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A NOTE ON THE MESOPROTEROZOIC NAIN PLUTONIC SUITE AND ROCKS OF THE SOUTHEASTERN CHURCHILL PROVINCE, LOWER KINGURUTIK RIVER AREA (NTS MAP SHEET 14D/15)

D. James[1] and D. Byrne
Regional Geology Section

ABSTRACT

In the lower Kingurutik River map area (NTS 14D/15), 1:50 000-scale mapping has shown that the Mesoproterozoic Nain Plutonic Suite is dominated by two groups of rocks: an anorthosite–leuconorite group and a monzonite–ferrodiorite group. The first group, including the western part of the regionally extensive Pearly Gates intrusion, comprises units having varied compositions, textures, and structures, and are typical for the north central part of the batholith. In contrast, some components of the second group, including a distinctive unit of clinopyroxene- and oxide-rich ferrodiorite, appear to be atypical for this part of the Nain Plutonic Suite. Field relationships suggest that the ferrodioritic rocks may represent the relicts of a mafic floor to units of monzonite and quartz monzonite. The 2004 field study suggests that the Nain Plutonic Suite rocks in the NTS 14D/15 map area have limited exploration potential for troctolite- or olivine–gabbro-hosted sulphide deposits.

INTRODUCTION

The 2004 field season marked the second year of a multi-year, 1:50 000-scale bedrock-mapping program designed to map, describe and interpret the geology of the Mesoproterozoic Nain Plutonic Suite (NPS) and its country rocks in the lower Kingurutik River area, west and northwest of Nain, Labrador covering the northern half of NTS map area 14D (Figure 1). The outcome of this project will be a greater understanding of the evolution of the NPS, and a better appreciation of the exploration potential of NPS and pre-NPS rocks in the region.

The 2004 study area (Figures 2 and 3) included all of 1:50 000-scale NTS map area 14D/15. This area had not been mapped, in any systematic manner, at any scale greater than 1:250 000 prior to the present work, although certain sections had been investigated by E.P. Wheeler in the 1950s and 1960s, one small area was mapped as part of a Ph.D. study in the early 1970s, and other parts of the map area

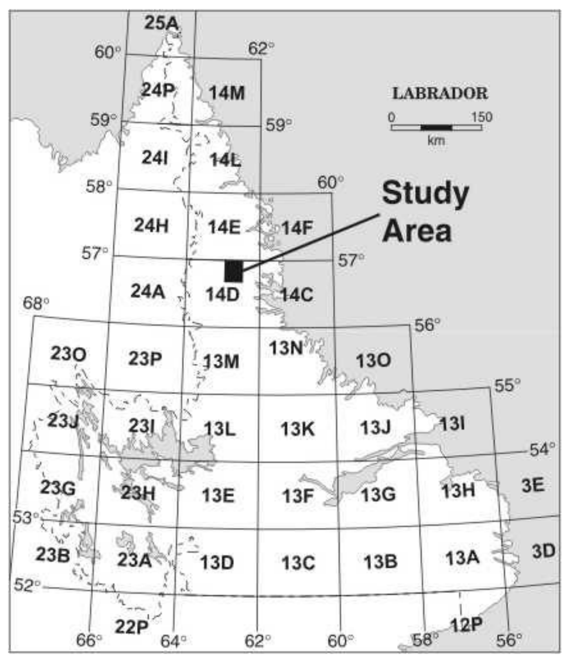

Figure 1. *NTS index map of Labrador showing location of the NTS 14D/15 study area.*

[1] Present address: Canada - Nunavut Geoscience Office, PO Box 2319, Iqaluit, NU X0A 0H0

