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crone

2-56506

Crone Pulse-EM Survey

Northern Sun Mining Corp.
Groves Project

*Geophysical Survey & Logistics Report
July 2015*

Conducted by:
Crone Geophysics & Exploration Ltd.



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Introduction

Crone Geophysics & Exploration Limited was contracted by Northern Sun Mining Corp. to conduct 3D Borehole Pulse Electromagnetic Surveys on its Groves Project located in the Northern Ontario, approximately 9km South East of Gogama. This report summarizes the geophysical work carried out in April 2015.

Three (3) holes covered from one (1) transmitting loop were surveyed during April 8th – 24th, 2015. The appendices to this report contain page size plan and section maps, linear 5-axis profiles, and step response profiles for select boreholes.



Property Location & Access

The Groves Property consists of 17 claim blocks with 216 claim units/3456 hectares. The property resides along the Rideout Deformation Zone and approximately 20km east northeast of the IAMGOLD Cote Lake Deposit.

The Northern Sun Mining Corp. 100% owned Groves Property resides 6km southeast of the town of Gogama in the Porcupine Mining Division (Figure 1). Ground access to the Groves Property from Timmins, Ontario, Canada begins by traveling approximately 20km west of Timmins on highway 101. Proceed an additional 120km south on highway 144 until reaching highway 560 (Watershed), and an additional 24km east on highway 560 until reaching Little Londonderry Road. From this point travel 19km north to northwest along Little Londonderry Road until reaching the Northern Sun drill trail. An all-terrain vehicle is required for the remaining 10km to reach the center of the property.

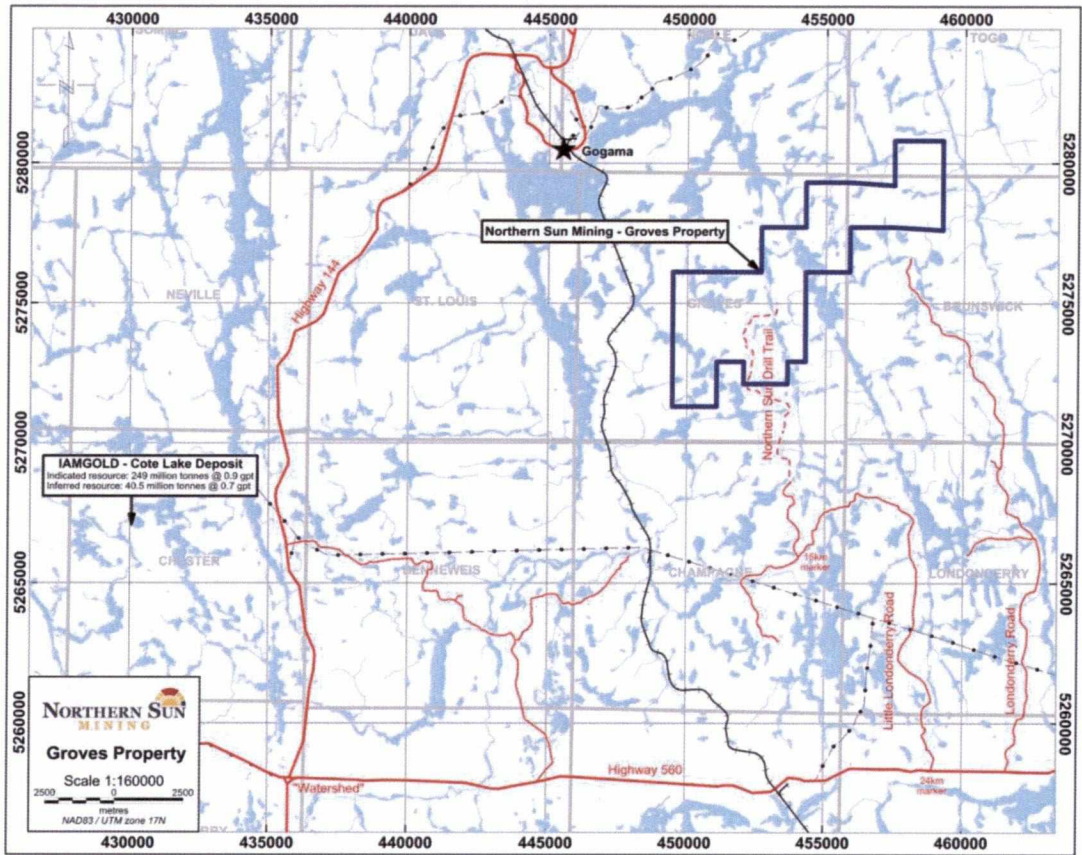


Figure 1: Groves property location and access map



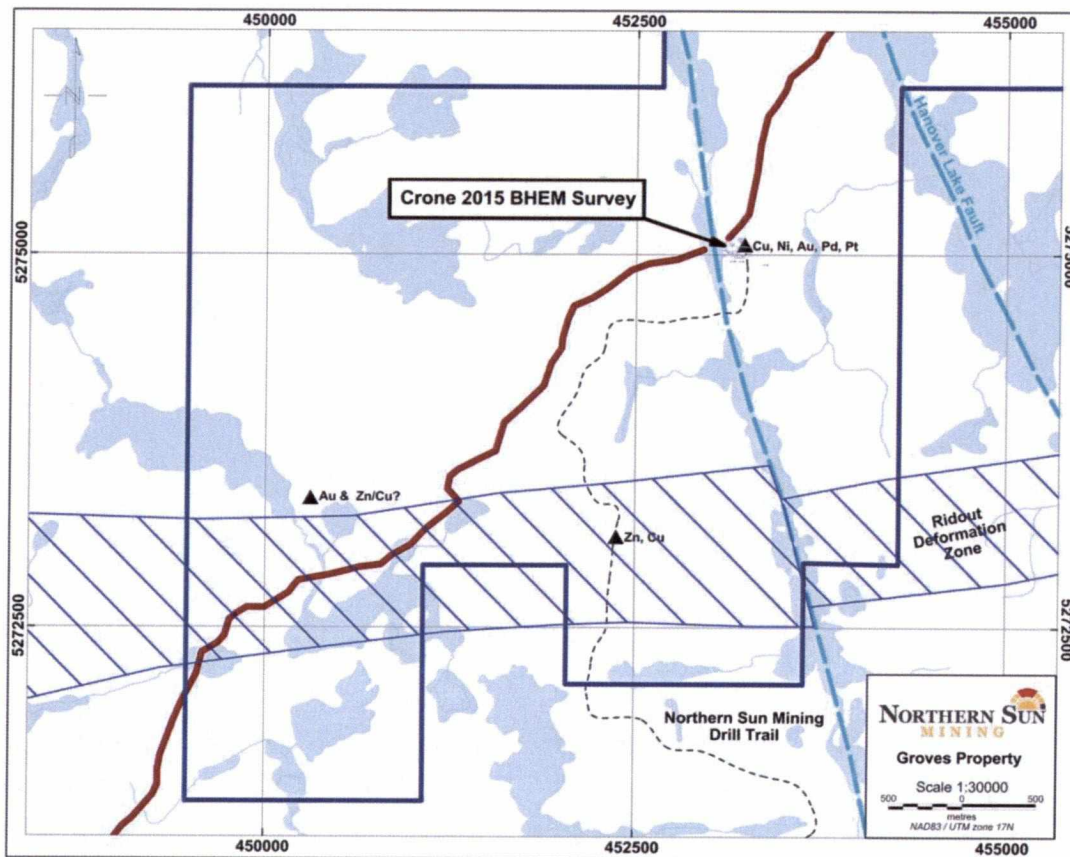


Figure 2: Location of the BHEM survey on the Groves property

Personnel

The personnel involved in this project during the reporting period include:

Survey Operator: Jordan Wilson

Data Processing: Joshua Lymburner

Report: Eric Meunier

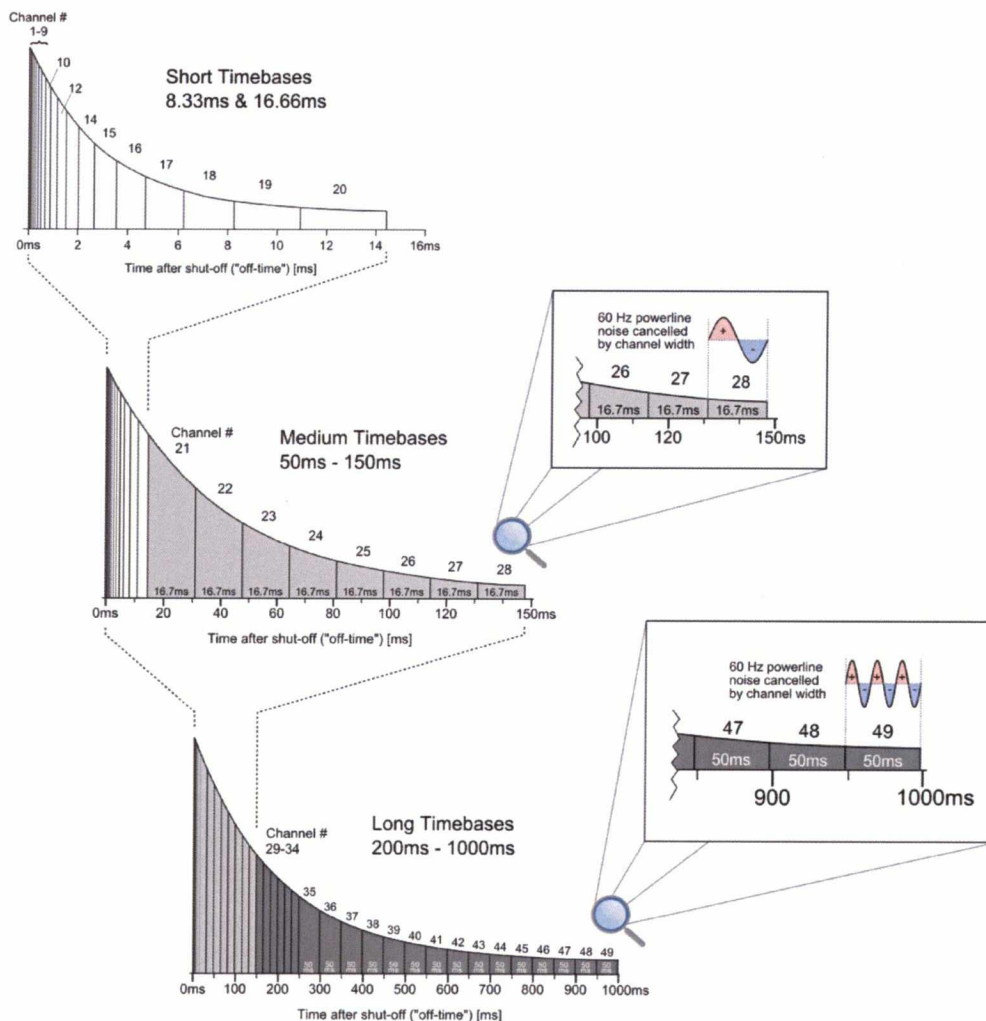
Equipment



Pulse-EM CDR2 Receiver

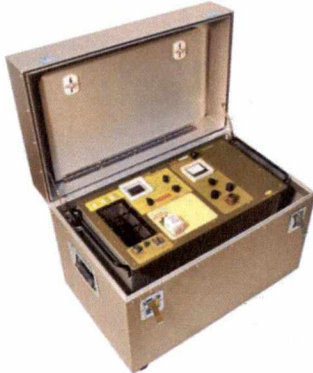
- 26-Bit equivalent A/D resolution and Smartstacking
- Sampling rate: 250K samples/second, 4 μ sec
- Auto Gain Ranging (AGR) on each 4 μ sec sample
- Settling time: 12 μ sec to 0.01% for a full scale pulse input
- Precision crystal oscillator or cable synchronization
- Entire ramp and off-time in 1 sweep

Standard Channel Configuration



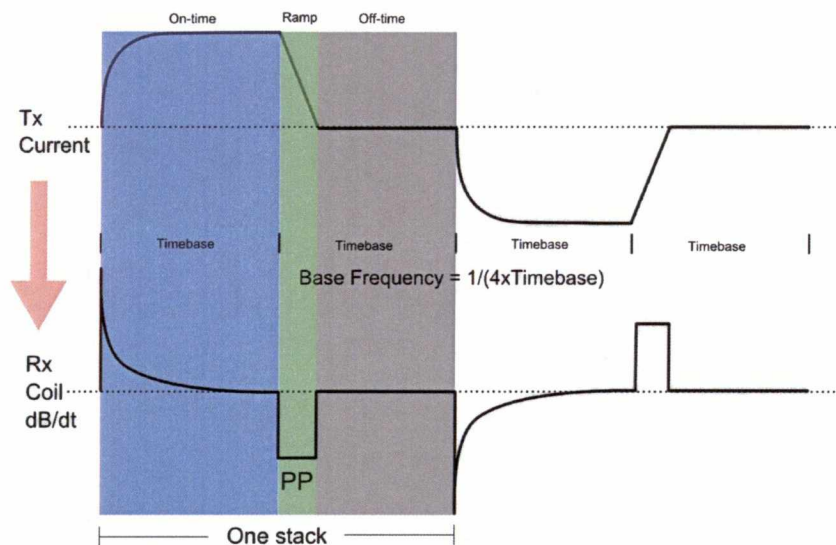


Pulse-EM Transmitter



- 4.8kW for up to 30 Amps in single or 60 Amps in dual mode
- Timebases: 8.33ms to 2000ms
- Ramp Settings: Fast Ramp, 0.5ms, 1.0ms or 1.5ms
- 50Hz or 60Hz cultural noise filters (through stacking)
- Auto Loop Damping with Current Control and Monitoring
- Auto Shutdown and grounded case for safety

Pulse EM Waveform



Pulse-EM Induction Coil Probe

- Measures dB/dt in 3 components
- Ferrite cored induction sensor
- Pressure tested to 2800m
- RAD Tool orientation with 3 Axis Magnetometer and 3 Axis Accelerometer



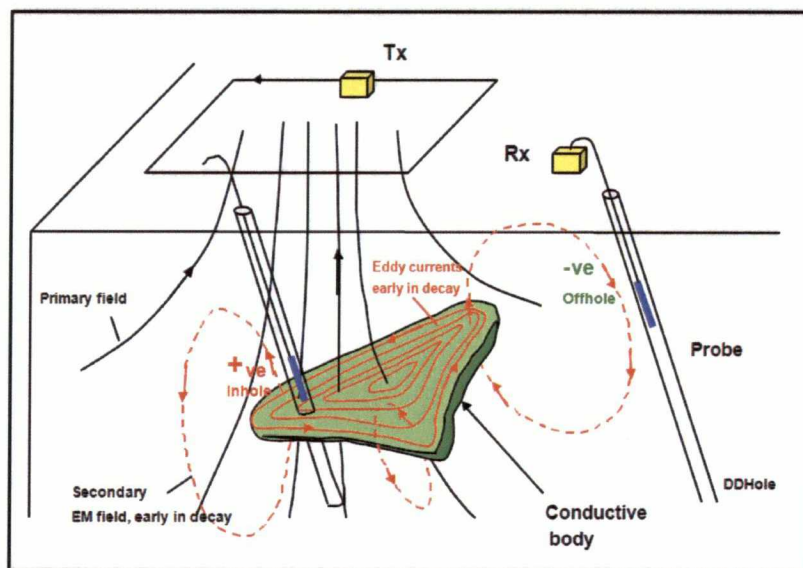
Pulse-EM Fluxgate Probe

- Measures B in 3 components
- High speed fluxgate for Pulse EM
- Pressure tested to 2500m
- RAD Tool orientation with 3 Axis Magnetometer and 3 Axis Accelerometer

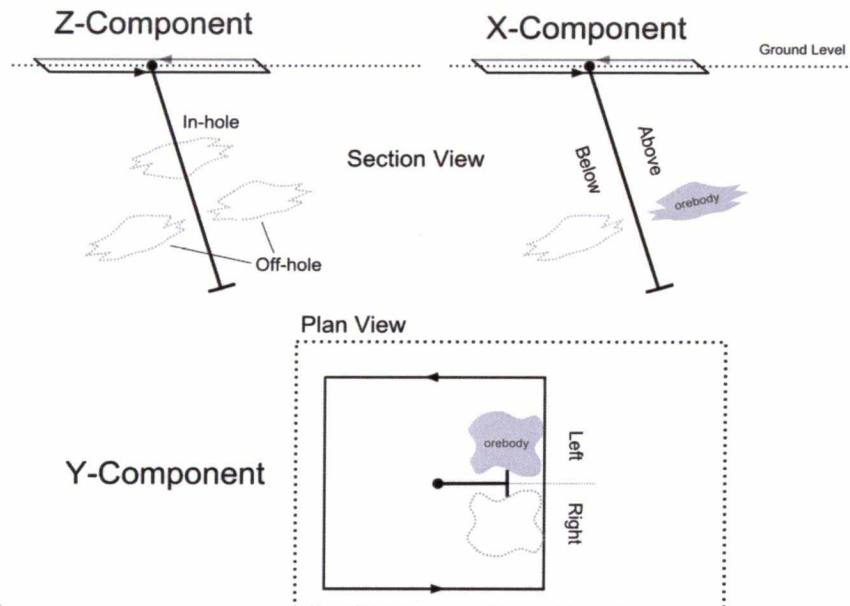


Survey Methods

Crone Pulse EM is a time domain electromagnetic method in which a precise pulse of current with a controlled linear shut off is transmitted through a large loop of wire on the ground and the rate of decay (dB/dt) of the induced secondary field is measured across a series of time windows during the off-time. Crone fluxgate and SQUID instruments measure the amplitude of the decay directly (B). The EMF created by the shutting-off of the current induces eddy currents in nearby conductive material thus setting-up a secondary magnetic field. When the primary field is terminated, this magnetic field will decay with time. The amplitude of the secondary field and the decay rate are dependent on the quality and size of the conductor.



On this project, a 3D Borehole Pulse EM system was assembled in which the axial component (Z) and cross components (XY) of the induced secondary field were measured with a high bandwidth fluxgate magnetometer borehole probe. The Z component detects any in-hole or off-hole anomalies and provides information on size, conductivity, and distances to the edge of conductors. The XY components measure two orthogonal components of the EM field in a plane orientated at right angles to the borehole. These results give directional information to the center of the conductive body.



In addition to providing the off-time and a late on-time channel, the Crone B-field Step Response was also calculated on select boreholes. The Step Response is widely regarded as a very important tool in the search for high conductance massive sulphides. Crone Geophysics & Exploration is the first EM company to provide a full B-field Pulse EM step transformation. **Crone's unique calculation** results in step channel data covering *double* the off-time. The step response requires geometrical control in which the loop position and the borehole geometry are accurately determined.

In the current surveys positional information was collected by Crone using a sub-meter capable GPS and regional base station. Positional information is provided in the UTM projection (Zone 17 North), using the NAD 1983 (Canada) datum. Borehole orientation data was provided by the client in the form of depth, azimuth, and dip.

The borehole surveys were carried out using a time base of 50ms (20 Hz), with a 1.5ms shut-off ramp time (Table 3). The primary inducing field is defined as positive up inside the transmitter loop. The data were acquired at a nominal survey interval of 5m.

Data units were nT/sec for the induction coil probes and pT/A for the fluxgate probes.



Data Acquisition Parameters

Table 1: Borehole Survey Transmitter Loop Coverage

Tx Loop	Property / Target	Size (meters)	Corner Coordinates	
			UTM NAD83 Zone 17N	
1	Groves	~ 435 x 380	453439E, 5274869N	
			453458E, 5275251N	
			453004E, 5275251N	
			453076E, 5274871N	

Table 2: Borehole Survey Coverage

Hole	Zone	Tx loop	Timebase	Off Time	Ramp	Current	Station		Length	Comp
			(ms)	Channels	(ms)	(Amps)	From	To	(m)	
GR-11-05 (Induction Probe)	Groves	1	50.00	22	1.5	25	5	70	65	Z
GR-11-05 (Fluxgate Probe)	Groves	1	50.00	22	1.5	25	5	70	65	X,Y,Z
GR-11-13 (Induction Probe)	Groves	1	50.00	22	1.5	25	5	205	200	Z
GR-11-13 (Fluxgate Probe)	Groves	1	50.00	22	1.5	25	5	205	200	X,Y,Z
GR-90-I65 (Induction Probe)	Groves	1	50.00	22	1.5	25	5	95	90	Z
GR-90-I65 (Fluxgate Probe)	Groves	1	50.00	22	1.5	25	5	90	85	X,Y,Z



The following table shows the various time gates that constitute the channel configuration set up in the Crone Pulse-EM Receiver used in the surveys discussed in this report.

Table 3: 22-Channel Configuration for the 50.00 ms time base

Channel	Start	Finish	Channel	Start	Finish
PP	-0.0002	-0.0001			
1	4.8e-05	6.4e-05	2	6.4e-05	8.4e-05
3	8.4e-05	0.000112	4	0.000112	0.000152
5	0.000152	0.000204	6	0.000204	0.000268
7	0.000268	0.00036	8	0.00036	0.00048
9	0.00048	0.00064	10	0.00064	0.000848
11	0.000848	0.001128	12	0.001128	0.001496
13	0.001496	0.001992	14	0.001992	0.002644
15	0.002644	0.003512	16	0.003512	0.004664
17	0.004664	0.006192	18	0.006192	0.00822
19	0.00822	0.010916	20	0.010916	0.0144
21	0.0144	0.031068	22	0.031068	0.047736

Production Summary

Date (d.m.y)	Type of Day	Comments
08-Apr-15	MOB	Mississauga to Gogama.
09-Apr-15	Survey	Assessed access and conditions, and looked for hole GR-11-05.
10-Apr-15	Weather	Warm weather and rain, causing great difficulty travelling through the snow.
11-Apr-15	Survey	After another very difficult day travelling in the soft and wet snow, it was decided that a Polaris 800 Big Boss was needed.
12-Apr-15	MOB	Sudbury to Mississauga to pick up the Polaris 800 Big Boss.
13-Apr-15	MOB	Mississauga back to Sudbury.
14-Apr-15	Survey	The Polaris needed servicing, and was ready for pick-up at 2:00 PM. Another truck and trailer was also picked up.
15-Apr-15	Survey	Dropped gear off at hole GR-11-05, and dropped spools of wire off near the loop edge.
16-Apr-15	Survey	Dummied holes GR-11-05, GR-11-13, and GR-90-I65. Placed borehole gear at the first hole. Began laying transmitter loop.
17-Apr-15	Survey	Continued to lay the transmitter loop.
18-Apr-15	Survey	Surveyed 65m of hole GR-11-05 with the coil in the Z component. Encountered problems with the equipment and had to survey with the Fluxgate probe for 65m in the XYZ components.
19-Apr-15	Survey	Moved borehole gear to hole GR-11-13. Surveyed the hole using the coil-probe in the Z-component from 5m to 205m, and with the fluxgate-probe in the XYZ-components from 5m to 205m. Moved borehole gear to the next hole.



20-Apr-15	Survey	Surveyed hole GR-90-165 with the coil-probe from 5m to 90m in the Z-component and with the fluxgate-probe from 5m to 95m in the XYZ-components.
21-Apr-15	Survey	After reaching the transmitter 15km into the bush, the Polaris experienced a damaged tie-rod. For safety reasons, the operators had to leave the bush on foot.
22-Apr-15	Standby	Standby while the tie-rod is replaced.
23-Apr-15	Survey	Picked up an Argo, picked up the transmitter loop, and fixed the Polaris.
24-Apr-15	DEMOB	Demob to Mississauga.

Respectfully submitted,

A handwritten signature in black ink, appearing to read 'Eric Meunier'.

Eric Meunier, M.Sc.

Project Geophysicist

Crone Geophysics & Exploration Ltd.



Appendix 1: Plan & Section Maps



453000E -
453100E -
453200E -
453300E -
453400E -
453500E -

5275300N -

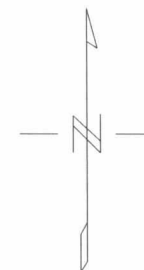
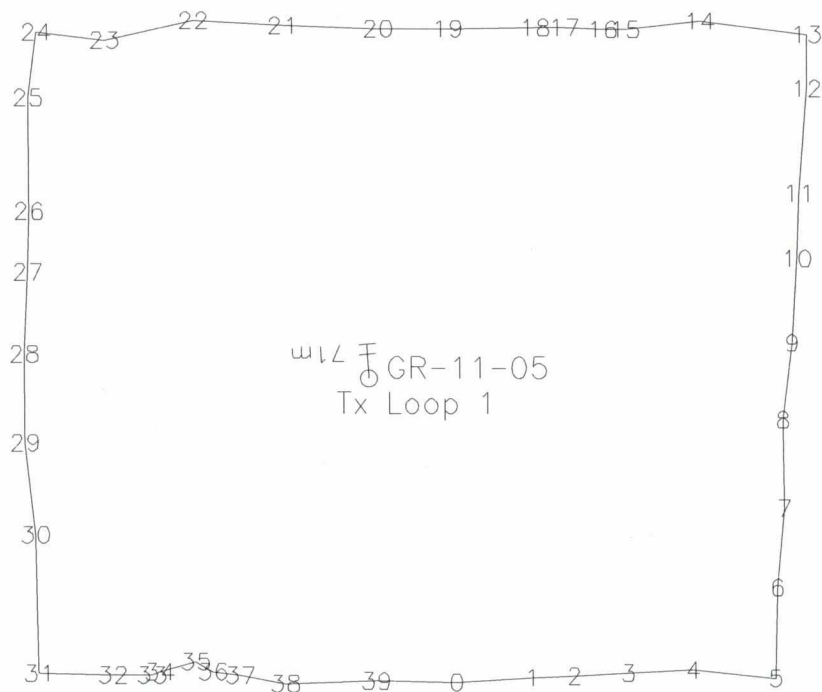
5275200N -

5275100N -

5275000N -

5274900N -

5274800N -



Scale 1:5000
50 0 50 100
(meters)

Northern Sun Mining Corp.

