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# Diamond-Drilling of Rare Element Pegmatites in Southwestern Nova Scotia

*M. C. Corey*

**Nova Scotia Department of Natural Resources**

**Honourable Donald R. Downe, Minister**

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## DIAMOND DRILLING OF RARE ELEMENT PEGMATITES IN SOUTHWESTERN NOVA SCOTIA.

### Introduction

Worldwide, granitic pegmatites are mined to extract a wide variety of ore and industrial minerals (e.g. Sn, W, Nb, Ta, U, Li, Be, Cs) as well as provide gemstock. In recognition of the potential of rare element pegmatites, the Nova Scotia Department of Natural Resources (N.S.D.N.R.), as part of the current Mineral Inventory Project recently investigated the characteristics and economic potential of several Be $\pm$ Li pegmatites which occur in southwestern Nova Scotia (Corey, 1993). An integral part of this program was diamond drilling as many of the pegmatites have been previously mapped (Oldale, 1959) but little was known regarding their vertical zonation and geometric configuration.
This report presents the descriptive logs of the drillholes and includes several sections and information, detailing the internal zoning and some mineralogical characteristics of the pegmatites investigated. The core is stored at the N.S.D.N.R core library facilities in Stellarton N.S.

### Areas of Study

With the exception of several isolated occurrences in eastern mainland Nova Scotia, beryl-bearing pegmatites are confined to the Meguma Terrane of southwestern Nova Scotia where they primarily occur within three different geological environments (Fig.1). These include:

#### Port Mouton / Port Joli Be-Pegmatites:

Pegmatite occurrences within this area are represented by zoned and layered pegmatite dykes and pods associated with biotite $\pm$ muscovite granitoids of the Port Mouton Pluton (PMP; Fig.1). Details about the geological history of the area are provided by Hope et al.(1988) who discuss the metamorphic, structural and petrographic characteristics of the metasedimentary country rocks and intrusive rocks of the Port Mouton to Lockport area, and Douma (1988) who investigated the geology of the Port Mouton Pluton. These authors have determined that the Port Mouton Pluton consists of ten distinct units which collectively range in composition from tonalite to trondhjemite, granodiorite, monzogranite, leucomonzogranite and lamprophyre. These units sometimes show complex intrusive relationships which can produce extreme local heterogeneity. Volumetrically, the most abundant units are a coarse-grained foliated biotite tonalite which forms the pluton perimeter and texturally variable granodiorite and monzogranite which form the central part of the pluton.

The pegmatites range in size from <1 to 5 m wide and <3 to 100 m long, have a shallow to moderate dip ($\leq$50°) and can show dramatic variation in width over their exposed strike length. Zoning is commonly reflected by a fine -to medium- grained granitic margin and a core commonly comprising coarse blocky, perthitic K-feldspar, quartz and large blades (3cm long) of biotite $\pm$ muscovite; although a few dykes have an aplitic core (Fig.2). The highest concentrations of beryl often occur within massive quartz in the core zone, where individual beryl crystals may be $\leq$8cm in length. No beryl was observed in pegmatites with an aplitic core. Accessory minerals within these dykes include, apatite, tourmaline, garnet, zircon and

andalusite. As part of this investigation, several pegmatite occurrences were plane-table mapped and two were drilled (see Results of diamond drilling section below).
In contrast, pegmatites occurring within and adjacent to the Barrington Passage(BP) and Shelburne Plutons(SP) located west of the Port Mouton Pluton are commonly <1 m thick, dip steeply and rarely contain small (≤1cm) beryl crystals (Fig.1).

Jordan River Be-Mo Occurrence:

This occurrence is situated approximately 5km north of Jordan Falls, Shelburne County (Fig.1) within biotite + garnet ± andalusite-bearing Meguma Group metasediment (granofels). The reader is referred to White (1984) for information about the regional geology. The occurrence is characterized by, abundant, white opaque to translucent pale green, anhedral to subhedral beryl crystals (<3cm long) and crystal masses (≤10 cm long), and minor molybdenite which occur within a parallel set of northeast-trending quartz veins, ≤ 1.5m in width (Fig.2). The veins trend northeast and dip steeply north. The beryl crystal masses in some cases have a feathery texture and appear to be a intergrowth of abundant fine-grained translucent beryl and medium grained, white, opaque albite (cleavelandite?). Small(<2cm long), euhedral, pale green to yellow beryl crystals also occur within quartz veins, often intergrown with small pods of coarse-grained muscovite. The quartz veins show two distinct textures; 1) massive, milky white, and 2) translucent with prominent white banding. The quartz is frequently intensely sheared and the bands themselves may represent shear bands. However, beryl crystals which occur in the sheared quartz do not always show evidence of deformation. This suggests that beryl crystallization was syn -to post- deformation. Molybdenite occurs as ≤1cm blebs within massive quartz and also within pods of massive muscovite where it may be associated with small beryl crystals. Previous trenching and diamond drilling by Talisman Mines (Geisler, 1962) discovered the main vein (see Fig.3) and traced the vein along strike for 90m, and to a depth of 130m. Vein contacts are commonly marked by a zone of intense bleaching and tourmalinization within the metasediment wall-rock (Fig.2)

Brazil Lake Li-Sn Pegmatite:

Brazil Lake is located approximately 25km northeast of Yarmouth (Fig.1). The Brazil Lake pegmatite represents the only known occurrence of spodumene-bearing pegmatite within Nova Scotia. Pegmatite in the area of Brazil Lake was first documented by Taylor (1967), who briefly described the mineralogy and provided a map of the area of pegmatite outcrop. Although there is mention of the pegmatite being drilled during the late 1960's no information is on file with N.S.D.N.R. The pegmatite was also the focus of an exploration mapping and sampling program by Shell Canada Resources Ltd. in 1981 (Palma et al., 1982), a BSc. thesis in 1982 (Hutchinson, 1982) and a detailed multimedia geochemical study by the Department (MacDonald et al., 1992). The occurrence is currently the focus of an H.BSc. thesis by S. Hughes at Saint Mary's University.

The occurrence consists of several northeast-trending outcrops of spodumene-bearing pegmatite which occur within a northeast-trending, folded sequence of mixed, metavolcanics and metasediments of Ordovician to Silurian age, informally termed the Yarmouth syncline. Recent study (O'Reilly et al., 1992) indicates that the portion of the syncline which hosts the pegmatite also encompasses the extrapolated extension of a regional northeast-trending shear zone. The Brazil Lake pegmatite is characterized by the presence of very large (≤60 cm) spodumene crystals, and a accessory mineral assemblage which includes;

tourmaline, apatite, cassiterite, wolframite, zircon, columbite / tantalite and epidote. Very minor lithiophilite ($Li(Mn,Fe)PO_4$), variscite ($AlPO_4$) and other as yet unidentified phosphate minerals also occur (Hughes, pers. comm.). Although dark green beryl is reported to occur within the pegmatite (Hutchinson, 1982), it was not identified in this study. Instead, an area where abundant beryl was previously reported was examined during this study and the mineral was identified as green tourmaline. Although several outcrops occur, it was unclear prior to this investigation as to whether they constituted a single dyke discordant to the regional foliation or, a series of lenticular pods oriented parallel to the structural trend (see Results of diamond drilling below). The largest outcrop is about 24m long by 4m wide and shows three distinct mineralogical / textural zones (Hutchinson, 1982). Local development of black tourmaline can be observed within the wallrocks, presumably reflecting exomorphic alteration related to the later-stages of pegmatite consolidation. Another metasomatic mineral previously reported to occur within the wallrock (based on microprobe analysis) is that of the Li-amphibole holmquistite (Hutchinson, 1982), but it was not identified during this study.

**Results of Diamond Drilling**

Port Joli Pegmatite Occurrences:

Two pegmatite occurrences approximately 650m apart were selected as drill sites (Fig.4) based on their exposure and ease of access. A single vertical hole was at each location. Numerous shallow to moderately-dipping (30-50°) pegmatite dykes varying in thickness from <0.25m to 20m were intersected in both holes. Although most of the dykes show a zonal pattern similar to observed in outcrops in the area, some are layered. The layered dykes are generally <1m thick and show a vertical transition from a lower zone consisting of medium -to coarse- grained plagioclase (graphic) + K-feldspar (graphic/perthitic) + muscovite + quartz + biotite ± garnet; to a very coarse-grained quartz + K-feldspar (± perthitic) + muscovite ± beryl-bearing intermediate zone, to an upper zone consisting of quartz + K-feldspar (± graphic) + muscovite, with the feldspars occurring as long slender crystals commonly oriented perpedicular to the wallrock contact. The muscovite is commonly plumose and has an overall orientation similar to the feldspars. No beryl was observed in any of the dykes intersected in drill core. Accessory minerals that were identified include small (<1cm), euhedral, dark green apatite which was locally abundant in the border zone of several pegmatite dykes and <1cm garnet crystals which frequently showed distinct colour zoning from pinkish-red rims to brownish-black cores. Although speculative, this may reflect compositional zoning from a spessartine-rich rim to an andradite-rich core. Pegmatite/wall rock contacts are sharp and commonly at 30-50° to the core axis, an attitude consistent with that of pegmatites exposed in nearby outcrop. Steeper intersections of 70-90° to core axis were also observed, but much less frequently.

Granitic host rocks observed form part of the Port Mouton Pluton and are consistent with units identified by Douma (1988). However, only 4 of her granitic units were discernable from the drill core (Fig.4). Other textural and mineralogical variations observed in the core such as biotite-rich banding and leucogranite are interpreted as contact-related features.
Drilling of the Port Joli pegmatites indicates that they occur as shallow-dipping dykes, which collectively may form a series of vertically stacked pegmatite dykes (Fig.4). Although the dykes are of variable thickness, they do show a fairly consistent compositional zonation. While the pegmatites appear to be best developed within intersections of muscovite-biotite monzogranite, further study is required before a source rock can be indentified.

Jordan River Be-Mo Occurrence:

Four holes totalling 445m of core were drilled during October to December 1992 (Figs.2,3,5). Spotted to obtain information about the veins down-dip and along strike, drilling indicates that veining occurs for at least 500m along strike, >100m down-dip and that the area of veining is at least 700m wide. Although beryl ± molybdenite-bearing quartz veins were present in all 4 holes, their distribution was sporadic (Fig.5). The veins vary in orientation from 30-70° to the core axis, range in thickness from <5cm to 1m and occur most frequently within biotite ± chlorite-bearing psammite. In all cases the presence of beryl is accompanied by intense bleaching and tourmalinization (Fig.6). In contrast to the large beryl + cleavelandite (?) intergrowths seen in the main vein, beryl in the narrower veins occurs as small, euhedral, commonly translucent, pale-yellow crystals. The main trench vein intersected in JOR92-1 appears to be of constant thickness to about 28m vertical depth at which point it appears to pinch out. A vein of similar thickness and texture occurs in JOR92-2 approximately 40m deeper than the vein in JOR92-1. Although the lower vein is hosted by leucogranite it may be that this vein represents the down-faulted extension of the upper vein or be part of an en echelon vein array.

Drilling also intersected a texturally variable, muscovite-rich, leucogranite dyke in two of the drill holes (JOR92-2, 4m wide; JOR92-4,30cm). The dykes contain minor disseminated pyrite, chalcopyrite and molybdenite and are associated with intense tourmalinization of the adjacent wallrock. The dyke in JOR92-2 also contains beryl-bearing, banded quartz veins. The banding is characterized by alternating, mm-thick bands of milky and glassy quartz oriented perpendicular to the vein / wallrock contact. The orgin of the texture is uncertain, either reflecting primary growth or shear banding. Numerous pink to green, garnet-bearing calc-silicate bands/pods were also intersected in the drill holes. These skarnoids are cross-cut by the quartz veins indicating metamorphism preceeded mineralization.

Brazil Lake Pegmatite:

Five holes were drilled (October to November 1993) in an area of scattered spodumene-bearing pegmatite outcrop and rubble-crop (Fig.7). With the exception of BZL93-1, which had to be terminated in pegmatite due to technical difficulties, drilling recovered entire sections through spodumene-bearing pegmatite. Drilling has established the presence of a single, sub-vertical, zoned pegmatite dyke traceable along strike for 100m and to about 75m depth. The dyke shows considerable variation in thickness ranging from <10m to approximately 25m (Fig.8). The drilling suggests that the dyke has a lenticular shape which may thicken to the south. Although the pegmatite displays mineralogical and textural zoning similar to that described by Hutchinson (1982) for surface outcrop, the core does provide additional information and allows for some modification. The most obvious refinement is the delineation of a very coarse-grained spodumene + quartz ± plagioclase (± cleavelandite) zone which contains minor K-feldspar and rare cassitierite and columbite(Fig.9). This zone in one drill hole contains 10m of massive quartz.

Volumetrically, the most common zone has a medium -to coarse- grained texture and contains abundant spodumene (≤35%) + quartz + albite (cleavelandite) ± muscovite (Fig.8). The spodumene shows distinct colour variation from, yellow to dark-green to white, likely reflecting a variation in contained iron within the spodumene; with the white spodumene containing the least amount iron. The albite/cleavelandite is white, and commonly occurs interstitial to coarser quartz and spodumene (Fig.9). While fine-grained disseminated cassiterite, apatite, columbite/tantalite and tourmaline may also occur within this zone, these minerals are most abundant within a fine grained aplite textured zone where they can occur as fine grained crystals and coarse grained crystal clusters (Fig.9). Compositionally the aplitic zone is composed of plagioclase (albite±cleavelandite) and quartz with minor green-blue tourmaline, blue apatite, cassiterite, columbite/tantalite, lithiophilite and other phosphate minerals (Figs.8,9). As shown in Figure 9 the aplitic zone has two distinct textures; massive, and with a prominent sub-vertical (shear?) fabric. Although not evident from exposed outcrops, in drill core the sheared (?) sections occur proximal to the wall rock contact. If the fabric is tectonic it is curious as to why other section of this zone and surrounding pegmatite zones do not reflect a similar fabric. One possible explanation is that the aplitic zone reflects magmatic and metasomatic derived portions. Further detailed study will attempt to resolve this problem.

The wall rock comprises interbedded, pelite, psammite and amphibolite and minor mafic tuff; and a massive, milky to glassy quartz-rich unit which occurs above the uphole pegmatite contact (Fig.8). These units show local intense sub-vertical foliation and tourmalinization. Below the downhole pegmatite contact the host rock is massive to locally intensely foliated, fine- to medium -grained amphibolite .

These units have been placed by Hutchinson (1982) within members of the Silurian-Devonian, White Rock Formation as described by Sarkar(1978). The massive, milky to glassy, quartz-rich rock has been interpreted by Taylor(1967) and Hutchinson(1982) to be orthoquartzite typical of that occurring within the White Rock Formation. However, in drill core this unit is characterized by irregular zones of massive to granular white quartz, and dark, inclusion-rich (muscovite, tourmaline, amphibole) quartz and locally abundant coarse black tourmaline and minor disseminated pyrite and chalcopyrite (Fig.9). In some cases, clots very similar to the surrounding amphibolite occur within this unit, often showing the same fabric as the adjacent amphibolite (Fig.10). These features suggest that the quartz-rich unit may be a zone of silicified amphibolite rather than White Rock orthoquartzite. While the presence of abundant tourmaline and possible holmquistite (Hutchinson, 1982) likely reflects exomorphic alteration related to the influx of pegmatite-derived, borate-rich fluids into the country rock during the late stages of pegmatite consolidation (London, 1990). The metasomatic development of tourmaline through this process requires a supply of Fe and Mg from the host rock, elements not readily available from within quartzite.

Another zone defineable based on the drill core is composed of coarse-grained, K-feldspar (microcline) + albite (cleavelandite); with the cleavelandite occurring as a replacement of the microcline. This zone varies from .1m to 1m in width and is most prevalent within and proximal to the coarse-grained quartz + spodumene zone (Fig.8,9). The rare occurrence of rounded, intensely altered spodumene crystals within sections of massive cleavelandite suggest that cleavelandite also replaced spodumene-bearing sections.

The accessability of the Brazil Lake occurrences allowed for an on-site, multi-parameter downhole geophysical survey of drillhole BZL94-4 by the Borehole Geophysics Section of the Geological Survey of Canada. This data can be very useful for characterizing lithologic units and delineating mineralogical variation in particular. Although interpretation of the geophysical log for BZL94-4 (Fig.11) is preliminary, several characteristics of the pegmatite are readily obvious. Most apparent are the elevated levels of K and U in the pegmatite compared to the wall rocks. This is not surprising given the presence of coarse-grained K-feldspar and the likely occurrence of U-bearing mineral phases within the pegmatite as part of a varied accessory mineral assemblage. The density and ratio logs show a uniform elevated response for wallrock lithologies compared to the pegmatite. The ratio log (W6 / W1) is a measure of the concentration of minerals containing elements of high atomic number. Conversely, areas of marked decrease in the ratio reflect zones of low atomic number element-bearing minerals. In these cases, it appears to reflect the presence of coarse-grained spodumene-bearing zones within the pegmatite (e.g.55m) and abundant tourmaline occurring within the wallrock (e.g.110m). The core sections termed silicified zones in this study, show responses similar to the adjacent pegmatite for the upper zone and a response similar to the adjacent amphibolite for the lower silicified zone. Surficial boulders of similar siliceous rock have been interpreted as White Rock Formation quartzite by earlier workers, however core observations suggest that the siliceous zones instead represent zones of intense, pervasive silicification. The electromagnetic logs (IP, resistivity, SP) appear to corroborate the lithologic divisions in the wall rock as well as delineate zonation within the pegmatite. The magnetic susceptability (MS) log, primarily reflects the presence of disseminated pyrrhotite in the amphibolite.

**Discussion:**

The drilling has investigated three distinct types of pegmatite. The pegmatites investigated record the characteristics of a spacial sequence of pegmatites from; within the source granitoid (Port Joli), to proximal to the granitoid source (Jordan River), to that which occurs distal to a possible granitoid source (Brazil Lake). According to the rare-element pegmatite classification of Cerny (1991), these occurrences all appear to belong to the L (lithium) C (cesium)T(tantalum) family of pegmatites; specifically the beryl and albite-spodumene types. The pegmatites also show a regional zonation reflected by increasing fractionation and mineralogical complexity with distance from a possible source.
The exception to this may be the Jordan River Be-occurrence which given the absence of zoning and feldspar, and the dominance of quartz and muscovite may be more of a greisen-type of occurrence than a pegmatite (cf.Trueman, 1988). However, evidence that similar magmatic-metasomatic processes associated with pegmatite crystallization (e.g. Brazil Lake) occurred at Jordan River is shown by the occurrence of intense tourmalinization of wall rock adjacent to the beryl-bearing quartz veins. Although beryl-bearing quartz veins occur over an extensive area at the Jordan River occurrence; the veins intersected to date are narrow and contain only sporadic disseminated beryl. If however this is a greisen type of occurrence, there may be good potential for associated Sn-W-Mo mineralization similar to that documented throughout southwestern Nova Scotia (O'Reilly et al. 1992). The intersections of leucogranite in several of the drillholes, showing features (beryl, molybdenite, metasomatic tourmaline in wallrock) similar to those observed within the quartz veins suggests that the leucogranite represents a likely source of the vein/alteration forming fluids.

The pegmatite with perhaps the best economic potential is the Brazil Lake pegmatite. This study has delineated a single, sub-vertical, dyke-like body of pegmatite, $\leq$25m thick, continuous along strike for 100m and to about 75m vertical depth. This pegmatite represents the most mineralogically complex (and fractionated?) pegmatite occurrence documented in the province. Aside from possibly providing gem stock, the economic potential of this occurrence would seem dependant on the delineation of high lithium, low iron (<.10wt.%), spodumene for use in the manufacture of thermal shock resistant cookware (Ober, 1992). The results of an 1971 metallurgical test on approximately 200kg of pegmatite from surface rubble, indicates an average head assay of 2.75% $Li_2O$ with .30-.18wt% $Fe_2O_3$ (Walsh, 1971). The $Li_2O$% is much higher than most pegmatite deposits worldwide and is comparable to the grade reported for spodumene concentrate from the producing Bernic Lake pegmatite deposit (2.8% $Li_2O$; Bleiwas and Coffman, 1985). Future work on this occurrence will focus on mineralogical studies to indentify all minerals and to delineate zones of low iron, ceramic /glass grade spodumene. Together, these and other rare-element pegmatites within southwestern Nova Scotia constitute a unique metallogenic domain within the Meguma Terrane of Nova Scotia.

