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PRELIMINARY REPORT OF THE STRATIGRAPHY AND MINERALIZATION OF THE NUIKLAVIK VOLCANIC ROCKS OF THE FLOWERS RIVER IGNEOUS SUITE

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ABSTRACT

The peralkaline granites and volcanic rocks of the Flowers River Igneous Suite have been identified as good targets for rare-metal mineralization. A program of mapping and sampling was initialized in the summer of 1991 to help evaluate the volcanic rocks (Nuiklavik volcanic rocks) of this suite for rare metals (e.g., Y, Zr, REE).

The Nuiklavik volcanic rocks underlie a roughly circular-shaped area 14 km in diameter. Rocks mapped include: feldspar–quartz porphyry, quartz and quartz–mafic porphyry, ignimbritic flows, aphyric and quartz-poor flows, amphibole-bearing ignimbrite and porphyry, and feldspar–quartz–amphibole porphyry. Stratigraphic sections indicate that the preserved volcanic rocks are at least 300 m thick.

Although geochemical results for rare metals are not yet available, radioactivity measurements indicate that the rare-metal content is probably very high for some rock units. Measurements up to 3000 cps (20 times background) were recorded for ignimbrites, aphyric flows and quartz-poor flows. These more radioactive rock units occur in the upper portion of the stratigraphic section where they form mappable units up to 50 m thick. Geochemical and other laboratory studies are on-going.

INTRODUCTION

The Flowers River Igneous Suite (FRIS) is a Mid-Proterozoic felsic volcanic–intrusive complex that occupies a 70 by 50 km area near the coast of Labrador 70 km south of the community of Nain (Figure 1). The complex is dominated by aegirine and arfvedsonite–riebeckite-bearing peralkaline granite plutons. Felsic volcanic rocks, which occupy approximately 4 percent of the complex, consist of feldspar–quartz porphyries, feldspar–quartz–amphibole porphyries, quartz porphyries, phenocryst-poor or aphyric flows, volcanic breccias and ignimbrites.

Rocks of the FRIS were first mapped in 1953 (Beavan, 1954) by BRINEX during a reconnaissance exploration program. The granites and volcanic rocks in the vicinity were further mapped in 1971, at a scale of 1:250 000, in a Geological Survey of Canada regional mapping program (Taylor, 1979). More detailed mapping, at a scale of 1:50 000, was carried out in the period 1977 to 1982 by the Newfoundland Department of Mines and Energy (Hill, 1981, 1982).

The major host rocks of the Flowers River Igneous Suite are the anorthosite–gabbroic and quartz monzonitic intrusive phases of the Nain Plutonic Suite (NPS) (Figure 2). Other host rocks include Lower Proterozoic and Archean gneisses.

Exploration activity in the Flowers River Igneous Suite commenced in 1953 (Beavan, 1954) when the volcanic portion was visited by BRINEX geologists; no significant mineral

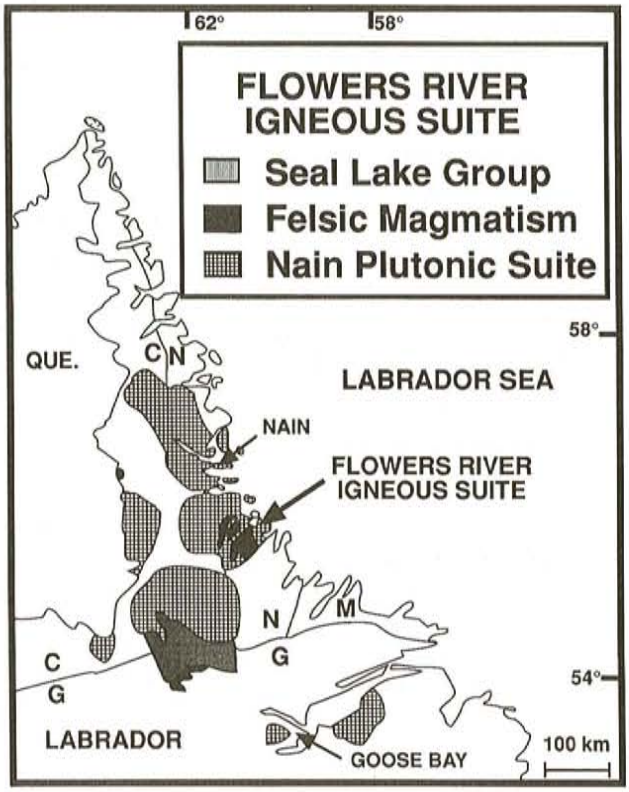

Figure 1. *Location map of the Flowers River Igneous Suite, Labrador. Structural provinces: C = Churchill, N = Nain, G = Grenville, M = Makkovik.*

