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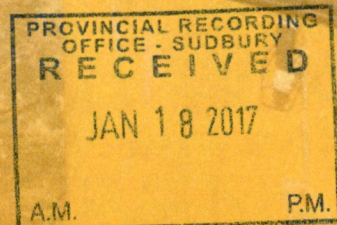
crone

Crone Pulse-EM Survey

Northern Sun Mining
Groves Project

Geophysical Survey & Logistics Report
August 2016

Conducted by:
Crone Geophysics & Exploration Ltd.





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Introduction

Crone Geophysics & Exploration Limited was contracted by Northern Sun Mining to conduct 3D Borehole Pulse Electromagnetic Surveys on its Groves Project, MATHU Project, located approximately 9km Southeast of Gogama in the Northern Ontario. The MATHU Showing is a recent discovery of Ni/Cu mineralization within a large VTEM anomaly, which was in the process of being drilled during the time of surveying. This report summarizes the geophysical work carried out in August 2016 that was completed to better define the conductors that may be associated with the Ni/Cu mineralization.

Three (3) holes covered from one (1) transmitting loop were surveyed during August 26th – 30th, 2016. The appendices to this report contain page size plan and section maps, linear 5-axis profiles, step response profiles for select boreholes, and Crone instrument specifications.

Property Location & Access

The Groves property, MATHU project, is located in Northern Ontario, Canada, approximately 9 kilometers South East of Gogama. (*Figure 1*). Access to the MATHU grid was by helicopter (*Figure 2*).