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# DESCRIPTIVE DRILL LOGS

## N.S.D.N.R. DRILLHOLE PMP92-1: DESCRIPTIVE LOG

**Vertical hole; Total depth = 230.4 metres**
**UTM Coordinates: northing - 4857200 / easting - 350610**

**0.0 to 2.13: OVERBURDEN:**

**2.13 to 4.81: BIOTITE MONZOGRANITE**: medium grained, moderately equigranular, (6-8%) bladed biotite, (2-4%) fine-grained muscovite.

**4.81 to 5.0: PEGMATITE**: 30cm wide, very coarse grained, bladed biotites and quartz-muscovite intergrowths; accessory garnet and apatite, no beryl. Contacts are sharp at 80°/ca. (core axis), moderate chloritization, of biotite.

**5.0 to 11.95: BIOTITE MONZOGRANITE**: medium grained, moderately equigranular, biotite (6-8%), muscovite (2-4%).

**11.95 to 12.8: PEGMATITE**: coarse grained, sharp contacts at 20°/ca.; biotites are bladed, 3cm. long; rare garnet and apatite.

**12.8 to 13.35: BIOTITE MONZOGRANITE**: medium grained, moderately equigranular, (6-8%) bladed biotite, (2-4%) fine-grained muscovite.

**13.35 to 13.7: PEGMATITE**: coarse grained, similar to above; contacts sub-vertical to core axis.

**13.7 to 18.74: BIOTITE MONZOGRANITE**: medium grained, moderately equigranular, (6-8%) bladed biotite, (2-4%) fine-grained muscovite.

14.0: PEGMATITE: 5cm.in width, sub-horizontal to core axis.
18.6: PEGMATITE: 2cm.in width, very small euhedral garnets

**18.74 to 19.05: PEGMATITE**: medium grained, contacts perpendicular to core axis; euhedral garnet and perthitic K-feldspar.

**19.05 to 20.66: BIOTITE MONZOGRANITE:** medium grained, moderately equigranular.

**20.66 to 20.9: PEGMATITE:** contacts 80°-90°/ca, coarse grained, feldspars show graphic texture, bladed biotite and rare apatite.

**20.9 to 82.1: BIOTITE MONZOGRANITE:** medium grained, moderately equigranular.

21.6: PEGMATITE: contacts at 25°/ca.

25.1 - 25.7: PEGMATITE: contacts perpendicular to core axis, coarse grained; biotite and muscovite intergrowths, graphic feldspars, abundant garnets.

26.2: PEGMATITE; 5cm. wide, sub horizontal/ca. coarse grained with bladed biotites, minor

garnet and pale green mineral apatite.
27.12: monzogranite becomes finer grained, increase in muscovite content.
28.65 - 28.90: biotite-poor, leucocratic section, contact at 35°/ca.; fracture faces coated with sericite, ±limonite and manganese.
33.5: PEGMATITE; 7cm. sub-horizontal/ca., zoned with 1cm wide coarse-grained band in the center and fine-grained margins.
37.0 - 37.8: PEGMATITE; at 45°/ca, occurs as 3 narrow (1-1.5cm) bands 2cm. Gradational contacts with monzogranite.
48.31 - 50.6: zone of narrow leucocratic, biotite-poor banding at 45°/ca., texturally similar to the monzogranite.
50.6: PEGMATITE; 25cm wide, coarse grained, abundant garnet at downhole contact, possible beryl, contacts at 70°/ca.
53.8: sharp contact between the monzogranite and a 30cm wide biotite-enriched zone (60°/ca.). Contact is marked by a 1.5cm wide PEGMATITE at 90°/ca.
58.36: foliated, biotite rich bands at 30°/ca.
64.1: PEGMATITE; 2cm. wide, 90°/ca.
67.36: PEGMATITE; 2cm in width at 40°/ca., bladed-biotite and muscovite intergrowth ± garnet.
68.6: PEGMATITE; 2cm in width at 70°/ca., ± garnet.
69.2: PEGMATITE; 10cm. in width at 90°/ca., coarse K-feldspar and muscovite with minor biotite and plagioclase; plagiclase can contain abundant, small, euhedral garnet inclusions.
74.7: PEGMATITE; 2x3cm. 50°/ca, adjacent monzogranite is biotite-rich with slight-foliation.
75.4: PEGMATITE; 10cm in width, coarse K-feldspar and quartz, with bladed biotite + muscovite intergrowths.
76.5: PEGMATITE; 5cm wide, 40°/ca., locally-foliated.

**82.14 to 97.17: MUSCOVITE-BIOTITE MONZOGRANITE**: fine to medium grained, contact is gradational; biotite(4-6%), muscovite(2-4%).

84.3: PEGMATITE: 5cm.
85.7: PEGMATITE: 5cm, at 60°/ca.
96.77: PEGMATITE: 10cm wide, ± garnet. Monzogranite adjacent to dyke shows 5cm zone of intensely hematized K-feldspar.

**97.17 to 102.7: BIOTITE MONZOGRANITE**: fine-grained, slightly porphyritic. Contacts are sharp at 70°/ca.

101.5: pegmatite segregations.
102.4 - 102.7: biotite-rich, foliated at 70°/ca.

102.7 to 101.8: PEGMATITE: coarse grained, at 30°/ca. The pegmatite shows zoning, with margins of medium-to coarse- grained muscovite+plagioclase+K-feldspar and a core of coarser-grained K-feldspar and quartz.

103.6-104.4: section is 80% quartz, fractured at 45°-50°/ca.
104.2: coarse-bladed aggregates of muscovite and biotite with small dark-green apatite. K-feldspar is fractured/sheared with fractures (gashes?) infilled with quartz.
104.2-104.7: massive quartz replaced by coarse K-feldspar and muscovite ± apatite;

104.8: sharp contact at 30°-40°/ca.

**104.8 to 110.0: BIOTITE MONZOGRANITE:** fine-grained, slightly porphyritic. Contacts are sharp at 70°/ca. Fine grained biotite banding, the bands range from 1-4.5 cm. in width, oriented at 45°/ca.

**110.0 to 111.5: PEGMATITE:** contains abundant small plagioclase crystals, and coarse muscovite+biotite intergrowths.
361.5 - 366.2: section with biotite bands

**111.5 to 123.0: MUSCOVITE-BIOTITE MONZOGRANITE:** medium -to coarse- grained, moderately equigranular.

112 - 113.3: section of fine grained monzogranite, sharp contact at 70°/ca. Contains narrow (<5mm) biotite bands at 70°/ca.
113.3: PEGMATITE; contact is marked by biotite enrichment
118.8 - 119.1: sharp contact with fine grained section at 50°/ca.; variable biotite content.
119.1 - 119.8: slightly hematized, thin (<5mm) bands of muscovite and biotite at 45-50°/ca.
122.2 - 123: biotite bands oriented parallel to granodiorite contact at 45°/ca;

**123.0 to 123.7: GRANODIORITE:** medium to coarse grained, moderately equigranular.

**123.7 to 126.8: LEUCOMONZOGRANITE**: fine grained, equigranular, several thin biotite bands oriented parallel to contact at 45°/ca.

**126.8 to 129.8: GRANODIORITE:** fine -to medium-grained, moderately equigranular, biotite-rich; foliated parallel to the contact at 50°/ca. Contains minor pegmatite.

128.7: leucocratic section, containing 8-12% biotite is in sharp contact (90°/ca.) with biotite-rich, banded section oriented at 45°/ca., 1mm thick.
129.1: biotite-banded leucocratic section.

**129.8 to 137.6: MUSCOVITE-BIOTITE MONZOGRANITE**: medium -to coarse-grained, moderately equigranular, foliated at 40°/ca. Minor biotite banding and clots.

131.3 - 134.1: section of biotite-banding at 30°/ca.

**137.6 to 138.0: GRANODIORITE:** fine to medium grained, moderately equigranular, foliated and biotite-rich (15-25%); possible tonalite. Contact is at 60°/ca..

**138.0 to 142.0: MUSCOVITE-BIOTITE MONZOGRANITE:** medium -to coarse-grained, moderately equigranular, foliated at 40°/ca. Minor biotite banding and clots. Several aplite dykes ($\leq$ 10cm.).

**142.0 to 142.3: GRANODIORITE:** fine-grained, equigranular, slight to intensely foliated at 45°/ca.; possible tonalite.
**142.3 to 143.8: MUSCOVITE-BIOTITE MONZOGRANITE**: medium -to coarse-grained, moderately equigranular, foliated at 45°/ca. Minor biotite banding and clots.

**143.8 to 145.1: GRANODIORITE:** medium -to coarse- grained, moderately equigranular; sharp contact (145.1) with monzogranite at 15°/ca.

**145.1 to 146.6: MUSCOVITE-BIOTITE MONZOGRANITE:** fine -to medium- grained, moderately equigranular;

**146.6 to 147.6: GRANODIORITE:** medium -to coarse- grained, moderately equigranular.

**147.61 to 148.4: MUSCOVITE-BIOTITE MONZOGRANITE:** fine -to medium- grained, moderately equigranular; biotite is much coarser.

**148.4 to 149.6: GRANODIORITE**: fine -to medium -grained, moderately equigranular.

**149.6 to 150.4: MUSCOVITE-BIOTITE MONZOGRANITE**: fine -to medium- grained, moderately equigranular, sharp contact marked by biotite bands.

**150.4 to 150.8: PEGMATITE**: coarse myrmekitic texture at contact; at 30°/ca.

**150.8 to 154.5: GRANODIORITE:** fine -to medium -grained, moderately equigranular.

**154.5 to 155.7: LEUCOMONZOGRANITE**: fine -to medium -grained, moderately equigranular. Local biotite enrichment in bands at 45°/ca.

**155.7 to 157.7: GRANODIORITE:** medium -to coarse- grained, moderately equigranular, local muscovite and biotite enrichment.

**157.7 to 159.1: PEGMATITE;** coarse, blue quartz, with abundant muscovite and dark green apatite.

**159.7 to 162.7: GRANODIORITE:** medium -to coarse- grained, moderately equigranular. varies to fine -to medium -grained, moderately equigranular adjacent to downhole contact. Possible tonalite.

**162.7 to 165.2: LEUCOMONZOGRANITE**: medium -to coarse -grained, sharp contact at 45°/ca., marked by a 5cm. wide aplitic band. Contains several mm thick biotite bands.

**165.2 to 195.4: GRANODIORITE:** medium -to coarse -grained, moderately equigranular, sharp contact at 60°/ca; locally porphyritic. Several PEGMATITE / APLITE dykes (30-40°/ ca.)

**195.4 to 196.2: LEUCOMONZOGRANITE**; fine -to medium- grained, moderately equigranular; sharp contact at 45°/ca. Contains mm-thick biotite bands oriented parallel to the contact.

**196.2 to 200.6: GRANODIORITE:** medium -to coarse -grained, moderately equigranular. Minor PEGMATITE, 40°/ca.

**200.6 to 202.8: MUSCOVITE-BIOTITE MONZOGRANITE:** medium -to coarse -grained, moderately equigranular; sharp contact with a 15cm. wide PEGMATITE dyke, 60°/ca. (+ beryl). The downhole contact is marked by PEGMATITE at 45°/ca.

**202.8 to 208.2: GRANODIORITE:** fine -to medium -grained, moderately equigranular.

**208.2 to 209.8: BIOTITE MONZOGRANITE:** medium -to coarse -grained, moderately equigranular; mild to moderate, pervasive, chloritization, saussuritization and hematization. Contact at 60°/ca.

**209.8 to 213.5: GRANODIORITE:** medium grained, equigranular; contact at 30°/ca. Local intense, pervasive chloritization and hematization.

**213.5 to 215.2: LEUCOMONZOGRANITE:** medium -to coarse -grained, moderately equigranular; sharp contact at 40°/ca. The downhole contact shows 1.5cm. of subvertical displacement at 40°/ca.

**215.2 to 218.4: BIOTITE MONZOGRANITE:** medium -to coarse -grained, moderately equigranular.

**218.4 to 221.3: PEGMATITE**: zoned, contact at 70°/ca.

**221.3 to 225.7: MUSCOVITE-BIOTITE MONZOGRANITE:** fine -to medium-grained, moderately equigranular, contacts at 40°/ca.; several PEGMATITE dykes.

**225.7 to 230.3: GRANODIORITE**: medium grained, equigranular, sharp contact; locally foliated.

**230.3 to 230.4: MUSCOVITE-BIOTITE MONZOGRANITE**: medium -to coarse -grained, moderately equigranular.

**230.4: END OF HOLE!**

## N.S.D.N.R. DRILLHOLE PMP-92-2: DESCRIPTIVE LOG

**vertical hole; Total depth = 236.5 metres**
**UTM Coordinates: northing - 4857615 / easting - 350250**

**0.0 to 3.9: OVERBURDEN:**

**3.9 to 4.4: PEGMATITE**: 20°/ca; coarse quartz and plagioclase, pink K-feldspar, bladed biotite and plumose muscovite; plagioclase shows graphic texture and biotite is chloritized. Section includes fine -to medium -grained, equigranular to slightly foliated (parallel to contact) granodiorite (tonalite?) xenoliths.. Moderately hematized down to 4.4m.

**4.4 to 50.75: MUSCOVITE-BIOTITE MONZOGRANITE**: sharp contact with a medium grained, moderately equigranular, biotite(6-8%); slightly foliation at 50°/ca. Mild to moderate hematization and kaolinization. Section contains several pegmatite dykes.

7.9 - 8.3: PEGMATITE: 10-20°/ca; K-feldspar, quartz, and muscovite with minor plagioclase.
9.0: PEGMATITE; 1.5 cm in width, contact sub-parallel to ca.
10.6 to 11.2: PEGMATITE: contains coarse muscovite.
20.6: PEGMATITE ; 25cm in width, 40°/ca. ; 5cm aplitic section in the core region. Contacts with the monzogranite are gradational .
22.1: PEGMATITE: 60cm thick, contains biotite-rich bands (45°/ca.), ranging from 1.5-10cm in width. Bands are oriented parallel to the contact. Also contains coarse bladed muscovite.
24.5: PEGMATITE:; 5cm at 30°/ca, contains minor dark green apatite and show areas of biotite enrichment (clots and bands).

31.7 - 32.3: core becomes more altered (hematized, chloritized), with less biotite.

32.3: PEGMATITE: 60cm., sharp contact (60/°ca), marked by a 3mm biotite band and a 1cm aplite band below it. The dyke contains coarse, quartz, K-feldspar, and bladed biotite (± intergrown muscovite) at the margins and a aplitic core. The core region contains segregations of monzogranite (xenoliths?) and minor apatite. Small, euhedral, zoned plagioclase crystals are common in the core zone. The downhole contact is marked by a 10cm zone of enriched, slightly foliated (50°/ca), biotite.

37.1 - 40.1: PEGMATITE: sharp contact (45°/ca), marked by long bladed biotite (variably chloritized). Pegmatite contains coarse K-feldspar and graphic plagioclase. At 130.5, the pegmatite is fine to medium grained and muscovite-rich. The downhole contact is sharp at 60°/ca.

41.1 PEGMATITE; sharp contact, 60°/ca, ± pale green apatite.
41.6 - 42.3: PEGMATITE : sharp contacts up and downhole (60-70°/ ca.)
42.4: PEGMATITE; contact irregular, 30-70°/ca., apatite present.
42.9: PEGMATITE; narrow bands, 45°/ca.
43.8 - 44.0: PEGMATITE: sharp contacts, 30-40°/ca; monzogranite wallrock shows moderate hematization adjacent to pegmatite.
44.5: PEGMATITE; 8cm. 45°/ca.

45.8 - 47.4: PEGMATITE: predominately coarse K-feldspar and quartz, with minor graphic plagioclase , muscovite and biotite. Contact with the above at 60°/ca. Last 20cm is biotite-rich and fine grained, contact at 35°/ca.

45.7 - 50.4: biotite bands 1-20cm wide locally developed at 45°/ca.

48.3 - 50.3: PEGMATITE: 30°/ca. quartz, plagioclase + >muscovite and small, pink garnets. Approximately 50% of this section is fine grained and biotite-rich .

**50.75 to 53.5: LEUCOMONZOGRANITE**: medium grained, moderately equigranular, biotite(4-6%) is locally concentrated in bands. 174.5 - biotite-rich (15-20%) segregation.

**53.5 to 63.4: MUSCOVITE-BIOTITE MONZOGRANITE:** medium- to coarse -grained, moderately equigranular; sharp contact 35°/ca.
54.1: 30cm zone of banded biotite ≤3mm., oriented parallel to contact.
54.9: biotite shows slight foliation at 40°/ca., 1.5cm in width; locally banded.

61.1 - 62.8: intense pervasive kaolinization; intensely fractured, at 25-30°/ca.

**63.4 to 65: LEUCOMONZOGRANITE**: fine -to medium- grained, moderately equigranular, numerous biotite bands at 35-45°/ca.

**65.0 to 82.0: MUSCOVITE-BIOTITE MONZOGRANITE**: sharp contact at 30°/ca.; texturally variable.

66.1: PEGMATITE; 7cm, at 40°/ca.; minor pale green apatite.
67.4 - 72.5: PEGMATITE; 35°/ca; section contains several dykes 5-35cm in width; contain, K-feldspar, quartz, muscovite, plagioclase ± apatite ± garnet.
72.5: PEGMATITE: 5cm to 10cm in width, coarse muscovite.
72.8: PEGMATITE: 5-10cm in width.

72.5 - 77.7: core becomes more leucocratic and finer grained; section contains faint biotite bands.
78.3 - 82.0: section contains biotite-rich segregations (5-15 cm wide).

**82.0 to 86.8: PEGMATITE:** banded with aplite (5-30cm wide; ± garnet) at 45-50°/ca., contact at 45°/ca. Local brecciation of the pegmatite is evident. Biotite bands (1-3cm) occur at 35-90°/ca., particularly abundant from 84m.

**86.8 to 89.0: MUSCOVITE-BIOTITE MONZOGRANITE**: sharp contact at 30°/ca.; texturally variable.
86.8 - 88.1: intense biotite enrichment (15-25%), slight porphyritic phase.
88.5: aplitic band

**89 - 90.2: PEGMATITE:** contact at 45°/ca. marked by 0.5cm wide aplite; there is a 5cm wide biotite-rich phase adjacent to the aplite.

**90.2 to 91.0: BIOTITE MONZOGRANITE:** sharp contact at 40°/ca., biotite-rich,(15-20%), fine- to medium -grained, slightly porphyritic; maybe xenolith.

**91.0 to 92.5: MUSCOVITE-BIOTITE MONZOGRANITE**: sharp contact, section contains biotite-rich segregations and bands oriented parallel to contact..

**92.5 to 93.3: PEGMATITE:** contains coarse pink K-feldspar and bladed biotite with intergrown muscovite (secondary?); interlayered with pink aplitic segregations.

**93.3 to 96.6: LEUCOMONZOGRANITE**: fine- to medium -grained, moderately equigranular, biotite (2-4%), muscovite (≤4%). Mild clay alteration and moderate pervasive hematization. Section contains several PEGMATITE dykes.

94.6 - 94.8: MUSCOVITE-BIOTITE MONZOGRANITE: xenolith ?

94.8 - 96.6: texturally variable, from aplitic to medium-grained.

**96.6 to 103.5: PEGMATITE:** contact at 45°/ca., marked by 7cm of muscovite ± garnet-bearing aplite. The pegmatite is similar to those above, containing, coarse, graphic textured, pink K-feldspar, which also shows evidence of strain; quartz and minor, white to pale yellow plagioclase. Biotite occurs as coarse- bladed, chloritized crystals which are often associated with coarse aggregates of plumose muscovite. Both show general orientation perpendicular to the contact.

