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GEOLOGY OF THE UPPER ST. PAUL RIVER MAP REGION, GRENVILLE PROVINCE, EASTERN LABRADOR

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ABSTRACT

The St. Paul River map region comprises 1:50 000-scale NTS map areas 13B/01, 13B/02, 13B/07, and 13B/08. Rounded, spruce-covered hills interspersed with wetland clearings characterize the area, hence exposure is generally poor, except in the southwest where the vegetation cover is sparser due to old forest fires.

Rocks mapped can be classified into three main groups: i) metasedimentary gneisses, orthogneisses, foliated granitoid rocks and minor associated amphibolite, of late Paleoproterozoic or early Mesoproterozoic age, ii) the 1500 Ma Upper Paradise River AMCG intrusive suite, and, iii) foliated to massive granitoid plutons of suspected syn- to late-Grenvillian age (ca. 1050 to 950 Ma?). The metasedimentary gneisses are believed to be the oldest rocks present and are assumed to be Labradorian (1710 to 1600 Ma) or older. Sillimanite-bearing metasedimentary gneiss was discovered in the northwest corner and near the central-south margin. Other rocks of possible metasedimentary protolith include metasedimentary diatexite in the northwest corner and sporadic outcrops of 'anomalous-looking' granitic gneiss in the northern part that might be derived from an arenaceous protolith. The well-banded gneiss and foliated granitoid rocks show a continuum of fabrics suggesting that both are derived from a common igneous plutonic protolith. The rocks are overwhelmingly granitic, but minor granodiorite and quartz monzonite also occur. Well-banded orthogneiss is most common in the southwest and is interpreted to be the product of a deformational and metamorphic event that only had minor and sporadic effects farther north and east.

The Upper Paradise River AMCG intrusive suite consists of a core of monzonite, quartz monzonite, syenite, quartz syenite and granite surrounded by a 10-km-wide envelope of anorthosite, leucogabbronorite, monzogabbronorite, gabbronorite and metamorphosed derivatives. The present study completes mapping of this 5000 km^2 body.

One outcrop of massive, ophitic-textured diabase found in the northeastern part is interpreted to be a representative of the northeast-trending 1250 Ma Mealy dyke swarm.

Previously unknown, foliated to massive K-feldspar megacrystic granitoid rocks were mapped along the western boundary of the study area. Their age has not been determined, but the rocks are provisionally assigned to the third group of units. Delineation of several massive, unrecrystallized, granitoid plutons extending into the study area from previously mapped regions was completed, and other plutons were mapped that were only previously suspected from positive magnetic anomalies. These plutons are included as part of a suite of late- to post-Grenvillian plutons, already known to be widespread throughout southern Labrador.

The structural grain is northeast over most of the region, but a northwest-trending foliation, interpreted to be younger, becomes increasingly dominant toward the southwest. Metamorphic grade is at amphibolite facies. Mylonitic zones were seen locally, but their regional significance remains unknown. A northwest-trending linear magnetic feature separating the southwest district from the remainder of the region is interpreted as a major structural discontinuity of uncertain nature.

No mineral occurrences were found during mapping, but traces of pyrite in an amphibolite within the mafic to anorthositic envelope of the Upper Paradise River intrusive suite suggests that these rocks might have some potential.

INTRODUCTION

LOCATION AND MAPPING SCHEDULE

The Upper St. Paul River map region is situated in southern Labrador, 130 km from Goose Bay at its northwest corner and 220 km from Goose Bay at its southeast corner. Its southern boundary is coincident with the Labrador–Quebec border (Figure 1). The region includes 1:50 000-scale NTS map areas 13B/01, 13B/02, 13B/07, and 13B/08 (13B/southeast), collectively embracing an area of about 3700 km^2. Mapping in the region was carried out between June 10th and July 16th, 1999, as part of the continuing program of geological reconnaissance mapping in Labrador by the Newfoundland Department of Mines and Energy. In particular, this study forms part of a 4-year project to map NTS sheet 13B (*cf.* Gower, 1998, 1999). After completion of the 1999 mapping program (including the mapping of James and Nadeau, *this volume*), of the fifty 1:100 000-scale map regions in the Labrador part of the Grenville Province, only four and a half now remain unmapped.

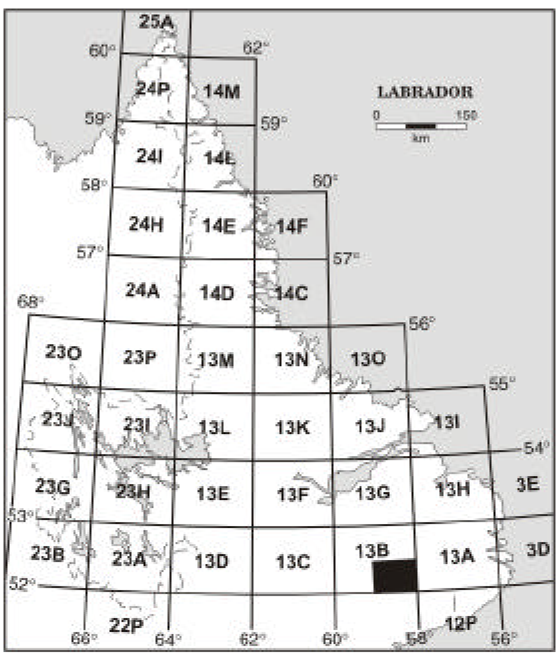

Figure 1. *Location of the Upper St. Paul River map region (NTS 13B/southeast) in Labrador.*

TOPOGRAPHY AND OUTCROP

The region topographically belongs to a 350- to 550-m-high dissected plateau that extends throughout most of interior southeast Labrador. The highest elevations in the area are in the northwest quadrant, where much of the terrain is over 500 m, reaching 588 m at one hilltop. Elevations exceeding 500 m are also achieved near the east and southeast corners, at 567 and 531 m, respectively. Most of the region is within the upper part of the St. Paul River drainage basin, but the western portion belongs to the northeastern headwaters of the St. Augustin River and small areas in the southeast form the headwaters of the Coxipi and Napetipi rivers. Very small sections in the northwest and extreme northeast, belong to the Eagle and Paradise rivers drainage basins, respectively. The Eagle and Paradise rivers discharge into Sandwich Bay and the remainder drain into the Gulf of St. Lawrence.

From an outcrop perspective, the dominant feature is a broad, convex-west, crescent-shaped region of wetlands, 6 to 10 km wide, extending from the northeast corner, sweeping through the centre of the map and then to the southeast corner. This region is devoid of any outcrop, except rare exposures along the banks of major tributaries of the St. Paul River. In the north, associated with the wetland, are several moderate-sized (less than 10 km long), shallow, boulder-filled lakes that are essentially the flooded flanks of the St. Paul River. Elsewhere, the wetlands are characterized by numerous, small, shallow lakes and ponds, surrounded by extensive string bogs and interspersed with low spruce-covered rises. Immediately west of the crescent-shaped wetlands region, especially in the central and southeast parts of the map region, exposure is also poor, despite moderately high elevations and varied topography. This is because bedrock is smothered in a blanket of hummocky moraine that has extremely variable thickness over short distances. In such terrain, rare exposures of bedrock exist (mostly in hollows), but are easy to miss, even from a helicopter. It is possible that a few more outcrops would be found in these areas with additional helicopter traversing.

In the remainder of the map region, exposure is poor to moderate in the northwest quadrant, moderate to good in the southwest quadrant, and moderate or poor along the eastern border. The northwest region is characterized by spruce-covered hills separated by numerous small to extensive marshlands. Exposure occurs in a variety of settings, including tops of hills, on their steeper slopes and adjacent to marshes, but is generally poor, being mostly lichen- and moss-covered. In contrast, in the southwest quadrant most of the forest cover has been destroyed in ancient fires leaving sparsely treed caribou-moss barrens and easy-to-spot, lichen-free outcrops (Plate 1). In the eastern section, outcrop is good in upland barrens in the eastern part of NTS 13B/08 and moderate in the heavily forested, somewhat rugged southeast corner of NTS 13B/01. It was possible to gain direct access to most outcrops by helicopter, or by short walks from the nearest clearing. Only in a few instances was it necessary to walk more than 200 to 300 m, but even a 200 m traverse to an outcrop in this region is very time-consuming, impeded as it is by thick undergrowth, abundant dead fall and uneven, moss-covered ground.

Plate 1. *Typical outcrop of lichen-free foliated granite in the southwest part of the map region where most of the forest cover was removed during ancient fires.*

Topography and vegetation are helpful (although far from diagnostic) guides to underlying bedrock. Orthogneiss, metasedimentary gneiss and foliated granitoid rocks typically underlie wetlands and associated intervening, spruce-covered, low, rounded rises. In contrast, mafic rocks tend to correlate with generally rounded, densely forested hills. Outcrops in these areas are found on forested hilltops, on the banks of large rivers, or, rarely, on lakeshores. Monzonitic rocks belonging to anorthosite–monzonite–charnockite–granite (AMCG) suites, are commonly well exposed on the tops of barren hills, which are separated by broad, densely wooded valleys. Heavily forested, steep-sided hills (or rock cliffs) capped by craggy outcrops are typical in areas underlain by late- to post-Grenvillian plutons. This topography reflects two main factors: i) the massive nature of the rocks, which has made them resistant to glacial erosion, hence they tend to remain as upstanding areas, ii) their coarse grain size and high feldspar content, which have made them more susceptible to crumbly (rapakivi) weathering, creating relatively favourable soil and drainage conditions for forest growth.

Mapping was carried out by helicopter, augmented by two guest traverses by visitor Staci Loewy (*see* acknowledgments). During 5 weeks of mapping, 389 data stations were established, a slightly higher rate of data acquisition compared to that achieved in 1997 and 1998 during mapping of the Upper Eagle River and Crooks Lake map regions (Gower, 1998, 1999). This represents a major advance on the 7 structural observations from this area recorded on the map of Eade (1962). Samples were collected from all data stations, slabbed and then stained to assist in the identification of potassium-bearing minerals, as well as more effective examination of textures. Samples have also been submitted for petrographic, geochemical and geochronological analysis.