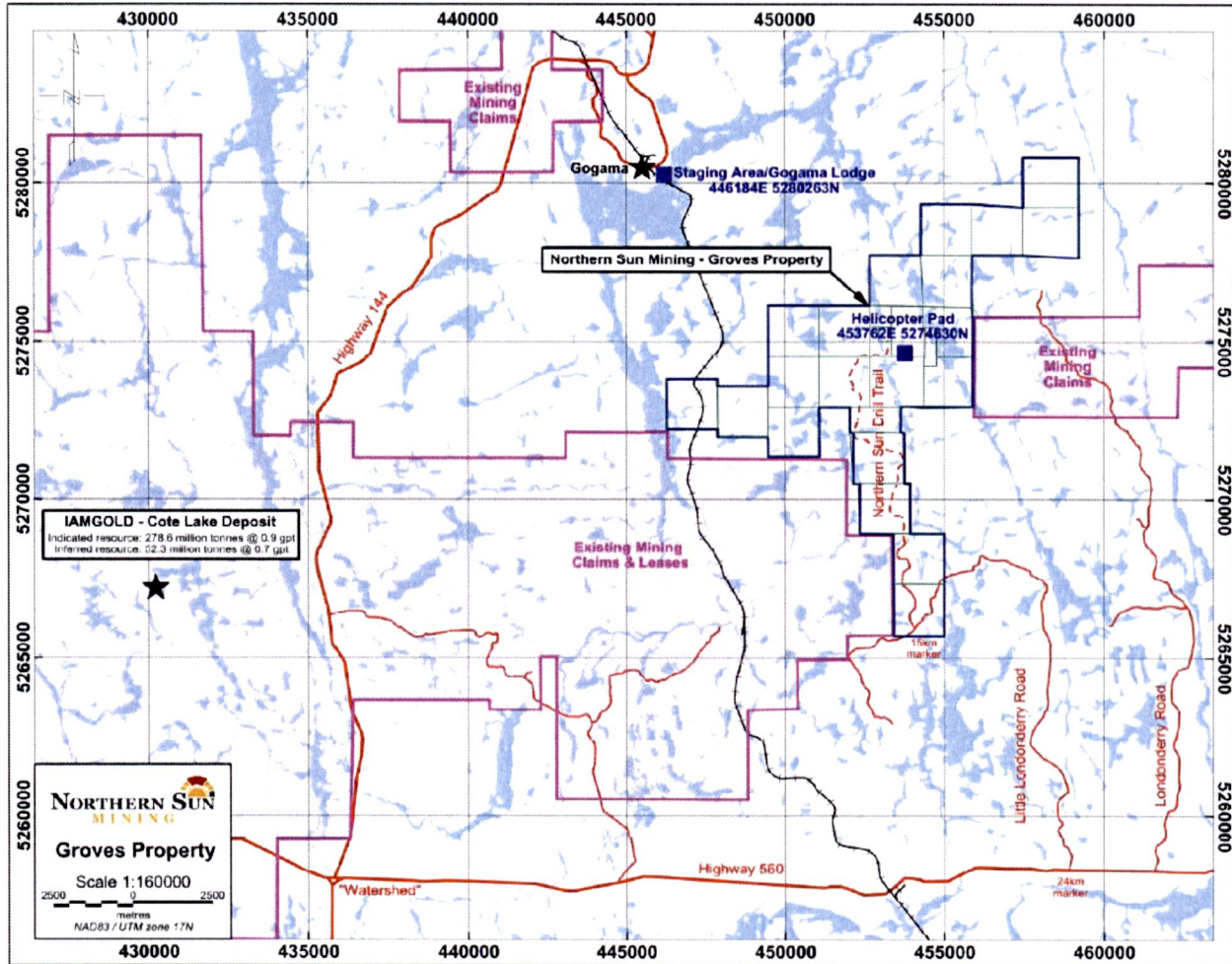


Figure 1: Groves Project Location and Access Map

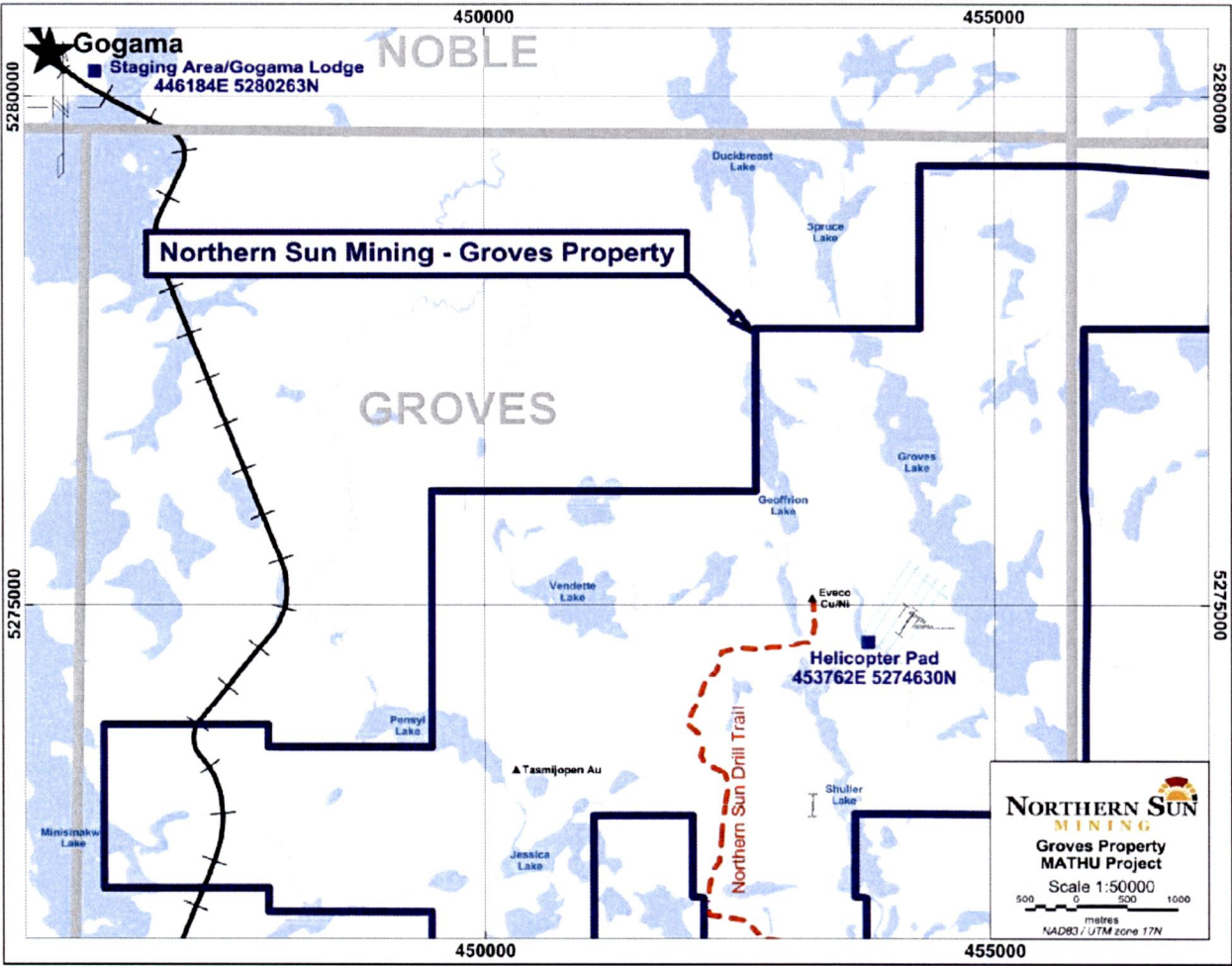


Figure 2: MATHU Project Location Map

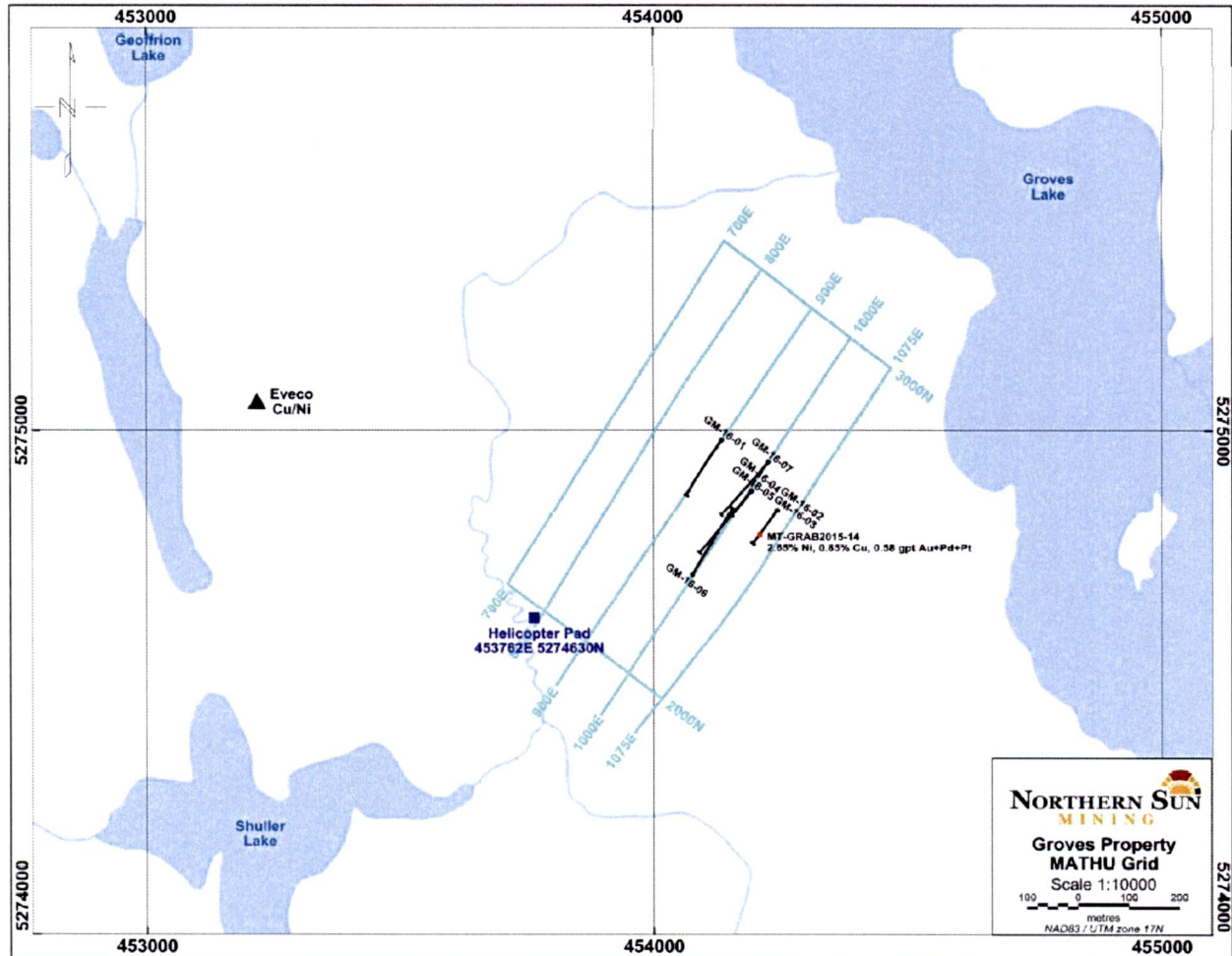


Figure 3: BHEM Location Map

Personnel

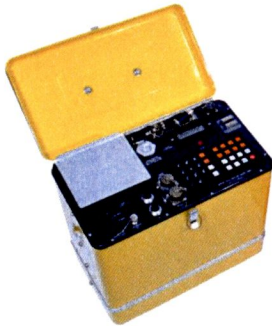
The personnel involved in this project during the reporting period include:

