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BER RESOURCES LTD

GEOPHYSICAL EXPLORATION REPORT

on the

PATHFINDER CLAIM GROUP

GEOLOGICAL BRANCH
ASSESSMENT REPORT

19,979

D. Cukor, Geologist and V. Cukor, P. Eng., NVC ENGINEERING LTD

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ILLUSTRATIONS

BER RESOURCES INC.
PATHFINDER CLAIM GROUP
GRAND FORKS, B.C. AREA

1. INTRODUCTION

The exploration program on Ber Resources' Pathfinder Claim Group was performed as a subcontract under the management of Ocean Engineering Inc. NVC Engineering Ltd. performed the geophysical surveys - ground magnetics, VLF-EM and resistivity. Prior to the survey, the existing grid was expanded to cover the areas of known showings. Damir Cukor, geologist, carried out the field program under the overall supervision of V. Cukor, P.Eng.

Field work was carried out during the months of January and February under adverse weather conditions. Accumulating fresh snow combined with the steep slopes made progress of field work relatively slow.

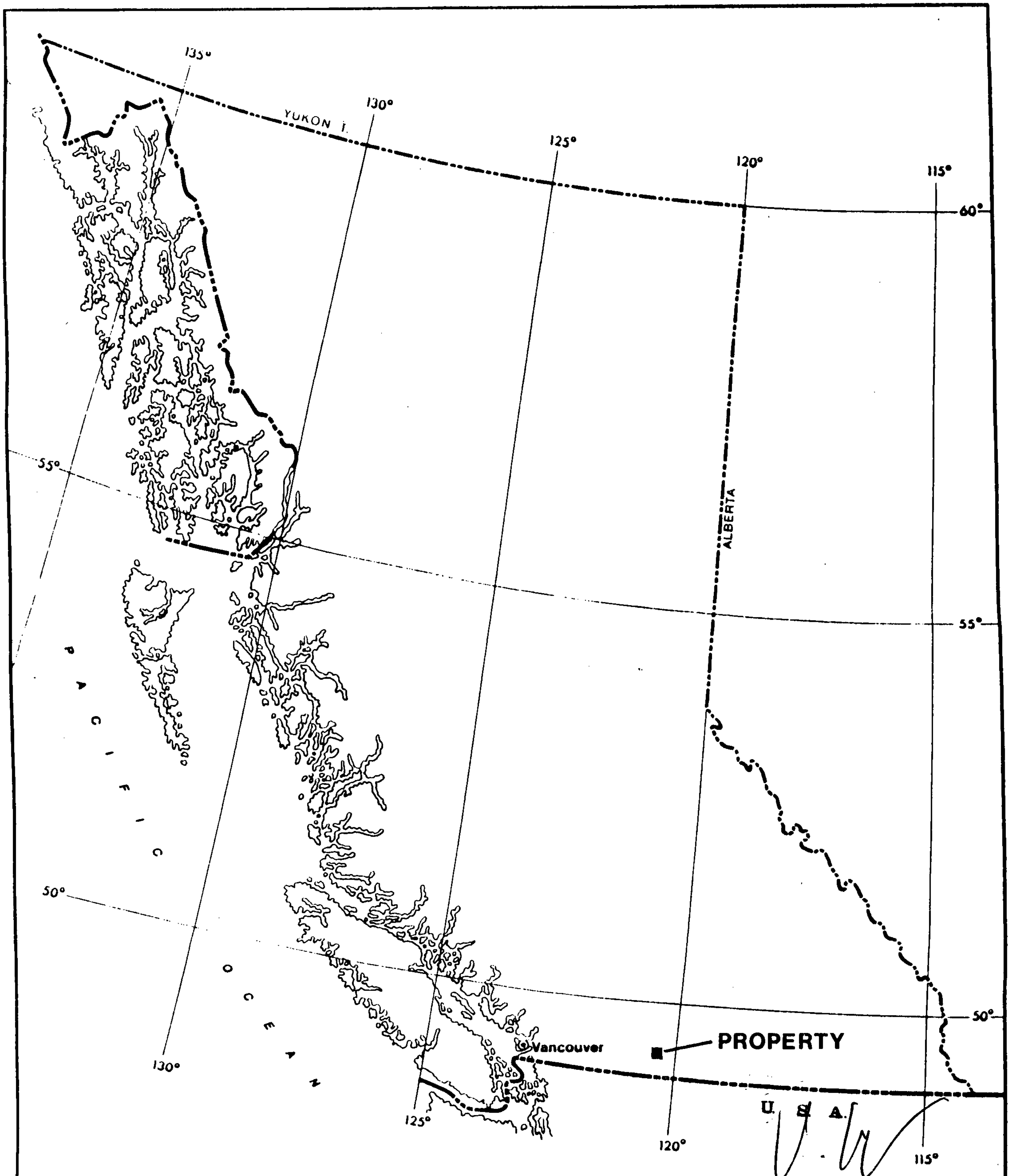
The objective of this work was to attempt to find extensions of the known vein structures and to outline drill targets.

2. SUMMARY AND CONCLUSIONS

Gold-copper hosting massive sulfide structures, producing hand picked ore in the past are the subject of this phase of exploration of the Pathfinder mineral property. The area of immediate interest is the Little Bertha workings.

The main workings were developed and mined from the glory hole and the No. 1 adit. Two subsequently excavated adits did not reach the structure. In the following phase of exploration the grid, surveyed in 1989 by S. Presunka, did not cover the showings area.

The surveys by NVC Engineering, the subject of this report, were designed to cover the known showings and to explore for the extensions. Although the VLF-EM survey did not respond to the showings of massive sulfides, the correlating magnetic low and low resistivity anomalies coincided well with the two showing locations, extending both these areas of interest eastwards. As an extension of the present program, both these areas should be explored by diamond drilling.



BER RESOURCES INC.		
PATHFINDER CLAIM GROUP		
LOCATION MAP		
GREENWOOD M.D.		NTS 82 E-1
NVC ENGINEERING LTD.		VANCOUVER B.C.
DATE: FEB 1990	SCALE: 0 — 100 Miles	FIG. 1

3. PROPERTY

3.1 LOCATION

Ber Resources' Pathfinder Claim Group is located in the southern central portion of British Columbia, east of Granby River, 18 kilometres almost due north of Grand Forks, B.C. The property is in the Greenwood Mining Division, on NTS 82E/1 and it is centred on north latitude 49° 11.5' and west longitude 118° 25'. The general location of the property is shown on fig. 1.

