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GEOLOGY OF THE LAC BIENVILLE AREA (33P)

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RG 2003-04

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Aerial view of Lac Bienville.

2004

Québec

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Abstract

This report presents the results of a geological survey carried out in the summer of 2001 at the 1:250,000 scale. It covers the Lac Bienville area (NTS 33P), located 360 km northeast of Radisson. This area was previously interpreted as underlain by the Bienville geological Subprovince. Based on the results of our survey, it appears located along the boundary between the Minto and La Grande subprovinces.

The Lac Bienville area (33P) is mainly underlain by Archean units, with the exception of an outlier of sedimentary rocks of the Sakami Formation and a few Paleoproterozoic diabase dykes. The La Grande Subprovince is essentially represented by the *Brésolles Suite* (2811 ±4 Ma), composed of early tonalitic gneisses. The Minto Subprovince covers most of the area. It includes a trondhjemite-tonalite-granodiorite (TTG) intrusive series, composed of four lithodemic suites: the *Favard Suite* (2741 ±4 Ma) which consists of biotite trondhjemite and tonalite, the *Coursolles Suite* (2719 ±4 Ma) composed of hornblende tonalite and diorite, the *Desbergères Suite* (2714 ±12 Ma) including biotite granodiorite and granite, and the *Maurel Suite* (2707 ±5 Ma) characterized by megaphyric granodiorite. Tonalitic units are affected by a "granitization" phenomenon that translates into the presence of granodioritic injections, associated with the emplacement of younger granodioritic suites. Tonalitic units are also intruded by gabbronoritic and ultramafic rocks of the *Châteauguay Suite*. The *Loups Marins Complex* is also included in the Minto Subprovince. It is composed of an orthopyroxene unit, formed of hypersthene quartz diorite and enderbite, bordered by a clinopyroxene unit. The latter is divided into sub-units comparable to certain regional suites that were probably formed or metamorphosed at higher pressure and temperature conditions. All units described above are cut by late Archean intrusions of the *Tramont Suite* (2701 ±4 Ma) composed of biotite granite, of the *Ossant Suite* composed of amphibole granite, and of the *Turbar Suite* comprising coarse-grained monzodiorite and diorite.

In the map area, five phases of deformation were recognized (D1 to D5). Phase D1 corresponds to a relic foliation preserved in enclaves of early rocks. Phase D2 is the most important. It is responsible for the S2 foliation which represents the most penetrative structural feature in the area. Phase D3, which produced F3 folds with axial traces oriented NE-SW to NNE-SSW, is restricted to the boundary zone between the La Grande and Minto subprovinces. Phase D4 is responsible for the formation of F4 folds with WNW-ESE to NW-SE axial traces as well as a system of brittle-ductile faults oriented NW-SE. Finally, deformation D5 generated a set of late brittle faults oriented ENE-WSW. This system appears to control the Proterozoic Saindon-Cambrien collapse structure.

The regional metamorphic grade corresponds to the middle amphibolite facies throughout the map area, except within the Loups Marins Complex where metamorphic conditions range from the upper amphibolite facies to the granulite facies. Retrograde metamorphism at the greenschist facies is recorded locally, namely along fault zones.

Our work led to the discovery of the *Sophie showing* (0.36% Ni, 0.30% Cu, 104 ppm Co and 180 ppb Au), a rusty zone with less than 5% disseminated sulphides (pyrite, pyrrhotite, chalcopyrite) hosted in a gabbro of the Châteauguay Suite. The economic potential of mafic-ultramafic intrusions in the area was previously outlined in 2000 with the discovery of the *Qullinaaraaluk showing*.

The Lac Bienville area (33P) is very promising for diamond exploration. It occurs at the junction of three important structures: the Saindon-Cambrien corridor (SCC), the Kapuskasing tectonic zone and a major gravity lineament. Furthermore, the recent discovery of chrome picroilmenite grains in two samples of fluvioglacial sediments within the SCC further enhances the diamond potential of the area.

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CONTENTS

INTRODUCTION

The survey conducted in the Lac Bienville area during the summer of 2001 was carried out within the context of the Far North Project, initiated in 1997 by the Ministère des Ressources naturelles du Québec (MRN). The objectives of this vast project are to complete the geological map coverage, to acquire new geoscience data and to open new territories to mineral exploration north of the 55th parallel. The survey was conducted at the 1:250,000 scale and covers NTS sheet 33P (Lac Bienville, Figure 1). The map area, covering roughly 13,900 km², is bounded by longitudes 72°00' and 74°00' and latitudes 55°00' and 56°00'.

Mapping in the Lac Bienville area (33P) completes the geological coverage of a quadrilateral of more than 55,000 km², which includes recent mapping surveys conducted in the Lacs des Loups Marins area (34A), the Lac Maricourt area (24D) and the Lac Gayot area (23M) (Figure 1; Gosselin *et al.*, 2001; Simard *et al.*, 2001; Gosselin and Simard, 2000). Based on tectono-stratigraphic subdivisions previously proposed by other authors for the northern Superior Province (Card and Ciesielski, 1986; Percival *et al.*, 1991; Percival *et al.*, 1992), the Lac Bienville area is reportedly located within the Bienville Subprovince (Figure 1). Despite subsequent modifications by Ciesielski (1998), our map area (33P) was still considered as almost entirely located within this subprovince (Figure 1). However, fieldwork conducted in 2001 suggests the Lac Bienville area should be included within the Minto Subprovince, since lithostratigraphic units of the Minto encountered in areas to the north (cf. Figure 2) extend into map sheet 33P. We also propose to assign the southeastern part of the area to the La Grande Subprovince.

Access

The Lac Bienville area (33P) is only accessible by floatplane or helicopter. The airports closest to the centre of the area are those of Fontanges (150 km), LG-4 (190 km) and Umiujaq (240 km, Figure 1). Two floatplane bases also provide access to the area from LG-4 or from Lac Pau (200 km, Figure 1). Large water bodies are present in the map area, providing easy access to certain parts of the area. In the southern part, Lac Bienville covers an area in excess of 1,000 km² (cf. Figure 3). Further north, lakes Saindon and d'Iberville and the Petite Rivière de la Baleine form an important drainage basin that covers an area of roughly 1,700 km².

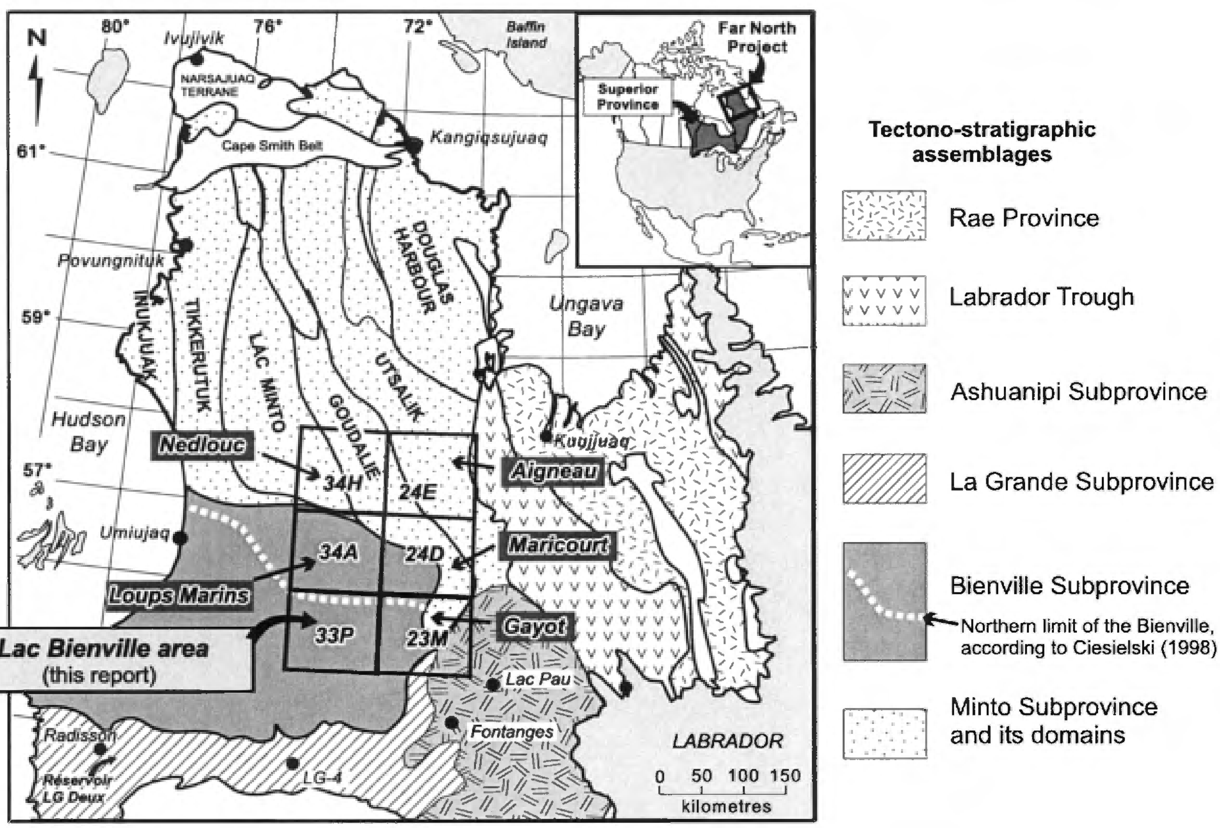


FIGURE 1 - Location of the Lac Bienville (33P, this report), Gayot (23M, RG 99-06), Maricourt (24D, RG 2000-07), Loups Marins (34A, RG 2001-10), Aigneau (24E and 24F/04, RG 2001-01) and Nedlouc (34H and 24E, RG 99-13) areas, as well as the main tectono-stratigraphic assemblages in the northern Superior Province (modified after Card and Ciesielski, 1986 and after Percival *et al.*, 1992).

Methodology

Fieldwork during the summer of 2001 was carried out by a team of six geologists and seven assistants, who traversed the area on foot. A number of outcrops were also examined by helicopter spot checks, and the drainage basin formed by Lac Saindon, Lac d'Iberville and Petite Rivière de la Baleine was mapped, in part, with the help of motorboats. On average, fourteen traverses about ten kilometres in length were carried out in each 1:50,000 scale NTS sheet area. Overall, outcrops are abundant and scattered throughout the map area. However, certain zones extending for tens of square kilometres, especially in the eastern part of the map area, are almost entirely devoid of outcrops due to the presence of overlying glacial deposits, swamps and lakes.

Lithogeochemical analyses were performed in order to better define mapped lithologies and observed mineral occurrences. One hundred and seventeen rock samples were analyzed for major and trace elements. Another twenty-three samples were analysed for economic elements. All these analytical results were integrated to the geomining information system (SIGÉOM) of the Ministère des Ressources naturelles du Québec. Over 400 thin sections of rock samples were examined for a petrographic study of the different lithological assemblages. Finally, six samples were collected for U-Pb dating (Table 1). The ages were obtained from zircons by *in situ* laser ablation, using a MicroMass Isoprobe high-resolution inductively coupled plasma mass spectrometer (HR-ICP-MS). Geochronology analyses were performed by Jean David at the GÉOTOP laboratory of the *Université du Québec à Montréal.*

Previous Work

Reconnaissance mapping at the 1:1,000,000 scale was carried out in the Lac Bienville area between 1957 and 1959 by the Geological Survey of Canada (Eade, 1966). Work by Card and Ciesielski (1986) to define major tectono-stratigraphic assemblages within the Superior Province, work by Percival *et al.* (1991, 1992), more specifically focussed on the Minto Subprovince, and work by Ciesielski (1999) in the Bienville Subprovince represent valuable geoscience contributions.

Uranium exploration programs were carried out between 1976 and 1979 by Uranerz Exploration and Mining, Seru Nuclear of Canada and Eldorado Nuclear. Studies conducted on an outlier of Proterozoic sediments of the Sakami Formation located in the north-central part of the map area, (cf. Figure 3) failed to detect any uranium mineralization. Note that a Proterozoic outlier located some 125 km further east in the Gayot area, hosts a deposit with reserves estimated at 50 million metric tonnes at a grade of 0.10% U_3O_8 (Marcoux, 1980).

Regional diamond exploration also touched our study area between 1994 and 2000. This work, which did not becone public knowlwdge, was carried out by Monopros in 1994 and by the Ashton Mining/Soquem joint venture between 1996 and 1999. The area was also covered by a vast lake sediment survey carried out in 1997 by the Ministère des Ressources naturelles du Québec, in partnership with a few mineral exploration companies (MRN, 1998). Unpublished maps showing the results of this survey were kindly supplied by Marc Beaumier of Géologie Québec (MRN). Finally, a fluvioglacial sediment survey (eskers), combined with a glacial dynamic study, was carried out in the summer of 2001 (Parent *et al.*, 2001, 2002). The presence of chrome picroilmenite grains in two samples indicates the prospective nature of the Lac Bienville area for diamond exploration.

Acknowledgements

We wish to thank all the members of our field crew for their involvement in the field survey during the summer of 2001. In addition to the authors, the team also included geologists Christine Beausoleil, Sophie Lafontaine, Geneviève Leblanc and Bronislaw Popiela, along with geological assistants Charles Corriveau, Carl Guilmette, François Kerr-Gillespie, Rynee Kokiapik, Nancy Lafrance, Mélanie St-Arnault and Audrey Tremblay. We would also like to acknowledge the contribution of Guy Bouchard (camp manager) and Raymond Pelletier (cook). Finally, Christine Beausoleil and Manon Dufour were significantly involved in the production of geological maps and figures for this report.

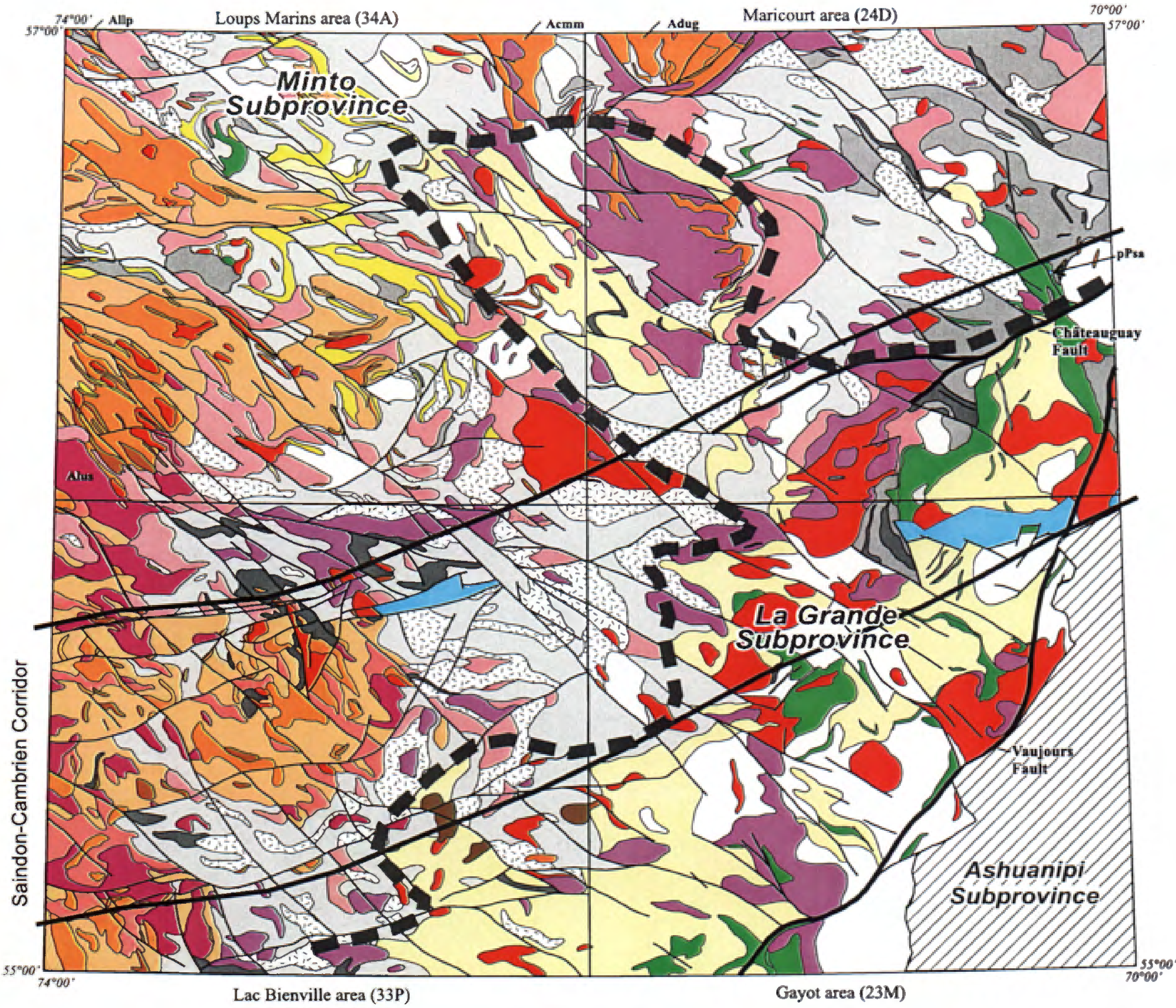
We also extend our gratitude to our colleagues at Géologie Québec; Marc Beaumier for the production of unpublished lake sediment geochemistry maps, Denis-Jacques Dion for the production of geophysical maps, as well as Louis Madore, for his critical review of an early draft of this report.

REGIONAL AND LOCAL GEOLOGICAL FRAMEWORK

Our study area is located within the Superior Province. Work carried out by the Geological Survey of Canada (Card and Ciesielski, 1986; Percival *et al.*, 1991; Percival *et al.*, 1992; Ciesielski, 1998 and 1999) placed the Lac Bienville area within the Bienville Subprovince. However, mapping by the MRN during the summer of 2000 revealed that most lithological assemblages encountered in the Loups Marins area (34A) were comparable to those in the Nedlouc area, located immediately to the north (map sheet 34H; Parent *et al.*, 2000), and could be considered as part of the Minto Subprovince (Figure 2; Gosselin *et al.*, 2001). Furthermore, the latter proposed to extend the La Grande Subprovince

TABLE 1 - Revised and updated stratigraphic correlations between the main units encountered in the Gayot (23M), Maricourt (24D), Loups Marins (34A) and Bienville (33P, this report) areas. See lithological, mineralogical and textural abbreviations in Sharma (1996). See also Figure 2.

