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MAPPING IN THE TORNGAT OROGEN, NORTHERNMOST LABRADOR: REPORT 3, THE NAIN CRATON (INCLUDING A NOTE ON ULTRAMAFIC DYKE OCCURRENCES IN NORTHERNMOST LABRADOR)

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ABSTRACT

In the Seven Islands Bay area, the eastern foreland of the Early Proterozoic Torngat Orogen is underlain by granulite-facies Archean gneisses (correlated with the Nain craton) that have experienced a variable Proterozoic metamorphic overprint. The predominant rock type is granulite-facies, migmatitic tonalite orthogneiss having abundant interlayers of mafic gneiss and podiform enclaves of meta-anorthosite. Supracrustal rocks consisting of quartzitic and pelitic gneiss interlayered with mafic granulite and ultramafic lenses are prolific in the western part of the area.

Early Proterozoic rocks consist of diorite and granite intrusions of probable 1.89 to 1.86 Ga age and are restricted to the western part of the area, and one or more mafic dyke swarms comprising non-porphyritic, black plagioclase–porphyritic (Avayalik dykes) and possibly younger diabasic or dioritic green dykes.

The western part of the map area has received a static high-pressure, granulite-facies metamorphic overprint, defined by garnet–clinopyroxene assemblages, which affects both gneisses and dykes and is of Early Proterozoic age. The metamorphism is tentatively attributed to deep burial as a result of eastward-directed thrusting from the interior of the Torngat Orogen. In the northwest corner of the map area, the high-pressure assemblages have been retrogressed to the amphibolite facies and also straightened and locally sheared in association with development of the nearby 1.79 to 1.71 Ga Komaktorvik shear zone. East-side-up uplift on this structure is probably responsible for exhumation of the high-pressure granulites.

Phanerozoic rocks are represented by east–west-trending Cambrian dykes and (external to the map area) by small, scattered dykes of ultramafic lamprophyre.

The Archean gneisses in this area contain a much higher proportion of supracrustal rocks than elsewhere in the Nain craton and may have a proportionately higher potential for base-metal mineralization. The presence of ultramafic lamprophyre dykes in northernmost Labrador may indicate a potential for other intrusions of the kimberlite–lamprophyre clan that might be prospective for diamonds.

INTRODUCTION

The 1993 field season was the last of a three-year project targeted at mapping of the Archean and Early Proterozoic rocks of the Torngat Orogen in northernmost Labrador. The project has been run co-operatively with the Geological Survey of Canada, and also with various university research groups under the auspices of the LITHOPROBE ECSOOT project. This report deals with mapping of Archean crust, referred to as the Four Peaks domain (Figure 1), which forms the eastern foreland to the Early Proterozoic Torngat Orogen. The Four Peaks domain is thought to represent a northerly extension of the Nain craton and is separated from the internides of the Torngat Orogen by the Komaktorvik shear zone, a portion of which is exposed in the westernmost part of the map area. The current work was undertaken in

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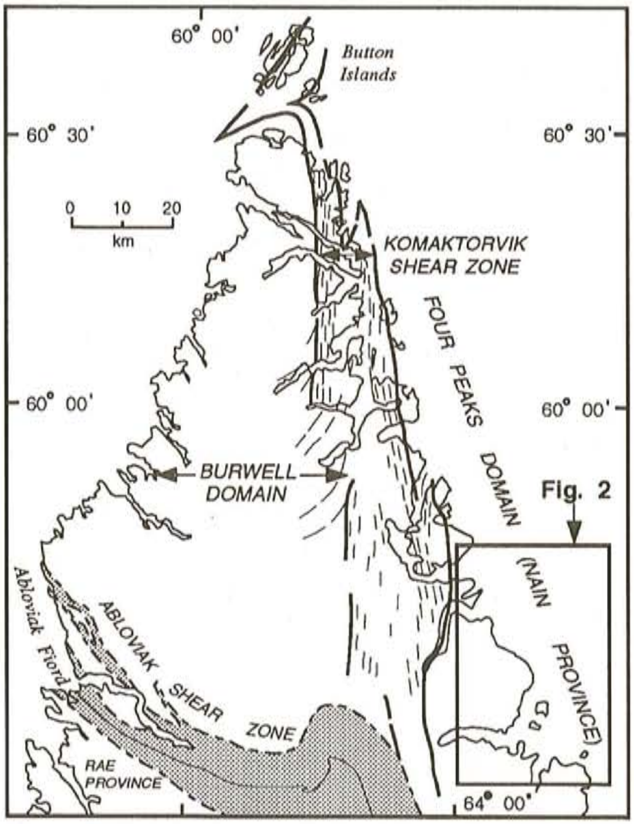

Figure 1. *Regional setting of the map area, after Van Kranendonk* et al., in press.

conjunction with continued mapping in the interior of the Torngat Orogen, which is summarized by Van Kranendonk *et al. (in press).*

The map area lies in the northern part of the Torngat Mountains and is characterized by rugged, glaciated topography rising to 1340 m. Some preliminary coastal mapping was undertaken by DB and AH during the 1992 field season but the bulk of the area, including all of the inland work, was completed in 1993 using helicopter-emplaced ground traversing. Parts of the area that proved too precipitous for such work, were mapped by a combination of aerial observation and spot landings.

