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Report on

A RECONNAISSANCE HYDROGEOCHEMISTRY SURVEY OF THE SOUTHWESTERN DRAINAGES OF MOUNT CAYLEY, BRITISH COLUMBIA

Prepared for

GEOLOGICAL SURVEY OF CANADA

by

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1. SUMMARY

A reconnaissance hydrogeochemistry survey was conducted of the southwestern drainages of Mount Cayley, to identify anomalously mineralized surface waters possibly associated with hydrothermal fluids. Conductivity measurements were taken in surface waters, and samples were collected for chloride (Cl^-) and sulphate ($SO_4^=$) analysis. In addition samples from selected sites were submitted for more complete major element analysis, to characterize local thermal fluids and groundwaters.

Thermal waters of variable composition exist over a considerable vertical range and areal extent at Mount Cayley. These waters include near-neutral pH sodium bicarbonate waters at high elevation, encountered in the Shovelnose-2 drill hole, sodium chloride/bicarbonate/sulphate waters at the Turbid Creek hot springs, and sodium sulphate waters at the EMR 304-2 drill hole in the Squamish River Valley.

Turbid Creek and Shovelnose Creek show distinct chemical "signatures" of the thermal effluent discharged to them from the hot springs in their respective drainages. Other anomalously mineralized surface waters were identified in the upper Shovelnose Creek drainage, in Hook Creek, and in the vicinity of the Cayley-1 drill hole. Sulphate concentrations in Terminal Creek are marginally below the calculated "threshold" value for local surface waters. Waters of high conductivity identified in the headwaters of Shovelnose Creek may be related to the high-bicarbonate thermal waters encountered at Shovelnose-2. They appear to be associated with a late stage subvolcanic dacite dome.

2. INTRODUCTION

2.1 Terms of Reference

Nevin Sadlier-Brown Goodbrand Ltd. (NSBG) was engaged by the Geological Survey of Canada, under Department of Supply and Services Contract Serial Number 0SB82-00296, to conduct a reconnaissance hydrogeochemistry survey at the Mount Cayley geothermal area, British Columbia. The scientific authority was Dr. J.G. Souther of the Geological Survey of Canada (Vancouver).

Chemical analysis of water samples was conducted at the University of Waterloo, Ontario. This report documents work performed and presents the survey data obtained under this contract.

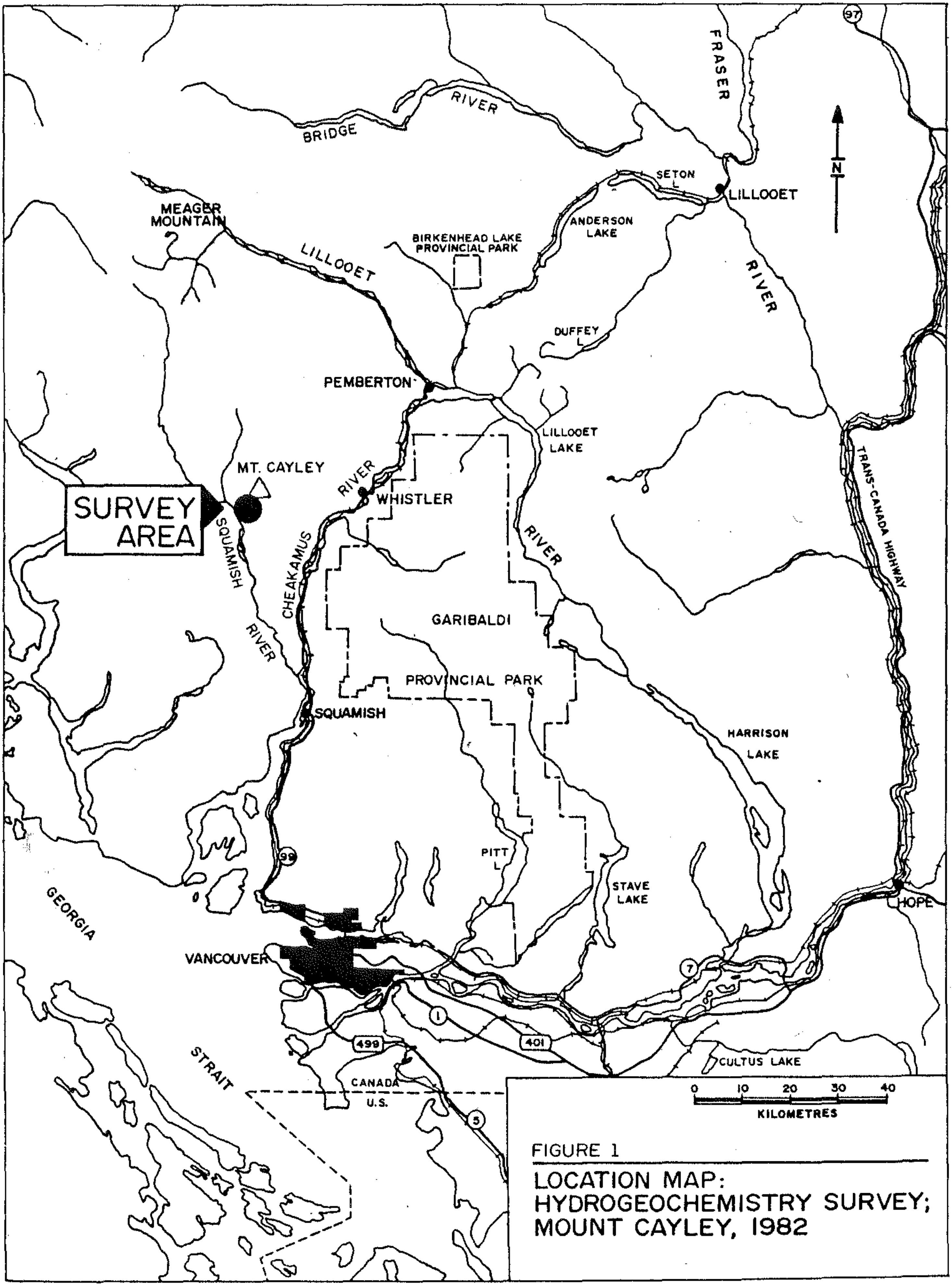

FIGURE 1

LOCATION MAP:
HYDROGEOCHEMISTRY SURVEY;
MOUNT CAYLEY, 1982

2.2 Location and Access

The survey area is located on the southwest flank of Mount Cayley, in the Coast Mountains of southwestern British Columbia, approximately 90km north of Vancouver. Access to the survey area is via Highway 99 to Squamish then north-northwest on the Squamish Main logging road (Squamish River Valley) to 34 Mile. Most of the survey area is inaccessible by road; branch logging roads afford limited access to Turbid and Shovelnose Creeks at low elevation. Access to creek headwaters is by foot or helicopter only.

The topography of the present Mount Cayley volcanic complex is very rugged. The poorly consolidated volcanic debris and intensely fractured flow-rocks are particularly deeply dissected. Drainages off the southwest flank are immature, typically deeply incised and of steep grade. A permanent ice-field exists above elevation 2135m (7000 ft).

2.3 Geologic Setting

Mount Cayley is a major Quaternary volcanic complex in the central part of the north-northwesterly trending Garibaldi Volcanic Belt. The central Garibaldi Belt is underlain by plutonic, mainly quartz diorite, and metamorphic rocks of the Mesozoic to early Tertiary Coast Plutonic Complex (Roddick and Hutchinson, 1974).

Basement rocks at Mount Cayley have been differentiated into three distinct assemblages, comprising a large pendant of metasediments; a quartz diorite, diorite, and amphibolite assemblage; and a hornblende, biotite granodiorite (Souther, 1980).

The volcanic edifice of Mount Cayley is made up of predominantly porphyritic dacite and rhyodacite flows, breccias and pyroclastics. Three stages of volcanism are evident. During the final stage of volcanism several subvolcanic intrusions were emplaced. These domes and cupolas have subsequently been exposed by uplift and erosion (Souther, 1980). Post volcanic debris flows and landslide material occupy much of the present Turbid Creek and upper Shovelnose Creek drainages (Clague and Souther, 1982).

2.4 Previous Work

Temperature gradient measurements in shallow diamond drill holes and surface geologic mapping have been the principle exploration techniques used to date to assess the geothermal potential of Mount Cayley. A D.C. electrical resistivity survey (dipole-dipole) has been conducted of the upper Shovelnose Creek-Mount Fee-Brandywine Mountain area.

