B.C. Hydro and Power Authority

# INTERIM REPORT ON MEAGER CREEK SELECTED AREA
# GEOTHERMAL INVESTIGATION, PHASE II.

October 1974 - March 1975.

NEVIN | SADLIER-BROWN | GOODBRAND | LTD

NEVIN SADLIER-BROWN GOODBRAND LTD.
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May 14, 1975.

TO: Mr.W.M. Walker, Chief Engineer.
Mr.J. Stauder, Senior Generation Planning Engineer.

B.C. Hydro and Power Authority.

Dear Sirs,

Re: Geothermal Investigation - Phase II.

Herewith are four copies of our Interim Report on the recently completed detailed exploration at Meager Creek.

Electrical resistivity and one research well were the main undertakings. Five resistivity lines totalling 25 line miles produced significant low values at depth (to 2500 feet) on parts of two intersecting lines. The area of influence of this anomaly is 1.5 to 2 square miles. This area includes the Meager Creek hot spring and the newly discovered "79D" hot spring.

Research well 74-H-1 established that the area is underlain by fractured quartz diorite containing copious scalding water at various temperatures up to 69°C. Thus, we feel that a large sub-commercial geothermal reservoir has been established.

Questions remaining relate to the commercial promise of this reservoir. We have revised our recommendations somewhat in order to try to establish the exact lateral limits of the reservoir, the position of any underlying steam dominated reservoir, and the geologic controls on these features. We are proposing that 20 additional line miles of resistivity surveying and six shallow wells totalling 2000 feet be conducted during the summer of 1975 along with supporting work. Costs have been of concern to us. They have been much higher than originally anticipated. A more accurate estimate of the new funding needed to complete the geophysical work as outlined is $96,400.

We will be happy to review this report with you at your convenience.

Very truly yours,
NEVIN SADLIER-BROWN GOODBRAND LTD.

Andrew E. Nevin.



AEN/jrt.

B.C. Hydro and Power Authority

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Drill house at 74-H-1 in February, 1975.

## APPENDICES

# PART A - OPERATIONS

## 1.0. INTRODUCTION

### 1.1. Terms Of Reference

The Meager Creek area is located 35 miles northwest of Pemberton and on the southwest side of the Lillooet River. Phase I of the geothermal investigation identified it as the leading area for follow-up work on the basis of geologic evidence of geothermal potential, specifically a complex Quaternary volcano 10 miles in diameter and 5,000 feet high, and the occurrence of hot springs which indicated high sub-surface temperatures.

The Meager Creek investigation comprises the major part of Phase II of a geothermal investigation on behalf of the British Columbia Hydro and Power Authority. (The other part of Phase II is a reconnaissance of western Vancouver Island). An outline of the work to be performed at Meager Creek is contained in a report by Nevin Sadlier-Brown Goodbrand Ltd. to the B.C. Hydro and Power Authority dated June 1974. Authority for this project was given by Mr.W.M. Walker, P.Eng., Chief Engineer of B.C. Hydro in a letter of October 8, 1974.

The principal objective of the Meager Creek program is to conduct a geophysical program, mainly resistivity surveys and temperature profile measurements in shallow drill holes, sufficient to determine whether or not the area is of continuing interest for geothermal power.

### 1.2. Work Performed by Nevin Sadlier-Brown Goodbrand Ltd. and Subcontractors.

To date project has consisted of the following operations performed by us or at our instruction:

(a) photogrammetric topographic map for control - by Integrated Resources Photography Ltd., Vancouver.

(b) resistivity surveys - by McPhar Geophysics Company, of Toronto and Vancouver.

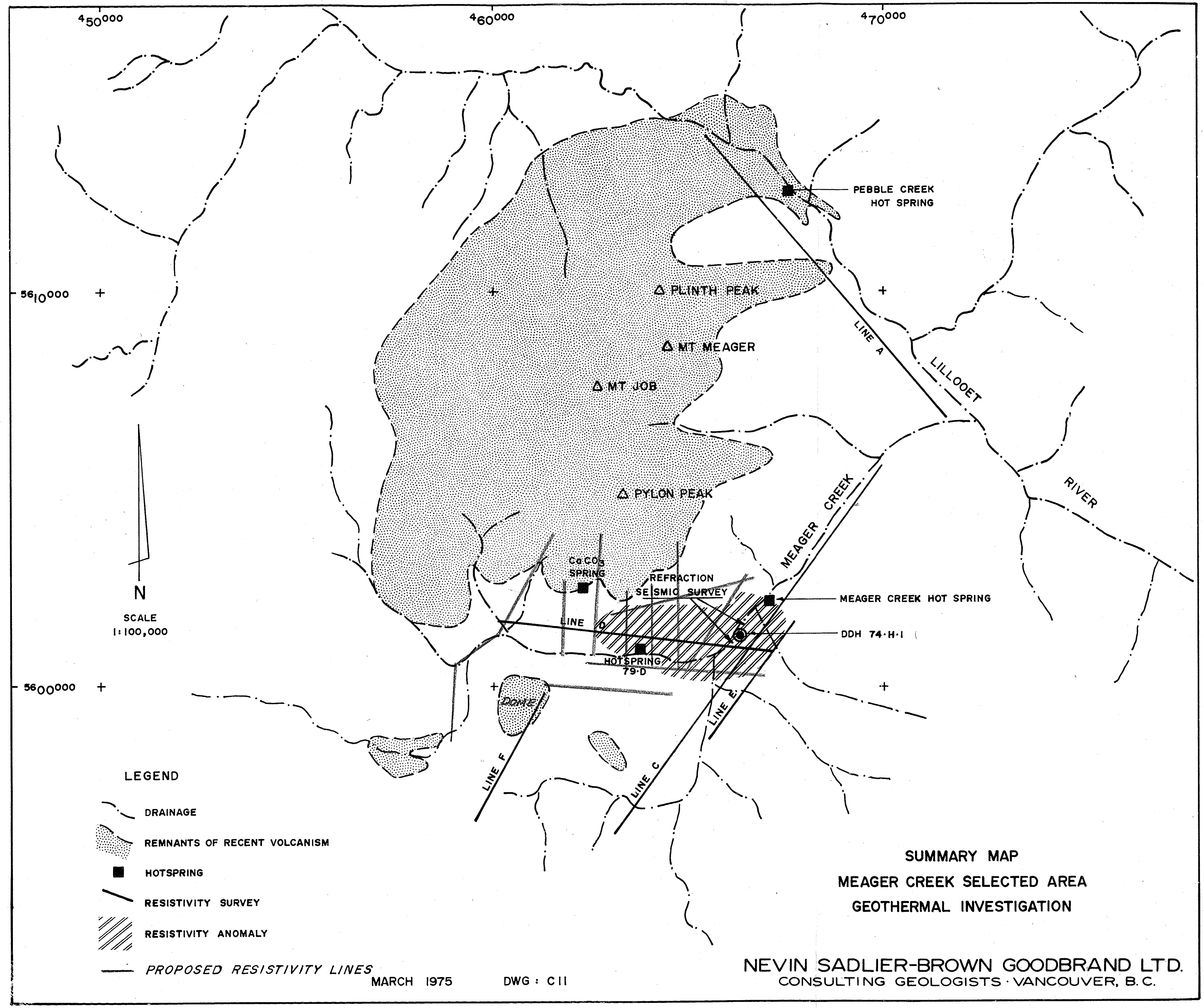
(c) geologic mapping.

(d) refraction seismic profile - by GeoRecon Exploration Ltd., of Vancouver and Seattle.

(e) drilling - by Kendrick Drilling Company, Vancouver.

(f) down-hole temperature measurements - instruments provided by the Earth Physics Branch of the Department of Energy, Mines and Resources, Ottawa.

(g)/


450000
460000
470000
5610000
5600000
PEBBLE CREEK HOT SPRING
PLINTH PEAK
MT MEAGER
MT JOB
PYLON PEAK
LINE A
LILLOOET
RIVER
MEAGER CREEK
N
SCALE 1:100,000
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REFRACTION SEISMIC SURVEY
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SUMMARY MAP
MEAGER CREEK SELECTED AREA
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NEVIN SADLIER-BROWN GOODBRAND LTD.
CONSULTING GEOLOGISTS · VANCOUVER, B.C.

(g) passive seismic surveys - by the Earth Physics Branch of Energy, Mines and Resources, Victoria, with our co-operation.

(h) helicopter support and operation of a 6 to 14 person tent camp.

### 1.3. Work Performed by B.C. Hydro Personnel.

The project was supervised by B.C. Hydro Generation Planning Engineer, J.Stauder, P.Eng., who inspected the site several times. B.C. Hydro's public relations personnel continued to inform the public of this work.

## 2.0. PHOTOGRAMMETRIC MAP FOR CONTROL

The most accurate publicly available map of the Meager Creek area is the federal government's "four mile series" at a scale of 1:250,000. On this map the Meager Creek volcanic complex, the target of this investigation, appears about 2" across. Since this is an inadequate scale for detailed work, we instructed Integrated Resources Photography Ltd. to compile a photogrammetric manuscript at a scale of 1:10,000 with 100-foot contour intervals from the most suitable of available air photos. They selected photos taken in 1965 and distributed by the B.C. Government. Their finished product covers about 280 square kilometres and is adequate for all exploratory purposes. It will also be of value for development and construction purposes should the project reach that stage in the future.

## 3.0. GEOLOGIC MAPPING.

During the course of supervising other field activities in October and November we conducted additional preliminary geologic mapping of the Meager Mountain volcanic complex. Most of this was done on air photos, as the 1:10,000 topographic base was not completed until January.

A summary of the new geologic information is as follows:-

(a) The contact of Meager Mountain volcanics overlapping Coast Range granites is revised from previous maps; in some localities the volcanics are less extensive than previously believed and in some more extensive;

(b) A newly discovered hot spring (called "79-D" from its position relative to resistivity line 'D') south of the complex and a nearby calcium carbonate spring complete a picture of an arc of thermal and mineral springs around the volcanic complex. The arcuate geometry supports the concept that these waters are related to a volcanic heat source.

(c) The Coast Range granites are far more fractured than previously supposed.

(d)/

(d) A mountain located southwest of the hot springs area (labelled "dome" in Drawing C-11) is cut through by dozens of tension fractures, indicating an instability which might be explained by domal uplift or deep volcanic activity taking place at the present time.

Transfer of information from air photos to the 1:10,000 scale maps is still in progress.

## 4.0. RESISTIVITY SURVEYS

### 4.1. General

Electrical resistivity is generally the most valuable geophysical tool for the identification and delineation of geothermal reservoirs. Its application is premised on high electrical conductivity of hot, saline water, and clay minerals found in geothermal reservoirs.

Resistivity is commonly used in metal and oil field surveys, and contractors well versed in the technology and operation of such surveys are readily available in Canada. McPhar Geophysics Company were selected on the basis of their world wide experience in the adaption of resistivity techniques to geothermal investigations.

McPhar carried out this survey during October and November 1974. Altogether they ran about 25 line miles on five lines (located on map C-11) which were selected by us. The lines passed close to the two hot spring complexes previously known and one discovered during the course of this work.

Prior to the surveys, lines were cut through the bush with axe and machette and marked with stations every 100 feet.

Equipment used was a variable frequency square wave 2.5 kw transmitter of McPhar manufacture and a McPhar receiver. The principal frequency used was 0.3 Hz.

Lines A, C, D, E and F were run using a dipole-dipole electrode array and an electrode spacing of 1000 feet. This gives an effective depth of penetration of about 2500 feet. Follow-up work on line C consisted of running a short interval at 500-foot electrode spacing.