PREVIOUS WORK

The only previous published non-derivative geological map that includes the region, is the 1:506 880-scale map of Eade (1962). Despite the cursory nature of Eade's map, three key elements were captured, namely orthogneisses in the southwest, monzonite in the northeast and the remainder of the area underlain by foliated granitoid rocks, a subdivision to which present mapping has substantially changed and added, but not fundamentally rejected.

Geological mapping at 1:100 000 scale has been completed to the northwest (Gower, 1999), north (Gower, 1998), northeast (van Nostrand, 1992; van Nostrand *et al.*, 1992), and east (Gower *et al.*, 1993). The southwest, south and southeast regions (in Quebec) are included in the 1:250 000 compilation map of Avramtchev (1983), which is partly based on unpublished mapping by Roy in 1982. The area to the west is scheduled for mapping during the 2000 field season. Aeromagnetic coverage of the region is available at 1:63 360 scale (Geological Survey of Canada, 1974a,b, 1976a, b) and 1:250 000 scale (Geological Survey of Canada, 1976c) as uncoloured maps, and as a coloured magnetic anomaly map at 1:1 000 000 scale (Geological Survey of Canada, 1985). Shaded-relief coloured aeromagnetic maps based on the Geological Survey of Canada data are available at 1:250 000 and 1:100 000 scale from the Newfoundland Department of Mines and Energy. The study area is also included as part of the 1:500 000 Bouguer anomaly map for Battle Harbour–Cartwright (Thomas, 1974), a regional lake-sediment and geochemical survey for NTS map area 13B (Friske *et al.*, 1994) and a regional surficial deposits study of southern Labrador (Fulton *et al.*, 1975).

Poor access, poor exposure and lack of geological information have discouraged mineral exploration in the region. The area attracted no attention during the 1994 to 1995 Labrador staking rush.

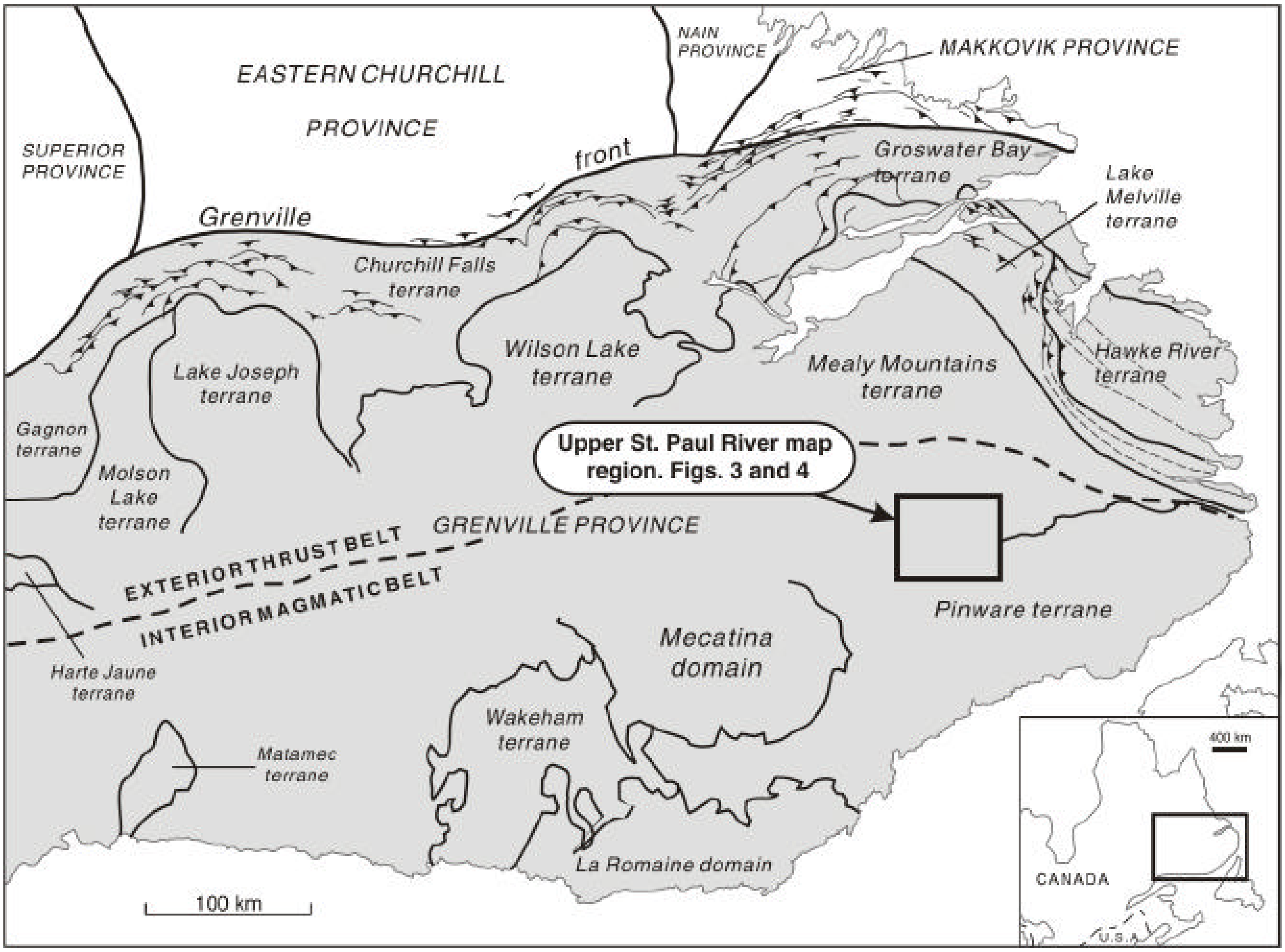

Figure 2. *Geological context of the Upper St. Paul River map region in the eastern Grenville Province.*

REGIONAL GEOLOGICAL SETTING

The region is situated in the Mealy Mountains and/or Pinware terranes (the boundary between the two being undefined in this region) within the Grenville Province in eastern Labrador and belongs to the Interior Magmatic Belt of Gower *et al.* (1991) (Figure 2). Geochronological data are currently unavailable for the area, but, by inference from adjacent regions, most rocks are believed to be late Paleoproterozoic or Mesoproterozoic. A geological map of the region is presented as Figure 3 and a shaded-relief aeromagnetic map, from which geological boundaries are partly interpreted, as Figure 4.

In broadest terms, rocks within the map region can be divided into three major groups. The first group comprises foliated granite and granodiorite, well-banded gneissic compositional equivalents, and minor remnants of metasedimentary gneiss and amphibolite. These are suspected to be Paleoproterozoic or early Mesoproterozoic. The second group embraces rocks assigned to the Upper Paradise River AMCG intrusive suite emplaced at 1500 Ma (Wasteneys *et al.*, 1997; *see* below for details). The third group includes granitoid plutons emplaced during or immediately after Grenvillian orogenesis. The only rocks not included in the above groups are metamorphosed and unmetamorphosed, recognizable mafic dykes. No geochronological studies have been carried out in the map region, so ages assigned to these three groups are preliminary, based on extrapolations from outside the area.

DESCRIPTION OF MAP UNITS

METASEDIMENTARY GNEISS

Rocks considered to have been derived from a metasedimentary protolith are divided into three types, namely: i) sillimanite-bearing pelitic gneiss, ii) quartz- and/or K-feldspar-rich ‘anomalous' gneiss, and, iii) metasedimentary diatexite. Of these, it is only the sillimanite-bearing gneiss for which a metasedimentary protolith is reasonably assured. The age of the rocks is uncertain, but is interpreted to be pre-Labradorian (pre-1710 Ma) on the basis of preliminary studies on potentially correlative metasedimentary gneiss in the Mealy Mountains terrane farther north (Krogh *et al.,* 1996).

Sillimanite-bearing metasedimentary gneiss was found at two localities – in the extreme northwest corner and close to its central-southern margin. The occurrence in the northwest corner was the more thoroughly examined of the two (Plate 2). It is a pink-, creamy- and black-weathering, medium- to coarse-grained, heterogeneous, schistose to well-banded gneiss, containing abundant sillimanite associated with biotite and garnet in melanosomes, and interlayered with pegmatitic leucosomes that are unusually quartz-rich. The significance of this outcrop is better understood in context with localities to the northwest (Crooks Lake map region; Gower, 1999) and north (Upper Eagle River map region; Gower, 1998). In the Crooks Lake map region, an isolated area of sillimanite-bearing metasedimentary gneiss was mapped (the only one in the whole region) 5 km from the southeast corner of the map region (i.e., the northwest corner of the Upper St. Paul River map region). In southwest corner of the Upper Eagle River map region, Gower (1998) mapped the rocks as granodiorite orthogneisses, but noted (p. 129, *op cit.*) that " a sedimentary protolith can be entertained for unusually heterogeneous gneisses in the southwest [corner] of the map region". He went on to mention that the only specific feature in favour of a metasedimentary protolith for these rocks is that they are unusually quartz-rich. With the subsequent discovery of sillimanite-bearing rocks elsewhere in the vicinity, the originally less-favoured option of an arenaceous protolith for those gneisses (versus granodioritic) can now be reconsidered to be the more probable.

The sillimanite occurrence near the southern (central) margin of the map region is a white- to slightly rusty-weathering, medium-grained, well-banded, quartz-rich pelitic gneiss, with which psammitic rocks and some quartz-rich diatexitic pegmatitic material are associated. An outcrop of orange-grey-weathering, medium-grained, well-banded, anomalously quartz- and biotite-rich granitic gneiss on strike 2 km to the southwest is also interpreted as perhaps having a sedimentary (arenaceous) protolith, in light of the nearby sillimanite-bearing gneiss.

The term ‘metasedimentary diatexite' is used by the present author for a white-weathering, texturally heterogeneous, aplitic to pegmatitic rock, commonly containing diffuse rafts of pelitic gneiss, spatially regionally associated with pelitic gneiss and considered to have been derived from it by extensive partial melting. Rocks fitting this description were found at two localities in the northwest corner of the map region. As is typical for such rocks, both contain garnet. In 1997, Gower wrote that one reason for not favouring a metasedimentary protolith over a granodioritic one for the gneisses in the southwest corner of the Upper Eagle River map region was that the characteristically associated white-weathering diatexite had not been found – now it has.