**103.5 to 105.2: MUSCOVITE-BIOTITE MONZOGRANITE**: similar to above; contacts are muscovite-rich and contain abundant fine-grained, dark green apatite crystals.

**105.2 to 119.5: BIOTITE GRANODIORITE:** medium -to coarse -grained, moderately equigranular, biotite (12-18%). Local development of biotite-rich bands and leucocratic, pegmatitic zones at 45°/ca.

**119.5 to 125.0: MUSCOVITE-BIOTITE MONZOGRANITE**: sharp contact at 45°/ca., section contains several PEGMATITE dykes.

122.5: PEGMATITE: 25cm, at 60°/ca., coarse-grained K-feldspar-rich rim.
123.5: PEGMATITE: 20CM, at 30°/ca.
124 - 125: BIOTITE GRANODIORITE: sharp contacts; xenolith?
125 - 126.8: PEGMATITE: banded, contacts at 30°/ca., similar to above contains apatite.

**126.8 to 136.7: BIOTITE GRANODIORITE:** medium- to coarse- grained, moderately equigranular. Section contains several PEGMATITE dykes, texturally similar to those described above, contacts at 45°/ca. Dykes range from 10-30cm thick. Minor apatite present in dykes. Dykes associated with narrow bands (segregation?) of muscovite-biotite monzogranite.

**136.7 to 168.2: MUSCOVITE - BIOTITE MONZOGRANITE:** predominately medium- to coarse -grained, moderately equigranular with local variation to slightly porphyritic. Section contains leucocratic, (biotite <6%) zones which show sharp and gradational contacts. Local banded texture zones also occur characterized by alternating biotite-rich and poor zones parallel to the contact. These are often associated with pegmatite.

137.7 - 138.7: PEGMATITE; at 45°/ca.; the margin adjacent to monzogranite is marked by alternating bands (≤3cm thick) of aplite and coarse-grained biotite oriented parallel to the contact. Pegmatite shows a transition from an aplite border phase to an intermediate zone of coarse-grained K-feldspar + quartz + plagioclase + muscovite to a core of coarse K-feldspar + quartz to a plagioclase + quartz + K-feldspar ± apatite zone adjacent to the downhole contact. No aplite was noted along the lower contact.

138.7 - 139.2: monzogranite has slight porphyritic texture.

139.2 - 145.5: fine- to medium -grained, slightly porphyritic biotite-rich (≤25%) tonalite. Shows foliation of biotite parallel to contacts at 45°/ca. The lower .5m consists of alternating biotite-rich and poor bands (1-5cm thick) parallel to contact.

145.6: PEGMATITE; 14cm thick, minor garnet.
146.5: PEGMATITE; 8cm.
147.1: PEGMATITE; 17cm, 45°/ca.

150.6 - 157.2: section is coarser grained with some local banding; also contains several metasediment-looking xenoliths.

167.3 - 168.2: PEGMATITE; at 45°/ca., uphole contact marked by muscovite-rich aplite. Pegmatite contains minor garnet and apatite.

**168.2 to 175.0: MUSCOVITE - BIOTITE LEUCOMONZOGRANITE:** medium -to coarse - grained, moderately equigranular; gradational contact. Muscovite content varies from 4-8%, biotite is fine grained . Contains minor, pale-pink garnet.

171 - 172.5: texturally variable with several PEGMATITE dykes, contacts at 45°/ca. Dykes contain coarse, plumose muscovite + bladed biotite and minor garnet.
174 - 175: PEGMATITE; similar to above; muscovite aplite along downhole contact.

**175.0 to 236.5: MUSCOVITE - BIOTITE MONZOGRANITE:** medium -to coarse -grained, moderately equigranular; contacts at 50°/ca. Contains several narrow (≤6cm) PEGMATITE dykes and leucocratic zones with biotite-rich banding (188.4m).

197.6: PEGMATITE; 4cm, at 15°/ca.; contains minor light-pink coloured garnet and dark-green apatite.

199.5: PEGMATITE; 10cm, at 60°/ca.; uphole half is dominated by graphic plagioclase and lower half by K-feldspar + quartz.

199.8 - 205.1: PEGMATITE; contacts at 45°/ca.(uphole) and 60°/ca.(downhole). Shows zonation from a coarse-grained K-feldspar + plagioclase + quartz + bladed biotite +plumose muscovite border zone adjacent to the uphole contact to a intermediate zone at 201m, containing abundant coarse, plumose muscovite and less K-feldspar.

200.7 - 201.6; perthitic K-feldspar + coarse muscovite + garnet zone
201.6 - 202.4; plagioclase + bladed biotite + quartz ± muscovite
202.4 - 203.3; K-feldspar (± graphic) + plumose muscovite + quartz + plagioclase ± garnet. Lower part of zone consists of coarse plagioclase + quartz + muscovite.
203.3 - 204; coarse, dark-grey quartz + graphic K-feldspar.

204 - 205.1; section stars with coarse quartz + muscovite then quartz + K-feldspar + garnet (dark brown-black). Lower contact zone contains K-feldspar + plagioclase + quartz + dark-coloured garnet.

206.3: PEGMATITE; 5cm, 60°/ca.; coarse K-feldspar + plagioclase + quartz + muscovite + garnet.
207.3: PEGMATITE; 25cm, 35°/ca.
208: PEGMATITE; 15cm, at 60°/ca.
211.5: PEGMATITE: 10cm, at 60°/ca.
215.1: PEGMATITE: 5cm thick, at 45°/ca.; quartz + muscovite + apatite.
215.6: PEGMATITE: 18cm, at 20°/ca.; boarder zone consists of plagioclase + quartz + muscovite with a coarse K-feldspar-rich core zone + apatite.
221.3: PEGMATITE; 15cm, at 70°/ca.; minor apatite. Wallrock adjacent to downhole contact shows muscovite and apatite enrichment.

**221.4 to 236.5: BIOTITE GRANODIORITE:** medium -to coarse -grained, moderately equigranular. Section contains several metasediment-looking xenoliths (≤6cm) and PEGMATITE dykes (≤10cm) at 40-45°/ca.

**236.5: END OF HOLE!**

# N.S.D.N.R. DRILLHOLE JOR-92-1: DESCRIPTIVE LOG

**Azimuth: 140° Dip: -70° ; Total depth = 95.7 metres**
**UTM Coordinates: northing - 4858150 / easting - 32130**

**0.0 to 3.7: OVERBURDEN**:
psammite and minor fine-to medium-grained, moderately equigranular, muscovite + biotite monzogranite.

**3.7 to 27.8: PSAMMITE**: massive, dark grey, chlorite + biotite porphyroblasts, sericitic. Local intense pervasive tourmalinization; characterized by abundant black tourmaline (5.8 to 6.4m). Section contains several glassy quartz veins containing, tourmaline + beryl at 45°/ca. Beryl commonly occurs as pale green, opaque crystals in the core of the vein (≤1cm). Wallrock is bleached adjacent to vein for 1.5cm and contains black tourmaline. Psammite shows progressive coarsening downhole.

8.1: glassy quartz vein at 55°/ca, no tourmaline or wall rock bleaching.

12.8 - 24.2: coarse-grained, sericite-rich, phyllitic,with abundant biotite and minor chlorite porphyroblasts. Section contains narrow (≤5cm) calc-silicate bands at 70-80°/ca (8.7, 10.1, 15.8, 18.1m). The latter two contain coarse-grained, pink garnets.

24.2 - 27.8: banded section; buff colored, tourmaline-rich section 1-2cm in width intercalated with dark grey, massive psammite.

**27.8 to 28.6: CALC-SILICATE**: zoned, oriented at 70°/ca, contains abundant pink garnet.

**28.6 to 38.4: PSAMMITE**: progressive coarsening;
31.8 - 32.5 shows mild bleaching with abundant pale pink garnets.

**38.4 to 39.6: QUARTZ VEIN**: glassy with milky grey patches, banded texture. Barren except for a 2mm blue-grey metallic mineral in quartz at 38.5m. Uphole contact marked by a tourmaline-rich zone in wallrock.

**39.6 to 54.1: PSAMMITE**: Psammite is predominantly medium grained, dark grey to locally bleached and sericite-rich. Contains abundant biotite and chlorite porphyroblasts, and rare garnet interbedded with biotite and tourmaline-rich layers at 45°/ca .

40.2: calc-silicate band at 80°/ca, 15cm wide.
40.8: calc-silicate, 10cm wide.
45.5: 1.5cm wide muscovite-rich vein at 45°/ca, psammite is bleached adjacent to the vein.
45.7: 7cm wide, biotite-rich, calc-silicate; no garnet or amphibole present.
46.3: 5cm calc-silicate pod, with garnet and amphibole
46.0: fine-grained psammite; becoming progressively coarser grained downhole.
48.5: 28 cm wide calc-silicate; with amphibole-rich rim and a garnet-rich core.
50.1: 25cm wide garnet-rich section, with associated bleaching and amphibole, some garnet development in psammite adjacent to calc-silicate pod.

51.8- 52.1: garnet development in fine-grained massive psammite; no associated bleaching.
51.9: tourmaline-rich pod oriented at 45°/ca., characterized by white bleached rim with massive black tourmaline core. Associated with a 3mm wide quartz-tormaline-beryl vein.

**54.1 to 78.3: PSAMMITE**: medium-grained, interbedded with pale- grey biotite-rich banding at 45°/ca; interbedded with pale pink, subeuhedral garnets. Section contains two narrow, banded calc-silicate bands.
59.7: coarse-grained band, contains abundant black tourmaline, 3cm wide at 45°/ca.
69.7 - 78.3: fine-to medium-grained, with alternating dark grey and pale grey layers at 45°/ca. Layers vary from <1 to 10cm wide, and may contain minor garnet.

**78.3 to 87.5: PSAMMITE**: massive, fine-grained, dark grey; contains abundant disseminated pale pink garnet. No bleaching and/or calc-silicate development.

79.2: 1cm quartz vein at 45°/ca.
80.6 - 80.9: bleached zone, 1.5cm quartz + beryl vein at 45°/ca. Quartz is fractured parallel to vein contact. Beryl occurs as small, subhedral, pale green, opaque crystals restricted to the center of the vein. No associated tourmaline.
81.4-81.9: banded section; psammite is coarser grained with coarse biotite to 87.2.
85.0: 1cm glassy quartz vein at 45°/ca; barren.
87.2 - 87.5: garnet-rich calc-silicate.

**87.5 to 95.7: PSAMMITE**: interbedded with biotite-rich bands at 40-50°/ca.

**95.7: END OF HOLE**

# N.S.D.N.R. DRILLHOLE JOR-92-2: DESCRIPTIVE LOG

**Azimuth: 140° Dip: -50° ; Total depth = 154 metres**
**UTM Coordinates: northing - 485815 / easting - 321310**

**0.0 to 2.1: OVERBURDEN:**

**2.1 to 2.7: PSAMMITE:** coarse-grained, dark grey, biotite and minor garnet porphyroblasts.

**2.7 to 3.1: QUARTZ VEIN:** sharp contact at 28°/ca; the vein is milky to grey with abundant muscovite along the contacts. The vein contains mm-thick laminations perpendicular to vein/wallrock contact.

**3.1 to 5.3: PSAMMITE:** medium-grained, contains abundant disseminated fine-grained tourmaline.

4.2 - 4.3: tourmalinized zone; adjacent to both contacts with a 13cm thick QUARTZ VEIN at 4.3m, the vein is in sharp contact with the psammite at 40°/ca.
4.6: QUARTZ VEIN; 1cm wide at 75°/ca., barren.

**5.3 to 6.5: PSAMMITE**: fine-grained, gradational contact. Locally intense tourmalinization.

**6.5 to 10.8: PSAMMITE**: sharp contact with a coarse-grained psammite. Predominately medium-grained at bottom of section.
7.2 to 8.7: bedding at 75°/ca.

8.7: calc-silicate; 6cm wide, gradational contact with psammite, minor garnet.
8.8: calc-silicate; 7cm wide, sub-horizontal to core axis. Garnet and amphibole (tremolite?) present along uphole contact.
9.3 to 10.8: medium to progressively finer grained.
9.7: calc-silicate; 8cm wide, amphibole-rich rim with garnet-rich core.
10.4: calc-silicate; 16cm wide, sub-horizontal to core axis, contacts are amphibole-rich.

**10.8 to 18.2: PSAMMITE:** coarse-grained, becoming finer-grained at bottom of section.

14.4: calc-silicate; 28cm wide, garnet+amphibole. Minor bleaching along downhole contact (42°/ca).
15.0: carbonate vein, 80°/ca, 2mm wide.
15.7: calc-silicate; 46cm wide, uphole contact at 45°/ca. Garnet + amphibole (coarser grained than above).
17.3: calc-silicate; 7cm wide.

**18.2 to 19.2: PSAMMITE/PELITE**: intercalated psammite and pelite; irregular contacts.

18.7: QUARTZ VEIN: 2cm, subhorizontal to core axis.

**19.2 to 24.4: PSAMMITE:** medium-to coarse-grained.

21.3 : calc-silicate; 8cm wide, 50°/ca, garnet with minor amphibole. Cut by a 7cm wide laminated quartz vein. Laminations (mm thick) are oriented perpendicular to vein contact. Wallrock adjacent to vein is tourmalinized.
24.7: calc-silicate; amphibole concentrated at contacts, small pink garnets throughout, no zoning.
25.9: bedding at 42°/ca.
26.7: calc-silicate; 2cm, sub-parallel to ca., minor garnet, no amphibole.
28.3: QUARTZ VEIN; 15cm, dark grey quartz, adjacent psammite is silicified.

**28.6 to 29.7: PSAMMITE/PELITE**: irregular contacts.

**29.7 to 32.0: PSAMMITE:** finer grained, section includes a 16cm wide calc-silicate band sub-horizontal to ca. with an amphibole-rich rim with slight bleaching, core contains abundant garnet.

**32.0 to 33.2: PSAMMITE/PELITE**: coarse-grained psammite, irregular contacts.

32.9m: QUARTZ VEIN; 2cm wide, barren; at 70°/ca.

**33.2 to 33.5: PSAMMITE**: coarse-grained becoming finer grained downhole.

34.1: calc-silicate; bleached, contains amphibole-rich rim, and a garnetiferous, bleached core. At 70°/ca.
35.6: 10cm wide silicified zone, fracture cleavage at 70°/ca.
37.8: calc-silicate; 33cm wide, contacts are at 55°/ca. Contains fine-grained disseminated pyrite.
39.0 to 41.4: core becomes finer-grained.
40.6: garnets scattered througout this section.

**41.4 to 59.7: PSAMMITE/PELITE:** intercalated psammite and pelite beds at 68-70°/ca. Progresses into massive psammite beds 1-20cm in width. Section contains several calc-silicate bands.
45.4: zoned calc-silicate (amphibole rim/garnet core) cut by a 6cm QUARTZ VEIN at 20°/ca.
45.7: 4cm wide muscovite-rich alteration zone, at 42°/ca.
46.7: calc-silicate; zoned, 33cm wide.

**59.7 to 85.0: PSAMMITE**: fine-grained; becoming progressively coarser downhole until 70.5m at which point the psammite becomes finer-grained until 92.0m.

59.8: calc-silicate,15cm.
60.4: QUARTZ VEIN; .5cm wide at 70°/ca.
61.1: calc-silicate, zoned, 7cm wide at 50°/ca.
61.3: QUARTZ VEIN; 1cm wide at 40°/ca; pyrite.
61.5:calc-silicate, zoned, 33cm wide, 50°/ca.
63.7: QUARTZ VEIN; 1cm wide at 65°/ca.
65.2: calc-silicate, 6cm wide.
73.3: calc-silicate, 36cm wide, at 60°/ca, zoned.
75.4: calc-silicate; 15cm.
75.9: calc-silicate; 15cm.

76.6: QUARTZ VEIN; .5cm, barren at 45°/ca.
77.0: calc-silicate; 3cm wide, at 60°/ca.
77.6: calc-silicate, at 60°/ca.
81.2: calc-silicate; 51cm, disseminated pyrite, at 45°/ca.
84.6m: QUARTZ VEIN; .5cm in width, at 12°/ca.

**85.0 to 86.2: PSAMMITE/PELITE**; 45°/ca, beds range from 1-10cm wide.

**86.2 to 112.60: PSAMMITE**: massive, dark-grey. 1.5cm wide QUARTZ VEIN (84.6); section includes 1m of disseminated pyrite.

91.6 - 94.4: interbedded medium-grained and
fine-grained psammite beds (70:30) at 55°/ca.
96.3: calc-silicate; 15cm wide, zoned, at 52°/ca.
97.5 - 112.60: fine-to medium-grained, bedding at 55°/ca.
104: calc-silicate.
107.8: QUARTZ VEIN , 1cm, dark grey , barren at 45°/ca.
108: calc-silicate, 15cm wide, zoned.
108.8 to 111.3: core becomes finer grained
111.3 to 111.7: biotite-enriched section.

**112.6 to 120.5: LEUCOGRANITE**: sharp contact at 45°/ca., texturally variable (fine-grained to coarse-grained equigranular to pegmatitic); muscovite (6-8%) ± garnet (small, euhedral pinkish-red crystals), locally 1-2% .

113.4 - 114.6: QUARTZ VEIN: massive, glassy to milky contacts with leucogranite sharp at 45°/ca., vein is locally laminated perpendicular to contacts.
114.6 - 116.8: muscovite-rich, texturally variable; feldspars are graphic to perthitic. Locally vuggy.
116.8 to 117.0: QUARTZ VEIN: massive, glassy with several opaque, pale greenish-yellow opaque beryl crystals. Contacts at 45°/ca.
117.3 to 117.8: QUARTZ VEIN: massive, laminated, glassy to milky; several pale green beryl crystals (3cm in length) located adjacent to uphole contact. Downhole contact (70°/ca.) marked by 15cm of pegmatite.
120.2 - 120.5: zone of intense tourmalinization adjacent to contact (at 40°/ca.).

**120.5 to 154.0: PSAMMITE:** sharp contact, highly fractured.

123.6: QUARTZ VEIN; 1cm, dark grey, at 45°/ca.
123.7 - 124.3: tourmalinized section.
124.3: QUARTZ VEIN; 0.5 cm, at 45°/ca.
130.1: calc-silicate; 5cm wide, unzoned, at 54°/ca.
130.6: calc-silicate; 23cm wide, zoned at 36°/ca.
132.9: calc-silicate;
134.2 to 135.6: psammite becomes light grey and coarser-grained; intercalated with pelite at 60°/ca.
136: 2 cm QUARTZ VEIN; at 56°/ca, grey and barren.
136.5: calc-silicate; 19cm wide, poorly zoned .
137.7 - 140.8: coarse-grained psammite.

140.8: sharp contact with medium-grained section
at 45°/ca.
142.0: QUARTZ VEIN; 2cm thick, at 54°/ca., barren. Also at 142.3 / 142.9m.
143.0: calc-silicate; 4cm wide, zoned, contacts at 56°/ca.
144.0: calc-silicate.
144.6: calc-silicate; zoned, amphibole-rich rim and garnet-rich core.
148.5: QUARTZ VEINS; two (<1cm), barren, 40°/ca and 16°/ca.
149.7: calc-silicate band.
152.7: QUARTZ VEIN; 5mm thick, vein, at 45°/ca.

**154.0: END OF HOLE**

# N.S.D.N.R. DRILLHOLE JOR-92-3: DESCRIPTIVE LOG

**Azimuth : 140° Dip: -50° ; Total depth = 62.5 metres**
**UTM Coordinates: northing - 485810 / easting - 321300**

**0.0 to 4.59: OVERBURDEN**: containing abundant biotite+cordierite hornfels and minor foliated blue-grey, muscovite+biotite leucomonzogranite.