Survey Operator: Joshua Lymburner, Eric Meunier

Data Processing: Joshua Lymburner

Report: Joshua Lymburner

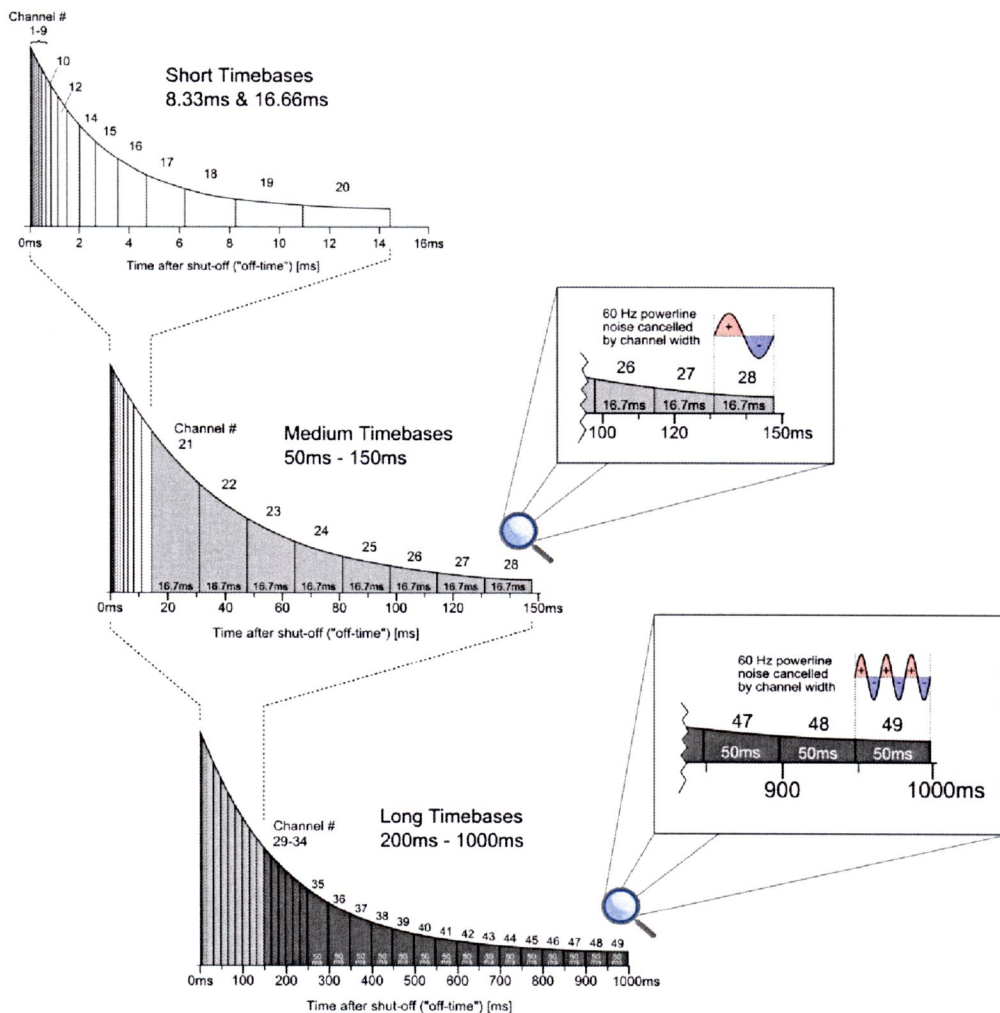
Equipment



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

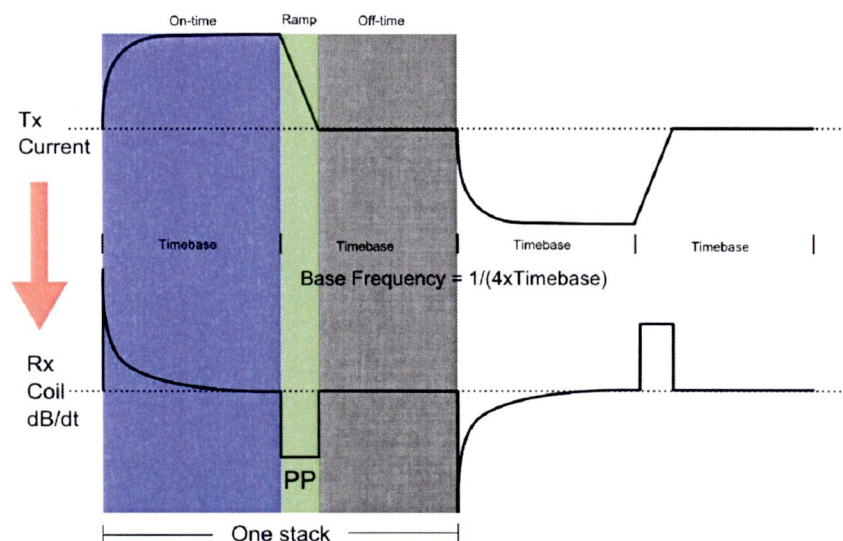


Pulse-EM Transmitter



- 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



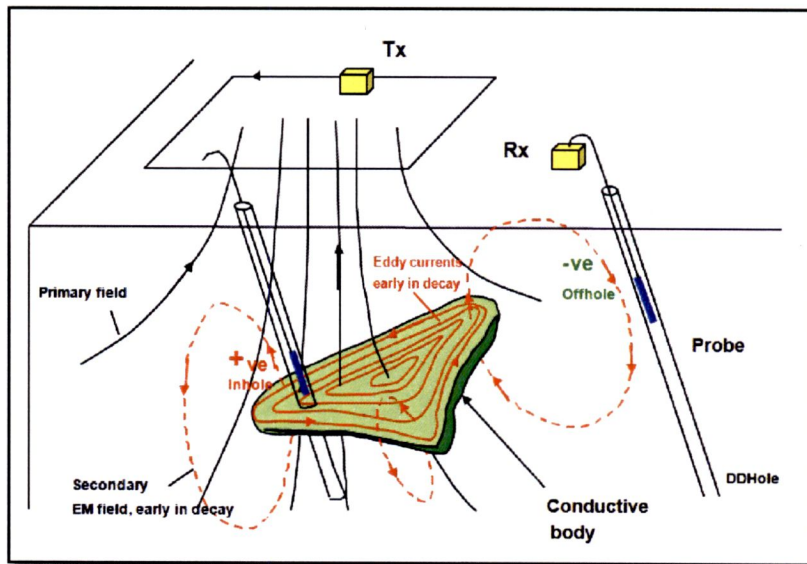
Pulse-EM Induction Coil Probes

- 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

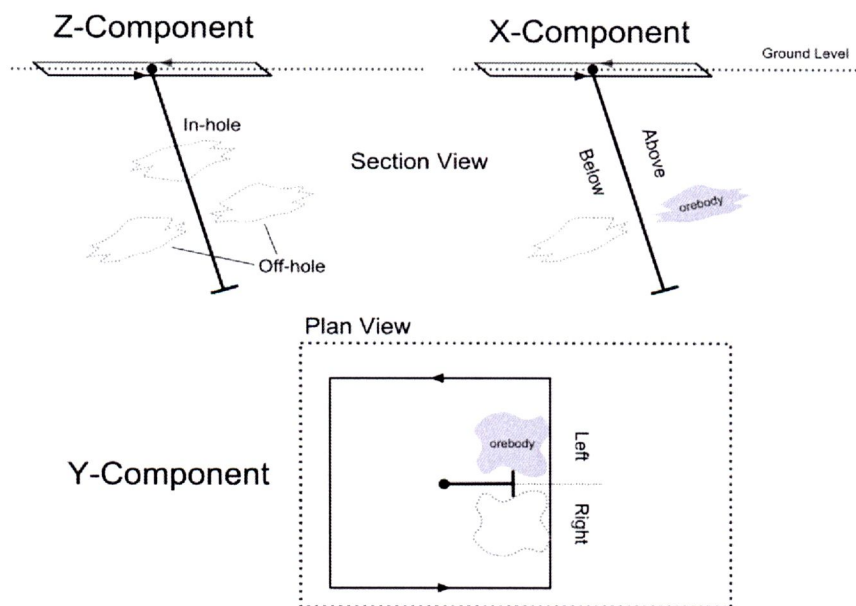


Survey Methods

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. 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 component (XY) components 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 gives 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. Data is usually collected at a nominal sample interval of 10m.



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 (CONUS) 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, with a 1.5ms shut-off ramp time (Table III). The primary inducing field is defined as positive up inside the transmitter loop. The data were acquired at a nominal survey interval of 20m or 10m with 5m detailing.

Data units were nT.

Data Acquisition Parameters

Table 1: Borehole Survey Transmitter Loop Coverage

Tx Loop	Property / Target	Size (meters)	Corner Coordinates
			UTM NAD83 Zone 17N
1	Groves	500 x 400	454222E, 5275308N
			453940E, 5274895N
			454223E, 5274699N
			454517E, 5275107N

**Table 2: Borehole Survey Coverage**

Hole	Zone	Tx loop	Timebase	Off Time	Ramp	Current	Station		Length	Comp
			(ms)	Channels			From	To		
GM-16-01	17	1	50	24	1.5	23.1	10	159	149	XYZ
GM-16-03	17	1	50	24	1.5	23.1	20	185	165	XYZ
GM-16-06	17	1	50	24	1.5	23	20	290	270	XYZ

Table 3: 50ms Channel Configuration

Channel	Start (ms)	Finish (ms)	Channel	Start (ms)	Finish (ms)
PP	-0.200	-0.100			
1	0.048	0.064	2	0.064	0.084
3	0.084	0.112	4	0.112	0.152
5	0.152	0.204	6	0.204	0.268
7	0.268	0.360	8	0.360	0.480
9	0.480	0.640	10	0.640	0.848
11	0.848	1.128	12	1.128	1.496
13	1.496	1.992	14	1.992	2.644
15	2.644	3.512	16	3.512	4.664
17	4.664	6.192	18	6.192	8.220
19	8.220	10.916	20	10.916	14.400
21	14.400	31.068	22	31.068	47.736

Production Summary

Date (d.m.y)	Type of Day	Comments
26-Aug-2016	MOB	Travelled from Mississauga to Gogama.
27-Aug-2016	Survey	Laid loop 1 and surveyed hole GM-16-06.
28-Aug-2016	Survey	Surveyed hole GM-16-03 and The Z component of GM-16-01.
29-Aug-2016	Survey	Surveyed the XY of GM-16-01. Picked up Loop 1 and packed up all the gear.
30-Aug-2016	MOB	Travelled from Gogama to Mississauga.

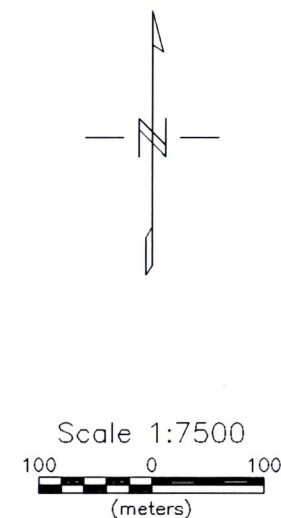
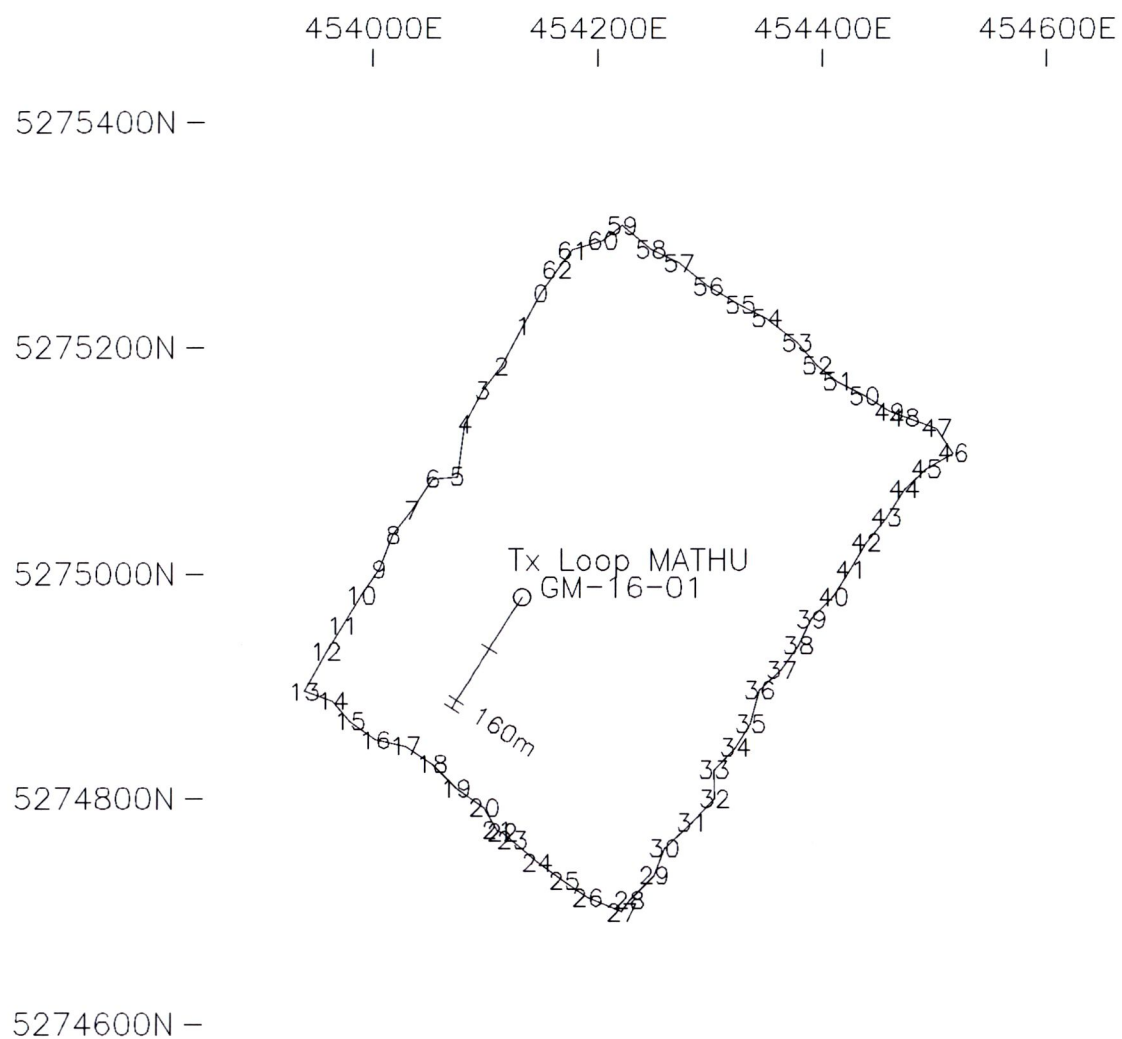
Respectfully submitted,

Joshua Lymburner, M.Sc.

Crone Geophysics & Exploration Ltd.



