Report on

# 1982 TEMPERATURE GRADIENT DRILLING ON SHOVELNOSE CREEK AT MOUNT CAYLEY, SOUTHWESTERN BRITISH COLUMBIA

Prepared for

Geological Survey of Canada

by

NEVIN SADLIER-BROWN GOODBRAND LTD.

January 1983

NEVIN | SADLIER-BROWN | GOODBRAND | LTD

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John F. Reader, B.A.Sc., P.Eng.

Stuart A.S. Croft

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## TABLE OF CONTENTS

FIGURES

# 1. SUMMARY

During August-September, 1982, Nevin Sadlier-Brown Goodbrand Ltd. on behalf of the Geological Survey of Canada, managed a helicopter-supported, geothermal gradient drilling program at the Mount Cayley Volcanic Complex in southwestern British Columbia. The drill site was located at elevation 1540m in the upper reaches of Shovelnose Creek which drains the southeastern side of the Complex.

Using diamond drilling equipment, one hole (Shovelnose One) was abandoned at 516' (157.3m) when rods were stuck in the hole during cementing to alleviate severe hole conditions. After moving the rig by hand, Shovelnose Two was completed uneventfully to 1500' (457.3m).

The holes penetrated a quartz diorite of the Coast Plutonic Complex cut by at least three stages of volcanic intrusion. Numerous dykes of dacitic and andesitic composition are visible throughout the core. Alteration and precipitate assemblages are typical of extensive hydrothermal activity similar to that at the Meager Creek volcanic complex to the north.

The highest temperature measured was 48.9°C at total depth in Shovelnose Two. Measured gradients display the influence of a warm water flow which enters the hole at 835' (254.6m). A background thermal gradient of approximately 95°C/km is interpreted from the bottom hole temperatures.

Water from the flowing zone was sampled at the surface and is seen to be highly saline with $Na^+$, $Cl^-$, $Mg^{++}$, $HCO_3^-$ being the dominant ions. A clear, colourless, non-flammable gas observed bubbling up the well is assumed to be dominantly carbon dioxide. Geothermometer estimates are variable with the most encouraging being the quartz conductive model which yields temperatures of 85.3°C and 115.7°C in two samples. Chalcedony precipitation and surface groundwater dilution probably yield a lower estimate of equilibrium temperatures.

# 2. INTRODUCTION

## 2.1 Terms of Reference

Nevin Sadlier-Brown Goodbrand Ltd. was engaged by the Geological Survey of Canada under Department of Supply and Services Contract Serial Number OSB82-00238, to manage helicopter-supported drilling operations and conduct thermal studies of a borehole at Mount Cayley in southwestern British Columbia. The scientific authority was Dr. J.G. Souther of the Geological Survey of Canada.

Nevin Sadlier-Brown Goodbrand Ltd. selected a diamond drilling contractor, and provided a geologist and support for management of mobilization and demobilization, drill supervision, core logging and downhole temperature surveying. This final report summarizes the work performed and results obtained under this contract.

Measurement units in this report are in metric with the exception of drillhole depths which were reported by the driller in feet (metric equivalents are presented in brackets).

## 2.2 Location, Access and Topography

The drill site is situated in the upper Shovelnose Creek drainage, one kilometre southeast of Wizard Peak, a dacite pile which is part of the Mount Cayley volcanic complex in southwestern British Columbia (Figure 1). The site is at treeline at elevation 1540m (5050') on the eastern bank of Shovelnose Creek.

From Vancouver, the Mount Cayley area is north 40km on Highway 99 to Squamish and about 50km on well maintained logging road to Shovelnose Creek in the Squamish River valley (Figure 2). Access to the drill site is by helicopter, a distance of 7km northwest from the staging point at Mile 33 on the Squamish Main logging road. The vertical lift by helicopter is 1450m.

The topography in the area is extremely rugged. Peaks range in elevation to nearly 2400m (8000') and maximum relief is about 2300m (7700'). Uplift has in places, left isolated blocks of the gently undulating Eocene erosional surface (between approximately 1200m (4000') and 1800m (6000')) amidst rugged peaks of the glacially sculptured Coast Mountains. Drainage is immature and stream courses are commonly structurally controlled.

The Mount Cayley edifice has a topography typical of the Garibaldi Belt volcanics. The large domes and piles of extrusive rock have afforded erosional protection to the underlying basement while uplift and glaciation have greatly oversteepened the slopes on the volcanics. The effect is to produce rugged ramparts of volcanic rock with near vertical faces.

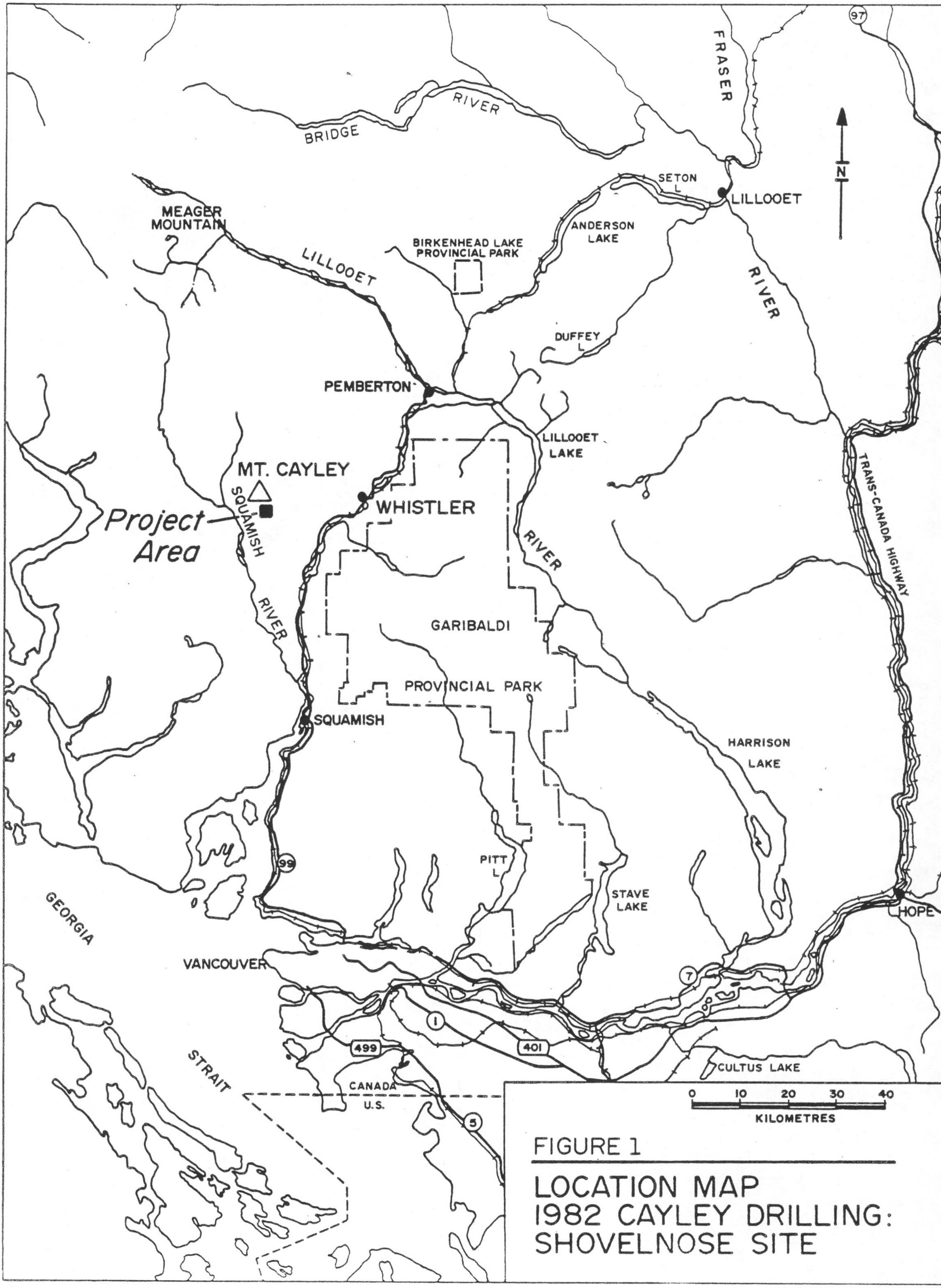



FIGURE 1

LOCATION MAP
1982 CAYLEY DRILLING:
SHOVELNOSE SITE

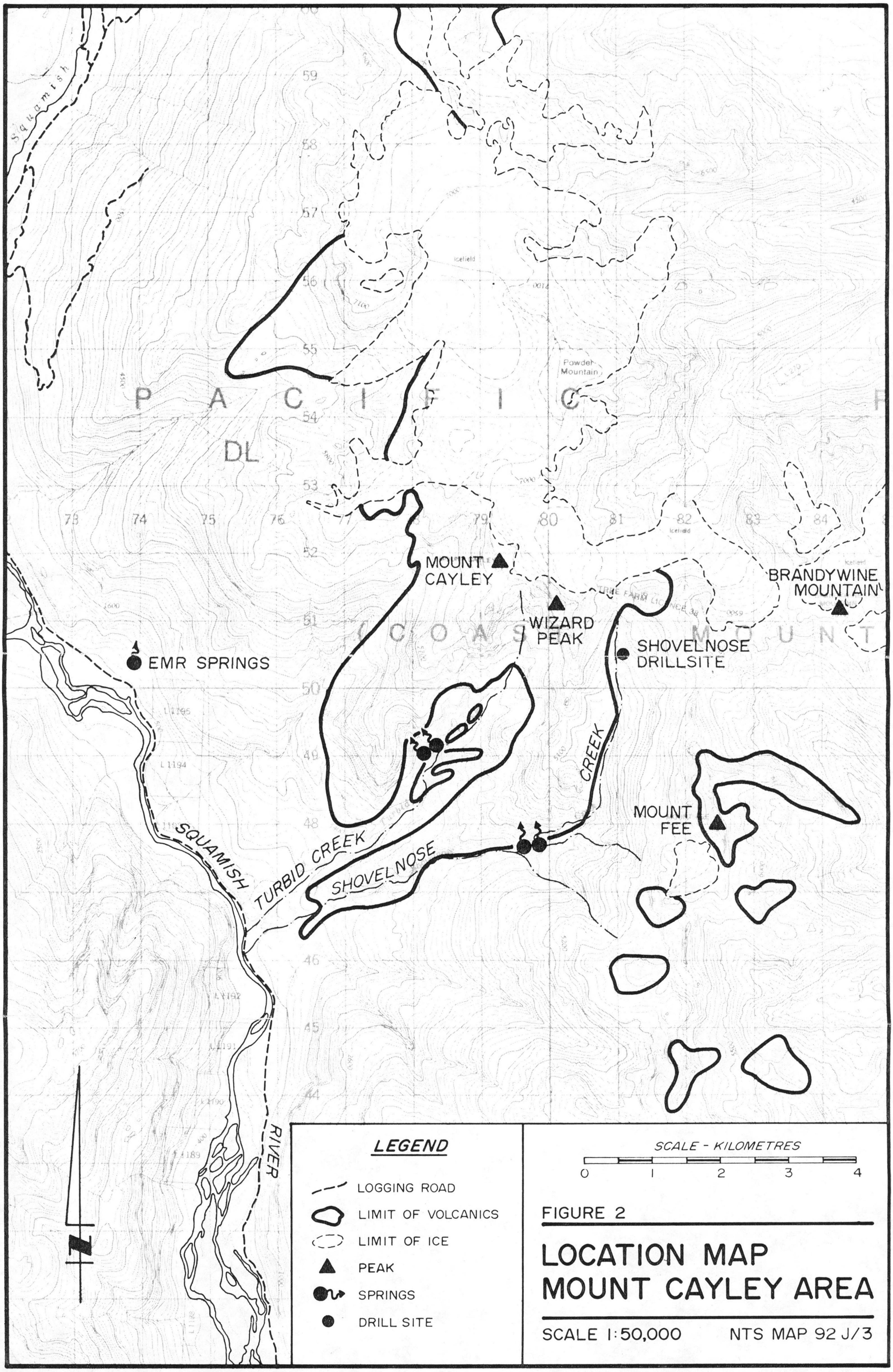



FIGURE 2

## LOCATION MAP MOUNT CAYLEY AREA

SCALE 1:50,000 NTS MAP 92 J/3

## 2.3 Geological Setting

Basement rocks of the Coast Mountains are mainly of plutonic origin emplaced primarily in the late Upper Cretaceous with compositions ranging from diorite through quartz monzonite. About fifty percent of the Coast Plutonic rocks are comprised of quartz diorite and granodiorite (Roddick and Hutchinson, 1974). Lenses of metamorphosed sediments and volcanics which predate the plutonic activity generally occur in long steeply dipping lenses usually trending north-northwest. These rock types form the basement stratigraphy in the immediate vicinity of Mount Cayley.

Associated with the placement of the Coast Plutonic Intrusives are several stages of volcanic activity. In southwestern British Columbia the latest activity is represented by the Cenozoic Garibaldi Volcanic Belt of which the Mount Cayley assemblage is a member. Extrusive rocks at Mount Cayley vary in composition from basalt to rhyodacite with the bulk being dacite. Endogeneous and exogenous domes, piles, and flows are all visible in the project area.

The drill site is situated on the eastern contact of the main volcanic pile and quartz diorite basement. Several stages of volcanic activity are visible from the site and numerous porphyritic dykes were observed in the quartz diorite in the upper Shovelnose Valley.

## 2.4 Previous Work

In 1974, Nevin Sadlier-Brown Goodbrand Ltd. (NSBG, 1974) under contract to B.C. Hydro and Power Authority included the central Garibaldi Belt in a geothermal study of southwestern British Columbia. An aerial infrared scan was flown over the Mt. Cayley Complex at this time.

