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GEOLOGY OF THE LACS DES LOUPS MARINS AREA (34A)

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Charles Gosselin
Martin Simard
Jean David

Accompanies map
SI-34A-C2G-01J

Base camp on the Lac des Loups Marins.

2002

Québec

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ABSTRACT

This report contains the results of a geological survey carried out over the course of the 2000 summer season at a scale of 1 : 250 000. It corresponds to the area covered by NTS sheet 34A (Lacs des Loups Marins) and located about 355 km southwest of Kuujjuaq and 410 km northeast of Radisson. The Lacs des Loups Marins area was considered to be almost entirely underlain by rocks of the Bienville Subprovince. Our mapping suggests it should rather be included, for the most part, in the Minto Subprovince, except for the southeast sector, which lies in the La Grande Subprovince.

Lithological assemblages in the area are Archean in age, with the exception of a few Proterozoic diabase dykes. Volcano-sedimentary rocks are assigned to the ***Dupire Complex*** (2787 ±2 Ma) and are mainly concentrated in two small belts located in the NW part of the area. Tonalitic rocks belong to four lithodemic suites: the gneisso-tonalitic ***Brésolles Suite*** (2811 ±4 Ma), the ***Sem Suite*** composed of biotite-rich tonalites, the ***Coursolles Suite*** (2756 ±8 Ma) essentially composed of hornblende-biotite tonalites, and the ***Favard Suite*** (2749 ±4 Ma) characterized by biotite trondhjemites and leucotonalites. These tonalitic units underwent a regional granitization phenomenon of variable intensity. The tonalitic units are cross-cut by dykes and small bodies of diorite, gabbro and ultramafic rocks assigned to the ***Châteauguay Suite***. Granodioritic units are represented by the ***Desbergères Suite*** (2714 ±12 Ma), which consists of massive granodiorite, and by the ***Lussay Suite*** (2712 ±9 Ma) composed of clinopyroxene-bearing megaphyric granodiorite. Granulite-facies lithological assemblages were observed and assigned to the ***Lippens Suite*** (2709 +3/-2 Ma), the ***MacMahon Suite*** (2697 ±8 Ma) and the ***Loups Marins Complex*** (2694 ±3 Ma). Late intrusive suites were also recognized. The ***Maurel Suite*** (2.685 Ga) is characterized by megaphyric granodiorites to granites, and finally, the ***Tramont Suite*** consists of granites that cut all other Archean units in the area.

The regional metamorphic grade reached the amphibolite facies, except for a few sectors that contain mineral assemblages typical of the granulite facies. In these sectors, the distinction between metamorphosed rocks and charnockitic rocks is difficult to establish clearly. Retrograde metamorphism to the greenschist facies was observed locally, mainly along fault zones.

In the area, several successive phases of deformation took place. Relics of an early phase of deformation D1 are detected in enclaves hosted in Brésolles gneisses. Phase of deformation D2 generated the regional foliation S2, which is the most penetrative structural element in the area. This foliation was reoriented and folded by three subsequent phases of deformation. Phase D3, weakly represented in our area, produced rare NE-SW to ENE-WSW folds. Phase D4 is responsible for the regional structural trend broadly oriented NW-SE. It is associated with folds oriented WNW-ESE to NW-SE along with a well-developed system of NW-SE faults. Finally, phase D5 generated poorly exposed ENE-WSW to NNE-SSW faults.

Our regional mapping coverage led to the discovery of several sites of economic interest related to different settings. Occurrences associated with paragneisses and volcanic rocks yielded a few anomalous gold grades. These correspond to disseminated sulphide zones as well as iron formation horizons less than a metre to a few metres in thickness. Occurrences associated with gabbroic intrusions correspond to gossans, occasionally sheared and with disseminated sulphides, where a few anomalous copper grades were obtained. The economic potential of gabbroic intrusions was outlined during the summer of 2000 with the discovery of a massive sulphide showing in the Lac Qullinaaraaluk area, north of our study area. Several sites of economic interest were discovered along regional faults. These consist of pyrite-rich zones hosted in shear zones a few metres wide, generally affected by carbonate, silica or hematite alteration. One of these occurrences yielded anomalous zinc and lead concentrations.

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INTRODUCTION

Mapping conducted over the course of the summer season of 2000 was carried out within the scope of the Far North project launched in 1997 by the Ministère des Ressources naturelles du Québec (MRN). The objectives of this vast project are to complete the geological mapping coverage, acquire new geoscience data and open new territories to mineral exploration north of the 55th parallel. This survey was conducted at 1 : 250 000 scale, and corresponds to NTS sheet 34A (Lacs des Loups Marins area, Figure 1). This quadrangle represents a surface area of about 13 700 km^2, bounded by longitudes 72°00' and 74°00', and latitudes 56°00' and 57°00'.

The Lacs des Loups Marins area (34A) lies along the extension of previously mapped areas to the east and southeast, in the Maricourt and Gayot areas (Figure 1; Simard *et al.*, 2002; Gosselin and Simard, 2001). To the north, it borders the Nedlouc area (Parent *et al.*, 2000). Based on subdivisions previously proposed for the northern Superior Province (Card and Ciesielski, 1986; Percival *et al.*, 1991 and 1992), the Lacs des Loups Marins area is considered to lie almost entirely within the boundaries of the Bienville Subprovince (Figure 1). However, a recent compilation by the Geological Survey of Canada (Ciesielski, 1998) sets the Bienville boundary further south, just beyond our study area. The results of our work tend to support the latter interpretation and suggest, for the moment, that a major portion of the map area is underlain by rocks of the Minto Subprovince. We also suggest that the southeastern part of the area may be underlain by part of the northernmost extension of the La Grande Subprovince (Figure 2).

Access

The area is only accessible by floatplane or helicopter from Kuujjuaq located 355 km to the northeast, from Radisson 410 km to the southwest, from Fontanges 280 km to the southeast, or from the Lac Pau base located near the Réservoir Caniapiscau 285 km to the southeast (Figure 1).

Methodology

Fieldwork conducted during the summer of 2000 was carried out by a team of six geologists and six assistants. The base camp was located on an island in the eastern part of the Lac des Loups Marins, in the west-central part of the area. The survey was performed by traditional traverses on foot, as well as a series of helicopter spot checks in more isolated areas. On average, fourteen traverses were carried

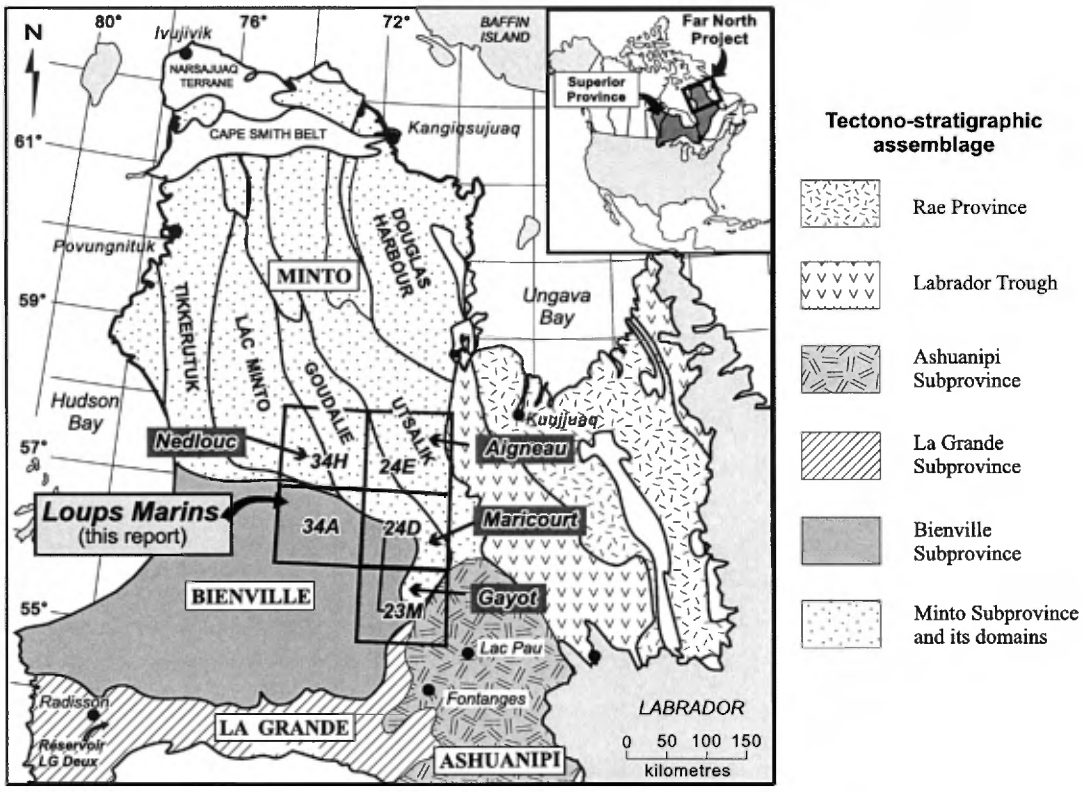


FIGURE 1 - Location of the Lacs des Loups Marins area (NTS 34A, this report), the Gayot area (NTS 23M, RG 2000-03), the Maricourt area (NTS 24D, RG 2001-07), the Aigneau area (NTS 24E, RG 2001-05), the Nedlouc area (NTS 34H and 24E, RG 2000-09) and the principal tectono-stratigraphic assemblages in the northern Superior Province (modified after Card and Ciesielski, 1986 and after Percival *et al.*,1992).

out in each 1 : 50 000 scale NTS sheet. Outcrops are generally well distributed throughout the area. However, vast expanses several tens of square kilometres in size are entirely covered by glacial deposits or swamps, especially in the area corresponding to map sheet 34A/01 (1 : 50 000) in the SE corner of the map area.

Lithogeochemical analyses were performed in order to better define mapped lithologies and observed mineral occurrences. Fifty-five rock samples were analyzed for major and trace elements; of these, twenty-five were re-analyzed for rare earth elements. Eighty-three additional samples were alsoanalysed for elements of economic interest. All this analytical data was integrated into the geomining information system (SIGÉOM) of the Ministère des Ressources naturelles du Québec. About 260 thin sections of rock samples were prepared for a petrographic study of the various lithological assemblages of the area. Finally, six samples were collected for U-Pb age dating. These age determinations were conducted by Jean David, at the GÉOTOP laboratory of the Université du Québec à Montréal.

Previous Work

Reconnaissance mapping was conducted in our area by the Geological Survey of Canada, at 1 : 1 000 000 scale in the early 1960s (Stevenson, 1968). Studies by Card and Ciesielski (1986), on the subdivision of major tectono-stratigraphic assemblages in the Superior Province, and by Percival *et al.* (1991, 1992), more specifically focussed on the Minto Subprovince, and by Ciesielski (1999) in the Bienville Subprovince, are important contributions that helped build a global setting in which to view the Lacs des Loups Marins area.

The area was also covered by a lake sediment geochemistry survey conducted in 1997 by the Ministère des Ressources naturelles du Québec, in partnership with several mineral exploration companies (MRN, 1998). Unpublished maps presenting the results of this survey were graciously supplied by Marc Beaumier of Géologie Québec (MRN). Finally, to our knowledge, no exploration work appears to have been conducted in this specific area.

Acknowledgements

We wish to thank all the members of our field crew for their contribution to the work conducted during the summer of 2000. In addition to the authors, the team also included geologists Sonya Chalifour, Jean-Marc Séguin, Sophie Lafontaine and Marie-Josée Mailhot as well as geological assistants Truong Xuan Hoan, Pascal Meilleur, Mathieu Rochon, Marjorie Simard, Marie-Line Tremblay and Marie-Andrée Vézina. Finally, we also wish to thank our camp manager Guy Bouchard and our cook Serge Arseneau. Furthermore, Marie-Josée Mailhot was also involved in the preparation of geological maps and figures for this report.

Finally, we wish to thank our colleagues from Géologie Québec : Marc Beaumier who prepared exclusive lake sediment geochemical maps, Denis-Jacques Dion for the preparation of geophysical maps, and Pierre Pilote for his critical review of the manuscript of this report.

REGIONAL GEOLOGICAL SETTING

According to existing subdivisions for the northeastern Superior Province (Card and Ciesielski, 1986; Percival *et al.*, 1991 and 1992), the Lacs des Loups Marins area is considered to lie, for the most part, within the boundaries of the Bienville geological Subprovince, just south of the Minto Subprovince (Figure 1).In recent publications by the Geological Survey of Canada (Ciesielski (1998, 1999), the location of the eastern and northern limits of the Bienvillehave been modified, and the boundary between the Bienville and the Minto has been shifted immediately to the south of our study area. This new interpretation thus places the Lacs des Loups Marins area to the NE of the Bienville, within the Minto Subprovince (Figure 2). The various lithological assemblages observed over the course of our fieldwork lead us to support the latter hypothesis. We do propose however, in an informal and preliminary manner, to extend the limits of the La Grande Subprovince up to the SE corner of our study area (Figure 2). Moreover, according to the work of Percival *et al.* (1991, 1992) and Parent *et al.* (2000), the Minto Subprovince observed to the north of our area, is represented by the Tikkerutuk Domain to the west, the Lac Minto Domain in the centre and the Goudalie Domain to the east (Figure 1). The continuation of these domains in our study area will not be discussed here at the moment, since the very definition of the latter remains to be established in a more formal manner. We therefore prefer to consider the units defined during our work from an essentially lithological or lithodemic standpoint, without regard to their relation to a specific domain.

LITHOSTRATIGRAPHY

The Lacs des Loups Marins area (34A) is essentially underlain by Archean rocks and a few Proterozoic dykes. The stratigraphic nomenclature used in this report corresponds, whenever possible, to units defined in adjacent areas during recent mapping campaigns (Gosselin and Simard, 2001; Parent *et al.*, 2000; Simard *et al.*, 2002). The area contains several lithological assemblages that were subdivided into lithodemic suites and complexes. Informal sub-units assigned to these different assemblages are also described in order to define the specific nature of certain

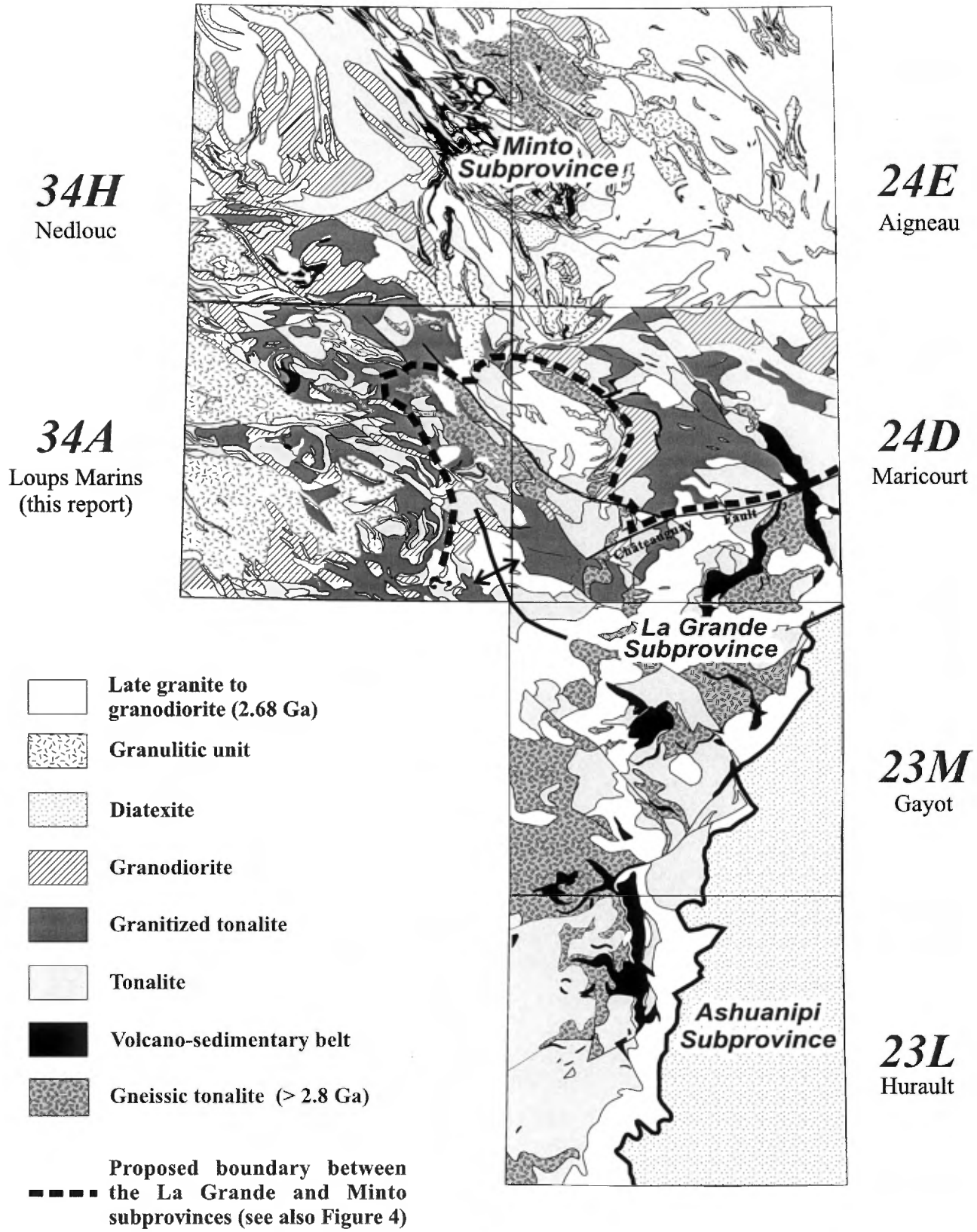


FIGURE 2 - Proposed boundary between the La Grande and Minto subprovinces, and regional compilation of the principal lithological assemblages encountered in the Hurault, Gayot, Maricourt, Aigneau, Nedlouc and Loups Marins (this report) areas.

zones within the map area. Figure 3 shows all the units encountered and lists them in a chronological order based on observed cross-cutting relationships and obtained preliminary isotopic ages.

Volcano-sedimentary rocks are relatively scarce, and are mainly concentrated in the Pastorel and De l'Île belts (Figure 3), both of which are assigned to the Dupire Complex (Adpr). This complex consists of sedimentary assemblages, to which are associated iron formations as well as tholeiitic volcanic rocks. Volcano-sedimentary rocks also occur elsewhere in the area, but do not constitute mappable units. They occur as mega-enclaves or as horizons intercalated in tonalitic and granodioritic units, and their relation with volcano-sedimentary belts has not been established.

Tonalitic units cover the largest surface in the map area. They are subdivided into four lithodemic units : the Brésolles gneisso-tonalitic Suite (Abre), restricted to the eastern half of the area, the Sem Suite (Asem) in the centre, characterized by biotite-rich (about 20 to 40%) tonalite, the Coursolles Suite (Acou) composed of hornblende-biotite tonalite, and the Favard Suite (Afav) mainly composed of biotite trondhjemite and leucotonalite. Tonalitic units underwent a "granitization" phenomenon of variable intensity that particularly affected the Coursolles (Acou) and Favard (Afav) suites.

Gabbro, diorite and ultramafic intrusions are assigned to the Châteauguay Suite (Achg). This unit is particularly abundant in the SW quadrant of the area. It consists of massive, weakly deformed rocks that occur as dykes or small, very restricted bodies often injected with whitish granitic material, giving them a brecciated aspect.

Granodioritic units belong to two lithodemic suites. The Desbergères Suite (Adeb), the most widespread, consists of homogeneous granodiorite occurring as relatively important intrusive bodies. We would like to point out that the granodioritic fraction associated with the "granitization" phenomenon that affects the Coursolles (Acou) and Favard (Afav) tonalitic suites shows the same composition as the Desbergères granodiorites (Adeb), and may therefore be related to this intrusive phase. The Lussay Suite (Alus), which is restricted to the SW corner of the area, is composed of a megaphyric granodiorite with clinopyroxene and red biotite.

Important *granulitic units* were also observed. The Loups Marins Complex (Alma) is the dominant unit, and covers vast expanses in the western half of the area. It consists of a clinopyroxene-bearing tonalite and diorite unit (Alma1), characterized by the presence of salmon pink plagioclase, and a unit of greenish rocks (Alma2) composed of norite, enderbite and orthopyroxene-bearing tonalite (Figure 3). In most cases, the orthopyroxene unit (Alma2) is surrounded by the clinopyroxene unit (Alma1). The Lippens (Allp) and MacMahon (Acmm) charnockitic suites, identified by Parent *et al.* (2000) in the Nedlouc area (34H), were respectively encountered in the NW and NE corners of their map area.

