823435

MINNOVA INC.

GEOPHYSICAL REPORT ON A
BOREHOLE PULSE EM SURVEY

DDH RG-395

SAMATOSUM PROJECT
BARRIERE, BRITISH COLUMBIA

LATITUDE: 51°07'N
LONGITUDE: 119°56'W

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

DATE OF WORK: 1 - 7 July 1991
DATE OF REPORT: 18 September 1991

TABLE OF CONTENTS **PAGE**

TABLES

ILLUSTRATIONS

INTRODUCTION:

During the period 1 to 7 July 1991, a borehole pulse EM survey was carried out in diamond drill hole RG-395 at the Samatosum Project in south-central British Columbia for Minnova Inc. Six separate passes were carried out in the drill hole using six different positions of the transmitter loop. A Crone 2000 Watt Pulse EM system was used for the survey.

The purpose of the survey was to explore for conductive mineralization in the vicinity of the drill hole and to determine its potential relationship to the Samatosum ore deposit.

The results of the survey are presented in this report along with a technical description of the borehole Pulse EM method, survey procedures, data presentation and interpretation procedures. The interpretation is based primarily on the borehole PEM results, augmented by drill core information where available.

SURVEY LOCATION AND ACCESS:

The Samatosum Mine is located on the north side of Samatosum Mountain in the Adams Lake area about 70 kilometres north-northeast of Kamloops, B.C. (Figure 1). The mine site was accessed from Highway #5 at Barriere via the Agate Bay and Minnova roads. Accommodation was obtained at the Johnson Lake Fishing Camp near the mine. Access to the drill site is via a four-wheel-drive road which begins at the

Figure 1.
Location Map
Samatosum Project
Minnova Inc.

Johnson Lake Road immediately below the tailings pond east of the mine site.

CRONE BOREHOLE PULSE EM SYSTEM:

The Crone borehole Pulse EM system is a time domain downhole EM instrument capable of detecting conductive mineralization intersected by the drill hole or lying off-hole. The borehole Pulse EM system utilizes a special downhole receiver coil, 600 or 1200 metre 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 by 150 metre square surface loop driven by the 500 watt PEM transmitter. Large loop surveys (i.e. up to 1000 metres) using the 2000 watt transmitter, and small loop surveys using the 10 metre 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 drill hole. The minimum size of drill hole which can be accommodated is AQ (1.75" diameter). The receiver measures 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. The digital Crone PEM receiver can be programmed to record 20 samples of the secondary decay from .09 to 13.0 ms on a 16.7 ms time base.

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

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 drill hole. 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 type curves for various conductor to borehole geometries from Woods (1975) and primary field vector diagrams from Macnae (1980) 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 change in coupling between the conductor and the primary field from different transmitter loop setups, will provide information on the attitude and position of the conductive mineralization.

If the conductor tends towards a more spheroidal shape, the shape as well as the magnitude of the anomaly will change as the primary field direction is altered. This occurs because the eddy currents are not constrained to flow within a single plane but rather tend to circulate perpendicular to the primary field direction. Thus, multiple transmitter loop coverage can also provide information about 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:

The borehole PEM survey was carried out in RG-395 using a 2000 watt Crone PEM system and six separate 300 m by 300 m transmitter loops (the southwest loop around the open pit mine was approximately 300 m by 400 m). The transmitter generated from 6 to 8 amps in the loops depending on the size of the transmitter loop and the grade of the loop wire. Transmitter loop locations are shown in Figure 2 and the surveys are itemized below in Table 1.

Table 1 Borehole Pulse EM Survey

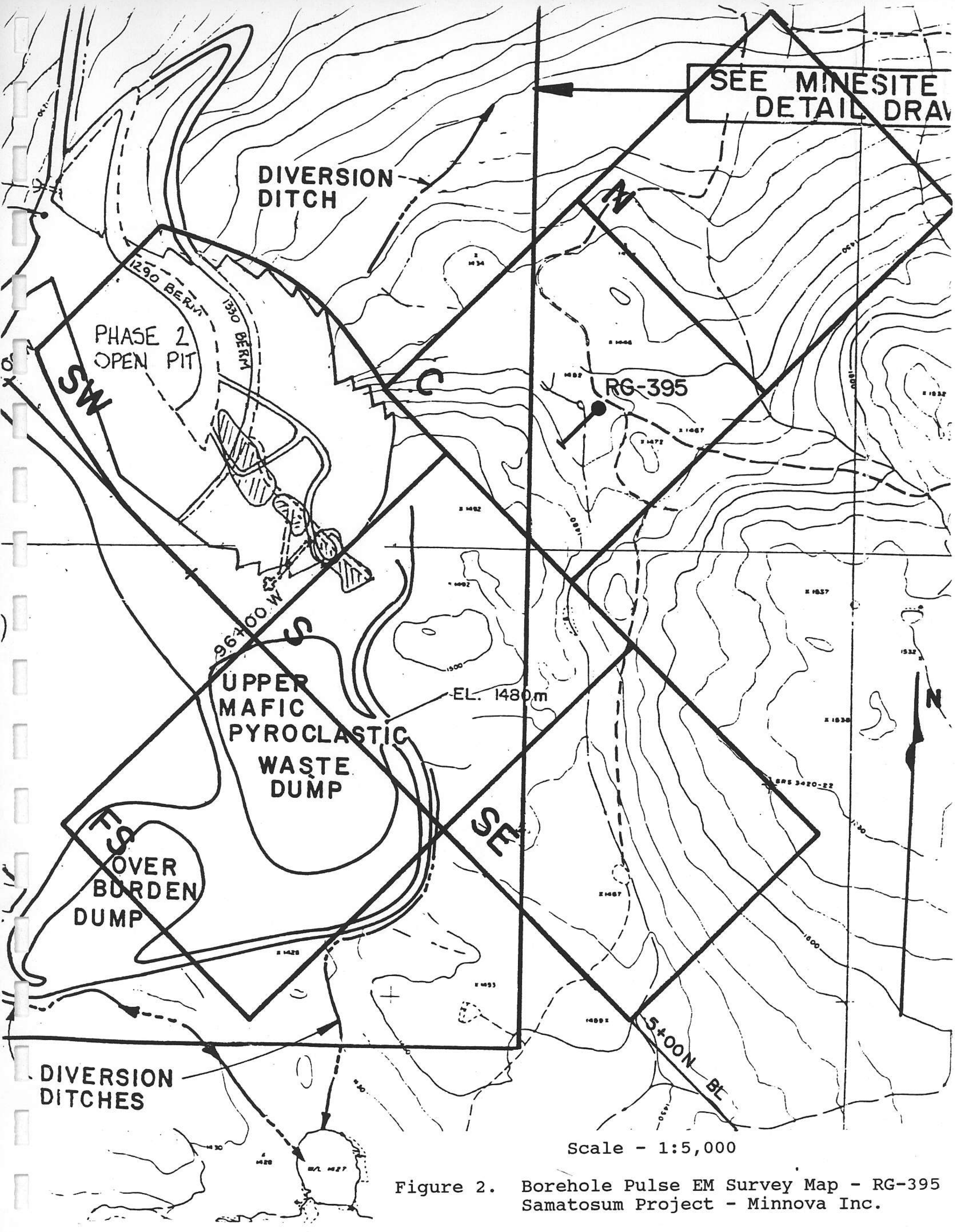
Hole	Location	Attitude	Depth (m)	Tx Loop	Survey (m)	Length (m)
RG-394	93+00W/6+00N	225°/-75°	387	blocked - not surveyed		
RG-395	95+25W/9+50N	225°/-88°(-79°)	615	C	30 to 610	580
				N	140 to 610	470
				S	100 to 610	510
				FS	100 to 610	510
				SE	100 to 610	510
				SW	100 to 610	510
RG-396	94+00W/9+25N	225°/-75°	648	blocked - not surveyed		
					total	3,090 m

RG-394 and RG-396 were examined with a dummy probe and found to be blocked above the zones of interest. They were not surveyed.

RG-395 was surveyed at 5 to 20 m intervals depending on how rapidly the secondary response changed with depth. Secondary fields were measured with the receiver on maximum gain, except where the response was greater than 1000 units in which case the gain was decreased by one-half or one-quarter and the reading was then increased by the same factor. The Crone borehole Pulse EM system measures only the axial component in the drill hole. Time synchronization between transmitter and receiver was obtained using a direct cable link.

DATA PRESENTATION:

The borehole PEM survey results are shown in Profiles 1 to 6 at the back of the report. There is a separate plot for each transmitter loop location and each profile is plotted twice: a) linear amplitude



Scale - 1:5,000

Figure 2. Borehole Pulse EM Survey Map - RG-395
Samatosum Project - Minnova Inc.

scale, and b) logarithmic amplitude scale. The data are plotted as recorded on constant receiver gain.

The linear amplitude plots are arranged with the primary field strength across the top, the first four channels of secondary response combined on one amplitude axis in the centre, and the last four channels combined on a separate and expanded amplitude axis along the bottom. The amplitude axes are arbitrarily set to expand the data to maximum size, to a limit of 4 PEM units per cm.

The logarithmic amplitude plots are in the standard format and size originally adopted by Woods (1975). This plotting procedure enhances resolution since small anomalies can be plotted on the same profile as large amplitude responses. It also facilitates direct comparison of anomalies from different transmitter loops, and to scale model type curves.

INTERPRETATION PROCEDURES:

The discussion of the borehole Pulse EM results is primarily a qualitative analysis of the profile plots based on past experience and aided by scale model studies (Woods, 1975) and primary field vector plots (Macnae, 1980). Quantitative interpretations are made using the nomograms from Woods, et al. (1980) and the conductance formulae given by Gallagher, et al. (1985).