Studies focusing on the geothermal potential of the Mt. Cayley area by Energy, Mines and Resources, Canada (EMR) began during the late 1970's. In the fall of 1977, two shallow diamond drill holes were completed in the Squamish valley on the western flanks of the Mt. Cayley Volcanic Complex. Geothermal gradients of 52.2 and 66.1°C/km were encountered, indicating the potential of a high-temperature thermal regime in this study area (Lewis, 1977). Subsequently, three more holes have been drilled (Souther, personal communication). Two diamond drill holes in the vicinity of Turbid and Shovelnose Creeks (Cayley 1 and Cayley 2) both indicate geothermal gradients of about

100°C/km. A fifth hole, drilled during the autumn of 1981 on Brandywine Creek east of the Mt. Fee Complex, shows a gradient of about 50°C/km (Souther, personal communication).

Souther (1980) conducted detailed geological mapping in the central Garibaldi Belt. Several volcanic centres were identified along the north-south trending Squamish-Cheakamus divide. Geological mapping outlined the complex volcanic stratigraphy in the Cayley area. The study discovered two groups of thermal springs within the Mt. Cayley Complex ranging in temperature from about 18°C to 40°C. In addition, a dipole-dipole, DC resistivity survey was performed in the higher elevations over plutonic basement rock adjacent to the Mt. Cayley volcanic centres (Souther, personal communication).

## 3. DRILLING

Iron Mountain Drilling Ltd. was selected as the diamond drill contractor for the project. A Longyear Super 38 was moved from the Squamish Main logging road to the site on August 23, 1982 with drilling commencing the following day. The hole was designated Shovelnose One (SN-1).

SN-1 was collared with BW casing (73.0mm O.D.) to 20' (6.1m) and drilling to depth followed with BQ equipment (60mm hole dia). The penetration rate was exceptional with over 60m drilled in each of the first two days. Drilling was then brought to a virtual halt in highly altered and fractured quartz diorite. Binding and squeezing of the drill rods threatened to break the string and cementing was attempted several times to stabilize the hole.

Each cement job was unsuccessful and little cement was encountered when the hole was redrilled. It was suspected that the fractured rock was taking the cement plug. At 516' (157.3m) a slurry of high-early-strength cement was placed at the bottom of the hole. The drill rods were pulled off bottom 200' (61m) and flushed until clean water appeared at surface. The following morning the drill string was discovered stuck in the hole. After considerable effort the hole was abandoned with seven drill rods and a core barrel unrecovered. Traces of cement were observed on one of the recovered rods.

The drill was moved approximately one metre northeast in order to drill a parallel hole. NQ drilling equipment was brought in to the site. The second hole, Shovelnose Two, was collared with NW casing (88.9mm O.D.) to 30' (9.2m) and cemented. Drilling proceeded with NQ (75.7mm hole dia.) to 630' (192.1m) then was reduced to BQ to a total depth of 1500' (457.3m). Very blocky ground was encountered at similar depths to SN-1 but a mixture of bentonite and organic polymer mud in this zone sufficiently stabilized the hole so that no cementing was required.

## 4. CORE GEOLOGY

### 4.1 Introduction

As expected, SN-1 and -2 display considerable similarity in lithology, alteration, precipitates and structure. Good correlation between rock types was noted with the exception that the depth of intersection of distinct dykes and structures are slightly shallower in SN-1 indicating steeply dipping structure trending roughly northwest. Steeply dipping dykes mapped at surface also trend northwest. It is considered that binding in SN-1 may have been caused by drilling along steeply dipping fractures.

The following descriptions of the core will concern the general bore intersection with hole-specific comments added where substantial differences exist.

### 4.2 Core Lithology

Shovelnose core comprises moderately to strongly altered quartz diorite intruded by numerous dykes of varying size and composition. The quartz diorite exhibits a uniform, medium-grained texture with equant feldspar and quartz grains 1-2mm in diameter. In thin section, strongly zoned plagioclase grains are sheared and exhibit some intergrowth. Both feldspar and recrystallized quartz are sutured along grain boundaries indicative of a more recent phase of alteration. Ten to twenty-five percent of the plutonic rock is composed of secondary biotite crystals in books 2 to 5mm in diameter. Biotite distribution and alteration is strongly affected by fracturing and shearing. Foliation in the quartz diorite is generally weak but at times becomes intense near dykes or breccia contacts.

Hypabyssal intrusions into the quartz diorite are numerous and range in composition from andesite to dacite. Three distinct volcanic rock types and at least three different intrusive phases are easily identified. A lavender to medium-grey, hornblende, feldspar, porphyry dacite, most prominent in the first 150m of the hole, exhibits anhedral phenocrysts of feldspar and minor quartz(?) ranging in size from 0.5 to 2mm in an aphanitic groundmass. Hornblende occurs in sparse lathes to 2mm length. Dacite dykes are generally 3 to 5m (10 to 15') in apparent thickness and contact relations are often obscure due to the intensity of fracturing and alteration in these zones. Angular, pebble-sized inclusions of both plutonic and volcanic fragments are common, particularly towards dyke margins. Dacite intrusions are generally more intact, and exhibit a lesser degree of alteration than other dykes. The dacite is part of a later phase of volcanism as evidenced by crosscutting relations with an earlier andesite dyke at 216' (65.8m) in SN-1.

A medium to dark grey, fine-grained andesite is present numerous dykes ranging in apparent width from 0.5 to 4.5m (2 to 15') and often occuring in swarms. The andesite typically contains small altered hornblende phenocrysts within a uniform aphanitic groundmass. Contact relations are unclear because of the incompetent nature of the rock.

A third intrusive of minor extent is a dark grey-green, aphanitic andesite.

Additionally, numerous breccias occur throughout the core suggesting a violent intrusive character. Breccias consist of sand to pebble-sized angular fragments of kaolinized dacite and quartz diorite. Breccia dykes often occur in zones of weakness such as on the border of other dykes and in shear zones and range in size from 2cm to several metres. The most notable of these breccias is seen at 941' to 952' (286.9-290.2m). Here a coarsely brecciated dacite (3cm clasts) is intensely bleached to a chalky white colour.

### 4.3 Alteration and Mineral Precipitates

Rock in the Shovelnose drill holes exhibits various phases of alteration. The earliest alteration consists of secondary biotite which pervades the bulk of the core, most commonly in the quartz diorite and locally in older volcanic dykes. The biotite is present in books to 5mm diameter which are deformed around other grains to conform with the continuous fabric of the core.

A regional weak propylitic alteration variably affects all of the mafics present. The secondary biotite exhibits chloritic fringes, and hornblende in the plutonic rock is largely replaced by chlorite. Buff to olive clays are found on most fractures throughout the hole. Additionally, feldspars exhibit weak sausseritization in most grains.

A pervasive argillic alteration (kaolinite) has replaced most plutonic feldspars to a moderate degree. Interstitial clays are common throughout the quartz diorite. Pervasive argillic alteration occurs in dykes to a lesser and more variable degree. Localized zones of strong silicification have flooded the rock at 1063'-1210' (324.1-368.9m). The core contains extensive fine-grained quartz and some salmon pink k-feldspar.

Near zones of dyke contact or brecciation intense alteration commonly reduces the core fabric entirely to clay and quartz grains. Numerous zones of broken rock where core recovery is poor (at 400'-540', 122.0-164.6m) may be attributed to the washing of the clay fraction. Return flow from the drill casing often displayed a milky colour suggesting clay washing.

Precipitates are common on most fracture surfaces. Clay coatings predominate throughout the hole with a carbonate-clay or clay-hematite-magnetite assemblages occurring locally. Some zones, spacially associated with dykes, exhibit a nondescript black coating in thicknesses to 5mm cutting across the core. This black mineral is probably a manganese oxide; (ie. psilomane, pyrolucite, wad). Gypsum and carbonate also occur as scaley coatings.

Primary vein minerals consist of carbonates, epidote and quartz. Carbonates occur as cryptocrystalline coatings and rarely as macro-crystalline fillings, both usually in or near volcanic dykes. Epidote and quartz are present locally, and usually in association with carbonate-clay precipitates, sericitic alteration, silicification of the wall rock and sericite on fractures. Epidote can occur in small crystals lining open spaces, or as broad (5-10cm) zones of flooding sometimes with a quartz centre and silicic wall alteration to 10cm width.

Sulphides are notably lacking with the exception of extremely fine-grained, disseminated pyrite, often in cubes and occurring periodically throughout the core.

## 4.4 Structure

Intense tectonic activity and repeated intrusions have resulted in a complex structural pattern in the Shovelnose core. Fracturing is highly disordered with only a few distinct joint sets identifiable. In a number of zones, ragged sub-vertical fractures cut the core. More common however, are "broken zones" consisting of closely spaced (1-3cm) randomly oriented fractures. These zones are typically present in the vicinity of hypabyssal intrusions though long sections of quartz diorite are similarly affected.

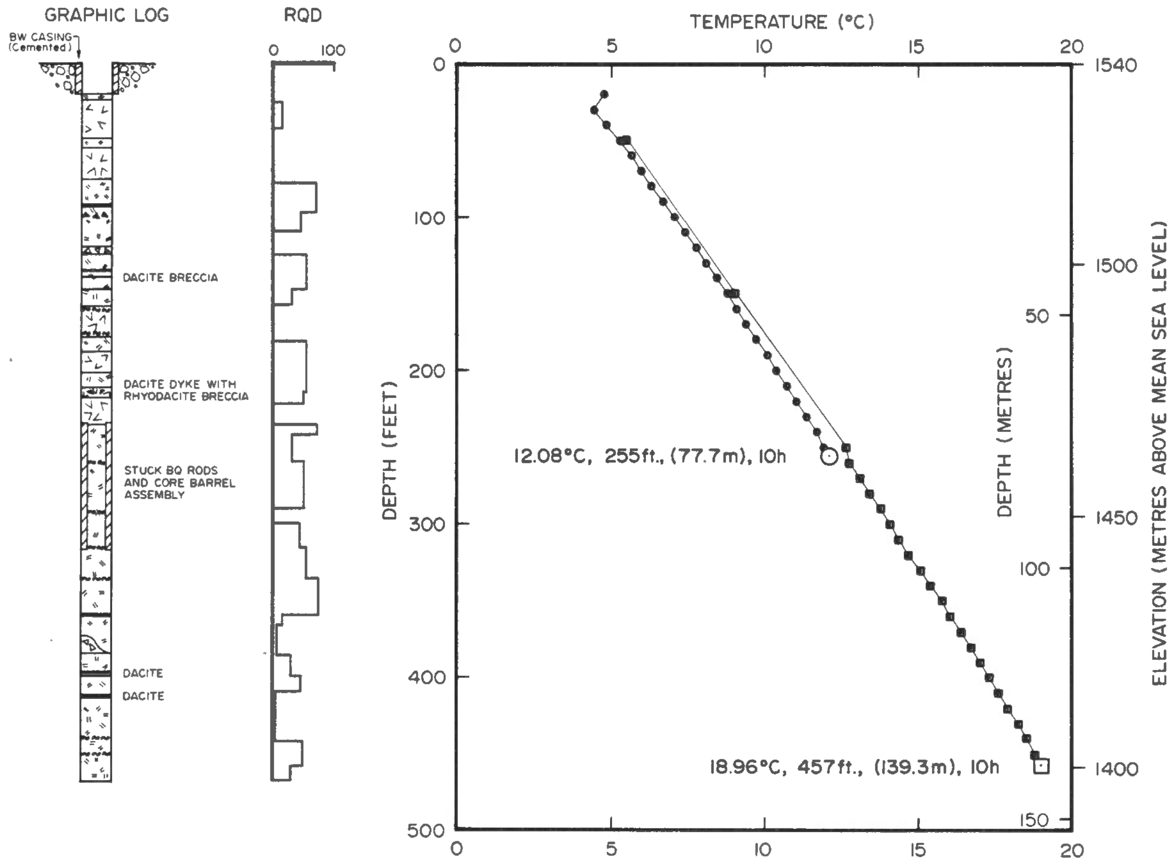
Foliation is only weakly developed except near zones of alteration and shearing, where a gneissic texture is developed. Attitudes are difficult to determine but are usually at moderate angles to the core axis.

## 5.0 TEMPERATURES

Downhole temperature traverses were conducted at the end of the twelve hour period between drilling shifts. Each traverse overlapped the previous one at 50' (15.2m) intervals and surveyed the newly drilled hole at 10' (3.1m) intervals (Figures 3 & 4). Upon reaching total depth and after a 14 hour stabilization period, the entire hole was surveyed at 10' (3.1m) intervals (Figure 5).

Downhole temperatures were measured with a thermistor-based transducer read with a resistance bridge both on loan from the Earth Physics Branch of EMR. The tool was run inside of the drill rods except for the last 2m where the bit was lifted off bottom to allow an undisturbed bottom hole temperature measurement. The data quality is good although flow in the hole resulted in a few unsteady measurements.

A major upward fluid flow from about 835' (254.6m) is observable in the final traverse. Minor flows out of the formation are evident throughout the hole. Bottom hole temperatures, which most accurately represent the undisturbed rock temperature and therefore the insitu thermal gradient, display two distinct gradients. The upper gradient is 105°C/km and the lower is 87°C/km with the inflection at the main source of warm water inflow (835', 254.6m). This observation reflects the effect of a warm water flow travelling transverse to the bore over a lengthy period of time. The flow acts as a heat source and serves to raise and




## *LEGEND*

**LITHOLOGIES**

OVERBURDEN – Recent alluvium.

DACITE – Medium grey hornblende feldspar porphyry dykes, locally brecciated.

ANDESITE 1 – Medium grey hornblende porphyry dykes.

ANDESITE 2 – Dark grey-green aphanitic dykes.

QUARTZ DIORITE – medium to coarse grained plutonic rock exhibiting minor foliation; extremely variable alteration.