Late intrusions were observed throughout the area. All the preceding units are cross-cut by younger granodiorite and granite intrusions that belong to two suites. The Maurel Suite (Amau) consists of a massive homogeneous rock with a granodioritic to granitic composition that displays a very distinctive megaphyric texture. The Tramont granitic Suite (Atra) is the youngest Archean unit. It consists of a pink, massive, fine to medium-grained granite that is very homogeneous and practically devoid of mafic minerals. This granite forms plutons or dykes of variable thickness that cross-cut all other lithological assemblages of Archean age.

Volcano-Sedimentary Units

Volcano-sedimentary rocks are essentially concentrated within two small belts located in the northwest quadrant of the area : the Pastorel and De l'Île belts (Figure 3). The latter are currently assigned to the Dupire Complex (Adpr) located a few kilometres north of our study area (NTS 34H; Lamothe, 1997; Parent *et al.*, 2000). A few outcrops of mafic volcanic rock, paragneiss and occasional iron formation representing large, albeit restricted in size, isolated enclaves were also observed here and there throughout the area, enclosed in younger units. These volcano-sedimentary enclaves are particularly abundant in the Brésolles gneisso-tonalitic Suite (Abre) as well as in the Sem Suite (Asem). These enclaves represent an important component of these suites, and will therefore be described below, in the section dealing with these respective units. The main volcano-sedimentary rock outcrops located outside of the Pastorel and De l'Île belts are identified on the geological map available in SIGÉOM with the lithology code corresponding to the dominant lithology (*e.g.*: amphibolite = M16, paragneiss = M4, etc.) (Simard and Gosselin, 2001).

Dupire Complex (Adpr)

Lamothe (1997) identified, in the Lac Dupire area (34H/03) a few kilometres north of our area, five small supracrustal rock remnants, which he associated with the "Lac Dupire volcano-sedimentary zone (LDVZ)". Three of these remnants (LDW, LDC and LDE) are dominated by sedimentary rocks, and the remaining two (LDN and LPW) are mainly composed of volcanic rocks. The volcano-sedimentary rocks in this sector are characterized by a strong magnetic signature attributed to the presence of numerous iron formation horizons. Later on, the term "Dupire Complex" was used by Parent *et al.* (2000; NTS 34H) to designate all volcano-sedimentary rocks in this sector. In the Nedlouc area (34H), a U/Pb analysis carried out on a crystal tuff assigned to this complex yielded an age of 2787 ±4 Ma (Table 1; Parent *et al.*, 2000).

In our area, the Pastorel and De l'Île volcano-sedimentary belts were assigned to the Dupire Complex. Geographically situated near the Dupire sector, they are composed of similar lithological assemblages, and also exhibit a strong magnetic

① = Geochronology sample location (see Table 1)

PROTEROZOIC

Diabase dyke (I3B)

ARCHEAN

LATE INTRUSIONS

Tramont Suite (Atra)

Pink massive granite; pegmatite

Maurel Suite (Amau)

Megaphyric granodiorite to granite

GRANULITIC UNITS

Loups Marins Complex (Alma)

(Alma2) Norite to enderbite and orthopyroxene tonalite

(Alma1) Clinopyroxene tonalite and quartz diorite

Lippens Suite (Allp, restricted to the NW quadrant of the area)
MacMahon Suite (Acmm, restricted to the NE quadrant of the area)

Enderbite, opdalite and charnockite; orthopyroxene tonalite

GRANODIORITIC UNITS

Lussay Suite (Alus, restricted to the SW quadrant of the area)

Clinopyroxene-bearing megaphyric granodiorite

Desbergères Suite (Adeb)

Homogeneous granodiorite to granite

GABBRO, DIORITE AND ULTRAMAFIC INTRUSIONS

Châteauguay Suite (Achg)

Massive to foliated gabbro, diorite and pyroxenite

TONALITIC UNITS

Favard Suite (Afav)

(Afav1) Biotite (<10 %) trondhjemite and leucotonalite

(Afav1a) Trondhjemite and leucotonalite associated with layers of paragneiss, tonalitic gneiss and amphibolitized volcanic rocks

(Afav1b) Granitized biotite trondhjemite and leucotonalite

Coursolles Suite (Acou)

Hornblende-biotite tonalite, occasionally granitized

Sem Suite (Asem)

Biotite-rich tonalite (20 to 40 %)

Brésolles Suite (Abre)

Tonalitic to dioritic gneiss, banded trondhjemite

VOLCANO-SEDIMENTARY UNIT

Dupire Complex (Adpr)

Amphibolitized volcanic rocks; biotite paragneiss and hornblende-biotite paragneiss; gabbro and ultramafic rocks; iron formation

FIGURE 3 - Simplified geology of the study area (NTS 34A).

signature. The *Pastorel belt* is located in the northwestern part of the area, just north of the Lacs des Loups Marins (Figure 3). It is the largest belt, covering a surface area of about 14 km in length by 4 km wide. Several lithological assemblages described by Lamothe (1997) in the Lac Dupire sector (34H/03) are present. The Pastorel belt is mainly composed of paragneiss and mafic volcanic rocks, to which are locally associated a few thin layers of felsic pyroclastic rocks. Minor iron formation horizons as well as mafic and ultramafic intrusions are also observed. All these rocks are metamorphosed to the amphibolite facies and are strongly deformed, which gives them a laminated to thinly banded aspect. The *De l'Île belt* was delineated from only two outcrops located at the easternmost end of the Lacs des Loups Marins, in the west-central part of the area (Figure 3). The outcrops show banded amphibolitized intermediate to mafic volcanic rocks, locally strongly sulphide-rich, as well as oxide and silicate-facies iron formation horizons from 1 to 3 m thick.

Paragneisses present in the Dupire Complex (Adpr) form two distinct assemblages. The first and most abundant assemblage consists of a *biotite-garnet paragneiss* that forms fine-grained banded sequences, often disturbed by numerous tight folds. The rock is medium grey, with a yellowish grey to brownish grey weathered surface. In several locations, the paragneiss is affected to varying degrees by a migmatization process that translates into the appearance of small bands of whitish to pinkish granitic mobilizate, one to ten centimetres in size, parallel to the foliation. It is regularly associated with iron formation horizons, and more rarely, with layers of biotite-sillimanite schist. The paragneiss is composed of 80 to 85% quartz and plagioclase, generally largely dominated by quartz. It also contains 10 to 15% biotite flakes aligned parallel to the foliation. Garnet generally accounts for less than 2% of the volume of the rock, but is commonly concentrated in granitic mobilizate bands, where it reaches 10% or more. Sillimanite, tourmaline and apatite were also observed in a few samples.

The second assemblage contains *hornblende-biotite-garnet-bearing rocks* that form one to ten-metre thick horizons intercalated in amphibolite sequences. The rock is light grey in fresh surface and brownish grey in weathered surface. It is composed of 75 to 80% very fine-grained quartz and plagioclase that form an equigranular texture. Plagioclase grains are generally neither twinned nor altered, which makes it difficult to assess the respective quartz and plagioclase content in thin section. The rock also contains 10 to 20% green hornblende and 3 to 10% small tabular biotite grains. Mafic minerals are aligned parallel to the regional foliation. Small pyrite grains are often observed, and may form up to 2% of the rock. Sphene, apatite and carbonates are occasionally observed. In the Lac Dupire area, Lamothe (1997) identified similar hornblende-biotite rocks intimately associated with amphibolites, and interpreted them as paragneisses with a protolith inferred to be a lithic wacke. The significant hornblende content in these rocks, as well as their close association with amphibolites, may also indicate that these consist of intermediate pyroclastic horizons intercalated with basaltic layers.

Amphibolites constitute an important proportion of the Dupire Complex. They are abundant in the Pastorel belt and represent the dominant lithological assemblage in the De l'Île belt. As with all other lithological assemblages in the complex, the strongly deformed amphibolites have a thinly banded aspect. Metamorphism and deformation have completely obliterated primary textures. However, their association with sedimentary sequences as well as the chemical composition of these amphibolites suggest they have a volcanic origin. These rocks are composed of 60 to 80% hypidiomorphic hornblend grains aligned parallel to the foliation, and 20 to 40% plagioclase, forming an equigranular texture. Large plagioclase phenocrysts and glomerocrysts were observed in one sample most likely representing a porphyritic lava flow. Another slightly coarser-grained sample, which may be derived from a fine-grained gabbro sill, contains nearly 20% altered clinopyroxene grains. These observations demonstrate that the amphibolites may belong to various volcanic and intrusive facies. Note that breccia horizons were also described in the Lac Dupire sector (Lamothe, 1997).

Oxide or silicate-facies iron formation horizons, a few metres thick, are associated with biotite paragneisses, or are intercalated in amphibolite sequences. These rocks are well banded, and often disturbed by tight folds. They are particularly well exposed over a thickness of at least 30 m in the De l'Île belt, where they form layers 1 to 4 m thick, intercalated in an amphibolite sequence. A thin section derived from a silicate-facies iron formation shows layers composed of 95% quartz with 5% magnetite, alternating with layers composed of 50% grunerite, 35% garnet, 10% quartz and 5% magnetite.

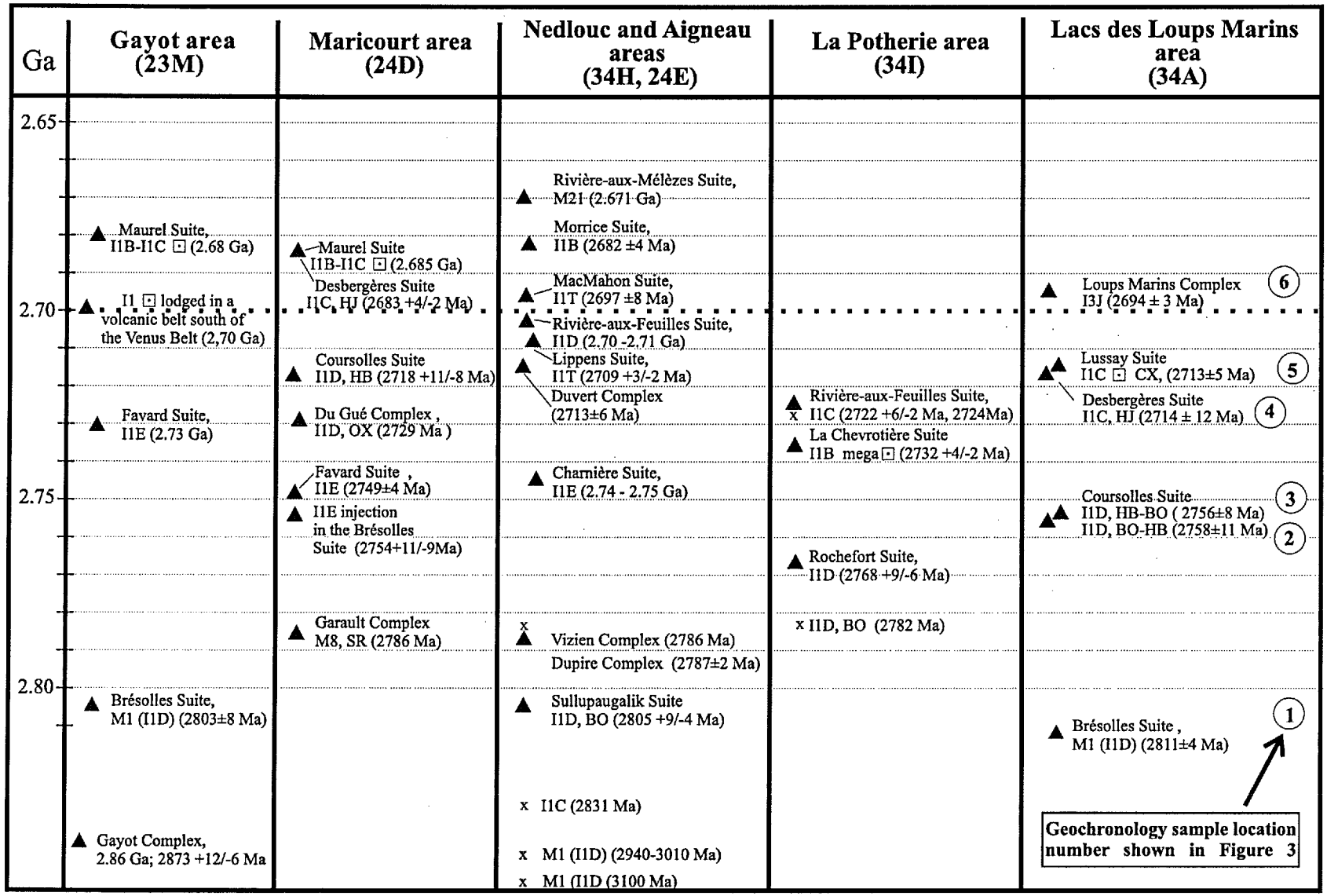
Gabbros and ultramafic rocks are not abundant in the Dupire Complex. They are mainly observed in the north part of the Pastorel belt. Only a few medium-grained amphibolite horizons one to ten metres in size, alternating with finer-grained amphibolites were interpreted as amphibolitized gabbro sills. Ultramafic rocks were observed in two outcrops. The first consists of a massive homogeneous hornblendite observed over a thickness of more than 100 m. The second is composed of blackish pyroxenite that weathers to a brownish grey colour, mainly composed of tremolite, large crystals of serpentinized olivine, and magnetite.

Tonalitic Units

Tonalitic units cover an important proportion of the map area (Figure 3). They are subdivided into four lithodemic units : the Brésolles (Abre), Sem (Asem), Coursolles (Acou) and Favard (Afav) suites.

The Brésolles gneisso-tonalitic Suite (Abre) is the earliest tonalitic unit (2811 ±4 Ma; Table 1). It covers a relatively important surface area in the Gayot and Maricourt areas

TABLE 1 - Compilation of geochronology data collected within the scope of the Far North project. Gayot area, map sheet 23M (Gosselin and Simard, 2001), Maricourt area, map sheet 24D (Simard *et al.*, 2002), Nedlouc and Aigneau areas, map sheets 34H and 24E (Parent *et al.*, 2000; Berclaz *et al.*, 2002), La Potherie area, map sheet 34I (Leclair *et al.*, 2002) and the Loups Marins area, map sheet 34A (this report).



- U/Pb ages : x Data derived from Percival *et al.* (1992) and Skulski *et al.* (1996). ▲ New data obtained within the scope of the Far North project. ⊡ Porphyry
- See lithological and mineralogical abbreviations as well as textural symbols in Sharma (1996).

(23M and 24D, Figure 2), and extends into the eastern part of the Loups Marins area (34A).

The Sem, Coursolles and Favard suites form the remaining tonalitic assemblages in the area. The Sem Suite (Asem) is composed of heterogeneous biotite-rich (20 to 40%) tonalite, with a diatexitic aspect. The Coursolles Suite (Acou) is composed of hornblende-biotite tonalite with a high mafic mineral content. The Favard Suite (Afav) consists of trondhjemite and leucotonalite with a low biotite content (< 10%). These three units contain enclaves of diorite and amphibolite, indicating the presence of one or several early mafic units. The timing of the Sem Suite (Asem) relative to the other two tonalitic units could not be established. Cross-cutting relationships observed in the Maricourt area (Simard *et al.*, 2002) suggest that the Favard Suite (Afav) is younger than the Coursolles Suite (Acou). U-Pb zircon ages obtained for the two units are fairly close, *i.e.* between 2740 and 2760 Ma (Table 1). It is therefore possible that these two units belong to a single tonalite-trondhjemite evolution series. On the other hand, a younger age of 2718+11/-8 Ma (Table 1) was obtained from a sample of hornblende-biotite tonalite seemingly belonging to the Coursolles Suite in the Maricourt area. This clearly illustrates the complex relations existing between the tonalitic units, and the possibility that tonalites with comparable morphological and mineral characteristics may have been emplaced at different eras.

The *tonalitic units* are affected, in a more or less intense fashion, by an important "regional granitization" phenomenon (Figure 2). This phenomenon corresponds to what was observed and described to the east of our study area, in the Maricourt area (NTS 24D), as "migmatization" (Simard *et al.*, 2002). It has particularly affected the Coursolles and Favard suites. In this report, we prefer to use the broader descriptive term "granitization", since the process responsible for the introduction of K-feldspar in tonalitic units, and the presence of an important granodioritic fraction in these intrusive bodies is not fully understood.

Tonalitic units located near contacts with granulitic units are affected by higher-grade metamorphism. This increase in metamorphic grade generates morphological and textural modifications that affect the tonalites in the different units. It mainly results in the appearance of a greenish tinge or a dark smoky grey colour, and in the presence of red biotite, clinopyroxene and occasionally orthopyroxene.

Brésolles Suite (Abre)

The Brésolles gneisso-tonalitic Suite (Abre) was originally identified in the Gayot area (NTS 23M; Gosselin and Simard, 2001) where it covers a vast area. In this area, a sample derived from a dioritic horizon of the Brésolles Suite was dated at 2803 ±8 Ma (Table 1). The age of the dioritic fraction of this unit was confirmed in our area with a result of 2811 ±4 Ma (Table 1). In the Maricourt area (NTS 24D), a sample representing a m-scale layer of homogeneous trondhjemite intercalated with well-banded dioritic and tonalitic sequences was dated. It yielded an age of 2754 +11/-9 Ma (Table 1), indicating that these trondhjemitic layers are late relative to the dioritic fraction (Simard *et al.*, 2002). This age is comparable to that of a trondhjemite sample of the Favard Suite collected in the Maricourt area (2749 ±4 Ma; Table 1). These regional results suggest that certain trondhjemitic layers in the Brésolles Suite represent injections contemporaneous with the emplacement of the Favard Suite.

The Brésolles Suite (Abre) is mostly exposed in the eastern half of the Lacs des Loups Marins area (Figure 3). It is represented by a banded to gneissic assemblage comprising alternating light and dark layers, respectively composed of tonalite to trondhjemite, and diorite to melanocratic tonalite. These compositionally distinctive bands range from a few centimetres to a few metres in thickness. However, the layers that characterize this unit best exhibit straight and regular banding, from one to ten centimetres thick, generally disturbed by complex folding. The diorites and melanocratic tonalites also form, in several locations, horizons several tens of metres thick, intercalated between gneissic sequences. As stated above, certain layers of massive and homogeneous leucotonalite, conformable or unconformable relative to the foliation, probably represent later injections associated with the Favard Suite (Afav). The Brésolles Suite (Abre) also hosts numerous diorite and amphibolite enclaves elongated parallel to the regional foliation. Finally, numerous injections of late granite, one to ten centimetres thick and parallel to the foliation, enhance the gneissic aspect of the unit.

Leucocratic tonalitic bands are mainly composed of variable proportions of quartz and plagioclase. They contain 10 to 20% mafic minerals, represented by variable proportions of biotite, hornblende and chlorite, generally dominated by biotite. Chlorite, locally very abundant, is derived from the alteration of biotite. The presence of small xenomorphic grains of opaque minerals often agglomerated to the mafic minerals, explains the relatively magnetic character of the rock. Apatite and allanite are the most commonly observed accessory minerals.

Melanocratic layers largely consist of diorite and quartz diorite, and more rarely, of tonalite with a high mafic mineral content. These layers generally form cm-scale to m-scale horizons in banded sequences, although they frequently reach a few tens of metres in thickness. In thin section, dioritic bands contain between 20 and 35% brown biotite and green hornblende, in roughly equal proportions. Small xenomorphic opaque mineral grains are often agglomerated to the mafic minerals. The quartz content ranges from 2 to 15%, making the rock either a diorite or a quartz diorite. Plagioclase is partially to strongly altered to sericite. Strong plagioclase alteration is generally accompanied by chloritization of biotite.

Cm-scale to m-scale amphibolite enclaves are frequently observed within the banded sequences of this unit. The

proportion of amphibolite is generally less than 10%, but may exceed 50% in certain outcrops, where it forms layers a few tens of metres thick, sometimes associated with biotite-garnet paragneiss horizons. These lithologies probably represent remains of older volcano-sedimentary belts, such as those recognized in the Gayot and Maricourt areas (Gosselin and Simard, 2001; Simard *et al.*, 2002).

