Current Research (1988) Newfoundland Department of Mines, Mineral Development Division, Report 88-1, pages 37-48

AN INVESTIGATION OF THE MARGIN OF THE LAC JOSEPH ALLOCHTHON, GRENVILLE PROVINCE, SOUTHWESTERN LABRADOR

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ABSTRACT

Mapping in 1987 was directed toward examining the boundary zone between the Lac Joseph allochthon and the stucturally underlying parautochthonous terrane of southwestern Labrador, and investigating an area around Lac Joseph within the allochthon proper. Mylonites derived from rocks in both the allochthonous and parautochthonous terranes were documented along the boundary zone, which separates the upper-amphibolite- to granulite-facies Lac Joseph allochthon (composed of polydeformed 1650 Ma, two-leucosome paragneisses and younger megacrystic granite and gabbronorite) from the greenschist- to upper-amphibolite-facies parautochthon (comprising metasediments of the Knob Lake Group, which contain a single leucosome in the areas of highest metamorphic grade, and which are intruded by gabbros and equigranular granite). Scarce kinematic indicators suggest that the allochthon was emplaced toward the north to northwest over the parautochthon. North of the Lac Joseph allochthon, an intrusive domain within the parautochthon has been identified; it is thought to be separated from the predominantly metasedimentary domain to the north by an intraparautochthon thrust.

In the Lac Joseph area, gabbros of the Shabogamo Intrusive Suite are bounded by high strain zones that form the contact with the surrounding allochthonous gneisses. These rocks are interpreted to be part of the parautochthonous terrane exposed in a structural window through the overlying Lac Joseph allochthon. Extensive retrogression of the mafic gneiss along the contact may be attributed to upward fluid migration during or after emplacement of the allochthon. Although critical radiometric dates are lacking, a model, consistent with available data, involves emplacement of the ca. 1650 Ma allochthon gneiss terrane onto the parautochthon (which was shortened internally by thrusting and folding) during the Grenvillian Orogeny.

INTRODUCTION

Recent work in southwestern Labrador has resulted in identification of a number of terranes within the Grenville Province that are thought to be parautochthonous and allochthonous relative to the Churchill and Superior foreland to the north and northwest of the Grenville Front (Rivers, 1983a; Nunn *et al.*, 1984; Rivers and Nunn, 1985; Rivers and Chown, 1986; Wardle *et al.*, 1986; and Thomas *et al.*, 1985) (Figure 1). These terranes were recognized through regional mapping and the subsequent realization that significant lithological, structural and metamorphic contrasts existed between terranes within this part of the Grenville Province. Aeromagnetic patterns were of use in the definition of the terrane boundaries. Radiometric investigations further revealed that gneisses within the allochthonous terranes, which were previously thought to have formed during the Grenvillian Orogeny, had developed during a previously unrecognized ca. 1650 Ma thermotectonic event termed the Labradorian Orogeny by Nunn *et al.* (1984), Nunn *et al.* (1985) and Thomas *et al.* (1985). The effects of the Grenvillian thermotectonism on the allochthons, if any, are still not understood. The 1650 Ma gneiss terranes are distinct from the parautochthonous and autochthonous terranes to the north and west in that, the latter two terranes, are thought to have been affected mainly by the Grenvillian Orogeny. In spite of regional mapping that has led to the identification of these terranes, there have been no detailed studies along the terrane boundaries.

During the 1987 field season, the author examined the boundary zone between the allochthonous Lac Joseph terrane and the underlying parautochthon in western Labrador, and compared rock types and the structural and metamorphic histories within each terrane. Four areas (labeled A–D in Figure 2) were selected along the boundary, as defined previously by regional mapping (Rivers, 1985a,b,c; Nunn and Christopher, 1987; and Wardle, 1982), where the exposure was sufficient to warrant a more detailed examination of the contact zone and the rock types on either side. Work within Area E (Figure 2) around Lac Joseph was performed in an attempt to explain the diminished aeromagnetic signature in the central part of the Lac Joseph allochthon.

REGIONAL GEOLOGY

The autochthon immediately to the north of the Grenville Front constitutes the southerly extension of the metasedimentary foreland of the Superior and Churchill provinces (Figure 1). Metasediments within the autochthon

This project is a contribution to the Canada–Newfoundland Mineral Development Agreement, 1984–1989

