martignole, 1995; Corriveau *et al.*, 1996), and a minimum age of 1078 Ma (Martignole and Friedman, 1998) for the *Kinonge-Labelle shear zone*. Furthermore, metamorphic ages for the area are bracketed between 1180 and 1165 Ma (Friedman and Martignole, 1995; Corriveau *et al.*, 1990).

DESCRIPTION OF UNITS

Whenever possible, we used the same terminology as that used previously in map sheet 31J/10 to the east (Hébert *et al.*, 1996; Hébert and Nantel, 1999), when describing equivalent lithodemes, in order to standardize information. Thus, for several lithodemes that extend from east to west, we have used descriptions taken from the latter report (RG 99-03).

All the rocks are Mesoproterozoic in age (mP) (Figure 2), and the oldest correspond to supracrustal rocks of the *L'Ascension metamorphic Suite*. Rocks of the *Curières supracrustal Sequence*, belonging to the *L'Ascension metamorphic Suite*, were invaded by gabbro and pyroxenite sills of the *Tic-Tac-Toc mafic intrusive Suite*. Furthermore, orthogneisses of the *Lacoste intrusive Suite* intrude the assemblage formed of supracrustal rocks of the *L'Ascension metamorphic Suite* and gabbro sills of the *Tic-Tac-Toc mafic intrusive Suite*. Eastward, the *Lanthier Granite* was introduced in the supracrustal rock and grey gneiss sequence. The latest magmatic events correspond to the emplacement of the *Lac-Saguay intrusive Suite*, the *Chute-Saint-Philippe granitic Suite*, the *Sainte-Véronique Ring Complex*, the *Mont-Laurier monzonitic Suite* and the *Guénette granitic Suite* (Figure 3).

L'Ascension Metamorphic Suite

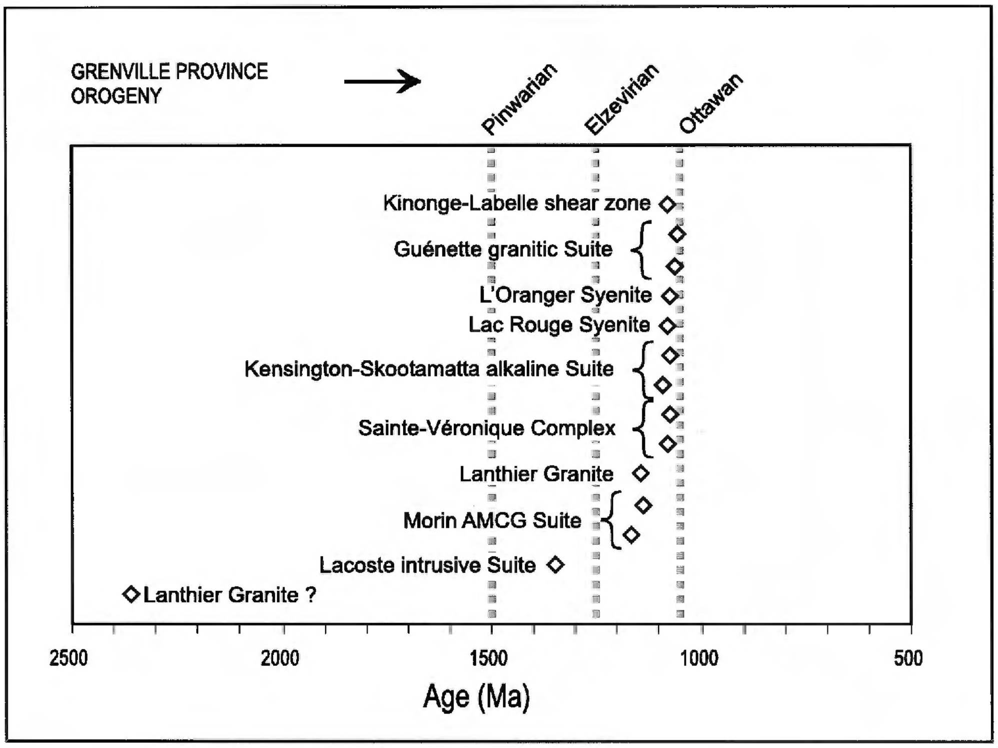
The *L'Ascension metamorphic Suite* was previously described in NTS sheet 31J/10 (Hébert and Nantel, 1999), where it consists of two supracrustal rock sequences. These are the *Rouge-Mattawin supracrustal Sequence* (mPwin) and the *Curières supracrustal Sequence* (mPcur). In NTS sheet 31J/11, only the *Curières supracrustal Sequence* (mPcur) is present and will be described below. The *Curières supracrustal Sequence* is composed of various units represented by one or several lithologies (for example: *carbonate* unit or *paragneiss and carbonate* unit). The characteristic name of each unit is based on the dominant lithology. Furthermore, certain units may contain one or several sub-units (for example: unit mPcur2 is subdivided into two sub-units, mPcur2a and mPcur2b).

Curières supracrustal sequence (mPcur)

The *Curières supracrustal Sequence* represents the dominant lithodeme in the map area (Figure 3). It is geographically divided into three units. The first (mPcur1) mainly outcrops in the central part of the area. The second (mPcur2) is concentrated in the NE corner of the map area. The third unit (mPcur3) is located in the SW corner of the map area.

Paragneiss, Quartzite and Carbonate Unit (mPcur1)

This unit, as in map sheet 31J/10, is composed of three sub-units, namely the paragneiss sub-unit, the quartzite sub-unit and the carbonate sub-unit (Hébert and Nantel, 1999). However, these could not be represented individually on the 31J/11 map given their rapid variation, restricted extent and the scale of mapping. We can mention, however, that quartzites are more abundant in the NE part of the map area, and also that marbles increase westward. Proximal to the *Lanthier Granite* (mPlat) or other large intrusive bodies, the amount of granitic mobilizate increases in supracrustal



Age (Ma)	Lithodeme / Geological Event	Reference
2357±131	Lanthier Granite (lat)	Hébert and Nantel, 1999
1346±27	Lacoste intrusive Suite (lac)	Hébert and Nantel, 1999
1165±11	Morin AMCG Suite (mor)	Emslie and Hunt, 1990; Doig, 1991; Friedman and Martignole, 1995
1135±3	Morin AMCG Suite (mor)	Emslie and Hunt, 1990; Doig, 1991; Friedman and Martignole, 1995
1143±55	Lanthier Granite (lat)	Hébert and Nantel, 1999
1081±2	Sainte-Véronique Complex (csv)	Corriveau *et al.* 1990
1076±3	Sainte-Véronique Complex (csv)	Corriveau *et al.* 1990
1090±2	Kensington-Skootamatta alkaline Suite	Corriveau *et al.* 1996
1076±2	Kensington-Skootamatta alkaline Suite	Corriveau *et al.* 1996
1081±2	Lac Rouge Syenite	Corriveau *et al.* 1990
1076±3	Loranger Syenite	Corriveau *et al.* 1990
1063±4	Guénette granitic Suite (gué)	Friedman and Martignole, 1995
1054±2	Guénette granitic Suite (gué)	Corriveau *et al.* 1996
1078±6	Kinonge-Labelle shear zone (KLSZ)	Martignole and Friedman, 1998

FIGURE 2 - A few ages for the main lithodemes and tectonic events occurring in the immediate viccinity of NTS sheet 31J/11.

rocks, until the latter are finally partially to completely digested.

The *paragneiss sub-unit* of unit mPcur1 is the most characteristic of the *Curières supracrustal Sequence*, representing over 65% of the rocks in this sequence (Appendix 1, photo 1). It consists of quartz-rich paragneiss and fine-grained quartzite in thinly layered beds (3 to 4 cm), with grey or rusty feldspathic biotite paragneisses. It also contains the most distinctive rocks in the sequence, namely nodular biotite-fibrolite-muscovite paragneisses, as well as rare tourmalinites. Hébert and Nantel (1999) used the term "sub-facies" to describe this sub-unit.

Feldspathic biotite paragneisses mainly consist of orthoclase, plagioclase and biotite (20-25%), and rusty gneisses contain traces of pyrite, disseminated or concentrated in laminations parallel to bedding. Scapolite is occasionally observed in these rocks.

Quartz-rich paragneisses contrast with feldspathic biotite paragneisses due to their higher quartz content and lower biotite content. These quartz-rich and feldspathic paragneisses contain less than 5% muscovite, and a few samples reveal about 1% green tourmaline of the schorlite variety.

Nodular biotite-fibrolite-muscovite paragneisses form less than 5% of the paragneiss sub-unit assemblage (Appendix 1, photo 2), and occur as 1 to 10-cm thick beds. Each nodule consists of a single large muscovite crystal (5 mm) partially or completely replaced by fibrolite or by an assemblage of fibrolite and orthoclase. These nodules may form up to 25% of the rock. The muscovite has completely disappeared,

