MINNOVA INC.

GEOPHYSICAL REPORT ON AN
BOREHOLE PULSE EM SURVEY

SAMATOSUM PROJECT, HOLES RG-254,
RG-256 and RG-2[illegible]

LATITUDE: 51°09'N [illegible]: [illegible]19°[illegible]

NTS: [illegible]2M [illegible]4[illegible]

AUTHOR: DENNIS V. WOODS, Ph.D. P.Eng.
Geophysicist

DATE OF WORK: 16 - 22 May 1989

DATE OF REPORT: [illegible]9 June 1989

8[illegible]45

TABLE OF CONTENTS **PAGE**

ILLUSTRATIONS

INTRODUCTION:

On 16 - 22 May 1989, a borehole Pulse EM survey was carried out in diamond drillholes **RG-264, RG-256** and **RG-257** at the **Samatosum Project** of **Minnova Inc.** near Barriere, B.C.

The purpose of the survey was to explore for possible zones of conductive sulphide mineralization in the vicinity of the drillholes, not necessarily intersected by the holes.

PROPERTY LOCATION AND ACCESS:

The **Samatosum Project** is located about 20 km east of Barriere, B.C. on the Adams Plateau. Access is via an all-weather road from Highway # 5 south of Barriere east towards Adams Lake and then northeast towards Johnson Lake.

BOREHOLE PULSE EM TECHNIQUE:

The Crone borehole pulse EM system is a time domain downhole EM instrument capable of detecting conductive mineralization intersected by the drillhole or lying offhole. The borehole pulse EM system utilizes a special downhole receiver coil, 600 m cable and winch in conjunction with a standard PEM transmitter and receiver normally employed in surface surveys.

The primary field is produced by a 150 m by 150 m square surface loop driven by the 500 watt PEM transmitter. Large loop surveys (e.g. up to 500 m by 1000 m) using the 2000 watt transmitter, and small loop surveys using the 10 m diameter portable equipment, can be carried out depending on the depth and size of the expected conductive target.

The time derivative of the secondary EM field is measured using an axial receiver coil lowered down the diamond drillhole. The minimum size of drillhole which can be accommodated is AQ (1 3/4" diameter). The receiver obtains eight samples of the secondary field during the primary field off-time. Sample times range from 0.15 to 6.4 ms after primary field shut-off on a 10.8 ms transmitter time base.

Multiple transmitter loops may be used to provide various loop to conductor coupling geometries in order to obtain conductor attitude and position information. A complete survey of a given borehole may entail logging the hole from five transmitter loop setups. One of these loops would be approximately centred over the area of interest with the remaining four loops away from and distributed around the borehole.

When an anomalous response is observed in a borehole log from a single transmitter loop, the nature of this anomaly allows the determination of the location of the conductive source relative to the drillhole. As shown by Woods and Crone (1980, Figs. 7 & 8), the response can indicate whether the borehole is intersecting the centre of the conductor, the margin of a conductor, with the bulk of conductive material away from the hole, or whether the conductor is entirely off-hole.

Model study curves for various conductor to borehole geometries from Woods (1975) are employed in the interpretation. Quantitative analysis of the conductor's attitude, position and conductance is made using nomograms presented by Woods, et al. (1980). Computer plate modelling, using the routines developed by Dyck, et al (1980), can be used to confirm the interpretation.

In the case of a dike-like or tabular conductor, the magnitude of an anomaly varies with the angle that the primary field cuts the conductor. Thus, the degree to which coupling is obtained to the conductor, in coverage of a borehole from several loop setups, will provide information on the attitude and position of the conductive mineralization.

If the conductor tends towards a more spheroidal shape, the anomaly character will change, as well as its magnitude, when the primary field angle is altered. This occurs because the eddy currents are not constrained to flow within a conductive sheet. Thus, multiple transmitter loop coverage can also provide information on the shape of a conductive body.

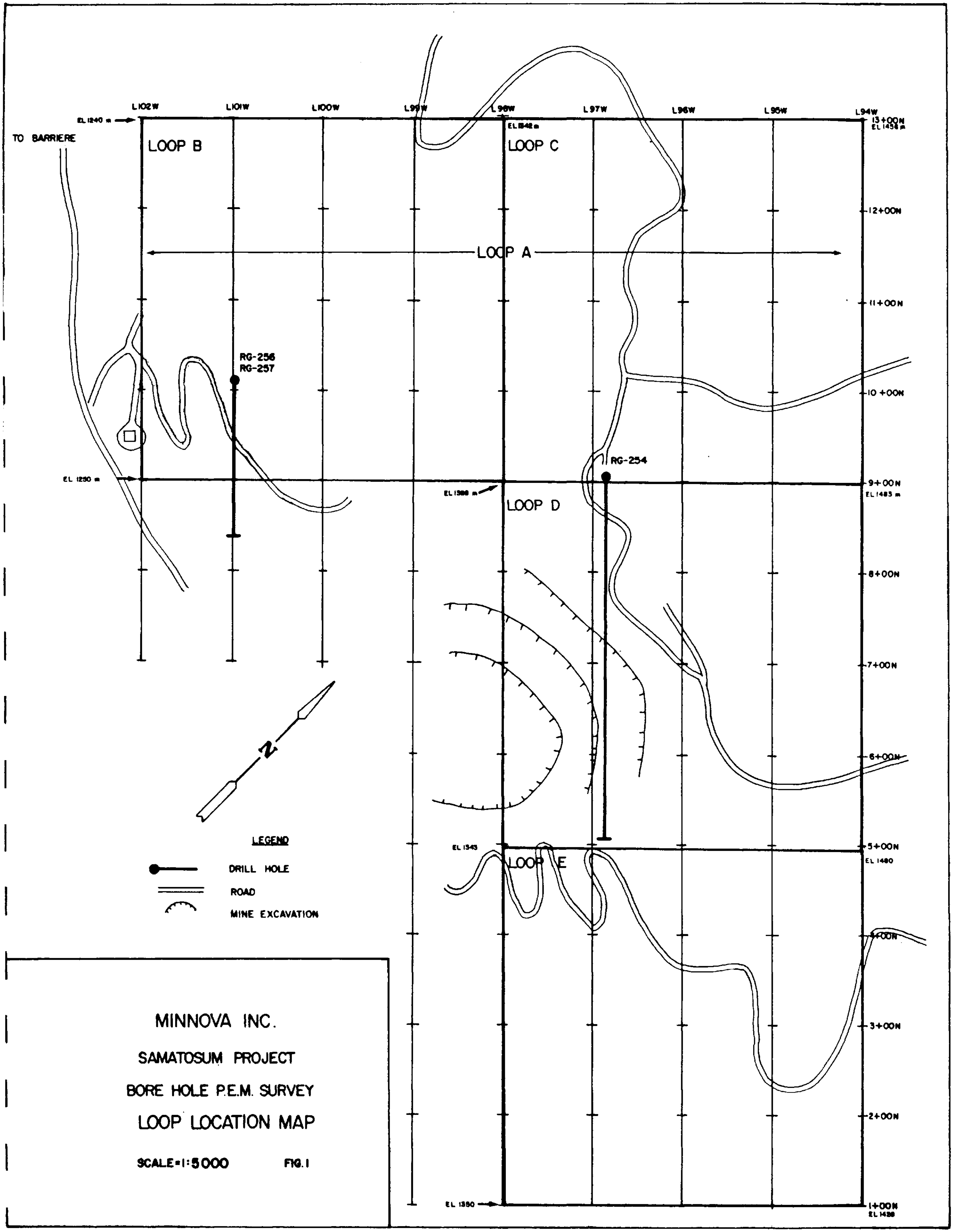
In practice the responses observed in field situations are much more complex than those of simple models, but the results are sufficiently interpretable that the method has general acceptance and a number of discovery case histories exist.

SURVEY PROCEDURE:

Holes **RG-254, RG-256** and **RG-257** were surveyed on 16-22 May 1989, using the Crone 2000 watt 8-channel Pulse EM system. Before carrying out the Pulse EM surveys, each hole was tested with a dummy probe. **RG-254** was found to be partially collapsed between 345 m and 365 m, and completely blocked at 650 m. After a bit of effort and one lost dummy probe, the blockage at 345 m to 365 m was cleared and **RG-254** was made safe for PEM probing to a depth of at least 640 m.

Dummy probing also found **RG-255** to be blocked at only 213 m, and **RG-256** and **RG-257** to be blocked at 323 m and 204 m respectively. It was decided not to bother with the PEM survey on **RG-255** but to go ahead with the survey of **RG-256** (and **RG-257** since the two holes are right beside each other), since **RG-256** was open at least to the depth of interest.

The entire length of **RG-254**, above the blockage at 650 m depth, was initially surveyed using a 400 m by 800 m transmitter loop (loop A) as shown in Figure 1. Additional PEM surveys of the bottom half of **RG-254** were then carried out with four different 400 m by 400 m transmitter loops (loops B to E) as shown in Figure 1. Some of the surveys were carried out while the open



MINNOVA INC.

SAMATOSUM PROJECT

BORE HOLE P.E.M. SURVEY

LOOP LOCATION MAP

SCALE=1:5000 FIG. I

pit mine was shut down for a holiday weekend, this being the only way that transmitter loops D and E could be laid out over the mine site. The open sections of **RG-256** and **RG-257** were surveyed using one of the 400 m by 400 m transmitter loops (loop B).

DISCUSSION OF RESULTS:

Two separate anomalous responses are observed in the borehole PEM profiles from **RG-254** as shown in Figures 2 to 6. A wide positive anomaly centred at 360 m is typical of an in-hole response: i.e. where a borehole intersects the central region of a large sheet-like conductor. The sharp positive peak between 350 m and 365 m depth indicates that this is the zone of high conductivity. The great width of the anomaly, extending from near-surface to over 500 m in depth, indicates that the conductor extends for considerable distance down-dip and along strike.