Appendix 1: Plan & Section Maps



Northern Sun
Mathu

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

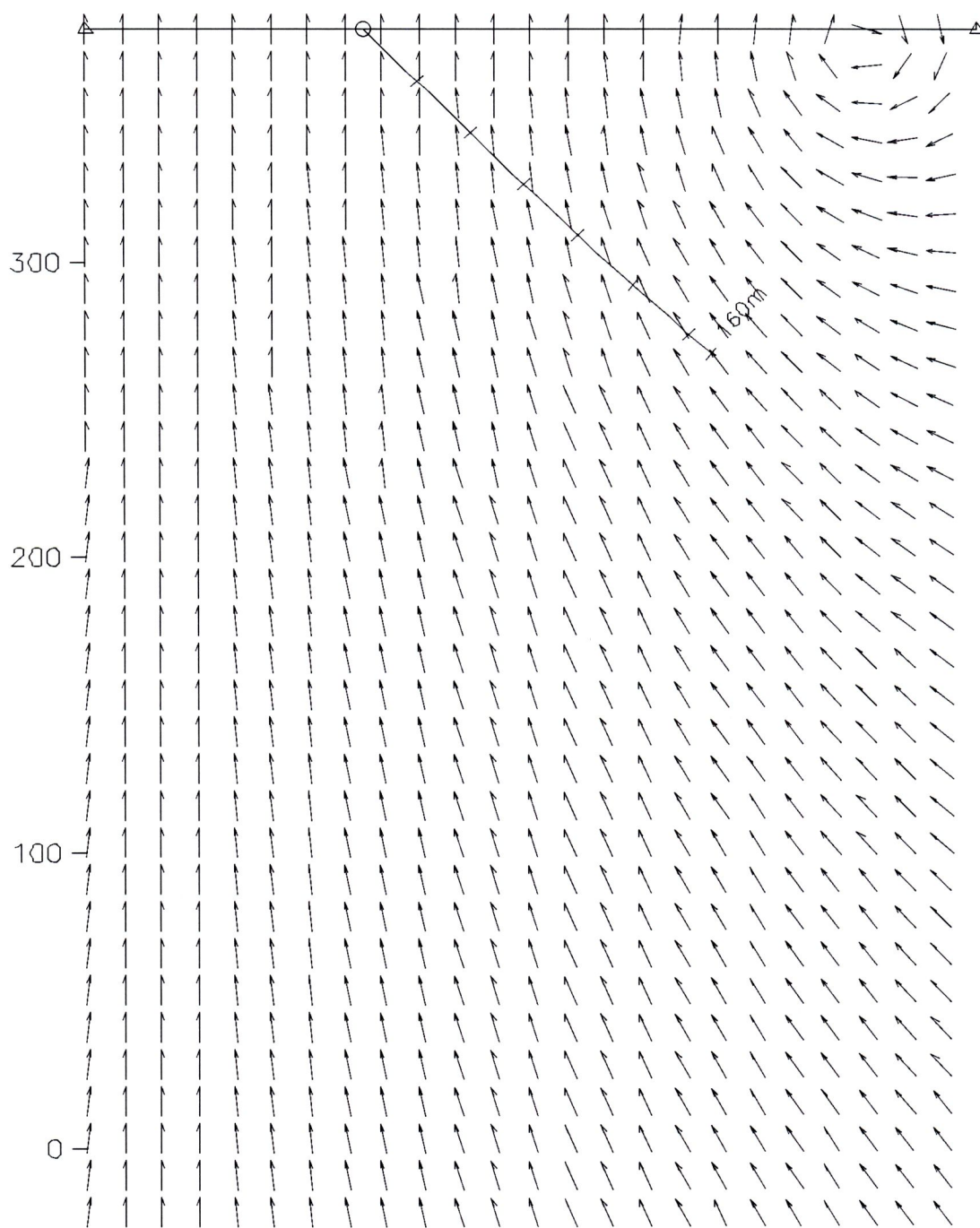
Hole: GM-16-01
Survey Date: August 29, 2016

Crone Geophysics & Exploration Ltd.

454184E, 5275059N

GM-16-01

454023E, 5274806N



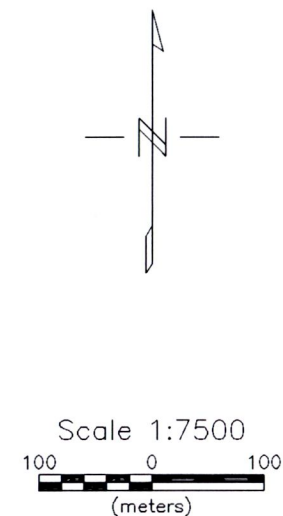
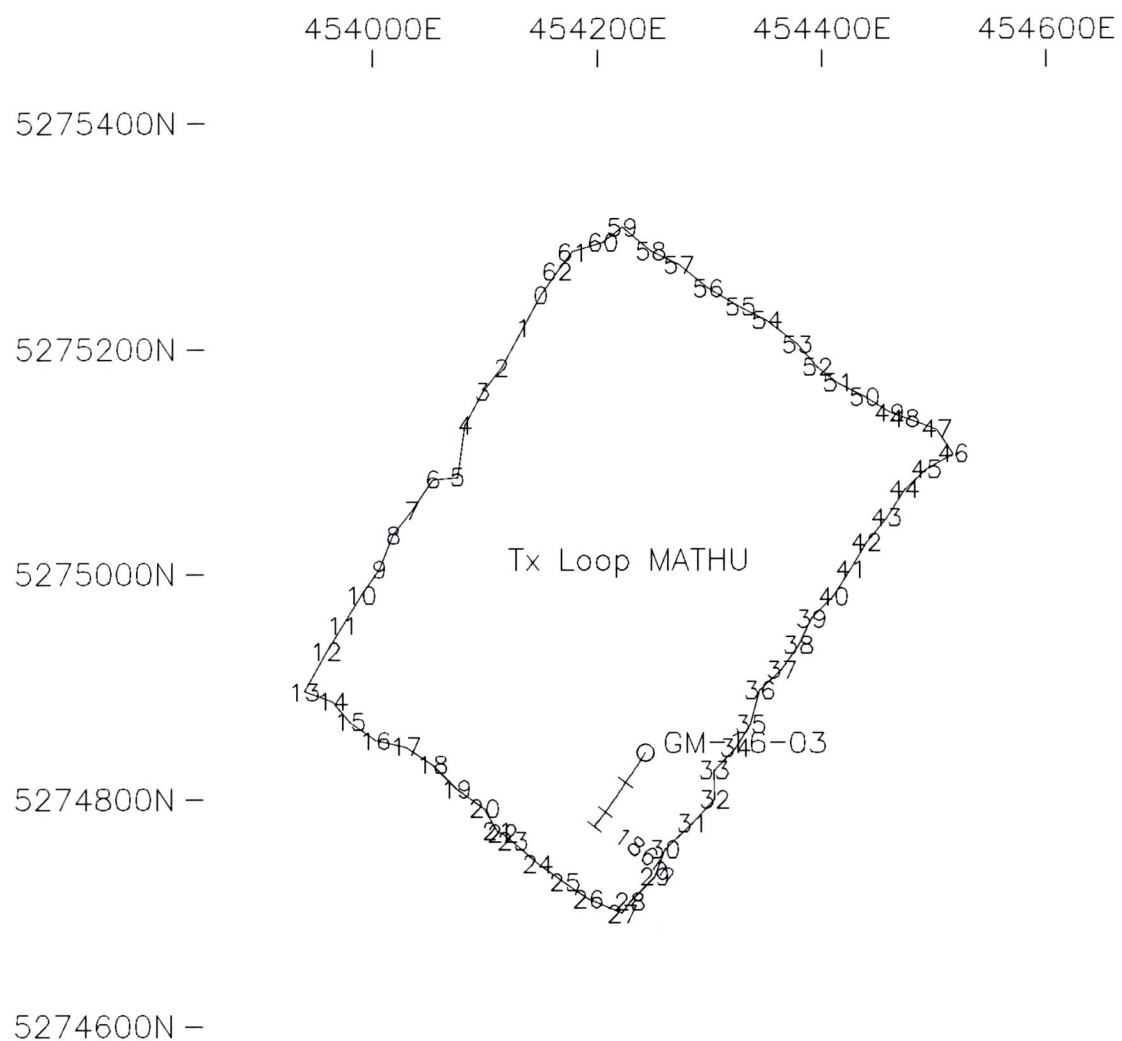
Scale 1:2500
25 0 25 50
(meters)

Northern Sun
Mathu

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

Hole: GM-16-01, Loop: 1
Survey Date: August 29, 2016

Crone Geophysics & Exploration Ltd.



Northern Sun
Mathu

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

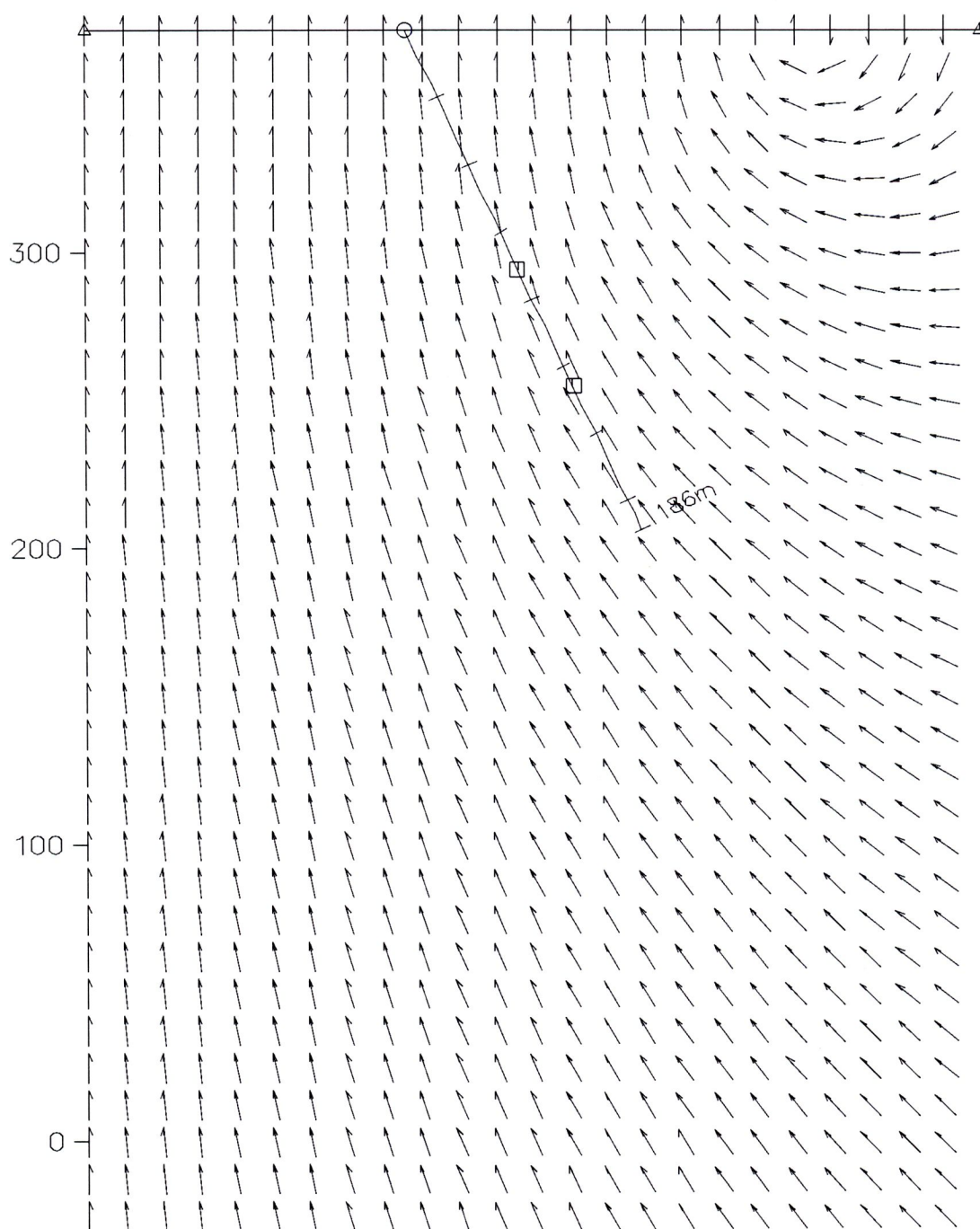
Hole: GM-16-03
Survey Date: August 28, 2016