DISCUSSION OF RESULTS:

The borehole Pulse EM survey results from RG-395 are shown in Profiles 1 to 6. There are two different types of anomalies in the data (seen best in the profiles from the south (S) and southwest (SW) transmitter loops - Figures 3 and 6 respectively): 1) a broad, 6-channel, negative response centred at a depth of about 540 m, and 2) a series of narrow, positive and negative anomalies at 345 m, 410 m, 445 m, and 470 m. The sharp negative anomaly at 410 m also appears to be combined with a somewhat broader negative response immediately above this depth. These different types of anomalies are combined in the profiles to produce a rather complex response pattern.

The broad negative anomaly toward the bottom of the hole is due to a large (i.e. greater than 200 m width), 30-40 mho conductor at about 100 m distance from the hole. The conductor must be south of the hole (i.e. up dip) since the response from the south (S) loop is much greater than the north (N) loop. It probably continues quite close to surface since the far south (FS) loop response is also large and does not change sign as expected from the primary field direction of the far south loop (see Figure 3d).

The conductor is also clearly west of the hole (i.e. beneath the mine) since the southwest (SW) loop produced the largest amplitude response and the southeast (SE) loop anomaly is very small. The conductor appears to lie some 100-150 m below the Samatosum horizon and may have a flatter dip than the Samatosum stratigraphy. It

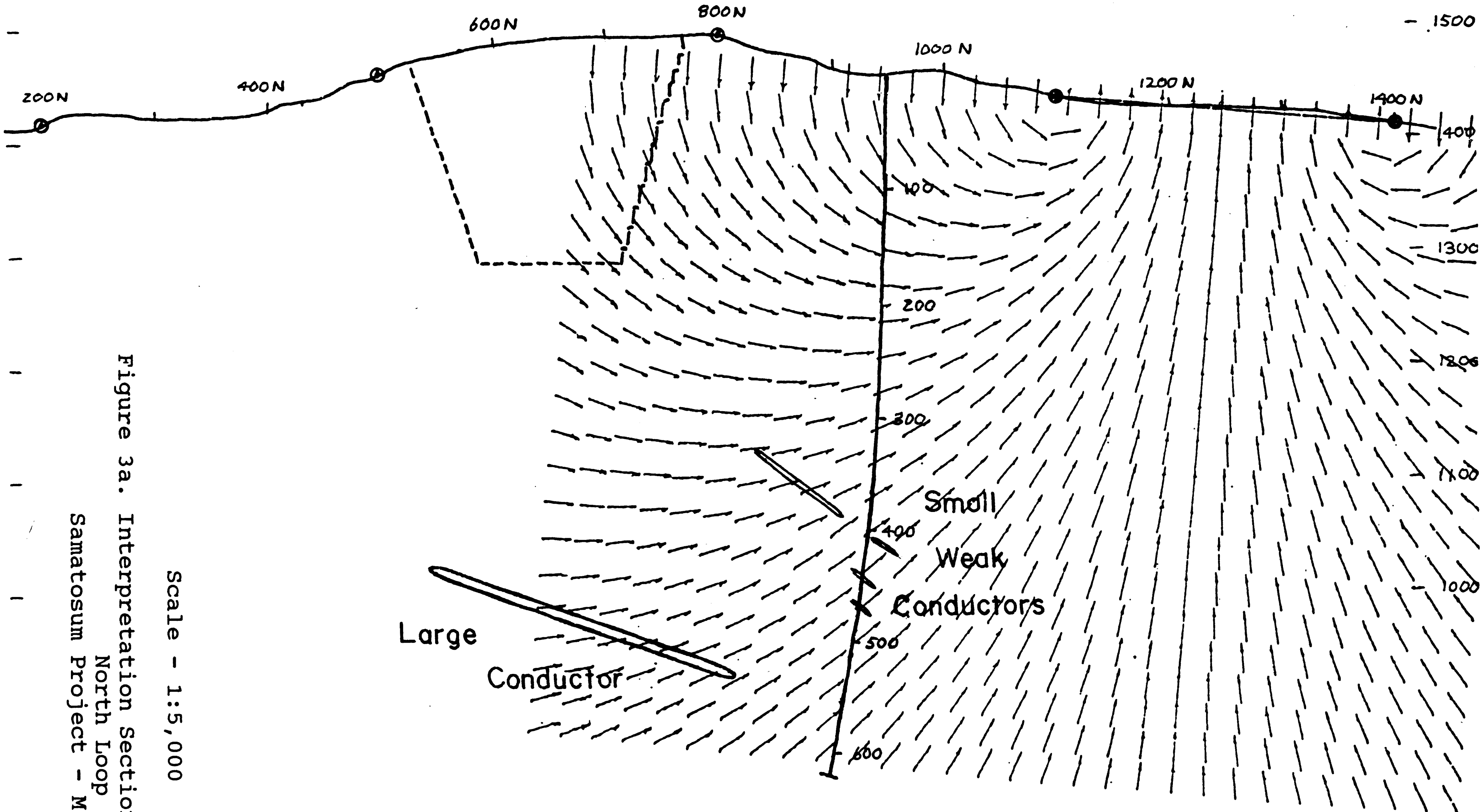
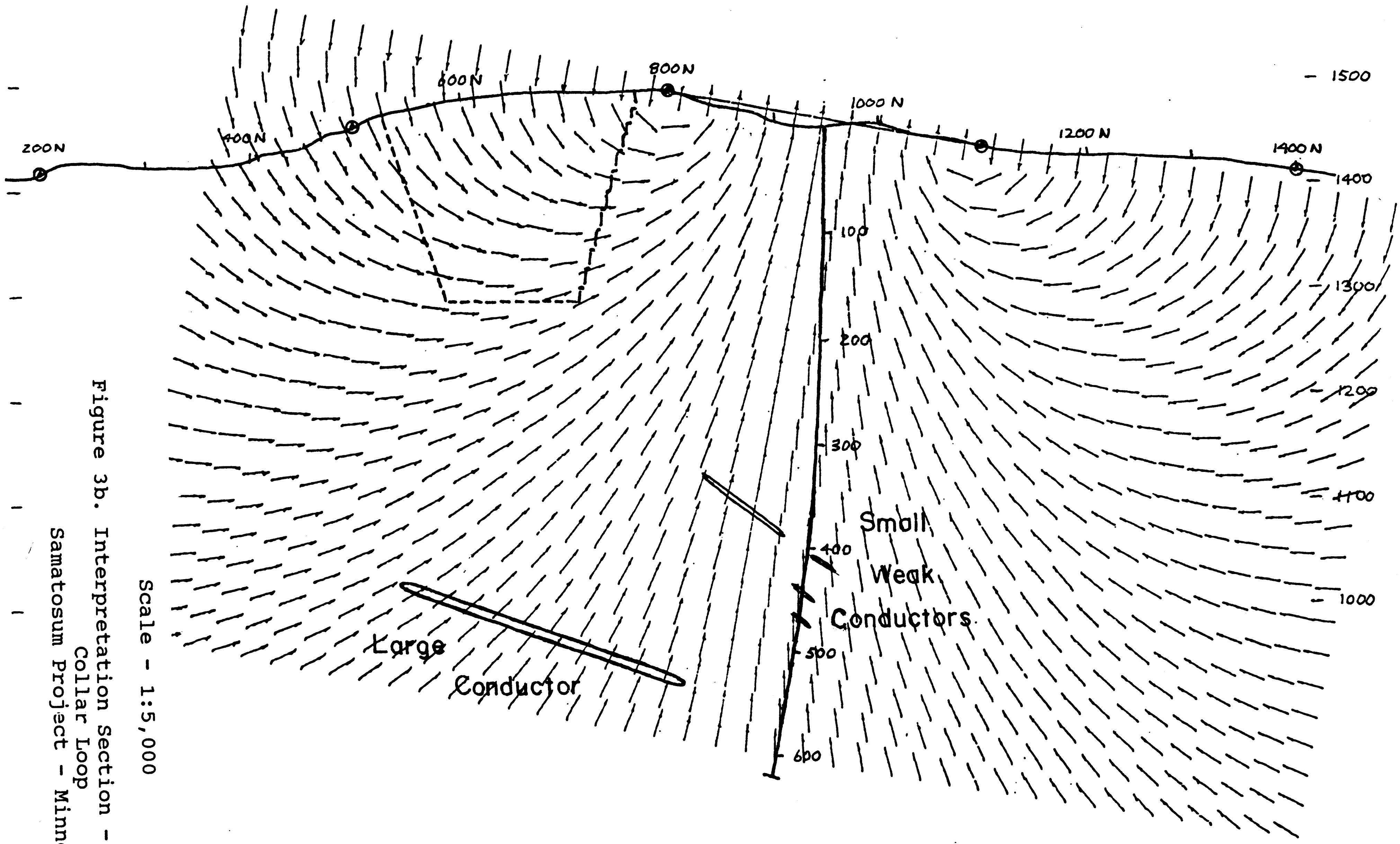


Figure 3a. Interpretation Section - RG-395
North Loop
Samatosum Project - Minnova Inc.

Scale - 1:5,000



Scale - 1:5,000

Figure 3b. Interpretation Section - RG-395
Collar Loop
Samatosum Project - Minnova Inc.