occurrences were located at that time. A regional lake sediment and water geochemical survey (Geological Survey of Canada, 1978, 1979) carried out under the Uranium Reconnaissance Program indicates that the FRIS, especially the volcanic portion, exhibits anomalies of F, Zn, Mo and Pb. The detailed mapping of Hill (1981, 1982) and the follow-up geochemical work of McConnell (1984) concluded that showings of pyrite, sphalerite, galena, molybdenite and fluorite are common in these volcanic rocks. Hill (*op. cit.*) also noted that high radioactivity is associated with some of the pyrite-bearing volcanic rocks.

The documentation of rare-metal mineralization in the Strange Lake peralkaline granite and the Red Wine Intrusive Suite–Letitia Lake Group resulted in the formulation of an exploration model for rare metals in felsic peralkaline rocks (Miller, 1988). Application of this model to other parts of Labrador indicates that the FRIS is a good rare-metal target. Geochemical analyses of some samples of the FRIS (Hill, 1982; White, 1980), especially the volcanic units, indicate that rare metals, such as Y, Zr and REE (Miller, 1988), reach values that are of economic interest. Consequently, the volcanic rocks were targeted for more detailed mapping and geochemical and petrological study to further evaluate their rare-metal potential. These volcanic rocks were mapped during a 6-week period in the summer of 1991. Laboratory studies on samples collected during this period are on-going.

The volcanic rocks of the Flowers River Igneous Suite were initially called the 'Nuiklavik volcanics' (Beavan, 1954) after the nearby bay, which was called Nuiklavik Dart or Jem Lane Bay on the old British hydrographic charts. Hill (1981) renamed these volcanic rocks and the related granites the Flowers River Igneous Suite after the Flowers River, which cuts through the peralkaline granites and empties into Nuiklavik Dart Bay (later renamed Flowers Bay). In this report, 'Flowers River Igneous Suite' is retained to designate the entire suite, both plutonic and volcanic as Hill had proposed, and the name 'Nuiklavik volcanic rocks', as Beavan had proposed, is retained for the volcanic portion of the FRIS.

This report will outline the results of the 1991 field-mapping program, including a description of the volcanic stratigraphy of the Nuiklavik volcanic rocks of the Flowers River Igneous Suite.

STRATIGRAPHY

The Nuiklavik volcanic rocks were mapped at a scale of 1:50 000. Detailed mapping was carried out in areas of nearly continuous outcrop that were chosen for stratigraphic work (Figure 2). This mapping has identified the following units, which are summarized in the stratigraphic section (Figure 3): upper feldspar–quartz porphyry, upper quartz and quartz–mafic porphyry, ignimbritic flows, aphyric and quartz-poor flows, lower quartz and quartz-mafic porphyry, lower feldspar–quartz porphyry, amphibole-bearing ignimbrite and porphyry, feldspar–quartz–amphibole porphyry and dark feldspar–quartz porphyry. Members of the Nain Plutonic Suite, especially quartz monzonite, form the basement upon which the volcanic rocks were deposited. High-level and medium-grained peralkaline granite intrudes the NPS and some of the Nuiklavik volcanic rocks.

Each unit has been characterized by field observations. Chemical, petrographic and other laboratory studies may result in changes to the stratigraphy presented here (Figure 3).

Nain Plutonic Suite

Rocks of the NPS occur at the contact between the Nuiklavik volcanic rocks (NVR) and the peralkaline granite. They also occur within the outcrop area of the volcanic rocks. Quartz monzonite is the most abundant member, which is associated with subordinate monzonite, diorite and gabbro members. The NPS rocks are crosscut by peralkaline granite and are stratigraphically lower than the NVR.

Peralkaline Granite

The NVR is completely surrounded by a ring of peralkaline granite, which consists of medium-grained granite, pegmatitic granite and feldspar porphyritic granite. This granite is characterized by riebeckite–arfvedsonite amphibole, quartz and perthitic feldspar. Portions of the granite, particularly in the southwest and western contact zones, are characterized by fine grain-size and rarely aplitic texture; this sub-variety has been mapped separately as 'high-level granite'. Peralkaline granite crosscuts the lower part of the NVR but does not crosscut units above the lower feldspar–quartz porphyry. The peralkaline granite intrudes the NPS.