**4.6 to 54.3: PSAMMITE:** contains biotite and minor small pale pink garnets .

4.87: calc-silicate; 10cm wide, zoned, garnet-rich rim and amphibole (actinolite?) -rich core.
6.3: 10cm of intercalated biotite psammite (grey) and light brown (sericitic), <1-3cm wide at 45°/ca.
8.1 - 10.1: pale grey, slightly coarser grained than above; silicified?
12.7 - 13.7: fine-grained psammite with severalcalc-silicate bands, 3-6cm wide, 45°/ca.
13.7 - 15.5: core shows progressive coarsening down-hole to 15.5m then becomes finer grained.
16.4 - 17.0: calc-silicate, zoned.
17.0 - 25.9:: section shows progressive coarsening from fine grained to medium-to coarse-grained psammite (mostly coarse from 24.4-25.9m). Contacts at 45°/ca. Fractures are limonitic .
26.5: 20cm banded section, well developed cleavage at 30°/ca.
28.8: zoned calc-silicate, garnet-rich core, amphibole-rich rim 2cm wide, cross-cut by a 2.5cm highly fractured quartz vein, milky and barren; 65°/ca to 28.9m, minor disseminated pyrrhotite.
30.5: calc-silicate; garnet+amphibole-rich.
38.7 - 39.6: interbedded, chlorite and biotite-rich section, prominent cleavage at 30°/ca.
41.8 - 41.9: sericite-rich, almost phyllitic. Minor pink euhedral garnets.
44.0- 44.2: amphibole-rich calc-silicate, abundant garnet 44m: 1cm wide quartz-feldspar vein at 60°/ca.
44.8: 25cm biotite-rich phyllite band, core appears to become coarser grained downhole.

48.7 - 49.1: QUARTZ VEIN: laminated texture, 1.5cm bleached zone ajacent to the vein, contains minor pale-green, opaque beryl, oriented normal to vein/wallrock contact. Clots of coarse grained muscovite also occur.

51.0: banded section, oriented at 45°/ca., with abundant black tourmaline.
53.0 - 54.3: section of fine-grained, dark grey psammite. Calc-silicate bands at:
53.2: garnet + amphibole, at 45°/ca.
53.5 - 53.9: zoned calc-silicate, characterized by 5cm wide bleached contacts.
54.1- 54.3: tourmaline-rich zone; abundant black tourmaline (75%) in white quartz matrix.

**62.5:** END OF HOLE

# N.S.D.N.R. DRILLHOLE JOR-92-4: DESCRIPTIVE LOG

**Azimuth : 140° Dip: -50° ; Total depth = 132.6 metres**
**UTM Coordinates: northing - 4875070 / easting - 259950**

**0.0 to 1.2: OVERBURDEN**:

**1.2 to 13.1: PSAMMITE**: predominately medium-grained, contains biotite and garnet porphyroblasts. Locally sericite and chlorite-enriched. Also several, zoned calc-silicate pods (purple rim/pale orange core).

4.4: finer grained psammite; milky QUARTZ VEIN 1cm wide at 20°/ca. Black tourmaline alteration in wallrock immediately adjacent to vein.
3 - 5.0: intensely-fractured at 65°/ca.
6.6: 10cm wide amphibole + garnet-bearing calc-silicate at 45°/ca.

Psammite shows progressive coarsening to 7.3m, then becomes finer grained.

9.2 - 9.6: amphibole + tourmaline-rich section, contact at 45°/ca.
9.6 - 12.2: fine -to medium-grained.
12.2 - 12.2: 10 cm wide tr-rich zone, up and downhole contacts marked by a 1cm wide bleached band at 45°/ca.
12.5: 25cm zoned calc-silicate

**13.1 to 15.5: QUARTZ VEIN**: banded texture, reflected by alterating mm.-thick bands of glassy and milky quartz oriented parallel to vein contact (50°/ca.). Vein contains several, small (<2cm long), pale green, translucent beryl crystals and abundant coarse-grained black tourmaline along up-hole contact and a 1cm thick bleached, tourmaline-rich band adjacent to the downhole contact.

**15.5 to 27.8: PSAMMITE**:

15.5 - 21.3: grey, medium-grained, contains abundant chlorite porphyroblasts; interbedded with pale-grey, biotite and sericite-rich, bands at 45°/ca.
21.3 - 23.2: darker grey, fine-grained; uphole contact marked by a 10cm wide zoned calc-silicate.

Psammite is locally pyritic (occurs as 1-3mm. thick stringers oriented at 30-35°/ca.

22.6 - 23.00: zoned calc-silicate band, contacts at at 50°/ca.
23.2 progressively coarser grained.
25.3 - 25.9: psammite becomes finer grained.
25.9: 10cm wide glassy, banded QUARTZ VEIN, barren with no associated tourmaline alteration at 55°/ca.
25.9 - 27.1: psammite becomes progressively coarser-grained.
27.1 - 27.8: finer-grained, dark-grey psammite.
27.8: 7cm wide, banded QUARTZ VEIN at 70°/ca.

**27.8 to 48.8:PSAMMITE**: dark grey, interbedded with pale-grey, biotite and chlorite-rich bands, 3-10cm wide(semi-pelite?). Contacts at 45°/ca.

30.8 - 31.3: intensely fractured and silicified. Fractures show some dilation and are vuggy with quartz crystals oriented at 50°/ca.
35.1 - 3 5.4: banded (glassy & milky) quartz vein at 70°/ca; barren. Bands oriented at 45° to vein margin. Wallrock tourmalinized adjacent to vein.
35.7 - 36.2: zoned calc-silicate
36.7: 15cm wide, zoned, garnet + amphibole calc-silicate. Psammite appears finer grained.
38.0: psammite contains abundant, small(<3mm), rounded cordierite(?).
38.0 - 42.4: section is less banded than above.
42.4 - 45.1: section contains several calc-silicates bands.

**48.8 to 62.8:PSAMMITE**: becomes coarser-grained with abundant black biotite and small tourmaline crystals.

58.8-61: very coarse grained.
60.7-61.2: intensely-fractured.
61.1: massive, fine-grained.
61.8: 8cm wide calc-silicate.
61.9m: coarser-grained psammite.

**62.8 to 63.3: QUARTZ VEIN**: banded texture, glassy to milky. Uphole contact marked by a 1cm hematized fault gouge.

**63.3 to 75.3: PSAMMITE**: massive, fine-grained, intensely fractured and sericitic.

68.0 - 69.5: broken and brecciated, locally vuggy and pyritic. Quartz and clay(?) filled tension gashes oriented at primarily 20°/ca.
70.0: 10cm zoned calc-silicate.
72.0 - 74.2: fine-grained psammite; intensely fractured. Similar to above.

**75.3 to 78.2: PSAMMITE**: interbedded (at 66°/ca.) section, similar that described above.

76.7 - 77.0: intensely fractured sub-parallel to core axis.
78.1 - 78.2: quartz vein, glassy, at 70°/ca.

**78.2 to 103.8: PSAMMITE**: medium-grained, massive, locally intensely fractured. Contains a few, interbedded, narrow biotite-rich beds at 60°/ca.

81.1-81.8: QUARTZ VEIN: at 60°/ca., banded texture oriented perpendicular to vein margin. Uphole contact contains several small(≤3cm), pale-green translucent beryl crystals aligned parallel to vein contact. Contact marked by a 2cm wide bleached and tourmaline-rich zone in wallrock. Vein contains 10cm wide piece of intensely bleached and tourmalinized psammite. Downhole contact shows no bleaching or tourmalinization.

93.0-93.5 **QUARTZ VEIN:** shows features similar to above vein except no beryl was observed. Contact at 60°/ca.
94.2 - 94.6: zoned calc-silicate.

97.0 - 103.8: psammite is intensely fractured with some areas of ground and lost core(99.1-102.1). Minor interbedded biotite-rich beds and zoned calc-silicates.

**103.8 to 104.4: LEUCOGRANITE:** texturally variable, with pegmatitic segregations. Muscovite-rich with minor disseminated pyrite, chalcopyrite and rare molybdenite. Contacts are sharp and marked by >>intense tourmalinization for about 10cm into the adjacent psammite. No tourmaline or beryl were observed in the dyke.

**104.4 to 111.3: PSAMMITE**: massive, locally fractured, with minor interbedded biotite-rich layers at 60°/ca.

**111.3 to 112.5: BRECCIA**: siliceous, vuggy, locally pyritic.

**112.5 to 132.6: PSAMMITE**: finer grained, massive. Section contains several 1mm quart stringers at 30°/ca. Associated with bleaching of host rock adjacent to stringers.

122.7 - 123.3: section contains 10cm glassy QUARTZ VEIN with contacts marked by intense tourmalinization and sericitization.
123.3 -132.6: medium-grained, massive with minor calc-silicate.

**132.6: END OF HOLE!**

# N.S.D.N.R. DRILLHOLE BZL93-1: DESCRIPTIVE LOG

**Azimuth: at surface - 145° Dip: -50° Total depth = 97.54 metres**
**at 97.54m - 148° -45°**
**UTM Coordinates: northing- 4875120 / easting - 260080**

**0.0 to 3.8: OVERBURDEN:**

**3.8 to 7.5: AMPHIBOLITE**: medium-grained, foliation at 40°/ca. Minor quartz-carbonate veins present at 40°/ca.

**7.5 to 7.8: AMPHIBOLITE:** intensely altered, biotite-rich bands at 30°/ca.

**7.8 to 8.2**: **AMPHIBOLITE**: fine-to medium- grained, unfoliated.

**8.2 to 11.1: PELITE**: with minor medium-grained amphibolite. Contacts at 35-40°/ca.

**11.1 to 11.9**: **AMPHIBOLITE**: sharp contact at 15°/ca with a coarse-grained amphibolite. Minor quartz-carbonate veining at 20°/ca.

**11.9 to 13.6: PELITE**: with minor amphibolite, contacts at 30°/ca.

**13.6 to 17.7**: **AMPHIBOLITE**: fine-grained, massive, with minor pelite. Contacts at 45°/ca. Several narrow carbonate veins at 30°/ca.

16.3 - 17.7: alternating medium and coarse-grained amphibolite, contacts at 45°/ca. Foliation at 40°/ca.

**17.7 to 18.4: PELITE:** contact at 40°/ca.

**18.4 to 21.6: AMPHIBOLITE**: no prominant foliation.

**21.6 to 22.2: PELITE**: grey-green, contact at 62°/ca.

**22.2 to 22.9: AMPHIBOLITE**: coarse-grained, contact at 45°/ca. Several quartz-carbonate veinlets (≤5mm) oriented parallel to foliation (40°/ca). The amphibolite is finer grained adjacent to the pelite downhole.

**22.9 to 25.8: PELITE**: intensely-fractured, at 30-35°/ca., several quartz-carbonate veins (≤1cm.) within section.

23.78-23.93 and 24.7-25.03: zones of mixed pelite and medium-grained amphibolite, foliated at 40°/ca.

**25.8 to 28.2**: **AMPHIBOLITE**: predominately fine-grained. Minor carbonate veining at 40°/ca.
27.2 to 28.2: sharp contact at 30°/ca with coarse-grained amphibolite, foliated at 60°/ca; 7cm wide bleached zone at 27.8m.

**28.2 to 28.8**: **PELITE**: irregular contact with above at 40-45°/ca; intensely-fractured at 30°/ca.

**28.8 to 31.0**: **AMPHIBOLITE**: coarse-grained; section contains numerous quartz-carbonate veins at 15°/ca; amphibolite shows local bleaching.

**31.0 to 33.1**: **PELITE**:

**33.1 to 47.3: SILICIFIED ZONE**: sharp contact with above at 50°/ca; this rock-type has been referred to as quartzite, but appears instead to be a zone of intense-pervasive silicification, of mixed amphibolite and pelite.

33.08 - 34.68: pale-grey, intensely silicified pelite, saccroidal texture.
34.68 - 36.89: pale greenish-grey, intensely silicified amphibolite, contact with above at 60°/ca, remnant foliated (40°/ca) amphibolite present in zone.
36.89 - 39.18: zone of near-complete silica replacement; up hole contact is gradational. Contains tourmaline-rich veins at 10°/ca (same orientation as fractures).
37.19 - 38.6: zone of complete silica-replacement, massive quartz.
39.18: 5cm band of c.g. amph, sharp contacts at @50/ca.
39.18 to 39.50: intensely-silicified pelite/amph.
39.50: minor disseminated pyrite.
40.7: 6cm band of pegmatite/aplite at 40°/ca.
39.51 - 47.26: intensely silicified pelite and amphibolite, remnant wallrock shows foliation similar to unaltered wallrock. Section contains minor to locally abundant clots and crystal clusters of black tourmaline. Contacts at 62°/ca.

**47.3 to 47.4: PELITE**: greenish-grey, contact marked by quartz-carbonate vein.

**47.4 to 53.1: AMPHIBOLITE**: texturally variable, from fine to coarse- grained.

47.9 - 48.2: coarse grained, contact at 40°/ca, section contains 10cm wide pyritic, bedding parallel quartz vein.
48.2 - 49.2: fine -to medium- grained with abundant plagioclase.
49.2 - 53.1: coarse-grained, contact at 48°/ca, fractured 30°/ca.

**53.1 to 60.1**: **PSAMMITE**: intensely silicified, contact at 50°/ca.above).

**60.1 to 61.1**: **AMPHIBOLITE**: coarse-grained.

**61.1 to 64.3**: **PELITE**: contact at 35°/ca; with interbedded amphibolite.

**64.3 to 66.2**: **PSAMMITE:** medium-grained, massive; contact at 75°/ca.

**66.2 to 82.4**: **PELITE**: dark greenish-black, minor quartz and quartz-carbonate stringers at 30-70°/ca. Downhole contact marked by 10cm. wide quartz-plagioclase vein.

**82.4 to 82.7**: **PELITE**: with interbedded amphibolite, contact at 45°/ca. Minor crosscutting quartz-carbonate stringers.
82.62: quartz vein (at 20°/ca) with minor tourmaline.

**82.7 to 86.3**: **PELITE**: section is cut by several quartz-carbonate veins at 50°/ca.

**86.3 to 89.1: PELITE / AMPHIBOLITE:**
88.48: 2cm pegmatite vein.

**89.1 to 97.5: PEGMATITE**: texturally and mineralogically variable; contacts between zones are commonly gradational but may be sharp.

89.25 - 89.93: aplite zone, saccaroidal texture with coarse pale green muscovite and quartz clots.

89.93 - 90.23: very coarse-grained K-feldspar + cleavelandite ± tourmaline, (small, euhedral, dark-green) zone; the cleavelandite has replaced K-feldspar.

90.23 - 92.73: aplite zone, foliated at 40°/ca. Minor dark blue apatite grains.

92.73 - 93.27: spodumene (5-10%)+ muscovite + albite (± cleavelandite) + quartz zone; quartz varies in colour from milky to dark grey. Spodumene is white and occurs as euhedral crystals ≤ 5cm in length.

93.27 - 93.72: K-feldspar + cleavelandite zone, minor quartz.
93.72 - 96.01: aplite zone, foliated at 35°/ca; minor dark-green tourmaline. Quartz shows distinct nodular texture. Minor dark blue apatite and unknown light to dark-brown dentritic textured mineral also present.
96.01 - 97.54: spodumene(5-10%) + muscovite + albite + quartz zone; ± cleavelandite replacement; spodumene is pale green in colour.

**97.54: END OF HOLE**: hole abandoned due to technical difficulties.

## N.S.D.N.R. DRILLHOLE BZL-93-2: DESCRIPTIVE LOG

**Azimuth: at surface - 145°   Dip: -50°   Total depth = 92.6 metres**
**at 92.6m   - 150°   -43°**
**UTM Coordinates: northing - 4875140 / easting - 260060**

**0.0 to 4.8: OVERBURDEN**:

**4.8 to 5.1: MIXED PSAMMITE/AMPHIBOLITE**:

**5.1 to 5.6**: **PELITE**: dark greenish-black, contact at 38°/ca. fractures at 90°/bedding.

**5.6 to 5.9: AMPHIBOLITE**: dark green with pervasive foliation parallel to bedding.

**5.9 to 7.3**: **MIXED PELITE/AMPHIBOLITE**: pelite is dark-green and tourmalinized, with tourmaline oriented to shear fabric at 20°/ca.; uphole contact at 25°/ca., marked by 2cm. thick, biotite rich band. Pelite is interbedded with tourmalinized amphibolite schist. Contacts at 25°/ca.

**7.3 to 8.1: AMPHIBOLITE**: medium-to coarse-grained, sharp contact at 25°/ca., biotite-rich, with well developed shear fabric sub-parallel to core axis.

**8.1 to 8.8**: **PELITE**: dark-green, tourmalinized; well-developed shear fabric at 40°/ca.; tourmaline overgrows also contains thin (1mm.)quartz-carbonate stringers parallel to the fabric.

**8.8 to 9.6**: **AMPHIBOLITE:** biotite-rich, medium to coarse grained, dark green, mild tourmaline alteration, contact at 38°/ca., shear fabric not well developed in this section.

**9.6 to 10.4: PELITE**: intense pervasive tourmaline alteration, 15cm adjacent to uphole contact. Interbedded with minor biotite-rich, dark-green AMPHIBOLITE. Contact at 55/ca.

**10.4 to 13.8: MIXED PELITE/AMPHIBOLITE:** interbedded at 55°/ca, foliation at 62°/ca.

**13.8 to 15.5: AMPHIBOLITE SCHIST**: fine to medium grained, foliated, dark green. Minor interbedded coarse grained amphibolite. Local intense pervasive tourmaline alteration.

**15.5 to 24.4: SILICIFIED ZONE:** contact with dark grey, inclusion-rich to massive quartz. Inclusions include coarse black tourmaline, biotite and chlorite, orientated at 40°/ca. Minor hematization.

16.1 - 16.7: relatively inclusion-free, massive, milky quartz. Sharp contact downhole with inclusion-rich quartz zone at 40°/ca.
16.7 - 17.4: biotite +tourmaline-rich quartz zone.
17.4 - 18.0: massive, milky quartz zone. Granular texture, appears to be recrystallized. Section contains minor black tourmaline. Includes 60cm. of inclusion-rich quartz.
18.6 - 19.5: inclusion-rich quartz zone.Contains angular blocks of what appears to be silicified

amphibolite wall-rock. Inclusions have general orientation similar to the wall-rock fabric of 40°/ca.
19.5 - 20.1: Inclusion poor, massive, milky quartz. Very minor black tourmaline.
20.1 - 24.2: dark grey, inclusion-rich quartz interspersed with inclusion-free quartz bands/veins, at 40°/ca.

**24.4 to 24.7: PELITE**: pale grey to pale green, silicified.

**24.7 to 34.8**: **AMPHIBOLITE**: medium-to coarse- grained, biotite-rich amphibolite, dark greenish grey. Interbedded with fine grained amphibolite and minor PELITE. Foliated at 65-68°/ca.

26.1: contact at 42°/ca with a 30cm. intensely silicified zone which contains abundant tourmaline inclusions.
28.4 - 32.0: medium to coarse grained, contains coarse quartz+plagioclase clots, section becomes progressively finer grained from 30.1-31.1.
31.5 - 32.0: medium to coarse grained, dark green, biotite rich amphibolite.
32.0 - 33.1: QUARTZ VEIN; sharp contact at 55°/ca., vein is pale-grey, opaque to slightly glassy, contains abundant silicified amphibolite inclusions.
33.1-34.8: coarse-grained section containing biotite and tourmaline.

**34.8 to 59.6**: **PEGMATITE:** sharp contact at 20°/ca, texturally variable; quartz-rich adjacent to contact.

34.85 - 35.5: quartz (milky grey-glassy) + muscovite (green) + plagioclase (bladed, white; var. cleavelandite).

34.9 - 35.5: aplite zone; prominent fabric at 80°/ca.; vuggy, contains locally abundant, fine-grained, dark-green tourmaline and subhedral blue-green apatite crystals oriented parallel to fabric. Also contains, dendritic-textured reddish-brown mineral + euhedral, black metallic mineral (Ta/Nb-oxide?).

35.5 - 37.8: coarse-grained zone; contains pale-green spodumene + dark grey, glassy quartz + cleavelandite, the latter occurs as coarse crystal masses and as interstitial material between coarse quartz grains; produces a nodular texture.
36.7: coarse-grained, pale orange-pink, fractured K-feldspar (microcline), surrounded by coarse-grained bladed cleavelandite. Suggests the latter to be metasomatic in orgin.
37.6: 15cm aplite pod, contains abundant small, dark green tourmaline crystals; pale-green muscovite also present.