**STRUCTURES**

Sharp Contact

Fault

Shear or Shear Zone

Breccia

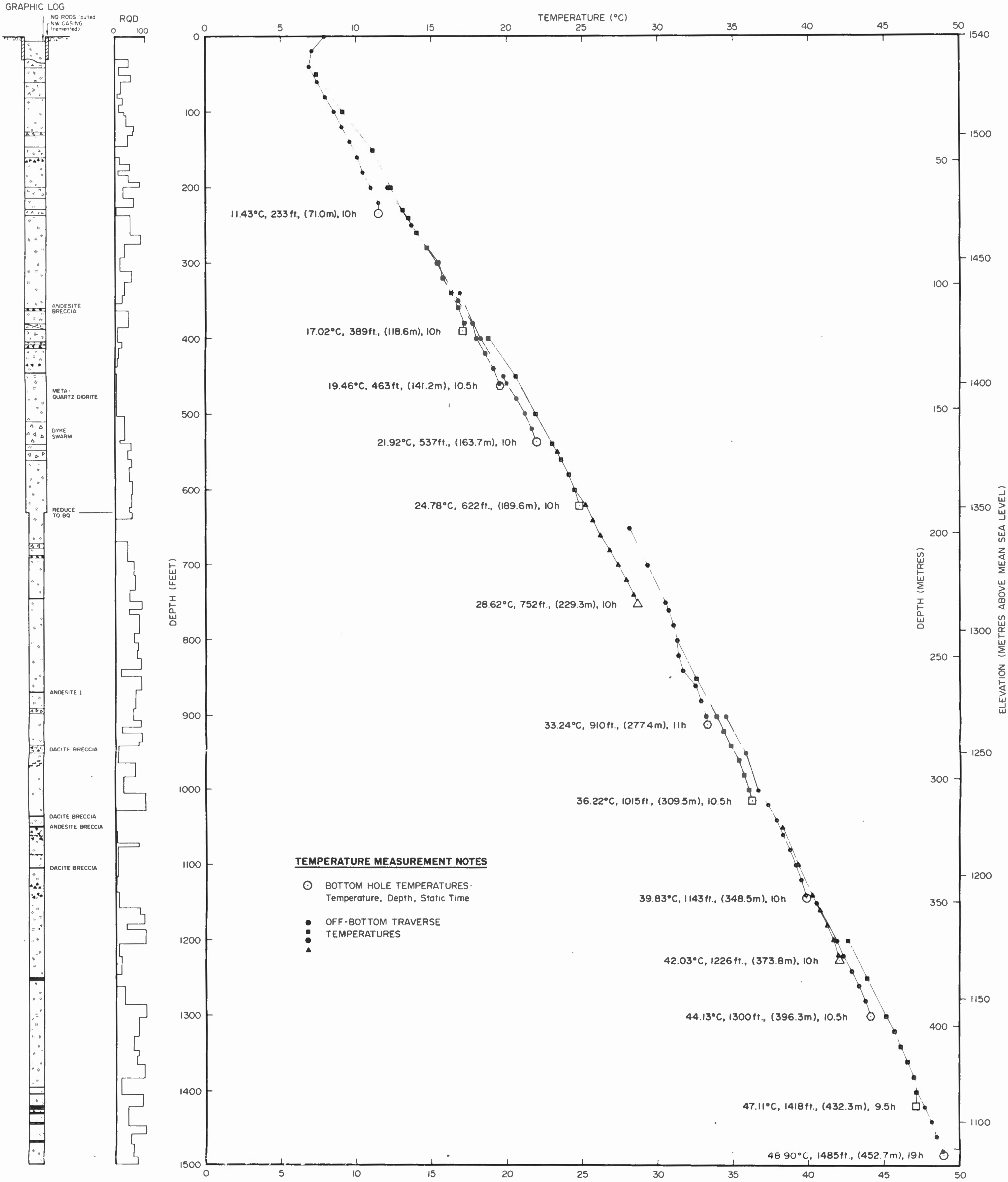
**TEMPERATURE MEASUREMENT NOTES**

⊙ BOTTOM HOLE TEMPERATURES: Temperature, Depth, Static Time

● ■ OFF-BOTTOM TRAVERSE TEMPERATURES

**FIGURE 3**

# TEMPERATURE PROFILES AND GRAPHIC LOG – SHOVELNOSE ONE




## *LEGEND*

**LITHOLOGIES**

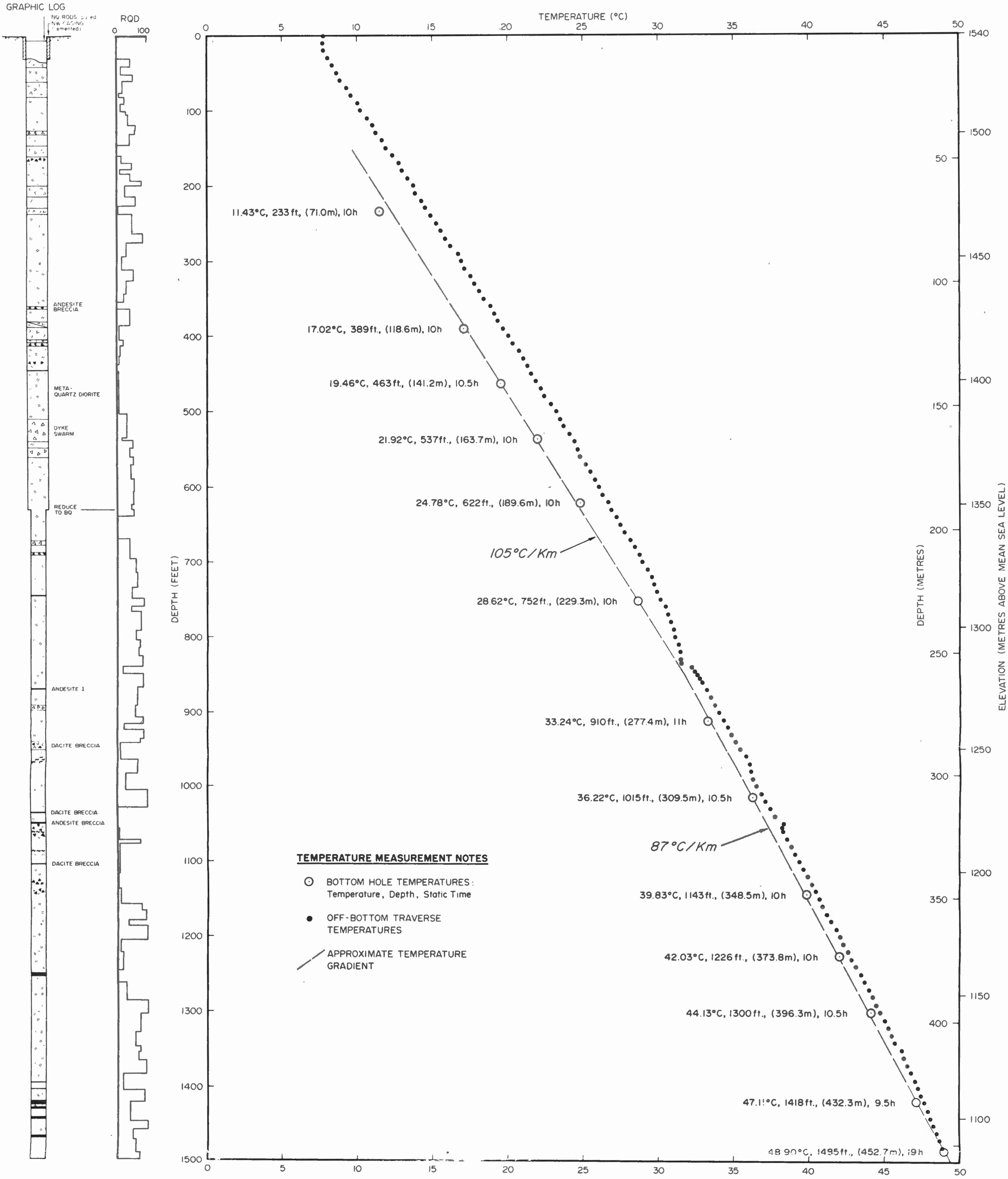
- OVERBURDEN – Recent alluvium.
- DACITE – Medium grey hornblende feldspar porphyry dykes, locally brecciated.
- ANDESITE 1 – Medium grey hornblende porphyry dykes.
- ANDESITE 2 – Dark grey-green aphanitic dykes
- QUARTZ DIORITE – medium to coarse grained plutonic rock exhibiting minor foliation; extremely variable alteration

**STRUCTURES**

- Sharp Contact
- Gradational Contact
- Fault
- Shear or Shear Zone
- Breccia

**FIGURE 4**

**TEMPERATURE PROFILES AND GRAPHIC LOG – SHOVELNOSE TWO**




## *LEGEND*

**LITHOLOGIES**

- OVERBURDEN – Recent alluvium
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- ANDESITE 2 – Dark grey-green aphanitic dykes
- QUARTZ DIORITE – medium to coarse grained plutonic rock exhibiting minor foliation; extremely variable alteration

**STRUCTURES**

- Sharp Contact
- Gradational Contact
- Fault
- Shear or Shear Zone
- Breccia

**FIGURE 5**

**FINAL TEMPERATURE TRAVERSE AND GRAPHIC LOG – SHOVELNOSE TWO**

lower the gradients respectively, above and below the flowing layer (Lewis, 1977). The true gradient lies between the two values, probably near 95C/km (T. Lewis, Pers.Comm.). This gradient is about three times the globally averaged gradient.

## 6.0 HYDROGEOCHEMISTRY

During the early stages of drilling SN-2, the hole produced minor quantities of water. As drilling progressed, traces of a colourless, non-flammable gas began to effervesce out of solution and the outflow increased.

At 917' (279.6m) the flow rate stabilized at 1-2 L/min and gas was bubbling constantly from the hole. Sample 54 was recovered from the top of the casing after a 12 hour static period during which no hole disturbance took place.

The hole continued to produce water and gas at similar flow rates until T.D. at 1500' (457.3m). Sample 34 was taken 16 hours after the hole was completed. The measured pH was between 6.5-7.0 and the conductivity was 3400 µmhos (measured at the time of sampling).

The sampling treatment is summarized as follows:

Cations - 245ml, 40µ filter, 5ml $HNO_3$ acid added
Anions - 250ml, 40µ filter
$SiO_2$ - 20 ml sample, 40µ filter, 180ml distilled water added

The results of two suites of analyses with applicable geothermometer calculations are shown in Table 1.

Of immediate interest is the concentration of sodium and chloride ions which is exceptionally high for thermal water from the Garibaldi Belt. High carbonate can be considered indicative of the presence of carbon dioxide gas.

The Na-K-Ca geothermometer appears to be influenced by high Mg and after incorporating an Mg correction (after Fournier and Potter, 1979) yields temperatures of 32.2 and 37.5°C close to the temperature of the inflow to the borehole (31.5°C). This suggests that the fluid may be in equilibrium with the rock in the bore. However until a source for the Mg can be determined, the validity of either of these geothermometers is in question. The quartz conductive model for the $SiO_2$ geothermometer yields temperatures of 85.3°C and 115.7°C possibly indicating a more encouraging past

TABLE 1 - HYDROGEOCHEMISTRY OF SHOVELNOSE 2 WATER

| Sample No. | Hole Depth | Ca | Mg | Na | K | Fe | Mn | Sr | Li | Cs | $HCO_3$ | F | Cl | $SO_4$ | $SiO_2$ | TDS | Quartz Conductive | Chemical Geothermometer Results (°C) | | | Na/Li |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | | | | | | Chalcedony | Na-K-Ca | Na-K-Ca-Mg | |
| SN2-34 | 1500' (457.3m) | 272 | 105 | 780 | 32.4 | 175 | 1.52 | 1.94 | 1.06 | <0.05 | 2317 | 0.36 | 685 | 88.3 | 66.6 | 0.272% | 115.7 | 85.3 | 140.6 | 37.5 | 97.6 |
| SN2-54 | 917' (279.6m) | 311 | 135 | 880 | 37.6 | 432 | 1.95 | 1.86 | 1.24 | <0.05 | 2613 | 0.18 | 810 | 106 | 37.6 | 0.260% | 89.1 | 56.4 | 142.6 | 32.2 | 99.8 |

All results reported as ppm.

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temperature. Fluid dilution may be suppressing the silica-indicated temperatures. The chalcedony equilibria geothermometer suggests temperatures of 56.4°C and 85.3°C although deposition of chalcedony was not observed in the core. This geothermometer may also yield conservative results due to dilution. Reasonable correlation with the conductive silica temperatures is achieved with the less understood Na/Li geothermometer which yields 97.6 and 99.8°C (Fouillac and Michard, 1981). Rock lithium content, however, can produce erratic results with this method.

High iron content can be explained by the presence of the drill rods in the hole during sampling. A rusty tinge to the water was noted especially after long equilibrium times. Other impurities from the drilling process should be minimal as little mud or cement was used in SN-2.

## 7. DISCUSSION

The Shovelnose core penetrates a typical quartz diorite of the Coast Plutonic Complex. The unit is characterized in the immediate area of the drill site by pervasive secondary biotite and a minor to moderate degree of hydrothermal alteration consistent with the proximity to units of the Mount Cayley volcanic complex. Three distinct phases of volcanic dyke intrusion can be recognized in the drill site vicinity and in the core.

Lateral flow of warm water at a depth of about 835' (254.6m) has disturbed the temperature gradient in the hole. A gradient of 95°C/km is assumed to approximate the pre-flow gradient. This gradient is similar to drill hole results from near the base in slope on Shovelnose Creek and Turbid Creek (Souther, pers.comm.). Comparable gradients have been measured at the Meager Creek volcanic complex to the north, near the edges of the near surface convective hot zones. There is a striking similarity between the observed Cayley phenomena and Meager Creek data in regard to both geology and temperature.