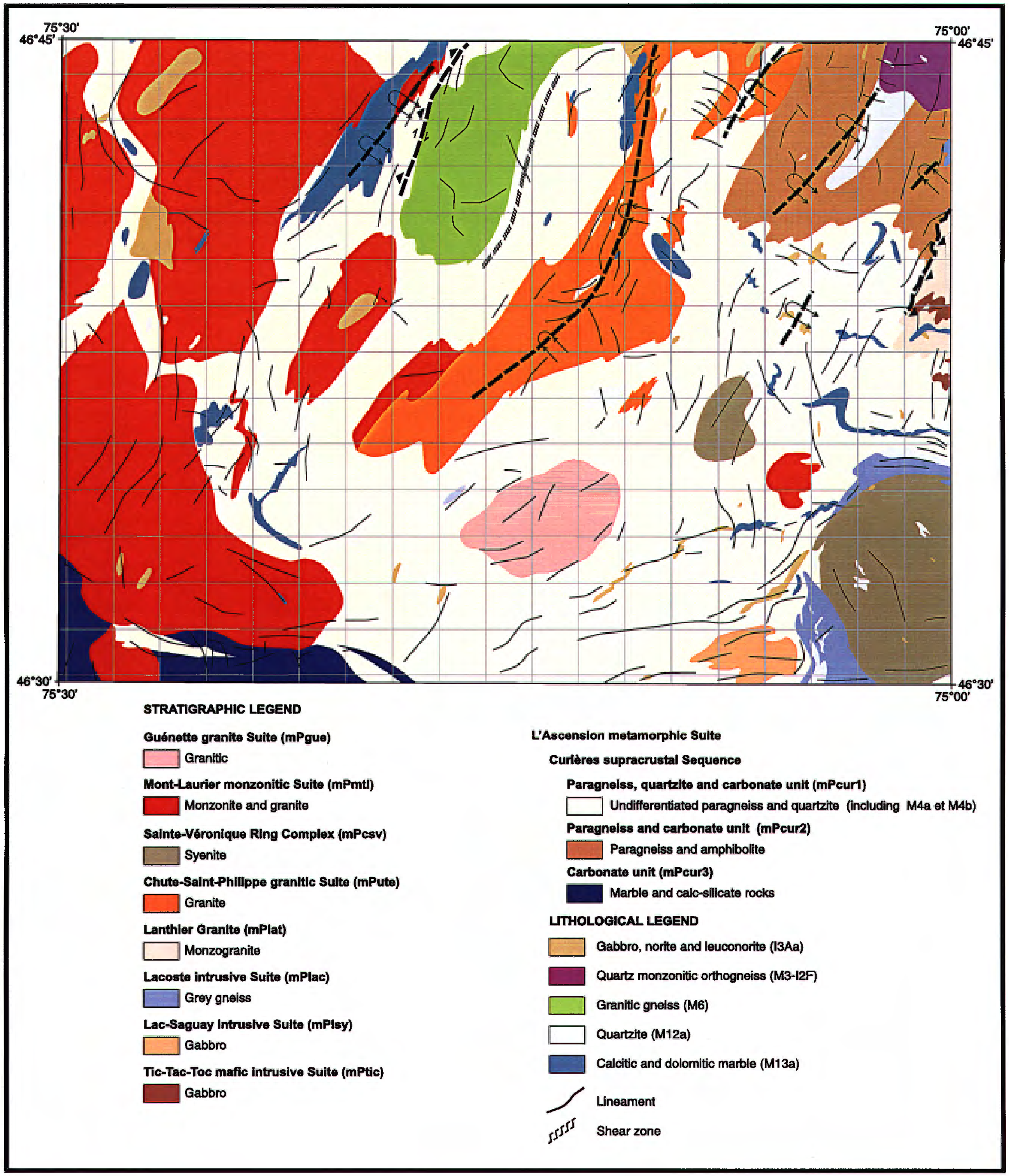


FIGURE 3 - Simplified geology of the Ferme-Neuve area (NTS sheet 31J/11) as well as some of the observed lineaments.

replaced by sillimanite and recrystallized quartz in more deformed zones. The groundmass supporting these large muscovite crystals always includes quartz (1-80%), biotite (2-50%), muscovite (2-10%), graphite (trace to 5%), tourmaline (trace to 5%) and zircon (trace). It also contains K-feldspar (0-25%) and/or plagioclase (0-25%) although the two types of feldspar may be completely absent. K-feldspars consist of microcline and/or orthoclase with or without perthite. Locally, mesoperthite and plagioclase form porphyroblasts riddled with small inclusions of graphite, biotite, muscovite and tourmaline. Traces of rutile and apatite are also present. Biotite is often brown-red, indicating a titaniferous composition. The muscovite in the groundmass is parallel to the biotite, except where it forms large crystals oblique to this alignment direction.

A study of tourmalines throughout the Mont-Laurier basin has demonstrated a systematic correlation between the composition and the colour of tourmaline. Olive green tourmalines correspond to the schorlite-dravite variety, whereas orange tourmalines fall in the dravite variety (Nantel, 1994a).

As opposed to map sheet 31J/10 (Hébert and Nantel, 1999), where sillimanite and fibrolite only occur in nodular paragneisses, we identified in the field (31J/11) zones of feldspathic paragneiss that contained up to 25% of these minerals. These grey-black feldspathic paragneisses with a brownish weathered surface are associated with strongly deformed zones (Appendix 1, photo 3). The *Curières supracrustal Sequence* (mPcur1) is also characterized by the nearly complete absence of garnet, except in rare biotite paragneisses that rarely contain more than 5%.

The *quartzite sub-unit* of unit mPcur1 represents about 20 to 25% of the *Curières supracrustal Sequence*. It consists of more than 85% m-scale beds of quartzite interbedded with less than 10% rusty feldspathic or quartz-rich paragneisses that contain minor biotite and muscovite. The quartzites are medium grey, and coarse to medium-grained (Appendix 1, photos 4 and 5). In thin sections of quartz-rich paragneiss, biotite is transformed into chlorite with rutile inclusions. Small (<1 mm) altered feldspar crystals are often disseminated in the quartzite.

Along the margins of the *Lanthier Granite* (mPlat) and other large intrusive bodies, it becomes difficult to distinguish the quartzite from the granite due to mixing and the degree of partial melting of the rock.

The *carbonate sub-unit* of unit mPcur1 forms less than 5% of the *Curières supracrustal Sequence*, as in map sheet 31J/10 further east (Hébert and Nantel, 1999). Typical rock types include rusty graphite-bearing calc-silicate rocks, and calcitic marbles with diopside and phlogopite.

All the rocks in this carbonate sub-unit occur as cm-scale beds. Marble units outcropping in the eastern part of the map area, between the *Sainte-Véronique Ring Complex* (mPcsv) and the *Lanthier Granite* (mPlat) host graphite deposits (Hubert and Parent, 1994). They are characterized by clinopyroxene porphyroblasts and cordierite, that are particularly abundant at the contact with metasediments (Simandl, 1992). Graphite occurs as inclusions in the porphyroblasts, but is also disseminated between calcite crystals.

Paragneiss and Carbonate Unit (mPcur2)

The second unit of the *Curières supracrustal Sequence* is mainly characterized by a sub-unit of paragneiss and amphibolite (mPcur2a). It also includes a minor quantity of marble and calc-silicate rock (mPcur2b). As is the case for rocks in unit mPcur1, these supracrustal rocks become more and more migmatitic as they approach the *Lanthier Granite* (mPlat) to finally form an assemblage sometimes resembling an intrusive breccia (Hébert and Nantel, 1999).

Paragneiss and Amphibolite (mPcur2a)

These light grey paragneisses are generally banded and essentially contain quartz, feldspar and biotite (Appendix 1, photo 6). A few horizons are rusty. Garnet is fairly rare overall.

Compared to the eastern map area (31J/10), garnet amphibolites are less commonly observed. Amphibolites represent less than 25% of this sub-unit. They are grey-black, fine-grained and often form more or less dissected boudins within paragneiss sequences, or highly folded horizons less than 40 cm thick (Appendix 1, photos 7 and 8). Thin quartzite beds are occasionally associated.

Marble and Calc-Silicate Rock (mPcur2b)

These calcitic marbles are white and medium to coarse-grained; coarse-grained olivine marbles are locally present. These marbles, when they are not distinctly calcitic-dolomitic, containnumerous xenoliths a few centimetres in size and of various origins (quartzite, paragneiss, calc-silicate rock). Calc-silicate rocks, not abundant, mainly consist of diopsidites. In the northeastern part of the map area, the proportion of calc-silicate rocks increases near marble units (mPcur2b). These calc-silicate rocks consist of highly variable mineral assemblages; the most common constituents are quartz, plagioclase, orthoclase, diopside, scapolite, carbonate, garnet, amphibole, sphene, epidote and allanite.

Carbonate Unit (mPcur3)

We have inserted a third unit in the *Curières supracrustal Sequence* in order to define the *Val-Barrette Marble Zone* more accurately. This zone, located south of the town of Mont-Laurier, is mainly composed of homogeneous calcitic and dolomitic marble with a high brightness index. We defined four sub-units (*mPcur3a to mPcur3d*) in this area (see SIGÉOM map).

The first sub-unit (mPcur3a) corresponds to the principal marble zone in the Val-Barrette area. Vast outcropping areas are present. The rock is coarse-grained and milky white.

Zones of calc-silicate rocks and greenish brown serpentine are observed in a few locations. These marbles also contain traces of diopside, mica (phlogopite), scapolite and graphite.

The second sub-unit (mPcur3b) corresponds to rocks found on either side of sub-unit mPcur3a. This assemblage is almost exclusively composed of banded biotite and/or hornblende paragneiss, with rare quartzite horizons. Within these paragneisses, in addition to their principal mineral constituents such as quartz and feldspar, the presence of garnet, sillimanite, graphite and occasional traces of pyrite is noted.

The third sub-unit (mPcur3c) consists of marble and calc-silicate rock that locally contain a few zones of paragneiss and quartzite.

The fourth sub-unit (mPcur3d) contrasts with the previous sub-unit due to the presence of metasomatic rocks containing pyroxene, sphene and apatite. These metasomatic rocks are probably the result of the emplacement of the *Mont-Laurier monzonitic Suite*.

Tic-Tac-Toc Mafic Intrusive Suite (mPtic)

Amphibole-bearing gabbro sills of the *Tic-Tac-Toc mafic intrusive Suite* (mPtic) (Hébert and Nantel, 1999) cross-cut the *Curières supracrustal Sequence* (mPcur) and the *Lanthier Granite* (mPlat). These sills range from a few tens of metres to a few hundred metres in thickness.

Typical outcrops of this suite are found in the eastern part of the map area (Figure 3), where they form small outcropping areas. Evidence of magmatic differentiation is sometimes visible in the thicker sills. In fact, a well-developed magmatic layering is exposed in an area located east of Lac Frasier (eastern shore of Réservoir Kiamika).

The gabbro consists of plagioclase (30-60%), amphibole (40-60%), biotite (< 5%), garnet (0-5%) and traces of quartz. In thin section, the amphiboles are generally hypidiomorphic to idiomorphic, dark green or pale green, and generally contain small quartz inclusions. Plagioclase shows a mosaic granoblastic texture, a clear evidence of recrystallization. Brown biotite (trace) occurs as small aggregates. Garnet is xenomorphic, and often contains quartz inclusions. Quartz is generally disseminated in the rock, or occurs as small inclusions in crystals. Accessory minerals account for less than 2% of the mineral assemblage, and essentially consist of apatite, sphene and ilmenite.