Dark Feldspar–Quartz Porphyry

This unit is the lowest in the NVR stratigraphy. It is a dark-grey rock that is characterized by up to 20 percent feldspar and quartz phenocrysts that range up to 4 mm in diameter. Many outcrops contain amphibole in the matrix or as small phenocrysts and the matrix is commonly aphanitic to very fine grained. Well-developed columnar joints were observed at one occurrence but more commonly this unit is massive or occurs as rounded to subrounded inclusions in the overlying feldspar–quartz–amphibole porphyry. This unit is at least 20 m thick in some areas but does not appear to be continuous although its occurrence as inclusions in the more wide-spread overlying unit suggests a wider distribution. Field observations suggest that this unit is a volcanic flow.

Feldspar–Quartz–Amphibole Porphyry

This unit is distinguished from the feldspar–quartz porphyry unit above it by the occurrence of up to 2 percent amphibole phenocrysts and fine-grained amphibole in a fine-grained matrix. It commonly contains up to 40 percent quartz and feldspar phenocrysts, which are less than 4 mm in diameter. In some occurrences, it contains inclusions of the dark feldspar–quartz porphyry unit and rarely quartz monzonite of the NPS. It has been observed at or near all

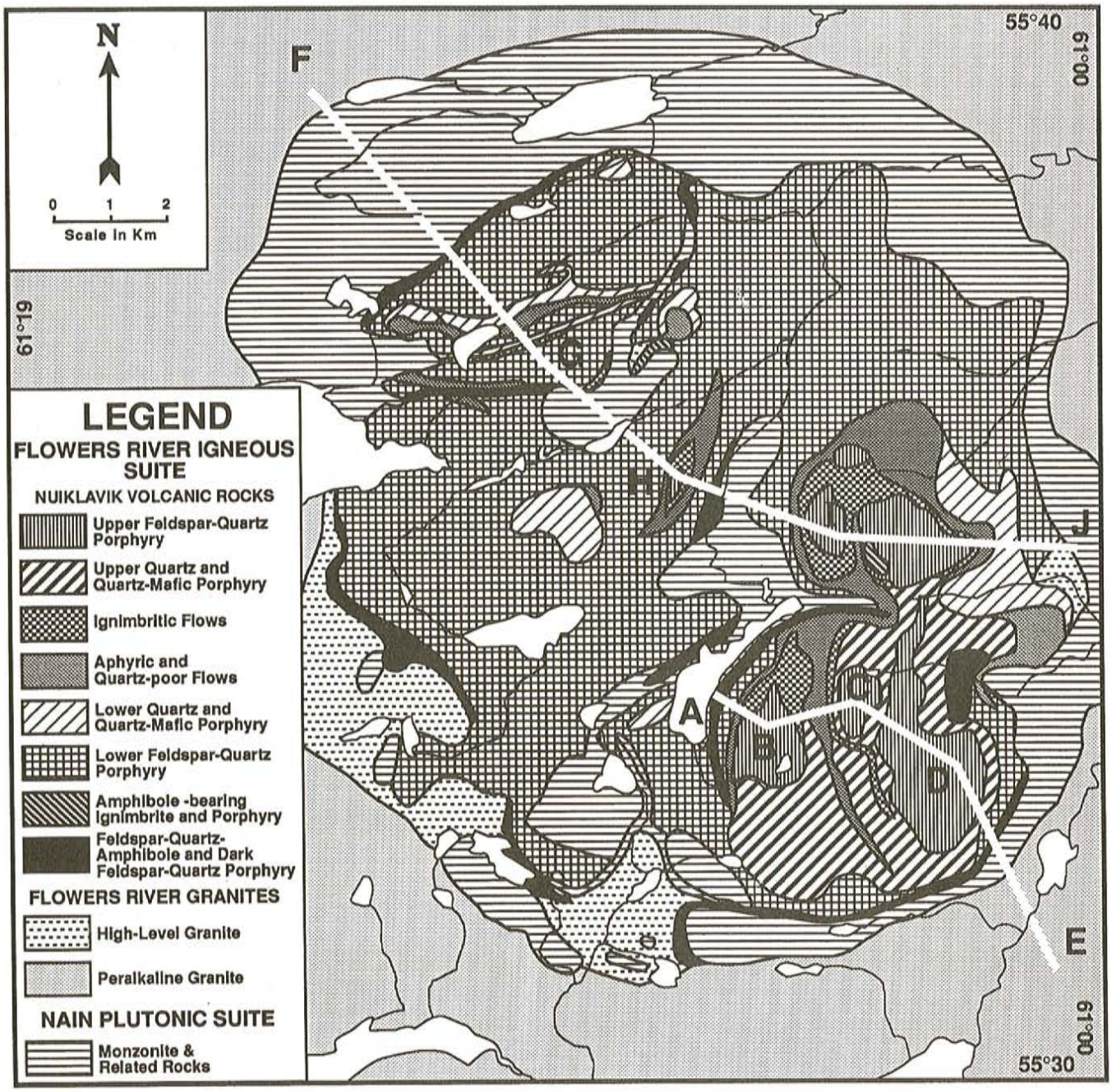

Figure 2. *General geology of the Nuiklavik volcanic rocks of the Flowers River Igneous Suite and the surrounding host rocks.*

observed and most inferred contacts between the NVR and the NPS. It is not clear whether this unit is extrusive or intrusive. Features that contribute to the confusion include: its constant position in the stratigraphy (sill or volcanic flow), its close association with amphibole-bearing ignimbrite (volcanic unit), the abundance of inclusions (derived by intrusion?) and its fine-medium grained texture (similar to the high-level peralkaline granite). These contradictions suggest that this unit may have both intrusive and extrusive phases. The unit is up to 40 m thick.

Amphibole-Bearing Ignimbrite and Porphyry

Several closely related rock types have been grouped into this unit: amphibole ignimbrite, oikocrystic-amphibole porphyry and amphibole porphyry. These rock types are all spatially associated and commonly grade into one another. Features they have in common are the occurrence of up to 30 percent amphibole, few or no quartz phenocrysts and an aphanitic to very fine-grained matrix. Amphibole occurs as single grains, linear aggregates or oikocrystic aggregates. Many samples also contain up to 20 percent red or pink