Previous mapping was restricted to the 1 inch = 4 miles reconnaissance work of Taylor (1977, 1979). Morgan and Taylor (1972) described metamorphosed basic dykes from the area and Bridgwater and Wardle (1993) reported on preliminary Pb isotope results from Archean gneisses. In the descriptions which follow, italics are used to indicate map units shown on Figure 2.

GEOLOGY

THE ARCHEAN GNEISSES

The dominant rock type is a brown- to buff-coloured *tonalitic orthogneiss,* generally strongly migmatitic and characterized by numerous disrupted layers and pods of ultramafic and mafic gneiss (Plate 1) intermixed with pelitic to psammitic metasedimentary rocks. The only indication of the age of the orthogneiss is a U–Pb zircon determination of 2834 ± 4 Ma on migmatitic orthogneiss from the Avayalik Islands, 40 km north of the map area (D. Scott, personal communication, 1993). The orthogneisses have been subdivided mainly according to their metamorphic mineralogy (Figure 2), a feature that is discussed further below.

The orthogneisses also contain podiform enclaves of pale-grey *meta-anorthosite* that vary from tens (Plate 2) to hundreds of metres (Plate 3) in size (Figure 2; see also Taylor, 1977). The meta-anorthosites usually preserve compositional layering and are associated with layered leucogabbroic rocks. It is probable, therefore, that they represent the more differentiated parts of dismembered layered mafic intrusions. Igneous texture, defined by primary plagioclase and relict orthopyroxene, is only locally preserved and has generally been totally recrystallized to granoblastic assemblages of grey to purple plagioclase, garnet, clinopyroxene and minor hornblende. Garnet occurs intergrown with quartz in prominent symplectites up to several centimetres across. The anorthosite pods are intruded by veins of pegmatite and leucotonalite that were apparently generated during granulite-facies melting of the ambient tonalitic gneisses. The relationship of the anorthosites to the protolith of the tonalitic gneisses prior to migmatization is not clear.

Mafic gneisses, including layered to massive mafic granulites and thin pods and layers of massive to layered pyroxenite, range from metres to kilometres in extent and are only locally large enough to be mapped as individual units (Figure 2). The mafic gneisses are generally characterized by prominent development of red garnet and bright green clinopyroxene; the ultramafic rocks generally preserve orthopyroxene as the principal mafic phase but this may be recrystallized to garnet and clinopyroxene around the periphery of ultramafic lenses. These rocks generally have gradational contacts with metasediment-dominated supracrustal belts and probably represent a mixture of supracrustal (metavolcanic?) rocks and mafic intrusions.

Belts of rusty-weathering *supracrustal gneiss* occur interspersed with the orthogneisses throughout the area but are most prevalent west of Komaktorvik Fiord. The principal rock type is a thinly layered, white and rusty brown, strongly migmatitic gneiss consisting of white leucogranite and garnet quartzite intercalated with layers of rusty, sillimanite-bearing pelitic gneiss and garnet psammite gneiss. Also present are layers and lenses of the various mafic and ultramafic rocks described above.

A potentially *early supracrustal assemblage* is preserved as layers within orthogneiss near Abbate Point east of Komaktorvik Fiord (Figure 2). The assemblage consists of interlayered marble, calc silicate, magnetite–quartz iron formation and quartzite all containing variable proportions of garnet, clinopyroxene and orthopyroxene. Preliminary