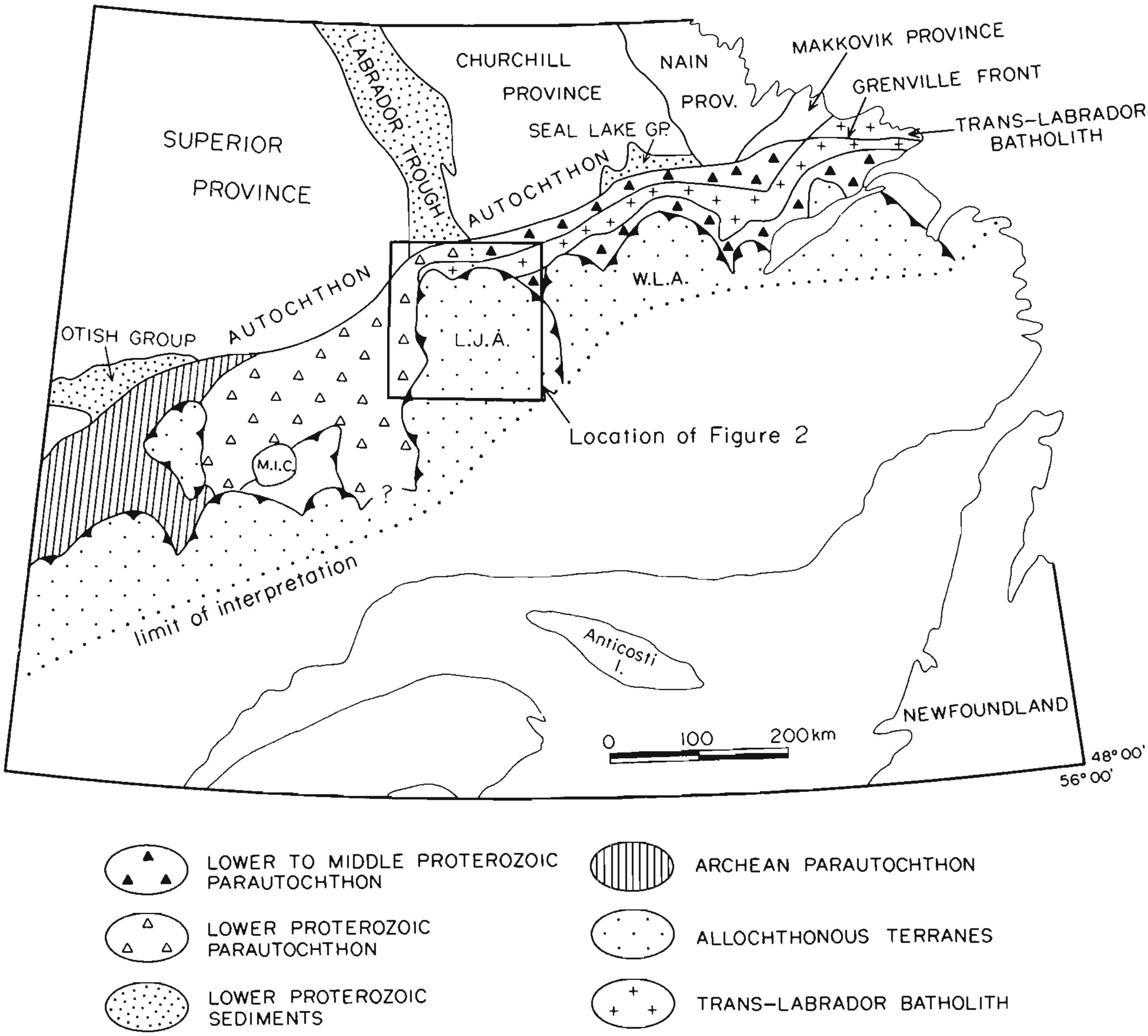

Figure 1. *Tectonic subdivisions of the Grenville Orogen in Labrador and Quebec. Lithological units that can be traced from autochthon to parautochthon are shown. L.J.A. –Lac Joseph allochthon (from Rivers and Chown, 1986); M.I.C. –Manicouagan Impact Crater; W.L.A–Wilson Lake allochthon.*

belong to the Kaniapiskau Supergroup of the Labrador Trough. These rocks are principally represented in the study area by the lower Knob Lake Group, a predominantly clastic and carbonate sequence with minor amounts of metavolcanic rocks. These metasediments have been intruded by the 1375 Ma gabbroic Shabogamo Intrusive Suite (Brooks *et al.*, 1981; Zindler *et al.*, 1981 and Dallmeyer, 1982).

The transition from autochthon to parautochthon toward the southeast is marked by the first significant thrust fault or major ductile shear zone (Rivers and Chown, 1986). The parautochthon, like the autochthon, is composed of rocks of the Knob Lake Group, middle Proterozoic granitic and basic intrusive rocks and minor sillimanite-bearing paragneiss. Metamorphic rocks within the parautochthon west of Ossokmanuan Lake (Figure 2), within the Gagnon terrane (Rivers *et al.*, *in press*), are thought to have obtained their tectonometamorphic imprint during the Grenville Orogeny. Within the parautochthon east of Ossokmanuan Lake (Churchill Falls terrane), sillimanite-bearing paragneiss is cut by Trans-Labrador batholith granite which is subsequently metamorphosed, indicating plutonism and metamorphism during both the Labradorian and Grenvillian orogenies. Grenvillian metamorphism within the parautochthon reached upper-amphibolite-grade conditions (Rivers and Chown, 1986).

The allochthonous terranes comprise Labradorian (ca. 1650 Ma) amphibolite- to granulite-facies paragneisses and younger basic and acid plutonic rocks. Models have been proposed (Nunn *et al.*, 1985; Rivers and Chown, 1986) in which it is envisaged that these terranes were emplaced on top of the telescoped parautochthonous terrane during the Grenvillian Orogeny. However, the concordant nature of the ca. 1650 Ma U–Pb dates from within the allochthon implies that the allochthons did not undergo extensive thermal reworking during the Grenvillian Orogeny (Nunn *et al.*, 1985).

RESULTS

Area A: Wabush–Ross Bay Junction

Previous work in this area by Rivers (1985b) resulted in the separation of a middle- to upper-amphibolite-facies metasedimentary terrane intruded by gabbroic and granitic rocks east of Labrador City (in the parautochthon) from an upper-amphibolite- to granulite-facies paragneiss–gabbro–granite terrane to the east (the Lac Joseph allochthon). A 50-km transect in this area between Labrador City–Wabush and Ross Bay Junction (Figure 2) was chosen because of the known occurrence of mylonites near the boundary between these terranes (T. Rivers, personal communication). Exposure within the boundary zone is patchy.

The two terranes within this area are lithologically, metamorphically, and, to a lesser extent, structurally distinct. Three significant lithological differences were observed:

1) granites within the allochthon tend to be megacrystic and may contain orthopyroxene whereas the parautochthonous granites are equigranular, muscovitic and biotitic, and are typically strongly foliated (Plate 1);

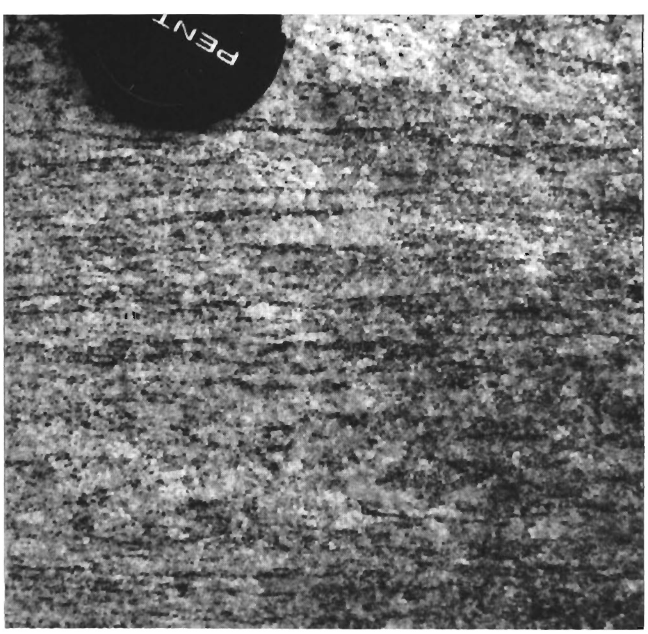

Plate 1. *Strongly-foliated, biotite granite from the parautochthon east of Wabush–Labrador City*

2) gabbros in the allochthon are typically extensively recrystallized and equigranular, but may be coarse grained to pegmatitic with primary igneous textures (Plate 2); the gabbros in the parautochthon are equigranular, variably deformed, garnet bearing and commonly exhibit corona textures (Plate 3); and