### 4.2. Resistivity Results

The methods of reporting and analyzing results are discussed in the McPhar report which is reproduced in Appendix 'A', in its complete form. Records are plotted in the form of a "pseudo-section", a graphic record of resistivities measured at each 1000-foot set-up along the line and at each 1000-, 1500-, 2000-, and 2500-foot depth.

Significant/

Significant anomalies were measured on lines C and D. On line C, a fracture system containing hot water (confirmed in well 74-H-1) having an apparent resistivity of 20-50 ohm-feet/2 $\pi$ is present at depth between stations 200 SW and 275 SW. The reservoir occurs in quartz diorite which has a background resistivity generally on the order of 200 to 4000 ohm-feet/2 $\pi$. The quartz diorite is discontinuously overlain by water-saturated clay and gravel deposits having resistivities in the range of 60-95 ohm-feet/2 $\pi$.

The eastern 12,000 feet of line D measured resistivity values between 7 and 80 ohm-feet/2 $\pi$, with a median at about 25. The more attractive part of this anomaly appears to lie at depth below stations 50W to 100W, or adjacent the hot spring near station 79W.

In plan view the area dominated by anomalously low resistivities at depth (or those consistent with geothermal potential) is an ellipse of 1.5 to 2 square miles (Drawing C-11).

Line E, which was surveyed to investigate the southeastern projection of the resistivity lows measured on line C, did not have the same success. We have inferred either of two basic reasons for this:

(a) the low resistivity zone terminates in the 2000 feet between C and E;

(b) E is 300 feet higher than C and evidently on thicker overburden, and deep effects are masked by the low resistivity and lateral extent of the overburden.

Line F was run to inspect the resistivity near the domal uplift described in Section 3.0. Results were uniformly high resistivities from ordinary granitic rock.

Line A detected features which were already known: a welded dacite ash bed overlying an unconsolidated gravel, in turn overlying granitic rock, at the west end; and on the east end, some resistivity lows 2000 - 2500 feet from the line, which are believed to represent Lillooet River gravels off to the side of the line.

These interpretations were made subjectively on the basis of experience. The data are too complex for McPhar's program for computer interpretation.

McPhar's preliminary report and conferences with their personnel on the significance of the results were used as the basis for locating the site of research well 74-H-1 in November, opposite station 211 on line C.

5.0./

# 5.0. DRILLING

## 5.1. Purpose

One diamond drill hole, named Research Well 74-Hydro-1 was put down with the intent of obtaining a temperature gradient and collecting thermal conductivity data for the purpose of calculating a heat flow value. The reason for this exercise was to see if this part of the Meager Creek region met the temperature gradient (+18°C/100 metres) and heat flow values (+6 microcalories/sec-cm$^2$) which have been noted in productive geothermal areas elsewhere in the world. A secondary purpose for the well was to gain information on the extent of fracturing in the underlying granitic rock (i.e. the porosity and permeability of a potential reservoir) and to learn something of the nature of the ground water (i.e. the depth of influence of the cold water table).

## 5.2. Location

The research well 74-H-1 is located approximately 4,000 feet southwest of the camp at the main hot spring vent. It is upstream in the valley of Meager Creek offset from station 211 on resistivity line C. Its metric co-ordinates on the 1:10,000 scale map are 601,440 metres north, 466,350 metres east. The elevation of the collar of the hole is 30 feet above the bed of Meager Creek or approximately 2,085 feet above sea level. The drill hole was located in the "hottest" target area on the basis of preliminary resistivity and geological information, modified by logistical considerations such as helicopter access, access by foot trail from camp, and availability of water for drilling.

## 5.3. Drilling Engineering.

Kendrick Drilling of Vancouver was selected as the contractor. In late November they moved a skid mounted Longyear 34 drill, bits, steel, pipe, pumps and other equipment to the site using an Alouette II helicopter operated by Transwest Helicopters Ltd. Drilling was started November 27, 1974 and completed February 5, 1975, including a break from December 18 through January 6.

We had anticipated about 250 feet of overburden and encountered 406 feet. Completion of the well through that thickness of overburden with a small machine was a significant achievement and a credit to the contractor. The description of the tools used and the present position of casing in the hole is shown on Drawing D-2, the graphic log of the well. The details of the drilling technique are given in Appendix 'B'.

The hole took a continuous core, of AQWL diameter (1.375"), from the bedrock surface to the total depth at 1140 feet.

5.4./

5.4. Summary Geologic Log

The hole encountered 406' of overburden and penetrated 734' of bedrock to a total depth of 1140 feet (see also Appendix 'C' - Detailed Log and Drawing D-2 - 1:600 graphic log).

Overburden consisted of layers of boulders, gravel, sand and clay:

| | | |
|---|---|---|
| 0 - 230' | - | alternating sand, gravel and boulder seams, boulders are mainly granitic with some volcanic porphyries. |
| 230'- 350' | - | clay, gritty or with subangular ¼" rock fragments; occasional granitic boulders; outwash. |
| 350' -370' | - | granitic boulders. |
| 370' -406' | - | varved clays with occasional granitic boulders. |

Bedrock is a gneissic quartz diorite, which is the regionally dominant rock type. It is generally medium grained (1 to 3 mm) and medium grey coloured. Major constituents are quartz, plagioclase feldspar, biotite; lesser are orthoclase feldspar, hornblende; accessory minerals are epidote, apatite, magnetite, sphene and allanite (see Appendix 'F'). Kaolinite occurs as elongate interstitial stringers, coatings and fracture fillings to varying degrees throughout the hole, most notably during the first fifty feet of rock. Otherwise the rock was fairly fresh and unaltered.

The gneissic foliation varies in attitude locally throughout the hole from $-45^{\circ}$ to $-70^{\circ}$. The degree also is variable and is reflected in the local biotite content and aspect. Biotite appears as even disseminations to large elongate lens, in some cases S-shaped.

Fractures within the rock are both concordant and discordant to the foliation. Their attitudes have been grouped empirically for the purposes of presentation into three categories: 0 to $-30^{\circ}$, $-30^{\circ}$ to $-60^{\circ}$ to $-90^{\circ}$. Most fractures fall within the central grouping throughout the length of the hole. Flatter and steeper concentrations of fractures occur sporadically throughout as well. Fracture frequencies are slightly high from 406 to 525 and below 850.

Fractures range from hairline to ¼" wide. They are present in groups or singly. Some are open and others are filled. Fillings are mainly carbonate and siliceous carbonate, but also kaolinite. Quartz veins are not uncommon. Frequently there is iron oxide stain ranging in colour from ochre through red-browns to black. Hematite is developed on some fracture planes, frequently exhibiting slickensides.

Broken/

Broken and crumbly zones have been indicated on the log. Some of these form the loci of water courses. Generally they are open fracture systems although some contain siliceous carbonate fracture fillings. Gouge is present in several of these broken zones. It did not survive as core, but washed out with sludge and artesian flow.

## 5.5. Nature of the Geothermal Waters

Geothermal waters were intersected discontinuously throughout the length of hole 74-H-1. The principal distinguishable waters are:-

(a) - a cold ground water extending downward from the water table at 30 feet;

(b) - this same water, increasing rapidly in temperature downward to a maximum of about 69°C at a depth of 157 feet;

(c) - a 54°C water at 340 feet, still in permeable overburden, and still standing static in the well;

(d) - a water increasing in temperature from 54° at the bedrock surface at 406 feet to 60.5° at the bottom of the hole, 1140 feet, which flowed to the surface under a super pressure.

The waters within the overburden are perched on impermeable clay seams varying in thickness from several inches to 130 feet. These did not flow to the surface of the drill hole, although they may have risen or fallen in the hole.

The water intersected at the bedrock surface flowed to the top of the drill hole, when it was opened, under a super pressure or an artesian pressure which varied as the hole went down. Increased flow followed intersection of open fracture zones.

Pressure and flow were estimated at approximately 9 p.s.i.g. at the collar (or 24 p.s.i.g. above the water table) and 40 Imp. gallons/minute (respectively 0.6 $kg/cm^2$ and 180 litres/min.)

Samples for chemical analyses were taken when the bottom of the hole was at 877 feet and at 1140 feet. The results of these analyses and others are presented in Table 1, along with the calculated equilibrium temperatures of the possible reservoirs. (The chemical temperature estimators were described in the report of June 1974, and the formulas are repeated in Appendix 'E' to this report).

TABLE 1. - ANALYSIS OF HOT WATERS FROM RESEARCH WELL 74-H-1 AND SURFACE

| Sample, Location and Date. | Analysis in ppm. or mg/1. | | | | | | | | | Temp. | Est.Reservoir Temp. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **New Samples:** | $SiO_2$ | Na | K | Ca | Cl | $SO_4$ | $HCO_3$ | $CO_3$ | pH | $^{o}C.$ | $SiO_2$ | Na-K-Ca. |
| H-74-1 (406 to 877') (5 February, 1975) | 41 | 910 | 52.1 | 150 | - | - | - | - | - | 55 | 92.9 | 163.2 |
| H-74-1 (406' to 1140') (21 February, 1975) | 80.5 | 2300 | 90 | 380 | - | 1880 | 1396 | -0.1 | 7.2 | 55 | 125.6 | 239.5 |
| Spring 79D - Upper Meager Creek (30 October, 1974) | 108 | 150 | 32 | 40 | 275 | 76 | 387 | -.01 | 6.7 | 33 | 142 | 216 |
| Meager Creek - Main Vent (30 October, 1974) | 150 | 330 | 54 | 51 | 600 | 190 | 504 | -.01 | 6.6 | 57.5 | 161.3 | 132.4 |
| **Previously Reported:** | | | | | | | | | | | | |
| Meager Creek - Main Vent (January 5, 1974). | 164 | 450 | 47 | 81 | 675 | 110 | 468 | - | 7.2 | 58 | 167 | 188 |
| Meager Creek - GSC DH-1 (Mar.29, 1974). | 151 | 435 | 27 | 85 | 650 | - | 513 | - | - | 59 | 161.7 | 159.7 |

The most distinct "group" of the 12 calculated temperatures lies between 159.7 and 167°C and is made up of three $SiO_2$ and two NaKCa estimators. Other values are scattered between 92.9°C and 239.5°C.

Chemically the 74-H-1 drill hole waters from 406' to 877' are poorer in $SiO_2$, Na, K, Ca than the water collected from 406' to 1140'. This type of divergence indicates that a rapid mixing and re-equilibration is taking place independently within a series of relatively small separate fracture-type reservoirs and conduits. In addition, the two 74-H-1 water samples are probably a mixture of the outflow of several fracture systems.

5.6. Summary of Temperature Log

As the drilling advanced, down the hole temperature measurements were taken using a thermistor probe (#YS1 44033) connected to a wheatstone bridge. This instrumentation was supplied to us by the Earth Physics Branch (Ottawa), Department of Energy, Mines and Resources and we were instructed in its use by Mr.Al Taylor who was at Meager Creek from 28 November to 3 December, 1974.

Before the artesian flow developed at 406 feet, temperatures were taken a minimum of 12 hours after close of a drilling shift to allow the fluid in the hole to approach thermal equilibrium with the surrounding sediments. Subsequently the fluid in the hole reached a stable temperature in 30 minutes. The probe did not reach the bottom of the hole in overburden due to upwelling sand.

The temperature increased on a gradient of 0.44°C/ft. (1.56° C/m) to 68.876°C at 157 feet. This was the highest temperature recorded in the hole. At 198' the value fell to 35.215°C. Once into the clay series from 230 to 406 the strong temperature fluctuations ceased and the bottom hole profile shows a steady temperature increase with depth.

Intersection with bedrock produced an artesian flow which increased or declined slightly as new water bearing fractures were penetrated. As is the general case the temperature of the flowing hot water completely masked the temperatures taken previously at shallower depths. The temperature at 406' was 54.3°C, rising to 60.5°C at 1140'.