These gabbro sills only intrude rocks of the *Curières supracrustal Sequence* (mPcur), and almost exclusively unit mPcur1. They were not reported by Hébert and Nantel (1999) in the *Rouge-Mattawin supracrustal Sequence* (mPwin).

Lac-Saguay Intrusive Suite (mPlsy)

The *Lac-Saguay intrusive Suite* (mPlsy) is a new unit in the area, and corresponds to a geographically restricted unit. It consists of a km-scale roughly rounded body located southwest of the town of Sainte-Véronique. This intrusive suite is composed of amphibole-bearing gabbro sills. Texturally, it is fine to medium-grained, homogeneous and massive. Partially sericitized plagioclase phenocrysts are present, along with hornblende and biotite. The mineral assemblage also contains pyroxene and magnetite.

In the east-central and southeastern parts of the map area, m-scale gabbroic horizons that we have identified under the heading *I3Aa* display glomeroporphyritic textures. These gabbros resemble those described eastward in the *Tic-Tac-Toc mafic intrusive Suite* (Hébert and Nantel, 1999). The rock is composed of pale green amphibole oikocrysts riddled with small inclusions of quartz and opaque minerals, or of amphibole aggregates in replacement of these oikocrysts. Amphibole grains in the aggregates are monoclinic and finely twinned; they are colourless in the centre of the aggregates and pale green along the margins. The aggregates themselves are surrounded by a string of small garnet and biotite grains. They lie with the oikocrysts in a groundmass composed of plagioclase prisms that do not display any sign of deformation.

The texture of plagioclase grains and oikocrysts confirms the magmatic origin of the glomeroporphyritic gabbros, and by extension, of all amphibole-bearing stratiform rocks, since there is a gradual transition between the two rock types (Hébert and Nantel, 1999).

It would be interesting to study the nature and possible relationship existing between this type of glomeroporphyritic gabbro and those in the *Tic-Tac-Toc mafic intrusive Suite*, where nodular gabbros were also described locally (Hébert and Nantel, 1999) as well as the different horizons or types of amphibolite outcropping throughout the area.

Lacoste Intrusive Suite (mPlac)

The term "*Lacoste Series*" was originally introduced by Osborne (1935), and we later proposed to rename it the "*Lacoste intermediate to felsic intrusive Suite*" (Hébert *et al.*, 1997). This suite is now called the *Lacoste intrusive Suite* (Hébert and Nantel, 1999). It mainly consists of grey gneisses of intermediate composition, such as quartz monzonite, quartz diorite and monzodiorite. More felsic phases are also present, namely monzogranite, quartz syenite, tonalite and granodiorite.

The *Lacoste intrusive Suite* does not outcrop much in map area 31J/11. It essentially occurs in the southeast corner of the map area, along the western margin of the *Sainte-Véronique Ring Complex*. It also forms a small body north of the *Lanthier Granite*.

Intermediate to felsic rocks are light grey to dark grey, and medium to fine-grained. They are generally gneissic, and occasionally display a migmatitic aspect. These rocks are for the most part composed of quartz, microcline and plagioclase. Traces (< 2%) of biotite, muscovite, sphene, apatite and allanite are observed. The rocks display a porphyroid or granoblastic texture. Microcline is sometimes perthitic, and plagioclase is weakly zoned. Biotite is dark brown. Relics of clinopyroxene and/or green amphibole were observed in quartz diorites and monzodiorites. The clinopyroxene is partially replaced by amphibole. Allanite rimmed by an epidote corona, apatite and zoned zircon are present in certain samples. The rocks generally exhibit a polygonal mosaic texture.

The *Lacoste intrusive Suite* (mPlac) intrudes the *L'Ascension metamorphic Suite* and the *Tic-Tac-Toc mafic intrusive Suite* (mPtic) as indicated by the presence of numerous enclaves. Given the small size of most enclaves and the scale of our map, it was difficult to represent them on the map.

An average age (ICP-MS method) of 1346±27 Ma (Hébert and Nantel, 1999) was obtained from a sample of hornblende-biotite tonalitic gneiss collected in the eastern map sheet (31J/10). Since supracrustal rocks of the L'Ascension metamorphic Suite and gabbros of the Tic-Tac-Toc mafic intrusive Suite occur as enclaves in rocks of the Lacoste intrusive Suite, then the minimum age for the first two suites is 1346 Ma. Also, a few heterogeneous zircons indicate the existence of a metamorphic event at 1200 Ma (Hébert and Nantel, 1999).

Morin AMCG Suite

Originally described outside of our area (31J/11) by Martignole and Corriveau (1993), the Morin AMCG Suite (AMCG = Anorthosite-Mangerite-Charnockite-Granite) was recognized in map sheet 31J/10 by Hébert *et al.* (1996) and is composed of a mafic phase and a felsic to intermediate phase.

The rocks we are tempted to correlate with this suite within NTS sheet 31J/11 are essentially composed of mafic phases (gabbro, norite and leuconorite) which we have grouped under the heading *I3Aa*. Small cm-scale fragments of anorthosite are occasionally observed.

Outcrops of gabbro, norite and leuconorite are nevertheless fairly rare and almost always occur associated with monzonite and porphyritic granite. A more important zone of leuconorite-norite (I3Aa), a few hundred metres thick, was observed west of Lac Pérodeau (NNE of the map area) and extends into map sheet 31J/14 where it is known as the "*Pérodeau Leuconorite*" (Nantel, 2000). These coarse-grained rocks sometimes preserve beautiful primary textures. Rare gabbro-norite enclaves also outcrop within the *Lan-thier Granite*. Consequently, rocks of the *Morin AMCG Suite* are older than this granite.

Lanthier Granite (mPlat)

Most of the pluton that makes up the *Lanthier Granite* (mPlat) is located to the east, in map sheet 31J/10. In map sheet 31J/11, the western margin of this felsic pluton is composed of monzogranite and quartz monzonite. Its very low ferromagnesian mineral content is characteristic, and gives the rock a very uniform white colour. It is a massive homogeneous medium-grained rock which frequently contains disseminated or small pods of fluorite and tourmaline. A pegmatitic facies is also present.

Under the microscope, the rocks have a coarse grained texture and are composed of quartz, orthoclase, microcline, plagioclase, biotite, muscovite, allanite, fluorite and zircon. In a few samples, orthoclase and microcline are perthitic. Biotite is partially resorbed by a muscovite-quartz symplectite, or is replaced by chlorite with fine acicular rutile. Allanite is sometimes rimmed by an epidote corona.

Another characteristic feature of this pluton is the great number and diversity of enclaves it contains. The map showing the vertical gradient suggests that this pluton has a markedly greater diameter at depth than what appears on surface (Hébert and Nantel, 1999). Visible outcrops therefore occur at a very high erosion level, and they represent the upper margin of the pluton. This explains the presence of intrusive breccia and abundance of enclaves derived from the various lithodemic units forming the country rocks. The most common are fragments of paragneiss and quartzite, similar to rocks in surrounding supracrustal sequences. There are also, as mentioned previously, fragments of gabbro from the Tic-Tac-Toc mafic intrusive Suite, monzodioritic gneiss from the Lacoste intrusive Suite, and norite and anorthosite from the Morin AMCG Suite.

As observed in the east, white granite and pegmatite dykes are related to the *Lanthier Granite*. These pegmatites contain tourmaline, most likely inherited from paragneisses of unit mPcur1, which they intrude (Hébert and Nantel, 1999).

A sample of *Lanthier Granite* was dated by ICP-MS method at the Université de Montréal, using twenty prismatic or rounded zircons. The ages obtained range from the Archean (2357 Ma) to the Mesoproterozoic (1143 Ma) regardless of the zircon shape. A more detailed study is warranted to explain this wide range of ages (Hébert and Nantel, 1999).

Several hypotheses are proposed to explain the origin of these granites. One hypothesis, proposed by Sawyer (1996) and applied to our area, suggests that the assemblage comprising the *Lanthier Granite* and its enclaves may represent a diatexite unit (Hébert and Nantel, 1999).

Chute-Saint-Philippe Granitic Suite (mPute)

The *Chute-Saint-Philippe granitic Suite* (mPute) is a new unit. It constitutes a large elongate km-scale body located in the centre of the map area, along with a few small satellite bodies. The dominant facies is a pinkish granite grading to a monzonite with an augen texture and a medium to coarse grain size. The rock is magnetic and foliated. The aeromagnetic map in fact indicates a magnetic high corresponding to this unit.

The rock is often cut by whitish pegmatites, and enclaves of supracrustal rocks are locally encountered. In this unit, a scintillometer survey revealed radiometric values of 600 cps (counts per second). At a regional level, values of less than 200 cps and often less than 80 cps were obtained in supracrustal rocks. Exploration work for uranium was performed mostly north of here, in map sheet 31J/14 (Nantel *et al.*, 1998; Laliberté, 1970).

Sainte-Véronique Ring Complex (mPcsv)

This complex outcrops in the southeast part of the map area (31J/11) and extends eastward (31J/10). It was mapped by Rive (1976) at 1:12,000 scale. For the purposes of the map, we carried out only a few cross-sections in order to recognize the various sub-units. The following brief descriptions of these lithologies are largely derived from data collected by Rive (1976).

The *Sainte-Véronique Ring Complex* (mPcsv) is a circular intrusion with a diameter of about 8 km. This complex is an ultrapotassic alkaline intrusion belonging to the Kensington-Skootamatta Suite (Corriveau, 1989). The central part of the complex is composed of ultramafic rocks, namely pyroxenite (mPcsv1b), serpentinite (mPcsv1a) and shonkinite (mPcsv2), surrounded by a ring of syenite (mPcsv3) that evolves into a pulaskite (mPcsv4) towards the margins. Unit mPcsv5 is an intrusive breccia, or hybrid zone. In the external ring segment, lens-shaped bodies of rocks are derived from the central part outcrop. In the north, the country rocks belong to the *Curières supracrustal Sequence* and the *Tic-Tac-Toc mafic intrusive Suite*. To the east and southwest, the complex is in contact with gneisses of the *Lacoste intrusive Suite*, which host enclaves of rocks from the *Curières supracrustal Sequence* and the *Tic-Tac-Toc mafic intrusive Suite*.