A broad negative anomaly is observed below the in-hole response at a depth of 530 m. This anomaly is typical of a large conductor located away from the hole (Woods, 1975). The shape of the anomaly, separate from the overlying in-hole response, indicates that the conductor is almost perpendicular to the hole. The width of the anomaly can be used to estimate the size of the conductor (from 250 m to 400 m wide) and the distance it lies away from the drillhole (50 m to 70 m) using the nomograms from Woods, et al. (1980).

Finally, the amplitude decay of the response is used to estimate the conductivity-thickness product of the conductor (between 15 and 25 mhos) using a nomogram in Woods (1975).

By comparing the relative amplitude of the off-hole anomaly using loops B and C, the conductor is interpreted to lie more to the southeast of line 98+00W than to the northwest. Also, by comparing the response profiles from loops C, D and E, it is possible to determine the position of the conductor in section as shown on the primary field diagrams shown in Figures 9, 10 and 11 respectively. These diagrams graphically depict the only position of the conductor which is consistent with all the available data.

No significant anomalies were obtained in drillholes **RG-256** and **RG-257** (Figures 7 and 8). There is a moderate decrease of the early channel amplitudes toward the bottom of **RG-256** and an amplitude increase in **RG-257** similar to the upper sections of **RG-254.** These responses are probably related to the same in-hole conductor observed in **RG-254.** The fact that the vertical hole **RG-256** has a weak negative response suggests that this conductor is perhaps limited in its down-dip extent.

As shown in Figures 9, 10 and 11, the upper conductor observed in **RG-254, RG-256(?)** and **RG-257** is probably a graphitic argillite within the sedimentary unit known as the Samatosum horizon. The near-surface sections of this horizon contain ore-grade sulphide mineralization which constitutes the Samatosum ore body. Sulphide ore mineralization cannot be differentiated from the graphitic argillite response on the basis of the borehole PEM results alone.

The fact that the upper conductor produces a 15 m wide amplitude peak, particularly from loop D (Figure 5) where the primary field is aligned parallel to the horizon (Figure 10), indicates that the entire width of the horizon is conductive. Also the slight negative response in **RG-257** compared with the positive anomalies in **RG-254** and **RG-256,** indicates that the conductive horizon terminates down-dip from the intersections in **RG-254** and **RG-257.** This last conclusion, however, should be considered speculative without further supporting evidence.

The lower conductor observed in **RG-254** appears to be situated stratigraphically between the Rea Gold "Discovery" horizon and the Samatosum horizon. The dip of this conductor is decidedly