In 1977 Energy, Mines and Resources (EMR) completed two temperature gradient diamond drill holes in the Squamish River Valley, approximately 6.5km west of Mount Cayley. Both holes encountered minor water flows; bottom-hole temperatures gave gradients of 51.6 and 66.1°C/km (Lewis and Jessop, 1981). Cayley-1 and Cayley-2, drilled subsequently in the vicinity of Turbid Creek and Shovelnose Creek, recorded temperature gradients of approximately 100°C/km. A single hole drilled some 7km to the east of Mount Cayley in the Brandywine Creek valley (Brandywine-1) recorded a temperature gradient of 50°C/km.

Souther (1980) conducted geologic mapping in the central Garibaldi Volcanic Belt. Seven volcanic centres were described, in a north-south trend between the Squamish and Cheakamus River valleys. Detailed mapping at Mount Cayley defined the complex volcanic stratigraphy, and located two groups of thermal springs, ranging in temperature from 18 to 40°C, in the upper Turbid Creek and mid-Shovelnose Creek drainages.

A sixth temperature gradient hole (Shovelnose-2) was completed in September 1982 in the upper Shovelnose Creek valley, at an elevation of 1540m (5050 ft). A flow of warm water was encountered. Bottom hole temperatures gave a gradient of approximately 95°C/km (NSBG, 1983).

3. 1982 HYDROGEOCHEMISTRY SURVEY

Thermal springs at high elevation in Turbid Creek and Shovelnose Creek and an artesian flow of thermal water encountered in the EMR 304-2 drill hole in the Squamish Valley suggest that hydrothermal fluids may exist within the shallow subsurface over a wide area at Mount Cayley. However, with the high annual precipitation, local groundwater movement through the poorly consolidated and deeply dissected volcanic assemblage, and associated debris-flow material at lower elevation, may be masking the true extent of thermal water leakage at surface.

Because of their significantly greater mineralization, hydrothermal fluids should impart a chemical signature to near-surface groundwaters with which they intermix. The nature of the signature will depend upon the composition and level of mineralization of the thermal fluids. Measured water conductivities for anomalously mineralized non-thermal groundwaters will be in marked contrast to conductivities for normal run-off waters.

In volcanic and subvolcanic environments the thermal waters discharged at surface are invariably related to secondary hybrid waters that develop above or peripheral to higher temperature waters at depth (Mahon, et al., 1980). Chloride is commonly the dominant anion in most primary high-temperature waters and is therefore an important chemical tracer in assessing waters of hydrothermal origin. Similarly, spring waters in volcanic regions may have high sulphate concentrations, where hydrogen sulphide transported in rising steam and vapour phases is oxidized to sulphate in near-surface groundwaters (Ellis and Mahon, 1977).

3.1 Scope of Work

The hydrogeochemistry survey at Mount Cayley covered only a limited area. As such, it represents an orientation survey aimed to assess the application of surface water geochemistry studies to geothermal exploration at Mount Cayley. Objectives of the survey were;

- to identify anomalously mineralized surface waters of possible hydrothermal origin; and

- to obtain representative surface water chemistry data, for comparison with data for local thermal waters.

The survey was centred on the Turbid Creek and Shovelnose Creek drainages, from the Squamish River at elevation 120m (400 ft) in the west to elevation 1770m (5800 ft) in the east. Hubert's Creek and Hook Creek[1] define the north and south limits, respectively, of the survey area.

The survey was conducted in two stages, from September 16-18, 1982, and November 1-2, 1982. Fieldwork comprised measurement of surface water, conductivities, and sampling for analysis for chloride and sulphate. Samples were also obtained for more complete chemical analyses.

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1 NSBG designation.

3.2 Sampling and Analysis

The Shovelnose Creek hot springs discharge at an elevation of approximately 990m (3250 ft) (Souther, 1980, Figure 1.2). These springs provide a hydrologic reference for the maximum discharge elevation of thermal waters at Mount Cayley.

The major drainages e.g. Hubert's Creek, Terminal Creek, Turbid Creek, Shovelnose Creek, and Hook Creek were sampled at sites pre-selected on the basis of reasonable access from existing logging roads. In addition, surface waters in the upper Shovelnose Creek drainage were surveyed from 1280m to 1770m (4200 to 5800 ft) elevation. Samples were collected of all waters with anomalous conductivity. Samples were also collected of thermal water encountered in the Shovelnose-2 and EMR 304-2 drill holes, and of the EMR warm spring.

Fifty six samples, unfiltered and untreated, were collected for chloride and sulphate analysis, in 250ml polyethylene bottles. At each sample site, water temperature, pH, and conductivity were recorded.

To provide chemical data for comparison of representative groundwaters and mineralized thermal waters at Mount Cayley, seventeen water samples were collected at selected sites and submitted for more complete analyses of major elements. At each sample site, two samples were collected; a 250ml sample unfiltered and untreated, and a second 250ml sample filtered and acidified (to pH <3) with concentrated nitric acid.

Analyses were performed by the Geochemistry Laboratory of the Department of Earth Sciences at the University of Waterloo, Ontario. Hydrogeochemistry data are tabulated in Appendix A. Compositions of waters submitted for detailed and partial analyses are presented in Table 1 and Table 2 respectively. Computed molar ratios for selected samples are given in Table 3. Sample locations are shown in Figure 2 (in pocket).

3.3 Thermal Waters at Mount Cayley

Locations of hot springs and temperature gradient drill-holes are shown in Figure 2. Detailed analyses for the EMR warm spring, the Turbid Creek springs, and for thermal waters encountered in the EMR 304-2 and Shovelnose-2 (SN2) drill-holes are included in Table 1.

TABLE 1: CHEMICAL ANALYSES OF SURFACE AND DIAMOND DRILL HOLE WATER SAMPLES, MT. CAYLEY

SAMPLE NUMBER	DATE	TEMP (°C)	pH	CONCENTRATIONS (ppm) Li	Na	K	Cs	Ca	Mg	Mn	F	Sr	Cl	SO_4	SiO_2	Fe	HCO_3	TOTAL CO_2	TDS	LOCATION
SURFACE WATERS																				
CAY-022	17/9/82	12	5.0	<0.05	5.0	1.39	<0.05	15.9	10.1	<0.05	0.42	0.06	1.18	8.71	9.95	<0.05	105	n.d.	0.012%	HEADWATERS OF SHOVELNOSE CREEK
CAY-049	18/9/82	13	5.8	<0.05	1.55	0.46	<0.05	1.01	1.72	<0.05	0.24	<0.05	<0.1	1.12	16.8	<0.05	<7	n.d.	<0.003%	WATER SUPPLY, DRILL CAMP (EMR-
CAY-101	1/11/82	3	5.4	<0.05	1.50	0.28	<0.05	0.97	0.26	<0.05	<0.03	0.15	0.39	2.43	12.1	<0.05	<7	<7	0.000%	LOWER HUBERT'S CREEK
CAY-103	1/11/82	17	5.5	0.12	567	6.90	<0.05	330	3.60	<0.05	1.48	3.24	394	1218	16.8	<0.05	15.5	11.2	0.250%	SEEPAGE, VICINITY EMR 304-2 (DDH)
CAY-104	1/11/82	5	5.4	<0.05	1.60	0.43	<0.05	1.30	0.95	<0.05	<0.03	0.17	0.50	5.56	11.6	<0.05	9.11	6.57	0.010%	LOWER TERMINAL CREEK
CAY-105	1/11/82	6	5.4	0.21	41.0	8.30	<0.05	32.0	17.8	0.22	0.08	0.51	71.3	69.5	22.6	0.06	96.3	69.4	0.040%	LOWER TURBID CREEK
CAY-106	1/11/82	4.5	5.4	0.10	13.4	2.58	<0.05	1.99	1.41	<0.05	<0.03	0.21	22.1	3.43	15.8	0.06	15.5	11.2	0.070%	LOWER SHOVELNOSE CREEK
A*	09/7/79	28.8	5.99	n.d.	968	76.2	n.d.	483	159	1.23	n.d.	n.d.	1080	1180	90.5	6.40	1470	n.d.	0.550%	MOUNT CAYLEY HOTSPRING
B*	09/7/79	15.0	5.88	n.d.	745	64.2	n.d.	394	128	1.73	n.d.	n.d.	720	984	72.7	7.60	1310	n.d.	0.443%	MOUNT CAYLEY COLD SPRING
DRILL HOLES																				
SN2-034	18/9/82	8	6.5-7.0	1.06	780	32.4	<0.05	272	105	1.52	0.36	1.94	685	88.3	66.6	175	2317	n.d.	0.272%	DDH SHOVELNOSE #2 (HOLE DEPTH 457m)
SN2-054	12/9/82		7.0	1.24	880	37.6	<0.05	311	135	1.92	0.18	1.86	810	106	37.6	432	2613	n.d.	0.260%	DDH SHOVELNOSE #2 (HOLE DEPTH 279.5m)
CAY-102	1/11/82	17.5	5.6	0.12	606	7.20	<0.05	355	3.70	<0.05	1.41	3.51	439	1339	16.6	<0.05	14.3	10.3	0.280%	DDH EMR 304-2

NOTES

n.d. Not Determined
* Ref. Clark, I.D., 1980.