To the northwest of this complex, we delineated a km-scale subrounded body that we associated with the pyroxenite sub-unit (mPcsv1b) given its nature and composition. This melanocratic zone is composed of amphibole, feldspar and traces of quartz, and sometimes exhibits deformation textures.

Serpentinite (mPcsv1a)

This sub-unit forms small heterogeneous bodies contained within the central zone mainly composed of pyroxenite. These bodies are folded and fractured. The fine-grained serpentinite is characterized by a greenish tinge and is composed of serpentinized and pseudomorphed minerals, green spinel, apatite, magnetite, diopside and traces of plagioclase and calcite.

Pyroxenite (mPcsv1b)

Three types of pyroxenite were identified by Rive (1976), namely *massive pyroxenite*, *magnetite pyroxenite* and *biotite pyroxenite*. *Massive pyroxenite* is a holomelanocratic rock with pyroxene phenocrysts reaching up to 1 cm long. An adcumulus texture was observed, and the main constituents are: augite (90%), apatite (5%), hornblende (2%) and opaque minerals (4%). Locally, weakly serpentinized forsterite (< 1%) is observed. This pyroxenite contains up to 3% sulphides (pyrite and pyrrhotite). The *magnetite pyroxenite* outcrops within the two other types of pyroxenite, and the contacts with the latter are gradual. The magnetite content may reach 20 to 30%. The *biotite pyroxenite* is the most abundant variety. Fine-grained, it also stands out due to the habit of biotite, which occurs in layers, thus giving the rock a roughly layered structure. This rock contains 30 to 40% augite, 45 to 50% biotite, as well as apatite and traces of hornblende, sphene, calcite and opaque minerals. Clinopyroxene is partially replaced by green hornblende. In certain cases, the pyroxene is entirely pseudomorphed into actinolite sheafs, whereas strongly pleochroic brown-red biotite shows a lobate texture and is microfolded.

Shonkinite (mPcsv2)

The shonkinite is distinguished from pyroxenites due to its orthoclase content. There are four facies of shonkinite (Rive, 1976): *porphyritic, spotted, homogeneous* and *pegmatitic* shonkinite (Appendix 1, photo 9).

The *porphyritic shonkinite* contains bluish grey idiomorphic orthoclase crystals reaching up to 4 cm. It shows a transitional contact with pyroxenites. In the central part of the intrusion, the thickness of this facies varies from 1 to 7 m, but increases to 20 to 50 m in the border zone. Furthermore, its lateral extension is also more restricted in the centre (< 30 m) than along the borders (> 100 m). Biotite is the dominant mafic mineral (> 40%) followed by augite (~25%) and cryptoperthitic orthoclase forming about 20% of the rock. The other mineral phases consist of at least 5% apatite, and hornblende, sphene and opaque minerals.

The *spotted shonkinite* facies outcrops in the satellite bodies around the central stock and near the contact with the syenite per se (mPcsv3). In this rock, orthoclase are ovoid or circular in shape and are riddled with mafic mineral inclusions. Essential minerals consist of biotite (> 35%), orthoclase (30%), augite (25%), 3% apatite and 1% hornblende as well as traces of magnetite, calcite, sphene, quartz and plagioclase.

The *homogeneous shonkinite* facies is rare. It consists of a mesocratic rock where orthoclase forms nearly 40% of the rock, and where augite (5%) has nearly disappeared, and is replaced by hornblende (12%).

Finally, *pegmatitic shonkinite*, which is even more rarely observed than the previous facies, outcrops only along the borders of the intrusion. The mineral distribution is heterogeneous due to the coarse grain size. Biotite occurs as 3 to 5 cm flakes stacked one on top of the other. The texture of orthoclase crystals varies from granular to porphyritic.

Sainte-Véronique Syenite (mPcsv3)

A porphyritic syenite with orthoclase phenocrysts surrounds the central stock. Rive (1976) also mentioned a less abundant melanocratic facies that outcrops along the contact with the central stock. The latter disappears rapidly to make way to the syenite per se, which he called the *Sainte-Véronique Syenite* (mPcsv3), and which forms the dominant unit of the ring complex.

This syenite is a leucocratic rock with a porphyritic texture. The principal mafic minerals are biotite (18%), amphibole (2%) and clinopyroxene (2%). These mafic minerals are interstitial to the orthoclase phenocrysts which represent the main constituent (nearly 75%) of the rock. Augite is often pseudomorphosed into green hornblende. Orthoclase phenocrysts are often bent or curved and their margins are strongly granulated.

Pulaskite (nepheline syenite) (mPcsv4)

By definition, pulaskite is a *nepheline syenite* (mPcsv4), which in this case corresponds to the marginal facies of the syenitic intrusion. It forms a complex ring composed of several sheets around the Sainte-Véronique Syenite. The contact between these two types of syenite is gradual. The nepheline syenite displays a greyish tinge and a porphyritic texture. Nepheline phenocrysts reach up to 2 cm long and are preferentially oriented. Mafic minerals make up only 5 to 7% of the rock. There is at least 65% orthoclase, a little over 15% nepheline and about 10% plagioclase. Nepheline, visible only on weathered surfaces, occurs in negative relief in outcrop, and forms small idiomorphic crystals (0.3 to 6 mm) or occurs as inclusions in orthoclase phenocrysts. Augite, as in the syenite, is partially pseudomorphosed to green hornblende. Orthoclase is perthitic, strongly tectonized and grain margins are granulated.

Intrusive breccia, hybrid zone (mPcsv5)

This intrusive breccia was formed by the emplacement of the *Sainte-Véronique Ring Complex* which provoked a strong recrystallization and less developed fenitization of enclaves of supracrustal rocks and gabbros which constitute the breccia. The enclaves may reach km-scale dimensions. The presence of hypersthene in paragneiss enclaves indicates very high temperature and pressure conditions.

Mont-Laurier Monzonitic Suite (mPmtl)

The *Mont-Laurier monzonitic Suite* (mPmtl) is a new lithodeme. It was subdivided into four sub-units in the area, namely *mPmtl1a*, *mPmtl1b*, *mPmtl2a* and *mPmtl2b* (see SIGÉOM map).

The dominant sub-unit (*mPmtl1a*) is composed of weakly deformed, magnetic monzonite and porphyritic monzodiorite. The type section is located on Highway 117, 4 km east of the town of Mont-Laurier. Feldspars sometimes exhibit a pinkish-red to brownish colour, and are weakly deformed. These feldspar phenocrysts often form a rapakivi texture in a grey-green fine-grained matrix, rich in biotite and amphibole, and essentially composed of fine-grained plagioclase. Subconformable leucocratic fine-grained granitic phases and other more melanocratic phasesare also associated with this unit. Pinkish white pegmatite injections are also present; these form subconformable horizons and diffuse pods. The southwest part of this intrusion is bounded by a metasomatized zone (mPcur3d).

Sub-unit *mPmtl1b* is a monzonite occurring as a marginal facies relative to the principal body formed by sub-unit mPmtl1a. Zones of intrusive breccia with 1 to 10 m enclaves of paragneiss and quartzite are present. Outcrops typical of this sub-unit are visible along the road leading from Mont-Laurier to Ferme-Neuve.

Sub-unit *mPmtl2a* is composed of brownish pink to whitish, fine to medium-grained weakly deformed granite (sometimes monzonite) with stretched and deformed mafic enclaves (Appendix 1, photo 10). This rock locally resembles the *Guénette granitic Suite*. The type section of this sub-unit is located just east of Ferme-Neuve, about 2 km along the road going east. The topographic relief is more accentuated in this sector and forms high hills. The mineral assemblage is composed of feldspar, quartz and chloritized mafic minerals (20%). White-pink pegmatite dykes a few centimetres thick are also present. Other more monzonitic layers are composed of a fine pinkish groundmass of pink feldspar with greenish sub-rounded mafic phenocrysts (1-3 mm). These zones are similar to what is observed southward in sub-unit mPmtl1a. Traces of pyroxene are also observed. The rock locally appears to have a granitic composition, leucocratic and quartz-rich, and contains m-scale enclaves of paragneiss, quartzite, amphibolite and gabbro.

Sub-unit mPmtl2b is located in the northwest part of the map area. The rock is essentially composed of a weakly foliated and magnetic granitic assemblage (rarely monzonitic) characterized by a pale pink to whitish colour, and contains a few folded gabbroic enclaves.

Guénette Granitic Suite (mPgue)

The *Guénette granitic Suite* (mPgue) was first recognized in map sheet 31J/11. It was originally introduced by Corriveau and Jourdain (1993) and Corriveau and Madore (1994) to designate pink or white, late intrusions respectively observed in 31J/06 and 31J/03. We use this lithodemic term to describe a very homogeneous brownish pink granite that is fine to medium-grained, weakly foliated and fairly massive. This lithology forms a km-scale subrounded body and constitutes what we have called the *"quarry" type*.

Several quarries are or were located in this rock type (Bellemare, 1999). A few zonesare however monzogranitic and aplitic. Hornblende and biotite-rich mafic enclaves are sometimes present, and may take on a very elongate shape extending for tens of metres. Mafic dykes a few centimetres thick were also observed locally.

The typical mineral assemblage mainly consists of quartz, plagioclase, K-feldspar as well as traces of biotite, fluorite, muscovite, allanite, and iron and titanium oxides.

The *Guénette granitic Suite* was dated at 1054 Ma (Corriveau *et al.*, 1996) and at 1063 Ma (Friedman and Martignole, 1995). It is therefore post-tectonic and post-metamorphic.

Other Lithological Units

A few other lithological units are present in NTS sheet 31J/11. We did not give them formal names for two main reasons. First, these lithologies are often included within other lithodemes. Second, their extension or association with formal units is not entirely clear.

M13a – These bands of calcitic and dolomitic marble represented on the map are often fairly thin (< 100 m) and may contain calc-silicate rocks and minor paragneiss. In these units, marbles are dominant. They are whitish, medium to coarse-grained and banded. Their location and deformation indicates a complex regional tectonic setting.

M12a – These zones mainly consist of quartzite with associated paragneiss. They generally form small isolated elongate patches about 10 m in size, enclosed within different units.