Loups Marins area (34A) (modified after Gosselin *et al.*, 2001)	**Bienville area (33P)** (this report)	**Maricourt area (24D)** (modified after Simard *et al.*, 2001)	**Gayot area (23M)** (modified after Gosselin and Simard, 2000)
Tramont Suite (Atra) I1B	Atra (inferred), Atub?, Aoss?	Atra	Atra
Maurel Suite (Amau) (L) I1C, PO	Amau (L) (inferred) / Adeb (L) (inferred) Atra (P), I1B (2701±4 Ma, #1)	Amau (L) (2.685 Ga) / Adeb (T) (2683 +4/-2 Ma)	Amau (E) (2,68 Ga; 2683 ±4 Ma)
Loups Marins Complex (Alma2) I2Q; I1T; I1S (2694 ±3 Ma)	Alma2 I2Q; I1T; I1S (2720 ±2 Ma, #6)	Du Gué Complex (Adug) I1T I1P, PO I1D, OX, (2729 Ma) M21 M4 M1(I1D)	
Amau (E) I1C, PO / Lussay Suite (Alus) equivalent to Alma1c (2713 ±5 Ma)	Amau (E) I1C, PO (2707±5 Ma, #2) / Alma1c I1C, Cx, PO	Amau (E) (inferred)	Amau (E) (inferred)
Desbergères Suite (Adeb) (E) I1C (2714 ±12 Ma)	Adeb (E) / Alma1b I1C, Cx (2709 ±2 Ma, #3)	Adeb (E) (inferred)	
Châteauguay Suite (Achg) I3A-I3Q	Achg	*Achg	
Coursolles Suite (*Acou) (L) I1D, Hb, (I1B)	Acou2 (L) I1D, Hb (I1B)	*Acou2a (L) I1D, Hb (I1B) *Acou2 (L) I1D, Hb (2718 +11/-8 Ma)	Acou (L) I1D, Hb, (I1B) replaces in part the La Bazinière Suite (unit abandoned)
*Acou (L) I2I-I2J previously assigned to Achg	Acou1 (L) I2J-I2I (2719 ±2 Ma, #5)	*Acou1 (L) I2J-I2I	Acou (L) I2J-I2I replace *Afav1
Favard Suite (Afav): Afav1b I1E (I1B) Afav1 I1E Afav1a I1E with M1 bands (I1D) Loups Marins Complex (Alma1) I1D and I2I, CX	Afav I1E (I1B) granodioritic fraction 2713 ±2 Ma and tonalitic fraction (2741 ±4 Ma, #4) Alma1a I1D, I2I I2G and I1C, Cx	Afav1b I1E (I1B) Afav1 I1E (2749 ±4, 2754 +11/-9 Ma) Afav1a I1E with M1 bands (I1D)	Afav I1E (I1B) recognized in 2001 in the western part **Afav2,** I1E **and Afav2a,** magnetic I1E (2.73 Ga)
Acou (E) I1D, Hb (2756 ±8 and 2758 ±11 Ma)	Acou (E) (inferred)	Acou (E) (inferred)	
Brésolles Suite (Abre) M1 (I1D) (2811 ±4 Ma)	Abre	Abre	Abre (2803 ±8 Ma)



Sakami Formation (pPsa)
- Sandstone and conglomerate

Tramont (Atra) and Ossant (Aoss) suites
- Biotite granite and amphibole granite

Turbar Suite (Atub)
- Monzodiorite and diorite

Orthopyroxene unit (Alma2) of the Loups Marins Complex. *Locally : Lippens Suite (Allp), MacMahon Suite (Acmm) and Du Gué Complex (Adug)*
- Enderbite, hypersthene diorite; opdalite and charnockite

Clinopyroxene unit (Alma1) of the Loups Marins Complex. *Locally in 34 A: Lussay Suite (Alus)*
- Clinopyroxene-bearing megaphyric granodiorite
- Clinopyroxene-bearing granodiorite and granite
- Clinopyroxene-bearing tonalite and quartz diorite

Maurel Suite (Amau)
- Megaphyric granodiorite

Desbergères Suite (Adeb)
- Biotite granodiorite

Châteauguay Suite (Achg)
- Gabbronorite, gabbro and ultramafic rocks

Coursolles Suite (Acou)
- "Granitized" hornblende tonalite and granodiorite
- Tonalite and quartz diorite
- Diorite and quartz diorite ; gabbro

Favard Suite (Afav)
- "Granitized" biotite trondhjemite and tonalite
- Biotite trondhjemite and tonalite

Sem Suite (Asem)
- Biotite-rich tonalite

Brésolles Suite (Abre)
- Gneissic tonalite and diorite

Gayot, Garault and Dupire complexes (undifferentiated)
- Volcanic and sedimentary rocks; mafic to ultramafic intrusions

Proposed boundary between the La Grande and de Minto subprovinces (from Gosselin *et al.* (2001) and this report)

FIGURE 2 - Updated regional geology of the Gayot, Maricourt, Loups Marins and Lac Bienville areas, showing the location of the proposed boundary between the La Grande and Minto subprovinces and the Proterozoic Saindon-Cambrien collapse structure (SCC).

up to the eastern part of map sheet 34A. The current study shows that the main lithodemic units in the Lac Bienville area (33P) are in lithotectonic continuity with those further north, in map sheets 34A and 34H. Thissuggests that most of the rocks of this map area belong to the Minto Subprovince. The rocks in the southeastern corner of the area, on the other hand, are assigned to the La Grande Subprovince, given the presence of the Brésolles gneisso-tonalitic Suite, associated with the latter (Figure 2).

The Lac Bienville area (33P) is essentially composed of Archean plutonic rocks. Tonalitic to granodioritic rocks are widespread; charnockitic intrusions, granites, monzodiorites, diorites and gabbros are also encountered. Paleoproterozoic rocks occur in minor amounts. An outlier of sedimentary rocks of the Sakami Formation (pPsa) is present, along with diabase dykes a few centimetres to a few metres thick.

The Brésolles gneisso-tonalitic Suite (Abre) covers the southeastern part of the area. It corresponds to the oldest lithostratigraphic unit. It is composed of gneissic tonalite and diorite, dated at 2803 ±8 and 2811 ±4 Ma (cf. Figure 3 and Table 1). An important trondhjemite-tonalite-granodiorite series, represented by the Favard (Afav), Coursolles (Acou), Desbergères (Adeb) and Maurel (Amau) suites, covers the northeastern and south-central parts of the area (cf. Figure 3). Isotopic ages obtained from samples in map sheet 33P for these different units are: 2741±4 Ma for the Favard Suite (Afav), 2719 ±2 Ma for diorites of the Coursolles Suite (Acou1), 2709 ±2 Ma for a unit equivalent to the Desbergères Suite (Alma1b, see below) and 2707 ±5 Ma for the Maurel Suite (Amau) (Table 1). The Favard and Coursolles suites are affected by a “granitization” phenomenon, illustrated by the injection of granodioritic material within the tonalites. The granodioritic fraction primarily corresponds to late injections that invade the tonalitic fraction. These injections appear to be associated with the emplacement of granodiorites of the Desbergères and Maurel suites.

The western part of the area is underlain by an extensive granulitic complex, the Loups Marins Complex (Alma; Figure 3). On maps showing the shaded total residual magnetic field, this complex is characterized by a signature of magnetic highs and lows, giving it a distinctive patchy aspect (Figure 4). The Loups Marins Complex is composed of orthopyroxene-bearing intermediate to felsic intrusions (Alma2) (hypersthene diorite and enderbite) and clinopyroxene-bearing rocks (Alma1), emplaced or metamorphosed at pressure and temperature conditions corresponding to the upper amphibolite facies or the granulite facies. Clinopyroxene-bearing rocks (Alma1) were subdivided into three sub-units: sub-unit *Alma1a* mainly consists of tonalitic and dioritic rocks, considered to be equivalent to rocks of the Favard (Afav) and Coursolles (Acou) suites, sub-unit *Alma1b* is characterized by homogeneous granodiorites equivalent to the Desbergères Suite (Adeb), and sub-unit *Alma1c* is composed of megaphyric granodiorites equivalent to the Maurel Suite (Amau) (Table 1).

In the area, Archean mafic to ultramafic intrusions are assigned to the Châteauguay Suite (Achg). The latest Archean units are represented by the Tramont, Ossant and Turbar suites (Figure 3). The Tramont Suite (Atra) is composed of biotite granite, the Ossant Suite (Aoss) of amphibole granite, and the Turbar Suite of coarse-grained monzodiorite and diorite characterized by an antiperthitic texture.

From a structural standpoint, the Lac Bienville area shows many characteristics similar to those in the adjacent Gayot, Maricourt and Loups Marins areas (cf. Table 2). Five phases of deformation (D1 to D5) were recognized. Phase of deformation D1 is inferred from the presence of relics of an early foliation observed in enclaves, and phase D2 is represented by the regional S2 foliation. Phases of deformation D3 and D4 affect the regional S2 foliation. Phase D3 produced ENE-WSW-trending folds, essentially observed within or very near the La Grande Subprovince. Phase D4 is responsible for the reorientation of the regional S2 foliation towards the NW-SE. It is associated with a set of brittle-ductile faults and folds, broadly oriented NW-SE. Finally, phase of deformation D5 is represented by a network of late brittle faults, oriented ENE-WSW to NNE-SSW, which may have exerted some control on the Saindon-Cambrien corridor (SCC). The boundaries of the SCC, broadly defined on the basis of the presence of sedimentary outliers of the Sakami Formation and of D5 brittle faults, are shown on Figure 2.

LITHOSTRATIGRAPHY

The rocks of the Lac Bienville area (33P) are essentially composed of Archean plutonic rocks, with a minor component of Paleoproterozoic rocks represented by the Sakami Formation (Figure 3) and a few diabase dykes. Archean assemblages were subdivided into lithodemic units, as shown in Figure 3 and listed in Table 1. The stratigraphic nomenclature we used corresponds, whenever possible, to that defined in adjacent areas in recent mapping campaigns (Gosselin and Simard, 2000; Gosselin *et al.*, 2001; Simard *et al.*, 2001). In this section, each unit will be described based on field observations and petrographic observations. They are presented in chronological order, from the oldest to the youngest. This order was defined based on isotopic ages (inferred or dated) and cross-cutting relationships between units. These ages were obtained from U-Pb zircon analyses conducted by *in situ* laser ablation, using a high-resolution inductively coupled plasma mass spectrometer (HR-ICP-MS). However, the Loups Marins granulitic Complex does not fit perfectly into this geochronological order, since it is composed of several

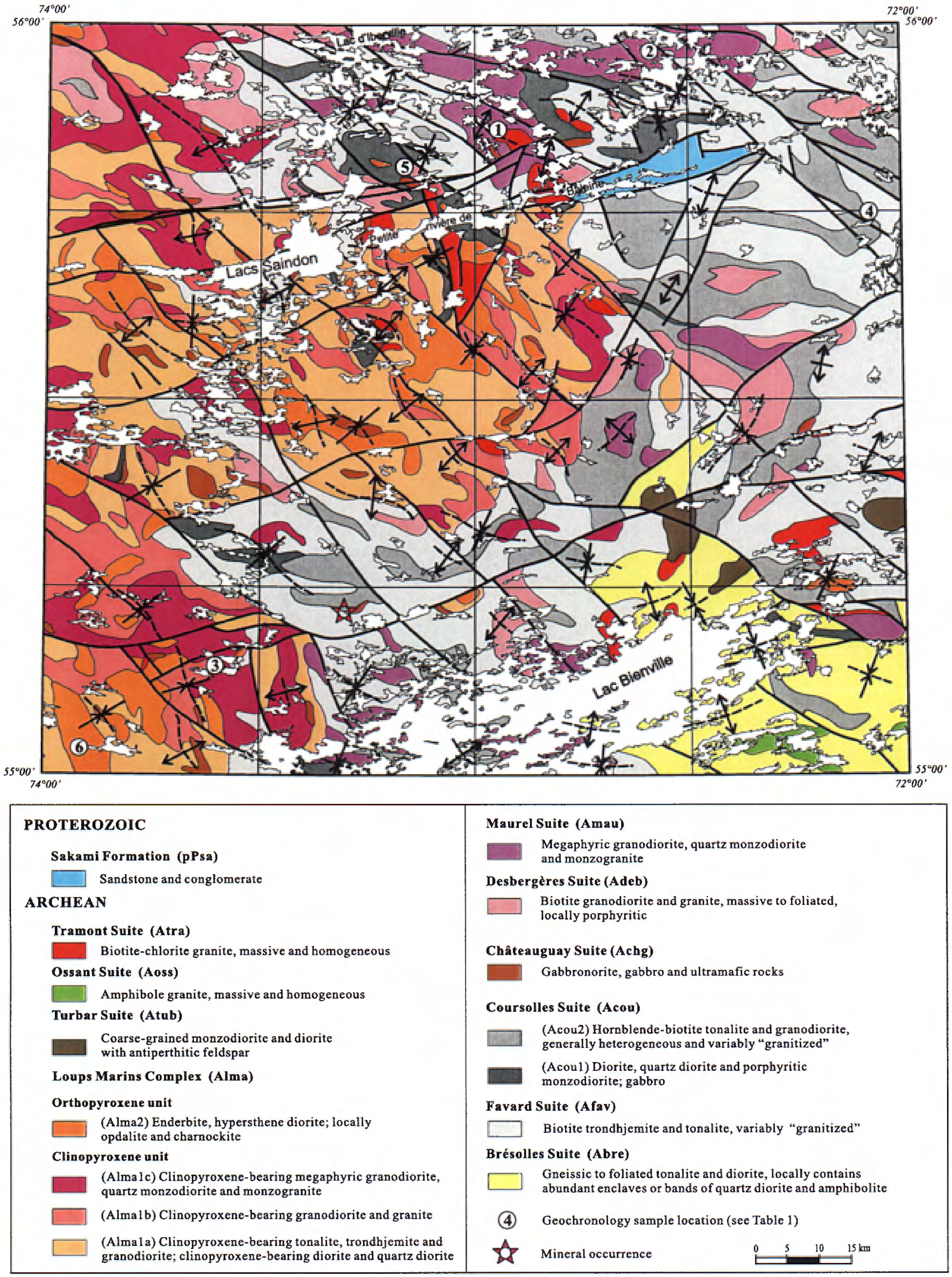


FIGURE 3 - Geology of the Lac Bienville area (33P).

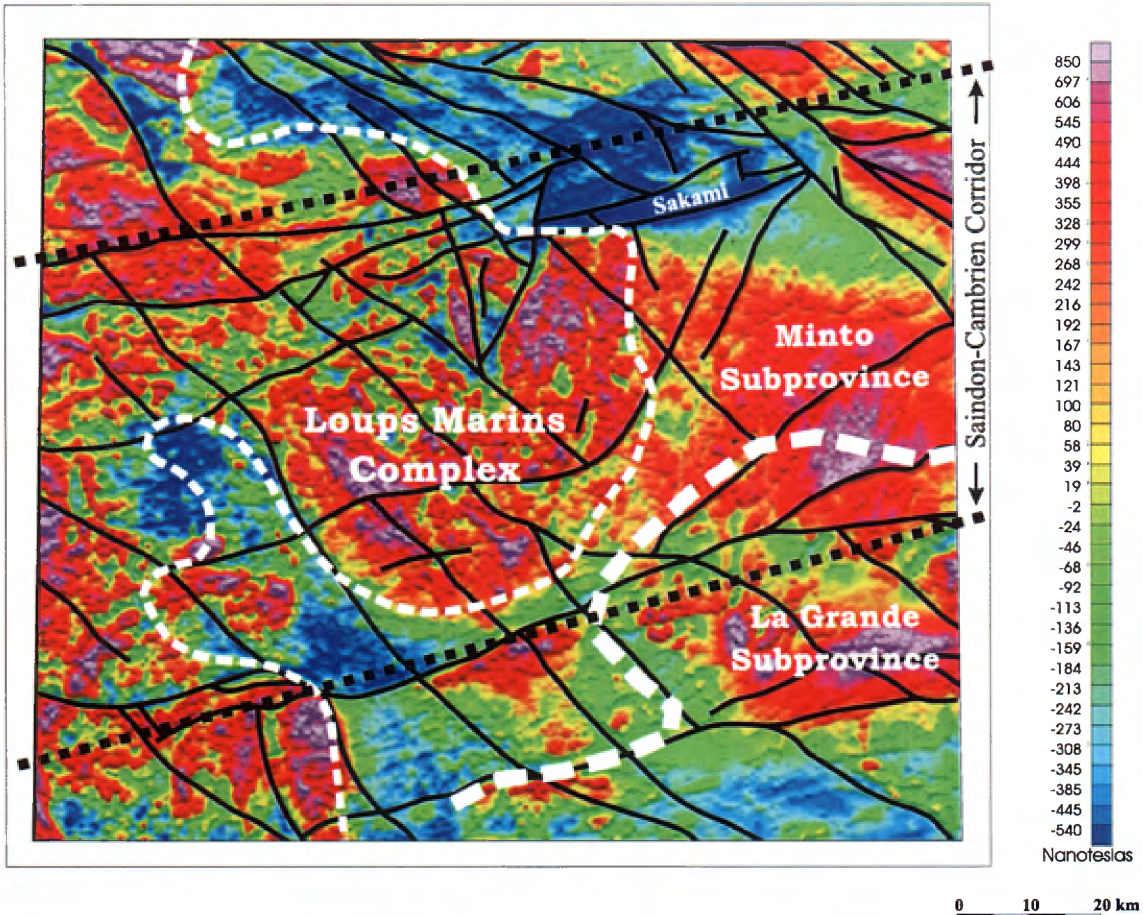


FIGURE 4 - Shaded total magnetic field map of the Lac Bienville area (33P) showing the location of: **1)** the area mainly underlain by the Loups Marins Complex, **2)** the boundary between the La Grande and Minto subprovinces, **3)** the inferred extent of the Proterozoic Saindon-Cambrien Corridor, and **4)** major faults. Prepared by D.J. Dion and data derived from DP 99-01 (Dion and Lefebvre, 1999).

pyroxene-bearing units equivalent to certain regional suites of various compositions and ages that do not contain pyroxene.

Archean

Brésolles Suite (Abre)

The Brésolles Suite (Abre) was introduced in the Gayot area (23M) to identifya unit of early gneissic tonalite associated with the La Grande Subprovince (Figure 2 and Table 1; Gosselin and Simard, 2000; Simard *et al.*, 2001; Gosselin *et al.*, 2001). On a regional scale, this suite also includes trondhjemites, diorites and granites intercalated with the gneisses, as well as amphibolite enclaves. Gneissic tonalites of the Brésolles Suite are typically composed of white tonalitic bands alternating with grey dioritic bands. Two isotopic ages obtained from dioritic bands in tonalitic gneisses (Abre) in the Gayot and Loups Marins areas were respectively of 2803 ±8 and 2811 ±4 Ma (Table 1). In the Maricourt area, an age determination conducted on a sample from an m-scale trondhjemite layer intercalated with gneisses yielded 2754 +11/-9 Ma (Table 1). These trondhjemitic layers (I1E) are therefore interpreted as late relative to Brésolles tonalitic gneisses, and considered equivalent to the Favard Suite (Afav), dated in the same map area at 2749 ±4 Ma (Table 1). In the Bienville area, trondhjemitic injections in rocks of the Brésolles Suite (Abre) are in fact more abundant near contacts with rocks of the Favard Suite (Afav).

The Brésolles Suite (Abre) was recognized in the southeastern quadrant of the Bienville area. It is essentially composed of tonalite, tonalitic gneiss and gneissic diorite occurring in shades of white and grey. It is distinguished from younger suites due to its well-developed gneissosity, which produces compositional banding. Individual bands are cm-scale to m-scale, but locally range from a few millimetres to several metres in thickness. They are generally straight and fairly regular, although complex folding is observed in many locations.

Tonalites, whether foliated or gneissic, have similar overall compositions. They have a medium-grained equigranular texture in weakly deformed rocks and a granoblastic texture in gneisses. These rocks are essentially composed of plagioclase (50-65%) and quartz (20-40%). K-feldspar is absent or occurs in minute amounts (< 3%). Plagioclase is hypidiomorphic to polygonal. Quartz is more abundant in leucocratic gneiss bands, and occurs as strings of elongate grains parallel to the foliation. The tonalites generally contain 5 to 20% ferromagnesian minerals. The ferromagnesian mineral content may reach 40% in dioritic bands. Green biotite is ubiquitous; it forms flakes that define the foliation. Hornblende is concentrated in diorite bands or in melanocratic tonalite. Chlorite occurs as an alteration product of biotite. Oxides, apatite, titanite, zircon and epidote are observed as accessory phases. In certain samples, epidote grains contain allanite cores.