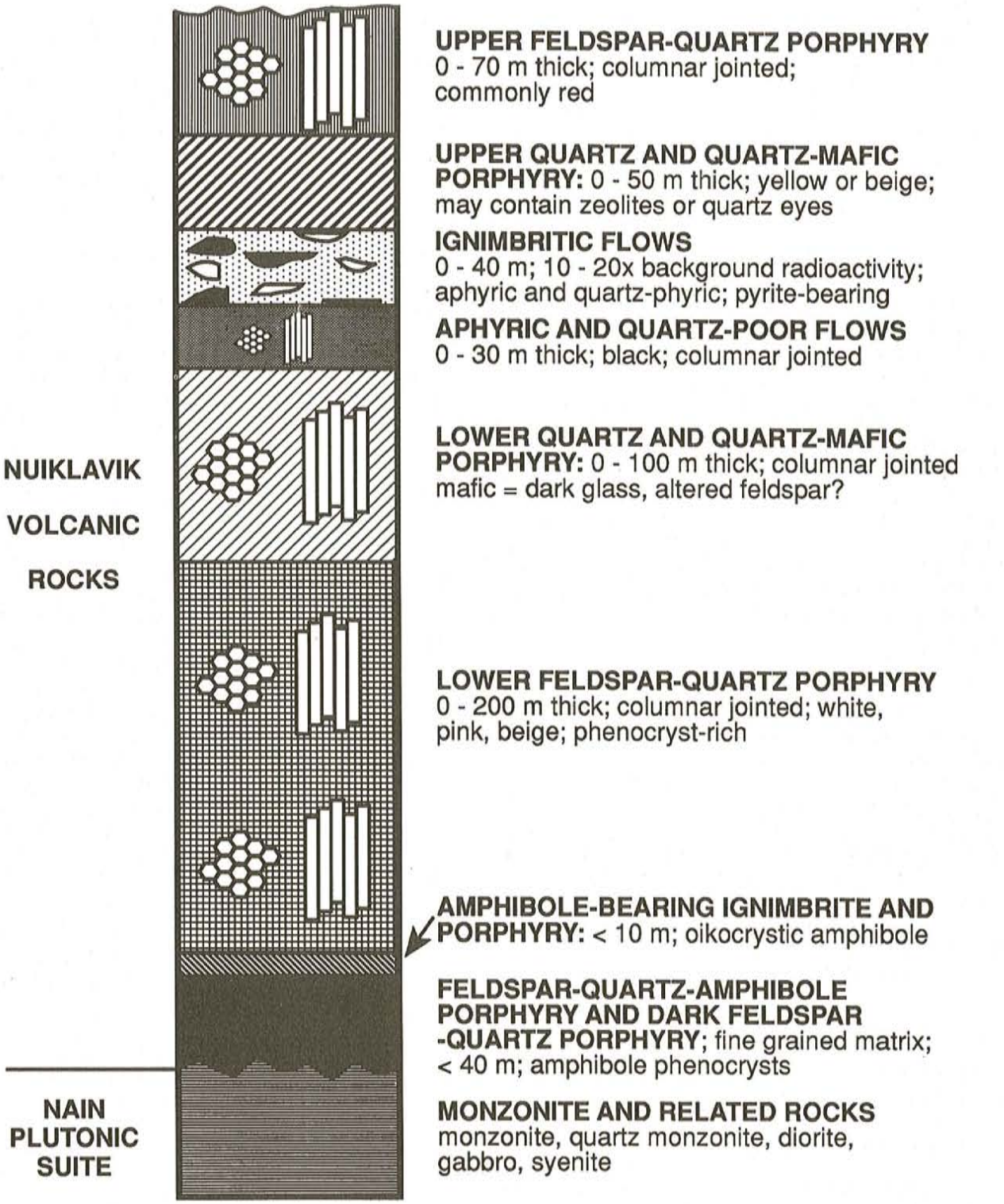

Figure 3. *Generalized stratigraphic section of the Nuiklavik volcanic rocks.*

feldspar(?) aggregates. The outcrop area of this unit is very small, as it is only found in seven locations, and it has a maximum thickness of 10 m. The three textural types of this unit may represent at least two different modes of formation: the ignimbritic texture as a gas-charged pyroclastic flow, and the porphyry intrusive dykes or extrusive flows.

Lower Feldspar–Quartz Porphyry

This porphyry is the most widespread of the units in the Nuiklavik volcanic rocks. The thickness ranges from 70 m in the southeast, to 200 m in the northwest. It is characterized by 2 to 10 percent quartz phenocrysts, 10 to 40 percent

feldspar phenocrysts, an aphanitic to very fine-grained matrix and phenocryst size up to 5 mm across. Amphibole has been found in a few outcrops. Well-defined, five- or six-sided columnar joints, from 30 to 70 cm wide and up to 10 m long, are very common in larger outcrops of this unit. This texture and the scarcity of matrix textures and fragments indicate that this porphyry was deposited as lava flows or domes.

Lower Quartz and Quartz–Mafic Porphyry