Upflow of water in Shovelnose 2 suggests the intersection of the source water of Shovelnose (and possibly Turbid Creek) warm springs. The water chemistry of both SN-2 and Turbid Creek springs are anomalously high in magnesium, the source of which is probably common but as yet undetermined. The elevation of the water flow is approximately 4000' AMSL (1220m) and, since the hydraulic gradient can be expected to be generally downslope, it is reasonable to expect that the thermal waters are emanating from under the Wizard Peak - Mt. Cayley pile. Since the granitic terrane distal from the volcanic activity is massive and virtually unfractured, the shattered zone through which the extruded rock rose is proposed as a likely conduit for rising thermal fluids.

The location of such a conduit is uncertain due to the considerable distance through which fracture controlled flow can be expected to move freely. Since the observed thermal water is at 4000' (1220m) elevation the source area must be higher in elevation limiting the target area. A detailed structural examination may assist in this search.

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# Appendix A - Hole Summary Sheets

# DRILLING SUMMARY

WELL: SHOVELNOSE ONE

GENERAL LOCATION: Upper Shovelnose Valley

COORDINATES: 5 550 470m N, 481 050m E

DATE COLLARED: August 24, 1982

DATE COMPLETED: Abandoned September 2, 1982

COLLAR ELEVATION: 5,050 feet (1540m)

TOTAL DEPTH (TD): 516 feet (157.3m)

BEDROCK DEPTH: 8 feet (2.4m)

WATERTABLE DEPTH: --

TEMP AT TD: not measured

HIGHEST TEMP RECORDED: 18.96°C @ 457 feet (139.3m)

TEMP GRADIENT AT BOTTOM: 110°C/km

| CASING: | Type | I.D. | Depth | Cemented? |
|---|---|---|---|---|
| | BW | 2 3/8" (6.030m) | 20 feet (6.1m) | Yes |

| WELL BORE BELOW CASING: | Bit Size | Dia. | Depth Interval |
|---|---|---|---|
| | BQ | 2.36" (5.99cm) | 0-516ft. (157.3m) |

| LINER: | Type | I.D. | Depth | Perforation Interval |
|---|---|---|---|---|
| | NONE | | | |

WELLHEAD (cap, valves, liner hanger or sleeve, etc.):

NONE

| DIP TESTS: | Depth | Angle | Instrument |
|---|---|---|---|
| | NONE | | |

NOTES: 70 feet (21.3m) BQ rods and a BQ core barrel assembly stuck between 235 feet (71.6m) and 317 feet (96.6m). Probably stuck in cement and hole consequently abandoned.

DRILLING SUMMARY

WELL: SHOVELNOSE TWO

GENERAL LOCATION: Upper Shovelnose Valley

COORDINATES: 5 550 470m N, 481 050m E

DATE COLLARED: September 4, 1982

DATE COMPLETED: September 17, 1982

COLLAR ELEVATION: 5,050 feet (1540m)

TOTAL DEPTH (TD): 1,500 feet (457.3m)

BEDROCK DEPTH: 8 feet (2.4m)

WATERTABLE DEPTH: --

TEMP AT TD: 48.90°C

HIGHEST TEMP RECORDED: 48.90°C @ T.D.

TEMP GRADIENT AT BOTTOM: 87°C/km

| CASING: | Type | I.D. | Depth | Cemented? |
|---|---|---|---|---|
| | NW | 3.5" (8.89cm) | 30 feet (9.1m) | Yes |

| WELL BORE BELOW CASING: | Bit Size | Dia. | Depth Interval |
|---|---|---|---|
| | NQ | 2.98" (7.57cm) | 0-630 feet (192.1m) |
| | BQ | 2.36" (5.99cm) | 630 feet (192.1m)-1500 feet (457.3m) |

| LINER: | Type | I.D. | Depth | Perforation Interval |
|---|---|---|---|---|

NONE

WELLHEAD (cap, valves, liner hanger or sleeve, etc.):

NONE

| DIP TESTS: | Depth | Angle | Instrument |
|---|---|---|---|

NONE

NOTES:

Step-off hole from Shovelnose One. About 3 feet (1m) northeast of Shovelnose One.

# Appendix B - Drill Logs

## Shovelnose One

## Shovelnose Two

**NEVIN SADLIER-BROWN GOODBRAND LTD.**

## DIAMOND DRILL LOG SHEET

HOLE SHOVELNOSE #1 SHEET 1 OF 7

### DRILLING LOG

| FROM | TO | % | ROD | DRILLING COND |
|---|---|---|---|---|
| 20 | 30 | 95 | 0 -25- 16 | BW casing set to 20'; attempt to cement to 37' is unsuccessful. |
| 30 | 40 | | | |
| 40 | 50 | 95 | -43- | |
| 50 | 60 | | -0- | |
| 60 | 70 | 95 | 0 | |
| 70 | 80 | | -78- | |
| 80 | 90 | 95 | 71 | |
| 90 | 100 | | -97- 47 | |

GRAPHIC LOG: ALTERATION (PROPYLITIC, ARGILLIC, PHYLLIC, POTASSIC, SILICIFIED) / PRECIPITATES (CARBONATE, GYPSUM, CLAY, EPIDOTE, QUARTZ) / LITHOLOGY STRUCTURE

### GEOLOGIC LOG

| LITHOLOGY STRUCTURE | ALTERATION | PRECIPITATES |
|---|---|---|
| 20-24 Biotite QUARTZ DIORITE; extremely broken, fissile. | Epidote clays are common between quartz grains. | |
| 24-49 Dark grey aphanitic DACITE dyke is intensely fractured "crackled". Remnant hornblende (± biotite) has been strongly chloritized. Rock is soft, friable. Contact attitudes are unclear. Volcanic intrusive is weakly magnetic. | Clay is common throughout. Biotite, hornblende are entirely chloritized. | Calcite infillings occur in most fracture spaces. |
| 49-55 Intensely altered QUARTZ DIORITE is fractured, friable. Uniform texture in equant quartz grains 2mm in diameter. Veinlets containing biotite(?) throughout. | Extensive secondary biotite occurs in books 2-5mm in diameter. Feldspar is replaced by clays, epidote. | |
| 55-76 Feldspar porphyry DACITE. Fracturing and/or shearing is intense throughout. Dacite contains fissile cryptocrystalline volcanic dykes 5-15cm in width in 55-65m. Contacts with quartz diorite are jagged, attitudes unclear (though lower contact roughly follows micro veining). | Epidote and clays are common in and around fractures. Mafics have been moderately chloritized and generally are fringed by red-pink hematite. | Clay is common as a thin fracture filling. |
| 76-92 QUARTZ DIORITE is intensely altered though somewhat more intact. Uniform texture is regularly interupted by thin shear zones containing thin, dark veinlets. | Secondary biotite in books 2-3mm diameter occurs throughout. | Trace carbonates accompany clay on fracture faces. |
| 92-94 Dark grey aphanitic ANDESITE dyke. Sharp, jagged contact at 80° to c.a. | | |

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## DIAMOND DRILL LOG SHEET

HOLE SHOVELNOSE #1 SHEET 2 OF 7

### DRILLING LOG

| FROM | TO | % | ROD | DRILLING COND. |
|---|---|---|---|---|
| 100 | 110 | 95 | 47 -110- | |
| 110 | 120 | | 0 | |
| 120 | 130 | 95 | -125- | |
| 130 | 140 | | 53 | |
| 140 | 150 | 95 | -148- | |
| 150 | 160 | | 31 -158- | |
| 160 | 170 | 95 | 0 | |
| 170 | 180 | | 0 | |

GRAPHIC LOG: ALTERATION (PROPYLITIC, ARGILLIC, PHYLLIC, POTASSIC, SILICIFIED) / PRECIPITATES (CARBONATE, GYPSUM, CLAY, EPIDOTE, QUARTZ) / LITHOLOGY STRUCTURE

### GEOLOGIC LOG

| LITHOLOGY STRUCTURE | ALTERATION | PRECIPITATES |
|---|---|---|
| 94-120 QUARTZ DIORITE. Brecciated zone at 97-98m contains angular volcanic and basement fragments. Texture becomes variable below 105'; some finer grained phases apparent. | Clay and epidote replace feldspars. Mafics are chloritized and secondary biotite is common throughout. Moderate to strong epidote flooding in vicinity of shear zone. | Clay and trace carbonates are present as coatings on fractures and as open space fillings in broken or sheared zones. |
| 120-125.5 Fine grained medium-dark grey ANDESITE. Some remnant hornblende blades occur in cryptocrystalline matrix. | | Carbonates and gypsum coat fracture faces. |
| 125.5-159 QUARTZ DIORITE. Rock is moderately fractured, intensely altered. Texture is variable and foliation is weak. Dark microveinlets occur throughout. Thin volcanic breccia dykes 2-3cm thick intrude at 136', 140', and 148'. Dykes generally kaolinized. | Secondary biotite occurs throughout. Chlorite is present in microveins and as replacement of mafics. Minor epidote fringes veinlets and mafic (chloritic) portions of rock. | Clay and minor gypsum are present on most fracture faces. |
| 159-179 Lavender-dark grey porphyritic DACITE is intensely shattered, cut by several shears. Feldspar and quartz(?) crystals are anhedral ranging in size from 0.5-2mm. | Epidote is common around more prominent fractures. Chlorite after hornblende is present throughout. | Clay and minor gypsum occur on fracture faces. |

NEVIN SADLIER-BROWN GOODBRAND LTD.

## DIAMOND DRILL LOG SHEET

HOLE SHOVELNOSE #1 SHEET 3 OF 7

| FROM | TO | % | RQD | DRILLING COND | LITHOLOGY STRUCTURE | ALTERATION | PRECIPITATES |
|---|---|---|---|---|---|---|---|
| 180 | 190 | 95 | 182, 0 | | 179-188 QUARTZ DIORITE is intensely altered, moderately fractured. Lower contact with dyke is 35° to c.a. | Fine veinlets of chlorite occur throughout. Secondary biotite and epidote replace all original mafics. | Trace magnetite and fine pyrite cubes present on fracture faces. |
| 190 | 200 | | 55 | | 188-202.5 Fine grained medium grey DACITE dyke. Texture is uniform throughout; contains fine chlorite after hornblende in grey groundmass. Contacts are sharp , texture is unchanged. | Epidote forms in alteration envelopes around some fractures and in fractured areas where it occurs in irregular patches. Mafics are chloritized; rock is soft. | Calcite and epidote are common as fracture fillings |
| 200 | 210 | 95 | | | 202.5-212 Medium grained altered QUARTZ DIORITE. Uniform texture throughout. Rock is soft, friable; fracturing is moderate. | Secondary biotite forms books 2-4mm diameter. Minor chlorite and epidote throughout. | Trace magnetite, gypsum on fracture faces. Chlorite (± epidote) common. |
| 210 | 220 | | 215, 50 | | 212-218 DACITE dyke containing extensive chlorite after mafics is intruded and brecciated by later aphanitic RHYODACITE(?) dyke. | | Epidote thinly coats fracture faces. |
| 220 | 230 | 95 | 222, 0 | | 218-219 QUARTZ DIORITE. 219-236 Purple-grey porphyritic DACITE dyke. Highly fractured as rock is relatively hard. | Feldspars are replaced by epidote at dyke margins. | Chlorite is common on fracture faces. Some minor gypsum present. |
| 230 | 240 | | 236, 71 | | Feldspar and quartz(?) crystals up to 2mm diameter. Dyke contains numerous small inclusions. | | |
| 240 | 250 | 95 | 242, 31 | | 236-359 Altered QUARTZ DIORITE. Rock is sheared locally, contains microveins with chlorite. | Secondary biotite is common throughout; particularly near fractures and microveins. Epidote common near fractures and bordering mafics near shears. | Minor clay and gypsum occur in some fractures. |
| 250 | 260 | | 259 | | | Mild kaolinization at 250-251'. | |

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## DIAMOND DRILL LOG SHEET

HOLE SHOVELNOSE #1 SHEET 4 OF 7

| FROM | TO | % | RQD | DRILLING COND. | LITHOLOGY STRUCTURE | ALTERATION | PRECIPITATES |
|---|---|---|---|---|---|---|---|
| 260 | 270 | 95 | | | 236-359 QUARTZ DIORITE. Rock is moderately fractured, locally sheared. Texture is uniform medium grained throughout. | Mafics are entirely chloritized, and are generally rimmed by minor epidote. Large secondary biotite crystals (2-5mm diameter) occur throughout. | Gypsum becomes a prominent precipitate on fracture faces forming thin encrustations. Sparse pyrite and minor magnetite occur in fractures. Massive, microcrystalline chlorite occurs on most fractures, veinlets |
| 270 | 280 | | 51 | | | | |
| 280 | 290 | 95 | | | | | |
| 290 | 300 | | 290, 0 | | Quartz diorite is locally broken, vuggy. Open space filling comprises gypsum, minor clay. | | |
| 300 | 310 | 95 | 300, 43 | | | | |
| 310 | 320 | | 316 | | | Clay alteration is common around fractures associated with shears and broken zones. | |
| 320 | 330 | 95 | 53 | | | | |
| 330 | 340 | | 336, 73 | | Quartz diorite becomes more intact;alteration intensity is slightly decreased. | | Minor epidote flooding along fractures. |