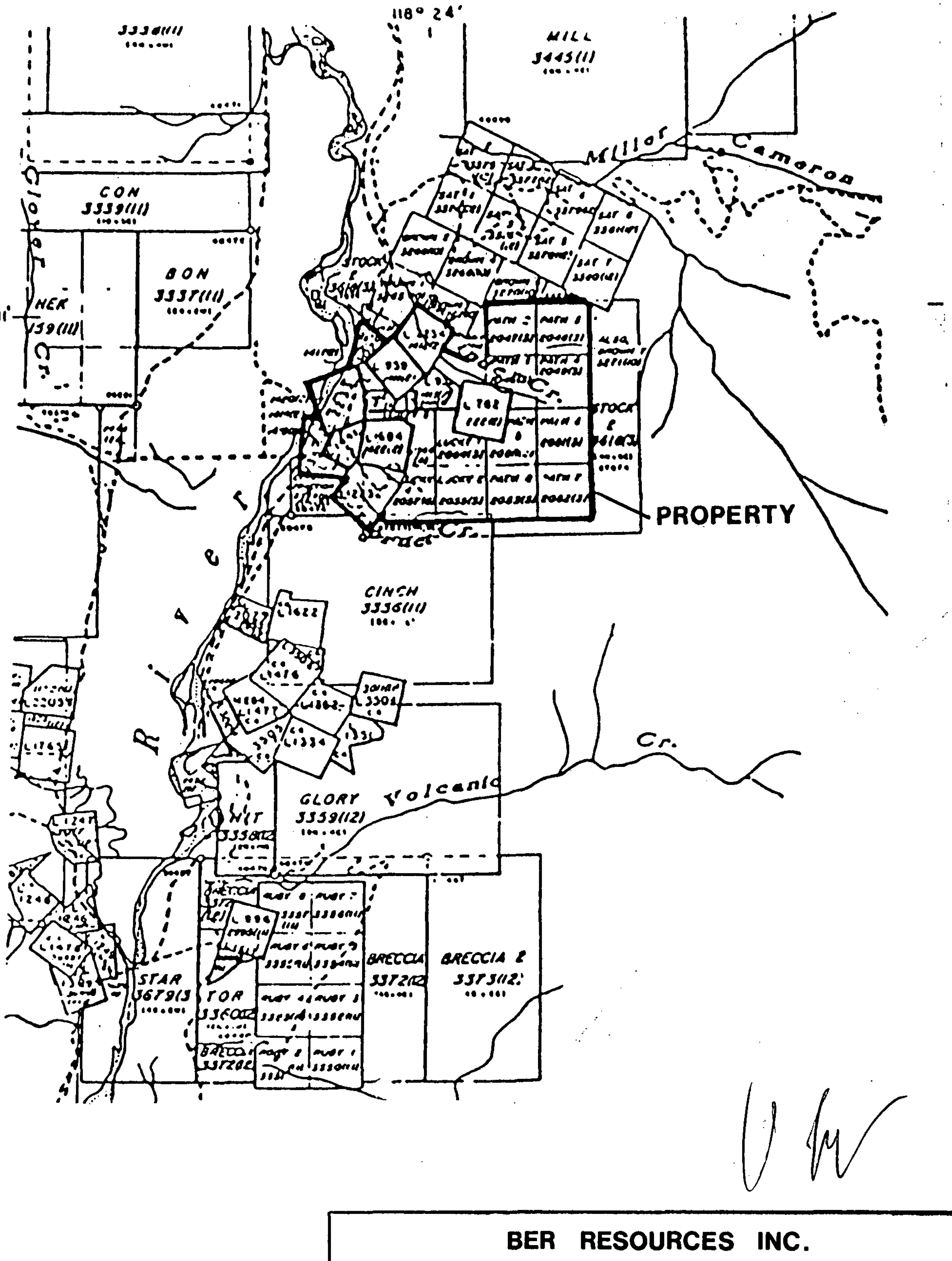
3.2 ACCESS

From Grand Forks, the property is accessible by the North Fork highway following Granby River along its east side. The entire 21 kilometres of the highway between Grand Forks and the turnoff to the claims is paved. Branching from the highway, a network of forestry and mining roads provide easy access to most of the mine workings within the claim group.

3.3 CLAIMS

The property comprises nine reverted crown granted mineral claims and 14 claims located on the two post system. All claims form a contiguous group.

The claims, record numbers and recording dates are as follows:



BER RESOURCES INC.

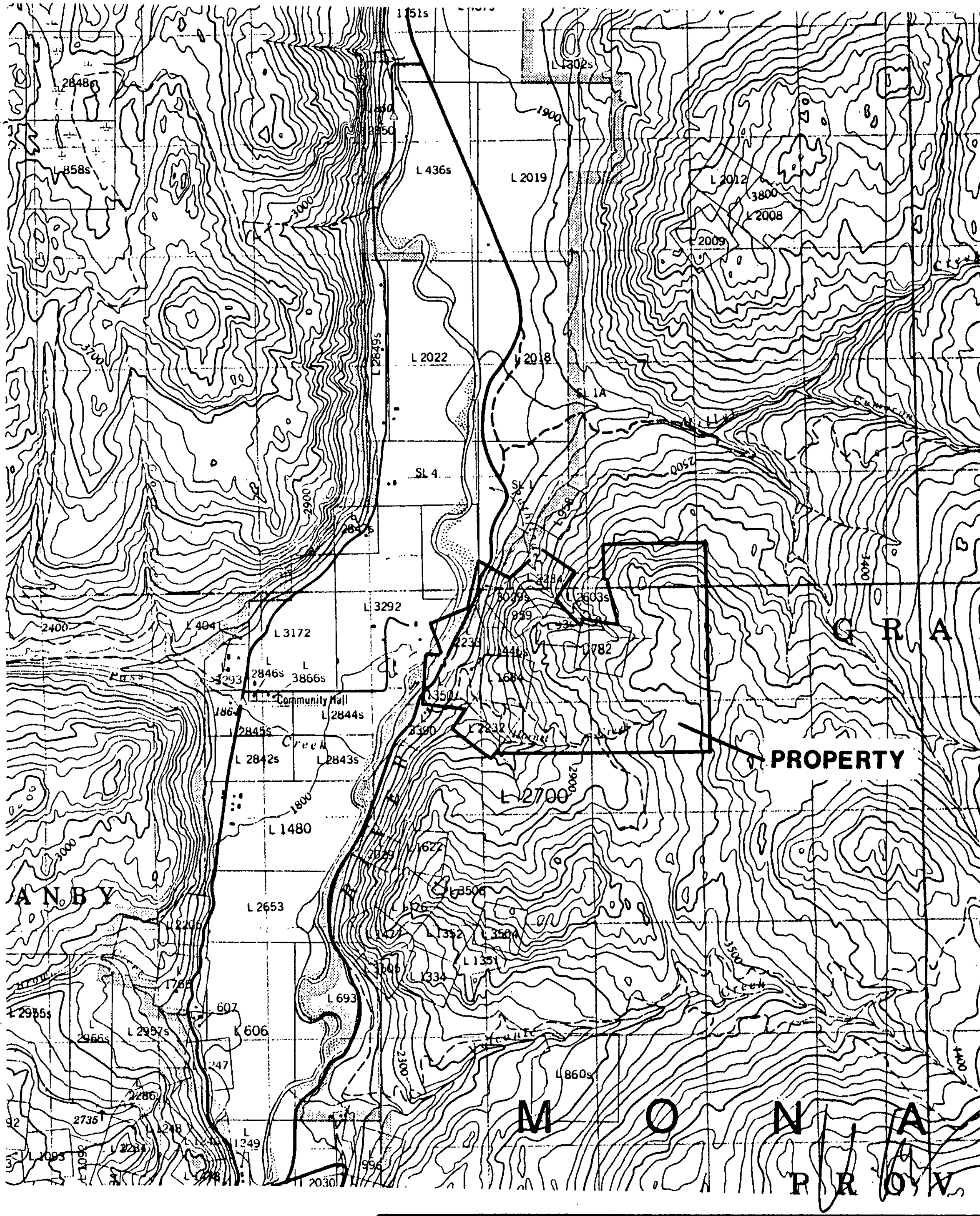
PATHFINDER CLAIM GROUP

CLAIM MAP

GREENWOOD M.D. NTS 82 E-1

NVC ENGINEERING LTD. VANCOUVER B.C.