TABLE 2: PARTIAL CHEMICAL ANALYSES OF SELECTED SURFACE WATERS, MT. CAYLEY

SAMPLE NUMBER	DATE	TEMP (°C)	pH	Na	K	Ca	Mg	Cl	SO_4	HCO_3	TOTAL CO_2	LOCATION
				CONCENTRATIONS (ppm)								
CAY-107	1/11/82	7	5.4	40.0	8.10	31.3	17.0	70.2	70.8	93.6	67.5	TURBID CREEK
CAY-113	2/11/82	5	5.4	15.2	2.90	2.10	1.44	25.2	3.65	17.4	12.6	SHOVELNOSE CREEK
CAY-115	2/11/82	6	5.3	2.40	0.44	4.29	4.98	0.92	1.67	31.7	22.8	SEEPAGE, NORTH OF TURBID CREEK
CAY-116	2/11/82	7	5.4	18.2	1.74	2.12	3.68	16.1	18.5	26.2	18.9	SEEPAGE, NORTH OF TURBID CREEK
CAY-118	2/11/82	4	5.3	1.70	0.46	1.37	0.98	0.58	6.14	10.3	7.43	TERMINAL CREEK
CAY-119	2/11/82	7	5.4	2.30	0.71	1.40	0.69	1.82	3.55	10.7	7.72	"HOOK CREEK"
CAY-120	2/11/82	7	5.4	1.70	0.36	1.16	1.92	1.24	6.14	8.1	5.84	SMALL STREAM, VICINITY DDH 304-2

TABLE 3: MOLAR RATIOS, SELECTED WATER SAMPLES, MT. CAYLEY

SAMPLE NUMBER	CHLORIDE TO			SODIUM TO				Ca/Mg	LOCATION
	F	SO_4	HCO_3	Li	K	Ca	Cl		
CAY-104	-	0.12	0.09	-	6.3	2.1	4.9	0.8	TERMINAL CREEK
CAY-105	477	1.4	1.3	59.0	8.4	2.2	0.89	1.1	TURBID CREEK
CAY-116	-	1.2	1.1	-	18.0	14.9	1.7	0.35	TURBID CREEK
CAY-106	-	8.8	2.5	40.4	8.8	11.8	0.93	0.9	SHOVELNOSE CREEK
CAY-102	167	0.44	52.9	1526	143.3	3.0	2.1	58.2	DDH EMR 304-2
CAY-103	143	0.44	43.7	1427	140.1	3.0	2.2	55.6	DDH EMR 304-2
SN2-034	1020	10.5	0.51	222	40.9	5.0	1.76	1.6	DDH SHOVELNOSE-2
SN2-054	2404	10.4	0.53	214	39.8	4.9	1.70	2.1	DDH SHOVELNOSE-2
SPRING A[1]	-	1.2	1.3	-	21.6	1.7	1.4	1.8	MT. CAYLEY HOT SPRING
SPRING B[1]	-	1.0	0.95	-	19.7	1.6	1.6	1.9	MT. CAYLEY COLD SPRING

NOTES

[1] Ref. Clark, I.D., 1980

\- No data.

EMR 304-2 was drilled to a total depth of 244m (800 ft). A flow of water (10L/min) was encountered at a depth of approximately 140m (460 ft) (Lewis and Jessop, 1981). The composition of the artesian flow from EMR 304-2 and the EMR warm spring are virtually identical, with only very minor dilution evident in the water discharged by the warm spring. Presumeably the spring is a result of the direct communication now provided by the drill-hole between the artesian flow at 140m and a permeable fracture intersected at shallower depth.

The thermal water discharged is a sodium-sulphate water. Sulphate concentrations of 1339 and 1218 ppm (artesian flow and warm spring respectively) are the highest recorded for any of the thermal waters at Mount Cayley. Flouride and strontium concentrations are also elevated with respect to other local thermal waters (Table 1). Chloride is moderate (439 and 394 ppm) but silica concentrations are low (16.6 and 16.8 ppm).

From the analyses quoted by Clark (1980), the Turbid Creek springs are essentially sodium chloride (1180 ppm) waters but contain significant sulphate (1180 ppm) and bicarbonate (1470 ppm). Silica is moderately high, (90.5 ppm). The springs are further characterized by high calcium and magnesium (483 and 159 ppm respectively). Such high Ca^{2+} and Mg^{2+} concentrations may suggest interaction with the basement metasediments mapped locally at Mount Cayley and which crop out in the upper Turbid Creek drainage. Souther (1980) noted an intensely deformed crystalline limestone within the pendant of metasediments.

Two samples were collected of thermal water encountered in the Shovelnose-2 drill hole (NSBG, 1983). Sample SN2-054, recovered after a 12hr period during which no hole disturbance took place, is least affected by dilution and more likely reflects the composition of the thermal water encountered.

The water discharged by Shovelnose 2 is a near-neutral pH sodium bicarbonate water. The bicarbonate concentration (2613 ppm) is twice that of the Turbid Creek hot springs and chloride is again moderately high (810 ppm). Ca^{2+} and Mg^{2+} concentrations are similar to the Turbid Creek springs, but silica and sulphate concentrations are lower, 66.6 and 106 ppm respectively. Appreciable bubbling of exsolved gas was noted in the water flowing from Shovelnose-2 (NSBG, 1983).

In volcanic regions thermal waters containing varying concentrations of bicarbonate and sulphate as the dominant anions and sodium as the major cation appear to be formed by steam and gases condensing in or passing through cold meteoric waters (Mahon, et al., 1980). The composition of these waters is controlled primarily be the volume and composition of the gases passing through them, typically carbon dioxide and hydrogen sulphide. These waters are classified as near-neutral pH sodium/bicarbonate/sulphate waters. Based on existing analyses, the Turbid Creek springs and possibly the thermal water encountered at Shovelnose-2 may reflect a similar origin.

3.4 Hydrogeochemistry of Surface Waters

3.4.1 Control Data and Threshold Calculations

Hydrogeochemistry data for the various thermal waters at Mount Cayley are summarized below.

LOCATION	ELEV. (m)	TEMP (°C)	pH	SPEC.COND. µmhos/cm	Cl- (ppm)	$SO_4^{=}$ (ppm)
EMR Spring	152	17	5.5	2500	394	1218
DDH 304-4	152	17.5	5.6	1650	439	1339
Turbid Creek Hot Spring	915	28.8	5.9	3300	1080	1180
Shovelnose Creek Hot Spring	990	-	-	-	-	-
DDH SN-2[1]	1540	(31)	6.5	3400	810	106

[1] Data for sample SN2-054; temp. = measured temp @ approx. 225m (NSBG, 1983)

Data for Turbid Creek and Shovelnose Creek, sampled approximately 2.5km (A) and 4.0km (B) downsteam of the hot springs in their respective drainages (below), provide additional control. These data indicate the degree of mineralization of local surface waters due to thermal fluid effluent:

LOCATION	ELEV. (m)	TEMP (°C)	pH	SPEC.COND. µmhos/cm	Cl- (ppm)	$SO_4^{=}$ (ppm)
Turbid Creek - A	305	7	5.4	315	70.2	70.8
Turbid Creek - B	140	6	5.4	335	71.3	69.5
Shovelnose Ck - A	365	5	5.4	75	25.3	3.65
Shovelnose Ck - B	140	4.5	5.4	60	22.1	3.43

Threshold values for anomalous conductivity and anomalous chloride and sulphate concentrations in local surface waters, were established as follows.

a) Conductivity

A threshold value of 40 micromhos/cm was tentatively selected for surface waters, based on results of earlier fieldwork by NSBG (March, 1982) in the Squamish Valley. Water conductivities measured during the present survey and subsequent chemical analyses support this as an appropriate reconnaissance threshold value.

Surface water conductivities typically ranged from 0-25 micromhos/cm, compared with conductivities of 60 and 335 micromhos/cm for the mineralized non-thermal groundwaters of Shovelnose Creek and Turbid Creek respectively.

The high conductivity measured at the EMR warm spring (2500 micromhos/cm) also indicates that even relatively minor, low temperature thermal manifestations can be readily identified against anomalous conductivities for mineralized non-thermal groundwaters.

b) Chloride and Sulphate

Data for sixty-nine water samples were used to calculate anomalous concentrations for chloride and sulphate in the local surface waters. Based on this statistical population mean (logarithmic base e) concentrations for chloride and sulphate are 0.64 and 2.12 ppm respectively.

