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# GEOLOGY OF THE CROOKS LAKE MAP REGION, GRENVILLE PROVINCE, EASTERN LABRADOR

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## ABSTRACT

*The Crooks Lake map region comprises 1:50 000-scale NTS map areas 13B/11, 12, 13 and 14. The northwestern part of the area is moderately well exposed, but outcrop deteriorates progressing east and south. Exposure is rare in extensive wetlands in the central–east district.*

*The region is divided into two parts, i) in the south, gneisses, foliated granitoid rocks and a metamorphosed mafic intrusion, all of assumed Paleoproterozoic age, and ii) in the north, the Mealy Mountains Intrusive Suite, of Paleoproterozoic age. Of the gneisses, granite to granodioritic orthogneisses are dominant and represent a continuation of similar rocks previously mapped farther northeast. A small area of sillimanite–garnet-bearing metasedimentary gneiss and diatexite was discovered in the southeast corner. The gneisses are believed to be the oldest rocks present and assumed to be pre-Labradorian (>1710 Ma) on the basis of preliminary dating outside the Crooks Lake map region.*

*Metamorphosed pyroxenite, melagabbro, gabbro, leucogabbro and monzogabbro (and/or orthopyroxene equivalents) are inferred to underlie a large portion of the southern half of the map region and the outcrops are collectively interpreted as representatives of a mafic intrusion, layered in places. A spatial relationship with an area of foliated diorite to monzodiorite may imply genetic linkage.*

*The Mealy Mountains Intrusive Suite in the map region consists of almost equal quantities of anorthosite and monzonite, and minor leucotroctolite, leuconorite, monzonorite, quartz monzonite and granite. Two major anorthosite bodies and one small one have been newly defined as a result of the mapping.*

*A group of foliated monzonoritic, quartz monzonitic and granitic rocks occupies a spatial, compositional and textural intermediate position between the orthogneisses, metamorphosed mafic intrusion and the Mealy Mountains Intrusive Suite, but any affiliation to these three groups remains uncertain.*

*One outcrop of massive, ophitic-textured diabase found in the western part of the map region is interpreted as a representative of the northeast-trending 1250 Ma Mealy dykes swarm.*

*Newly mapped massive, unrecrystallized granite in the southeast quadrant is assigned to a suite of late- to post-Grenvillian plutons, already known to be widespread throughout southern Labrador. Magnetic anomalies are interpreted as indicating two adjacent plutons, but exposure is only sufficient to delineate, with confidence, the more southerly of the two bodies.*

*The structural grain of the region is east–northeast, onto which a late northwest-trending foliation has been superimposed. No major fold or thrust structures were recognized, although sporadic evidence hints at their existence. Metamorphic grade is at amphibolite facies.*

*Previous mineral exploration has been directed at Ti(Fe) oxide mineralization associated with anorthosite in the northwest part of the map region. The present mapping suggests further potential of this type. A newly identified base-metal mineral exploration target is the metamorphosed mafic intrusion. One sulphide–oxide showing was discovered during mapping and sparse, interstitial disseminated sulphide was found elsewhere in the intrusion. Numerous pegmatites were mapped, but no minerals of economic interest were found in any of them.*

## INTRODUCTION

The Crooks Lake map region is situated in southern Labrador, 45 km from Goose Bay at its northwest corner and 130 km from Goose Bay at its southeast corner (Figure 1). The region includes 1:50 000-scale NTS map areas 13B/11, 13B/12, 13B/13, and 13B/14 (13B/northwest), collectively embracing an area of about 3700 $km^2$. Mapping in the region was carried out during June and July, 1998, as part of the continuing program of geological reconnaissance mapping in Labrador. After completion of the 1998 mapping program, of the fifty 1:100 000-scale map regions (one quadrant of a 1:250 000 NTS map) in the Labrador part of the Grenville Province, only seven now remain unmapped.

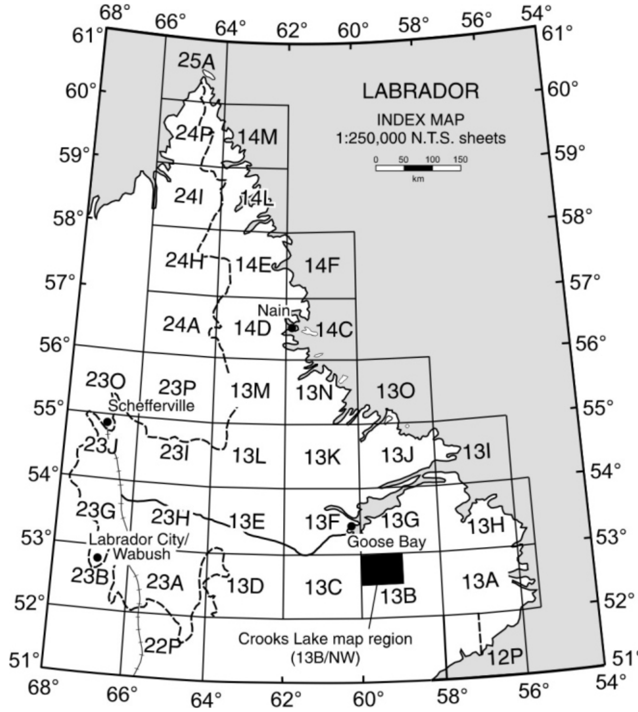


**Figure 1.** *Location of the Crooks Lake map region (NTS map area 13B/northwest) in Labrador.*

The region topographically belongs to a 300- to 500-m-high dissected plateau that extends throughout much of interior southeast Labrador. The three highest elevations are 585, 594 and 595 m, in the northwest, northeast and southeast quadrants respectively. Most of the region is within the western Eagle River drainage basin, but the southern areas include the northern headwaters of the St. Augustin and Joir rivers and the western margin of the map region belongs to the Kenamu River drainage basin. The Eagle River discharges into Sandwich Bay, the Joir River (a tributary of the Petite Mecatina River) and St. Augustin River discharge into the Gulf of St. Lawrence, and the Kenamu River into Lake Melville.

The northwest quadrant is the most rugged and is characterized by numerous craggy hilltop outcrops (Plate 1), as well as exposures on wooded hillsides, and adjacent to abundant small lakes and wetland clearings. Progressing east and south, the ground gives way to more rounded wooded hills and broader valleys with more common marshes. Rock exposure is also common in these areas, but is less accessible. The central and east–central part of the map region provides a marked contrast, as it forms a huge wetland almost completely devoid of outcrop. In this area, large shallow lakes are fringed by vast string bogs separated by low spruce-covered rises. The southern half of the map region is characterized by spruce-covered hills along with numerous small to extensive marshlands. Locally, outcrop occurs at the tops of hills

**Plate 1.** *Typical scenery in the northwest part of the Crooks Lake map region showing hilltops in the background where monzonite belonging to the Mealy Mountains Intrusive Suite is exposed.*

or on their steeper slopes, but only rarely is it possible to gain direct helicopter access because of tree cover. Most commonly, it is necessary to walk into such outcrops from the nearest clearing, which, however, is generally within 500 m. Traversing through the woodlands is impeded by thick undergrowth, abundant deadfall and uneven, moss-covered ground.

Mapping was carried entirely by helicopter, apart from a few short ground traverses. During one month of mapping, 316 data stations were established, a comparable rate of data acquisition to that achieved in 1997, when mapping the Upper Eagle River map region (Gower, 1998), and representing a major advance on the three structural observations from this area recorded on the map of Eade (1962). Samples were collected from all (except two) helicopter landing sites, slabbed and then stained to assist in the identification of potassium-bearing minerals and more effective examination of textures.

## PREVIOUS WORK

The only previous published non-derivative geological map that includes the region, is the 1:506 880-scale map of Eade (1962), but even on that map the southwest quadrant of the present region was excluded as unmapped. Despite the cursory nature of Eade's map, a bipart division (confirmed during present mapping) between anorthosite–monzonite in the north and gneiss–granite plus mafic rocks in the south (*see below*) was captured, although the proportions of major rock types shown by Eade (1962) differ radically from that determined during the current, more detailed, mapping.

Geological mapping at 1:100 000 scale has been completed to the west (James and Lawlor, *this volume*), northwest (Wardle and Ash, 1986; Wardle and Crisby, 1987), north (Nunn and van Nostrand, 1996), northeast (Gower and van Nostrand, 1996) and east (Gower, 1998). The southwest, south and southeast regions remain unmapped. Aeromagnetic coverage of the region is available at 1:63 360 scale (Geological Survey of Canada, 1971a,b,c,d) and 1:250 000 scale (Geological Survey of Canada, 1976) 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, except in its northwest corner, where Vulcan Minerals Inc. has conducted base-metal sulphide and oxide mineral exploration (*see* Economic Potential). Apart from these claims, the area attracted no attention during the 1994-1995 Labrador staking rush.