37.8 - 38.6: aplite zone; foliated, contains blue-green apatite + green tourmaline.

38.6 - 39.6: coarse-grained spodumene + quartz + muscovite + interstitial cleavelandite. Minor, dark reddish-brown resinous mineral seen as inclusions in spodumene crystals (cassiterite? 38.7m.). Spodumene in this section is modally 25 to 50%.

39.6 - 40.5: aplite zone; mineralogically similar to above see above, less foliated.

40.5 - 45.8: coarse-grained, spodumene + quartz + albite (cleavlandite) zone;

spodumene varies from pale green to white. Locally abundant green muscovite and very minor disseminated, dark bluish-black metallic mineral (Ta-Nb-oxide?). Section contains narrow, unfoliated aplite zones (41.1, 41.6m) containing garnet + apatite + tourmaline, no obvious foliation.

44.3 - 47.1: microcline + cleavelandite zone; microcline shows replacement by the cleavelandite.
45.3: 10cm of coarse-grained, green muscovite.

47.1 - 49.7: coarse-grained zoned; quartz + muscovite (green) + spodumene (white to pale green) + cleavelandite. The latter occurring as coarse bladed crystals; the quartz is dark grey and has a nodular texture (see above). Section contains several microcline + albite zones (48.5-49.4; 47.9-48.0) characterized by cross-hatched, pink-orange microcline surrounded by and partially replaced by cleavelandite.

49.7 - 50.0: aplite zone; with blue- green apatite and quartz + muscovite (green) clots. Contact of this zone with the above is sharp at 45°/ca.

52.3 - 53.0: microcline + cleavelandite zone, microcline showing replacement by cleavelandite; some nodular textured grey quartz blebs also in the cleavlandite.

53.0 - 54.8: very coarse-grained quartz + spodumene (25-50%) zone; minor cleavelandite with disseminated cassiterite in quartz and as small (<1mm), inclusions in spodumene (53.2 - 53.5). Section contains a 10cm muscovite-rich segregation (53.6m).

54.8 - 55.1: medium- to coarse- grained muscovite-rich zone.

55.1 - 55.4: aplite zone; see above

55.4 - 55.6: spodumene + muscovite + cleavelandite+ quartz zone.

55.6 - 57.1: very coarse grained, spodumene microcline + quartz + cleavelandite. Spodumene varies from white to dark greenish-yellow, and contains inclusion of a dark black metallic mineral (cassiterite, Ta/Nb-oxides?). Quartz is massive, glassy and contains coarse (≤1cm) euhedral black cassiterite (?) crystals at the contact with cleavelandite section (see below). Plagioclase also occurs as massive to vuggy, white, opaque, chalky crystals.

57.1 - 58.8: coarse grained, albite (cleavelandite) + quartz zone; the quartz contains abundant coarse (<1cm-1.5cm) disseminated, euhedral black cassiterite crystals (see above). Includes section of very coarse-grained quartz + spodumene + minor cleavelandite and section of massive microcline, showing partial replacement by cleavelandite. Minor blue apatite and green tourmaline within zone.

**58.8 to 62.0: AMPHIBOLITE:** foliated (60°/ca.), fine-grained, dark-green; sharp contact at 36°/ca. Pegmatite shows 1cm-wide chilled margin. 59.6 - 61.1: dark-greenish grey, weakly foliated.

**62.0 to 64.2: PEGMATITE**: sharp contact at 35°/ca; contact zone consists of massive cleavelandite with clots of green muscovite + quartz. Section is predominately massive aplite zone material, containing common small (<1mm) metallic mineral inclusion. Includes 10cm section of sheared/foliated aplite (35°/ca.). Also contains amphibolite xenoliths and common blue-green apatite grains parallel to the foliation.

**64.2 to 65.8: AMPHIBOLITE**: fine-grained, dark greenish-grey, foliated at 50°/ca. Locally intense carbonitization with irregular carbonate stringers.

**65.8 to 68.3: SILICIFIED ZONE**: local intense, pervasive silicification of amphibolite. Beginning of section marked by 15cm wide calcite breccia. Section also shows local intense, pervasive carbonitization + carbonate veining (42°/ca). Minor pyrrhotite.

**68.3 to 70.1: AMPHIBOLITE**: contains pyrrhotite stringers and minor carbonate veining at 45°/ca. Section is intensely silicified, showing near complete replacement.

68.8 - 70.1; coarse-grained, sharp contact with above at 48°/ca. Minor disseminated pyrrhotite and chalcopyrite.

**70.1 to 77.7: MIXED PSAMMITE/AMPHIBOLITE:** intense pervasive silicification, remnant bedding is apparent at 45°/ca. Mottled texture.

**77.7 to 92.6: AMPHIBOLITE**: contact with strongly foliated amphibolite schist at 42°/ca (parallel to bedding). Schist shows intense pervasive silicification.

**92.6: END OF HOLE**

## N.S.D.N.R. DRILLHOLE BZL-93-3: DESCRIPTIVE LOG

**Azimuth: at surface - 145° Dip: -50° Total depth = 153.1 metres**
**at 153.1m - 153° : -42°**
**UTM Coordinates: northing - 4875130 / easting - 260040**

**0.0 to 4.9: OVERBURDEN:**

**4.9 to 10.3: AMPHIBOLITE**: fine- to medium-grained, strongly foliated; contains fine disseminated pyrrhotite, chalcopryite and pyrite.

**10.3 to 12.0: AMPHIBOLITE:** medium- to coarse- grained, predominantly unfoliated, minor disseminated pyrrhotite and chalcopyrite.

**12.0 to 38.6: PELITE**: dark greenish-grey, penetrative cleavage at 40°/ca, locally biotite rich. Section down to 38.6m consists of predominantly dark greenish-grey, massive pelite mixed with unfoliated medium-to coarse -grained amphibolite and strongly foliated fine-grained amphibolite. Minor pegmatite also observed.

15.9 - 18.9: massive pelite; cleavage at 50°/ca, marked by thin quartz stringers.
18.9 - 20.4: coarse-grained amphibolite with abundant coarse-grained biotite.
24.7 - 27.1: massive, dark greenish-grey pelite.

**38.5 to 52.3: SILICIFIED ZONE:** sharp contact with amphibolite at 40°/ca. Zone is characterized by massive, glassy and milky quartz. Clots of intensely silicified wall-rock (amphibolite), occur within the alteration zone.
39.0 - 39.6: section contains abundant quartz-calcite stringers at 90°/ca to cleavage observed within silicified pelite and amphibolite. Section also contains very minor, disseminated, dark-black metallic mineral .

39.6 - 52.3: intensely silicified zone; near complete replacement of original rock.

**52.3 to 56.7: AMPHIBOLITE**: fine-grained, foliated at 62°/ca.

**56.7 to 62.8: SILICIFIED ZONE:** contains pale-green bands and clots which likely represent intensely silicified amphibolite. Band orientation is same as foliation in the amphibolite wallrock (62°/ca).

**62.8 to 70.9: AMPHIBOLITE:** sharp contact (30°/ca); intensely deformed + foliated at 48°/ca. Medium-to coarse-grained, biotite-rich; with minor disseminated pyrrhotite and chalcopyrite.

66.7 - 70.9: predominately fine-grained.

**70.9 to 71.6: PELITE:** massive, dark green.

**71.6 to 88.1: AMPHIBOLITE**: interbedded, foliated (at 38°/ca.) and unfoliated amphibolite, with minor pelite. Local enrichment of pyrrhotite as fine-grained disseminations and stringers in the amphibolite parallel to the foliation.

**88.1 to 94.5: PEGMATITE**: coarse grained, spodumene + muscovite + albite (minor cleavelandite) + quartz. Includes narrow, discrete zones of sheared (55°/ca) aplite which contains minor blue-green apatite, tourmaline and rare cassiterite. Section also shows patches of microcline which shows replacement by cleavelandite.

91.15-91.62; sheared at 30°/ca.
91.62 - 92.1; dark, glassy, quartz-rich zone (>50%)

**94.5 to 110.7: AMPHIBOLITE**: mixed with minor interbedded pelite.

**110.7 to 118.9: SILICIFIED ZONE**: variably silicified amphibolite, minor to complete replacement.

**118.9 to 128.7: PELITE:** interbedded with minor amphibolite.

**128.7 to 129.7: AMPHIBOLITE:**

**129.7 to 130.5: MIXED AMPHIBOLITE/PELITE:**

**130.5 to 131.4: BRECCIA** : siliceous with carbonate veins and minor disseminated chalcopyrite and pyrrhotite.

**131.4 to 153.1: MIXED AMPHIBOLITE/PELITE:**

**153.1: END OF HOLE**

## N.S.D.N.R. DRILLHOLE BZL-93-4: DECRIPTIVE LOG

**Azimuth: at surface - 145° Dip: -50° Total depth = 120.6 metres**
**at 120.1m - 156° : -47°**
**UTM Coordinates: northing - 4875070 / easting - 259950**

**0.0 to 3.7: OVERBURDEN:**

**3.7 to 7.0: PELITE:** dark grey with biotite porphyroblasts; interbedded with very minor amphibolite (.3m section), coarse-grained, with abundant biotite; contact with above at 50°/ca.

**7.0 to 7.3: AMPHIBOLITE**: fine -to medium-grained, strongly foliated at 50-60°/ca. Sharp contact with above at 50°/ca.

**7.3 to 7.8: AMPHIBOLITE**: coarse-grained, massive, foliated 50-60°/ca.

**7.8 to 9.9: AMPHIBOLITE**: fine to mostly medium-grained, foliated at 48°/ca. Local intense pervasive, tourmalinization (8.2-8.9).

8.9 - 9.9; silicified, with numerous quartz stringers (<1mm) sub-parallel to the core axis; 15 cm wide skarnoid.

**9.9 to 11.7: PELITE**: dark grey to greenish-grey, slightly foliated.

**11.7 to 19.5: AMPHIBOLITE:** fine- to locally coarse-grained, foliated (48°/ca.). Biotite rich bands (≤1.5cm) in coarse grained sections.

**19.5 to 19.8: PELITE:** dark-grey; chloritic and sericitic.

**19.8 to 21.2: AMPHIBOLITE**: foliated at 43°/ca, minor disseminated pyrrhotite.

**21.2 to 25.6: PELITE:** massive, dark grey to greenish-grey; minor interbedded amphibolite, contacts at 46°/ca. Section contains abundant quartz-carbonate stringers oriented sub-parallel to core axis.

**25.6 to 28.4: AMPHIBOLITE:** massive to foliated at 40°/ca. Contains minor disemminated pyrrhotite and quartz lenses, oriented parallel to the shear fabric.

**28.4 to 29.7: PELITE**: massive, dark greenish -grey, locally phyllitic with quartz-carbonate stringers. Section contains 30cm of interbedded amphibolite; contact at 40°/ca.

**29.7 to 33.5: AMPHIBOLITE**: massive, coarse-grained; foliated at 22°/ca. Contains minor disseminated pyrrhotite.

33.5 to 34.5: **PELITE:** dark greenish-grey, with well developed cleavage at 45°/ca.

**34.5 to 37.5: AMPHIBOLITE**: medium-to coarse grained, massive to locally foliated. Intensely silicified from 34.5 to 35.2; section contains 50% massive, glassy to milky quartz.

**37.5 to 43.1: PELITE**: dark greenish-grey, cleavage at 35°/ca. interbedded with amphibolite at 42°/ca. Section contains disseminated (<5%) coarse black tourmaline.

39.3: coarse-grained pegmatite clot.
41.1 - 43.1: similar to above, interbedded pelite + amphibolite; locally foliated at 30°/ca. Section contains disseminated black tourmaline, 42.8 to 43.1; 75% tourmaline with abundant fine-grained disseminated sulphides.

**43.1 to 47.1: SILICIFIED ZONE**: varies from dark grey to massive milky quartz; numerous quartz-carbonate stringers at 45°/ca. Local development of black tourmaline + minor pyrite.

44.7 - 45.1: intense carbonate veining (minor brecciation), sericitic. This section appears to be intensely silicified amphibolite.

**47.1 to 89.0: PEGMATITE:** sharp contact with silicifed wallrock at 40°/ca. Texturally and mineralogically variable.

47.1- 47.7: zone of coarse-grained nodular quartz + muscovite + cleavelandite + spodumene. The spodumene shows spotty alteration to a soft, dark-green mineral.

47.7- 48.2: microcline + cleavelandite zone, showing intense replacement by the albite.

48.2 - 49.2: (refer to 47.1-47.7); muscovite-rich(8-10%), also contains minor blue-green apatite.

49.2 - 50.5: see above 47.1, coarse-grained zone; spodumene varies from white to dark-green. The latter colouration appears to reflect intense alteration. The albite (cleavelandite) contains very minor apatite and black mineral inclusions (Ta, Nb, Sn- oxides?)

50.5 - 51.1: aplite zone, 90% white cleavelandite; contact with above marked by abundant coarse-grained muscovite.

51.1 - 61.3: very coarse-grained zone; milky quartz (75%) + spodumene (25%), no muscovite and very minor white intergranular albite; spodumene varies from pale yellowish-green to white to dark green. Inclusions of black oxides are common. Quartz is glassy and interstitial to spodumene, which varies from white to pale green and contains common black to dark brown mineral inclusions.

61.3 - 61.6: section of near complete albitization of coarse-grained microcline abundant cleavelandite. Also from 62.8 to 63.2m.

63.2 - 63.6: aplite zone; intense shear fabric observed at 45-55°/ca. Contains abundant disseminated black/dark-brown mineral and blue-green apatite. Section also contains clots of coarse-grained nodular-textured quartz + muscovite + albite.

63.6 - 73.5: coarse-grained, spodumene + quartz (glassy) + muscovite + cleavelandite zone. Spodumene (about 40% modal vol.) ranges in colour from white to pale green, may contain abundant black mineral inclusions and shows local alteration to a soft, deep-green mineral (63.7,72.9m). Section also contains several narrow zones and patches of coarse K-feldspar showing replacement by secondary albite (cleavelandite).

73.5 - 74.1: K-feldspar (microcline?) + secondary white albite (cleavelandite) + minor quartz.

74.1 - 74.8: see above, (63.6-73.5m).

74.80 - 76.50: aplite zone: shear fabric a 45°/ca, with coarse-grained, glassy quartz and abundant blue apatite ($\leq$5mm) + black mineral (Sn, Ta?-oxide). Section is highly fractured perpendicular to shear fabric; appears to be later brittle deformation.

76.5 - 77.8: see above, (63.6-73.5m). Spodumene shows dark-green alteration along crystal margins.

77.8 - 79.4: aplite zone: section contains coarse clots of soft black mineral and minor fine-grained pale-pink to orange mineral. Prominent shear fabric.

79.4 - 80.0: K-feldspar (microcline?) + secondary white albite (cleavelandite) + minor quartz.

80.0 - 83.5: see above (76.5-77.8); spodumene varies from white to deep-green (altered), common fine-grained black mineral inclusions along cleavage planes.

83.5 - 86.0: K-feldspar (microcline?) + secondary white albite (cleavelandite) + minor quartz. Includes 50cm section of very coarse-grained glassy quartz + K-feldspar + minor spodumene (84.2 to 84.9).

86.0 - 88.7: Section of coarse-grained spodumene (25-30% modal vol.) + quartz + albite + minor K-feldspar and muscovite.

88.7 - 89: zone of abundant small,($\leq$ 1.5cm) tourmaline euhedra in cleavelandite and quartz. Adjacent wall rock (see below) shows intense tourmalization up to 3cm away from the pegmatite contact.

**89.0 to 97.3: PELITE:** dark grey to black, sericitic, contact with above at 65°/ca; intense tourmalinization of pelite adjacent to pegmatite. Locally contains numerous quartz-carbonate stringers (<5cm) at 20-30°/ca; minor set oriented at 48-52°/ca. Some veins have a sigmoidal morphology (92.7).

94.2 - 97.3: fine-to medium-grained with local enrichment of sericite.

**97.3 to 99.1: AMPHIBOLITE**: biotite-rich, intensely foliated at 48°/ca. Much of this section has been silicified with narrow zones of complete replacement.

**99.1 to 104.6: PSAMMITE**: massive, dark grey, fine-to medium-grained; common mottled bleached banding with local intense pervasive silicification (102.4m). Quartz veins with minor disseminated pyrite $\pm$ pyrrhotite (104m, 104.3-104.6).

**104.6 to 111.1: AMPHIBOLITE**: coarse-grained, variably silicified with abundant, disseminated fine-grained black tourmaline.

**111.1 to 112.4: SILICIFIED ZONE:** section of intense pervasive silicification of amphibolite. Faint banding at 48°/ca, is same as foliation within the amphibolite.

**112.4 to 117.1: AMPHIBOLITE:** medium-to coarse-grained, intense foliation at 48°/ca. Common disseminated fine -grained pyrrhotite ± pyrite.

**117.1 to 118.5: PELITE:** massive, greenish-grey; penetrative cleavage at 58°/ca. Contact parallel with above.

**118.5 to 119.1: AMPHIBOLITE**: massive, fine-to medium- grained.

**119.1 to 120.6: PSAMMITE:** intensely silicified; near complete replacement to massive milky quartz. Remnant light grey psammite intercalated with quartz.

**120.6: END OF HOLE!**

## N.S.D.N.R. DRILLHOLE BZL-93-5: DESCRIPTIVE LOG

**Azimuth: at surface - 145° Dip = -50° Total depth = 112.8 metres**
**at 112.7m - 158° = -45°**
**UTM Coordinates: northing - 4875000 / easting - 259800**

**0.0 to 4.0: OVERBURDEN:** predominately pebbles of interbedded fine- to medium- grained amphibolite with dark greenish-black pelite.

**4.0 to 6.9: AMPHIBOLITE:** fine- to medium- grained, dark green; abundant biotite and feldspar porphyryoblasts oriented parallel to foliation at 30°/ca. Minor tourmalinization evident by the presence of <1mm tabular black crystals, aligned parallel to foliation.

4.7 - 5.3: interbedded with minor dark greyish-black pelite; sharp contact at 40°/ca. Pyrite occurs as small stringers in the pelite.
5.3 - 5.8: medium -to coarse - grained amphibolite, biotite-rich; foliation at 40°/ca.

**5.8 to 6.9: AMPHIBOLITE:** light grey, fine-grained amphibolite in sharp contact (45°/ca) with the above.

**6.9 to 8.1: AMPHIBOLITE:** medium -to coarse- grained, minor disseminated pyrite. Section is tourmalinized and foliated at 55°/ca.; tourmaline crystals are parallel to foliation.
7.1 to 8.08; interbedded fine and coarse-grained amphibolite.

**8.1 to 11.3: INTERBEDDED AMPHIBOLITE/PELITE:** core takes on a greyish-green color (pelite); beds are at 40°/ca. A section of quartz veins (2-10mm wide) located at 10.67m, are grey, glassy and barren with pyrite stringers adjacent to both sides of the vein.

**11.28 to 13.87: AMPHIBOLITE:** medium -to coarse- grained, biotite-rich with abundant black tourmaline. Foliated at 42°/ca.; sharp contact at 30°/ca. Core becomes progressively finer grained to 13.82m.

13.82-13.87: PEGMATITE; coarse-grained, quartz - plagioclase - biotite + coarse disseminated chlacopyrite and minor rutile.

**13.87 to 16.77: PELITE:** massive, grey, fine -to medium- grained, contains mm wide quartz stringers at 45° to sub vertical to the core axis.

**16.77 to 32.5: AMPHIBOLITE:** fine -to medium- grained, biotite-rich, foliated at 45°/ca.

21.03 - 22.71; tourmalinized, sharp contact with the above at 45°/ca.
22.71 - 23.48; highly fractured section, possible shear zone.
23.48 - 23.78: amphibolite is coarser-grained and chloritized.
23.78 - 32.5 : fine -to medium -grained, intensely fractured; minor chloritization. No prominant foliation observed.
25.92m: sharp contact at 60°/ca., with a coarse-grained, highly chloritized amphibolite.
31.70 sharp contact with medium-grained section, foliated at 20°/ca.