M4b – This unit is located in the northwest part of the map area, and extends along a north-south axis, northward into map sheet 31J/14. This band appears to be wedged within the *Mont-Laurier monzonitic Suite* (mPmtl). Essentially formed of paragneiss and quartzite, it locally contains traces of granitic to monzonitic gneiss, and resembles other supracrustal rocks that we assigned to the *Curières supracrustal Sequence* (mPcur) in other locations. Pegmatite injections are often associated with these lithologies.

M4a – This band of supracrustal rocks occurs east of the *Mont-Laurier monzonitic Suite* (mPmtl). Observed lithologies consist of paragneiss, calc-silicate rock and minor quartzite.

M6 – This unit is located in the north-central part of the map area, and is bounded on both sides by a corridor of strong deformation. The rock consists of migmatized granitic and quartzofeldspathic gneiss, pinkish to greyish, magnetic, foliated and exhibiting very heterogeneous deformation features. Remains of supracrustal rocks are locally observed (Appendix 1, photos 11 and 12) as well as textures reminiscent of a brecciated aspect. Late pegmatite injections are present. This unit is puzzling for the region from both lithological and structural standpoints. The attitude of the foliation and the overall structural trend are significantly different from those in surrounding rocks.

M3(I2F) – This unit is located in the northeast corner of the map area, where it forms a subrounded body corresponding to a magnetic high. The rock is composed of pink orthogneiss with a quartz monzonite composition, medium to coarse-grained and showing an augen texture that is frequently very stretched and deformed.

I3Aa – These rocks consist of gabbro, norite and leuconorite. They are scattered throughout the area. They often form sills or bodies between 10 m and 1 km in size. In the eastern part of the map area, these rocks were previously described and associated with the *Morin AMCG Suite*. Elsewhere, these gabbros are fine to medium-grained, and rare relic textures are locally preserved.

METAMORPHISM

The region near Ferme-Neuve – Mont-Laurier is metamorphosed to the amphibolite facies. Overall, amphibolite-grade metamorphic conditions translate into the appearance of muscovite in paragneisses and epidote associated with plagioclase in quartz-feldspar-garnet-biotite paragneisses. With regards to regional metamorphic conditions, our mapping therefore corroborates observations made by Wynne-Edwards (1966) at 1:250,000 scale in the Mont-Laurier area.

The rocks are metamorphosed to the amphibolite facies, but the presence of mesoperthite and perthitic microcline reveals a certain increase in the metamorphic grade, also indicated by the transformation of muscovite nodules into fibrolite in nodular paragneisses (Hébert and Nantel, 1999). Furthermore, the transformation of muscovite augen into fibrolite and orthoclase, which crystallize in pressure shadows, also indicates an increase in the metamorphic grade to the upper amphibolite facies.

The presence of minor hypersthene in paragneisses and granitic and perthitic mobilizate, as well as brown hornblende indicate higher-grade metamorphism, at the granulite facies, in certain areas. A portion of the area to the west of Ferme-Neuve reached the granulite facies, and the boundary roughly corresponds to the position of the Rivière La Lièvre.

Typical mineral assemblages described in area 31J/11 are identical to those reported by Hébert and Nantel (1999) in map sheet 31J/10 for paragneisses of the *Curières supracrustal Sequence*. They are, as follows:

1 – quartz - biotite - muscovite;

2 – quartz – prismatic sillimanite;

3 – quartz - orthoclase - plagioclase - biotite - muscovite - (chlorite + rutile);

4 – quartz - perthite and/or mesoperthite - microcline ± plagioclase - biotite - muscovite - fibrolite - rutile;

5 – quartz - mesoperthite – perthitic microcline – biotite - muscovite - fibrolite – prismatic sillimanite - rutile.

Some evidence of retrograde metamorphism was observed in the *Curières supracrustal Sequence*, shown by the transformation of biotite into chlorite accompanied by fine acicular rutile. This phenomenon is mainly associated with the presence of late faults or deformation zones. Furthermore, in the Val-Barrette Marble Zone (mPcur3a), the presence of large fibroradial tremolite and serpentine crystals is also inferred to be the result of a retrograde reaction. This latter mineral association is indicative of the amphibolite facies.

A zone of contact metamorphism is also observed around the *Sainte-Véronique Ring Complex* and the *Mont-Laurier monzonitic Suite*. These rocks were strongly altered by metasomatic fluid circulation. In certain locations, mafic minerals are entirely transformed into biotite, probably due to a potassium input during the conditions of the country rock.

STRUCTURAL GEOLOGY

The three fabrics S_1, S_2 and S_3, recognized in area 31J/11 are also present in NTS sheet 31J/10 further east (Hébert and Nantel, 1999). Fabrics S_1 and S_2 are associated with tectonic events, whereas S_3 is related to late magmatic events. These fabrics do not however represent the earliest tectonic events in the area. Evidence of earlier fabrics are observed in the north part of the map area, in the granitic gneisses (unit M6; Appendix 1, photos 11 and 12) that were deformed and migmatized prior to the development of fabrics S_1 and S_2. Our observations are currently insufficient to determine the timing of these earlier events. Fabrics S_1 and S_2 do not represent fabric S_0, *i.e.* the primary bedding of supracrustal rocks. In fact, we were unable to recognize true primary structures that could qualify as S_0, apart from the magmatic layering in gabbros from the *Tic-Tac-Toc mafic Suite*.

The oldest fabric is an S_1 foliation or gneissosity that varies from an E-W to an ESE-WNW orientation. It is partially obliterated by an S_2 fabric in the western part, and more strongly so in the eastern part of the map area. Fabric S_2 shows a regional NNE-SSW orientation. This fabric is inferred to be associated with the presence of the *Kinonge-Labelle shear zone* (Hébert and Nantel, 1999). Finally, the late S_3 fabric is the result of the emplacement of various late intrusive bodies, and obliterates fabrics S_1 and S_2.

The area may be subdivided into two major domains: the eastern domain and the western domain. We did not delineate them on the SIGÉOM map, but they are shown in Figure 4. The boundary between the two domains corresponds to a line cutting the map area in two through the centre.

In the *eastern domain*, the structural style is fairly flat-lying (Appendix 1, photos 1, 5, 6 and 8) and consists of a series of undulations forming alternating antiforms and synforms where the folds are nearly recumbent or overturned to the NW. The S_2 fabric is dominant, with variable dips. Fabric S_3 is developed around late intrusive bodies. Most mineral stretching lineations are oriented towards the south with a very shallow plunge at 40° that progressively changes to less than 20°.

In the *western domain*, the structural style is not as well defined due to the presence of several intrusive bodies that obliterate everything. The S_2 fabric is present, as well as S_1 and S_3. Lineations essentially trend to the SSW and W; SSW-trending lineations have shallower plunges than their W-trending counterparts.

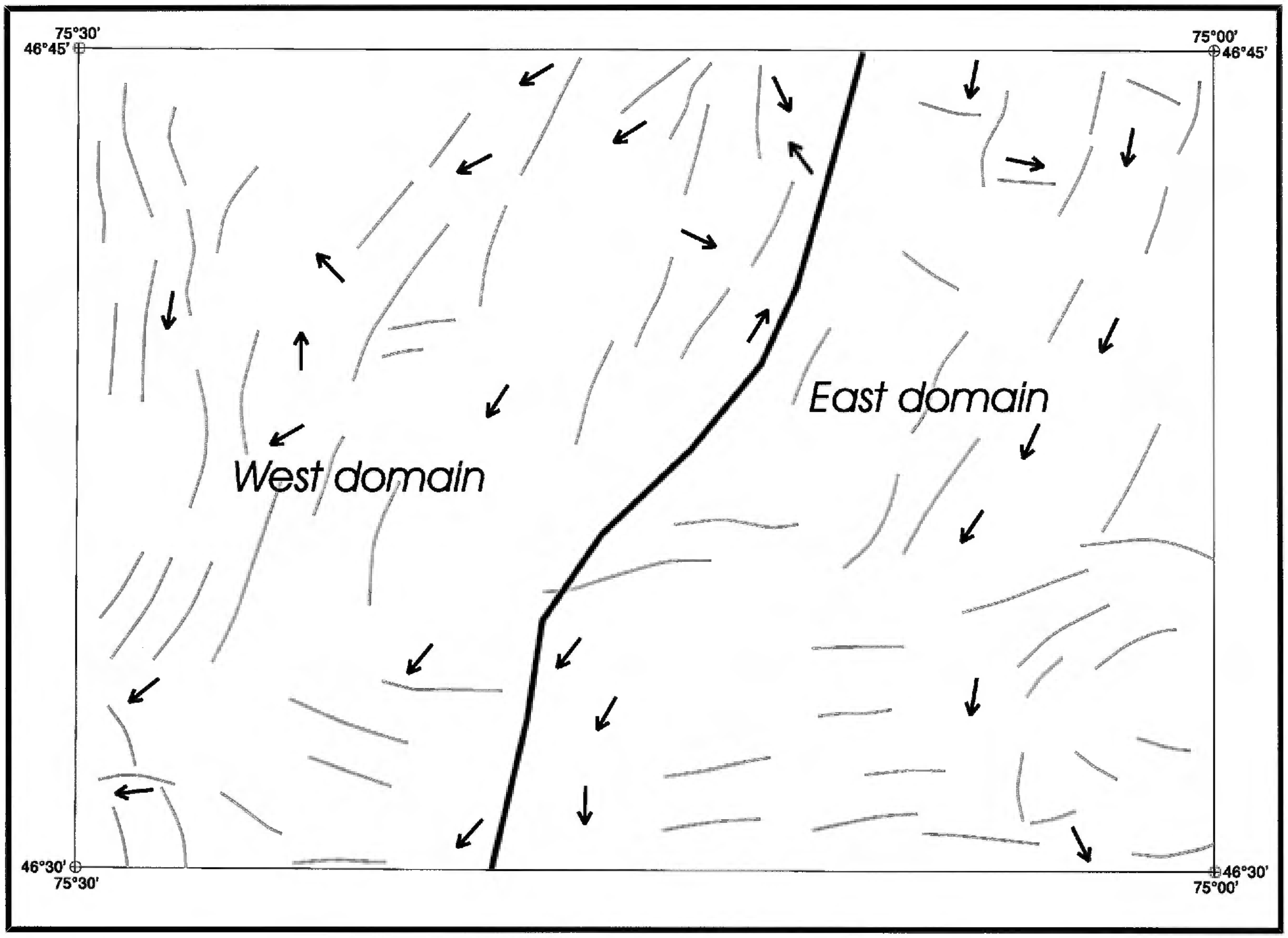
Regional fold axes, identified in the NE part of the map area, correspond to variations in the S_2 fabric and, furthermore, show the same features as those observed eastward in map sheet 31J/10 (Hébert and Nantel, 1999). Overall, these fold axes plunge to the S-SW and show the same orientations as lineations (Figure 4). Folds are open and form undulations. A few zones of NNE-SSW trending banding or straight gneisses are observed here and there. They are aligned parallel to the S_2 direction, or coincide with the margins of certain intrusions.