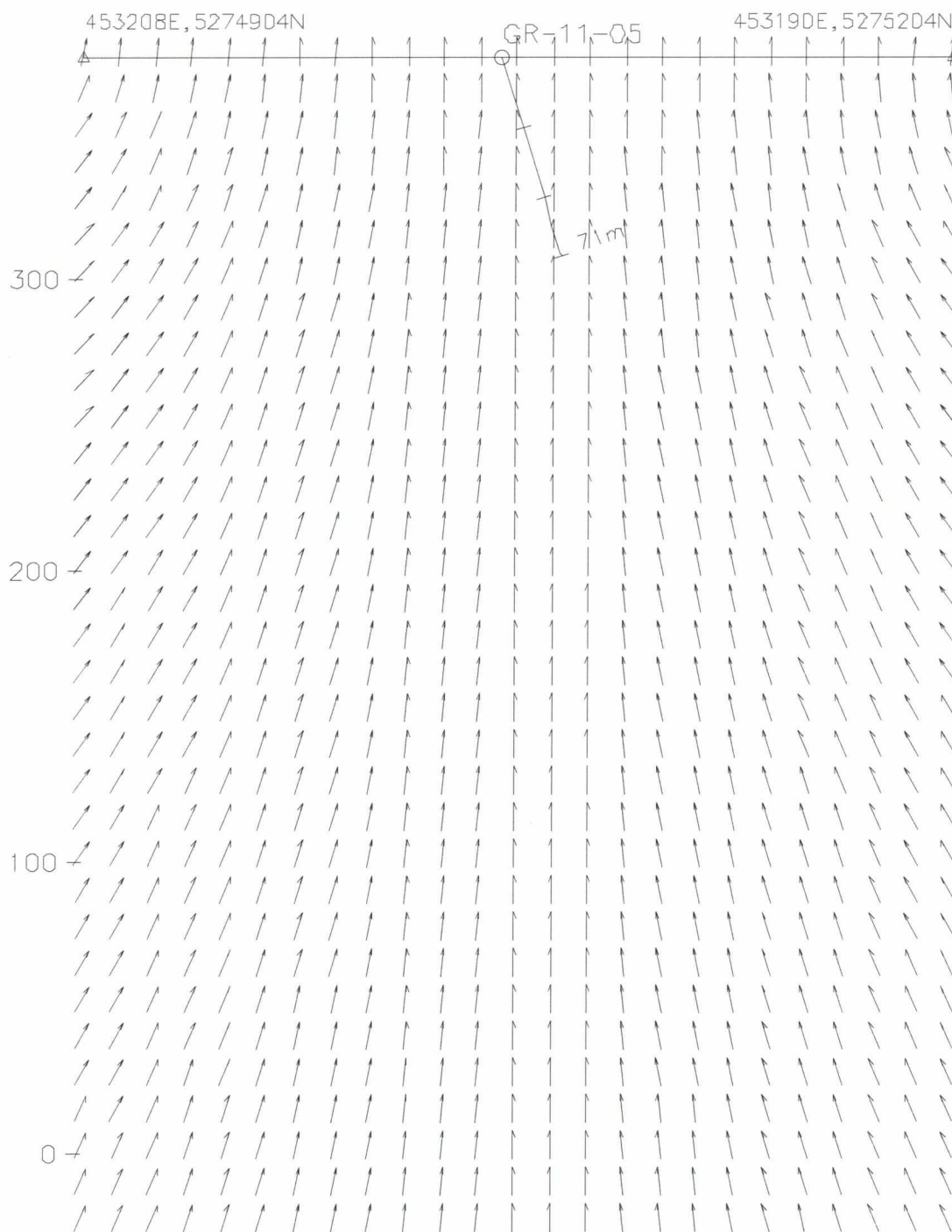
Groves Project

3-D Borehole Pulse EM Survey
Borehole & Loop Location Map

Hole: GR-11-05

Survey Date: April 18, 2015

Crone Geophysics & Exploration Ltd.



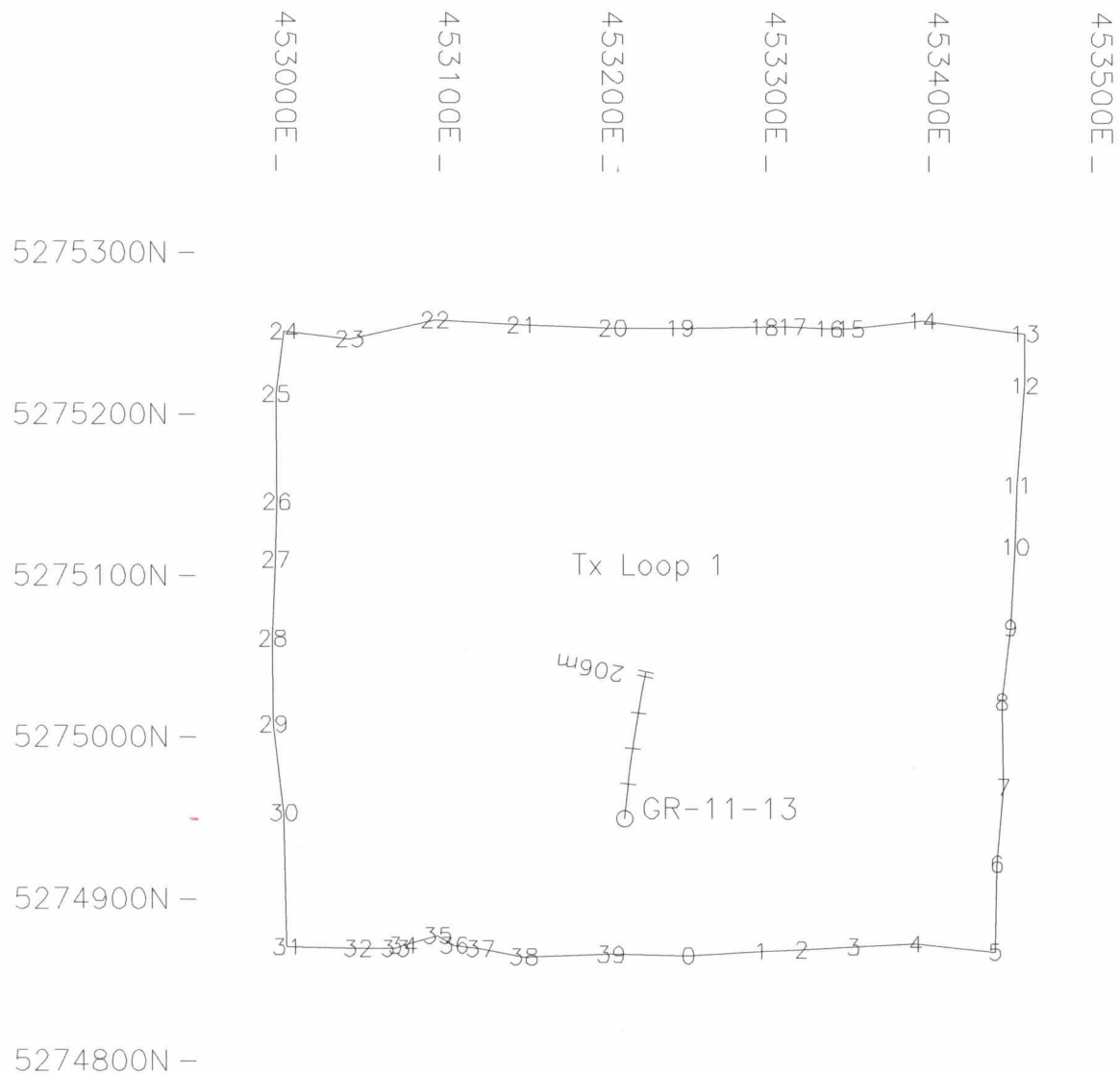
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 25 0 25 50
 (meters)

Northern Sun Mining Corp.
 Groves Project

3-D Borehole Pulse EM Survey
 Hole Section with Primary Field

Hole: GR-11-05
 Survey Date: April 18, 2015

Crane Geophysics & Exploration Ltd.



Northern Sun Mining Corp.

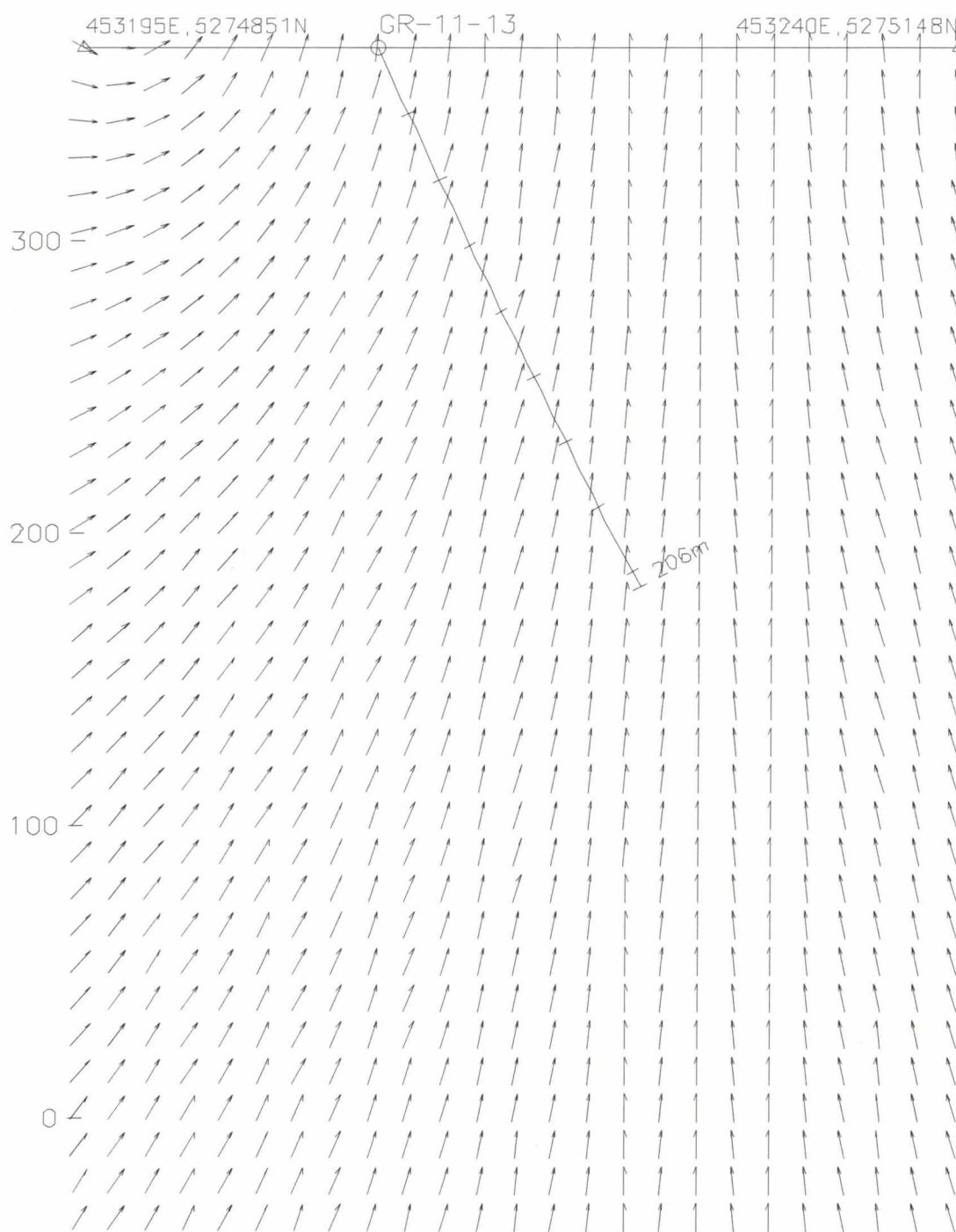
Groves Project

3-D Borehole Pulse EM Survey
Borehole & Loop Location Map

Hole: GR-11-13

Survey Date: April 19, 2015

Crone Geophysics & Exploration Ltd.



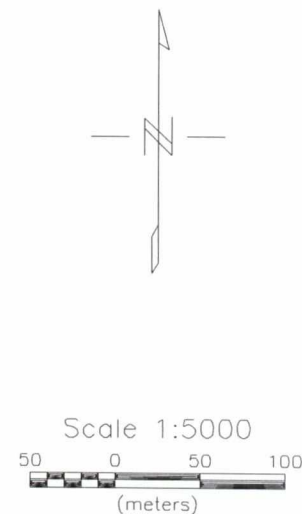
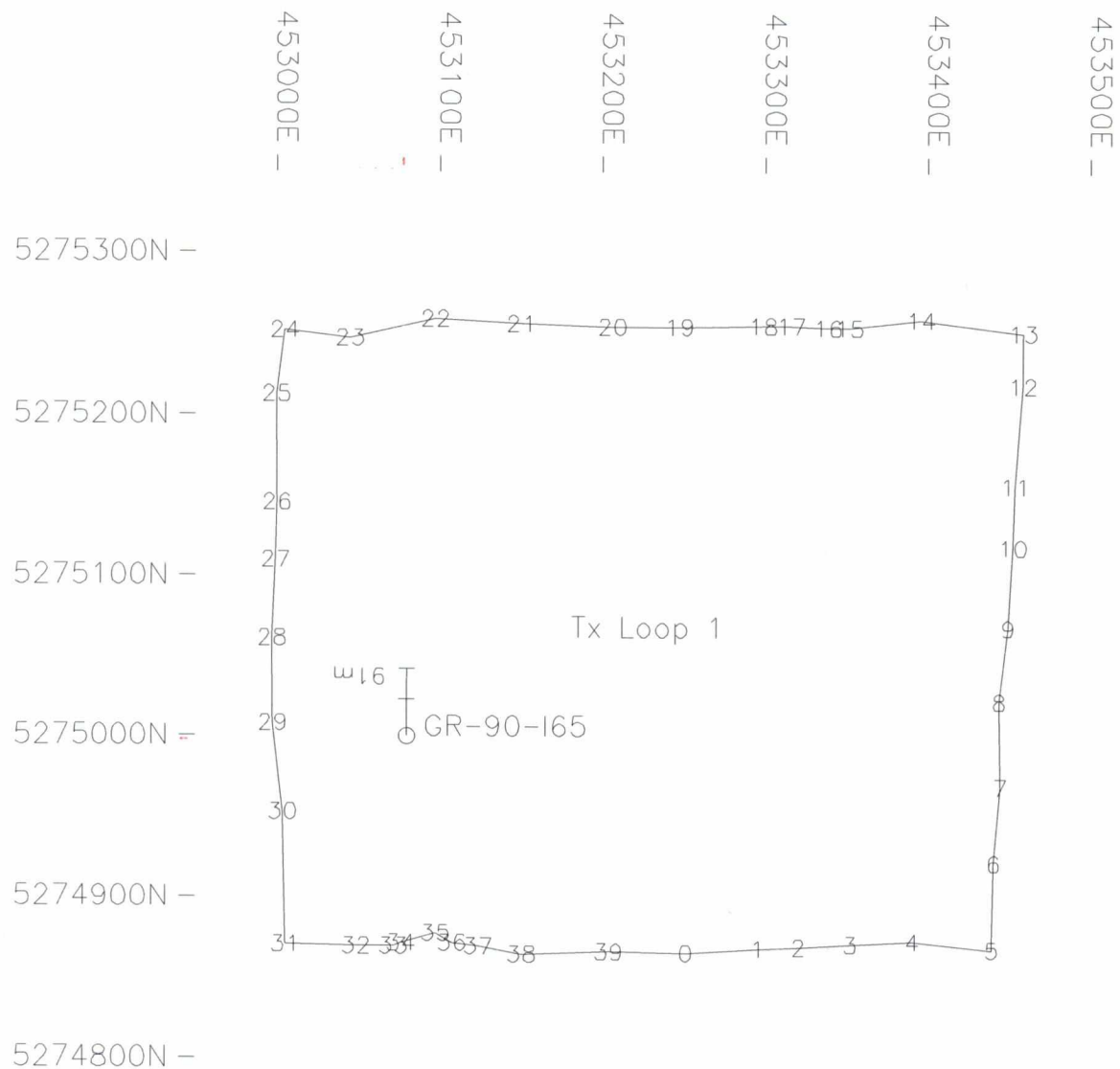
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 (meters)

Northern Sun Mining Corp.
 Groves Project

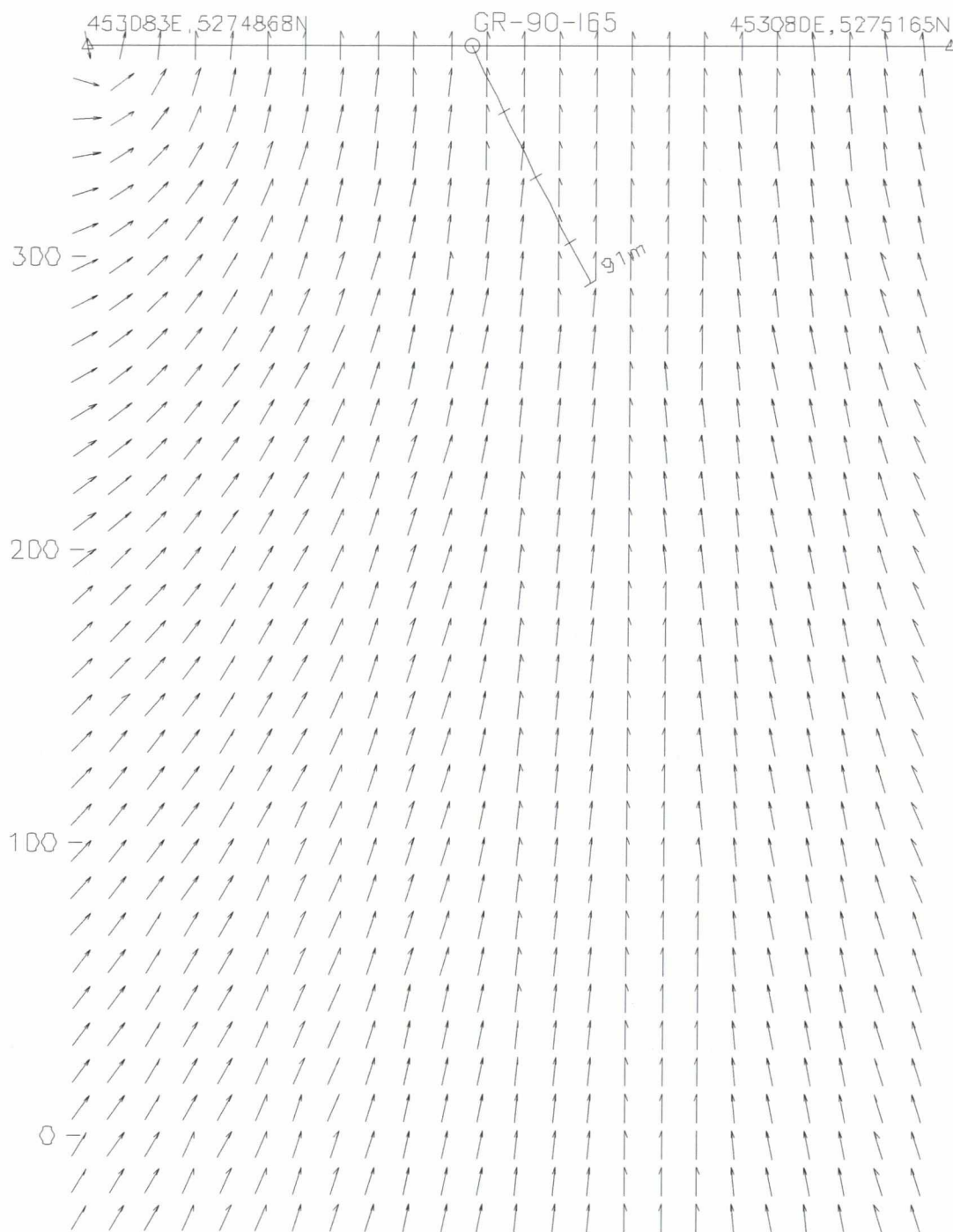
3-D Borehole Pulse EM Survey
 Hole Section with Primary Field

Hole: GR-11-13
 Survey Date: April 19, 2015

Crone Geophysics & Exploration Ltd.



Northern Sun Mining Corp.
Groves Project
3-D Borehole Pulse EM Survey Borehole & Loop Location Map
Hole: GR-90-165 Survey Date: April 20, 2015
Crone Geophysics & Exploration Ltd.



Northern Sun Mining Corp.
Groves Project

3-D Borehole Pulse EM Survey
Hole Section with Primary Field

Hole: GR-90-165
Survey Date: April 20, 2015

Crane Geophysics & Exploration Ltd.



Appendix 2: Linear (5-Axis) Pulse-EM Data Profiles



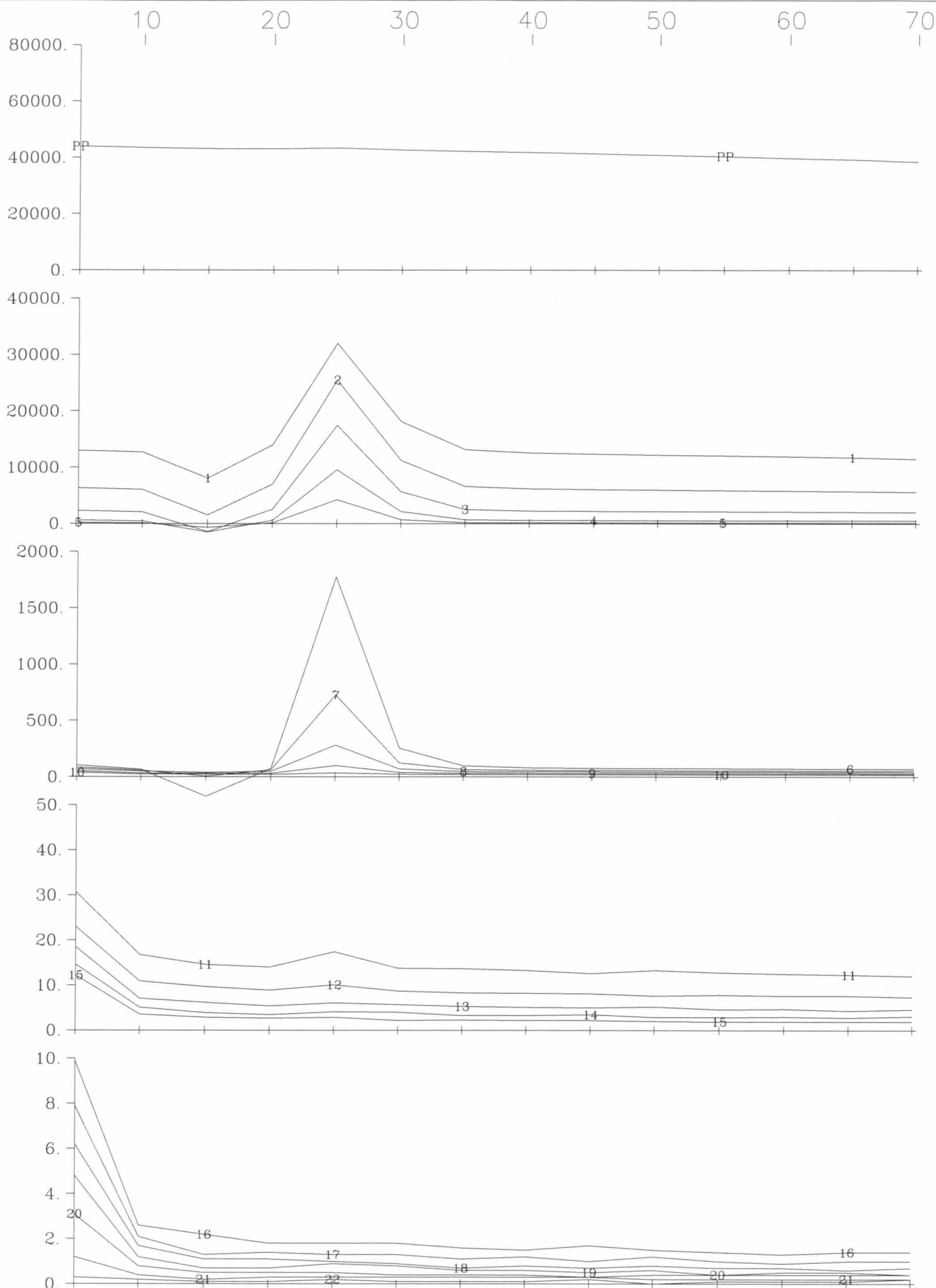
Primary Pulse
(nT/sec)

Channels 1 - 5
(nT/sec)

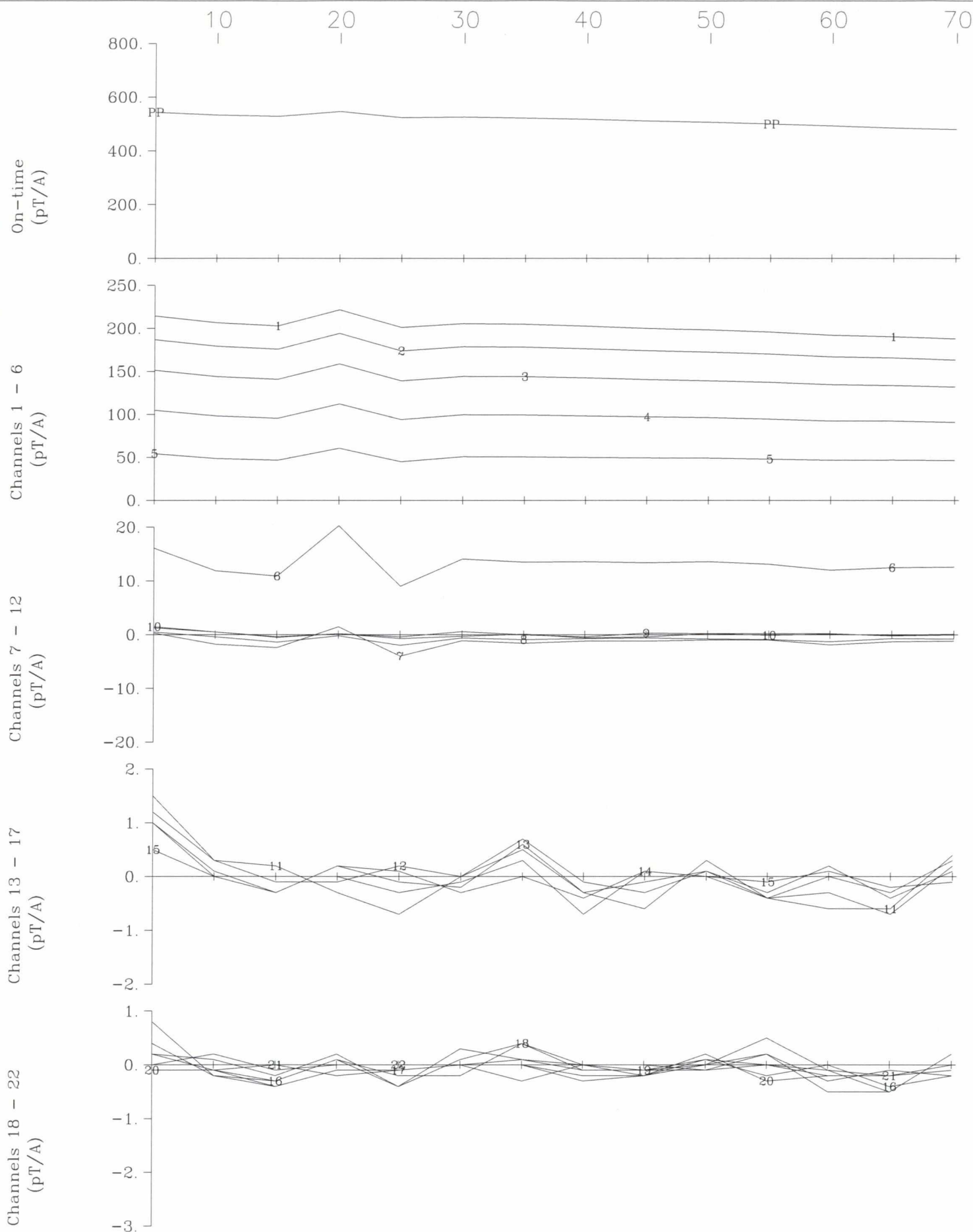
Channels 6 - 10
(nT/sec)