Amphibolite enclaves are commonly observed within the tonalites. They are cm to m-scale, and represent less than 10% of outcrops. Locally, they can reach 10 m in size and constitute more than 50% of outcrops. These amphibolite enclaves may correspond to early volcanic units such as those observed in the Gayot area further east (Gosselin and Simard, 2000). In thin section, amphibolites are fine-grained and exhibit a granoblastic texture in gneissic samples. They are largely composed of hornblende (30-80%) and sericitized plagioclase (1-45%). Hornblende is locally poikilitic and contains cores of fine-grained disseminated relics of clinopyroxene ($\leq$10%) and biotite (< 8%). Epidote and apatite are the most commonly observed accessory minerals.

Favard Suite (Afav)

The Favard Suite (Afav) was defined in the Gayot area (23M), to the east, as a unit of biotite trondhjemite that also includes foliated diorite (Gosselin and Simard, 2000). In the Lac Bienville area (33P), the Favard Suite consists of "granitized" biotite trondhjemites and tonalites that correspond to sub-unit Afav1b, respectively defined as "granitized" and "migmatized" in the Loups Marins (34A) and Maricourt (23M) areas. Two ages obtained from trondhjemite (I1E) samples yielded 2.73 Ga in the Gayot area and 2749 ±4 Ma in the Maricourt area (Table 1).

The Favard Suite (Afav) is the most widespread unit in the Lac Bienville area (Figure 3). It comprises weakly foliated to massive, pale grey to white biotite trondhjemite and tonalite. These lithologies are affected by a "granitization" phenomenon that involves 10 to 60% of the volume of the rock. This phenomenon generally translates into the injection of granodioritic or granitic material within the tonalite. This material is injected as bands, lenses or pockets, from 1 mm to 10 cm thick, in irregular and diffuse contact with the tonalite. The "granitization" is observed both on a microscopic scale and on the scale of the outcrop. Two distinct zircon populations were recovered from a heterogeneous "granitized" trondhjemite sample (sample location number 4, Figure 3; Table 1). The first population yielded an age of 2713 ±2 Ma, interpreted as the age of crystallization of the granodioritic fraction. The second population, associated with the tonalitic fraction, yielded an age of 2741 ±4 Ma, which corresponds to the age of trondhjemites of the Favard Suite (Table 1). The granodioritic fraction associated with the "granitization" phenomenon is the same age as granodioritic intrusions (I1C) of the Desbergères Suite (Table 1). This granodioritic fraction is also compositionally similar to rocks of the Desbergères Suite. Furthermore, the proportion of granodioritic material found within trondhjemites and tonalites of the Favard Suite generally increases near the border of intrusions of the Desbergères Suite. It is therefore quite likely that the "granitization" process is related, at least in part, to the emplacement of the Desbergères Suite.

The Favard Suite contains enclaves of amphibolite and diorite varying from 1 cm to 10 m in size. These enclaves generally make up less than 5% of the total volume of the rock, but locally constitute up to 40% of outcrops. They frequently exhibit reaction rims of variable thickness, in diffuse contact with the tonalitic country rock. These rims are granodioritic in composition and contain coarse hornblende crystals. When enclaves are completely assimilated, only bands, lenses or pockets of granodioritic material with coarse-grained hornblende remain. The assimilation of enclaves therefore appears to have contributed, at least in part, to the "granitization" of the Favard Suite, and to its very heterogeneous and banded nature.

In thin section, trondhjemites and tonalites of the Favard Suite are largely composed of sericitized plagioclase. Quartz grains often exhibit undulatory extinction. Microcline, generally occurring in phenocrysts, is not abundant (< 5%). It may however reach 40% in bands or pockets of granitic material. Green biotite (2-12%) is the dominant ferromagnesian component. It is commonly altered to chlorite. Hornblende is scarce (< 2%), except in samples that show evidence of assimilation of mafic enclaves. Trondhjemites and tonalites contain minor amounts of apatite, epidote, magnetite, titanite and zircon.

Coursolles Suite (Acou)

The Coursolles Suite (Acou) was originally described in the Maricourt area (24D), to the northeast of our study area (Figure 2; Simard *et al.*, 2001), where it is composed of a unit of diorite (Acou1), a unit of hornblende tonalite (Acou2) and a sub-unit of granitized tonalite and granodiorite (Acou2a; Table 1 and Figure 2). In the Maricourt area, a U/Pb age determinations carried out on a tonalite sample of the Coursolles Suite (Acou2) yielded an age of 2718 +11/-8 Ma (Table 1). In the Loups Marins area (Figure 2), two samples of hornblende-biotite tonalite assigned to the Coursolles Suite (Acou) yielded ages of 2758 ±11 Ma and 2756 ±8 Ma, *i.e.* some 40 Ma older than the age obtained for unit Acou2 in the Maricourt area (Table 1; Gosselin *et al.*, 2001). The difference between these ages suggests the existence of two phases of magmatism within the Coursolles Suite, an early phase (E) and a late phase (L) relative to the Favard Suite (Table 1).

In the Lac Bienville area (33P), the Coursolles Suite is divided into two units, similar to those defined in the

Maricourt area (24D). The first unit (Acou1) is mainly composed of diorite (I2J) and quartz diorite (I2I). It was dated at 2719 ±2 Ma (sample location number 5, Figure 3; Table 1), an age comparable to that obtained for unit Acou2 in Maricourt (Table 1). The second unit (Acou2) is more widespread than the first, and consists of hornblende-biotite tonalite and granodiorite. These rocks are variably affected by a "granitization" phenomenon similar to that observed and previously described for the Favard Suite (Afav). The two units of the Coursolles Suite contain cm to m-scale enclaves composed of foliated fine-grained amphibolite. These enclaves represent less than 5% of outcrops, but this proportion may reach 35% in certain locations. Late granitic dykes from 1 to 10 cm thick locally intrude rocks of the Coursolles Suite.

Diorite and Quartz Diorite Unit (Acou1)

Unit Acou1 forms lenses several kilometres in length by a few kilometres in width. It is mostly exposed in the north-central part of the map area (Figure 3). It mainly consists of diorite and quartz diorite, but also includes gabbro and monzodiorite, which are locally porphyritic. Injections of tonalitic and granodioritic material, most likely associated with the Coursolles (Acou2) and Maurel (Amau) suites locally cut the diorite and quartz diorite (Acou1).

Coursolles diorites and quartz diorites (Acou1) are medium to light grey and commonly greenish. They are massive to strongly foliated, and medium to coarse-grained. These rocks are essentially composed of plagioclase, but may locally contain K-feldspar phenocrysts (< 7%). They contain 15 to 45% mafic minerals, most commonly green hornblende phenocrysts (1-35%) and greenish biotite (0-10%), which defines the foliation. Clinopyroxene (0-8%), where observed, occurs as partially resorbed cores in hornblende grains. The magnetite content ranges from < 1 to 7%. Primary epidote occurs in minor amounts (< 5%), in aggregates of ferromagnesian minerals. Apatite, titanite and zircon are present in trace amounts.

"Granitized" Hornblende Tonalite and Granodiorite Unit (Acou2)

Unit Acou2 forms a string of lens-shaped bodies several kilometres in length and variably folded, extending from the northeastern part to the south-central part of the map area (Figure 3). It is composed of hornblende-biotite tonalite and granodiorite, with a minor proportion of quartz diorite. These rocks are affected by a "granitization" phenomenon that may represent up to 60% of the volume of the rock. This phenomenon is the same as that observed in rocks of the Favard Suite (Afav). It mainly translates into the emplacement of pockets and lenses of granodioritic to granitic material that generally contain 2 to 20% K-feldspar phenocrysts. Note that the most porphyritic injections are compositionally very similar to megaphyric granodiorites of the Maurel Suite (Amau).

Coursolles tonalites and granodiorites are somewhat pinkish and light grey. They are medium-grained and exhibit a foliated to massive fabric. In thin section, they are composed of 20 to 30% quartz and up to 25% K-feldspar occurring as phenocrysts from 0.5 to 1.0 cm. These rocks contain 10 to 16% ferromagnesian minerals, essentially hornblende (3-11%) and green biotite (0-7%). Hornblende occurs as automorphic phenocrysts, whereas biotite forms flakes that define the foliation. Chlorite occurs in trace amounts, but may reach up to 7% where it forms an alteration product of biotite. Xenomorphic magnetite (≤ 1%) is concentrated in mafic mineral aggregates. Epidote, allanite, titanite, apatite and zircon were observed in minor amounts (< 1%).

Châteauguay SuiteAchg)

The Châteauguay Suite (Achg) was introduced in the Maricourt area (24D) to designate mafic to ultramafic intrusions of a few hundred metres in diameter. In the Lacs des Loups Marins area (34A), diorites and quartz diorites were also included in this unit. Field observations made in the Bienville area (33P) suggest that these dioritic rocks are representative of the Coursolles Suite (Acou) and were thus assigned to the latter (Figure 2 and Table 1). In our map area, intrusions of the Châteauguay Suite (Achg) generally occur within the Loups Marins Complex (Alma) or along its borders, and along major lineaments (Figure 3). They are mainly composed of mesocratic to melanocratic gabbronorite but also include gabbro, pyroxenite and hornblendite. The intrusions are tabular or form dykes from 10 cm to a few hundred metres wide that may reach several kilometres in length. Certain intrusions are layered and include quartz gabbronorite, gabbronorite and pyroxenite facies. Note that the distinction between rocks of the Châteauguay Suite (Achg) and the more mafic phases associated with orthopyroxene diorites of the Loups Marins Complex (Alma2) is sometimes difficult to establish, both in the field and under the microscope. Given the spatial association often observed between rocks of the Châteauguay Suite and those of unit Alma2 of the Loups Marins Complex, it is possible that the two may be, at least in part, contemporaneous and genetically related (Table 1).

Gabbronorites constitute the dominant lithology of the Châteauguay Suite in our study area. These rocks are grey to dark green or brownish black. They are generally massive or weakly foliated, and range from coarse to fine-grained. Coarse-grained rocks are characterized by hornblende poikiloblasts, whereas fine-grained rocks are granoblastic. These gabbronorites contain enclaves of fine-grained foliated amphibolite and diorite, frequently rimmed by coarse-grained intermediate material. Granitic, pegmatitic and charnockitic material is commonly injected in the gabbronorites, giving them a typical agmatitic texture.

In thin section, gabbronorites are essentially composed of plagioclase (20-60%), green hornblende (4-65%), clinopyroxene (2-30%), orthopyroxene (4-30%) and biotite (1-25%). Plagioclase locally occurs as phenocrysts up to 1 cm in size. Hornblende forms oikocrysts from 1 to 4 cm, or coronas around pyroxene grains. The latter is either granoblastic or is rimmed by retrograde hornblende. Biotite (1-25%) is concentrated around hornblende-pyroxene aggregates. Magnetite, ilmenite and pyrite are the dominant opaque minerals (≤ 5%) associated with gabbronorites. Epidote (≤ 5%) and apatite are disseminated in the vicinity of ferromagnesian minerals.

Desbergères Suite (Adeb)

The Desbergères Suite (Adeb) was defined in the Maricourt area (24D), northeast of the Lac Bienville area (Figure 2). It comprises homogeneous biotite granodiorites and granites (Simard *et al.*, 2001). Similar to the Coursolles (Acou) and Maurel (Amau) suites, U-Pb analyses conducted on samples of the Desbergères Suite (Adeb) yielded two different ages. A granodiorite sample collected in the Maricourt area yielded an age of 2683 +4/-2 Ma, whereas a similar sample from the Loups Marins area yielded an age of 2714 ±12 Ma (Table 1). In the Lac Bienville area, an age was obtained from a sample of "granitized" trondhjemite of the Favard Suite (Afav) that contains a granodioritic fraction comparable to rocks of the Desbergères Suite. This analysis yielded an age of 2713 ±2 Ma, which supports our interpretation that the granitization phenomenon observed in the Favard Suite (Afav) is related to the same magmatic event that produced the Desbergères Suite (Adeb).

In our map area, the Desbergères Suite (Adeb) occurs in elongate intrusions several kilometres in size, somewhat folded or curved along the foliation direction. It is essentially composed of medium or fine-grained, massive to foliated granodiorite and granite. These rocks range from pink to light grey depending on the colour of the feldspar component. The latter sometimes occurs as 1 to 2-cm phenocrysts that generally represent less than 5% of the rock, but locally reach up to 25%. Cm to m-scale amphibolite enclaves are frequently enclosed in rocks of the Desbergères Suite (Adeb), but represent less than 5% of the rock. Foliated to gneissic tonalite enclaves were also observed locally.

In thin section, microcline and perthite are the dominant varieties of K-feldspar. The quartz content ranges from 20 to 40%. It shows sub-grains, undulatory extinction and is associated with plagioclase in myrmekitic textures. Green biotite is the dominant ferromagnesian mineral (0-5%). It is often altered to chlorite. Green hornblende (0-3%) was observed in a few samples. Xenomorphic magnetite grains are often clustered around other ferromagnesian minerals. Epidote, apatite, white mica, titanite and zircon occur in trace amounts.

Maurel Suite (Amau)

The Maurel Suite (Amau) was originally described in the Gayot area (23M) to designate a megaphyric granodiorite unit (Figure 2; Gosselin and Simard, 2000). It was also recognized in the Maricourt (24D) and Loups Marins (34A) areas (Simard *et al.*, 2001; Gosselin *et al.*, 2001). U-Pb analyses carried out on samples collected in the Gayot (23M) and Maricourt (24D) areas yielded respective ages of 2683 ±4 Ma and 2.685 Ga (Table 1). In the Lac Bienville area (33P), a megaphyric granodiorite (11C, PO) of the Maurel Suite (Amau) yielded an age of 2707 ±5 Ma (sample location number 2, Figure 3; Table 1). This age is older than those obtained in the Lac Gayot and Lac Maricourt areas, suggesting the existence of two episodes of emplacement (early and late) for rocks of the Maurel Suite (Amau). However, granodioritic bodies associated with these episodes cannot be distinguished from one another megascopically, petrographically or geochemically.

In the Lac Bienville area (33P), the Maurel Suite (Amau) forms extensive bodies, particularly abundant in the north-central part of the map area (Figure 3). It also forms m-scale injections and smaller intrusions intimately associated with intrusions of unit Acou2 of the Coursolles Suite. The Maurel Suite (Amau) is mainly composed of megaphyric hornblende-biotite granodiorite, but it also includes quartz monzodioritic and monzogranitic facies. It is distinguished from other granodioritic units thanks to the omnipresence of K-feldspar phenocrysts from 1 to 5 cm in size, which constitute 10 to 40% of the rock. Granodiorites of the Maurel Suite also contain less than 5% but locally up to 40% fine-grained amphibolite enclaves from 1 cm to less than 1 m in size. Late granitic injections locally cut rocks of the Maurel Suite; these decimetre-scale injections form up to 20% of the rock.

The megaphyric granodiorite is light grey with a variable pinkish to orange tinge. It is medium to coarse-grained, with a massive to weakly foliated fabric. In thin section, plagioclase forms the groundmass between microcline and perthite phenocrysts. Irregular quartz grains (20-30%) are interstitial to feldspar grains, and commonly exhibit undulatory extinction. Observed mafic minerals include automorphic green hornblende (1-10%) and greenish biotite (0-7%), frequently altered to chlorite. Magnetite (1-2%) is disseminated in ferromagnesian mineral aggregates. Titanite (≤ 2%) occurs as diamond-shaped crystals of variable dimensions. Allanite, apatite, epidote and zircon are accessory phases.

Loups Marins Complex(Alma)

The Loups Marins Complex (Alma) was defined in the Lacs des Loups Marins area (34A), to designate an assemblage of clinopyroxene-bearing rocks and orthopyroxene-bearing intrusive rocks (Figure 2; Gosselin *et al.*, 2001). This complex extends into our map area, where it covers one third of the landmass in the central and western parts of the map area (figures 2 and 3). On maps showing the shaded total magnetic field, the Loups Marins Complex (Alma) is characterized by a very sharp signature composed of magnetic highs and lows, which give it a distinctive patchy appearance (Figure 4). The Loups Marins Complex (Alma) was subdivided into two units: unit *Alma1* is composed of various lithological assemblages characterized by the presence of clinopyroxene, and unit *Alma2* is essentially composed of orthopyroxene-bearing granulitic and intrusive rocks, essentially enderbitic to dioritic in composition.

The clinopyroxene unit (Alma1) is generally comparable to certain regional lithodemic units, but it was formed or metamorphosed at higher pressure and temperature conditions, at the boundary between the amphibolite and the granulite facies. Two ages were obtained from rocks in this unit. In the Bienville area (33P), a granite assigned to sub-unit Alma1b (see below) and considered equivalent to the Desbergères Suite (Adeb) yielded an age of 2709 ±2 Ma (sample location number 3, Figure 3; Table 1). In the Loups Marins area (34A), a porphyritic granodiorite of the Lussay Suite (Alus), similar to sub-unit Alma1c and equivalent to the Maurel Suite (Amau), yielded an age of 2713 ±5 Ma (Table 1; Gosselin *et al.*, 2001). The orthopyroxene unit (Alma2) was also dated in two locations. In the Loups Marins area (34A) (Gosselin *et al.*, 2001), a hypersthene diorite (I2Q) yielded an age of 2694 ±3 Ma, whereas in the Lac Bienville area (33P), another hypersthene diorite (I2Q) yielded an age of 2720 ±2 Ma (sample location number 6, Figure 3; Table 1).

Clinopyroxene Unit (Alma1)

The clinopyroxene unit (Alma1) forms a complex lithological assemblage subdivided into three sub-units that exhibit a number of common characteristics. In addition to the presence of clinopyroxene, this unit contains reddish biotite and plagioclase ranging from salmon pink to light green. Red biotite is easily recognized thanks to its reddish tones in strong lighting. Salmon pink plagioclase is also a diagnostic feature of this unit; its proportion varies from less than 1% to more than 30%. However, when the plagioclase takes on a greenish tinge, the unit (Alma1) is difficult to distinguish from the orthopyroxene unit (Alma2). Enclaves of diorite and amphibolite, from 10 cm to 1 m in size, were observed in this unit, as in all other units in the area. These enclaves may however contain red biotite and clinopyroxene (Gosselin *et al.*, 2001).

Sub-units Alma1a, Alma1b and Alma1c are considered equivalent to one or several regional lithodemic suites (Table 1), but were formed or metamorphosed at pressure and temperature conditions that correspond to the upper amphibolite facies or the lower granulite facies. Sub-unit Alma1a is composed of clinopyroxene-bearing tonalite and diorite, considered equivalent to the Favard (Afav) and Coursolles (Acou) suites. Sub-unit Alma1b consists of clinopyroxene-bearing granodiorite corresponding to the Desbergères Suite (Adeb), and sub-unit Alma1c is characterized by megaphyric granodiorite equivalent to the Maurel Suite (Amau).

Tonalite Sub-Unit (Alma1a)

The clinopyroxene-bearing tonalite sub-unit (Alma1a) is the most widespread in the Loups Marins Complex (Figure 3). It is mainly composed of clinopyroxene-bearing tonalite, trondhjemite, granodiorite, diorite and quartz diorite. It is considered to be equivalent to the Favard (Afav) and Coursolles (Acou) suites (Table 1). These rocks are medium-grained and display an igneous or granoblastic texture, with less than 10% feldspar phenocrysts locally. The colour of Alma1a rocks is highly variable, ranging from beige grey to greenish grey to medium green. Mm to cm-scale salmon pink plagioclase crystals are characteristic of the unit.