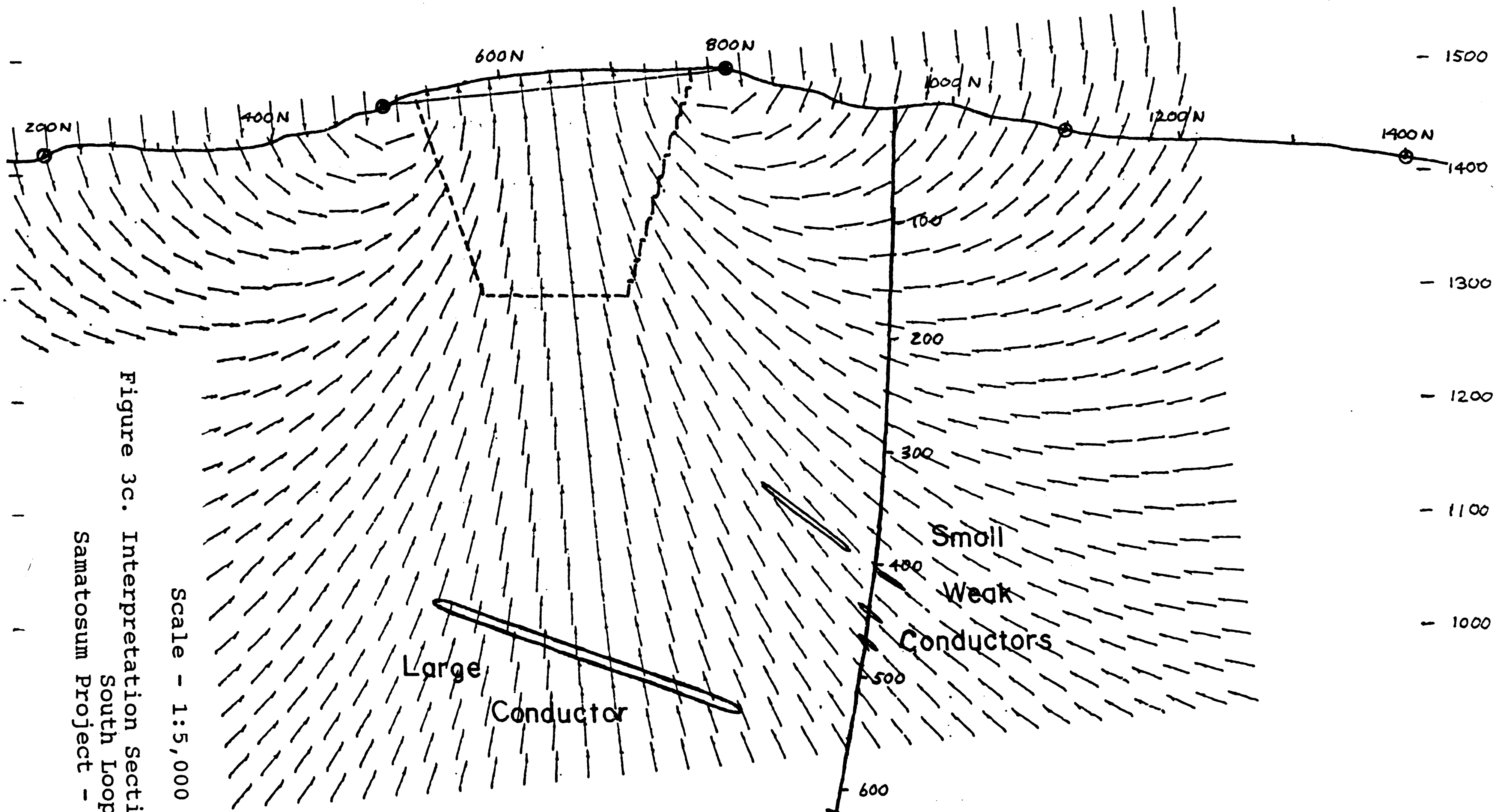
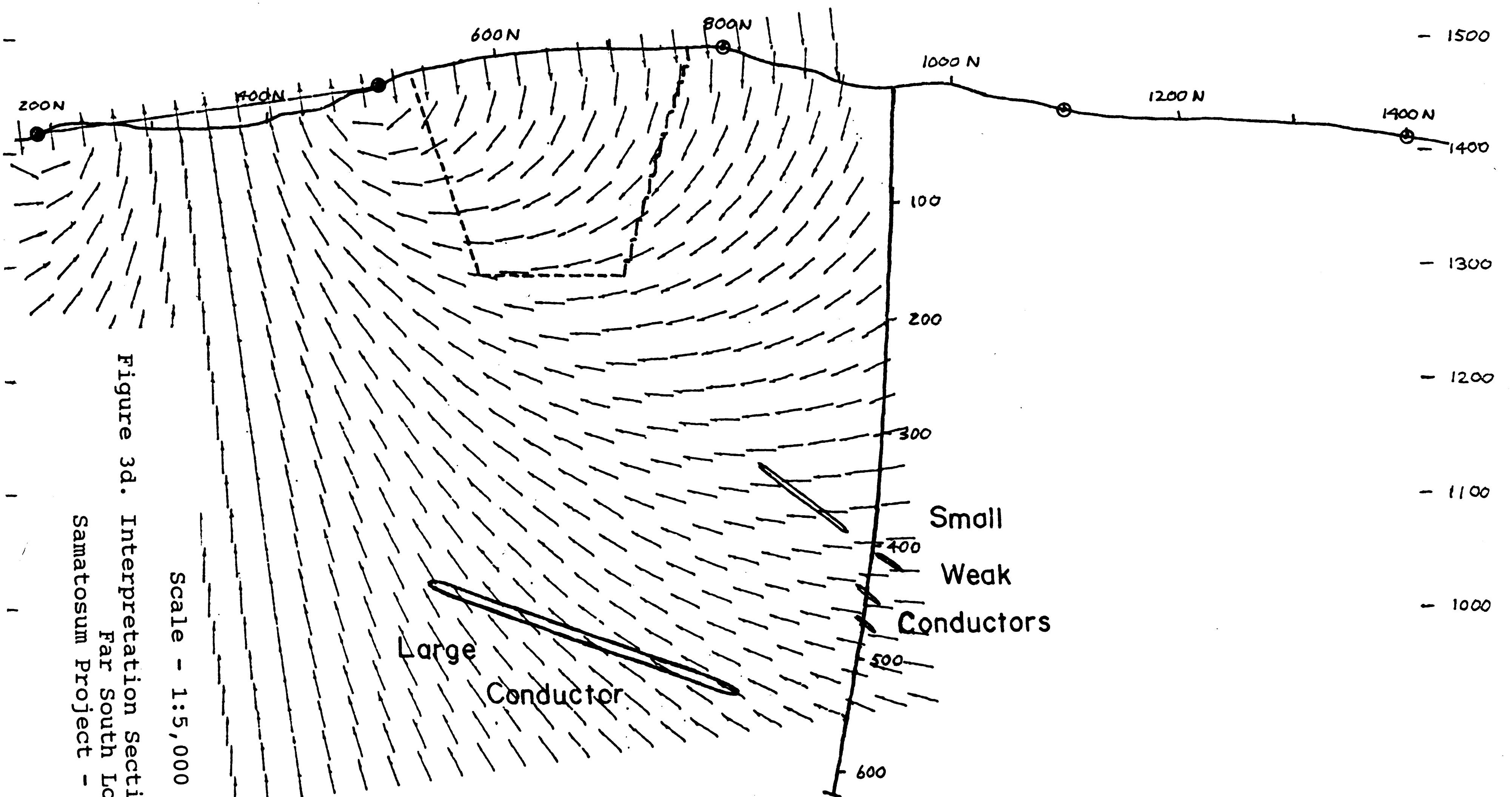


Figure 3c. Interpretation Section - RG-395
South Loop
Samatosum Project - Minnova Inc.

Scale - 1:5,000



Scale - 1:5,000

Figure 3d. Interpretation Section - RG-395
Far South Loop
Samatosum Project - Minnova Inc.

appears to be the same conductor as was interpreted from a previous borehole PEM survey of RG-254 (Woods, 1989). The approximate location of the conductor is depicted in the drill hole section shown in Figure 3.

The narrow anomalies are due to small conductors (i.e. less than 20 m lateral extent), with conductances of order 10 to 20 mhos, situated close to or intersected by the hole. These small conductive zones appear to lie within or near the Samatosum horizon (see Figure 3). The broader negative response immediately above the small conductor at 410 m depth is probably due to a slightly larger conductive zone on the same stratigraphic horizon 10 to 20 m up-dip from the hole (see Figure 3). The anomalous responses are also greatest with the southwest (SW) transmitter loop indicating that the Samatosum horizon is generally more conductive toward the mine and less conductive to the southeast.

CONCLUSION AND RECOMMENDATIONS:

The narrow anomalies between 345 m and 470 m depth are due to small localized zones of conductive mineralization within or near the Samatosum horizon. They should all be evident in the drill core, even if not explicitly intersected, and further drilling to explain them is probably not required. The only possible exception is the off-hole conductor interpreted to be causing the broader negative response at about 390 m depth. However, the drill hole intersection at 410 m is probably representative of this conductive zone.

The large conductor interpreted to lie below the open pit mine should be investigated by drilling if not already done so. The optimal drill location would be on the floor of the pit, or otherwise immediately above the back wall of the pit at about 97+25W/8+00N if it is not possible to set up in the pit.

Respectfully submitted,

PROFESSIONAL PROVINCE OF D. V. WOODS COLUMBIA ENGINEER

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

Consulting Geophysicist

REFERENCES:

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

Gallagher, P.R., Ward, S.H. and Hohmann, G.W.: A model study of a thin plate in free space for the EM37 transient electromagnetic system, Geophysics, vol.50, no.6, pp.1002-1019, 1985.

Macnae, J.C.: An Atlas of Primary Fields Due to Fixed Transmitter Loop EM Sources, Research in Applied Geophysics #13, Geophysics Laboratory, Department of Physics, University of Toronto, 1980.

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

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

Woods, D.V., Rainsford, D.R.B. and Fitzpatrick M.N.: Analogue modelling and quantitative interpretation of borehole PEM measurements (abstract only); EOS Transactions of the American Geophysical Union, vol.61, no.17, pp.412-415, 1980.

Woods, D.V.: Geophysical Report on a Borehole Pulse EM Survey, Samatosum Project, Holes RG-254, RG-256 and RG-257; for Minnova Inc., White Geophysical Inc., June 1989.