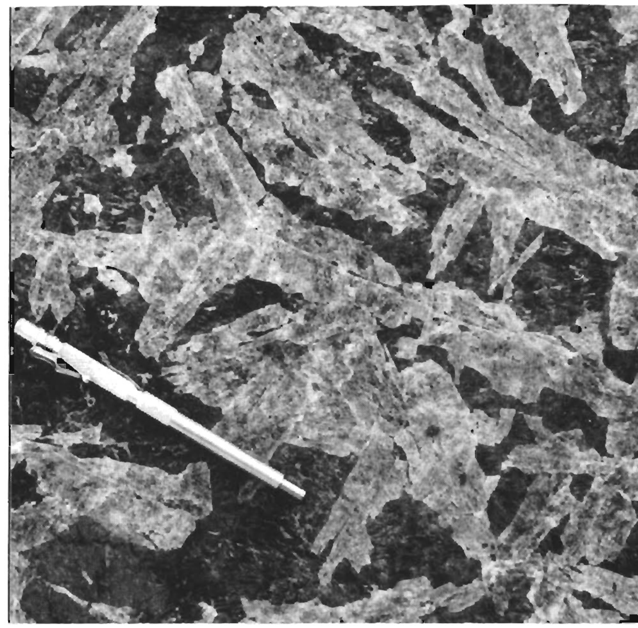

Plate 2. *Coarse grained gabbronorite from the Lac Joseph allochthon east of Ross Bay Junction.*

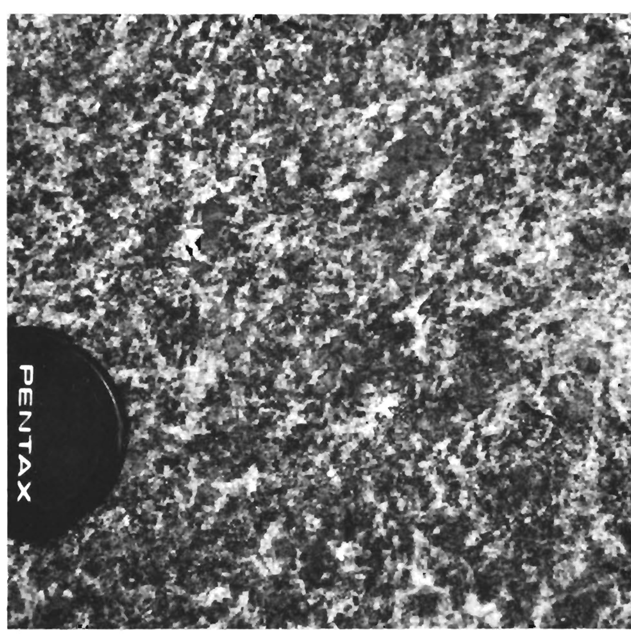

Plate 3. *Garnet-coronatic gabbro of the Shabogamo Intrusive Suite within the parautochthon east of Wabush–Labrador City.*

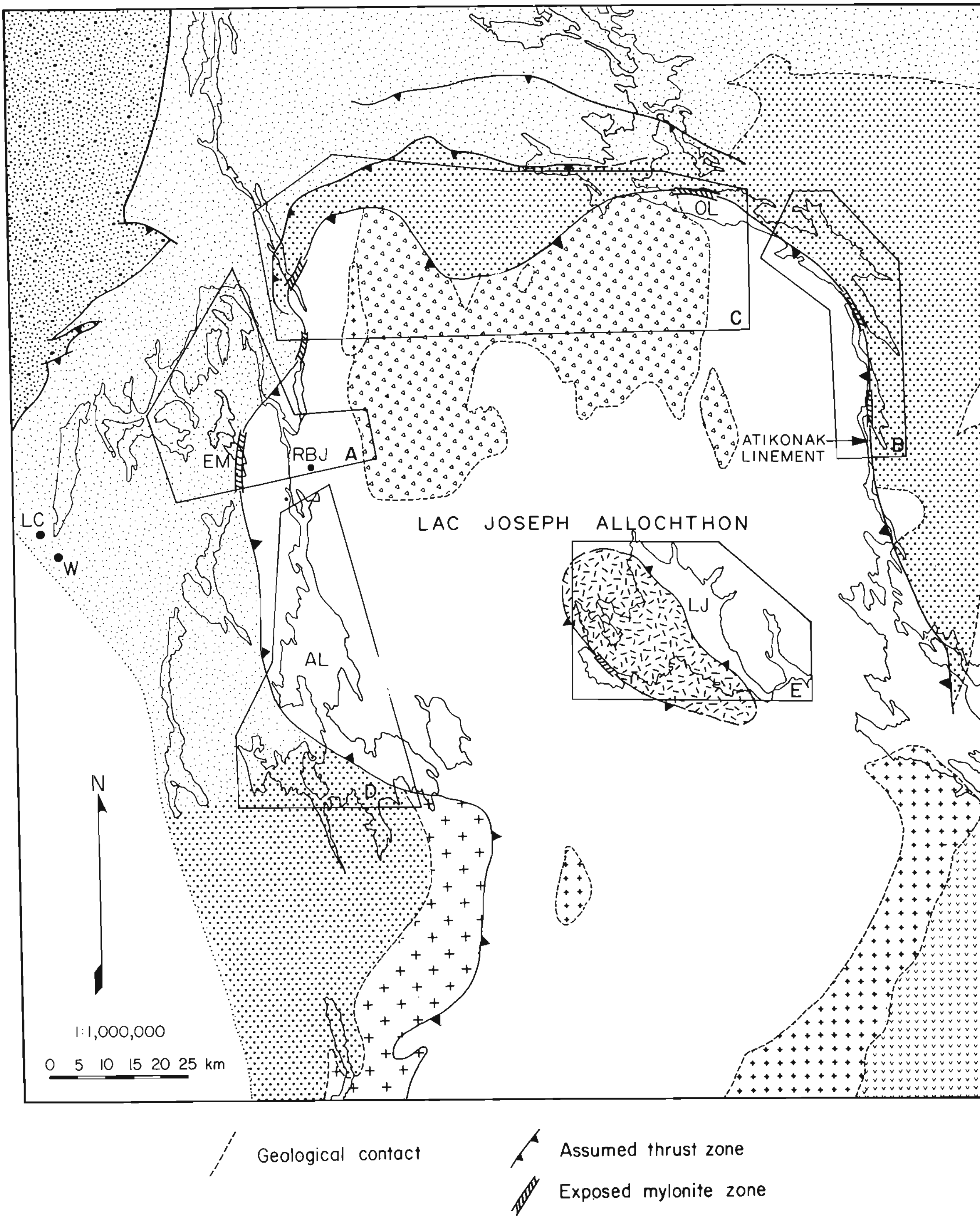

Figure 2. *Map showing simplified geology of southwestern Labrador and location of map areas labeled A–E. AL–Ashuanipi Lake; LE–Lac Emerillon; LC–Labrador City; LJ–Lac Joseph; OL–Ossokmanuan Lake; RBJ–Ross Bay Junction; W–Wabush. For location of map area see Figure 1.*

LEGEND

PARAUTOCHTHON

Granite; equiqranular, weak- to moderately-foliated

Shabogamo Intrusive Suite: *partially recrystallized and foliated gabbro with garnet corona texture*