Four outcrops of quartz- and/or feldspar-rich ‘anomalous' gneiss are termed anomalous because they are atypical in their field context, being surrounded by foliated granite, rather than because they are especially distinctive rocks in their own right. All were described as well-banded, granitic gneisses in the field, and an arenaceous protolith was speculated for some of them at the time (e.g., Plate 3). Examination of stained slabs has strengthened support for a metasedimentary origin, particularly in demonstrating abnormally high quartz content, or sharply defined compositionally contrasting feldspar layers, or being unusually rich in biotite. That these rocks might have a common (sedimentary) protolith derives some credence from the fact that three of the four outcrops fall roughly along a line parallel to the regional northeast strike trend, which, if extrapolated in to the adjoining Upper Eagle River map region to the north, would also include an outcrop of sillimanite–garnet pelitic gneiss. The fourth outcrop is at the central–southern margin of the map region and is situated 2 km southwest of, and on strike with the sillimanite-bearing gneiss in the same area described above.

ORTHOGNEISS

Two types of orthogneiss are distinguished in the map region, namely granitic and granodioritic gneiss. The age of the protolith is uncertain but is assumed to be late Paleoproterozoic or early Mesoproterozoic, and to have been subsequently affected by Grenvillian deformation and metamorphism (*see* Gower, 1996 for regional geochronological background).

Granitic Gneiss

The granitic gneiss (Plate 4) is mostly pink-, pale pink-, creamy- or grey-weathering, but shades of white, orange, or red are locally present. Recrystallization is complete. The rocks are typically medium to coarse grained, less commonly fine to medium grained, and rarely pegmatitic. The diagnostic feature is a well-banded appearance, the banding being defined by both grain-size variation and compositional heterogeneity. Compositional banding varies from poor and diffuse, to obvious and continuous. It is expressed by biotite-rich veneers, narrow diffuse biotite- or hornblende-rich layers, quartz-feldspar leucosome and rare dioritic or amphibolitic lenses or bands. Concordant pegmatitic layers,

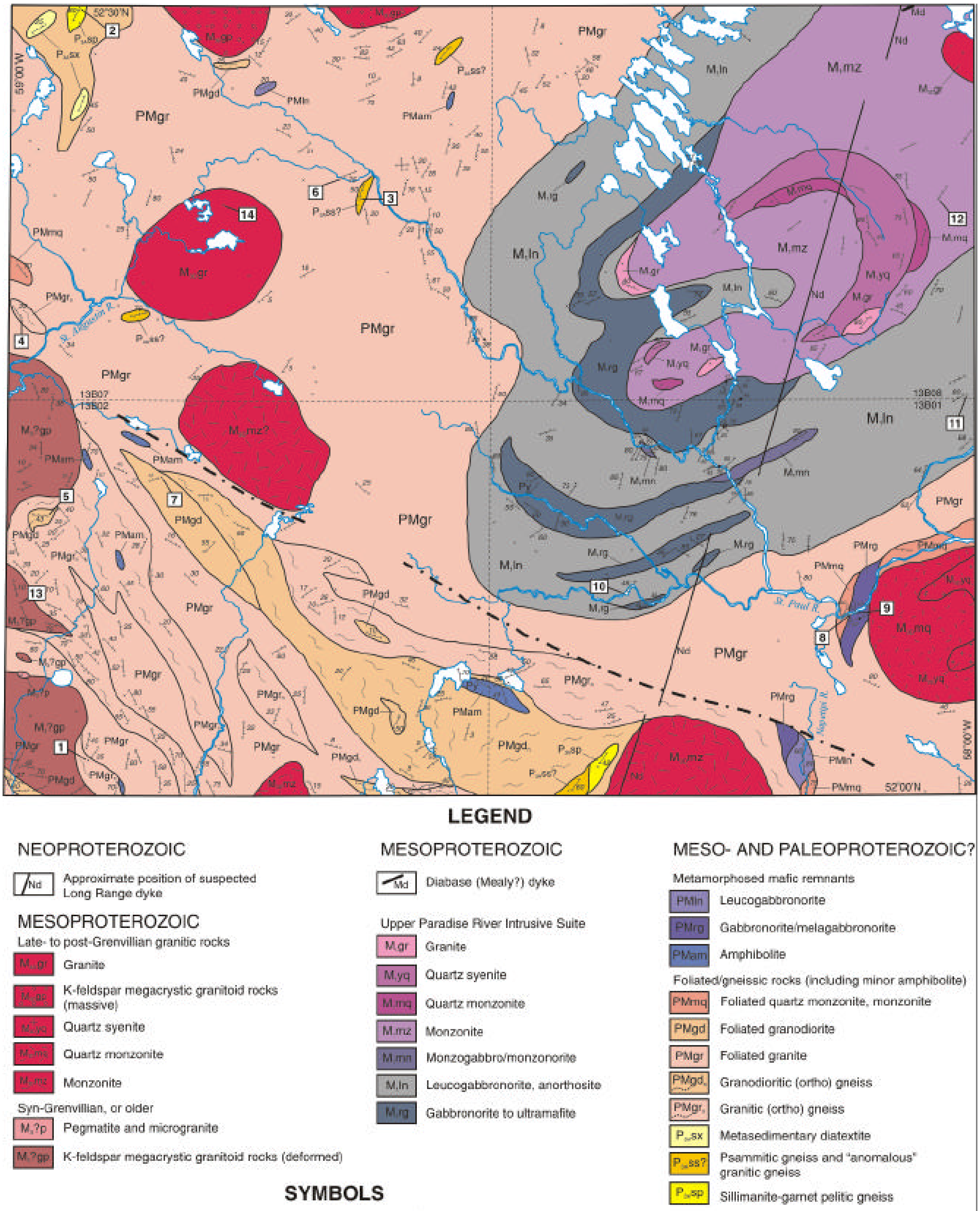

Figure 3. *Geological map of the Upper St. Paul River region. The boundaries of some units have been locally inferred from aeromagnetic data (cf. Figure 4).*

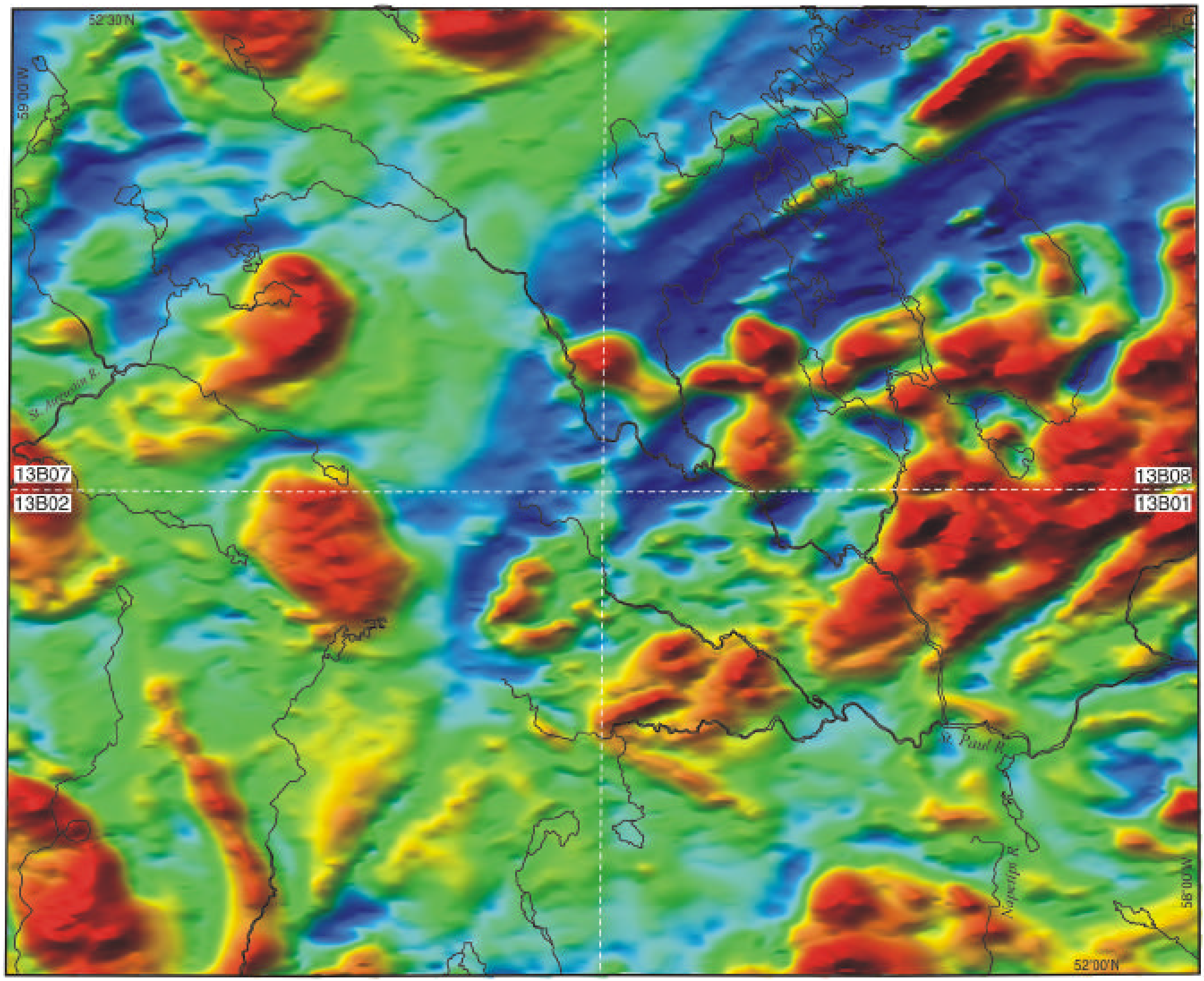

Figure 4. *Coloured shaded-relief aeromagnetic map of NTS 13B/southeast. Red end of spectrum – magnetic highs; blue end of spectrum-magnetic lows; map prepared by G. Kilfoil.*

and less-continuous pods or lenses also serve to accentuate the banding.