In thin section, the tonalites and diorites show a xenomorphic to granoblastic texture. They contain up to 30% quartz, often occurring in myrmekitic intergrowths with plagioclase. The dominant mafic minerals are reddish biotite (2-8%), clinopyroxene (≤ 5%) and green hornblende (≤ 5%). They are clustered in cm-scale aggregates with magnetite (≤ 3%). Apatite, zircon and titanite are the most common accessory minerals.

Granodiorite Sub-Unit (Alma1b)

The Alma1b sub-unit is composed of clinopyroxene-bearing granodiorite and granite. These rocks are considered as equivalents to the Desbergères Suite (Adeb) (Table 1). A U-Pb analysis conducted on a granite sample of sub-unit Alma1b yielded an age of 2709 ±2 Ma (sample location number 3; Table 1). Granodiorites and granites of sub-unit Alma1b are brownish to greenish grey or pink. Plagioclase is green or salmon pink, whereas K-feldspar takes on an orange-pink to brownish colour. Biotite shows a reddish tinge. These rocks are medium to fine-grained and locally porphyritic. They exhibit a massive fabric or a weak foliation defined by biotite. In the southwestern part of the area, rocks of sub-unit Alma1b commonly form bands or lenses injected within the orthopyroxene unit (Alma2), which is dated at 2720 ±3 Ma in this area.

In thin section, the granodiorite and granite exhibit an igneous or granoblastic texture. They are composed of 5 to 60% microcline and perthite, locally occurring as phenocrysts, and up to 40% quartz. Mafic minerals are represented by red biotite (1-7%) and clinopyroxene (≤ 4%). Green hornblende (0-3%) and chlorite (0-5%) were also observed in a few samples. Xenomorphic magnetite represents less than 3% of the rock. Minor amounts of disseminated apatite and zircon are also observed.

Megaphyric Granodiorite Sub-Unit (Alma1c)

The clinopyroxene-bearing megaphyric granodiorite sub-unit (Alma1c) of the Loups Marins Complex is equivalent to the Lussay Suite (Alus) defined in the Loups Marins area (Table 1; Gosselin *et al.*, 2001). Furthermore, sub-unit Alma1c and the Lussay Suite (Alus) are now considered as equivalent to the Maurel Suite (Amau). They consist of rocks that were formed or metamorphosed at higher pressure and temperature conditions, in which clinopyroxene may crystallize. We have therefore included sub-unit Alma1c within the Loups Marins Complex, for the same reasons as sub-units Alma1a and Alma1b. Note that in the Loups Marins area (34A), a U-Pb zircon age of 2713±5 Ma (Table 1) was obtained from a granodiorite sample of the Lussay Suite (Alus; equivalent to sub-unit Alma1c).

The Alma1c sub-unit is mainly composed of clinopyroxene-bearing megaphyric granodiorite, but it also includes quartz monzodiorite and monzogranite. The granodiorite is pinkish or orange grey to greenish brown. Its dominant fraction is medium or coarse-grained; it also contains 5 to 30% K-feldspar phenocrysts from 1 to 5 cm long. The unit is characterized by a strong magnetic susceptibility that clearly stands out on regional aeromagnetic surveys (Figure 4).

In thin section, granodiorites of sub-unit Alma1c contain 10 to 80% K-feldspar, essentially microcline. Quartz, ranging from 3 to 35%, forms mosaics interstitial to coarser feldspar grains. The granodiorite contains 5 to 20% mafic minerals, namely red biotite (3-12%), green hornblende (0-6%) and clinopyroxene (0-5%). Magnetite grains represent up to 4% of the volume of the rock, and are clustered with the mafic minerals. Xenomorphic titanite crystals are occasionally observed in significant amounts (≤ 3%). Apatite, epidote and zircon are the most common accessory minerals.

Orthopyroxene Unit (Alma2)

The orthopyroxene unit (Alma2) was defined in the Loups Marins area (34A). In the Bienville area, it forms intrusive bodies a few tens of kilometres long with a variably folded aspect (Figure 3). The orthopyroxene unit (Alma2) is mainly composed of hypersthene diorite (quartz-bearing or not) and enderbite. Minor amounts of charnockite, opdalite, jotunite and gabbronorite are also encountered. An orthopyroxene diorite sample was dated at 2720 ±2 Ma (sample location number 6, Figure 3; Table 1). Note that in the Loups Marins area (34A), a hypersthene diorite (or quartz norite) yielded an age of 2694 ±3 Ma.

Felsic orthopyroxene-bearing intrusions of unit Alma2 have a typical "bottle green" colour, whereas intermediate lithologies are generally darker. On weathered surfaces, these rocks take on a honey brown colour. Under extreme weathering conditions, they break down into granules. Orthopyroxene-bearing rocks are medium to fine-grained and massive to foliated. Potassic facies often contain up to 25% orange to brownish microcline phenocrysts. Unit Alma2 is commonly cut by cm to m-scale injections of clinopyroxene-bearing granodiorite of sub-unit Alma1b. Fine-grained dioritic to pyroxenitic enclaves are widely scattered throughout the unit. They are 1 to 10 cm in size and generally represent 1 to 10% of the volume of outcrops, but may locally reach up to 50%.

In thin section, enderbites and orthopyroxene diorites are generally granoblastic, although preserved igneous textures and automorphic pyroxene grains are observed in certain samples. The quartz content varies from one sample to the next; certain diorites are quartz-free whereas enderbites may contain up to 45% quartz. The most K-rich rocks contain no more than 35% K-feldspar. The ferromagnesian mineral content ranges from 3% in charnockites and enderbites to about 30% in diorites. These minerals consist mainly of brown to red biotite (≤ 15%), orthopyroxene (≤ 10%), clinopyroxene (≤ 10%) and green hornblende (0-5%). Magnetite may represent up to 5% of the rock. Apatite and zircon are ubiquitous, but in minor amounts.

Turbar Suite (New unit, Atub)

The Turbar Suite (Atub) is a monzodioritic unit encountered in the southeastern quadrant of the map area, near the northernmost extent of the Brésolles Suite (Figure 3). It comprises three stocks, each covering several square kilometres. The Turbar Suite (Atub) was not dated. Its homogeneity, massive to weakly foliated fabric and coarse antiperthitic texture however suggest that these rocks are relatively young relative to other suites in the area (Table 1).

The Turbar Suite (Atub) is composed of monzodiorite, diorite and monzonite. The rock typically shows a glossy polished surface, such that its colour is highly variable; the most commonly encountered colours are bluish grey, beige and pink. The suite is also characterized by its coarse grain size or its porphyritic texture, with antiperthitic feldspars that are outlined by feldspar staining. It is massive or exhibits a weak foliation defined by tabular minerals, essentially feldspars and amphiboles.

In thin section, the monzodiorite and diorite are essentially composed of feldspar grains with fine antiperthitic to perthitic exsolution textures. These textures indicate crystallization at high temperatures. Rocks of the Turbar Suite (Atub) also include a fine-grained K-feldspar component and very little to no quartz. Mafic minerals (5-35%) form compact aggregates, interstitial to coarse feldspar grains. The most common ferromagnesian minerals are hornblende and biotite, whereas clinopyroxene and orthopyroxene are present in minor amounts. Hornblende forms the core of ferromagnesian mineral aggregates, and biotite occurs as inclusions or rims around other mafic minerals. Magnetite, ilmenite, titanite, apatite and sulphides are also associated with these aggregates.

Ossant Suite (New unit, Aoss)

The Ossant Suite (Aoss) represents a fairly restricted unit of amphibole granite, concentrated in the southeastern part of the area. It consists of granitic intrusions several kilometres in size, emplaced and confined within the Brésolles gneissic Suite (Abre, Figure 3). The Ossant Suite was not dated. Ossant granites (Aoss) are characterized by a patchy pink and grey colour. The rock is homogeneous, massive to very weakly foliated and exhibits a porphyritic texture. This granite is mainly composed of perthitic feldspar phenocrysts embedded in a quartz-plagioclase groundmass. It contains 5 to 10% mafic minerals, essentially sodic amphibole aggregates (5-8%). Biotite and chlorite occur along the edges or in replacement of amphiboles. Epidote, allanite, apatite, titanite and iron oxides are associated with the mafic mineral aggregates.

Tramont Suite(Atra)

The Tramont granitic Suite (Atra) was defined in the Gayot area (23M), to the east of our study area (Figure 2; Gosselin and Simard, 2000). Later on, it was recognized in the Maricourt (24D), Loups Marins (34A) (Figure 2) and Hurault (23L) (Thériault and Chevé, 2001) areas, south of Gayot. The Tramont (Atra) granitic Suite was dated in our map area at 2701±4 Ma (sample location number 1, Figure 3; Table 1) and represents the youngest Archean unit in our study area.

The Tramont Suite (Atra) outcrops in the central, southeastern and southwestern parts of the area (Figure 3). This suite is composed of oval intrusions of leucocratic granite reaching a length of more than 10 km and a width of 5 km. It also includes granitic dykes and injections, from 10 cm to 10 m in size, that intrude all other Archean units. Pegmatite dykes are abundant and probably represent a late phase of this suite. The granite occasionally hosts cm to m-scale enclaves of foliated amphibolite or of country rock lithologies. The proportion of enclaves increases near the borders of intrusions.

The Tramont granite is light pink to white. It is homogeneous, and massive to weakly foliated. In deformation zones, where it is frequently encountered, the granite develops a mylonitic fabric typical of striped gneisses. The rock is medium to coarse-grained in large intrusive bodies, but generally fine-grained in dykes, injections and smaller plutons.

In thin section, the Tramont (Atra) granite is essentially composed of K-feldspar, with a minor amount of quartz and plagioclase in equal proportions. The K-feldspar phase, most commonly microcline, forms phenocrysts which constitute up to 5% of the rock. Quartz is often made up of sub-grains and exhibits undulatory extinction. Plagioclase is sericitized and displays myrmekitic textures. The granite contains less than 5% mafic minerals, essentially chlorite and chloritized biotite. Muscovite is present in minor amounts. Trace amounts of apatite and epidote occur near mafic minerals. Allanite, titanite and zircon are occasionally observed in these rocks.

Paleoproterozoic

Sakami Formation (pPsa)

The Sakami Formation was defined by Eade (1966) to designate a sequence of Proterozoic sedimentary rocks occurring in isolated outliers, unconformably deposited on the Archean basement. Based on cutting relationships observed between rocks of this formation and various gabbro dyke swarms, the age of the Sakami Formation is bracketed between 2500 and 2216 Ma (Goutier *et al.*, 2001). An outlier of the Sakami Formation lies in the northeastern part of the map area (Figure 3). Eade (1966) named it the "*Little Whale River Outlier*", although the term "Mildred outlier" is also used in certain publications (Holmstead *et al.*, 1981; Moorhead *et al.*, 1999).

In our area, the Sakami Formation (pPsa) is represented by an outlier of rocks up to 7 km wide that extends for about 30 km along an ENE-WSW-trending axis (Figure 3). The southern limit of the Sakami Formation corresponds to an escarpment of Archean granitoids that coincides with a discontinuity on the aeromagnetic survey (Figure 4). This southern boundary is interpreted as an important fault, oriented ENE-WSW, associated with the Proterozoic Saindon-Cambrien collapse structure (figures 2 and 4). The northern extent of the Sakami Formation was also interpreted based on the aeromagnetic survey as an ENE-WSW fault, whereas the eastern and western contacts are interpreted as NW-SE-trending faults. The sedimentary rocks within the outlier form an ENE-striking homoclinal sequence with southerly dips of less than 40°.

The internal stratigraphy of the "Sakami outlier" was not studied in detail during our field campaign. However, Eade (1966) provides a thorough description of the sequence encountered in our map area. Eade (1966) divided the formation into two distinct units separated by an unconformity, namely a lower sequence of red beds, including conglomerates, arkosic sandstones and mudstones, and an upper sequence composed of orange-coloured quartzose sandstone. In greater detail, Eade (1966) indicated that the base of the lower sequence consists of a polygenic conglomerate about 30 m thick, separated from the Archean basement by a regolith zone. The conglomerate is composed of a variety of granitoid pebbles, probably derived from the Archean basement, supported by a sandy feldspar and quartz matrix that is strongly hematitized, which gives it a red colour. It is overlain by conglomeratic and arkosic sandstones interbedded with shales over a thickness of 150 m, followed by 100 m of sandy mudstone then 150 m of conglomerate with quartz and pink granite clasts. Eade (1966) interpreted the lower sequence deposits as representative of a continental basin setting, probably fairly restricted in size. The upper sequence, roughly 600 m thick, exclusively consists of orange-coloured quartzose sandstone. It is essentially composed of well-rounded quartz grains cemented by a clayey matrix. The sandstone is bedded, and locally exhibits 2 to 10 mm-thick laminations. It is locally cut by white quartz veins. Eade (1966) associated the quartzose sandstone with an epicontinental depositional environment, whereas Holmstead and Orr (1981) suggested an eolian origin.

Diabase Dykes

Diabase dykes are not abundant and are generally concentrated in the northern half of the map area. They range from a few cm to 25 m in thickness, and therefore cannot be represented on the map at the 1:250,000 scale.

These dykes show different orientations depending on their geographic location. In the northern part of the map area, they are divided into two swarms, a NNW-SSE-trending swarm and an E-W to ENE-WSW-trending set. In the southeastern part of the map area, the dykes are oriented NW-SE to WNW-ESE.

The diabase is dark greenish to reddish grey with a brown to orange weathered surface. It forms homogeneous bodies. It is very fine to medium-grained and exhibits an ophitic to sub-ophitic texture. The diabase is essentially composed of plagioclase, clinopyroxene and magnetite with traces of pyrite. It is generally massive, but may also show evidence of brittle-ductile deformation, in the form of a schistosity defined by the appearance of chlorite. Conjugate shear zones with associated hematitization obliterate primary textures.

LITHOGEOCHEMISTRY

A total of 117 rock samples representing lithologies typical of the main lithostratigraphic units in the map area were analyzed for major and trace elements. Whole rock analyses were carried out at the Consortium de Recherche minérale (COREM). Major elements and certain trace elements (Ga, Nb, Rb, Sr, Ta, Y and Zr) were analyzed by X-ray fluorescence (XRF) and elements Ag, As, Au, Ba, Br, Co, Cr, Cs, Ir, Mo, Ni, Sb, Sc, Th, Se, U and W were analyzed by neutron activation (INAA). The results are available in the SIGÉOM database, and are partially presented on diagrams in figures 5, 6 and 7.

Most suites identified in the area consist of intermediate to felsic rocks (Figure 5). Felsic rocks have a normative composition ranging from tonalitic to granitic, and intermediate rocks, from dioritic to monzodioritic (Figure 5a and b). Felsic lithologies are peraluminous to metaluminous, and intermediate lithologies are metaluminous (Figure 5c). Felsic and intermediate rocks are calc-alkaline, whereas mafic intrusions of the Châteauguay Suite (Achg) show a tholeiitic affinity (Figure 6a, b and c). On the discrimination diagram by Bachelor and Bowden (Figure 6d), analytical results indicate that rocks in the area formed in geotectonic settings ranging from pre-collisional to late orogenic. Finally, binary diagrams showing major element oxides Al_2O_3, CaO, MgO, TiO_2 and Fe_2O_3 versus SiO_2 yield, for intermediate to felsic rocks, negatively-sloped correlations (Figure 7a, b, c, d and e), whereas the K_2O content increases along with the SiO_2 content (Figure 7f). The main geochemical characteristics of each unit will be briefly discussed, with the exception of the Turbar monzodioritic Suite, which was not analyzed.

Brésolles Suite

The Brésolles Suite (Abre) is composed of cm-scale alternating tonalitic and dioritic bands. On normative diagrams by Le Maître (1989) and O'Connor (1965), analyzed samples plot in the field of tonalites (Figure 5a and b). Their major and trace element compositions are similar to tonalitic rocks of the Favard Suite and the Loups Marins Complex (figures 6 and 7). These rocks are low in potassium (< 1.2% K_2O) and their SiO_2 content ranges from 64 to 71% (Figure 7). On the diagram by Bachelor and Bowden (Figure 6d), they plot in the field corresponding to a pre-collisional tectonic setting.

Mafic enclaves and m-scale horizons enclosed in rocks of the Brésolles Suite were also analyzed (figures 6 and 7). These rocks show a tholeiitic to transitional magmatic affinity (Figure 6b), and a silica content between 47 and 51% (Figure 7). Although the intrusive or effusive origin of these mafic rocks could not be determined, their chemical composition is similar to that of volcanic rocks in the Gayot Complex, encountered to the east of our map area (Gosselin and Simard, 2000).

Favard Suite

In the Lac Bienville area, the Favard Suite (Afav) is composed of two distinct, albeit intimately associated, lithological fractions, as described above. Samples of the tonalitic fraction plot in the field of tonalites on normative diagrams (Figure 5a and b), and sometimes in the field of trondhjemites (Figure 5b). The granodioritic fraction, associated with late injections in the tonalites, was also analyzed. On the normative diagram by O'Connor (Figure 5b), these samples form a tight cluster near the granodiorite-trondhjemite-granite triple junction. These granodiorites are megascopically identical to biotite granodiorites of the Desbergères Suite (Adeb) and are in fact considered equivalent to the latter. They are not as potassic since their overall K_2O content ranges from 2.9 to 3.8% rather than from 4 to 5% (Figure 7f). Furthermore, granodiorites of the Favard Suite exhibit, on most diagrams, a composition midway between Favard tonalites and Desbergères granodiorites (figures 5 and 6d), possibly due to the assimilation

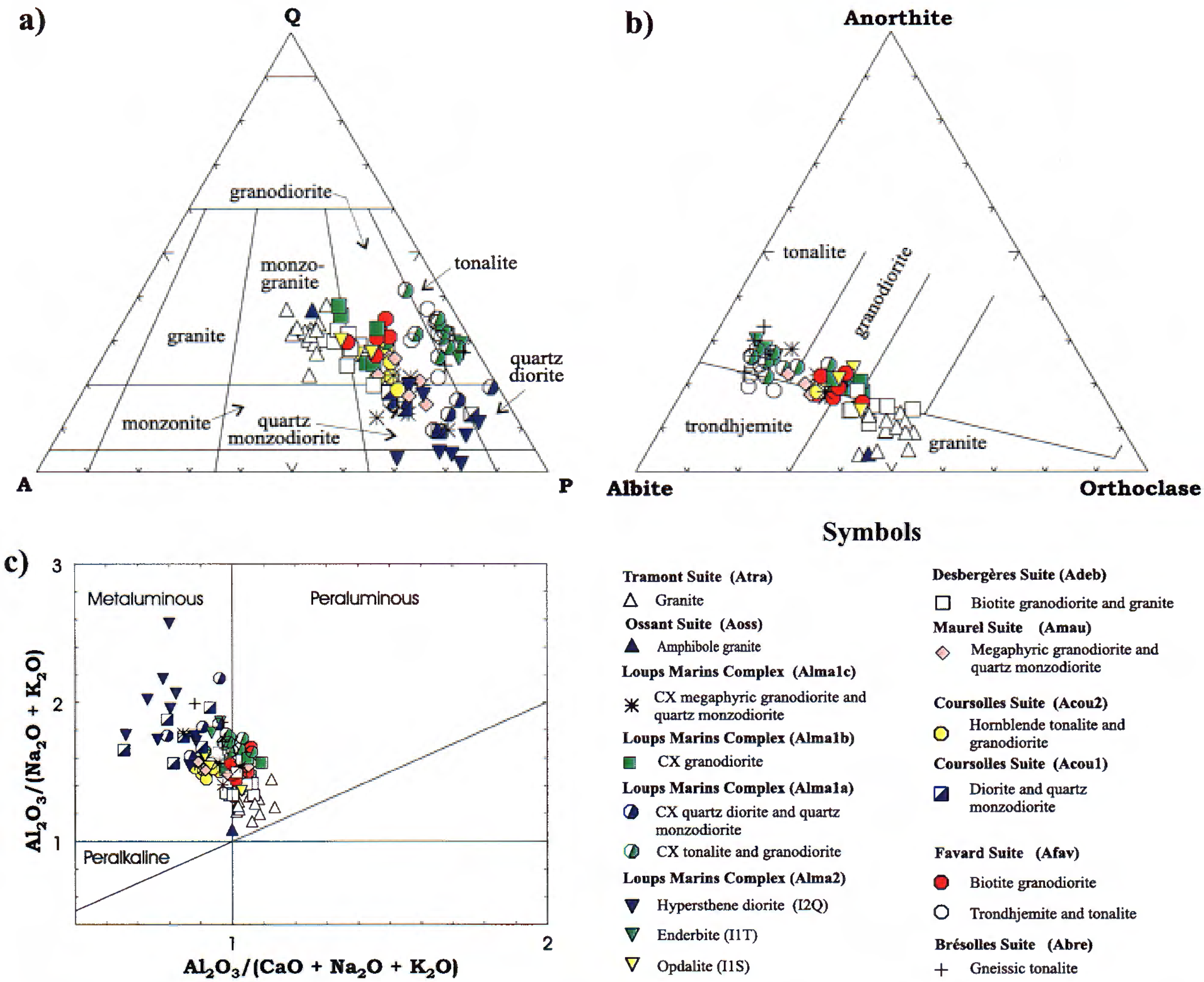


FIGURE 5 - Main felsic to intermediate intrusive suites in the Lac Bienville area (33P) in diagrams: **a)** by Le Maître (1989), **b)** by O'Connor (1965), and **c)** by Maniar and Piccoli (1989).

of a certain amount of tonalitic material into the granodioritic magma. On the diagram by Bachelor and Bowden (Figure 6d), tonalites and granodiorites of the Favard Suite mostly plot in the field corresponding to a pre-collisional tectonic setting. Overall, the results of lithogeochemical analyses outline the mixed nature of the Favard Suite. Note that these same features were observed in the Loups Marins and Maricourt areas (sub-unit Afav1b of the Favard Suite in Gosselin *et al.*, 2001 and Simard *et al.*, 2000).