## REGIONAL GEOLOGICAL SETTING

The region is situated in the Mealy Mountains terrane within the Grenville Province in eastern Labrador and straddles the ill-defined boundary between the Exterior Thrust Belt and 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 the geological boundaries are partly interpreted, as Figure 4.

In broadest terms, the map region is divided into two parts. The southern half is underlain (crudely from south to north) by quartzofeldspathic gneisses, a metamorphosed mafic intrusion and foliated quartz-poor granitoid rocks; these are of uncertain age, but probably Paleoproterozoic. The northern half is underlain by massive monzonitic and anorthositic rocks that can be confidently assigned to the Paleoproterozoic Mealy Mountains Intrusive Suite. Massive, undeformed granitoid rocks emplaced into gneisses in the south are inferred to be late Mesoproterozoic (late- to post-Grenvillian).

## DESCRIPTION OF MAP UNITS

### METASEDIMENTARY GNEISS

One small area of metasedimentary gneiss was mapped in the southeast corner of the map region, but, here, the rocks are moderately well exposed in a cluster of outcrops. The age of the metasedimentary gneiss is unknown, but assumed to be pre-Labradorian (> 1710 Ma). Much of the outcrop is white-weathering diatexite containing abundant mauve garnet up to 2 cm in diameter, associated with restite containing common sillimanite. Also present is banded quartzite and grey-weathering, well-banded gneiss separated into garnet-bearing leucosome and sillimanite–biotite-rich melanosome. This is the only locality in the whole map region at which sillimanite was recorded. Apart from some tiny crystals in a pegmatite elsewhere, it is also the only outcrop at which garnet was recorded.

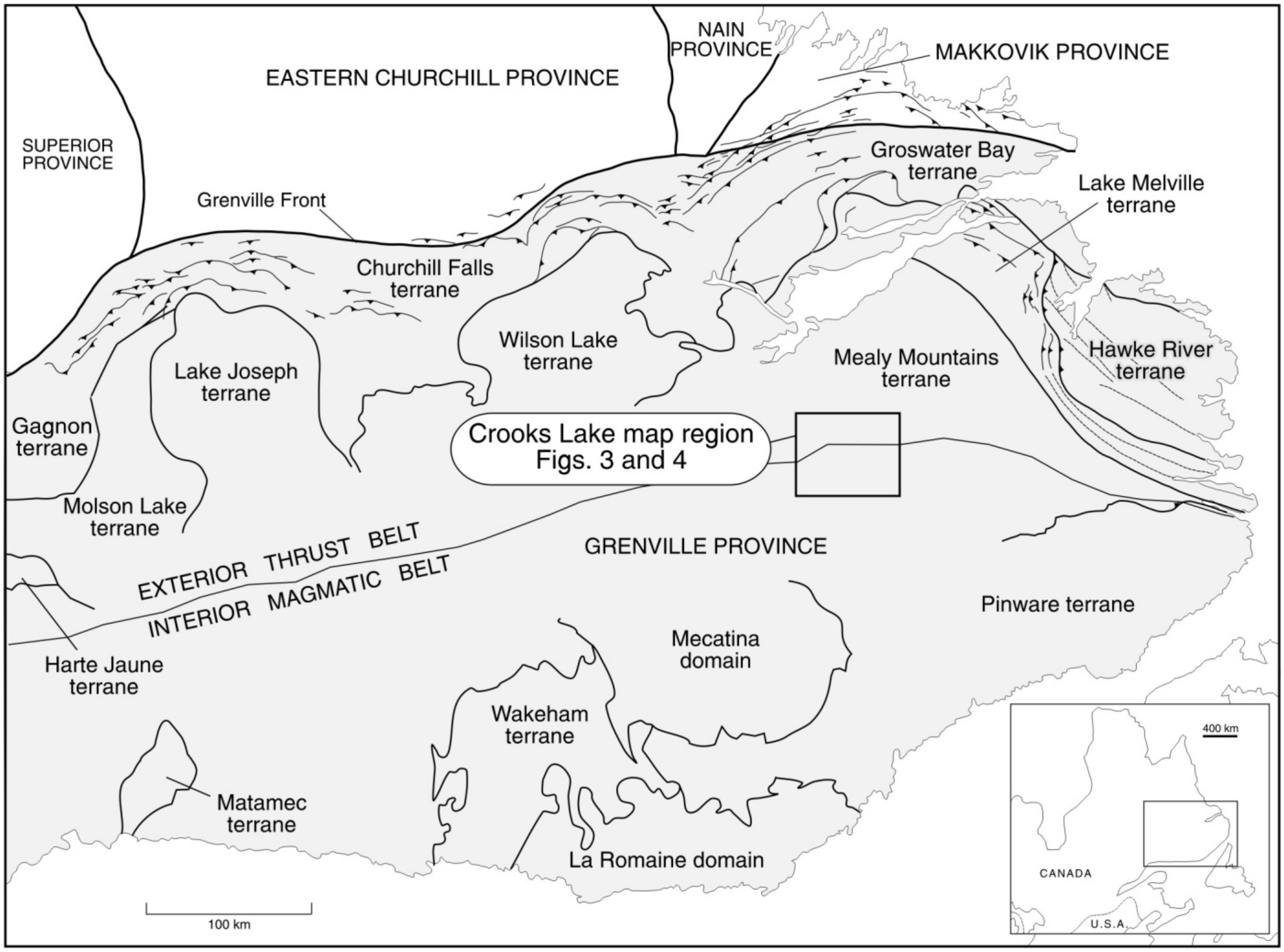


**Figure 2.** *Geological context of the Crooks Lake map region in the eastern Grenville Province.*

The only other rock in the map region that is thought possibly to have a metasedimentary protolith was found 7.5 km farther west. The preferred interpretation is that it is an orthogneiss, however.

## ORTHOGNEISS

Orthogneiss in the region is mostly granitic or granodioritic-to-granitic in composition, but very minor quartz dioritic gneiss and a K-feldspar megacrystic variant of the granitic gneiss were recorded (both of which are too small to show on Figure 3). The rocks are assumed to be pre-Labradorian (1780 to 1710 Ma) or Labradorian (1710 to 1600 Ma), by indirect correlation with gneisses dated farther northeast by Krogh *et al.* (1996).

All the gneisses are creamy-, pink-, orange- or grey-weathering, medium grained and recrystallized. Gneissic layering is mostly wispy, diffuse, discontinuous or lens-like – only rarely are the rocks well banded (Plate 2). Texturally, there is complete gradation from merely foliated granitoid rocks into well-banded gneiss and it is a moot point whether any real mappable, age or genetic differences exist between the two end members. In the better banded gneisses, layering is defined by leucosome, melanosome, concordant pegmatite, local amphibolite screens, or rare quartz- rich zones. The mineral assemblage comprises quartz, K-feldspar, plagioclase, biotite, hornblende and opaque mineral (invariably magnetite where tested). Distinction between granodioritic and granitic gneiss relies on estimates of the proportions of felsic minerals in outcrop and from stained slabs, but since the rocks were only briefly examined in the field and the slabs are too small to be entirely representative, the two-fold classification is open to question. The quartz dioritic variant is more clearly compositionally separate, but as the rock type is intercalated with amphibolite and pegmatite, it may well represent a hybrid rock, rather than reflecting a primary protolith composition. A megacrystic variant of the granitic gneiss (seen at one outcrop only) was mapped on the basis of aggregates of polygonal K-feldspar up to 2 by 1 cm, which are thought to represent former megacrysts. Lens-like concentrations of polygonized K-feldspar that could repre-