DATE: FEB. 1990	SCALE: 0 — 1 km	FIG. 2



BER RESOURCES INC.

PATHFINDER CLAIM GROUP

CLAIMS AND TOPOGRAPHY

GREENWOOD M.D. NTS 82 E-1

NVC ENGINEERING LTD. VANCOUVER B.C.

DATE: FEB. 1990	SCALE: 0 — 1 km	FIG. 3

Claim Name	Lot No.	Record No.	Recording Date
Reverted Crown Grants			
Diamond Hitch	1684	1422	February 28
Christina	1356	1419	February 23
Derby	2233	1420	February 23
Jasper Fr.	3029 S	1417	February 27
Iron Bell Fr.	938	1413	February 21
London (Bonnock)	2234	1412	February 21
Little Bertha	959	1411	February 21
Lonestar Fr.	1446 S	1418	February 23
Pathfinder	782	222	February 17
Two Post Claims			
Path 1-8		2046 - 2053	March 4
Lucky 1-4		2054 - 2057	March 4
Hike 1 & 2		3605 & 3606	March 14

The claims are jointly owned by the Boundary Gold Corp. and Nu-Lady Gold Mines Ltd. Ber Resources Inc. entered into an option agreement with the former companies to earn a 1/3 working interest in the property. The outline of the property is shown on figs. 2 and 3.

3.4 TOPOGRAPHY AND CLIMATE

The western limit of the property is at the bottom of the Granby River Valley. From there, in the easterly direction, the property covers moderately steep, west facing slope of the Monashee Mountains. The claims lie between elevations of 3,800 feet and 1,800 feet for a total relief of 2,000 feet. Two streams, Pathfinder Creek on the north side and Hornet Creek on the south sides of the claims, have carved deep and steep valleys; both discharge into the Granby River.

The claims are located within the range of the British Columbian dry belt. Typical of this variation of the continental climate are the hot summers, cold winters and generally low atmospheric precipitation. This produces a characteristic forest of ponderosa pine, jack pine, tamarack with some spruce and very little or no underbrush.

LEGEND

Ema	MARRON GROUP *Undifferentiated andesite, dacite and trachyte of the Marron Group: may include minor epiclastic rocks equivalent to* Ewl *and* Esb.
Ec	*CORYELL SYENITE: alkalic to calc-alkalic, high level, pink and buff syenite and quartz monzonite and trachytic pink feldspar porphyry dykes: plutonic equivalent of the Marron Group especially the Kitley Lake Formation. gradational to pulaskite and to Shingle Creek Porphyry: probably includes JKg undifferentiated in East half of map area: poorly dated*
JKg	*OKANAGAN BATHOLITH: massive, light grey weathering, medium- to coarse-grained, equigranular to porphyritic, unfoliated to weakly foliated, fresh biotite granodiorite and granite. includes undifferentiated granodiorite of the Nelson suite: age poorly constrained*
mJg	*NELSON PLUTONIC ROCKS: massive, generally moderately foliated, medium grey weathering, medium- to coarse-grained, equigranular, hornblende-biotite granodiorite, quartz diorite and granite. includes undifferentiated biotite granite of the Valhalla suite: age poorly constrained*
CPa	ANARCHIST GROUP: *dark grey weathering, recessive, amphibolite, greenstone, quartz-chlorite schist, quartz-biotite schist, minor serpentinized peridotite: "chert" breccia that resembles* Trbc *is locally included:* CPap- *peridotite and serpentinized equivalents:* CPaa- *amphibolite: age unknown*
ODs	*Schist, thin bedded argillaceous limestone, slate and limestone includes metamorphosed equivalents mostly biotite-diopside-quartz skarn and marble: age unknown*
Pgfa	*Amphibolite, amphibolitic gneiss, minor marble: Preto unit IV*
Pgfq	*Coarsely crystalline, thick layered quartzite, minor marble and pegmatite: Preto unit II*
Pgfg	*Sillimanite-biotite quartz paragneiss, amphibolite and amphibolitic gneiss, marble, biotite schist and gneiss, garnet-biotite-quartz schist, micaceous quartzite: includes minor leuco-orthogneiss:Preto unit I*

Geology compiled 1985, 1986 by Dirk Tempelman-Kluit, from sources referenced with new fieldwork during 1983, 1984. I acknowledge the excellent help in compilation by J. Rhodes, A. Jung, R.A. Arnold, E.A. Fuller, and G. Lynch.

BER RESOURCES INC.

PATHFINDER CLAIM GROUP

REGIONAL GEOLOGY MAP

GREENWOOD M.D. NTS 82 E-1

NVC ENGINEERING LTD. VANCOUVER B.C.

DATE: FEB. 1990 | SCALE: 0 — 5 km | FIG. 4

4. GEOLOGY

The general geological information is shown on the GSC Map 1736A (Penticton), scale 1:250,000, compiled by D. Tempelman-Kluit. This shows the area underlain by various sedimentary and volcanogenic rocks of Quaternary to Proterozoic ages, introduced by acidic to ultramafic intrusive rocks in several stages. In the closer proximity of the claim area, the most prominent are the Cenozoic intrusives of the Coryell Syenite group and the Cretaceous and/or Jurassic, Okanagan Batholith granodiorite (see fig. 4).

The property's geological features were mapped in 1980 by R. Saunders on the 1:5,000 scale. This map shows that the majority of the property area is underlain by granodioritic intrusive, with much smaller areas being covered by syenitic to monzonitic intrusives and with andesitic extrusives and related chert layers.

Mineral showings consist mainly of quartz veins, containing 5-10% pyrite and of massive sulfide, gold-copper bearing veins.

Three showing areas are known on the property: Pathfinder workings, Little Bertha workings and Diamond Hitch showings. In the past, about 1,260 tons of hand sorted ore was shipped to smelters. Various shipments contained 0.09 to 3.72 oz/t gold, 2.0 to 12.0 oz/t silver and up to 2.5% copper.

The objective of this survey was an attempt to outline the possible extensions of the known Little Bertha showings and to outline targets for drilling.

Extensive snow cover of the area during this part of the survey hampered any attempts to expand on the geological knowledge of the claims and to more closely correlate outlined geophysical structures with geological features.

5. GEOPHYSICAL SURVEYS

5.1 GENERAL DESCRIPTION

The geophysical surveys consisted of ground magnetic, VLF-EM and resistivity surveys. They were run simultaneously, utilizing the Scintrex IGS-2 system.

The part of the system dedicated to magnetics utilizes two console units, one set up as the base station, the other as the portable unit, and two similar proton precission sensors measuring total magnetic field. The base station and field unit are time synchronized so that the background field, diurnal variations and micro pulsations can be filtered from the data. The base station was programmed to measure the field and record the readings at five second intervals.

The VLF unit was set up to receive signals from NKL Seattle, Washington, 24.8 kHz, measuring the horizontal field strength and the in-phase or quadrature and out-of-phase components of the vertical field. The instrument uses a sensor consisting of a three coil system, one horizontal and two vertical coils, all at 90° angles to each other.