Coursolles and Maurel Suites

Field observations suggest there may exist a close genetic link between the Coursolles (Acou) and Maurel (Amau) suites. The Coursolles Suite is composed of a unit dominated by diorite and quartz monzodiorite (Acou1) and a heterogeneous unit (Acou2) of hornblende tonalite (I1D, Hb) injected by a late phase of variably porphyritic granodiorite. The Maurel Suite (Amau) corresponds to vast intrusions (Figure 3) essentially composed of granodiorite and quartz monzodiorite characterized by a megaphyric texture. Rocks of the Maurel Suite are considered as equivalents to the granodioritic phase observed as injections in units of the Coursolles Suite. Note that these units generally contain more than 10% mafic minerals (hornblende and biotite), which may affect the normative composition and the position of analyzed samples in normative classification diagrams shown in Figure 5a and b.

Analyzed samples of unit Acou1 show a normative composition ranging from a quartz diorite to a quartz monzodiorite, whereas samples of unit Acou2 are essentially composed of granodiorite, with a few analyses near the boundary with the monzodioritic (Figure 5a) or trondhjemitic (Figure 5b) fields. The Maurel Suite shows a very similar composition, ranging from a granodiorite to a quartz monzodiorite (Figure 5a). On diagrams by Irvine and Baragar (Figure 6a) and Pearce and Cann (Figure 6c), the Coursolles and Maurel suites show a calc-alkaline magmatic affinity, whereas on the Zr vs Y diagram (Figure 6b), several samples plot within the transitional field (Zr/Y ratio between 5 and 7). Note that this particular magmatic affinity, straddling the calc-alkaline/transitional boundary, was also observed for samples of the Coursolles Suite in the Loups Marins area (see Figure 6g in Gosselin *et al.*, 2001) and in the Maricourt area (see Figure 6b in Simard *et al.*, 2000). On the diagram by Bachelor and Bowden (Figure 6d), samples of the Coursolles Suite plot in a field corresponding to a pre-collisional to post-collisional tectonic setting, whereas those of the Maurel Suite mainly plot in the post-collisional field.

Châteauguay Suite

The Châteauguay Suite (Achg) corresponds tointrusions of mafic to ultramafic compositions. Analyzed samples show a tholeiitic magmatic affinity, near the transitional field, with an average Zr/Y ratio of about 4.5 (Figure 6a, b and c). Their MgO content ranges from 5 to 12% (Figure 7), indicating gabbro and magnesian gabbro compositions.

Desbergères Suite

The Desbergères Suite (Adeb) is defined in adjacent areas as a granodioritic unit (Gosselin *et al.*, 2001; Simard *et al.*, 2001). In our study area, it appears to be slightly

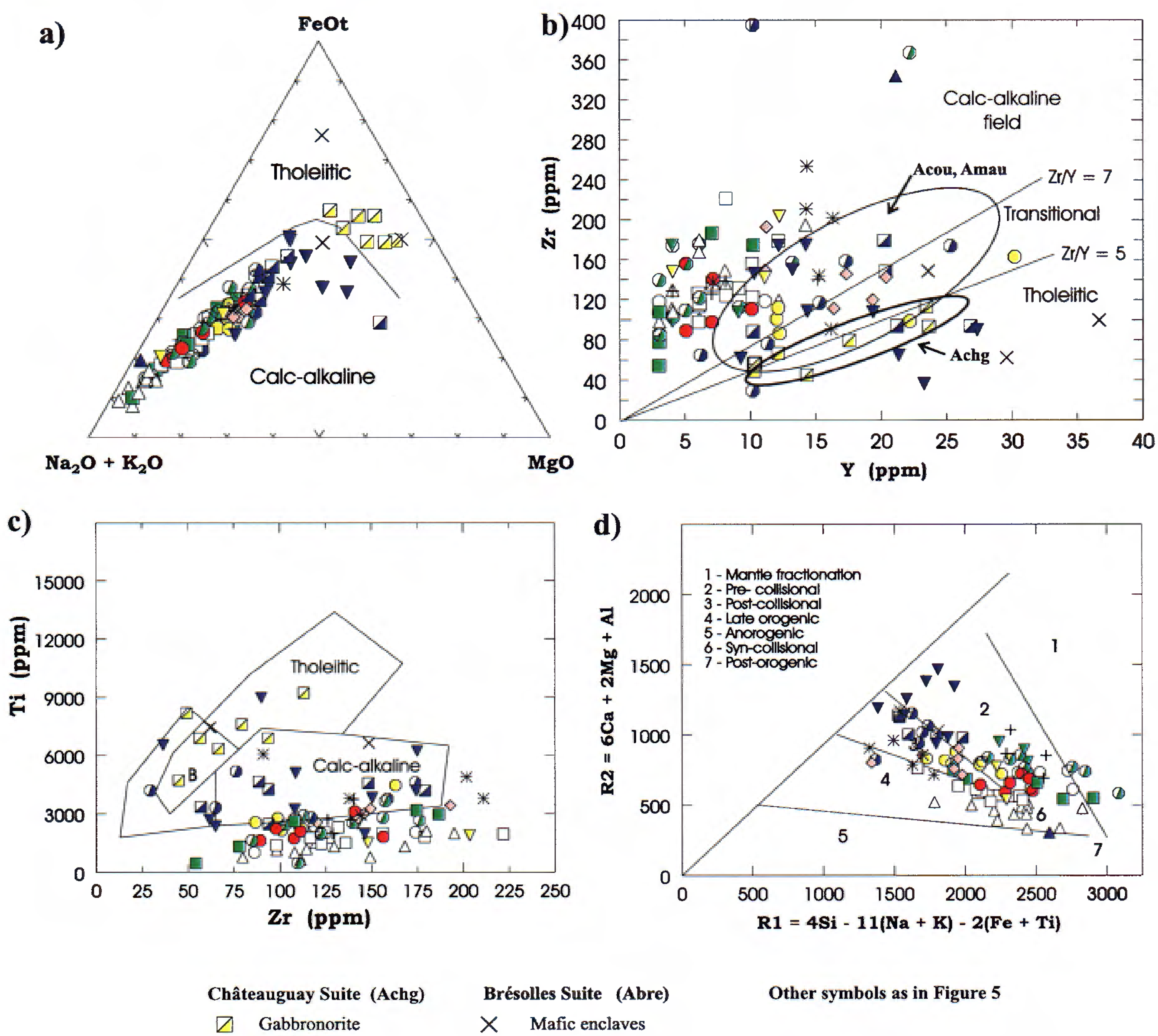


FIGURE 6 - Intrusive suites of the Lac Bienville area (33P) in: **a)** AFM diagram by Irvine and Baragar (1971), **b)** Zr vs Y diagram, **c)** Ti vs Zr diagram by Pearce and Cann (1973), and **d)** discrimination diagram by Bachelor and Bowden (1985).

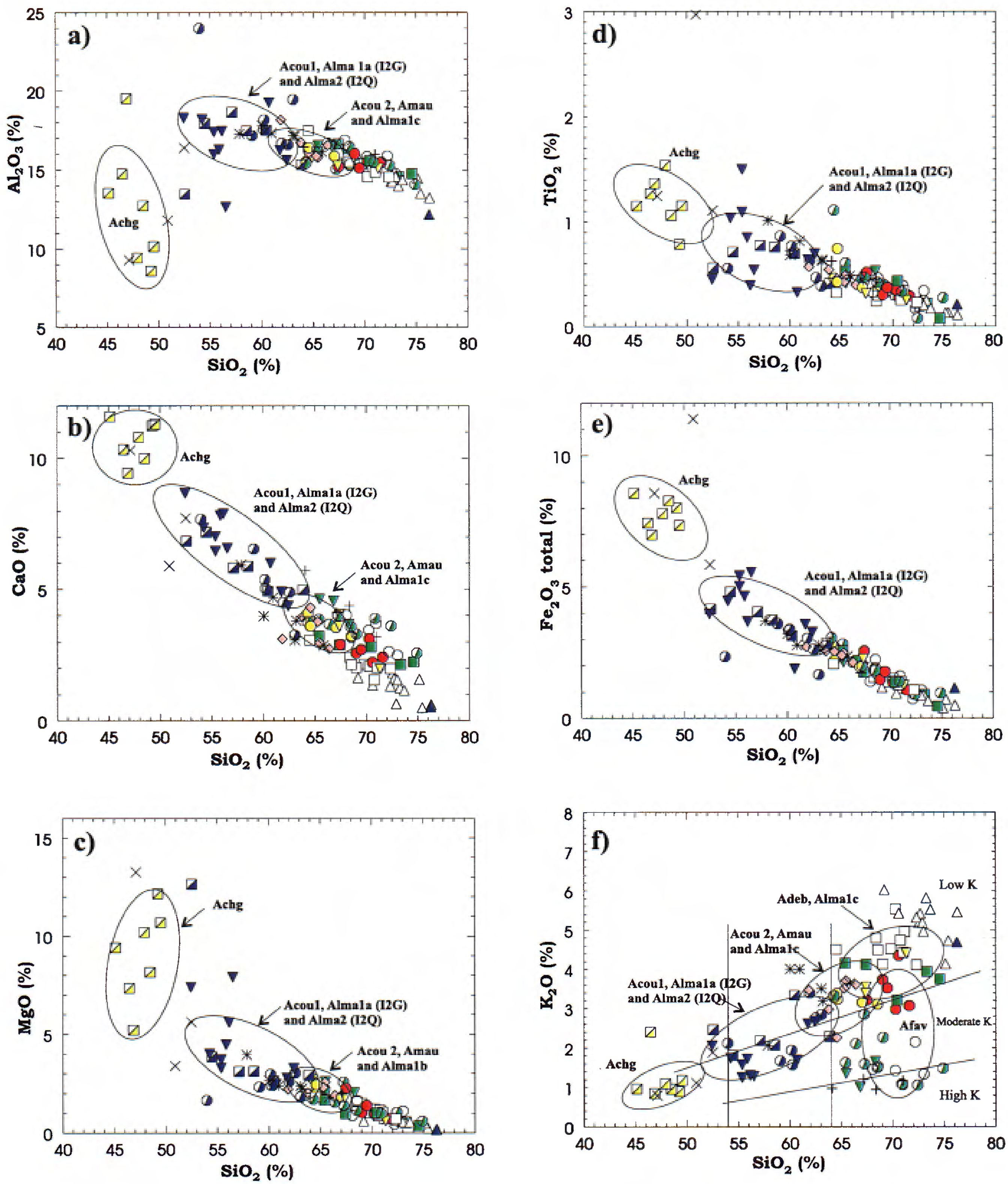


FIGURE 7 - Binary diagrams showing variations in Al_2O_3, CaO, MgO, TiO_2, Fe_2O_3 and K_2O as a function of SiO_2 content for the main lithostratigraphic units of the Lac Bienville area (same symbols as in figures 5 and 6).

more potassic. Analyzed samples show a normative composition ranging from granodioritic to monzogranitic (Figure 5a and b). They may be distinguished from granites of the Tramont (Atra) and Ossant (Aoss) suites however, thanks to their lower SiO_2 and K_2O contents (Figure 7f) and slightly higher Al_2O_3, CaO, TiO_2 and Fe_2O_3 contents (Figure 7a, b, d and e). On the diagram by Bachelor and Bowden (Figure 6d), they plot in fields corresponding to a syn-collisional to late orogenic tectonic setting.

Loups Marins Complex

The Loups Marins Complex (Alma) corresponds to a granulitic assemblage, composed of a clinopyroxene unit (Alma1) and an orthopyroxene unit (Alma2). Field observations and relations suggest that clinopyroxene sub-units Alma1a, Alma1b and Alma1c are equivalent to certain suites encountered in our map area (Table 1). Lithogeochemistry results also support this interpretation. Clinopyroxene-bearing tonalites and granodiorites of sub-unit Alma1a of the Loups Marins Complex show lithogeochemical characteristics similar to tonalites of the Favard Suite (Afav) and sometimes to granodiorites of unit Acou2 of the Coursolles Suite (figures 5, 6 and 7). Clinopyroxene-bearing diorites and quartz monzodiorites of the same sub-unit (Alma1a) are very comparable to dioritic rocks of unit Acou1 of the Coursolles Suite (figures 5, 6 and 7). Furthermore, granodiorites of sub-unit Alma1b of the Loups Marins Complex are chemically comparable to the Desbergères Suite (Adeb). Finally, megaphyric granodiorites and quartz monzodiorites of sub-unit Alma1c are similar to granodiorites of the Maurel Suite (Amau).

The Loups Marins Complex contains orthopyroxene-bearing intrusions represented by unit Alma2. Analyzed samples from this unit mainly consist of hypersthene diorite (I2Q), enderbite (I1T), and rare opdalite (I1S). These lithologies are difficult to distinguish from other regional units of the same nature solely on the basis of their geochemistry (figures 5, 6 and 7). Note however that hypersthene diorites and enderbites generally show slightly lower SiO_2 and K_2O contents (Figure 7f) compared to similar lithologies encountered in other units.

Tramont and Ossant Suites

The Tramont (Atra) and Ossant (Aoss) suites are both composed of granite, respectively characterized by the presence of biotite and amphibole. In most diagrams shown in figures 5, 6 and 7, samples from the Tramont Suite show a relatively homogeneous composition, distinct from other units. Only one sample from the Ossant Suite was analyzed. The results indicate a chemical composition similar to granites of the Tramont Suite, with greater zirconium and yttrium concentrations in the Ossant sample however (Figure 6b), which may reflect a more evolved and possibly later source.

REGIONAL STRATIGRAPHIC CORRELATIONS

Mapping conducted since 1998 in the Gayot, Maricourt, Loups Marins and Bienville areas completes the geological coverage of a quadrilateral of more than 55,000 km^2. Figure 2 shows an updated geological compilation of these areas. The legend identifies each unit according to its lithological composition and its link to a regional lithodemic entity. Table 1 details suggested stratigraphic correlations between the main units and sub-units defined and described in each of these four areas. In the table, stratigraphic codes (Afav, Acou, etc.) refer as much as possible to those used in previous reports for each of these areas (Gosselin and Simard, 2000; Gosselin *et al.*, 2001; Simard *et al.*, 2001). However, mapping conducted in recent years has led us to reconsider certain interpretations. When the stratigraphic position has been modified relative to the original interpretation proposed in a report, the stratigraphic code is preceded by an asterisk, such as ***Acou1** for example. A compilation of isotopic ages obtained in these areas indicates that identical lithologies assigned to the same lithodemic unit may be related to intrusive phases of different ages. These phases are identified in Table 1 as late **(L)** or early **(E)** phases. Finally, the addition "*inferred*" indicates that the presence of the unit in the area is possible but only interpreted and cannot be verified based on currently available data.

This preliminary synthesis is essentially based on observed characteristics and lithological associations, on cutting relationships and on obtained geochronology data. Its purpose is to standardize the entire dataset collected in these four regions, in order to facilitate the regional compilation of surveys conducted within the scope of the Far North Project since 1998.

The *Brésolles Suite* (Abre) is a distinctive unit, relatively easy to identify. It was recognized in all map areas considered in this synthesis (Figure 2). Obtained isotopic ages are coherent, and bracket its age between 2803 ±4 and 2811 ±8 Ma (Table 1).

The *Sem Suite* (Asem) was only identified in the Loups Marins area (Figure 2). It represents a particularly biotite-rich tonalitic unit of restricted extent. Its timing relative to other units remains unknown, and therefore it does not appear in Table 1.

The *Favard Suite* (Afav) covers an important proportion of the area (Figure 2). Although it is essentially characterized by biotite trondhjemites and tonalites, these rocks are often invaded by an important granodioritic to granitic fraction, related to a "granitization" phenomenon (see section entitled "Lithostratigraphy"). Initially described as "migmatized" trondhjemites in the Maricourt area (Simard *et al.*, 2001), then as "granitized" trondhjemites in the Loups Marins (Gosselin *et al.*, 2001) and Lac Bienville (this report) areas, this compositionally heterogeneous unit constitutes the dominant component of the Favard Suite in all three regions (Figure 2). It was also identified in the summer of 2001, following field checks, in the western part of the Gayot area (Figure 2, Table 1). In the Lac Bienville area, analyses of a "granitized" sample of the Favard Suite (sample location number 4, Figure 3) revealed two distinct zircon populations. The first population yielded an age of 2713 ±2 Ma interpreted as the age of crystallization of the granodioritic fraction. The "granitization" phenomenon that affects rocks of the Favard Suite therefore appears to be comparable in age to the Desbergères granodioritic Suite (Adeb), dated in the Loups Marins area (34A) at 2714 ±12 Ma (Table 1). The second zircon population yielded an age of 2741 ±4 Ma, which roughly corresponds to ages obtained for Favard trondhjemites in the Gayot (2.73 Ga) and Maricourt areas (2749 ±4 and 2754 +11/-9 Ma; Table 1).

In the Gayot area (23M), a dioritic unit (Afav1; I2J-I2I) had been assigned to the Favard Suite (Gosselin and Simard, 2000). This unit is now considered as the late phase of the Coursolles Suite (Acou) in light of new observations and data obtained in subsequent surveys (Table 1). In the Maricourt and Loups Marins areas, a relatively restricted trondhjemite sub-unit (Afav1a; I1E) was defined (Table 1). This unit is characterized by the presence of numerous tonalitic gneiss (M1) bands that probably represent enclaves of the Brésolles Suite (Abre).