Granodioritic Gneiss

The distinction between granitic and granodioritic gneiss (Plate 5) is somewhat arbitrary as a continuum exists between the two. Nevertheless, map patterns suggest that there may be some distributional significance, so the subdivision has been retained pending more thorough assessment of the samples. Dominant weathering colours are pink and grey, although some outcrops were noted as white-, creamy-, red- or orange-weathering. In this respect, there would seem to be no difference between the granitic and granodioritic gneisses, but, grey-weathering shades are much more common in the granodioritic gneisses, reflecting lower K-feldspar content, subsequently confirmed by staining. Grain size varies from medium to coarse and the rocks are thoroughly recrystallized, generally well banded and have an overall inhomogeneous appearance. Granitic material (*sensu stricto*) occurs as concordant microgranite and pegmatitic layers, segregations and lenses, and as discordant irregular micrgranitic or pegmatitic veins. The dominant mafic mineral is biotite with hornblende present locally and garnet rarely. One outcrop was found in which granodioritic gneiss occurs as concordant layers within a foliated granite with sufficient lithological contrast to accept that they could be two genetically separate rock types (this locality has been selected for follow-up U–Pb geochronological study).

FOLIATED GRANITOID ROCKS

Granite

Granite showing variable fabrics ranging from massive to gneissose, but mostly moderately to strongly foliated (locally mylonitic), underlie much of the northwest, north–central and central parts of the map region. The rocks weather mostly to pink, pale pink, creamy, or white, although hues of buff, grey, orange, and red occur sporadically. Typically, the rocks are recrystallized, fairly homogeneous and medium to coarse grained (Plate 6), but departures from the norm include fine-grained, pegmatitic and seriate-textured rocks. There is sufficient textural variation to indicate that several different granitoid bodies are present, but the sparsity of outcrop and the scale of mapping precludes meaningful subdivision. The seriate texture is not well developed and none of the rocks in this unit can be described as megacrystic. The texture may have been produced by a porphyroclastic process, by which the larger original feldspars resisted polygonization and deformation. The gneissic variants (a minority) result mostly from variability of grain size, rather than compositional layering. The grain-size variability is the main factor in generating a gneissic appearance in those rocks in which it is present. The banding is typically lensy and discontinuous, and expressed by pegmatite or microgranite. In contrast to the previously described gneisses, it cannot be overemphasized that compositional layering or migmatization are not major factors in causing any gneissic fabric that might be present.

Plate 2. *Sillimanite–garnet metasedimentary gneiss.*

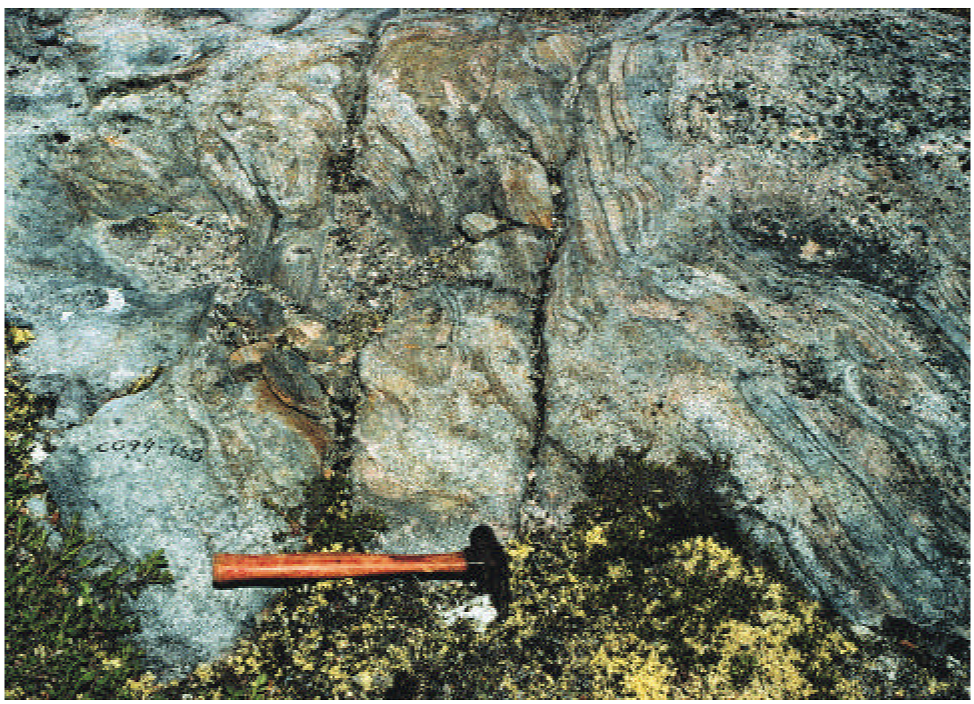

Plate 3. *Gneiss possibly derived from an arenaceous protolith.*

The mineral assemblage is straightforward, comprising mostly quartz, K-feldspar, plagioclase, biotite and magnetite. K-feldspar is normally in excess of plagioclase, and some of the rocks could be termed alkali-feldspar granite or quartz syenite. Hornblende is a common additional mafic mineral, but normally subsidiary to biotite. Hornblende is somewhat more common in rocks in the north–central area, than in those from the northwest. Garnet was seen at a few localities in the north part of the region. The garnets are small (generally less than 2 mm in diameter) and subhedral.

Discordant minor granitoid intrusions were recorded sporadically, but more commonly such intrusions are concordant to foliation and an integral part of the foliated granite unit. Diffuse and irregular contacts with the prevailing granitic host are typical. Biotite books up to 6 cm in diameter were seen in one pegmatite. Quartz veins and segregations, usually only a few centimetres wide and ten's of centimetres long, are also a feature of this unit. Mafic enclaves, up to 30 by 15 cms, within the foliated granites were seen at a few localities and consist of black-weathering, medium-grained, amphibolite invaded by quartz-feldspar veins. One foliated granite enclave within a less-foliated host granite was also recorded, which implies that not all the granitoid rocks have the same age.

Plate 4. *Granitic gneiss.*

Plate 5. *Granodioritic gneiss.*

Granodiorite

Pink- to grey-weathering, medium- to coarse-grained, foliated and recrystallized, but generally homogeneous granodiorite is a subsidiary rock type associated with the foliated granite. It shows most of the characteristics of the foliated granite, but is separated from it on the basis of visual estimates of K-feldspar:plagioclase ratios estimated both in outcrop and stained slab. Locally granodiorite is distinct enough to consider it to be genetically distinct from the granite, but, for the most part, it is little more than a variant simply containing less K-feldspar. Some mafic enclaves and later minor granitic intrusions are present (Plate 7).

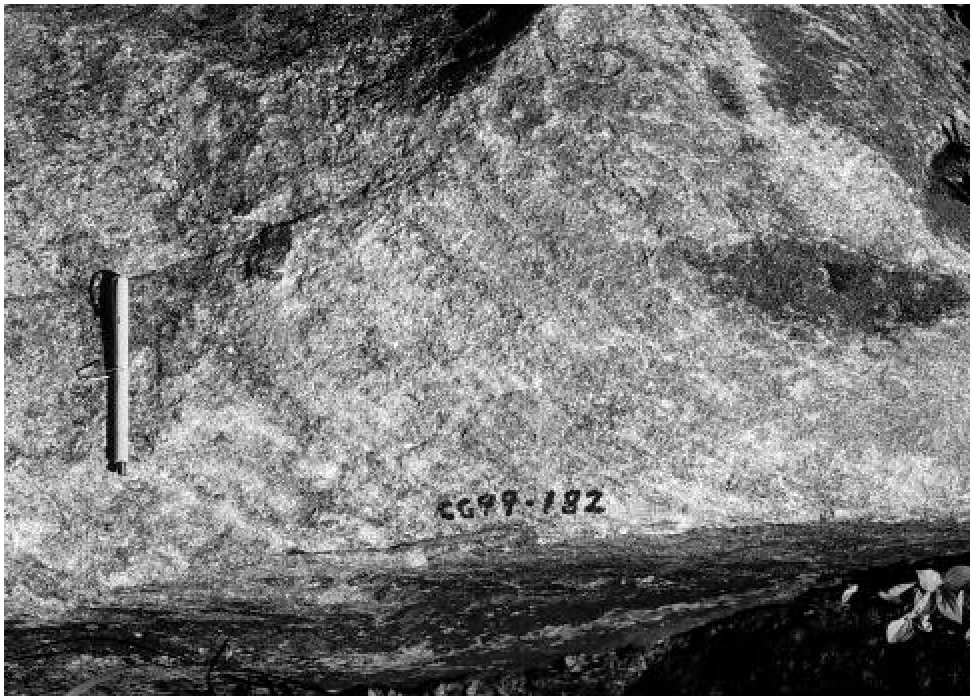

Plate 6. *Foliated granite.*

Plate 7. *Foliated granodiorite associated with mafic enclaves and later pegmatitic veins.*

Quartz Monzonite and Monzonite

Foliated monzonite grading into quartz monzonite and granodiorite occurs in the southeast part of the map region and is a continuation of similar rocks farther east mapped by Gower *et al.* (1993) in the Upper St. Lewis map region. The rocks weather pale pink and grey, are medium to coarse grained, recrystallized, strongly foliated, and grade into gneiss. Mafic minerals present are hornblende and biotite. Enclaves of fine-grained amphibolite up to 30 cm long were recorded at one locality, and interlayering of foliated monzonitic rocks with amphibolite and amphibolitic gneiss at another. The overall composition of the more homogeneous monzonite is similar to that in the Upper St. Paul River (northwest) monzonite introducing the possibility that it could represent the foliated margin of the pluton, but this interpretation is not encouraged as the fabric is much stronger than that typically seen at borders of the late- to post-Grenvillian plutons.