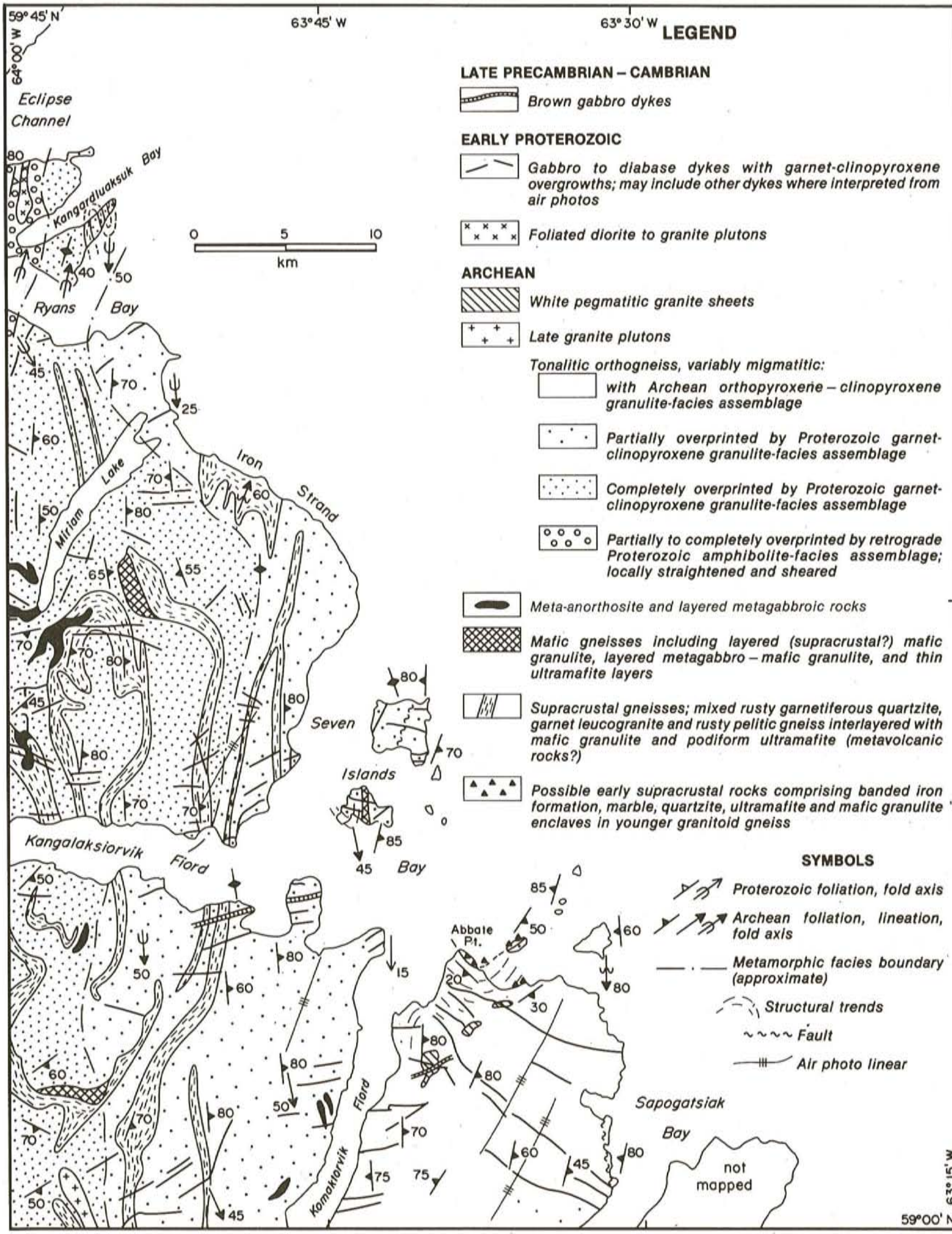

Figure 2. *Geology of the Seven Islands Bay area.*

Plate 1. *Dismembered orthopyroxenite in Archean tonalitic orthogneiss, Iron Strand.*

Plate 2. *Anorthosite pods in Archean orthogneiss, Outer Bryant Islands.*

Pb–Pb isotopic analysis of these rocks (Bridgwater and Wardle, 1993) revealed a Pb-isotopic signature very similar to that of Early Archean (>3.6 Ga) granulite-facies gneisses in the Saglek area; U–Pb dating by J. Connelly (Memorial University) is in progress to test this correlation.

The Archean gneisses have been intruded by a variety of late granitoid bodies, typically small but locally of mappable scale, e.g., the *late granite pluton* body located in the southwest corner of the map area and the sheets of white, *pegmatitic, quartz-plagioclase granite* east of Komaktorvik Fiord (Figure 2). These units, which crosscut gneissic layering but have been affected by subsequent granulite-facies recrystallization, are therefore presumed to be of Archean age.

EARLY PROTEROZOIC ROCKS

The Archean gneisses west of Kangardluaksuk Bay (Figure 2) are intruded by sheets of foliated, grey, hornblende–biotite-bearing *diorite and granite* similar to those described by Van Kranendonk and Scott (1992) from the area to the north and dated at 1.89 to 1.86 Ga (Scott *et al.*, 1993).