Quartz–mafic porphyry is the most prominent rock type of this unit. It is characterized by 5 to 15 percent quartz phenocrysts, up to 3 mm in diameter, aphanitic to very fine-grained matrix and 5 to 15 percent black to green mafic grains up to 10 mm in diameter. In many cases, the nature of the mafic grains is uncertain in hand-sample but some possible explanations include: altered feldspar phenocrysts, altered glass shards, aphanitic mafic rock fragments and altered zeolitic amygdules. The presence of columnar joints in several outcrops of this unit indicates that it is a flow or a dome. Quartz porphyry, which contains no mafic grains but similar quartz contents, occurs as small volume flows closely associated with the quartz–mafic porphyries. Outcrops of the lower quartz and quartz–mafic porphyries are found throughout the outcrop area. The unit has a maximum thickness of approximately 100 m.

Aphyric and Quartz-Poor Flows

The aphyric or phenocryst-poor flows are characterized by less than 5 percent quartz phenocrysts, which are less than 2 mm in diameter, are black or dark-grey and have an aphanitic to very fine-grained matrix. Some outcrops of this unit also contain up to 8 percent amphibole or mafic spots (mineralogy unknown) and up to 1 percent pyrite. Well-developed columnar joints, which range in size from 10–40 cm across, are also common. Although this unit has flow textures in most outcrops, these textures appear to grade laterally and upward into ignimbritic textures in others. These flows are up to 30 m thick and are found in the northwest and southeast portions of the NVR.