Amphibolite Associated with Foliated and Gneissic Granitoid Rocks

Black-weathering, medium-grained, weakly to strongly foliated amphibolite is a sporadic accessory rock type associated with both the foliated and the gneissic granitoid rocks. An anomalous compositional variant seen at one outcrop is a pale-grey-weathering, medium-grained, recrystallized, strongly foliated to gneissic diorite or metamorphosed leucogabbronorite. The rocks are mostly homogeneous, except for small, uncommon melt pods, which may contain pyroxene. Generally, the rocks are completely recrystallized, but diabasic texture is preserved locally and it is clear that the protolith was a mafic intrusion, although contacts with the granitoid rocks are now concordant. A hornblende–plagioclase mineral assemblage is typical, accompanied by some biotite and an opaque mineral. Some amphibolite is intruded by quartz-feldspar ± carbonate stringers or larger, discordant pegmatite dykes. Most of the amphibolite bodies are relatively small, only forming part of outcrops consisting mostly of granite or granodiorite. The only sizable body of amphibolite is situated in the southeast part of NTS 13B/02, where it appears to form a northwest-trending body about 4 km long.

Plate 8. *Well-banded amphibolitic gneiss.*

MAFIC ROCKS IN SOUTHEAST CORNER OF MAP REGION

Mafic rocks of diverse composition and fabric were found in two areas in the southeast part of the map region – on the St. Paul River and in the valley of the upper part of the Napetipi River. The rocks are black- to grey-weathering, fine to coarse grained, leucocratic to melanocratic and weakly to strongly foliated, or form well-banded amphibolitic gneisses (Plate 8). Compositions range from ‘leucodiorite' (probably metamorphosed leucogabbronorite) to ultramafite (Plate 9) and have mostly been metamorphosed to amphibolite facies. They contain irregular hornblende- and biotite-rich pegmatitic pods and layers, quartz-feldspar stringers, irregular hornblende-rich veneers and lenses, and show common evidence of shearing or grain-size comminution. The quartz-feldspar veins have either gradational or discordant contacts against the rocks in which they occur. Also present are enclaves and/or boudins of fine-grained amphibolite within coarser grained material. The rocks have a close spatial relationship with their enveloping granitoid rocks, interlayered with them as composite gneisses or having been injected by them in an irregular, anastomosing manner.

Plate 9. *Metamorphosed melagabbro.*

The impression obtained is that these rocks represent the remnants of a small layered mafic intrusion that has been extensively disrupted by deformation and invaded by granitoid material during a high-grade, partial-melting, metamorphic event. In this context, the rocks compare with ultramafic to monzogabbroic rocks in the southwest part of the adjacent Upper St. Lewis River map region (Gower *et al.*, 1993) and may well be the (discontinuous?) extension of them to the west, wrapping around the late- to post-Grenvillian Upper St. Paul River (northwest) monzonite. Such an interpretation is consistent with foliation trends in the district and foliated monzonitic rocks (in an area otherwise characterized mostly by foliated granitoid rocks), that are spatially associated with the mafic rocks. The more extensive metamorphism and invasion by granitoid rocks sets this package of rocks apart from compositionally similar units associated with the Upper Paradise River intrusive suite.

UPPER PARADISE RIVER INTRUSIVE SUITE

Rocks assigned to the Upper Paradise River intrusive suite are divided into two groups, namely: i) mafic to anorthositic units and, ii) monzonitic to granitic units. The mafic to anorthositic rocks form a 5- to 15-km-wide envelope around the southeast, southwest and northwest flanks of a monzonitic to granitic core. The spatial association between the two groups of rocks is taken as grounds for inferring a genetic link and for making the assumption that the mafic–anorthositic rocks have an age similar to granitoid rocks correlative with the monzonite and dated in the Alexis River map region to the northeast (1495 ± 7 Ma and 1501 ± 9 Ma, Wasteneys *et al.*, 1997).

Mafic to Anorthositic Rocks

The mafic to anorthositic rocks have been divided into the following units: i) gabbronorite grading into melagabbronorite and ultramafic rocks, ii) leucogabbronorite and anorthosite, iii) monzogabbronorite and, iv) hybridized border zone. Of these, the leucogabbronorite and anorthosite unit is the most abundant, with the gabbronorite to ultramafite unit being indicated as crescent-shaped areas within the leucogabbronorite. This depiction is undoubtedly highly oversimplified, only reflecting observed outcrops and from constraining boundaries to conform with the overall interpreted margins of the mafic to anorthositic unit. Along the St. Paul River, where outcrop is better, only one gabbronorite to ultramafic layer was mapped and this is merely about 30 m thick, and it seems likely that thin (preferentially exposed?) mafic layers might be the case in the forested areas also.

Gabbronorite to Ultramafic Rocks

Within the gabbronorite to ultramafic rock unit, strictly ultramafic rocks (less than 10 percent felsic minerals) are uncommon (about 5 to 10 percent of collected samples of this unit, including borderline cases), and no sample was collected that is completely devoid of plagioclase. Gabbronorite grading into leucogabbronorite (including metamorphic, amphibole-rich derivatives) is most usual. The rocks weather black, grey, brown, green, or, rarely, ocherous. They are mostly medium to coarse grained, although fine-grained variants are found. Very coarse-grained rocks were not seen. In a few samples, where primary textures are evident, the original igneous grain size is about 0.5 cm, but typically, the rocks have been moderately to completely recrystallized, although the polygonized outline of former larger primary grains can commonly be discerned. Fabric ranges from weakly foliated, homogeneous, igneous-looking rocks to strongly foliated equivalents and even well-banded mafic gneiss; weakly to moderately foliated rocks are most common, however. In the gneissic variants, banding is defined by melanocratic veneers/lenses and leucocratic layers, streaks and segregations. The melanocratic veneers tend to be made up mostly of hornblende and the leucocratic segregations to consist of plagioclase, sporadically accompanied by quartz and K-feldspar. Lenses and blocks of mafic material, either of contrasting composition or texture, are present locally, and may be entrapped representatives of earlier magmatic pulses. Vague-looking primary layering was noted at one locality, but variations in composition and texture from one outcrop to the next suggest that layering may be more widespread than the lichen- and moss-covered outcrops permit the eye to see. Gneissosity may also have preferentially developed in rocks already possessing primary layering. A few microgranite or pegmatitic veins intrude the mafic rocks, both concordantly and discordantly to the host-rock fabric. One outcrop, within an area mapped as mafic rocks, exposes solely pegmatite, except for a 3-m-long, 40-cm-wide enclave of metamorphosed melagabbro contained within it. In this instance, in the absence of more conclusive evidence, the composition of the enclave has been taken as representative of the dominant (unexposed) bedrock in the immediate surrounding vicinity. Ironically, this enclave (of undetermined source, of course) is the only rock in the mafic–anorthositic unit containing noteworthy sulphide (mostly pyrite, but possibly minor chalcopyrite).

The mineral assemblage consists mostly of pyroxene, plagioclase and lesser hornblende, accompanied by minor biotite, rare olivine in ultramafic rocks and opaque minerals. In a few rocks, opaque oxides (magnetic and probably titaniferous magnetite) are unusually abundant, forming up to 5 percent of the modal assemblage.

Leucogabbronorite to Anorthosite

The leucogabbronoritic (Plate 10) to anorthositic rocks are a continuation of similar rocks mapped by Gower *et al.* (1993) in the Upper St. Lewis map region. They weather white, grey, brown, buff, creamy and, rarely, pale pink, are medium to coarse grained, generally homogeneous, moderately to completely recrystallized, and have a variable fabric. A few rocks are massive, but weakly to moderately foliated is most typical, and strongly foliated, gneissic and mylonitic variants are also present. Textural variation includes rare occurrences of very coarse-grained rocks in which plagioclase crystals exceed 10 cm in length, and porphyroclastic rocks containing primary plagioclase ovoids in a fine-grained, recrystallized matrix. Anorthosite forms less than 10 percent of the unit (Plate 11). A few of the more metamorphosed rocks could be referred to as foliated diorite, but the collective lithological assemblage makes this name inappropriate. At a few sites, indistinct layering was seen, expressed more by differences in grain size than by compositional contrasts, although the latter do occur. Mafic enclaves, typically fine-grained amphibolite, are found sporadically, the largest being about 3 m long and 20 cm wide, but most are less than a few centimetres. A few quartzofeldspathic stringers and pink microgranite dykes, locally *en echelon,* intrude leucogabbronorite in places.

The mafic minerals are mostly pyroxene, accompanied by hornblende and lesser biotite in the strongly foliated and gneissic rocks. Plagioclase is typically the sole felsic mineral, but is accompanied by traces of K-feldspar (evident in stained slabs) in clusters of small, interstitial grains in some rocks. In hand sample, K-feldspar-bearing leuconorite can be mistaken for monzonite, as there is little mineralogical difference, beyond K-feldspar proportions. In correlative rocks farther east, Gower *et al*. (1993) observed partially retrograded garnet, but no garnet, retrograde or otherwise, was seen within leucogabbronoritic or anorthositic rocks in the Upper St. Paul River map region.

Monzogabbronorite

Monzogabbronorite associated with mafic–anorthositic rocks of the Upper Paradise River intrusive suite is rare. It is grey-brown- or buff-weathering, medium to coarse grained, homogeneous, and weakly foliated. It differs from the K-feldspar-bearing leucogabbronorite in having a higher colour index, higher K-feldspar, and perhaps higher hydrous mafic mineral content. Two outcrops consisting mostly of K-feldspar-rich mafic gneissic rocks having relatively high colour indices have also be grouped with this unit, but the K-felspar content in these examples is more likely the result of K-rich fluid introduction during deformation, rather than reflecting igneous crystallization.