This represents a thermal gradient of 6.2°C/734 feet, 2.77°C/ 100 metres, or 27.7°C/km. The value of a thermal gradient taken within a reservoir of convecting fluid is very limited. No heat flow calculations can be performed on such a system.

5.7./

5.7. Current Well Condition

The hole is cased to a depth of 406.5 feet with 'BXWL' rods (O.D. 2.250", I.D. 1.906") serving as casing. It is capped with a 'Christmas tree' valve system screwed into the top of the casing. One 1½" gate valve in a horizontal attitude allows venting for pressure and flow rate measurements. One 1½" gate valve in a vertical attitude allows the introduction of the temperature probe. There is a very slight leakage of gas through the valves and a very slight leak of water at the Christmas Tree - casing union. With the valves all closed there is a slight amount of flow up around the casing, believed to be from fluid entering between 406 and 1140 feet and bypassing the casing. The drill hole collar is well above high flood mark and should be accessible for many years to come.

Kendrick Drilling has left their Longyear 34 set up over the hole pending future decisions.

## 6.0. REFRACTION SEISMIC PROFILE

By mid-December the string of drill tools selected in anticipation of about 250 feet of overburden was strained to the limit at 363 feet, still short of bedrock. We requested a refraction seismic profile from GeoRecon Explorations to determine the depth to bedrock so that we could plan the appropriate drilling tools and procedure to continue the hole following the holidays. The survey was conducted between December 28 and 31, 1974. This report is reproduced in Appendix 'G'.

The survey consisted of one 2000-foot seismic spread, centred on the drill hole and laid in the creek flood plain. The centre of the spread was offset approximately 200' northwest of the drill hole collar. Nine shots were made including four off-end to obtain refracted arrivals from the lower refracting surface over the entire length of the seismic spread.

Computer derived depths to bedrock were calculated based on two possible second layer velocities of 8300 fps and 9500 fps yielding depths below the drill collar of 380 feet and 463 feet respectively.

On this basis we decided to use our 'B' size tools (about 2.25"O.D.) as casing in overburden, and reduce to "A" size tools (1.75" O.D.) for drilling in bedrock. As noted, the bedrock surface was intersected at 406 feet.

One extra bit of information from the seismic profile is that well 74-H-1 is centred on a low velocity zone, 14,000 feet per second, as contrasted with 17,500 fps upstream and 16,500 fps downstream. This is interpreted as part of the wide fractured system indicated by resistivity data and intersected in the well.

## 7.0. PASSIVE SEISMIC WORK

After observation of the volcanic-capped ridge which appears to be unstable and actively doming at the present time, it was decided to install a passive seismic station in order to see if this could be confirmed by the detection of local earthquakes. Mr.G.C. Rogers, Earth Physics/

Physics Branch, Department of Energy, Mines and Resources, installed a short period vertical seismograph station on November 27, 1974 and it was operated periodically until February 1975. In addition to immediate studies, its purpose was to accumulate data on the seismic characteristics of the area to allow Mr.Rogers to design a more comprehensive study for the summer of 1975.

The instrument used was a standard regional SPZ helicorder station with 500 feet of cable between the helicorder and a Willmore seismometer. The paper speed was 1mm/sec., the gain setting was 18 db. and the high cut filter 6 Hz (because of previous experience with high frequency wind noise in heavily forested areas).

Of the 730 hours of useable recording 35 hours contained micro-earthquakes or suspected microearthquakes. The possible microearthquakes can be divided into 4 types on the basis of their apparent S-P intervals (See Roger's memo, Appendix 'H'). Two types (S-P 3/4 sec. and S-P 4 sec.) are thought to be genuine micro-earthquakes. The S-P 3/4 sec. type relates to a 5 km. radius and occurred timewise in 3 groups: 25 in a six hour period on December 11, 10 in an hour on December 13 and a single event, the largest on December 15. They appear to be microearthquakes which ultimately must be related to some faulting process. There is, however, a possibility that they may be related to a freezing-thawing cycle. The S-P 4 sec.type was a micro-earthquake observed on December 5 at a distance of about 30 km. Two other observable types (S-P 1½ - 2 sec. and S-P less than ½ sec.) do not display precise enough signatures to allow their classification as micro-earthquakes at this stage of the study.

The winter season imposed several limitations on the precision and accuracy of the study. The diurnal freezing - thawing cycle with its attendant soil-rock shifting, snowslides, snow failing off trees and dripping water is the major problem.

## PART B: DISCUSSION

## 1.0. CURRENT STATE OF THE PROJECT

### 1.1. Geothermal Model

The geologic, resistivity, seismic and drill hole data collected to date add some known parameters to the geothermal model.

The Meager Mountain volcanic complex is flanked by a definite geothermal system. The known part of the system consists of copious scalding water, at 55°C - 69°C, which fills a network of fractures in a granitic host rock. The upper limit of this fracture-type reservoir is within a few tens to several hundred feet of the surface. The reservoir is partially capped by discontinuous lenses of impermeable glacial clay deposits; in other localities it is probably depressed by pressure of the ordinary ground water system.

The minimum lateral limits of the reservoir coincide with the oval shape assigned to the anomalously low resistivity values obtained on two intersecting lines.

The scalding water is under a weak superpressure, enough so that it forms local hot springs, and has the ability to flow out of well 74-H-1. This superpressure is not thermally derived, but is a simple product of ordinary ground water pressure gradients in a saturated region of high relief.

The scatter among the values of the $SiO_2$ and Na-K-Ca geochemical temperature estimators and inconsistencies from place to place indicate that the near surface hot waters of the Meager Creek geothermal system violate the basic requirements for the accurate application of geochemical thermometry. The concentration of silica, potassium, etc. dissolved in a geothermal fluid is dependent on the temperature. Geochemical thermometry requires that equilibrium be reached in the core of the reservoir, and that the fluids ascend rapidly to the sampling site without having the opportunity to re-equilibrate at a lower temperature. The waters analyzed and reported here have partially re-equilibrated, and have mixed with non-thermal waters to an unknown degree. Hence the geochemical thermometers are valid only as indicating a minimum possible reservoir temperature - - possibly at 165°C, or equally possibly at 220°C or 240°C.

### 1.2. Unknowns

Several properties of the geothermal reservoir remain unknown. The most basic are:-

(a) the detailed lateral limits of the 55 - 69°C thermal water and whether or not it represents a blanket of condensate overlying a steam-dominated reservoir;

(b)/

(b) the position of such an underlying reservoir (i.e. directly under the resistivity anomaly? Offset north toward the volcanic complex?);

(c) the exact geometry, thicknesses and frequency of the fractures making up the reservoir, and quantitative values of porosity and permeability for representative volumes of reservoir rock;

(d) the thermal pattern below 1140' and the base temperature of the deeper fluids.

(e) the significance of the unstable tension fracture pattern on the "dome" and the extent or role of active faulting in this area.

1.3. Summary of Status

The geothermal area remains promising, but requires additional indirect geophysical work in order to decide whether or not a deep exploratory well is justified. We have a broad target, but still do not have adequate knowledge as to where the "bullseye" is located.

## 2.0. PROPOSED WORK OF FEDERAL GOVERNMENT

The federal Department of Energy, Mines and Resources is anticipating a budget of $2.35-million over the next five years for geothermal investigation, much of which will be used throughout the west for accumulation of basic regional geologic and geophysical data. (See memo to J. Stauder from A.E. Nevin, December 16, 1974). Some of E.M.R's proposed work will directly benefit the Meager Creek program. In the summer of 1975 they are planning:-

(a) An expanded seismic study from three stations, at Gold Bridge, Pemberton, and the Meager Creek camp site under the direction of Mr.G.C. Rogers, Victoria Geophysical Observatory (Appendix 'H');

(b) A magnetotelluric study, on these stations, to identify any large scale zones of low resistivity to depths of several tens of kilometres, under Dr.L.K. Law, Victoria Geophysical Observatory;

(c) Detailed geologic mapping of the Meager volcanic complex, by Dr.J.G. Souther and associates.

(d) Continued availability of equipment and consultation on temperature profiles and heat flow, by Drs.A.M. Jessop and Al Taylor, Earth Physics Division, Ottawa.

This work will require mutual co-operation for maximum benefit. B.C. Hydro will have access to all of the information from these projects as it unfolds.

3.0./

## 3.0. REVISED RECOMMENDATIONS

### 3.1. Summer 1975

The recently completed work has led us to propose revision of some techniques and of the overall program. Following are the leading points:-

(a) Resistivity appears to work very well and the total line-miles can be cut back from a proposed 80 to about 55.

(b) Research wells need not be as deep as the 1140 feet of 74-H-1, which was programmed to obtain a deep profile. The extent of fracturing and the water temperature and flow remained relatively constant over 734 feet from the bedrock surface to the bottom of the well. Thus a shallow penetration of bedrock, say 300 feet, can be planned.

(c) The large area enveloping the resistivity anomaly suggests that a greater number of shallow research wells is warranted.

(d) A special effort should be made to drill most additional research wells in non-fractured rock, so that meaningful heat flow data can be obtained. This means near, but not exactly over, resistivity lows, and preferably where bedrock can be observed in outcrop.

(e) Quantitative permeability measurements should be made in wells where it is practical and meaningful to do so.

(f) Costs (see Section 4.1 below) of support and drilling are higher than anticipated and have been revised.

The recommendations of June 1974 are revised to the following, to be conducted in the summer of 1975:-

(a) 20 line miles of resistivity survey (as plotted on Drawing C-11), which will be part of the basis for locating additional research wells.

(b) 2,000 feet of drilling (in place of 2,400-3,600 feet), in 6 wells of 300 to 350 feet in depth. Following completion of the first two wells we would seek approval from B.C. Hydro for continuation of the drilling.

(c) Continued co-operation with Energy, Mines and Resources in the fields of geologic mapping, seismic studies, heat flow determinations, etc.

(d) Preliminary interpretation of the new information, and report.

3.2./

3.2. Fall and Winter 1975-6.

We foresee the following functions for the several months commencing September 15, 1975:-

(a) Ascertain whether or not more geophysical investigation is warranted;

(b) If so, plan and estimate the cost of this work, and review the feasibility of a pioneer road to the head of Meager Creek.

(c) If warranted, begin planning of a deep exploratory well and estimate costs.

## 4.0. REVISED BUDGET

### 4.1. Analysis of Costs, October 1974 - March 1975.

A matter of serious concern to us has been that costs of several items, direct expenses and indirect support costs, were higher than anticipated during the recently completed phase of the program. Our budget of the June 1974 report was based on typical costs for this type of work experienced during the 1973 summer season. The factors which led to higher experienced costs were: error in original estimates, inflation in goods and wages, caving ground in well 74-H-1, a decision to complete the well rather than abandon it, and the onslaught of winter during delays in drilling.

A breakdown of the costs by function is given in Table 2.