An irregular swarm of black *gabbro to diabase dykes* is a very prominent component of the area (Plate 4) and has several different trends, varying from east–west to north–south. In places, this variation is due to the presence of more than one dyke set, for example, north–south dykes cutting east–west dykes, but in others it is due to branching within the same dyke set. At least three types of dyke are present: i) black, non-porphyritic diabase to gabbro dykes, which form

Plate 3. *Folded anorthosite enclave in Archean orthogneiss (pale area), west of Miriam Lake. Length of enclave is approximately 400 m.*

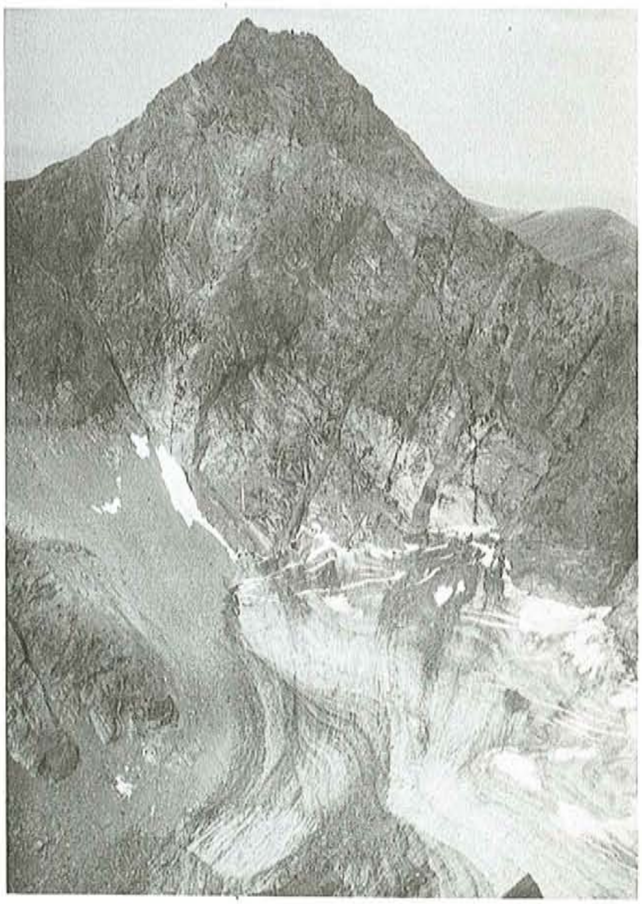

Plate 4. *Faulted Early Proterozoic mafic dykes cutting Archean orthogneiss, southwest of Miriam Lake.*

the predominant variety; ii) dykes similar to (i) but which contain phenocrysts of black plagioclase and which form a subordinate variant; and iii) green non-porphyritic, diabasic or possibly dioritic dykes that form a minor variant. The non-porphyritic dykes may be a variant of the black plagioclase dykes, alternatively they may belong to the 2.4 to 2.2 Ga dyke swarm that intrudes the Nain craton to the south of Nachvak Fiord. The black plagioclase dykes are correlated with the Avayalik dyke swarm, first described from the Four Peaks domain to the north (Wardle *et al.*, 1993; Van Kranendonk *et al.*, 1993). This type is characterized by en echelon development, pronounced branching and abrupt changes in trend. A preliminary U–Pb age of 1835 ± 2 Ma (D. Scott, personal communication, 1993) has been determined on zircons taken from one of these dykes, however, there is uncertainty as to whether this represents the age of intrusion or subsequent recrystallization (see discussion in Van Kranendonk *et al.*, *in press*). The green dykes at least locally have north–south trends and cut east–west-trending, black plagioclase dykes of type (ii). Chemical studies of the various dykes, underway at Copenhagen University, should further refine the dyke classifications. It should also be noted that many of the dykes shown on Figure 2 were either mapped from the air or interpreted from air photographs; consequently their affiliation is unknown and some could belong to the Cambrian set described below.

Virtually all dykes examined on the ground show some evidence of static recrystallization to an assemblage of garnet–clinopyroxene, an effect that increases in intensity to the west (see below) and was initially noted by Morgan and Taylor (1972).

CAMBRIAN DYKES

These diabase to gabbro dykes are distinguished by their brown-weathered appearance and the fact that they cut all the other dykes (Plate 5). The dykes have an overall east–west trend and moderate dips. The Cambrian age assignment is based on a single K–Ar age determination of 524 ± 78 Ma by Taylor (1979) from west of the map area.

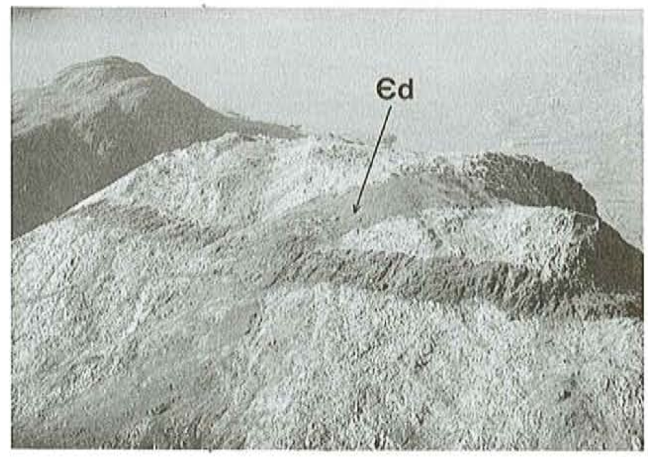

Plate 5. *East–west-trending Cambrian dyke (Єd), approximately 80 m thick, cutting an Early Proterozoic dyke emplaced within pegmatitic granite forming a hill capping, east of Komaktorvik Fiord. Seven Islands Bay is in background.*