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## DIAMOND DRILL LOG SHEET

HOLE SHOVELNOSE #1 SHEET 5 OF 7

| FROM | TO | % | RQD | DRILLING COND. | LITHOLOGY STRUCTURE | ALTERATION | PRECIPITATES |
|---|---|---|---|---|---|---|---|
| 340 | 350 | 95 | 73 | | 236-359 QUARTZ DIORITE. Rock is moderately fractured, cut by numerous microveins. Texture is uniformly medium grained throughout, with coarse biotite grains. | Mafics, feldspars completely altered to chlorite, epidote. Fresh secondary biotite persists. | Gypsum coats most fracture surfaces. |
| 350 | 360 | | 360 | | | | |
| 360 | 370 | 95 | 17<br>366 | | 359-361 Dark, fine-grained ANDESITE dyke. Sharp, even upper and lower contacts at 40° to c.a. Some parallel (flow?) banding. | | Gypsum and epidote fill fractures at 10° to c.a.<br>Gypsum, chlorite, minor clay in fractures. |
| 370 | 380 | | 8 | | 361-374 Shattered QUARTZ DIORITE. Erratic fracturing and shearing make rock very friable. Some sub-vertical foliation (intrusion stress related?) | Epidote, chlorite replace mafics and feldspars. Secondary biotite throughout. | |
| 380 | 390 | 95 | 386 | | 374-385 Alternating ANDESITE-DACITE dykes and shattered, or sheared QUARTZ DIORITE. Dykes are generally brecciated and contain extensive precipitates. Quartz diorite is "gritty", intensely altered. | | Shattered andesite dyke is healed with calcite, gypsum. Chlorite is common on fractures, where present. |
| 390 | 400 | | 30 | | 385-397 Fractured QUARTZ DIORITE. Medium grained texture with coarse biotite throughout. | More prominent fractures contain epidote flooding with minor hematite present, bounded by 5-15cm argillic envelopes. Secondary biotite persists. | Gypsum coats fractures throughout. |
| 400 | 410 | 95 | 400<br>46 | | 397-400 Medium to fine grained DACITE dyke intruded at head-wall by DACITE(?) breccia.<br>400-412 QUARTZ DIORITE is moderately fractured, alteration intensity somewhat decreased. | Secondary biotite is common; epidote, chlorite are sparse. Moderate argillic alteration. | Epidote, chlorite, gypsum in dyke fractures.<br>Gypsum present on fracture faces. |
| 410 | 420 | | 410<br>3 | | 412-414 DACITE dyke.<br>414-470 QUARTZ DIORITE. | Chlorite after hornblende is predominant. | |

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## DIAMOND DRILL LOG SHEET

HOLE SHOVELNOSE #1 SHEET 6 OF 7

| FROM | TO | % | RQD | DRILLING COND. | LITHOLOGY STRUCTURE | ALTERATION | PRECIPITATES |
|---|---|---|---|---|---|---|---|
| 420 | 430 | 95 | 3 | | 414-470 QUARTZ DIORITE. Medium grained texture is consistent throughout.<br>425-440 Quartz diorite becomes extremely broken, intensely altered. | Secondary biotite throughout.<br>Chlorite, epidote present throughout. Moderate hematite staining in clays near base of broken zone. Some pink k-feldspar is present. | Gypsum present throughout on fractures. |
| 430 | 440 | | | | | | |
| 440 | 450 | 95 | 442<br>48 | | Quartz diorite becomes more intact. | Epidote, chlorite are present as replacement minerals throughout. | Minor epidote along fractures. |
| 450 | 460 | | 459 | | Rock becomes broken; near vertical fracturing is present. | | |
| 460 | 470 | | 29<br>467 | | | | Magnetite, hematite occur in sinuous, sub-vertical veins 1-3mm thick. |
| 470 | 480 | 30 | | Recovery is poor; rods sticking. Persists to TD | 470-485 Highly altered and severely sheared DACITE. Where present, intact rock contains fine grained biotite and feldspar within a buff-white cryptocrystalline matrix. Fragments of quartz diorite 1-3mm diameter occur throughout comprising 30-50%. | 470-485 Extreme kaolinization has occurred within volcanic matrix. | 470-485 Precipitates are obscure because of broken nature of rock. Clay is present along entire section. |
| 480 | 490 | 25 | 0 | | | 485-502 Medium to coarse grained feldspars are almost entirely kaolinized. Trace sericite is present. | 485-500 Clay is present with minor gypsum on fracture/shear faces. |
| 490 | 500 | 50<br>65 | | | 485-496 Strongly sheared QUARTZ DIORITE. | | |

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# DIAMOND DRILL LOG SHEET

HOLE SHOVELNOSE #1 SHEET 7 OF 7

| DRILLING LOG | | | | | GRAPHIC LOG | GEOLOGIC LOG | | |
|---|---|---|---|---|---|---|---|---|
| FROM | TO | % | RQD | DRILLING COND | ALTERATION / PRECIPITATES / LITHOLOGY STRUCTURE | LITHOLOGY STRUCTURE | ALTERATION | PRECIPITATES |
| 500 | 510 | 65<br>85 | 0 | | | 496-515.5 Purple-dark grey META-QUARTZ DIORITE. Weak foliation is imparted by aligned biotite-hornblende. Rock is competent though still shattered. Crystal outlines are hazy suggesting moderate re-crystallization. | 502-515.5 Weak to moderate argillic alteration (with weak propylitic?) is obscured by later recrystallization. | 500-515.5 Minor clay and gypsum present on fracture faces. |
| 510 | 520 | 90 | | 515.5 Hole is lost (cemented rods in). | | | | |

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## DIAMOND DRILL LOG SHEET

HOLE SHOVELNOSE #2 SHEET 1 OF 19

| FROM | TO | % | ROD | DRILLING COND | LITHOLOGY STRUCTURE | ALTERATION | PRECIPITATES |
|---|---|---|---|---|---|---|---|
| 0 | 6 | | | Triconed with 4" bit-good progress. | Overburden - assorted boulders of basement and volcanics. | | |
| 6 | 30 | | | NW casing set and cemented to 30' | QUARTZ DIORITE basement cut by volcanic dykes. | | |
| 30 | 40 | 80 | 30 46 | | 30-35 Near vertical, irregular contact between QUARTZ DIORITE and grey, fine grained DACITE. 35-41 Grey, fine grained DACITE. | 30-35 Moderate-high argillic alteration, moderate propylitic alteration. | 30-35 Clay precipitate on all fractures, buff coloured. 35-41 Clay-carbonate precipitate on fractures. |
| 40 | 50 | 90 | 41 13 | | 41-47 Broken QUARTZ DIORITE, moderate foliation at ~60° to c.a. although variable. 47-48.5 Grey DACITE. 48.5-60 Homogeneous, moderately | 41-47 Minor propylitic and argillic alteration. 47-48.5 Trace propylitic. 48.5-60 Moderate, propylitic | 41-47 Clay precipitate (buff coloured) 47-48.5 Clean fracture surface 48.5-60 Green to buff clay |
| 50 | 60 | 90 | 51 54 60 | | foliated, biotite QUARTZ DIORITE, 20% quartz, 60% feldspar, 20% mafics - especially blebs and books of secondary biotite to 1cm | alteration of original mafic minerals, trace argillic. | precipitate on all fractures |
| 60 | 70 | 85 | 20 | | diameter. 49.5-50 Small dacite dyke. 60-80.5 Medium grey, hornblende, feldspar porphyry DACITE. Randomly oriented hornblende blades to 1cm length. Upper contact broken. | 60-80.5 Secondary biotite blebs pervasive. Trace chlorite alteration pervasive. | 60-80.5 Hematite pervasive throughout core. Clay (yellow-green) present on most fractures. Some veins epidote to 2mm thick. |
| 70 | 80 | 90 | 76.5 8 | | Lower contact ~45° to c.a. Rather broken with various fracture angles. Crystal outlines hazy throughout. | | |

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## DIAMOND DRILL LOG SHEET

HOLE SHOVELNOSE #2 SHEET 2 OF 19

| FROM | TO | % | ROD | DRILLING COND. | LITHOLOGY STRUCTURE | ALTERATION | PRECIPITATES |
|---|---|---|---|---|---|---|---|
| 80 | 90 | 90 | 80.5 25 | | 80.5-126 Variably foliated QUARTZ DIORITE. Core competence improves with depth. 95-103 Zone permeated with fine volcanic veinlets associ- | 80.5-126 Nearly all original mafics gone. Moderate argillic alteration throughout. Removes only the plagioclase feldspar to a light green | 80.5-126 Bands of biotite in some places to 5cm thick. Crusty yellow mineral with mamillary texture coats some fractures, no fizz |
| 90 | 100 | 70 | 91 13 | | ated with zones of fine breccia and stockwork of unknown dark mineral (psilomane?) and hematite. Broken core through this zone. | clay. Secondary biotite fairly fresh with indistinct outlines. Alteration decreases below 115m. | (dolomite?). Minor quartz veining. Pervasive hematite in small blebs and on fractures. |
| 100 | 110 | 80 | 100.5 31 105 | | | | Some epidote, minor clay precipitate on most fractures |
| 110 | 120 | 95 | 38 119 | | | | |
| 120 | 130 | 95 | 63 126 60 | | 126-131 Dark grey hornblende, porphyry ANDESITE-fine grained phenocrysts and very hard groundmass. Breaks along very fine hairline fractures. .7cm section of QUARTZ DIORITE at 128.5m. | 126-131 Quite fresh. | 126-131 Mild carbonate fizz in yellow-green clayey precipitate which appears on all hairline fractures. |
| 130 | 140 | 95 | 131 42 | | 131-146 Medium grained QUARTZ DIORITE, upper contact at 45° to c.a. Lower contact broken. Homogeneous with poorly developed variable foliation. | 131-146 Trace pervasive argillic, moderate propylitic (chloritization of original mafics). Secondary biotite blebs are quite | 131-146 Green to buff clayey precipitate on most fractures, no fizz, possible MnO on many fractures. Trace magnetite. |
| 140 | 150 | 70 | 146 | 146-160 Poor core recovery due to broken rock. | 10cm section of cemented, medium-grained volcanic breccia at 142m. 146-160 Feldspar, hornblende? porphyry DACITE--quite broken | fresh. 146-160 No visible hornblende phenocrysts left--only | 146-160 Green to buff clay on most fractures, no fizz. |

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## DIAMOND DRILL LOG SHEET

HOLE SHOVELNOSE #2 SHEET 3 OF 19

GRAPHIC LOG — ALTERATION: PROPYLITIC, ARGILLIC, PHYLLIC, POTASSIC, SILICIFIED / PRECIPITATES: CARBONATE, GYPSUM, CLAY, EPIDOTE, QUARTZ / LITHOLOGY STRUCTURE

| FROM | TO | % | RQD | DRILLING COND. | LITHOLOGY STRUCTURE | ALTERATION | PRECIPITATES |
|---|---|---|---|---|---|---|---|
| 150 | 160 | 70 | 0 | | with considerable secondary biotite--upper and lower contacts broken--possible weak foliation in biotites. Dark grey in colour. | pseudomorphs of (chlorite?) clay--secondary biotite slightly altered. Feldspar quite fresh. | Hematite stain pervasive in the core. Very thin quartz veneer on some fractures. |
| 160 | 170 | 85 | 160<br>15<br>169 | | 160-163 QUARTZ DIORITE<br>163-165 Volcanic-basement breccia clasts to 4cm diameter. Generally angular and of various composition. | 160-163 As above.<br>163-165 Matrix moderately altered to clay. | 160-163 As above. |
| 170 | 180 | 90 | 50<br>178.5 | | 165-199 Medium grained QUARTZ DIORITE. Variably foliated (weak). Periodic thin, breccia filled dykes of light and dark grey volcanics up to 1cm thick | 165-199 Moderate pervasive propylitic alteration of original mafics. New biotite is fresh. Moderate argillic alteration from 165-169m. | 165-199 Periodic epidote veins and disseminated. Very fine disseminated pyrite. |
| 180 | 190 | 95 | 10<br>183.5<br>44 | | Broken in some zones.<br>182-182.5 Grey hazy volcanic dyke. Probable dacite as per 146-160m. | | Trace magnetite throughout. Buff-green clay precipitate on most fractures. Thin veneers of silica on some fractures. |
| 190 | 200 | 95 | 193<br>83<br>199.5 | | | | Some fractures coated with black precipitate, very fine grained mafic since chloritized or Mn oxide-hardness 3-4- not magnetite. |
| 200 | 210 | 95 | 28 | | 199-213.5 Fine grained, medium grey volcanic dyke. Visible hornblende needles and blotchy fine white feldspar crystals. Probable DACITE. Lower contact | 199-213.5 Possible trace propylitic alteration, mostly quite fresh looking. Moderate argillic alteration in places near 202, 208'. | 199-213.5 Minor clay-carbonate precipitate on most fractures. Some carbonate veining near broken zones, some epidote veins. |
| 210 | 220 | 85 | 213.5<br>63 | | at 70° to c.a.<br>213.5-228 QUARTZ DIORITE as in 165-169m. Small volcanic dykes frequent, 1cm-10cm thick. | 213.5-228 As per 165-169'. Trace of sericite? very fine flashy crystal faces on altered fracture surfaces. | 213.5-228 As per 165-169'. Trace hematite stain locally around some fractures. |
| 220 | 230 | 85 | 226 | | Lower contact at 45° to c.a.<br>228-237 Feldspar porphyry DACITE. Very broken dyke. Medium grained | 228-237 Relatively fresh except chloritized mafic minerals | 228-237 Epidote, chlorite, Mn oxides on most fractures. |

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## DIAMOND DRILL LOG SHEET

HOLE SHOVELNOSE #2 SHEET 4 OF 19

GRAPHIC LOG — ALTERATION: PROPYLITIC, ARGILLIC, PHYLLIC, POTASSIC, SILICIFIED / PRECIPITATES: CARBONATE, GYPSUM, CLAY, EPIDOTE, QUARTZ / LITHOLOGY STRUCTURE

| FROM | TO | % | RQD | DRILLING COND. | LITHOLOGY STRUCTURE | ALTERATION | PRECIPITATES |
|---|---|---|---|---|---|---|---|
| 230 | 240 | 85 | -3<br>237.5 | | with nearly completely weathered mafic phenocrysts of biotite? (of secondary origin) Some remnants of hornblende needles similar to 146-160m. | including the cores of secondary biotite. All core appears somewhat re-crystallized with small bands and veins with surrounding | Some siliceous veining.<br>237-360 Generally epidote and green to buff clay present throughout the core in minor |
| 240 | 250 | 90 | 51<br>249 | | 237-360 Homogeneous QUARTZ DIORITE Variable fracture intensity but generally quite competent. Homogeneous medium grained composition--with secondary | silicification. Hematite red hue throughout fabric of the core.<br>237-260 Generally moderate propylitic alteration of | amounts. i.e. periodic epidote veins, clay on most fractures. Also periodic small veins and micro breccia containing fine networks of |
| 250 | 260 | 90 | 51 | | biotite as the predominant mafic mineral. | original mafics. Trace argillic alteration of feldspars. Local silicification and sericite on many fractures, especially those | dark mineral. Some Mn oxides and also periodic magnetite and hematite. Some quartz associated with epidote but not frequent. Chlorite on |
| 260 | 270 | 95 | 263.5<br>86 | | | associated with epidote. | some fractures. |
| 270 | 280 | 95 | 275 | | 274-312 Core is moderately broken throughout this zone. | 274-312 Somewhat higher level of argillic alteration accompanies broken zone. | |
| 280 | 290 | 90 | 30 | | | | |
| 290 | 300 | 90 | 293 | | | | |
| 300 | 310 | 90 | 16 | | | | |