**32.5 to 33.23: QUARTZ VEIN:** pale grey, glassy, contains carbonate inclusions; fractured at 20°/ca. Uphole contact at 50°/ca., contact marked by a 1cm wide biotite-rich band. Downhole contact also marked by a 3cm wide biotite-rich band at 45°/ca., within 25cm of intensely chloritized amphibolite. Another quartz vein is present adjacent to the chloritized zone, contains small tourmaline crystals.

33.23 to 38.25: INTERBEDDED AMPHIBOLITE/PELITE: fine-grained, greenish-grey pelite with fine -to medium -grained amphibolite, foliated at 40°/ca. Bedding at 45°/ca; 1m wide zone of intense silicification adjacent to the pegmatite below; similar in appearance to a quartzite.

**33.2 to 72.0: PEGMATITE:** contact at 30°/ca., uphole contact marked by a 3cm wide tourmaline-rich zone within the pegmatite. Pegmatite shows textural and compositional zonation as described below;

33.2 - 39.5; spodumene + muscovite + albite + quartz zone, represented by coarse-grained pale-green to white spodumene, abundant green muscovite and massive dark-grey quartz. The quartz has a nodular appearance characterized by coarse spherical blebs surrounded by fine-grained, white, acicular albite (var. cleavelandite). The spodumene is milky- white and shows a dark greenish-black alteration along the outer rims of some crystals. Cleavelandite is secondary replacing K-feldspar, this particular section shows about 50% replacement.

39.5 - 39.7; silicified zone with fractures infilled with muscovite..

41.15 - 41.3; K-feldspar + cleavelandite zone which shows clear replacement of K-feldspar by cleavelandite.
41.3 - 42.7; (see 33.2-39.5), spodumene has a pale green color and quartz is now light grey.

42.7 - 43.0; aplite zone: sharp contact with above at 30°/ca., contact marked by abundant muscovite. Aplite has prominent foliation at 45°/ca.(structural/magmatic?) and contains small dark grey quartz blebs, small (<1cm.) dark-green, tourmaline crystals and minor small, subhedral, bluish-green apatite crystals (3mm to 2cm). Zone also contains a single 1.5cm wide molybdenite crystal surrounded by a ring of dark-green muscovite..

43.0 - 44.4; (see 33.2-39.5): contact is sub-horizontal to core axis, quartz is no longer nodular and less abundant; there is a 1cm wide black tabular tantalite crystal and K-feldspar shows partial replacement by cleavlandite. Spodumene contains quartz inclusions. Minor tourmaline.

44.4 - 44.8; section of coarse-grained quartz + spodumene + albite with minor K-feldspar + muscovite. Quartz is fractured sub-parallel to the core axis. Quartz is dark grey and spodumene is very abundant (25-50%).
46.10 - 46.25 intensely altered spodumene-rich zone.

48.2 - 50.3: aplite zone: minor tourmaline + apatite. Also contains dendritic reddish-brown mineral.
49.18 - 49.3; section of intense manganese stained, cleavlandite-rich area. Disseminated , pyrite and chalcopyrite along fracture faces.

50 - 50.3; intensely fractured (30°/ca.), quartz-rich zone.

50.3 - 52.6: coarse K-feldspar + cleavelandite + quartz

52.6 - 53.0; very coarse-grained spodumene + quartz zone: spodumene has a pale greenish color and is cross-cut by several narrow (<3mm) quartz veins at 30-50°/ca.

53.0 - 54.3; spodumene + muscovite + albite + quartz zone (see above)..

54.3 - 55.2; K-feldspar + cleavelandite.

55.2 - 57.6; aplite zone; foliated at 45°/ca. Uphole contact at at 55°/ca. Intercalated with discrete segregations of coarse-grained spodumene + muscovite( 55.63 / 56.25 / 56.80).

57.6 - 59.1; spodumene + muscovite + albite + quartz zone: spodumene has a dull off-white to pale-green colour. The rims of the spodumene crystals show a dark-green alteration. Quartz is massive, dark to light grey. Minor small, dark-green tourmaline.

59.1 - 59.4; K-feldspar + cleavelandite zone: almost complete replacement by cleavelandite, fractured at 50°/ca.

59.4 - 62.3; spodumene + muscovite + albite + quartz zone: possible cassiterite in this zone at 61.5m..

62.37 - 62.8; aplite zone; vuggy, foliated at 40°/ca., fractured at 60-70°/ca.

62.8 - 67.7; spodumene + muscovite + albite + quartz zone: intercalated with minor aplitic material..

67.7 - 68.9; K-feldspar + cleavelandite zone: feldspar shows extensive replacement by cleavelandite.

68.9 - 72.0; spodumene + muscovite + albite + quartz zone: spodumene rims replaced by dark-green mineral. Minor aplite. Contact with amphibolite wallrock is sharp at 80°/ca., and sheared. .

**72.0 to 74.6: AMPHIBOLITE:** medium-grained, interbedded with minor greenish- grey pelite.

**74.6 to 77.4: SILICIFIED AMPHIBOLITE:** intensely silicified, black tourmaline-rich section. Fractured at 50°/ca. Silicified sections contain massive, inclusion-rich, milky quartz which contains pale remnants of amphibolite and pelite in which the host foliation is evident..

**77.4 to 112.8: AMPHIBOLITE:** interbedded amphibolite and minor pelite, containing carbonate strings. Massive pelite from 81.43 to 90.24m, contains carbonate stringers at 45°- sub parallel to ca., also disseminated chalcopyrite and pyrite.
110.97 to 112.81 interbedded massive quartz and minor black tourmaline.

**112.81: END OF HOLE**

## APPENDIX -1

## GEOPHYSICAL LOGS, BRAZIL LAKE, NS: HOLE BL93-4

P.G.Killeen and C.J. Mwenifumbo
Geological Survey of Canada
601 Booth St. Ottawa K1A0E8

### Introduction

Borehole geophysical measurements were made in hole BL 93-4 using the R&D logging system operated by the Geological Survey of Canada (GSC). The 120m deep NQ (76mm) hole, located in the Brazil Lake area, was drilled by the Nova Scotia Department of Natural Resources (NSDNR) as part of a study to investigate the potential for Beryllium and Lithium in pegmatites. Five separate logging runs were made in the hole to record information from the following geophysical probes.

1. Natural gamma-ray spectrometry (TC, K, U, Th)
2. Density/Spectral gamma-gamma (SGG)
3. Induced Polarization/Resistivity/Self Potential (IP/R/SP)
4. Magnetic Susceptibility (MS)
5. Temperature/Temperature-Gradient (T/TG)

Logs of the twelve parameters recorded from the five probes were combined with the geological log supplied by M. Corey (NSDNR), and are plotted here in two parts showing 60m of hole per page. More detailed descriptions of the five logging tools, the parameters measured and explanatory notes regarding their general relationships to geology, mineralogy and structural features, are given in the section on 'The GSC Borehole Geophysical Logging System'.

### Geophysical Log Responses: Brazil Lake Hole 93-4

Some of the more notable features in the logs include:

1 -Pegmatites are clearly outlined by low magnetic susceptibility and high count rates in the natural gamma-ray spectral logs. The gamma-ray logs also indicate the relative inhomogeneity of the pegmatite which contains numerous thin zones of higher activity. The variability in the U-log implies that much of this is due to uranium variations. It is interesting to note that the Th-log shows a lower count in the pegmatites than the adjacent rocks, including the amphibolites which are usually very low in radioelement content.

2 -Several geologic units are characterised by the density log, such as the pelites and amphibolites (high density), and the pegmatites (low but variable density).

3 -There are a few thin zones (at 57, 78, 102m) with low SGG Ratio values which could be indicative of the presence of low atomic number material such as beryllium and lithium minerals.

4 -The 'mineralized zone' is anomalously low in radioactivity compared to the enclosing pegmatite, except for a thin zone between 55 and 56m. It is also characterized by very low magnetic susceptibility.

5 -A thin zone of relatively high magnetic susceptibility occurs in the middle of the pegmatite (60 to 89m) at a depth of about 67m suggesting increased magnetite content.

6 -The amphibolite between 97 and 100m has been silicified, which explains its low density compared to the other amphibolites.

7 -The amphibolite between 30 and 33m is more magnetic than the other amphibolites intersected by the borehole.

8 -The high resistivity values, decreased density values, and decreased MS values between 110 and 111m suggest a possible silicified zone such as indicated one metre below. Possibly core loss could explain the depth discrepancy.

9 -The Temperature and Temperature-gradient logs indicate a significant water flow at about 27m depth and a lesser flow at about 44m.

**The GSC Borehole Geophysical Logging System**

The GSC R&D digital logging system records measurements on 9-track magnetic tape from a suite of geophysical probes. The system, which is mounted in a 4-wheel drive truck has five borehole logging tools (probes) with sensors that in total can measure up to twelve parameters. In this application, four logging measurements (geophysical logs) were found to be the most informative; natural gamma-ray spectrometry, density/spectral gamma-gamma, induced polarization/resistivity and magnetic susceptibility. Their characteristics are as follows:

1. Natural Gamma Ray Spectral Logs

The gamma ray probe measures the natural gamma radiation emitted by potassium-40, uranium and thorium series isotopes in the rocks surrounding the drillhole. In igneous and metamorphic geological environments, these sources of natural radiation may contribute equally to the total number of gamma rays counted by a scintillation detector in the probe. In sedimentary formations potassium usually dominates.

Each second, full gamma ray spectra are recorded in 256 channels covering a gamma ray energy range from approximately 0.1 MeV to 3.0 MeV as the probe moves along the borehole. The four standard windows used in data analysis include the potassium (K) window (1.36-1.56 MeV) centred on the K-40 gamma-ray peak at 1.46 MeV, the uranium (U) window (1.61-2.3 MeV) covering the 1.76 MeV gamma-ray peak from bismuth-214 in the uranium decay series, and the thorium (Th) window (2.4-3.0 MeV) straddling the 2.62 MeV gamma-ray peak from thallium-208 in the thorium decay series. The fourth window, the Total Count (TC) window, which covers a wide energy range from 0.1 MeV to 3.0 MeV, is used to monitor the overall levels of radioactivity. The scintillation detector used in the present work was a 32 mm x 127 mm (1.25 x 5.0 inch) cesium iodide (CsI(Na)) detector. The logging speed was 3 m/minute, producing a measurement every 5 cm along the hole. The sample radius is approximately 20 to 30 cm around the borehole, depending on the rock density. The four logs produced are TC, K, U and Th count rates. If the count rates are too low, computations of K, U and Th concentration logs are not possible. In that case, the TC log is presented with the raw, K, U and Th logs in cps (counts/second).

2. Density/Spectral Gamma Gamma (SGG) Log

The tool is essentially the spectral gamma ray logging tool described above, but used in a gamma-gamma density configuration. In this case the probe consists of a weak (10 millicurie) gamma-ray source ($^{60}Co$) separated by 17.5 cm of shielding from a scintillation detector (cesium iodide). In the GSC system, every second, the gamma rays backscattered through rock from the source are recorded as 1024 channel spectra covering an energy range from approximately 0.03 to 1.0 MeV.

Density information is determined from the count rate (which is inversely proportional to the rock density) in an energy window from 0.2 to 0.5 MeV. Information about the elemental composition of the rock can also be obtained, based on the ratio of the count rates in two energy windows, one at high energy (W6=0.2to 0.5MeV), and one at low energy (W1=0.05 to 0.1 MeV). If there is an increase in heavy element content (high atomic number, Z) in any region in the hole, the number of low energy gamma rays is decreased not only by the increased density, but also by photoelectric absorption (which is roughly proportional to $Z^5$). The spectral gamma-gamma (SGG) ratio log is a ratio of counts in W6 to counts in W1 (i.e. W6/W1). This ratio increases when the probe passes through zones containing high Z materials which decreases the count in W1. Thus the log can be considered as a heavy element indicator. Tin (Sn) has an atomic number, Z, of 50, which is significantly higher than Si (Z=14) and most common major rock-forming elements.

The sample volume is smaller than for natural gamma ray logging since the gamma rays must travel from the probe, out into the rock and back to the detector. A sample of 10 to 15 cm radius around the probe is estimated, which is still considerably larger than the drill core volume. At 6m/min, a density measurement is made every 10 cm along the borehole.

3. Induced Polarization/Resistivity/Self Potential Logs

The IP tool consists of an assembly of electrodes in the hole, usually including current electrodes and potential (measurement) electrodes. The current waveform is essentially a square wave (of duration 1, 2, 4 or 8 seconds) with an 'off' time between positive and negative parts of the waveform. Measurements made at various points in the transmitted waveform can be related to the IP effect (chargeability), and to the electrical resistivity of the rocks as well as to self potentials generated in the rock.

Induced polarization measurements primarily respond to the presence of polarizable and conductive minerals such as disseminated sulphides. Thus alteration in the form of pyritization would be detectable, for example.

The resistivity of rocks depends on several factors. The amount of conductive minerals such as iron sulfides, oxides and graphite in the rock have a strong influence on the resistivity. Most rocks are usually poor conductors and their resistivities are governed primarily by their porosity, degree of saturation of the pore spaces and salinity of the pore water, and to a lesser extent by the intrinsic minerals that constitute the rock. The logging speed was 3m/minute with one measurement every 5 cm. The sample radius is roughly proportional to the electrode spacing which in this case was 40 cm.

Self Potential (SP) anomalies are mainly an indication of the presence of graphite and/or high concentrations of base metal sulfides including pyrite. Large self potentials observed within and around sulfide and graphite bodies are mainly caused by electrochemical processes. Low resistivity anomalies correlating with SP and IP anomalies are, therefore, good indications of the presence of conductive minerals. Also SP anomalies can be generated by fluid flow in porous media (electrokinetic or streaming potentials) and heat flow (thermal electric coupling).

4. Magnetic Susceptibility Log

The magnetic susceptibility (MS) of a volume of rock is a function of the amount of magnetic minerals, mainly magnetite, and pyrrhotite, contained within the rock. MS measurements can provide a rapid estimate of the ferromagnetism of the rock. These measurements can be interpreted to reflect lithological changes, degree of homogeneity and the presence of alteration zones in the rock mass. During the process of hydrothermal alteration, primary magnetic minerals (e.g. magnetite) may be altered (or oxidized) to weakly- or non-magnetic minerals (e.g. hematite). Anomalously low susceptibilities within an otherwise homogeneous high susceptibility (ferromagnetic) rock unit may be an indication of altered zones.

The volume of investigation or 'sample volume' is roughly a sphere of 30 cm radius, surrounding the sensing coil in the probe. The sensing coil forms part of a balanced electrical circuit. When the coil passes near ferromagnetic material, the inductance changes causing a phase shift in the current in the coil. The probe is calibrated so that this shift is converted into a measurement of the magnetic susceptibility. Logging is carried out at 6m/minute and a measurement is taken every second or each 10 cm along the hole.

5. Temperature/Temperature-gradient Log

Temperature measurements are used to detect changes in thermal conductivity of the rocks along the borehole or to detect water flow through cracks or fractures. Fractures or shear zones may provide pathways for groundwater to flow if hydrologic gradients exist within the rock mass. Groundwater movements produce characteristic anomalies and their detection may provide information on the location of the fractured rock mass and hence aid in the structural interpretation of the area. The temperature gradient log amplifies small changes in the temperature log, making them easier to detect.

Large concentrations of metallic sulphides and oxides may perturb the isothermal regime locally since metallic minerals have very high thermal conductivities. This perturbation may be delineated with the high sensitivity temperature logging system. This, however, would be observed only in a thermally quiet environment. In areas where there are numerous fracture zones with ground water movements, thermal anomalies due to ground water movements are much larger than those that would be observed due to perturbation caused by the presence of metallic minerals.

The ultra-high sensitivity temperature probe designed at the GSC has a 10 cm long tip of thermistor beads with sensitivity of 0.0001 degrees Celsius. Changes in temperature of the fluid in the borehole are measured and sent as a digital signal to the surface. The signal is then converted into true temperature after correcting for the effect of the thermistor time constants; the temperature gradients are computed from the temperature data. All temperature logging is carried out during a downhole run so the sensor is measuring the temperature of the undisturbed fluid. The usual logging speed is 6m/minute with data sampled every 1/5 of a second (approximately every 2 cm). This high spatial resolution of data is necessary if accurate temperature gradients are to be determined from the temperature data.

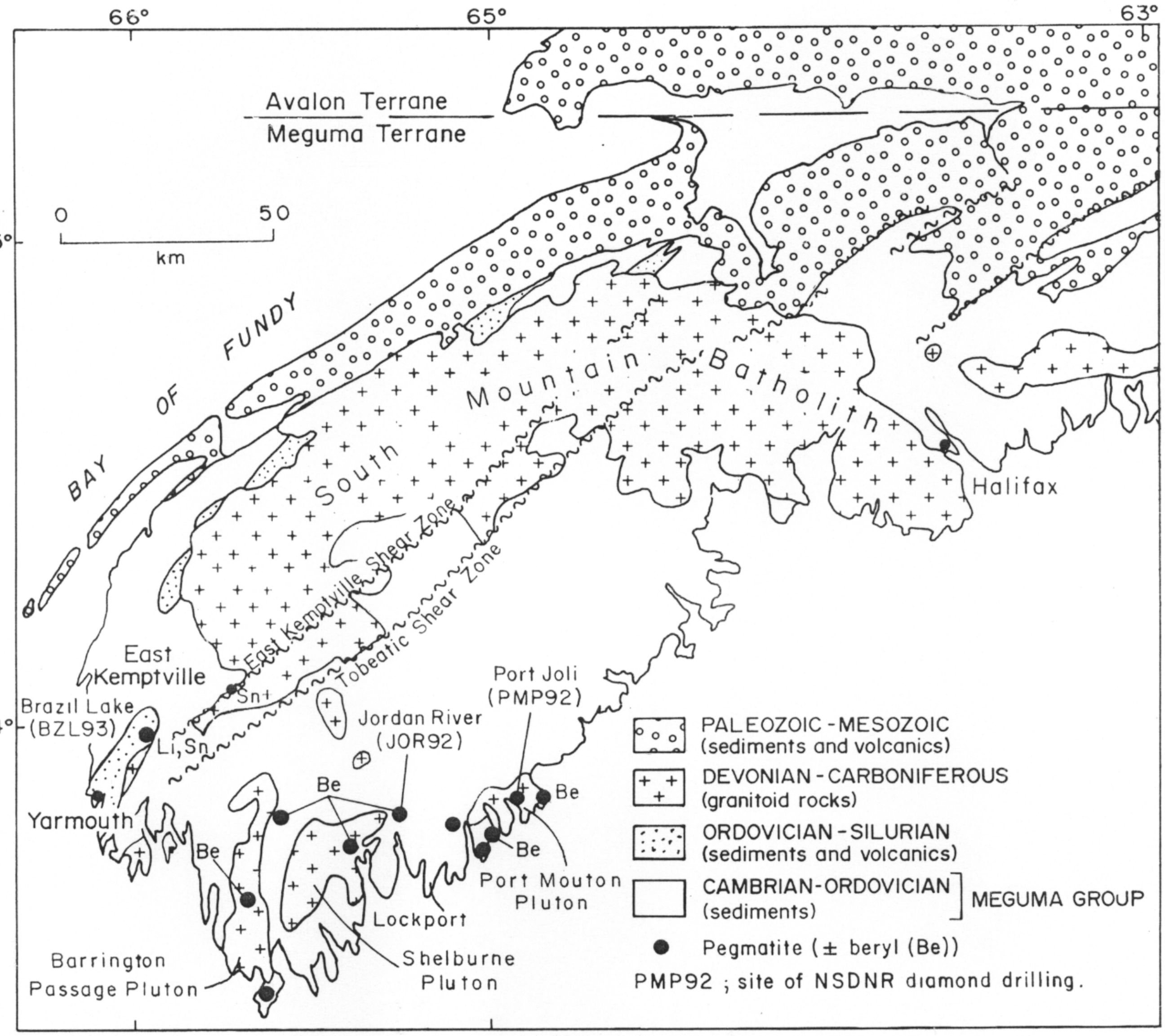



**Figure 1.** General geology map of southwestern Nova Scotia showing pegmatite occurrences and Nova Scotia Department of Natural Resources diamond-drill hole locations.