The Coursolles Suite (Acou) is primarily composed of hornblende tonalites and granodiorites, commonly associated with quartz diorites. The compilation of geochronology data and lithological associations encountered in all the map areas lead us to break down the Coursolles Suite into two distinct intrusive phases, namely an early phase (E) and a late phase (L; Table 1). These are however lithologically similar, and could not be differentiated in the field nor on the maps (Figure 2). The early phase of the Coursolles Suite (Acou-E) was recognized in the northeastern part of the Loups Marins area (34A). Two hornblende tonalite intrusions were dated in this area (sample locations number . 2 and 3, Figure 3 in Gosselin *et al.*, 2001); they yielded isotopic ages of 2756 ±8 and 2758 ±11 Ma (Table 1). These intrusions, assigned to the Coursolles Suite, may in fact correspond to an early phase of the Favard Suite, which would explain certain cutting relationships observed locally in the Maricourt area, where Coursolles-type hornblende tonalites are injected by Favard-type trondhjemites (Simard *et al.*, 2001). The late phase of the Coursolles Suite (Acou-L) appears to be the predominant unit in this suite, and the "quartz diorite/hornblende tonalite" combination is more obvious in this unit. In the Maricourt area (24D), where the Coursolles Suite was defined, a hornblende tonalite yielded an isotopic age of 2718 +11/-8 Ma (Table 1). In the Lac Bienville area (33P), the Coursolles Suite shows the same lithological associations as in the Maricourt area, and a new isotopic age of 2719 ±2 Ma was obtained from a diorite sample (I2J) of unit Acou1. Note that diorites and quartz diorites (I2J-I2I) that had originally been assigned to the Châteauguay Suite in the Loups Marins area (Gosselin *et al.*, 2001) are now considered to belong to the Coursolles Suite. The same can be said of unit Afav1, which had been assigned to the Favard Suite in the Gayot area (Table 1).

The Coursolles Suite, similar to the Favard Suite, includes a unit of "granitized" hornblende tonalite (Figure 2). The granitization phenomenon that affects these tonalites is comparable to that observed in the Favard Suite. The unit is composed of a tonalitic fraction invaded by a granodioritic fraction of variable importance. The granodioritic fraction is late and often characterized by the presence of K-feldspar phenocrysts. It is lithologically comparable to megaphyric intrusions of the Maurel Suite (Amau) and seems to be, at least in part, genetically related to this suite.

The Châteauguay Suite (Achg), as defined in the Maricourt area (24D), represents small mafic to ultramafic intrusions. No isotopic data is available for this unit. However, a number of observations may be used to infer its timing relative to other suites (Table 1). In the Maricourt area (24D), intrusions of the Châteauguay Suite are considered to be late relative to the Favard and Coursolles suites (Simard *et al.*, 2001). They are therefore probably younger than 2718 +11/-8 Ma, the age obtained in this area for the late phase of the Coursolles Suite (Acou2, Table 1). In the Loups Marins (34A) and Bienville (33P) areas, these intrusions are often cut by orthopyroxene-bearing intrusions (Alma2) associated with the Loups Marins Complex, suggesting an age earlier than 2694 ±3 Ma, the youngest age obtained for the latter unit (Table 1). Furthermore, in the Loups Marins area, gabbroic enclaves were observed in granodiorites representing the early phase of the Desbergères Suite (see below), dated in this area at 2714 ±12 Ma (Adeb-E, Table 1). If these gabbro enclaves are indeed representative of the Châteauguay Suite, this relation constrains the age of the Châteauguay Suite between the early phase of the Desbergères Suite (2714 ±12 Ma) and the late phase of the Coursolles Suite (2718 +11/-8 Ma in Maricourt and 2719 ±2 Ma in Bienville areas, Table 1).

The *Desbergères* (Adeb) and *Maurel* (Amau) *suites* are the main granodioritic units in the area. Geochronology data indicate that each suite is represented by two distinct intrusive phases; an early phase (E) and a late phase (L). The early phase of the Desbergères Suite (Adeb) was identified in the Loups Marins area (34A) and dated at 2714 ±12 Ma (Table 1). In the Bienville area (33P), the presence of the early phase of the Desbergères Suite is inferred from an age of 2709 ±2 Ma obtained from a clinopyroxene-bearing granodiorite sample of unit Alma1b of the Loups Marins Complex, considered to be equivalent to the Desbergères Suite (Table 1). The early phase of the Maurel Suite was identified during this study in the Bienville area, where an age of 2707 ±5 Ma was obtained (Table 1). In the Loups

Marins area, the Lussay Suite (Alus), considered to be equivalent to unit Alma1c of the Loups Marins Complex and to the Maurel Suite, yielded a comparable age of 2713 ±5 Ma (Table 1).

The late phases of the Desbergères and Maurel suites were the first to be identified during mapping in the Gayot and Maricourt areas (Gosselin and Simard, 2000; Simard *et al.*, 2001). Intrusions assigned to these suites yielded isotopic ages hovering around 2685 Ma (Table 1), which correspond to much younger ages than those obtained for the early phase (Table 1). From a lithological standpoint however, the two phases cannot be distinguished from one another. It therefore appears difficult to discuss the regional distribution of one or the other based on currently available data. Nevertheless, it seems that intrusions associated with the early phase of the Desbergères and the Maurel suites are more abundant in the Loups Marins and Bienville areas, although there are no indications to confirm or deny the presence of intrusions related to the late phase. Inversely, in the eastern Maricourt and Gayot areas, the late phase seems to be predominant, whereas the presence of the early phase can only be inferred (Table 1).

The *Loups Marins Complex* represents an important lithodemic assemblage that covers the western part of the Loups Marins and Bienville areas (Figure 2). It consists of orthopyroxene-bearing intrusions (Alma2) and clinopyroxene-bearing rocks (Alma1).

The *clinopyroxene unit* (Alma1) of the complex is equivalent to a number of other regional units of variable ages and compositions (Table 1). A granodiorite (I1C, Cx) of sub-unit Alma1b, considered equivalent to the Desbergères Suite (Adeb-E), yielded an age of 2709 ±2 Ma (Table 1). In the Loups Marins area (Gosselin *et al.*, 2001), the Lussay Suite (Alus), equivalent to sub-unit Alma1c in the Bienville area, yielded an isotopic age of 2713 ±5 Ma (Table 1). As previously mentioned, this age is comparable to the age of 2707 ±5 Ma, obtained from a porphyritic granodiorite of the Maurel Suite (Amau) in the Bienville area (Table 1).

The *orthopyroxene unit* of the Loups Marins Complex (Alma2) was dated, in the area of the same name, at 2694 ±3 Ma and in the Bienville area at 2720 ±2 Ma (Table 1). These results indicate that the emplacement of these intrusions may correspond: 1) to two distinct intrusive phases of different ages, or 2) to charnockitic intrusions emplaced over a more or less continuous period spanning about 25 Ma. This second interpretation is preferred in Table 1, given the existence of ages determined at 2709 +3/-2 and 2697 ±8 Ma (David, personal communication) for the charnockitic Lippens and MacMahon suites further north in the Nedlouc area (34H, Figure 1). These ages outline different periods of charnockitic intrusion within the same time frame.

The *Du Gué Complex* (Audg), defined in the Maricourt area (24D), shows many similarities with the Loups Marins Complex. It includes primary orthopyroxene-bearing phases (megaphyric charnockites, enderbites) as well as metamorphosed rocks equivalent to adjacent regional units (Simard *et al.*, 2001; Table 1). However, these metamorphosed rocks are characterized by the omnipresence of orthopyroxene, which indicates higher-grade metamorphic conditions than those represented by clinopyroxene-bearing units in the Loups Marins Complex. Furthermore, the Du Gué Complex is composed of several granulitic volcano-sedimentary bands as well as diatexites. An orthopyroxene-bearing tonalite sample from the Du Gué Complex yielded an age of about 2729 Ma (Table 1). The igneous or metamorphic origin of these orthopyroxene-bearing rocks could not be determined however.

The *Tramont Suite* (Atra) was defined in the Gayot area (23M). It corresponds to late granitic intrusions that cut all other Archean units (Table 1). Cutting relationships observed for these intrusions suggest an age younger than 2685 Ma, which is the age of the late phase of the Maurel Suite (Amau-L, Table 1). However, in the Bienville area, an isotopic age of 2701 ±4 Ma was obtained from a granitic body assigned to the Tramont Suite, which indicates that a certain proportion of these granites belong to an earlier intrusive phase (Table 1). This situation is comparable to those of the Coursolles, Desbergères and Maurel suites. Obtained ages indicate that these lithodemic units are associated with more than one intrusive phase. The bimodal age of each of these suites also outlines the limits of using essentially lithological criteria within a complex regional intrusive framework.

Finally, the *Ossant* (Aoss) and *Turbar* (Atub) *suites* are restricted to the Bienville area. They correspond to specific and rarely encountered lithologies. Although they appear to consist of late intrusions relative to other regional Archean units, no geochronology data is available to establish their relative timing in Table 1.

METAMORPHISM

Volcano-sedimentary rocks generally contain the most diagnostic mineral assemblages in terms of metamorphic facies. In the Lac Bienville area, the absence of these rocks makes it that much more difficult to interpret metamorphic conditions. Exposed rocks essentially consist of felsic intrusions, and their mineralogy is not always useful to identify the metamorphic facies with confidence. Recrystallization textures therefore play an important role in trying to determine metamorphic conditions.

The rocks in the area are characterized by metamorphic assemblages ranging from the amphibolite facies to the granulite facies. Within certain fault zones, greenschist-facies retrograde metamorphism is associated with deformation and late circulation of hydrothermal fluids.

Rocks outside of the Loups Marins Complex are generally affected by metamorphic conditions typical of the middle amphibolite facies. They are characterized by the following mineral assemblage: green biotite + green hornblende + plagioclase + quartz ± epidote ± muscovite. Locally, rocks in the eastern part of the area reach the upper amphibolite or the granulite facies. These local phenomena, not mappable at the scale of our work, were namely observed in gneisses of the Brésolles Suite (Abre) and in the Favard (Afav) and Coursolles (Acou) suites. They are characterized by the appearance of clinopyroxene, red biotite and salmon pink plagioclase.

The Loups Marins Complex, exposed in the western and central parts of the area, is characterized by mineral assemblages typical of high-grade metamorphism. The orthopyroxene unit (Alma2) generally occurs in the core of the complex. Rocks in this unit are represented by the assemblage orthopyroxene + clinopyroxene + brown-red biotite + plagioclase + quartz ± green hornblende. The granoblastic texture, which is predominant in these rocks, provides evidence of recrystallization at high pressure and temperature conditions, typical of the granulite facies. However, certain areas exhibit a primary igneous texture, with well-preserved automorphic pyroxene grains. This texture indicates that primary, charnockitic orthopyroxene-bearing intrusions were emplaced within the complex. The coexistence of these facies also indicates that high pressure and temperature conditions persisted following the emplacement of orthopyroxene-bearing intrusions, leading to metamorphic recrystallization. The orthopyroxene unit (Alma2) is surrounded by a metamorphic aureole several kilometres wide formed by the clinopyroxene unit (Alma1). The latter is characterized by the assemblage clinopyroxene + reddish biotite + plagioclase + quartz ± green hornblende. Igneous textures are predominant in the clinopyroxene unit, although granoblastic textures are commonly observed. Mineral assemblages and textures indicate these rocks were formed or metamorphosed at pressure and temperature conditions typical of the upper amphibolite facies or the lower granulite facies. As mentioned in the section entitled "Lithostratigraphy", the clinopyroxene unit (Alma1) may be an equivalent of suites with amphibolite-grade mineral assemblages, but these were formed or metamorphosed at higher pressure and temperature conditions. This hypothesis is supported by similar chemical compositions for clinopyroxene-bearing rocks and amphibolite-grade rocks, despite their distinct mineralogy.

STRUCTURAL GEOLOGY

From a structural standpoint, the Lac Bienville area (33P) is comparable, in many respects, to the Gayot area (23M) to the east, the Maricourt area (24D) to the northeast and the Loups Marins area (34A) to the north. In these areas, the dominant structural trend is oriented NW-SE, a direction that characterizes the southern part of the Minto Subprovince (Percival *et al.*, 1992). Table 2 provides a broad comparison of the main structural features associated with the regional phases of deformation. Figure 8 shows an overview of the attitude of the regional S2 foliation in the Lac Bienville area, as well as the location of regional faults and folds. Figure 9 shows the boundaries of structural domains defined in the area and a compilation of regional foliation measurements (S2).

Structural Elements and Phases of Deformation

Tectonic events that affected the rocks in the area may be associated with five phases of deformation (Table 2).

Phase D1 is interpreted from an early S1 foliation, at an angle relative to the regional foliation. It was observed in a few mafic enclaves enclosed in gneisses of the Brésolles Suite. This early foliation (S1) was also noted in enclaves in gneisses in adjacent areas, and represents the only visible remains of phase D1 (Table 2).

Phase D2, associated with regional foliation S2, affects all Archean rocks in the area, albeit at a variable intensity. Younger units are generally more weakly foliated than earlier units. The distinction between the gneissosity observed in enclaves of the Brésolles Suite (S1) and the regional S2 foliation could not be determined. These fabrics are oriented parallel to one another and no cutting relationships were observed. However, isoclinal folds, locally refolded, affect the gneissosity observed in the Brésolles Suite. This type of deformation was not observed affecting the S2 foliation in younger units in the area. Subsequent phases of deformation (D3 and D4) reoriented, folded or enhanced the regional S2 foliation.

Phase D3 was mainly identified in the Gayot (23M) and Maricourt (24D) areas. It is characterized by folds with ENE-WSW to NNE-SSW-trending axial traces, with no associated axial planar cleavage. These folds are often obliterated by D4 deformation (Table 2). In the Bienville area, phase of deformation D3 is restricted to structural domains 2a and 2b, located in the southeastern part of the area (figures 8 and 9). These two domains roughly correspond to the extent of the La Grande Subprovince (Figure 2), to which F3 folds are associated (figures 8 and 9).

Phase D4 gave rise to the dominant NW-SE orientation of most structural features encountered in the Gayot, Maricourt, Loups Marins and Bienville areas (Table 2). This phase of deformation folded regional foliation S2 and produced NW-SE-trending open to tight F4 folds without an axial planar cleavage. A well-developed network of D4 faults with the same orientation is also associated with this phase (domains 3 and 4, figures 8 and 9). These faults define corridors a few tens of kilometres wide, in which F4 folds occur. F4 axial traces generally form a weak angle relative

TABLE 2 - Main structural elements associated with phases of deformation (D1 to D5) that affected the Gayot (Gosselin and Simard, 2000), Maricourt (Simard *et al.*, 2001), Loups Marins (Gosselin *et al.*, 2001) and Bienville (this report) areas.

Phases	Loups Marins area (33A)	Phases	Bienville area (33P)	Phases	Gayot (23M) and Maricourt (24D) areas
	Descriptions		**Descriptions**		**Descriptions**
D5	-Late D5 faults, ENE-WSW to NNE-SSW, weakly developed, movement undetermined.	D5	-Late D5 faults, ENE-WSW to NNE-SSW, well developed, associated with brittle deformation, movement undetermined. May have exerted some control on the Saindon-Cambrien Corridor.	D5	-D5 faults, ENE-WSW to NNE-SSW, reverse movement. The Châteauguay and Vaujours faults are interpreted to be associated with this phase. -A few ENE-WSW associated folds ?
D4	-Anastomosing D4 fault, NW-SE to E-W. Well-developed mylonitic fabric with sulphide zones in the Alegrain fault area. The regional Loups Marins fault represents an E-W segment of the main broadly NW-SE-trending system. -F4 folds, WNW-ESE to NW-SE, open to tight, dragged along NW-SE faults.	D4	-D4 faults, NW-SE corresponding to strongly foliated to mylonitic shear zones. -F4 folds, NW-SE, open to tight, dragged along NW-SE faults.	D4	-D4 fault, NW-SE, with crenulation cleavage locally developed. -F4 folds, WNW-ESE to NW-SE, open to tight, dragged along NW-SE faults.
D3	-Local presence of ENE-WSW folds possibly related to this phase.	D3	-F3 folds, ENE-WEW to NNE-SSW (with no associated foliation), locally reoriented by phase of deformation D4.	D3	-F3 folds, NE-SW to NNE-SSW (with no associated foliation), locally reoriented by phase of deformation D4.
D2	-Regional S2 foliation.	D2	-Regional foliation S2.	D2	-Regional foliation S2.
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.	D1	-Relics of an early S1 foliation that predates the regional foliation in enclaves.

to the orientation of these faults. They are generally dragged or cut by the faults, indicating the latter are late or postdate the folding episode. Most D4 faults are interpreted from lineaments observed on aeromagnetic maps (Figure 4). In the field, they correspond to shear zones, in which the rocks are strongly foliated or mylonitized. In these zones, various types of alteration, namely hematitization, epidotization, chloritization and silicification, are observed. Movements along D4 faults could not be determined.

Phase D5 corresponds to the development of late faults oriented ENE-WSW to NNE-SSW (Table 2). These faults, well developed in the Bienville area, extend towards the northeast into the Gayot and Maricourt areas (Figure 2). Poorly exposed, they are interpreted indirectly using aeromagnetic and topographic maps. As opposed to D4 faults that drag earlier structures into their path, D5 faults form discrete planes having no impact on the orientation of the fabrics they cut. D5 faults correspond to a cataclastic-type brittle deformation, characterized by mortar textures and intense fracturing, with the appearance of hematite, chlorite, epidote and quartz stringers. 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 (D5) (Figure 2; Simard *et al.*, 2001). Note also that these faults are probably associated with the Proterozoic Saindon-Cambrien collapse structure (Figure 2).

The *Proterozoic Saindon-Cambrien corridor* (SCC) is defined by the alignment of outliers of the Sakami Formation (Figure 2). It is bounded to the north by major ENE-striking regional faults that may extend into the Maricourt area, to the Châteauguay fault. A small Proterozoic outlier of the Sakami Formation was in fact recognized in that area (Simard *et al.*, 2001). The southern boundary of the corridor is proposed based on an important ENE-WSW-trending magnetic lineament that coincides with a regional D5 fault (figures 4 and 8). This major fault appears to extend eastward, to an outlier of the Sakami Formation in the northern Gayot area (Figure 2). The SCC contains three sets of subsidiary faults oriented ENE-WSW, NNE-SSW and NW-SE. These faults may have been reactivated during the Proterozoic, given that several Proterozoic dykes were emplaced in their vicinity. The SCC also transects the boundary between the La Grande and Minto subprovinces in the southeastern part of the Bienville area and the northern Gayot area (Figure 2).