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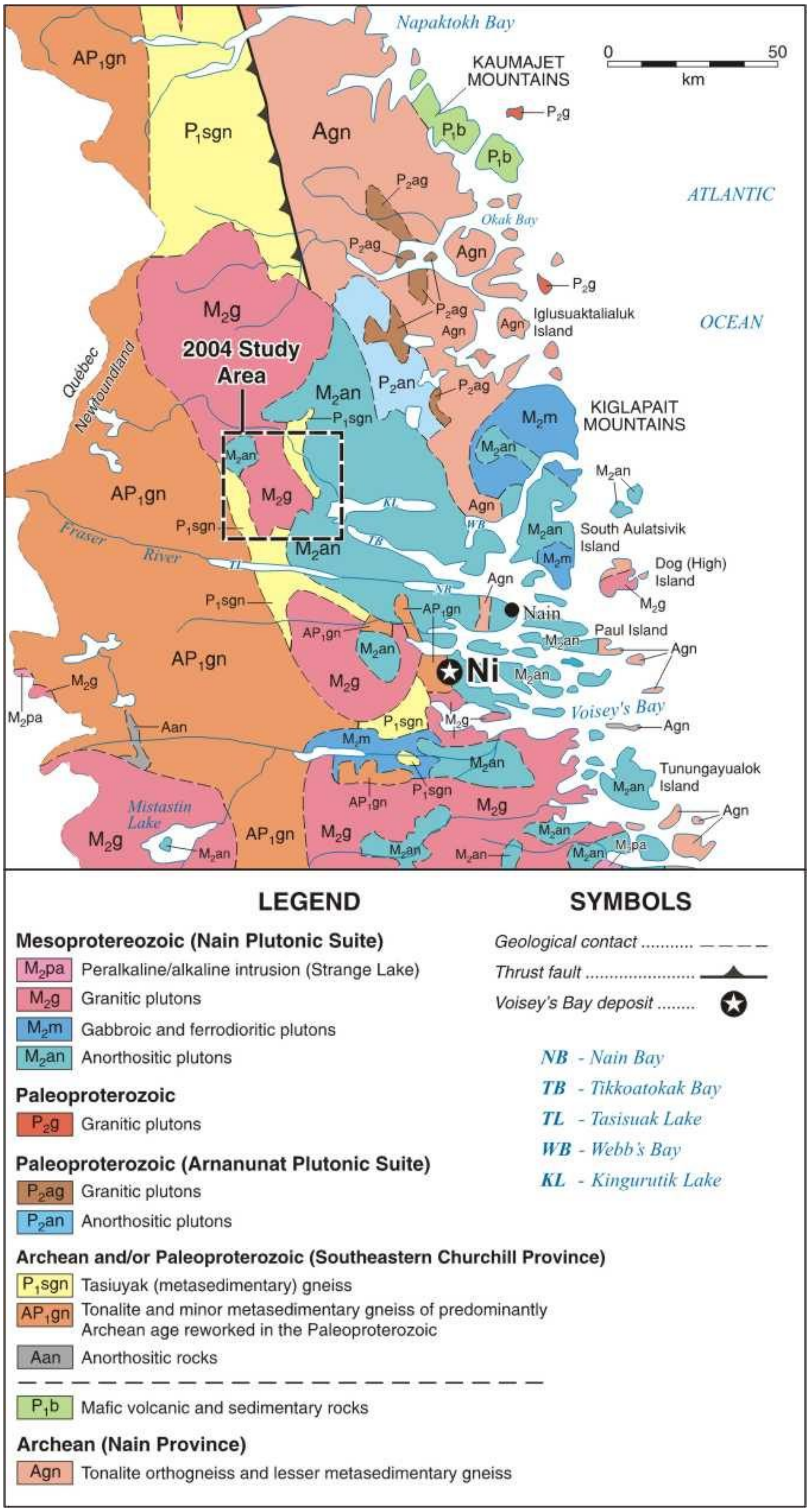