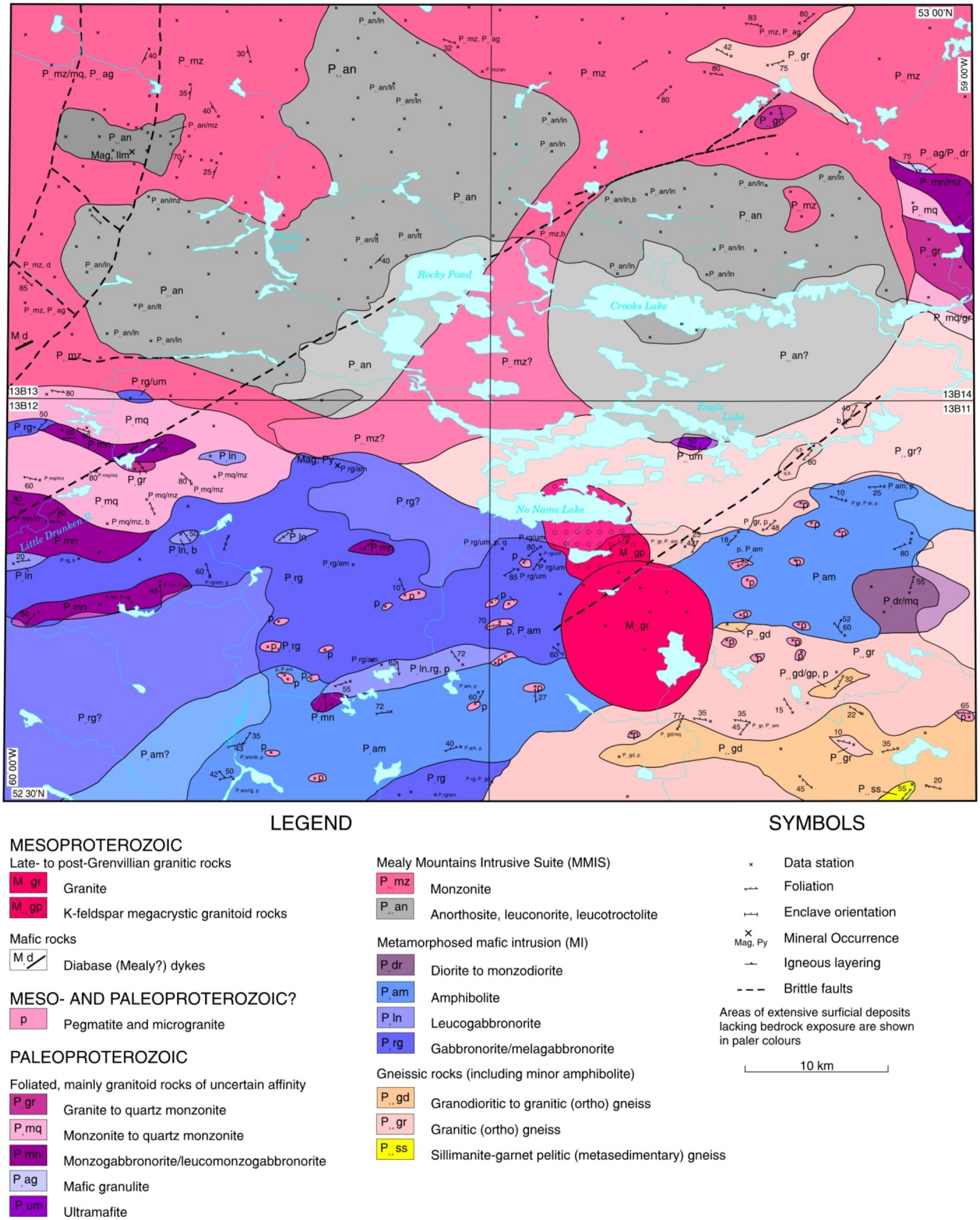


**Figure 3.** *Geological map of the Crooks Lake region. The boundaries of most units have been partially inferred from aeromagnetic data (cf. Figure 4).*

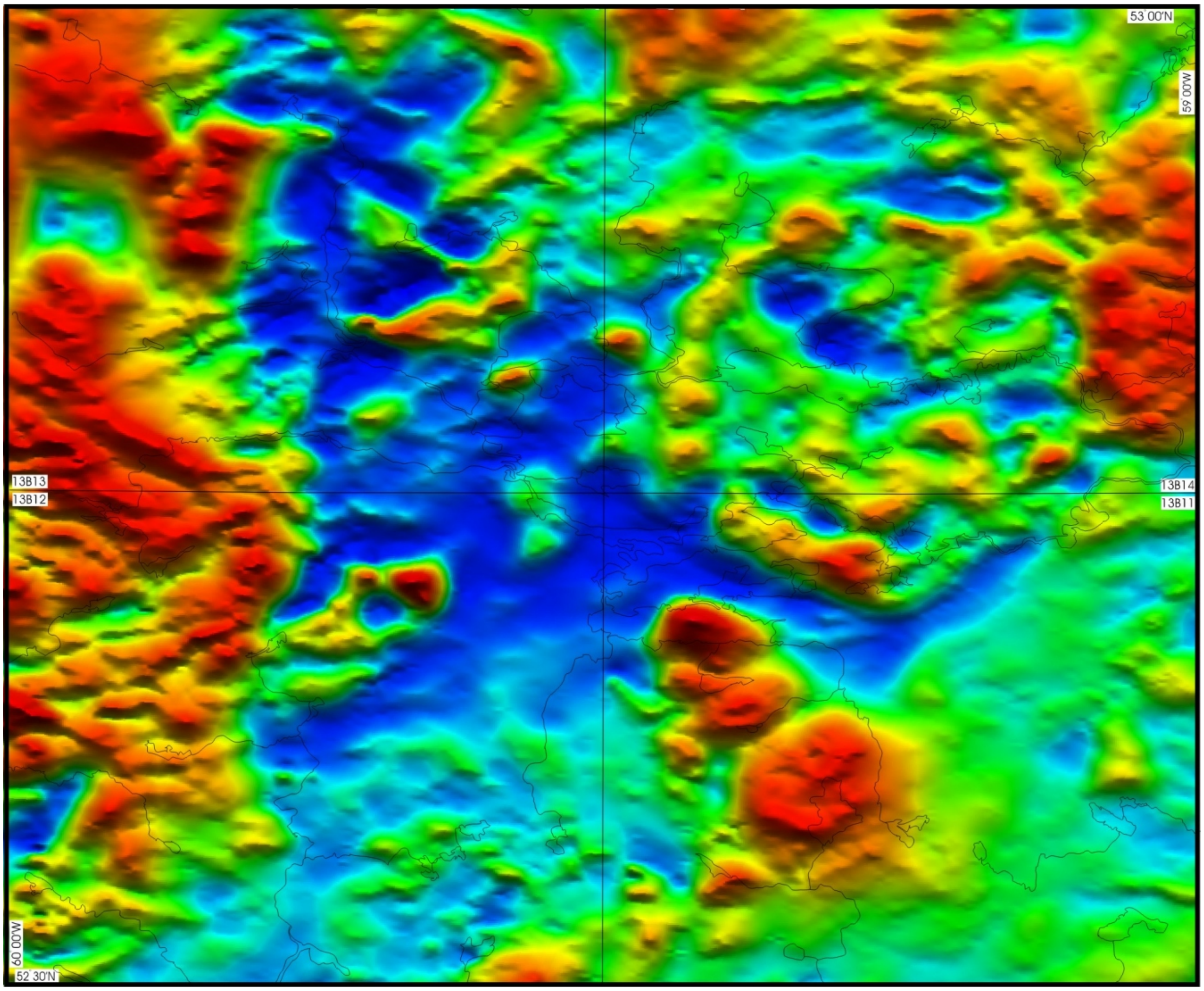


**Figure 4.** *Coloured shaded-relief aeromagnetic map of NTS map area 13B/northwest. Red end of spectrum - magnetic highs; blue end of spectrum–magnetic lows (map prepared by G. Kilfoil, Geological Survey of Newfoundland and Labrador).*

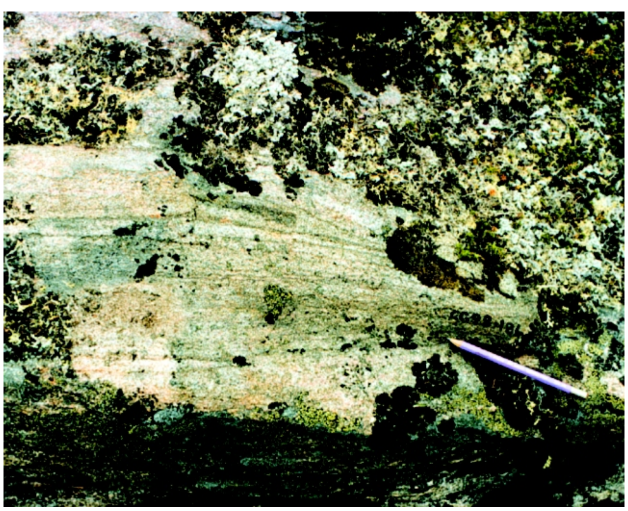

**Plate 2.** *Characteristic fabric in orthogneiss, exemplified by wispy, discontinuous banding; southeast corner of map region.*

sent relict megacrysts were seen at two other sites, but the rocks are too recrystallized for confident identification. There is no indication that the protolith to these gneisses was anything other than granitoid plutonic material.