STRUCTURE AND METAMORPHISM

The trend of gneissic fabrics within the Archean gneisses is controlled by a set of moderate, south-plunging folds that vary in size from small, outcrop-scale structures to the large map-scale folds that control the distribution of many of the supracrustal gneiss belts (Figure 2). The folds increase in tightness to the west with the result that structures west of Komaktorvik Fiord are mainly isoclinal and characterized by north–south trends. Folds east of Komaktorvik Fiord are more open resulting in more irregular fabric trends in this area. All of these folds predate the intrusion of the Early Proterozoic mafic dykes and are therefore presumed to be Archean. Thin, north–south-trending brittle shear zones that cut the Early Proterozoic dykes are generally the only discernable affects of Early Proterozoic deformation in the greater part of the map area.

In the westernmost part of the area, however, the gneisses are locally refoliated in north–south mylonitic shear zones associated with fabric straightening and mylonitization. In the eastern part of this zone, the Early Proterozoic dykes crosscut these shear fabrics but farther to the west, they become folded and mylonitized together with their host gneisses in the Komaktorvik shear zone (1.79 to 1.71 Ga; Scott *et al.*, 1993) that defines the eastern margin of the Torngat Orogen. This shear zone is also marked by the injection of pink (syn-shear?) pegmatites. Both pre- and post-dyke shear zones are associated with south-plunging folds and lineations that mimic the orientation of Archean folds to the east. Local kinematic indicators provide evidence for oblique, sinistral east-side-up movement associated with the main phase of amphibolite-facies deformation on the Komaktorvik shear zone.

The age of the pre-dyke shears, which appear to define an ancestral Komaktorvik shear zone, could range from Late Archean to Early Proterozoic but must predate the 1835 Ma age (metamorphic or igneous?) obtained for an Avayalik dyke (D. Scott, personal communication, 1993). Evidence from elsewhere along the eastern boundary of the Komaktorvik shear zone (Van Kranendonk *et al.*, *in press*) indicates that the Early Proterozoic mafic dykes, including both the Avayalik and green dykes, show evidence of syntectonic intrusion. It is conceivable, therefore, that the two generations of shearing may not be dramatically different in age.

Metamorphic assemblages in the Archean gneisses and Early Proterozoic dykes show systematic variations across the map area (Figure 2). East of Komaktorvik Fiord, the Archean gneisses are characterized by orthopyroxene–clinopyroxene–plagioclase granulite-facies assemblages that are clearly associated with the migmatization of these rocks prior to folding and dyke intrusion. The age of this metamorphism is probably given by a ca. 2770 Ma U–Pb overgrowth age on a similar gneiss from the Avayalik Islands (D. Scott, personal communication, 1993). Early Proterozoic dykes east of Komaktorvik Fiord generally preserve igneous assemblages, apart from the development of fine garnet in pegmatitic pods and within thin fractures at dyke margins.

West of Komaktorvik Fiord, the orthopyroxene in quartz-bearing felsic gneisses becomes locally rimmed and in places totally replaced by aggregates of fine, red garnet and green clinopyroxene. This is indicated as a zone of partial Proterozoic overprint on Figure 2. Farther to the west, the orthopyroxene-bearing assemblages in all but ultramafic rocks have been completely replaced by prograde, garnet–clinopyroxene assemblages (Figure 2). Dykes in this area also show pervasive development of garnet, clinopyroxene and quartz, both in the form of reticulate vein systems (Plates 6 and 7), and as blotchy overgrowths. Mengel and Rivers (1993) have also described carbonate as an additional component of the dyke vein assemblage in the Four Peaks domain to the north. The development of these textures is generally accompanied by a whitening of the black plagioclase phenocrysts and a recrystallization of the dyke matrix to a granoblastic texture. The garnet–clinopyroxene assemblage probably formed by the general reaction orthopyroxene + plagioclase = garnet + clinopyroxene + quartz, which is indicative of granulite-facies metamorphism at pressures probably in excess of 8 kilobars (Wells, 1979; Harley, 1989), although theoretically it could occur at somewhat lower pressures.