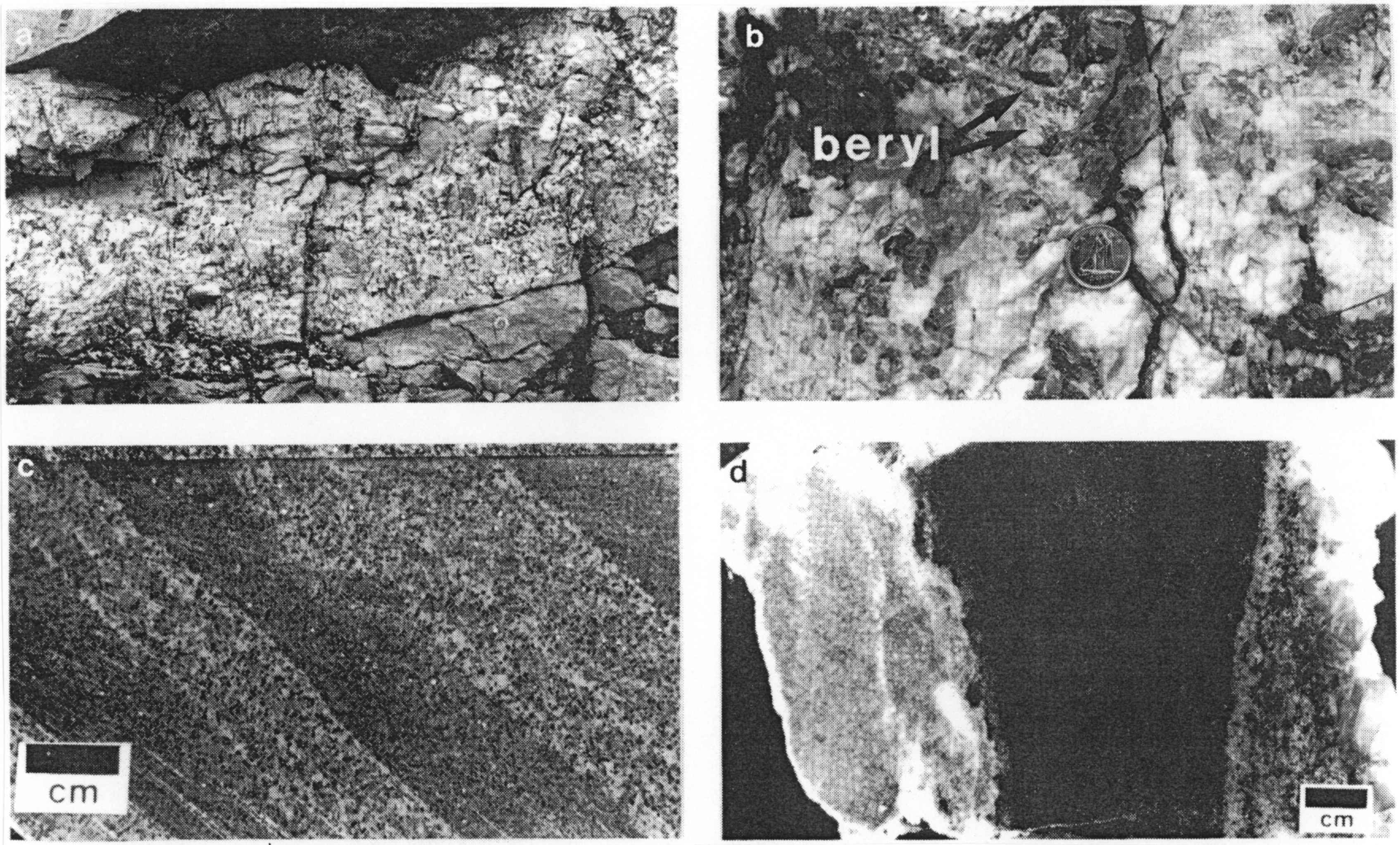



**Figure 2.** (a) Example of one of the many shallow-dipping pegmatite dykes that occur in the Port Joli area. The dyke shows zoning typical to many of the pegmatites. This particular dyke occurs in a roadside outcrop and is about 1 m wide. The host rock is muscovite + biotite monzogranite. (b) Cluster of small, euhedral, pale yellow beryl crystals in the intermediate zone of a pegmatite. The beryl is associated with coarse muscovite, apatite and garnet. (c) Sample of core from the Jordan River drillholes showing a typical section of interbedded, light grey, biotite ± garnet ± chlorite-bearing psammite and fine-grained biotite-rich semipelite to pelite. These units show progressive fining uphole. (d) Photo of sample taken from the main trench, showing dark grey semipelite bordered by a pale beige zone of intense pervasive sericitization on the left and a narrow bleached zone containing abundant black tourmaline on the right adjacent to a quartz vein. The sericitized zone may also contain disseminated fine-grained beryl and molybdenite.

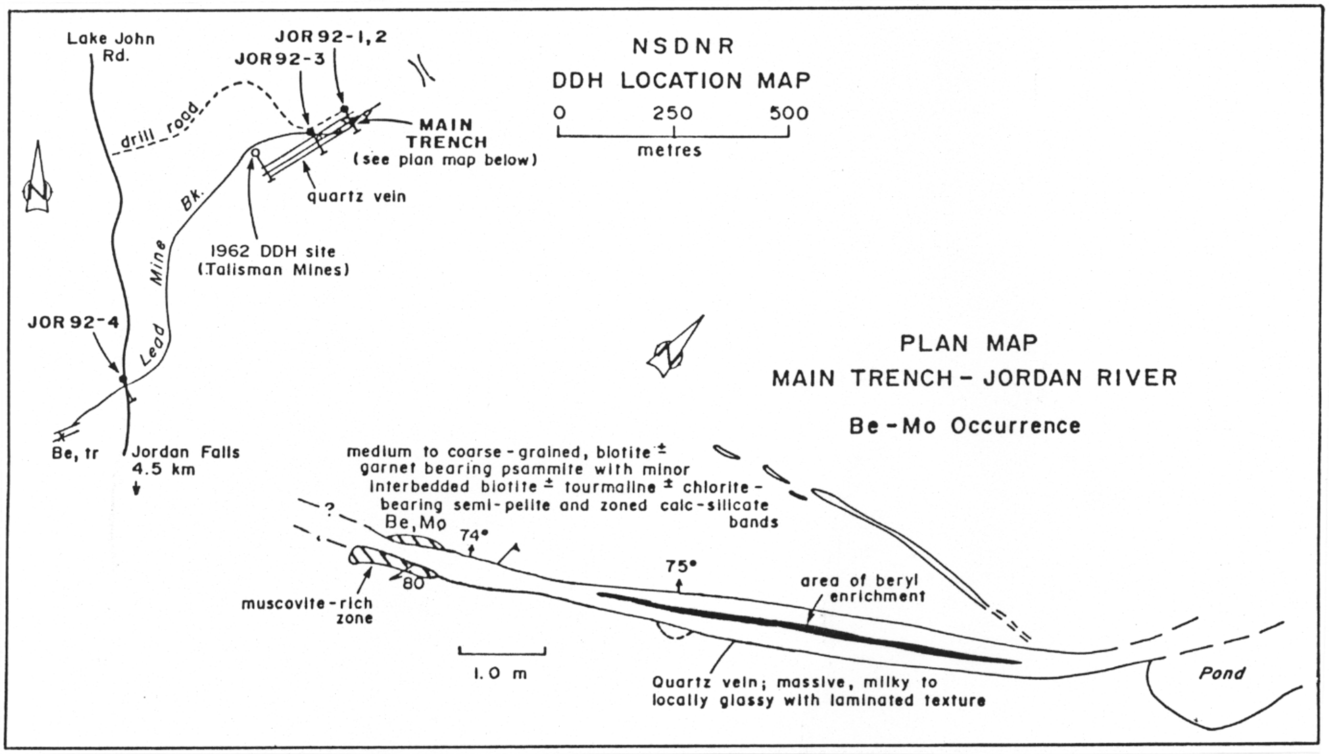



**Figure 3.** Map of the Jordan River pegmatite occurrence, showing locations of drillholes and detailed geology of the main trench area.

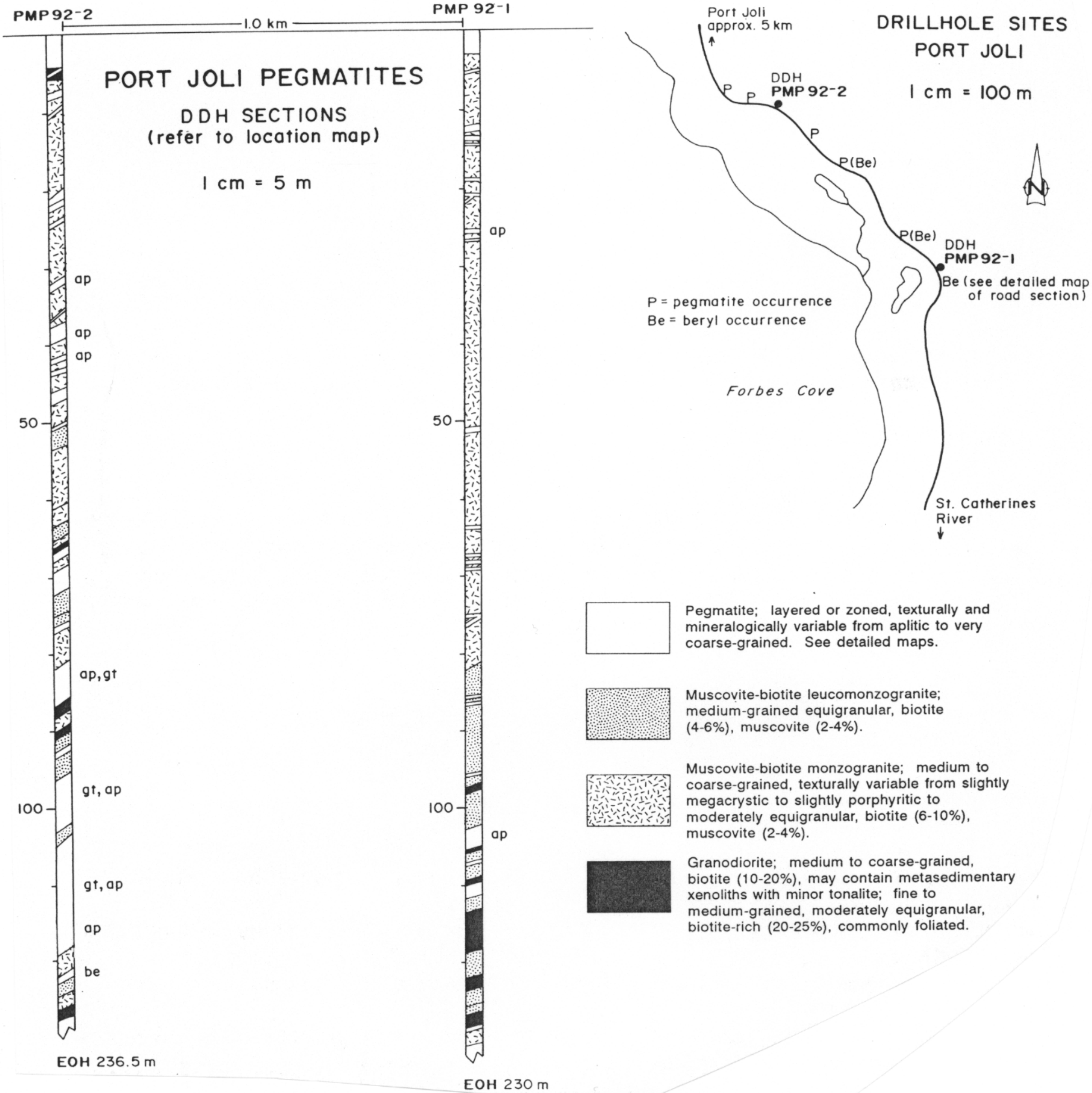



**Figure 4.** Map showing drillhole locations in the Port Joli area and drillhole sections.

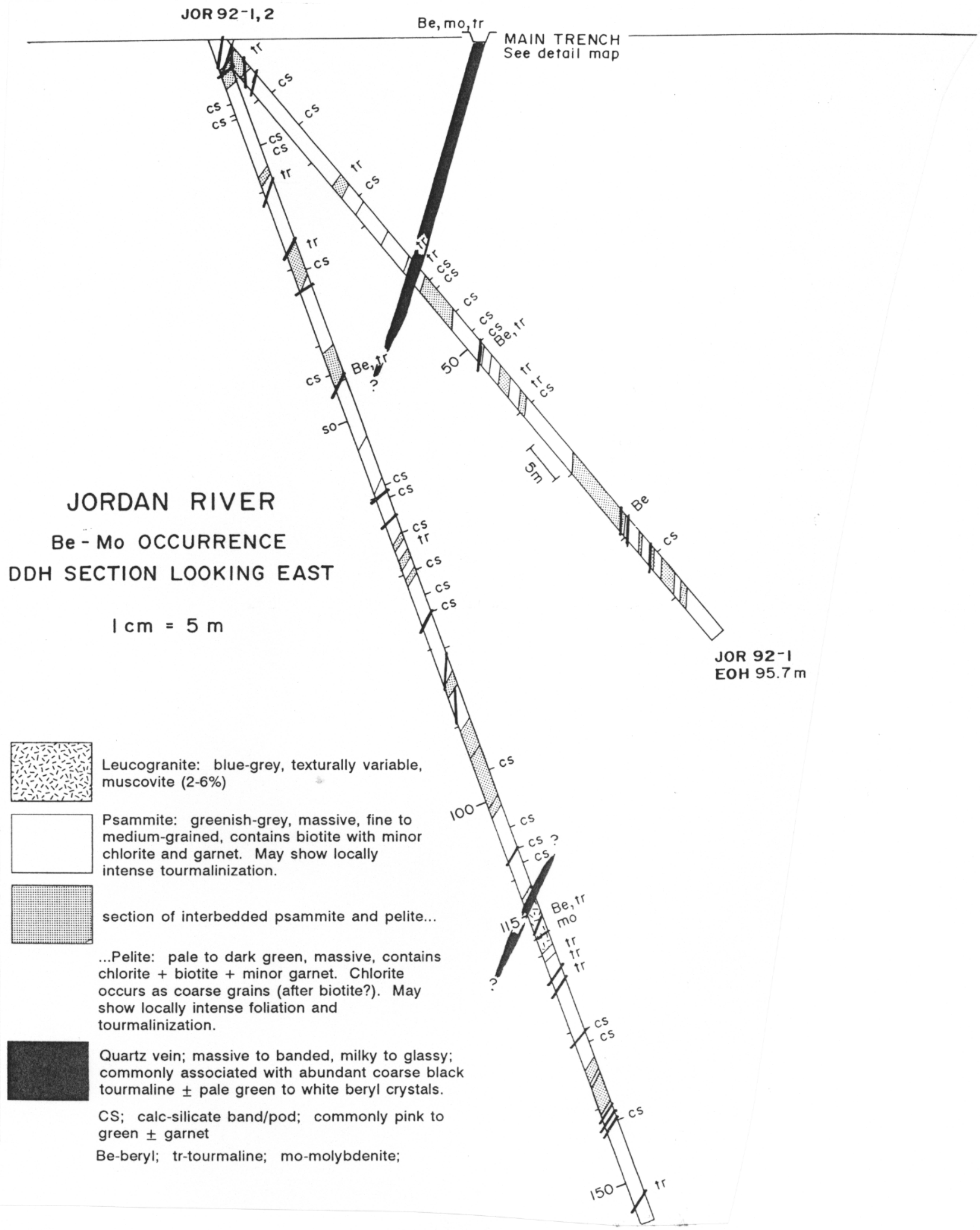



**Figure 5.** Drillhole sections from the main trench area, Jordan River.

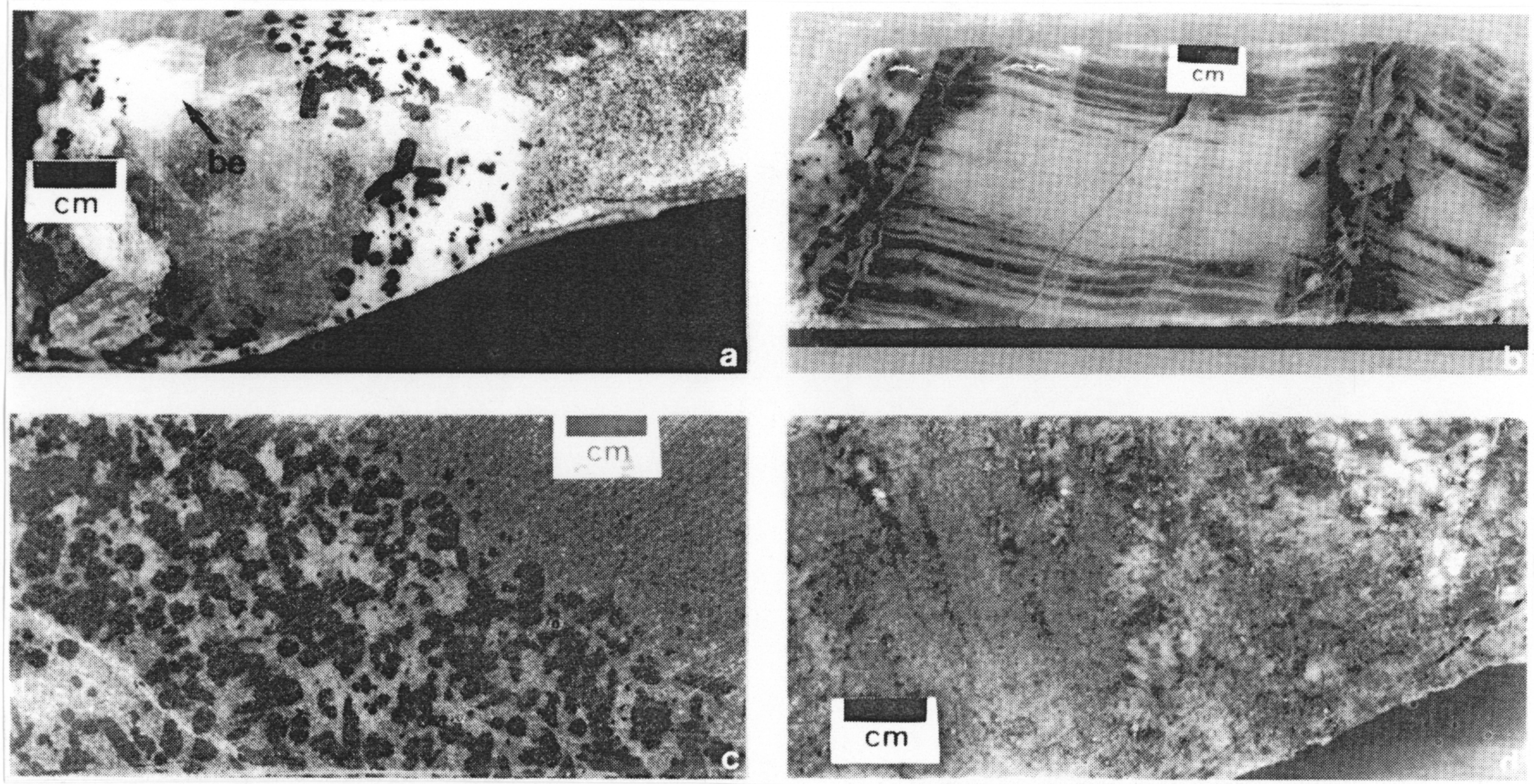



**Figure 6.** (a) This photo shows a core sample containing translucent, pale yellow beryl crystals (be) within a massive, glassy quartz vein. These beryl-bearing quartz veins are associated with intense bleaching and tourmalinization of the wallrock. The veins are up to 60 cm in width. (b) Photo of a core specimen showing the banded texture common to many of the quartz veins. Bands are oriented perpendicular to the vein contact and are thought to represent either shear bands, formed through extensional stress, or growth bands. Note the intensely bleached and tourmalinized metasedimentary wallrock. (c) Core sample showing the metasomatic development of coarse black tourmaline within bleached metasediment adjacent to a beryl-bearing quartz vein. (d) Example of a texturally variable leucogranite dyke intersected in two of the Jordan River drillholes. The leucogranite is muscovite rich and contains minor disseminated fine-grained pyrite, chalcopyrite, molybdenite and tourmaline. The contacts of the leucogranite are marked by intense tourmalinization.