Amphibolite associated with the orthogneiss was only seen at a few sites and is presumed minor elsewhere. The amphibolite is black- or grey-weathering, medium grained and weakly to strongly foliated. Folded quartzofeldspathic or hornblende-rich stringers are locally present (Plate 3a). Where deformation is more severe, amphibolite forms elongate, schistose bands of highly foliated material (Plate 3b). Both amphibolite and quartzofeldspathic gneisses are discordantly intruded by pegmatite (Plate 3c). Intercalation of amphibolite with coarse-grained pegmatite, granitic gneiss and quartz diorite at two other localities near the boundary between orthogneisses and a metamorphosed layered mafic intrusion (*described below*) may indicate interfingering of the two.

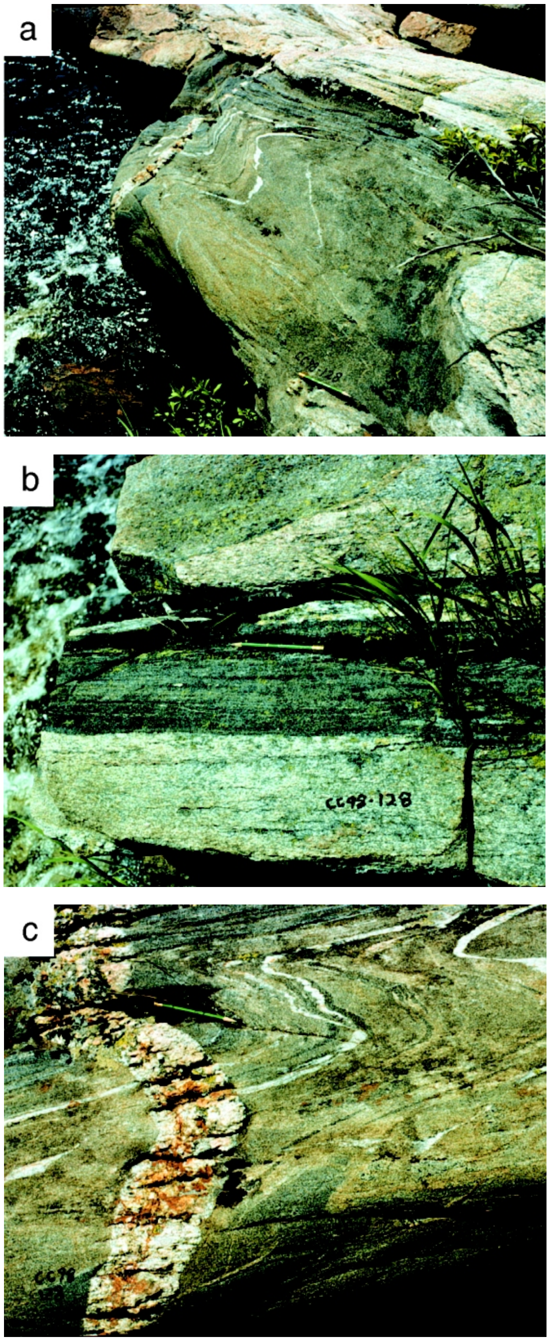


**Plate 3.** *a) Amphibolite boudin containing folded quartzofeldspathic stringers in orthogneiss; south of Eagle Lake, b) contrasting, severe deformation that has affected another amphibolite boudin from the same outcrop, c) close-up of part of Plate 3a, illustrating discordant, but mildly deformed pegmatite.*

## POSSIBLE COUNTRY ROCKS WITHIN THE MEALY MOUNTAINS INTRUSIVE SUITE

Two outcrops in the northeast part of NTS map area 13B/14 are quite distinct from the surrounding monzonites assigned to the Mealy Mountains Intrusive Suite. The rocks are considered at this juncture on the assumption that they may be affiliated with the previously described orthogneisses, with which they are grouped in Figure 3. They are pink-, creamy- or grey-weathering, fine to medium grained and completely recrystallized, showing a distinctly granular texture. The mineral assemblage comprises K-feldspar, quartz, plagioclase, magnetite and biotite. Both outcrops display a distinctly banded fabric, partially defined by quartz-rich pegmatitic veinlets (Plate 4). Stained slabs clarify that the banded fabric is also a product of 2- to 3-mm-wide streaks enriched in plagioclase or quartz. The material is similar to fine-grained quartzofeldspathic enclaves within Mealy Mountains Intrusive Suite monzonite farther southeast described by Gower (1998, p. 134). He, interpreting them in conjunction with gneiss and amphibolite enclaves at the same locality, presumed them to represent country-rock material entrapped in monzonite close to its margin. Provisionally, therefore, the fine- to medium-grained, banded and recrystallized quartzofeldspathic rocks are regarded as a variety of the host rock into which the monzonites were intruded. Two other, less-favoured, interpretations are that they represent either, (i) chilled border material in a roof pendant or (ii) deformed minor intrusions within the monzonite. No field relationships with the surrounding monzonites were observed to evaluate these alternatives. If the fine-grained quartzofeldspathic rocks represent a border phase, then fractionation or contamination must be invoked to account for the contrast in composition, given that the material is granitic rather than monzonitic. In contrast to the country-rock concept, the minor intrusion suggestion fails to explain why it is only in this area that the surrounding monzonites are foliated.

**Plate 4.** *Fine-grained quartzofeldspathic rock containing concordant quartz–feldspar veinlets that is possibly a country-rock remnant in the Mealy Mountains Intrusive Suite; northeast NTS map area 13B/14.*

Two other anomalous rocks within the monzonites occur in the same general region. One, 12 km to the southeast of the presumed country rocks, is a pale grey–brown-weathering, fine-grained, banded granoblastic-textured granulite containing plagioclase, orthopyroxene, clinopyroxene, quartz, minor K-feldspar and magnetite. The banding is mainly due to diffuse, coarser grained concordant veinlets of quartz- and clinopyroxene-rich material. The other atypical rock, 2 km to the northeast, comprises recrystallized amphibolite enclaves within monzonite (Plate 5). The enclaves are lensoid, 5 to 40 cm long and 5 to 10 cm wide.


**Plate 5.** *Amphibolite enclaves within the Mealy Mountains Intrusive Suite; northeast NTS map area 13B/14.*

## METAMORPHOSED MAFIC INTRUSION

From sporadic exposures, a large portion of the southern half of the Crooks Lake map region is inferred to be underlain by a metamorphosed mafic intrusion. The rocks are here classified into four types, i) gabbronorite/melagabbronorite grading into ultramafic rocks, ii) leucogabbronorite, iii) amphibolite, iv) diorite to monzonite. Descriptions given below also apply to apparently isolated areas of comparable rocks mapped outside the main intrusion.

The dominant pyroxene in all the units is considered to be clinopyroxene from field evidence, but the term norite (melanorite, leuconorite and monzonorite), rather than gabbro would apply if this is incorrect. Igneous names have been retained where vestiges of igneous textures remain, although most rocks have been partially transformed to metamorphic assemblages. The main transformations are recrystallization of both mafic and felsic minerals and hydration of mafic minerals to amphibole and, less commonly, phyllosilicate minerals. In all four units, pegmatite dykes or veins are common and late-stage shearing, perhaps accompanied by greenschist alteration, is apparent sporadically. Potassium metasomatism has affected mafic rocks adjacent to some granitic intrusions.

### Gabbronorite/Melagabbronorite, Grading into Ultramafic Rocks

The rocks weather black, grey, brown or green, are medium to coarse grained and are weakly to moderately recrystallized. Primary rock types were probably gabbro, melagabbro and pyroxenite. Some evidence remains of igneous layering, both in mafic minerals and plagioclase. In this unit, plagioclase-rich layers are thin (less than 10 cm wide) and sparse (where abundant, the rocks are assigned to the leucogabbro unit described below). Cumulate and ophitic textures can be commonly identified, although both are modified by metamorphic overprinting. More extensive metamorphic effects include the development of plagioclase-rich segregations, felsic veinlets and minor shearing. Foliation evident in some outcrops is mostly attributable to post-crystallization deformation, but, in a few cases, may reflect primary igneous mineral alignment.