Plate 10. *Metamorphosed leucogabbronorite, southwest Upper Paradise River intrusive suite.*

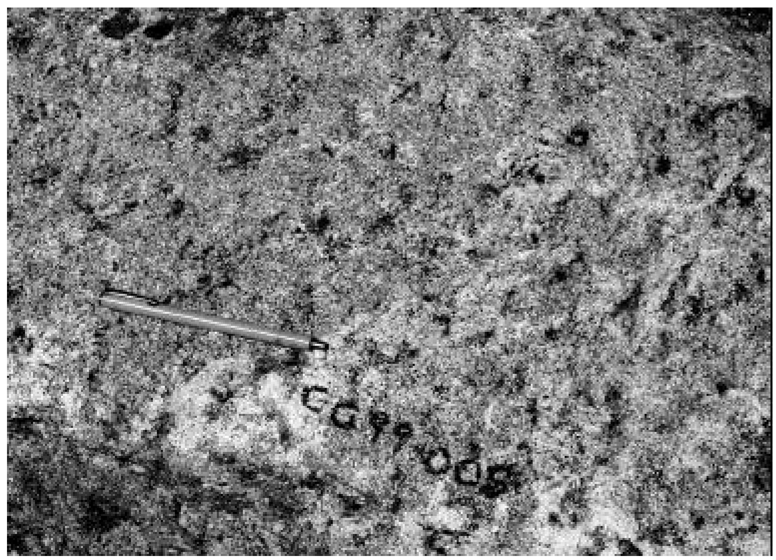

Plate 11. *Recrystallized anorthosite from the Upper Paradise River intrusive suite.*

Hybridized Border Zone

Two outcrops on the western side of the Upper Paradise River pluton are complex mixtures of amphibolitic, leucoamphibolitic and granitic rocks, and are here interpreted as representatives of the border of the mafic-anorthositic rocks that have been hybridized with the surrounding granitoid units. The mafic component occurs as irregular masses of recrystallized and migmatitic material, enveloped in inhomogeneous white to creamy granitoid material. The outcrops are isolated from both the granitoid rocks to the west and the mafic-anorthositic rocks to the east, so it was not possible to determine relationships to either.

Monzonite, Syenite and Granite

Of the three rock types that make up this unit, monzonite is by far the dominant, but the distribution of the other two contributes to the overall structural interpretation (see below).

Monzonite (including minor quartz monzonite)

Monzonitic rocks weather, buff, orange, grey, creamy or white, are characteristically severely weathered and very crumbly, and appear rusty on ‘fresh' surfaces (Plate 12). The rocks are mostly homogeneous and vary from massive to moderately foliated. They are partly recrystallized, commonly resulting in a fine-grained, recrystallized matrix enveloping euhedral to ovoid remnants of primary grey feldspar. Both K-feldspar (typically perthitic) and plagioclase are present and mantled-feldspar textures are common. The simplest and most common scheme is a subhedral to locally euhedral plagioclase core and a K-feldspar rim (p-k), but a K-feldspar core, surrounded by plagioclase shell and an outer K-feldspar rim is also common (k-p-k), and even more complex patterns are found (p-k-p-k and k-p-k-p-k). Mafic minerals occur in granular, interstitial clusters and comprise orthopyroxene, clinopyroxene and amphibole. In the more deformed rocks, plagioclase is ovoid and K-feldspar occurs as elliptical aggregates containing dispersed flecks of plagioclase. The opaque mineral is invariably magnetite. Neither enclaves nor minor granitoid intrusions were seen in the monzonite, and the only significant non-standard features are: i) a locally gneissic fabric near the southern margin of monzonite, implying that the boundary with the adjacent leucogabbronorite may be a zone of ductile deformation, and, ii) a suggestion that the monzonite in the northwest part of the unit is more melanocratic, contains more plagioclase and fewer composite zoned/mantled feldspars.

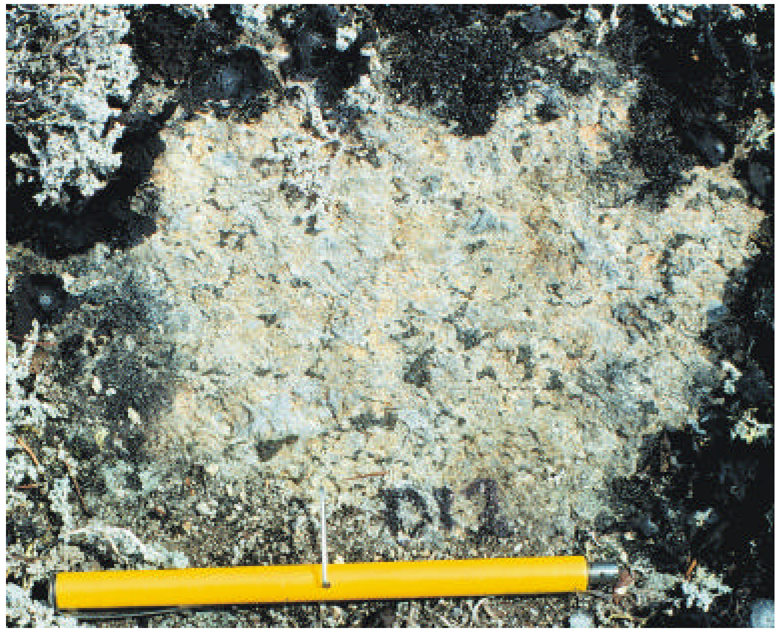

Plate 12. *Monzonite from the Upper Paradise River intrusive suite.*

Syenite (including minor quartz syenite)

Syenitic rocks represent little more than a compositional variant of the monzonite, showing the same weathering, outcrop homogeneity and grain-size characteristics. The main differences are the more common presence of minor quartz and decreased plagioclase abundance. Quartz occurs both as an interstitial phase and locally as phenocrysts up to 2 cm long and 0.5 cm wide. Plagioclase is sparse to non-existent, and in some rocks, stained slabs show it to be relegated to thin necklaces of recrystallized granules at K-feldspar grain boundaries. In these cases, it is probably albite derived by exsolution from perthitic K-feldspar. In syenite in which plagioclase is a significant phase, it tends to be associated with clusters of small mafic and opaque grains. A mafic enclave was recorded at one data station (CG99-040, UTM 424509 5801121; all UTM's in Zone 21).

Granite

A gradation to granite from the above two rock types is expressed by both quartz monzonite and quartz syenite, but neither rock type is common and true granite even less so, having only been recorded at three localities. Apart from higher quartz content, the rocks differ little in composition from their syenitic neighbours, and need only be regarded as slightly more fractionated variants.

The bulk of the syenitic to granitic rocks can be grouped into a crescent-shaped area, the boundary of which derive some support from an arcuate trend to foliations in the monzonite and syenite, and the magnetic signature of the area (Figure 4). This arcuate trend is reciprocated at the boundary between the monzonite and mafic anorthositic unit and is compatible with the distribution of various rock types in the mafic–anorthositic envelope. The syenitic and granitic rocks are here interpreted to represent the core of the body that has been folded into a northeast-plunging antiform (*see* structure).

DIABASE (MEALY) DYKE

One outcrop of a dark-brown-weathering, medium- to coarse-grained, homogeneous, massive diabase in the northeast corner of the map is assigned to the Mealy dyke suite (1250 ± 2 Ma; Hamilton and Emslie, 1997). No contacts against the surrounding rocks were observed, but, if it is a Mealy dyke having a typical east-northeast trend, then this example is at least 30 m wide, a width consistent with the relatively coarse grain size of the rock. The feature most supportive of interpretation as a Mealy dyke is a characteristic ‘felted' diabasic texture in stained slab, and the presence of skeletal plagioclase. Although the rocks into which the inferred dyke intrude are not exposed, regional relationships suggest that the area is underlain by the Upper Paradise River intrusive suite, which is known to be intruded elsewhere by east-northeast-trending dykes (e.g., at locality

CG91-072, cf. van Nostrand *et al.*, 1992; Wasteneys *et al.*, 1997). The outcrop described here and locality CG91-072 line up along a typical Mealy dyke (067°) trend. Whether this is coincidence, or means that they both belong to the same dyke, is unknown. Mealy dykes have been mostly mapped within the ca. 1640 Ma Mealy Mountains intrusive suite, where their pristine form has been preserved because the host anorthositic rocks have resisted Grenvillian deformation (whereas Mealy dykes in the immediately surrounding country rocks are increasingly deformed and metamorphosed, progressing away from the Mealy Mountains intrusive suite; Gower and van Nostrand, 1996). It may be that the Upper Paradise River intrusive suite has acted as a similar, albeit perhaps less effective, buttress against internal deformation, hence also provides a refuge for Mealy dykes from recognitional obscurity due to Grenvillian deformation and metamorphism.

Plate 13. *K-feldspar megacrystic granitoid rock.*

K-FELDSPAR MEGACRYSTIC GRANODIORITE TO QUARTZ MONZONITE

K-feldspar megacrystic granodiorite to quartz monzonite occurs as a distinctive and easily mappable rock type in three areas along the western margin of the map region in NTS 13B/02, and extending westward for an unknown distance. The rock shows very little variation from one area to another and it seems likely that they were either originally part of a single intrusion that has subsequently been disrupted by deformation, or are still linked at depth or farther west. The rocks are pink-weathering, coarse grained, homogeneous, weakly to extensively recrystallized and massive to moderately foliated (Plate 13). Some rocks show a strong foliation, and mylonitic fabrics are present locally. The rocks are not migmatized. K-feldspar megacrysts are subhedral to euhedral and typically range in size from 2 by 1 cm to 4 by 3 cm. The megacrysts are mostly uniform, without much indication of zoning or mantled textures. Rarely, some indication of internal plagioclase shells is present in the form of concentrically arranged plagioclase inclusions within the K-feldspar. In stained slabs, K-feldspar megacrysts are seen to be mantled by white plagioclase rims. Currently lacking thin section information, these are assumed to be albitic. The dominant mafic mineral is biotite, but minor hornblende is also present in some samples. Irregular amphibolite enclaves measuring roughly 30 by 10 cm are present sporadically and the rocks are discordantly intruded by planar microgranite dykes and a few minor, narrow pegmatites. A metamorphosed mafic dyke was seen at one outcrop.

The age of these rocks is unknown and field evidence within the Upper St. Paul River map area provides no time constraints. In some respects they resemble the deformed Labradorian K-feldspar granitoid units that are prevalent in the Lake Melville terrane, but they are a considerable distance from those rocks. They could be as young as early- to mid-Grenvillian. They are unlikely to post-date ca. 980 Ma, the time of the last major Grenvillian deformation in the southeastern part of the eastern Grenville Province.