Figure 2. *Regional geology of central north Labrador.*

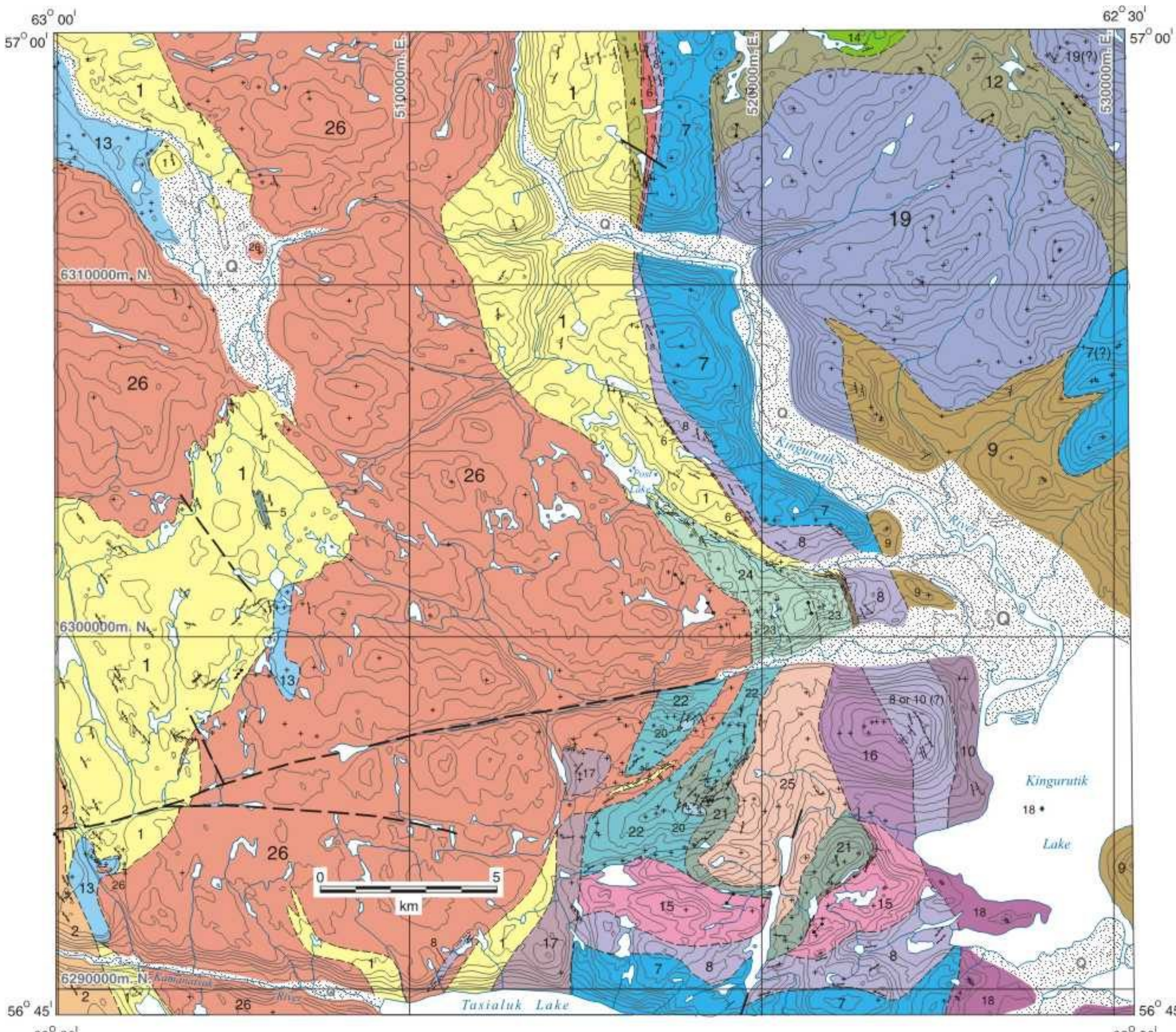
were explored in the mid-1990s following discovery of the Voisey's Bay Ni deposit. The work in 2004 represents a continuation of mapping by the Geological Survey in NTS map areas 14D/16 and 14D/9 in 2003 (*see* Ryan and James, 2004), and follows a preliminary examination of parts of the northern half of map area NTS 14D in 2002 (Ryan and James, 2003). The 2004 field season was conducted from a base camp located at Kingurutik Lake. Helicopter-supported field work occurred between the first weeks of July and September.