Channels 11 - 15
(nT/sec)

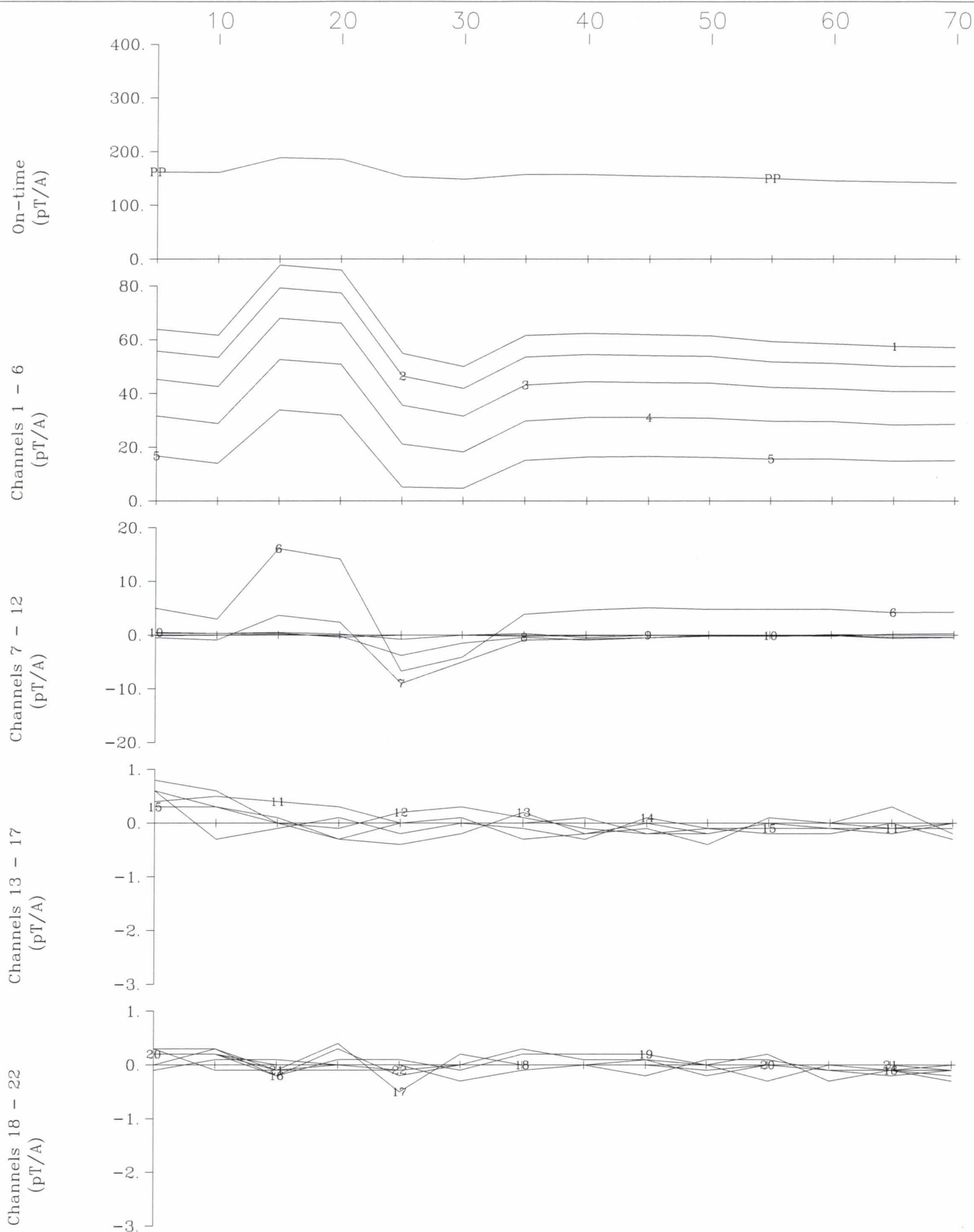
Channels 16 - 22
(nT/sec)



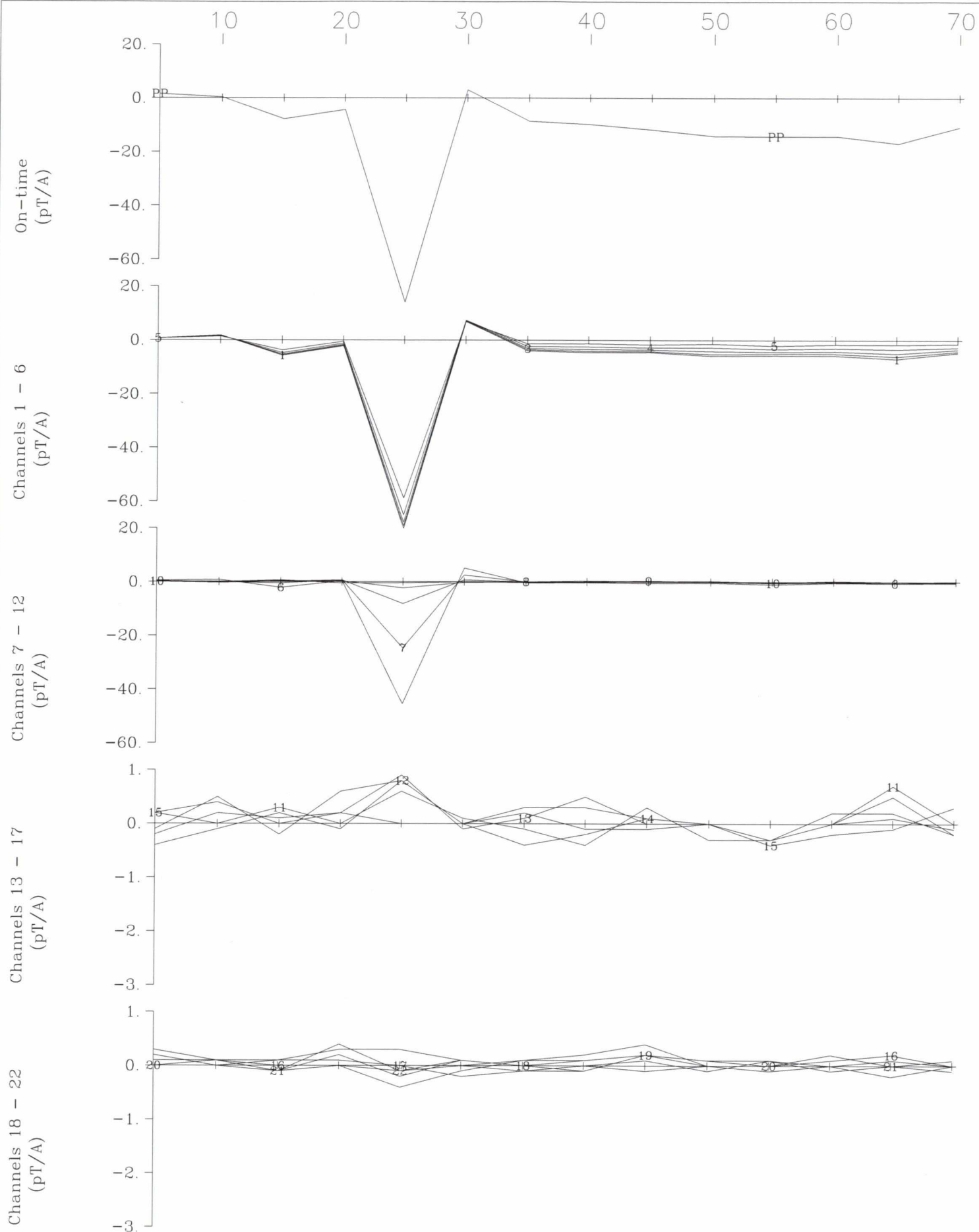
Northern Sun Mining Corp. Groves Project
Hole GR-11-05 Z Component Induction Probe
Crone Geophysics & Exploration Ltd.



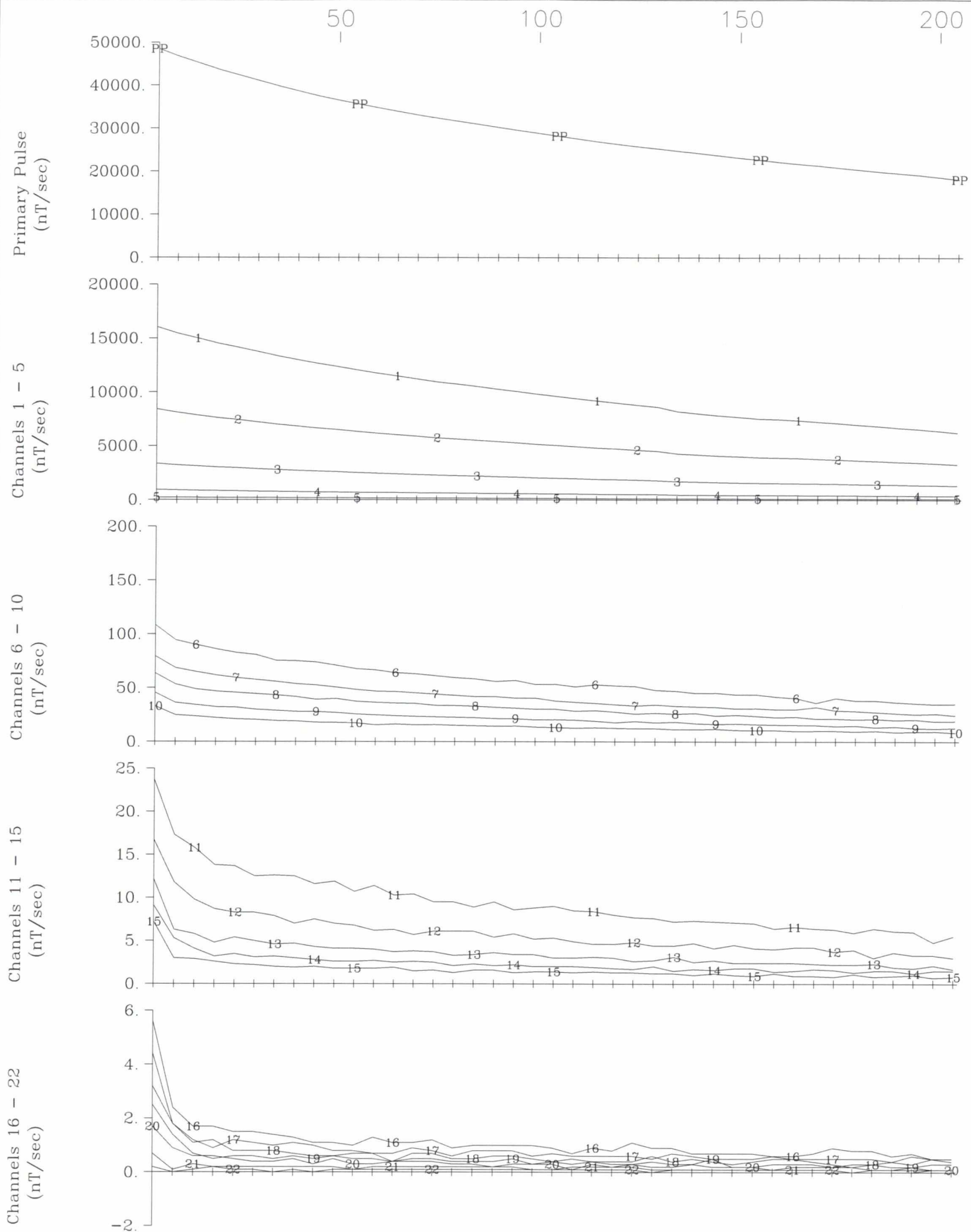
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Crone Geophysics & Exploration Ltd.



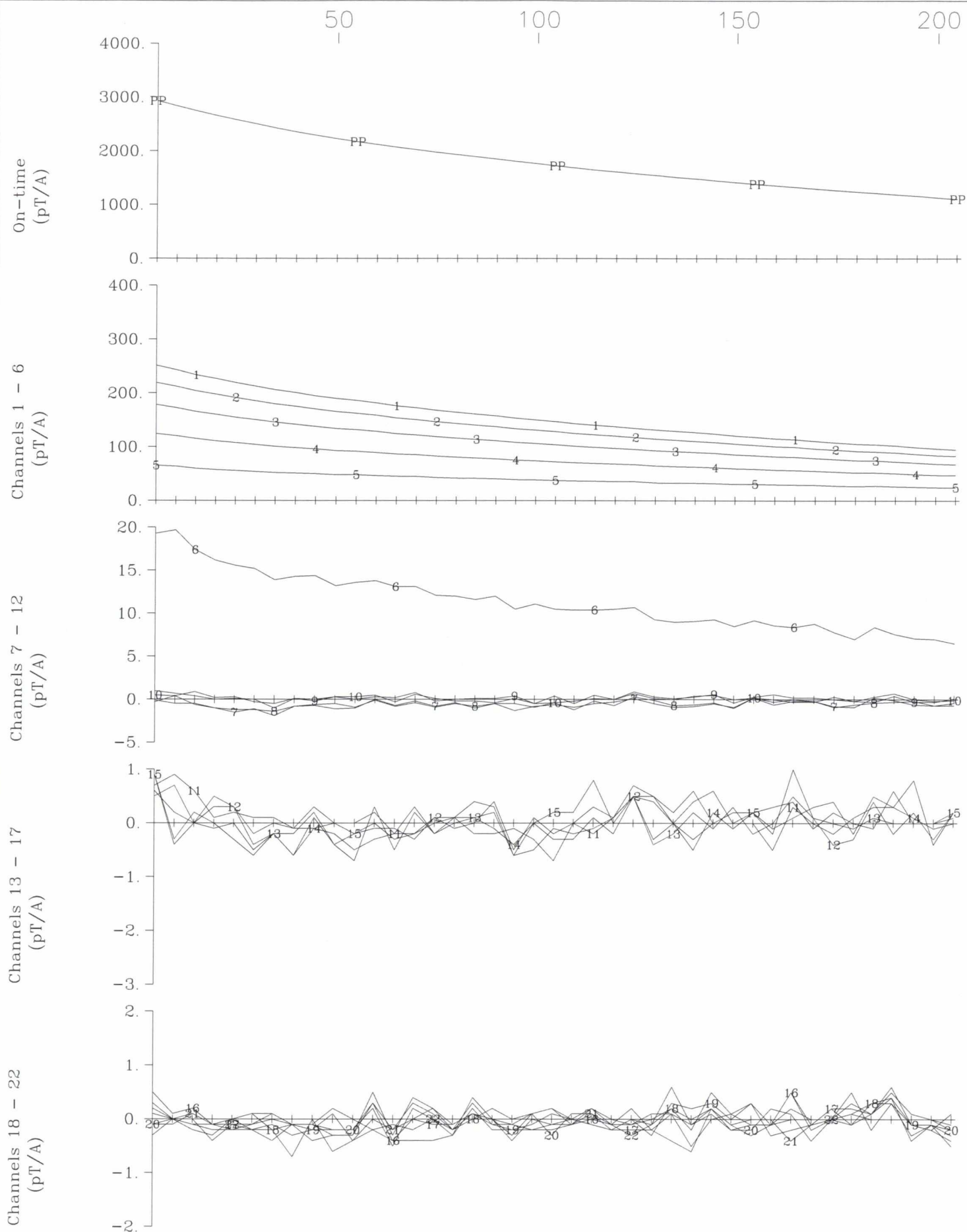
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Hole GR-11-05 X Component Fluxgate Probe
Crone Geophysics & Exploration Ltd.



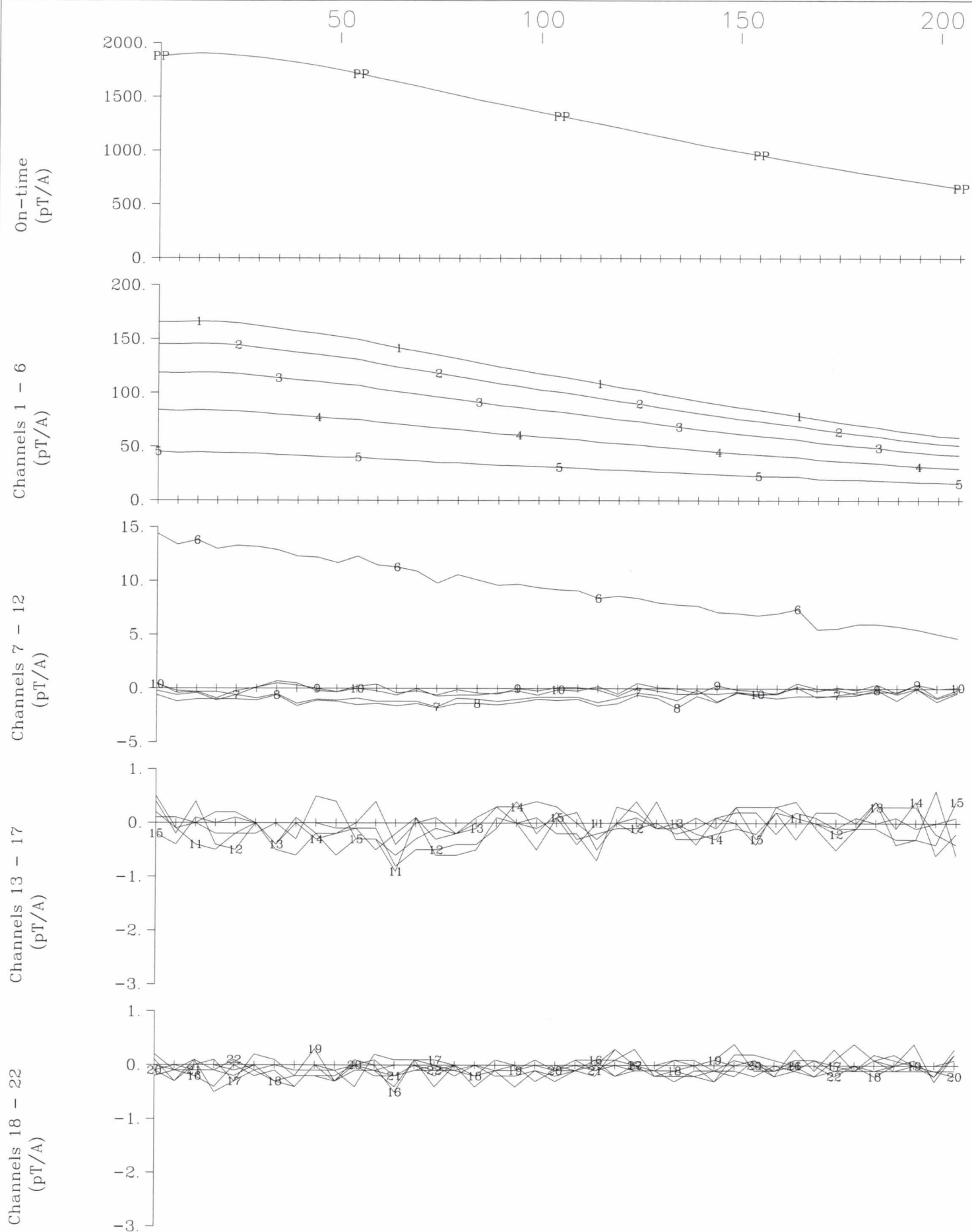
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Crone Geophysics & Exploration Ltd.



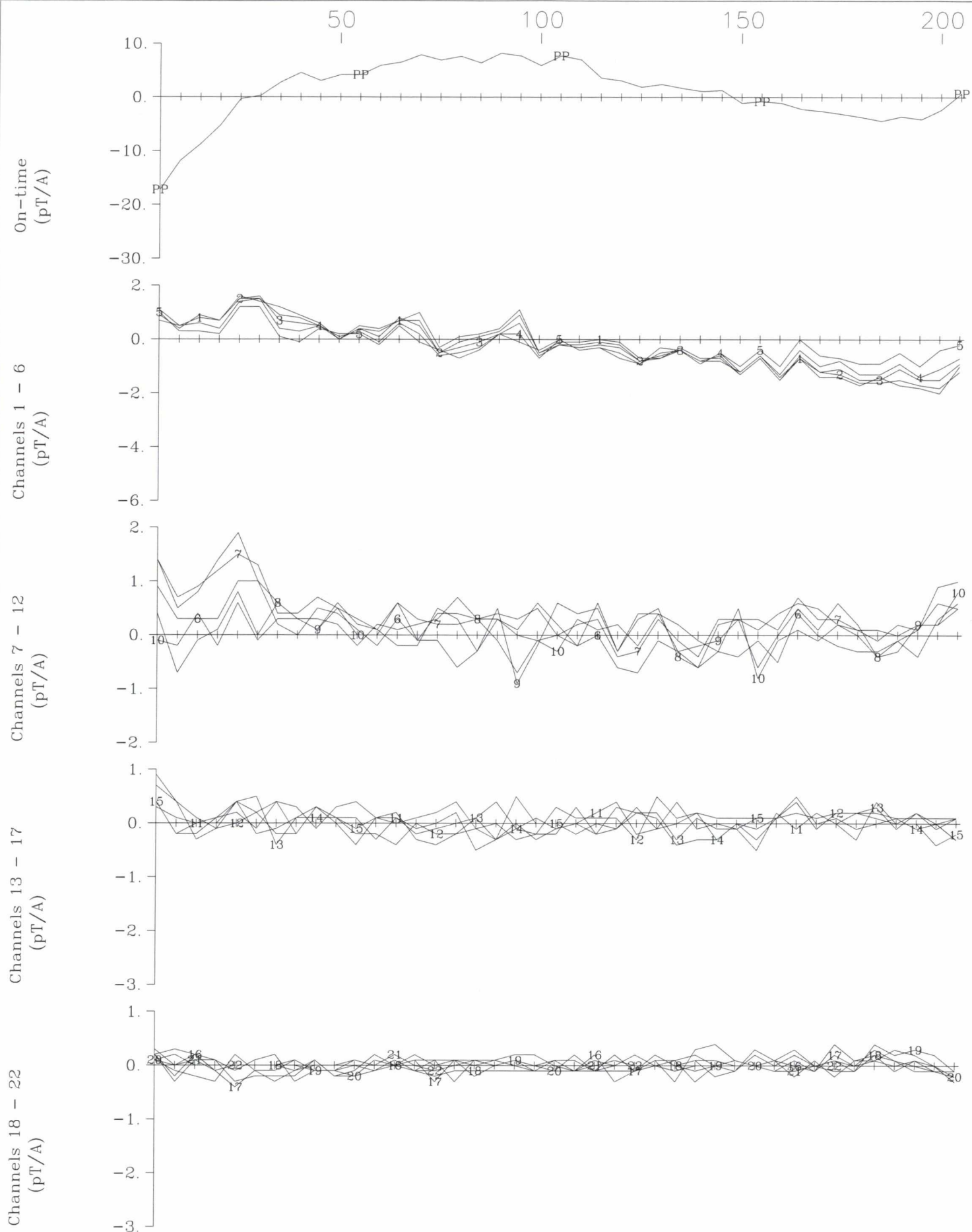
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Hole GR-11-13 Z Component Induction Probe
Crone Geophysics & Exploration Ltd.



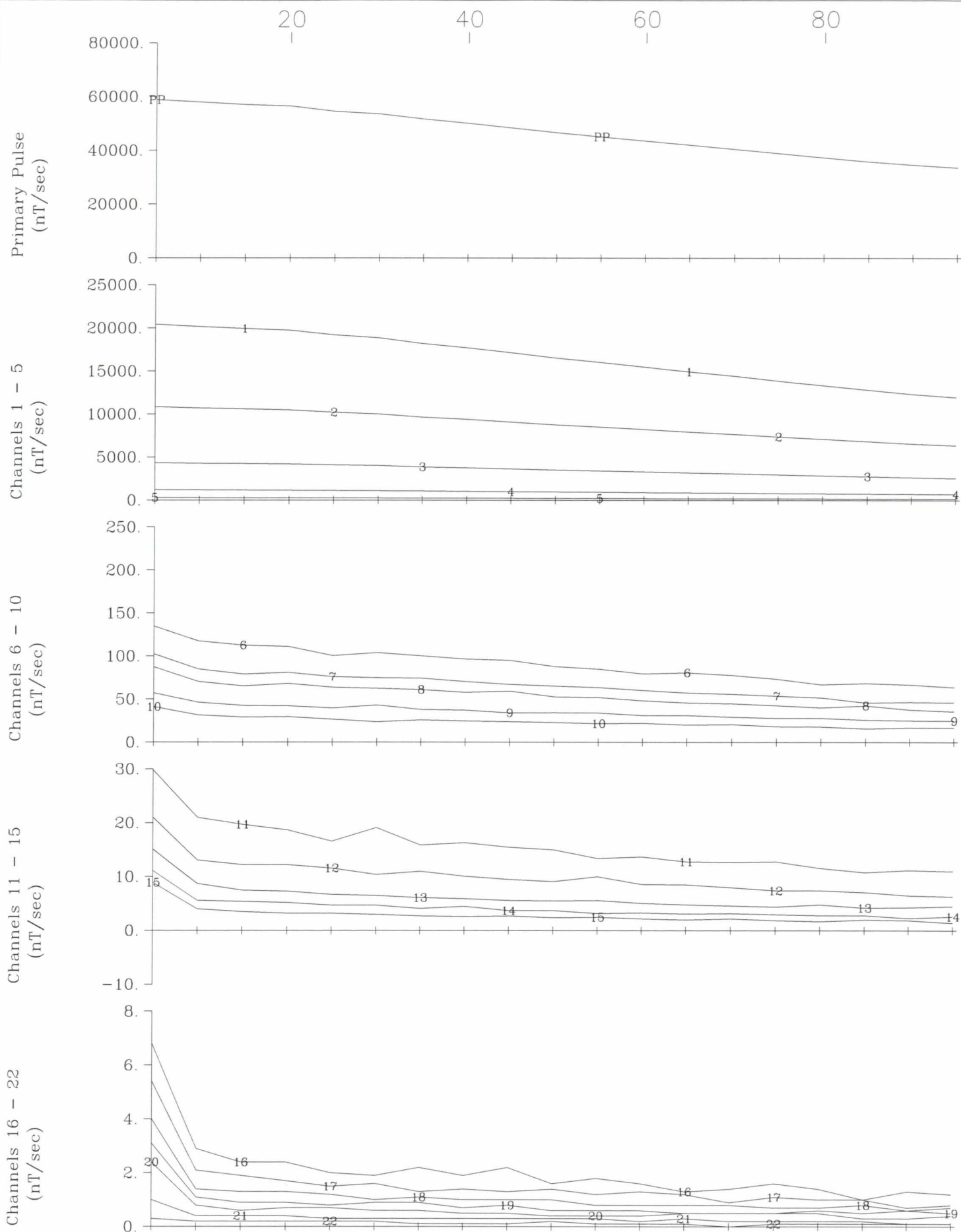
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Hole GR-11-13 Z Component Fluxgate Probe
Crone Geophysics & Exploration Ltd.