Threshold concentrations of 2.5 ppm for chloride and 6.5 ppm for sulphate were calculated from the logarithmic mean plus one log standard deviation. Reported chloride and sulphate concentrations in excess of these values are considered anomalous for surface waters within the survey area. Background chloride and sulphate concentrations are typically <0.1 to 0.58 ppm, and 1.0 to 2.50 ppm respectively.

Chloride and sulphate data for all samples are tabulated in Appendix A. Interpreted anomalous data are presented in Figure 2.

3.4.2 Interpreted Data - southwestern drainages

It would be inappropriate to attempt a comprehensive assessment of the hydrology of the thermal waters at Mount Cayley on the basis of the hydrogeochemistry survey data presented in this report. The survey was of a small scale and therefore data density is limited. The comments and interpretations that follow should be reviewed in this context.

Surface waters with anomalous mineralization were identified at a number of locations. In several cases, it is not possible to attribute the anomalies unequivocally to mixing of mineralized thermal fluids with local groundwaters. Data for samples submitted for detailed and partial chemical analysis have been plotted on a Piper Tri-linear graph (Figure 3) to further compare their relative chemistries. Hydrogeochemistry data from the major drainages surveyed are reviewed below.

a) Hubert's Creek

Clean groundwater with a conductivity of 5 micromhos/cm; a single sample at 214m (700 ft) elevation has Cl^- and $SO_4^=$ concentrations of 0.39 and 2.43 ppm respectively.

b) Terminal Creek

Measured conductivities ranged from 10-25 micromhos/cm. Three samples were collected at 152m (500 ft), 350m (1150 ft) and 490m (1600 ft) elevation. Cl^- concentrations are very low, 0.50 to 0.58 ppm. However $SO_4^=$ concentrations of 6.12 and 6.14 ppm for the upstream samples (ref Figure 2, 82CAY118 and 82CAY117) are only marginally below the calculated local threshold of 6.5 ppm.

At a reconnaissance level these sulphate concentrations are interesting. They are almost twice the observed sulphate of Shovelnose Creek (3.43 to 3.65 ppm), of similar flow, which receives thermal effluent from the hot springs at 990m elevation. In addition, high sulphate (1218 ppm) thermal waters are known to discharge at surface approximately 2.5km to the northwest at the EMR warm spring.

A single sample (82CAY120) from a small stream some 200m south of the EMR spring recorded Cl^- and $SO_4^=$ concentrations of 1.24 and 6.14 ppm respectively.

c) Turbid Creek

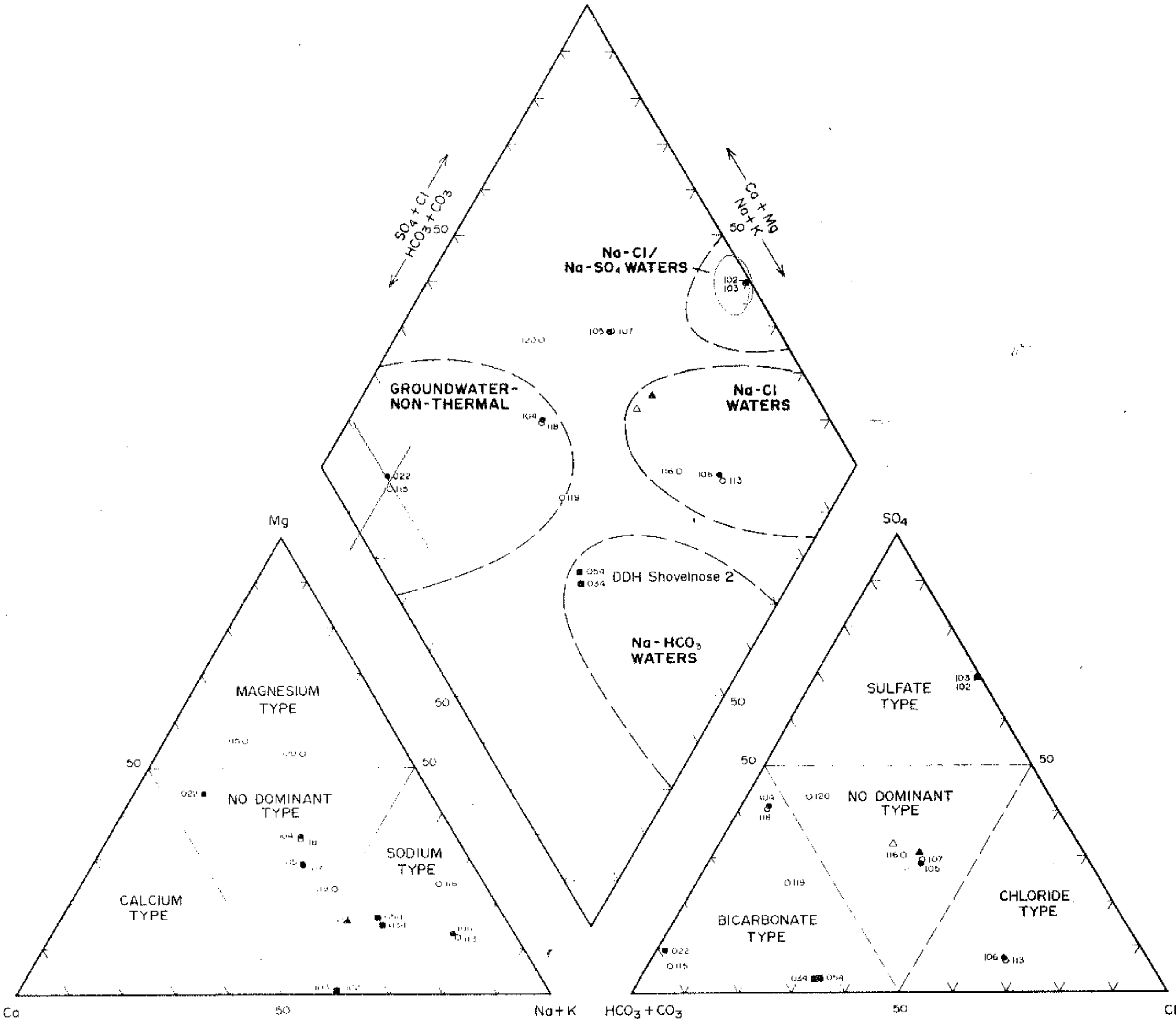
Mineralized thermal fluids from the Turbid Creek hot springs produce a pronounced chemical "signature" downstream in Turbid Creek. High anomalous conductivity (335 micromhos/cm) is consistent with high chloride and sulphate concentrations of 70.2 to 71.3 ppm, and 70.8 to 69.5 ppm respectively (Figure 2; Section 3.4.1). Bicarbonate concentrations are also elevated (93.6 to 96.3 ppm).

In contrast to analyses from other major drainages, which reflect progressive dilution downstream, the mineralization in Turbid Creek remains remarkably consistent over a sampled interval of 1.5km. In fact Cl^- and HCO_3^- concentrations show a slight increase downstream, with a corresponding increase in water conductivity. It is possible that this uniform level of mineralization reflects mixing with additional thermal fluids, migrating through the thick debris-flow material that occupies the lower Turbid Creek drainage and area north to Terminal Creek.

The common association of the anomalously mineralized water of Turbid Creek and the Turbid Creek hot springs is evident in a Piper Tri-linear plot of their major relative cation and anion concentrations (Figure 3). From the graph, the hot spring waters are classified as sodium chloride springs. Samples from Turbid Creek plot well beyond the position for typical groundwaters, and are displaced from the hot spring data along a line parallel to the base of the central field of the Piper graph.

Surface waters with anomalous conductivities were identified at two locations north of Turbid Creek, in the vicinity of the Cayley-1 drill hole.

Anomalous chloride and sulphate concentrations of 16.1 and 18.5 ppm respectively, and bicarbonate of 26.2 ppm in a small seep at 460m (1500 ft) elevation are consistent with a measured conductivity of 110 micromhos/cm (Sample 82CAY116, Table 2). Na^+ and K^+ concentrations are slightly elevated with respect to local groundwaters. Cl/SO_4 and Cl/HCO_3 ratios of 1.2 and 1.1, respectively, are compatible with equivalent ratios for Turbid Creek and the Turbid Creek hot springs (Table 3). However, while the relative position of sample 82CAY116 in Figure 3 supports an association with waters of a thermal origin it is unclear whether it is directly related to the Turbid Creek hot springs.



CATIONS

ANIONS

LEGEND

105 ● Surface water – full analysis

113 ○ Surface water – partial analysis

054 ■ Water sample from diamond drill hole (sample collected at surface)

▲ Mt. Cayley Hot Spring (Clark, I.D, 1980)

△ Mt. Cayley Cold Spring (Clark, I.D., 1980)

N.B.