In thin section, the amphibolites range from medium to fine-grained. Medium-grained samples consist of 45 to 60% mafic minerals with 40 to 55% partially to strongly altered plagioclase. The mafic minerals are represented by green hornblende, along with 8 to 20% clinopyroxene. Finer-grained amphibolites consist of 60 to 70% mafic minerals largely dominated by green hornblende, with a small proportion of brownish biotite.

SEM Suite (New unit, Asem)

The Sem Suite is a new unit established to designate a biotite-rich tonalite, mainly located in the central and north-central parts of the Lacs des Loups Marins area (Figure 3). These tonalites are visually very similar to migmatites such as the "diatexites" observed in the Nedlouc and Maricourt areas (34H and 24D; Figure 2). However, their tonalitic composition suggests a different origin. Diatexites generally have a granodioritic to granitic composition, and are derived from *in situ* partial melting of an important volume of rock. The age of the unit has not been established and its timing relative to other units remains uncertain.

The Sem Suite (Asem) is composed of a medium grey tonalite in fresh surface that weathers to a yellowish grey to yellowish brown colour. This tonalite is characterized by a high biotite content (20 to 40%). It generally contains 1 to 5% small rounded to subrounded plagioclase phenocrysts that stand out in positive relief on weathered surfaces. On outcrop, the tonalite has a heterogeneous aspect, largely due to the variable grain size and the uneven distribution of biotite, which most often occurs as cm-scale undulating discontinuous bands. These bands have sharp contacts, and look like biotite *schlieren*, a texture generally encountered in diatexites. The tonalite is usually well foliated. This foliation is outlined by the presence of biotite bands, and stretched enclaves of different compositions. Folding is quite frequent, and is more easily observed in areas where stretched enclaves are abundant. Numerous granitic injections between one and ten centimetres thick, either conformable to or cross-cutting the regional foliation, also enhance the banded aspect of this unit.

The most common enclaves are dioritic in composition. They generally represent less than 5% of the outcrop surface although they may be much more abundant locally. These enclaves are stretched along the foliation direction, and their length ranges from a few centimetres to more than one metre. The enclaves consist of dark grey amphibolitized diorite, more or less magnetic, weakly to strongly foliated, ranging from fine to coarse-grained. In certain areas, enclaves and preserved layers of biotite-garnet paragneiss are predominant, occasionally associated with iron formation enclaves. These paragneisses often display a migmatitic texture. Fine-grained amphibolite enclaves, probably derived from mafic lavas, as well as ultramafic enclaves are also observed locally. Occasional outcrops of diorite, paragneiss or amphibolite most likely represent larger-scale enclaves preserved within the tonalite.

In thin section, the heterogeneous grain size of the tonalite is obvious, and is enhanced by the presence of coarse rounded plagioclase grains. The tonalite consists of 20 to 30% quartz and 30 to 60% plagioclase. It also contains on average 20 to 25% aligned biotite flakes that are unevenly distributed, often occurring in clusters between large plagioclase grains. This percentage may reach up to 40% in certain samples. The biotite contains small zircon inclusions that may be very abundant. It is generally brownish, except in samples from the southwestern and north-central sectors, where the metamorphic grade is higher. In these areas, the biotite takes on a very pronounced reddish tinge, and is accompanied by clinopyroxene and occasional orthopyroxene grains. This mineral variation, related to the metamorphic grade, was also observed in samples collected in paragneiss enclaves. Tonalite samples collected in areas with abundant paragneiss enclaves frequently contain garnet, and more locally, sillimanite and cordierite. The magnetite content is variable, but overall is less than 1%. Magnetite occurs as small xenomorphic grains most often agglomerated to biotite flakes. Apatite is an accessory mineral. Epidote, green hornblende and K-feldspar were also observed in minor quantities in a few samples.

Coursolles Suite (Acou)

The Coursolles Suite (Acou) was defined in the Maricourt area (Simard *et al.*, 2002), just east of our study area (Table 2). In the Maricourt area, it consists of an early diorite unit and a dominant unit of hornblende-biotite tonalite affected in several sectors by an important granitization phenomenon.

In our study area, the Coursolles Suite (Acou) covers a relatively modest surface area (Figure 3). It is represented by a single unit (Acou) composed of hornblende-biotite tonalite similar to the one recognized in Maricourt. The Coursolles tonalite in the Loups Marins area has also been affected by this "granitization" phenomenon that has produced compositional variations gradually shifting from tonalitic to granodioritic. Two samples of hornblende-biotite tonalite were dated in our area. They yielded respective U-Pb zircon ages of 2758 ±11 Ma and 2756 ±8 Ma (Table 1). An age of 2718 +11/-8 Ma (Table 1) was obtained from a tonalite sample collected in the Maricourt area (Simard *et al.*, 2002). The ages obtained in the Loups Marins area appear to corroborate cross-cutting relationships observed in the field, namely with the Favard Suite (Afav).

Coursolles tonalites (Acou) are fine to medium-grained medium grey to dark grey rocks, occasionally massive but

TABLE 2 - Preliminary regional stratigraphic correlations for major units encountered in the Gayot (23M), Maricourt (24D), Nedlouc (34H), Aigneau (24E), and Loups Marins (34A, this report) areas.

	Gayot (23M) and Maricourt (24D) areas		Loups Marins area (34A)		Nedlouc (34H) and Aigneau (24E) areas	
	Lithostratigraphic units	**Brief description** (Gosselin and Simard, 2000; Simard *et al.*, 2001)	**Lithostratigraphic units**	**Brief description** (this report)	**Lithostratigraphic units**	**Brief description** (Parent *et al.*, 2000; Berclaz *et al.*, 2001)
LGU	Tramont Suite	Biotite leucogranite	Tramont Suite	Biotite leucogranite	Morrice Suite (2682±4Ma)	Granite
LGU	Maurel Suite (2.68 Ga)	Megaphyric granite to granodiorite	Maurel Suite	Megaphyric granite to granodiorite		
GU	Du Gué Complex (2729 Ma)	Orthopyroxene tonalite, enderbite, paragneiss, volcanic, diatexite	Loups Marins Complex (2694 ±3 Ma)	Norite to enderbite, orthopyroxene tonalite	Lippens (2709 +3/-2 Ma) and MacMahon (2697±8 Ma) suites	Enderbite and charnockite
GU			Lippens and MacMahon suites	Enderbite opdalite and charnockite		
GGU			Lussay Suite (2713 ± 5 Ma)	Clinopyroxene-bearing megaphyric granite to granodiorite	? Monchy Suite	Heterogeneous granodiorite
GGU	Desbergères Suite (2683 +4/-2 Ma)	Homogeneous biotite-hornblende granodiorite	? Desbergères Suite 2714±12 Ma	Homogeneous biotite granodiorite	Rivière-aux-Feuilles Suite granodiorite (2722 +6/-2 Ma)	Homogeneous hornblende-biotite granodiorite
					La Chevrotière Suite (2732 +4/-2 Ma)	Megaphyric granite
IMI	Châteauguay Suite	Mafic to ultramafic intrusions	Châteauguay Suite	Gabbro, diorite and ultramafic rock	Bacqueville Suite	Diorite and gabbro
TU	Favard Suite (2.73 Ga; 2749 ±4 Ma	Trondhjemite and leucotonalite Granitized leucotonalite Leucotonalite associated with other lithologies	Favard Suite	Trondhjemite and leucotonalite Granitized leucotonalite Leucotonalite associated with other lithologies	Charnière Suite (2.74-2.75 Ga)	Biotite leucotonalite or trondhjemite
TU	Coursolles Suite (2718 +11/-8 Ma)	Hornblende-biotite tonalite Diorite and gabbro	Coursolles Suite (2758±11; 2756±8 Ma)	Hornblende-biotite tonalite	? Rivière-aux-Feuilles Suite, tonalite (2.7-2.71 Ga)	Hornblende tonalite
			? Sem Suite	Biotite tonalite		
TU	Brésolles Suite (2803±8 Ma)	Gneissic tonalite and diorite	Brésolles Suite (2811±4 Ma)	Gneissic tonalite and diorite	Sullupaugalik Suite (2805 +9/-4 Ma)	Migmatized gneissic tonalite
VSA	Garault Complex (2786 Ma)	Volcano-sedimentary sequence dominated by metasediments; calc-alkaline lavas and diorite	? Dupire Complex	Volcano-sedimentary sequence; metasediments and tholeiitic lavas	? Duvert Complex (2713 ±6 Ma)	Volcano-sedimentary sequence; tholeiitic lavas and calc-alkaline andesitic unit
VSA	Gayot Complex, (2873 +12/-6 Ma)	Volcano-sedimentary sequence and mafic to ultramafic intrusions			Dupire Complex (2787±2 Ma)	Volcano-sedimentary sequence; tholeiitic lavas

VSA = Volcano-sedimentary assemblages; **TU** = Tonalitic units; **IMI** = Intermediate to ultramafic intrusions; **GGU** = Granodioritic and granitic units; **GU** = Granulitic units; **LGU** = Late granodioritic and granitic units; **?** = Problematic or undetermined stratigraphic correlation (location of areas shown in figures 1 and 2).

generally well foliated. They contain between 15 and 25% green hornblende and biotite in roughly equal proportions, that form pods often stretched along the foliation direction. Xenomorphic magnetite grains, which may account for up to 1% of the rock, are often agglomerated to the mafic minerals. The rock contains 20 to 30% quartz, 50 to 60% plagioclase and 0 to 15% K-feldspar. Xenomorphic to hypidiomorphic grains of sphene and subrounded apatite grains are abundant, most often agglomerated to the mafic minerals. Epidote was observed in several samples, and may represent nearly 1% of the volume of the rock in certain cases. Small allanite grains often occur in the core of epidote grains in samples where epidote is abundant.

Locally, the tonalite hosts fine-grained melanocratic diorite enclaves that are frequently magnetic, and usually account for less than 2% of the volume of outcrops. These enclaves range from one to ten centimetres in size, are rarely of m-scale, and are stretched parallel to the regional foliation direction.

In several locations, the tonalite has undergone "granitization". This granitization translates into the presence of a greyish granodioritic to granitic phase, with a lower mafic mineral content than the tonalitic phase, which is largely dominated by biotite. This more potassic phase forms small ribbons, pockets, pods or lenses with gradual and poorly defined contacts with the tonalite. Its distribution is strongly heterogeneous at the scale of the unit, the outcrop and even in hand sample. The granitization may represent from 1 to over 50% of the volume of the outcrop. In hand sample, it translates into the presence of K-feldspar grains of variable size and abundance (0 to 15%), distributed in a very heterogeneous fashion. In the SE corner of the map area, tonalites often contain K-feldspar phenocrysts, which give the rock a porphyritic aspect. Locally, the phenocryst content becomes fairly important, and the rock takes on a granodioritic composition.

Favard Suite (Afav)

The Favard Suite (Afav) was defined in the Gayot area (NTS 23M; Gosselin and Simard, 2001), to the southeast of our area, and recognized further east, in the Maricourt area (NTS 24D; Simard *et al.*, 2002). It is mainly composed of biotite trondhjemite and leucotonalite. Two age dating analyses performed on these rocks yielded U-Pb zircon ages of 2742 ±3 Ma in Maricourt, and a preliminary age of 2.73 Ga in Gayot (Table 1).

The Favard Suite covers a vast surface in the Loups Marins area (Figure 3). In addition to the dominant unit consisting of biotite trondhjemite and leucotonalite (Afav1), this suite also contains two sub-units. *Sub-unit Afav1a* is characterized by the association of leucotonalite with other lithologies such as gneiss, paragneiss, amphibolite, gabbro, diorite and hornblende tonalite, which form a diverse unit. *Sub-unit Afav1b* corresponds to sectors where the tonalite has undergone an important "granitization" phenomenon, which gives the rock a strongly heterogeneous aspect, and a composition ranging from tonalitic to granodioritic. This sub-unit is equivalent to the one qualified as "migmatized" in the Maricourt area.

Biotite Trondhjemite and Leucotonalite (Afav1)

This unit (Afav1) is characteristic of the Favard Suite, as defined in the Gayot area (NTS 23M; Gosselin and Simard, 2001). It consists of whitish to slightly pinkish medium-grained trondhjemite and leucotonalite, which contains less than 10% biotite. The latter mineral is sometimes concentrated along poorly defined cm-scale layers, which give the unit a roughly banded but fairly distinctive aspect. However, the rock is commonly homogeneous, and massive to weakly foliated. Locally, the foliation may be more intense near deformation zones. In the southeast quadrant of the area, the quartz contained in the rock is often of a dark smoky variety, which may be indicative of a slightly higher metamorphic grade or intensity of deformation in the sector. Unit Afav1 may contain a small proportion (less than 10% of the volume of the outcrop) of granodioritic to granitic material similar to that observed in the granitized sub-unit (Afav1b).

Leucotonalites contain cm-scale to m-scale enclaves mainly composed of diorite and amphibolite, which generally represent less than 2% of the total volume of the outcrop, but locally reach up to 40%. Along the enclave margins, a reaction rim of variable thickness is frequently observed, characterized by a high amphibole content in the leucotonalite. This phenomenon is more strongly developed in enclave-rich sectors. The enclaves are often stretched and foliated parallel to the regional foliation. However, a few exhibit an early foliation, crenulated by the regional foliation.

In thin section, the leucotonalite is composed of 30 to 40% quartz, 50 to 60% plagioclase and less than 10% brownish biotite, sometimes partially chloritized. The biotite always hosts small zircons, which may be abundant on occasion. K-feldspar crystals are common, but not abundant, representing less than 2% of the rock. Xenomorphic magnetite and sphene grains, as well as small subrounded apatite grains are often found agglomerated to biotite grains. White mica, epidote and apatite are accessory minerals, found in minor quantity. Quartz grains nearly always show a pronounced undulating extinction. Sericite alteration of plagioclase grains is generally weak, except in certain samples collected in areas that were affected by late faults. In these samples, intense sericitization of plagioclase grains is accompanied by very strong and often complete chloritization of biotite.

Trondhjemite and Leucotonalite Associated with Other Lithologies (Afav1a)

Sub-unit Afav1a is restricted to a small sector located in the northeast corner of the map area (Figure 3). It was traced in order to respect the structural continuity of this unit

identified in the adjacent Maricourt area (Simard *et al.*, 2002). In Maricourt, this sub-unit is essentially characterized by the abundance of enclaves and layers between 10 cm and 1 m in size, of paragneiss, tonalitic gneiss, diorite, gabbro and amphibolite, intercalated in trondhjemites and leucotonalites of the Favard Suite. However, the trondhjemite and leucotonalite of sub-unit Afav1a mapped in this area do not contain such a wide variety of enclaves. Nevertheless, numerous diorite and hornblende tonalite layers were observed. These represent, in several locations, over 20% of the volume of the outcrop.

Granitized Biotite Trondhjemite and Leucotonalite (Afav1b)

The trondhjemites and leucotonalites of the Favard Suite (Afav1b) have undergone a very widespread "granitization" phenomenon of variable intensity, which was originally recognized further east in the Maricourt area (Figure 2; Simard *et al.*, 2002).

In the Lacs des Loups Marins area, sub-unit Afav1b was defined to designate sectors where the "granitization" process is particularly intense and regular. This sub-unit covers most of the area underlain by the Favard Suite (Figure 3). The "granitization" translates into the presence of a pinkish grey medium to coarse-grained granodioritic to granitic fraction, which constitutes between 10 and 60% of the total rock. This more potassic fraction forms bands between 1 and 10 cm, more or less continuous with blurry contacts, which give the biotite trondhjemite and leucotonalite a banded heterogeneous aspect. It also occurs as pockets, pods or lenses of variable dimensions, with diffuse and very gradual contacts difficult to distinguish from the main tonalitic fraction. The distribution of the potassic fraction is heterogeneous both at the scale of the outcrop and in hand sample. The extent and intensity of the granitization process within the unit is also highly variable, such that it is not uncommon to find outcrops formed of massive and homogeneous trondhjemite or leucotonalite, similar to those in unit Afav1. The granitization phenomenon often becomes more intense near the borders of granodiorite bodies of the Desbergères Suite (Adeb). This fact may suggest that the emplacement of these plutons is somehow linked with the granitization of the Favard Suite (Afav).

Gabbroic, Dioritic and Ultramafic Intrusions

Gabbroic, dioritic and ultramafic intrusions were mapped throughout the area, and were assigned to the Châteauguay Suite. These ultramafic to intermediate rocks are younger than the volcano-sedimentary rocks in the Pastorel and De l'Ile belts, and are therefore not associated with the Dupire Complex.

Châteauguay Suite (Achg)

The Châteauguay Suite (Achg) was historically introduced to the east of our area, in Maricourt (Simard *et al.*, 2002), to describe gabbroic intrusions observed throughout the area, and which could not be linked to other existing units. In this area (NTS 24D), it was subdivided into two distinct sub-units. The first consists of hornblende gabbro dykes, often associated with ultramafic intrusions. The second less widespread sub-unit consists of a few clinopyroxene-biotite gabbro dykes. In the Maricourt area, these intrusions cross-cut lithological assemblages in the Coursolles and Favard suites, and are themselves cross-cut by pegmatitic and granitic injections of the Tramont Suite (Simard *et al.*, 2002).

In the Loups Marins area, the Châteauguay Suite (Achg) is represented by a single unit of minor extent, observed throughout the area (Figure 3). It is composed of gabbro, diorite and ultramafic rocks that form restricted bodies or dykes a few kilometres long. Gabbro is the dominant lithology. It forms a medium to coarse-grained rock, with a variable magnetic susceptibility and a generally massive aspect. The gabbro may be leucocratic or melanocratic, with a brownish grey weathering rind. It is commonly injected with abundant whitish granitic material 1 to 10 cm thick, which gives the rock a brecciated aspect. Diorite enclaves were also observed in certain locations in the gabbro.

In thin section, the gabbro contains between 40 and 75% mafic minerals, mainly represented by green hornblende and clinopyroxene, nearly always dominated by hornblende. The rock also contains less than 5% biotite, and locally, minor orthopyroxene. The magnetite content is highly variable, ranging from a few disseminated grains to more than 3% of the volume of the rock in certain samples. In addition to mafic minerals, the gabbro contains plagioclase, and occasionally less than 5% quartz.

In the field, diorite occurs in the same fashion as gabbro, to which it is sometimes associated. It is generally lighter-coloured due to its lower mafic mineral content, ranging from 20 to 40%. The diorite contains the same constituents as the gabbro, although the quartz content may reach 10% in certain samples, which demonstrates that the global composition may vary from a diorite to that of a quartz diorite.

Ultramafic rocks are not widespread, and are mainly observed in the southwesternmost part of the map area. Since these occur as isolated outcrops, the relationship between the ultramafic rocks and the gabbro has not been clearly established. They consist of hornblendites, pyroxenites or peridotites which, like the gabbro, are often injected with granitic material.

The timing of the Châteauguay Suite (Achg) relative to other units in the Loups Marins area is difficult to establish, since contacts between rocks of the Châteauguay Suite (Achg) and other units are very rarely exposed. Gabbro

enclaves similar to gabbros in the Châteauguay Suite (Achg) were observed in the Desbergères (Adeb) granodiorite in a few locations, near contacts between the Desbergères (Adeb) and gabbro intrusions of the Châteauguay Suite (Achg). This appears to suggest that the Châteauguay Suite (Achg) is older than the Desbergères Suite (Adeb). Within granulitic sectors, a gabbro similar to the Châteauguay Suite (Achg) is cross-cut by greenish granitic injections that underwent granulite-grade metamorphism probably associated with the emplacement of charnockitic rocks of the Loups Marins Complex (Alma). Based on these interpretations, the Châteauguay Suite (Achg) is inferred to be older than this complex. Intrusive rocks of the Châteauguay Suite (Achg) are also cross-cut by late injections of pink granite assigned to the Tramont Suite (Atra).

Granodioritic Units

Granodioritic units cover an important proportion of the study area (Figure 3). They belong to two lithodemic suites : the Desbergères Suite (Adeb), the most widespread, composed of homogeneous granodiorite, and the Lussay Suite (Alus), restricted to the SW corner of the map area, composed of megaphyric granodiorite with red biotite and clinopyroxene.