STATEMENT OF QUALIFICATIONS:

NAME:	WOODS, Dennis V.
PROFESSION:	Geophysical Engineer
EDUCATION:	B.Sc. Applied Geology, Queen's University, 1973 M.Sc. Applied Geophysics, Queen's University, 1975 Ph.D. Geophysics, Australian National University, 1979
PROFESSIONAL ASSOCIATIONS:	Registered Professional Engineer, #15745 Province of British Columbia Active Member, Society of Exploration Geophysicist Canadian Society of Exploration Geophysicist Australian Society of Exploration Geophysicist
EXPERIENCE:	1971-79 - Field geologist with St. Joe Mineral Corp. and Selco Mining Corp. (summers) - Research graduate student and teaching assistant at Queen's University and the Australian National University 1979-86 - Assistant Professor of Applied Geophysics at Queen's University - Geophysical consultant with Paterson Grant & Watson Ltd., M.P.H. Consulting Ltd., James Neilson & Assoc. Ltd., and Foundex Geophysics Inc. - Visiting research scientist at Chervon Geosciences Ltd., Geological Survey of Canada, and the University of Washington 1986-89 - Project Geophysicist with Inverse Theory & Applications (ITA) Inc. - Chief Geophysicist at White Geophysical Inc. - Chief Geophysicist at Premier Geophysics Inc 1989- - President of Woods Geophysical Consulting

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: 2.9 cm (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.

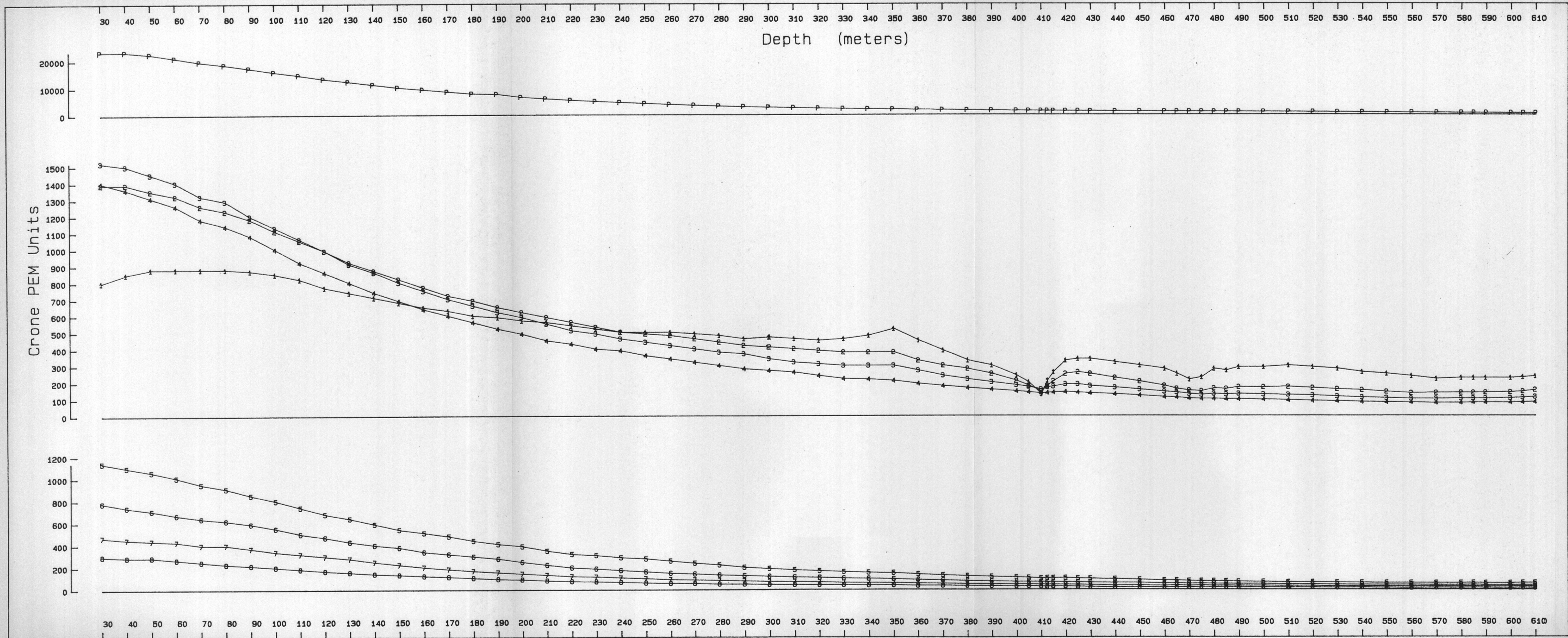
OPTIONAL CRYSTAL CLOCK TIMING LINK:
Installed in the Digital Rx and external box mounted to be plugged into PEM-Tx. Gel rechargeable power supply. Weight: 10 kg, shipping: 15 kg.

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.



MINNOVA INC.

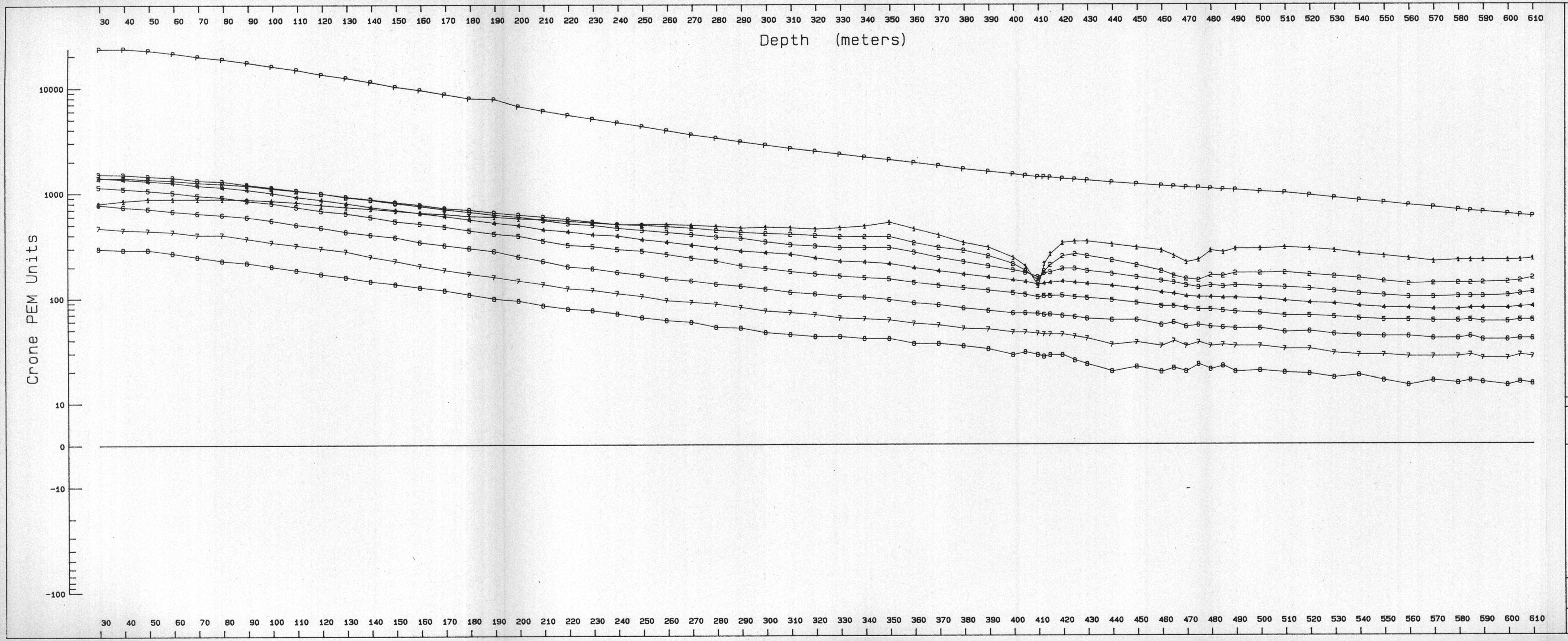
SAMATOSUM PROJECT
BOREHOLE PULSE EM SURVEY
HOLE RG-395 LOOP C

Scale 1: 1000.0

0 20 40 60 80 100 M

Date: Sept 1991	Survey: July 1991	Profile: 1a

WOODS GEOPHYSICAL CONSULTING



MINNOVA INC.