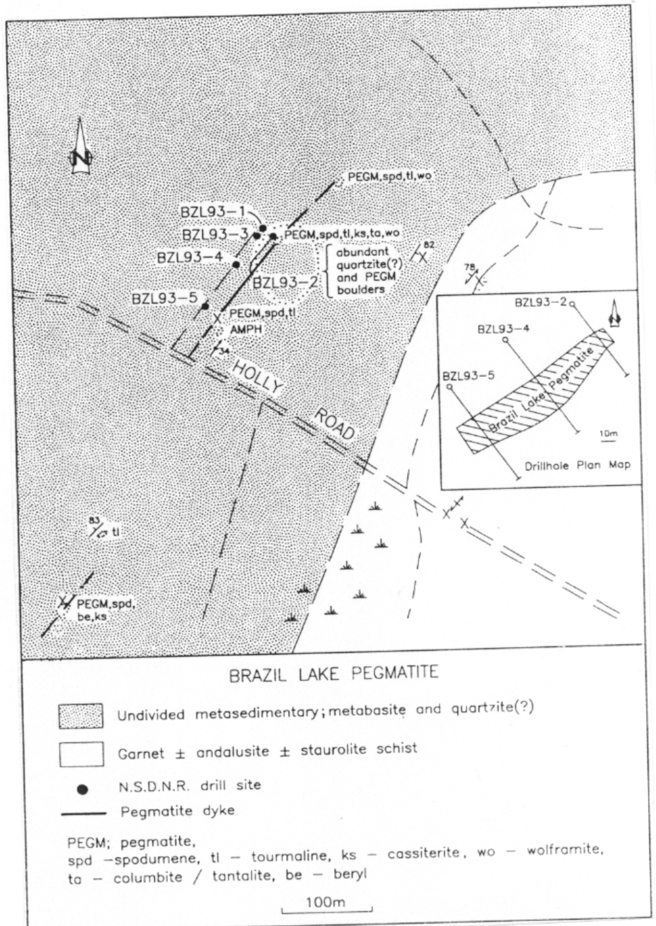



**Figure 7.** Geology of the area surrounding the Brazil Lake pegmatite, showing Nova Scotia Department of Natural Resources drillhole locations.

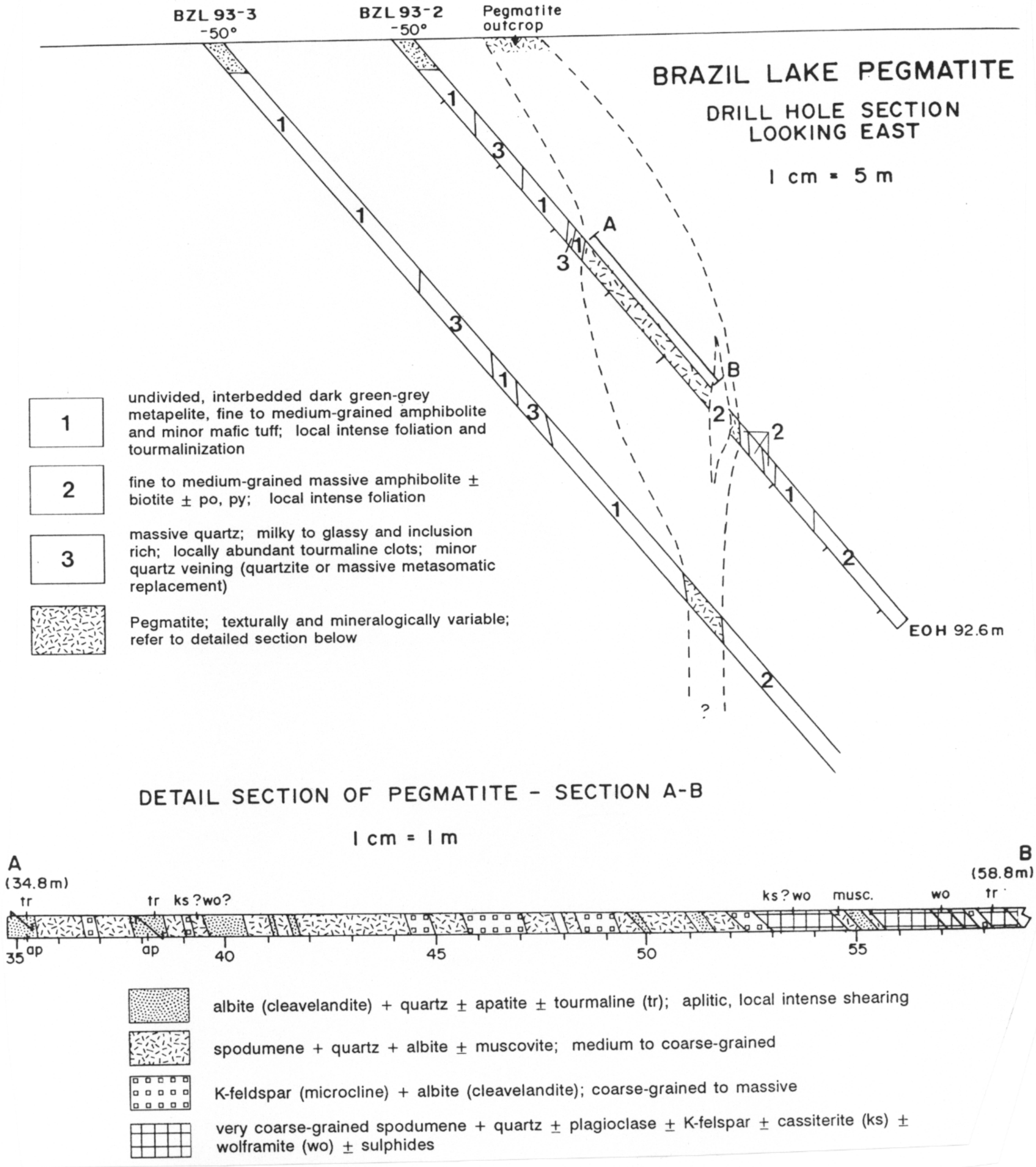
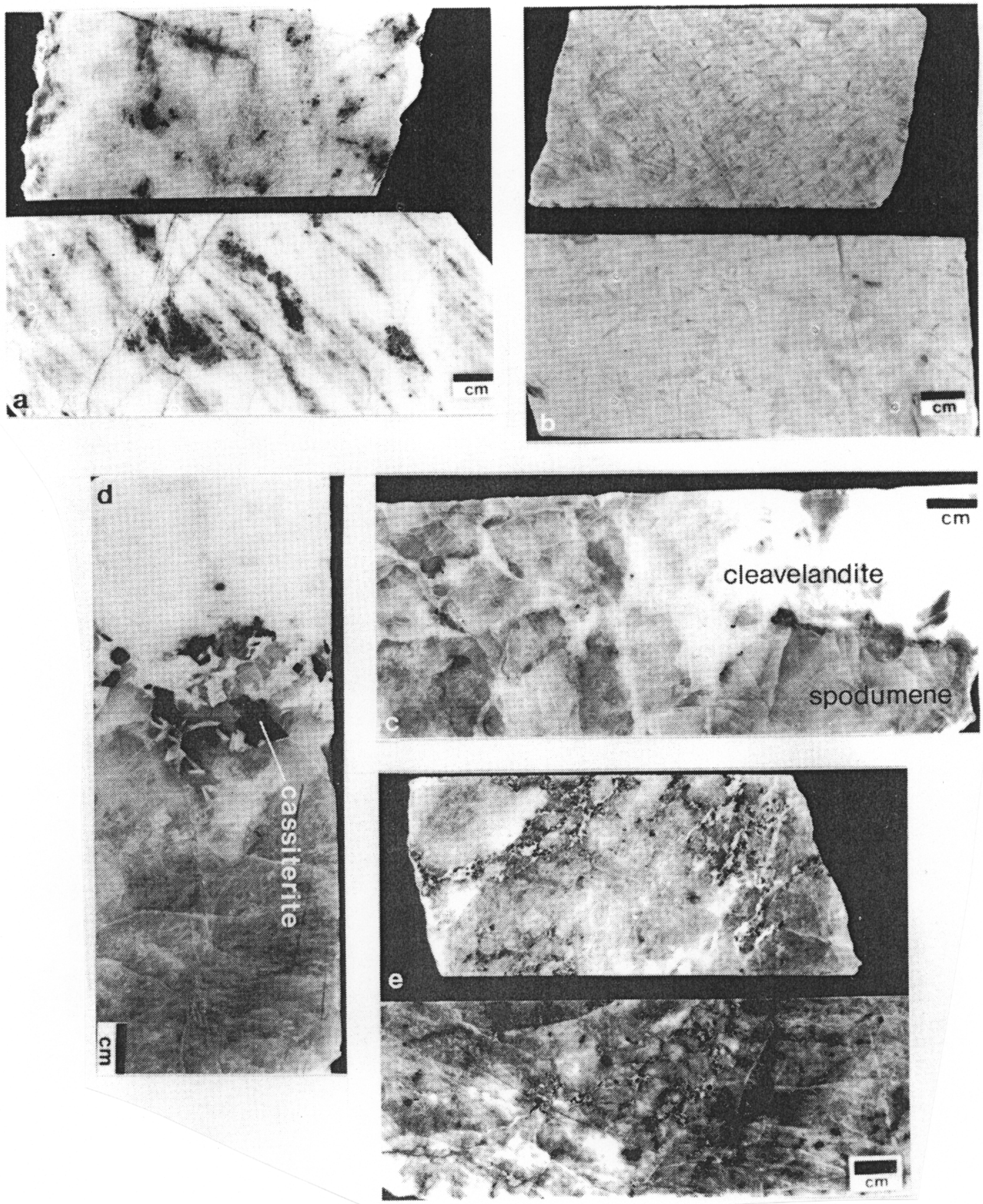



**Figure 8.** Drillhole sections from Brazil Lake.

**Figure 9 (facing page).** (a) This photo shows two core specimens from the aplitic zone, composed of plagioclase (albite $\pm$ cleavelandite) and quartz with minor tourmaline, apatite, cassiterite and garnet. As shown, this zone can display a prominent sub-vertical shear fabric. (b) This photo shows examples of the coarse-grained microcline (cross-hatched twinning) + cleavelandite (white) zone. Cleavelandite appears to replace microcline. (c) Core specimen from the quartz + spodumene + albite (cleavelandite) $\pm$ green muscovite zone. Spodumene varies from white to pale green, with the latter presumably reflecting an increased Fe content. The concentration of spodumene can reach up to 35% in this zone, which may also contain minor, fine-grained disseminated cassiterite, apatite, tourmaline and columbite/tantalite. (d) Photo of the extremely coarse-grained quartz + spodumene + albite (cleavelandite) zone. In one zone, massive quartz occurs over 10 m. The coarse black mineral is cassiterite. (e) Two core specimens of a quartz-rich unit. Previously referred to as quartzite, this unit is inclusion rich and is characterized by the presence of abundant black tourmaline clots and minor disseminated pyrite and chalcopyrite (lower photo). These features likely represent exomorphic alteration related to fluid movement during late stage consolidation of the pegmatite. The presence of what appears to be silicified wallrock with the same fabric as unaltered wallrock suggests that much of this quartz-rich unit may be the result of intense pervasive silicification.


a
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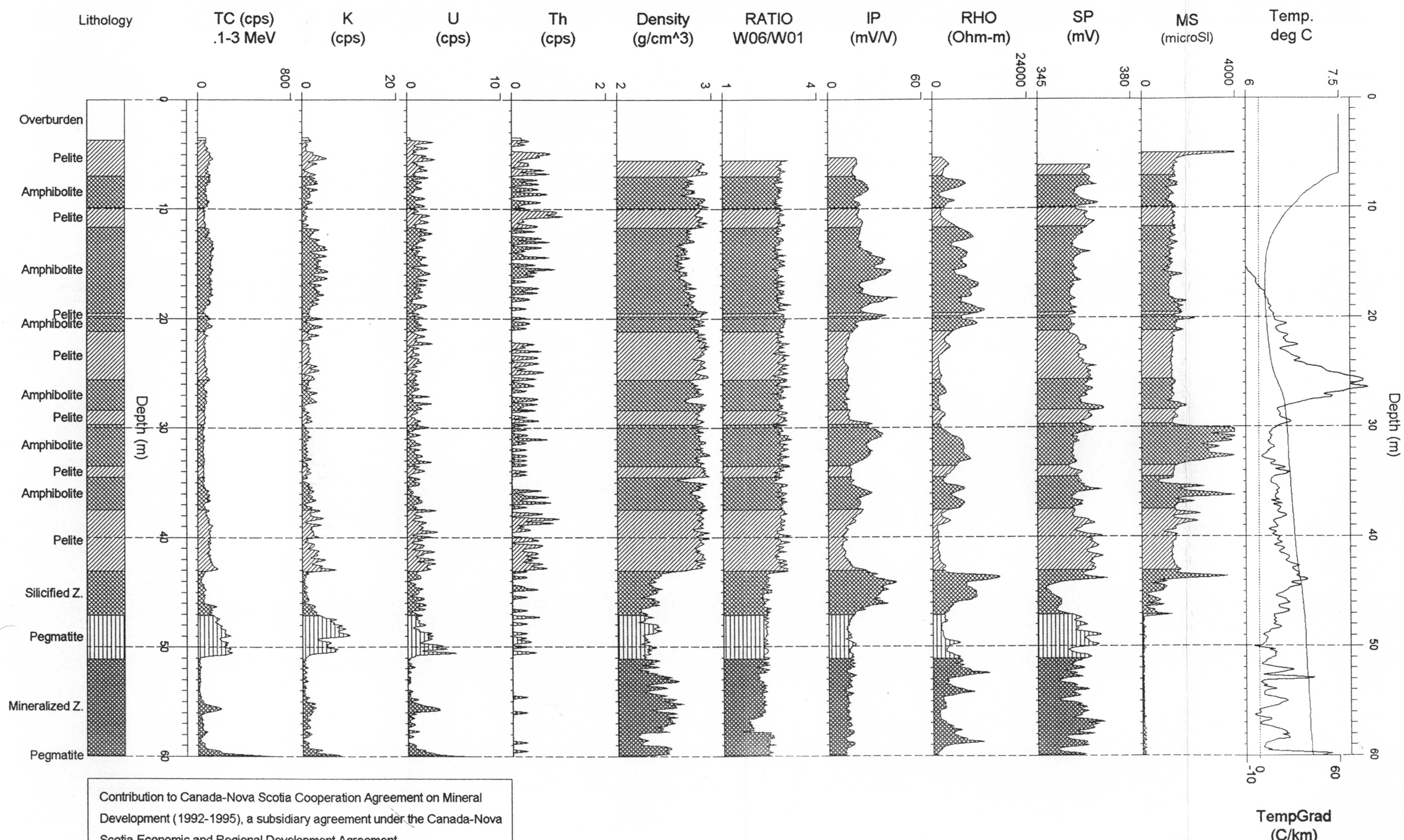
Hole BL 93-4 (Part 1 of 2)

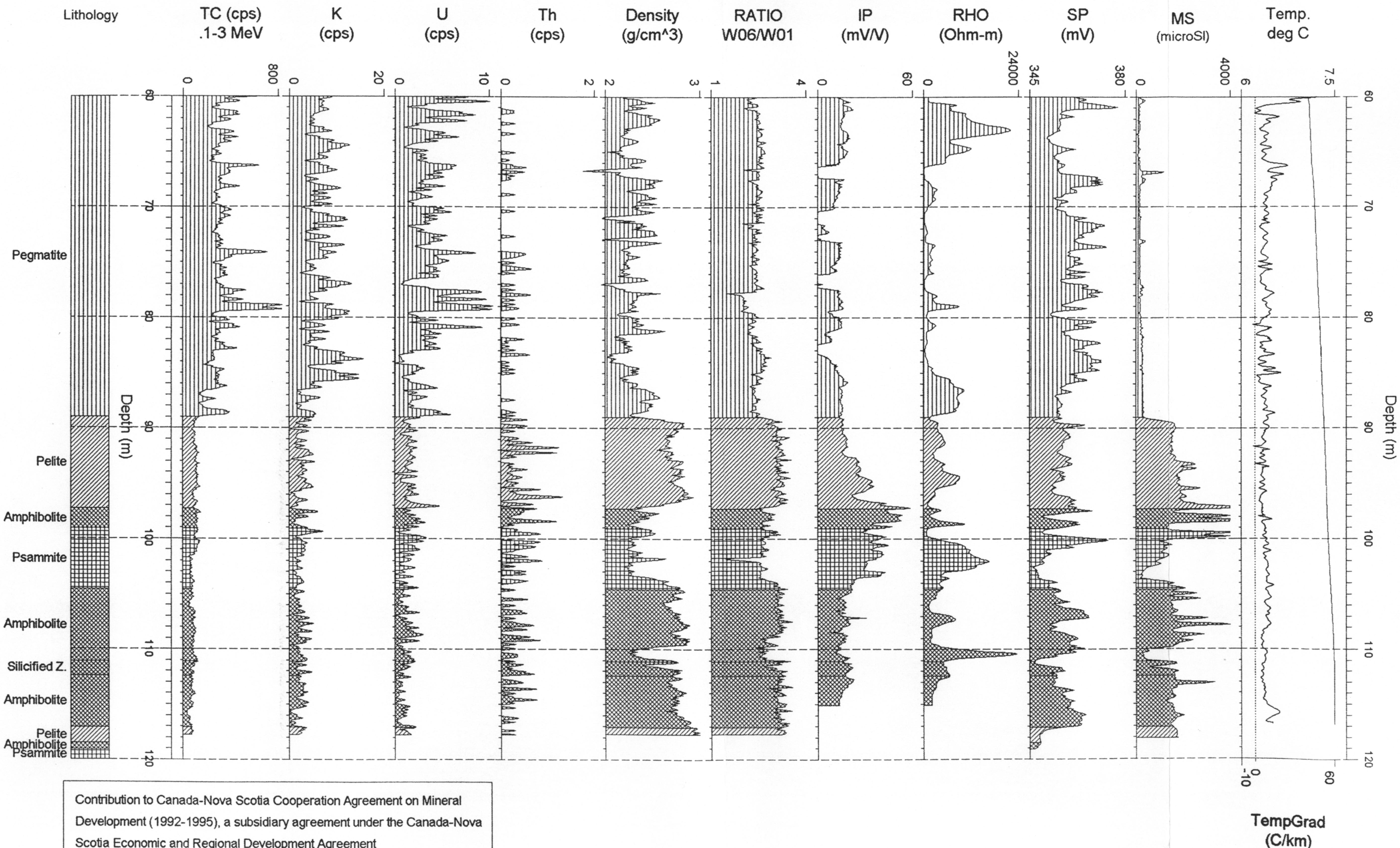
# GEOPHYSICAL LOGS, BRAZIL LAKE, N.S.
## Geological Survey of Canada
## Borehole Geophysics Section




Contribution to Canada-Nova Scotia Cooperation Agreement on Mineral Development (1992-1995), a subsidiary agreement under the Canada-Nova Scotia Economic and Regional Development Agreement

Hole BL 93-4 (Part 2 of 2)

# GEOPHYSICAL LOGS, BRAZIL LAKE, N.S.
## Geological Survey of Canada
## Borehole Geophysics Section




Contribution to Canada-Nova Scotia Cooperation Agreement on Mineral Development (1992-1995), a subsidiary agreement under the Canada-Nova Scotia Economic and Regional Development Agreement