Desbergères Suite(Adeb)

The Desbergères Suite (Adeb) was originally identified in the Maricourt area (Simard *et al.*, 2002), east of our current map area. It is mainly composed of homogeneous granodioritic to granitic rocks. An age dating analysis conducted on a granodiorite sample from the Maricourt area yielded a relatively young U-Pb zircon age of 2683+4/-2 Ma (Table 1), whereas a second analysis from the Loups Marins area yielded an older age of 2714±12 Ma (Table 1). As mentioned previously, Desbergères granodiorites are compositionally and texturally similar to the granodioritic fraction observed in the granitized Favard unit (Afav1b).

The Desbergères Suite (Adeb) occurs in fairly well circumscribed intrusive bodies several kilometres in size, except in the southwest sector, where it occupies a more important area (Figure 3). It is mainly composed of medium-grained massive to weakly foliated homogeneous granodiorite and granite. Granitic rocks generally exhibit a pink colour, whereas granodiorites are more pinkish grey or whitish grey. However, the colour is not always a diagnostic feature to estimate the K-feldspar content, such that granitic rocks can sometimes also exhibit a whitish grey colour. In the field, these greyish rocks were often erroneously described as homogeneous tonalites, given the whitish colour of K-feldspars. The granites and granodiorites have a good magnetic susceptibility, and contain from 3 to 10% mafic minerals, disseminated in the rock or distributed in pods. K-feldspar phenocrysts 1 to 2 cm in size are common. They generally represent less than 2% of the total rock, but locally may form up to 25%. Enclaves ranging from 1 to 50 cm in length observed in this unit consist almost exclusively of dark grey diorite, often strongly magnetic. They are most often stretched along the foliation direction, and account for 1 to 2% of the total surface of outcrops. In the NW corner of the area, m-scale enclaves of foliated enderbite were noted in a granitic rock.

In thin section, the rock is composed of 20 to 30% quartz, 15 to 45% K-feldspar and 25 to 50% plagioclase, giving the rock a granodioritic or granitic composition. Quartz characteristically exhibits a fairly pronounced undulating extinction. Myrmekitic textures are common and well developed. The rock contains 3 to 10% biotite, often greenish, partially to completely chloritized. Green hornblende was observed in minor quantity in a few samples. Xenomorphic grains of magnetite and sphene, and small subrounded apatite grains are often observed agglomerated to the biotite. Allanite, epidote and white mica are occasional minerals.

Lussay Suite (New unit, Alus)

The Lussay Suite (Alus) is a new unit introduced to describe a few intrusions of megaphyric granodiorite with red biotite and clinopyroxene located in the southwest corner of the area (Figure 3). An age dating analysis performed on a sample from one of these intrusions yielded a U-Pb zircon age of 2713±5 Ma (Table 1). This age is very similar to one obtained for the Radisson pluton (2712 ±3 Ma, Mortensen and Ciesielski, 1987), formed of a porphyritic monzodiorite considered as part of the Bienville Subprovince in the LG-2 sector (Goutier *et al.*, 1998).

The Lussay Suite (Alus) is composed of pinkish grey to greenish brown medium to coarse-grained granodiorite, characterized by a well-developed megaphyric texture. This texture is due to the presence of 10 to 25% K-feldspar phenocrysts ranging from 0.5 to 3 cm in length. This rock possesses a strong magnetic susceptibility, a feature that makes intrusions of the Lussay Suite easily detectable on regional aeromagnetic surveys. This granodiorite also contains between 10 and 20% mafic minerals represented by highly variable proportions of red biotite, green hornblende and clinopyroxene, with more rarely, a few orthopyroxene grains. Magnetite grains are associated with the mafic minerals, and generally represent a little over 1% of the volume of the rock. Xenomorphic sphene grains as well as small subrounded apatite grains are agglomerated to the mafic minerals. Epidote and allanite were also observed in a few samples.

For the moment, we cannot establish if the granodiorites of the Lussay Suite (Alus) belong to a charnockitic suite or if the greenish tinge of these rocks along with the presence of red biotite, clinopyroxene and orthopyroxene is the result of high-grade metamorphism related to the emplacement of charnockitic rocks of the Loups Marins Complex.

Granulitic Units

Granulitic rocks are fairly widespread in the Minto Subprovince (Figure 2). They were mapped in the Nedlouc area (NTS 34H; Parent *et al.*, 2000), the Aigneau area (NTS 24E; Berclaz *et al.*, 2002) and the Maricourt area (NTS 24D; Simard *et al.*, 2002).

In the Lacs des Loups Marins area, granulitic rocks mostly occur in the western half of the map area (Figure 3). They often cover vast expanses corresponding to well-defined positive magnetic anomalies (Figure 4). The vast majority of these rocks are assigned to the Loups Marins Complex (Alma). In the northern part of the map area however, certain sectors were assigned to the charnockitic Lippens Suite (Allp) and the MacMahon Suite (Acmm) (Parent *et al.*, 2000), in order to respect the cartographic continuity of these units into our area.

Lippens Suite (Allp)

The Lippens Suite (Allp) was introduced by Parent *et al.* (2000) in the Nedlouc area, north of our study area. These authors describe it as a strongly magnetic suite mainly composed of medium to coarse-grained enderbite. These rocks are cross-cut by a charnockitic sub-unit that forms a pluton covering a surface area of 50 km^2. An age dating analysis performed on a sample of enderbite yielded a U-Pb zircon age (crystallization age) of 2709+3/-2 Ma (Table 1).

In our area, the Lippens Suite (Allp) covers a restricted surface located in the northwest corner of the map area (Figure 3). It consists of greenish grey medium-grained enderbite with orthopyroxene and red biotite, strongly magnetic and massive to weakly foliated. These tonalites contain between 10 and 20% mafic minerals grouped into cm-scale clusters, formed of variable proportions of red biotite, clinopyroxene and orthopyroxene. Biotite predominates whereas orthopyroxene is less abundant and may locally be absent. This contrasts with enderbites in the Nedlouc area, where orthopyroxene is predominant. Well-foliated fine-grained diorite enclaves are abundant in rocks of the Lippens Suite. They make up between 3 and 10% of the outcropping rocks, with sizes ranging from 0.2 to 5.0 m long. They are stretched along the regional foliation direction.

MacMahon Suite (Acmm)

The MacMahon Suite (Acmm) was introduced in the Nedlouc area (Parent *et al.*, 2000) to describe weakly deformed charnockitic rocks ranging from tonalitic to granitic in composition. An enderbite sample collected in this area yielded a U-Pb zircon age of 2697±8 Ma (Table 1).

In our area, the MacMahon Suite (Acmm) is restricted to the northeast corner of the map (Figure 3). It was traced along the extension of this same unit recognized further north in the Nedlouc area by Parent *et al.* (2000). The MacMahon Suite is mainly composed of weakly deformed, medium-grained greenish enderbite. It also contains lesser quantities of opdalite and charnockite. Opdalites generally display a megaphyric texture with K-feldspar phenocrysts, whereas the charnockites occur as late cm-scale to m-scale injections that take on a greenish golden brown colour. These different lithologies contain about 10% mafic minerals, represented by red biotite, clinopyroxene and orthopyroxene. Along the eastern part of the unit, near the contact with the Favard Suite, fine-grained greenish trondhjemites containing less than 5% mafic minerals are occasionally observed. These trondhjemites were included in the MacMahon Suite given the presence of orthopyroxene. However, it is possible that these rocks may represent a metamorphosed equivalent of the Favard Suite. This interpretation is supported by their lithogeochemistry (see section entitled "LITHOGEOCHEMISTRY") as well as by their weak magnetic susceptibility, which contrasts with the generally high magnetic susceptibility associated with granulitic rocks of the MacMahon Suite (Parent *et al.*, 2000).

Loups Marins Complex (New unit, Alma)

The Loups Marins Complex (Alma) is a new unit located in the western half of the map area (Figure 3). It consists of compositionally diverse greenish rocks with orthopyroxene and clinopyroxene, and generally corresponds to sectors with a high magnetic susceptibility (Figure 4). The complex was subdivided into two units : a unit mainly composed of clinopyroxene-bearing tonalitic rocks (Alma1), which roughly surrounds an orthopyroxene-bearing unit (Alma2), dominated by dark green rocks of intermediate or tonalitic composition. The contact between the two units is drawn approximately, based on the presence or absence of orthopyroxene. The Loups Marins Complex (Alma) is thus composed of both intrusive rocks belonging to charnockitic suites, and of older country rocks metamorphosed to the granulite facies. More detailed work is however needed to help classify these various lithological assemblages, which are often visually and compositionally very similar.

An age dating analysis conducted on a quartz norite in the orthopyroxene-bearing unit (Alma2) yielded a preliminary U-Pb zircon age of 2694±3 Ma (Table 1). The relative timing of units Alma1 and Alma2 was not established with confidence, but the central orthopyroxene unit (Alma2) is most likely younger than the adjacent unit (Alma1). This hypothesis is supported by the presence of orthopyroxene-bearing intrusions that cross-cut clinopyroxene-bearing rocks of unit Alma1 in a few locations.

Clinopyroxene Unit (Alma1)

The *clinopyroxene unit* (Alma1) is mainly composed of a medium-grained massive to weakly foliated rock with a high magnetic susceptibility. Its composition ranges from that of a quartz diorite to a tonalite. It contains between 10 and 25% mafic minerals, distributed in cm-scale clusters, which are

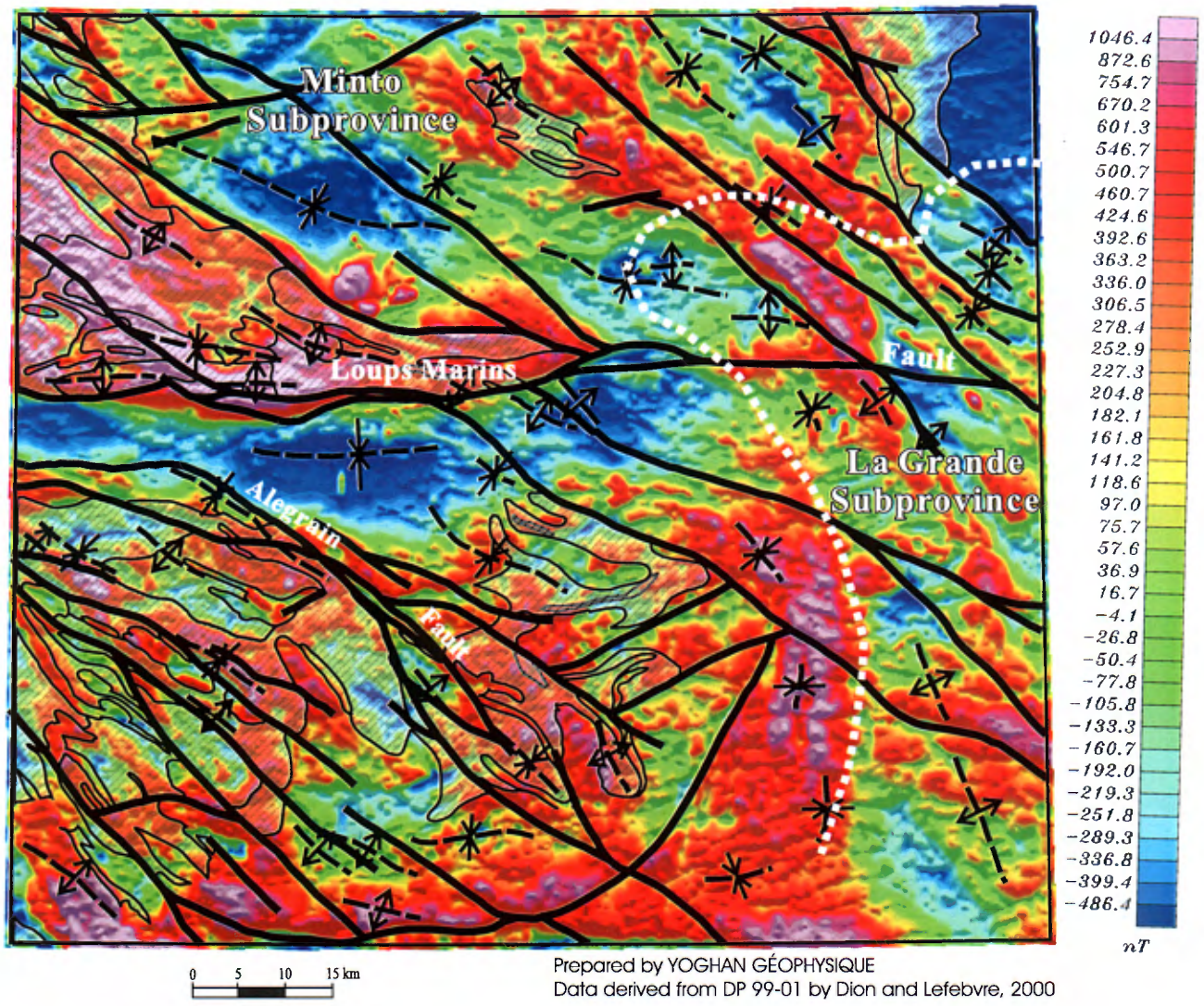


FIGURE 4 - Shaded total magnetic field map for the Loups Marins area showing the correlation with the proposed boundary between the La Grande and Minto subprovinces as well as with granulitic units (shaded areas), and major faults and fold axes.

generally associated with small magnetite grains. Its colour is highly variable, grading from a pinkish grey to greenish grey to a medium green without any apparent contacts. It contains salmon pink plagioclase grains, mm-scale to cm-scale, which often give the rock a somewhat porphyritic aspect. These pink plagioclase grains are quite distinctive and may easily be confused with K-feldspar. With a few exceptions where they may form between 5 and 10% of the rock, the latter are generally absent or very scarce.

In thin section, sample compositions range from a quartz diorite to a tonalite, although tonalitic compositions are largely predominant. The rock contains 10 to 30% quartz, 55 to 70% plagioclase and 15 to 25% mafic minerals. The latter are represented by variable proportions of red biotite and clinopyroxene, with biotite being most often slightly more abundant. Green hornblende was observed in a few samples, especially in intermediate rocks or in tonalites with a greater mafic mineral content. Xenomorphic magnetite grains are commonly agglomerated to mafic minerals, and regularly represent 1 to 3% of the total volume of the rock. Apatite, occurring as small subrounded grains, is also very widespread. The rock displays a granoblastic texture typical of this unit. It is formed of a very fine-grained groundmass of quartz and plagioclase, surrounding coarser quartz and plagioclase grains. Red biotite flakes are also found in the groundmass.

The clinopyroxene unit (Alma1) also includes, in certain sectors, yellowish grey tonalite with a lower mafic mineral content between 5 and 8% red biotite and clinopyroxene in variable proportions. The distinctive salmon pink plagioclase grains were also noted in the tonalite. The rock often contains a granitic fraction, also clinopyroxene-bearing, which forms pockets, small layers or lenses with diffused and poorly defined contacts. These horizons may represent

metamorphosed layers of granitized tonalite of the Favard Suite.

Diorite and amphibolite enclaves between 0.1 and 1.0 m in size, similar to those observed in all other units in the area, were also observed in the clinopyroxene unit. Here, however, the enclaves contain red biotite and clinopyroxene grains.

Orthopyroxene Unit (Alma2)

The *orthopyroxene unit* (Alma2) covers an important surface in the western half of the map area, where it occurs in three fairly well-defined sectors (Figure 3). The unit is composed of greenish orthopyroxene-bearing rocks with a high magnetic susceptibility. The rock is medium-grained and its composition varies from dioritic (norite) to tonalitic (enderbite). On outcrop, it is homogeneous, massive to weakly foliated. In the field, it is difficult to distinguish felsic phases from intermediate phases, although norites often exhibit a darker greenish tinge compared to enderbites. All these rocks are commonly cross-cut by cm-scale to m-scale injections of charnockite with a low mafic mineral content. These injections are either parallel, or at a sharp angle relative to the regional foliation. The charnockite is massive, fine to medium-grained and has a characteristic golden brown colour. Porphyritic opdalites, containing 10 to 25% K-feldspar phenocrysts, were also observed locally. Fine-grained diorite enclaves are abundant, and were noted in all the lithological assemblages in the unit. These enclaves range from 0.01 to 5.0 m in size, and represent 1 to 10% of the volume of outcropping rocks. They are formed of a fine-grained orthopyroxene-bearing rock that is generally well foliated and exhibits a strong magnetic susceptibility.

Tonalite layers, with 5 to 8% mafic minerals as orthopyroxene and red biotite, were also observed in several locations. These rocks have a golden brown colour, as opposed to the enderbitic rocks of the unit, which are rather greenish. They also contain an important granitic fraction, and their appearance suggests that they could represent layers of granitized tonalite of the Favard Suite that were metamorphosed to the granulite facies.

All the lithological assemblages observed in the orthopyroxene unit (Alma2) are also cross-cut by cm-scale to m-scale injections of fine to coarse-grained pink granite assigned to the Tramont Suite (Atra).

A study of thin sections helped demonstrate that intermediate orthopyroxene-bearing rocks (norite) are an important component of unit Alma2. More than a third of the samples observed contained less than 10% quartz, whereas the remaining samples contained between 15 and 25%. As previously mentioned, it is difficult to distinguish intermediate (norite) phases from felsic (enderbite) phases in the field. The norites and enderbites also contain 10 to 25% mafic minerals, mainly represented by red biotite and orthopyroxene. Clinopyroxene is common but not abundant, and green hornblende, although generally absent, may represent between 6 and 10% of the rock in certain norite samples. K-feldspar is a subordinate phase, although certain norite samples contain up to 20%, giving the rock a monzonorite composition. The magnetite content ranges from 1 to 3%, and apatite is nearly always present, albeit in minor quantity.

Late Archean Intrusive Units

All previously described units are cross-cut by granodioritic to granitic rocks assigned to the Maurel and Tramont suites.

Maurel Suite (Amau)

The Maurel Suite (Amau) was originally described in 1998 in the Gayot area (Gosselin and Simard, 2001), to the southeast of our map area (NTS 23M). This unit is composed of granodioritic to granitic rocks characterized by a megaphyric texture and a strong magnetic susceptibility. Isotopic analyses of samples in the Gayot and Maricourt areas yielded preliminary U-Pb zircon ages of 2.68 and 2.685 Ga respectively (Table 1).

In our area, the Maurel Suite (Amau) is formed of intrusive bodies several kilometres in size, located in the eastern half of the map area (Figure 3). It also occurs as small injections and dykes within older units. The importance of this unit considerably decreases westward, where only a few intrusions and injections too small to appear on the map were observed.

The Maurel Suite (Amau) is mainly composed of granodioritic to granitic rocks. It contrasts with other units due to its megaphyric texture caused by the presence of K-feldspar phenocrysts ranging from 1 to 5 cm in length. The phenocryst content ranges from 5 to 50%, with an average of about 15 to 25% of the volume of the rock. The rock is pinkish grey to dark pink, and is medium to coarse-grained. It is most frequently massive and homogeneous, although a weak foliation is often visible, defined by a weakly developed preferential orientation of phenocrysts, or by the alignment of mafic minerals. In fault zones, however, the foliation may be extremely well developed.

Enclaves of diorite, which commonly exhibit a strong magnetic susceptibility, were observed in a few locations in the granodiorites of the Maurel Suite (Amau). These enclaves are stretched to varying degrees, and their size ranges from a few centimetres to less than a metre, although they may locally reach a few metres. The diorite is dark grey and fine-grained.

In thin section, megaphyric rocks of the Maurel Suite (Amau) show a heterogeneous grain size, and grain boundaries are often dendritic. They are mainly composed of quartz, plagioclase and K-feldspar in variable proportions, which gives the rock a granitic or granodioritic composition. Quartz crystals generally exhibit fairly pronounced undulating extinction. K-feldspar phenocrysts locally contain well-developed perthitic textures. Myrmekitic textures are

however very widespread. Plagioclase grains are partially altered to sericite. The rock contains between 5 and 20% mafic minerals, most often distributed in clusters. These consist of biotite and green hornblende in roughly equal proportions, but sometimes the biotite dominates. The latter shows a fairly dark brownish tinge, and is occasionally replaced by chlorite. The rock always contains magnetite, in xenomorphic grains, associated with mafic minerals or disseminated in the rock, which explains the high magnetic susceptibility of this unit. Xenomorphic sphene grains, as well as small subrounded apatite grains are also very widespread, most often observed agglomerated to the mafic minerals. A few samples also contain minor allanite and epidote.