TABLE 2/

## TABLE 2 - COST OF MEAGER CREEK INVESTIGATION - OCT.1974 - MAR.1975

### Itemized by Function

| ITEM | Cost | % of Total | Unit Cost |
|---|---|---|---|
| **Administration** | | | |
| General (design, research, office, lab, communications, drafting, reporting) | $ 30,775 | | |
| Burden on disbursements | 9,795 | | 6 mths @ |
| Photogrammetric base map | 7,849 | 27.5 | $8,070/mo. |
| | 48,419 | | |
| **General camp and field support** | | | |
| Senior staff | 5,191 | | |
| Junior staff, employees | 15,698 | | |
| Helicopter charges* | 9,152 | | |
| Equipment and supplies | 7,161 | | |
| Food | 3,096 | | |
| Hotel and meals | 1,038 | | 5 mths @ |
| Travel and vehicle rentals | 3,084 | 25.2 | $8,880/mo. |
| | 44,420 | | |
| **Resistivity survey** | | | |
| Linecutting - Labour | 5,920 | | |
| - Helicopter* | 2,774 | | |
| Resistivity - McPhar charges | 15,118 | | $605/line-mile. |
| - Helicopter | 3,359 | | |
| | 27,171 | 15.4 | $1080/line-mile. |
| **Drilling** | | | |
| Kendrick's charges | 29,495 | | $25.90/foot |
| Helicopter | 9,691 | | |
| Field supervision and logging | 7,190 | | |
| Misc. | 294 | | |
| Demobilization** Helicopter* | 2,200 | | |
| Contractor | 1,800 | | |
| | 50,670 | 28.8 | $44.45/foot. |
| **Refraction seismic survey** | | | |
| Geo-Recon charges | 3,113 | | |
| Helicopter* | 901 | | |
| Labour and supervision | 1,200 | | |
| Travel | 243 | | - |
| | 5,457 | 3.1 | |
| **Total** | $176 ,137 | 100.0 | |
| * Total helicopter time | 28,077 | 15.9 | |

** Estimated liability for moving drill off site.

Several "unit costs" are derived from this table, and are modified as a basis for anticipated costs for further work. (Some of the items were non-recurring start-up costs, i.e. base map, part of equipment and supplies etc.)

## 4.2. Budget for Summer 1975

The operations recommended in Part B, Section 3.1. are cost-estimated as follows:-

| | | |
|---|---|---|
| (1) | Drilling: | |
| | 2000 feet @ $22.00/foot contractor's charges........................................ | $ 44,000 |
| | Indirect support @ $10.00/foot................ | 20,000 |
| (2) | Resistivity: | |
| | Contractors charges @ $600/line-mile for 20 line miles........................................ | 12,000 |
| | Linecutting and support @ $350/line-mile....... | 7,000 |
| (3) | Administration, Lab.Work: Communications, etc. | |
| | 4 Months @ $6,000.. ......................... | 24,000 |
| (4) | General Camp and Field Support: | |
| | 3 Months @ $7,000............................ | 21,000 |
| | Total - | $ 128,000 |

We are thus requesting additional funds as follows:-

| | | |
|---|---|---|
| (1) | Total remaining in Phase II budget ($202,600 less $176,000 spent or committed to date)................................ | $ 26,600 |
| (2) | Remaining under Phase I purchase order........ | 5,000 |
| (3) | Additional funding..... .................... | 96,400 |
| | | $128,000 |

Respectfully Submitted:

NEVIN SADLIER-BROWN GOODBRAND LTD.

AEN/jrt.

May 14, 1975.

APPENDIX 'A'

RESISTIVITY - McPHAR GEOPHYSICS..

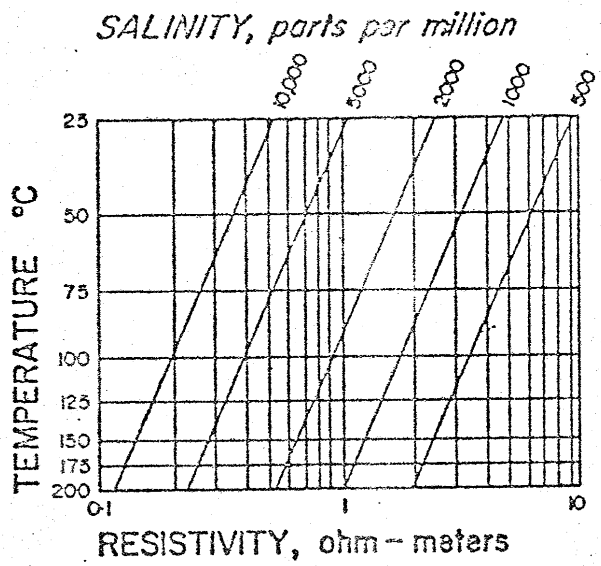
# NOTES ON GEOTHERMAL EXPLORATION USING THE RESISTIVITY METHOD

Many geophysical methods have been tried in the exploration for geothermally "hot" areas in the upper regions of the earth's crust. The only method that has been consistently found to be successful has been the resistivity technique. In this geophysical method, the specific resistivity (or its reciprocal, the specific conductivity) of the earth's subsurface is measured during traverses over the surface.

The principle of the technique is based on the fact that the resistivity of solution-saturated rocks will decrease as the salinity of the solutions is increased and/or the temperature of the system is increased (see Figure 1). Therefore, volumes of the earth's crust that contain abnormally hot and saline solutions can often be detected as regions of low resistivity.

The resistivity measurements are usually made using grounded current and potential electrodes, but some useful data can sometimes be obtained using electromagnetic techniques. The field data shown on plan maps in Figure 2 are from the Broadlands Area in New Zealand; in this area there are substantial flows of hot water and steam at the surface.

The results show resistivity lows measured with a Wenner Configuration Resistivity Survey and a loop-loop electromagnetic survey. The anomalous pattern is much the same in both cases and the regions of low resistivity correlate well with the areas of increased rock temperature.

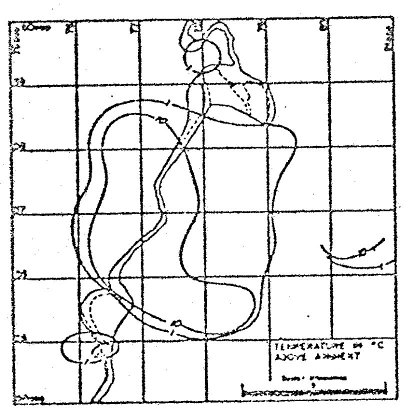



VARIATIONS OF SOLUTION RESISTIVITY
WITH TEMPERATURE AND SALINITY

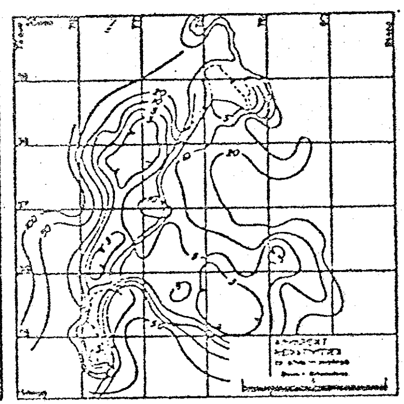
FIG. I

GEOPHYSICAL SURVEY

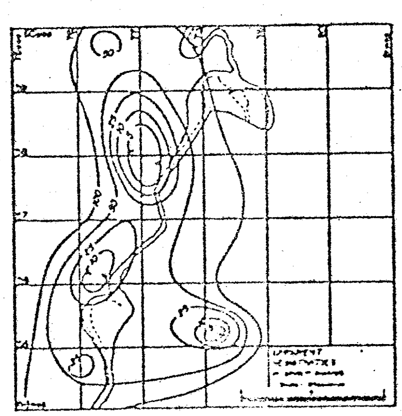
BROADLANDS AREA, NEW ZEALAND



A. TEMPERATURE AT 15m DEPTH



B. APPARENT RESISTIVITY SURVEY USING
WENNER CONFIGURATION A = 180m.



C. APPARENT RESISTIVITY SURVEY USING
LOOP TO LOOP ELECTROMAGNETIC METHOD

FIG. 2

If the rock volume saturated with hot solutions does not extend to the surface it will be necessary to use large electrode intervals to detect the resistivity lows. The resistivity data shown in "pseudo-section" form in Figure 3 is from Java. Along this line there are two deep regions of low resistivity detected for the larger electrode intervals used. Zone A is associated with surface manifestations of geothermal activity. The source of the resistivity low at Zone B is unknown.

If the abnormally hot region occurs in a sedimentary basin, the general resistivity level can be quite low, due to the high porosity in normal sediments. This is the case in the Imperial Valley of California. The resistivities shown in Figure 4 are from an area near El Centro, California. The largest electrode separation used was 12,000 feet.

The results show a two-layer geometry with the upper layer having a thickness of approximately one-half electrode interval (i.e. 1,000 feet). The resistivity in the upper layer is 3.0 ohm-meters; the resistivity of the lower layer is 1.5 ohm-meters. Due to the small resistivity contrast, additional measurements would be necessary to determine the possible geothermal importance of the lower resistivity layer at depth.

The results shown in Figure 4 are from a dipole-dipole electrode configuration survey. Our dipole-dipole data is plotted as a "pseudo-section" for several values of n; the separation between the current electrodes and potential electrodes, as well as the location of the electrodes along the survey line, determine the position of the plotting point. The two-dimensional array of

APPARENT RESISTIVITY SURVEY, DIENG PLATEAU AREA, JAVA, INDONESIA

Pseudo Section Plotting Method Along Dieng–Batur Road

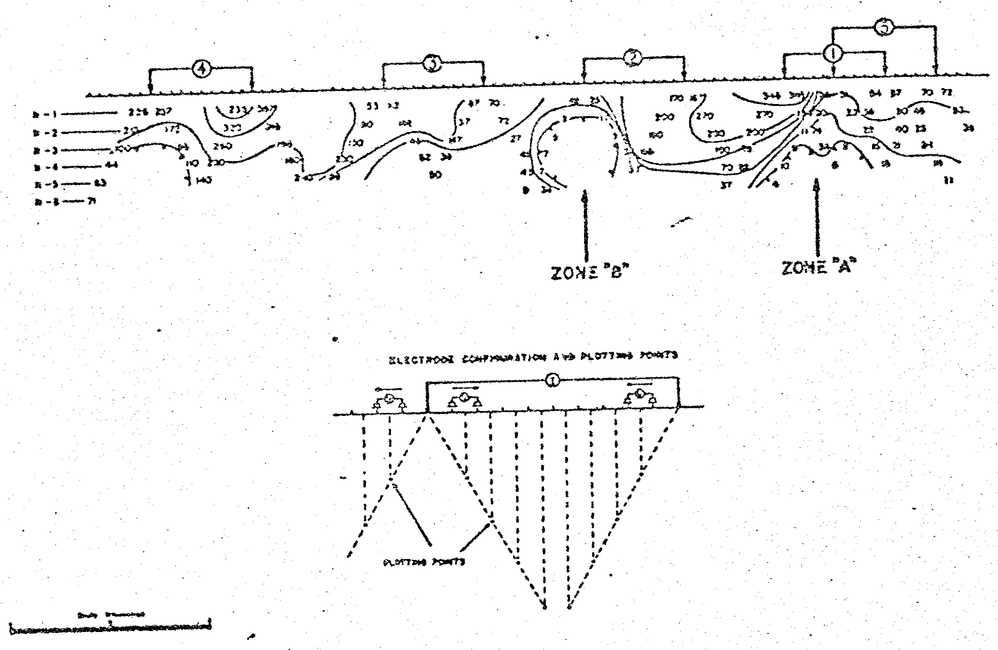



FIG. 3

RESISTIVITY SURVEY, IMPERIAL VALLEY–CALIFORNIA.

LINE–"O", FREQUENCY–0·125 Hz.