For the resistivity survey, the IGS-2 makes measurements of the VLF electric field, utilizing a dipole with an electrode spacing of five metres. The instrument then automatically calculates apparent resistivity from the in-phase and quadrature components of the horizontal electric field, using the horizontal magnetic field as a phase reference. See the Appendix for the apparent resistivity calculation.

The geophysical surveys were conducted over a closely spaced grid; line spacing was 40 metres and station separation was 20 metres; total length about 8 kilometres. Since the grid, surveyed by S. Presunka in 1989, did not cover the area of showings, this year's grid was expanded in all directions. To better outline the areas of interest, ground magnetometer and resistivity methods were added to the VLF-EM survey. These two methods proved, subsequently, to give important information in outlining the drill targets.

5.2 GROUND MAGNETIC SURVEY

The results of the ground magnetic survey were plotted on fig. 5 on a scale of 1:1,000. The total magnetic relief measured was 1,222 gammas, with a low of 340 and a high of 1,562 gammas. The base field was 57,000 gammas. Two general observations can be made from the map; firstly, the map area displays a uniform and flat response overall, as would be expected from a single and magnetically homogenous rock unit; secondly, the trends displayed run parallel to the baseline, at 20° or due north-south.

From the map, it is apparent that lows are coincident with known structures. The strongest low occurs on the extension of the structure near the highway, on lines 280S and 320S. This low indicates a possible extension of the structure zone 50 metres southwards to the edge of the grid, and then beyond. As well, there is a possible magnetic low structure 50 metres to the east of the main low, as indicated by the lobed extensions as shown on the map. Another potentially important low structure, at 180E, stretching from 80N to 80S, lies on strike with the Little Bertha vein. Several weak lows, starting at 120S 80E, and running south, parallel to the baseline may be due to some weak structure.

In conclusion, the linearity of the structures and their conformity to two general trends suggests vein structures and/or fracture controlled alteration zones.

5.3 VLF-EM SURVEY

The data from the VLF-EM survey is presented on two plans, one the Stacked Profile Plan, fig. 6, and other, the Fraser Filter Plan, fig. 7, both drawn to a scale of 1:1,000. The Stacked Profile Plan displays a single good conductor, which is coincident with the fence, running parallel to the road near the baseline. All other responses show up as weak inflections on the profiles. The Fraser Filter Plan is also strongly affected by the fence which masks any possible weaker conductors in the vicinity that may lie below. Some weak response was obtained from the extension of the Little Bertha - a weak high to the west of the showings, extending to the southwest. As well, some response limited in areal extent was obtained from the southwest showing near the highway - a small high right in the area of the shaft.

In general, the VLF-EM method has produced only fair results due in part to interference from the fence and complications due to slope effects from steep topography. However, it is obvious that there are no strong conductors within the survey area, except for the fence.

5.4 RESISTIVITY

The apparent resistivity is presented on the Resistivity Plan, plotted on a 1:1,000 scale map, fig. 8. Total relief on the map if 4,910 ohm-metres. The map is characterized by strong relief throughout and trends coincident with the magnetic data and the known mineral structures. Prominent lows coincide with the main showings. From the Little Bertha showing, a low bounded to the east and west by highs, extends nearly due southwards to line 80S, delineating a possible 200 metre extension of the structure. This structure is open to the north. The southwest showing coincides with the strongest lows on the map area. The low stretches for some 240 metres and is open to the north, across the highway, and to the south, off the grid. Both of these structures, the Little Bertha and the southwest structure, show strong response on both the resistivity and ground magnetic methods. The structure, some 80 metres east and parallel to the baseline, is also supported by the resistivity data, with a low running from the baseline, line 80N to line 440S 80E. This structure is paralleled by another, some 60 metres to the east.

5.5 CORRELATION OF GEOPHYSICAL RESULTS

In the fall of 1989, Ber Resources had a Ronka EM-16 survey carried out over a small closely spaced grid in the vicinity of the Little Bertha old workings. The survey was conducted by S. Presunka, an experienced field operator, under the supervision of K. Hun, P.Eng. The survey outlined a strong conductor, mostly just east of the baseline (see fig. 6). Although no total correlation was evident, this conductor is suspiciously close to the wire fence following the bush road. Also, the grid was of such a size and position, that it did not cover the two showing areas.

In 1990, NVC Engineering expanded the grid to cover the known showings and carried out VLF-EM, magnetic and resistivity surveys. The VLF-EM survey confirmed Presunka's anomaly, although the correlation was not perfect in all locations. Where the conductors do not coincide, NVC's conductor normally falls closer to the wire fence, making the interpretation of the source of the anomaly even more placable. This method did not respond to either of the showing areas. However, the Fraser Filter showed some structural trends in these areas.

Both other methods, the magnetic and the resistivity, produced distinct anomalies in both areas of the main Little Bertha showings and the "southwest" showings west of the baseline. Coinciding, elongated low resistivity and low magnetic anomalies straddle the zones of massive sulfides and extend southwards, showing a potential for an extension of mineralized zones in that direction. Northward extensions were not explored; on the main showings, this was due to the closeness to approximate property boundary, and on the western zone since it ran into the highway's right of way.

In both cases, the position and strength of the outlined anomalies indicate a strong possibility for the presence of the zone extensions and both areas should be considered excellent drill targets.

Respectfully Submitted
NVC Engineering Ltd.

D. Cukor, Geologist

February 1990

V. Cukor, P.Eng.

COSTS OF THE GEOPHYSICAL PROGRAM ON THE PATFINDER CLAIMS

Field Work:

Locating grid	$ 3,000.00
Geophysical surveys 15 days @ $ 950...........	14,250.00
Mobilization, demobilization 2 days	1,000.00
Field supplies	350.00

Report:

Data compilation 8 days @ $ 300	2,400.00
Drafting,map enlarging	2,500.00
Report preparation	4,000.00
V.Cukor, P. Eng., engineering and supervision	3,000.00
Total Expenditure	$30,500.00

V. Cukor, P.Eng.
NVC ENGINEERING LTD.

CERTIFICATE

I, VLADIMIR CUKOR, of 304 - 1720 Barclay Street in the City of Vancouver, Province of British Columbia, DO HEREBY CERTIFY that:

1. I am a Consulting Geological Engineer with NVC Engineering Ltd., with business address as above;

2. I graduated from the University of Zagreb, Yugoslavia in 1963 as a Graduated Geological Engineer;

3. I am a registered Professional Engineer in the Geological Section of the Association of Professional Engineers in the Province of British Columbia, Registration No. 7444;

4. I have practiced my profession as a Geological Engineer for the past 24 years in Europe, North America and South America in engineering geology, hydrogeology and exploration for base metals and precious metals;

5. I have no interest in the Pathfinder Claim Group of Ber Resources Inc.

6. I have supervised the work program on the Pathfinder Mineral Claims.

February 1990

V. Cukor
NVC ENGINEERING LTD.

<u>CERTIFICATE</u>

I, DAMIR CUKOR, of 6108 McKee Street, Burnaby, British Columbia, DO HEREBY CERTIFY that:

1. I graduated from the University of British Columbia in 1984 as a Bachelor of Science in Geology;

2. Since 1983, I have been employed as a geologist with NVC ENGINEERING LTD.;

3. I have worked in the field of exploration geology and geophysics for 12 seasons and have held positions of responsibility since 1982;

4. I performed and/or supervised work as documented in this Report;

5. I have no interest, direct or indirect, in the properties of Ber Resources Inc.

February 1990

D. Cukor
NVC ENGINEERING LTD.

A P P E N D I X

GEOPHYSICAL THEORY AND INSTRUMENT SPECIFICATION

1. THE IGS-2 SYSTEM

1.1 General Information

The IGS-2 Integrated Geophysical System is a portable microprocessor-based instrument which allows more than one type of survey measurement to be performed by a single operator during a survey.