Tramont Suite (Atra)

The Tramont granitic Suite (Atra) was originally described in the Gayot area (Gosselin and Simard, 2001). It was also recognized in the Maricourt area (Simard *et al.*, 2002), east of our map area, and in the Hurault area (Thériault and Chevé, 2001), south of Gayot. It corresponds to the youngest Archean suite identified in our study area. These granites are however devoid of significant amounts of zircon, which makes it difficult to date them. Nevertheless, diatexite enclaves related to the Opiscotéo Suite (2637±8 Ma) were observed in Tramont granites in the Gayot area.

The Tramont Suite (Atra) is formed of granitic bodies of variable dimensions, mainly concentrated in the southern and eastern half of the area (Figure 3). The number and size of these intrusions considerably decrease towards the northwest. The Tramont Suite (Atra) also forms dykes and multiple injections between one and ten metres in size, that cross-cut all other Archean units throughout the area. The injection process is more important along the margins of plutonic bodies, where granitic dykes commonly separate numerous enclaves of country rock.

The granite is pale pink, homogeneous, massive to very weakly foliated, except in deformation zones where a quasi-gneissic texture may develop. The grain size is generally medium to coarse in large-scale intrusive bodies, and finer in the dykes, injections and smaller-scale plutons. Pegmatitic dykes are commonly observed, and appear to correspond to a late phase of this suite. The granite occasionally contains between 1 and 5% cm-scale to m-scale enclaves of foliated diorite, most often stretched and partially absorbed by the granite. Enclaves of surrounding country rock lithologies are also occasionally encountered. Their size and numbers increase towards the intrusion margins.

The Tramont granite (Atra) is characterized by a low mafic mineral content, ranging from 1 to 5%, but which in most cases remains less than 1%. These essentially consist of small tabular chlorite grains or almost entirely chloritized biotite. Small magnetite grains are often observed, either as inclusions in the chlorite and biotite, or disseminated throughout the rock. The magnetic susceptibility, generally fairly weak, may therefore vary based on the mafic mineral content. The rock contains roughly equal proportions of quartz, K-feldspar and plagioclase. Quartz grains show an undulating extinction that is often very pronounced. K-feldspar crystals are commonly perthitic, and myrmekitic textures are nearly always present. Plagioclase grains have undergone more or less pronounced sericitization that increases along with chloritization of the biotite. Epidote and allanite are accessory minerals generally associated with mafic minerals.

The granite locally contains large hornblende crystals with well-developed crystal faces. These are particularly abundant in areas with a high proportion of mafic to intermediate enclaves, which suggests that this abundance may be the result of contamination due to the presence of a large number of enclaves.

Proterozoic Diabase Dykes

Diabase dykes were observed in more than one hundred outcrops. Their thickness generally ranges from less than a metre to a few metres, but some dykes reach up to 200 m in thickness. Although they generally exhibit a strong magnetic susceptibility, they are not visible on 1 : 250 000 scale regional aeromagnetic maps.

The orientation of diabase dykes is highly variable, ranging from NE-SW to NW-SE. They are most often NE-SW directed in the eastern half of the map area, whereas E-W, ESE-WNW, WSW-ENE and NW-SE orientations are very widespread in the western half. These orientations were also observed to the NW, in the Nedlouc area, by Parent *et al.* (2000). These authors mention that the diabase dykes may belong to three different dyke swarms, based on paleomagnetic and geochronological studies conducted in the Rivière-aux-Feuilles area (Buchan *et al.*, 1998). Dykes oriented E-W, ESE-WNW and WSW-ENE are similar to Maguire Dykes (2230 Ma), NW-SE dykes are akin to Minto Dykes (1998±2 Ma), and finally, NE-SW dykes may belong to the Ptarmigan Swarm (2505±2 Ma).

The diabase is massive and bears no evidence of deformation. The rock is dark grey to greenish grey, with a dark brown weathering rind. It ranges from fine to medium-grained. In thin section, diabase samples exhibit ophitic, subophitic and intergranular textures, and are composed of elongate plagioclase grains, clinopyroxene and interstitial magnetite.

LITHOGEOCHEMISTRY

Major and trace elements were analyzed in 55 rock samples representing the most characteristic lithologies of the principal lithostratigraphic units in the area. Analytical results were integrated to the MRN geomining data system (SIGÉOM) and are plotted on diagrams shown in figures 5 and 6. They will be briefly discussed in five broad categories,

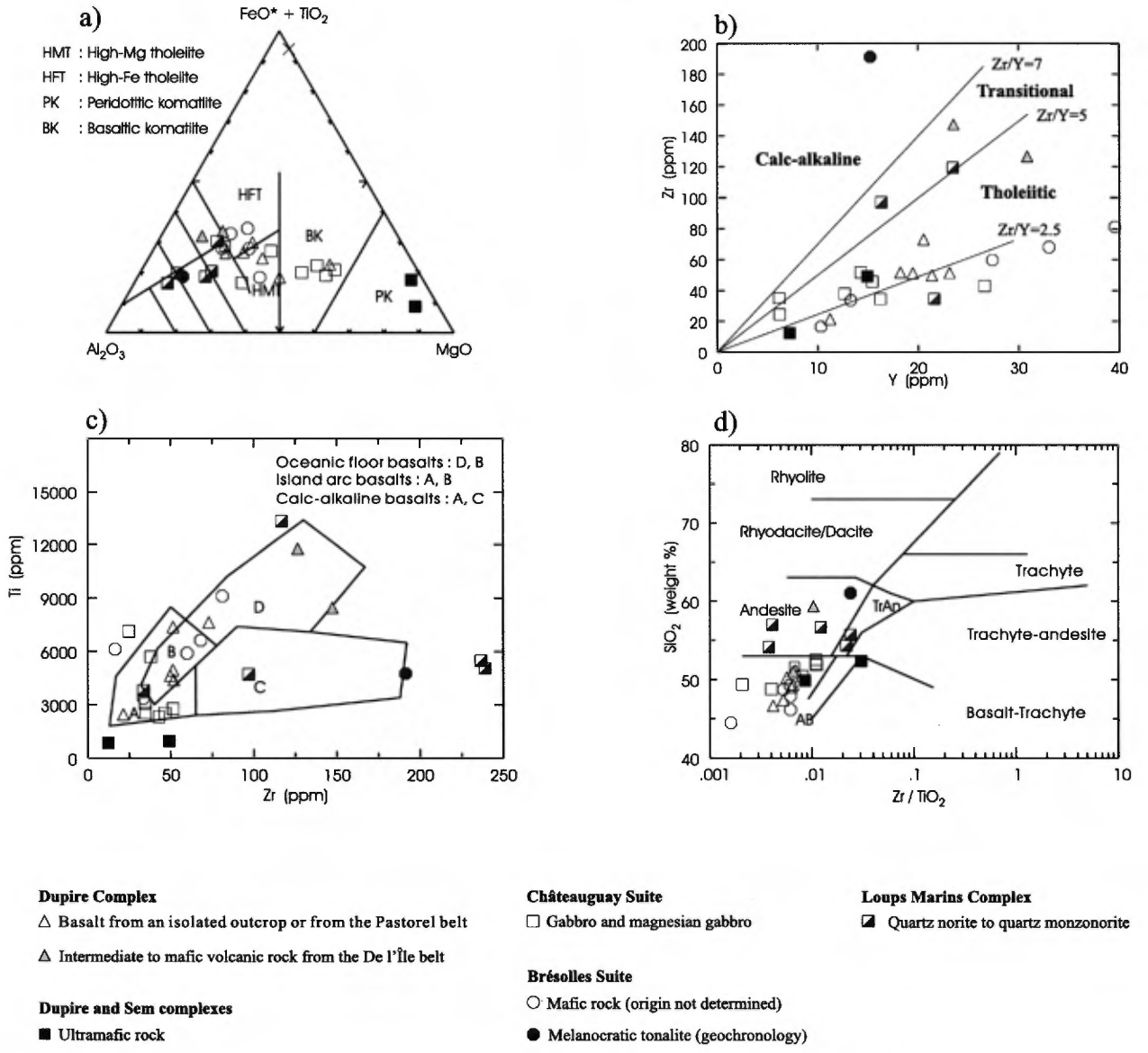


FIGURE 5 - Composition of intermediate to ultramafic volcanic and intrusive rocks associated with different units, plotted on : a) a Jensen diagram (1976), b) a Zr vs Y diagram, c) a diagram by Pearce and Cann (1973), and d) a diagram by Winchester and Floyd (1977).

namely : 1) mafic rocks, 2) ultramafic rocks, 3) tonalitic rocks, 4) granulitic and charnockitic rocks, and 5) granodioritic and granitic rocks.

Mafic Rocks

Analyzed samples of mafic rocks are either effusive or intrusive, or else their origin is uncertain or undetermined. The results are shown on diagrams in Figure 5. Samples of effusive rocks belong to the Dupire Complex, and are mainly derived from the Pastorel and De l'Île volcano-sedimentary belts (Figure 3). A few samples were also collected from isolated outcrops of volcanic rocks, which represent large enclaves found within younger units. Rocks of effusive origin are basaltic in composition for the most part, and have a tholeiitic affinity, with a Zr/Y ratio of about 2.5 (Figure 5b). Samples from the De l'Île belt are the exception however. One of these shows a Zr/Y ratio of 4.0, and the second, andesitic in composition (Figure 5a and 5d), plots in the transitional field with a Zr/Y ratio of 5.9 (Figure 5b).

In gneisses of the Brésolles Suite, a few samples were collected in amphibolitized mafic rock remnants of undetermined origin. These rocks have a chemical composition that closely resembles that of basaltic rocks in the area (Figure 5). Their intrusive or effusive origin cannot be determined with confidence. However, several belts and remnants of

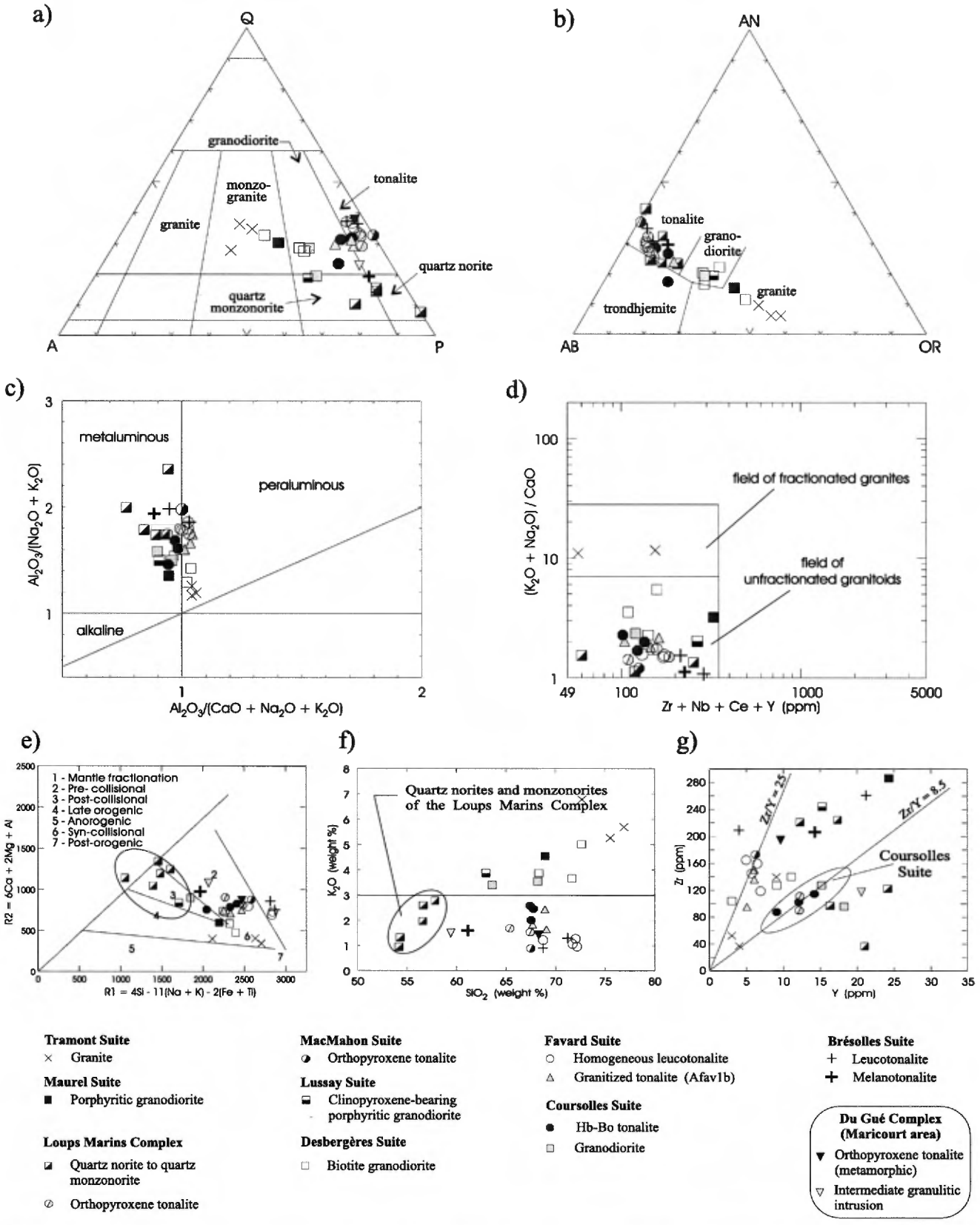


FIGURE 6 - Dominant intrusive suites in the area (34A) illustrated in diagrams by : a) Le Maître (1989), b) Baker (1979), c) Maniar and Picoli (1989), d) Whalen *et al.*, (1987), e) Bathelor and Bowden (1985), f) K_2O vs SiO_2, and g) Zr vs Y.

volcanic rocks were observed within the Brésolles Suite, in the Gayot (Gosselin and Simard, 2001) and Maricourt areas (Simard *et al.*, 2002).

Most analyzed mafic intrusive rock samples are gabbros assigned to the Châteauguay mafic-ultramafic Suite (Achg). They have a basaltic composition (Figure 5d), sometimes strongly magnesian (Figure 5a), and belong to a tholeiitic suite (Figure 5b).

Ultramafic Rocks

Two ultramafic rock samples were analyzed (Figure 5). The first was taken in a m-scale layer found within biotite tonalites of the Sem Suite (Asem). The second, from the Dupire Complex, was collected in a horizon several hundred metres thick, located in the Pastorel volcano-sedimentary belt. The origin of these ultramafic rocks has not been determined. However, in both cases, the rocks are closely associated with sedimentary or volcanic rocks. Furthermore, the ultramafic horizon in the Pastorel belt has a Zr content of 46 ppm, while its Y content is of 14 ppm (Figure 5b), which seems abnormally high for this type of lithology. Ultramafic rocks with similar concentrations for these elements were however encountered in the Gayot area, and correspond to ultramafic lavas assigned to the Gayot volcano-sedimentary Complex (Gosselin and Simard, 2001).

Tonalitic Rocks

Samples analyzed to characterize the Brésolles, Favard and Coursolles suites generally show a tonalitic composition according to mesonormative diagrams by Le Maître (1989) and by Barker (1979; Figure 6a and 6b). These tonalites show K_2O contents below 3.0% (Figure 6f).

The Brésolles gneisso-tonalitic Suite is composed of early diorites and melanotonalites, cross-cut by younger injections of leucotonalite. A melanotonalite sample characteristic of unit a was analyzed. Its composition plots along the boundary between quartz diorites and tonalites (Figure 6a). Most of the samples analyzed for the Brésolles Suite were collected in homogeneous horizons of younger leucotonalite, and probably correspond to injections contemporaneous with the emplacement of the Favard Suite. This hypothesis is supported by the fairly similar chemical composition of both Brésolles and Favard leucotonalites (Figure 6), as well as age dating analyses which yielded identical ages. On the diagram showing Zr vs Y (Figure 6g), Brésolles and Favard leucotonalites show a similar Zr/Y ratio of about 25, although samples of the Favard Suite show lower concentrations for these elements. According to Simard *et al.* (2002), Favard leucotonalites in the Gayot and Maricourt areas generally display a *trondhjemitic* composition, as opposed to those in the Loups Marins area, which have a dominantly *tonalitic* composition (Figure 6b). Tonalite samples collected in the granitized sub-unit of the Favard Suite (Afav1b) show enrichment in K_2O relative to homogeneous leucotonalites of the Favard Suite (Figure 6f). This enrichment is inferred to be related to the regional "granitization" phenomenon that characterizes the sub-unit.

Tonalites of the Coursolles Suite tend to stand out from the other two tonalitic suites on most diagrams (Figure 6). This distinction is most obvious on the Zr vs Y diagram (Figure 6g), where samples of Coursolles tonalite show a Zr/Y ratio of about 8.5 compared to 25 for Brésolles and Favard leucotonalites. The Coursolles Suite also contains hornblende-biotite granodiorites (Figure 6) closely associated with the tonalites. These granodiorites do not form well-defined bodies, and are difficult to distinguish from tonalites in the field. They could be the result of a "granitization" process, similar to that observed in the Favard Suite.

Granodioritic and Granitic Rocks

The principal lithological assemblages with granodioritic to granitic compositions belong to the Desbergères (Adeb), Lussay (Alus), Maurel (Amau) and Tramont (Atra) suites. Samples of the Desbergères Suite (Adeb) are derived from relatively homogeneous bodies. They yielded a granodioritic composition, more rarely plotting in the monzogranite field (Figure 6a and 6b). A single rock sample was collected and analyzed for the Lussay Suite (Alus). It shows a granodioritic composition, near the boundary with quartz monzodiorites (Figure 6a and 6b). A sample from the Maurel Suite (Amau) was also analyzed. It shows a granitic composition, near the granodiorite field. Note that the Maurel Suite generally shows a granodioritic composition (Gosselin and Simard, 2001; Simard *et al.*, 2002). Rock samples from the Tramont Suite (Atra) form a homogeneous group clearly plotting in the monzogranite field, and with a chemical composition that is quite distinct from all other units on all diagrams (Figure 6).

Granulitic and Charnockitic Rocks

Samples of granulitic or charnockitic rocks analyzed in our area are essentially derived from the Loups Marins Complex (Alma). They consist of norites to quartz monzonorites and orthopyroxene tonalites (enderbites). The norites and quartz monzonorites have an intermediate composition, quite distinct from all other granitoids in the area (Figure 6). These rocks are an important component of unit Alma2 in the Loups Marins Complex, particularly in the NW quadrant of the area, north of the Lacs des Loups Marins. They also occur elsewhere in the area, as relatively circumscribed dykes a few hundred metres wide, cross-cutting lithological assemblages of various units. Analyzed samples of orthopyroxene tonalite represent units Alma1 and Alma2 of the Loups Marins Complex. In geochemical diagrams, these tonalites have compositions similar to tonalitic units of the Favard and Coursolles suites. Their Zr/Y ratio is

about 8.5 (Figure 6g), comparable to the ratio for Coursolles tonalites, and also for certain quartz norite samples of the Loups Marins Complex.

A sample of orthopyroxene tonalite from the MacMahon Suite was also collected in the NE part of the area, near the boundary with the Favard Suite. Similar to the orthopyroxene tonalites of the Loups Marins Complex, this rock is compositionally similar to regional tonalitic units (Figure 6a to 6f). It shows a Zr/Y ratio of about 25, very different from the ratio of orthopyroxene tonalites of the Loups Marins Complex, but identical to that of Favard Suite tonalites (Figure 6g). It is possible that these orthopyroxene tonalites represent metamorphosed equivalents of the Favard Suite leucotonalite.

REGIONAL STRATIGRAPHIC CORRELATIONS

Table 2 presents a compilation of the principal lithostratigraphic units encountered in the Gayot (Gosselin and Simard, 2001), Maricourt (Simard *et al.*, 2002), Nedlouc (Parent *et al.*, 2000), Aigneau (Berclaz *et al.*, 2002) and Loups Marins (this report) areas. Certain stratigraphic correlations may be considered between the different lithodemic units defined in these various regions. However, available geochronological data show that these correlations are often quite complex (tables 1 and 2), even for units showing similar lithological features. These regional lithostratigraphic correlations will be discussed in light of six types of assemblages, namely 1) volcano-sedimentary assemblages, 2) tonalitic units, 3) intermediate to ultramafic units, 4) megaphyric granodioritic and granitic units, 5) granulitic units, and 6) late granite and megaphyric granodiorite units.