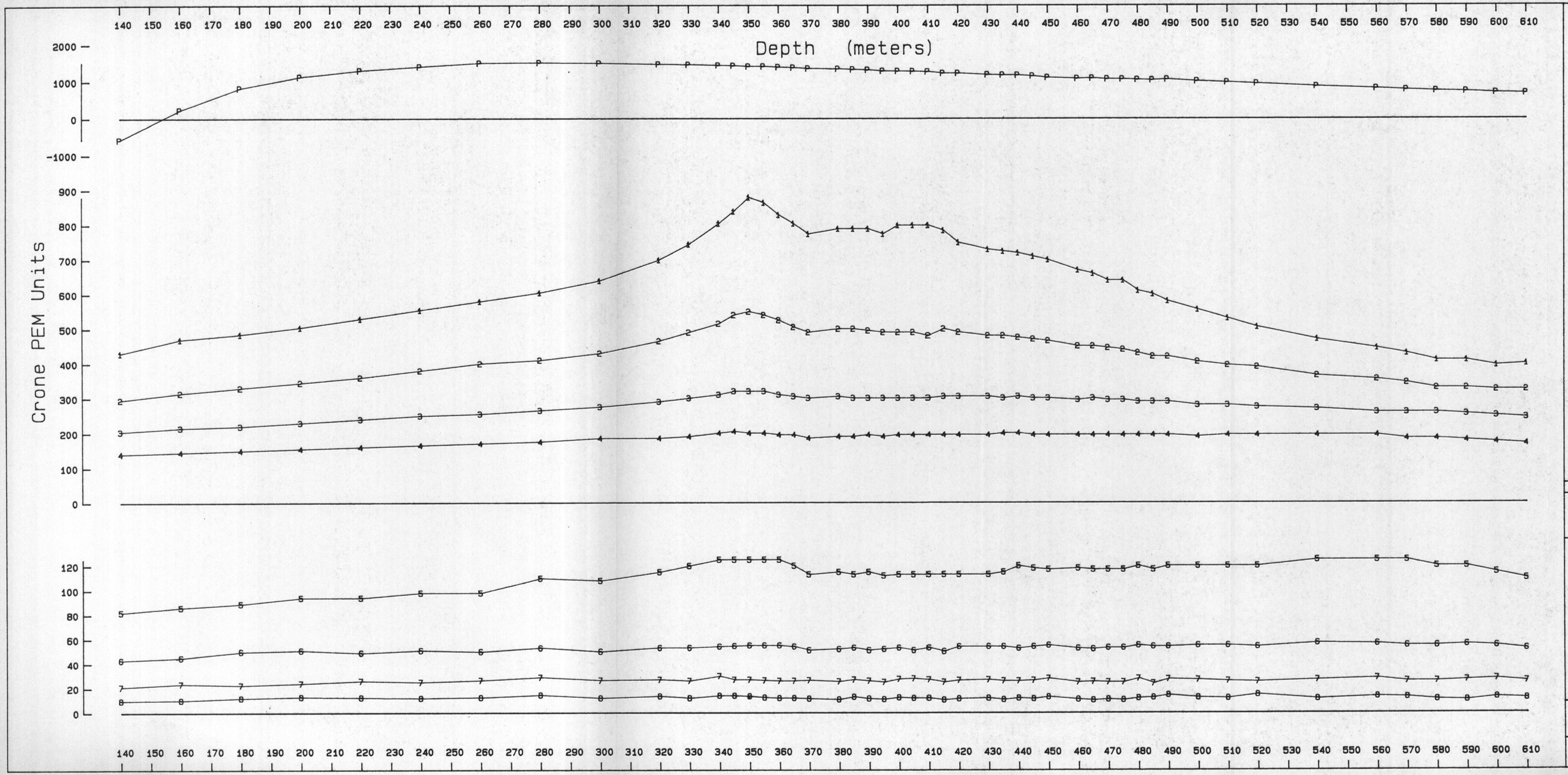
SAMATOSUM PROJECT
BOREHOLE PULSE EM SURVEY
HOLE RG-395 LOOP C

Scale 1: 1000.0

0 20 40 60 80 100 M

Date: Sept 1991	Survey: July 1991	Profile: 1b

WOODS GEOPHYSICAL CONSULTING



MINNOVA INC.

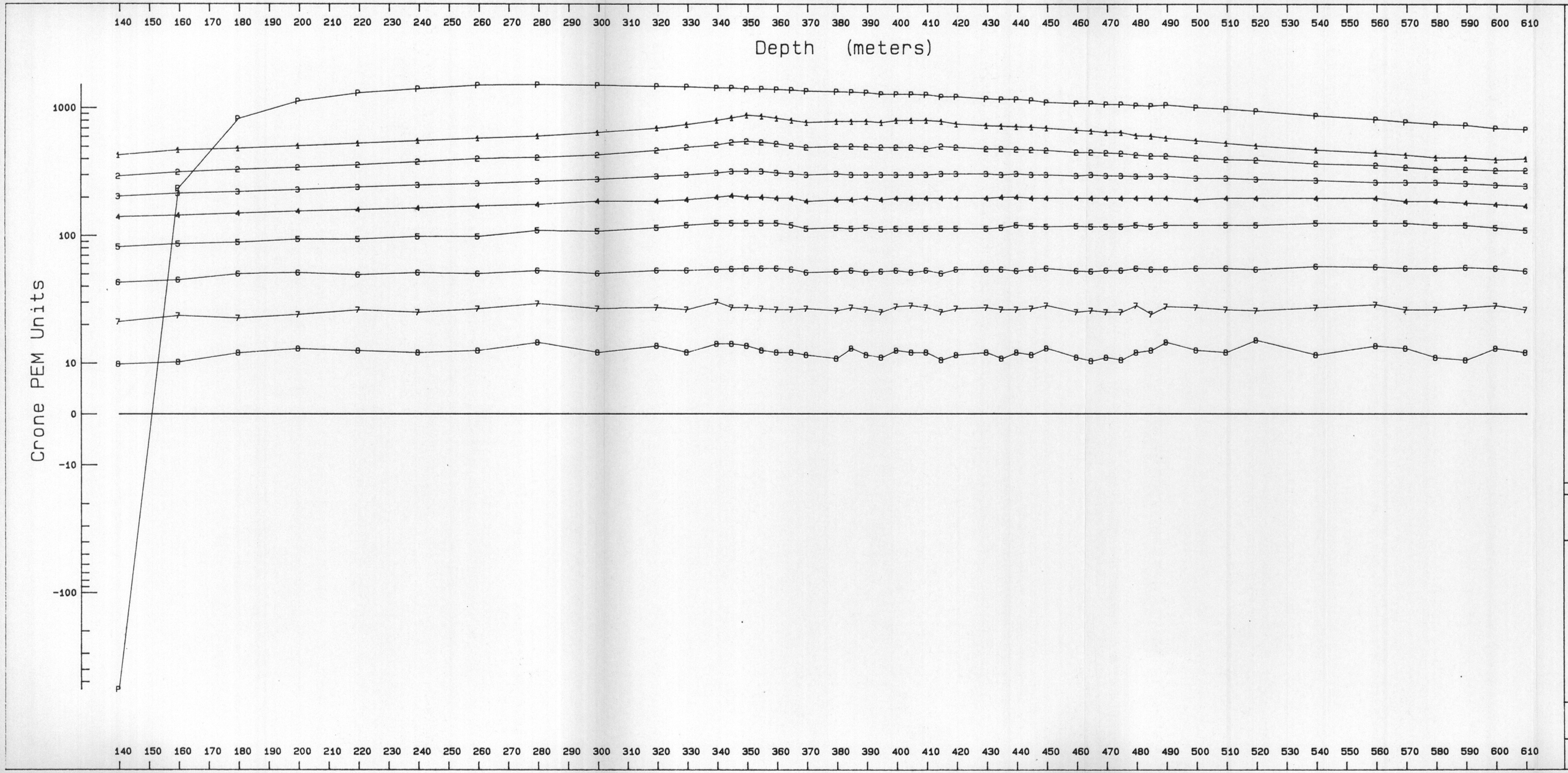
SAMATOSUM PROJECT
BOREHOLE PULSE EM SURVEY
HOLE RG-395 LOOP N

Scale 1: 1000.0

0 20 40 60 80 100 M

Date: Sept 1991	Survey: July 1991	Profile: 2a

WOODS GEOPHYSICAL CONSULTING



MINNOVA INC.

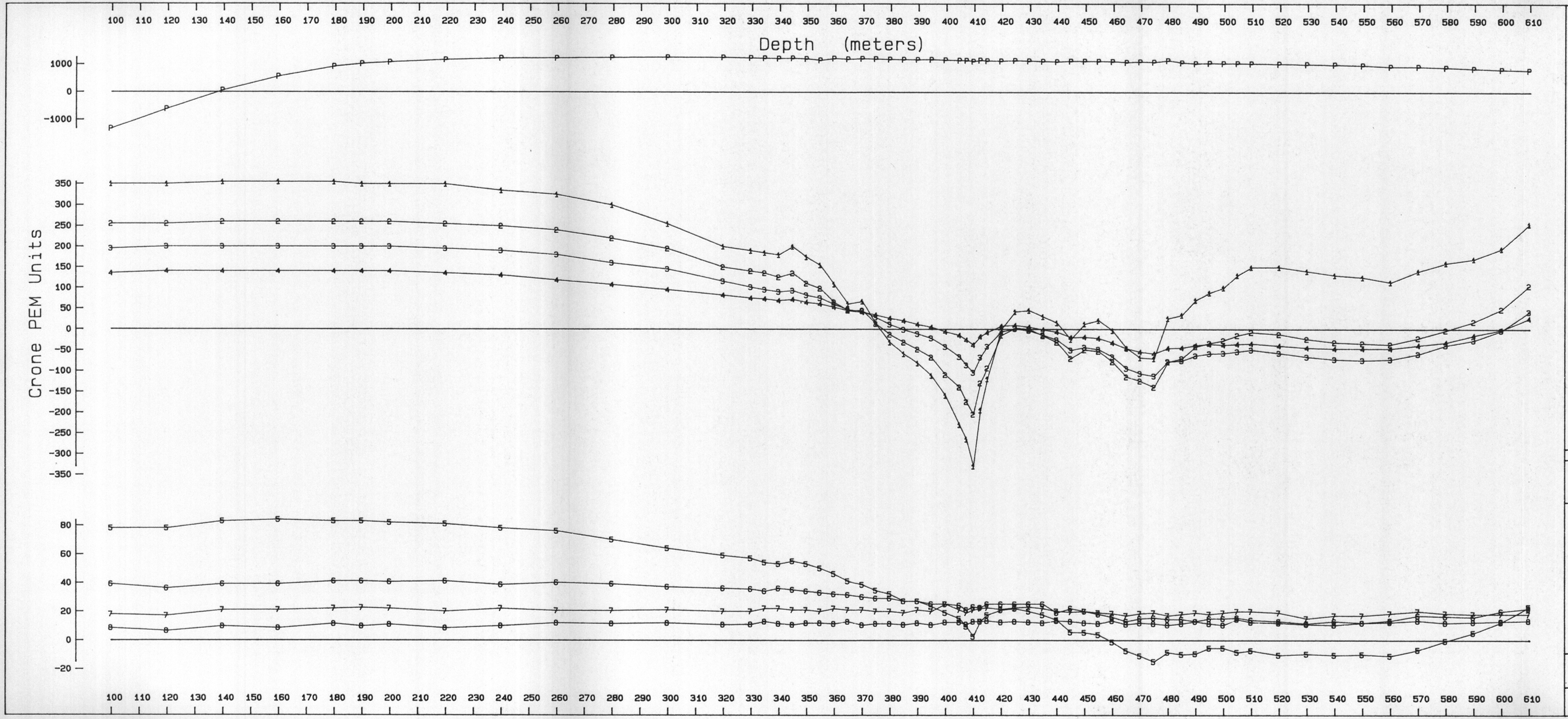
SAMATOSUM PROJECT
BOREHOLE PULSE EM SURVEY
HOLE RG-395 LOOP N

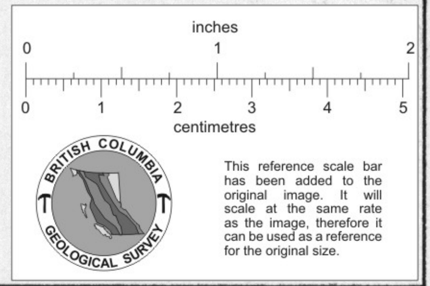
Scale 1: 1000.0

0 20 40 60 80 100 M

Date: Sept 1991	Survey: July 1991	Profile: 2b

WOODS GEOPHYSICAL CONSULTING

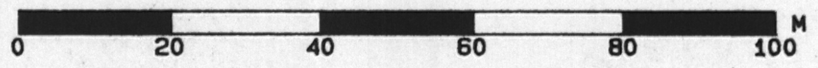




MINNOVA INC.