In support of the bedrock mapping program, Dr. Jim Connelly of the University of Texas, is conducting U–Pb geochronology studies of samples collected from the map area for the purpose of determining the emplacement ages of various intrusive units. The bedrock mapping and geochronology are supported by the NRCan Targeted Geoscience Initiate (TGI-2) program. In addition, Krista Reddy of the Department of Earth Sciences, Memorial University of Newfoundland, is studying the chemistry of orthopyroxene megacrysts from anorthosite as part of an undergraduate dissertation and thesis.

This report is a preliminary note on the geological survey undertaken in the study area during the 2004 field mapping seasons.

PREVIOUS WORK

Geological work in the Nain area was initiated by Wheeler (1942). Later, in the 1950s, parts of the region were examined by Christie (1952), and by British Newfoundland Exploration (BRINEX) as part of a reconnaissance examination of Labrador for mineral deposits (cf. Grimley, 1955). In subsequent years, E.P. Wheeler continued his work on the Nain Plutonic Suite (Figure 2), and later, in the late 1960s the Nain Anorthosite Project was initiated by S.A. Morse of the University of Massachusetts to study the origin of anorthositic rocks and the geologi-



LEGEND

Q Quaternary deposits

Mesoproterozoic Rocks
Nain Plutonic Suite (*ca.* 1290 to 1350 Ma)
Monzonite-Ferrodiorite group

- 26 Umiakovik Lake intrusion: pyroxene- or hornblende-bearing monzonite and quartz monzonite,local granite
- 25 Monzonite and local quartz monzonite
- 24 Undivided ferrodiorite, monzodiorite, monzonite, and leuconorite
- 23 Undivided ferrodiorite, monzodiorite, monzonite, and leuconorite containing abundant inclusions of anorthosite
- 22 Ferrodiorite and monzodiorite (light-weathering phase)
- 21 Ferrodiorite (dark-weathering phase), contains common inclusions of garnetiferous "gneiss" of uncertain origin

Anorthosite - Leuconorite group

- 20 Anorthosite "rafts" of uncertain correlation (in ferrodiroite and monzonite)
- 19 Fuji anorthosite (coarse-grained, massive white anorthosite)
- 18 Kingurutik anorthosite (contains inclusions of layered leuconorite)
- 17 Leuconorite IV
- 16 Leuconorite III

Anorthosite - Leuconorite group (continued0

- 15 Coarse-grained white anorthosite
- 14 Layered leuconorite and olivine-bearing leuconorite
- 13 Western leuconorite
- 12 Northeastern leuconorite and anorthosite (intruded by Fuji anorthosite)
- 11 Layered leuconorite II
- 10 Layered leuconorite and anorthosite I (equivalent to Unit 9?)
- 9 Eastern layered, brown leuconorite
- 8 Pearly Gates anorthosite and leuconorite; foliated margin
- 7 Pearly Gates anorthosite
- 6 Pyroxene +/- olivine-bearing "marginal" monzonite

Paleoproterozoic Rocks (Southeastern Churchill Province)

- 5 Metamorphosed pyroxenite and mafic intrusive rocks
- 4 Enderbitic gneiss (metamorphosed gabbronorite, diorite and quartz diorite)
- 3 Granulite-facies orthogneiss of uncertain origin
- 2 Undivided granulite-facies rocks: charnockite, garnet granite, and diatexite
- 1 Tasiuyak metasedimentary gneiss

Figure 3. *General geology of the lower Kingurutik River study area (NTS 14D/15).*

cal history of the NPS (*see* Morse, 1970, 1983a,b; Morse and Wheeler, 1974). However, the rocks in map area NTS 14D/15 received very little attention, with the exception of a Ph.D. thesis study by Brand (1976), which focussed on ferrodioritic and monzonitic rocks (part of the NPS), in the Post Lake area (Figure 3). As the result of the discovery of the Voisey's Bay Ni–Cu–Co deposit in the early 1990s, NTS map area 14D/15 received some mineral exploration attention, most notably in the area referred to as the West Margin showing (North, 1998; Kerr, 2002).