Sample numbers and locations as per Table 1.

FIGURE 3

PIPER TRI-LINEAR PLOT – SURFACE AND DIAMOND DRILL HOLE WATER SAMPLES, MT. CAYLEY, B.C. (1982)

Approximately 300m northeast of Cayley-1 a small stream registered a conductivity of 60 micromhos/cm. Cl^- and $SO_4^=$ concentrations of 0.92 and 1.67 ppm respectively (Sample 82CAY115, Table 2), are well below the calculated threshold values. The high conductivity must therefore be due to the comparatively high dissolved bicarbonate (31.7 ppm). In addition to high dissolved bicarbonate, the water contains elevated Ca^{2+} and Mg^{2+} concentrations (Table 2). The origin of this water is unclear. It shows similarities to the chemistry of sample 82CAY022 (reviewed below) from the headwaters of Shovelnose Creek.

d) Shovelnose Creek

Shovelnose Creek has an anomalous conductivity of 60 micromhos/cm; chloride concentrations are anomalous (22.1 to 25.2 ppm) but sulphate (3.43 to 3.65 ppm) is below the local threshold. The water is characterized by sodium as the major cation (13.4 ppm) and chloride as the dominant anion (22.1 ppm).

Unfortunately analyses for the Shovelnose Creek hot springs are not available. The weaker mineralization evident in Shovelnose Creek, relative to Turbid Creek, implies that either a lesser volume of thermal effluent is discharged to the creek (from the Shovelnose Creek hot springs), or that the mineralization in Turbid Creek is enhanced by additional leakage of thermal fluids at lower elevation.

Cl/SO_4 ratios for the Turbid Creek and Shovelnose Creek samples are 1.4 and 8.8 respectively (Table 3). This implies that, like the thermal waters at the Shovelnose-2 drill hole (Cl/SO_4 ratio of 10.4), Shovelnose Creek hot springs have significantly lower sulphate compared to the Turbid Creek thermal water (Figure 3).

Drilling of the Shovelnose 2 temperature gradient hole provided access to the upper Shovelnose Creek drainage. Detailed conductivity prospecting and sampling of surface waters from 1280m to 1770m (4200 to 5800 ft) was co-ordinated with the final stage of the drilling program.

Anomalous chloride from hydrothermal fluids would not be expected in surface waters above the maximum discharge elevation of the hot springs (990m, at Mount Cayley). More mobile steam and gases, however, could intermix with circulating groundwaters at higher elevations. For the survey in the upper Shovelnose Creek valley more emphasis was therefore placed on sampling surface waters for Cl^- and $SO_4^=$ analyses than on water conductivity measurements alone.

Measured conductivities for surface waters in the upper Shovelnose Creek drainage were typically 0-15 micromhos/cm, with corresponding background Cl^- and $SO_4^=$ concentrations of <0.1 to 0.30 ppm, and 0.5 to 1.50 ppm respectively.

Approximately 0.8km north of the drill site, anomalous conductivities of 120 micromhos/cm and 200 micromhos/cm were recorded in surface waters at 1740m (Sample 82CAY022) and 1770m (Sample 82CAY023) elevation, in the headwaters of Shovelnose Creek (Figure 2). Cl^- is only slightly elevated (1.18 and 1.51 ppm) against local background but well below the calculated threshold. $SO_4^=$ concentrations however are anomalous, 8.71 and 11.7 ppm (Appendix A). The pH of these two waters is also elevated, 5.8 and 6.2, against pH's of 5.4 to 5.6 for surrounding waters; sample 82CAY023 had a measured temperature of 17°C.

Analysis of sample 82CAY022 (Table 1) shows Ca^{2+} and Mg^{2+} as the dominant cations (15.9 and 10.1 ppm respectively) and HCO_3^- (105 ppm) as the dominant anion. In contrast Ca^{2+}, Mg^{2+}, and HCO_3^- concentrations in local groundwater (sample 82CAY049, drill camp water supply; Table 1) are 1.01, 1.72, and <7 ppm respectively. The anomalous conductivity of sample 82CAY022 is explained by the very high bicarbonate (highest of all non-thermal waters analyzed). Similarily Ca^{2+} and Mg^{2+} are considerably elevated relative to other non-thermal waters (Tables 1 and 2).

Approximately 0.9km south of the drill site, at an elevation of 1355m (4450 ft), a sample from a small creek has anomalous sulphate of 7.46 ppm (sample 82CAY039, Appendix A). Cl^- is very low (0.17 ppm) and measured conductivity was 30 micromhos/cm. On measured conductivity alone the anomalous sulphate in this water would have been overlooked.

Shovelnose-2 penetrated intensely fractured lithologies and encountered a high-bicarbonate water at approximately 1280m AMSL (NSBG, 1983). The anomalous waters of samples 82CAY022, -023, and -039 may represent a similar water, substantially diluted and mixed with shallow groundwaters, rising along permeable fractures to surface. A simple structural association may explain the sulphate water at 1355m elevation (sample 82CAY039), downstream of Shovelnose-2.

The anomalous waters at the head of Shovelnose Creek (samples 82CAY022 and 82CAY023) can be rationalized on the basis of their geologic setting. They discharge near the southern margin of a porphyritic dacite subvolcanic intrusion, presumably along fractures associated with its emplacement. Approximately 3km to the south the Shovelnose Creek hot springs are associated with a similar endogeneous dome, and issue from basement rocks near the southern intrusive margin of the dome (Souther, 1980). The thermal springs in the upper Turbid Creek valley are also associated with fractures within the contact zones of dacite cupolas.

e) Hook Creek

Measured conductivities ranged from 5-22 micromhos/cm. Samples were collected at 43m (140 ft) and 250m (820 ft), and from a major tributary to the south, at 250m (820 ft) elevation. Sample 82CAY109 from Hook Creek at 250m elevation has anomalous chloride, 4.86 ppm; sulphate (5.62 ppm) is below threshold. Downstream, Cl^- and $SO_4^=$ concentrations are 1.82 and 3.55 ppm respectively.

Sample 82CAY109 was analyzed for chloride and sulphate only. However the suggestion of anomalous chloride in Hook Creek is interesting; there are no known hot springs in the Hook Creek drainage. Shovelnose Creek (1km to the north) is also anomalous with respect to chloride, but not sulphate. Besides Turbid Creek and Shovelnose Creek, Hook Creek is the only other major drainage to register anomalous chloride.

3.4.3 Discussion

The compositions of the thermal waters at Mount Cayley suggest that they may be derived from secondary hydrothermal fluids produced by steam-heating of meteoric water. Subsequent dilution and mixing with shallow groundwaters has further modified their chemistry (Table 1).

The significance of sodium/bicarbonate/sulphate waters in geothermal exploration in volcanic and subvolcanic environments has been reviewed by Mahon, et al. (1980). Such waters characteristically develop above or at the perimeters of higher temperature neutral-pH sodium chloride waters.