The IGS-2 is a modular system which can easily be configured to suit different and changing survey requirements. Reconfiguring the system is easy and offers both operational flexibility and minimal redundancy with a minimum number of spare consoles and/or modules.

When configured with any of the available senor options, the IGS-2 System Control Console becomes a method-specific instrument according to the senor option(s) utilized. In addition, the IGS-2 Console is an electronic notebook into which geophysical, geological or other data may be manually entered and digitally stored.

Data is stored in the IGS-2 in an expandable, solid state memory and can be output in the field by connecting the instrument to a printer, tape recorder, modem or microcomputer.

The 32 character digital display uses full words in most cases, ensuring clear communication. Both present and previous data are displayed simultaneously, allowing comparisons to be made at a glance during a survey.

The IGS-2 records header information, data values, station number, line number, grid number and the time of each observation in its internal memory. Data are first sorted by grid number, then in order of increasing line number and, within each line, by increasing station number. In this way, the data are organized logically regardless of the sequence in which they were taken. Ancillary data can also be manually entered and recorded at a given station, along with the survey parameters.

1.2 Standard Console Specifications

Digital Display	32 character, 2 line LCD display
Keyboard Input	14 keys for entering all commands, coordinates, header and ancillary information
Languages	English plus French is standard
Standard Memory	16K RAM. More than sufficient for a day's data in most applications
Clock	Real time clock with day, month, year, hour, minute and second. One second resolution, ± 1 second stability over 12 hours. Needs keyboard initialization only after battery replacement
Digital Data Output	RS-232C serial interface for digital printer, modem, microcomputer or cassette tape recorder. Data outputs in 7 bit ASCII, no parity format. Baud rate is keyboard selectable at 110, 300, 600 and 1200 baud. Carriage return delay is keyboard selectable in increments of one from 0 through 999. Handshaking is done through X-ON/X-OFF protocol. Allows IGS-2 to act as a master for other instrumentation.

Analog Output	For a strip chart recorder. 0 to 999 mV full scale with keyboard selectable sensitivities of 10, 100 or 1000 units full scale.
Console Dimensions	240 x 90 x 240 mm includes mounted battery pack.
Weights	Console; 2.2 kg. Console with Non-rechargeable Battery Pack; 3.2 kg. Console with Rechargeable Battery Pack; 3.6 kg.
Operating Temperature Range	-40°C to +50°C provided optional Display Heater is used below -20°C.
Power Requirements	Can be powered by external 12 V DC or one of the Battery Pack Options listed below.

2. IGS-2/MP MAGNETOMETER

2.1 The Magnetic Method

The magnetic method consists of measuring the magnetic field of the earth as influenced by rock formations having different magnetic properties and configurations. The measured field is the vector sum of induced and remanent magnetic effects. Thus, there are three factors, excluding geometrical factors, which determine the magnetic field. These are the strength of the earth's magnetic field, the magnetic susceptibilities of the rocks present and their remanent magnetism.

The earth's magnetic field is similar in form to that of a bar magnet's. The flux lines of the geomagnetic field are vertical at the north and south magnetic poles where the strength is approximately 60,000 nT. In the equatorial region, the field is horizontal and its strength is approximately 30,000 nT.

The primary geomagnetic field is, for the purposes of normal mineral exploration surveys, constant in space and time. Magnetic field measurements may, however, vary considerably due to short term external magnetic influences. The magnitude of these variations is unpredictable. In the case of sudden magnetic storms, it may reach several hundred gammas over a few minutes. It may be necessary, therefore, to take continuous readings of the geomagnetic field with a base station magnetometer while the magnetic survey is being done. An alternative field procedure is to make periodic repeat measurements at convenient traverse points, although this is a very unreliable method during active magnetic storms when it is important to have proper reference data.

The intensity of magnetization induced in rocks by the geomagnetic field F is given by:

$$I = kF$$

where I is the induced magnetization
k is the volume magnetic susceptibility
F is the strength of the geomagnetic field

For most materials, k is very much less than 1. If k is negative, the body is said to be diamagnetic. Examples are quartz, marble, graphite and rock salt. If k is a small positive value, the body is said to be paramagnetic, examples of which are gneiss (k =

0.002), pegmatite, dolomite and syenite. If k is a large positive value, the body is strongly magnetic and it is said to be ferromagnetic, for example, magnetite (k = 0.3), ilmenite and pyrrhotite.

The susceptibilities of rocks are determined primarily by their magnetite content since this mineral is so strongly magnetic and so widely distributed in the various rock types. (Of considerable importance, as well, is the pyrrhotite content.)

The remanent magnetization of rocks depends both on their composition and their previous history. Whereas the induced magnetization is nearly always parallel to the direction of the geomagnetic field, the natural remanent magnetization may bear no relation to the present direction and intensity of the earth's field. The remanent magnetization is related to the direction of the earth's field at the time the rocks were last magnetized. Movement of the body through folding, etc., and the chemical history since the previous magnetization are additional factors which affect the magnitude and direction of the remanent magnetic vector.

Thus, the resultant magnetization M of a rock is given by:

$$M - M_n + kF$$

where M_n is the natural remanent magnetization, and F is a vector which can be completely specified by its horizontal (H) and vertical (Z) components and by the declination (D) from true north. Similarly, M_n is specified when its magnitude and direction are known. Thus, considerable simplification results if $M_n = 0$, whereupon M merely reduces to kF. In the early days of magnetic prospecting, it was usually assumed that there was no remanent magnetization. However, it has now been established that both igneous and sedimentary rocks possess remanent magnetization, and that the phenomenon is a widespread one.

2.2 Magnetometer Specifications

Total Field Operating Range	20,000 to 100,000 nT (1 nT = 1 gamma)
Gradient Tolerance For Total Field	±5000 nT/m

Total Field Absolute Accuracy	±1 nT at 50,000 nT ±2 nT over total field operating and temperature range.
Resolution	0.1 nT
Tuning	Fully solid-state. Manual or automatic mode is keyboard selectable.
Reading Time	2 seconds. For portable readings this is the time taken from the push of a button to the display of the measured value.
Continuous Cycle Times	Keyboard selectable in 1 second increments upwards from 2 seconds to 999 seconds.

3. IGS/VLF-4 ELECTROMAGNETIC RECEIVER

3.1 VLF Theory

VLF stations (total of 12 stations located around the world) radiate electromagnetic waves on the VLF band in the range between 15 to 29 kHz. The signals are transmitted for purposes of navigation and ommunication with submarines. The VLF Electromagnetic Receiver picks up the magnetic and electric fields of these signals to provide information about the electrical properties of the earth.