REGIONAL GEOLOGY

The Nain Plutonic Suite is a north–south, elongate batholith covering an area of almost 20 000 km^2 (Figure 2). It represents an amalgamation of intersecting and nested plutons having a range of compositions from troctolite to granite, although the batholith is dominated by intrusions consisting mainly of leuconorite, anorthosite, and quartz monzonite. Gabbro, troctolite, iron-rich diorite (ferrodiorite), monzonite and granite make up lesser amounts of the batholith. Emplacement ages of NPS intrusive units, as determined by U–Pb geochronology, range between 1350 Ma and 1290 Ma (e.g., Ryan and Emslie, 1994). The geochronology has also shown that plutons having contrasting compositions were emplaced contemporaneously in different parts of the batholith (Hamilton *et al*., 1994).

In general, NPS rocks lack structural fabric elements. However, mantling the margins of two of the oldest and largest anorthosite plutons, the Pearly Gates and Mount Lister intrusions, are zones consisting of very strongly foliated leuconorite. The deformation in the leuconorite, and the variable degrees of mineral recrystallization, common in many of the NPS intrusions, are interpreted to be the products of strain during emplacement.

For the past decade, the NPS has been the focus of mineral-exploration programs spawned by the discovery of the Voisey's Bay Ni–Cu–Co deposit, which occurs approximately 50 km southeast of the present study area. The sulphide mineralization is hosted in mafic intrusive rocks, and is interpreted to be the result of the interaction of a mafic, Ni-rich magma and S-rich metasedimentary host rocks. For a more complete discussion of the deposit, the reader is referred to a special issue of Economic Geology (McKenzie, 2000).

The NPS straddles the north–northwest-striking Paleoproterozoic tectonic boundary between the Archean Nain Province in the east and the Southeastern Churchill Province (SECP) consisting of Archean and Paleoproterozoic components in the west (Figure 2). The NPS rocks obscure the exact position of the Nain–SECP boundary, although it is inferred to occur somewhere east of the present study area. In the study area, the NPS mainly intrudes granulite-facies metasedimentary gneisses correlated with the Paleoproterozoic Tasiuyak gneiss. East of the present study area, the NPS also intrudes, and locally envelops, variably metamorphosed and deformed lecuconoritic and anorthositic rocks that are locally difficult to distinguish from NPS rocks. Some of these metamorphosed rocks have Paleoproterozoic emplacement ages (Hamilton *et al.*, 1998; Ryan *et al*., 2003).

GENERAL GEOLOGY: HIGHLIGHTS OF MAPPING IN 2004

PALEOPROTREOZOIC ROCKS

In the study area (Figure 3), the Paleoproterozoic rocks (Units 1 to 5) are interpreted as having an affinity with the Southeastern Churchill Province (SECP). The oldest and most widespread unit, Unit 1, includes granulite-facies metasedimentary gneisses and related diatexitic rocks that are correlated with the Paleoproterozoic Tasiuyak gneiss, and are interpreted as being derived from Paleoproterozoic (>1900 Ma) pelitic and semipelitic precursors. The rocks consist of variable proportions of rusty-weathering paleosome, white, granitic neosome, and may contain garnet, sillimanite, and biotite. The garnet and sillimanite porphyroblasts, interpreted to be the products of Paleoproterozoic metamorphism, are variably overprinted by Mesoproterozoic orthopyroxene ± biotite, and cordierite + spinel, respectively, in the aureoles of the Mesoproterozoic intrusions. Intruding the Tasiuyak gneiss are units consisting of charnockite and garnet-bearing granite (Unit 2), metamorphosed gabbronorite, diorite and minor quartz diorite (Unit 3), and local occurrences of metamorphosed pyroxenite and undivided mafic intrusive rocks (Unit 5).