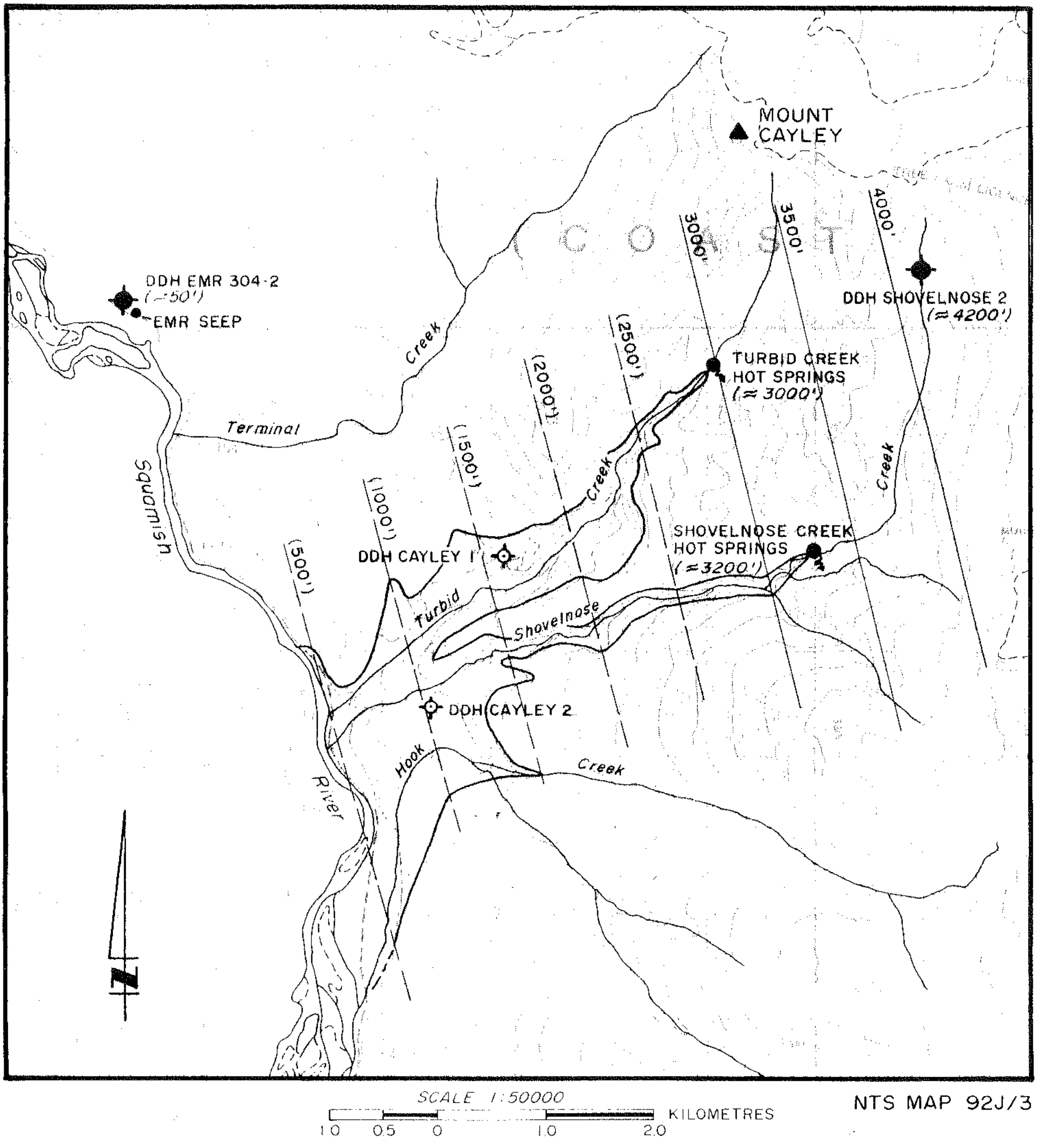
Application of standard chemical geothermometers to these waters is of limited use since calculated temperatures refer only to the secondary hydrothermal fluids, not the deeper waters. (Calculated geothermometers for thermal waters at Mount Cayley are included in Appendix B, to complement analyses presented in Table 1: they are not discussed further here).

Souther (1980) noted hydrothermally altered gouge-filled fractures adjacent to the thermal springs in Turbid Creek. From aerial photographs, many areas of hydrothermal alteration are evident along fault traces, particularly at structural intercepts, and reflect the structural complexity and pronounced anisotropy in the Mount Cayley area. Abundant argillic zones logged in core recovered from Shovelnose-2 are further evidence of extensive self-sealing of formerly permeable fractures (NSBG, 1983).

The very limited extent of the present geothermal manifestations at Mount Cayley is presumably a function of continued self-sealing and progressive reduction of the local fracture permeability. Similarly, the compositions of the thermal waters and their relative elevations may be related to this reduced permeability, reflecting the interaction of steam and acidic gases with circulating meteoric water, the deeper hydrothermal fluids now being unable to migrate to shallow depths.

A thermal water reference level relating the thermal water inflow at Shovelnose-2 and the Shovelnose Creek and Turbid Creek hot springs is shown in Figure 4. It is not meant to imply a piezometric surface or that a lateral subsurface outflow occurs from Shovelnose 2 to the hot springs or beyond. The structural anisotropy at Cayley would tend not to support this; fluid movement parallel to or along the dominant NNW structural trend is far more likely. The "strike" of the reference level, or plane, is consistent with a dominant NNW structural trend noted from aerial photographs.

The hot springs define points at which the reference plane intercepts the ground surface; if the reference plane is extended westward it intercepts the topography as defined by the shaded area of Figure 4. If a permeable structure west of the hot springs were a conduit for thermal fluids, the water could discharge to surface at an elevation implied by the thermal water hydraulic reference level, assuming it was under the same pressure control as the hot springs and the inflow at Shovelnose-2. In other words, for this simplified hydrologic model, thermal waters would not be expected to discharge to surface beyond the shaded zone of



LEGEND

- Hot spring
- Diamond drill hole
- 3000' Depth to hot water (AMSL)
- Surface intercept of hydraulic reference level

FIGURE 4

SCHEMATIC INTERPRETATION OF THERMAL WATER HYDRAULIC REFERENCE LEVEL

(See text for explanation)

Figure 4. If the results of the hydrogeochemistry survey are superimposed on Figure 4, all samples with anomalous Cl^- and $SO_4^=$, or anomalous Cl^- only, plot within the surface intercept of the hydraulic reference level. All samples with anomalous $SO_4^=$ only plot beyond this zone.

4. CONCLUSIONS AND RECOMMENDATIONS

The sensitivity of the hydrogeochemistry survey is dependent upon the level of mineralization in the local thermal fluids. Compared with data for other hot springs in southwestern British Columbia the thermal waters at Mount Cayley have a high mineralization.

Existing data and analysis of samples collected during the present survey show that thermal waters of variable composition exist over a considerable vertical range and areal extent at Mount Cayley.

Sodium bicarbonate waters exist at high elevation (1280m AMSL) beneath the upper Shovelnose Creek valley. 2km to the southwest sodium chloride waters, with appreciable bicarbonate and sulphate, are discharged by the Turbid Creek springs. Approximately 5.5km west of the hot springs a high-sulphate water discharges under artesian flow from a zone at about 17m AMSL from the EMR 304-2 drill hole, in the Squamish Valley.

Analyses of samples from Turbid Creek and Shovelnose Creek confirm a marked chemical "signature" in the creek waters of the hot spring effluent at higher elevation. From the hydrogeochemistry data, anomalous surface waters are indicated at several other locations, and are possibly associated with thermal fluids in the immediate subsurface. The anomalous chemistry in these surface waters appears to be consistent with the diverse chemistry noted in the local thermal waters.

Since measured water conductivities are directly related to the total chemistry of the waters, conductivity prospecting offers a rapid and effective reconnaissance technique for detecting strongly mineralized surface waters. For less mineralized waters it may be too insensitive at a reconnaissance level. Water sampling for Cl^- and $SO_4^=$ analyses and sampling of representative surface waters for more detailed chemical analysis provides better control for detecting waters with discrete levels of mineralization, possibly sourced from more mineralized thermal fluids (c.f. Terminal Creek, Upper Shovelnose Creek).

In spite of the limitations of the survey, anomalous surface waters have been identified. These anomalies and the spacial distribution of the various thermal waters need to be investigated further, using a similar strategy but on a more detailed basis.

The survey should be extended over a wider area and include drainages to the east of Mount Cayley, particularly Brandywine Creek and Callaghan Creek. Results from the upper Shovelnose Creek drainage emphasize the need to investigate these creeks in their headwaters as well as at lower elevation. If carried out in conjunction with other routine reconnaissance exploration activities, the survey technique used represents a rapid and cost effective strategy for assessing thermal fluid hydrology and leakage from a hydrothermal system.

A thorough assessment of the extent and nature of the hydrothermal alteration exposed at surface around Mount Cayley would greatly assist an interpretation of the past hydrology and structural control of the hydrothermal activity. These data might help to interpret the geologic and hydrologic controls on the present system.

* * * * * * *

5. REFERENCES

Clague, J.J. and Souther J.G., 1982: The Dusty Creek landslide on Mount Cayley, British Columbia. Can. J. Earth Sci. Vol. 19, p 524-539.

Clark, I.D., Fritz, P. and Michel, F.A., 1980: Isotope hydrogeology and geothermometry of the Mount Meager Geothermal Area. Final report prepared for EMR by Waterloo Research Institute. Project No. 707-10-03.

Ellis, A.J. and Mahon, W.A.J., 1977: Chemistry and Geothermal Systems. Academic Press, New York, 392pp.

Fournier, R.O., 1981: Application of water chemistry to geothermal exploration and reservoir engineering. In Rybach, L. and Muffler, L.J.P., Geothermal Systems: Principals and Case Histories. John Wiley and Sons, N.Y. p 109-144.

Fournier, R.O. and Potter, R.W. II, 1979: Magnesium correction to the Na-K-Ca chemical geothermometer. Geochim. Cosmochim. Acta. V 43, p 1543-1550.

Lewis, J.F. and Jessop, A.M., 1981: Heat flow in the Garibaldi Volcanic Belt, A possible Canadian geothermal energy resource area. Can. J. Earth Sci., Vol. 18, p 366-375.