Ignimbritic Flows

Ignimbritic flows in the NVR contain many different kinds of ignimbritic textures but they are characterized by an aphanitic matrix and up to 5 percent quartz phenocrysts, less than 2 mm in diameter. Many ignimbritic outcrops contain aphanitic aphyric fragments and collapsed pumice fragments or fiamme. Ignimbrites are most abundant in the southeastern portion of the NVR and occur as a unit up to 40 m thick.

Upper Quartz and Quartz–Mafic Porphyry

This unit is dominated by quartz porphyry and appears to only occur in the southeastern portion of the NVR. It is a yellow to beige rock characterized by 8 to 15 percent quartz phenocrysts ≤ 2 mm in diameter, and an aphanitic to very fine-grained matrix. Zeolites and other minerals fill lithophysae in many outcrops indicating that this is a flow unit. In some outcrops, the underlying quartz-bearing ignimbritic flows appear to grade into quartz porphyritic flows. Unit thicknesses range up to 50 m in uneroded sections. In some areas, the lower and upper quartz and quartz–mafic porphyry units form one combined unit as the intervening ignimbritic unit and aphyric and quartz-poor flow unit were not observed; this may be due to poor outcrop exposure.

Upper Feldspar–Quartz Porphyry

This unit is the highest of the NVR units. It is a dark-red rock, characterized by 10 to 45 percent feldspar phenocrysts, 10 to 15 percent quartz phenocrysts, and has an aphanitic matrix. It is found on the tops of the highlands in the southeastern part of the NVR where its thicknesses ranges up to 70 m. Well-developed columnar joints are common.

STRUCTURE

The structure of the Nuiklavik volcanic rocks is illustrated in Figure 4 (cross-section A–E) and Figure 5 (cross-section F–J). Dips of contacts and flow banding range from 20° to 45° toward a centre, which is found in the southeastern or thicker part of the structure. Dips of volcanic units at or near the outer contact with the Nain Plutonic Suite are near vertical. These observations suggest that the structure forms a saucer-shaped volcanic pile having a steep lip. Topographic lineaments, slickensides and the stratigraphy indicate that the volcanic pile is cut by many steeply dipping normal faults, some of which are illustrated in Figures 4 and 5. The obvious complexity of this fault system and the lack of outcrop make it difficult to place faults on the plan view of the volcanic suite.

ECONOMIC GEOLOGY

Several indications of mineralization, in addition to those outlined by Hill (1981, 1982), were located during this field program. Base-metal and radioactive showings are common.

Many outcrops of the ignimbrite flow unit, aphyric and quartz-poor flow units and the quartz porphyry unit contain veinlets or disseminated grains of pyrite and other sulphides. Sphalerite, in association with pyrite, was identified in several flows of the aphyric unit. Galena was observed in a peralkaline granite dyke cutting the NVR. All sulphide showings are minor in extent and rarely contain more than 1 percent pyrite and other sulphide minerals.

The Nuiklavik volcanics, especially the quartz-poor and ignimbritic flow units, contain a large number of radioactive showings that are greater than 5 times background values (i.e., greater than 750 cps). Most amphibole-phyric and quartz-phyric flow units and some aphyric flow units have radioactivity values over 600 cps with selected outcrops up to 2000 cps. All outcrops of the ignimbrite unit have radioactivity measurements of at least 500 cps, with many