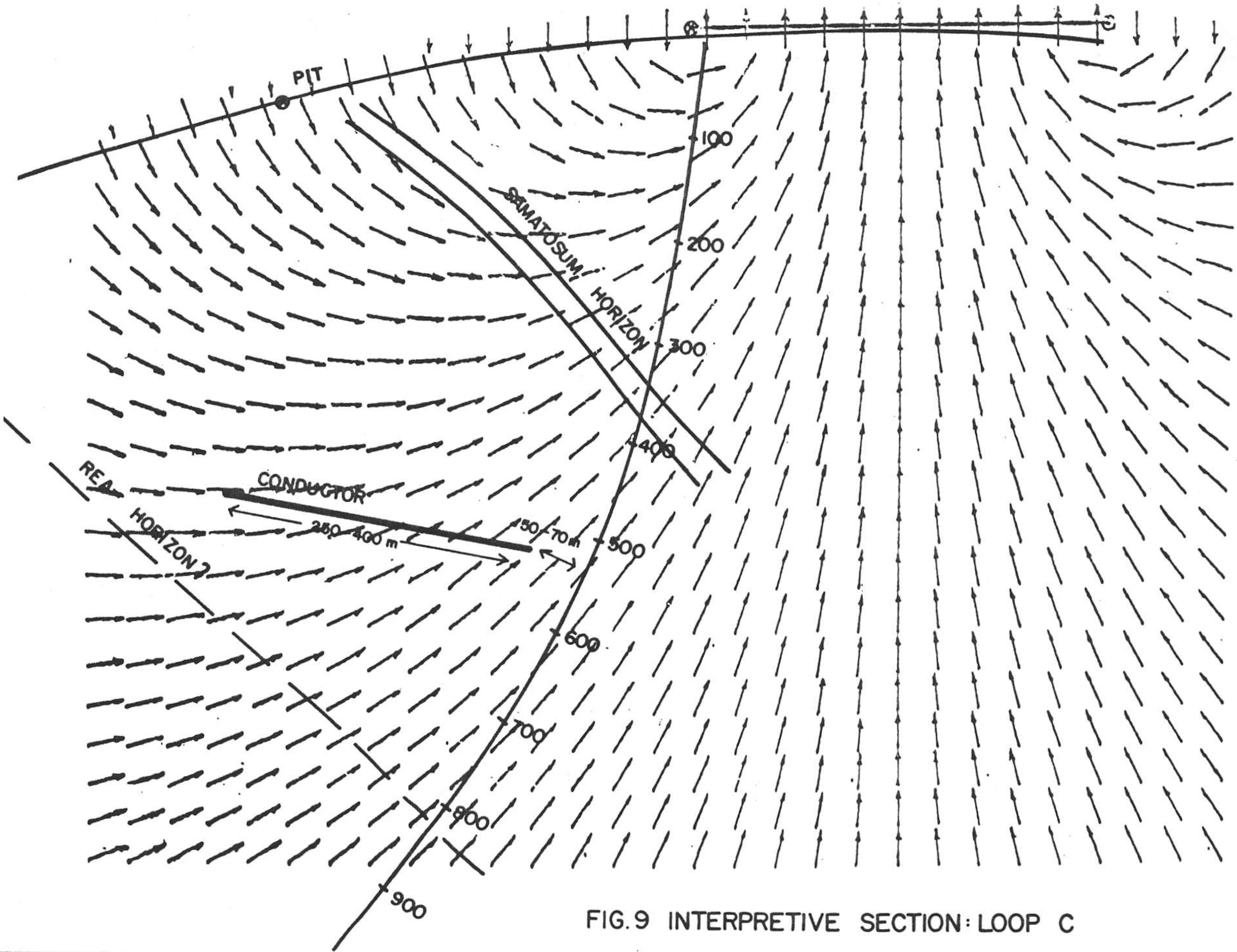


FIG. 9 INTERPRETIVE SECTION: LOOP C

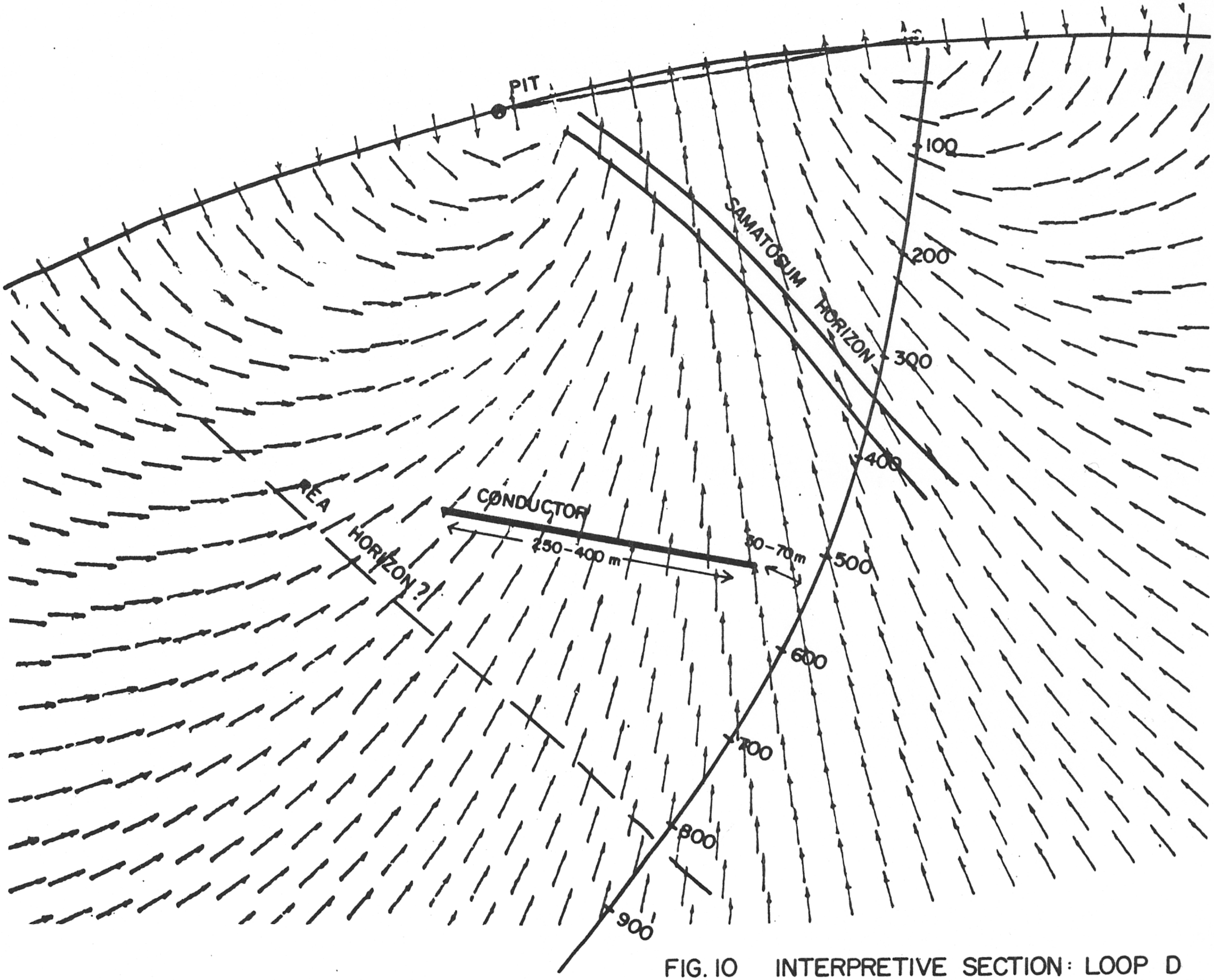


FIG. 10 INTERPRETIVE SECTION: LOOP D

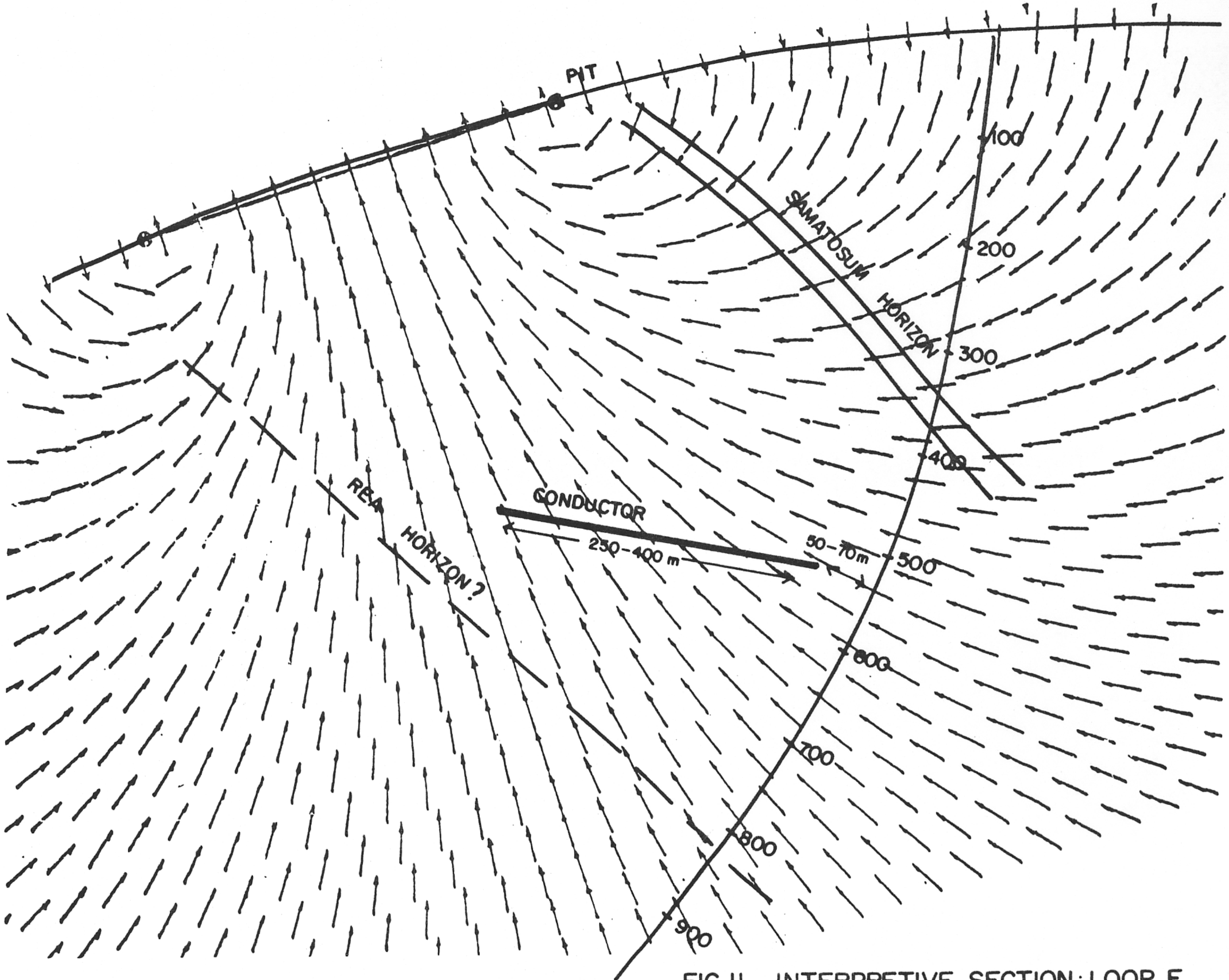


FIG.11 INTERPRETIVE SECTION: LOOP E

flatter than either the Rea Gold or the Samatosum horizons which suggests a structural complexity (e.g. fold or fault) in this area. The conductivity thickness of the lower conductor is not inconsistent with sulphides, however the conductor could also be due to graphitic argillites. Indeed, the drillhole log from **RG-254** indicates graphitic argillite at 550 m depth.

RECOMMENDATIONS:

The off-hole conductor observed at 530 m depth in **RG-254** should be tested by drilling. The recommended drillholes are:

1.	L97W/6+50N	/-90°	550 m
2.	L97W/8+25N	225°/-70°	600 m.

These, and other deep drillholes on the Samatosum property, should be surveyed with borehole PEM.

Respectfully submitted,

Dennis V. Woods, Ph.D., P.Eng.
Consulting Geophysicist

REFERENCES:

Dyck, A.V., Bloore, M., and Valles, M.A., 1980: User manual for programs PLATE and SPHERE; Research in Applied Geophysics, 23, University of Toronto.

Woods, D.V., 1975: A model study of the Crone Borehole pulse electromagnetic (PEM) system; unpublished M.Sc. thesis, Queen's University, Kingston, Ontario.

Woods, D.V. and Crone, J.D. 1980: Scale model study of a borehole pulse electromagnetic system; C.I.M. Bulletin, vol.73, no. 817, pp.96-104.

Woods, D.V., Rainsford, D.R.B. and Fitzpatrick M.N. 1980: Analogue modelling and quantitative interpretation of borehole PEM measurements (abstract only); EOS Transactions of the American Geophysical Union, vol. 61, no. 17, pp. 414-415.

SPECIFICATIONS – CRONE BOREHOLE PULSE EM EQUIPMENT

PROBE:
– Measures dB/dt of axial-component of borehole
– Ferrite cored antenna with preamplifier and self contained power supply (Ni.-Cd. rechargeable)
– 30 hours continuous operation
– Weight: 3.6 Kg.
– Length: 1.63 M.
– Diameter: 2.9cm (for "E" holes and larger)
– Pressure tested to 13.8 MPa (2000 PSI)

WINCH ASSEMBLY:
– 3 speed gear box, gear ratios 1:1, 2:1, 3:1
– Optional power winching for deep holes
– Borehole cable capacity of up to 2000 meters
– Portable

UNDERGROUND PUSHROD SYSTEM:
– For use in horizontal boreholes (‹ 45 degrees)
– Powered Pushrod assembly for holes › 500 meters

BATTERY SUPPLY:
±12 VDC, two internal, rechargeable, 12V gel type batteries

MEASURED QUANTITIES:
Primary shut-off voltage pulse (PP). Time derivative of the transient magnetic field by integrative sampling over eight, contiguous time gates (microseconds).

CH. NO.	WINDOW	WIDTH	MID PT.	REL. GAIN	WINDOW	WIDTH	MID PT.
PP	-100 to 0	100	-50	1.00	-200 to 0	200	-100
1	100 to 200	100	150	1.00	200 to 400	200	300
2	200 to 400	200	300	1.39	400 to 800	400	600
3	400 to 700	300	550	1.93	800 to 1400	600	1100
4	700 to 1100	400	900	2.68	1400 to 2200	800	1800
5	1100 to 1800	700	1450	3.73	2200 to 3600	1400	2900
6	1800 to 3000	1200	2400	5.18	3600 to 6000	2400	4800
7	3000 to 5000	2000	4000	7.20	6000 to 10K	4000	8000
8	5000 to 7800	2800	6400	10.00	10K to 15.6K	5600	12.8K
	10.8ms. Time Base				21.6ms. Time Base		

READOUT:
Readings are output on an analog meter (6V FSD), over three sensitivity ranges (X1, X10, X100). Data retrieval made by channel select switch.

TIMING:
A telemetry link ("sync.") is maintained by radio signal, or a back-up cable, between the transmitter and the receiver, and is meter monitored.

SENSITIVITY:
Adjustable through a ten turn, calibrated gain pot.

SAMPLING MODES:
"S & H" (Sample & Hold)
The receiver averages 512 (10.8 ms), or 256 (21.6ms), readings for all channels, and stores the results for display.
"CONT" (Continuous)
A running average for all channels is stored, enabling the operator to reject thunderstorm spikes and power line noise by visual inspection.

SPECIFICATIONS – PULSE EM TRANSMITTER EQUIPMENT

MOTOR GENERATOR:

4-1/2 H.P. Wisconsin, 4 cycle engine with belt drive to D.C. alternator; maximum output 120V, 30 amps; external gas tank; frame unit weight: 33 kg, shipping: 47 kg.

REGULATOR:

Controls and filters the alternator output; continuously variable between 24V and 120V D.C.; 20 amp maximum current; weight: 10 kg, shipping: 24 kg.

PEM WAVEFORM TRANSMITTER:

Controls bipolar, on-off waveform and linear current shut-off ramp time. Radio and cable time synchronization with housing for optional crystal clock sync system; on-off times for 60 Hz areas 8.33ms, 16.66ms, 33.33ms; for 50 Hz areas 10.0ms, 20.0ms, 40ms; for analog PEM operation 10.9ms, 21.8ms; linear controlled current shut-off ramp times of 0.5, 1.0 and 1.5ms; monitors for shut-off ramp operation, instrument temperature, Tx loop continuity, and overload output current; automatic shut-down for open Tx loop. Weight: 12.5 kg, shipping: 22 kg.

REMOTE RADIO, ANTENNA AND MAST:

Used for radio timing synchronization on large survey grids; range up to 2 km; radio has 12V rechargeable gell cell battery supply; antenna is fiberglass mounted on a 4 section aluminum mast each 2m long. Radio weight: 2.7 kg, shipping: 6.0 kg; mast and antenna shipped as bundle: 6.4 kg.