Volcano-Sedimentary Assemblages

Stratigraphic correlations are difficult to establish between the various volcano-sedimentary assemblages defined in the Gayot, Maricourt and Nedlouc areas (Simard *et al.*, 2002). For one, these assemblages form enclaves or remnants several kilometres in size, scattered and separated from one another by considerable distances. The Gayot Complex (tables 1 and 2) is the oldest volcano-sedimentary unit with preliminary U/Pb ages of 2.86 Ga and 2873 +12/-6 Ma obtained in the Gayot area. The Dupire Complex was dated at 2787 ±2 Ma in the Nedlouc area, which compares with the preliminary age of 2786 Ma obtained for the Garault Complex in the Maricourt area. However, the two complexes appear to be different from a chemical and lithological standpoint (Simard *et al.*, 2002). The Garault Complex is mainly composed of paragneiss with minor calc-alkaline volcanic rocks, whereas the Dupire Complex is composed of tholeiitic volcanic rocks with an important proportion of paragneiss. Finally, the Duvert Complex stands out due to its markedly younger age of 2713 ±6 Ma.

In the Loups Marins area, volcano-sedimentary rocks of the Pastorel and De l'Île belts were assigned to the Dupire Complex, based mainly on their geographic position, just south of Lac Dupire, and based on their lithological assemblages similar to those observed in the complex. However, no U-Pb ages were obtained in these belts to establish their relation to the Dupire Complex.

Tonalitic Units

On a regional scale, tonalitic units may be subdivided into three distinct groups.

The *first group of tonalites* corresponds to the gneissotonalitic Brésolles and Sullupaugalik suites. These so-called "early" suites appear to be comparable both lithologically and chronologically. The Brésolles Suite yielded a U-Pb age of 2803 ±8 Ma in the Gayot area, and of 2811 ±4 Ma in the Loups Marins area. The Sullupaugalik Suite yielded a U-Pb age of 2805 +9/-4 Ma in the Aigneau area (tables 1 and 2). Note that the Brésolles Suite is an important regional-scale unit that was mapped over a distance of more than 300 km, from the Hurault area (Thériault and Chevé, 2001) all the way to our map area (gneissic tonalite in Figure 2). Gneissic tonalites with comparable ages (between 2.78 and 2.80 Ga) were also identified further north, by Skulski *et al.* (1996), and also by Madore and Larbi (2001) in the Rivière Arnaud area (NTS 25D).

The *second group of tonalites* includes the Coursolles and Rivière-aux-Feuilles suites. These suites are mainly composed of tonalites characterized by the presence of hornblende, in contrast with the vast majority of other tonalitic units, which contain biotite instead. Although this mineralogical feature represents a distinctive field criteria, geochronology data suggest, on the contrary, a complex history involving several intrusive phases. Age dating analyses conducted in the Loups Marins area indicate an age of crystallization around 2758 ±11 Ma and 2756 ±8 Ma (tables 1 and 2) for the Coursolles Suite. These ages confirm cross-cutting relationships observed in several locations in the Maricourt area, between Coursolles tonalites and younger leucotonalites of the Favard Suite (Simard *et al.*, 2002). In the Maricourt area however, a hornblende tonalite sample from the Coursolles Suite yielded a much younger U-Pb age of 2718 ±8 Ma (tables 1 and 2). This result suggests that hornblende tonalites assigned to the Coursolles suite in the Maricourt area may belong to more than one intrusive phase. The hypothesis of multiple intrusive periods for hornblende tonalites is also supported by a relatively young preliminary age of 2.7 –2.71 Ga obtained from samples of the Rivière-aux-Feuilles Suite in the Nedlouc area (tables 1 and 2). As mentioned previously, hornblende tonalites of the Rivière-aux-Feuilles Suite are lithologically comparable to those of the Coursolles Suite.

The *third group of tonalites* includes the Favard and Charnière suites, characterized by biotite-bearing trondhjemites or leucotonalites. Ages obtained in the Gayot, Maricourt and Nedlouc areas are bracketed between 2.73 and 2.75 Ga (tables 1 and 2). Lithostratigraphic and chronostratigraphic correlations therefore appear likely between the two suites. The Favard Suite covers vast expanses in the Hurault, Gayot, Maricourt and Loups Marins areas, whereas the Charnière Suite is restricted to the southern part of the Nedlouc area. Note that biotite tonalites of the Rochefort Suite, encountered further north in the La Potherie area (NTS 34I), were dated at 2768+9/-6 Ma (Table 1) by Leclair *et al.* (2002). Finally, the Sem Suite, defined in the Loups Marins area and characterized by biotite-rich tonalites, represents a very peculiar unit, whose origin and relations with regards to other units remain to be determined.

Intermediate to Ultramafic Intrusions

Mafic and ultramafic intrusions encountered in the Maricourt area during mapping were considered as equivalents to certain isolated intrusions found in the Gayot area. In Maricourt, these intrusions had been assigned to the Châteauguay Suite (Simard *et al.*, 2002), and observed cross-cutting relationships indicated that this suite was older than granites of the Tramont Suite (Table 2), but younger than tonalites of the Favard and Coursolles suites. In the Loups Marins area, new observations indicate that intermediate, mafic and ultramafic intrusions assigned to the Châteauguay Suite are cross-cut by granodiorites similar to those of the Desbergères Suite, which suggests Châteauguay rocks are older than 2712 ±12 Ma (Table 2). In the Nedlouc area, late intermediate to mafic intrusions are described and assigned to the Bacqueville Suite (Table 2; Parent *et al.*, 2000). These intrusions are cross-cut by granite injections of the Morrice Suite, and may possibly represent equivalents of the Châteauguay Suite.

Megaphyric Granodioritic and Granitic Units

The main granodioritic and granitic units may be divided into two groups.

The *first group* corresponds to *massive and homogeneous granodiorite units*. It includes the Desbergères Suite in the Maricourt and Loups Marins areas, and the Rivière-aux-Feuilles Suite and the Monchy Suite in the Nedlouc and Aigneau areas (Table 2). Two age dating analyses conducted on granodiorite samples of the Rivière-aux-Feuilles Suite in the La Potherie area, just north of the Nedlouc area (Table 1), yielded U-Pb zircon ages of 2724 Ma (Skulski *et al.*, 1996) and 2722+6/-2 Ma (Leclair *et al.*, 2002). These ages are comparable to one obtained from a granodiorite sample of the Desbergères Suite (2714±12 Ma) in the Loups Marins area. In the Maricourt area, however, a granodiorite sample assigned to the Desbergères Suite yielded a U-Pb zircon age of 2683 +4/-2 Ma (tables 1 and 2). This result suggests that a certain proportion of massive and homogeneous granodiorites in the Maricourt area are rather associated with late megaphyric monzogranitic and granodioritic intrusions of the Maurel Suite (2.685 Ga). The likelihood of several episodes of emplacement for granodioritic intrusions is also supported by the results of two unpublished age dating analyses, conducted by the Geological Survey of Canada in the Maricourt area. These analyses, conducted on lithologically similar hornblende-biotite granodiorites, yielded respective ages of 2717 ±5 and 2679 ±4 Ma. As for the relation between granodiorites of the Monchy Suite and those of other granodioritic units, it remains to be defined.

The *second group* is composed of *megaphyric granodiorite to granite units* including the La Chevrotière Suite and the Lussay Suite (tables 1 and 2). The La Chevrotière Suite was defined in the Nedlouc area, and dated in the La Potherie area (see tables 1 and 2). It yielded an age of 2732 +4/-2 Ma, the oldest age among megaphyric intrusions. Lithologically and texturally, the Lussay Suite is comparable to the Maurel and La Chevrotière suites. It contrasts with these two suites however, due to its high-grade metamorphic mineral assemblages. The Lussay Suite yielded a U-Pb zircon age of 2713 ±3 Ma, which corresponds to an intrusive period roughly contemporaneous with the Lippens charnockitic Suite (2709 +3/-2 Ma; tables 1 and 2).

Granulitic Units

The principal granulitic units are represented by the Du Gué and Loups Marins complexes, along with the Lippens and MacMahon suites (Table 2). Most of these units consist of both granulite-facies metamorphic rocks, and intrusive rocks belonging to charnockitic suites. Charnockitic rocks of the Loups Marins Complex contrast with those in the Lippens and MacMahon suites due to the presence of norite and quartz norite intrusions, which appear to be absent in the other suites. An age dating analysis conducted on a sample of quartz norite from the Loups Marins area yielded a U-Pb zircon age of 2694±3 Ma, which is fairly close to ages obtained for enderbites of the Lippens Suite (2709 ±3 Ma) and particularly for those of the MacMahon Suite (2697±8 Ma; tables 1 and 2). As opposed to other granulitic units, the Du Gué Complex, described in the Maricourt area, contains a much greater proportion of metamorphic rocks relative to charnockitic intrusive rocks (Simard *et al.*, 2002). This feature may explain the relatively early preliminary age of 2729 Ma obtained from an orthopyroxene tonalite of the Du Gué Complex, a rock probably equivalent to a leucotonalite of the Favard Suite, albeit metamorphosed to the granulite facies. To shed some light on these questions, lithogeochemistry results from two granulitic samples of the Du Gué Complex were re-examined (Figure 6). One of these seems to

correspond to an orthopyroxene tonalite of metamorphic origin, compositionally similar to the leucotonalites of the Favard Suite (Figure 6a, 6e, 6f and 6g). The second sample appears to be derived from an intermediate charnockitic intrusion, akin to the quartz norite intrusions encountered in the Loups Marins Complex (Figure 6a, 6e, 6f and 6g).

Late Granodioritic and Granitic Units

The Maurel, Tramont and Morrice suites correspond to the latest Archean intrusions (Table 2). The Maurel Suite has a granitic or granodioritic composition and exhibits a distinctive megaphyric texture. It was recognized in the Gayot, Maricourt and Loups Marins areas (tables 1 and 2), and corresponds to the youngest porphyritic suite, with an age estimated at 2.68 Ga.

The granitic Tramont and Morrice suites are considered to be the latest Archean phases in all the areas under study (Table 2 in appendix). The Tramont Suite represents a distinct biotite leucogranite unit that cross-cuts all Archean lithologies observed in the Gayot, Maricourt and Loups Marins areas. This unit could not be dated, but its relation with the Maurel Suite indicates that it is younger than 2.685 Ga. In the Nedlouc area, the granitic Morrice Suite was dated at 2682±4 Ma (tables 1 and 2). These data indicate that Tramont granites may be younger than or contemporaneous with those of the Morrice Suite.

METAMORPHISM

The rocks of the Loups Marins area underwent prograde metamorphism ranging from the amphibolite to the granulite facies. Certain sectors, generally restricted to fault zones, also recorded retrograde metamorphism to the greenschist facies.

The amphibolite facies is the most widespread, and has affected a major portion of all lithostratigraphic units in the area. However, given the near-total absence of volcano-sedimentary units in the area, it becomes quite difficult to interpret with any confidence the intensity of amphibolite-grade metamorphism in intrusive rocks. Mineral assemblages observed in these intrusions may simply reflect initial emplacement conditions, without having undergone subsequent regional metamorphism. Whatever the case may be, these mineral assemblages are compatible with regional amphibolite-grade metamorphic conditions. These rocks contain assemblages composed of brown biotite + plagioclase + quartz + hornblende ± muscovite ± epidote. The few samples of volcano-sedimentary rocks collected in the Pastorel and De l'Île belts, or from enclaves hosted in younger intrusive rocks also display mineral assemblages indicating amphibolite-grade regional metamorphism. In paragneisses, mineral assemblages consist of garnet + biotite ± sillimanite ± muscovite, whereas in mafic volcanic rocks, hornblende + plagioclase ± quartz ± garnet assemblages are observed.

Rocks of the Lippens and MacMahon suites, as well as those in the Loups Marins Complex contain mineral assemblages characterized, among other things, by the presence of orthopyroxene. These assemblages indicate granulite-grade metamorphic conditions. However, the intrusive or metamorphic origin of these rocks remains uncertain. In the Nedlouc area (NTS 34H), north of our study area, the MacMahon Suite was interpreted as a charnockitic suite with a tonalitic to granitic composition (Parent *et al.*, 2000). However, in the NE part of our study area, this unit contains orthopyroxene trondhjemites that seem to correspond to metamorphosed equivalents of trondhjemites of the Favard Suite. It therefore appears that the MacMahon Suite may include both rocks metamorphosed to the granulite facies, and orthopyroxene-bearing intrusive rocks belonging to a charnockitic suite. Similar observations were made in the Maricourt area (NTS 24D), to the east of our area (Simard *et al.*, 2002). In that map area, the Du Gué Complex is composed of a mixture of charnockitic intrusive rocks and rocks representing granulite-grade metamorphic equivalents of various regional lithostratigraphic units.

The coexistence of primary pyroxene relics and granoblastic-textured pyroxene was observed in several samples collected in granulitic complexes in various areas of the Far North (Berclaz *et al.*, 2002; Leclair *et al.*, 2002; Madore and Larbi, 2001). The coexistence of these textures indicates that granulite-grade pressure and temperature conditions remained in place after the crystallization of orthopyroxene, leading to a partial recrystallization of the latter. These high-grade metamorphic conditions presumably also affected surrounding country rocks, thereby explaining the cohabitation of charnockitic intrusive rocks and granulite-grade metamorphic assemblages in the same areas of high metamorphic grade.

Loups Marins Complex

The Loups Marins Complex (Alma) exhibits a distinct high-grade metamorphic mineralogy, which appears in several fairly well circumscribed sectors, mainly located in the western half of the area (Figure 3). In general, the core of these sectors is occupied by the orthopyroxene unit (Alma2) of the Loups Marins Complex, composed of greenish orthopyroxene-bearing rocks, with mineral assemblages and textures typical of the granulite facies. This unit includes intrusive rocks belonging to charnockitic suites, introduced into rocks metamorphosed to the granulite facies. However, it is often quite difficult to distinguish the two rock types in the field, since they have fairly similar compositions and mineral assemblages, characterized by the presence of red biotite and orthopyroxene. The "intrusions" often have a massive and homogeneous aspect, whereas "metamorphosed country rocks" have a more heterogeneous aspect, similar to what is observed in the various tonalitic units in the area.

The orthopyroxene unit (Alma2) is nearly always surrounded or bounded by the clinopyroxene unit (Alma1), which forms zones several kilometres wide characterized by mineral assemblages typical of the upper amphibolite facies or the lower granulite facies. Unit Alma1 therefore reflects a higher metamorphic grade than the regional metamorphism, which generally lies at the lower to middle amphibolite facies. Rocks of the clinopyroxene unit (Alma1) contain assemblages with plagioclase - red biotite – clinopyroxene ± hornblende. They display a well-developed granoblastic texture. The clinopyroxene unit (Alma1) appears to represent an envelope around granulitic cores. However, the origin of this envelope, and its relationship with the granulitic centres remain poorly understood. Note that megaphyric granodiorite intrusions of the Lussay Suite (Alus), located in the SW part of the area (Figure 3), in the vicinity of orthopyroxene-bearing rocks of the Loups Marins Complex (Alma2), possess mineral assemblages and granoblastic textures similar to those observed in rocks of the clinopyroxene unit (Alma1). Much like the clinopyroxene unit (Alma1), the primary or metamorphic origin of observed mineral assemblages and textures in the porphyritic intrusions of the Lussay Suite (Alus) remain obscure for the moment.

STRUCTURAL GEOLOGY

From a structural standpoint, the Loups Marins area (34A) is comparable, in many respects, to the Gayot area (23M) to the southeast, the Maricourt area (24D) to the east and the Nedlouc area (34H) to the north. The dominant structural trend in these areas is oriented NW-SE to NNW-SSE, an orientation that characterizes the entire Minto Subprovince (Percival *et al.*, 1992). Table 3 provides a broad comparison of the principal structural elements associated with the deformation phases that affected these areas. Figure 7 shows the attitude of the principal regional foliation in the Loups Marins area, as well as the distribution of important faults and major folds.

Structural Elements and Phases of Deformation

The tectonic events that have affected the rocks of the field area may be associated with five distinct phases of deformation (Table 3).

TABLE 3 - Presentation of the principal structural elements associated with the déformation phases that have affected the Gayot (Gosselin and Simard, 2001), Maricourt (Simard *et al.*, 2002), Nedlouc (Parent *et al.*, 2000) and Lacs des Loups marins (this report) areas.

Gayot and Maricourt areas (23M et 24D)	Phases	Lacs des Loups Marins area (33A)	Phases	Nedlouc area (34H)
Descriptions		**Descriptions**		**Descriptions**
- ENE-WSW to NNE-SSW faults, reverse movement towards the NW (northern part) or towards the SE (Châteauguay and Vaujours faults) - A few ENE-WSW folds ?	D5	Late ENE-WSW to NNE-SSW faults, weakly developed, movement not determined	D5	Open to closed F5 folds oriented ENE-WSW, sporadic, without related foliation
- Network of NW-SE faults with local development of a crenulation cleavage - F4 folds, WNW-ESE to NW-SE, open to tight, dragged along NW-SE faults	D4	- Network of anastomosing NW-SE to E-W faults. Well-developed mylonitic fabric with sulphide zones in the vicinity of the Alegrain fault. The regional Loups Marins fault represents an E-W segment of the dominantly NW-SE main system. - F4 folds, WNW-ESE to NW-SE, open to tight, dragged along NW-SE faults	D4 and D3	- D4 NW-SE shearing (dextral), mylonitic fabric, F4 drag folds - F3 folds (or F4 in other areas), tight to isoclinal, reoriented by D4 shear zones - WNW-ESE orientation in the Goudalie Domain, and ENE-WEW in the Dupire sector (possibly correlated with D3 phase in other areas)
F3 folds, NE-SW to NNE-SSW (with no related foliation), locally reoriented by phase of deformation D4.	D3	Local presence of ENE-WSW folds possibly related to this phase.	D3	*(Local presence of ENE-WSW folds in the Dupire sector, possibly related to this phase)*
Regional S2 foliation	D2	Regional S2 foliation	D2	S2 foliation and F2 isoclinal folds oriented NNW-SSE
Relics of an early S1 foliation that predates the regional foliation in enclaves	D1	Relics of an early S1 foliation that predates the regional foliation in enclaves	D1	Relics of an early S1 foliation that predates the regional foliation in enclaves

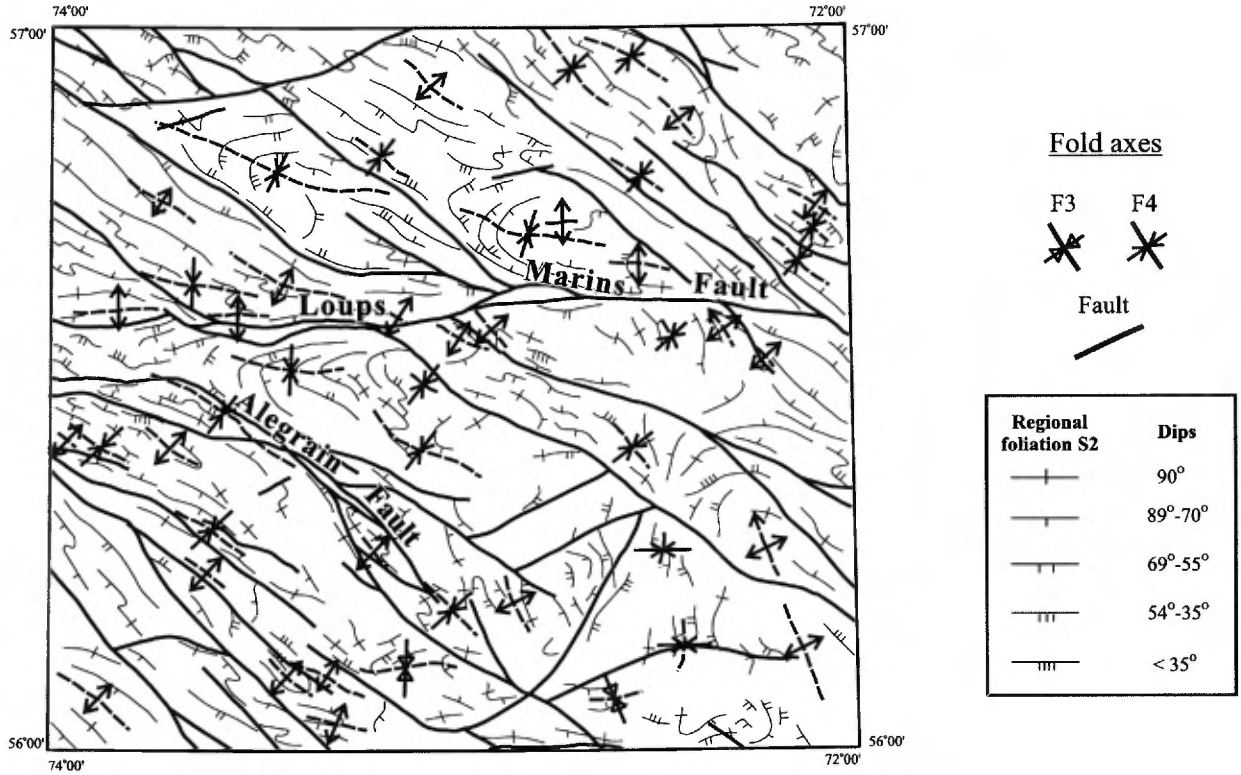


FIGURE 7 - Attitude of the régional foliation S2, and the distribution of important faults and major folds in the Loups Marins area (NTS 34A).