In the southwestern part of the study area, Unit 2 rocks locally contain north–northwest-striking high-strain fabrics related to regionally persistent ductile shear zones, which developed as part of the Torngat Orogen. In other parts of the area (e.g., in the west-central part of the study area), isoclinal folds of gneissosity are refolded to produce, open, north–northwest- to northwest-trending fold structures.

MESOPROTEROZOIC ROCKS

The lower Kingurutik River area is dominated by rocks belonging to the NPS (Units 6 to 26, Figure 3). In contrast to the Paleoproterozoic rocks, the NPS intrusions are not metamorphosed and have only local occurrences of deformation fabrics (e.g., Units 6, 8, and 21 to 24), interpreted to have formed during pluton emplacement. The NPS intrusions can be generally categorized as being part of an anorthosite-leuconorite group, or a monzonite–ferrodiorite group.

In the study area, the NPS is provisionally separated into more than 20 intrusions defined primarily on the basis of field characteristics including composition, texture, structure, and colour. In some cases, intrusive relationships between contiguous units can be mapped in the field, or are inferred from xenoliths, and these are used to interpret relative age relationships. The xenolith "tests" are particularly equivocal because determining the parentage of some inclusions is highly speculative. Thus, the numbers used to designate units, shown in the legend for Figure 3, cannot be reliably used to predict the relative ages of all the units. Moreover, some of the map units may not represent intrusive units. Ongoing geochronological studies by Dr. Jim Connelly at the University of Texas in Austin will help to elucidate some of critical age relationships.

Anorthosite and Leuconorite Group (Units 6 to 20)

The anorthosite–leuconorite group of rocks is most abundant in the eastern half of the study area. The group includes rocks belonging to the northwestern part of the Pearly Gates intrusion (Units 7 and 8), inferred to be one of the oldest and largest NPS anorthosite intrusions, as well as younger bodies of massive or layered anorthosite and leuconorite having a diversity of textures. As in other parts of the NPS, the Pearly Gates intrusion is a composite body having an interior consisting of very coarse-grained white anorthosite (Unit 7), and a margin consisting of strongly foliated, coarse-grained leuconorite (Unit 8). Separating the Pearly Gates intrusion from the Paleoproterozoic country rocks is a narrow unit of olivine-bearing "marginal" monzonite (Unit 6). In the southern part of the study area, near Tasialuk Lake, intrusions of anorthosite and leuconorite (e.g., Units 15, 16, 17, and 18), that postdate the Pearly Gates intrusion, excise the marginal monzonite and parts of the foliated leuconorite. In particular, Unit 18, informally named the Kingurutik anorthosite, is characterized by inclusions of foliated margin leuconorite (Unit 8), and abundant inclusions of rusty-weathering, layered leuconorite inferred to be derived from Unit 9 (and Unit 10?).

The informally named Fuji anorthosite (Unit 19) is one of the more extensive units in the study area. It is inferred to be a relatively flat-lying body having intrusive contacts along its base with older and underlying units of leuconorite (e.g., units 9 and 12). The Fuji anorthosite is white-weathered, and consists of coarse-grained plagioclase and local coarse-grained orthopyroxene, and is, locally, layered. Layering, defined by the percentage of orthopyroxene, is a common feature of leuconorite Units 9 and 10. West-dipping layering is particularly well developed in exposures west of the point where the Kingurutik River flows into Kingurutik Lake. A unit of reddish-weathering leuconorite and olivine-bearing leuconorite (Unit 14) occurs along the northern boundary of the study area.