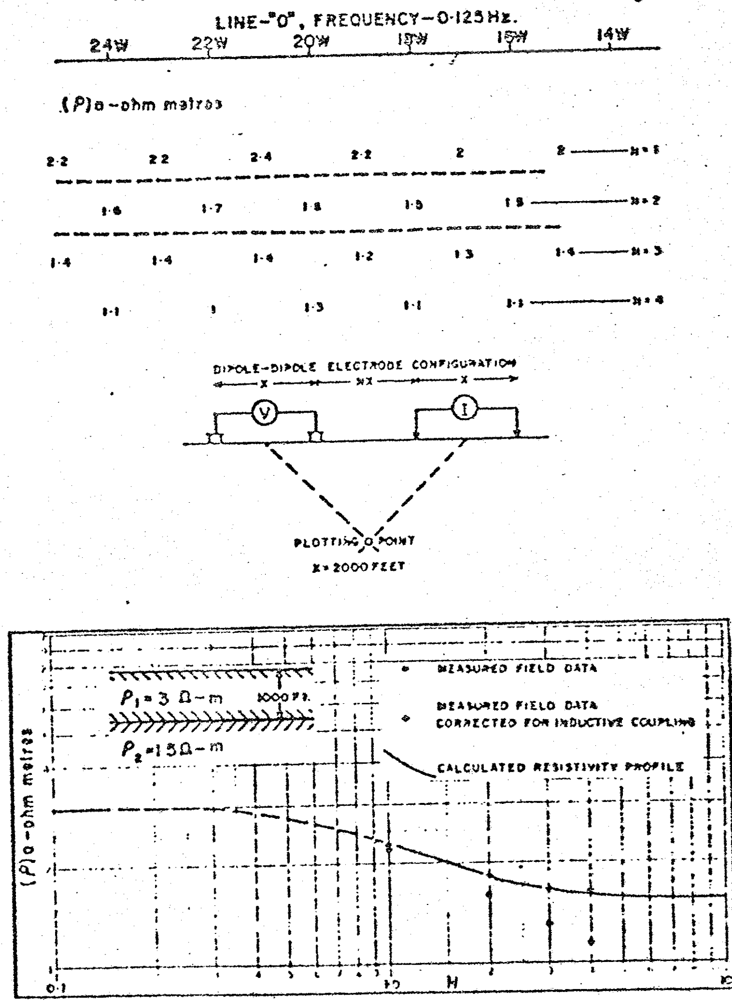
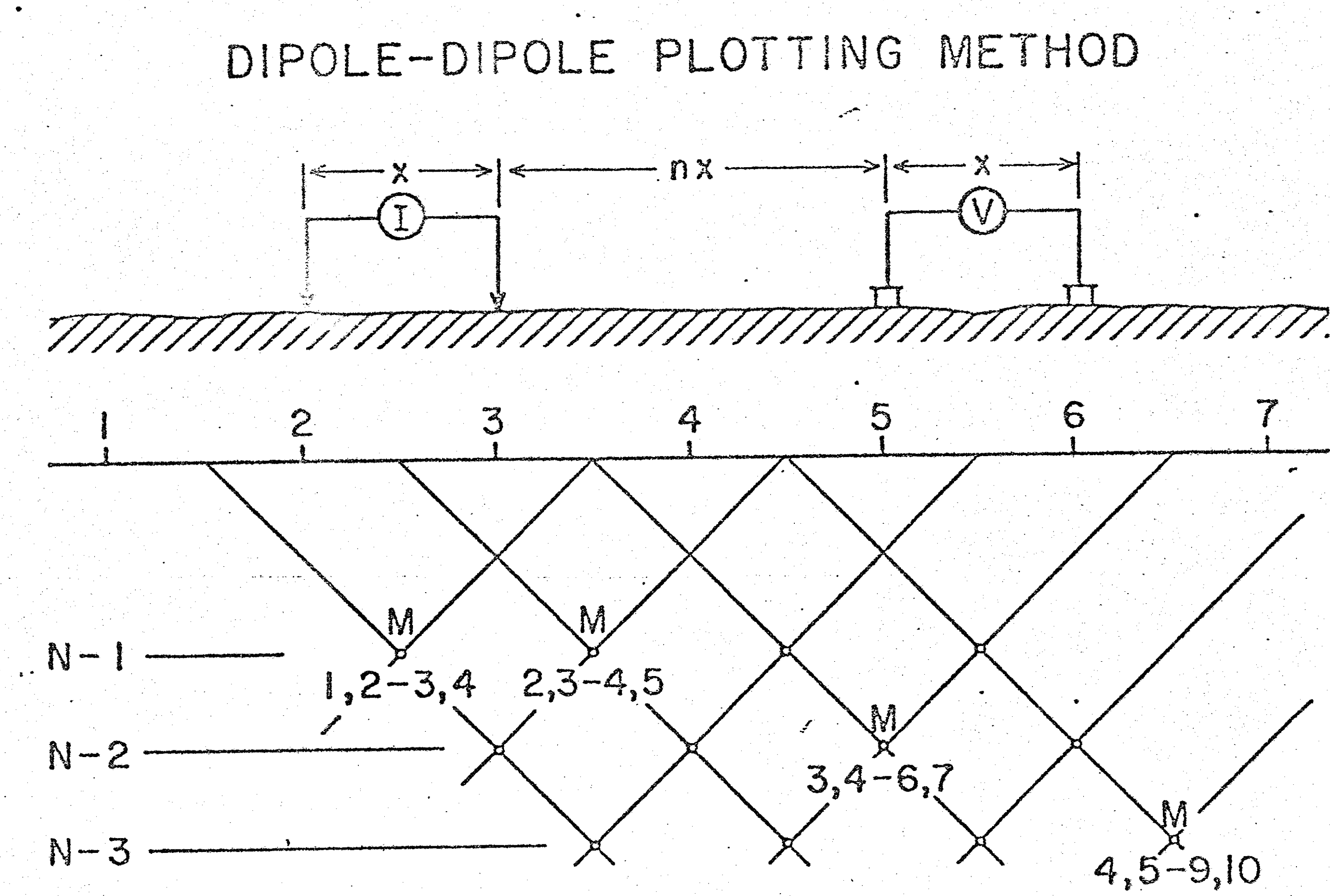



FIG. 4

data is then contoured (see below). The contour plots are not sections of the




electrical properties of the earth; they are convenient graphical representations of the measurements made. However, with experience the contour patterns can be interpreted to give some information about the source of the anomaly.

If the contour patterns indicate very simple geometries, more quantitative interpretations can often be made. For instance, if the contours are horizontal for a lateral distance of four to six electrode intervals, a horizontally layered geometry is indicated. In this situation, theoretical type-curves for dipole-dipole measurements in a layered geometry can be used in "curve fitting" techniques to give the true resistivities and depths for the earth.

McPHAR GEOPHYSICS

REPORT ON THE

RESISTIVITY SURVEY

IN THE

MEAGER CREEK SELECTED AREA,

LILLOOET RIVER REGION,

PEMBERTON, BRITISH COLUMBIA

FOR

NEVIN SADLIER-BROWN, GOODBRAND LTD.

BY

McPHAR GEOPHYSICS COMPANY

---

## 1. INTRODUCTION

We have completed a Reconnaissance Resistivity survey in the Meager Creek Selected Area, on behalf of Nevin Sadlier-Brown, Goodbrand Ltd. They in turn, are acting as consultants to B.C. Hydro. The area lies approximately thirty-five miles northwest of Pemberton, B.C.; the presence of several hot springs in the vicinity suggests that the area may be of possible importance as a source of geothermal energy.

As explained in the notes preceding this report, the known geothermally active areas in the world had been found to be regions of low resistivity. The reconnaissance resistivity survey in the Meager Creek Selected Area was planned to determine the general resistivity configuration in the immediate vicinity of the hot springs and also to detect any large zones of unusually low resistivity that might be present.

## 2. PRESENTATION OF RESULTS

The results of the reconnaissance resistivity survey are shown on the following enclosed data plots. The results are plotted in "pseudo-section" form, so that lateral variation in resistivity can be separated from vertical variations.

| Line | Electrode Intervals | Dwg. No. |
|---|---|---|
| A | 1000 feet | R-6253-1 Top |
| C | 1000 feet | R-6253-1 Centre |
| | 500 feet | R-6253-1 Bottom |
| D | 1000 feet | R-6253-2 Top |
| E | 1000 feet | R-6253-2 Centre |
| F | 1000 feet | R-6253-2 Bottom |

Two plan maps have been prepared showing the area surveyed, the relative position of the lines and some topographic features.

Dwg. No. RP 5036-1 (Scale 1:100,000) shows all of the lines

Dwg. No. RP 5036-2 (Scale 1: 10,000) shows detail for Line C, Line D and Line E.

## 3. GEOLOGY

The principal rock type underlying the area is Mesozoic granodiorite, which is overlain unconformably by late Tertiary and Quaternary volcanic rocks. The volcanics are intermediate composition and form flows, fragmental rocks and plugs on the upper slopes of Meager Mountain. Most of the resistivity lines were run along valley bottoms or in topographic saddles. With the exception of Line A, all of the lines are known or presumed to be run on granodiorite. The western part of Line A is run on a dacite ignimbrite, which overlies a bed of semi-consolidated gravel, which in turn unconformably overlies granodiorite. The dacite and gravel lie in the ancestral valley of the Lillooet River.

The eastern part of Line D and adjacent parts of Line C, are on thick overburden unbroken by rock outcrop. In places the overburden near the lines consist of banks 400' high containing clay deposits of volcanic origin.

The density of fractures in the granodiorite appears to be no more nor less than any other typical Coast Range intrusive rock. Locally, however, there are faults and fractures, and in particular there is a regional set of fractures trending west northwest and dipping steeply.

Near Line A, Line C and Line D, there are three hot spring complexes. The most important of these, near station 180SW on Line C, has been thoroughly studied as to its chemical make-up. It has a temperature of nearly 60°C, and contains about 2,000 ppm. total dissolved solids. The analysis on this spring and on a few shallow drill holes nearby is available. In general the springs adjacent to Line A and Line D have similar chemical compositions and similar total dissolved solids contents, although they have a lesser rate of flow.

## 4. DISCUSSION OF RESULTS

The reconnaissance resistivity survey in the Meager Creek Selected

Area was carried out using 1000' electrode intervals and n = 1, 2, 3, 4. A considerable resistivity variation was detected in the area surveyed.

Line A

This line extends NW-SE across the northern end of the area of interest. At the northwest end of the line the resistivity values show a near-surface, high resistivity layer overlying a lower resistivity second layer. This correlates with the known geology which shows a dacite overlying a semi-consolidated gravel. The apparent resistivity data in the interval from 260NW to 300NW was "computer-fit" to a layered media. The values are $H$ = 725 feet, $\rho_1/2\pi$ = 2784, $\rho_2/2\pi$ = 448; the fit is extremely good. The depth of 725 feet is therefore, the best estimate of the thickness of the non-porous volcanic rock unit.

Some sulphide mineralization has been observed in the vicinity of the deep, distinct resistivity low at about 150NW to 160NW.

At the southeast end of the line, the last few measurements suggest a narrow zone of very low apparent resistivities centred at approximately 70NW. At this point Line A is approaching the valley of Meager Creek. The resistivity anomaly appears to be due to a narrow, porous structure (fault?) rather than to a valley filled with unconsolidated sediment. The measurements on Line A would have to be extended to the southeast to complete the anomalous pattern and permit a more definite interpretation. Closely spaced parallel lines would also have to be surveyed in order to determine the strike of the anomalous feature.

The central portion of Line A passes over the granodiorite, with neither the dacite, nor unconsolidated sediments present in significant thickness. The apparent resistivities measured are moderately high. In the interval from 140NW to 170NW the apparent resistivities at depth are appreciably lower. This suggests greater porosity (fracturing or alteration) with the rocks.

Line C

This line was surveyed along the southeast side of Meager Creek, with the vast volume of the Meager Mountain volcanic complex lying to the northwest. Within the valleys, there could be thick (several hundred feet) sections of ash and other sediments derived from volcanics. The hot springs along Meager Creek and Lillooet River issue from the Mesozoic intrusive at the base of this volcanic complex.

A major crustal facture has been identified along the valley of Lillooet River and another along the valley of Meager Creek. If this fault structure has created increased porosity, this would be a low resistivity zone approximately parallel to the line.