The mineral assemblage is dominated by clinopyroxene and/or amphibole, with plagioclase (commonly in the 5 to 15 percent range) and olivine. The proportion of olivine is considered to be low, although metamorphic overprinting renders estimates suspect. Opaque minerals include an oxide (mostly magnetite) phase and, in a few of the more melanocratic rocks, minor sulphide (*see* Economic Potential).

### Leucogabbronorite

On the basis of outcrop proportions, leucogabbroic rocks probably form less than 15 percent of the mafic intrusion. On Figure 3, the specific areas shown may, of course, reflect fortuitous exposure, rather than being truly representative of their distribution, given the low outcrop density. The rocks are white-, buff-, creamy-brown- or black-weathering, medium grained, recrystallized, and weak to moderately foliated. The mineral assemblage consists of plagioclase, amphibole, pyroxene, and magnetite. Where metamorphism is advanced, the rocks have a dioritic appearance.

### Amphibolite

Rocks forming this unit weather green, grey or black, are generally medium grained and are moderately to strongly foliated (Plate 6). Although segregation into plagioclase-rich leucosome and hornblende-rich melanosome is evident, most outcrops are fairly homogeneous. The mineral assemblage consists of amphibole, plagioclase, rare interstitial K-feldspar and an opaque mineral. One strongly foliated variety exposed on the Joir River verges on a gneiss and displays plagioclase porphyroclasts, suggesting significant ductile deformation in the vicinity.

**Plate 6.** *Amphibolite intruded by pegmatite exposed on Joir River and assigned to a metamorphosed layered mafic intrusion that underlies much of the southern half of the map region.*

### Diorite to Monzodiorite

In the southeastern part of the map region, metamorphosed diorite to monzodiorite was found and is distinct from both the finer grained, more-strongly foliated amphibolites to the north and west, and the orthogneisses to the south. There is no compelling reason to link these rocks with the mafic intrusion, other than by spatial association. The rocks are creamy-, grey- or green-weathering, coarse grained, foliated and homogeneous. The mineral assemblage consists of amphibole, plagioclase, K-feldspar, biotite, an opaque mineral, and possibly clinopyroxene. The ratio between K-feldspar and plagioclase varies significantly (hence the rock name range), but textural similarity implies a common origin. Monzodiorite at one locality is intruded by undeformed pegmatite.

## MEALY MOUNTAINS INTRUSIVE SUITE

The Mealy Mountains Intrusive Suite is accepted as Paleoproterozoic on the basis of U–Pb zircon ages of 1645.5 ± 1.5, 1635 +22/–8 (Emslie and Hunt, 1990) and ca. 1730 Ma (Krogh *et al.,* 1996) obtained from northeast part of the suite. Within the Crooks Lake map region, rocks assigned to the Mealy Mountains Intrusive Suite are subdivided into either anorthosite plus minor leuconorite and leucotroctolite, or monzonite. Associated leucomonzonorite and quartz monzonite to granite addressed separately below could be genetically related.

### Anorthosite, Leuconorite and Leucotroctolite

#### *Rocky Pond Anorthosite*

The name Rocky Pond anorthosite is newly applied to an irregularly shaped body in NTS map area 13B/13.

Anorthosite is the overwhelmingly dominant rock type, but minor leucotroctolite and leuconorite are present. The rocks are creamy-, grey- and white-weathering, massive and homogeneous. Plagioclase was early crystallizing, occurring as well-twinned crystals up to 20 cm long, typically having euhedral shape and forming cumulates. The mafic mineral assemblage is represented by intercumulus clinopyroxene (commonly poikilitic), with which orthopyroxene and olivine may be associated. Olivine locally defines diffuse layers (Plate 7), and individual grains appear as rusty-chocolate crystals showing thin double coronas, most likely an inner corona of hypersthene and an outer corona of pargasitic amphibole plus spinel. A vertical, 15-cm-wide monomineralic seam of orthopyroxene was recorded at one locality. No indications of layering were seen at that outcrop and it is suspected that the seam is an injected vein. Poikilitic, late-crystallizing magnetite is also common.

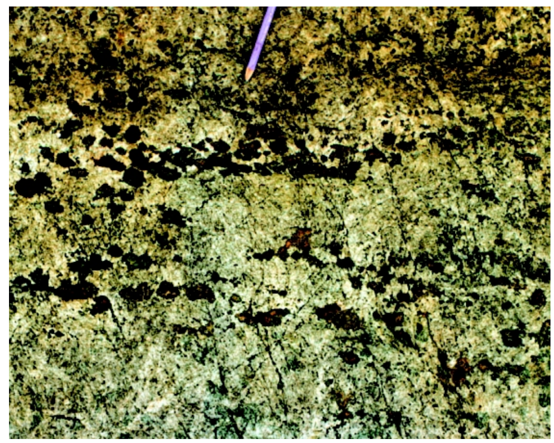

**Plate 7.** *Olivine with coronas defining a diffuse layering in leucotroctolite/anorthosite from the Rocky Pond intrusion of the Mealy Mountains Intrusive Suite; southwest NTS map area 13B/13.*

No compelling reason is readily available to explain the variations in magnetic signature within the body (Figure 4). There is no obvious correlation with lithological variations, which, in any case, are slight. Anomalous concentrations of magnetite, a common phase throughout the body, might be the cause.

#### *Vulcan Anorthosite*

Lacking named geographical features in the vicinity, the newly coined title, Vulcan anorthosite, is given to a body in the northwest corner of the map region on the basis of mineral claims in this area currently held by Vulcan Minerals Inc. The body is shown as separate from the Rocky Pond anorthosite, but it is possible that the Vulcan anorthosite is connected on its southeast side to the Rocky Pond body, in which case it would be a of lobe of that intrusion and the term 'Vulcan' redundant. Even if two bodies exist at the present surface, they could, of course, be connected at depth.

The anorthosite weathers creamy or grey, is very coarse grained, massive and homogeneous. The body is essentially monomineralic, composed of weakly aligned plagioclase crystals up to 20 cm long. Very minor poikilitic clinopyroxene, orthopyroxene and magnetite are ubiquitous mafic/opaque constituents. A feature unique to this intrusion is the presence of interstitial, anhedral K-feldspar (possibly both primary and secondary), which may be sufficient justification for regarding the Vulcan anorthosite as a separate body.

***Crooks Lake Anorthosite***

The northeastern quadrant of the map region (NTS 13B/14) is dominated by a roughly circular body of anorthosite approximately 20 km in diameter, here termed the Crooks Lake anorthosite. Minor leucogabbro, leuconorite and leucotroctolite are associated. Only the northern half of the Crooks Lake intrusion is exposed, but the extent of the pluton can be confidently delineated from aeromagnetic patterns (Figure 4), particularly by a ring of high magnetic anomalies that coincides with the rim of the body (unlike the Rocky Pond anorthosite, which has no such magnetic characteristic). The cause of the anomalies is uncertain, but may be due to a mafic/ultramafic border (*see below*).

Outcrops within the Crooks Lake anorthosite typically weather white or grey but, rarely, are tinged brown, purple, or pink. The anorthosite (Plate 8) is massive, homogeneous and is mostly fresh, but grades into rubbly, rotten material at some sites. Although there may be considerable variation in grain size, the rocks are generally coarse to very coarse grained and unrecrystallized. Plagioclase forms well-twinned, anhedral to euhedral crystals commonly exceeding 10 cm long. It was clearly an early crystallizing phase. Crystals are locally aligned to give a crude primary igneous lamination. Orthopyroxene is subordinate to clinopyroxene, and both are interstitial to plagioclase. Poikilitic pyroxenes normally occur as grains several centimetres across, although crystals up to 1 m were seen. Olivine, by contrast, is rare. Magnetite (late crystallizing), typically mantled by mafic silicate, is ubiquitous and, rarely, is found forming small pods. Minor sulphide (probably pyrite), apatite, biotite, amphibole and chlorite were seen on a small island in Crooks Lake, but not elsewhere. Greenschist-facies minerals, related to alteration adjacent to a late-stage brittle fault, were seen on the northwest side of the body.