Mixed granite, granodiorite, granitic orthogneiss and Shabogamo Intrusive Suite

Knob Lake Group: *pelitic metasediments, locally partially melted; intruded by Shabogamo Intrusive Suite and lesser amounts of granite*

LAC JOSEPH ALLOCHTHON

Granite; megacrystic and rapakivi-textured granite

Anorthosite

Gabbronorite to gabbro; recrystallized, locally foliated, fine to medium grained

Pelitic paragneiss; typically sillimanite-bearing restite interlayered with K-feldspar–plagioclase–quartz leucosome; interlayered with mafic gneiss and locally intruded by equigranular granite and gabbronorite

SUPERIOR PROVINCE

Ashuanipi Complex: undifferentiated gneisses

3) the allochthon is dominated by a homogeneous sillimanite–biotite–garnet–magnetite paragneiss unit that extends eastward beyond Churchill Falls, whereas the parautochthon comprises a supracrustal sequence that includes marble, psammitic and pelitic metasediments and mafic metavolcanic rocks.

Other distinctions of a structural and metamorphic nature include:

1) foliations within the parautochthon trend northwest due to a late cross-folding event, whereas fabrics within the Lac Joseph allochthon trend between north to northeast; and

2) the metamorphic assemblages in the pelitic supracrustal rocks within the respective terranes are distinct; the sillimanite–biotite–garnet–magnetite assemblage in restites is unique to the allochthon, in contrast to the biotite–garnet–hornblende± muscovite-bearing restite of the pelitic paragneisses within the parautochthon. Although a progressive increase in metamorphic grade toward the east could account for the different metamorphic assemblages (as was originally proposed by Rivers, 1983b), it seems unlikely that a prograde-reaction isograd would coincide with a boundary separating the lithologically and structurally distinct units. Moreover, the paragneisses in the allochthon commonly contain two distinct leucosomes, whereas in areas where the metasediments within the parautochthon have experienced partial melting, only one leucosome is recognized.

In spite of the discontinuous exposure within the boundary zone, several mylonite zones were observed. Near Lac Emerillon (Figure 2), Attikamagen Formation (lower Knob Lake Group) and granite have been mylonitized to form a northwest-trending straight belt about 100 m wide that is characterized by straight gneissic banding, ribbon quartz, extensive lineation development and pulled-apart pegmatitic dykes (Plate 4). This zone dips moderately to the southwest and is interpreted to have been affected by the late northwest-trending cross folds. After unfolding these mylonite layers about a northwest-trending, subhorizontal fold axis (assuming they are not overturned), scarce kinematic indicators (rotated feldspar and C/shear band relationships) imply that upper-plate rocks to the southeast moved northwestward over the parautochthon. Unmylonitized gabbro of the Shabogamo Intrusive Suite lies structurally above this mylonite zone; assuming that the mylonite zone formed coevally with the emplacement of the Lac Joseph allochthon, the presence of parautochthonous rocks above this shear zone implies that there must be an imbricated series of faults or shear zones which are collectively responsible for the emplacement of the allochthon rather than a single zone.

K-feldspar-megacrystic granite (locally rapakivi textured) occurs along the allochthon–parautochthon boundary. This unit, although highly strained, does not show mylonitic fabrics (Plate 5).

Rocks in the Lac Joseph allochthon close to the mapped boundary of the parautochthon do not show evidence of high strain. However, several outcrops about 11 km east of the boundary within the allochthon exhibit well-developed mylonitic fabrics, including C/S fabrics, shear bands,

Plate 4. *Mylonitized Knob Lake Group (dark bands) interlayered with granitic sheets along the margin of the Lac Joseph allochthon–parautochthon boundary near Lac Emerillon.*

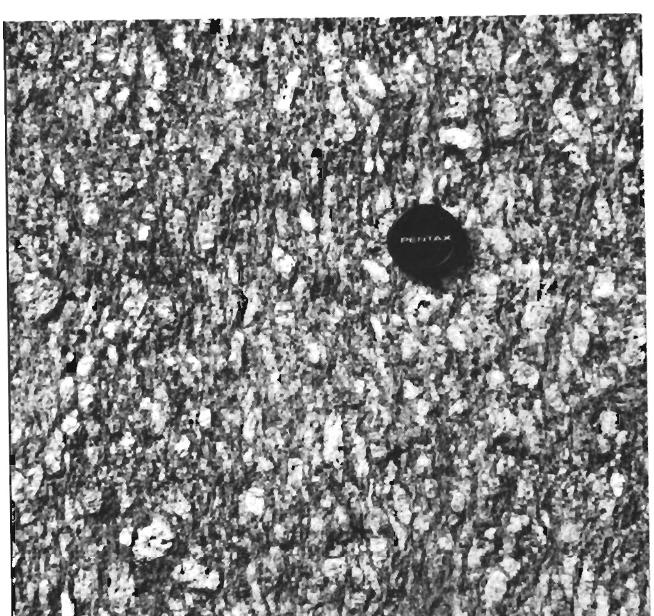

Plate 5. *K-feldspar-megacrystic granite along the Lac Joseph allochthon–parautochthon boundary north of Ross Bay Junction.*

slickensides, and asymmetrically pulled-apart pegmatites. Collectively, these indicate that the southeast block travelled northwest in a reverse motion.

Area B: Panchia Lake Area

Previous work by Nunn and Christopher (1987) and Wardle (1982) has resulted in the identification of the north-south-trending Atikonak Lineament (Figure 2) which separates a predominantly intrusive terrane with minor mixed supracrustal rocks (collectively comprising the parautochthon) in the east, from a paragneiss terrane that forms part of the Lac Joseph allochthon. Previous reconnaissance mapping along the poorly exposed lineament failed to correlate the lineament with high-strain rocks. However, a very low water level within Ossokmanuan Lake during the summer of 1987 has exposed outcrops that reveal locally developed, strongly deformed and mylonitized paragneiss (Plate 6), megacrystic granite and mafic gneiss along the Atikonak Lineament. This high strain zone is vertically dipping with a moderately plunging stretching lineation on the foliation surface. Kinematic indicators within this zone are poorly developed to absent, precluding speculation about tectonic transport direction. The present orientation probably reflects the effects of the latest folding event rather than the mylonite-forming event.

Plate 6. *Inhomogeneously mylonitized sillimanite-bearing paragneiss along the eastern margin of the Lac Joseph allochthon on Ossokmanuan Lake.*

The area immediately west of the high strain zone is mainly underlain by sillimanite-bearing paragneiss, typical of the Lac Joseph allochthon elsewhere, and subordinate amounts of megacrystic granite.