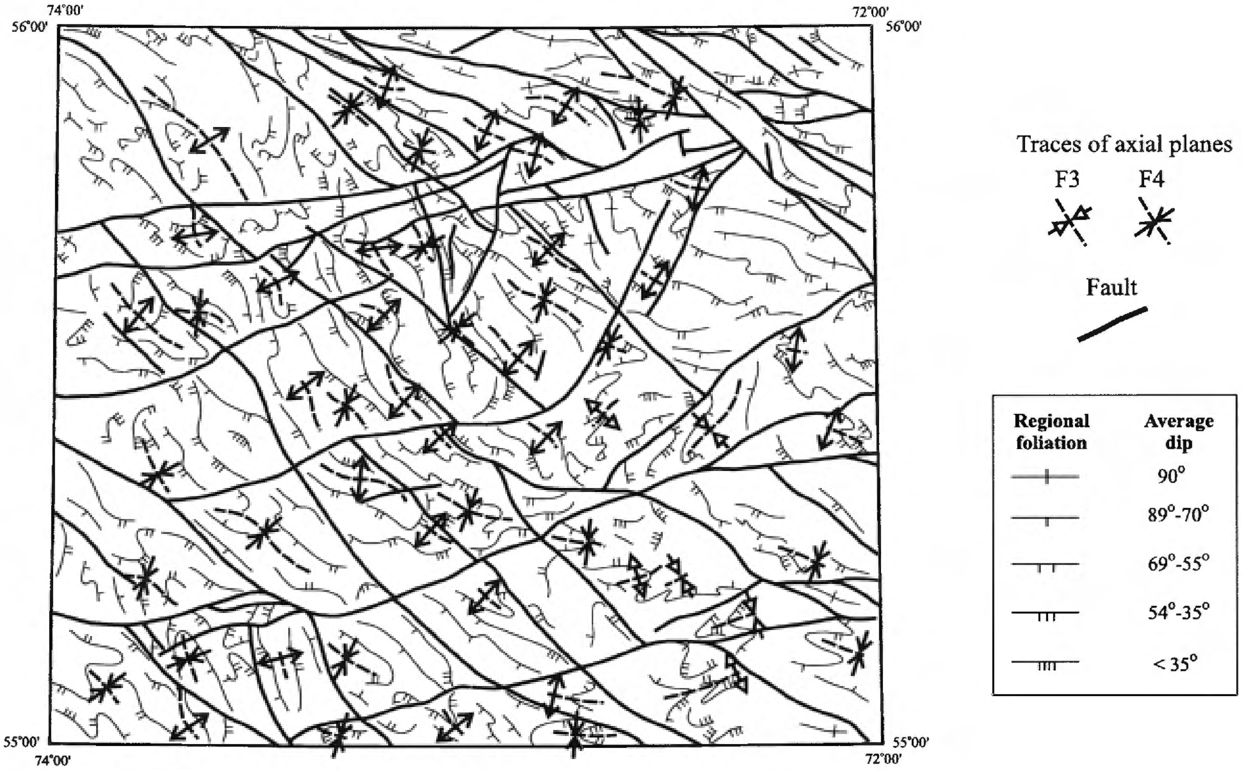


FIGURE 8 - Attitude of the regional foliation (S2), and of faults and folds in the Lac Bienville area (33P).

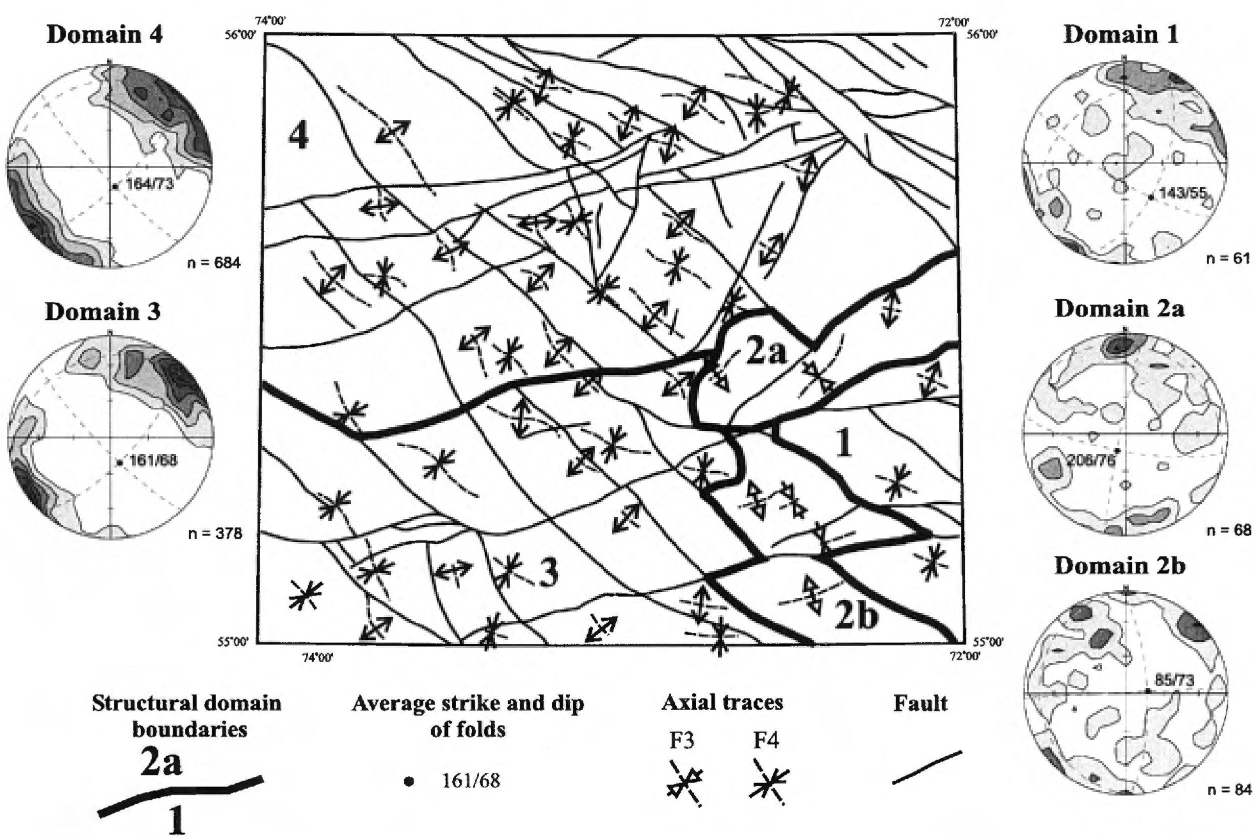


FIGURE 9 - Structural domain boundaries in the Lac Bienville area (33P), and statistical compilation on Schmidt stereograms of S2 regional foliation measurements. n = number of measurements.

Statistical Compilation

The area was subdivided into four structural domains (Figure 9). The poles of S2 regional foliation planes are plotted on stereograms (equi-area projections) for each structural domain. This stereographic analysis outlines the dominant NW-SE regional structural trend, as well as the average attitude of regional F3 and F4 fold axes. Domains 1, 3 and 4 represent more than 85% of the total surface area. The results indicate that F4 fold axes in these three domains trend at 143° to 164° on average and plunge towards the southeast at 55° to 73°. Domain 2 lies along the edge of the La Grande Subprovince and was defined in order to address the specific nature of folding related to phase D3. The compilation of foliation and gneissosity measurements in sub-domain 2a indicates the presence of NNE-SSW-trending folds, with an average fold axis orientation of 206°/76°. The compilation for sub-domain 2b highlights ENE-WSW-trending folds, with fold axis orientations at 085°/73° on average. The difference in F3 fold axis orientations between the two sub-domains is interpreted as the result of phase of deformation D4, oriented NW-SE, which is well-developed on either side of domain 2.

ECONOMIC GEOLOGY

Previous Work

Between 1976 and 1979, Uranerz Exploration and Mining, Seru Nuclear of Canada and Eldorado Nuclear conducted exploration in the Lac Bienville area (33P), in a search for uranium deposits. The area surrounding the sedimentary outlier of the Sakami Formation was covered by geological mapping, spectrometry and geochemistry surveys (lake sediments, lake water and soils) (MRN, 1976; Beauchamp, 1977; Belair *et al.*, 1976; Fouques *et al.*, 1977; Holmstead and Orr, 1978). These studies outlined geochemical anomalies in Cu, Ni, Co and U, but failed to outline any uranium mineralization within our map area. A deposit was however discovered in the Gayot area (23M), located further east (Figure 2). Reserves are estimated at 50 million metric tonnes at a grade of 0.10% U_3O_8, including 10 to 15 million tonnes at 0.25% U_3O_8 (Marcoux, 1980).

An extensive lake sediment geochemistry survey (MRN, 1998), carried out by SIAL in 1997 within the scope of the Far North Project, covered the entire Lac Bienville area (33P). This survey, funded by the MRN and five private industry partners, prompted a number of companies to acquire exploration licences in the adjacent Gayot (23M) and Maricourt (24D) areas. Diamond exploration was also conducted in the Bienville area from 1994 to 2000. Unpublished work was carried out by Monopros and the Ashton Mining/SOQUEM joint venture. A fluvioglacial sediment (esker) survey combined with a glacial dynamics study conducted in the summer of 2001 (Parent *et al.*, 2001) led to the discovery of two occurrences of chrome picroilmenite, a kimberlite indicator mineral (Parent *et al.*, 2002). No other exploration campaign was conducted in our map area, and no mineral occurrences were reported prior to our mapping survey.

Results of the Field Campaign

Our work led to the discovery of three occurrences, which may be of interest for mineral exploration, including a Ni-Cu-Co-Au showing (Sophie showing, Figure 10). They consist of rusty zones that were observed during field traverses. The three mineralized zones were sampled and analysed for base metals, gold and silver. Each mineralized zone is associated with a distinct geological setting: 1) the *Sophie showing* is associated with a gabbroic intrusion, 2) *site 1* is associated with an alteration zone in a tonalite, and 3) *site 2* is associated with a shear zone.

Sophie Showing (Ni-Cu-Co-Au)

The Sophie showing is enclosed in a gabbroic intrusion associated with the Châteauguay Suite (Figure 10). It corresponds to a rusty zone some 50 cm wide, which hosts disseminated sulphides. A sample collected within this zone yielded anomalous concentrations in Ni (0.36%), Cu (0.30%), Co (104 ppm), Pd (0.20 g/t), Pt (0.33 g/t) and Au (0.18 g/t). These concentrations are relatively high, given the minor proportion of sulphides in the mineralized zone (< 5%). Disseminated sulphides are dominated by pyrrhotite, pyrite and chalcopyrite.

In thin section, the gabbro is essentially composed of actinolite (tremolite) and plagioclase, with minor amounts of phlogopite and sulphides. Actinolite occurs as elongate prisms, meshed together with no preferential orientation. Plagioclase, interstitial to actinolite, is altered to sericite. Observed sulphides are chalcopyrite (1%), pyrrhotite (1%), pyrite (1%) and millerite (< 1%). A gold grain was observed along a grain boundary between chalcopyrite and pyrrhotite. Magnetite occurs in trace amounts. The predominance of actinolite suggests the gabbro underwent metamorphism at the lower amphibolite facies, possibly related to a local hydrothermal event. Mafic-ultramafic intrusions associated with the Châteauguay Suite are abundant in the area (Figure 10) and offer good potential for mineral exploration. For example, the Qullinaaraaluk showing located in the Lac Minto area (34G) further north, and composed of massive sulphides hosted in a pyroxenite, yielded grades reaching up to 2.60% Ni, 1.80% Cu and 0.27% Co (Labbé *et al.*, 2000).

Other Mineral Occurences

Site 1 (Figure 10) is composed of disseminated sulphides associated with an alteration zone in a tonalite. The alteration

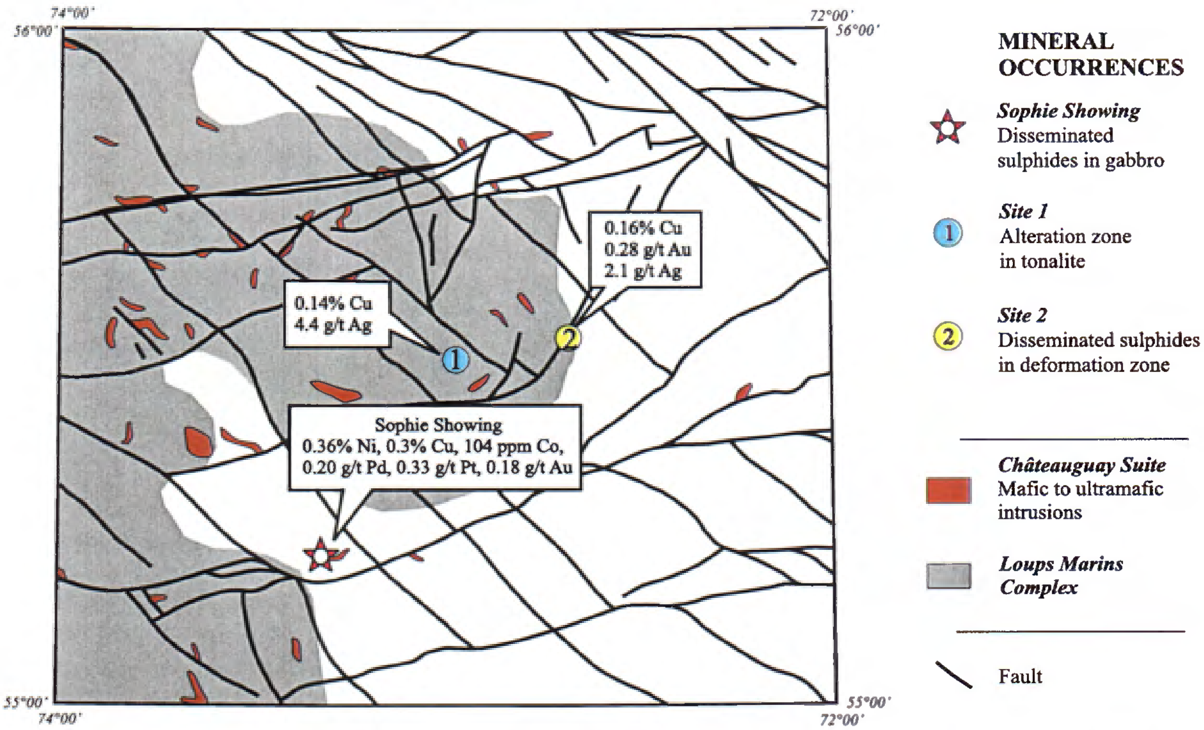


FIGURE 10 - Location of the main metalliferous sites of economic interest identified in the Lac Bienville area (33P).

zone consists of chlorite, epidote and hematite. The mineralization is characterized by the presence of disseminated pyrite with trace chalcopyrite. Analytical results from one sample reveal anomalous Cu (0.14%) and Ag (4.4 g/t). *Site 2* corresponds to a disseminated sulphide horizon hosted in an orthopyroxene-bearing diorite, within a regional NNE-SSW-trending shear zone (Figure 10). The disseminated sulphide (2-5%) horizon is essentially composed of pyrite, and exhibits a rusty weathered surface on outcrop. Concentratios of 0.16% Cu, 0.28 g/t Au and 2.1 g/t Ag were obtained from a grab sample.

Diamond Potential

Diamond exploration in Québec has reached a new peak since the discovery of macrodiamonds in kimberlitic rocks (Figure 11) in the Monts Otish area (Ashton Mining of Canada, press release dated December 17, 2001). The first diamond exploration boom began in 1998 with the discovery of diamond-bearing kimberlites in the Monts Torngat area (Twin Mining Corporation, press release in the fall 1999), then of a diamond in a lamprophyre near Lac Yasinski in the James Bay region (Dianor Resources, press release dated June 4, 2001). The Yasinski and Torngat areas are transected by the northeastern extension of the Kapuskasing tectonic zone, which also intersects the western part of the Saindon-Cambrien corridor (SCC) in the Lac Bienville area (Figure 11). Kimberlite fields are generally associated with this type of structural corridor that transects stable Archean cratons (Moorhead *et al.*, 1999; Moorhead *et al.*, 2000).

Saindon-Cambrien Structural Corridor (SCC)

The SCC extends for 350 km along an ENE-WSW axis, from the Labrador Trough to an area south of Lac à l'Eau Claire (Figure 11). It was defined from the alignment of seven Proterozoic sedimentary outliers of the Sakami Formation and of two carbonatite complexes in the Labrador Trough (Figure 11; Moorhead *et al.*, 1999; 2000). These geological entities are often spatially associated with kimberlites (Dawson, 1964; Kirkley *et al.*, 1992).

In the Lac Bienville area (33P), the SCC exhibits a number of features indicating it could be a prospective zone for the emplacement of kimberlite fields (Figure 12). This corridor: 1) forms a collapse basin constrained by ENE-trending faults, within which a Proterozoic sedimentary outlier is preserved, 2) intersects a major structural and gravity lineament oriented NW-SE, which stands out on both aeromagnetic and gravity surveys, 3) contains subsidiary brittle-ductile faults oriented NW-SE and NNE-SSW, which represent favourable conduits for the ascent of alkaline magmas, and 4) contains the largest number of Proterozoic diabase dykes encountered during our mapping program.

Geochemistry Surveys and Glacial Movements

In lake sediments, the proximity of a kimberlite may be indicated by an increase in Ba, in lithophile elements (Al, Mg, Na, K), in siderophile elements (Fe, Ni, Cr) and in light rare earth elements (Ce) (Beaumier *et al.*, 1993; Moorhead *et al.*, 1999). In the Lac de Gras area (NWT) for example, lake

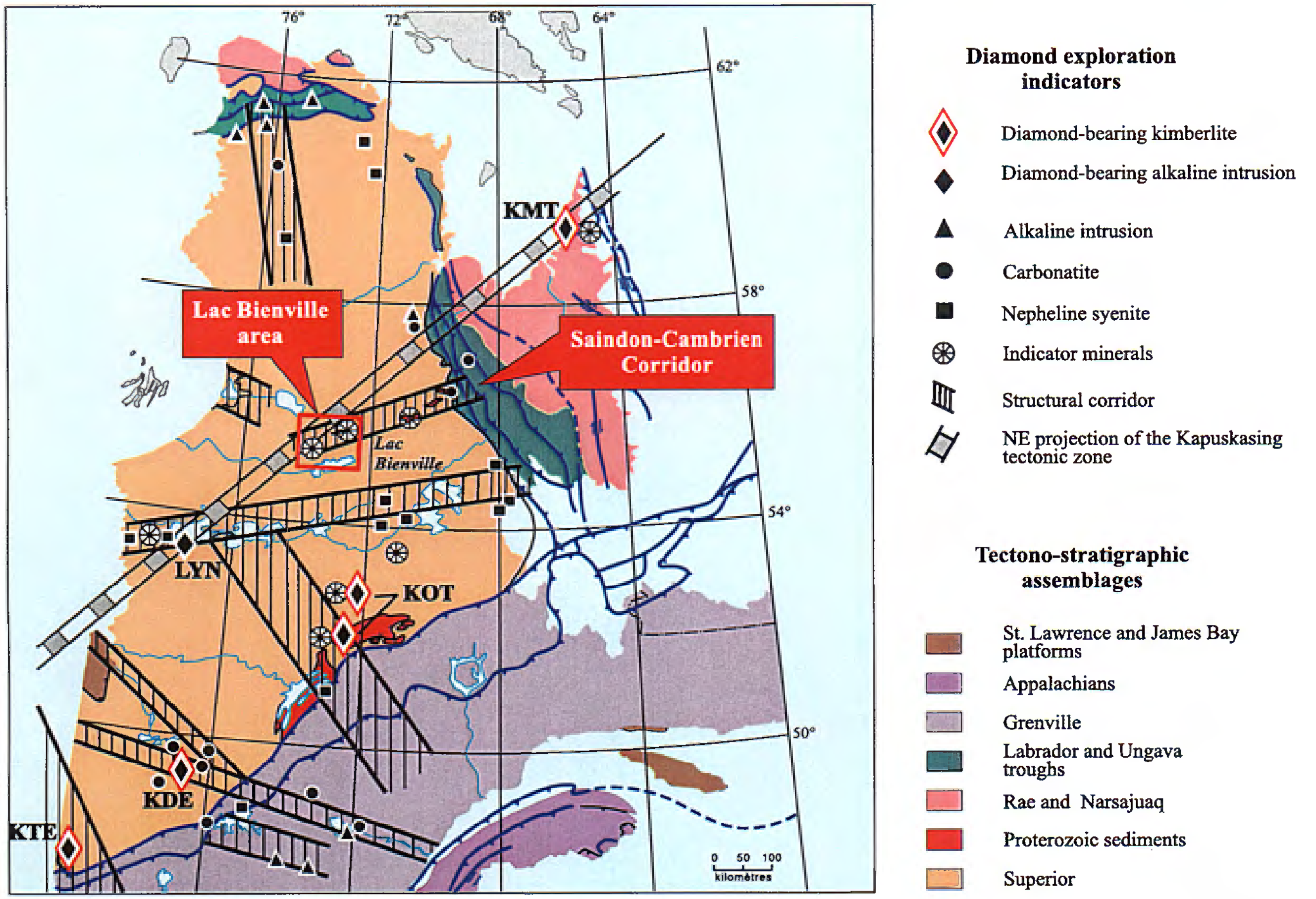


FIGURE 11 - Tectono-stratigraphic assemblages with the location of the main structural corridors and diamond exploration indicators (modified after Moorhead *et al.*, 2000). Kimberlite fields: Desmaraisville (KDE); Monts Torngat (KMT); Monts Otish (KOT); Témiscamingue (KTE).

sediment samples clustered around the kimberlite field show anomalies in Ba, Ce and Cr (Kjarsgaard *et al.*, 1992; Moorhead *et al.*, 2000). A lake sediment survey commissioned in 1997 by the MRN in partnership with the private sector, covers the entire map area (MRN, 1998). Anomalies in Ba, Ce, Cr and Ni are shown in Figure 12, and are concentrated in the northern part of the Bienville area (33P), within the SCC.