The signal transmitted by the VLF station is recorded by the vertical coils as:

$$H_p = A \sin w \; ; \; H_s = B \cos (w - \phi) \quad (1.0)$$

where H_p = primary signal

A = amplitude of primary signal

H_s = secondary (phase laged) signal

B = amplitude of secondary signal

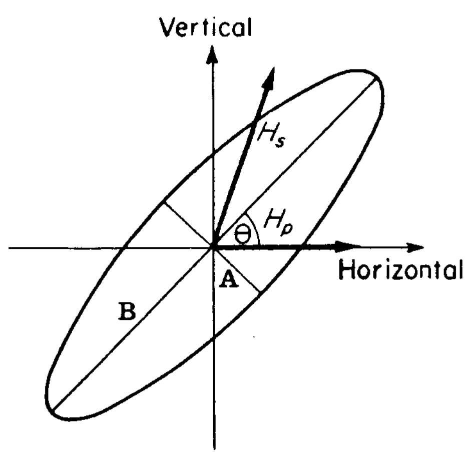
w = frequency

t = time

ϕ = phase lag

These two received signals combine giving an ellipse (see fig. A), which two axis correspond to the length and width of the ellipse.

i.e. $$\frac{H_p^2}{A^2} + \frac{H_s^2}{B^2} - \frac{2 H_p H_s \sin \phi}{AB} = \cos^2 \phi$$



By measuring the angle from the horizontal to the longaxis of the ellipse (θ), a conductor is located when this tilt angle is zero.

As its primary measurement, the IGS-2/VLF-4 employs two mutually orthogonal receive coils to determine three parameters of the VLF magnetic field. These are: 1) the horizontal amplitude vector in a direction perpendicular to a line joining the operator to the station; 2) the amplitude of the component of the vertical field vector which is in phase with the horizontal vector; and 3) the amplitude of the component of the vertical field vector which is 90° out of phase with the horizontal vector. These three parameters, for the given VLF transmitter, are recorded simultaneously. Since the vertical components are expressed as a percentage of the horizontal vector, they are automatically normalized for any changes in the amplitude of the transmitted primary field.

The primary field from a VLF station can, in fact, vary considerably. For the most part, the field fluctuates moderately during the course of the day due to changes in atmospheric conditions. There are, however, more dramatic changes. Towards evening there is a large upwards swing in the field strength, and at several points during the day, both partial and total drops in the field amplitude can be observed. In the light of these irregularities, the horizontal field data should always be considered with reservation as it is difficult to know whether changes are caused by conductors or by variations in the station's signal.

If the primary field strength is constant, changes in the amplitude of the horizontal magnetic field mainly reflect variations in the conductivity of the earth. Normally, there will be no vertical magnetic field. However, near a conductor, a vertical field will be observed. The relative amplitudes of the in-phase and quadrature components may be used to interpret the conductivity-size characteristics of the conductor.

3.2 IGS/VLF-4 Specifications

Frequency Tuning	Automatic digital tuning. Can be tuned to any frequency in the range 15.0 to 29.0 kHz with a bandwidth of 150 kHz.

	Up to three frequencies can be chosen by keyboard entry for sequential measurements.
Field Strength Range	Fields as low as 100 mA/m can be received. In practice, background noise may require fields up to 5-10 times this level. Maximum received field is 2 mA/metre. These values are specified for 20 kHz. For any other frequency, calculate the above limits by multiplying by the station frequency in kHz and dividing by 20.
Signal Filtering	Narrow bandpass, low pass and sharp cut-off high pass filters.
Measuring Time	0.5 seconds sample interval. As many as 216 samples can be stacked to improve measurement accuracy.
VLF-Magnetic Field Components Measured	1) Horizontal amplitude, 2) vertical in-phase component, and 3) vertical quadrature components. Vertical components are displayed as a percentage of horizontal component and are related in phase to the horizontal component. Their range is ±120%; reading resolution 1%.
VLF-Magnetic Field Sensor	Two air-cored coils in a backpack mounted housing with an electronic level for automatic tilt compensation. The error in the vertical in-phase component is less than 1% for tilts up to ±15°.

3.3 Fraser Filtering

This technique for filtering VLF-EM data was proposed by Dr. D. C. Fraser in 1969. The reason for applying this filter is that there is a dynamic range problem when presenting the data as profiles. In the same area that a 5° peak to peak anomaly may be significant, anomalies of 100° may also occur. This filtering operation transforms the zero cross-overs into peaks and noise is reduced by application of a low-pass filter. The data may be presented as profiles or the positive values may be contoured.

This filter was originally applied to dip angle data as collected by VLF receivers such as the Radem by Crone Geophysics. It is equally applicable to vertical in-phase and quadrature data.

The filter phase-shifts the data by 90° so that zero cross overs and inflections are transformed into peaks. It removes dc and attenuates long spatial wavelengths to increase resolution of local anomalies.

These requirements are met by the difference operator (R(n+1)-R(n)), where R(n) and R(n+1) are any two consecutive readings.

The filter does not exaggerate the random noise. This is achieved by applying a low-pass operator to the differences as follows:

0.25(R(n+1)-R(n)+0.50(R(n+2)-R(n+1)+0.25(R(n+3)-r(n+2)).

The filtered output is then 0.25(R(n+2)+R(n+3)-R(n)-R(n+1)).

As this filtering process was originally designed to be simple so it could be applied by field personnel with limited facilities, the constant is eliminated.

The plotted function then becomes F(n+1,n+2)=(R(n+2)+R(n+3)-(R(n)+R(n+1)).

The interpretation of filter plots is qualitative. Since the filter retains relative amplitudes, large responses can be equated with large and/or highly conductive zones. Very sharp responses indicate shallow sources, and, conversely, broader anomalies indicate progressively deeper sources. The contouring connects responses from line to line and serves to delineate the trend of conductive zones.

An additional interpretive tool is a pseudo-section of the filter outputs. This is produced by processing a given data profile with filters of various lengths or spans. As the length of the filter increases, responses from increasing depths are successively emphasized. Therefore, if these outputs are arranged on a section such that greater depths correspond to longer filters, then the section should approximately resemble the current pattern in the ground. However, it must be emphasized that this is only an approximation to the section (i.e. pseudo-section). Construction of the section follows a number of steps.

3.4 Resistivity

To permit measurement of the VLF-electric field, a dipole consisting of two cylindrical electrodes and five metres of wire is used. When this dipole is correctly laid out, the IGS-2/VLF-4 measures the in-phase and quadrature components of the horizontal electric field in the direction of the line joining the operator and the transmitter station. The phase reference is the horizontal magnetic field.

The IGS-2/VLF-4 uses the magnetic and electric field measurements to automatically calculate the apparent resistivity of the earth as well as the phase angle between the magnetic and electric field components. If the earth is uniform (not layered) within the depth of the VLF measurement, the phase angle between the horizontal magnetic and electric VLF fields will be 45°. A non-uniform earth will give rise to other phase angles.