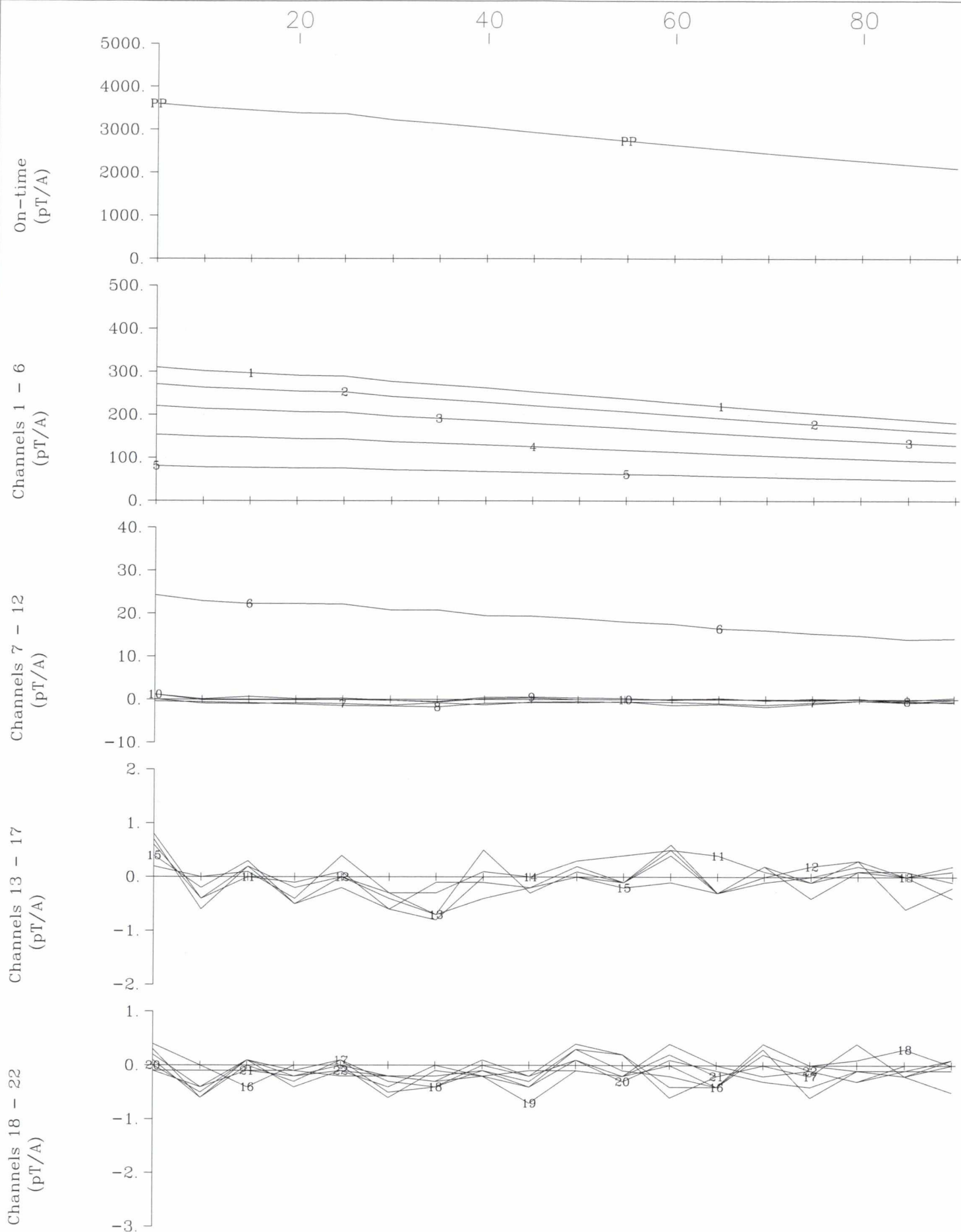
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Hole GR-11-13 X Component Fluxgate Probe
Crone Geophysics & Exploration Ltd.



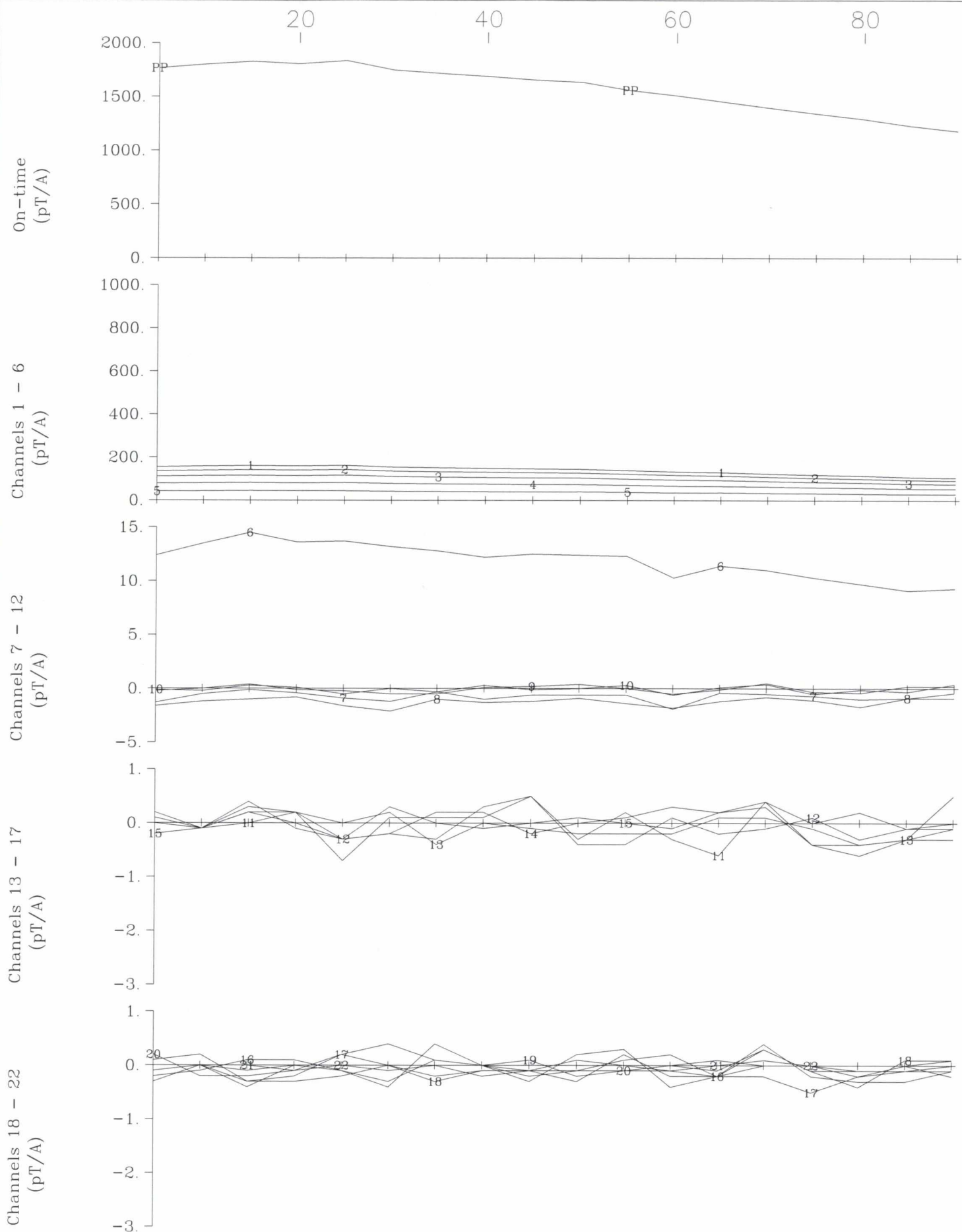
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Crone Geophysics & Exploration Ltd.



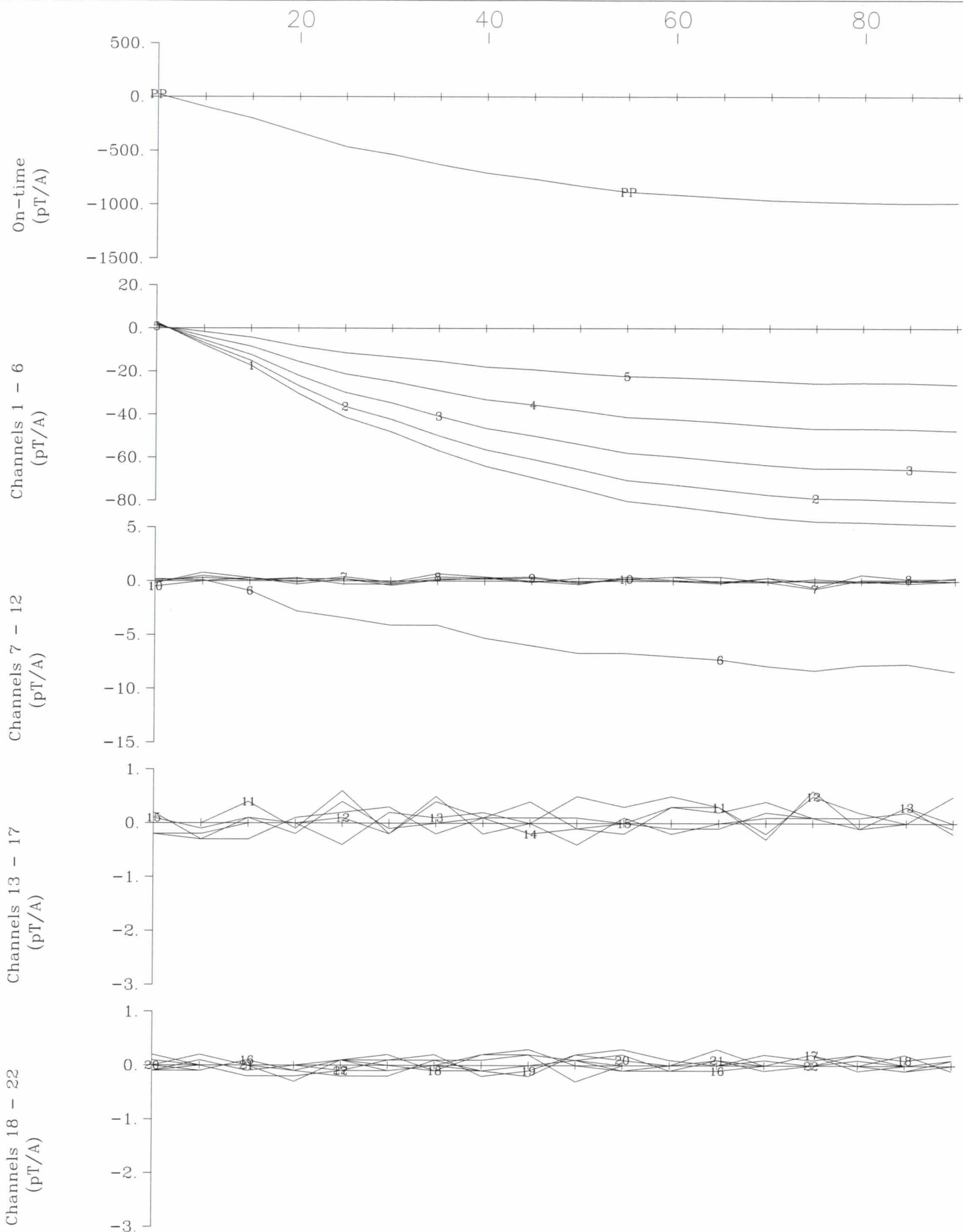
Northern Sun Mining Corp. Groves Project
Hole GR-90-165 Z Component Induction Probe
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Northern Sun Mining Corp. Groves Project
Hole GR-90-I65 Z Component Fluxgate Probe
Crone Geophysics & Exploration Ltd.



Northern Sun Mining Corp. Groves Project
Hole GR-90-I65 X Component Fluxgate Probe
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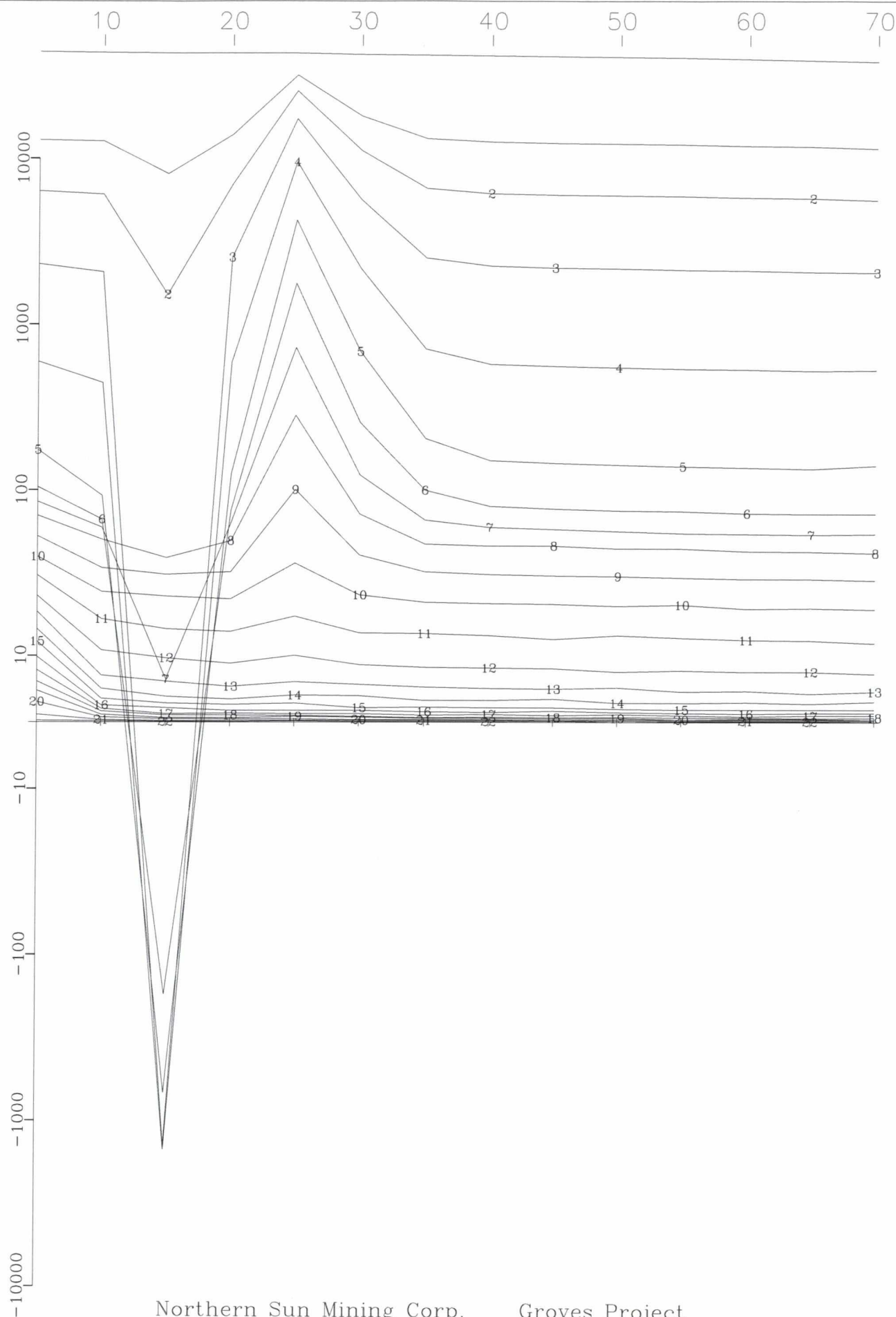
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Hole GR-90-165 Y Component Fluxgate Probe
Crone Geophysics & Exploration Ltd.



Appendix 3: Pulse-EM Data Profiles (Lin-Log) Scale

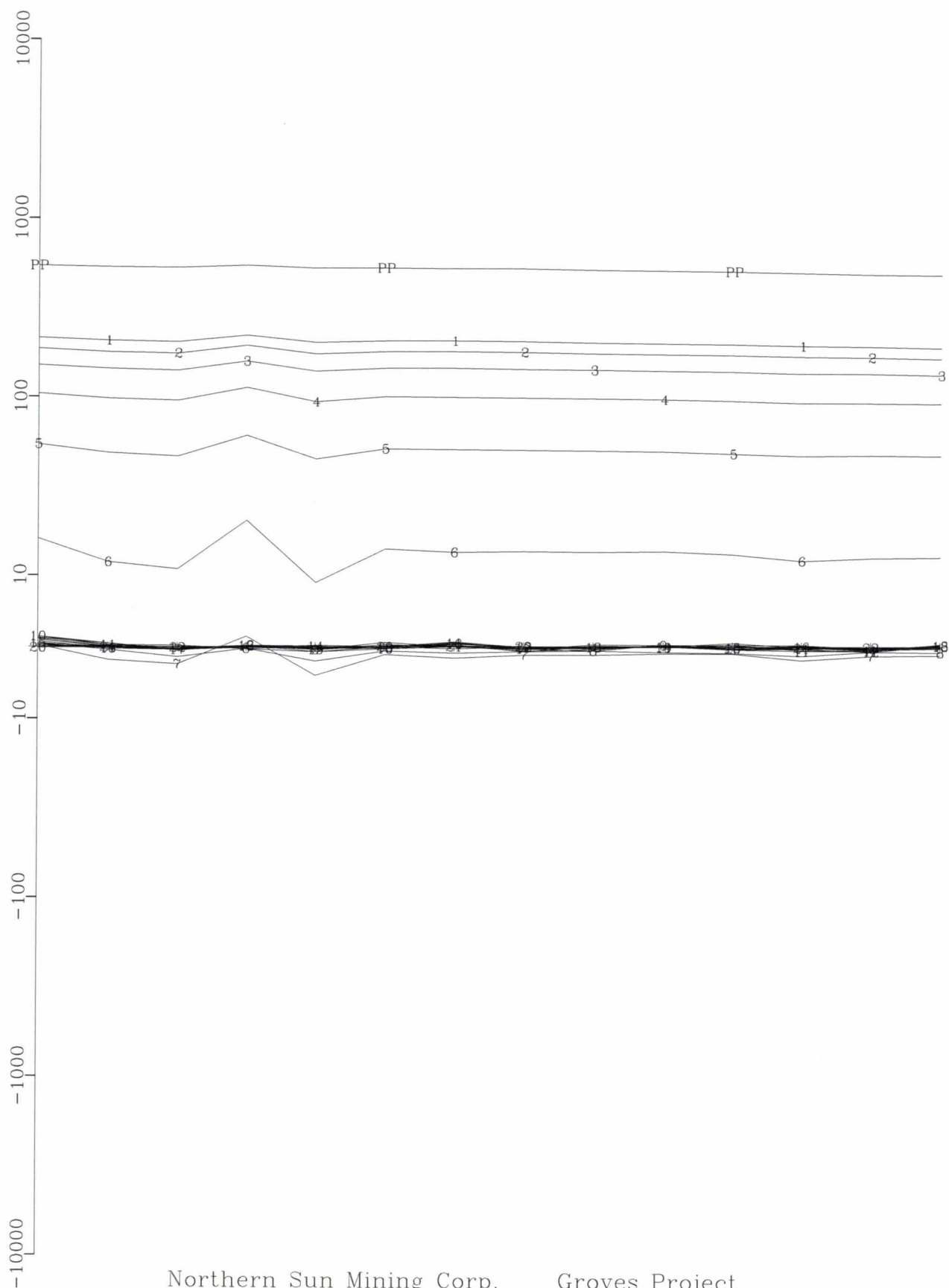


Primary Pulse and 22 Off-time Channels
(nT/sec)



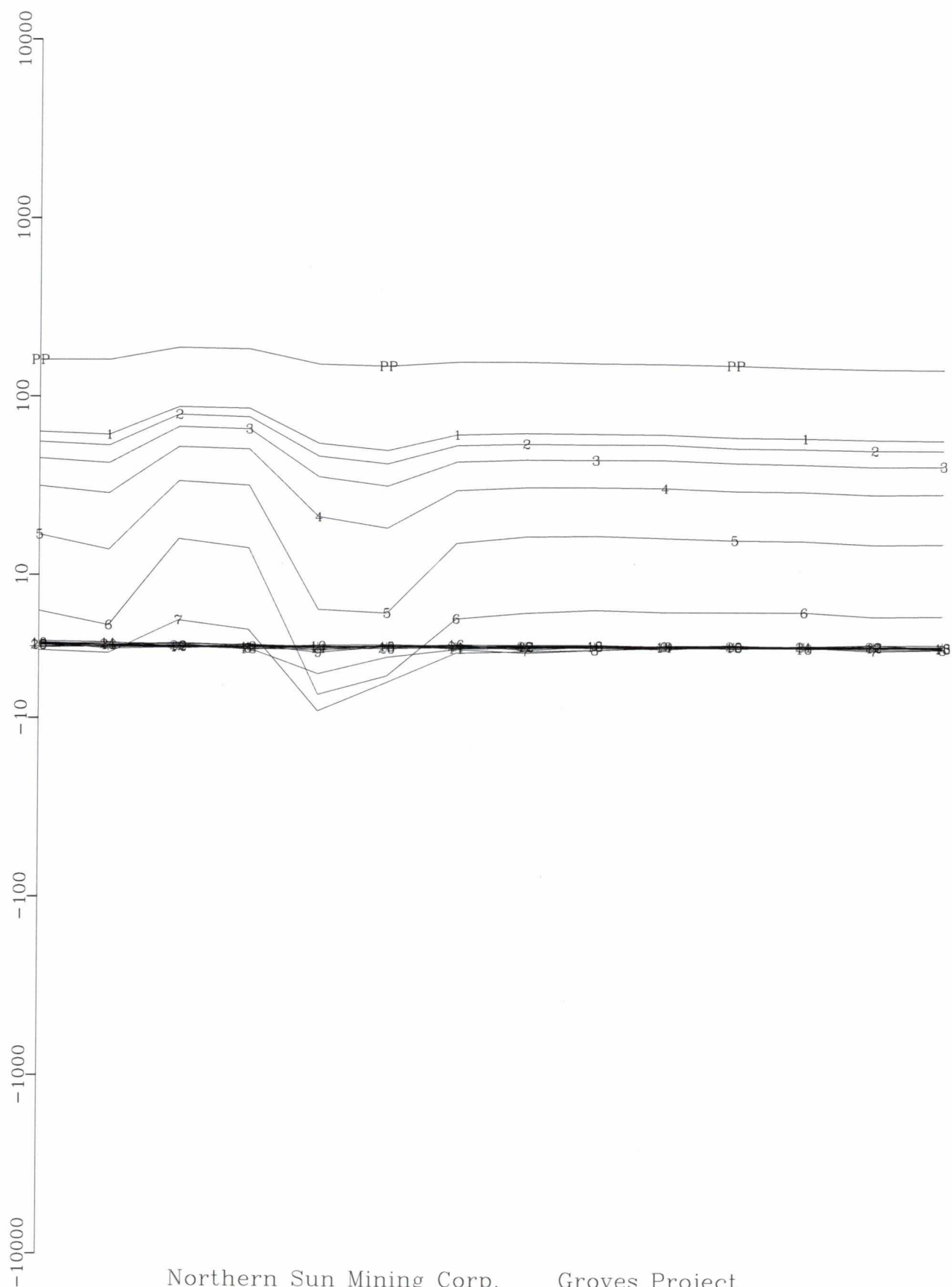
Northern Sun Mining Corp. Groves Project
Hole GR-11-05 Z Component Induction Probe
Crone Geophysics & Exploration Ltd.