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## DIAMOND DRILL LOG SHEET

HOLE SHOVELNOSE #2 SHEET 5 OF 19

| FROM | TO | % | RQD | DRILLING COND | LITHOLOGY STRUCTURE | ALTERATION | PRECIPITATES |
|---|---|---|---|---|---|---|---|
| 310 | 320 | 95 | 311<br>57 | | | | |
| 320 | 330 | 95 | 326 | | 326-360 Generally less competent core with places having a darker hue. Some zones completely broken. | 326-353 Minor silicification around small quartz-epidote veins. | 326-353 Quartz-epidote veins here and there. Some trace of carbonate associated with clay precipitate. Not common. |
| 330 | 340 | 90 | 31<br>31 | | | | |
| 340 | 350 | 80 | 344<br>24 | From about 350-540m very blocky drilling with consequent poor core recovery. | | | |
| 350 | 360 | 60 | 354<br>0 | | 353-360 No fabric remaining-crumbles in box. | 353-360 Intense alteration of feldspars and mafics. | |
| 360 | 370 | 95 | 364 | | 360-363.5 Medium grey aphanitic ANDESITE.<br>360-361.5 Volcanic breccia. Upper contact 45° to c.a. Lower contact mostly broken. | 360-361.5 Highly argillically altered.<br>361.5-363.5 Fairly fresh minor propylitic. | 360-363.5 Some carbonate and quartz veins. Minor clay on most fractures. |
| 370 | 380 | 90 | 45 | Thin section at 372'. | 363.5-381 QUARTZ DIORITE becoming increasingly broken with depth, shattered and veined for last 3' even though core relatively intact. | 377-381 Minor propylitic minor argillic-trace sericite. | 377-381 Minor carbonate-clay precipitate on most fractures. Clay appears chloritic and is generally green as opposed to buff. |
| 380 | 390 | 80 | 386 | | 381-387 Mixed QUARTZ DIORITE and hornblende-feldspar-porphyry DACITE. Various steeply dipping contact relationships. | 381-387 Minor to moderate propylitic and argillic alteration especially near contacts. | 381-387 Clay-carbonate precipitate on hairline and larger fractures throughout core. |

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## DIAMOND DRILL LOG SHEET

HOLE SHOVELNOSE #2 SHEET 6 OF 19

| FROM | TO | % | RQD | DRILLING COND. | LITHOLOGY STRUCTURE | ALTERATION | PRECIPITATES |
|---|---|---|---|---|---|---|---|
| 390 | 400 | 70 | 7 | | 387-403 Hornblende-feldspar porphyry DACITE. Very broken-rubble in places. | 387-405 Minor argillic alteration of feldspar phenocrysts. | 387-405 Buff clay precipitate on most fracture surfaces. No carbonate. |
| 400 | 410 | 90 | 405<br>22 | | 403-405 Finer grained version of DACITE. Ragged contact (lower) at ~45° to c.a.<br>405-409 Broken QUARTZ DIORITE. Variably foliated with inhomogeneous texture related to the disturbed nature of the rock. | 405-409 Minor argillic alteration. Most mafics are re-crystallized to biotite. | 405-409 Buff clay on most fractures. |
| 410 | 420 | 20 | 22<br>413 | Grinding of core because of blocky conditions. Consequent poor recovery of core. | 409-413 DACITE-QUARTZ DIORITE Breccia with volcanic matrix, dark grey, some shears at about 30° to c.a.<br>413-423 QUARTZ DIORITE typical appearance--reasonably competent despite only 20% core recovery. | 409-413 Moderate argillic alteration of breccia matrix leaving a dark clay.<br>413-423 Minor argillic alteration. | 409-413 Buff clay precipitate on fractures--post breccia alteration. No carbonate.<br>413-423 Buff clay on fractures rare thin black veinlets (MnO?). |
| 420 | 430 | 10 | 11<br>427 | | 423-435.5 Highly broken and altered QUARTZ DIORITE. Primarily rubble with minor highly altered aphanitic volcanic dyke at 430m. Highly foliated locally. | 423-435.5 Moderate-intense argillic alteration throughout. | 423-435.5 Minor buff clay precipitate on fractures. |
| 430 | 440 | 80 | 8<br>438 | | 435.5-438 Dacite-QUARTZ DIORITE Breccia. Volcanic matrix.<br>438-455 Broken and foliated QUARTZ DIORITE--homogeneous composition with well developed secondary biotite. Foliation moderately well developed at 60° to c.a. Highly broken in places. | 435.5-438 Moderate pervasive argillic alteration.<br>438-455 Minor-moderate argillic alteration of feldspar. Minor propylitic alteration of mafics to chlorite. | 435.5-438 Minor buff clay.<br>438-455 Substantial clay precipitates on all fractures. No carbonate. |
| 440 | 450 | 80 | 0 | | | | |
| 450 | 460 | 60 | 455 | Thin section at 486'. | 455-503 Highly broken meta-QUARTZ DIORITE-completely recrystallized to have the appearance of a fine grained volcanic rock of andesitic composition. | 455-503 Minor argillic alteration of some feldspar, more near contacts. Trace propylitic. Local pervasive hematite alteration lending | 455-503 Buff clay on most fractures. Frequent fractures lined with black precipitate probably MnO. |

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## DIAMOND DRILL LOG SHEET

HOLE SHOVELNOSE #2 SHEET 7 OF 19

GRAPHIC LOG: ALTERATION (PROPYLITIC, ARGILLIC, PHYLLIC, POTASSIC, SILICIFIED) / PRECIPITATES (CARBONATE, GYPSUM, CLAY, EPIDOTE, QUARTZ, MnO) / LITHOLOGY STRUCTURE

| DRILLING LOG | | | | | GEOLOGIC LOG | | |
|---|---|---|---|---|---|---|---|
| FROM | TO | % | RQD | DRILLING COND. | LITHOLOGY STRUCTURE | ALTERATION | PRECIPITATES |
| 460 | 470 | 40 | | | Moderately developed foliation at ~45° to c.a. Rock is very broken throughout. Upper and lower contacts core brecciated for about 2 feet with chlorite | pink tinge to core. | |
| 470 | 480 | 30 | | | altered matrix. | | |
| 480 | 490 | 40 | 6 | | | | |
| 490 | 500 | 70 | 6 | | 499-500 Breccia contact with | | |
| 500 | 510 | 90 | 503 | | ~~darker volcanic--probably~~ later phase of some andesite. Generally fresher. 503-510 Broken QUARTZ DIORITE highly foliated in places. | 503-510 Minor argillic alteration, trace propylitic ~~alteration.~~ | 503-510 Buff clay--MnO, trace epidote on fractures. |
| 510 | 520 | 90 | 32 | | 510-540 Series of andesitic intrusive dykes of at least two stages. Clasts of highly foliated QUARTZ DIORITE are present between 522 and 525'. | 510-540 Trace pervasive propylitic. Carbonates are present in core matrix. | 510-540 Buff clay frequently present on fractures. Some MnO. Epidote veining here and there. Nearly always |
| 520 | 530 | 90 | | | Darker hornblende andesite between 527-529'. Contacts where visible are about 45-60° to c.a. Some zones are highly broken. | | on sub-horizontal fractures. Carbonate veining is present to 1mm. |
| 530 | 540 | 90 | 535 17 539 | | | | |

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## DIAMOND DRILL LOG SHEET

HOLE SHOVELNOSE #2 SHEET 8 OF 19

GRAPHIC LOG: ALTERATION (PROPYLITIC, ARGILLIC, PHYLLIC, POTASSIC, SILICIFIED) / PRECIPITATES (CARBONATE, GYPSUM, CLAY, EPIDOTE, QUARTZ) / LITHOLOGY STRUCTURE

| DRILLING LOG | | | | | GEOLOGIC LOG | | |
|---|---|---|---|---|---|---|---|
| FROM | TO | % | RQD | DRILLING COND. | LITHOLOGY STRUCTURE | ALTERATION | PRECIPITATES |
| 540 | 550 | 95 | 51 549 | | 540-549 Moderately competent QUARTZ DIORITE with minor andesite stringers. 549-561 Moderately competent hornblende ANDESITE distinct | 540-549 Trace argillic and minor propylitic alteration throughout. Higher intensity near dykes (sericitic). 549-561 Quite fresh local | 540-549 Local intense clay precipitate. Local carbonate precipitate. Some sericite near dykes. Some MnO. 549-561 Epidote veinlets. |
| 550 | 560 | 95 | 41 | | from 510-540' in that less recrystallized with distinct hornblende needles. No foliation. Lower contact 30° to c.a. | minor argillic alteration (2-3mm) near epidote veinlets. | Some buff clay. Some carbonate veins to 2mm. |
| 560 | 570 | 95 | 561 54 | | 561-672 QUARTZ DIORITE with large pervasive secondary biotite. | 561-672 Trace argillic alteration pervasive. Local clay-carbonate alteration near epidote vein. | 561-672 Clay-carbonate present as precipitate on fractures. Epidote veins are frequent in various orientations. Some biotite in fractures. |
| 570 | 580 | 95 | 571 46 | | Poorly developed foliation of random orientation. Reasonably competent with fracture angles generally at moderate angles to c.a. In local zones of | | Clay-carbonate fracture coatings commonly accompanied by chlorite. |
| 580 | 590 | 95 | 589 | | quartz-epidote veining a gneissic texture is developed (see 593'). | | 585-615 Epidote flooding occurs along some veinlets forming envelopes 1-3cm in width. |
| 590 | 600 | 95 | 57 | | Well developed large secondary biotite crystals are prevalent. | | |
| 600 | 610 | 95 | 606 | Thin section at 603'. | | | |
| 610 | 620 | 95 | 56 | | | | |

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## DIAMOND DRILL LOG SHEET

HOLE SHOVELNOSE #2 SHEET 9 OF 19

GRAPHIC LOG: ALTERATION (PROPYLITIC, ARGILLIC, PHYLLIC, POTASSIC, SILICIFIED) / PRECIPITATES (CARBONATE, GYPSUM, CLAY, EPIDOTE, QUARTZ) / LITHOLOGY STRUCTURE

| FROM | TO | % | RQD | DRILLING COND | LITHOLOGY STRUCTURE | ALTERATION | PRECIPITATES |
|---|---|---|---|---|---|---|---|
| 620 | 630 | 95 | 623 46 630 | Reduce to BQ at 630 feet. | | 630-672 Weak to moderate propylitic alteration (minor chloritization of hornblende, some feldspars mildly kaolinized) with trace argillic. | |
| 630 | 640 | 95 | 55 639 | | | | |
| 640 | 650 | 95 | 0 | | | | |
| 650 | 660 | 95 | | | 561-672 QUARTZ DIORITE cont. | | |
| 660 | 670 | 95 | 0 669 | | Lower contact brecciated for 10cm with clay and MnO matrix. | | 661 5cm zone of buff clay with 2-3cm quartz crystals imbedded. |
| 670 | 680 | 95 | | | 672-677 Medium grained hornblende feldspar ANDESITE dyke. 677-688 QUARTZ DIORITE as per above. | 672-677 Contacts exhibit strong (argillic?) alteration though remainder of dyke is fresh. | 672-677 Carbonate veinlets common throughout dyke; generally accompanied by buff clay. |
| 680 | 690 | 95 | 40 | | 688-691 ANDESITE as above. | | 677-745 Clay-carbonate fracture coatings are common throughout QUARTZ DIORITE. Trace sericite and MnO are present on some fractures. |
| 690 | 700 | 95 | 695 | | 691-745 QUARTZ DIORITE fine to medium grained. 2nd biotite present. Reasonably competent fractures at various angles. | | |

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## DIAMOND DRILL LOG SHEET

HOLE SHOVELNOSE #2 SHEET 10 OF 19

GRAPHIC LOG: ALTERATION (PROPYLITIC, ARGILLIC, PHYLLIC, POTASSIC, SILICIFIED) / PRECIPITATES (CARBONATE, GYPSUM, CLAY, EPIDOTE, QUARTZ) / LITHOLOGY STRUCTURE

| FROM | TO | % | RQD | DRILLING COND. | LITHOLOGY STRUCTURE | ALTERATION | PRECIPITATES |
|---|---|---|---|---|---|---|---|
| 700 | 710 | 95 | 62 | | Original crystal structure very hazy or non-existant. Foliation weakly developed and at various angles mostly quite steeply dipping. | 700-710 Spotty strong propylitic alteration with moderate argillic zones within pervasive weak argillic. | |
| 710 | 720 | 95 | 716 | | | | 715-745 Numerous epidote fracture fillings 1-3mm thick. |
| 720 | 730 | 95 | 67 | | | 720-745 Pervasive propylitic alteration intensity increases to moderate with strong chloritization of mafics. | |
| 730 | 740 | 95 | 67 735 | | | | 735-745 Erratic fracturing with buff clay coatings occurs in vicinity of dyke. |
| 740 | 750 | 95 | 49 749 | | 745-746.5 Green-grey meta-ANDESITE--no original texture remaining. | 745-746.5 Strong epidote flooding in dyke. | 745-746.5 Minor clay precipitated in erratic fracturing. |
| 750 | 760 | 95 | 88 760 | | 746.5-869 Medium grained QUARTZ DIORITE. Generally as above except displaying a more medium grained texture especially in biotite. Locally | 746.5-777 Pervasive weak propylitic alteration of mafics to chlorite. Trace argillic alteration of feldspars. | 746.5-850 Silica with clay selvage fillings 2-3mm thick on fractures at 70° to c.a. 755-790 Massive silica fracture fillings 1-3cm in width |
| 760 | 770 | 95 | 47 767 | | veining produces a hazy, indistinct grey texture or a highly foliated gneissic texture. Foliation is generally steep but variable and poorly | 775-850 Weak to moderate argillic alteration occurs within halos surrounding major (silica filled) fractures. Envelopes are | are common; some contain fragments of QUARTZ DIORITE. 760-869 White to buff clay coats most fracture surfaces. Generally present with minor |
| 770 | 780 | 95 | 78 | | developed. Very competent. Fractures at all angles including subhorizontal and subvertical. Secondary biotite absent or sparse. | generally 2-4cm though some reach 30cm width. 777-745 Fresh to trace propylitic alteration. Rare kaolinization of feldspars. | carbonates and rarely, trace MnO or hematite, and sericite. |