OPTIONAL CRYSTAL CLOCK TIMING LINK:

Installed in the Digital Rx and external box mounted to be plugged into PEM-Tx. Gel rechargeable power supply. Weight: 10 kg, shipping: 15 kg.

WIRE, SPOOLS AND WINDERS:

Transmitter wire is usually No. 10 or No. 12 AWG copper in 310m or 410m lengths, 1 length per spool; 2 spools in a shipping box; winder is mounted on a magnesium packframe.

MULTI-TURN MOVING COIL:

7 turn, 13.7 meter diameter Tx loop with plugs to break into 2 sections. Aluminum or copper wire and various coverings depending on area being used.

BATTERY POWER SUPPLY:

24V, 20 amp hour; rechargeable battery supply for use with PEM-Tx as power source rather than motor-generator-regulator. In aluminum case, with clamp connectors. Weight: 20.5 kg, shipping: 29 kg.

- Battery chargers supplied for all rechargeable battery units
- All instruments and equipment operational from -40°C to +50°C.
- Shipping boxes are reusable plywood construction with closed cell foam shock protection.

STATEMENT OF QUALIFICATIONS

NAME: WOODS, Dennis V.

PROFESSION: Geophysicist

EDUCATION:

B.Sc. Applied Geology
Queens' University

M.Sc. Applied Geophysics
Queen's University

Ph.D. Geophysics
Australian National University

PROFESSIONAL ASSOCIATIONS:

Registered Professional Engineer
Province of British Columbia

Society of Exploration Geophysicists

Canadian Society of Exploration Geophysicists

Australian Society of Exploration Geophysicists

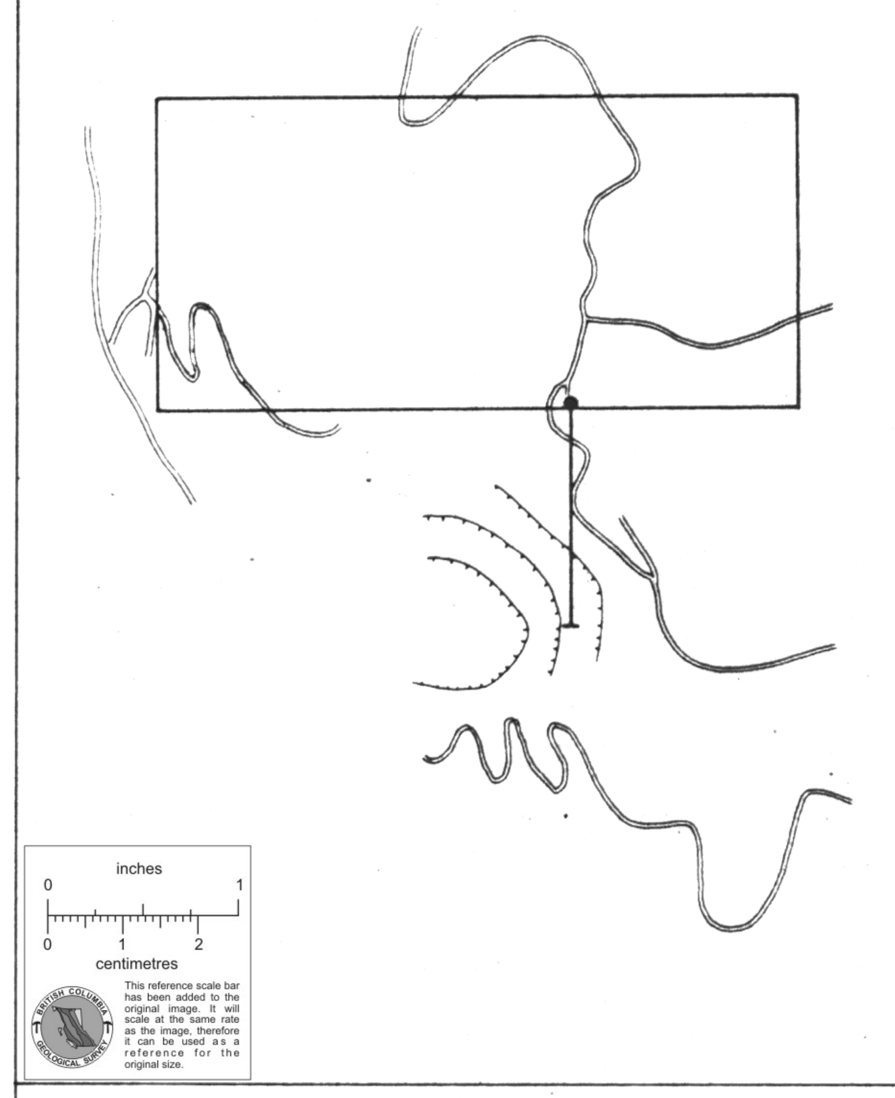
President, B.C. Geophysical Society

EXPERIENCE:

1971-79
- Field Geologist with St. Joe Mineral Corp. and Selco Mining Corp. (summers).
- Teaching assistant at Queen's University and the Australian National University.

1979-86
- Professor of Applied Geophysics at Queen s University.
- Geophysical consultant with Paterson Grant & Watson Ltd., M.P.H. Consulting Ltd., James Neilson and Assoc. Ltd., Foundex Geophysics Geophysics Ltd.
- Visiting research scientist at Geological survey of Canada and the University of Washington.

1986-88
- Project Geophysicist with Inverse Theory and Applications Inc.
- Chief Geophysicist with White Geophysical Inc.