Simplicity of outcrop pattern of the Crooks Lake anorthosite is disrupted by a small area of monzonite/syenite in the northeast part of the intrusion, the extent of which is interpreted from two outcrops that coincide with a magnetic high (Figure 4). Textures in the monzonite/syenite are subtly distinct from the monzonite surrounding the Crooks Lake intrusion, suggesting that these rocks represent an


**Plate 8.** *Leuconorite/anorthosite from the Crooks Lake pluton; north of Crooks Lake.*

independent block within the anorthosite. Outcrop relationships between the monzonite and anorthosite were not observed. The rocks are buff-grey-weathering, medium to coarse grained and recrystallized. K-feldspar dominates the mineral assemblage, hence the alternative name syenite. A few ovoid relict plagioclase crystals, up to 1 cm in diameter, and interstitial rounded grains of clinopyroxene, orthopyroxene and magnetite are also present. Enclaves or minor intrusions are lacking.

A single outcrop of metapyroxenite was located on the south side of the Crooks Lake anorthosite. The rock is brown- to black-weathering, medium to coarse grained and consists of amphibole replacing clinopyroxene, a magnetic opaque mineral, and minor biotite. The outcrop is coincident with one of the (Figure 4) highs situated on the circle defining the margin of the Crooks Lake intrusion, but whether the whole of the high-magnetic rim is due to a border of ultramafic rocks is open to question as, elsewhere, close to the border, parts of the high magnetic rim coincide with anorthosite on the ground. *En passant*, it is noted that although magnetic patterns can be used to imply a genetic link between the metapyroxenite and the Crooks Lake anorthosite, it should also be kept in mind that the metapyroxenite could be part of the layered mafic intrusion exposed farther south.

## Monzonite

***Northwestern Monzonite***

The most topographically rugged part of the map region is underlain by monzonite. The rocks are buff-white, creamy, grey, orange or brown, typically rubbly-weathering, medium to coarse grained, generally massive, homogeneous and slightly recrystallized (Plate 9). K-rich feldspar is the major phase present, commonly exceeding 90 percent of the rock, forming polygonal grains and larger crystals. Some

**Plate 9.** *Typical monzonite characteristic of the Mealy Mountains Intrusive Suite in the northwest part of the map region; northwest NTS map area 13B/13.*

relict, irregular plagioclase primary grains are present, which, in stained slabs, have white interiors and grey reaction rims; they are clearly in disequilibrium with the surrounding material (*i.e.,* xenocrysts). Both clinopyroxene and orthopyroxene are present and occur as aggregates or dispersed as individual crystals. Hornblende and quartz are rare accessory minerals. Magnetite is a ubiquitous accessory opaque mineral and commonly defines a diffuse layering.

The rocks are typically completely free of enclaves or minor intrusions, but exceptions occur. On a river outcrop in the northwest corner of the map region, two types of enclave were seen. One is a mesocratic two-pyroxene rock measuring 2 by 1 m and showing local coarse-grained hornblende–plagioclase veins; the other is a coarser grained monzonite forming rounded pods, also about 2 by 1 m across. On the southwest side of the Rocky Pond anorthosite, two localities were found where monzonite hosts mafic two-pyroxene granulite enclaves.

In the whole of the northwestern monzonite, only two minor intrusions were seen; one is a 2-cm-wide feldspathic vein and the other a 3-cm-wide pegmatite containing orthopyroxene.

### *Monzonite along the Northern Boundary of NTS Map Area 13B/14*

Taken together with the northwestern monzonite, these rocks make monzonite the sole rock type along the full length of the northern map boundary. This is consistent with the mapping of Nunn and van Nostrand (1996), to the north, who show monzonitic rocks as entirely (except for a few small enclave areas) underlying the southern half of the Kenemich River map region.

The rocks are essentially identical with those in the northwest quadrant, being buff-, creamy- or white-weathering, medium to coarse grained, massive, homogeneous and showing polygonal textures in places. They also contain relict plagioclase ovoids, up to about 1 cm across, and clinopyroxene–orthopyroxene±magnetite aggregates. Magnetite concentrations also define a diffuse layering. No quartz or hornblende was seen and the rocks lack minor intrusions. One enclave of banded amphibolitic material was seen, forming a pancake-shaped lens measuring at least 3 by 2 m across and 40 cm thick. Although the rocks are mostly massive, a moderate foliation is present at one locality, possibly due to proximity to country rock (*see above*).

### *Monzonite in the Northeast Corner*

The monzonitic rocks in the northeast corner of the region were recorded in field notes to be slightly different in texture from monzonite previously seen (to the west) and as containing hornblende. On the basis of these tenuous threads, it is speculated that the rocks underlying this area may belong to a separate pluton.

### *Monzonite between the Crooks Lake and Rocky Pond Anorthosites*

Although probably no more than an extension of the monzonite to the north, with which continuity exists, this area is mentioned separately to emphasize that the monzonite unequivocally separates the Rocky Pond and Crooks Lake bodies. In addition to the typical buff-weathering, a dark red–brown hue characterizes the rock locally in consequence of hematization along a late brittle fault that also passes between the two anorthosite bodies. As with other monzonites, it is medium to coarse grained, recrystallized, massive and homogeneous. The mineral assemblage is plagioclase, K-feldspar, clinopyroxene and magnetite. Stained slabs suggest that plagioclase content decreases in a southward direction. No quartz, hornblende or orthopyroxene was observed, although the latter mineral is probably present.

## FOLIATED, MAINLY GRANITOID ROCKS OF UNCERTAIN AFFINITY

Foliated, mainly granitoid rocks have been grouped separately from orthogneisses and the metamorphosed mafic intrusion that are situated mostly farther south, and the Mealy Mountains Intrusive Suite located to the north. In spatial relationships, composition and in fabric, the foliated granitoid rocks, in essence, occupy an intermediate position between all three. The foliated granitoid rocks differ from, i) the orthogneisses in lacking migmatization and having generally lower quartz contents, ii) the monzonitic rocks of the

Mealy Mountains Intrusive Suite in being foliated and containing quartz, and iii) from the metamorphosed mafic rocks in having a lower colour index and more K-feldspar plus quartz (although some of the mafic rocks do have noteworthy K-feldspar). Previous geochronological studies indicate that the orthogneisses are older than monzonite within the Mealy Mountains Intrusive Suite, so these quartz-poor, foliated granitoid rocks cannot simply be considered as transitional between those two units. Chronological relationship of the metamorphosed mafic intrusion to the orthogneiss and Mealy Mountains Intrusive Suite is equivocal, as the age of the mafic rocks is unknown. Needless to say, the geological affiliation of the foliated granitoid rocks requires further investigation.

### Monzogabbronorite and Leucomonzogabbronorite

Monzogabbronorite is present within the metamorphosed mafic intrusion, but is more common along its northern flank and within foliated monzonite to quartz monzonite to the north.

This unit is buff-grey-weathering, medium to coarse grained, mostly homogeneous and weakly to moderately recrystallized, and weakly to strongly foliated. It incorporates the most coarse-grained rocks within the layered mafic intrusion, locally achieving crystals up to about 2 cm long. The mineral assemblage comprises pyroxene, plagioclase, K-feldspar and magnetite. Of all the rocks potentially linked with the metamorphosed mafic intrusion, this is the one in which orthopyroxene is most common. Monzonite veins were recorded at one locality.

Buff-, pink- or grey-weathering, medium-grained, massive, homogeneous leucomonzonorite occurs at the eastern margin of the map region and is a continuation of rocks termed monzonorite by Gower (1998). Although the rocks are more melanocratic and contain more plagioclase than typical monzonite, they, nevertheless, also contain a high proportion of K-feldspar and the percentage of mafic mineral is still fairly low (ca. 10 percent), hence the provisional name range given above.

### Monzonite to Quartz Monzonite

The largest area of this unit is in the Little Drunken River area. The rocks are quartz monzonite to monzonite and are found intermixed with monzogabbronorite, leucogabbronorite and gabbronorite. The rocks are pink-, orange-, buff-, creamy- or grey-weathering, homogeneous, medium to coarse grained, moderately to extensively recrystallized and weakly to strongly foliated. K-feldspar megacrysts are present locally and reach 2 cm across, although are mostly less than 1 cm. Quartz commonly shows a bluish hue and grains are up to 0.5 cm across. Other minerals include plagioclase, clinopyroxene, lesser hornblende, biotite and orthopyroxene and accessory magnetite. Elongate quartz and alignment of mafic mineral clusters assist in defining the foliation. A few pegmatite veins were seen.