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## DIAMOND DRILL LOG SHEET

HOLE SHOVELNOSE #2 SHEET 11 OF 19

| FROM | TO | % | RQD | DRILLING COND | LITHOLOGY STRUCTURE | ALTERATION | PRECIPITATES |
|---|---|---|---|---|---|---|---|
| 780 | 790 | 95 | | | | | |
| 790 | 800 | 95 | 792 61 | | | | |
| 800 | 810 | 95 | 805 | | | | |
| 810 | 820 | 95 | 75 815 | | | | |
| 820 | 830 | 95 | 71 825 | | | | |
| 830 | 840 | 95 | 83 839.5 | | 832 20cm thick quenched ANDESITE dyke. Contacts are ragged. | Minimal change in alteration near dyke. | 835-850 Thicker silica veinlets are tinged with pink (finely disseminated hematite?) |
| 840 | 850 | | 18 849 | | | 845-860 Moderate pervasive propylitic alteration. Spotty weak argillic alteration of feldspars. | |
| 850 | 860 | 95 | 85 | | | | |

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## DIAMOND DRILL LOG SHEET

HOLE SHOVELNOSE #2 SHEET 12 OF 19

| FROM | TO | % | RQD | DRILLING COND. | LITHOLOGY STRUCTURE | ALTERATION | PRECIPITATES |
|---|---|---|---|---|---|---|---|
| 860 | 870 | | 867 | | 869-871.5 Fine grained hornblende ANDESITE porphyry dyke. | 860-892 Fresh to weak pervasive propylitic alteration with some trace argillic alteration. | 860-880 Minor hematite staining on some fractures. 869-871.5 Clay coatings and some veining on dyke. |
| 870 | 880 | 95 | | | 871.5-892 QUARTZ DIORITE as above. | | 871.5-892 Buff clay with minor carbonate coats most fracture faces. |
| 880 | 890 | | 67 | | | | |
| 890 | 900 | 95 | 892.5 59 | | 892-898 Andesite porphyry as in 869m. Meta QUARTZ DIORITE clasts included. 898-941 Medium grained QUARTZ DIORITE with uniform (though altered) crystals of hornblende, biotite. Fracturing is moderate to strong with prominent joint sets at 30° and 75° to c.a. Locally weak foliation is imparted by alignment of hornblende, trending 20-40° to c.a. Texture of QUARTZ DIORITE becomes hazy, with indistinct crystal boundaries in zones of more intense alteration. | 892-893 Strong argillic alteration in brecciated headwall of dyke. 893-910 Moderate pervasive propylitic alteration. | 892-893 Clay and calcite in sheared/brecciated headwall of dyke. 893-941 Buff clay coats most fractures. |
| 900 | 910 | 95 | 907 | | | 900-941 Feldspars become strongly kaolinized within patchy areas of intense argillic alteration. Thin sub-horizontal envelopes exhibit particularly strong argillic alteration. | 900-941 Sparse quartz veins (2-4cm thick) contain some massive chlorite, trace carbonates. |
| 910 | 920 | 95 | 83 916 | | | 910-941 Pervasive moderate to strong propylitic alteration with chloritization of mafics, some epidote flooding. | 915-925 Hematite staining accompanies clay on most fracture faces. |
| 920 | 930 | 95 | 21 924 | | | | 920-930 Fractures in vicinity of broken zone contain clay coatings 0.5 to 1.5mm in thickness. Clays generally contain trace carbonates. |
| 930 | 940 | 95 | 87 936 77 | | | | |

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## DIAMOND DRILL LOG SHEET

HOLE SHOVELNOSE #2 SHEET 13 OF 19

| FROM | TO | % | ROD | DRILLING COND | LITHOLOGY STRUCTURE | ALTERATION | PRECIPITATES |
|---|---|---|---|---|---|---|---|
| 940 | 950 | 95 | 77<br>942 | | 941-952 Intensely altered DACITE dyke containing brecciated fragments of plutonic and volcanic rock to 3cm diameter. Where present | 941-952 Dyke is intensely kaolinized to chalky white. Breccia fragments are altered to kaolinite on rims though centres are relatively | 941-952 Minor hematite staining on some breccia fragments though kaolinite predominates. |
| 950 | 960 | 95 | 8 | Thin section taken at 950' | dyke rock contains small porphyritic hornblende blades to 1mm length within buff-grey cryptocrystalline groundmass. Dyke is extremely friable, | fresh.<br>952-960 QUARTZ DIORITE is strongly silicified making igneous fabric hazy. Some [K-feldspar] alteration | 952-960 Some kaolinite and other clays on fracture faces. Trace hematite accompanies clay. |
| 960 | 970 | | 965 | | incompetent. Upper contact is ragged, indistinct; footwall is entirely fractured, contact relations destroyed.<br>952-960 Medium to fine grained | accompanies silicification along fractures.<br>960-970 Intense chloritization and epidote flooding along shears. Epidote veinlets | 960-970 Clay and carbonate coat most fracture faces. Trace hematite and sericite present. |
| 970 | 980 | 95 | 66 | | QUARTZ DIORITE. Original texture is hazy due to strong alteration. Fracturing is intense, erratic.<br>960-970 Medium-grained QUARTZ | throughout.<br>970-1000 Pervasive moderate propylitic alteration (strongly chloritized mafics) and argillic alteration | 970-1031 Patchy buff-coloured clay coat fracture surfaces. Trace carbonate accompanies sparse silica veinlets contain some pink k-feldspar |
| 980 | 990 | | 984 | | DIORITE. Intense fracturing and shearing parallel to core axis.<br>970-980 Medium-grained QUARTZ DIORITE with weak foliation. | of feldspars. Considerable epidote flooding. | |
| 990 | 1000 | 95 | 28 | Thin section taken at 993' | Fracturing is moderate and rock is more competent.<br>980-982 Thin synplutonic dyke.<br>982-1037 QUARTZ DIORITE as above. Homogeneous igneous | | 992-998 Sub-vertical fractures contain carbonate-clay coatings to 2mm thickness. |
| 1000 | 1010 | | 1006 | | fabric with only local, weak foliation.<br>992-998 Strong sub-vertical fracturing.<br>1000-1012 Fresher QUARTZ | 1000-1012 Alteration becomes weak with fresh mafics and feldspar. Some crystals fringed with chlorite. | 1005-1031 Minor epidote flooding occurs along fractures and in veinlets. |
| 1010 | 1020 | 95 | 100 | | DIORITE contains secondary biotite to 5cm diameter. Weak foliation sub-parallel to c.a.<br>1012-1031 QUARTZ DIORITE is very intact although alteration intensity increases. | 1012-1031 Alteration is patchy and variable ranging from weak propylitic to moderate propylitic + argillic. | |

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## DIAMOND DRILL LOG SHEET

HOLE SHOVELNOSE #2 SHEET 14 OF 19

| FROM | TO | % | ROD | DRILLING COND. | LITHOLOGY STRUCTURE | ALTERATION | PRECIPITATES |
|---|---|---|---|---|---|---|---|
| 1020 | 1030 | | 1029 | | | | |
| 1030 | 1040 | 95 | | | 1031-1037 QUARTZ DIORITE contains thin microcrystalline dacite(?) dykes parallel to c.a.<br>1037 20cm DACITE BRECCIA. | 1031-1037 QUARTZ DIORITE is strongly altered by intrusion grading towards intense argillic by 1037'. Some patchy silicification. | 1031-1037 Clay with some carbonate coats fracture surfaces. Hematite staining is stronger near intrusions. |
| 1040 | 1050 | | 3 | | 1037-1050 QUARTZ DIORITE becomes extensively sheared, strongly altered. Original texture is hazy indistinct. | 1037-1050 Moderate to intense epidote flooding, chloritization of mafics and kaolinization of feldspars. | 1037-1070 Epidote is flooded throughout along microfractures. Carbonate (some calcite), clay and minor silica are present on |
| 1050 | 1060 | 95 | 1057 | | 1050-1052 Highly altered ANDESITE dyke contains breccia fragments to 2cm.<br>1052-1070 QUARTZ DIORITE(?) is intensely sheared, locally | 1050-1052 Dyke is altered to a fragmental, sandy texture.<br>1052-1070 Intense propylitic alteration. Original textures obliterated by epidote and | fractures, and coating rock fragments.<br>1054-1073 Clay gouge contains substantial hematite. |
| 1060 | 1070 | | 6 | | brecciated. Large fragments of angular quartz are present throughout. Where clayey gouge is absent, rock is shattered (joints are spaced 1-2cm | silica flooding. Where intact, rock is moderately silicified. | |
| 1070 | 1080 | 95 | 1073<br>77<br>1078 | | apart, erratic).<br>1070-1097 Intensely altered QUARTZ DIORITE. No original fabric present. Quartz present in elongate blebs to 2cm. | 1070-1097 Shattered rock is moderately to strongly silicified. Epidote flooding has completely replaced original fabric and is accompanied by | 1070-1097 Carbonate-clay coatings present on fracture faces. Hematite present in varying amounts though more common near shears. |
| 1080 | 1090 | | 6 | | Rock, green to salmon pink in colour, is highly shattered though healed by epidote and silica flooding. | salmon pink k-feldspar. | |
| 1090 | 1100 | 95 | | Thin section taken at 1096' | 1097-1104 Altered QUARTZ DIORITE Remnant igneous texture present | 1097-1104 Strong propylitic alteration though degree of | 1096-1156 Clay-carbonate veins present on most fractures |

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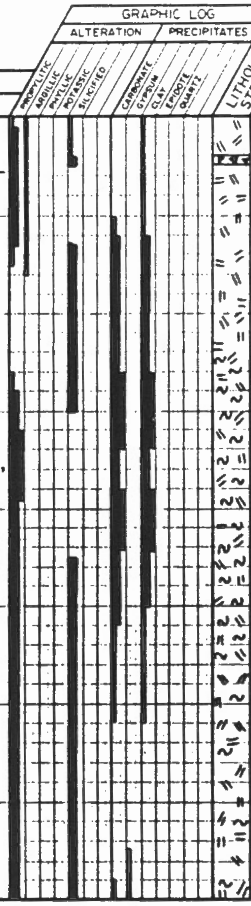
## DIAMOND DRILL LOG SHEET

HOLE SHOVELNOSE #2 SHEET 15 OF 19

| DRILLING LOG | | | | |
|---|---|---|---|---|
| FROM | TO | % | RQD | DRILLING COND. |
| 1100 | 1110 | | | From 1100' to T.D. -blocky drilling and caving. |
| 1110 | 1120 | 95 | 6<br>1117 | -drilling in 3rd gear. |
| 1120 | 1130 | | 2 | |
| 1130 | 1140 | 95 | 1137 | Thin section taken at 1135' |
| 1140 | 1150 | 95 | 10 | |
| 1150 | 1160 | | 1158 | |
| 1160 | 1170 | 95 | 80<br>1167 | |
| 1170 | 1180 | | 94<br>1180 | |




### GEOLOGIC LOG

**LITHOLOGY STRUCTURE**

though crystals are hazy. Fracturing is intense, erratic.
1104-1105 DACITE BRECCIA with QUARTZ DIORITE and silicified volcanic fragments. Rock is very friable.
1105-1124 QUARTZ DIORITE exhibits variable, patchy alteration. Though otherwise competent, strong sub-vertical fracturing has shattered core.
1124-1156 QUARTZ DIORITE is intensely altered, texture is absent in silicified zones. Shearing and fracturing is extreme resulting in large gouge-filled joints and extensive microfracturing.

1156-1199 Intensely altered QUARTZ DIORITE becomes more competent; rock is intact and fracturing is weak to moderate, nexshearing. Weak granitic texture is apparent though patchy. Highly altered rock is uniform grey-green with moderately well developed foliation trending 20-50° to c.a. Transition from "granitic" to "foliated" phases is abrupt.

**ALTERATION**

silicification is reduced.
1104-1105 Breccia is moderately silicified.
1105-1156 Patchy silicification alternates with intense propylitic alteration. Original texture visible in propylitic zones though destroyed in strongly silicified zones.
(Feldspathized) envelopes around larger fractures impart a mottled salmon pink colour to the greenish rock.

1156-1199 QUARTZ DIORITE is pervasively silicified, overprinting intense propylitic alteration. Small patches of salmon pink k-feldspar replacement is apparent in envelopes surrounding older (healed fractures).

**PRECIPITATES**

(especially sub-vertical set).
1104-1105 Extensive MnO(?) forms groundmass for breccia fragments.

1130-1140 Dilated fractures and shear zones contain kaolinite with carbonate.

1156-1199 Precipitates are sparse (owing to weak fracturing). Where present fractures are thinly coated with clay and carbonates.