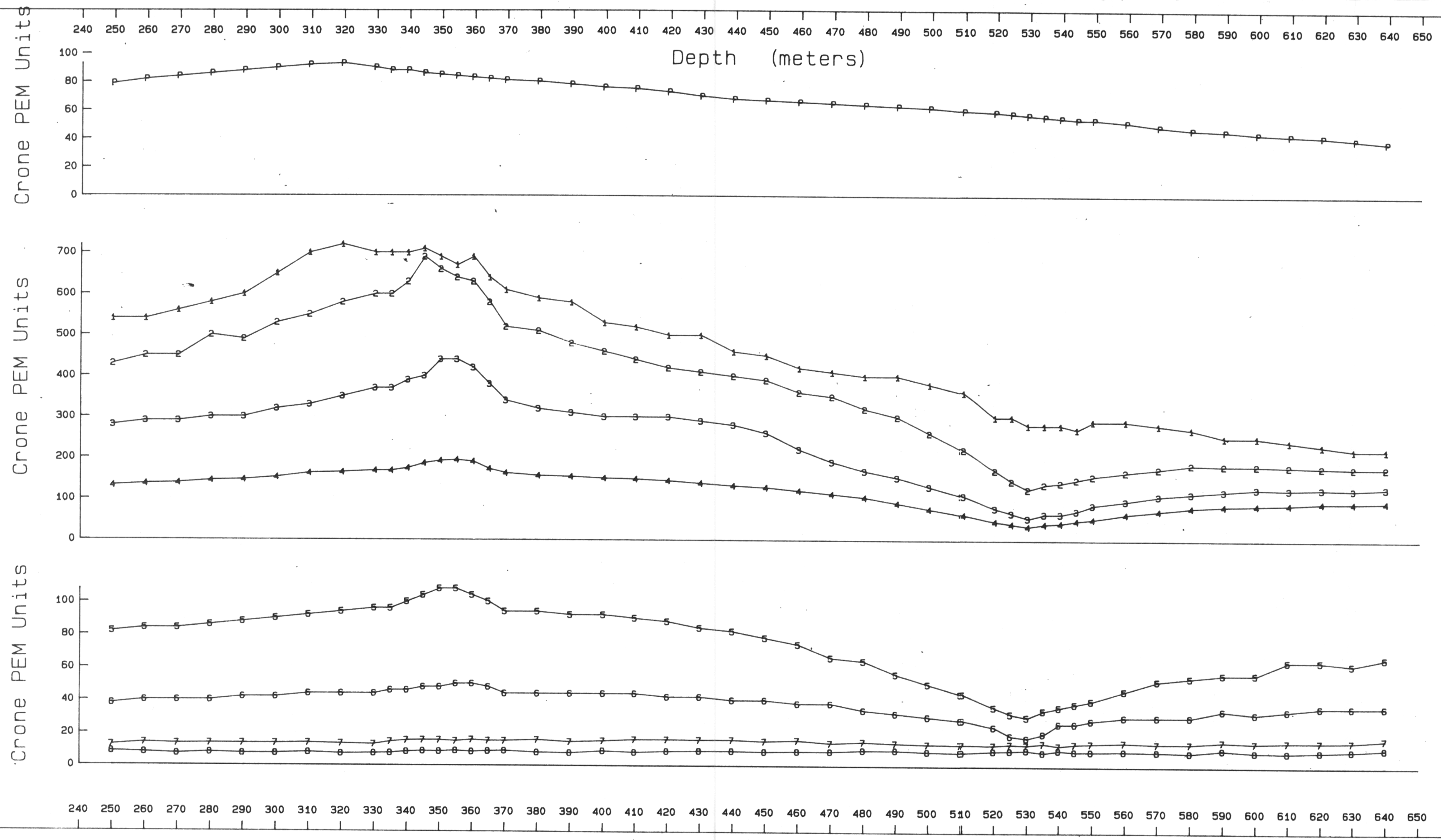


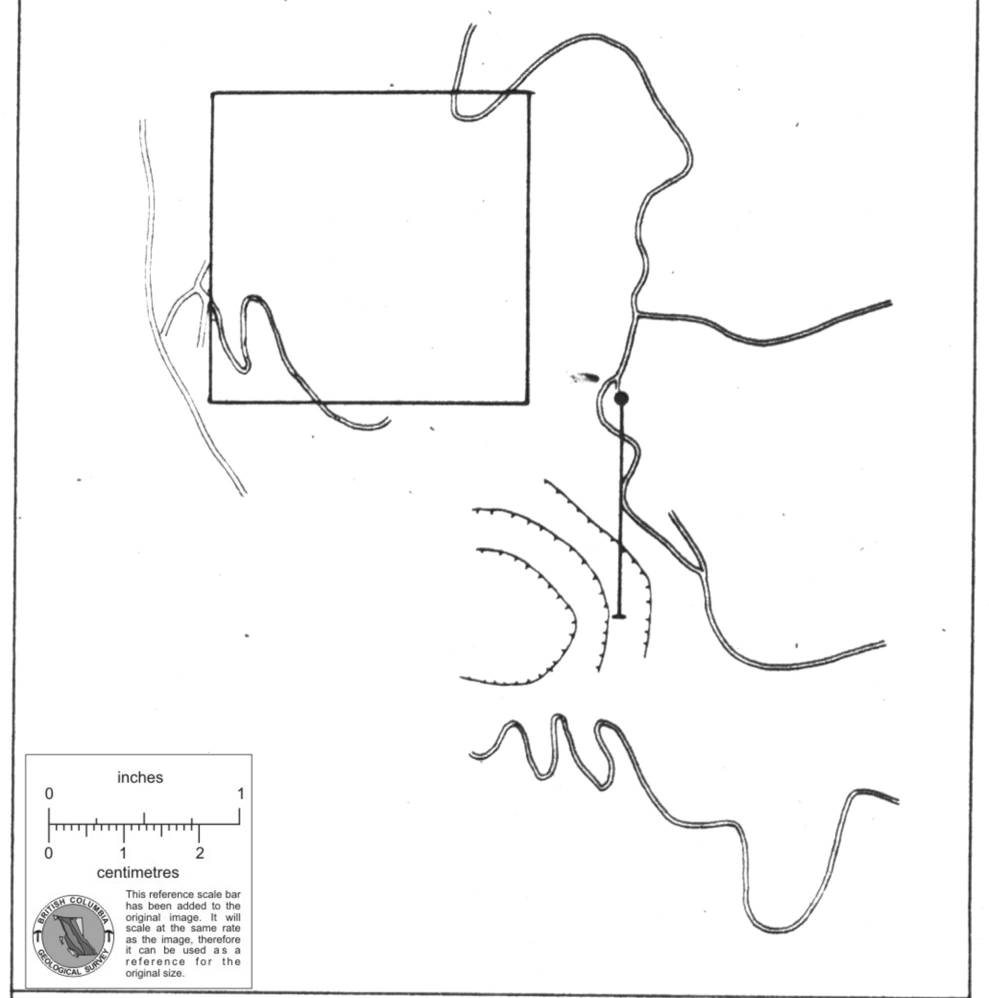
MINNOVA INC.

BOREHOLE PEM SURVEY
SAMATOSUM PROJECT
BOREHOLE RG254 LOOP A
Scale 1: 1000.0

Date: June 1989	Survey: May 1989	Figure: 2

WHITE GEOPHYSICAL INC.





MINNOVA INC.

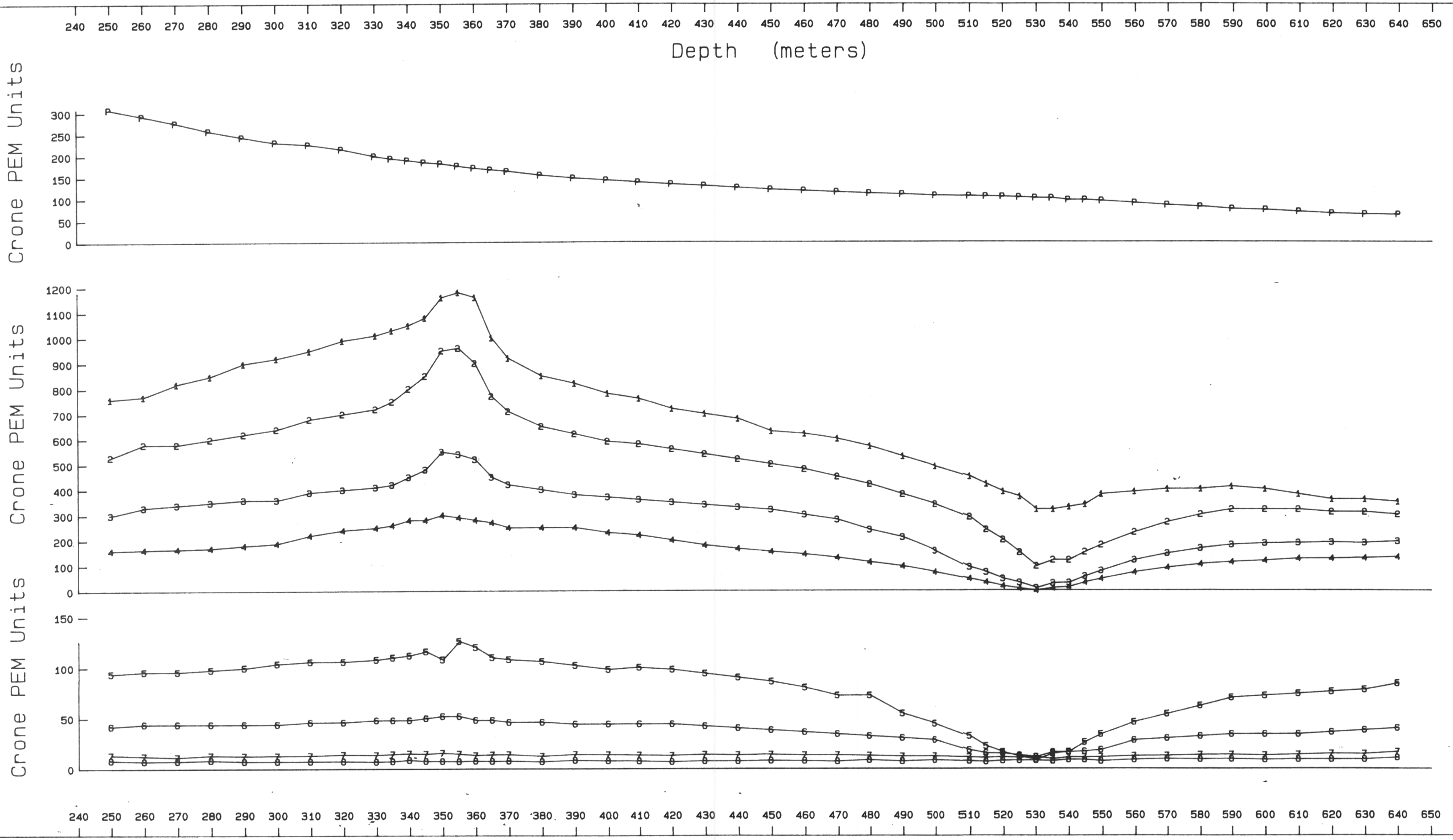
BOREHOLE PEM SURVEY
SAMATOSUM PROJECT
BOREHOLE RG254 LOOP B

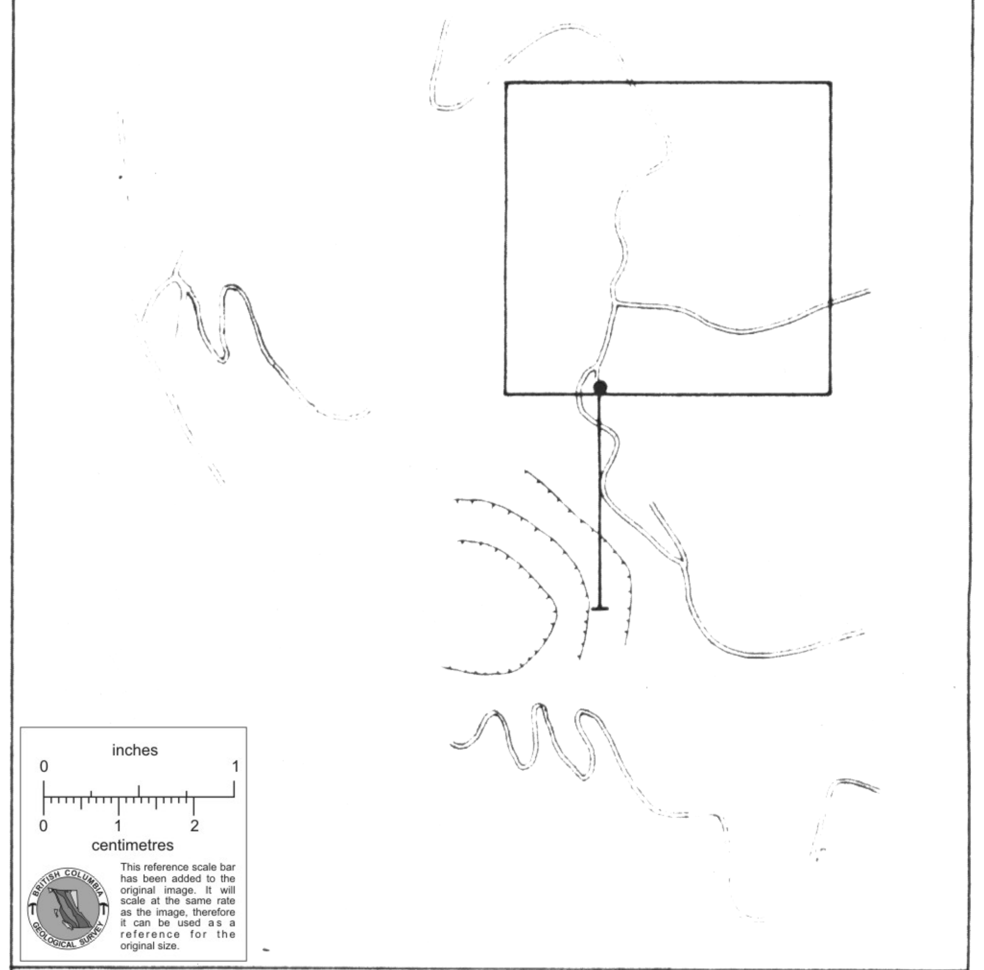
Scale 1: 1000.0

0 20 40 60 80 100 M

Date: June 1989	Survey: May 1989	Figure: 3 .