Crone Geophysics & Exploration Ltd.

454306E, 5274929N

GM-16-03

454135E, 5274683N



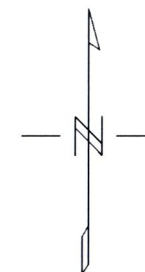
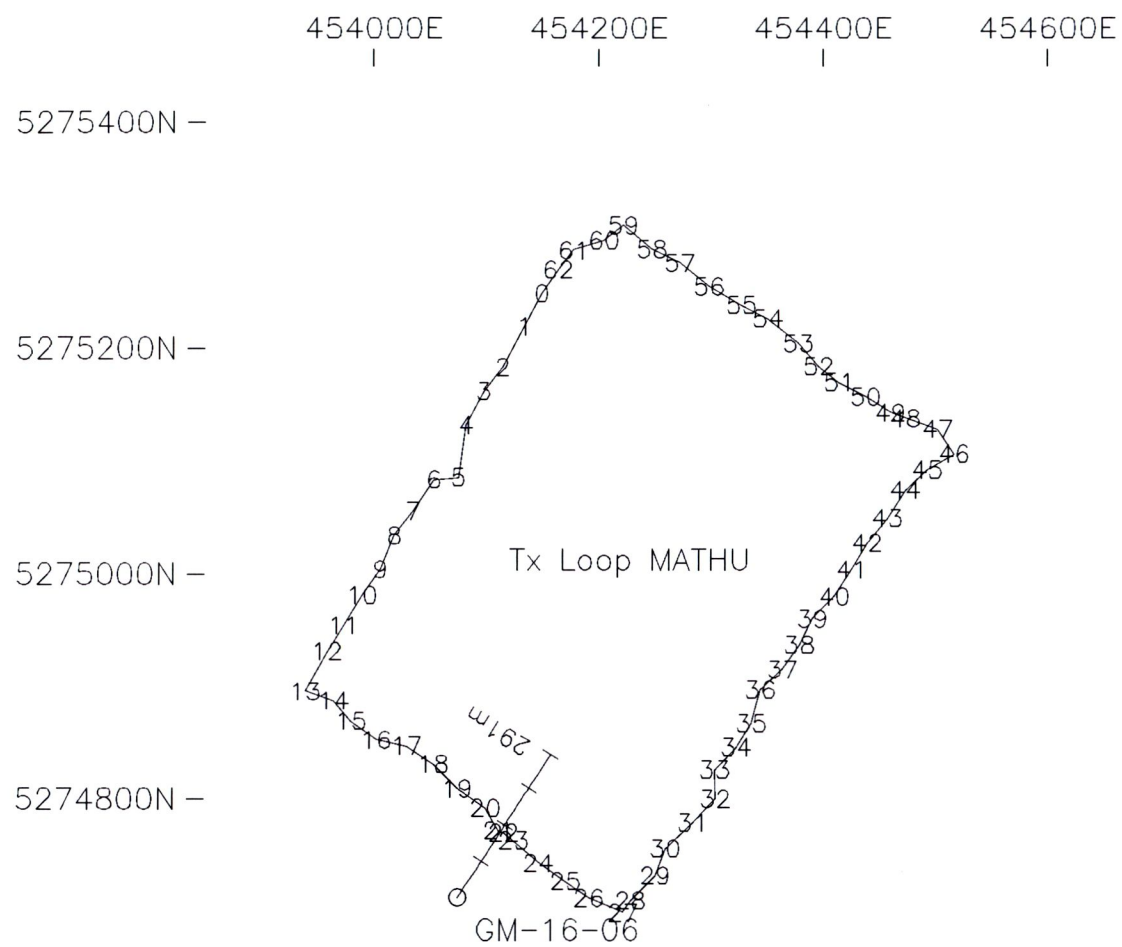
Scale 1:2500
25 0 25 50
(meters)

Northern Sun
Mathu

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

Hole: GM-16-03, Loop: 1
Survey Date: August 28, 2016

Crane Geophysics & Exploration Ltd.



Scale 1:7500
100 0 100
(meters)

Northern Sun
Mathu

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

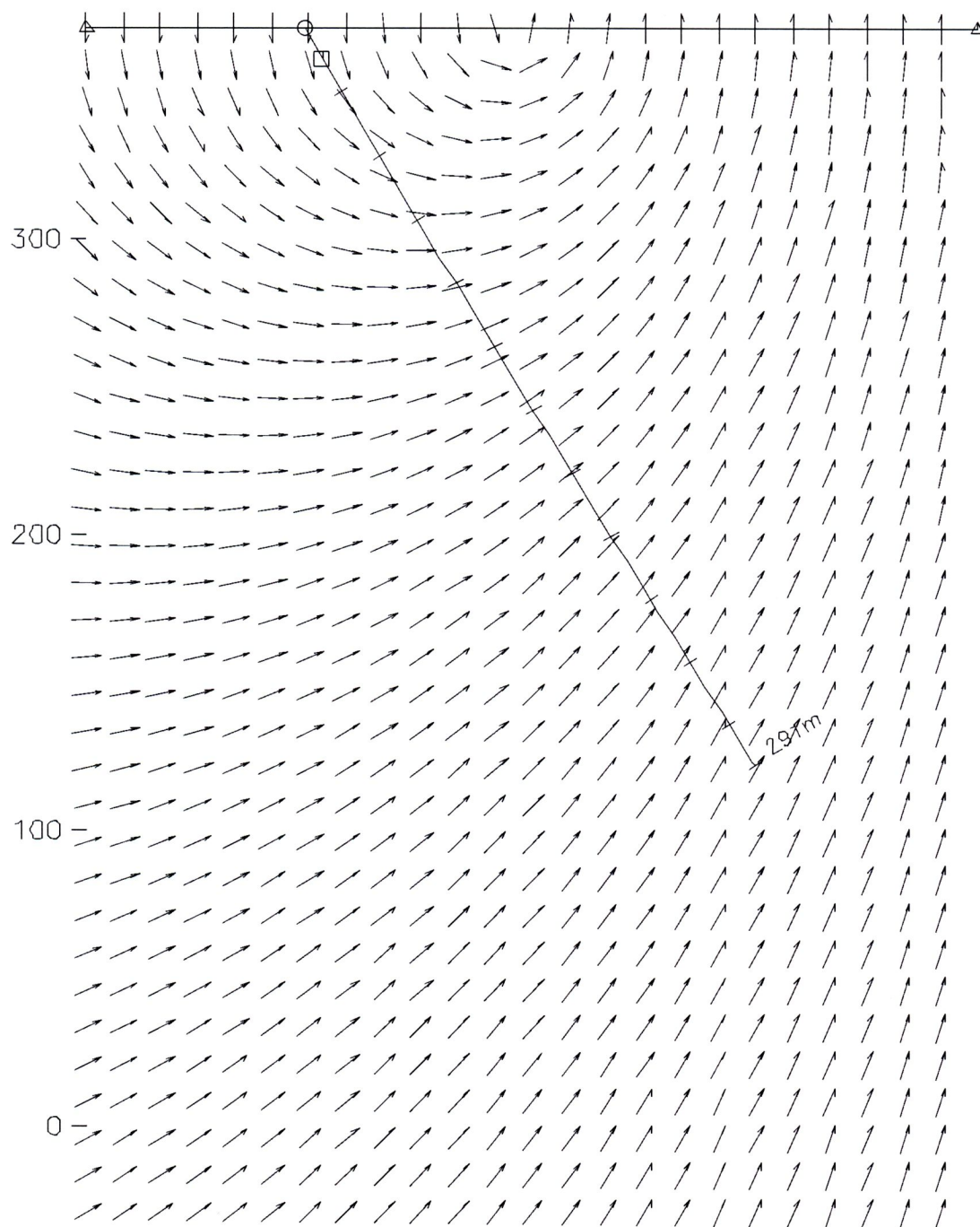
Hole: GM-16-06
Survey Date: August 27, 2016

Crone Geophysics & Exploration Ltd.