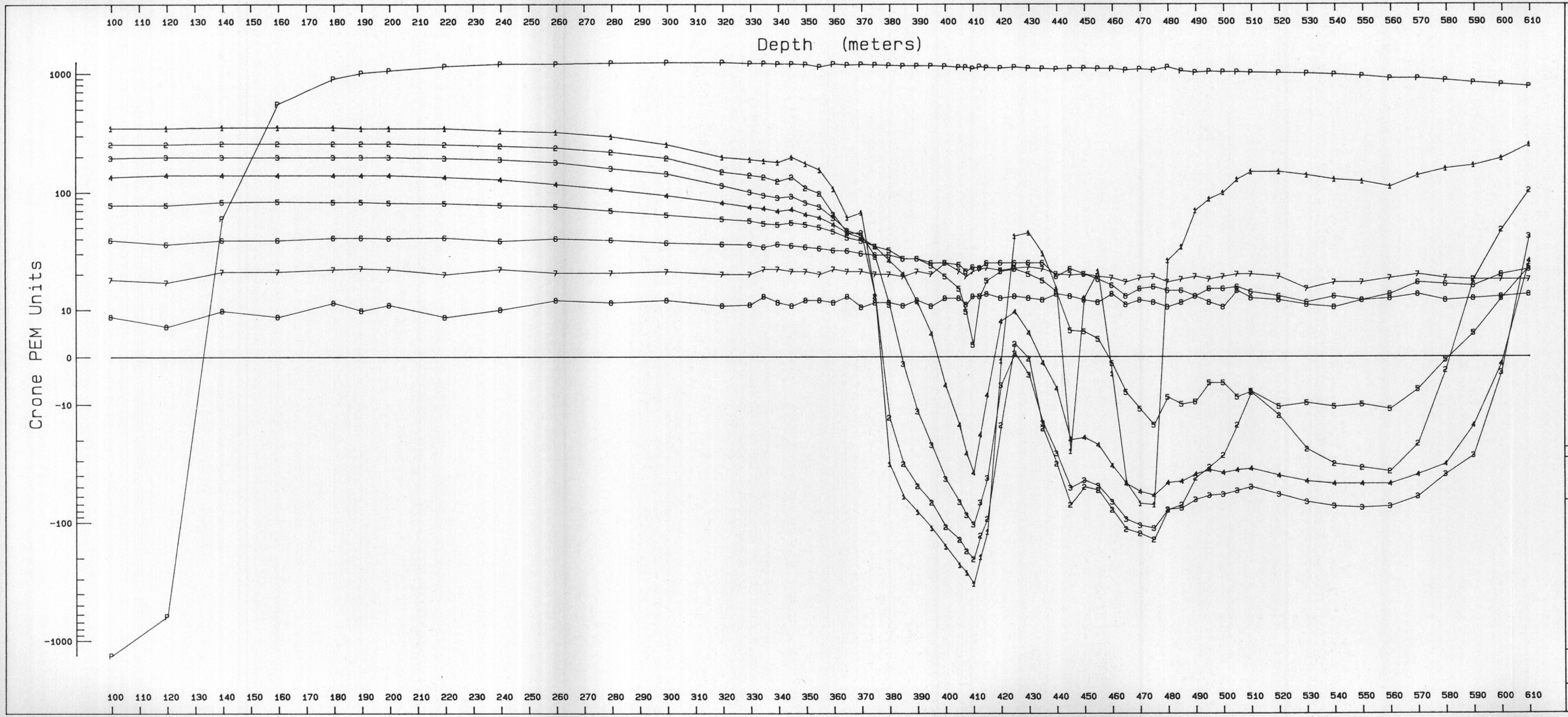
SAMATOSUM PROJECT
BOREHOLE PULSE EM SURVEY
HOLE RG-395 LOOP S

Scale 1: 1000.0



Date: Sept 1991	Survey: July 1991	Profile: 3a

WOODS GEOPHYSICAL CONSULTING



MINNOVA INC.