Phase D1 is interpret with respect to an early S1 foliation, at an angle relative to the regional foliation; it was observed in a few mafic enclaves hosted in gneisses of the Brésolles Suite. This early foliation (S1) was also noted in adjacent regions (Table 3). It represents the only remaining manifestation of phase D1.

The regional foliation (S2) is considered to be associated with *phase D2*, which almost completely obliterated or transposed structures associated with deformation D1. It affects all Archean rocks in the area to varying degrees, ranging from a simple discrete mineral alignment through to a strong gneissosity. These intensity variations appear to be largely controlled by the presence of regional fault zones. The age of lithological assemblages also plays an important role; younger units are generally not as strongly foliated as older ones. As opposed to the Nedlouc area, no folds specifically related to phase D2 were recognized in our map area.

Subsequent phases of deformation (D3, D4 and D5) have reoriented, folded and accentuated the regional S2 foliation. *Phase D3* is practically non-existent in the Loups Marins area. Defined in the Gayot and Maricourt areas, this phase is characterized by tight to isoclinal folds oriented NE-SW to NNE-SSW, without an axial plane schistosity. In the southern part of our study area, the attitude of the regional foliation suggests the presence of a few fold axes oriented ENE-WSW, possibly related to this phase (Figure 7). Furthermore, a few structures recognized in the Dupire sector (Table 3), further north, may also belong to this phase of deformation D3.

Phase D4, established in the Loups Marins area, corresponds to the same D4 phase recognized in the Gayot and Maricourt areas, as well as the D3 and D4 phases described in the Nedlouc area (Table 3; Parent *et al.*, 2000). This D4 phase is responsible for the dominant structural trend, oriented NW-SE. This phase produced the main regional folds, as well as a very important network of anastomosing faults oriented NW-SE to E-W. This fault network delineates corridors a few tens of kilometres wide, in which F4 folds with no associated schistosity are distributed. Although the axial planes of these folds are usually subparallel to fault planes, they are occasionally dragged or transected by these faults, thereby demonstrating that the latter are late, or were active after the folding episode. Most of these faults are interpreted from lineaments observed on aeromagnetic maps. In the field, they generally correspond to sheared and strongly foliated zones, where various types of alteration, namely hematization, epidotization, chloritization and silicification, are observed. Movement along D4 faults could not be determined. The apparent movement, which may be interpreted from the dragging of F4 fold axes, is sometimes dextral, sometimes sinistral. The Alegrain and Loups Marins faults are two important structures related to phase D4. The Alegrain fault is characterized by a mylonitic texture, often well developed, and by the presence of several sulphide zones (pyrite). The western segment of the Loups Marins fault

marks the southern boundary of the Loups Marins Complex (Alma) and corresponds to a very sharp break between areas of low and high magnetic susceptibility. In the field, this fault is represented by a strongly hematized zone between 300 and 500 m wide. Towards the east, this fault is much less developed.

A *D5 phase* was also recognized. It is represented by a few generally poorly exposed faults oriented ENE-WSW to NNE-SSW. These faults are interpreted from aeromagnetic maps, or from the general attitude of lithostratigraphic units. As opposed to D4 faults, D5 faults appear to have a very limited influence on the orientation of the regional foliation. However, they commonly mark boundaries and sharp changes in several lithostratigraphic units (Figure 3). Note that the Vaujours fault, in the Gayot area, and the Châteauguay fault, in the Maricourt area, are two major regional structures related to this fault system.

Statistical Compilation

The area was subdivided into six structural domains (domains 1 to 6), and a statistical compilation of the regional foliation (S2) was performed for each domain. The results were plotted on stereograms (Figure 8). This analysis highlights the dominant regional structural trend oriented NW-SE. The latter is represented by the general attitude of the foliation, as well as the orientation of F4 folds that disturb it. Domains 1, 3, 4 and 6 represent more than 80% of the total surface area. Results indicate that F4 fold axes in these domains show average trends of 110° to 127° and plunge at 47° to 73° towards the SE. Domain 5, located in the SE part of the area, is characterized by a major antiformal structure that steeply plunges to the NW. Its average orientation is roughly 335°/80°, although a more detailed analysis reveals that the fold axis straightens out in the northern part of the domain, and becomes oriented at 336°/71°. This antiform is abruptly bounded northward by the Loups Marins fault. Towards the southeast, it extends beyond our map area, into the NW corner of the Gayot area (Gosselin and Simard, 2001). The stereographic compilation of domain 2 outlines the reorientation of the foliation along important fault zones. In this domain, the foliation is oriented E-W, *i.e.* parallel to the Loups Marins fault.

ECONOMIC GEOLOGY

Previous Work

An important lake sediment geochemical survey (MRN, 1998), conducted by SIAL in 1997 within the scope of the Far North project, covered the entire Loups Marins area.

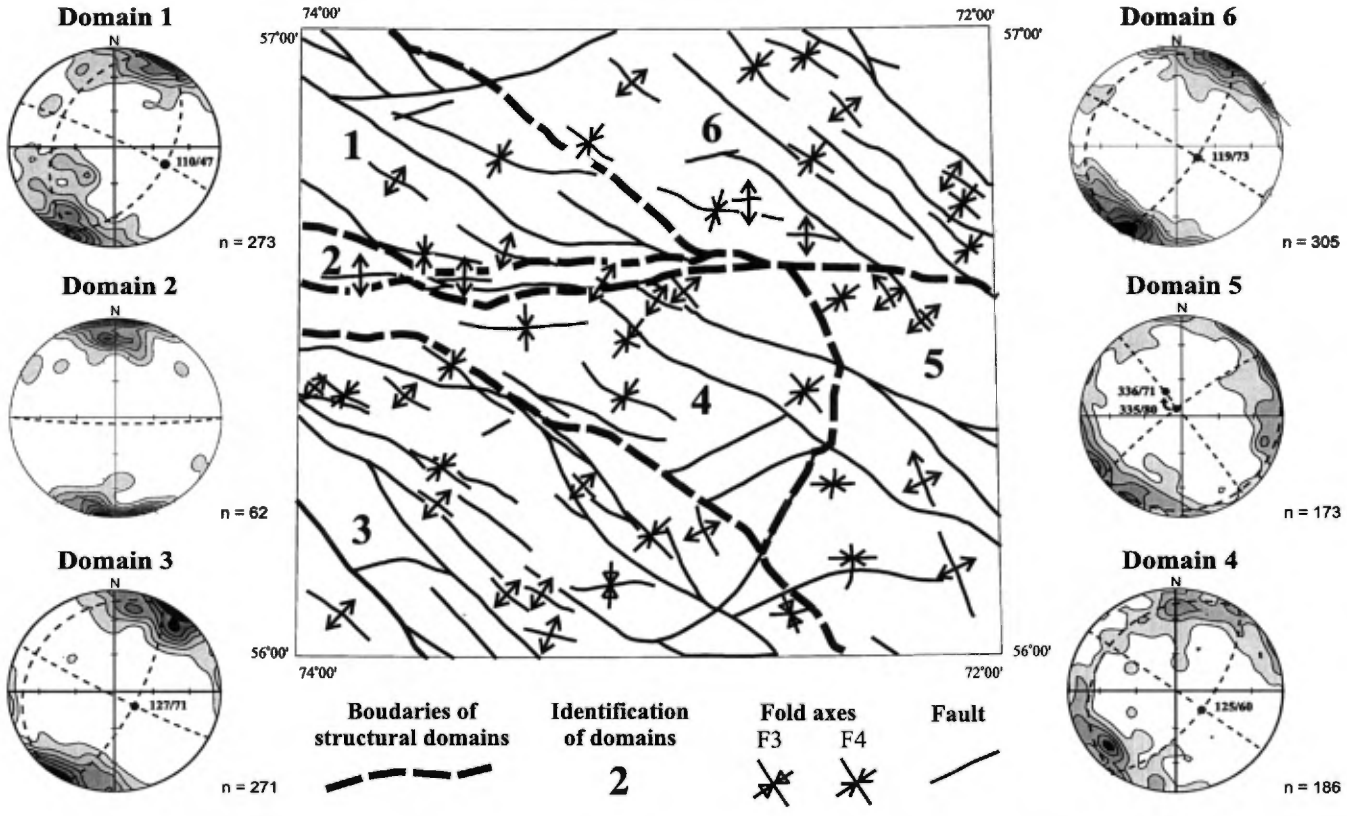


FIGURE 8 - Boundaries of structural domains in the Loups Marins area, and stereograms showing the results of a statistical compilation of S2 regional foliation measurements (n = number of measurements).

This survey, funded by the MRN in partnership with five private companies, led exploration companies to acquire exploration licences in the adjacent Gayot and Maricourt areas (NTS 23M and 24D). However, no exploration programs were carried out in the Loups Marins area, and no mineral occurrence had been reported prior to our mapping.

Results of the Field Campaign

Our work helped locate several occurrences that may create some interest in the search for mineral substances (Figure 9). These generally rusty zones or gossans were either discovered in the field during traverses, or from above during helicopter transport. These different mineral occurrences were sampled and assayed for their base and precious metal content. The occurrences fall into four categories : 1) mineralization associated with paragneisses and iron formations, 2) mineralization associated with mafic volcanic rocks, 3) mineralization associated with gabbros, and finally, 4) mineralization associated with regional fault zones. The location of sites of economic interest is revealed in Figure 9. They are briefly described in Table 4.

Mineralization associated with paragneisses and iron formations

Mineral occurrences associated with paragneisses most often correspond to disseminated sulphide horizons (pyrite and pyrrhotite), or to beds of silicate-facies or oxide-facies iron formations. The thickness of these layers varies from less than a metre to two metres (Table 4). These occurrences were encountered within the Brésolles Suite (sites 1 and 2), the Sem Suite (sites 3 to 6), the Loups Marins Complex (sites 7 to 12) and the volcano-sedimentary Dupire Complex (sites 13 and 14). Sites 4 and 8 are particularly attractive, in that the mineralized zones are associated with thick paragneiss sequences reaching up to several hundred metres thick. However, the best analytical results were obtained in the Dupire Complex, where anomalous gold concentrations (72 and 130 ppb) were obtained from samples of paragneiss

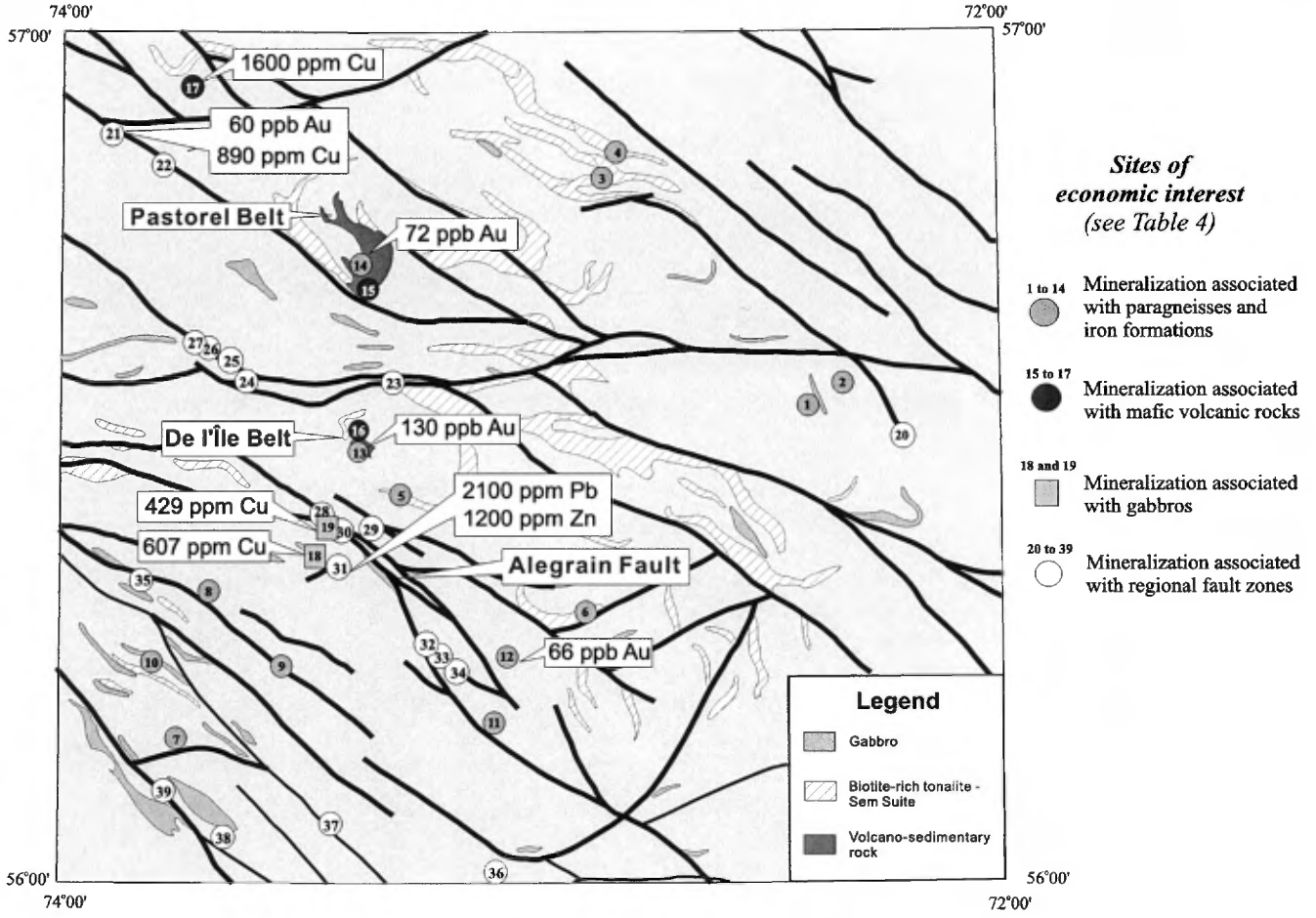


FIGURE 9 - Location of the main sites of economic interest and presentation of the best analytical results obtained from mineralized samples collected in the Loups Marins area (34A). See simplified geology in figure 3.

and iron formation collected in the Pastorel and De l'Île belts (sites 13 and 14; Figure 9 and Table 4).

Mineralizations associated with mafic volcanic rocks

Mineral occurrences associated with mafic volcanic rocks were mainly observed in the Pastorel and De l'Île belts (sites 15 and 16). These two occurrences correspond to gossans or silicate-facies iron formation horizons, several metres thick, intercalated in volcanic sequences. Samples collected in these locations failed to yield any important metal concentrations. But a value of 1600 ppm Cu was obtained from a pyrite-rich amphibolite enclave one to three metres long, hosted in a granodiorite located in the NW corner of the area (site 17).

Mineralization associated with gabbros

Sites of economic interest associated with gabbroic intrusions (sites 18 and 19; Figure 9) correspond to gossans with heavy disseminated sulphide mineralization. The gabbroic host rock at site 18 is interpreted as belonging to the Châteauguay Suite. This gabbro contains several pyrite-rich zones 3 to 15 m wide that extend over several hundred metres in length. A sulphide-rich sample yielded an anomalous copper concentration of 607 ppm. Mineralization at site 19 is hosted in a gabbro located directly along the trace of the Alegrain fault. Its relation to the Châteauguay Suite could not be determined. This gabbro, generally weakly deformed, is cross-cut by a silicified pyrite-rich shear zone about six metres wide. A sample from this zone yielded an anomalous copper concentration of 429 ppm. In the Maricourt area (24D), a mineralized zone hosted in an ultramafic intrusion assigned to the Châteauguay Suite had yielded contents of 0.37% Cu and 0.32% Ni. Moreover, a massive sulphide showing associated with a gabbro was discovered further north, in the Lac Qullinaaraaluk area. This discovery was made by an MRN field crew during the summer of 2000 (Labbé *et al.*, 2001). This showing, which yielded concentrations of 2.0% Ni and 1.8% Cu, rekindled interest in exploration for mineralization associated with mafic to ultramafic intrusions in Québec's Far North region.

Mineralization associated with regional fault zones

Regional faults that transect the area represent lineaments that are particularly attractive in the search for mineral deposits. About twenty sites of economic interest were uncovered during our survey (sites 20 to 39; Figure 9). Active prospecting along these fault zones would undoubtedly lead to the discovery of a large number of additional showings. Overall, fault-related occurrences correspond to pyrite-rich zones hosted in shear zones a few metres wide, generally affected by carbonatization, silicification or hematization (Table 4). A segment of the Alegrain fault, bracketed between sites 28 and 34 (Figure 9), offers particularly promising potential for the discovery of new showings. It hosts several mineralized zones with seemingly notable thicknesses and lateral extensions. Anomalous concentrations of 1200 ppm zinc and 2100 ppm lead were obtained in a breccia at site 31. In the NW quadrant of the map area, a sample from a pyrite-rich zone hosted in a sheared trondhjemite yielded anomalous grades of 890 ppm copper and 60 ppb gold (site 21).

Lake Sediment Survey

A lake sediment survey, conducted in 1997 by the MRN in partnership with the private sector, covers the entire study area (MRN, 1998). The most important zones with copper, nickel-chrome and gold anomalies detected during this survey are shown in Figure 10. The main anomalous areas for copper and nickel-chrome are found in the central and north-central parts of the area (Figure 10), more specifically to the northeast of the Pastorel belt. Anomalous zones also occur along the extension of the volcano-sedimentary Dupire Complex, located to the north (34H/03) beyond our study area (Lamothe, 1997). Gold anomalies are scarce and very weak, with concentrations below 12 ppb. Only one lake sediment sample, collected in the northeast corner of the map area, yielded a slightly greater anomalous gold value, between 13 and 20 ppb.

DISCUSSION ON MAJOR REGIONAL TECTONO-STRATIGRAPHIC ASSEMBLAGES

The broad tectono-stratigraphic subdivisions proposed by Card and Ciesielski (1986) and by Percival *et al.* (1991 and 1992) for the northern part of the Superior Province place the Gayot, Maricourt and Loups Marins areas straddling the boundaries of the Bienville, Minto and La Grande subprovinces (Figure 1). Our work indicates that most of the lithological units encountered in the Loups Marins area may be correlated with units defined in the Nedlouc area (Table 2; Parent *et al.*, 2000). These observations suggest that the Loups Marins area (34A) and the Nedlouc area (34H) may belong to the same major tectono-stratigraphic assemblage. Based on these considerations, we propose, for the moment, that the Loups Marins area be included, for the most part, in the Minto Subprovince (Figure 2). The contact between the Bienville Subprovince and the Minto Subprovince would therefore be located to the south of the Loups Marins area, as proposed in a recent interpretation by Ciesielski (1998). Furthermore, the continuity of stratigraphic units between the Loups Marins (34A), Maricourt (24D) and Gayot (23M) areas suggests that the Bienville boundary is located outside of these three areas.

TABLE 4 - Brief description of sites of economic interest observed in the Loups Marins area (34A). The numbers refer to site locations shown in figures 9 and 10, and economic grades correspond to concentrations obtained from grab samples.