454037E, 5274651N

GM-16-06

454199E, 5274903N



Scale 1:2500
25 0 25 50
(meters)

Northern Sun
Mathu

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

Hole: GM-16-06, Loop: 1
Survey Date: August 27, 2016

Crane Geophysics & Exploration Ltd.



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



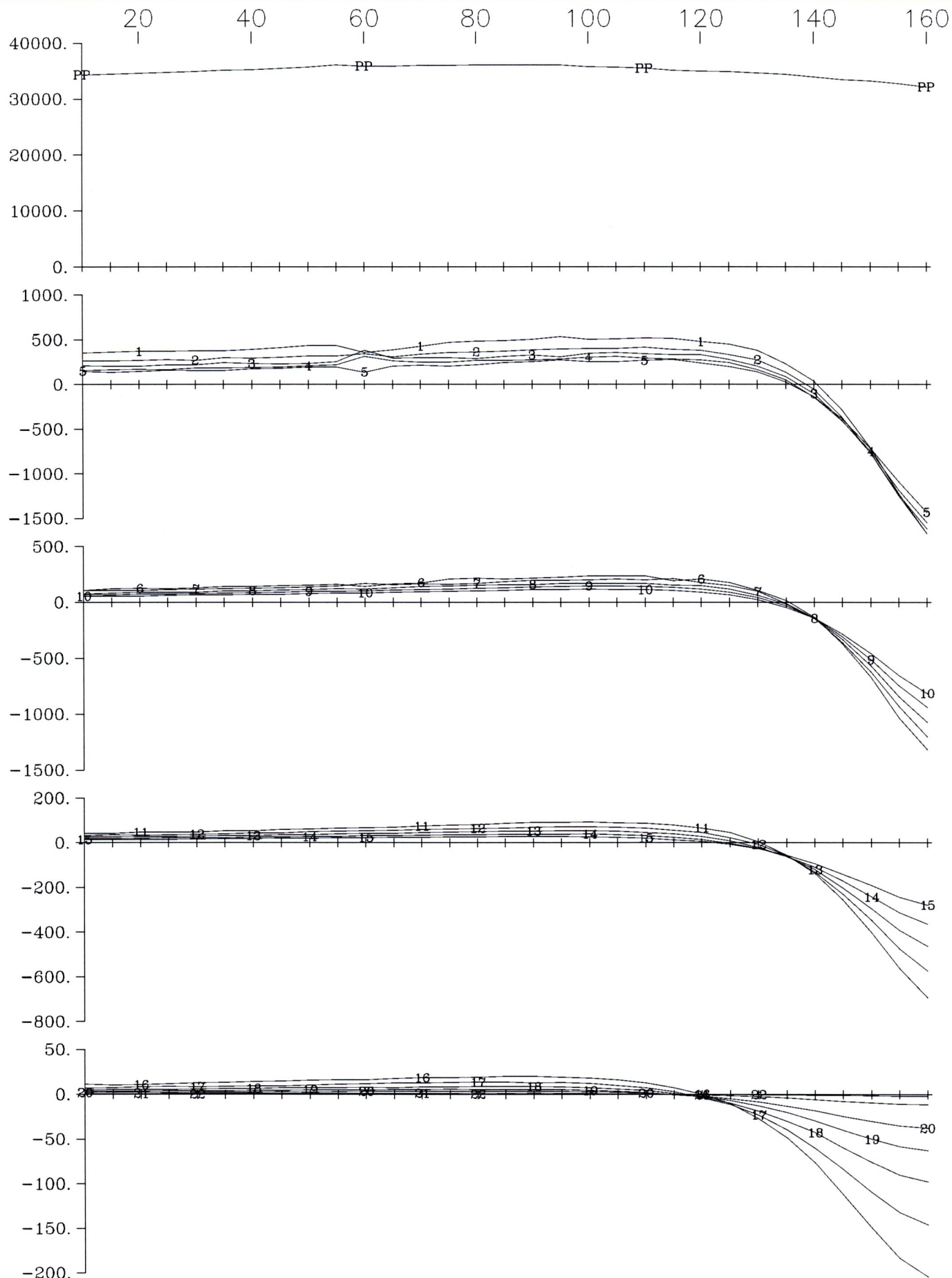
Primary Pulse
(nT/sec)

Channels 1 - 5
(nT/sec)

Channels 6 - 10
(nT/sec)

Channels 11 - 15
(nT/sec)

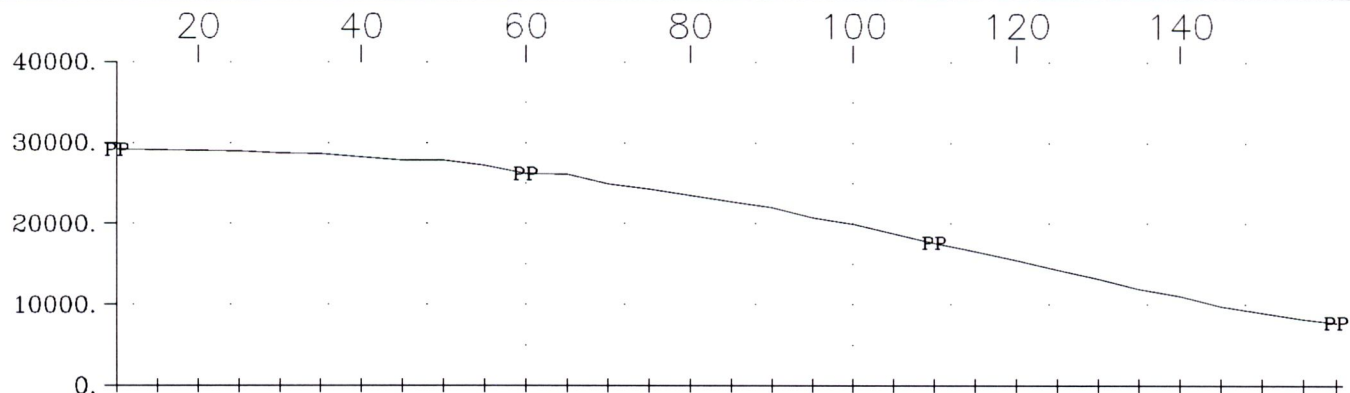
Channels 16 - 22
(nT/sec)



Northern Sun Mathu
Loop MATHU, Hole GM-16-01 Z Component
Crone Geophysics & Exploration Ltd.

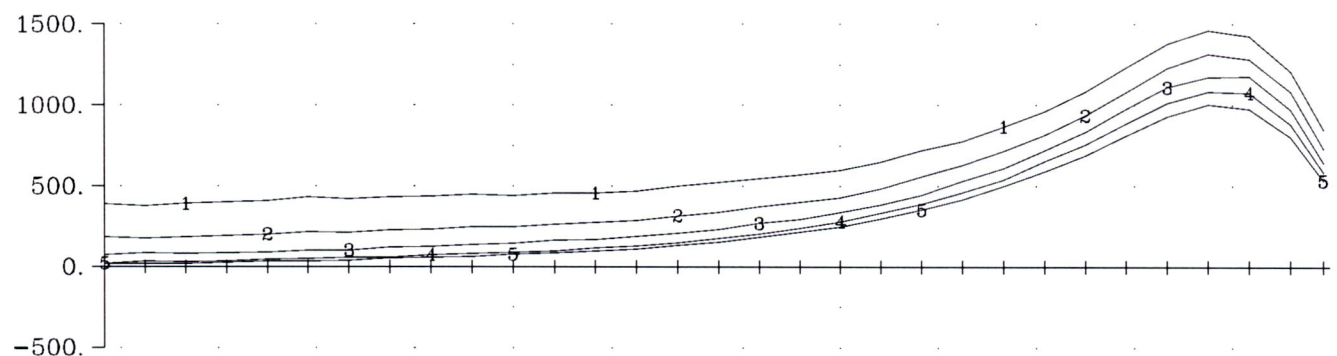
Primary Pulse

(nT/sec)



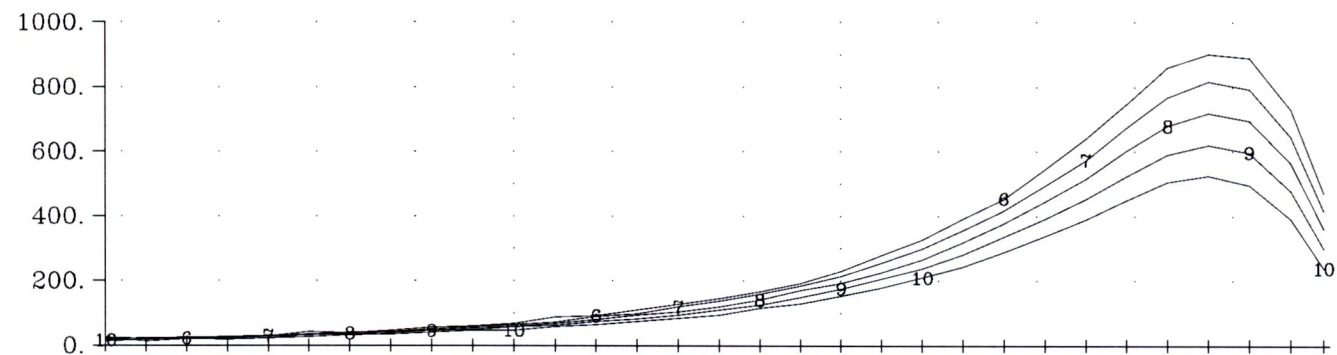
Channels 1 - 5

(nT/sec)