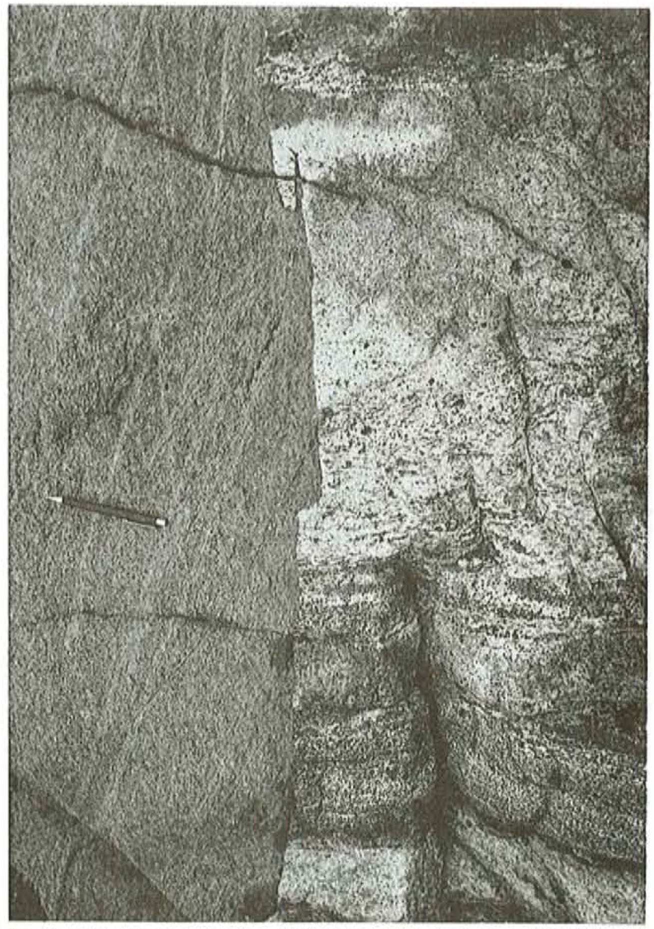

Plate 6. *Early Proterozoic dyke cutting granulite-facies orthogneiss. Both dyke and gneiss have been overprinted by a garnet-clinopyroxene development thought to be related to a static, Early Proterozoic metamorphic overprint. Metamorphism within the dyke is seen as blotchy overgrowths and reticulate veins of garnet and clinopyroxene. From western edge of map area near Kangalaksiorvik Fiord. Pen is 14 cm long.*

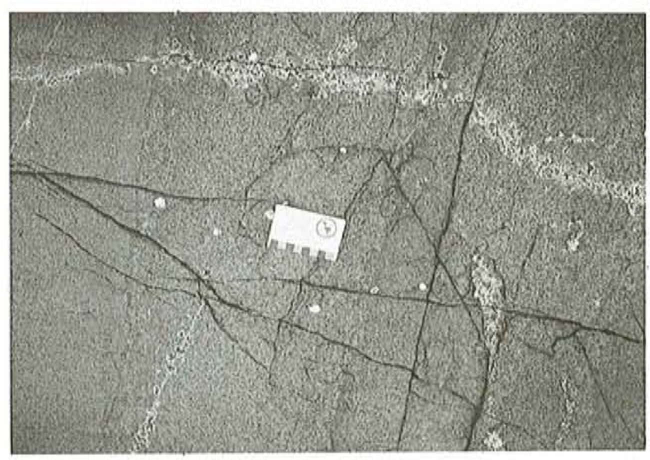

Plate 7. *Detail of garnet–clinopyroxene veins within an Early Proterozoic mafic dyke, Iron Strand area. Scale card is 8 cm long.*

The recrystallization to garnet–clinopyroxene assemblages is not associated with penetrative fabric development and appears to be a purely static overprint of presumably Early Proterozoic age. Garnet in these rocks is typically rimmed by thin bands of white plagioclase, a texture that may be due to reversal of the above reaction during uplift and decompression.

In the westernmost part of the area, the garnet–clinopyroxene assemblage in felsic and mafic gneisses has been partially retrogressed to amphibolite facies in association with the pre- and post-dyke shear zones described above, probably via the reaction clinopyroxene + garnet + water = hornblende + plagioclase + quartz. These retrogressed gneisses are generally distinguished by a grey appearance. Mafic gneisses have partially retained their garnet–clinopyroxene mineralogy but with some replacement by hornblende.

TECTONIC IMPLICATIONS

The development of the high-pressure garnet–clinopyroxene assemblage in the western part of the area implies deep burial to lower crustal depths possibly in excess of 30 km, followed by exhumation. The timing of the burial–exhumation events must postdate the emplacement of the Early Proterozoic dykes and predate the development of the Komaktorvik shear zone but is otherwise unconstrained. Figure 3 depicts the possible regional extent of the high pressure metamorphism in relationship to other Early Proterozoic metamorphic overprints. Garnet–clinopyroxene appears as a relict assemblage throughout the Archean mafic gneisses in the northern part of the Komaktorvik shear zone (T. Rivers and R. Patey, personal communication, 1992; Wardle *et al.*, 1993) and also affects dykes in Archean gneisses east of the shear zone. The locus of the event appears to have been in the Ryans Bay area where the pervasively recrystallized Archean gneisses are associated with an aeromagnetic low that is presumably related to the effects of magnetite-consuming reactions in these rocks. Shaded-relief aeromagnetic maps (produced in-house by G. Kilfoil, Geochemistry, Geophysics and Terrain Sciences Section) show the low to continue offshore in a northeasterly direction (Figure 3).