Mahon, W.A.J., Klyen, L.E. and Rhode, M., 1980: Neutral sodium/bicarbonate/sulphate hot waters in geothermal systems. Chinetsu (Jour. of the Japan Geothermal Energy Assoc.) Vol. 17, No. 1 Series No. 64, p 11-24.

Nevin Sadlier-Brown Goodbrand Ltd., 1982: Report on geothermal reconnaissance exploration of selected areas in southwestern British Columbia. Unpublished report to B.C. Hydro and Power Authority.

Nevin Sadlier-Brown Goodbrand Ltd., 1983: Report on 1982 Temperature Gradient Drilling on Shovelnose Creek at Mount Cayley, Southwestern British Columbia. Final Report, prepared for Geological Survey of Canada.

Roddick, J.A. and Hutchinson, W.W., 1974: Setting of the Coast Plutonic Complex, British Columbia. Pacific Geology 8, p 91-108.

Souther, J.G., 1980: Geothermal Reconnaissance in the Central Garibaldi Belt, British Columbia. In: Current Research, Part A, Geological Survey of Canada, Paper 80-1A, p 1-11.

APPENDIX A

SUMMARY OF HYDROGEOCHEMISTRY DATA, MT. CAYLEY

SAMPLE NUMBER	LOCATION (UTM CO-ORDINATES)		TEMP (°C)	pH	SPEC.COND. (μmhos/cm)	Cl ppm	SO_4 ppm	NOTES
82 CAY 001	4 81 110mE	55 50 830mN	6	5.4	5	<0.1	0.54	Trickle
82 CAY 002	4 81 375mE	55 51 100mN	9	5.6	5	<0.1	1.93	Small Creek
82 CAY 003	4 81 530mE	55 51 225mN	11	5.6	2	<0.1	2.23	Small Creek
82 CAY 004	4 81 670mE	55 51 150mN	11	5.6	2	<0.1	4.39	Small Creek
82 CAY 005	4 81 730mE	55 51 025mN	8	5.6	0	<0.1	1.19	Small Creek
82 CAY 006	4 81 860mE	55 50 910mN	14	5.6	0	<0.1	0.42	Trickle
82 CAY 007	4 82 050mE	55 50 330mN	18	5.6	0	<0.1	0.38	Small trickle
82 CAY 008	4 82 270mE	55 50 275mN	15	5.6	5	<0.1	3.77	Small Creek
82 CAY 009	4 82 095mE	55 49 985mN	16	5.6	5	<0.1	4.01	Trickle
82 CAY 010	4 81 990mE	55 49 650mN	8	5.6	0	<0.1	0.89	Small Creek
82 CAY 011	4 81 620mE	55 49 015mN	6	5.4	0	<0.1	2.12	Medium Creek
82 CAY 012	4 81 590mE	55 48 710mN	4	5.5	0	<0.1	0.49	Trickle
82 CAY 013	4 81 525mE	55 48 320mN	4	5.4	0	<0.1	0.50	Small Creek
82 CAY 014	4 81 550mE	55 48 095mN	6	5.6	0	<0.1	<0.3	Small Creek
82 CAY 015	4 81 680mE	55 50 150mN	9	5.6	0	<0.1	1.35	Trickle
82 CAY 016	4 81 585mE	55 50 300mN	7	5.4	0	<0.1	0.97	Trickle
82 CAY 017	4 81 500mE	55 50 590mN	11	5.4	0	<0.1	<0.3	Small Creek
82 CAY 018	4 81 050mE	55 51 200mN	9	5.8	115	<0.1	4.33	Trickle
82 CAY 019	4 81 020mE	55 50 525mN	9	5.6	5	<0.1	1.25	Minor Creek
82 CAY 020	4 81 080mE	55 50 935mN	9	5.6	2	<0.1	1.93	Small Creek
82 CAY 021	4 81 075mE	55 50 985mN	6	5.6	5	<0.1	0.83	Small Creek
82 CAY 022*	4 81 050mE	55 51 200mN	12	5.8	120	1.18	8.71	Trickle
82 CAY 023	4 81 080mE	55 51 320mN	17	6.2	200	1.51	11.7	Minor Creek
82 CAY 024	4 80 960mE	55 51 250mN	1	5.6	5	0.38	1.05	Major Stream
82 CAY 025	4 80 890mE	55 51 250mN	12	5.7	25	0.31	1.67	Trickle
82 CAY 026	4 80 880mE	55 51 140mN	11	5.6	35	<0.1	2.22	Trickle
82 CAY 027	4 80 890mE	55 50 990mN	6	5.6	15	<0.1	0.54	Trickle
82 CAY 028	4 80 950mE	55 50 500mN	4	5.6	45	<0.1	1.23	Small Creek
82 CAY 029	4 80 900mE	55 50 800mN	6	5.6	10	<0.1	0.52	Large Trickle
82 CAY 030	4 80 960mE	55 50 630mN	7	5.6	5	0.28	0.96	Major Stream
82 CAY 031	4 80 960mE	55 50 390mN	5	5.6	10	<0.1	1.15	Small Creek
82 CAY 032	DITTO		5	5.6	10	0.38	1.16	LAB CHECK, 031
82 CAY 033	DITTO		5	5.6	10	<0.1	1.15	LAB CHECK, 031
82 CAY 034*	4 81 030mE	55 50 475mN	8	6.5-7.0	3400	685	88.3	EMR SHOVELNOSE #2
82 CAY 035	4 81 030mE	55 50 475mN	3	5.8	5	0.26	1.21	WATER SUPPLY, RIG
82 CAY 036	4 81 200mE	55 50 130mN	8	5.9	5	<0.1	1.86	Major Creek
82 CAY 037	4 81 180mE	55 49 930mN	7	5.9	15	<0.1	4.90	Trickle
82 CAY 038	4 81 185mE	55 49 700mN	9	5.9	10	<0.1	5.28	Major Creek
82 CAY 039	4 81 050mE	55 49 570mN	9	5.9	30	0.17	7.46	Minor Creek
82 CAY 040	4 81 030mE	55 49 380mN	9	5.8	5	<0.1	1.84	Minor Creek
82 CAY 041	4 80 880mE	55 49 050mN	9	5.9	5	<0.1	0.55	Small Creek
82 CAY 042	4 80 750mE	55 48 380mN	6	5.9	0	0.33	1.41	Glacial Creek
82 CAY 043	4 80 840mE	55 49 135mN	9	5.9	15	0.12	0.43	Trickle
82 CAY 044	4 80 980mE	55 49 475mN	11	5.9	15	0.12	0.74	Small Creek
82 CAY 045	4 81 020mE	55 49 720mN	11	5.9	15	0.13	1.43	Small Creek
82 CAY 046	4 81 070mE	55 49 800mN	7	5.9	0	0.32	1.32	Major Glacial Creek
82 CAY 047	4 80 960mE	55 50 160mN	11	5.9	10	0.20	0.92	Trickle
82 CAY 048	4 80 950mE	55 50 290mN	13	5.8	15	<0.1	1.13	Filtered; Lab Check
82 CAY 049*	DITTO		13	5.8	15	<0.1	1.12	Camp Water Supply
82 CAY 050	DITTO		13	5.8	15	<0.1	1.18	Camp Water Supply
82 CAY 051	DITTO		13	5.8	15	0.27	1.14	Camp Water Supply
82 CAY 054*	4 81 030mE	55 50 475mN		7.0	N.R.	810	106	EMR SHOVELNOSE #2
82 CAY 101*	4 71 860mE	55 52 830mN	3	5.4	5	0.39	2.43	HUBERTS CREEK
82 CAY 102*	4 73 730mE	55 50 290mN	17.5	5.6	1650	439	1339	DDH EMR 304-2
82 CAY 103*	4 73 780mE	55 50 270mN	17	5.5	2500	394	1218	Seep, Vic. EMR 304-2
82 CAY 104*	4 74 160mE	55 49 000mN	5	5.4	10	0.50	5.56	TERMINAL CREEK
82 CAY 105*	4 75 585mE	55 46 450mN	6	5.4	335	71.3	69.5	TURBID CREEK
82 CAY 106*	4 75 550mE	55 46 125mN	4.5	5.4	60	22.1	3.43	SHOVELNOSE CREEK
82 CAY 107P	4 76 700mE	55 47 390mN	7	5.4	315	70.2	70.8	TURBID CREEK
82 CAY 108	4 76 850mE	55 45 920mN	2	5.4	0-5	0.34	2.8	"HOOK CREEK", S. TRIB.
82 CAY 109	4 76 895mE	55 45 970mN	3	5.3	22	4.86	5.62	"HOOK CREEK"
82 CAY 110	4 76 825mE	55 46 075mN	4	5.3	20	0.42	5.25	Small Creek
82 CAY 111	4 76 780mE	55 46 280mN	5	5.3	10	0.47	1.63	Small Creek
82 CAY 112	4 76 670mE	55 46 510mN	5.5	5.3	10	0.45	1.29	Small Creek
82 CAY 113P	4 76 850mE	55 46 900mN	5	5.4	75	25.3	3.65	SHOVELNOSE CREEK