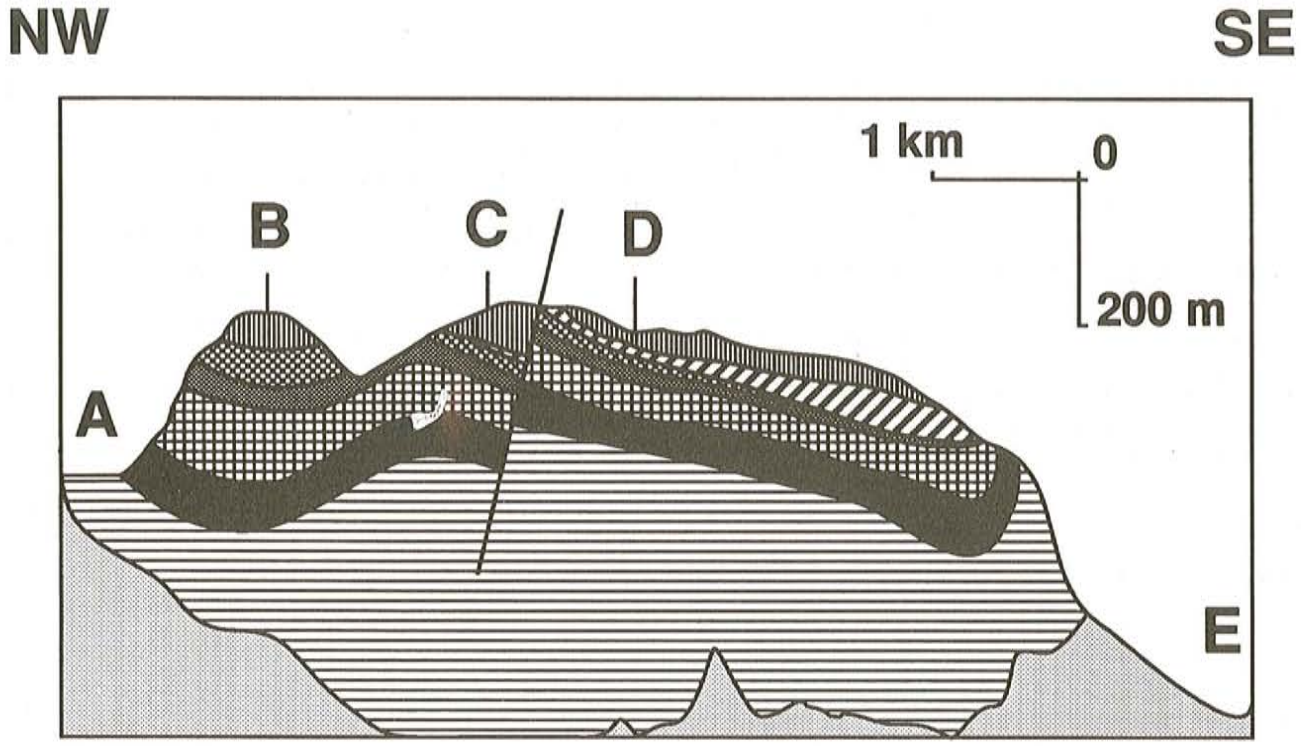

Figure 4. *Cross-section A to E through the Nuiklavik volcanic rocks from the centre of the outcrop area toward the southeast across the outer contact. See Figure 2 for cross-section location and legend.*

in the range 800 to 2000 cps; one radioactive showing in quartz-phyric ignimbrite has values around 3000 cps. Most feldspar–quartz porphyries, quartz–mafic porphyries, feldspar–quartz–amphibole porphyries and peralkaline granites, and many aphyric flows measure less than 400 cps. One peralkaline granite aplite dyke, with textures similar to aplite at Strange Lake, has a value of 940 cps.

Radioactive values are high in rare-metal occurrences in other peralkaline felsic suites in Labrador (e.g., Strange Lake, Miller 1986; Letitia Lake, Miller 1987). The abundance of radioactive showings with high values, similar to those at Strange Lake and Letitia Lake is encouraging for rare-metal exploration.

SUMMARY DISCUSSION

The Nuiklavik volcanics were deposited onto subaerially exposed igneous rocks of the Nain Plutonic Suite. The contact between the volcanic rocks and their basement indicates that the Nuiklavik volcanic rocks were deposited upon a highland during a period of rapid uplift; red beds or conglomerate sediments are absent at this contact.

Amphibole-bearing porphyries and ignimbrites are the oldest exposed volcanic units. The common presence of peralkaline amphibole in these units indicates that at least the lower portion of the NVR is peralkaline in the classical sense. Some of these porphyries may be near-surface intrusive sills or dykes.

The lower quartz and feldspar–quartz porphyry units account for between one third and two thirds of the preserved NVR. The feldspar–quartz porphyry unit is much thicker and much more dominant in the northern and western portions of the NVR. These porphyritic units are not as thick in the southeastern portion of the NVR with the quartz porphyry unit being more dominant there than the feldspar–quartz porphyry unit. These porphyries appear to have originated from several local vents or domes, which are marked by breccia zones.

Ignimbrite and lava flows are very closely associated both texturally and spatially. Both have aphyric and quartz-poor phases, they are dark-coloured and commonly contain pyrite or iron staining. In some outcrops, where they appear to grade into one another, it is difficult to distinguish a highly welded ignimbrite from a banded flow. Aphyric-flow rock fragments are commonly found along with the ubiquitous collapsed pumice fragments in ignimbritic flows. Columnar jointed and massive flows in some outcrops contain peralkaline amphibole phenocrysts and are thus peralkaline in the classical sense.