PEGMATITE, MICROGRANITE AND QUARTZ VEINS

Pegmatite, microgranite and quartz veins are a minor component of many outcrops. The granitic minor intrusions are pink-, white- or red-weathering, and occur both as concordant and discordant intrusions from narrow veins to dykes several metres wide. Several generations of intrusion are present, but no attempt was made to distinguish them during mapping. For the most part, the pegmatites and microgranites are only a minor proportion of an outcrop, and only one instance was found where the entire outcrop consists of pegmatite. Biotite is the typical mafic mineral, locally occurring in books up to 6 cm in diameter, although rarely more than a few millimetres thick. Pegmatite containing significant muscovite, or any exotic minerals, was not seen.

Quartz veins are common, and are characteristically associated with the foliated granitic rocks as concordant and discordant lenses and layers, ranging in size from a few millimetres to tens of centimetres in width, and up to about 2 m long.

LATE- TO POST-GRENVILLIAN GRANITOID INTRUSIONS

No age data are available from any of the rocks described below, but on the basis of collective field characteristics (summarized by Gower, 1998) they can generally be confidently assigned to a suite of late- to post-Grenvillian (966 to 956 Ma) plutons widespread throughout the southern part of the eastern Grenville Province (*cf.* Gower *et al.*, 1991).

Upper St. Paul River (Northwest) Monzonite to Syenite Pluton

The name, Upper St. Paul River (northwest) monzonite to syenite pluton, was assigned by Gower *et al.* (1993) to one of a cluster of undeformed, circular to ovoid plutons in the southwest part of the Upper St. Lewis River map region. Only the eastern half of the pluton was mapped at that time but delineation of the intrusion is now complete. It is elliptical in plan, measuring 16.5 by 10.5 km, elongate in an east-northeast direction.

The dominant rock type is a pink- to grey-weathering, massive, coarse-grained monzonite, grading into alkali-feldspar syenite in places. Characteristic features are unrecrystallized quartz and mantled feldspars. The mantled feldspars typically have a plagioclase core 0.5 to 1.0 cm in diameter with a K-feldspar border a few millimetres wide, but there are common instances where plagioclase is reduced to a narrow shell between an inner core and outer rim of K-feldspar. Mafic minerals are biotite, hornblende and minor relict clinopyroxene.

The rocks contain sparse, fine-grained enclaves of amphibolite and recrystallized granite and a few microgranite dykes. The enclaves are rarely more than a few centimetres long and tend to occur as elongate lensoid bodies. Both enclaves and microgranite dykes are well displayed at an excellent exposure on St. Paul River (CG99-045, UTM 424447, 5775979). At this locality, rounded amphibolite enclaves up to a metre in diameter can be traced across the southern part of the outcrop. Microgranite dykes occur in three sets, trending, in order of decreasing age, at 160°, 120° and 065°. The 160°-trending set is represented by one 30-cm-wide dyke, which is of particular interest in that it contains abundant, angular amphibolite enclaves. A few of the enclaves are composite, consisting of two texturally distinct types of amphibolite. The 120°-trending dykes are most common, are 10 to 30 cm wide and are characterized by cross-linked branches. The youngest set (065°) is also represented by one dyke, which is the most irregular and widest (about 1 m). The frequency of dykes at this locality can be attributed to close proximity of the outcrop to the inferred margin of the pluton.

Northeast NTS 13B/08 Granite

One outcrop of pink, coarse-grained, unrecrystallized, homogeneous, severely weathered biotite granite exhibiting horizontal jointing was mapped in the northeast corner of the map region. Based on one outcrop 2.5 km to the east, Gower *et al.* (1993) depicted part of a small stock in the northwestern corner of the adjacent Upper St. Lewis map region, described it as a two-feldspar biotite granite and interpreted it as a late- to post-Grenvillian pluton. During Eade's (1962) mapping of the region, an outcrop, positioned about 1 km southeast of that mapped by this author, was visited by one of Eade's assistants and also described (field notes) as a massive, biotite granite. This outcrop was not seen during the present survey. Collectively, the mapping of Eade (1962), Gower *et al.* (1993) and that of the present study, allows interpretation of an ovoid granite intrusion measuring 4 by 3 km and elongate in a southeast direction.

Monzonite at Southern Boundary of NTS 13B/02

Three outcrops of a brown-black- or rusty-weathering, coarse-grained, massive monzonite were recorded adjacent to the central-southern margin of NTS 13B/02 and interpreted to be part of a late- to post-Grenvillian pluton of unknown size that straddles the Labrador–Quebec border. The rock is characterized by euhedral plagioclase crystals averaging 1 cm long and 0.5 cm in cross-section, enveloped in a matrix of K-feldspar, quartz and mafic–opaque minerals. The K-feldspar and quartz are clearly late-crystallizing minerals, being interstitial and graphically intergrown. The mafic minerals include pyroxene, amphibole and biotite. The continuation of the intrusion is not shown on the compilation map of Avramtchev (1983) south of the Labrador–Quebec border, so it seems probable that the body is quite small.

Two Plutons at the Northern Margin of Map Region in NTS 13B/07

The southern extremities of two pink-weathering, coarse-grained, massive, homogeneous, seriate to megacrystic granitoid plutons were mapped near the northern border of the map region in NTS 13B/07. Extension of these plutons into NTS 13B/07 was anticipated from investigations in the Upper Eagle River, where over 95 percent of each pluton is situated (Gower, 1998). The eastern pluton is roughly circular, having a diameter of about 12 km and the western pluton is elliptical, measuring 12 by 7.5 km and elongate in a northwest direction. Both plutons are characterized by marked positive magnetic anomalies, the southern rims of which are evident in Figure 4.

Gower (1998) concluded that the mutual textural and compositional similarity of the two plutons suggests that they are magmatic kindred. Both plutons have the same mineral assemblage, namely anhedral to euhedral K-feldspar, anhedral, unrecrystallized quartz, anhedral plagioclase, biotite, magnetite and accessory minerals. Within the Upper St. Paul River map region, K-feldspar megacrysts (up to 1.5 by 1 cm) are more obvious in the eastern pluton than the western one, which is closer to a coarse-grained alkali-feldspar granite. The distinction is subtle, but is in keeping with Gower's (1998) findings that not all rocks in the western pluton have a seriate to megacrystic texture. One interesting megacryst seen in a slab from a sample collected from the eastern pluton has an inclusion-rich plagioclase core surrounding by inclusion-free plagioclase and then a rim of K-feldspar, clearly indicating disequibrium conditions during emplacement.

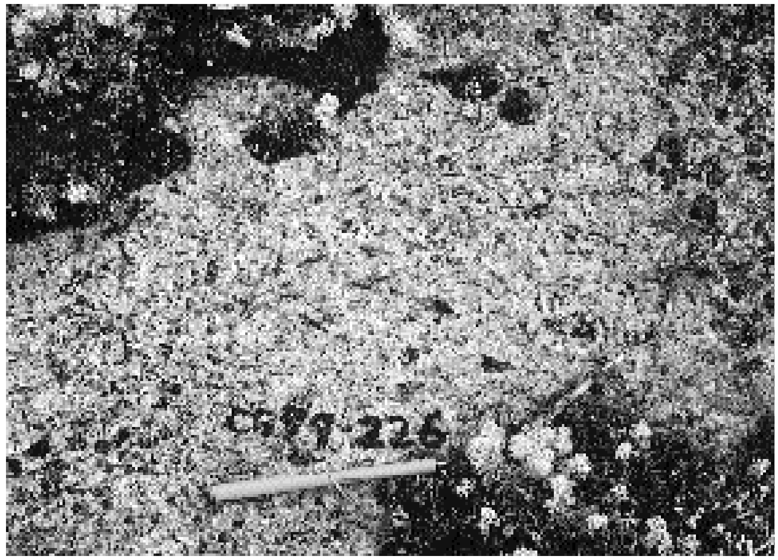

Plate 14. *Unfoliated granite interpreted to belong to the late- to post-Grenvillian suite.*

Central NTS 13B/07

On the basis of four outcrops and a distinct, ovoid magnetic anomaly (Figure 4), a late- to post-Grenvillian granitoid rock has been depicted in the centre of NTS 13B/07. The rock is a pink-weathering, coarse-grained, massive, homogeneous, unrecrystallized biotite granite (Plate 14).

Unexposed Pluton in the Southern Part of NTS 13B/01

An unexposed area in the southern part of NTS 13B/01 is characterized by a positive magnetic anomaly (Figure 4) and is interpreted to be underlain by a late- to post-Grenvillian monzonite on the basis of a single outcrop examined in Quebec, 1 km south of the Upper St. Paul River map region boundary. The outcrop is pink-buff-weathering and very rubbly weathered, despite forming a sizable hilltop exposure. The rock is massive, coarse grained, and consists almost entirely of perthitic K-feldspar, except for an interstitial mafic mineral suspected to be pyroxene. The rock type and its style of weathering, coupled with its magnetic expression are strong grounds for interpreting this to be a late- to post-Grenvillian monzonite. On the compilation map of Avramtchev (1983), the area is indicated as underlain by non-deformed granite extending about 25 km southward from the Labrador–Quebec border.

Unexposed Monzonite at Boundary between NTS 13B/02 and 13B/07?

An area characterized by a pronounced ovoid magnetic anomaly straddling the boundary between NTS 13B/02 and 13B/07 is interpreted to be underlain by a late- to post-Grenvillian monzonite, despite complete lack of exposure. That it is a late-to post-Grenvillian intrusion is based on the potential field anomaly, and that it is probably monzonite is an assumption based on the qualitative generalization that monzonite is typically the most poorly exposed, late- to post-Grenvillian rock type (in contrast to quartz monzonite, which is commonly fairly well exposed).