Thirty-three samples of fluvioglacial sediments (eskers) were collected and analyzed in the summer 2001 by Parent *et al.* (2001), within the scope of a joint QGC-MRN project. As a result, chrome picroilmenite grains, a mineral typical of kimberlites, were identified in two samples. The two grains were discovered in sediments sampled within the Saindon-Cambrien corridor; the first in the northeastern part of the area and the other in the southwestern part (Figure 12). This discovery attracted considerable interest, and over 500 exploration licences were acquired in the area.

The three main ice-flow movements observed in the Bienville area, in the vicinity of the picroilmenites, are shown in Figure 12. The most recent movement has a N260° direction. It produced a prominent west-directed dispersal train from sediments of the Sakami Formation. An intermediate movement is directed towards the northwest, but its impact on small sources such as kimberlites is poorly defined. Early movements range from 360° to 035° (Parent *et al.*, 2002). The superposition of these three ice-flow movements may translate into the presence of relatively obtuse dispersal fans in the area (Parent *et al.*, 2002). Consequently, the sources of chrome picroilmenite grains may be located within an area to the east and southeast of each sample location.

CONCLUSIONS

The Lac Bienville area has long been considered as belonging to the Bienville Subprovince tectono-stratigraphic domain. Our work suggests instead that it lies at the boundary between the Minto and La Grande subprovinces. This interpretation is based primarily on the presence of lithostratigraphic units typical of the Minto Subprovince and on the occurrence of early gneisses of the

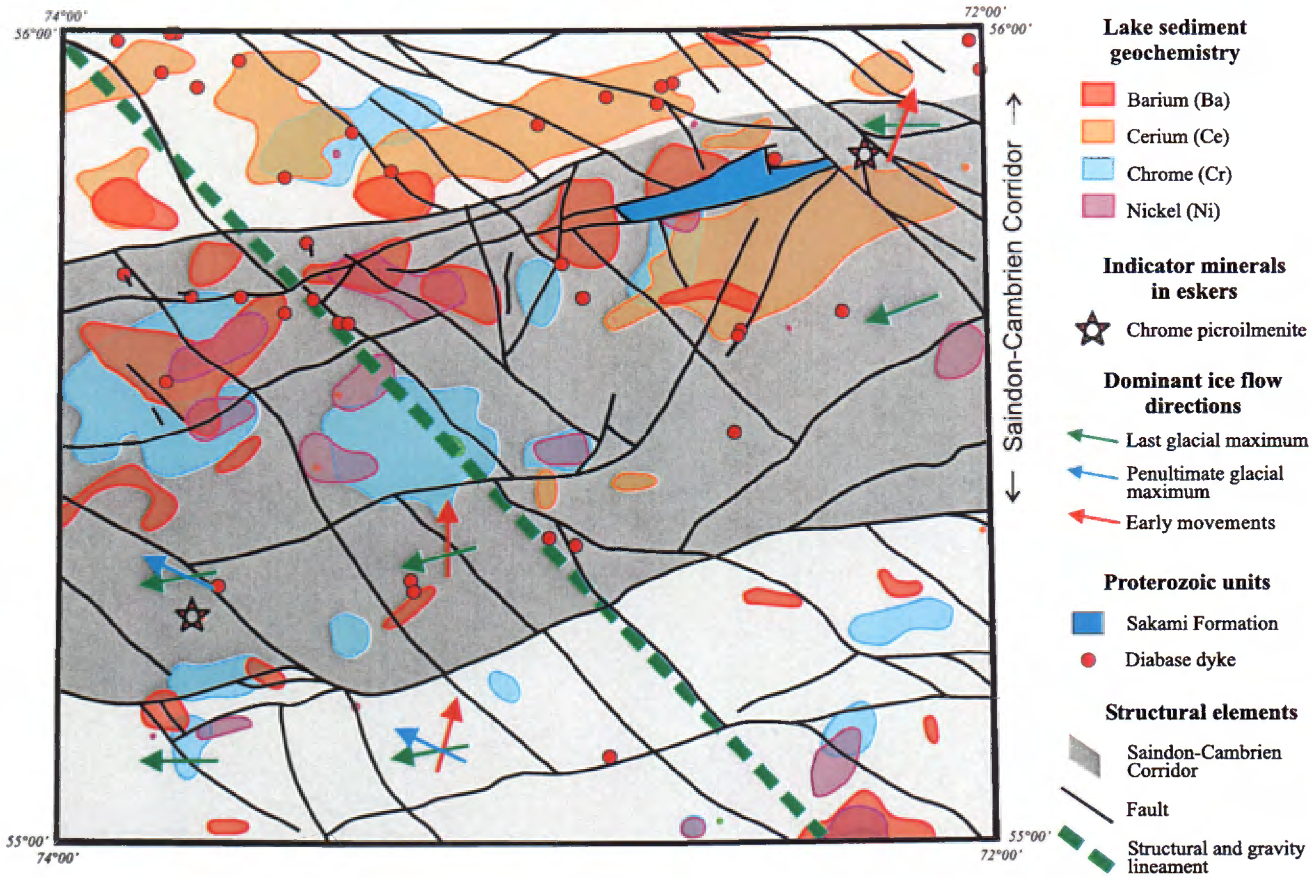


FIGURE 12 - Main diamond potential indicators in the Lac Bienville area (33P) and dominant ice flow directions taken from Parent *et al.* (2002). Geochemistry data modified from maps prepared by Marc Beaumier (MRN) using data derived from DP 98-01 (MRN, 1998).

Brésolles Suite (2.80-2.81 Ga) associated with the La Grande Subprovince.

Our study area is mainly composed of Archean units, with the exception of an outlier of sedimentary rocks of the Sakami Formation and of a few diabase dykes, all Paleoproterozoic in age. Archean rocks consist of: an early tonalitic gneiss suite (Brésolles Suite), an important assemblage of trondhjemite-tonalite-granodiorite (Favard, Coursolles, Desbergères and Maurel suites), an assemblage of granulitic rocks and pyroxene-bearing intrusions (Loups Marins Complex), mafic to ultramafic intrusions (Châteauguay Suite) and late units composed of granite (Tramont and Ossant suites) or diorite and monzodiorite (Turbar Suite).

The *Brésolles Suite* (Abre) (2811 ±4 and 2803 ±8 Ma; Table 1) is composed of gneissic tonalites and diorites cut by younger tonalitic to granitic injections. This suite is comparable in age and composition to certain units encountered in the La Grande Subprovince. It contains abundant mafic enclaves that probably represent the remains of volcanic rocks such as those assigned to the Gayot Complex, dated at about 2.86 Ga (Gosselin and Simard, 2000).

The *Favard Suite* (Afav) is composed of biotite trondhjemite and tonalite with an interpreted age of 2741±4 Ma in the Lac Bienville area. These rocks are invaded by a granodioritic fraction associated with a regional "granitization" phenomenon that affects the entire unit. This "granitization" translates into the presence of abundant granodioritic to granitic injections, estimated at 2713 ±2 Ma.

The *Coursolles Suite* (Acou) is composed of a dioritic unit (Acou1) and a heterogeneous unit of hornblende tonalite and granodiorite (Acou2). The latter is affected by a regional "granitization" phenomenon similar to that observed in the Favard Suite (Afav). The interpretation of regional isotopic data suggests that the Coursolles Suite is represented by two intrusive phases of similar compositions but different ages. The early phase, dated in the Loups Marins area, yielded ages of 2756 ±8 Ma and 2758 ±11 Ma (Table 1), whereas the late phase was respectively dated at 2718 +11/-8 and 2719 ±2 Ma in the Maricourt and Bienville areas.

The *Desbergères Suite* (Adeb) consists of biotite granodiorite, dated in the Loups Marins area at 2714 ±12 Ma. The composition and timing of this unit are both similar to the granodioritic fraction dated in the Bienville area and related to the "granitization" phenomenon that affects rocks of the Favard Suite (Afav). In the Maricourt area, the Desbergères Suite yielded an age of 2683 +4/-2 Ma, indicating that part of the granodiorites assigned to this suite may in fact belong to a later phase.

The Maurel Suite (Amau) is composed of granodiorites characterized by a megaphyric texture. It was dated in our area at 2707 ±5 Ma. However, more recent ages hovering around 2685 Ma were obtained in the Gayot and Maricourt areas. Similar to the Desbergères and Coursolles suites, the Maurel Suite (Amau) also includes two distinct intrusive phases. On a regional scale, it appears that intrusive phases associated with the Desbergères and Maurel suites are younger in the Gayot and Maricourt areas (2685 Ma) than in the Loups Marins and Bienville areas (2714 to 2707 Ma; Table 1).

The Loups Marins Complex (Alma) covers an extensive proportion of the map area. It is composed of a clinopyroxene unit (Alma1), generally peripheral to the orthopyroxene unit (Alma2; Figure 3). The clinopyroxene unit (Alma1) is subdivided into three sub-units comparable to certain major regional suites. These sub-units were emplaced or metamorphosed at pressure and temperature conditions corresponding to those of the upper amphibolite facies or the lower granulite facies. Sub-unit Alma1a is composed of tonalites and diorites considered equivalent to the Favard and Coursolles suites. Sub-unit Alma1b is composed of granodiorites equivalent to the Desbergères Suite, and sub-unit Alma1c is composed of megaphyric granodiorites. Alma1c replaces the Lussay Suite (Alus) described in the Loups Marins area (Gosselin *et al.*, 2001) and is considered to be equivalent to the Maurel Suite (Amau). Unit Alma2 comprises orthopyroxene-bearing intrusions mainly composed of hypersthene quartz diorite and enderbite. In our map area, isotopic analyses conducted on a hypersthene diorite sample of unit Alma2 yielded an age of 2720 ±2 Ma, whereas a similar rock sample yielded an age of 2694 ±3 Ma in the Loups Marins area (Table 1).

The Châteauguay Suite (Achg) represents relatively small mafic to ultramafic intrusions. They are mainly composed of gabbronorite, gabbro, hornblendite and pyroxenite. The distinction between these rocks and the more mafic phases of the Alma2 orthopyroxene unit is sometimes difficult to establish, both in the field and under the microscope. Considering the spatial association often observed in the field between the two units, it is possible that the two units are genetically related, in which case the Châteauguay Suite would represent a more primitive phase of orthopyroxene-bearing intrusions of the Loups Marins Complex.

The youngest Archean units are represented by the Tramont, Ossant and Turbar suites. The Tramont Suite (Atra) is composed of homogeneous biotite tonalite and pegmatitic injections. In the Lac Bienville area, Tramont granites yielded an age of 2701 ±4 Ma, and namely cut rocks of the Maurel Suite, dated at 2707 ±5 Ma. In the Gayot and Maricourt areas however, cutting relationships observed with the Maurel Suite, dated in these areas at about 2.685 Ga suggest a younger age for the Tramont Suite. The Ossant and Turbar suites (new units) are restricted to the southeastern part of the area and appear to be late; no cutting relationships or isotopic data has confirmed this however. The *Ossant Suite* (Aoss) consists of coarse-grained amphibole granite, whereas the *Turbar Suite* (Atub) is composed of coarse-grained diorite and monzodiorite with a distinctive perthitic feldspar component.

In the Lac Bienville area, five phases of deformation (D1 to D5) were identified. Relics of an early D1 phase of deformation are interpreted based on an older S1 foliation that affects enclaves enclosed in Brésolles gneisses. Phase of deformation D2 is responsible for the regional S2 foliation, which is the most penetrative structural feature in the area. Phase D3 was identified in a restricted area along the boundary between the La Grande and Minto subprovinces. This phase produced F3 folds with axial traces oriented NE-SW to ENE-WSW. These folds show no axial planar cleavage, and rework the S2 foliation. Phase D4 is responsible for the reorientation of the dominant regional structural trend to a NW-SE direction. It is associated with F4 folds with axial traces oriented WNW-ESE to NW-SE and a well-developed system of brittle-ductile faults oriented NW-SE. Finally, phase D5 is responsible for a system of poorly exposed late brittle faults oriented ENE-WSW to NE-SW. This system appears to control, at least in part, the Proterozoic Saindon-Cambrien collapse structure.

The overall regional metamorphic grade is the middle amphibolite facies, with the exception of areas underlain by rocks of the Loups Marins Complex, where metamorphic conditions range from the upper amphibolite facies to the granulite facies. Greenschist-facies retrograde metamorphism was locally observed, primarily along fault zones.

Our work led to the discovery of three mineral occurrences likely to stimulate interest in mineral exploration. The first two occurrences are respectively associated with an alteration zone in a tonalite and a shear zone with disseminated sulphides. The two yielded anomalous copper, gold and silver concentrations. The Sophie showing (0.36% Ni, 0.30% Cu, 103 ppm Co, 0.20 g/t Pd, 0.33 g/t Pt and 0.18 g/t Au) corresponds to a rusty zone that contains less than 5% disseminated sulphides (pyrite, pyrrhotite, chalcopyrite) hosted in a gabbro of the Châteauguay Suite. Mafic-ultramafic intrusions of this type represent prime targets for base metal exploration, as indicated by the Qullinaaraaluk showing (2.60% Ni, 1.80% Cu and 0.27% Co; Labbé *et al.*, 2000), located further north in the Lac Minto area.

The Lac Bienville area (33P) was identified by Moorhead *et al.* (1999; 2000) as one of the most promising for diamond exploration in Québec. Several key elements support this statement: 1) the area is located at the intersection of the Saindon-Cambrien corridor (SCC), the Kapuskasing tectonic zone and a major structural and gravity lineament, 2) the SCC corresponds to a Paleoproterozoic collapse basin in which outliers of sedimentary rocks are preserved (Sakami Formation), 3) in our map area, the SCC is cut by several subsidiary faults, 4) the presence of diabase dykes outlines a setting favourable for the emplacement of late intrusions, Proterozoic in age or younger, 5) several anomalies in Ba, Ni, Cr and Ce were observed in lake sediments sampled in our map area, within the SCC. Furthermore, the discovery of chrome picroilmenites (kimberlite indicator minerals) in two fluvioglacial sediment samples (Parent *et al.*, 2002) greatly enhances the diamond potential of the Lac Bienville area (33P).

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Abstract

This report presents the results of a geological survey carried out in the summer of 2001 at the 1:250,000 scale. It covers the Lac Bienville area (NTS 33P), located 360 km northeast of Radisson. This area was previously interpreted as underlain by the Bienville geological Subprovince. Based on the results of our survey, it appears located along the boundary between the Minto and La Grande subprovinces.

The Lac Bienville area (33P) is mainly underlain by Archean units, with the exception of an outlier of sedimentary rocks of the Sakami Formation and a few Paleoproterozoic diabase dykes. The La Grande Subprovince is essentially represented by the *Brésolles Suite* (2811 ±4 Ma), composed of early tonalitic gneisses. The Minto Subprovince covers most of the area. It includes a trondhjemite-tonalite-granodiorite (TTG) intrusive series, composed of four lithodemic suites: the *Favard Suite* (2741 ±4 Ma) which consists of biotite trondhjemite and tonalite, the *Coursolles Suite* (2719 ±4 Ma) composed of hornblende tonalite and diorite, the *Desbergères Suite* (2714 ±12 Ma) including biotite granodiorite and granite, and the *Maurel Suite* (2707 ±5 Ma) characterized by megaphyric granodiorite. Tonalitic units are affected by a "granitization" phenomenon that translates into the presence of granodioritic injections, associated with the emplacement of younger granodioritic suites. Tonalitic units are also intruded by gabbronoritic and ultramafic rocks of the *Châteauguay Suite*. The *Loups Marins Complex* is also included in the Minto Subprovince. It is composed of an orthopyroxene unit, formed of hypersthene quartz diorite and enderbite, bordered by a clinopyroxene unit. The latter is divided into sub-units comparable to certain regional suites that were probably formed or metamorphosed at higher pressure and temperature conditions. All units described above are cut by late Archean intrusions of the *Tramont Suite* (2701 ±4 Ma) composed of biotite granite, of the *Ossant Suite* composed of amphibole granite, and of the *Turbar Suite* comprising coarse-grained monzodiorite and diorite.

In the map area, five phases of deformation were recognized (D1 to D5). Phase D1 corresponds to a relic foliation preserved in enclaves of early rocks. Phase D2 is the most important. It is responsible for the S2 foliation which represents the most penetrative structural feature in the area. Phase D3, which produced F3 folds with axial traces oriented NE-SW to NNE-SSW, is restricted to the boundary zone between the La Grande and Minto subprovinces. Phase D4 is responsible for the formation of F4 folds with WNW-ESE to NW-SE axial traces as well as a system of brittle-ductile faults oriented NW-SE. Finally, deformation D5 generated a set of late brittle faults oriented ENE-WSW. This system appears to control the Proterozoic Saindon-Cambrien collapse structure.

The regional metamorphic grade corresponds to the middle amphibolite facies throughout the map area, except within the Loups Marins Complex where metamorphic conditions range from the upper amphibolite facies to the granulite facies. Retrograde metamorphism at the greenschist facies is recorded locally, namely along fault zones.

Our work led to the discovery of the *Sophie showing* (0.36% Ni, 0.30% Cu, 104 ppm Co and 180 ppb Au), a rusty zone with less than 5% disseminated sulphides (pyrite, pyrrhotite, chalcopyrite) hosted in a gabbro of the Châteauguay Suite. The economic potential of mafic-ultramafic intrusions in the area was previously outlined in 2000 with the discovery of the *Qullinaaraaluk showing*.

The Lac Bienville area (33P) is very promising for diamond exploration. It occurs at the junction of three important structures: the Saindon-Cambrien corridor (SCC), the Kapuskasing tectonic zone and a major gravity lineament. Furthermore, the recent discovery of chrome picroilmenite grains in two samples of fluvioglacial sediments within the SCC further enhances the diamond potential of the area.

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