As the Archean rocks are traced to the south toward Nachvak Fiord, the high-pressure rocks give way to a zone of mainly undisturbed Archean crust, which is locally reworked in narrow, Early Proterozoic, amphibolite-facies shear zones (Wardle, 1983), and then into an area of greenschist-facies retrogression around the mouth of Nachvak Fiord that represents Archean upper crust. The coast between Nachvak Fiord and Ryans Bay (Figure 3), therefore, reveals progressively deeper levels of the Archean crust to the north. Modelling of the deep burial and consequent static, high-pressure metamorphism will require a precise knowledge of the timing of garnet–clinopyroxene development. This is not yet available (dating is in progress by J. Connelly of Memorial University) but a possible scenario that involves burial as a result of early (pre-Komaktorvik shear zone) east-directed thrusting from the internides of the Torngat Orogen seems plausible. This event may have occurred in response to ca. 1.86 Ga collision of Nain and Rae cratons, or to subsequent post-collisional deformation in the interval 1.84 to 1.82 Ga (Van Kranendonk *et al.*, *in press*). The deep crust that presently comprises the Four Peaks domain may then have been subsequently exhumed by east-side-up uplift on the Komaktorvik shear zone, as originally postulated by Van Kranendonk and Scott (1992).

ECONOMIC POTENTIAL

Mineral occurrences are not known from the area; however, only a small percentage of the area was directly covered by traversing. The relative abundance of metasedimentary and metavolcanic rocks signifies that this area should have greater base-metal mineralization potential than other areas of Nain crust, which tend to be orthogneiss-dominated. Podiform ultramafic rocks, representing dismembered sills or flows, are abundant within supracrustal units and may have particular Ni–Cr potential. The metasedimentary rocks typically contain small amounts of finely disseminated iron sulphide. Unfortunately, the resulting rusty weathering, although it aids in the recognition of these units, may tend to obscure any more significant mineralization.

The garnet-rich nature of the bedrock in the area is reflected in the garnet concentrations of the beach sands at Iron Strand (Figure 2), which might be worth investigating for their heavy-mineral placer potential.

ULTRAMAFIC DYKE OCCURRENCES IN NORTHERNMOST LABRADOR

The recent surge of diamond exploration in the Canadian Shield has created interest in the potential of the Nain craton and its extensions into younger orogenic belts. To date, dykes of the kimberlite–lamprophyre clan have been described from the Nain and Saglek areas of the craton (see Ryan, 1993 for summary). Mapping during the course of the Torngat project (1991 to 1993) has now revealed an additional eight occurrences of these dykes in northernmost Labrador and adjacent parts of the Northwest Territories (Figure 4). The dykes are ultramafic lamprophyres, generally less than one metre in thickness, and with approximately east to northeast trends. Due to their recessive weathering, they usually define fractures or gullies and are difficult to spot. The examples shown on Figure 4 were found mostly in well-exposed coastal outcrop; however, many more examples undoubtedly exist inland. In field appearance, the dykes are fine-grained, dark-grey to black rocks, locally having small olivine nodules that protrude on weathered surfaces. Samples examined in thin section to date are alkalic, olivine–phlogopite–carbonate–perovskite rocks. The dykes are posttectonic but their age is otherwise unknown. The discoveries confirm that rocks of the lamprophyre–kimberlite association extend into northernmost Labrador and suggest that this area, in addition to the rest of the Nain craton, may warrant exploration for its diamond potential.