### Granite to Quartz Monzonite

Granite and quartz monzonite were mapped in the eastern part of NTS map area 13B/14 and are the western continuation of similar rocks mapped in the Upper Eagle River map region (Gower, 1998). The rocks are buff-, grey- and pink-weathering, medium to coarse grained (but mostly coarse grained), massive to (rarely) weakly foliated, partially recrystallized and homogeneous. Apart from K-feldspar and plagioclase, the rocks also contain quartz (blue in outcrop), orthopyroxene, clinopyroxene, biotite and magnetite. Separate areas of granite and quartz monzonite are shown in Figure 3, but more intimate mixtures of the two may be closer to reality, as illustrated by Gower (1998, Plate 5, which shows granite agmatically invading monzonite).

An isolated granite outcrop was found in the northeast part of NTS map area 13B/14. The rock is pale-pink- to white-weathering, indistinctly foliated and homogeneous. It is an alkali–feldspar granite containing K-feldspar, quartz, sodic plagioclase, biotite magnetite, and a brown mineral, possibly titanite. Relationships between the granite and the surrounding monzonite are unknown.

One outcrop of granite was found in the Little Drunken River area, apparently surrounded by outcrops of foliated monzonite to quartz monzonite. The rock is pink, abnormally leucocratic (for granite), coarse grained and homogeneous. Although the granite does not show an obvious fabric, it is assigned to the foliated granitoid rock package because it is intruded by a microgranite that does have a foliation, implying that the granite has experienced some deformation.

## DIABASE (MEALY) DYKES

Despite no contact relationships being observed, one outcrop is confidently assigned to the Mealy dyke suite, a member of which has been dated to be 1250 ± 2 Ma (U–Pb baddeleyite; Hamilton and Emslie, 1997). The rock is black-weathering, medium grained, massive and homogeneous. Apart from their east–northeast trend, a key feature used to identify the Mealy dykes is a well-developed ophitic texture accompanied by evidence of quenching in plagioclase. No obvious magnetic signature is associated with the dyke, but the outcrop is on line with an obvious east–northeast-trending topographic lineament. Mealy dykes are recessive weathering, so it is likely that other, unexposed, dykes are present in the region.

**Plate 10.** *One of the many pegmatites exposed in the southern half of the region (western part of NTS map area 13B/11).*

## PEGMATITE AND MICROGRANITE

At many outcrops in the southern half of the map region the sole rock type is pegmatite (Plate 10). Clustering of several such outcrops might suggest that some very large pegmatites exist, but, given that it is a rock type resistant to weathering, this could easily be a misleading impression. *Ceteris paribus*, only relatively small, but preferentially exposed, bodies need be present, which would mean that the overall proportion of pegmatite is quite low. At outcrops where other rock types are also exposed, it is commonly clear that the pegmatites are minor discordant intrusions truncating older fabrics (e.g., Plate 3c). Despite these caveats, a 20-m-high cliff of composite pegmatite–microgranite was found east of Joir River, so, obviously, not all pegmatites in the region are small.

The rocks are pink-, creamy- or white-weathering and very heterogeneous, ranging from aplite, through microgranite to very coarse pegmatite having an average grain size exceeding 10 cm. Some pegmatites are recrystallized and show obvious foliations, defined by heterogeneity of minerals in particular layers, or elongation of quartz veins, but others are massive and unrecrystallized. Associated quartz veins (locally irregular masses) vary from 1 cm to 2 m in width. In rare instances, enclaves of gneiss or amphibolite were noted, the largest about 2 m long. Where pegmatite is, otherwise, the only rock exposed, such enclaves are useful guides to the nature of surrounding rock types. Compositions and textures in the intrusions are variable, showing abrupt transitions between pegmatite, granite, microgranite and aplite in the same body. The quartz content and proportion of K-feldspar to plagioclase vary dramatically and, empirically, there is a hint that high plagioclase content correlates with emplacement into mafic rocks (explicable in terms of potassium consumption during metasomatism of the host rock at time of pegmatite emplacement). Graphic intergrowths of quartz and K-feldspar are common. The dominant mafic mineral is biotite; the largest biotite books seen are 2 cm across and 0.2 cm thick. Muscovite was seen at one outcrop and garnet noted in a stained slab from another. The garnets are very small (1 mm in diameter), euhedral, orange-brown and probably igneous. Minor magnetite is ubiquitous.

Variability of deformational state suggests that several generations of pegmatite are present, possibly reflecting the same time span as that represented between the early gneisses and the late- to post-Grenvillian granitoid plutons.

## LATE- TO POST-GRENVILLIAN GRANITOID INTRUSIONS

Two late- to post-Grenvillian (970 to 950 Ma) granitoid plutons falling within the Crooks Lake map region were inferred by Gower *et al.* (1991, their Figure 4) on the basis of magnetic patterns, but their existence on the ground remained uninvestigated until this mapping project. Adequate outcrop is present to confirm the more southerly, circular (in plan) pluton, but the status of the indicated northerly intrusion is very uncertain. Detailed criteria for the field identification of late- to post-Grenvilllian plutons were discussed by Gower (1998); the key features are, i) unrecrystallized textures, especially quartz grains, ii) sporadic to common zoned and mantled feldspars, and iii) horizontal jointing (cf., Gower *et al.*, 1994; Gower, 1998). The third criterion, although the most qualitative, is probably the most reliable.

The southerly pluton is a pink-weathering, massive, homogenous, 2-feldspar, biotite granite pluton (Plate 11). It

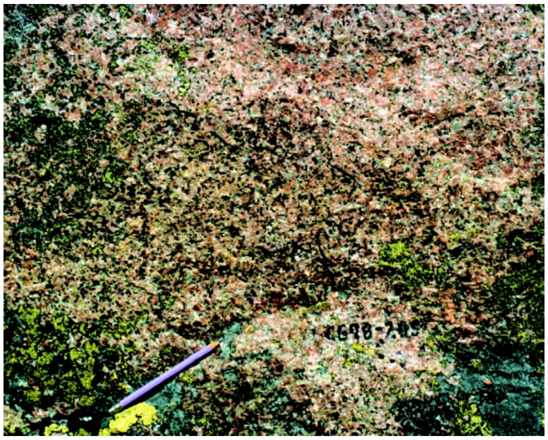

**Plate 11.** *Texture of granite in late- to post-Grenvillian pluton in southeast part of region; central NTS map area 13B/11.*

**Plate 12.** *Breccia and quartz veins associated with late-stage brittle faulting; northeast NTS map area 13B/11.*

contains roughly equal proportions of plagioclase and K-feldspar and subordinate quartz. K-feldspar commonly mantles plagioclase, but some feldspar grains also exhibit K-feldspar cores. Minor magnetite is also present. The inference that the pluton is circular in plan is based on topography and a distinct aeromagnetic high (Figure 4). The aeromagnetic expression of the granite is displaced 3 km to the east of the pluton – as it was mapped on the basis of outcrop and topographic constraints.

The field evidence for the northern pluton relies on one exposure. As for the southerly pluton, the rock is a pink-weathering, homogeneous, 2-feldspar, biotite granite. It differs texturally, however, in containing K-feldspar megacrysts up to 2 by 1 cm and some diffuse, fine-grained, enclaves that are slightly more melanocratic than their host. A fabric is defined by megacrysts and enclaves, both having an east–northeast alignment. The depicted boundary of the pluton assumes that the magnetic anomaly is not displaced, because, if an equal displacement to that for the southern pluton is assumed, then the single exposure would lie outside the anomaly determined 'displaced' position for the pluton. It is recognized that interpretation of the size and boundaries of these two plutons, utilizing magnetic data, remains unsatisfactory.

### FAULT BRECCIA

Fault breccia was seen in three outcrops aligned along an 050° trend east of Eagle Lake. The most northerly of three exposures comprises green-, white- and red-weathering, fine-grained, sheared and brecciated rock that has been extensively silicified, hematized, chloritized and epidotized (Plate 12). Deformation and alteration have rendered the original protolith unrecognizable. The fault breccia is at least 50 m wide and has been extensively injected, in an irregular, anastomosing manner, by quartz veins, ranging from 1 mm to 3 cm wide.

The two other outcrops, to the southwest, differ in that they consist almost entirely of vein quartz. Quartz, in the northeasterly exposure, occupies a linear zone at least 100 m wide and 500 m long and is mostly massive, although some shear zones are present.

## STRUCTURE

The regional structure grain is east–northeast, of which the foremost expression is the boundary between massive rocks of the Mealy Mountains Intrusive Suite in the northern half of the map area and foliated rocks in the south. Within the gneisses, foliated granitoid rocks and layered mafic intrusion, the structural fabric is variable but east–northeast, overall. The fabrics are rarely intense, but there are isolated exceptions (e.g., Plate 3b). In these examples, severely deformed straight gneisses also exhibit strong northwest- or north-plunging lineations. Data are inadequate, however, to define particular zones of severe ductile deformation within the map region.