The upper quartz, quartz–mafic and feldspar–quartz porphyry units are only found in the southeastern portion of the NVR where they form the tops of hills and make up to one third of the stratigraphic thickness. The feldspar–quartz porphyry is the youngest preserved unit in the NVR.

Faulting and subsequent erosion has exposed the underlying NPS in some places. Some of these occurrences of NPS occupy valleys formed by erosion, but others occur

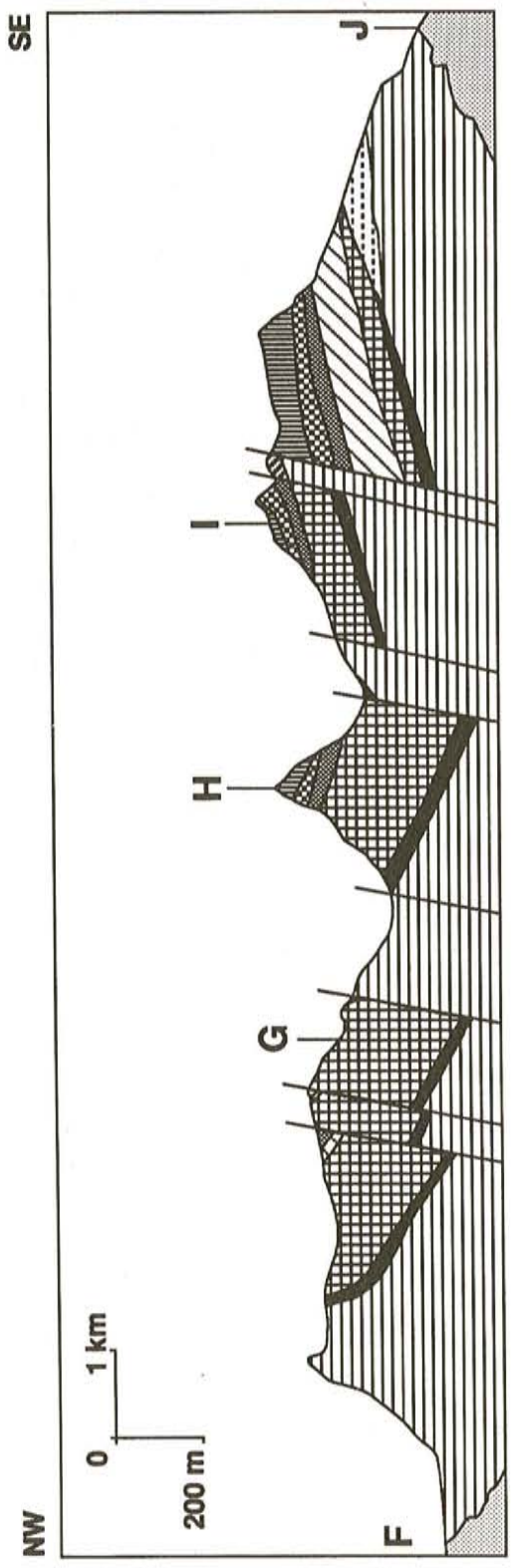

Figure 5. *Cross-section F to J through the Nuiklavik volcanic rocks from the northwest contact through the volcanic rocks and across the southeast contact. See Figure 2 for cross-section location and legend.*

on the tops of hills that are part of upward thrust fault blocks. The timing of the faulting episode is unknown although the interpretation of Hill (1991) suggests that the faulting is due to cauldron subsidence during the extrusion of the NVR.

The intrusion of peralkaline granite occurred during and/or before the extrusion of the NVR. Sills and dykes have been mapped crosscutting the earliest NVR units, including the lower feldspar–quartz porphyry unit.

Field evidence suggests the locations of at least four of the vents that produced the NVR. One vent in the northern portion of the NVR outcrop area is characterized by a breccia of aphyric and feldspar–quartz porphyritic fragments up to 1 m in size. A second vent is located in the northeastern portion of the outcrop area and is identified by breccia fragments of feldspar–quartz porphyry, quartz porphyry and ignimbrite flow. Two vent locations are also tentatively located in the eastern and southeastern portions of the NVR. One is identified by a thick ignimbritic unit (30 to 50 m thick) and an area of extensive quartz-vein stockwork. The other is suggested by thick (up to 35 m) rock-fragment-rich ignimbrites.

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