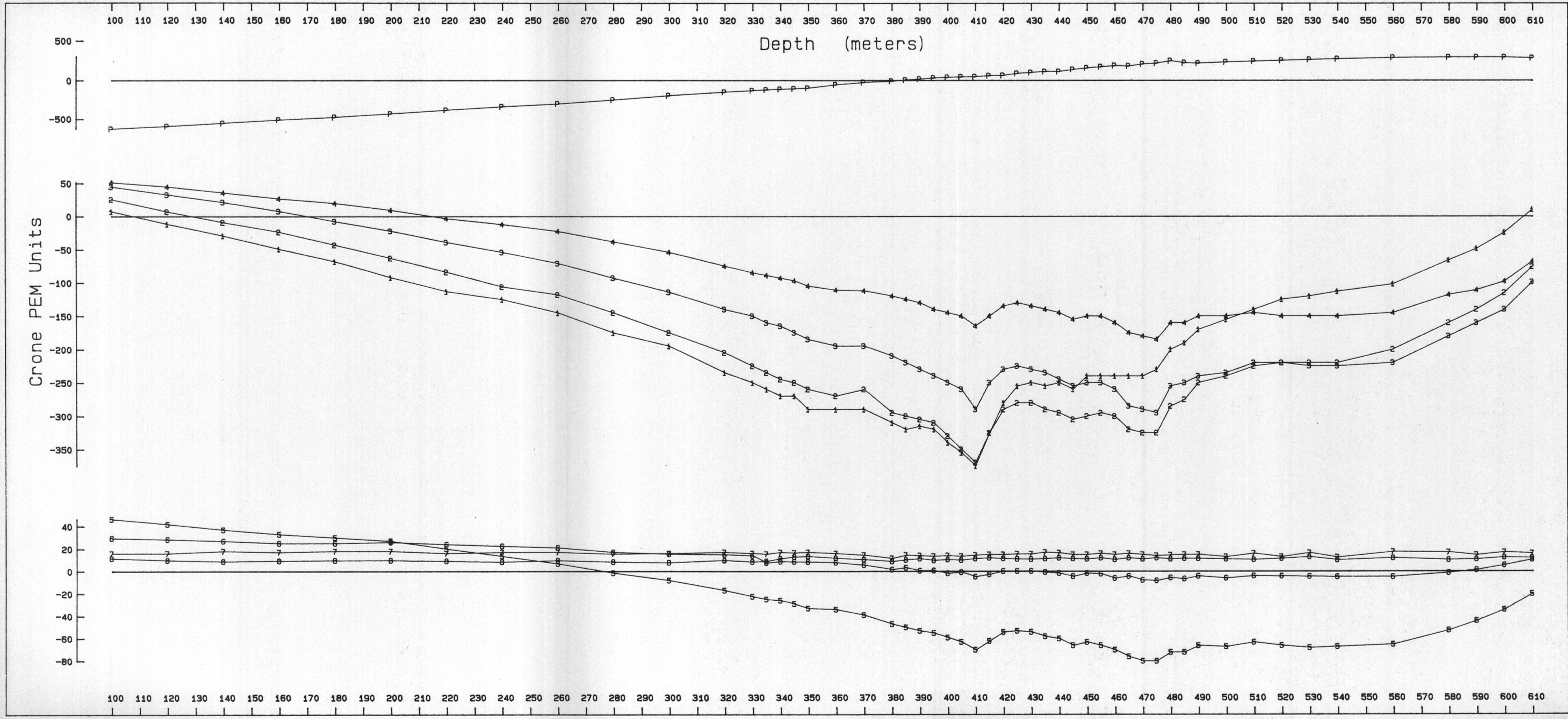
SAMATOSUM PROJECT
BOREHOLE PULSE EM SURVEY
HOLE RG-395 LOOP S

Scale 1: 1000.0

0 20 40 60 80 100 M

Date: Sept 1991	Survey: July 1991	Profile: 3b

WOODS GEOPHYSICAL CONSULTING



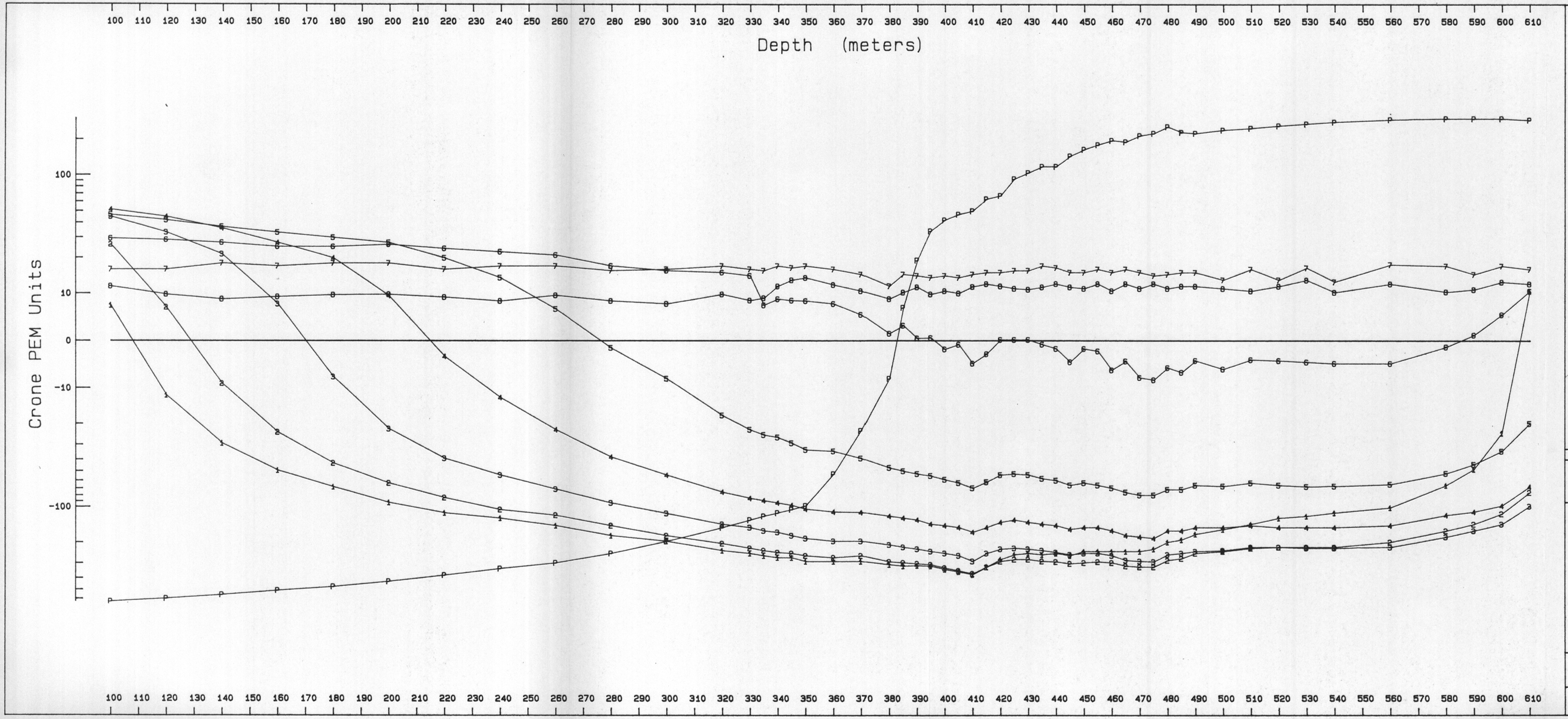
MINNOVA INC.

SAMATOSUM PROJECT
BOREHOLE PULSE EM SURVEY
HOLE RG-395 LOOP FS

Scale 1: 1000.0

Date: Sept 1991	Survey: July 1991	Profile: 4a

WOODS GEOPHYSICAL CONSULTING



MINNOVA INC.

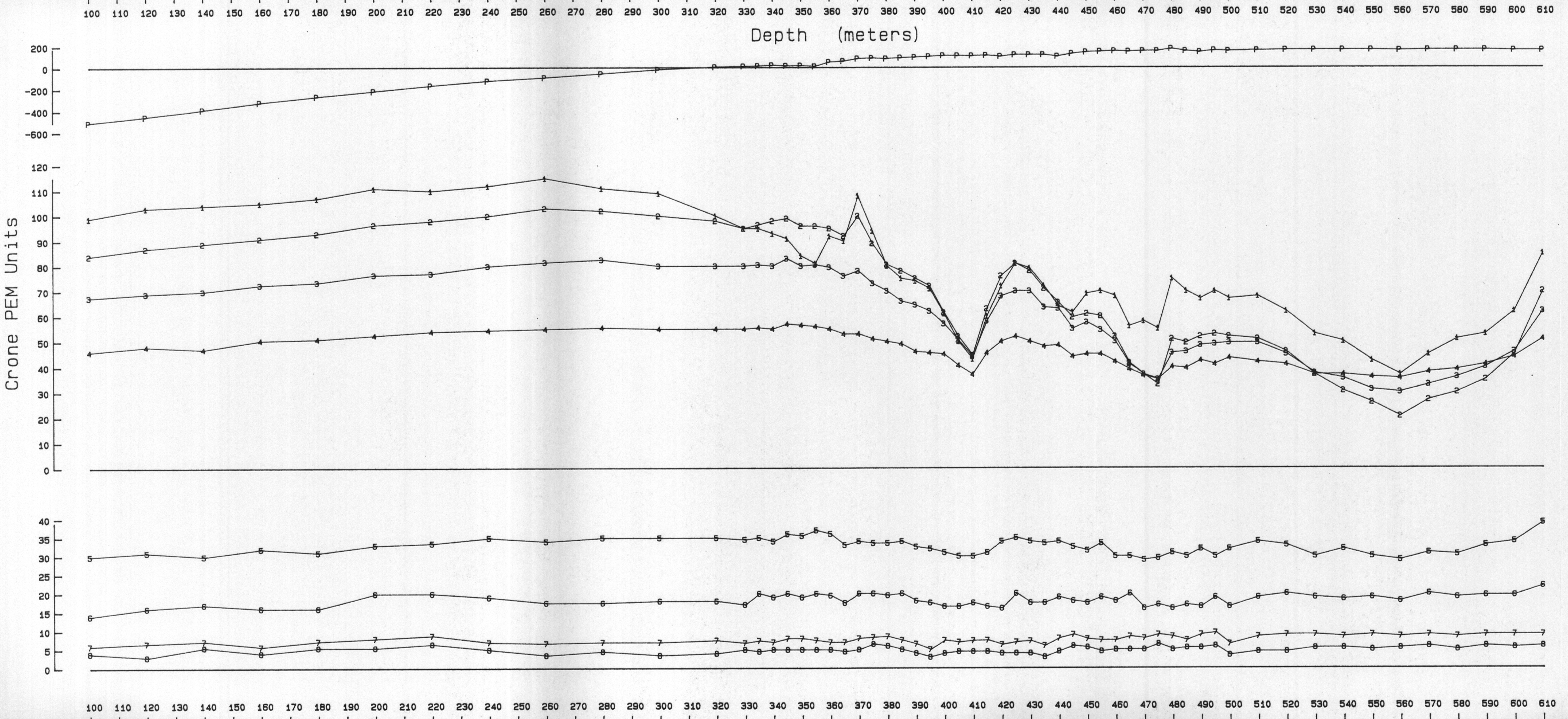
SAMATOSUM PROJECT
BOREHOLE PULSE EM SURVEY
HOLE RG-395 LOOP FS

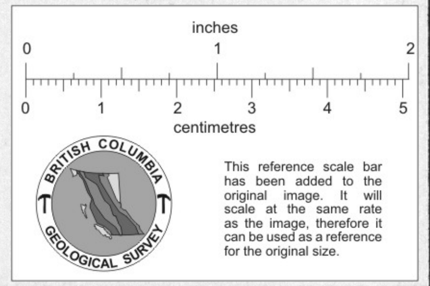
Scale 1: 1000.0

0 20 40 60 80 100 M

Date: Sept 1991	Survey: July 1991	Profile: 4b

WOODS GEOPHYSICAL CONSULTING

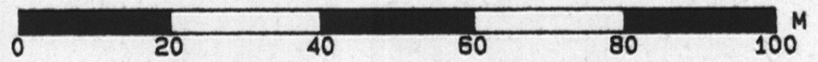




MINNOVA INC.