Anorthosite and monzonite within the Mealy Mountains Intrusive Suite are mostly massive and structureless (Plates 7, 8 and 9), but diffuse primary layering is locally present, particularly in the northwest monzonite where it dips moderately to steeply to the west. Penetrative foliations, with which enclaves are aligned, are present in monzonite in the northeast part of the map region, where they have been interpreted as reflecting proximity of monzonite to a country rock roof pendant or septum between individual plutons.

Another feature of potential structural significance in the Mealy Mountains Intrusive Suite is the contrast in outline between the Rocky Pond and Crooks Lake anorthosites. The Rocky Pond body appears to have some straight margins that change abruptly in direction, in contrast to a near-circular outline for the Crooks Lake pluton. It is suggested here that the Rocky Pond body may be fault controlled (presumably before intrusion as no evidence was found for post-emplacement fault contacts) *versus* diapiric intrusion for the Crooks Lake intrusion. Regardless of the merit of this idea, the differing shapes of the two bodies is sufficient reason alone to suspect differing times of emplacement.

The east–northeast regional structural fabric is masked by a northwest-trending foliation that, farther east, Gower and van Nostrand (1996) and Gower (1998) interpreted as having formed late in the active tectonic history of the region, possibly during the late Grenvillian. No indication of this fabric was seen in the circular granite pluton in the southeast quadrant of the map region, which, together with its lack of recrystallization and U–Pb data for similar plutons elsewhere, is taken as evidence of its late- to post-Grenvillian age.

Lineaments apparent on aerial photographs suggest that brittle faulting and/or major jointing occurs in almost any direction within the map region. Two trends are significant however; north–northeast and east–northeast. The north–northeast faults are concentrated in the northwest corner of the map region and are readily identifiable on the basis of obvious topographic lineaments and west-facing scarps. They are interpreted as belonging to the southeast flank of the Lake Melville Rift system (Gower *et al.*, 1986). No attempt was made to locate them exactly on the ground, thus any associated brecciation, shearing, or related features, was not recorded. In contrast, the east–northeast-trending faults have weak topographic expression, but have obvious surface effects, such as fault breccia, brittle fracturing and greenschist-facies alteration.

## METAMORPHISM

Metamorphic grade in the gneissic rocks is at amphibolite facies. Quartz–plagioclase–K- feldspar–biotite–sillimanite–garnet-accessory minerals characterize the only outcrop of metasedimentary gneiss known in the region. The remainder of the gneisses (i.e., orthogneisses), consist of quartz–plagioclase–K-feldspar ± biotite ± hornblende ± various accessory minerals. Garnet was not found in any orthogneiss, suggesting a lower grade of metamorphism than in the adjoining map region to the east where garnet was recorded, albeit as small and sporadic grains. The foliated granitoid rocks have a similar mineral assemblage, except they are more commonly characterized by anhydrous mafic minerals that are either igneous or recrystallized from an igneous progenitor. Metamorphic mineral assemblages in the mafic intrusion are also at amphibolite facies, again a contrast from mafic rocks farther east, which show evidence of granulite-facies conditions. Minerals such as garnet or orthopyroxene in plagioclase-rich sweats, both found farther east, were not seen in the Crooks Lake region.

In the Mealy Mountains Intrusive Suite, the only indication of metamorphism is recrystallization. Most commonly, this affected K-rich feldspar, and instances were seen where the K-rich feldspar is completely polygonized, whereas relict plagioclase xenocrysts are apparently unaffected. As noted by Gower (1998), the recrystallization might well be associated with emplacement rather than having been superimposed later. Primary textures and minerals in the ophitic-textured diabase assigned to the Mealy dyke swarm, and in the granite assigned to the late- to post-Grenvillian granite, is evidence that any subsequent tectonism did not affect these rocks. Greenschist-facies or lower grade alteration associated with brittle faulting is the last recognizable metamorphic effect in the region.

## ECONOMIC POTENTIAL

Lack of geological information, poor exposure, insufficiently attractive geophysical or geochemical targets, and inaccessibility have collectively deterred mineral exploration in the map region.

The only exception is in the northwest corner of the map region where Vulcan Minerals Inc. (Vulcan) have recently pursued base-metal oxide and sulphide mineralization on the Goose South property, following up on magnetic anomalies and surface mineralization first investigated by Newfoundland and Labrador Corporation Limited (NALCO) in the early 1950s. As a result of airborne geophysical surveys, NALCO identified several magnetic anomalies south of Lake Melville, one of which, in the Crooks Lake map region (NALCO Anomaly A528594-1-2-3-4), was described as having a maximum magnetic relief of 4000 gammas and consisting of two magnetic highs trending northeast and northwest and separated by a magnetic low (Sharon, 1952a,b). Four separate anomaly peaks were identified by MacDougall (1953), all of which were examined by geological traverse and ground magnetometer. The rocks in the vicinity were described as medium-grained anorthosite, in which disseminated mineralization was evident. Heavy mineralization was found in one area, but is only a few inches thick and occurs as a vertical vein. The most important mineralized zone was found in the southernmost portion of the anomaly, designated A528594-1. In this area, a zone of massive to near massive titaniferous magnetite and/or ilmenite over 1000 m long and 125 m wide was located and considered to be possibly much larger. MacDougall (1953) reported that other outcrops of anorthosite in the same general area contain 25 to 40 percent mineralization, but mentioned that samples had not been assayed at that time. The NALCO annual report (NALCO, 1953), however, noted that assays were disappointing.

In a press release dated August 19th, 1996, Vulcan reported that 20 grab samples of disseminated to semi-massive and gossanous magnetite/ilmenite had been selected for assay from the Goose South property. One whole-rock geochemical analysis indicated 26.76% total Fe oxide and 3.91% $TiO_2$. Assays on the twenty samples for Ti gave results ranging from 0.57 to 3.55%. Field observations indicated a body at least 600 m wide (east–west) and open, thus expanding the width from the 125 m originally reported by NALCO (MacDougall, 1953). The deposit was sampled for a length of 850 m. On August 29th, 1996, Vulcan announced that it had staked an additional 240 claims in the area. On Sept 5, Vulcan announced further assay results for 19 samples ranging between 1.14 and 8.67% $TiO_2$ and 5.44 to 41.53% total Fe oxides. In a March 26, 1997 press release, Vulcan announced that it had acquired 480 line kilometres of airborne electromagnetic and magnetic data over the Goose South property and on Nov 17th, 1997 reported that, in addition to the titanium-iron potential, several conductors having copper–nickel–cobalt potential had been identified.

The current 1:100 000-scale mapping project does not add to the information above, but it is perhaps worth observing that both the Rocky Pond and Crooks Lake anorthosite bodies may offer additional similar targets. Magnetic highs (Figure 4) within the region underlain by these bodies do not, for the most part, show any obvious correlation with rock type and it seems more likely that they are related to local concentrations of opaque minerals, of which magnetite would obviously be included. Exceptions to this observation are magnetic highs associated with monzonite–syenite within the Crooks Lake body and a magnetic high coincident with ultramafic rocks at its inferred southern rim (Figure 4). The latter offers an exploration target in its own right and any positive results would encourage exploration of magnetic highs located elsewhere around the rim of the Crooks Lake intrusion.

The mafic intrusion must be regarded as the prime newly identified exploration target for the map region. The melagabbro typically contains minor traces of disseminated sulphide and one outcrop was found where sulphide is sufficiently abundant for the site to be designated as a mineral occurrence (Figure 3). The sulphide in the exposed rock is estimated to be less than 1 percent of the rock and appears to be concentrated along anastomosing microfractures throughout the rock (cm-scale spacing) rather than being a primary phase. The sulphide mineral, which is very weathered and shows a wide range of iridescent colours, was not unequivocally identified, but is most likely pyrite. No secondary base-metal minerals were noted. The rock is also characterized by unusually high magnetite content, and a pronounced localized magnetic anomaly is spatially coincident with the outcrop (Figure 4). This site certainly deserves follow-up investigation.

Although pegmatites are abundant throughout the map region, they offer little promise for explorationists. No minerals of economic interest were found in any of them.

The only other rocks of obvious economic interest are the fault breccias and associated quartz veins. These might be considered worthy of investigation for gold, although no indications were found that might stimulate exploration.

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