WHITE GEOPHYSICAL INC.





MINNOVA INC.

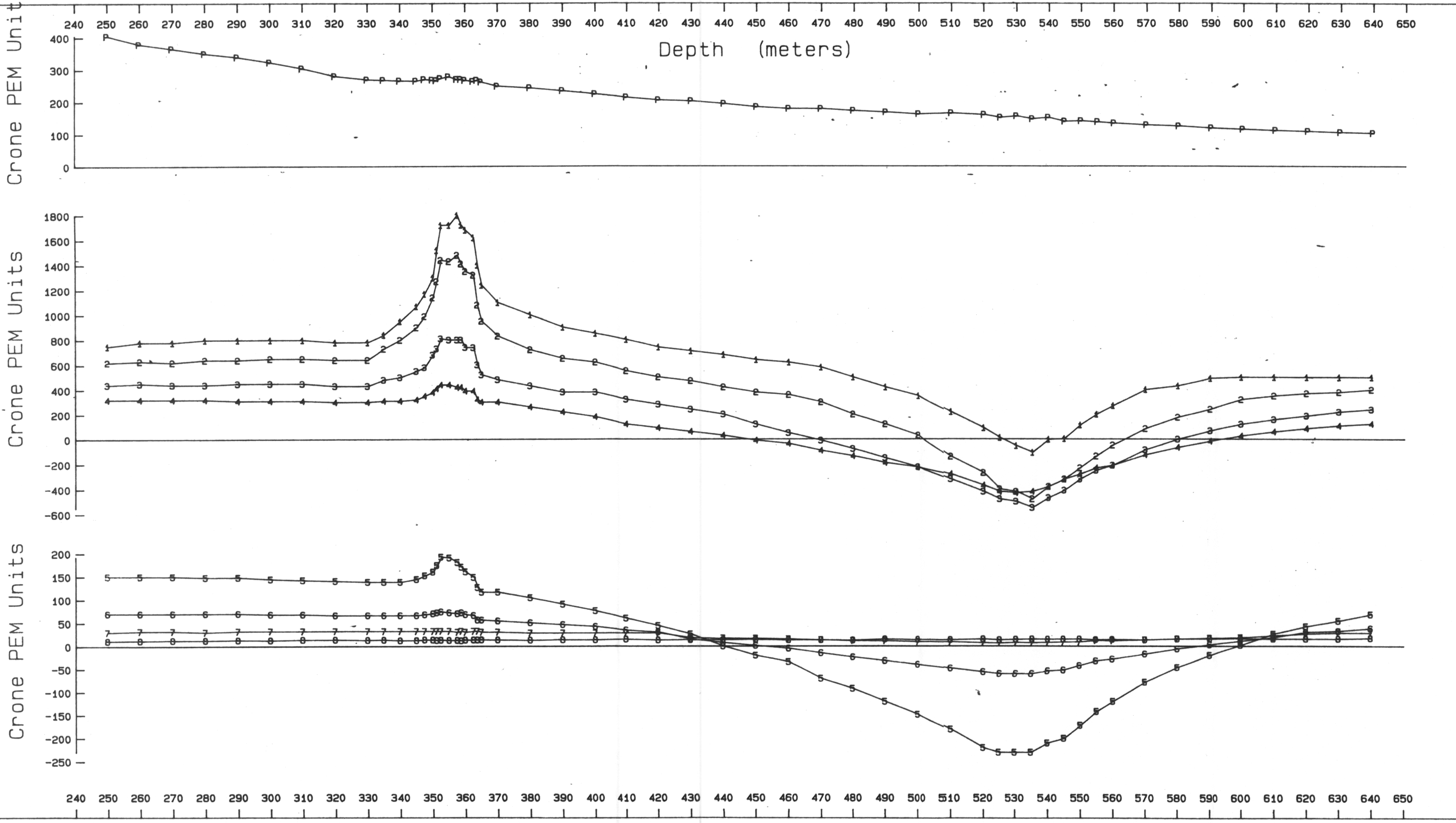
BOREHOLE PEM SURVEY
SAMATOSUM PROJECT
BOREHOLE RG254 LOOP C

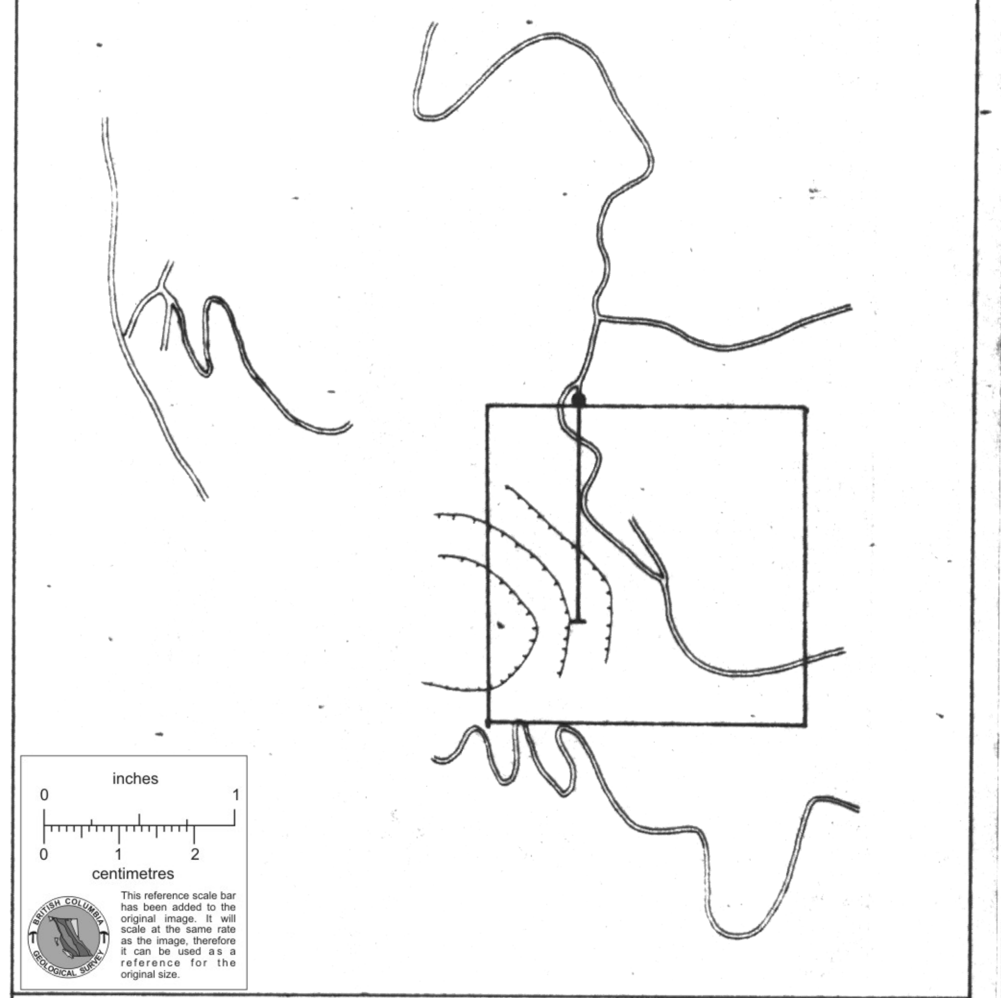
Scale 1: 1000.0

0 20 40 60 80 100 M

Date: June 1989	Survey: May 1989	Figure: 4 .

WHITE GEOPHYSICAL INC.





MINNOVA INC.