The apparent resistivity results from about 180SW to 90SW show that a lower resistivity zone is having an increasingly greater influence on the measurements as the survey proceeded to the southwest. To the northeast of 90SW to 80SW the apparent resistivities are high, probably reflecting the near-surface presence of the non-porous, unaltered, unfractured intrusive. The position at 90SW to 80SW is well within the valley of Meager Creek; however, the valley is much narrower to the northeast of this point and granodiorite outcrops just to the northeast of 90SW on Line C. Therefore, it is reasonable to suppose that the high resistivity rocks are much nearer to the measurement point here, than they would be to the southwest.

The apparent resistivity pattern suggests that either the overburden thickness increases to the southwest or that the line is approaching a narrow, conducting feature (fault) at a shallow angle. The apparent resistivity results in the interval from 120SW to 90SW were used to "computer interpret" a two-layer or three-layer geometry that would approximate actual earth situations.

The iterative computer program used for the inversion attempt is extremely good, and almost always gives some type of approximate answer, even in non-layered situations. In this case the program refused to give an approximate answer. It must therefore be assumed that the actual earth situation cannot be even remotely approximated by a layered medium. Certainly, it cannot be simply a gradually increasing wedge of conductive stream sediments. However, in a relatively narrow valley the conductive overburden could not be considered to be a "layered earth", in any case.

In the interval from about 270SW to 250SW the resistivity pattern changes again. To the southwest of this point the apparent resistivity level is once again moderately high, although not as high as at the northeast end of the line. In this area, the line begins to climb up the sides of the valley. At about this point the contour patterns indicate three narrow, conductive features.

There is a shallow, moderately low narrow feature centred at 295SW. There is a relatively narrow zone of low resistivities centred at

270SW to 260SW, at considerable depth. There is a very definite, narrow zone of low resistivities at 235SW. This feature seems to separate the two different resistivity environments that exist to the northeast and the southwest. This narrow, shallow feature was checked using X = 300 feet. The results show a narrow zone of low resistivities centred at 232+50SW. This anomaly has all the characteristics that one would expect from a zone of increased porosity with a narrow width and considerable vertical extent. The most obvious geologic feature would be a fault.

Line D

This east-west line extends along Meager Creek to the west of an almost 90° bend in the creek itself. At its eastern end it crosses both Line C and Line E. West of about 115W and east of about 15E, the apparent resistivities are moderately high, probably reflecting the relatively non-porous intrusive. In the interval from 115W to 15E the apparent resistivities range from low to very low.

Throughout this interval, the lowest apparent resistivity values were measured for n = 1. The values measured increase for increasing values of (n). Following the "computer interpretation" procedure used in portions of Line A and Line C, two apparently layered portions of this line were used. The apparent resistivity values in the region from 95W to 55W and from 35W to 5E were fed into the computer program. As on Line C, the result was that no layered earth could be found that would give rise to the measured values. Therefore, it cannot be assumed that the resistivity pattern measured from 105W to 15E is due simply to a thick layer of recent porous stream sediments. However, as on Line C, the topography of the valley suggests that the layering cannot extend very far to the north and south.

At the ends of this zone of low resistivities Line D still lies well within the valley of Meager Creek. Therefore, there is no reason to suppose that the overburden thicknesses would change abruptly. The ends of the resistivity low occur at topographic features (creeks, ravines, etc.) that could reflect fault structure.

It must be considered, therefore, that it is possible that the extremely low resistivities in the interval from 105NW to 15E are due to close proximity to a parallel, porous fault structure that may or may not be the conduit for geothermal solutions. The results from the brief survey reported here are not complete enough to permit a rigid interpretation.

Line E

This line was surveyed parallel to Line C, a distance of 2000 feet to the southeast. This line is entirely within the environment of moderately high apparent resistivities. There are narrow zones of somewhat lower values at 260SW to 250SW and at about 200SW. The sources of the slightly lower resistivities are indicated to be at some depth.

Line F

This line was surveyed along the top of a relatively flat hill just to the south of Meager Creek. The apparent resistivities measured are relatively uniform and moderately high.

## 5. CONCLUSIONS AND RECOMMENDATIONS

The first resistivity results from the Meager Creek Selected Area are of definite interest. There are distinct resistivity lows on Line C and Line D, and particularly at the intersection. The anomalous patterns of the resistivity lows appear to be due to increased thicknesses of porous, conductive stream sediments. However, attempts to do a "computer interpretation" of the results on Line C and Line D using a layered earth geometry have shown that the field data can not be approximated as being due to a layered earth. However, it must be recognized that the finite width of the valleys would limit the "infinite" behavior of the sediment layer. The possibility must be considered that the resistivity lows on Line C and Line D are due to the lines lying close to, and approximately parallel to, linear conductive features such as faults. The faults could be important as conduits for geothermal solution. The presently available data is not complete enough to permit a definite interpretation.

A drill hole has been started at about 210SW on Line C. The purpose of Hole No. 74-H-1 was to determine the nature of the sediments in the Meager Creek Valley and to determine the possible presence of a geothermal source at depth. The following drill hole log is available to date:

| | |
|---|---|
| 0 - 220 feet | coarse boulders, sand and gravel |
| 220 - 320 feet | clay, possibly unconsolidated tuffaceous material |
| 320 - 363 feet | boulders, sand and gravel |

Several samples from the drill hole were consolidated enough to permit resistivity measurements to be made in the laboratory. These values range from 8.0 to 28 for $\rho/2\pi$ in ohm-feet. The measured resistivity values should be correlated with the geologic log for Drill Hole No. 74-H-1; it would be expected that the clay layer from 220 feet to 320 feet would have the lowest apparent resistivity value.

A better interpretation for the source of the resistivity lows measured during this reconnaissance resistivity survey could be made only if further data is available. Closely spaced parallel lines and/or perpendicular lines would have to be surveyed to determine whether the regions of lower resistivity are due to a complex layering situation within the stream sediment filled valleys or to relatively narrow, linear, conductive features (such as faults) that occur approximately parallel to the lines surveyed, in the bedrock.

The results of the first drill hole, and further resistivity data will permit a more definite interpretation.

McPHAR GEOPHYSICS COMPANY

Philip G. Hallof

Philip G. Hallof,
Geophysicist

Bruce S. Bell

Bruce S. Bell, (per R. A. Bell)
Geologist

Dated: January 28, 1975

## APPENDIX 'B' - DRILLING TECHNIQUES

The well was drilled in two stages.

Stage 1: November 27, 1974 to December 17, 1974 (0 to 363')

In anticipation of about 250' of overburden a hole gauge of 2.360" was decided upon, using 'BQWL' rods (O.D. 2.188", I.D. 1.813") to be run inside 'BW' flush joint casing (O.D. 2.875", I.D. 2.375"). (The letters 'BQWL', 'BW' etc. are classification terms used within the drilling industry). Unstable hole conditions within the first 100' necessitated an additional outer string of casing, 'NW' flush joint casing (O.D. 3.500", I.D. 3.000"). The 'NW' casing penetrated to 71', the 'BW' casing to 274'. In both cases loss of circulation of drilling fluid caused spent shoes to become seized. Efforts to free the 'BW' casing resulted in it being twisted off (broken) somewhere inside the 'NW' casing. Searching for bedrock, 'BQWL' rods were advanced 89' ahead of the 'BW' casing to 363' where the bit became pinioned in a boulder bed causing the rods to twist off leaving 14' of derelict 'BQWL' hardware (bit, corebarrel, overshot) from 349' to 363'.

Stage 2: January 7, 1975 to February 5, 1975 (274' to 1140')

The hole gauge was reduced to 1.890" using 'AQWL' rods (O.D. 1.75", I.D. 1.375") to be run inside 'BXWL' rods/casing (O.D. 2.250", I.D. 1.906"). A wedge was effected between 285' and 300' by glancing off 20' of placed and cemented 'BQWL' rods. The angle of deflection was less than $1^{o}$ allowing the hole to bypass the derelict 'BQWL' hardware. The 'BXWL' casing was driven to 406.5', unable to go further with a spent shoe. It is intact and recoverable. The 'AQWL' rods completed the hole in bedrock to 1140'.

Drilling conditions in the overburden were difficult. Alternating zones of rounded, unsorted boulders and sand caused periodic loss of drilling fluid and seizing. Barite drilling mud and Quik-trol Gel were used to control caving however groundwaters lessened its effectiveness in many areas.

# APPENDIX 'D'

## CHEMEX ANALYTICAL REPORTS.

CHEMEX LABS LTD.

2 BROOKSBANK AVE.
NORTH VANCOUVER, B.C.
CANADA V7J 2C1
TELEPHONE: 985-0648
AREA CODE: 604

• ANALYTICAL CHEMISTS • GEOCHEMISTS • REGISTERED ASSAYERS

# CERTIFICATE OF ANALYSIS

CERTIFICATE NO. W 1738
INVOICE NO. 13413
RECEIVED Feb. 10/75
ANALYSED Feb. 19/75

TO: Nevin Sadlier-Brown Goodbrand Ltd.,
5th flr. 134 Abbott St.,
Vancouver, B. C.

ATTN:

| SAMPLE NO. : | #2 | #3 |
|---|---|---|
| $SiO_2$ (mg/L) | 41.0 | |
| Na (ppm) | | 910 |
| K (ppm) | | 52.1 |
| Ca (ppm) | | 150 |
| Mg (ppm) | | 24.0 |

H-74-1 (406 to 877')
(5 February, 1975)



CERTIFIED BY: R. J. James

CHEMEX LABS LTD.

2.2 BROOKSBANK AVE.
NORTH VANCOUVER, B.C.
CANADA V7J 2C1
TELEPHONE: 985-0648
AREA CODE: 604

• ANALYTICAL CHEMISTS • GEOCHEMISTS • REGISTERED ASSAYERS

# CERTIFICATE OF ANALYSIS

CERTIFICATE NO. W1817
INVOICE NO. 13473
RECEIVED Feb. 26/75
ANALYSED March 7/75

TO: Nevin Sadlier-Brown Goodbrand Ltd.,
5th flr. 134 Abbott St.,
Vancouver, B.C.

ATTN:

| SAMPLE NO. : | #1 | #2 | #3 | #4 |
|---|---|---|---|---|
| $HCO_3^-$ (mg/L) | 1396 | | | 1390 |
| $CO_3^=$ (mg/L) | < 0.1 | | | < 0.1 |
| $SO_4^=$ (mg/L) | 1880 | | | 1840 |
| pH | 7.34 | | | 7.01 |
| $SiO_2$ (mg/L) | | 80.5 | | |
| Na (ppm) | | | 2300 | |
| K (ppm) | | | 90 | |
| Ca (ppm) | | | 380 | |

H-74-1 (406' to 1140')
21 February, 1975.



CERTIFIED BY: R. J. Jones

**CHEMEX LABS LTD.**

212 BROOKSBANK AVE.
NORTH VANCOUVER, B.C.
CANADA V7J 2C1
TELEPHONE: 985-0648
AREA CODE: 604

• ANALYTICAL CHEMISTS • GEOCHEMISTS • REGISTERED ASSAYERS

# CERTIFICATE OF ANALYSIS

CERTIFICATE NO. W 1686
INVOICE NO. 13005
RECEIVED Nov. 1/74
ANALYSED Nov. 13/74

TO: Nevin Sadlier-Brown Goodbrand Ltd.,
5th Flr. 134 Abbott St.,
Vancouver, B. C.