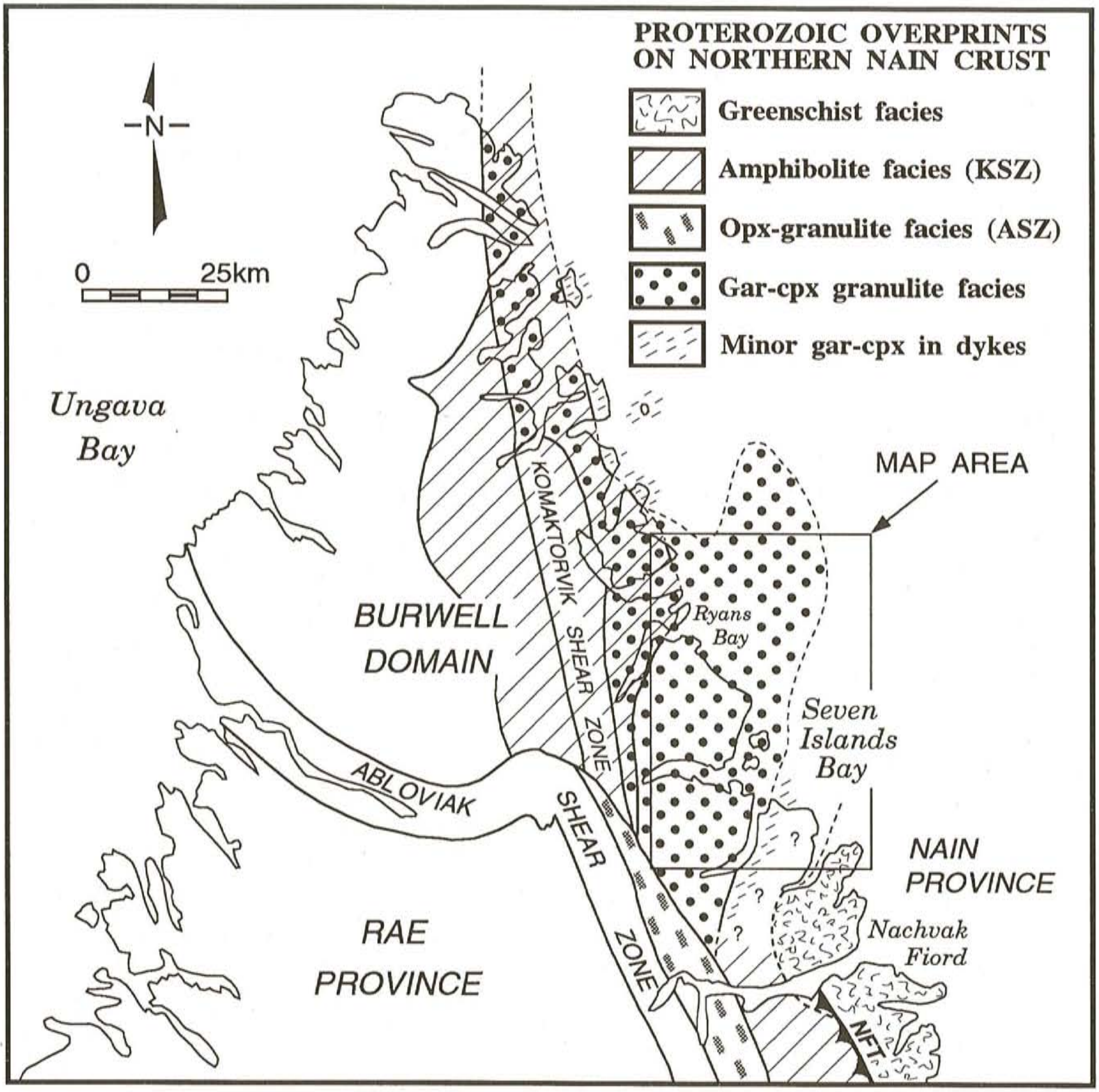

Figure 3. *Proterozoic metamorphic overprints on northern Nain crust.*

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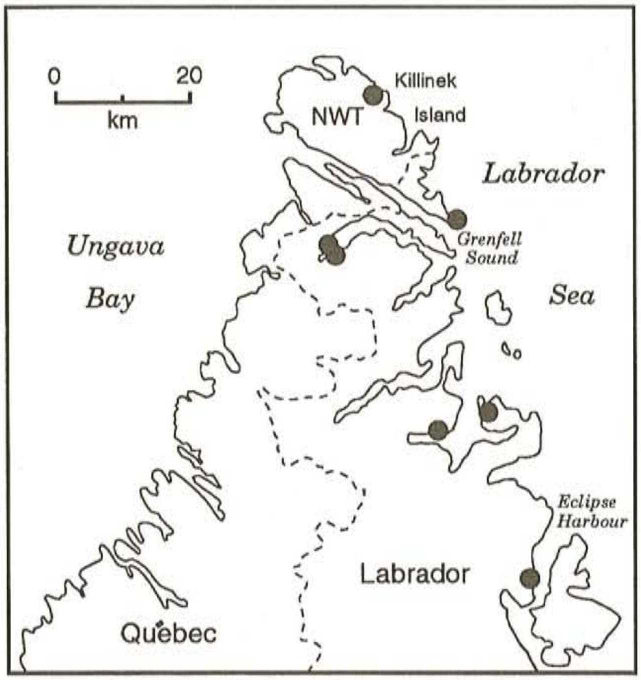

Figure 4. *Ultramafic lamprophyre occurrences in northernmost Labrador and part of the Northwest Territories.*

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