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SAMPLE NUMBER	LOCATION (UTM CO-ORDINATES)		TEMP (°C)	pH	SPEC.COND. (µmhos/cm)	Cl ppm	SO_4 ppm	NOTES
82 CAY 114	4 73 950mE	55 49 900mN	7	5.4	10	0.43	5.07	Small Creek
82 CAY 115p	4 77 415mE	55 48 020mN	6	5.3	60	0.92	1.67	Small Stream
82 CAY 116	4 77 200mE	55 47 910mN	7	5.4	110	16.1	18.5	Small Seep
82 CAY 117	4 76 040mE	55 49 000mN	3	5.3	25	0.50	6.12	TERMINAL CREEK
82 CAY 118p	4 75 460mE	55 48 950mN	4	5.3	20	0.58	6.14	TERMINAL CREEK
82 CAY 119p	4 75 880mE	55 43 850mN	7	5.4	20	0.58	3.55	"HOOK CREEK"
82 CAY 120p	4 73 830mE	55 50 080mN	7	5.4	10	1.24	6.14	Small Stream
82 CAY 121	4 74 080mE	55 49 550mN	7	5.4	10	0.58	3.88	Rusty stain in creek.

UTM CO-ORDINATES, from NTS Map 92J/3 (1:50 000)
82 CAY 052; 053 - No samples.

NOTES

*: Denotes sample submitted for detailed analysis, ref Table 1.
p: Denotes sample submitted for partial analysis, ref Table 2.

APPENDIX B

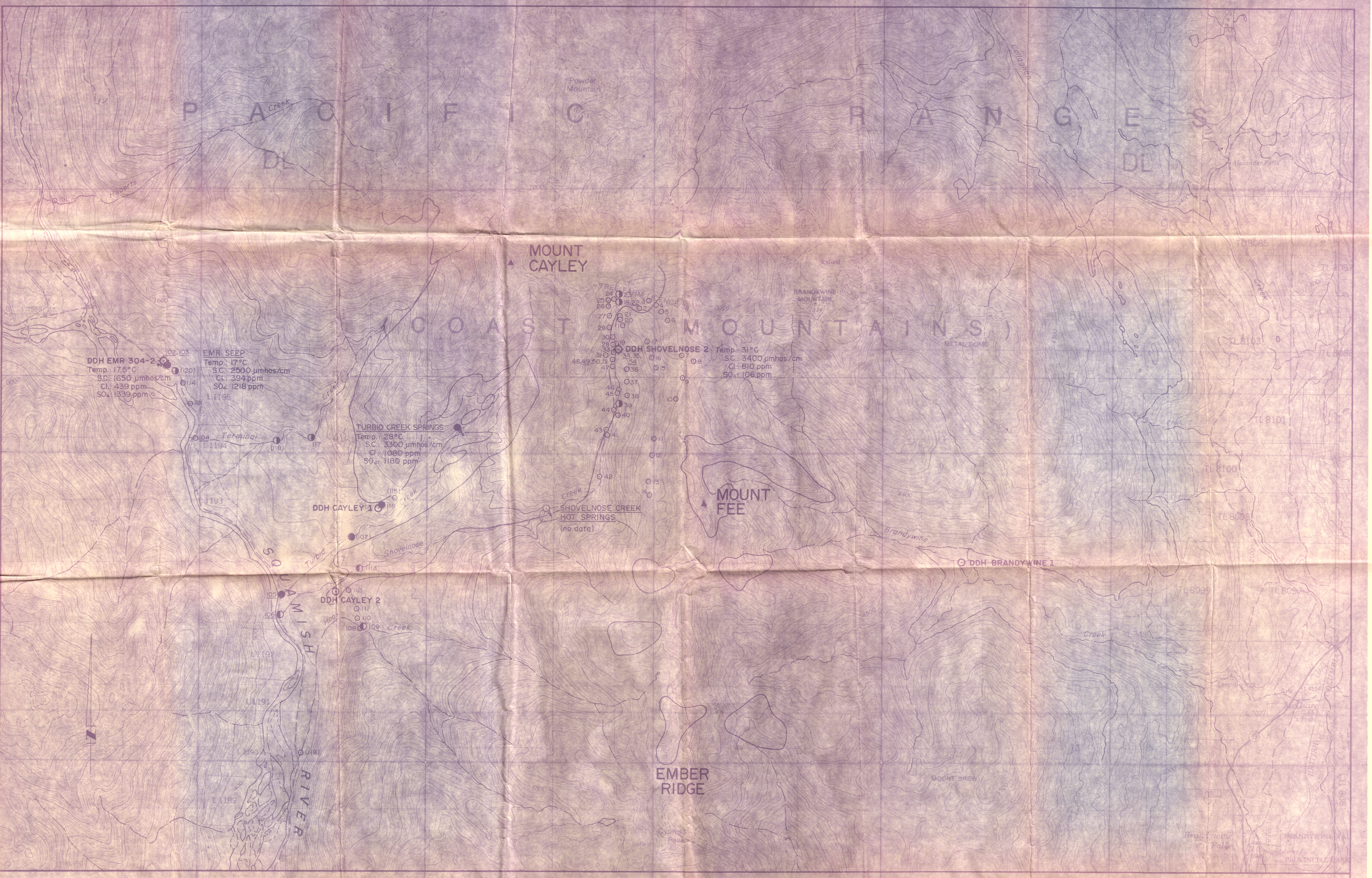
CALCULATED GEOTHERMOMETERS, ∿ MT. CAYLEY

SAMPLE NUMBER	MEASURED TEMP (°C)	SILICA : T_{SiO_2} (°C) (a)	(b)	(c)	(d)	(e)	CATION (°C) Na/K-Ca	Na/K-Ca-Mg(3)	LOCATION
CAY-102	17.5	64.0	56.8	22.8	-	-	47.7(1)	n.a.	SURFACE SEEP, VICINITY EMR 304-2
CAY-103	17.0	64.4	57.2	22.7	-	-	47.2(1)	n.a.	DDH EMR 304-2
SN2-034	-	115.6	115.7	85.3	17.5	65.0	140.6(2)	37.5	DDH SHOVELNOSE #2
SN2-054		92.5	89.1	56.4	-	38.8	142.6(2)	32.2	DDH SHOVELNOSE #2
A*	28.8	129.2	131.6	103.0	32.7	81.0	170.3	45.2	MT. CALEY HOT SPRING
B*	15.0	119.4	120.1	90.1	21.7	69.4	172.3	46.1	MT. CAYLEY COLD SPRING

NOTES

a. Quartz, Adiabatic (Fournier, 1981)
b. Quartz, Conductive (Fournier, 1981)
c. Chalcedony (Fournier, 1981)
d. B - Cristobalite (Fournier, 1981)
e. A - Cristobalite (Fournier, 1981)

(1) TNaKCa $\beta = 1/3$ (Fournier & Truesdell, 1973)
(2) TNaKCa, $\beta = 4/3$ (Fournier & Truesdell, 1973)
(3) TNaKCa with Mg correction (Fournier & Potter II, 1979)
n.a. Not Applicable, TNa/K-Ca <70°C
* Ref. Clark, I.D., 1980.



SCALE 1:25,000

LEGEND

36 ⊙	WATER SAMPLE SITE & SAMPLE NUMBER
105 ⊙	WATER SAMPLE SITE - DETAILED ANALYSIS (Ref. Table 1)
(107) ⊙	WATER SAMPLE SITE - PARTIAL ANALYSIS (Ref. Table 2)
106 ◐	CHLORIDE ANOMALY ≥ 2.5 ppm
39 ◑	SULPHATE ANOMALY ≥ 6.5 ppm
	HOT SPRING OR SEEP
	DIAMOND DRILL HOLE, SAMPLED
	DIAMOND DRILL HOLE, NO SAMPLE
	PERMANENT ICE COVERAGE
	LIMIT OF VOLCANICS
3200'	MAXIMUM KNOWN ELEVATION OF THERMAL WATERS DISCHARGED AT MT. CAYLEY

FIGURE 2 NTS MAP 92J/3

SAMPLE LOCATIONS AND INTERPRETED ANOMALOUS DATA; RECONNAISSANCE HYDROGEOCHEMISTRY SURVEY, MT. CAYLEY, B.C. (1982)

NEVIN SADLIER-BROWN GOODBRAND LTD
VANCOUVER, B.C. FEBRUARY 1983