ATTN: Doug. Nevin

| SAMPLE NO. : | 79 D-1 | 79 D-2 | 79 D-3 | 79 D-4 |
|---|---|---|---|---|
| $HCO_3^-$ (mg/L) | 387 | | | |
| $CO_3^=$ (mg/L) | <0.01 | | | |
| $Cl^-$ (ppm) | 275 | | | |
| $F^-$ (ppm) | 0.245 | | | |
| $SO_4^=$ (ppm) | 76 | | | |
| Diss: $Na^+$ (ppm) | | | 150 | 1.4 |
| $K^+$ (ppm) | | | 32 | 0.7 |
| $Ca^{+2}$ (ppm) | | | 40 | 7.8 |
| $Mg^{+2}$ (ppm) | | | 7.6 | 2 |
| $SiO_2$ (ppm) | | 208 | | 8.3 |

Spring 79D - Upper Meager Creek
(30 October, 1974).



CERTIFIED BY: R. J. Jones

# CHEMEX LABS LTD.

212 BROOKSBANK AVE.
NORTH VANCOUVER, B.C.
CANADA V7J 2C1
TELEPHONE: 985-0648
AREA CODE: 604

• ANALYTICAL CHEMISTS • GEOCHEMISTS • REGISTERED ASSAYERS

## CERTIFICATE OF ANALYSIS

CERTIFICATE NO. W 1685
INVOICE NO. 13005
RECEIVED Nov. 1/74
ANALYSED Nov. 13/74

TO:
Nevin Sadlier-Brown Goodbrand Ltd.,
5th flr. 134 Abbott St.,
Vancouver, B.C.

ATTN:
Doug. Nevin

| SAMPLE NO. : | MCCS 1 | MCCS 2 | MCCS 3 | MCCS 4 |
|---|---|---|---|---|
| $HCO_3^-$ (mg/L) | 504 | | | |
| $CO_3^=$ (mg/L) | < 0.01 | | | |
| $Cl^-$ (ppm) | 600 | | | |
| $F^-$ (ppm) | 0.313 | | | |
| $SO_4^=$ (ppm) | 190 | | | |
| Diss. $Na^+$ (Ppm) | | | 330 | 5 |
| $K^+$ (ppm) | | | 54 | 1.10 |
| $Ca^{+2}$ (ppm) | | | 51 | 6.8 |
| $Mg^{+2}$ (ppm) | | | 15 | 1.8 |
| $SiO_2$ (ppm) | | 150 | | 9.4 |

Meager Creek - Main Vent
(30 October, 1974)

CTA
MEMBER
CANADIAN TESTING ASSOCIATION

CERTIFIED BY: ..........

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# CERTIFICATE OF ANALYSIS

CERTIFICATE NO. W 367
INVOICE NO. 11060
RECEIVED
ANALYSED Jan. 15/74

TO: Nevin Sadler-Brown Goodbrand Ltd.,
5th Flr. 134 Abbott St.,
Vancouver, B. C.
V68 2K4
ATTN:

| SAMPLE NO. : ~~Location:~~ | Meager Creek 58°C |
|---|---|
| Reactive Silica (mg/L) (Dissolved | 164 |
| Dissolved: Li (PPM) | 1.2 |
| K (PPM) | 47. |
| Na (PPM) | 450. |
| Ca (PPM) | 81. |
| Mg (PPM) | 25. |
| $SO_4^{=}$ (PPM) | 110. |
| CI (PPM) | 675. |
| F (PPM) | <1.0 |
| $HCO_3$ (PPM) | 468. |
| pH | 7.1-7.3 |
| Total Dissolved Solids (mg/L) | 1810. |

Meager Creek - Main Vent
(January 5, 1974).



CERTIFIED BY: R. J. Jones

# CHEMEX LABS LTD.

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NORTH VANCOUVER, B.C.
CANADA
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AREA CODE: 604

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## CERTIFICATE OF ANALYSIS

CERTIFICATE NO. W 416
INVOICE NO. 11232
RECEIVED
ANALYSED April 5/74

TO: Nevin Sadler-Brown Goodbrand Ltd.,
5th flr. 134 Abbott St.,
Vancouver, B. C.

ATTN:

| SAMPLE NO. : Location: | MDH-1 | MDH-2 | MDH-3 |
|---|---|---|---|
| Na (ppm) | 430 | 440 | |
| K (ppm) | 27 | 27 | |
| Ca (ppm) | 85 | 85 | |
| $Cl^-$ (ppm) | 650 | | |
| $HCO_3^-$ (mg/L) | 513 | | |
| $SiO_2$ (ppm) | | | 151 |

Meager Creek - GSC DH-1
(Mar.29, 1974).



CERTIFIED BY: [signature]

# APPENDIX 'E' - GEOCHEMISTRY

## FORMULAS

There are two chemical systems, which can be measured in a hot spring, which have memory of the hottest temperature which the fluid may have reached in an underlying reservoir. The basic formula for the first of these, which makes use of the ratio between sodium, potassium, and calcium, is as follows:-

$$T^{o}C = \frac{1647}{\log \frac{Na}{K} + (B \log \frac{\sqrt{Ca}}{Na}) + 2.24} - 273$$

Where Na,K,Ca = molality of ionic species and where the rational number B = 1/3 for equilibrium temperature above 100°C and 4/3 below 100°C.

This relationship is empirical and it is based on the equilibrium constants between the various feldspars under conditions of high pressure and temperature. Because it is a ratio, it is relatively insensitive to dilution of the hot springs by surface waters.

The second chemical thermometer is the absolute silica content, which is based on the equilibrium of the hot water with quartz It owes its utility to the fact that upon rapid cooling the reaction which would tend to precipitate excess silica becomes increasingly sluggish. This can lead to an excess amount of silica in meta-stable solution in the hot spring. Absolute silica content is sensitive to dilution of the thermal water by cold surface water, but a "mixing model" can be applied (making certain assumptions), and an estimate of the reservoir's temperature may be obtained.

The principal formula relating silica content to temperature is as follows:-

$$T^{o}C = \frac{1309}{5.19 - (\log SiO_2)} - 273$$

Where $SiO_2$ = silica content in ppm or mg/l.

# APPENDIX 'F'

## PETROGRAPHIC REPORT

## MEAGER CREEK RESEARCH WELL 74-H1

### Petrography

Two specimens supplied #714 and #729 are 714 and 729 feet down hole from the collar. Both specimens are quartz diorite with a well developed gneissosity.

**Specimen 714:**
Medium-grained (1 to 3mm) gneissic hornblende biotite quartz diorite

35% 30 Quartz: Anhedral grains, slightly strained.
54% 49 Plagioclase ($An_{33}$): Anhedral, unzoned grains locally with potash feldspar blebs (antiperthite)
4% Orthoclase: Interstitial grains untwinned.
12% Biotite: Fresh, light brown to chocolate brown flakes
4% Hornblende: Fresh, olive grenn to olive brown prisms.
Accessory Minerals:
< .1% (a) Allanite: As cores to some epidote grains
.2% (b) Sphene
1.0% (c) Epidote: Faintly pleochroic
.3% (d) Opaque minerals
.1% (e) Apatite
tr (f) Zircon

No sign of late fracturing, fracture filling or alteration of specimen.

**Specimen 729:**
Medium-grained (1 to 2mm) biotite quartz diorite gneiss cut by thin fractures:

35% 33 Quartz: Anhedral grains, slightly strained.
52% 50 Plagioclase ($An_{34}$): Fresh, unaltered, unzoned grains with rounded minute inclusions of quartz and potash feldspar.
15% Biotite Light to chocolate brown which define a well developed foliation. Typically unaltered but some bent flakes with undulatory extinction.
1% Orthoclase: Small, anhedral, interstitial grains
.5% Accessory Minerals:
(a) Apatite
(b) Epidote
(c) Opaque minerals

Fracture fillings:
These represent about 5% of the rock and are of two types:
1. Calcite-quartz:
90% Calcite: Anhedral grains which locally replace and pseudomorph biotite.
10% Quartz 0.01 to 0.3mm, anhedral grains some of which grow in optical continuity with that present in walls.
Calcite-quartz shows a weak crustiform texture with quartz near the margin or in layers
2. Kaolinite: (Not present in thin section)
Light green in specimen and X-ray shows it is a 7Å layer silicate.

Fractures range from thick (1 to 2mm) planar fillings to hairline anastomosing fillings composed of calcite in quartz and plagioclase.

Specimens supplied are fresh and lack significant alteration. The lack of alteration depends partly on:

(a) Low temperature of geothermal water.
(b) Impermeability and medium grain size of intrusion.
(c) Relative stability of intrusion compared with volcanic rocks with aphanitic to glass material.

March 5, 1975

P. B. Read

APPENDIX 'G'

REFRACTIVE SEISMIC - GEO-RECON EXPLORATIONS LTD.

GEO-RECON
Explorations Ltd.

G-121-01

January 9, 1975

Nevin, Sadlier-Brown, Goodbrand, Ltd.
5th Floor
134 Abbott Street
Vancouver, B.C. V6B 2K4

RE: Seismic Refraction Survey
Meager Creek Area, Pemberton, B.C.

Dear Sirs:

This letter and attached figure presents the results of the seismic refraction survey, conducted by your authorization, in the Meager Creek Area near Pemberton, British Columbia. The purpose of the investigation was to define bedrock depth below drill hole 74-H1 to determine the feasibility of continuing the drilling program with the drilling machine on the drill hole at the time of the investigation. The survey was conducted between December 28 and 31, 1974.

The survey consisted of one 2000-foot seismic spread, centered on the drill hole and laid in the creek flood plain. The offset distance from the drill hole to center of the spread was approximately 200 feet. The center geophone opposite DH 74-H1 was measured to be approximately 27 feet below the collar of the drill hole. Due to the snow cover (4 to 5 feet) the surface elevations of the 23 geophone locations were not determined, and the ground profile represents an approximation of the ground surface. The attached figure presents the results of the seismic survey. In order to obtain refracted arrivals from the lower refracting surface over the entire length of the seismic spread, 4 off-end shots were made. Off the 0+00 end of the seismic spread, shots were placed at 1000 feet and approximately 2000 feet. Off the 20+00 end of the spread, shots were placed at 1000 feet and approximately 3000 feet. The refraction from the lower or bedrock surface shows three velocities. Upstream the bedrock velocity is 17,500 fps. Under the drill hole, at Station 10+00, the bedrock velocity drops to 14,000 fps. Downstream the velocity is 16,500 fps.

1661 W. 8th Avenue, Vancouver, B.C.
~~1605 Hamilton Avenue - North Vancouver, British Columbia~~
Telephone: ~~(604) 985-1214 Telex: 04-507-680 Twx: 610-923-5053~~
(604) 736-7361

Two overburden velocities were determined from the interior shots and the end shots. The first layer velocity was found to be a uniform 5500 fps. Second layer velocities were 8300 fps and 10,000 fps, to give an averaged velocity of 9,500 fps.

Preliminary depth to rock calcualtions before leaving the site area, gave a bedrock depth to the 14,000 fps material of 346 feet, below Station 10+00. The 27-foot difference between the drill hole and the geophone location places the rock surface at a depth of 373 feet below the drill collar. This calculation is based on a second layer velocity of 8300 fps.

Computer derived depth to bedrock calculation gives a bedrock depth below Station 10+00 of 353 feet at a velocity for the second layer of 8300 fps. Using the averaged second layer velocity of 9500 fps, the computer derived depth to bedrock is 436 feet. Below the drill hole the computer derived depth to bedrock is 380 feet and 463 feet respectively.

The drill hole log, at a depth of 363 feet at the time of the survey, shows a 121-foot thickness of varved clays (from 229 to 350 feet below the drill hole). This section of varved clays would typically have a velocity less than 9500 fps. For this reason, the depth calculations based on a second layer velocity of 9500 fps would be deep. Therefore, the calculations based on a second layer of 8300 fps would be a better estimation of the bedrock surface.