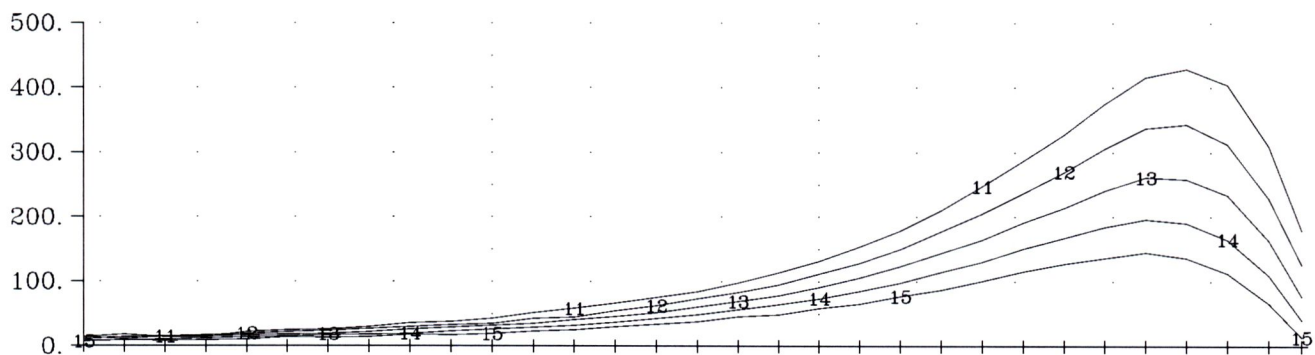
Channels 6 - 10

(nT/sec)



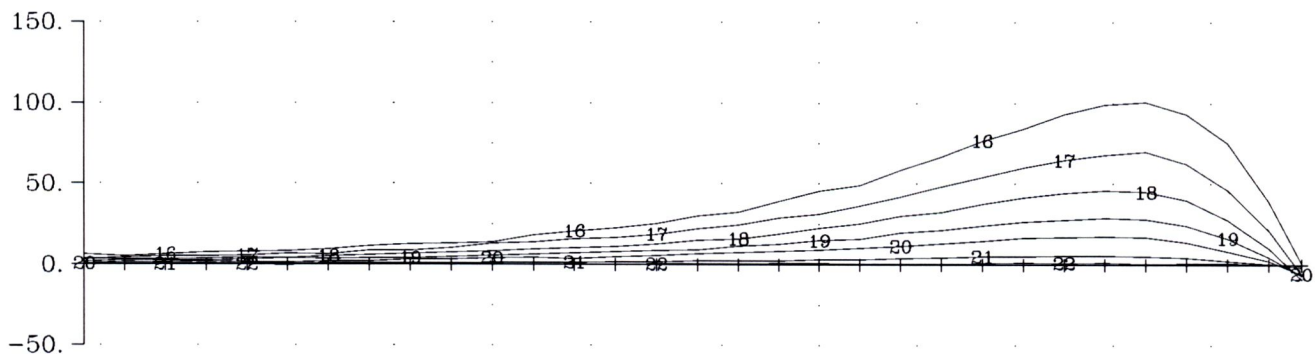
Channels 11 - 15

(nT/sec)



Channels 16 - 22

(nT/sec)



Northern Sun Mathu
Loop MATHU, Hole GM-16-01 X Component
Crone Geophysics & Exploration Ltd.

Primary Pulse

(nT/sec)

Channels 1 - 5

(nT/sec)

Channels 6 - 10

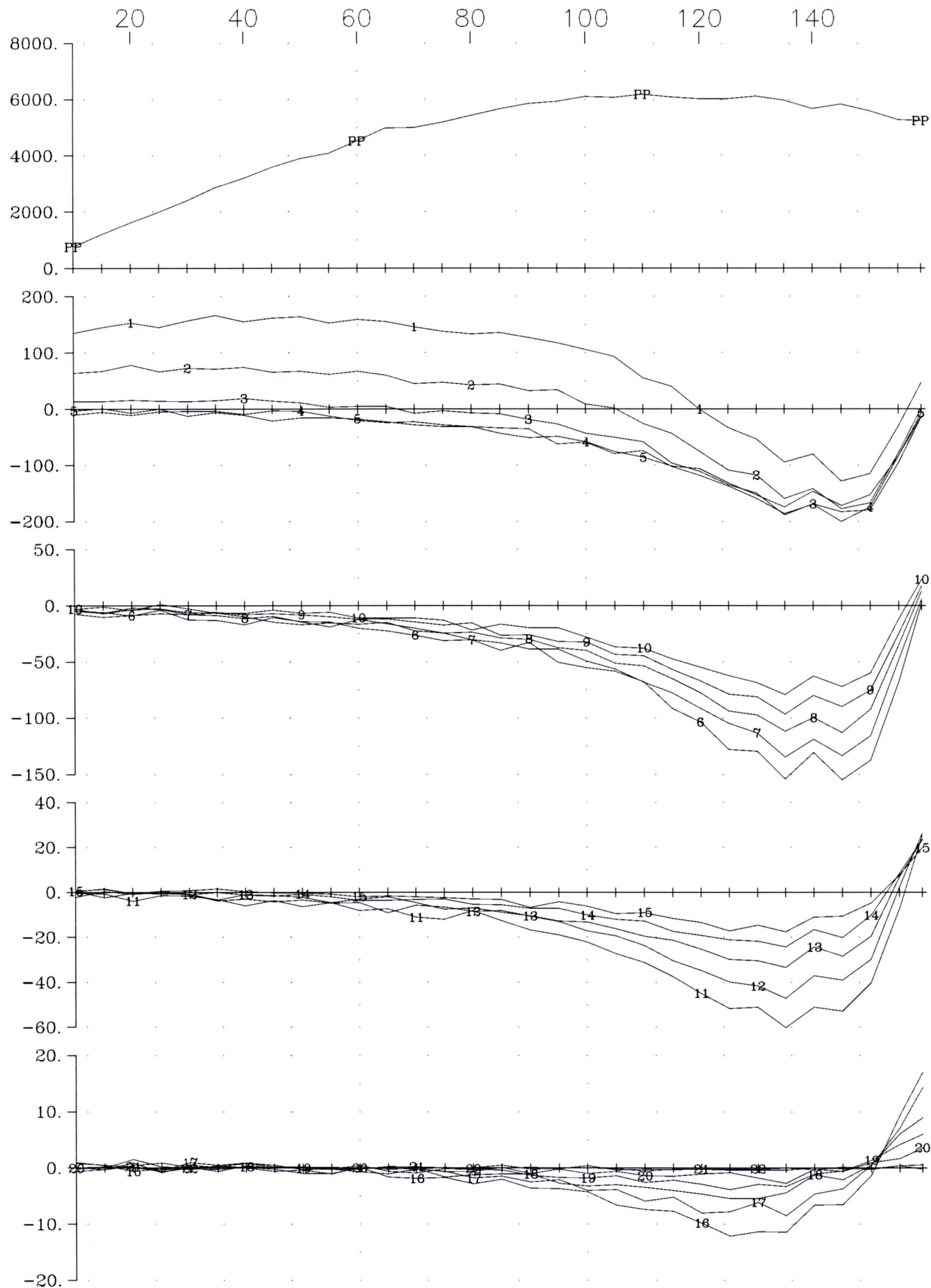
(nT/sec)

Channels 11 - 15

(nT/sec)

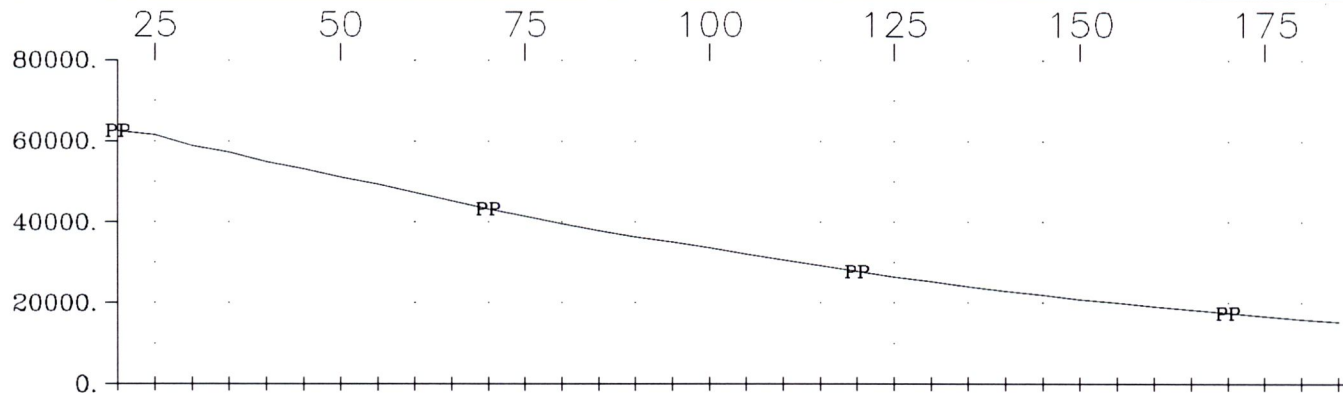
Channels 16 - 22

(nT/sec)

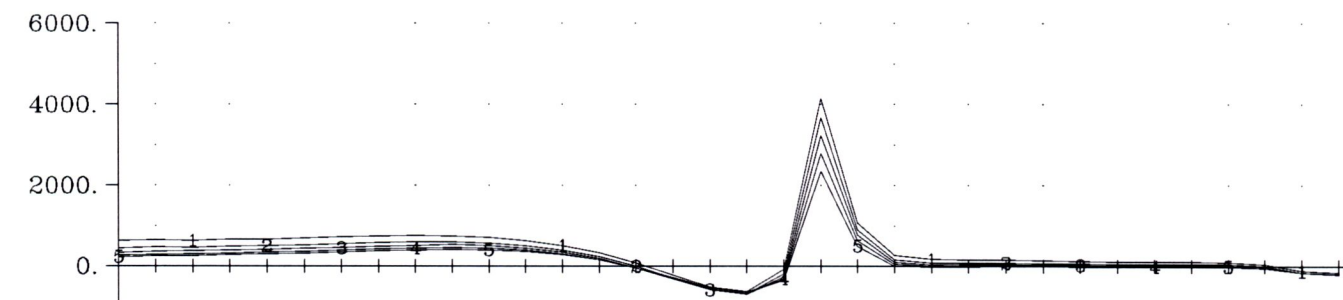


Northern Sun Mathu
Loop MATHU, Hole GM-16-01 Y Component
Crone Geophysics & Exploration Ltd.