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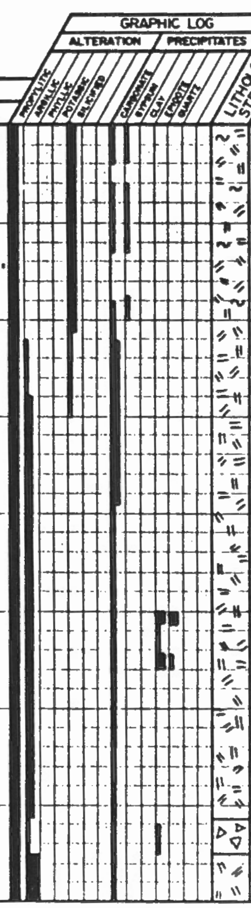
## DIAMOND DRILL LOG SHEET

HOLE SHOVELNOSE #2 SHEET 16 OF 19

| DRILLING LOG | | | | |
|---|---|---|---|---|
| FROM | TO | % | RQD | DRILLING COND. |
| 1180 | 1190 | 95 | 34<br>1187 | |
| 1190 | 1200 | | 98 | Thin section taken at 1193' |
| 1200 | 1210 | | 1206 | |
| 1210 | 1220 | | 10 | |
| 1220 | 1230 | | 1223 | |
| 1230 | 1240 | | 18 | |
| 1240 | 1250 | | 1247 | |
| 1250 | 1260 | | 0 | |




### GEOLOGIC LOG

**LITHOLOGY STRUCTURE**

1199-1217 QUARTZ DIORITE exhibits less intense alteration with igneous texture present (though hazy). Rock is a pastel pink-green from strong alteration. Fracturing is moderate with a prominent set at 5-10° to c.a. Numerous thin quartz stringers and deformed quartz veins throughout.

1217-1251.5 QUARTZ DIORITE. Moderate fracturing is erratic + rough. Older shears within rock are healed by epidote-quartz flooding.

1251.5-1255 Grey green fine-grained ANDESITE dyke. Contacts relations are destroyed in shattered zones.
1255-1260 Shattered QUARTZ

**ALTERATION**

1199-1217 Strong epidote-k-feldspar flooding are overprinted by moderate silicification (though degree of silicification decreases with depth).

1217-1251.5 Moderate to strong propylitic alteration (mafics completely chloritized) with weak to moderate argillic accompanying (feldspars are kaolinized). Envelopes 1-3cm thick of intense argillic surround some fractures. Silicification is absent and feldspathization is sparse and weak where present.

1251.5-1255 Dyke is moderately sericitized and is strongly chloritized.
1255-1260 Strong hematite staining accompanies strong

**PRECIPITATES**

1199-1220 Carbonates with minor clay is formed on fractures and infills dilated, sub-vertical joint surfaces. Hematite staining is strong in more intensely fractured zones.

1220-1251.5 Minor carbonates present on fracture faces. Locally, trace hematite. Clays are sparse to absent. Healed shears contain silic and epidote. Epidote is flooded into some fractures

1251.5-1255 Minor carbonates are present on fractures. Epidote is flooded into hairline fractures.
1255-1335 Carbonates form

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## DIAMOND DRILL LOG SHEET

HOLE SHOVELNOSE #2 SHEET 17 OF 19

| FROM | TO | % | RQD | DRILLING COND. |
|---|---|---|---|---|
| 1260 | 1270 | | 1272 | |
| 1270 | 1280 | 95 | 59 | |
| 1280 | 1290 | | 1286 | |
| 1290 | 1300 | 95 | 100 | |
| 1300 | 1310 | | 1304 | |
| 1310 | 1320 | 95 | 73 | |
| 1320 | 1330 | | 1329 | |
| 1330 | 1340 | 95 | 57 | |

GRAPHIC LOG: ALTERATION (Propylitic, Argillic, Phyllic, Potassic, Silicified) / PRECIPITATES (Carbonate, Gypsum, Clay, Epidote, Quartz); LITHOLOGY STRUCTURE

### GEOLOGIC LOG

**LITHOLOGY STRUCTURE**

DIORITE footwall. Numerous erratic fractures.
1260-1395 Medium-grained, dark grey-green QUARTZ DIORITE. Grains though hazy, are uniform size. Foliation, where present, is weak and erratic. Fracturing is light to moderate with one distinct joint set at 40° to c.a.
Rock is intact, particularly in silicified zones.

**ALTERATION**

argillic (and moderate propylitic) alteration.
1260-1378 Alteration is pervasive moderate propylitic with variable, patchy argillic. Control on variability of argillic alteration intensity is unclear. Epidote flooding is common along hairline fractures (particularly evident in zones of lesser argillic alteration).

**PRECIPITATES**

thin coatings on fracture faces. On more dilated fractures, microcrystalline calcite is present. Trace clays may accompany carbonates.

1325-1378 Epidote is flooded through fractures though alteration haloes are minimal.
1335-1378 Minor carbonates with buff coloured clay coat fracture surfaces.

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## DIAMOND DRILL LOG SHEET

HOLE SHOVELNOSE #2 SHEET 18 OF 19

| FROM | TO | % | RQD | DRILLING COND. |
|---|---|---|---|---|
| 1340 | 1350 | | 1347 75 | |
| 1350 | 1360 | 95 | 75 1354 69 | |
| 1360 | 1370 | | 1365 | Thin section taken at 1364' |
| 1370 | 1380 | 95 | 93 | |
| 1380 | 1390 | | 1383 | |
| 1390 | 1400 | 95 | 18 | |
| 1400 | 1410 | | 1405 | |
| 1410 | 1420 | 95 | 88 | |

GRAPHIC LOG: ALTERATION (Propylitic, Argillic, Phyllic, Potassic, Silicified) / PRECIPITATES (Carbonate, Gypsum, Clay, Epidote, Quartz); LITHOLOGY STRUCTURE

### GEOLOGIC LOG

**LITHOLOGY STRUCTURE**

1395-1396 ANDESITE dyke fed from below.
1396-1404 QUARTZ DIORITE as above.
1404-1405 ANDESITE dyke at 10° to c.a. Probably a tongue from larger dyke below.
1405-1420 QUARTZ DIORITE. Medium grained homogeneous grey green quartz diorite is competent, intact.

**ALTERATION**

1378-1385 Intense argillic alteration and minor silicification in this zone.
1385-1420 Moderate pervasive propylitic alteration throughout. Epidote and chlorite are most common along indistinct veinlets through rock. Argillic alteration occurs in broad zones.
1404-1405 Dyke is fresh though epidote flooding occurs along fractures paralleling contact.
1405-1420 QUARTZ DIORITE is moderately chloritized and argillized.

**PRECIPITATES**

1378-1385 Hematite and silica are present in veinlets trending 30° to c.a. Minor carbonates are present on fracture faces.
1385-1420 Minor carbonates, trace clay and trace hematite form thin coatings on fracture faces.
1404-1405 Minor epidote in fractures.

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# DIAMOND DRILL LOG SHEET

HOLE SHOVELNOSE #2 SHEET 19 OF 19

## DRILLING LOG

| FROM | TO | % | RQD | DRILLING COND. |
|---|---|---|---|---|
| 1420 | 1430 | | 1431 | |
| 1430 | 1440 | 95 | 40 | |
| 1440 | 1450 | | 1447 | |
| 1450 | 1460 | 95 | 100<br>1458 | |
| 1460 | 1470 | | 51 | |
| 1470 | 1480 | 95 | 1472 | |
| 1480 | 1490 | | 60<br>1490 | |
| 1490 | 1500 | | 74<br>1500 | Thin section taken at 1498'<br>Total depth =1500'. |

GRAPHIC LOG: ALTERATION (PROPYLITIC, ARGILLIC, PHYLLIC, POTASSIC, SILICIFIED) / PRECIPITATES (CARBONATE, GYPSUM, CLAY, EPIDOTE, QUARTZ) / LITHOLOGY STRUCTURE

## GEOLOGIC LOG

| LITHOLOGY STRUCTURE | ALTERATION | PRECIPITATES |
|---|---|---|
| 1420-1425 Dark green aphanitic ANDESITE dyke. Upper and lower contacts at 30° to c.a.; both are smooth.<br>1425-1428 QUARTZ DIORITE.<br>1428-1431 ANDESITE as above.<br>1431-1442 QUARTZ DIORITE. Alteration has rendered original medium-grained texture hazy. Fracturing is moderate, erratic. | 1420-1425 Dyke is moderately chloritized. Epidote is flooded along closely spaced fractures sub-parallel to c.a.<br>1428-1431 Dyke altered as above.<br>1431-1442 QUARTZ DIORITE exhibits moderate to strong argillic alteration over pervasive moderate propylitic. No change in alteration at contacts. | 1420-1442 Microcrystalline carbonates ± clay coat fractures. Hematite staining is associated with epidote flooding. |
| 1442-1445 Altered ANDESITE dyke. Partially sheared and strongly fractured. Contacts formed by fractures at 60° to c.a.<br>1445-1467 Grey-green medium-grained QUARTZ DIORITE. Texture is uniform and foliation is absent. Fracturing is moderate to strong and some local shearing is present.<br>1467-1470 Altered ANDESITE dyke. Dyke is highly fractured. | 1442-1445 Dyke is strongly chloritized; moderate epidote flooding. Some remnant porphyritic feldspars are entirely kaolinized.<br>1445-1467 QUARTZ DIORITE exhibits pervasive argillic and propylitic alteration. Intensity is variable though decreasing with depth. Feldspar crystals are completely kaolinized and are fringed by hematite.<br>1467-1470 Dyke is strongly flooded by epidote, hematite. Strongly chloritized. Porphyritic feldspars are kaolinized. | 1442-1445 Hematite is stained on all fracture surfaces. Minor carbonate and clay are accessory.<br>1445-1467 Carbonates ± buff clay coat fractures. Hematite staining occurs throughout.<br>1467-1470 Hematite and minor epidote accompany carbonate and clay on thin coatings. |
| 1470-1500 Dark grey QUARTZ DIORITE. Medium grained texture is crisp as rock becomes much fresher. Foliation is weak to absent. Fracturing is moderate and erratic; however, microfracturing is intense throughout. | 1470-1500 Alteration intensity is markedly decreased though some zones of moderate propylitic-argillic are evident. Mafics are only lightly chloritized and feldspars are fresh. Epidote floods along microfractures though envelopes are generally less than 1mm thick. | 1470-1500 Carbonates and clay are predominant precipitates forming crusts on fractures (though locally as fillings to 3mm thick). Silica forms sparse veinlets to 2mm (usually in dilated fractures at 80° to c.a.) Commonly carbonates fringe the outer edges of the silica veins. Trace hematite may accompany clays. |

# APPENDIX C

# RECOMMENDATIONS FOR FUTURE DRILLING METHODS AT MOUNT CAYLEY

## APPENDIX C

## RECOMMENDATIONS FOR FUTURE DRILLING METHODS AT MOUNT CAYLEY

Shovelnose 1 encountered severe drilling difficulties at about 450' (137.2m). Steeply dipping structures, fractured rock and formation squeeze caused continuous binding of the rods. By 516' (157.3m) conditions had deteriorated to an extent where continuation in the same fashion would have meant loss of the drill string due to breakage.

During remedial work to solve drilling difficulties in SN-1 the drill string stuck in the hole and the hole had to be abandoned. Hindsight suggests that cement adhered to and hardened on the rods and bound them to the formation. The cementing procedure adopted at the time was typical of the standard diamond drilling practice except that fast setting Ciment Fondue was used due to the failure of normal Portland cement in several previous applications. The high alumina Fondue is notorious in the drilling industry because it's fast set properties seem to be radically altered by water chemistry and particularly temperature. As a result, flash setting in less than five seconds has been observed.

It is apparent that formation water was probably rising in the hole and may account for difficulties encountered in the previous unsuccessful cement jobs. Cement may have begun to adhere to the rods before they were lifted from the bottom of the hole or cement may have risen from the bottom under the influence of formation water flow. A combination of these actions is plausible. It is virtually certain that cement seized the rods.

Past drilling at Mount Cayley had encountered very competent rock and holes had been completed with ease using BQ equipment (Brosinsky, pers.comm.). Drilling in the upper Shovelnose Creek valley however, encountered highly fractured and altered rock cut by numerous dykes and breccias. Drilling conditions were more comparable with those in hydrothermally altered areas at Meager Creek and consequently after the abandonment of SN-1 it was decided that NQ drilling equipment should be more utilized through the worst zones. Although the NQ drilling was blocky in SN-2, none of the severe problems that stopped the drilling of SN-1 were encountered and the hole was completed successfully.

Future diamond drilling in altered, broken basement at high elevations on the Mount Cayley complex should be started with NQ until rock quality indicates that BQ will be sufficient to complete the hole. Hole refusals would be greatly minimized with such a design at only a moderate additional cost.

Where drilling problems are encountered which require remedial action, the use of cement should be a last resort. Other formation stabilization techniques are currently available which entail less risk of losing the drill string (gels and urethane foams for example). In addition the careful use of sodium carboxymethylcellulose (CMC) organic polymer muds (such as Quicktrol and Alcomer) can help control formation squeeze and cave. These light muds are only fractionally more viscous than water and generally perform well in the stabilization of formation clay such as encountered in zones of intense argillic alteration. Formation plugging, characteristic of wall cake building properties of bentonite muds, does not occur with CMC muds due to the non-flocullating properties of the polymers. Consequently, in situations where polymer muds are effective for stabilizing the formation, the hydrologic properties of the formation remain intact.

If cementing becomes the only alternative then particular caution will be required. It is recommended that immediately after the placement of the cement on bottom, the rods be brought off bottom one hundred metres and flushed with water until the return is clean. Then the complete string should be pulled during the setting period as an extra precaution. Barring a flash set this technique should avoid the problems encountered in SN-1. Considering the high risk in using cement, the additional costs in tripping rods and waiting on cement, other methods are preferable.