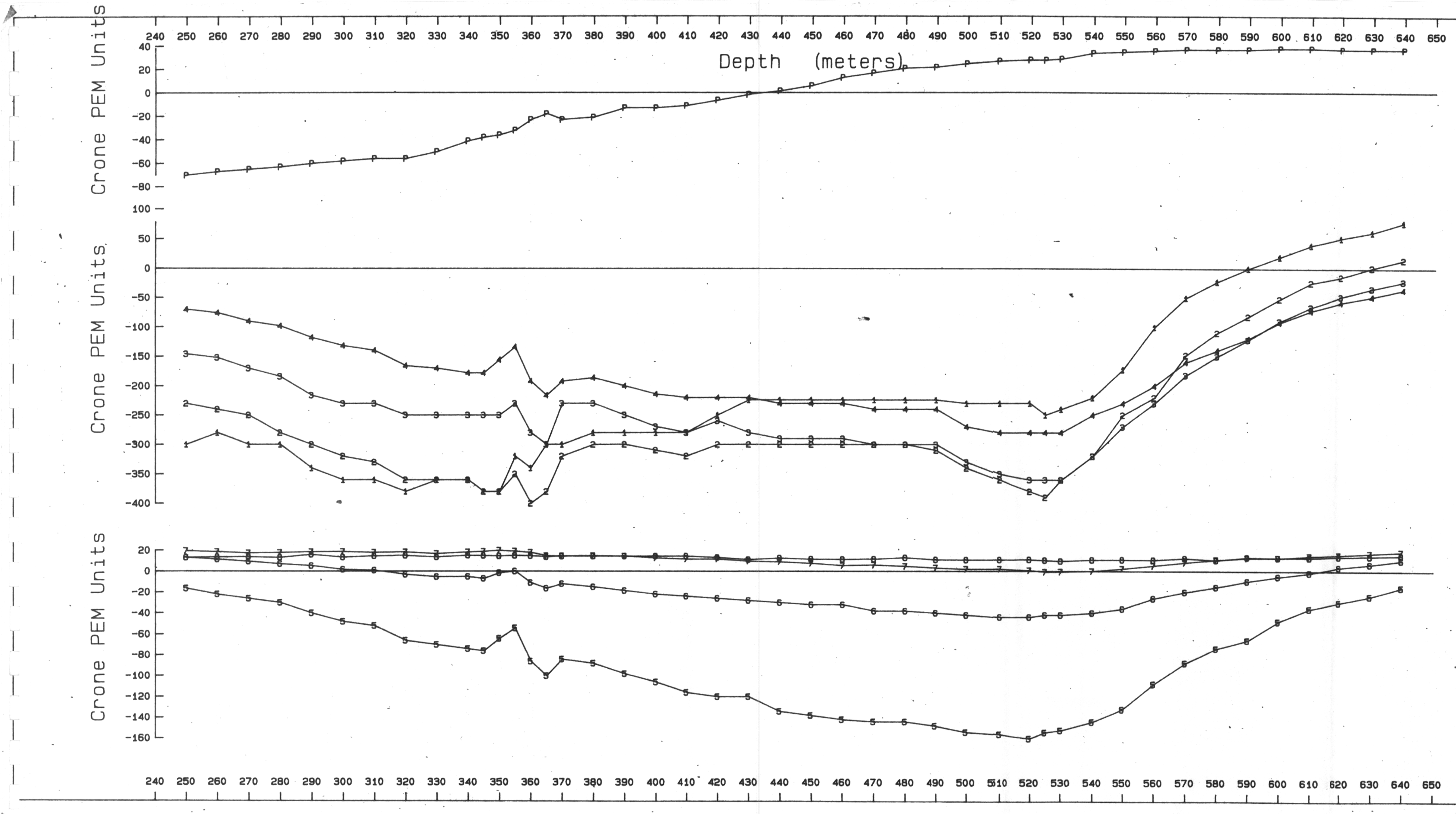
BOREHOLE PEM SURVEY
SAMATOSUM PROJECT
BOREHOLE RG254 LOOP D

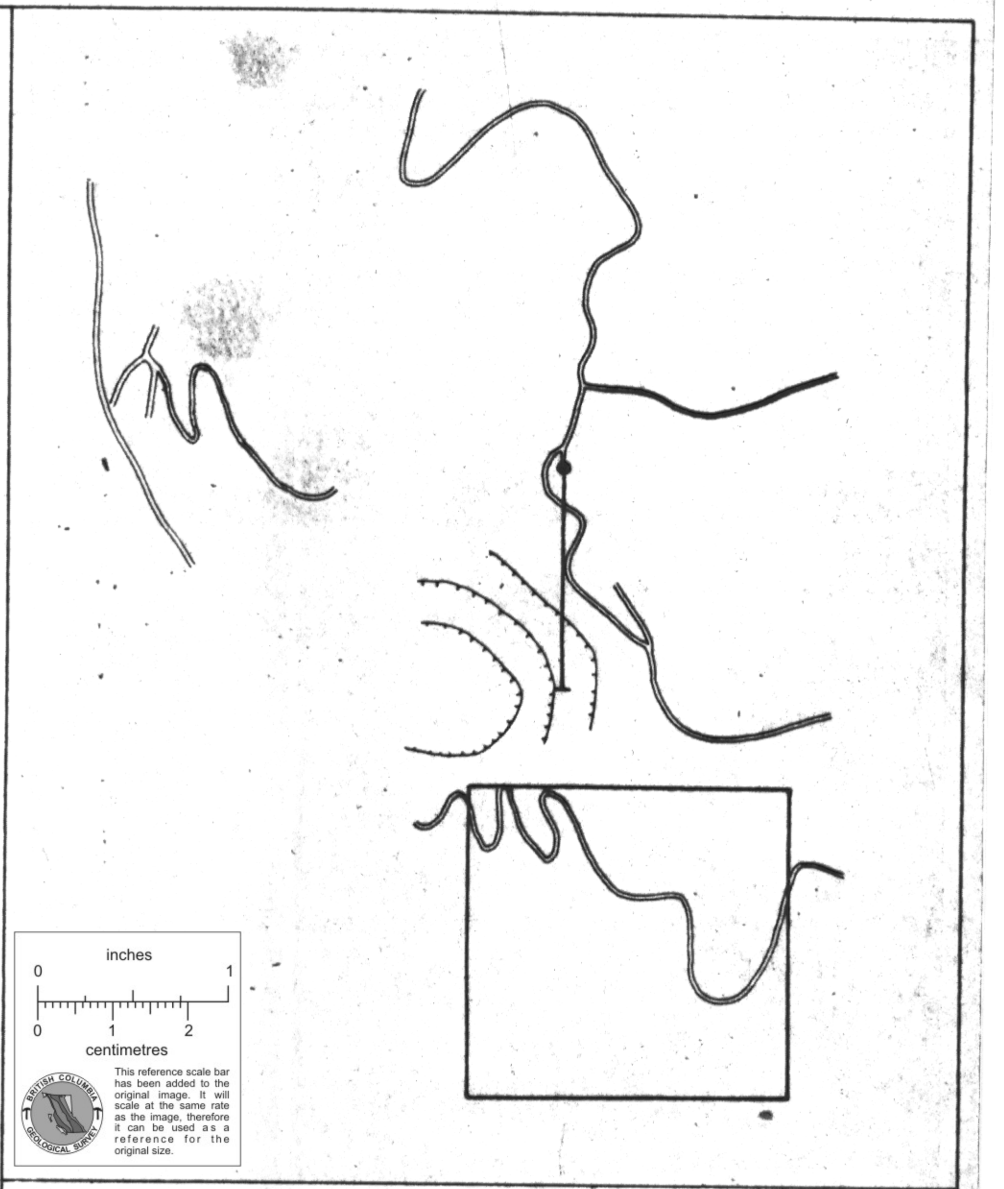
Scale 1: 1000.0

0 20 40 60 80 100 M

Date: June 1989	Survey: May 1989	Figure: 5 .

WHITE GEOPHYSICAL INC.





MINNOVA INC.