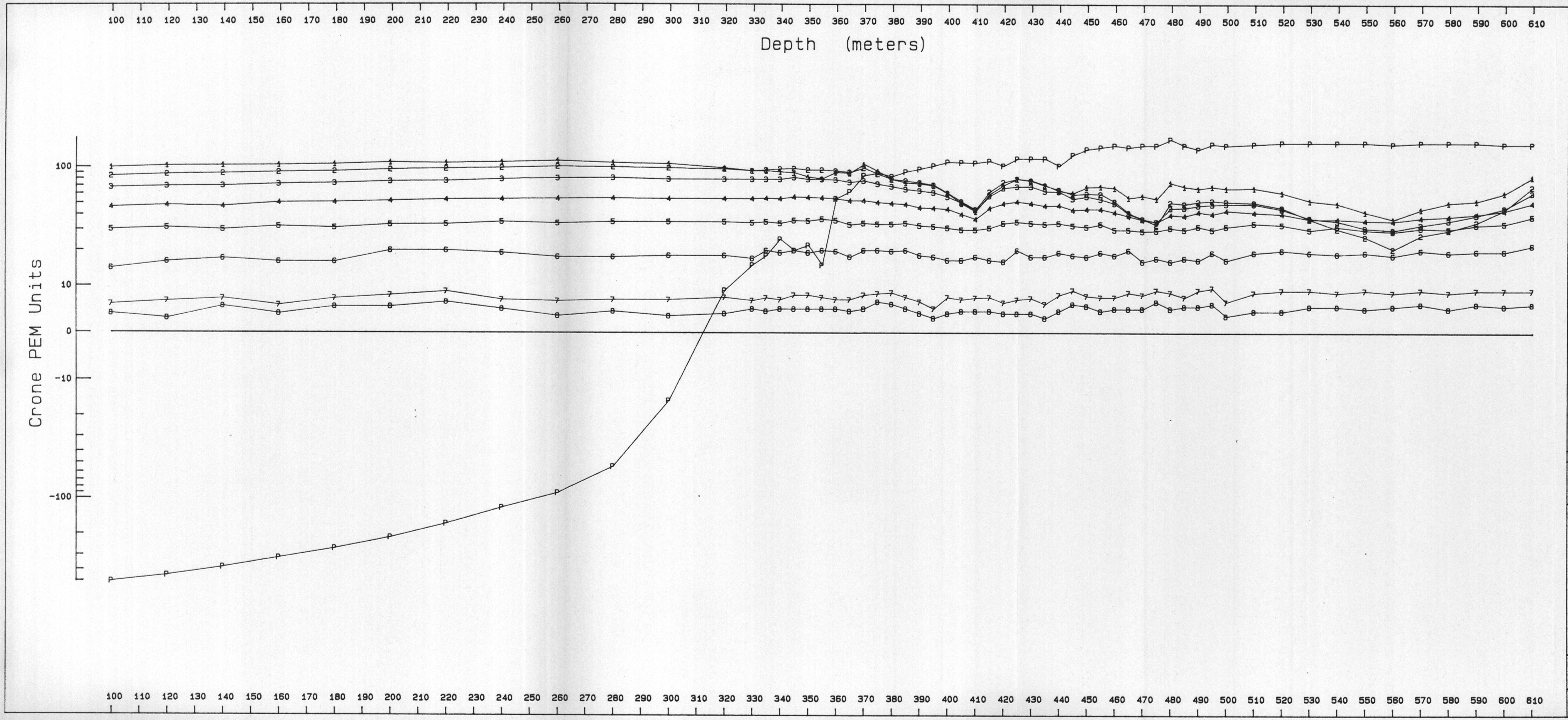
SAMATOSUM PROJECT
BOREHOLE PULSE EM SURVEY
HOLE RG-395 LOOP SE

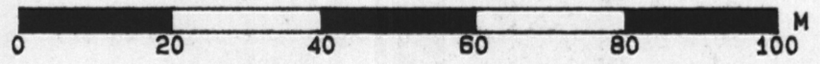
Scale 1: 1000.0



Date: Sept 1991	Survey: July 1991	Profile: 5a

WOODS GEOPHYSICAL CONSULTING





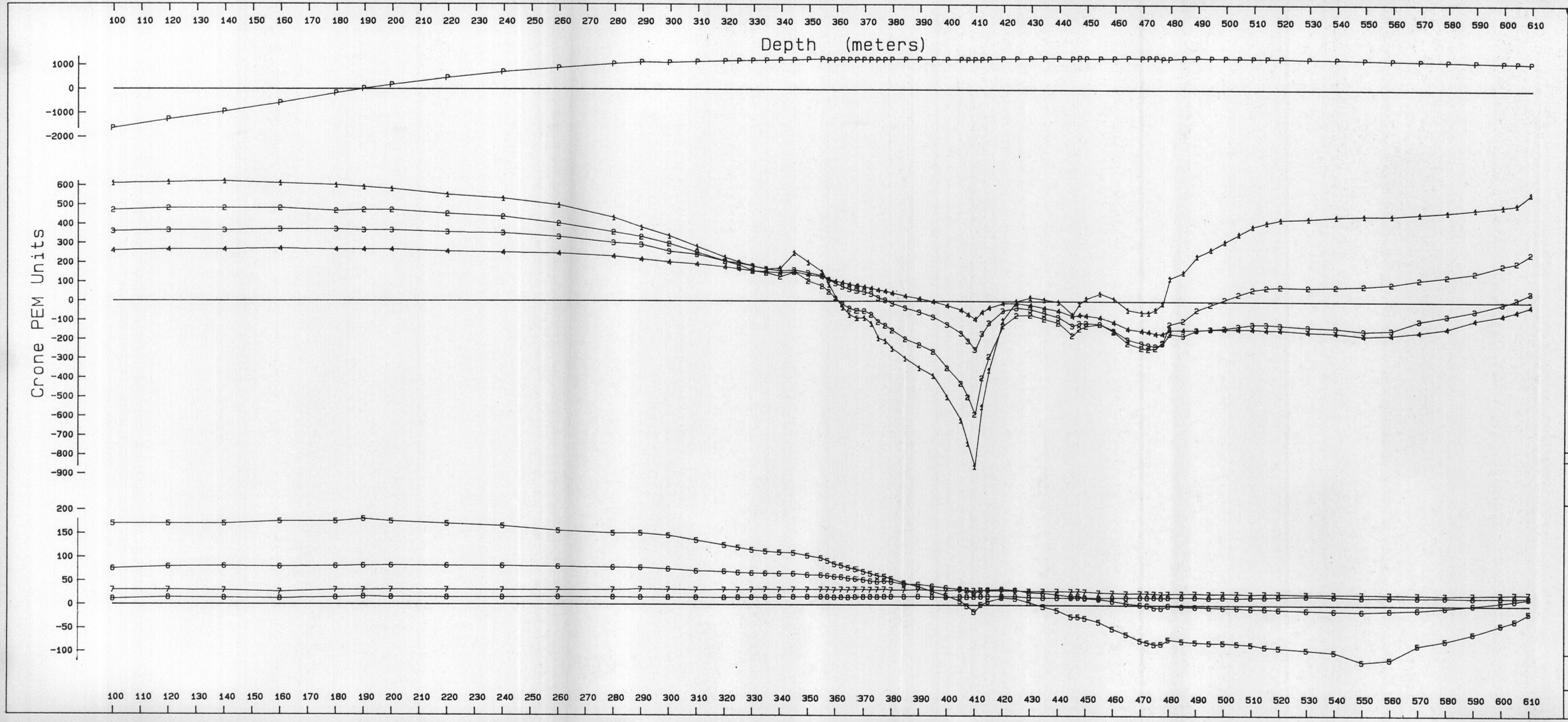
MINNOVA INC.

SAMATOSUM PROJECT
BOREHOLE PULSE EM SURVEY
HOLE RG-395 LOOP SE

Scale 1: 1000.0

Date: Sept 1991	Survey: July 1991	Profile: 5b

WOODS GEOPHYSICAL CONSULTING



MINNOVA INC.

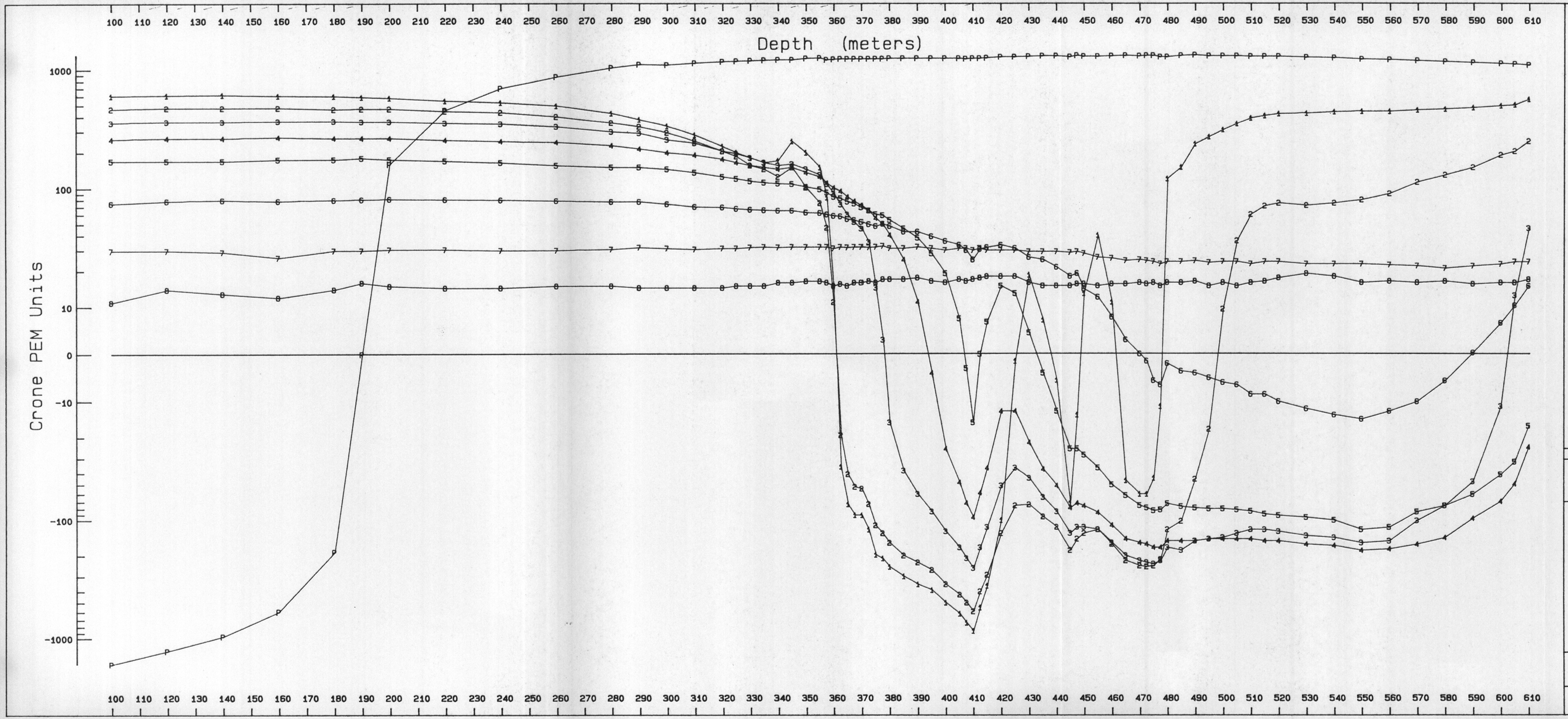
SAMATOSUM PROJECT
BOREHOLE PULSE EM SURVEY
HOLE RG-395 LOOP SW

Scale 1: 1000.0

0 20 40 60 80 100 M

Date: Sept 1991	Survey: July 1991	Profile: 6a

WOODS GEOPHYSICAL CONSULTING



inches
0 1 2
0 1 2 3 4 5
centimetres
BRITISH COLUMBIA GEOLOGICAL SURVEY
This reference scale bar has been added to the original image. It will scale at the same rate as the image, therefore it can be used as a reference for the original size.

MINNOVA INC.

SAMATOSUM PROJECT
BOREHOLE PULSE EM SURVEY
HOLE RG-395 LOOP SW

Scale 1: 1000.0

0 20 40 60 80 100 M

Date: Sept 1991	Survey: July 1991	Profile: 6b

WOODS GEOPHYSICAL CONSULTING