The following formulae are used for resistivity and phase calculations:

Apparent Resistivity Calculation:

$$\rho = \frac{1}{2\pi f \mu_o} \left| \frac{E_x}{H_y} \right|^2$$

where:

ρ = apparent resistivity on ohm metres

E_x = horizontal electric amplitude, calculated

$$E_x = (E_x(I)^2 + E_x(Q)^2)1/2$$

H_y = horizontal magnetic amplitude, measured

f = VLF station frequency in Hertz

μ_o = permeability of the ground in Henries/metre, a constant

The resistivity calculation has a range of 1 to 100,000 ohm metres with a resolution of 1 ohm metre.

Phase Angle Calculation:

The phase angle ϕ is expressed as:

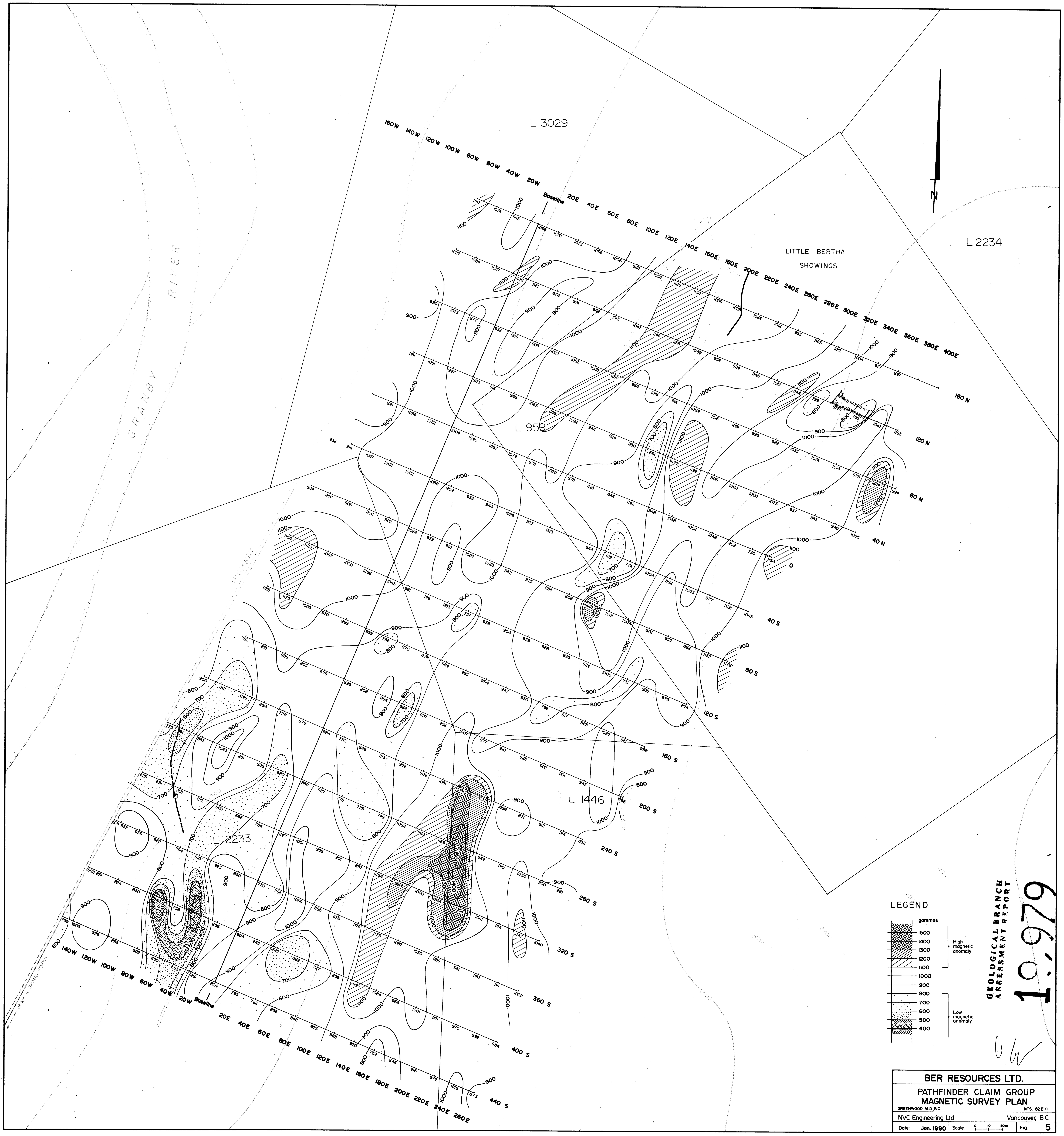
$$\phi = \text{arc tan } \frac{E_x(Q)}{E_x(I)}$$

where:

$E_x(Q)$ = horizontal quadrature VLF electric field

$E_x(I)$ = horizontal in-phase VLF electric field, phase referenced to the horizontal magnetic field, Hy.

The phase angle calculation has a range of -180° to +180° with a resolution of 1°. By definition, the angle is positive when the electrical field leads the magnetic field.



L 3029
L 2234
L 959
L 1446
L 2233
LITTLE BERTHA SHOWINGS
GRANBY RIVER
HIGHWAY
N
Baseline
160 N
120 N
80 N
40 N
0
40 S
80 S
120 S
160 S
200 S
240 S
280 S
320 S
360 S
400 S
440 S
LEGEND
gammas
1500
1400
1300
1200
1100
1000
900
800
700
600
500
400
High magnetic anomaly
Low magnetic anomaly
GEOLOGICAL BRANCH ASSESSMENT REPORT
19,979
BER RESOURCES LTD.
PATHFINDER CLAIM GROUP
MAGNETIC SURVEY PLAN
GREENWOOD M.D., B.C.
NTS. 82 E/1
NVC Engineering Ltd.
Vancouver, B.C.
Date: Jan. 1990
Scale: 0 10 20m
Fig. 5