LONG RANGE DYKE (INFERRED)

No exposures were found of the north-northeast-trending Long Range dyke, traced by a line in Figure 3. The dyke's presence is inferred by extrapolation from both north and south. To the north, exposures of a Long Range dyke were found by van Nostrand (1992) and, closer to Sandwich Bay, by Gower *et al.* (1985). The dyke intersects the shoreline of Sandwich Bay west of the mouth of Eagle River, where it has been dated by Kamo *et al.* (1989) to have an age of 615 ± 2 Ma. To the south, a major dyke was mapped by Davies (1968) in the Baie des Moutons area on the north shore of the Gulf of St. Lawrence. Its extrapolation farther north in Quebec is indicated by Avramtchev (1983), who, curiously, fails to include the part that Davies mapped. The inferred location in the Upper St. Paul River map region is based primarily on airphoto lineaments, and these are only obvious in the southern part of NTS 13B/08. Magnetic maps do not show any clear indication of the dyke. At one location in the central part of NTS 13B/08, a hill of metagabbro is divided into two parts by a deep north-northeast-trending cleft having straight, vertical, parallel-sided margins, which might well be the site of the (preferentially eroded) Long Range dyke. If this is the case, the dyke, here, is about 200 to 300 m wide, which is compatible with the known width of the dyke to the north and south. This is the westernmost, longest and largest dyke of the Long Range swarm.

STRUCTURE

Structures have a regional northeast trend throughout much of the map region, except in the southwest where the prevailing trend is northwest – a pattern that is here interpreted as reflecting two superimposed deformations. Using information from adjoining areas to the north (Gower, 1998, 1999), the event that produced the northeast trend is inferred to be the older, with the younger, northwesterly trending structures becoming increasingly dominant progressing toward the southwest.

Farther to the north, in the Eagle River map region, the northeast structural trend prevails, expressed, in particular, by the limbs of a major northeast-plunging antiformal structure. If extrapolated to the southwest, the axis of this fold would pass through the northwest quadrant of the Upper St. Paul River map region. The structure is assumed to be early Grenvillian, linked to northwest-directed thrusting in the Exterior Thrust Belt (Figure 2). Within the context of an overall northeasterly structural trend, there is considerable variation in local fabric attitudes at individual outcrops. In part, these departures may be more apparent than real due to errors in measuring the strike of shallowly dipping foliation and gneissosity planes, but such an explanation is inadequate to explain all the variation. It seems probable that much of the fabric reflects earlier deformation, and that older structures have been rotated into partial conformity with the younger northeast trend.

In the Upper Paradise River intrusive suite, the regional northeast structural trend is also evident at many localities, but with numerous exceptions. Along with outcrop distribution, topographic trends, and selective use of magnetic data, the exceptions have been used as a guide to the defining the orientation of boundaries between lithological units within the pluton. The outcome is an indication that the body has been folded into a northeast-plunging antiform, with two flanking synforms (D2, say), giving an overall dish-like structural form to the body. The northeast-convex distribution pattern of the syenitic–granitic rocks is consistent with this concept, assuming that they initially formed a northwest-trending synformal core (e.g., D1) and are preserved as part of a type-2 interference structure. Note that this interpretation implies that the most differentiated rocks are preserved in the structurally highest levels of the intrusion.

Although the northwesterly trend is only dominant in the southwest district of the map area, it has been recorded sporadically in areas to the north, where it was interpreted by Gower and van Nostrand (1996) and Gower (1998) as having formed late in the active tectonic history of the region, possibly during the late Grenvillian. On the basis of a linear magnetic discontinuity extending from the southeast corner to the midpoint on the western boundary (Figure 4), it is suggested here that a significant structure separates the southwest district from the rest of the region. The exact nature of the structural break remains unknown, as no indication of it was seen on the ground, hence it could be one single, continuous fault, several discontinuous faults, a transitional zone of ductile deformation, or something else. Note that well-banded granodioritic and granitic gneisses were only mapped in the southwest district, in contrast to compositionally similar foliated granitoid rocks farther north. Note also that northeast trends are still present in places in the southwest district. This leads to the inference that, if the northwest trend is indeed younger than the northeast trend, then the banding in the gneisses reflects younger metamorphism, migmatization and deformation superimposed onto the foliated granitoid rocks in a zonal, anastomosing, somewhat patchy manner. The prediction follows that no protolith age distinction is to be expected between foliated granitoid rocks and well-banded granitoid gneiss.

The fabric in the K-feldspar megacrystic granitoid unit along the western side of NTS 13B/02 is very variable. In some outcrops, the rocks are massive and only slightly recrystallized, introducing the option that they could be part of the late- to post-Grenvillian suite, but, generally, fabrics are much too well developed to accept such a classification. Nowhere are the rocks migmatized, however, so it seems likely that these rocks escaped the last major metamorphic event.

In places, structural trends are controlled by late- to post-Grenvillian granitoid rocks, due to forceful emplacement of the latter, causing fabrics in older rocks to conform to pluton boundaries. This seems to be particularly evident in the envelope around the Upper St. Paul River (northwest) monzonite, and, to a lesser extent, around the southern margins of the two K-feldspar megacrystic granitoid rocks straddling the northern boundary of the study area.

A substantial zone of mylonite and straight gneiss was mapped within mafic to anorthositic rocks of the Upper Paradise River intrusive suite along part of St. Paul River. It would seem that the mylonite must reflect a ductile structure of major significance, but what that is remains unknown. Neither magnetic signature, nor topographic patterns, nor distribution of rocks provide obvious clues as to how the deformation zone should be extrapolated beyond the limits of its exposure. A few kilometres to the south, kinematic indicators demonstrate dextral transposition, but, again, this information has yet to be accommodated into any regional structural framework. Mylonitized anorthositic rocks were also seen near the eastern margin of the map region at the southeastern margin of the Upper Paradise River intrusive suite, so it is possible that much of the contact between the leucogabbronoritic and foliated granitic rocks could be a zone of ductile deformation, and even that the whole of the Upper Paradise River intrusive suite might be allochthonous.

Brittle fault breccia was not seen anywhere in the map region, although some straight topographic lineaments could be reasonably interpreted as late-stage faults. For the Eagle River area to the north, Gower (1998) suggested that a north-northeast-trending brittle fault might exist on the northwest side of the Upper Paradise River intrusive suite and assist in defining the southwestward extrapolation of the Sandwich Bay graben. No evidence for such a fault was found in the present study area, thus any southward continuation remains conjectural.

METAMORPHISM

Metamorphic grade is at amphibolite facies with local indications of granulite-facies conditions.

Quartz–plagioclase–K-feldspar–biotite–sillimanite–accessory minerals characterize the two outcrops of pelitic metasedimentary gneiss known in the region. Garnet was seen at the pelitic gneiss outcrop in the northwest corner of the map region, but not at the outcrop near the central-southern border (but examination of the latter outcrop was somewhat cursory). Garnetiferous white-weathering pegmatite, interpreted to be metasedimentary diatexite, occurs in the same area. Garnet was also recorded in one rock equivocally interpreted to be derived from an arenaceous protolith.

The mineral assemblage in foliated granitoid rocks and compositionally equivalent well-banded gneiss consists of quartz–plagioclase–K-feldspar ± biotite ± hornblende ± various accessory minerals. Garnet was recorded at six outcrops, three in the north and three in the south. The garnets are small and are not abundant. Rare orthopyroxene-bearing sweats are present in foliated and gneissic granitoid rocks in the southwest part of the map region, consistent with the notion of increasing metamorphic grade progressing toward the southwest. Associated amphibolite consists of hornblende–plagioclase–opaque/accessory minerals, locally with melt patches containing large subhedral hornblende crystals.

In mafic to anorthositic rocks of the Upper Paradise River intrusive suite, some recrystallized igneous pyroxene is preserved but hydration and recrystallization to amphibole is most common. In the anorthositic and leucogabbronoritic rocks, plagioclase is typically recrystallized and only rarely is any evidence of former coarse-grained igneous texture retained. Mafic enclaves and lenses (some of which could be metamorphosed diabase dykes) in the monzonitic, syenitic and granitic rocks are amphibolite and contain rare quartzofeldspathic stringers.

Late- to post-Grenvillian plutons have primary textures and mineral assemblages. Unrecrystallized quartz is testament that these rocks escaped the last deformational event to affect the region.

ECONOMIC POTENTIAL

Present mapping has done little to challenge the sagacity of explorationists in avoiding this region. Although the study has generated a more substantial geological database than previously available, deterrents such as remoteness, poor exposure, lack of mineralization, and lack of geophysically or geochemically attractive targets still remain. Only one mineral occurrence (NTS 13B/08, Mica 1) is listed in the Newfoundland Department of Mines and Energy mineral occurrence database for the region. The mica is reported to occur at 52° 22.4'N, 58° 15.6'W. A very small (a few metres long) outcrop of monzonite exposed as an islet in St. Paul River is the only known exposure in the vicinity, and is the obvious candidate for the locality, but no mica was found, beyond normal accessory amounts typical of monzonite.

Despite the previous discouraging paragraph, the area might yet reward the optimist. Mafic rocks belonging to the Upper Paradise River intrusive suite include some melagabbro, verging on ultramafic compositions that could host sulphide mineralization. One amphibolite (a xenolith several metres long within a minor granitoid intrusion emplaced into metamorphosed gabbro/leucogabbro) is anomalously pyritic (but still less than 1 percent) with a hint in hand sample that traces of chalcopyrite might also be present (locality CG99-342; UTM 400233 5783074). In this case, obviously, the exact source of the amphibolite remains unknown, but it seems likely that it belongs to the metagabbro/leucogabbro envelope to the Upper Paradise River intrusive suite. Farther to the southwest, in amphibolite near the eastern border of 13B/02, traces of pyrite were seen in a slabbed sample (locality CG99-186; UTM 295670 5769284).

Granitoid rocks seem to be even less promising than the mafic rocks. The only departure from typical silicate minerals or oxides was found at locality CG99-220 (UTM 386004 5815168) in north 13B/07, where a pegmatitic patch in a foliated granite contains secondary Cu minerals in a microfracture 1 cm long and 0.1 cm wide, a discovery that is hardly likely to initiate a staking rush.

It would be misleading to consider any of the above pyrite occurrences or the secondary Cu minerals site as a formal mineral locality.

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