Within the parautochthon east of the high strain zone, granitoid orthogneiss (Plate 7) appears to have undergone at least one stage of deformation and metamorphism (grades up to upper-amphibolite facies). Mafic intrusive rocks range

Plate 7. *Granitoid orthogneiss within the Churchill Falls terrane of the parautochthon east of the Lac Joseph allochthon on Ossokmanuan Lake.*

from undeformed to moderately foliated. The plagioclase-, clinopyroxene-, garnet-, magnetite-bearing gabbro within this area is correlated with the Shabogamo Intrusive Suite on the basis of mineralogy and the coronitic texture.

Correlation of the deformation and metamorphism across the high strain zone is difficult. The granitic rocks may be traced from foliated granites of the Trans-Labrador batholith granitoid rocks in the lower grade areas to the north, into progressively higher grade and more highly deformed orthogneisses toward the south (Wardle, 1982; Rivers and Nunn, 1985). In the north, granitoid rocks have yielded U–Pb zircon dates of ca. 1650 Ma, an age typical of Trans-Labrador batholith rocks (Nunn *et al.*, 1985); in the higher grade areas, U–Pb analyses of zircons have yielded discordant ages with an upper intercept of 1650 Ma and a lower intercept of 993 Ma (no errors given, Rivers and Nunn, 1985). Some U–Pb ages from sphene are concordant at 998 Ma whereas others are discordant and yield upper and lower intercepts of 1653 and 993 Ma respectively (no errors given, Rivers and Nunn, 1985). The paragneisses within the Lac Joseph allochthon have not been dated within the map area, but are believed to have formed at 1650 Ma on the basis of ages obtained from comparable rocks (Nunn *et al.*, 1985) that do not show signs of subsequent thermal resetting. Collectively these dates suggest that the 1650 Ma paragneiss terrane of the allochthon may have been emplaced next to the 1650 Ma intrusive terrane, which was then reworked during the Grenvillian Orogeny at ca. 1000 Ma. This scenario requires that the allochthon and parautochthon experienced different metamorphic conditions during the Grenvillian Orogeny. Their present juxtaposition, together with the apparent metamorphic discontinuity, reinforces the interpretation that there is a significant tectonic break between the two terranes.

Area C: Northern Boundary of the Lac Joseph Allochthon: Map Sheets 23H/5, 6, 11(S), 12(S) and 23G/8 and 9

Map sheets 23H/11 and 12 and 23G/8 and 9 have been previously mapped by Rivers (1985b,c,d), but with a minimal amount of helicopter service available to cover the outlying areas. With increased helicopter support this past summer, reconnaissance mapping within important, but inaccessible, parts of this region has supplemented the original mapping. Map sheets 23H/5 and 6 had not been previously mapped by the Newfoundland Department of Mines.

This area may be divided into three distinct domains on the basis of rock types. The southern domain is thought to belong to the Lac Joseph allochthon whereas the two northern domains show lithological affinities with the parautochthon.

The southern domain, located in the map area covered by sheets 23H/5 and 6, and the areas immediately to the north and west, primarily comprises gabbronorite and gabbro, but includes subordinate amounts of sillimanite paragneiss. The gabbronorite suite ranges from fine- to medium-grained and is composed of plagioclase–clinopyroxene–orthopyroxene–magnetite±garnet±olivine. Plagioclase in the gabbro is typically recrystallized to a fine grained, granular matrix that hosts coarser grained mafic minerals. Sillimanite-bearing paragneiss is only locally exposed within the topographically lower, typically drift-covered areas. Rocks in this unit are similar to sillimanite-bearing paragneiss elsewhere in the Lac Joseph allochthon (i.e., see Area A above). The gneissic layering has been refolded into north- to northwest-trending isoclinal folds that have fold axes parallel to aligned sillimanite plunging moderately toward the southeast.

The central and northern domains of area C are thought to constitute the parautochthon. The central domain is underlain by medium grained gabbro and gabbronorite and muscovite–biotite granite, rock types that are typical of the parautochthonous terrane elsewhere (Connelly and Scowen, 1987). Most of the gabbroic rocks contain plagioclase–clinopyroxene–garnet–magnetite±orthopyroxene, commonly exhibit corona textures and have partially retained a primary igneous texture. Based on these criteria, this unit is correlated with the Shabogamo Intrusive Suite. A second gabbro unit, informally referred to as the Mount Fyne gabbro (G. Nunn, personal communication), is characterized by an unrecrystallized ophitic and/or cumulate texture and locally developed primary igneous layering. The age of this unit is unknown. The granite is equigranular, medium grained and is weakly to moderately foliated.

The northern domain, mapped in detail by Rivers (1985b,c), is distinguished from the central domain by the presence of abundant supracrustal rocks, ranging from pelitic schist to mafic metavolcanic rocks, and by a lack of granite. Rocks of the Shabogamo Intrusive Suite are common to both domains, and are present as fine- to medium-grained gabbro. The few metavolcanic outcrops within the northern domain appear to contain stable, syntectonic chlorite and actinolite. This upper-greenschist- to lower-amphibolite-facies subassemblage contrasts sharply with the upper-amphibolite-facies assemblage from within the paragneisses of the allochthon to the south. Unfortunately, the intrusive character of the central domain precludes comparisons of metamorphic facies.

The intraparautochthon boundary between the central and northern domains is not well exposed, however, a tectonic break is postulated for this zone based on the discontinuity of rock types across this line and the local presence of clearly mylonitized metasediments at the contact. C/S fabrics within this zone are consistent with the allochthon–parautochthon boundary fault zone, and indicate a reverse sense of south-side-up movement.

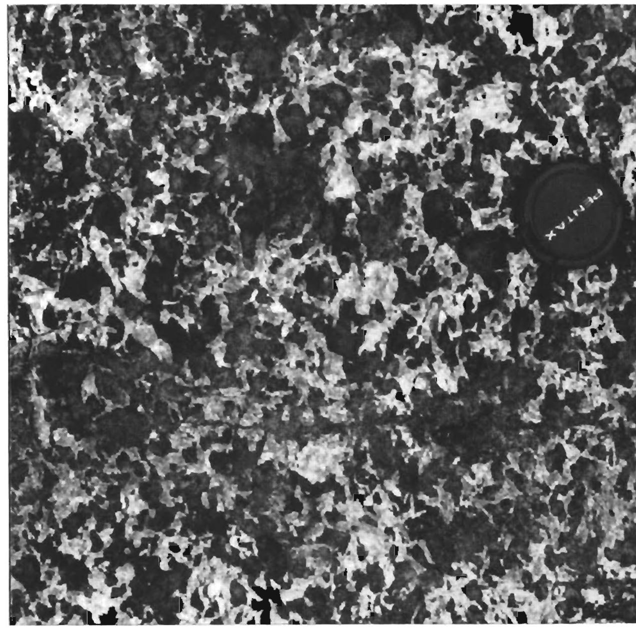

Plate 9. *Coarse grained gabbro of the Shabogamo Intrusive Suite along the northern shore of Ossokmanuan Lake at the boundary between the Lac Joseph allochthon and the parautochthon.*