S_1 Fabric

This foliation is easily recognized in the eastern part of the map area. Westward, it is more difficult to observe as it is almost entirely obliterated by fabrics S_2 and S_3. The S_1 fabric has an average orientation that varies from E-W to ESE-WNW. It is an axial plane foliation associated with folds overturned to the NE. Where S_1 is weakly folded or transposed by fabric S_2, it dips shallowly to the SSW, and the mineral stretching lineation on the limbs of these overturned folds is parallel to the dip direction, *i.e.* to the SSW.

The S_1 fabric is associated with an important episode of shortening if not thrusting (Hébert and Nantel, 1999). Movement direction is inferred from the SW towards the NE, based on the attitude of overturned first-generation folds.

The signature of this fabric (S_1) is not observed in the *Lanthier Granite* nor in the *Sainte-Véronique Ring Complex*. From this we can assume that this S_1 fabric results from a Grenvillian thrusting event, as in the eastern part of the map area. A minimum age for this fabric would therefore predate 1143 Ma (see Figure 2) or be associated with the Elzevirian orogeny.



P. Olivier, 1999

FIGURE 4 - Simplified diagram showing the alignment of lineaments (grey lines) and a representation of dominant lineations (arrows). The central black line corresponds to the boundary between the two structural domains.

S_2 Fabric

The S_2 fabric, dominant in map sheet 31J/10, is visible in certain areas in map sheet 31J/11. It is directly associated with the deformation episode that generated the *Kinonge-Labelle shear zone* (K-LSZ, Figure 1), located about 30 km east of our map area. For this fabric, three distinct structural styles have already been described (Hébert and Nantel, 1999) based on the intensity of deformation. These correspond to an axial plane foliation, a shear plane foliation and a gneissosity in straight gneisses. In the Ferme-Neuve – Mont-Laurier area, only the axial plane foliation is dominant given the moderate impact of the *Kinonge-Labelle shear zone*.

This S_2 fabric corresponds to an axial plane foliation oriented NNE-SSW. This foliation is associated with major second-generation regional folds that fold the S_1 fabric into folds overturned to the NW with SSW-plunging axes (Hébert and Nantel, 1999). The axial planes of these second-generation folds have shallow dips to the SE.

The S_2 fabric in the area represents a moderate intensity of deformation. On the other hand, evidence of a higher degree of deformation is observed in a few locations. This translates into a stretching of the limbs of major regional folds resulting in the formation of detachments and reverse faults. These correspond to thrust planes where the movement took place from the SE towards the NW, and where the stretching lineation plunges to the SE.

Scattered throughout the area, zones of straight gneisses a few tens of metres thick cut across the rocks in a NNE-SSW direction.

S_3 Fabric

This fabric is observed around various late intrusive bodies such as the *Mont-Laurier monzonitic Suite*, the *Guénette granitic Suite* and the *Sainte-Véronique Ring Complex*. This structure is observed up to a distance of nearly five kilometres from the margins of these intrusions, and is directly related to the pluton emplacement process. The fact that it obliterates fabrics S_1 and S_2 suggests a late- to post-tectonic timing relative to the *Kinonge-Labelle shear zone* (1078 Ma). This is compatible with the various ages obtained for lithologies in the area (see Figure 2).

ECONOMIC GEOLOGY

The area covered by NTS sheet 31J/11 is known for its industrial mineral potential. Extraction operations, which began in the early 20th century, were focussed on the production of dimension stone, crushed stone, agricultural lime (marble) and decorative aggregates (marble and granite). Graphite present in calcitic marble was also mined. Potential graphite, marble and nepheline syenite deposits are also known.

With the cooperation of Yves Bellemare (MRN), we have included in Appendix 2 a series of twelve photographs (photos 13 to 24) showing polished surfaces of typical rock samples collected in the field. These samples are useful in showing the grain size, colour and texture of certain rock types in our area (31J/11) which could generate some interest for dimension stone.

Furthermore, in map sheet 31J/11, anomalous concentrations in Ti, W, Cu, Zn, Cr, Pb, As, Ba, Sb, and Co in stream sediments, as well as anomalies in Ba, Br, Ce, Cs, Cu, La, P, Pb, Sb, Sr, Th, Tm, W, U, V, Zn in heavy minerals (Choinière, 1990) are reported. Further east, in map sheet 31J/10, zinc occurrences were noted in dolomitic marbles (Hébert *et al.*, 1997) and traces of Cu-Ni mineralization were observed (Poirier, 1988) in mafic and ultramafic rocks.

MRN mineral deposit files for NTS sheet 31J/11 indicate traces of pyrite, pyrrhotite mineralization, as well as fluorine, molybdenum and iron (magnetite) occurrences. Non-metallic occurrences identified in these files include graphite, feldspar and apatite.

Zinc

The *Mont-Laurier Terrane*, to which the map area belongs, has been the focus of many exploration programs for SEDEX-type zinc mineralization since the early 1900s. Known deposits occur in two belts that roughly follow the eastern and western margins of this terrane (Gauthier and Brown, 1980; Nantel, 1994a and 1994b). They are all hosted in dolomitic marbles (Sangster *et al.*, 1992) and calc-silicate rocks. About ten small showings have been discovered since the early 1990s (Roger and Lapointe, 1996; Abilab, 1996; Nantel, 1994a and 1994b; Pronovost, 1994; Goulet, 1994). The most recent discovery was made outside of our study area, during a mapping survey carried out in the map sheet to the east of us (Hébert *et al.*, 1997).

In our area (sheet 31J/11, eastern domain), the presence of calcitic-dolomitic marble horizons that we have assigned to the *Curières supracrustal Sequence* (mPcur) explains the zinc anomalies previously detected in stream sediments (Choinière, 1990). Further east (31J/10), indicator minerals such as gahnite, zinc spinel and manganese-bearing garnet were identified in heavy minerals (Bernier *et al.*, 1997; Hébert *et al.*, 1997). These areas remain attractive for exploration since these heavy minerals are recognized for their association with Montauban-type massive sulphide mineralization (Bernier and MacLean, 1993). Furthermore, south of our map area (31J/03 and 31J/06), magnetite and garnet-bearing rocks are associated with copper and gold mineralization hosted in mafic rocks (Corriveau *et al.*, 1996).

Copper-Nickel

Small zones mineralized with disseminated sulphides were encountered, but assay results did not yield any significant grades.

Within the syenite unit (mPcsv3) of the *Sainte-Véronique Ring Complex*, disseminated sulphides are observed. Analytical results indicate trace to 5% pyrite, pyrrhotite and chalcopyrite.

In the NW part of the map area, associated with an aluminous paragneiss, traces of sulphides were observed in the rock. This zone contains nearly 10% lilac pink garnet, and as much sillimanite. An assay sample from this zone yielded a grade of 200 ppm Cu.

Graphite

In the *Mont-Laurier Terrane*, the association of porphyroblastic marble and a high graphite content is typical. Numerous exploration programs for graphite were carried out in the late 1980s and early 1990s by the company Graphicor. This work led to the discovery, in map sheet 31J/10, of the *Mousseau deposit*, where mining reserves were established at 800,000 tonnes of ore at 8% gC (graphitic carbon), and the *Brunet deposit*, where a preliminary reserve estimate of 600,000 tonnes at 7% gC was reported (Hubert and Parent, 1994).

Several other zones of variable grade and tonnage were identified by drilling by exploration companies within the *Curières supracrustal Sequence*. These mineralized zones are within quartz-rich gneisses (Hébert *et al.*, 1990; Hébert, 1989 and 1993a and 1993b).

Electromagnetic anomalies located ENE of Réservoir Kiamika and about 5 km NW of the Mousseau deposit were intensely drilled (Leduc and Blain, 1990). The rocks consist of biotite paragneisses with more or less garnet, impure quartzites, diopside marbles and calc-silicate rocks, that we have assigned to the *Curières supracrustal Sequence*. The highest graphite grades are associated with altered marble horizons, and reach up to 13% gC (Leduc and Blain, 1990).

Another area worth mentioning for the presence of graphite was identified during our geological mapping; it is located WSW of Ferme-Neuve, in a paragneiss band (M4b). Grades of 1.72% and 2.34% gC were obtained from field samples. These rocks resemble those of the *Curières supracrustal Sequence*, and may offer some potential for graphite.

About 10 km south of the community of Guénette (outside of our map area), a deposit was mined for graphite at the turn of the century.

Nepheline Syenite

The *Sainte-Véronique Ring Complex* was already assessed as a potential source of nepheline syenite, at the request of the Pacific Coast Mines company, in 1993 (Robbins, 1995). The company JBR, who performed the assessment, confirmed the presence of nepheline, originally reported by Rive (1976) in the marginal facies (mPcsv4) of the *Sainte-Véronique Ring Complex*. However, the company judged the nepheline content insufficient and recommended to abandon the work program. More recent work (Jacob, 1998) was undertaken in order to characterize the material.

Granite

The immediate vicinity of the town of Mont-Laurier is known as a dimension stone and architectural stone production centre. In fact, stone material has been extracted from the Mont-Laurier area since the turn of the century, and several quarries were in operation. Currently active quarries are essentially located in the *Guénette granitic Suite*. The extracted rock is a pale pink fine to medium-grained aplitic monzogranite; it is mainly used for the production of tombstones.

A complete inventory of quarry sites in the entire 31J map area was performed by Bellemare (1999). It indicates that 33 quarries have been identified and are the object of inventory files for quarries and development sites.