Primary Pulse and 22 Off-time Channels
(pT/A)



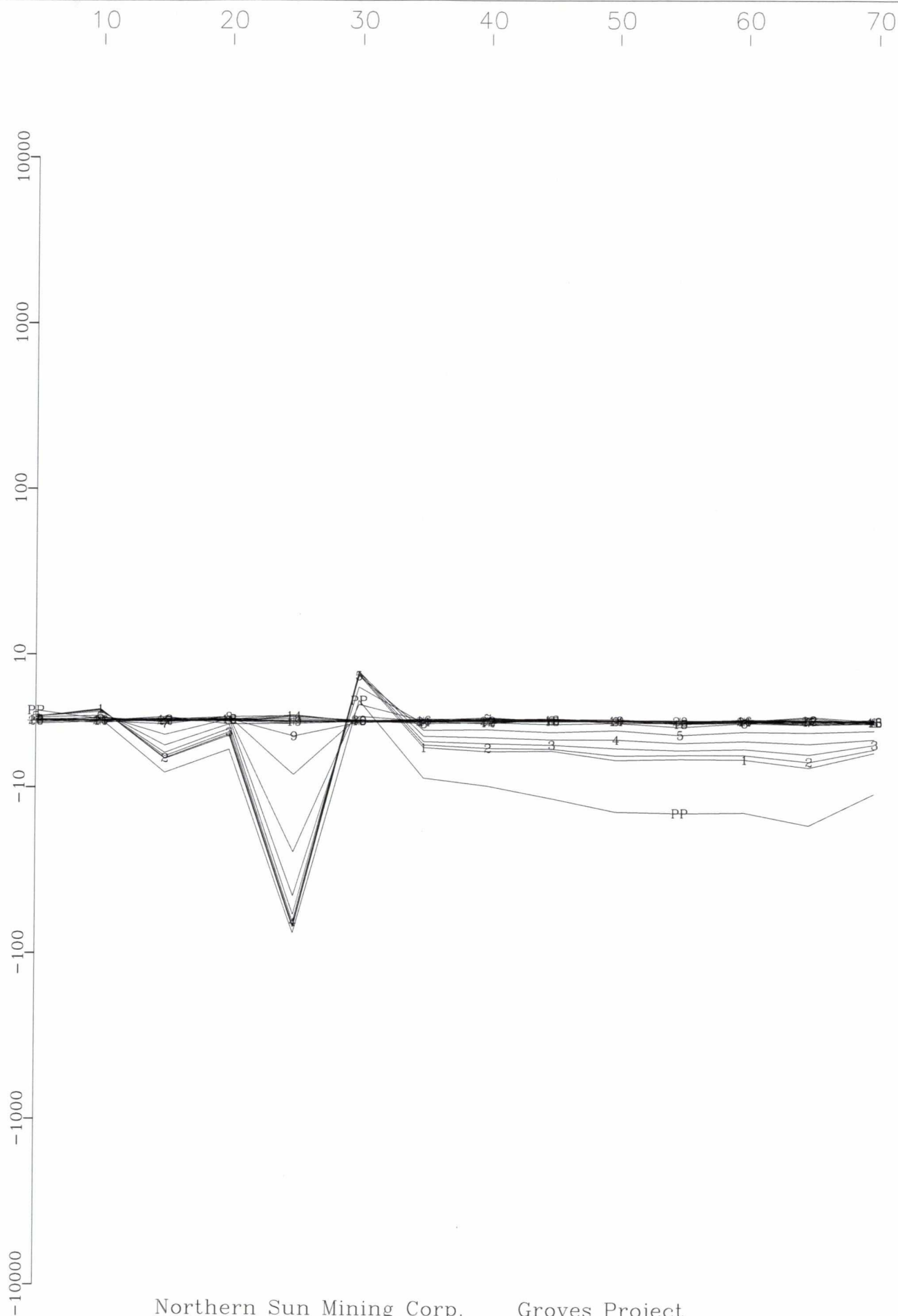
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Hole GR-11-05 Z Component Fluxgate Probe
Crone Geophysics & Exploration Ltd.

Primary Pulse and 22 Off-time Channels
(pT/A)



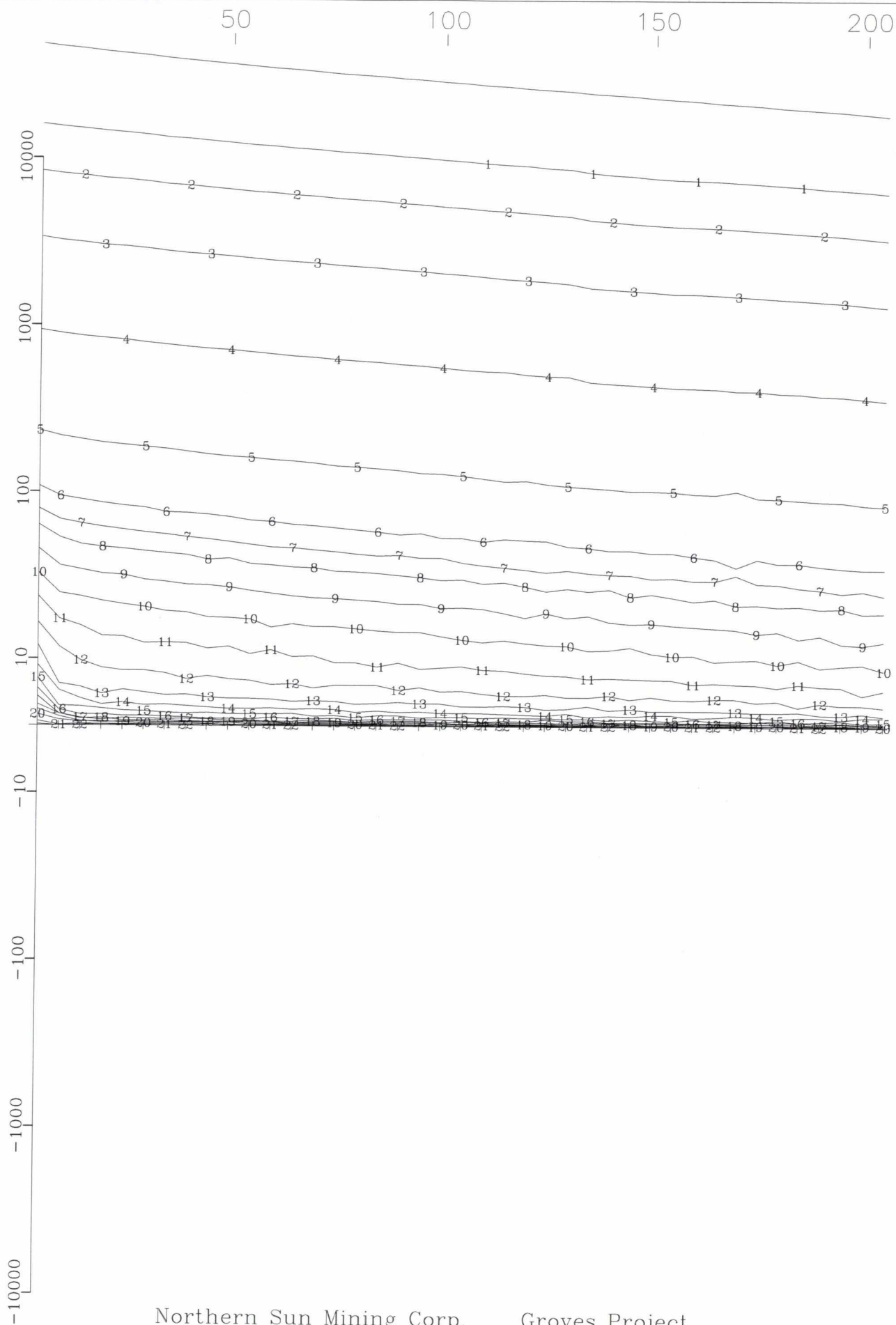
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Hole GR-11-05 X Component Fluxgate Probe
Crone Geophysics & Exploration Ltd.

Primary Pulse and 22 Off-time Channels
(pT/A)



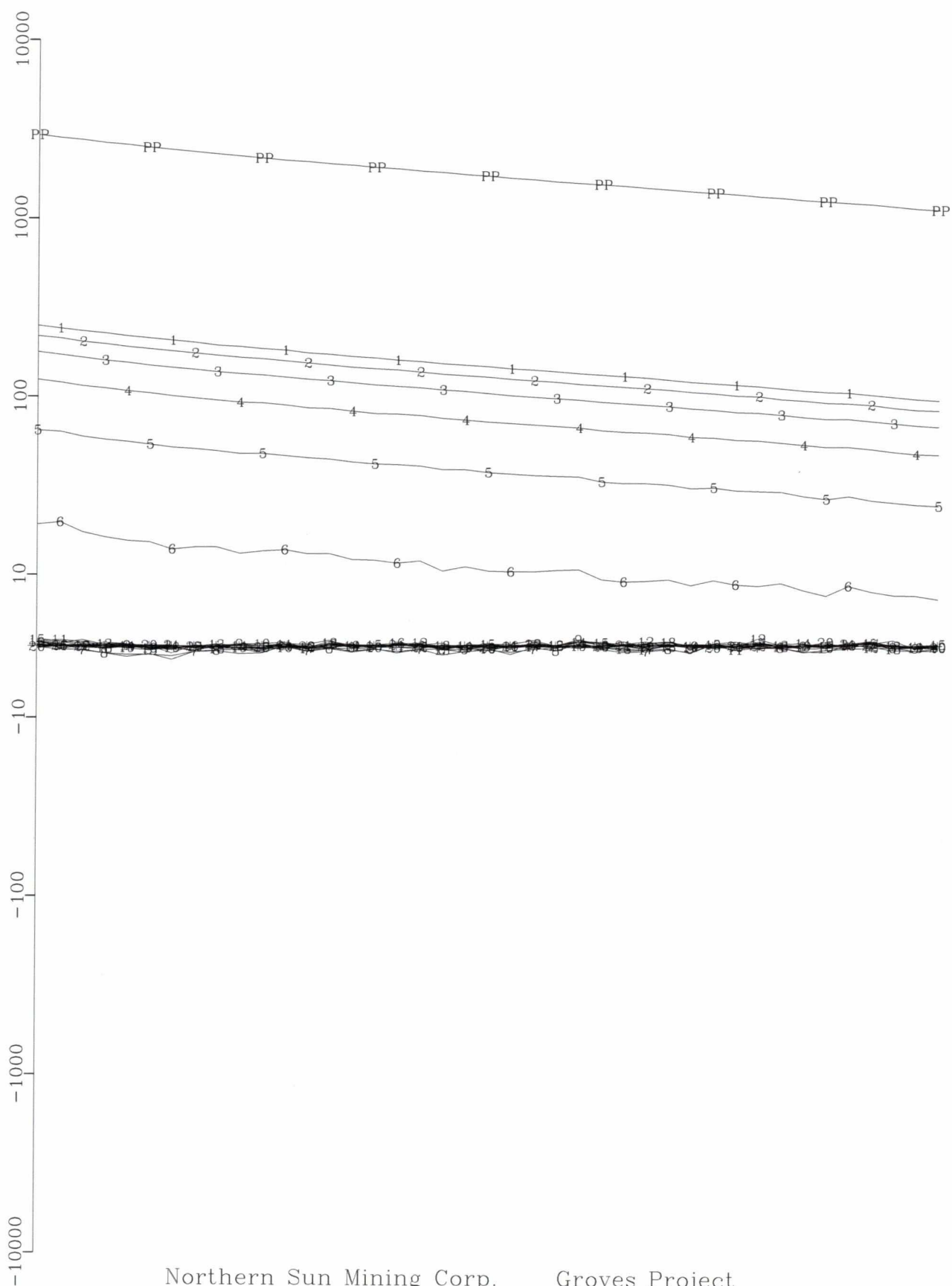
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Hole GR-11-05 Y Component Fluxgate Probe
Crone Geophysics & Exploration Ltd.

Primary Pulse and 22 Off-time Channels
(nT/sec)



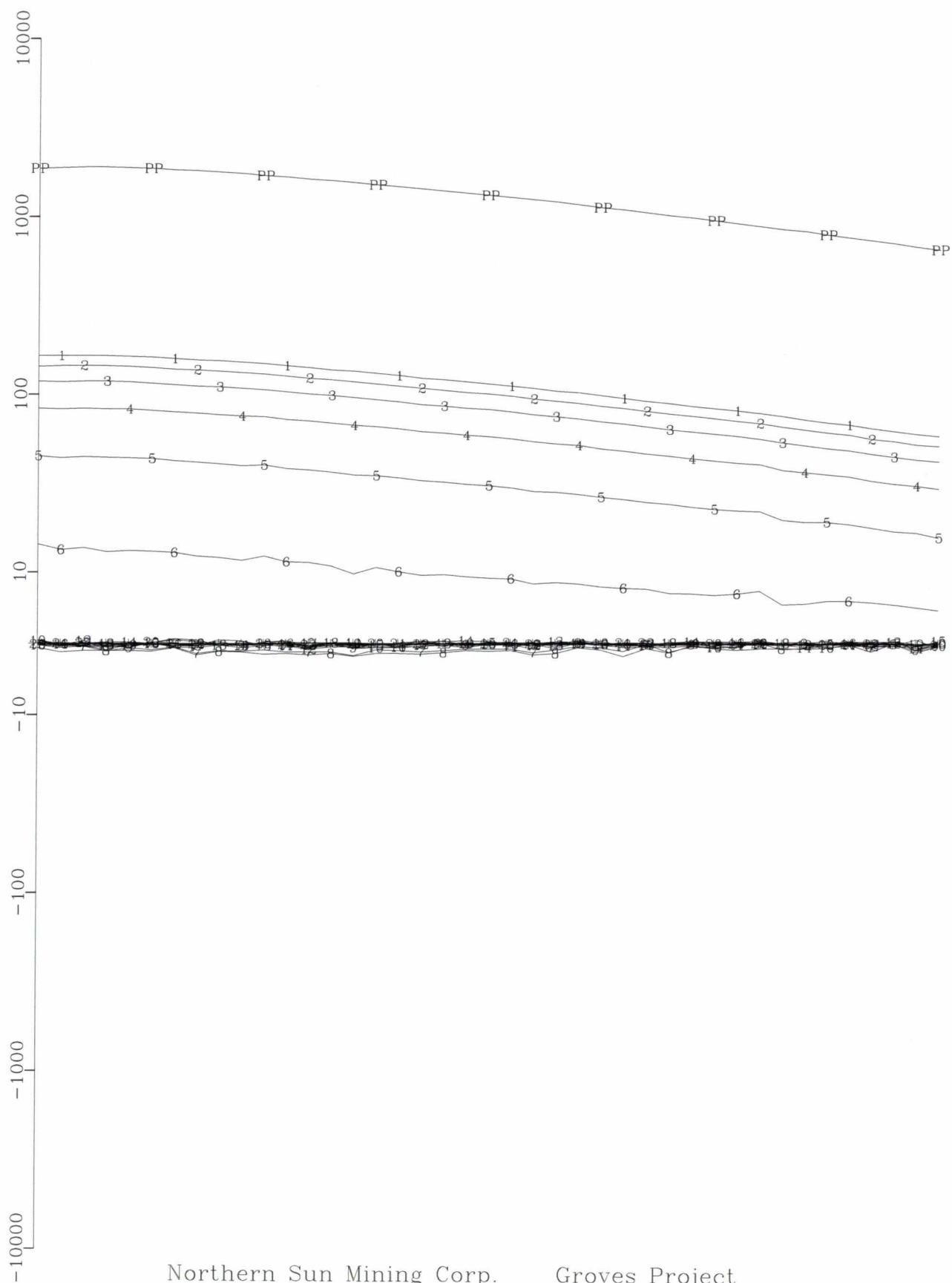
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Hole GR-11-13 Z Component Induction Probe
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Primary Pulse and 22 Off-time Channels
(pT/A)



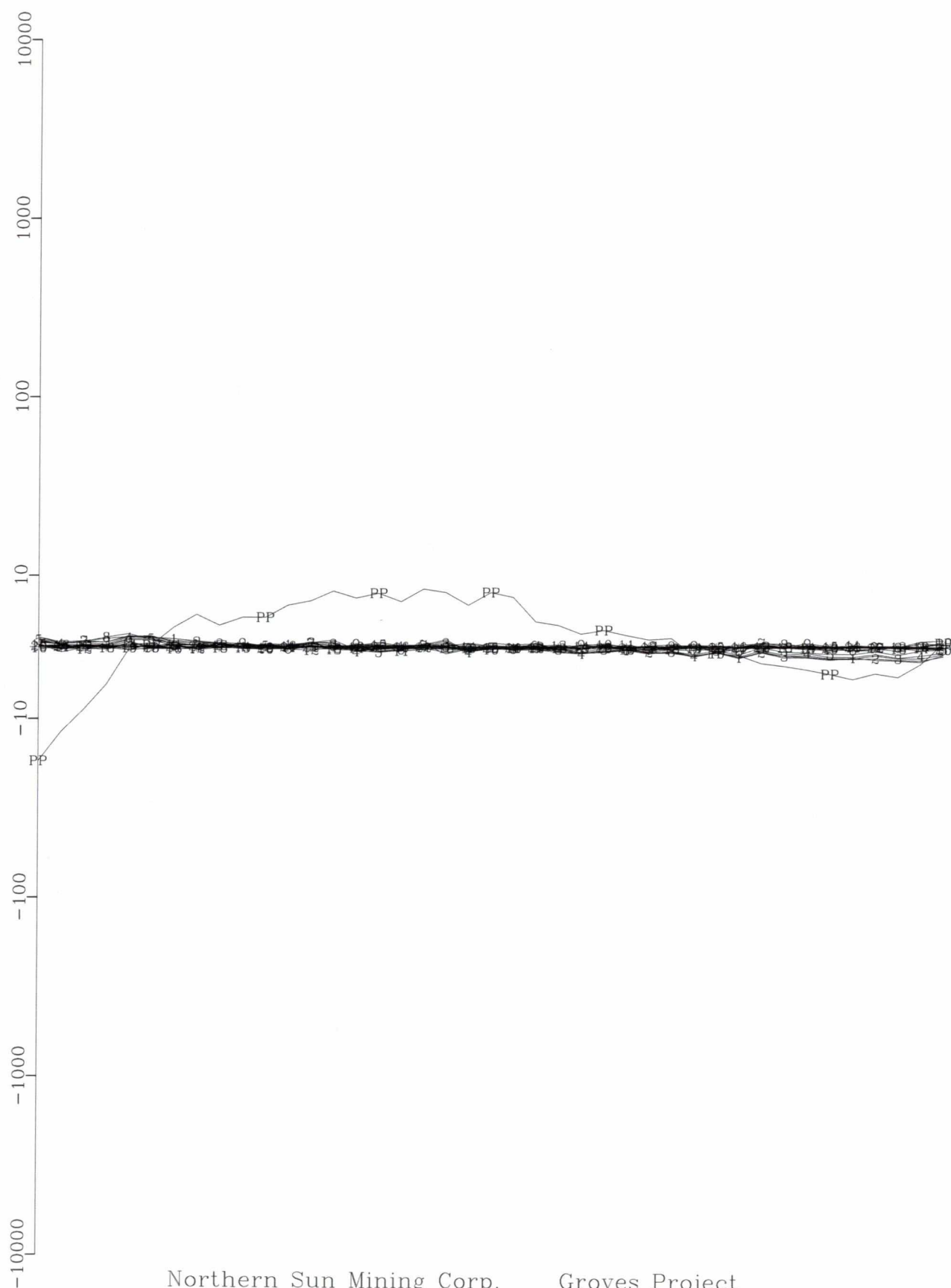
Northern Sun Mining Corp. Groves Project
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Primary Pulse and 22 Off-time Channels
(pT/A)



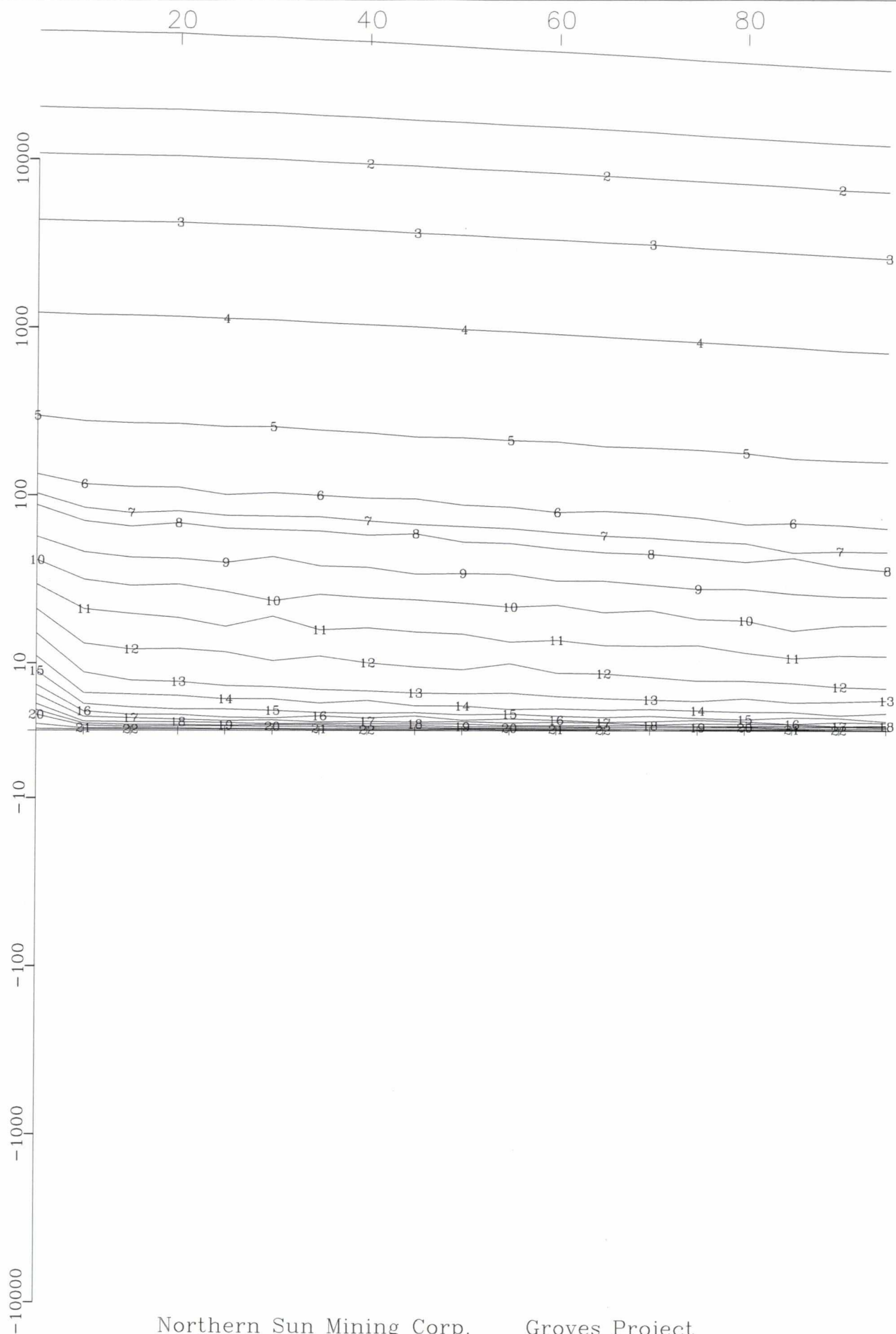
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(pT/A)



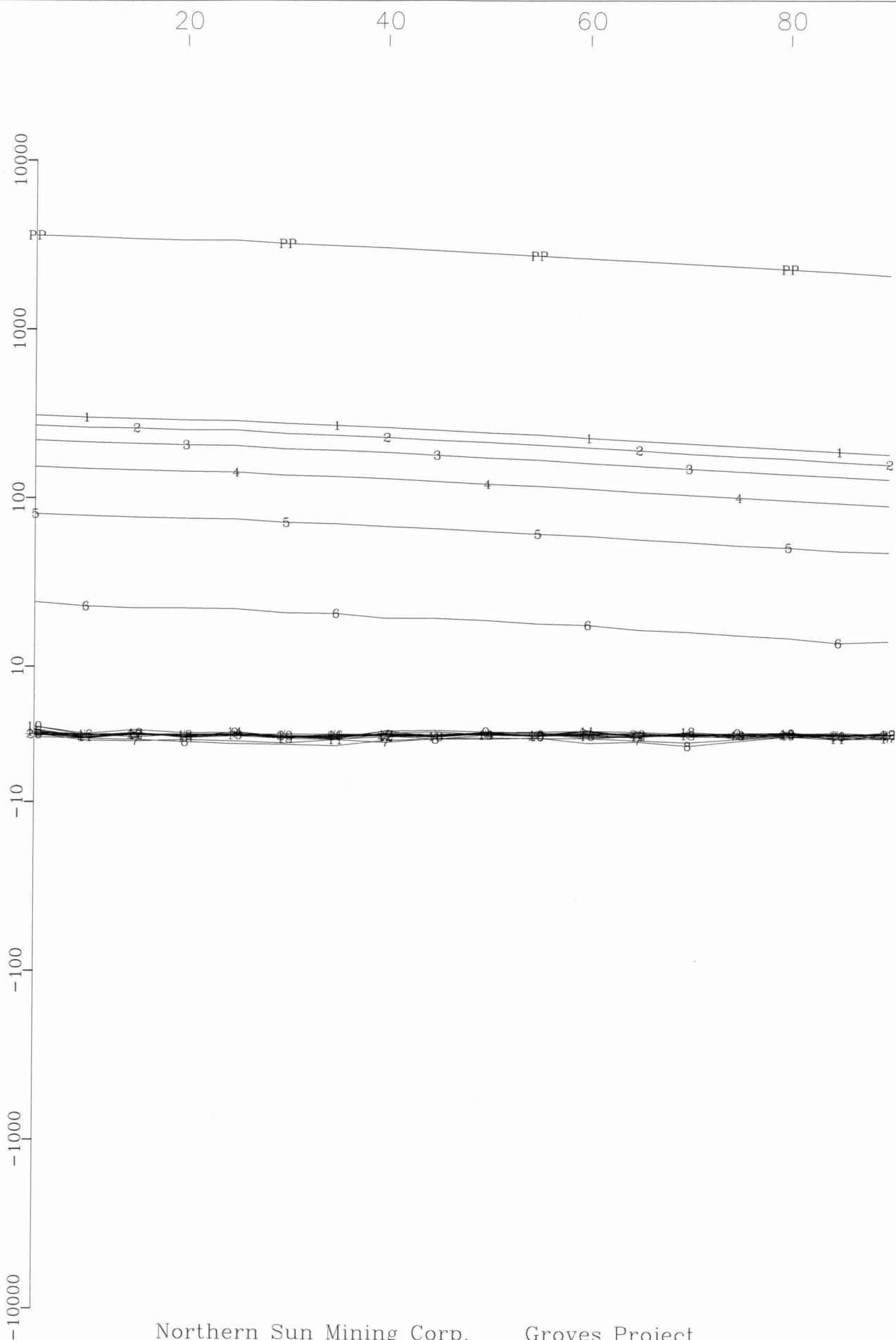
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Hole GR-11-13 Y Component Fluxgate Probe
Crone Geophysics & Exploration Ltd.