For this reason, the profile on the attached figure shows a bedrock depth of 353 feet below Station 10+00. The profile of the bedrock surface is based on the wave front targeting method of refraction interpretation and is considered to give an accurate profile of the bedrock relief. The depth of 380 feet below the drill hole collar is our estimate of bedrock depth.

Sincerely,

GEO-RECON EXPLORATIONS

BY John M Musser
John M. Musser, CEG
Senior Geologist

REGISTERED GEOLOGIST
JOHN M. MUSSER
NO. EG 861
CERTIFIED ENGINEERING GEOLOGIST
STATE OF CALIFORNIA

BY Boyd O. Bush
Boyd O. Bush, P. Eng.
Principle Geologist

PROFESSIONAL
PROVINCE OF
B. O. BUSH
BRITISH COLUMBIA
ENGINEER

JMM:sw

APPENDIX 'H'

PASSIVE SEISMIC - G. ROGERS.

# MEMORANDUM

CLASSIFICATION

TO / A

Dr. M.J. Berry,
Division of Seismology,
Earth Physics Branch,
Energy, Mines, and Resources,
Ottawa, Ontario, K1A 0E4.

YOUR FILE No. / Votre dossier

OUR FILE No. / Notre dossier 6082-6

DATE March 5, 1975.

FROM / De G.C. Rogers.

SUBJECT / Sujet <u>Meager Creek Geothermal Area - Microseismicity Study Winter 74/75.</u>

## Field Program

A short period vertical seismograph station was operated in the Meager Creek geothermal area (150 km north of Vancouver) from November 27 to December 17, 1974 and again from January 7 to January 21, 1975. The station was located at the camp of Nevin Sadlier-Brown Goodbrand Limited (consulting geologists). Mr. John Crandall changed records and operated the station. During the first observation period the instrument was recording 96% of the time. The second period was plagued with power supply problems and the instrument was recording only 76% of the time. Total useable recording time in the two periods was about 730 hours.

Snow cover was about 4 feet at the start of the exercise and about 8 feet near the end. Weather experienced included snow, rain and high winds with a temperature range of approximately +5°C to -15°C encountered.

## Instrumentation

The instrument used was a standard regional SPZ helicorder station with 500 ft of cable between the helicorder and Willmore seismometer. The paper speed was 1 mm/sec, the gain setting 18db and the high cut filter 6Hz. The approximate response curve is shown in figure 2. The gain setting was adequate through the whole program even though several days of very large microseism activity was experienced at Victoria (230 km south). It is possible that during quiet periods in the summer the gain could be set 6db higher. The high frequency filter was set at 6hz because of previous experience with high frequency wind noise in heavily forested areas.

## Nearby Events Recorded

One common event which occurred during times of high winds and/or warm temperatures had the appearance of a few high frequency oscillations. This is thought to be clumps of snow falling from trees in the vicinity of the seismometer. These can usually be distinguished from other seismic events that occur more distant from the seismometer because they lack a Coda or wave train. However very small high frequency seismic events occuring during the times of these snow falls cannot be separated because of their similar appearance.

There were a number of seismic events which may be interpreted as microearthquakes. For discussion they can be divided into 4 groups.

Type I (S-P 3/4 second)

These appear to be small microearthquakes with very sharp P and S phases and a definite seismic coda (figure 3). If a near surface velocity of 5 km/second and a Poisson's ratio of 1/4 are assumed then the S-P interval is equivalent to 5 km distance. These events occurred in 3 groups, about 25 in a 6 hour period on Dec. 11, ten in an hour on Dec. 13 and a single event, the largest ($M_L \sim 1\text{-}1/2$) on Dec. 15. Most events are between $M_L = 0$ and $M_L = 1$. The only thing suspicious about these events is that they all occurred during daylight hours when temperature was hovering near freezing and dropping below freezing at night. This introduces the possibility that they may be related to a freezing thawing cycle. However, they appear to be microearthquakes which ultimately must be related to some active faulting process.

Type II (S-P 1-1/2 - 2 sec)

There were about 10 events on Dec. 14, one on Dec. 17 and one on Jan. 13. These events vary in character and are probably not all related. Because of their unusual appearance, they may not be microearthquakes, but if they are not, their cause is unknown. Their P wave is much lower in amplitude and in frequency content than the S wave arrivals which have sharp onsets, high frequency (10Hz or greater) and very short coda length. They are all in the 0 to 1 magnitude range and occurred both in daylight hours and at night. All occurred when the temperature was below freezing.

Type III (S-P < 1/2 sec)

These are the most dubious of the possible microearthquakes, and they may be related to some phenomena close to the seismometer such as snow falling or water dripping. They all occurred during a warm spell starting in the afternoon of Dec. 2 at a rate of several per hour and continuing at a rate of about one per hour for 2 days. The events have a high frequency content (5Hz or greater), are impulsive and are short in duration. The smaller ones cannot be distinguished from snow falls. The larger ones have a slight coda (which is the main reason to think that they may be microearthquakes) and appear to have a secondary smaller phase about 1/2 second after the first phase, as if there was a large P and a very small S. All events would be between magnitude -1 and +1.

Type IV (S-P 4 seconds)

One microearthquake ($M_L \sim 1\text{-}1/2$) was observed on Dec. 5 with a S-P of 4 seconds (distance about 30 kilometers)

....../3

Summary

Of the 730 hours of recording, only 35 hours contained microearthquakes or suspected microearthquakes. The possible microearthquakes can be divided into 4 types on the basis of their apparent S-P intervals. Two types (S-P 3/4 sec and S-P 4 sec are thought to be genuine microearthquakes while the other two types cannot be positively identified as such at this time.

Acknowledgements

The Geological Survey provided a field vehicle for this exercise and the firm of Nevin Sadlier-Brown Goodbrand Limited (consultants to B.C. Hydro) provided helicopter time for installation and camp meals and facilities.

Yours truly,

G.C. Rogers,
Division of Seismology.

GCR:dc

cc Dr. W.G. Milne
Mr. G.A. McMechan
Dr. L.K. Law
Dr. A.M. Jessop
Dr. J.G. Souther
Nevin, Sadlier-Brown Goodbrand Limited.

Department of Energy, Mines and Resources
Ministère de l'Énergie, des Mines et des Ressources
CANADA

Victoria Geophysical Observator
5071 West Saanich Road, R.R. 7
Victoria, B.C.

File Number / Nº à rappeler 6082-6

# 1975 GEOTHERMAL PROJECT - 2ND CIRCULAR - MARCH 1975

## Meager Creek Microseismicity and Ground Noise Studies

### I MICROSEISMICITY STUDY

Three short period vertical seismograph stations will be deployed near Pemberton, near Gold Bridge and near the Meager Creek campsite, forming an equilateral triangle approximately sixty kilometers to a side. At the Meager Creek site an additional short period vertical station will be deployed so that one seismometer is located on each side of the valley, and both recorders are in the camp. This should enable the sorting of microearthquakes from phenomena near the seismometer. The instruments will be maintained in place from mid June to mid August subject to the time a camp is located in the Meager Creek area.

Expected operating gains should allow location of all events greater than magnitude 1-1/2 in or near the triangle. Detection of much smaller events will be possible in the vicinity of each of the stations. Data analysis will consist of microearthquake counts of any events in the immediate vicinity of each station and the location of all events possible in the vicinity of the triangle. If the microearthquake activity recorded during the winter of 74/75 persists or if other significant activity is found in the Meager Creek area (i.e. a rate of one or more events per day) attempts will be made to identify the local source of activity through the deployment of 2 additional Sprengnether portable seismographs. These seismographs may be deployed as individual stations or channelled into a single tape recorder to form a small array if this seems feasible.

<u>Gold Bridge Station</u>: This will be a SPZ helicorder station run from A.C. power. The station will be operated by B.C. Hydro personnel or on a contract basis with a local resident.

<u>Pemberton Station</u>: This will be a Sprengnether system also recording on analogue tape. The tape recorder will be that used in the Geomagnetism Division/U.B.C. short period equipment. This station will probably be deployed before the G.D./U.B.C. short period is ready to start, but after their long period experiment is underway. Tapes will be changed mainly by G.D. or U.B.C. personnel.

<u>Meager Creek Station</u>: This will be two Sprengnether systems each with about 1000 feet of cable between seismometer and recorder. One system will also record on analogue tape during the time of the G.D./U.B.C. short period experiment. Tapes will be changed mainly by G.D./U.B.C. personnel and hopefully paper records will be changed mainly by Meager Creek camp personnel.

..../2

## II GROUND NOISE STUDY

This will be done in conjunction with the G.D./U.B.C. short period experiment. During the summer, between 10 and 20 stations are expected to be established in the vicinity of Meager Creek during periods of high magnetic activity for a duration of a few hours for telluric work. A Sprengnether seismograph will be set up at each telluric station and be recorded on the analogue tape of the short period telluric system. Simultaneous sections from this mobile station, the Meager Creek station and the Pemberton station will be digitized and their spectra compared for spectral anomalies. If this spectral analysis shows differing or higher noise levels in some areas then a more detailed grid of measurements will be run near the end of the summer to define the character of any ground noise anomaly.

### Equipment Required

1 helicorder SPZ system
5 Sprengnether portable seismographs equipped for ink recording

### Personnel Involved

G.C. Rogers
G.A. McMechan

### Budget

About $2000. should cover field expenses. If more detailed microseismicity or ground noise studies are required up to $2000. in additional helicopter time would be required.

First Circular - November
copies to McMechan
Milne
Law

Second Circular - March
copies to Berry, Jessop, Milne, Draggert, McMechan, Souther, Law, Nevin Sadlier-Brown & Goodbrand

G.C. Rogers,
Seismology Division.

## APPENDIX 'I'

## LIST OF PERSONNEL ON PROJECT SITE

(* Denotes persons playing a substantial role without visiting site)

1. Nevin Sadlier-Brown Goodbrand Ltd.

| | |
|---|---|
| A.E. Nevin, P.Eng., | Senior Geologist. |
| T.L. Sadlier-Brown, | " " |
| D.W. Goodbrand, | " " |
| J.T. Crandall, | Project Geologist |
| E. Onasick, | Field Assistant |
| H.J. Crandall, | Cook |
| J. DeReus, | Cook |
| A. Dupras, | Linecutter |
| B. Locke, | " |
| Lloyd Lafferty, | " |
| Lawrence Lafferty | " |
| D.R. Davis, | Field Assistant |
| J.R. Tullis* | Secretary-Bookkeeper. |

2. McPhar Geophysics

| | |
|---|---|
| A. Wood, | Party Chief |
| M. Bureau, | Geophysicist |
| D. Coote, | " |
| R. Bing, | Operator |
| M. Walcer, | Assistant |
| G. Morrisey | " |
| Ash Mullan* | Regional Geophysicist |
| Bruce Bell | " " |
| P. Halloff* | Chief Geophysicist. |

3. Kendrick Drilling

| | |
|---|---|
| A. Kendrick, | Contractor |
| J. Wurtack, | Driller |
| B. Locke, | Helper |
| D. McCord, | Helper |

4. GeoRecon

| | |
|---|---|
| John Musser, | Geophysicist |
| J. Gant, | " |
| Boyd O. Bush*, | Chief Geophysicist. |

5. Other Services

Transwest Helicopters - R. Burton, L. Smale, R. Eschauzier, D. Forty.
Okanagan Helicopters - J. Logue
Mayo Helicopters - E.L. Talbott
H.S. Aikins Exploration Services - H.S. Aikins, Camp Construction.
Dr.P.B. Read - Petrographer.
Dept. Energy, Mines & Resources - G.C. Rogers, A. Taylor, Dr.J.G. Souther, Dr.A.M. Jessop*.