These stone quarries are for the most part located near Highway 117. Most quarries are located near the communities of Guénette and Val-Barrette. Of the 33 described quarries, 23 are for dimension stone. Among these, medium-grained aplitic monzogranite is extracted since 1960 from the Fairmont quarry for the production of tombstones, and is marketed under the name "Laurentian Pink".

From 1983 to 1997, two quarries were active; one of these only intermittently. The granite, now marketed under the name "Laurentian Pink", was formerly known as "Guénette Pink".

Historically, extraction of dimension stone in the Guénette area began in the early 20th century. In 1910, Joseph Ledoux opened a quarry which would later become Brodie's quarry. This operation was famous because the granite extracted here was the only one in Canada that met the very strict requirements to manufacture cylinder rollers for pulp and paper plants. Extraction operations at Brodie's quarry continued until 1960, at which time fracture problems in blocks extracted from the floor of the quarry led the closure of this quarry. Extraction operations for this same granite then resumed on the site of the Fairmont quarry.

In the Ferme-Neuve – Mont-Laurier area, the principal extracted mineral resources were used for the production of dimension stone, crushed stone and riprap.

Marble

The Val-Barrette area, south of Mont-Laurier, is known for the quality of its white marble. Several production sites were temporarily in operation. The stone essentially supplied markets for crushed stone, aggregates, ornamental stone and decorative stone.

Field and compilation work indicate the presence of important magnesite and dolomite zones about ten metres thick and extending for about one kilometre along strike.

Remains of former lime kilns are still visible in the field. These served in small-scale production for local use. The material used at the time consisted of nearby calcitic and dolomitic marble. The Val-Barrette Marble Zone (mPcur3a) may be used to this end.

CONCLUSION

Mapping in the Ferme-Neuve – Mont-Laurier area made it possible to recognize several lithodemes grouped within the *Mont-Laurier Terrane*, and to assess their extent and stratigraphic relations.

Rocks of the *Curières supracrustal Sequence* constitute the dominant assemblage that extends for several kilometres along strike. Furthermore, intrusive bodies contrast by their nature and their extent and age.

The region was subjected to several tectonic events, and three distinct structural fabrics are recognized in the field. The emplacement of syn- to post-tectonic intrusions and late deformation zones has obliterated the regional structural trend inherited from an earlier deformation event.

The Ferme-Neuve – Mont-Laurier area is mainly known for its industrial mineral potential and for its dimension stone. Extracted substances include granite, graphite and marble. The potential of marbles for SEDEX-type zinc mineralization is also quite interesting.

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APPENDIX 1 : Photographs

PHOTO 1 – Banding, folding and transposition in paragneisses of the *Curières supracrustal Sequence* (mPcur1). These banded paragneisses and quartzites, with a NW-SE envelope (parallel to the hammer), display open folds with a very shallow plungeto the SW (to the right). Outcrop 97-328 on the west shore of Réservoir Kiamika.

PHOTO 2 – Boudinaged and dislocated quartzite bed within a nodular biotite-sillimanite-garnet paragneiss of the *Curières supracrustal Sequence* (mPcur1). Outcrop 97-1067.

PHOTO 3 – Strongly deformed contact zone between paragneisses of the *Curières supracrustal Sequence* (mPcur1) and rocks of the *Guénette granitic Suite* (mPgue). Note the presence of folded and parallelized granitic injections in the paragneisses, where the fabric has been transposed to produce straight gneisses. Outcrop 97-2170.

PHOTO 4 – Note the banding of partially dislocated quartzite and paragneiss layers in the *Curières supracrustal Sequence* (mPcur1). Outcrop 97-231 on the east shore of Réservoir Kiamika.

PHOTO 5 – Thick subhorizontal sequence of quartzite and paragneiss horizons in the *Curières supracrustal Sequence* (mPcur1). Outcrop 97-2517.

PHOTO 6 – Banded quartzite and paragneiss layers in the *Curières supracrustal Sequence* (mPcur2a), showing cm-scale to m-scale bands with SE-dipping (to the right) detachment planes. Outcrop 97-232 on the east shore of Réservoir Kiamika.

APPENDIX 1 : Continued

PHOTO 7 – Thin layer of folded amphibolite within banded quartzite and paragneiss layers of the *Curières supracrustal Sequence* (mPcur2a). Outcrop 97-332.

PHOTO 8 – Folded and boudinaged subhorizontal amphibolite horizon within supracrustal layers of the *Curières supracrustal Sequence* (mPcur2a) showing undulations due to very open flat-lying folds. Outcrop 97-242.

PHOTO 9 – Magmatic layering in the shonkinite facies (mPcsv2) of the *Sainte-Véronique Ring Complex.* Outcrop 97-2201.

PHOTO 10 – Mafic remnant in the *Mont-Laurier monzonitic Suite* (mPmtl2a). Outcrop 97-317.

PHOTO 11 – Intense deformation and transposition in partially migmatized granitic gneisses (*M6* unit). Outcrop 97-3272.

PHOTO 12 – Strongly deformed migmatized granitic gneiss (*M6* unit) containing deformed amphibolite enclaves. Shear zones are dextral, parallel to S_1, and show a sinistral antithetic movement. Outcrop 97-3264.

APPENDIX 2: Photographs of polished surfaces of typical rock samples. (Design and production by Yves Bellemare and René Trudel)

(scale in centimetres)

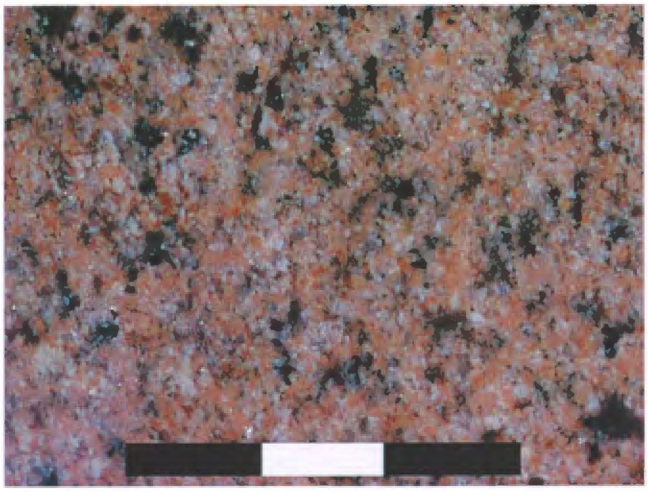

PHOTO 13 – Pink to brown fine to medium-grained granite, Guénette granitic Suite (mPgue).

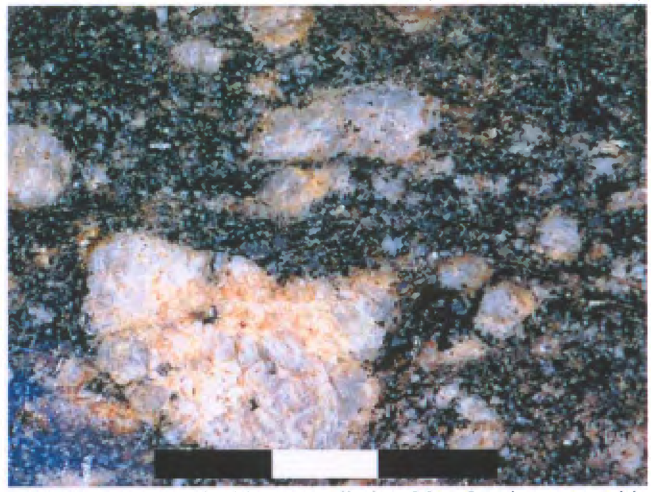

PHOTO 14 – Porphyritic monzodiorite, Mont-Laurier monzonitic Suite (mPmtl1a).

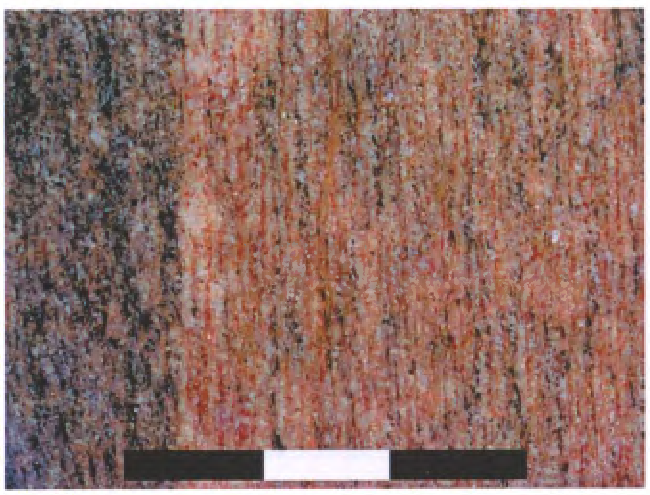

PHOTO 15 – Monzonite with a mylonitic aspect, Mont-Laurier monzonitic Suite (mPmtl1b).

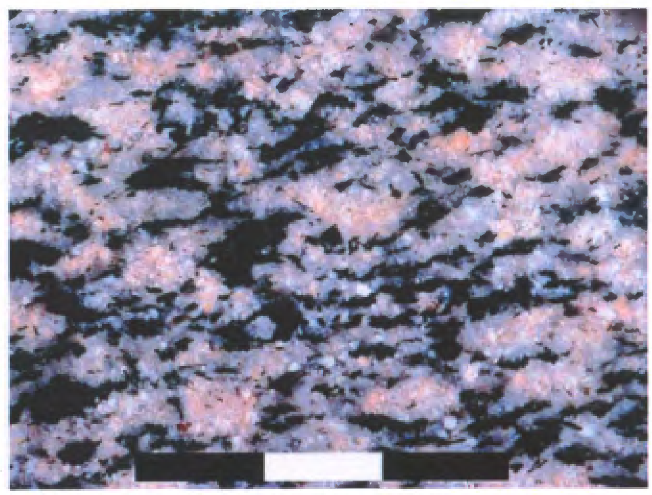

PHOTO 16 – Pink to brown medium-grained foliated granite, Mont-Laurier monzonitic Suite (mPmtl2a).