Primary Pulse and 22 Off-time Channels
(nT/sec)



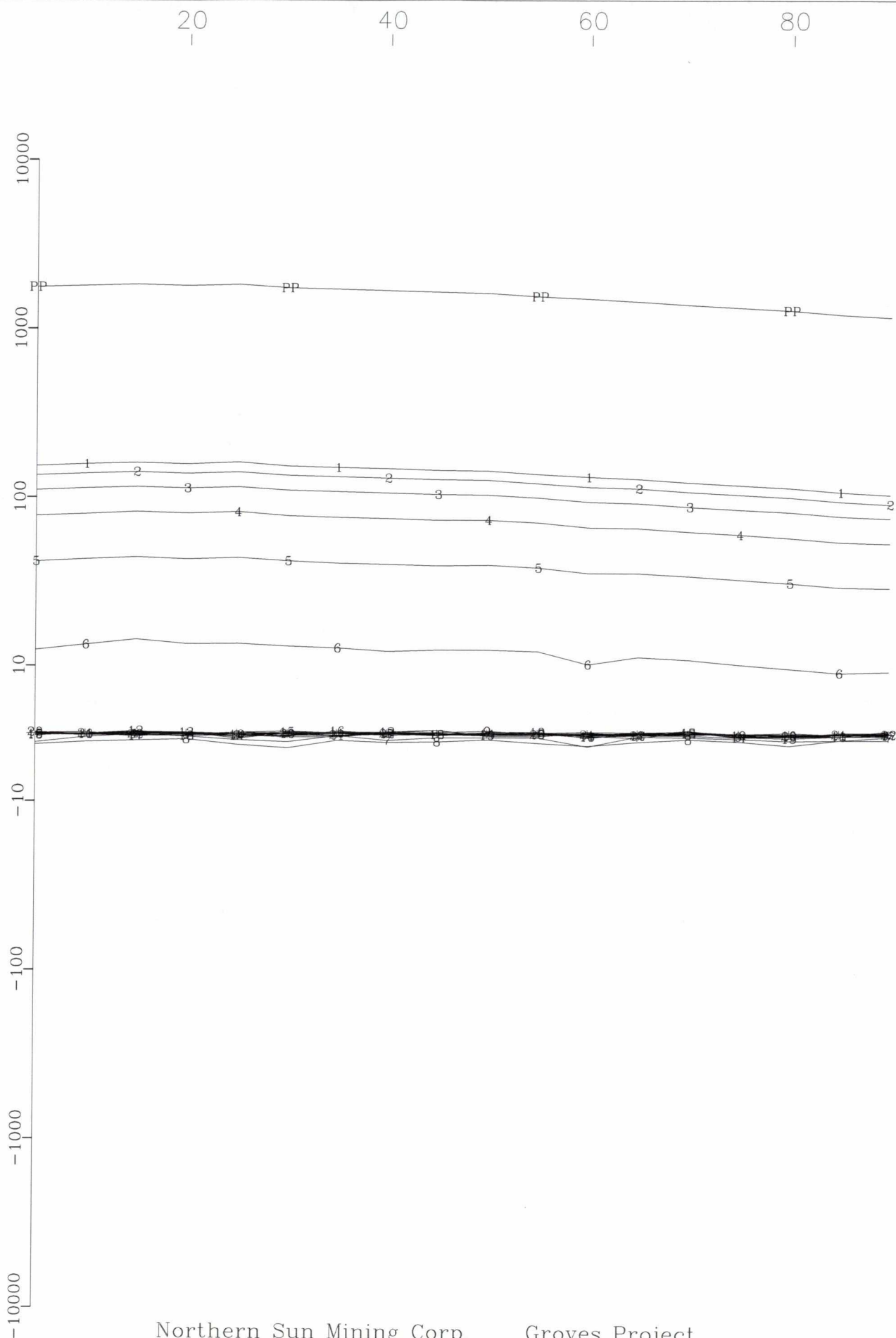
Northern Sun Mining Corp. Groves Project
Hole GR-90-165 Z Component Induction Probe
Crone Geophysics & Exploration Ltd.

Primary Pulse and 22 Off-time Channels
(pT/A)



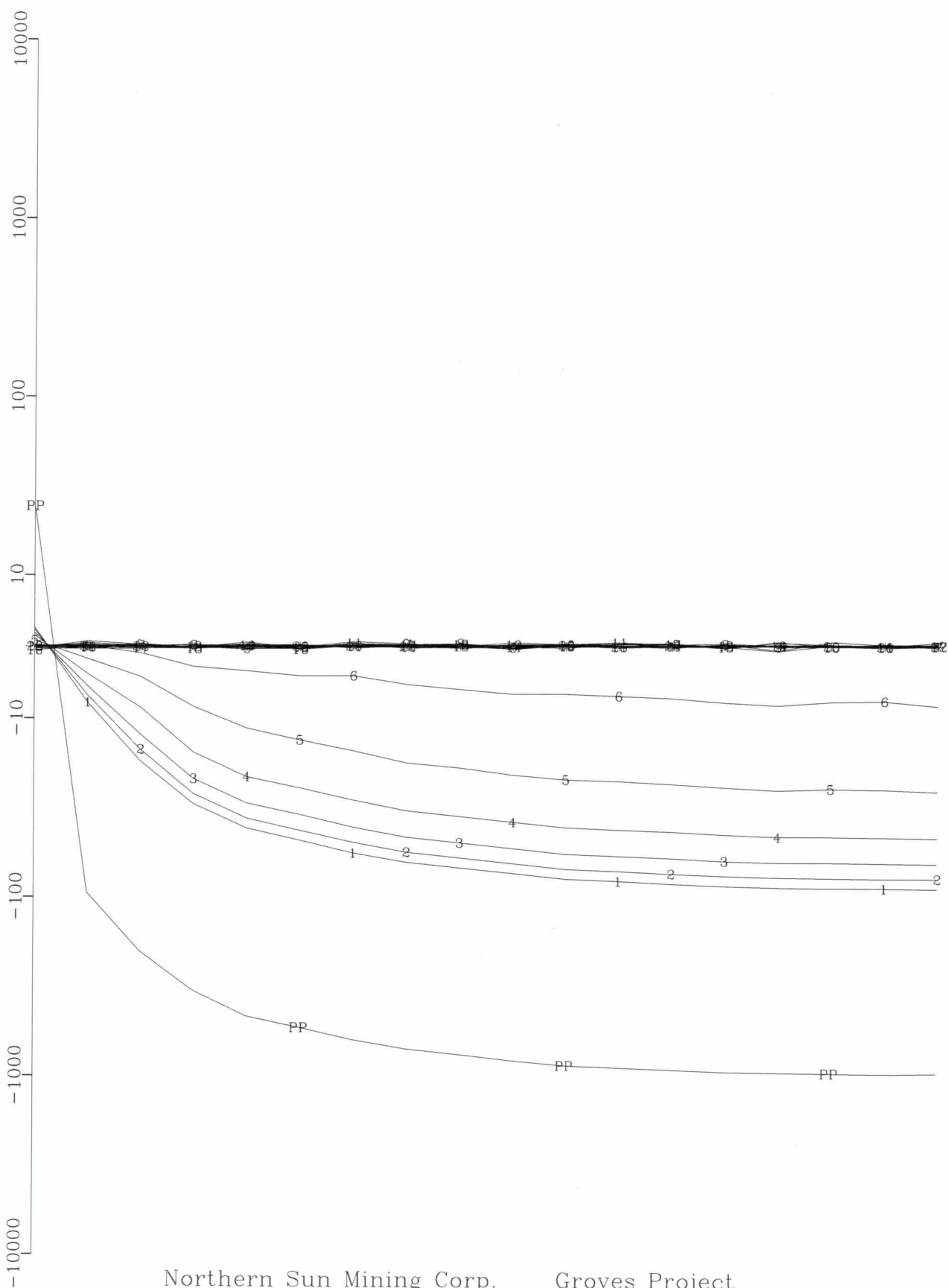
Northern Sun Mining Corp. Groves Project
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Crone Geophysics & Exploration Ltd.

Primary Pulse and 22 Off-time Channels
(pT/A)



Northern Sun Mining Corp. Groves Project
Hole GR-90-165 X Component Fluxgate Probe
Crone Geophysics & Exploration Ltd.

Primary Pulse and 22 Off-time Channels
(pT/A)

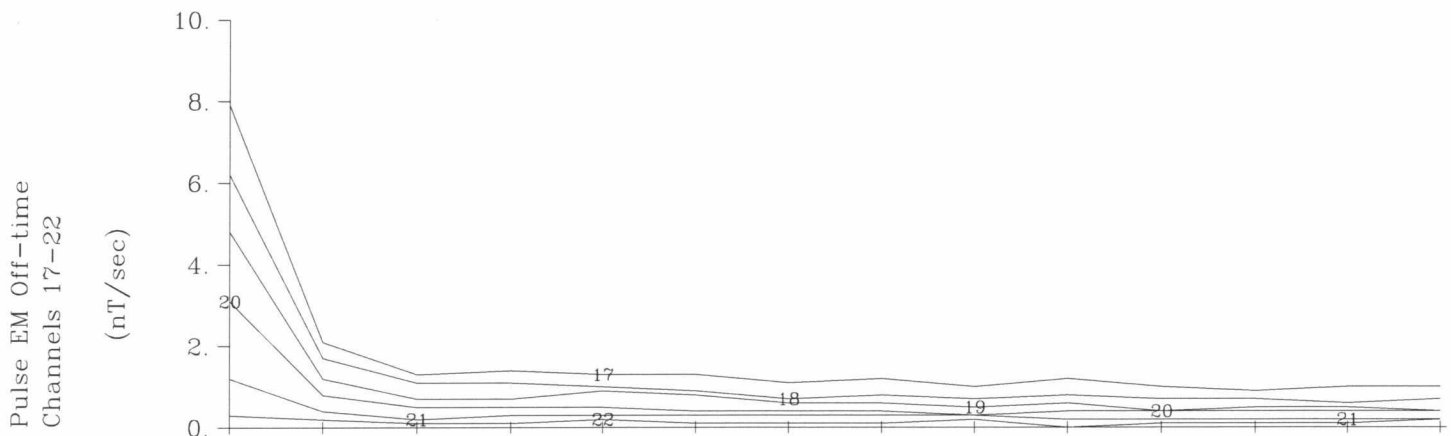
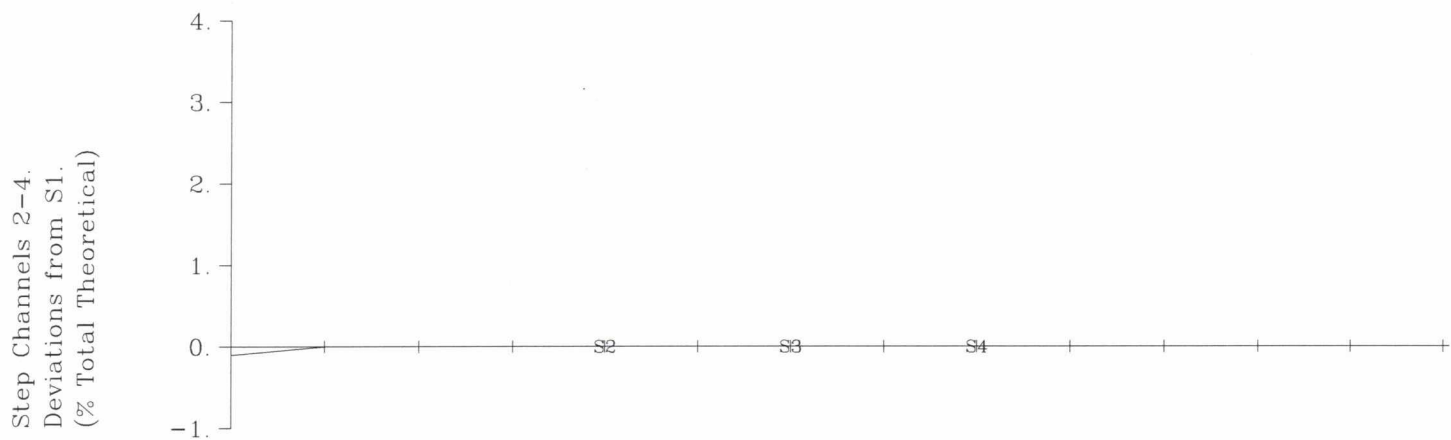
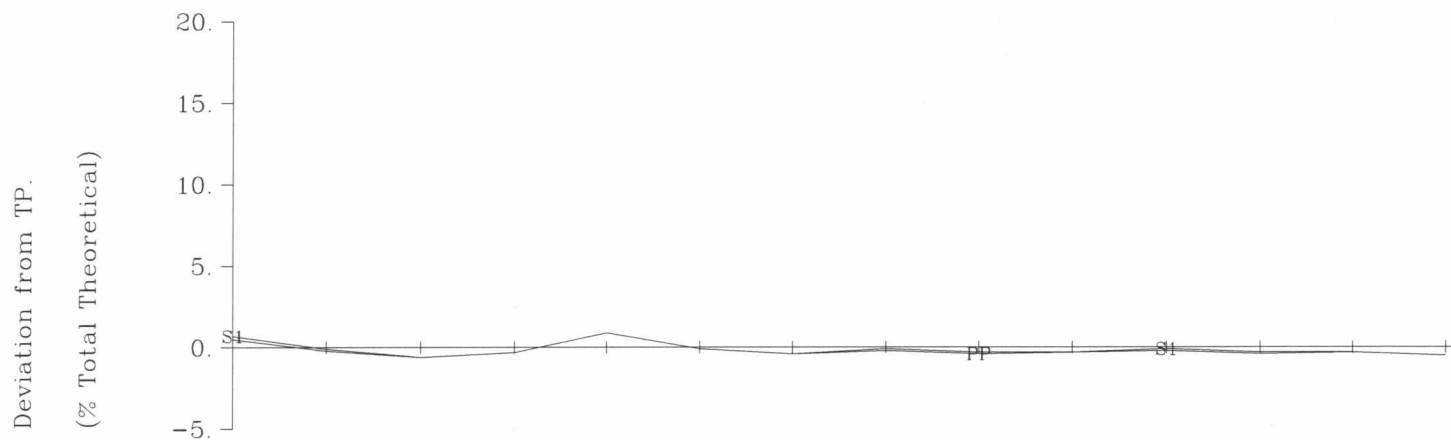
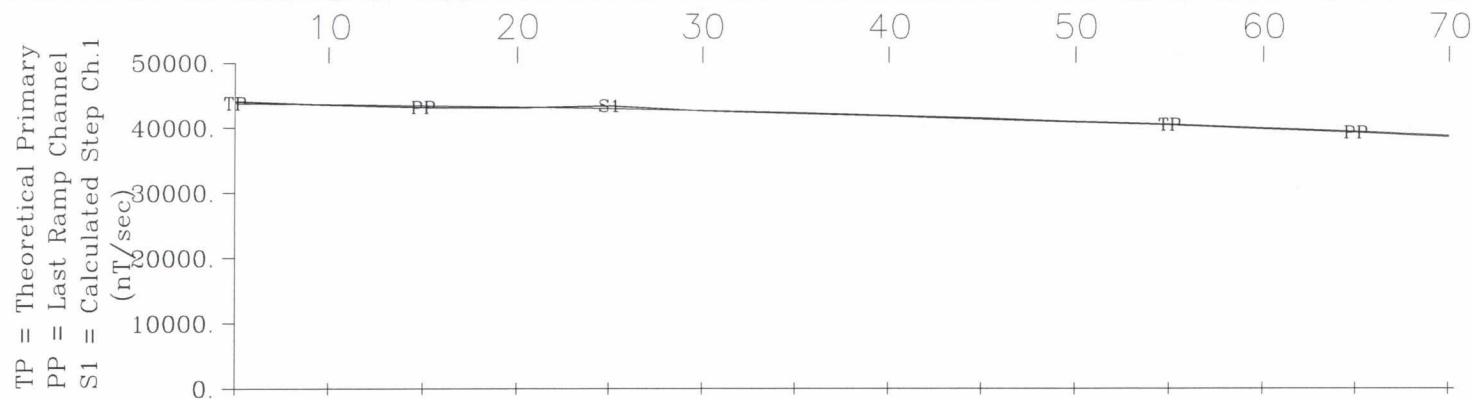


Northern Sun Mining Corp. Groves Project
Hole GR-90-165 Y Component Fluxgate Probe
Crone Geophysics & Exploration Ltd.



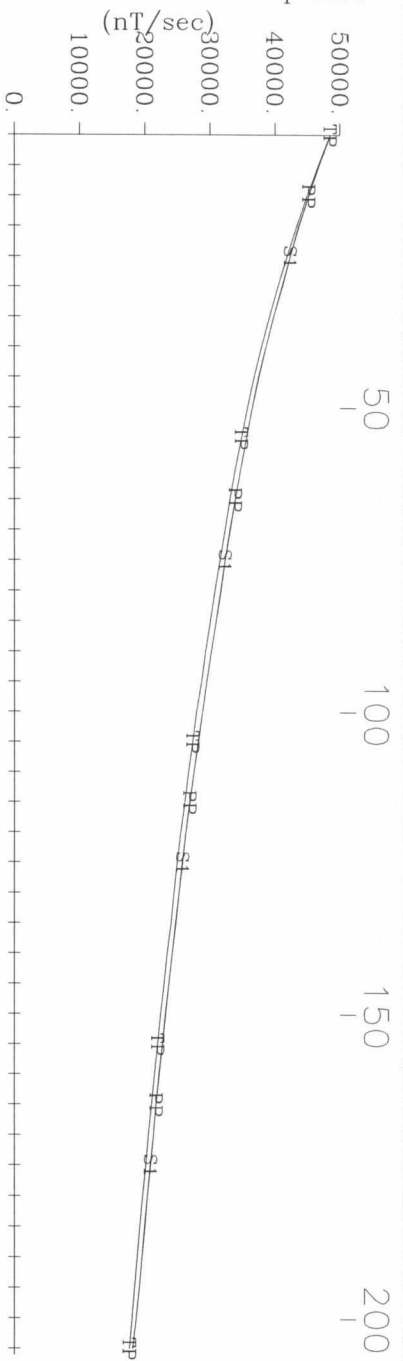
Appendix 4: Step Response Data Profiles



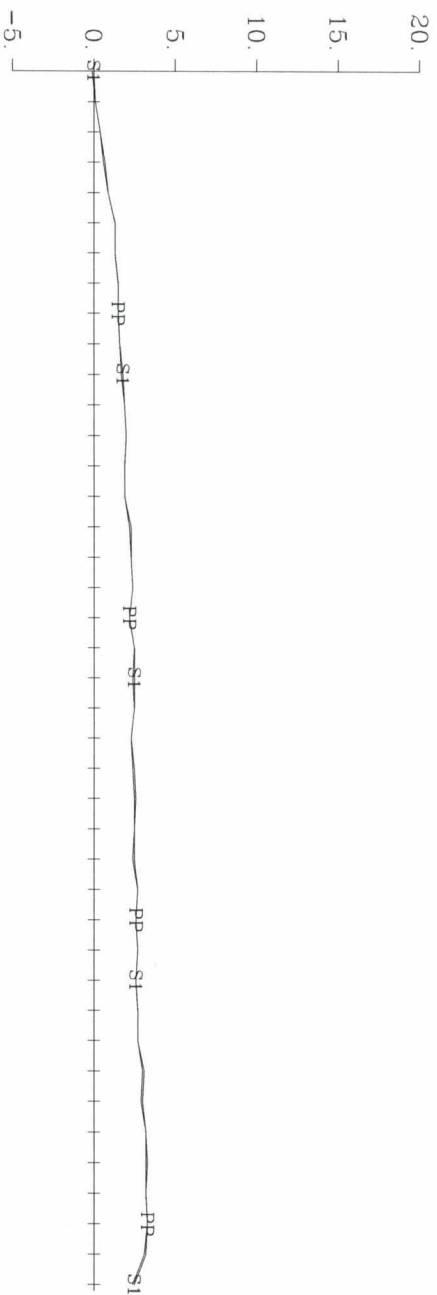


Northern Sun Mining Corp. Groves Project
 Loop 1, Hole GR-11-05 Z Component Induction Probe
 Crone Geophysics & Exploration Ltd.

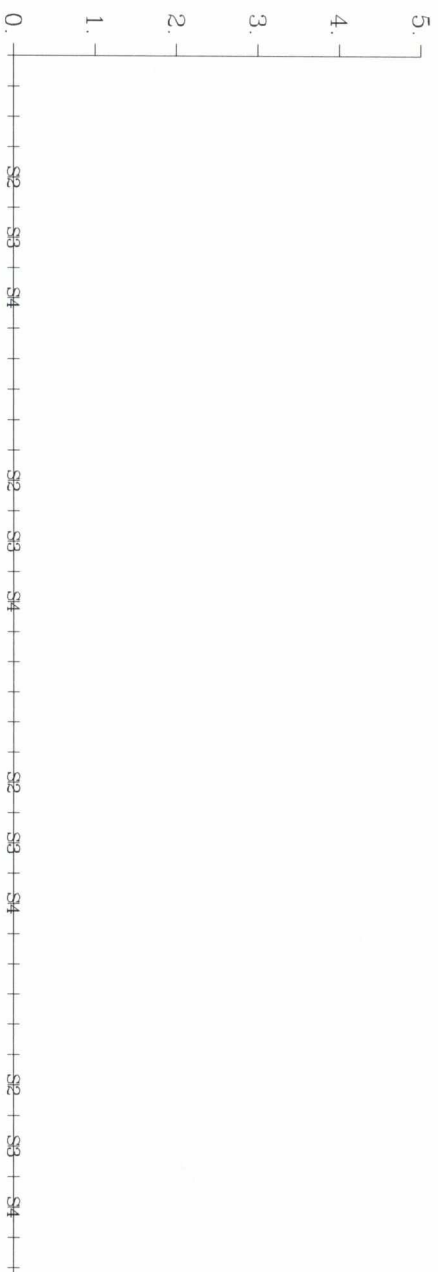
TP = Theoretical Primary
 PP = Last Ramp Channel
 S1 = Calculated Step Ch.1



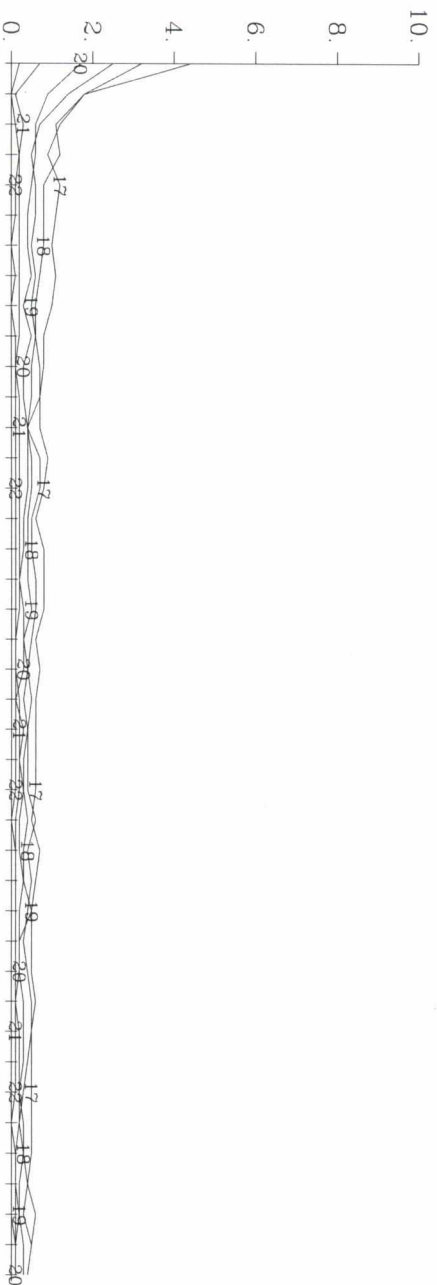
Deviation from TP.
 (% Total Theoretical)