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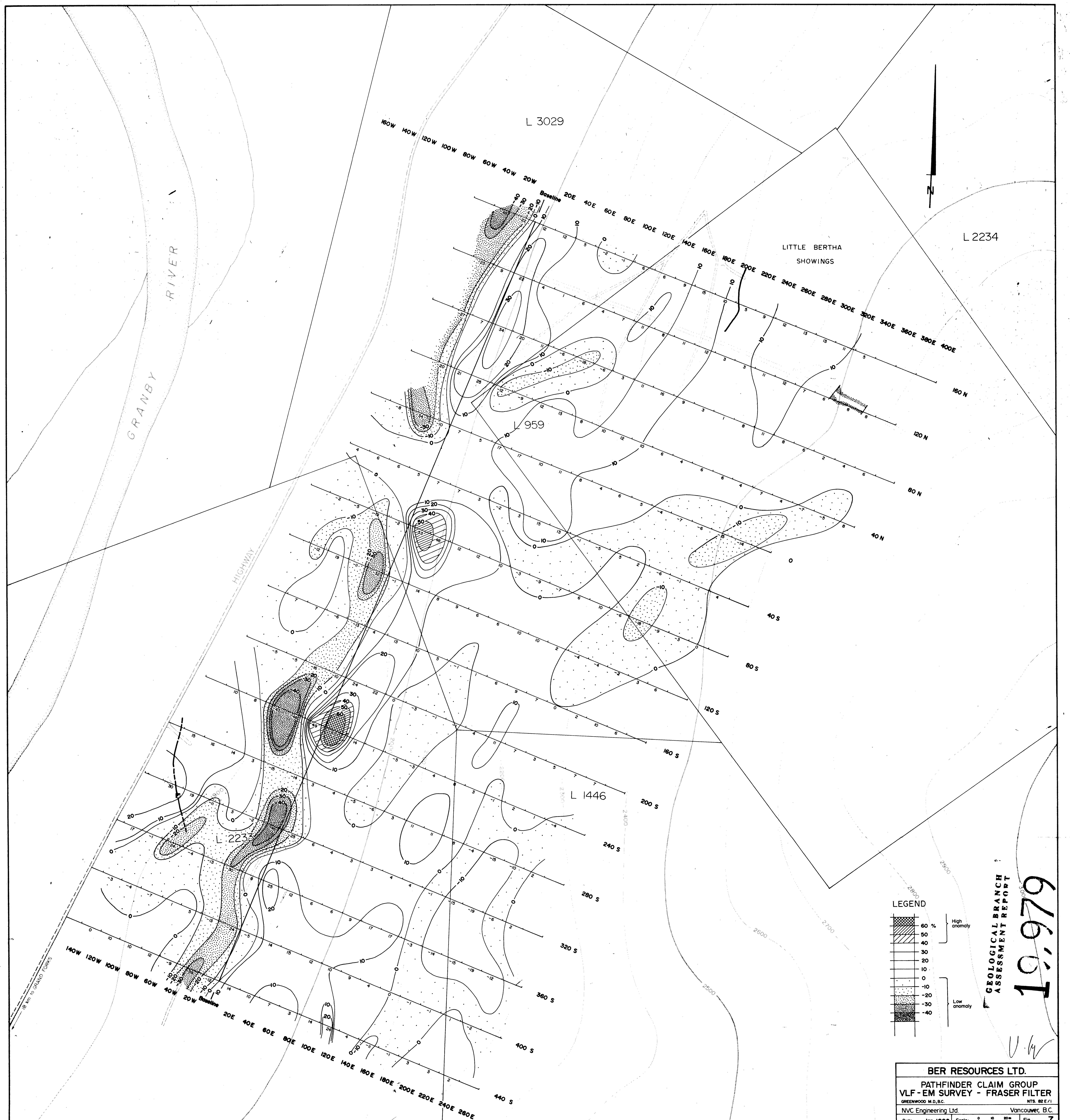
Date:	Jan. 1990	Scale:		Fig.	6



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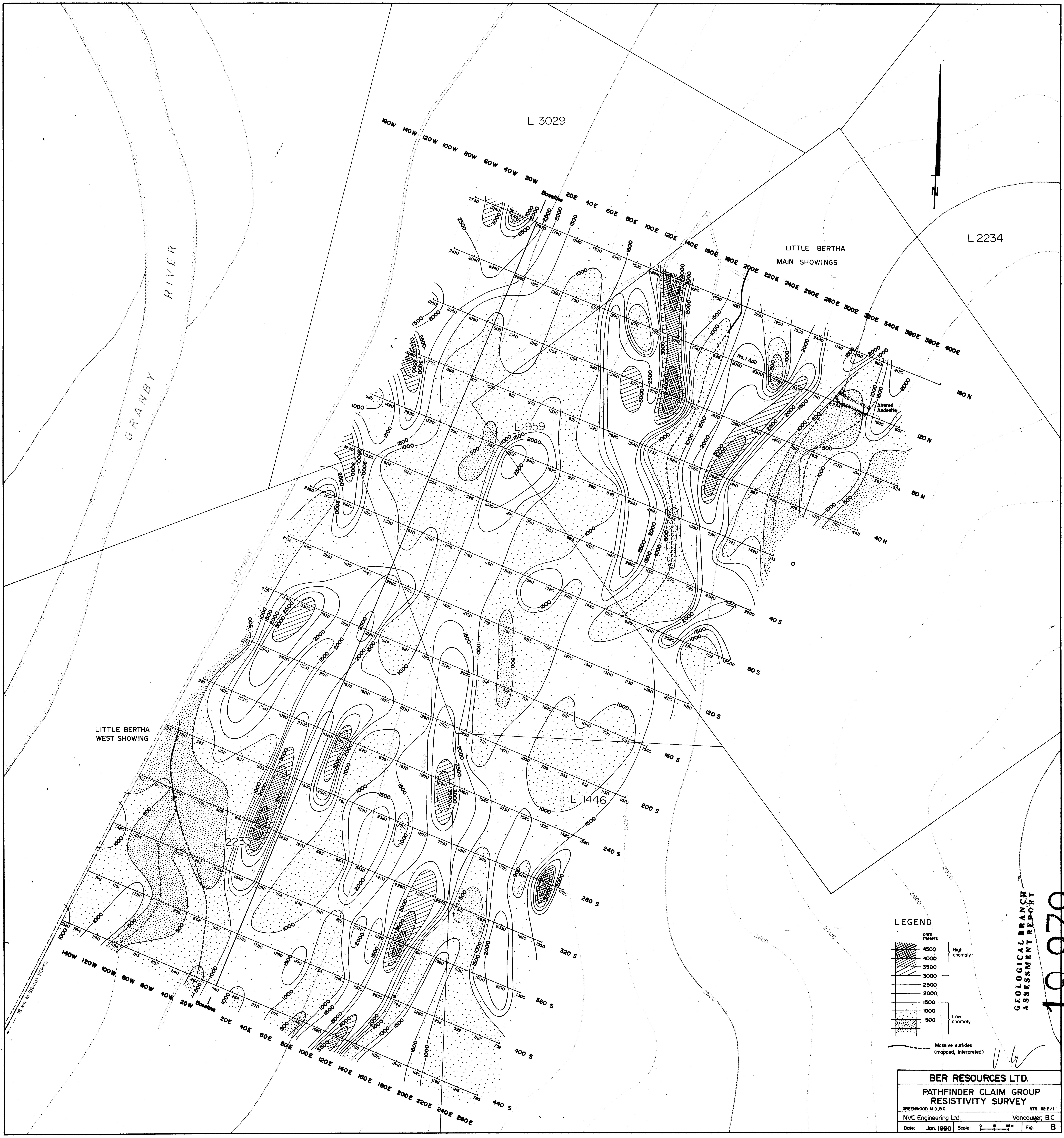
VLF - EM SURVEY - FRASER FILTER

GREENWOOD M.D., B.C. — NTS. 82 E/1

NVC Engineering Ltd. — Vancouver, B.C.

Date: Jan. 1990 — Scale: 0 10 20m — Fig. 7


L 3029
L 2234
L 959
L 1446
L 2233
GRANBY RIVER
HIGHWAY
LITTLE BERTHA
MAIN SHOWINGS
LITTLE BERTHA
WEST SHOWING
No. 1 Adit
Altered Andesite
Baseline
160 N
120 N
80 N
40 N
0
40 S
80 S
120 S
160 S
200 S
240 S
280 S
320 S
360 S
400 S
440 S
18 km to GRAND FORKS
N
LEGEND
ohm meters
4500
4000
3500
3000
2500
2000
1500
1000
500
High anomaly
Low anomaly
Massive sulfides (mapped, interpreted)
GEOLOGICAL BRANCH
ASSESSMENT REPORT
19,979
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RESISTIVITY SURVEY
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NVC Engineering Ltd.
Vancouver, B.C.
Date: Jan. 1990
Scale: 0 10 20 m
Fig. 8