The boundary zone between the allochthon and parautochthon is best exposed within the eastern part of map area C at Ossokmanuan Lake, where sillimanite-bearing paragneiss, gabbro of the Shabogamo Intrusive Suite and megacrystic granite are locally mylonitized and tectonically intercalated. The mylonitic fabrics vary in appearance and intensity according to rock type. Mylonitic layers within the paragneisses along the northern margin of the allochthon (Plate 8) are characterized by ribbon quartz, prominent stretching lineations on the foliation surfaces, pulled-apart leucosomes and rounded feldspar porphyroclasts. The mylonitic layers tend to be homogeneously developed over tens of metres. The mylonitized gabbro typically exhibits large strain gradients over several metres (Plates 9 and 10); in the zones of highest strain, plagioclase is extensively recrystallized and wraps around clinopyroxene porphyroclasts. Hinge lines of folds, developed within mylonitic layers, approach parallelism with the flow plane with increasing strain. Mylonitized granite, present as discrete shear zones within weakly deformed gabbro (Plate 11), contains ribbon quartz and plagioclase that wrap around K-feldspar megacrysts to form planar and linear fabrics.

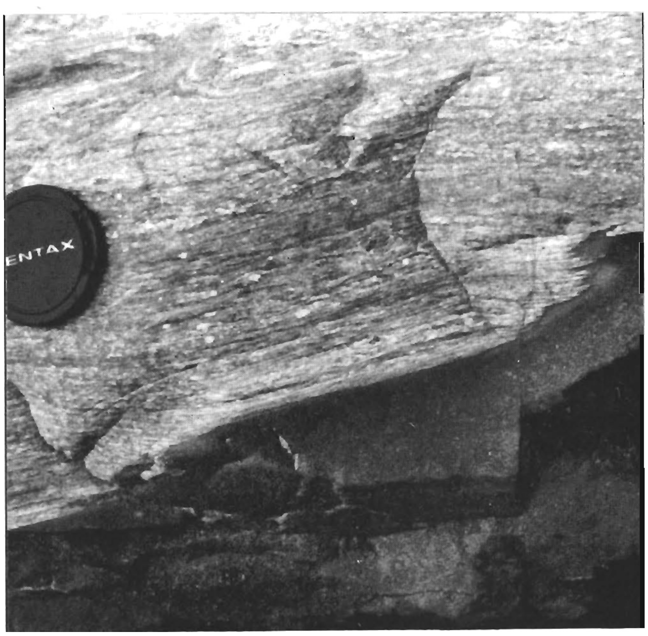

Plate 8. *Mylonitized sillimanite-bearing paragneiss along the northern margin of the Lac Joseph allochthon; the mylonitic fabric is cut by a gabbro dyke (bottom part of photoraph) of uncertain affinity.*

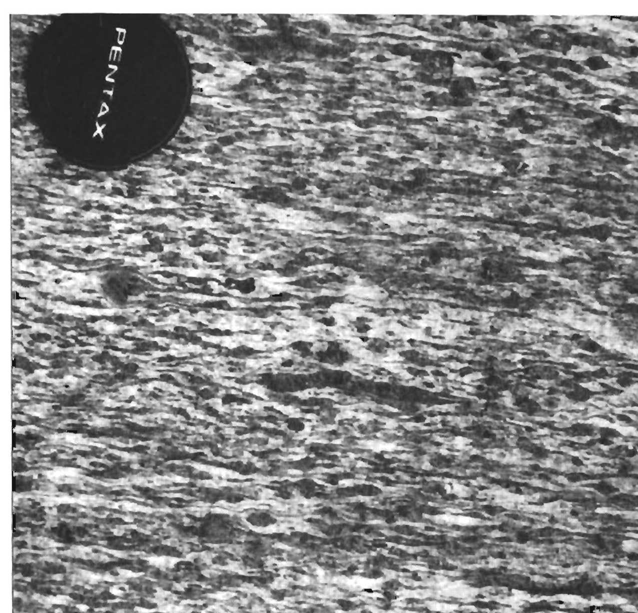

Plate 10. *A mylonitized equivalent of the gabbro shown in Plate 9, but photographed only 2.5 m away.*

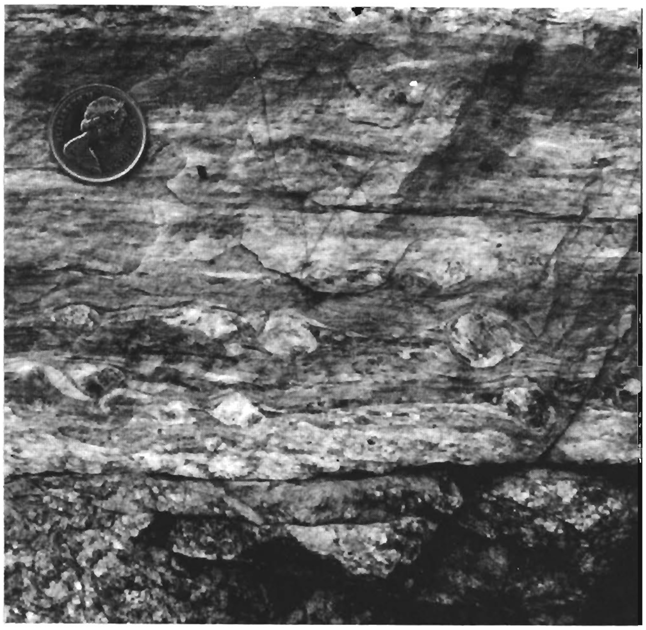

Plate 11. *Mylonitized megacrystic granite sheets within the gabbro along the Lac Joseph allochthon–parautochthon boundary on Ossokmanuan Lake.*

Mylonitic fabrics at several outcrops along the northern margin of the allochthon are cut by gabbronorite dykes (Plate 8). In these locations along the allochthon–parautochthon boundary, there are at least four possible affinities and ages of these dykes: 1) they may emanate from the gabbronorite bodies from within the allochthon; 2) they may be related to the Shabogamo Intrusive Suite from within the parautochthon; 3) they may represent late posttectonic diabase dykes, as yet unrecognized in this area; or 4) they may be related to the Mount Fyne gabbro, also from within the parautochthon. If either 1) or 2) is correct, the mylonites must have formed prior to the Grenvillian Orogeny. The uncertain age of the Mount Fyne gabbro or any potential late dykes precludes speculation about timing of the mylonitization, should scenarios 3) or 4) be correct.