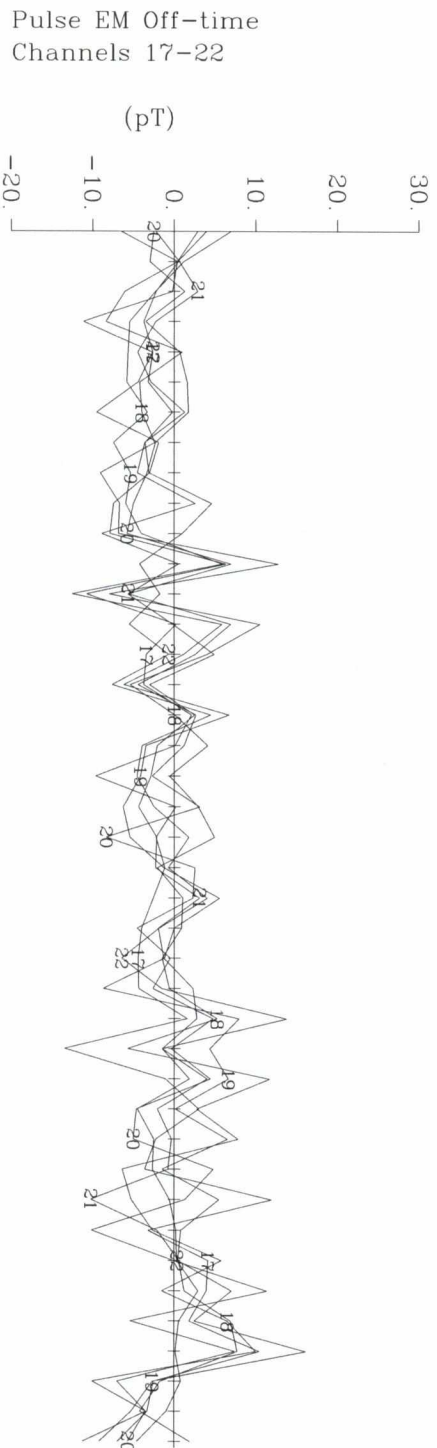
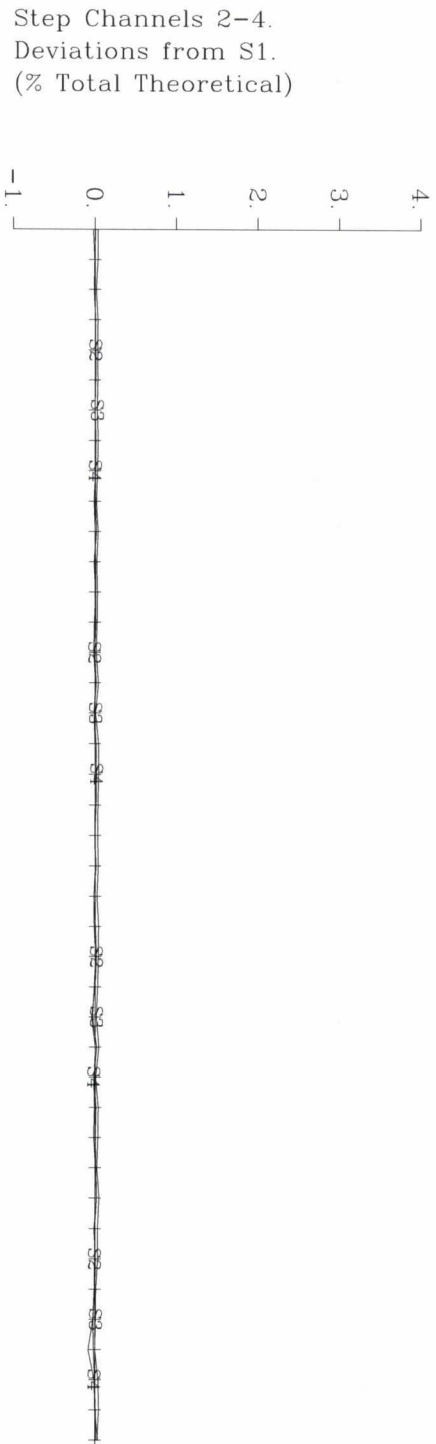
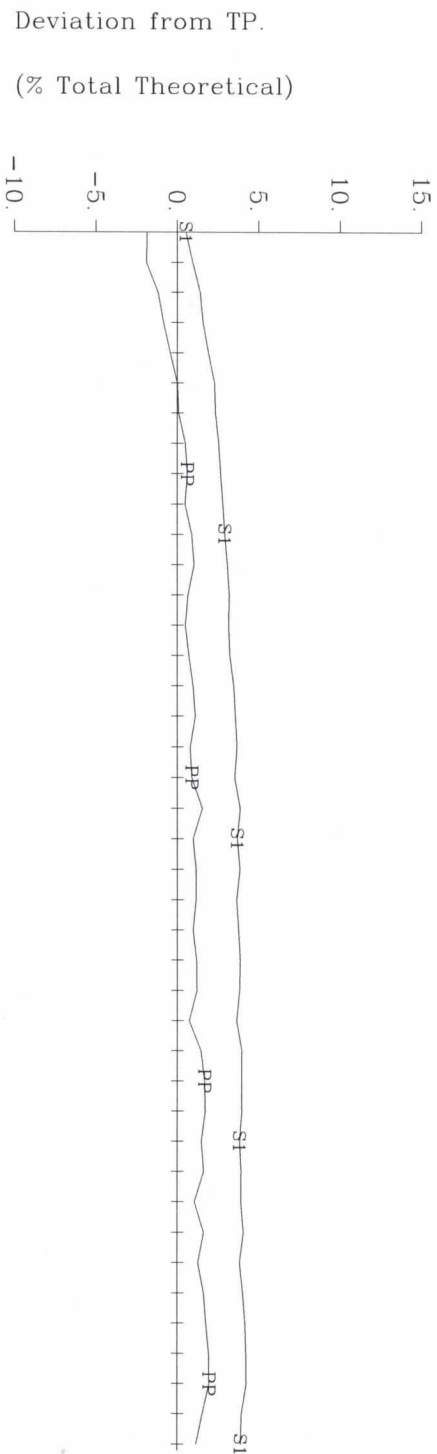
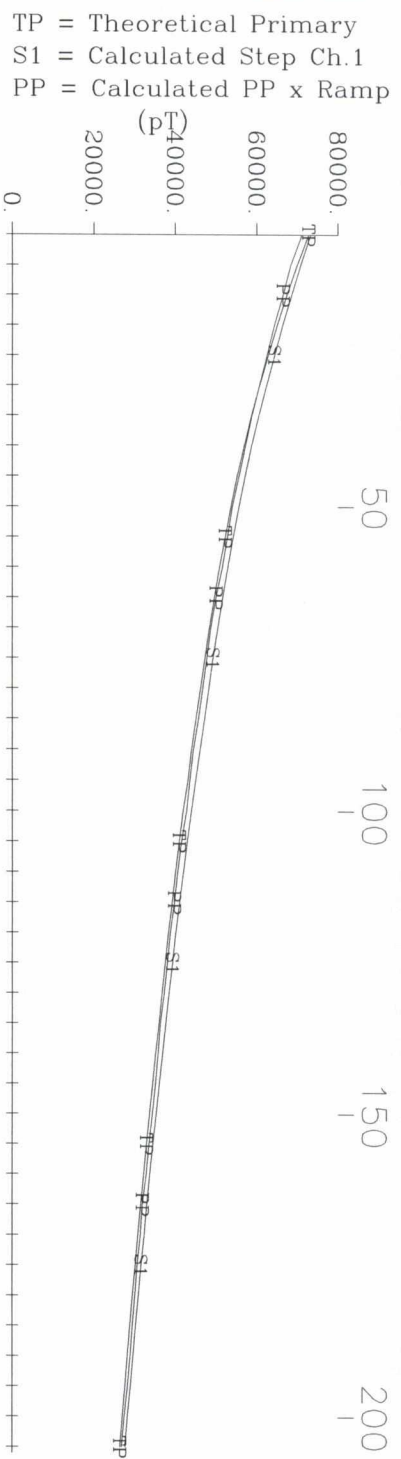
Step Channels 2-4.
 Deviations from S1.
 (% Total Theoretical)

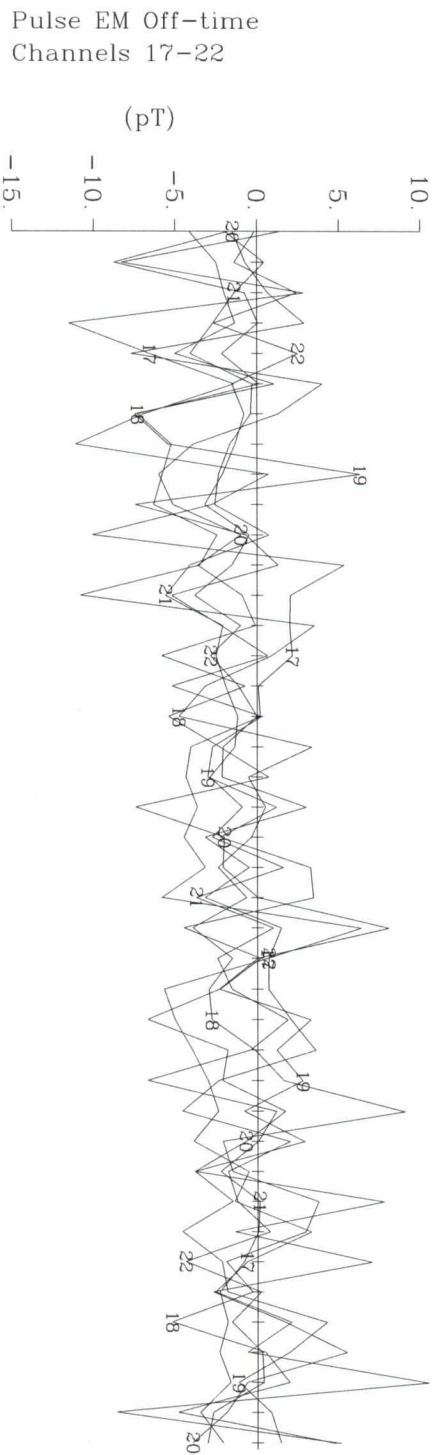
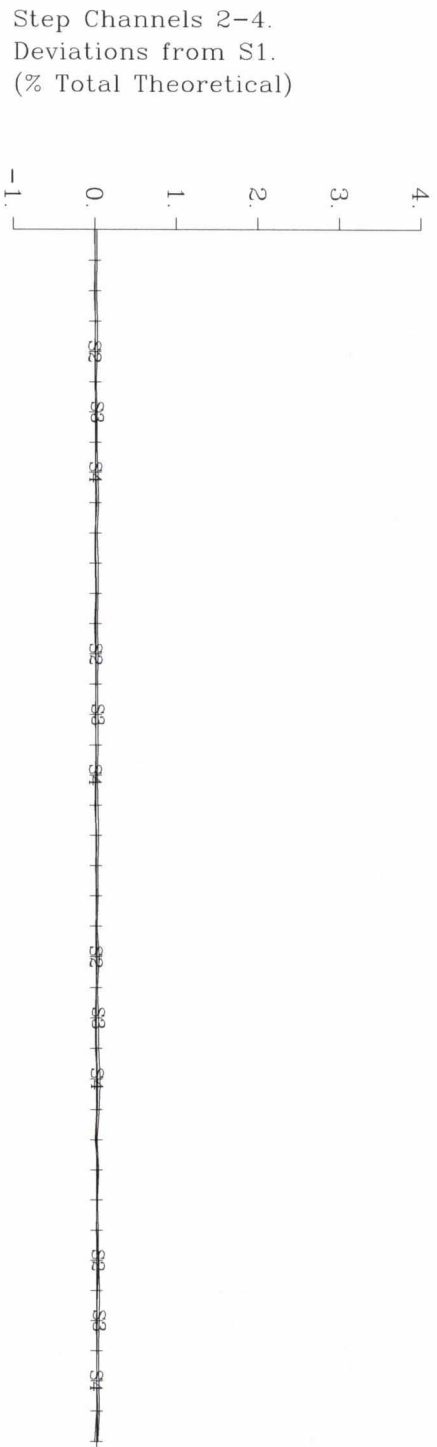
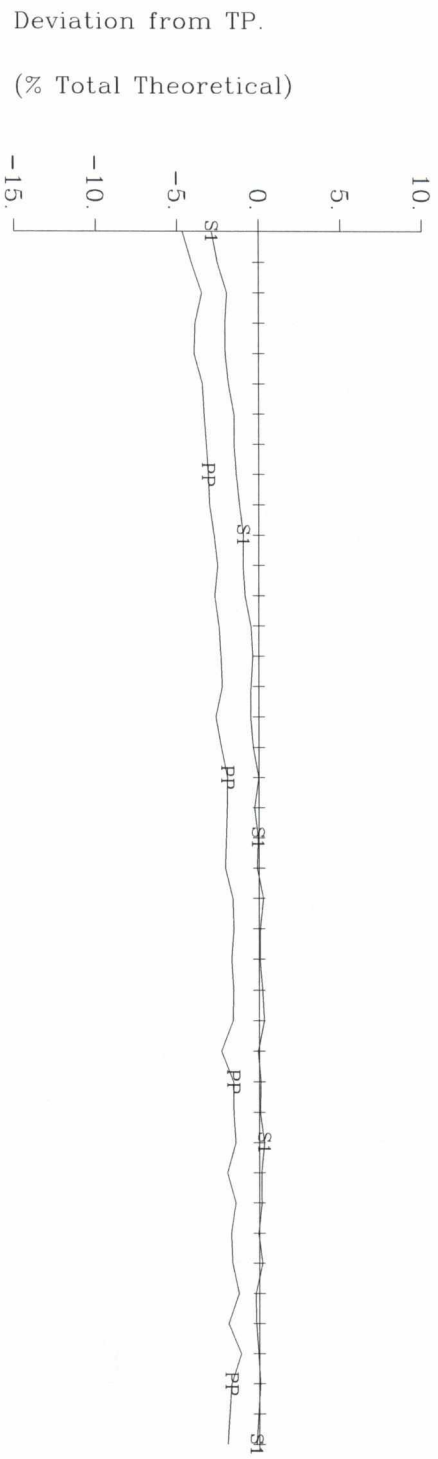
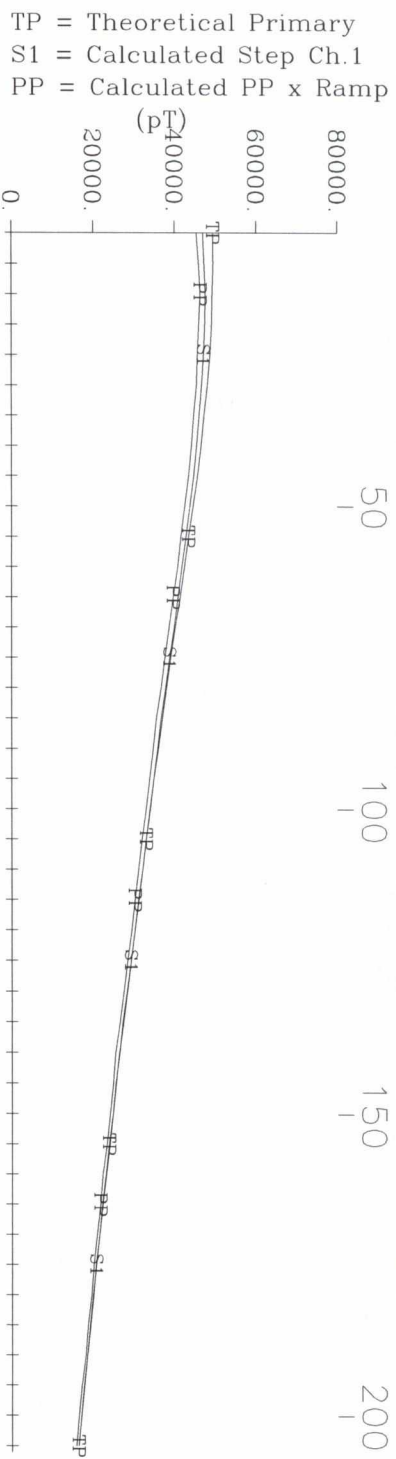


Pulse EM Off-time
 Channels 17-22
 (nT/sec)

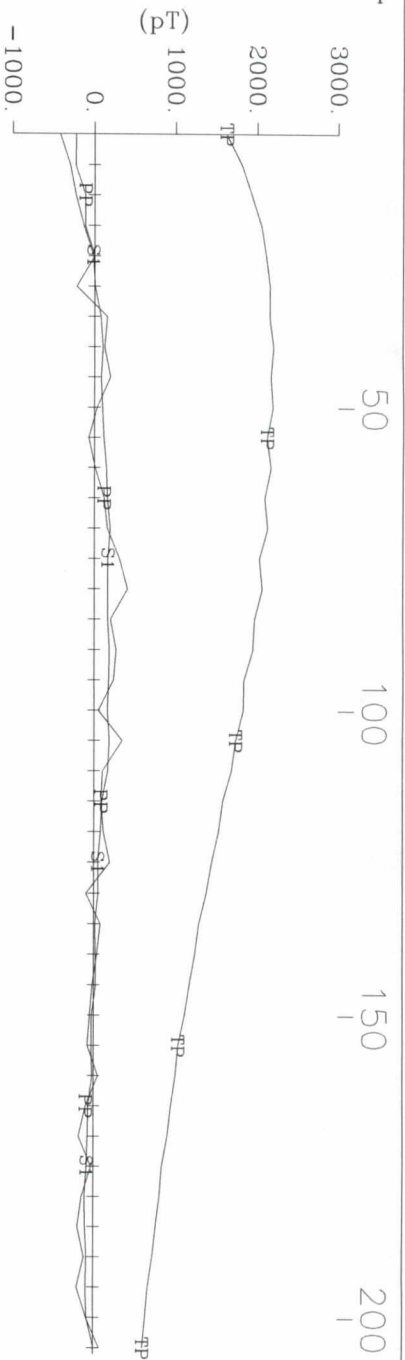


Northern Sun Mining Corp. Groves Project
 Loop 1, Hole GR-11-13 Z Component Induction Probe
 Crone Geophysics & Exploration Ltd.

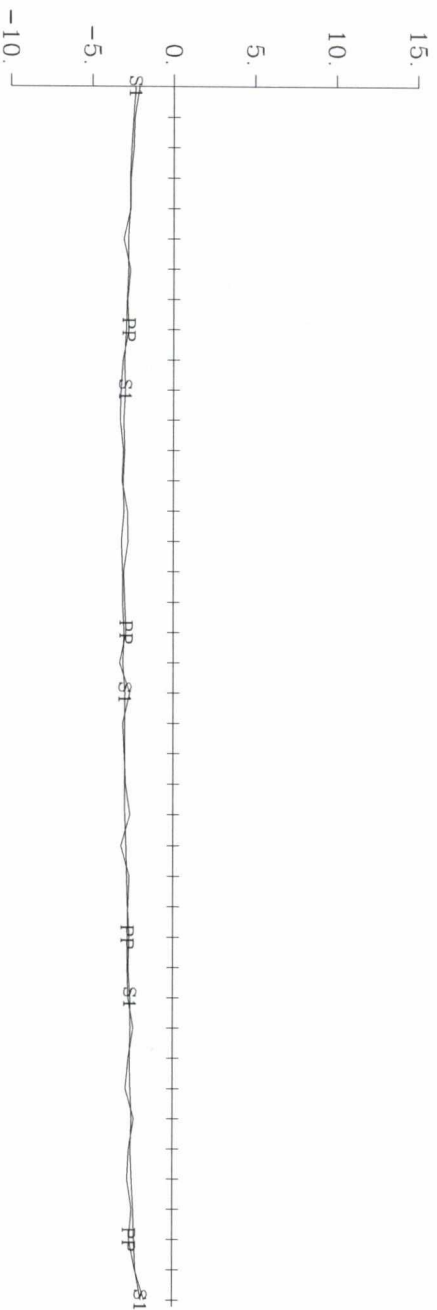




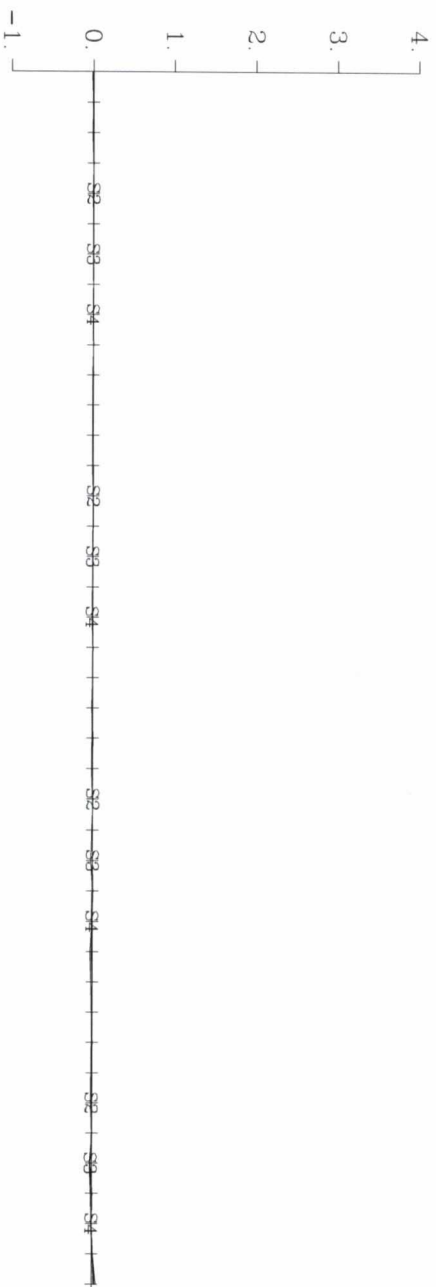
TP = Theoretical Primary
 S1 = Calculated Step Ch.1
 PP = Calculated PP x Ramp



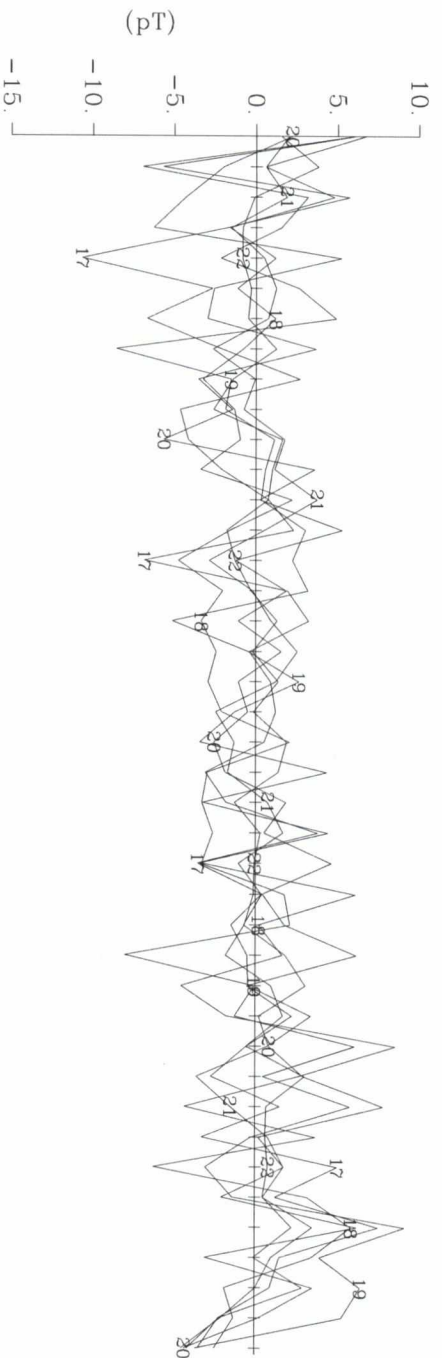
Deviation from TP.
 (% Total Theoretical)



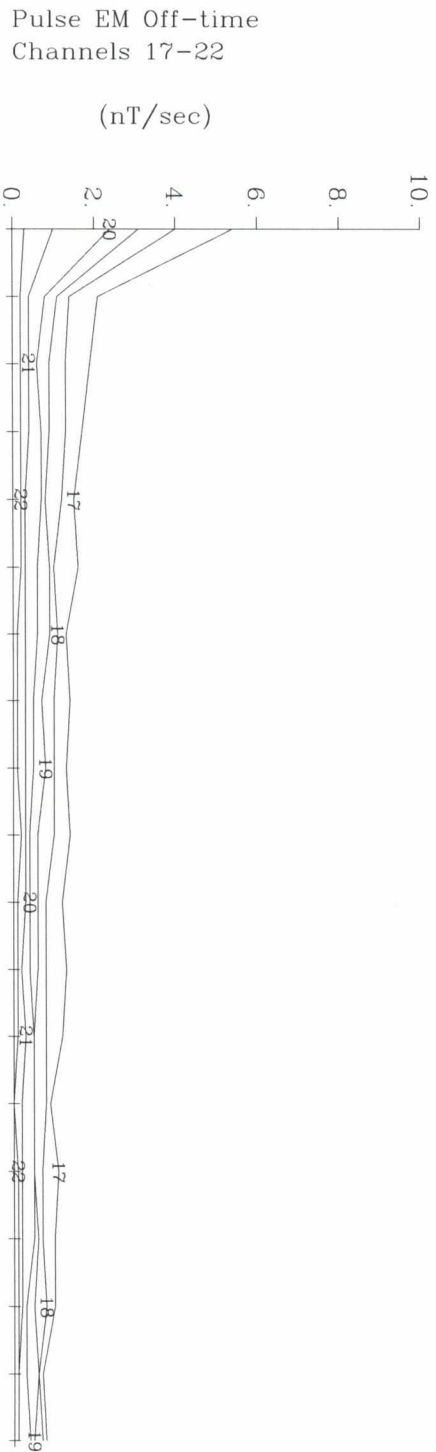
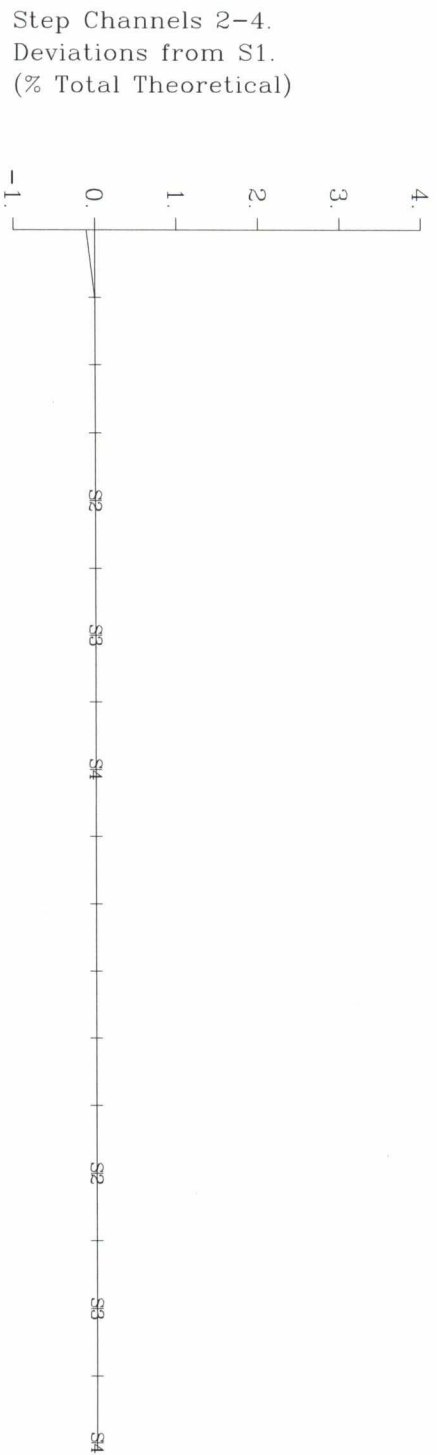
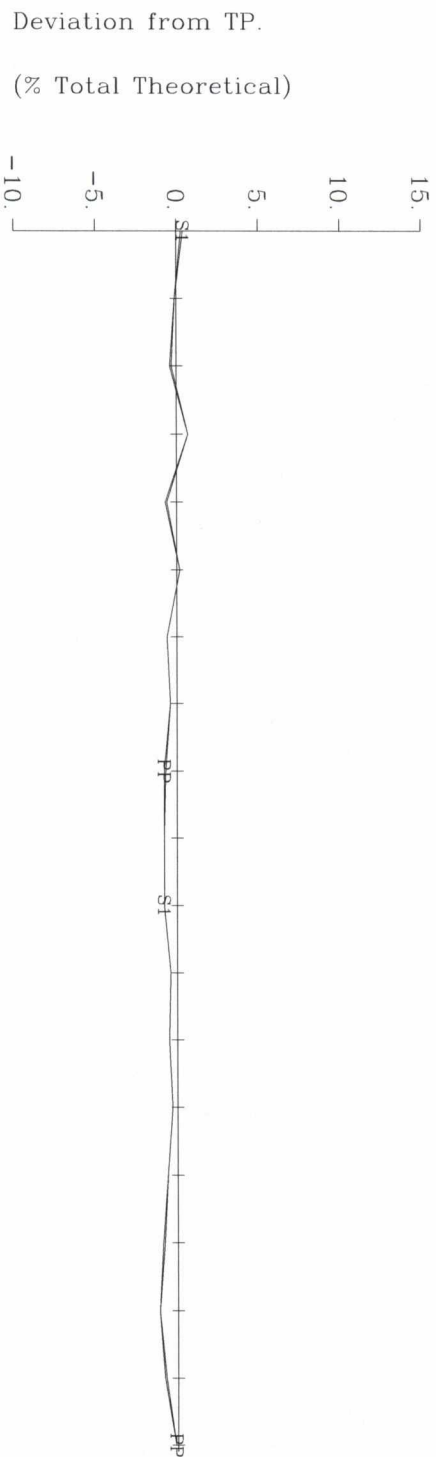
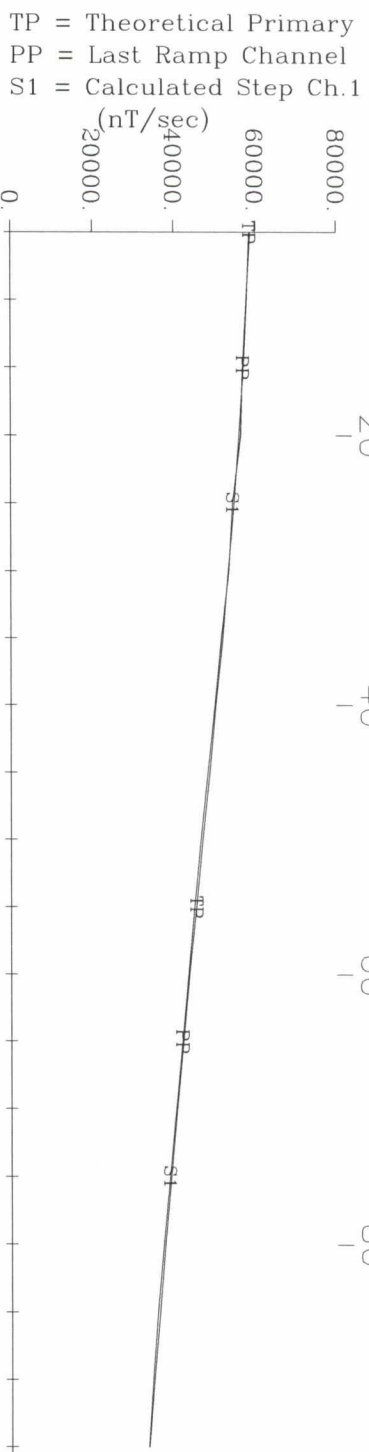
Step Channels 2-4.
 Deviations from S1.
 (% Total Theoretical)