A composite unit of leuconorite and anorthosite (Unit 13), correlated with the NPS, occurs locally in the west of the study area, more than 10 km west of the main exposures of NPS anorthosite and leuconorite. In general, outcrops of Unit 13 are dominated by leuconorite containing inclusions of an older anorthosite component. The leuconorite and anorthosite are cut by dykes of white-weathering aplitic granite, which are in turn cut by monzonite of the Umiakovik Lake intrusion (Unit 26). Occurrences of Unit 13 rocks are of some interest as they demonstrate that exposures of NPS basic rocks are more extensive to the west than previously thought.

Monzonite and Ferrodiorite Group (Units 21 to 26)

Rocks of the monzonite–ferrodiorite group dominate the western part of the study area. The most widespread unit in the group, defined as the Umiakovik Lake intrusion (Unit 26), is tacitly assumed to postdate all rocks of the anorthosite–leuconorite group. The Umiakovik Lake intrusion consists of reddish-brown-weathering, alkali-feldspar porphyritic, clinopyroxene- or hornblende-bearing monzonite. Minor amounts of quartz monzonite and granite also occur. The precise attitudes of contacts separating the Umiakovik Lake intrusion and the Tasiuyak gneiss are uncertain, although the contact patterns at the map-scale suggest the Umiakovik Lake intrusion is a somewhat flat, sheet-like body.

In the areas southeast of Post Lake (Figure 3), and extending into the south-central part of the study area, are units of distinctive pyroxene-bearing ferrodiorite and monzodiorite (Units 21 to 24) having compositions and textures that are unusual in the northwestern NPS. Unit 21 is a grey-, to green-, to black-and-white-weathering ferrodiorite containing abundant clinopyroxene and fine-grained oxide. The rocks commonly have a compositional layering, defined by concentration of clinopyroxene, are locally "gneissic", having diffuse layers containing garnet, coarse-grained xenocrystic plagioclase, and abundant inclusions of white anorthosite. In contrast, Unit 22 contains less clinopyroxene, is dominated by white, "blocky" xeocrystic plagioclase, and includes "wispy" patches of the gneissic garnet-bearing rocks that are more common in Unit 21.

Unit 25 is a pyroxene-bearing, alkali-feldspar porphyritic rock, locally containing a primary planar fabric defined by alignment of the phenocrysts and mafic minerals. Correlation of Unit 25 monzonite and the Umiakovik Lake intrusion (Unit 26) is uncertain. Unit 25 monzonite is in transitional contact with units of ferrodiorite, monzodiorite and norite (Unit 21), possibly suggesting the ferrodiorite and monzodiorite units (Units 21 to 24) may represent the relicts of a mafic floor to the units of monzonite and quartz monzonite (Units 25 and 26).

EXPLORATION POTENTIAL

Mapping in 2004 did not result in any new discoveries of significant sulphide mineralization in NPS rocks that would warrant detailed examination. Minor amounts of disseminated sulphide mineralization, commonly forming irregular pods, occur locally in anorthosite and leuconorite, and in particular in Unit 10 layered leuconorite near the west end of Kingurutik Lake. In the study area, the NPS is apparently lacking in troctolite and olivine-bearing gabbro.

Anomalous amounts of Ni, Cu, Pt and Pd were previously discovered in metapyroxenite units and boulders in the "West Margin" area (NTS 14D/15, UTM 505360m E, 6302115m N), first examined by Noranda Mining and Exploration (Squires *et al*., 1997) following discovery of the Voisey's Bay Ni–Cu–Co deposit, and subsequently re-examined and reported on by North (1998) and Kerr (2002). The metapyroxenite units (Unit 5?) probably represent pre- or syn-metamorphic, Paleoproterozoic mafic dykes that intruded the sedimentary protoliths of the Tasiuyak gneiss.

Occurrences of gossanous Tasiuyak gneiss are common, although the rocks contain only minor amounts of disseminated sulphide minerals. The Tasiuyak gneiss is interpreted to have limited exploration potential for economic base-metal deposits.

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