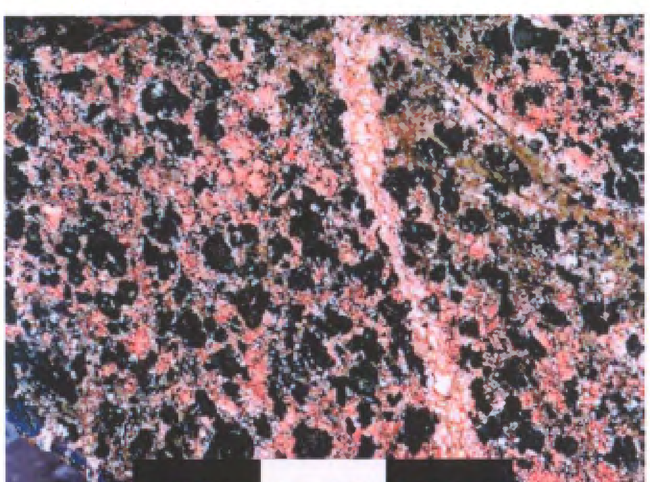

PHOTO 17 – Epidotized gabbro, Mont-Laurier monzonitic Suite (mPmtl2b).

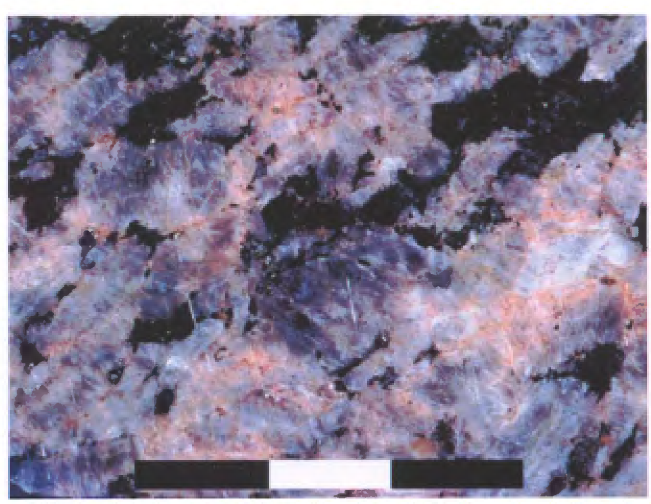

PHOTO 18 – Syenite, Sainte-Véronique Ring Complex (mPcsv3).

APPENDIX 2 : Continued

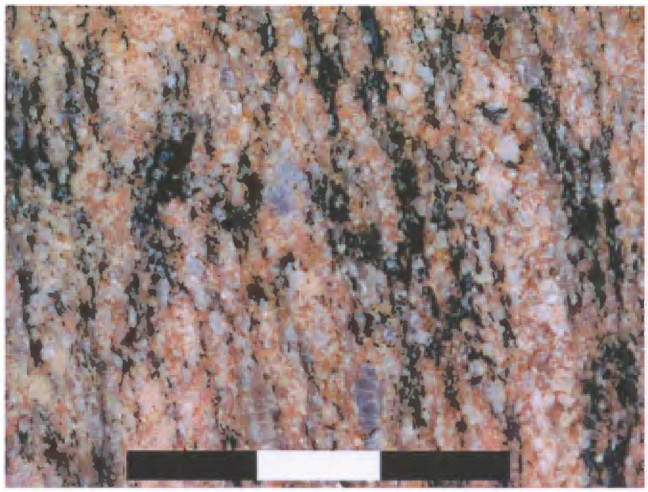

PHOTO 19 – Foliated pink monzonite, Chute-Saint-Philippe granitic Suite (mPute).

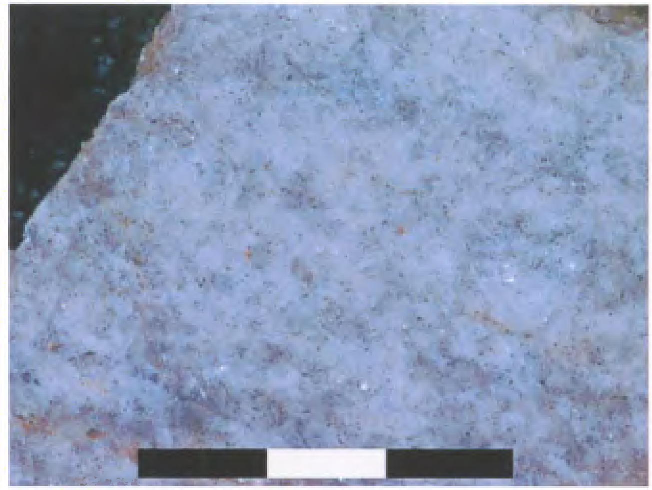

PHOTO 20 – Marble, Curières supracrustal Sequence (mPcur3a).

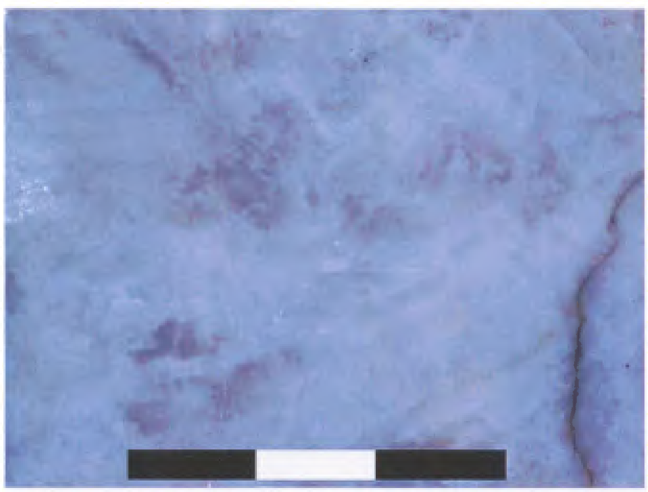

PHOTO 21 –Marble, Curières supracrustal Sequence (mPcur3a).

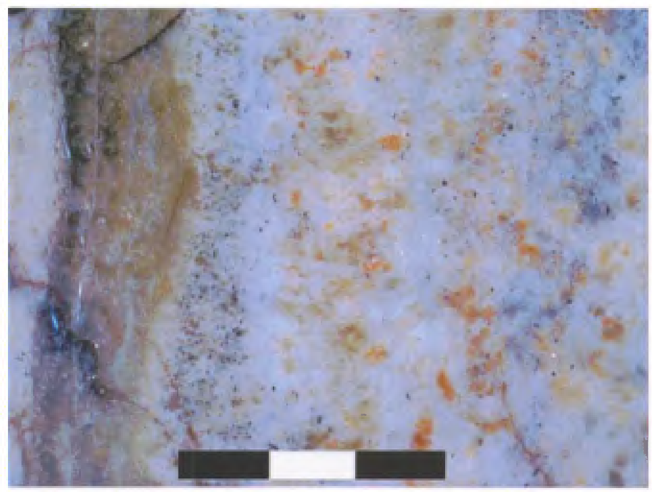

PHOTO 22 – Serpentine-bearing calc-silicate rock, Curières supracrustal Sequence (mPcur3a).

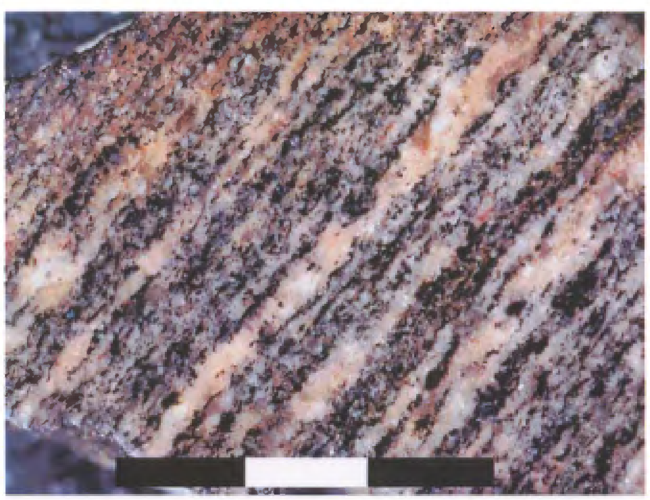

PHOTO 23 – Granitic gneiss injected by pegmatite (M6).

PHOTO 24 – Feldspar-biotite paragneiss with garnet and sillimanite (M4a).

Abstract

This geological mapping project at a scale of 1:50,000 in the Ferme-Neuve area (31J/11) forms the westward extension of a program encompassing map sheets 31J/10, 31J/14 and 31J/15.

The rocks belong to the "Central Metasedimentary Belt" of the Grenville Province. Several previously defined lithodemes extend from east to west, and a few new lithodemes were also introduced. The Curières supracrustal Sequence, which is part of the L'Ascension metamorphic Suite, constitutes the most important lithodeme in the map area. This sequence is formed of alternating layers of feldspar-biotite paragneiss, quartzite, paragneiss with sillimanite nodules, calcitic marble and graphite-rich paragneiss. This assemblage is intruded by m-scale gabbro sills (Tic-Tac-Toç mafic intrusive Suite) and white granite injections (Lanthier Granite) locally occurring as sills and dykes. Rocks of the Lacoste intrusive Suite were subsequently emplaced. The intrusive bodies that make up the Chute-Saint-Philippe granitic Suite, the Lac-Saguay intrusive Suite, the Mont-Laurier monzonitic Suite and the Guénette granitic Suite represent newly defined lithodemes in the area. The southeast corner of the map area is underlain by the Sainte-Véronique Ring Complex. Other minor intrusive bodies of variable composition and smaller size are also present.

The area is characterized by the presence of three structural fabrics. The ENE part of the map area contains large open folds with a shallow dip. In the west, the structural trend is essentially determined by the emplacement of intrusions and deformation zones.

The immediate vicinity of Guénette is well known for its quarries of pink granite used as monument stone, and of Val-Barrette, for its very white dolomitic and calcitic marbles used as aggregates. A few marble horizons appear pure enough in certain locations to form a source of agricultural lime to meet local needs, and a SEDEX-type zinc mineralization is associated with dolomitic marble, at the contact with commonly rusty diopsidite, especially in the eastern part of the map area. Furthermore, our work has revealed the presence of gabbro intrusions hosting traces of disseminated pyrite and pyrrhotite, as well as vast expanses of paragneiss outcrops containing at least 5% graphite. Finally, several zones offer potential for nepheline syenite.