Area D: Ashuanipi Lake

In spite of the extremely poor exposure within the Ashaunipi Lake area, this region was superficially examined in an attempt to correlate Rivers' (1985a) mapping in the 23B/16 and 23B/9 sheets with the mapping of Connelly and Scowen (1987) in the adjoining map sheets 23B/8 and 23B/1 to the south.

The northern part of the Ashuanipi Lake area is underlain by sillimanite-bearing paragneiss and a K-feldspar-megacrystic, rapakivi-textured granite, both typical of the Lac Joseph allochthon. Several outcrops of paragneiss examined on islands in the central part of the lake are reported to contain kyanite by Rivers (1983b). The occurrence of kyanite is atypical within the Lac Joseph allochthon where sillimanite is characteristic. The occurrence of kyanite along the western margin of the allochthon may indicate an increase in pressure from the centre of the allochthon toward the parauthochthon. This model is compatible with pressures in excess of 10 kbar within the parautochthon, which has been documented in preliminary P–T work by the author.

Toward the southern part of Ashuanipi Lake, gabbroic units are more voluminous and, in places, sillimanite-bearing paragneiss is absent. These gabbroic rocks vary in composition from gabbro to gabbronorite, and may be either unrecrystallized and massive, or recrystallized with garnet corona textures and with or without a tectonic fabric.

Several outcrops of layered metasedimentary rocks, thought to be part of the Knob Lake Group, occur within the southwestern part of Ashuanipi Lake. In contrast to the paragneisses to the north, these rocks have not experienced partial melting and appear to contain syntectonic chlorite and amphibole. The map of Rivers (1985a) shows these metasediments intruded by gabbro of the Shabogamo Intrusive Suite.

The association of upper-greenschist- to lower-amphibolite-grade metasedimentary rocks and Shabogamo Intrusive Suite gabbro suggests the southwestern part of Ashuanipi Lake is of parautochthonous affinity. Although the boundary is not exposed, the proximity of this lower-grade terrane with the terrane dominated by upper-amphibolite-facies paragneiss to the northeast suggests that a significant break may exist underneath the lake. This break would represent an extension of the boundary between the parautochthon and allochthon to the south suggested by Connelly and Scowen (1987). Mapping the location of the break is hampered by poor exposure and the uncertain affinity of the gabbro within the southern part of the lake.

Area E: Lac Joseph

With the limited availability of detailed mapping in western Labrador, the definition of the Lac Joseph allochthon margin has relied heavily on aeromagnetic surveys to supplement the reconnaissance mapping. The allochthon is characterized by high and locally variable magnetic intensities relative to the more subdued pattern characteristic of the surrounding parautochthon. In the Lac Joseph area, situated near the centre of the Lac Joseph allochthon, the characteristic high magnetic signature is flanked by a magnetic low to the northwest. Mapping within this well-exposed area was intended to investigate the occurrence of this atypical magnetic pattern and provide additional information about the paragneisses within the Lac Joseph allochthon.

The central part of Lac Joseph is underlain by an intrusive terrane consisting of medium grained, weakly to moderately deformed metagabbro to metagabbronorite comprising plagioclase–clinopyroxene–orthopyroxene–garnet–magnetite and very rarely olivine. The garnet occurs as rims on clinopyroxene and less commonly on orthopyroxene. Elsewhere orthopyroxene has clinopyroxene rims. The mineralogy and textures found within this unit implies that it is correlative with the Shabogamo Intrusive Suite gabbros of the parautochthon.

This central intrusive terrane is flanked to the east and west by sillimanite-bearing paragneisses and interlayered mafic gneisses. The sillimanite-bearing paragneisses exhibits two extensively developed, distinct leucosomes. An early grey leucosome is fine grained, biotite rich and typically foliated and lineated, whereas the later pink leucosome is coarser grained, contains less biotite and is commonly unfoliated. The restite comprises sillimanite–biotite–garnet–magnetite except near granitoid pegmatite veins where sillimanite is statically overgrown by muscovite.

A 500-m-wide continuous band of mafic gneisses underlies the area between the sillimanite paragneisses and western margin of the central intrusive domain. This zone contains relict orthopyroxene but is pervasively retrogressed to amphibolite-facies assemblages. Away from the central intrusive domain, small amounts of mafic gneiss are interlayered with sillimanite-bearing paragneiss, but these mafic gneisses do not appear to have been retrogressed.

The gabbro of the central intrusive terrane is never observed to intrude the gneisses in the adjacent terrane. Several outcrops along the terrane contact exhibit high strain features, such as ribbon quartz, feldspar porphyroclasts and anomalously straight banding (Plate 12). The presence in this area of gabbro of the Shabogamo Intrusive Suite, a unit that to date has only been found within the parautochthon, and the presence of the mylonitic high strain zone along the contact, suggests that the central part of Lac Joseph represents a small tectonic window (fenster) through the allochthon that exposes the structurally underlying parautochthonous terrane. Fluids necessary for the retrogression of the mafic gneisses that has occurred along the domain boundaries may have been derived from the parautochthon during the emplacement of the allochthon.

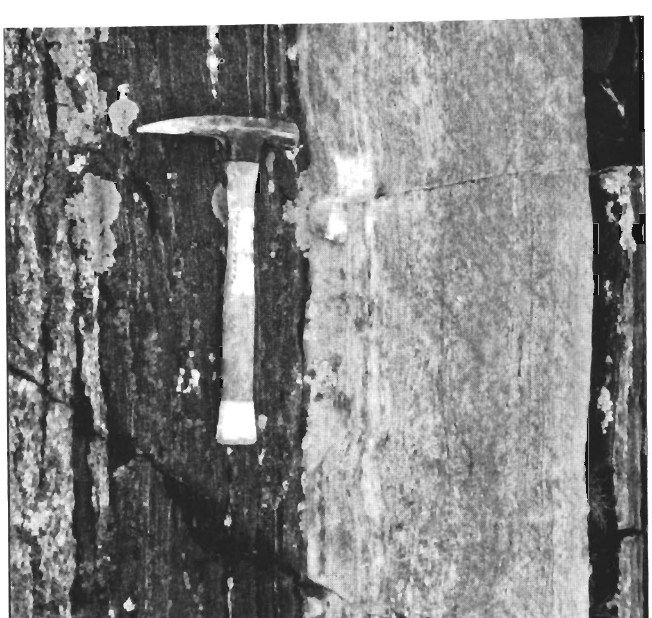

Plate 12. *Mylonitized mafic gneiss along the western margin of the window of the Shabogamo Intrusive Suite exposed at Lac Joseph in the centre of the Lac Joseph allochthon.*

Despite the identification of rocks of parautochthonous affinity in the Lac Joseph area, the surface distribution of rock types belonging to the respective terranes does not correspond to the aeromagnetic patterns. If the contact between paragneisses and the Shabogamo Intrusive Suite is shallow, as is likely, the magnetic patterns may reflect the subsurface distribution of the units.