Pulse EM Off-time
 Channels 17-22

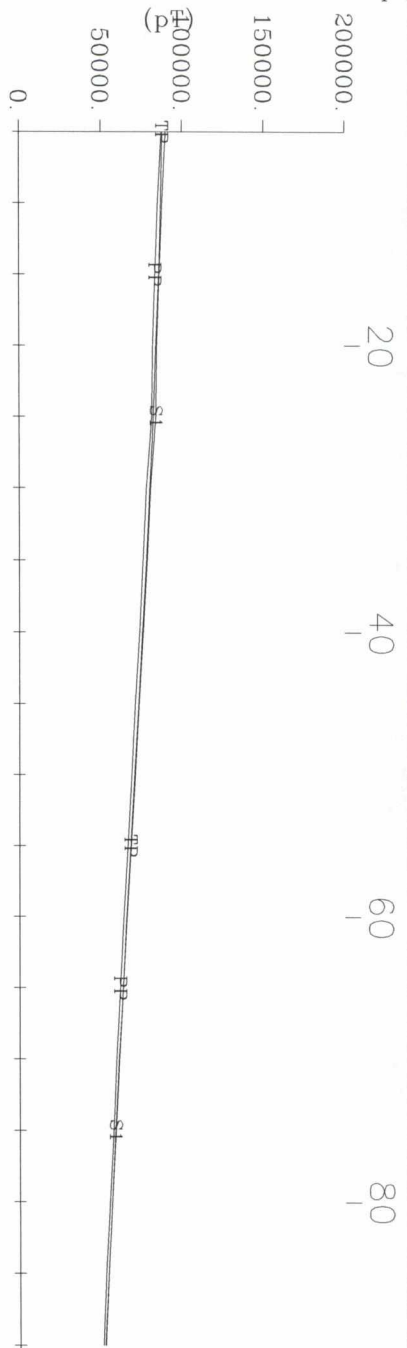


Northern Sun Mining Corp. Groves Project 100ms B-Field Step
 April 19, 2015 Loop: 1 Hole: GR-11-13 Comp: Y
 Crone Geophysics & Exploration Ltd.

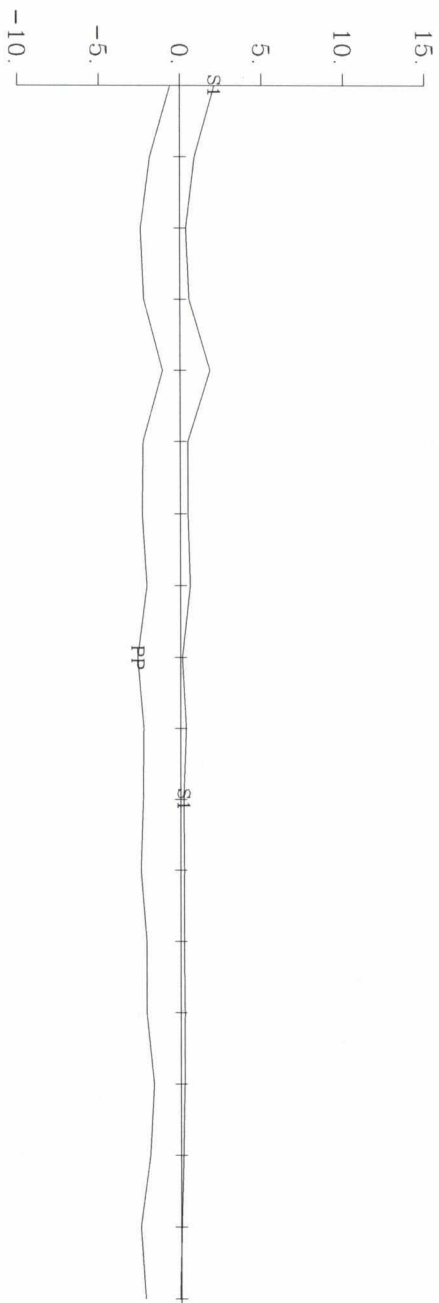


Northern Sun Mining Corp. Groves Project
Loop 1, Hole GR-90-165 Z Component Induction Probe
Crone Geophysics & Exploration Ltd.

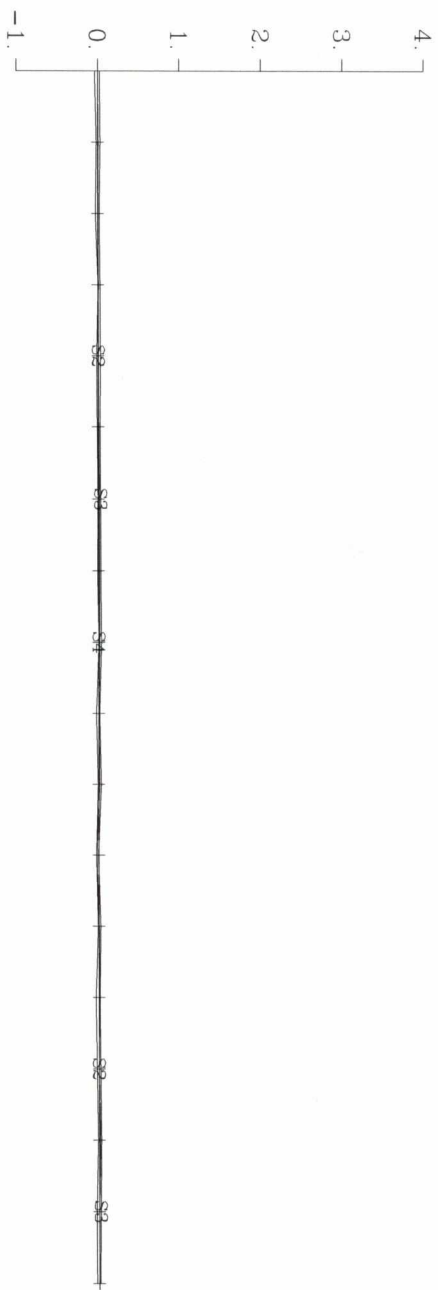
TP = Theoretical Primary
 S1 = Calculated Step Ch.1
 PP = Calculated PP x Ramp



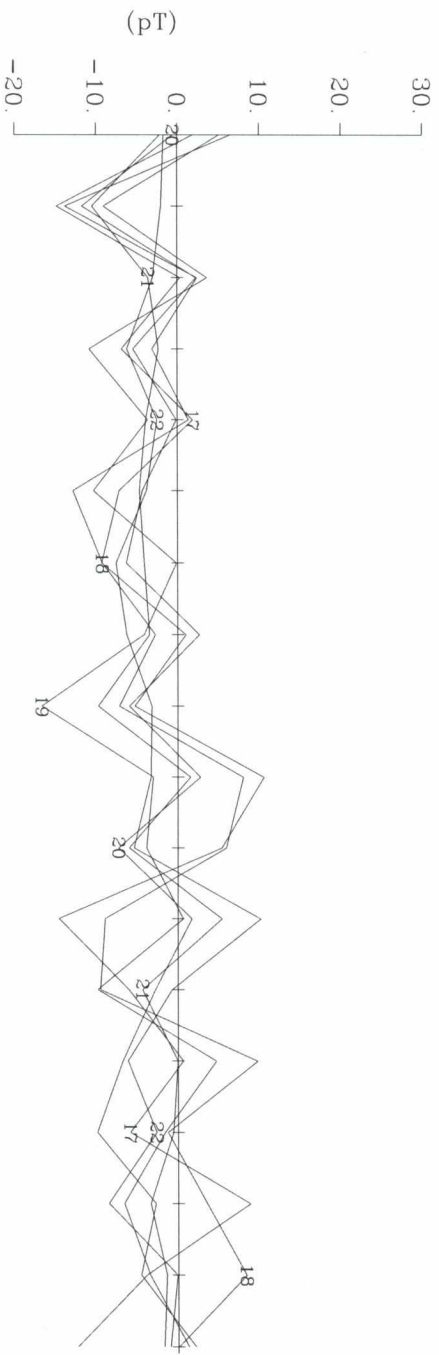
Deviation from TP.
 (% Total Theoretical)



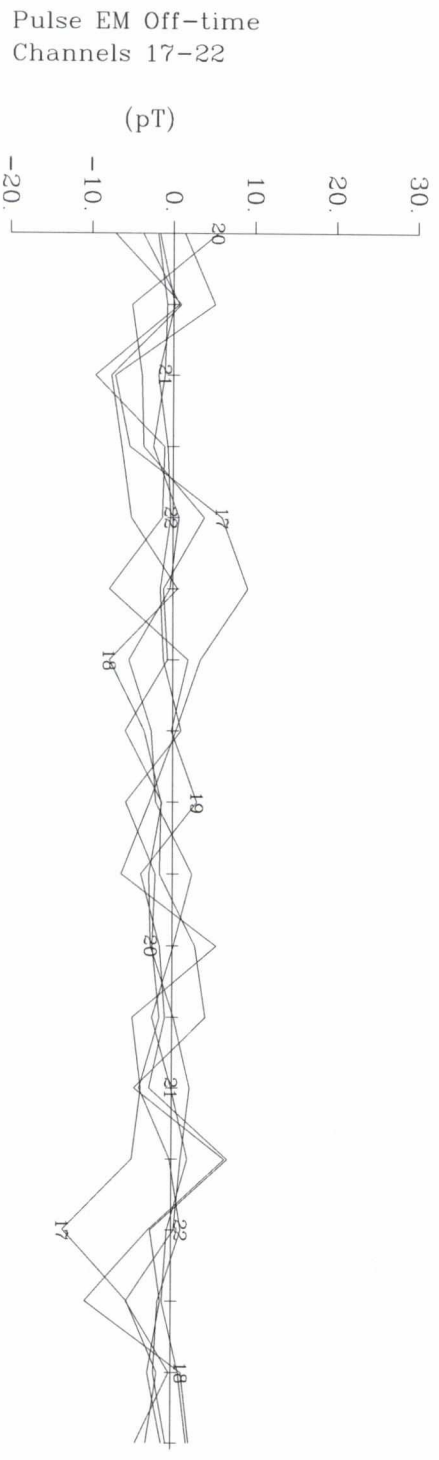
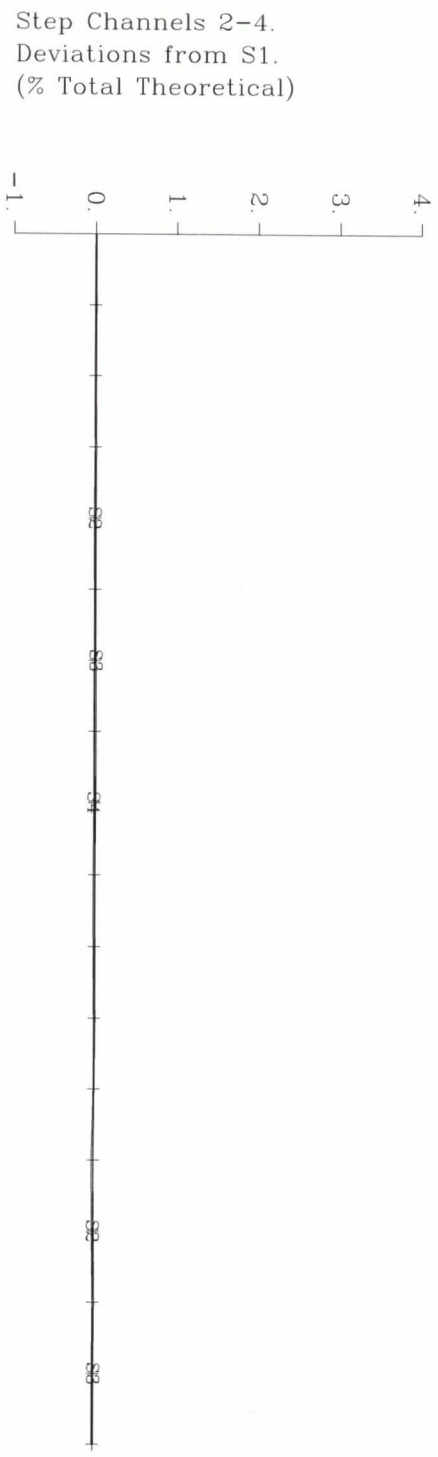
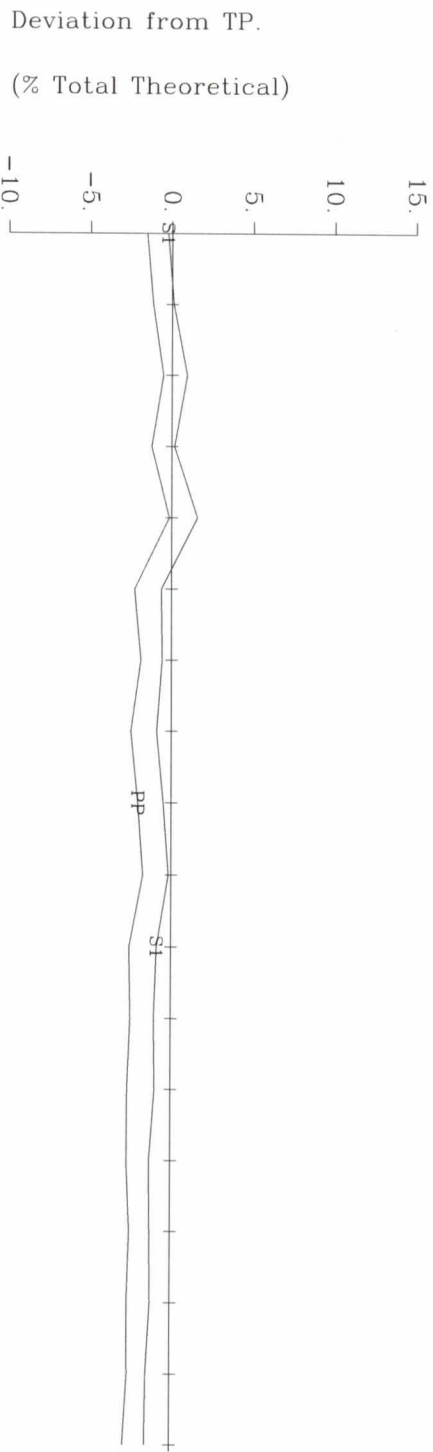
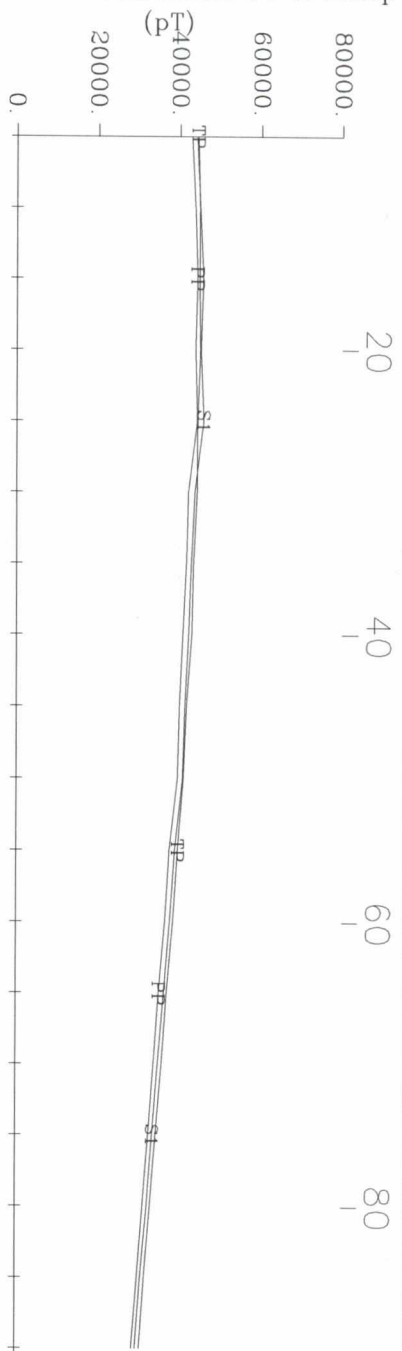
Step Channels 2-4.
 Deviations from S1.
 (% Total Theoretical)



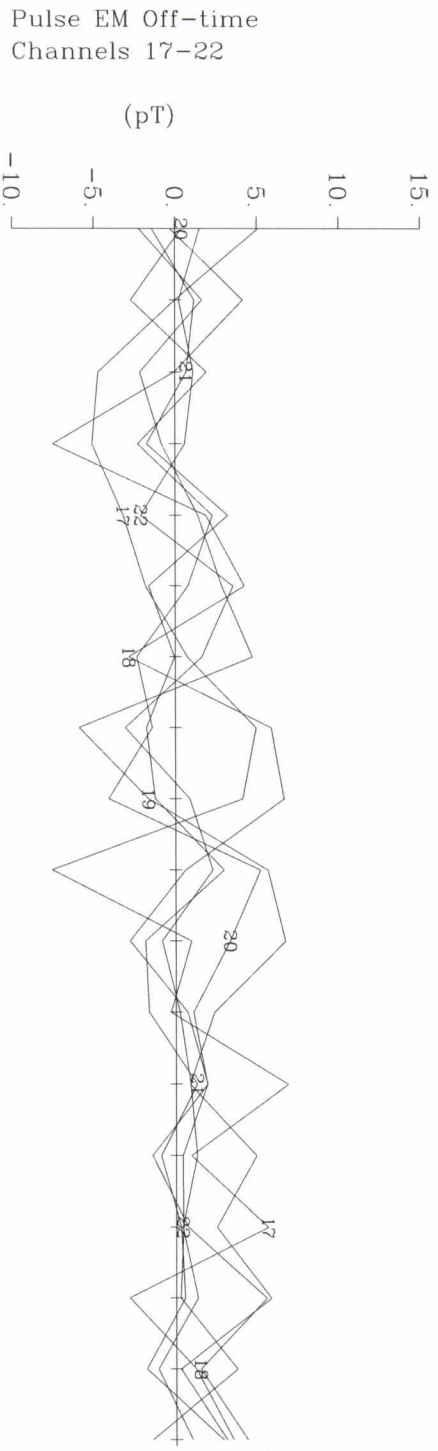
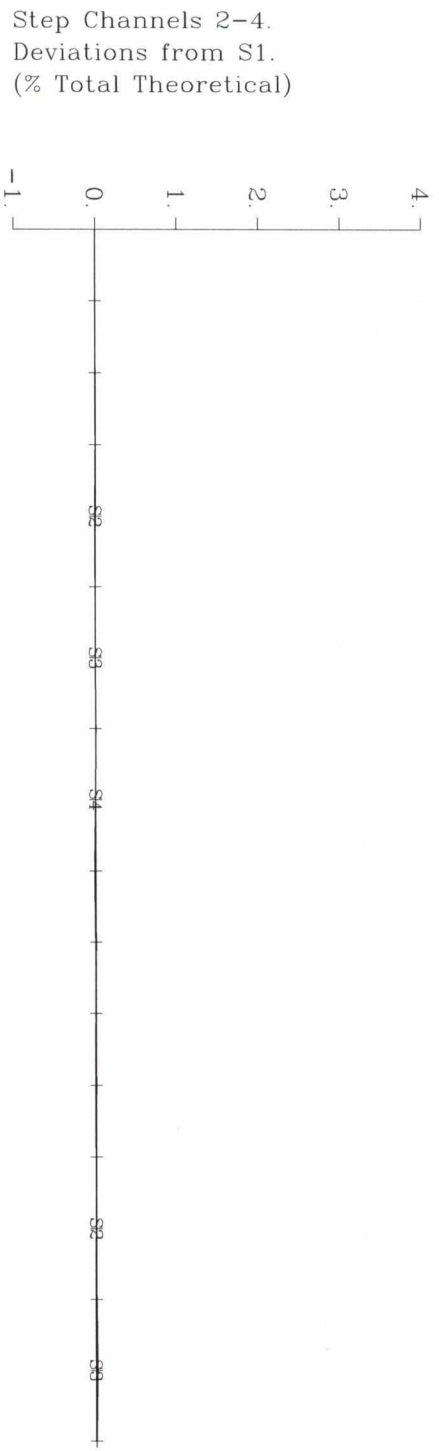
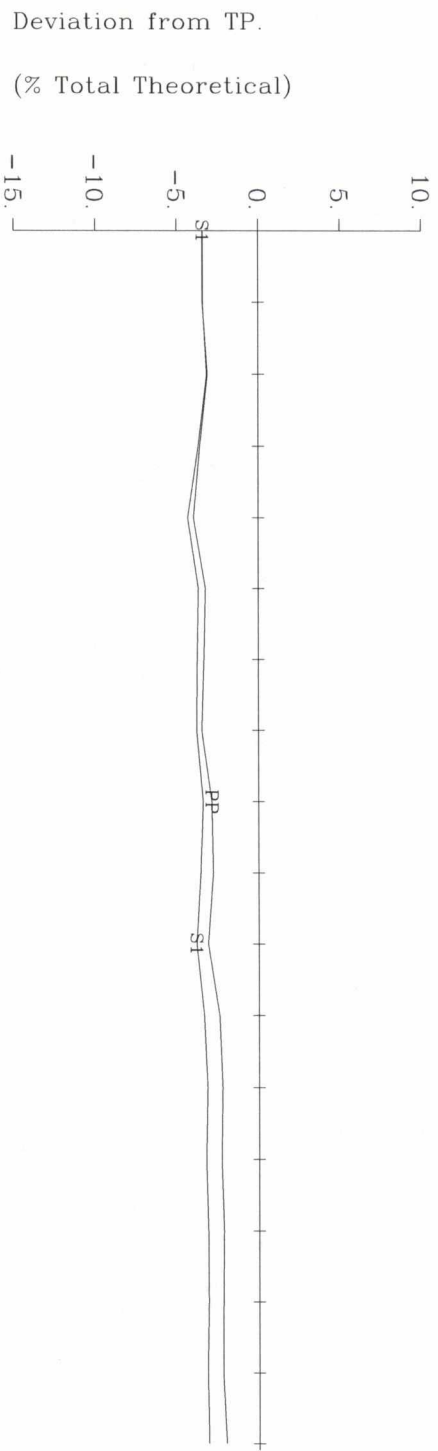
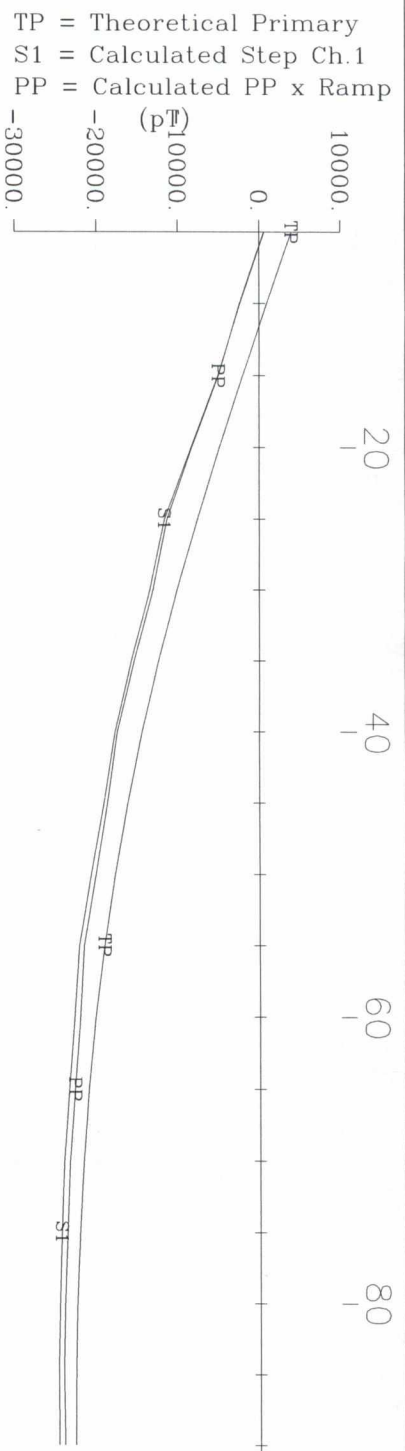
Pulse EM Off-time
 Channels 17-22



TP = Theoretical Primary
 S1 = Calculated Step Ch.1
 PP = Calculated PP x Ramp



Northern Sun Mining Corp. Groves Project 100ms B-Field Step
 April 20, 2015 Loop: 1 Hole: GR-90-165 Comp: X
 Crone Geophysics & Exploration Ltd.



Northern Sun Mining Corp. Groves Project 100ms B-Field Step
 April 20, 2015 Loop: 1 Hole: GR-90-165 Comp: Y
 Crone Geophysics & Exploration Ltd.