Site	Brief description	Site	Brief Description
1	Rusty hematized paragneiss layer between 30 cm and 1 m in thickness	15-16	Locally rusty mafic volcanic horizons
2	Pyrite-bearing oxide-facies iron formation horizon about 30 cm in thickness	17	Pyrite-rich amphibolite enclave 1 to 2 m in length, hosted in granodiorite
3	Oxide-facies iron formation horizon about 30 cm in thickness	18	Pyrite-rich zone about 20 m thick in a gbbro (607 ppm Cu)
4	Garnet paragneiss and oxide-facies iron formation in m-scale layers; quartz and sulphide pockets	19	Silicified pyrite-rich shear zone 5 to 6 m thick in a gabbro (429 ppm Cu)
5	Oxide-facies iron formation horizon from 2 to 3 m in thickness	20	Hematized and silicified breccia zone 1 to 3 m in thickness
6	Magnetic paragneiss and silicate-facies iron formation, in enclaves between 10 cm and 2 m in size	21	1-m thick pyrite zone in a trondhjemite (890 ppm Cu, 60 ppb Au)
7	Rusty garnet paragneiss layer, 1m in thickness	22	10-m thick silicified zone
8	2-m thick paragneiss layer with small sulphide lenses	23-26	Gossans from 2 to 20 m thick with variable sulphide content
9	Paragneiss with several m-scale zones of oxide-facies iron formation	27-30	Silicified gossans from 1 to 6 m thick with variable sulphide content
10	1 to 2-m enclaves of very rusty diorite or paragneiss	31	Hematized quartz breccia horizon, 1 to 2 m in thickness (2100 ppm Pb, 1200 ppm Zn)
11	Rusty paragneiss carbonatized over more than 20 m in thickness	32	1-m thick hematized zone in epidotized granodiorite
12	Rusty oxide-facies iron formation horizon, 1 to 2 m in thickness (66 ppb Au)	33-34	Sulphide-rich silicified zones 1 to 2 m thick in tonalites
13	Oxide and silicate-facies iron formation horizon, rusty for about 1 to 4 m in thickness (130 ppb Au)	35	1-m thick rusty shear zone in granite
14	Outcrop over 900 m^2 in size, of locally rusty and folded paragneiss (72 ppb Au)	36-39	Rusty, silicified shear zones 1 to 2 m thick, generally hosted in tonalites

The distribution of these major tectono-stratigraphic assemblages, shown in Figure 1, suggests a certain structural continuity between the Minto and La Grande subprovinces. As shown in this figure, the meeting point of these two assemblages had been positioned in the Gayot area, where the Minto is represented by the Goudalie Domain (Card and Ciesielski, 1986; Percival *et al.*, 1991 and 1992). Subsequent work conducted in 1998 in the Gayot area (Gosselin and Simard, 2001) demonstrated it was impossible to distinguish both lithologically and structurally the area corresponding to the Goudalie from the area representing the La Grande (Figure 2). An informal term, the "Goudalie – La Grande Series", was then proposed to temporarily designate this geological zone. Recent work conducted to the south in the Hurault area (Thériault and Chevé, 2001) outlines the continuity of the principal lithological and structural features of the "Goudalie – La Grande Series". The strategic position of the Hurault area (23L) was helpful in establishing a link between the La Grande Subprovince and the Gayot area, and to demonstrate that the "Goudalie – La Grande Series" does in fact form the extension of the La Grande Subprovince. Additional work performed to the north of the Gayot area, in the Maricourt area (24D), outlined the appearance of certain geological features that could eventually be used to establish a boundary (Figure 2) between the Minto and La Grande subprovinces (Simard *et al.*, 2002). Among these, note the appearance in Maricourt (24D) of a hornblende tonalite unit (Coursolles suite), the presence of an important "granitization" phenomenon affecting tonalitic units (Favard and Coursolles suites) as well as the appearance of units metamorphosed to the granulite facies (Du Gué Complex). Most of these characteristics were also observed in the Loups Marins area (34A).

It therefore appears possible to propose a new approximate boundary between the Minto and La Grande subprovinces (Figure 2), assuming that the following phenomena are considered as characteristics of the Minto Subprovince : 1 - the abundance of granitization, which affects tonalitic units in the Maricourt and Loups Marins areas; 2 - an increase in the relative importance of granodioritic units in these areas; 3 - the appearance of migmatitic rocks (diatexites); and 4 - the presence of important granulitic

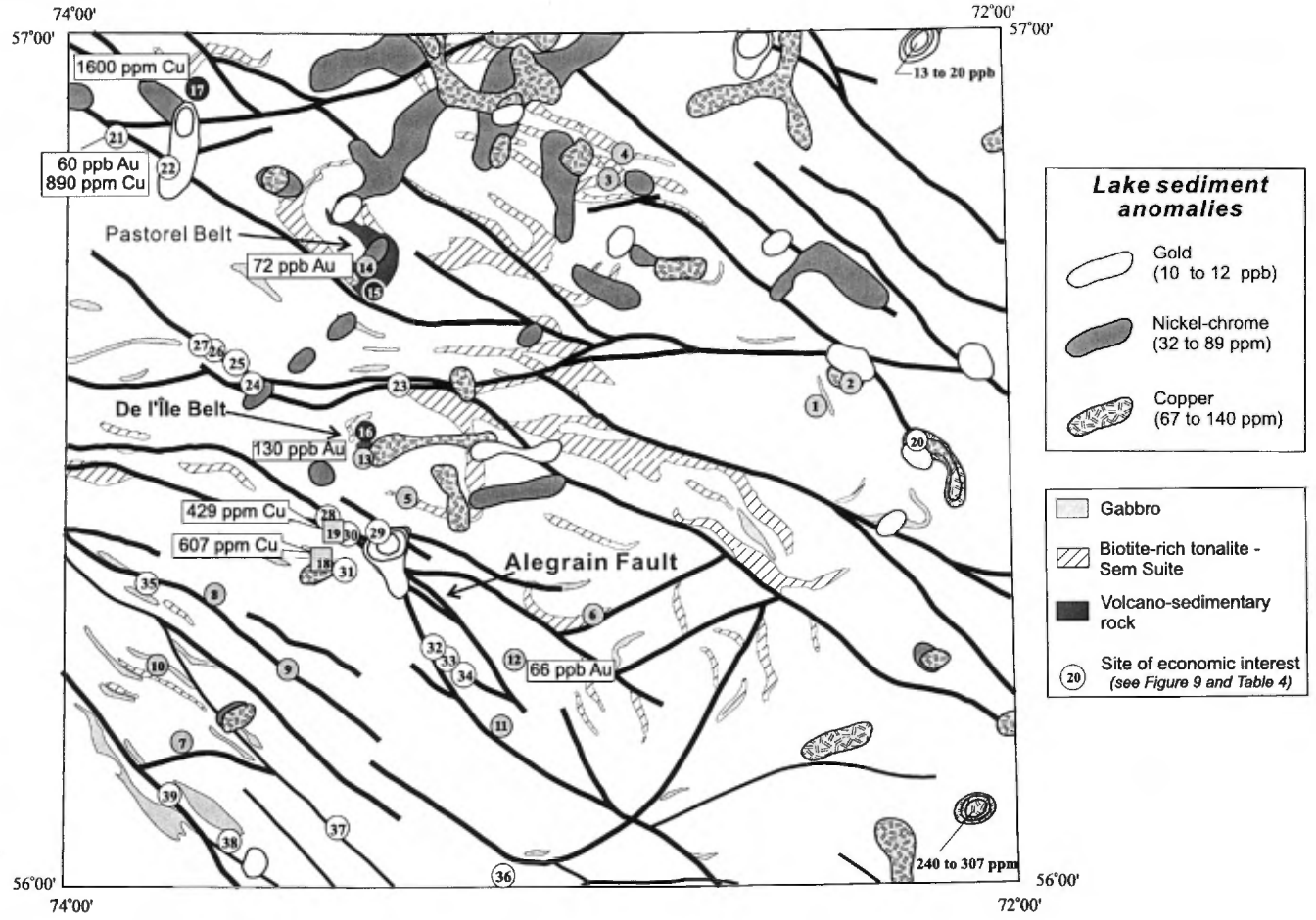


FIGURE 10 - Location of the main lake sediment geochemical anomalies in the Loups Marins area (34A). See simplified geology in figure 3.

units. This new boundary would also correspond with the near-complete disappearance northward of an important unit of early tonalitic gneisses (Figure 2; Brésolles Suite, 2803±8 Ma). These gneisses are considered as representative of the La Grande Subprovince (Gosselin and Simard, 2001).

From a structural standpoint, note that the proposed boundary between the Minto and La Grande subprovinces follows in part the trace of major regional faults (Figure 2). Thus, in the eastern part of the Maricourt area (24D), this boundary follows the Châteauguay fault, along a NE-SW direction, interpreted as a reverse or thrust fault with SE-directed movement. This fault delineates two structurally contrasting environments. To the north of the fault, the structural trend is clearly NW-SE and represents phase of deformation D4, whereas to the south, the structural trend is rather N-S to NE-SW, which corresponds to phase of deformation D3, well developed in this sector (Simard *et al.*, 2002). To the NW, the La Grande boundary follows an important deformation corridor along a N-S to NW-SE direction, which extends into the Loups Marins area (figures 2 and 4). In this corridor, a mylonitic zone, possibly corresponding to a folded thrust fault, was traced over more than 50 km (Simard *et al.*, 2002). In the Loups Marins area, the proposed boundary wraps around the main outcropping area of rocks of the Brésolles gneisso-tonalitic Suite (Abre) and extends southward (Figure 2). The northwestern boundary of the La Grande Subprovince in the Loups Marins area appears to correspond to the closure of an important anticlinorium. This structure is namely outlined by a major antiformal axis in the SE corner of the area (figures 2 and 4; Figure 8, domain 5), an axis that extends to the SE down into the Gayot area (Figure 2; Gosselin and Simard, 2001). In this sector however, the boundary between the two subprovinces is drawn in a temporary fashion. The results of a geological survey planned for the summer 2001 in the Bienville area (33P) will bring new elements, which may be useful to define this boundary more accurately southward.

CONCLUSIONS

Our work has allowed us to reconsider some of the major lithotectonic boundaries that had been previously defined.

According to historically accepted subdivisions for the northeastern Superior Province, the Loups Marins area (34A) was considered as part of the Bienville Subprovince. However, lithological units recently observed in the area appear quite comparable to those described in the Minto Subprovince. It is therefore proposed that an important part of the area belongs to the Minto (Figure 2). Furthermore, recent work performed in the surrounding Gayot (23M) and Maricourt (24D) areas, as well as observations made in the southeastern part of the Loups Marins area (34A), lead us to propose a new boundary between the Minto and La Grande subprovinces, a boundary that appears to correspond to the northern closure of the La Grande Subprovince (Figure 2). This hypothesis is based mainly on the sudden disappearance of early gneisses of the Brésolles Suite (2.80-2.81 Ga) northward, which are associated with the La Grande Subprovince. It is also based on the appearance in the Minto Subprovince : 1) of a regional granitization phenomenon in tonalitic units; 2) of an important volume of granodioritic bodies; 3) of the presence of migmatitic units (diatexites); 4) of granulitic units.

The Loups Marins area (34A) is essentially composed of Archean units, with the exception of a few Proterozoic dykes. Volcano-sedimentary rocks are not abundant, but those present are assigned to the *Dupire Complex* (2787 ±2 Ma). They mainly occur in two small belts located in the western half of the map area : the Pastorel and De l'Île belts.

Tonalitic units belong to four lithodemic suites : the Brésolles, Sem, Coursolles and Favard suites. The *Brésolles Suite* (2811 ±4 Ma) is composed of tonalitic to dioritic rocks with a gneissic aspect, cross-cut by younger tonalitic to granitic injections. This suite is comparable in age and composition to certain units encountered within the La Grande Subprovince. It contains numerous enclaves of volcanic and sedimentary origin, probably representing the remains of former belts such as those recognized in the Gayot and Maricourt areas and assigned to the Gayot Complex (2.86 to 2.87 Ga).

The *Sem Suite* corresponds to a new lithodemic unit composed of biotite-rich tonalites. The textural aspect of these rocks remains problematic. In the field, these tonalites exhibit several features generally encountered within migmatitic units such as diatexites. However, their tonalitic composition suggests a different origin. The relations of the Sem Suite with other regional units were not clearly established.

The *Coursolles Suite* (2756±8 Ma) is mainly composed of hornblende-biotite tonalite, and the *Favard Suite* (2749 ±4 Ma), of biotite trondhjemite or leucotonalite. Cross-cutting relationships observed in the field between these two suites support the ages obtained in the Loups Marins area, indicating that the Coursolles is slightly older. However, in the Maricourt area, tonalites lithologically similar to the Coursolles Suite yielded a U-Pb zircon age of 2718 +11/-8 Ma. This result suggests that part of the rocks assigned to this suite may be related to a more recent intrusive phase. Finally, the Favard and Coursolles suites were both affected to varying degrees by an important phenomenon of regional "granitization". This phenomenon, originally identified in the Maricourt area (Simard *et al.*, 2002), but which extends into our study area, translates into the appearance of an important granodioritic fraction that is intimately associated with the tonalitic phase.

Dykes and small bodies of diorite, gabbro and ultramafic rocks that cross-cut the tonalitic units were assigned to the *Châteauguay Suite*. These rocks, ultramafic to intermediate in composition, are younger than the volcano-sedimentary rocks in the area, and are therefore not associated with the Dupire Complex.

Granodioritic units belong to two lithodemic suites : the Desbergères Suite and the Lussay Suite. The *Desbergères Suite* (2714±12 Ma) consists of massive granodiorite, and may be related to the "granitization" phenomenon that affected the tonalitic suites. However, an age of 2683+4/-2 Ma, obtained in the Maricourt area (24D), indicates that part of the granodiorites assigned to this suite may belong to an intrusive phase that is lithologically similar but more recent. The *Lussay Suite* (2713±5 Ma) is a new unit restricted to the SW part of the area. It includes a few bodies of megaphyric granodiorite with red biotite and clinopyroxene. The red biotite and clinopyroxene may be metamorphic in origin, and related to the emplacement of an enderbite intrusion in contact with the granodiorite. Note that the age of the Lussay Suite is comparable to that of the monzonitic Radisson pluton, located in the Bienville Subprovince.

Our work has demonstrated the existence of rocks with high-grade metamorphic mineral assemblages, ranging from the upper amphibolite to the granulite facies. These belong to the *Lippens Suite* (2709+3/-2 Ma), the *MacMahon Suite* (2697±8 Ma), and the *Loups Marins Complex* (2694±12 Ma). Within these units, rocks metamorphosed to the granulite facies commonly coexist with intrusive rocks belonging to charnockitic suites. Thus, the Loups Marins Complex represents a new lithodemic unit containing a central orthopyroxene zone (Alma2) surrounded by a clinopyroxene zone (Alma1).

Late intrusive suites were also recognized. The *Maurel Suite* is characterized by granodiorites with a megaphyric texture. These rocks yielded in the Gayot (23M) and Maricourt (24D) areas similar U-Pb zircon ages on the order of 2.68 Ga. The granitic *Tramont Suite* is the youngest Archean unit in the area. It forms plutons and injections that cross-cut all other Archean units.

The regional metamorphic grade reached the amphibolite facies, except for a few sectors with mineral assemblages typical of the granulite facies. In these sectors, it is difficult to clearly distinguish metamorphic rocks from charnockitic rocks. Greenschist-facies retrograde metamorphism was observed locally, mainly along fault zones.

In the Loups Marins area (34A), several phases of deformation successively took place (Table 3). Relics of an early phase of deformation D1 are interpreted based on an early

S1 foliation that affects enclaves hosted in Brésolles gneisses. The D2 phase of deformation is responsible for the regional S2 foliation, which is the most penetrative structural element in the area. This foliation was reoriented and folded by three subsequent phases of deformation (D3 to D5). Phase D3, weakly developed and poorly represented in our study area, produced NE-SW to ENE-WSW F3 folds, without an axial plane foliation. Phase D4 is responsible for the dominant NW-SE regional structural trend. It is associated with F4 folds oriented WNW-ESE to NW-SE, along with a well-developed system of NW-SE faults. Finally, phase D5 resulted in a number of poorly exposed faults oriented ENE-WSW to NNE-SSW.

Our work led to the discovery of several mineral occurrences associated with paragneisses or iron formations, mafic volcanic rocks, gabbros and regional fault zones (Table 4; and Figure 9). Occurrences associated with paragneisses and mafic volcanic rocks yielded a few anomalous gold contents. They correspond to disseminated sulphide zones, gossans and oxide and silicate-facies iron formation horizons, less than a metre to a few metres in thickness. Sites of economic interest associated with gabbroic intrusions correspond to gossans, sometimes sheared with heavy disseminated sulphide mineralization. A few anomalous copper grades were obtained in this type of setting. The economic potential of gabbroic intrusions was outlined during the summer of 2000 with the discovery of a massive sulphide showing in the Lac Qullinaaraaluk area, to the north of our study area. Several sites of economic interest were discovered along regional fault zones. These consist of pyrite-rich zones hosted in shear zones a few metres in width, generally affected by carbonate, silica or hematite alteration. One of these occurrences yielded anomalous zinc and lead concentrations.

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Abstract

This report contains the results of a geological survey carried out over the course of the 2000 summer season at a scale of 1 : 250 000. It corresponds to the area covered by NTS sheet 34A (Lacs des Loups Marins) and located about 355 km southwest of Kuujjuaq and 410 km northeast of Radisson. The Lacs des Loups Marins area was considered to be almost entirely underlain by rocks of the Bienville Subprovince. Our mapping suggests it should rather be included, for the most part, in the Minto Subprovince, except for the southeast sector, which lies in the La Grande Subprovince.

Lithological assemblages in the area are Archean in age, with the exception of a few Proterozoic diabase dykes. Volcano-sedimentary rocks are assigned to the Dupire Complex (2787 ±2 Ma) and are mainly concentrated in two small belts located in the NW part of the area. Tonalitic rocks belong to four lithodemic suites: the gneisso-tonalitic Brésolles Suite (2811 ±4 Ma), the Sem Suite composed of biotite-rich tonalites, the Coursolles Suite (2756 ±8 Ma) essentially composed of hornblende-biotite tonalites, and the Favard Suite (2749 ±4 Ma) characterized by biotite trondhjemites and leucotonalites. These tonalitic units underwent a regional granitization phenomenon of variable intensity. The tonalitic units are cross-cut by dykes and small bodies of diorite, gabbro and ultramafic rocks assigned to the Châteauguay Suite. Granodioritic units are represented by the Desbergères Suite (2714 ±12 Ma), which consists of massive granodiorite, and by the Lussay Suite (2712 ±9 Ma) composed of clinopyroxene-bearing megaphyric granodiorite. Granulite-facies lithological assemblages were observed and assigned to the Lippens Suite (2709 +3/-2 Ma), the MacMahon Suite (2697 ±8 Ma) and the Loups Marins Complex (2694 ±3 Ma). Late intrusive suites were also recognized. The Maurel Suite (2.685 Ga) is characterized by megaphyric granodiorites to granites, and finally, the Tramont Suite consists of granites that cut all other Archean units in the area.

The regional metamorphic grade reached the amphibolite facies, except for a few sectors that contain mineral assemblages typical of the granulite facies. In these sectors, the distinction between metamorphosed rocks and charnockitic rocks is difficult to establish clearly. Retrograde metamorphism to the greenschist facies was observed locally, mainly along fault zones.

In the area, several successive phases of deformation took place. Relics of an early phase of deformation D1 are detected in enclaves hosted in Brésolles gneisses. Phase of deformation D2 generated the regional foliation S2, which is the most penetrative structural element in the area. This foliation was reoriented and folded by three subsequent phases of deformation. Phase D3, weakly represented in our area, produced rare NE-SW to ENE-WSW folds. Phase D4 is responsible for the regional structural trend broadly oriented NW-SE. It is associated with folds oriented WNW-ESE to NW-SE along with a well-developed system of NW-SE faults. Finally, phase D5 generated poorly exposed ENE-WSW to NNE-SSW faults.

Our regional mapping coverage led to the discovery of several sites of economic interest related to different settings. Occurrences associated with paragneisses and volcanic rocks yielded a few anomalous gold grades. These correspond to disseminated sulphide zones as well as iron formation horizons less than a metre to a few metres in thickness. Occurrences associated with gabbroic intrusions correspond to gossans, occasionally sheared and with disseminated sulphides, where a few anomalous copper grades were obtained. The economic potential of gabbroic intrusions was outlined during the summer of 2000 with the discovery of a massive sulphide showing in the Lac Qullinaaraaluk area, north of our study area. Several sites of economic interest were discovered along regional faults. These consist of pyrite-rich zones hosted in shear zones a few metres wide, generally affected by carbonate, silica or hematite alteration. One of these occurrences yielded anomalous zinc and lead concentrations.

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