DISCUSSION

The mylonites along the boundary between the Lac Joseph allochthon and the parautochthon tend to be narrow bands with variable orientations attributed to post-mylonitization folding. In order to determine a sense of relative motion from the relatively few unambiguous kinematic indicators in several outcrops, it is necessary to rotate the mylonitic layering about the local average fold axis–L lineation through the smallest angle such that the strike of the layering is perpendicular to the approximately horizontal fold axis after rotation; this method assumes that the layering has not been overturned. Results of this exercise suggest that the Lac Joseph allochthon moved northwestward to northward over the parautochthon.

The timing of the mylonitization and emplacement of the Lac Joseph allochthon is uncertain. A summary of the relevant information reveals that: 1) the paragneisses within the allochthon developed during the 1650 Ma Labradorian Orogeny; 2) the U–Pb systematics in the Lac Joseph allochthon were not reset during the Grenvillian Orogeny, indicating that the allochthon did not experience a major thermal event at that time; 3) although complicated by Hudsonian effects to the north and local Labradorian effects southeast of Churchill Falls, the main metamorphism within the parautochthon is thought to have occurred during the Grenvillian Orogeny on the basis of regional mapping (Wardle, 1982; Rivers, 1985a,b,c,d; Nunn and Christopher, 1987), partially or completely reset U–Pb systematics in zircon and sphene (Nunn *et al.* 1985; Rivers and Nunn, 1985), and growth of metamorphic sphene at this time (Nunn *et al.*, 1985; Rivers and Nunn, 1985); 4) the 1375 Ma Shabogamo Intrusive Suite is structurally deformed; and 5) there is a lack of any known 1650 Ma tectonothermal effects in the parautochthon west of Ossokmanuan Lake in the Gagnon terrane (Rivers *et al.*, *in press*). Given the present juxtaposition of the Lac Joseph allochthon and the parautochthon and the evidence that suggests that they apparently formed predominantly during two separate events, together with the restriction of the 1375 Ma Shabogamo Intrusive Suite to the parautochthon, it seems most likely that the allochthon was emplaced during the Grenvillian Orogeny.

The gabbro dykes crosscutting the mylonitic fabric within sillimanite-bearing paragneiss in shear zones along Ossokmanuan Lake are enigmatic. Although no gabbroic intrusions younger than 1400 Ma have been documented in maps of either terrane, T. Rivers (personal communication) has seen small posttectonic diabase dykes near Wabush. Thus, these dykes may correlate with them. Alternatively, these dykes may emanate from the presently undated Mount Fyne gabbro exposed east of the shear zone. However, until it can be shown that the dykes are related to post-Grenville magmatism, the possibility that this shear zone, or part of it, may predate the Grenvillian Orogeny must be borne in mind.

Within area C, the intrusive central domain to the north and northwest of the allochthon is abruptly replaced by metasediments of the Knob Lake Group and also gabbro of the Shabogamo Intrusive Suite. The abrupt contact at this location is interpreted to represent an intraparautochthon thrust, which may have formed coevally with the emplacement of the allochthon. This zone may merge with the main allochthon–parautochthon shear zone to the west, such that a more transitional boundary may exist between domains dominated by intrusive and supracrustal rocks west of Labrador City. The extension of this fault zone to the east through Ossokmanuan Lake is uncertain (see Figure 2); it may be overprinted by the Mount Fyne gabbro if this unit postdates the mylonitization as previously discussed.

The metamorphic affects on the Lac Joseph allochthon during its emplacement may be restricted to retrogression along the allochthon margins. For example, the amphibolite-facies retrogression in the mafic gneisses exposed near the parautochthon fenster of gabbro (Shabagamo Intrusive Suite) within the Lac Joseph area, and the local synkinematic retrogression of sillimanite to muscovite along the margins (Connelly and Scowen, 1987) may be attributed to the upward movement of hydrous fluids from the parautochthon into the allochthon during and after its emplacement. $^{40}Ar/^{39}Ar$ dating on the retrograde amphibole and muscovite will be attempted.

CONCLUSIONS

1. Rock types, metamorphic grade and to a lesser extent the structural styles within the Lac Joseph allochthon, are distinct from those in the adjacent parautochthon.

2. The presence of two distinct leucosome phases within paragneisses within the allochthon contrasts with the single leucosome typical of the areas within the parautochthon that have undergone partial melting. The later leucosome within the allochthon may represent a second pulse of melting during the Labradorian Orogeny or, alternatively, may have formed during the Grenville Orogeny. A sample of younger leucosome suitable for U–Pb dating has been collected.

3. Although generally poorly exposed, mylonite zones have been located at over 20 localities along the parautochthon–allochthon boundary. Field evidence suggests that the Lac Joseph allochthon was emplaced toward the north-northwest over the parautochthon along a series of shear zones rather than a single major shear zone. This fact, combined with the poor exposure, may explain the relative obscurity of mylonites in some exposed areas that are thought to be near or at the boundary.

4. Although the gabbroic units in the allochthon or parautochthon can be generally distinguished, those occurring along the northern margin of the Lac Joseph allochthon and in the Ashuanipi Lake area were not easily categorized in the field. Since the positioning of the allochthon boundary in areas of poor exposure depends largely on contrasting rock types, the location of the boundary in these areas should be considered tentative pending thin section examination and geochemistry.

5. Although the timing of the emplacement of the Lac Joseph allochthon is not dated isotopically, it must have occurred post-1375 Ma, the age obtained from the Shabogamo Intrusive Suite. The partial resetting of several U–Pb zircon and sphene dates from orthogneiss in the parautochthon to ca. 1150 Ma to ca. 1000 Ma and the generation of sphene at ca. 1000 Ma suggests that the allochthon emplacement probably occurred during the Grenvillian Orogeny. This does not preclude that some shear zones within the allochthon or near the margin may have formed originally at 1650 Ma.

6. The gabbro exposed within the Lac Joseph area is correlated with the Shabogamo Intrusive Suite, and is interpreted as a fenster of parautochthon underlying the allochthon.

ACKNOWLEDGMENTS

I am indebted to Kathy Manser for her competent assistance and friendship during the field season. The efforts of the accommodating staff at Ashuanipi Aviation of Labrador City went beyond the regular call of duty and are gratefully acknowledged. Gaetin Viens and Jacques Levesque of Viking Helicopters provided first rate helicopter service and were a pleasure to work with. Ken O'Quinn, Wayne Tuttle and Richard White are thanked for their efficient expediting on our behalf. Midseason visits to the field by G. Nunn and T. Rivers were extremely helpful and much appreciated. This paper benefited greatly from critical reviews by G. Nunn, P. O'Neill and T. Rivers.

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