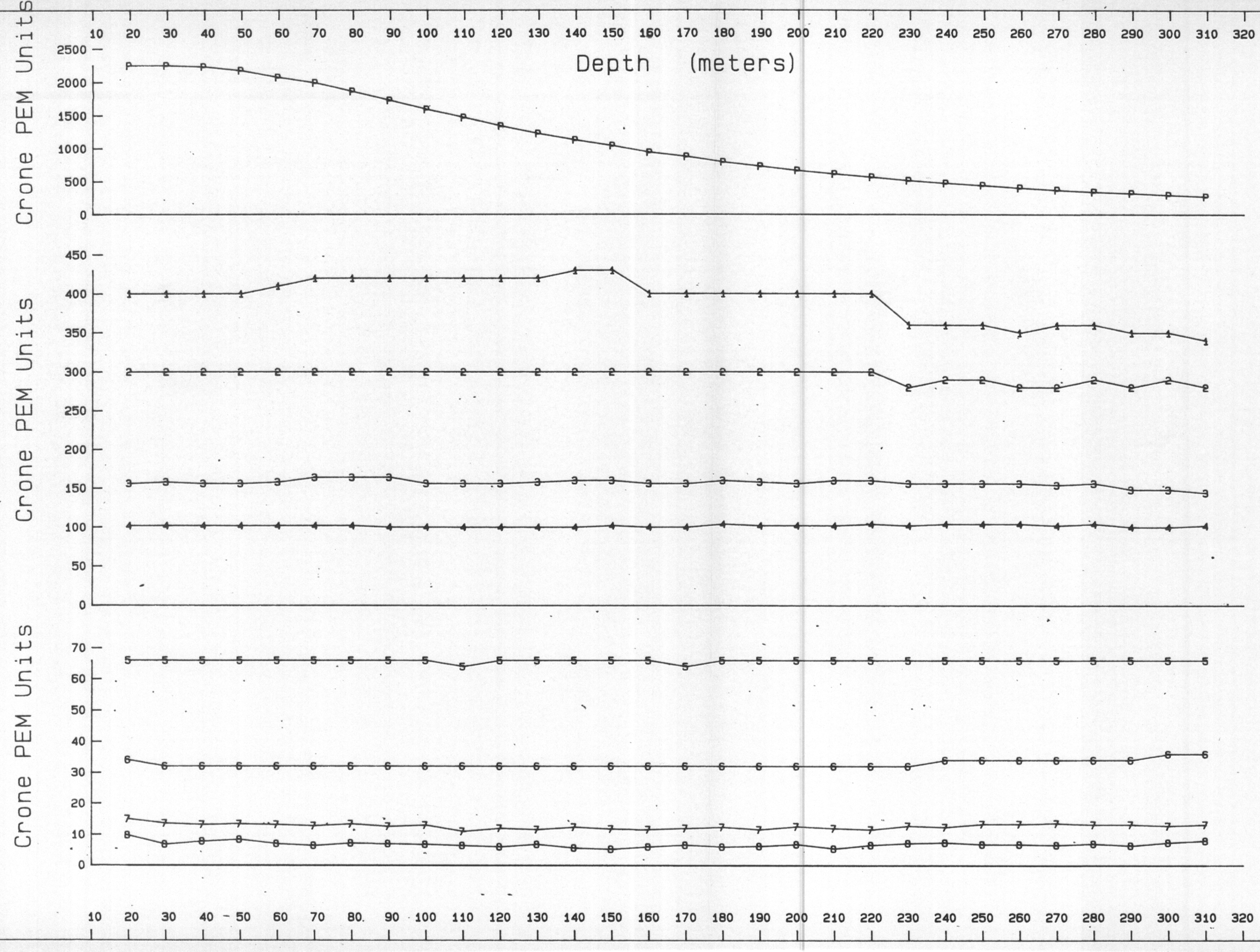
BOREHOLE PEM SURVEY
SAMATOSUM PROJECT
BOREHOLE RG254 LOOP E

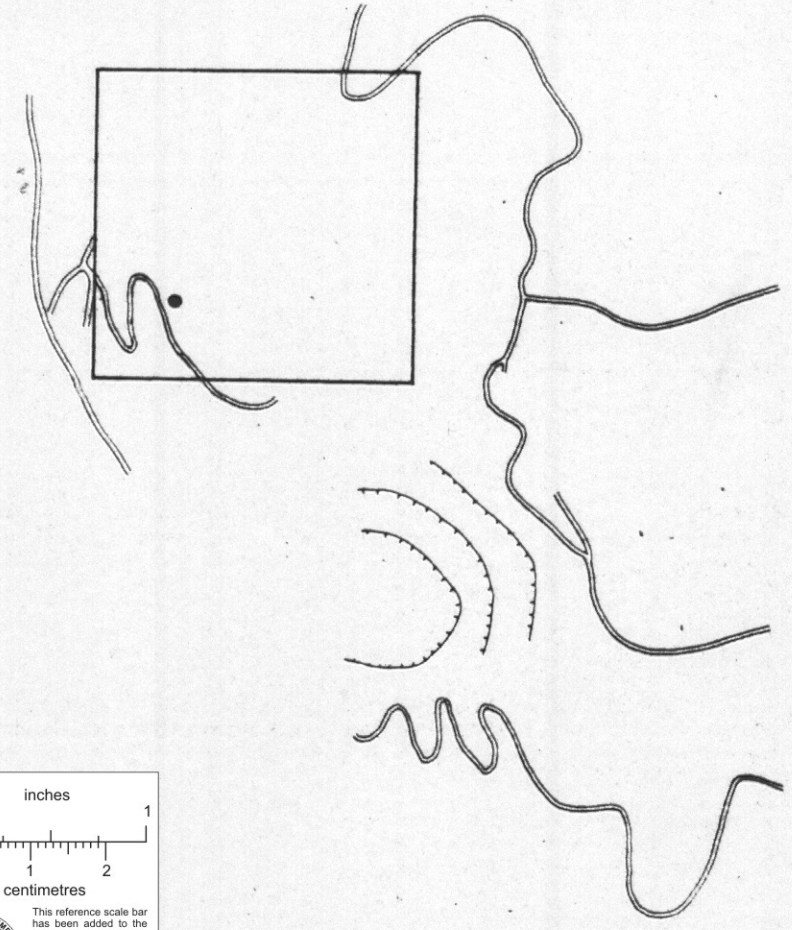
Scale 1: 1000.0

0 20 40 60 80 100 M

Date: June 1989	Survey: May 1989	Figure: 6.

WHITE GEOPHYSICAL INC.





MINNOVA INC.

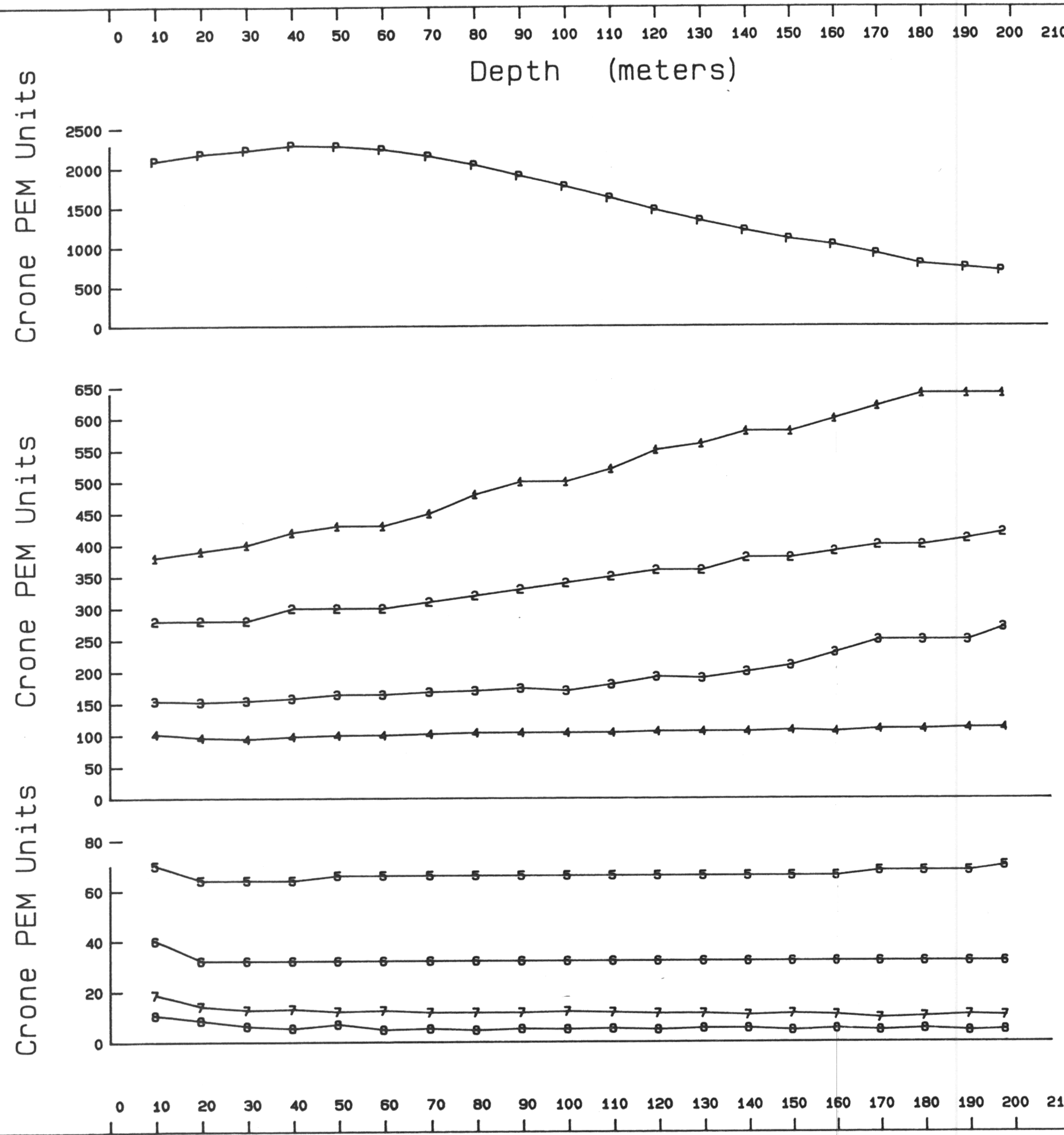
BOREHOLE PEM SURVEY
SAMATOSUM PROJECT
BOREHOLE RG256 LOOP B

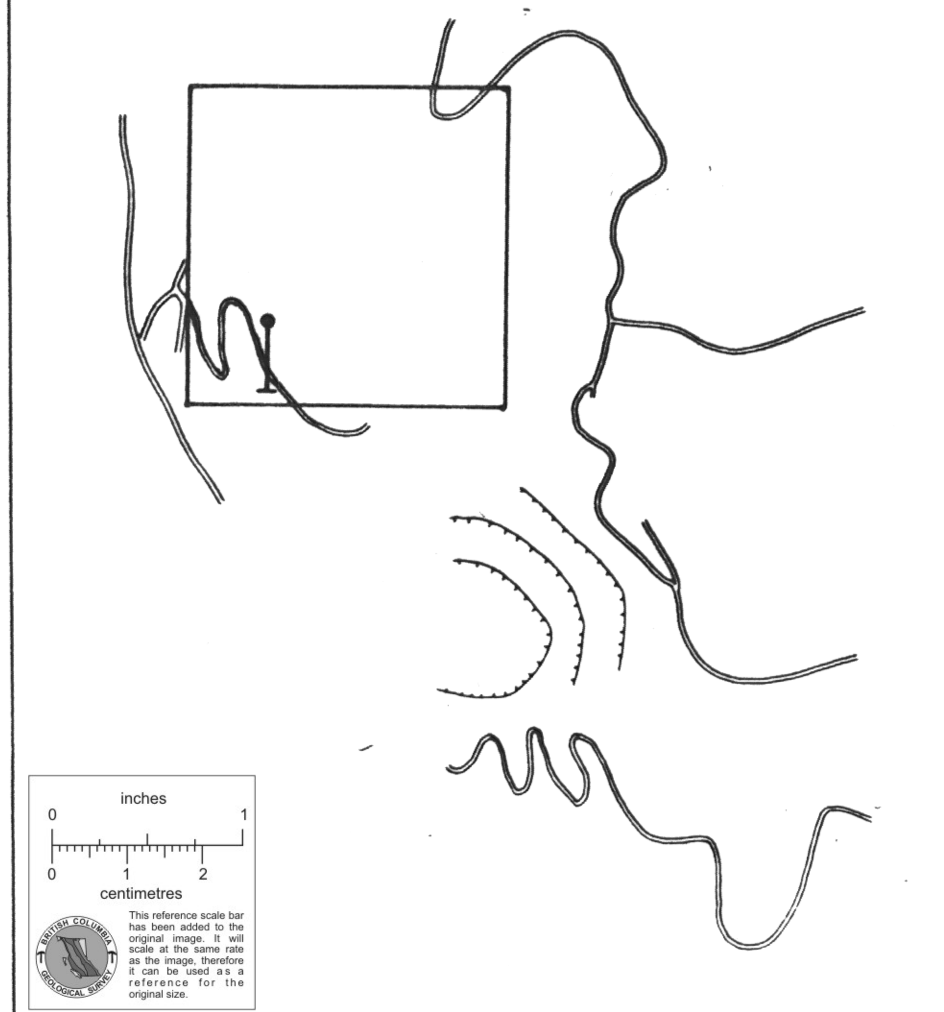
Scale 1: 1000.0

0 20 40 60 80 100 M

Date: June 1989	Survey: May 1989	Figure: 7 .

WHITE GEOPHYSICAL INC.





MINNOVA INC.

BOREHOLE PEM SURVEY
SAMATOSUM PROJECT
BOREHOLE RG257 LOOP B

Scale 1: 1000.0

0 20 40 60 80 100 M

Date: June 1989	Survey: May 1989	Figure: 8 .

WHITE GEOPHYSICAL INC.