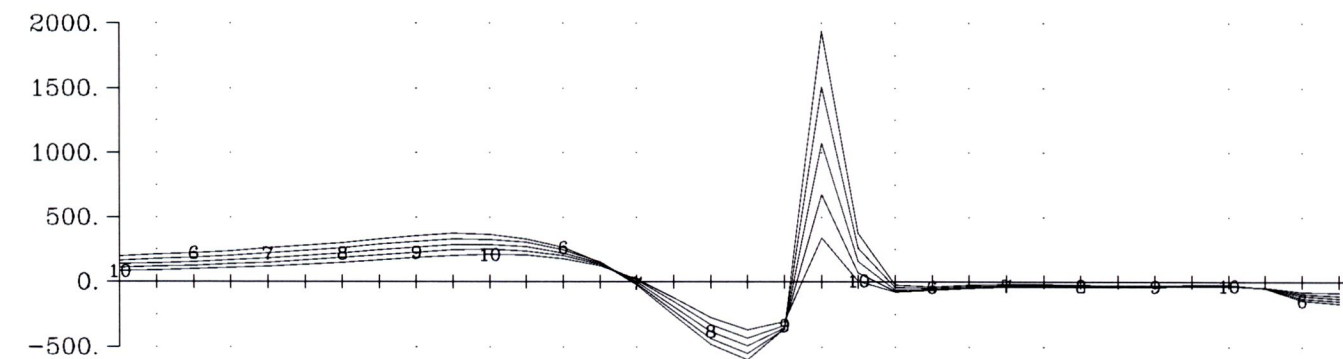
Primary Pulse
(nT/sec)



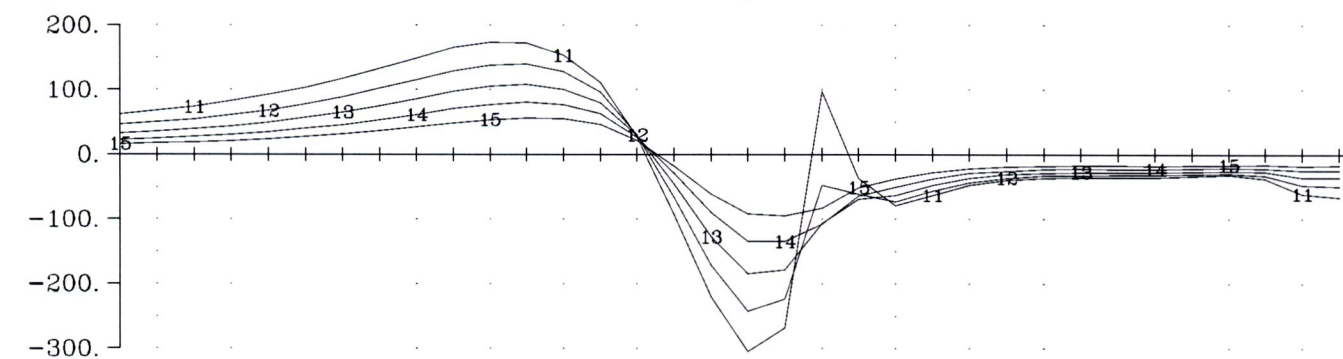
Channels 1 - 5
(nT/sec)



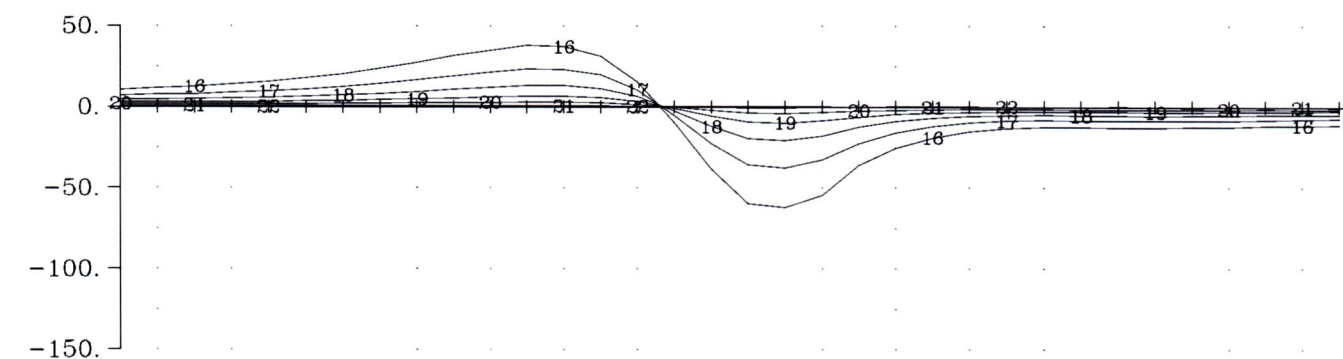
Channels 6 - 10
(nT/sec)



Channels 11 - 15
(nT/sec)



Channels 16 - 22
(nT/sec)



Northern Sun Mathu
Loop MATHU, Hole GM-16-03 Z Component
Crone Geophysics & Exploration Ltd.

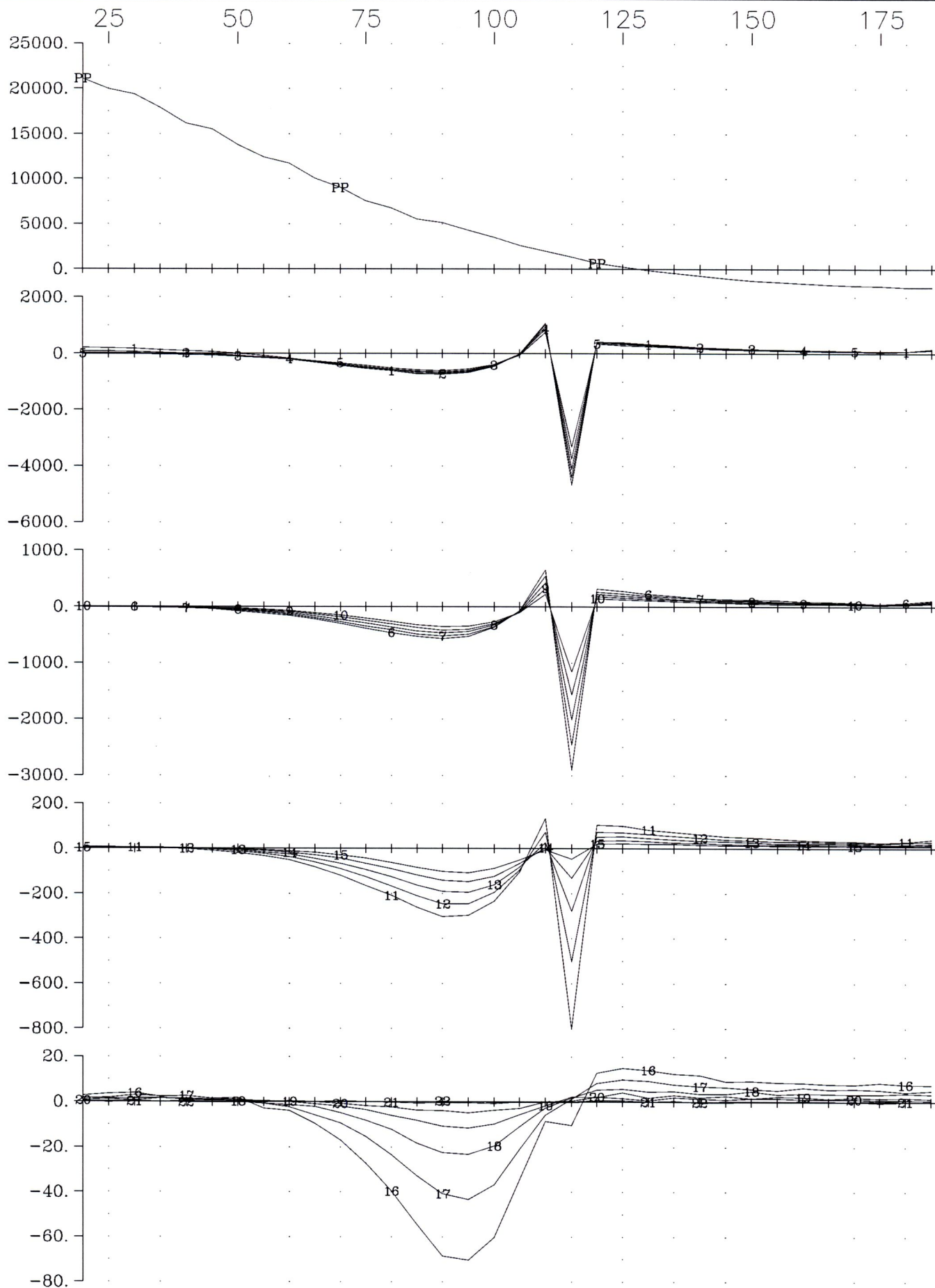
Primary Pulse
(nT/sec)

Channels 1 - 5
(nT/sec)

Channels 6 - 10
(nT/sec)

Channels 11 - 15
(nT/sec)

Channels 16 - 22
(nT/sec)



Northern Sun Mathu
Loop MATHU, Hole GM-16-03 X Component
Crone Geophysics & Exploration Ltd.

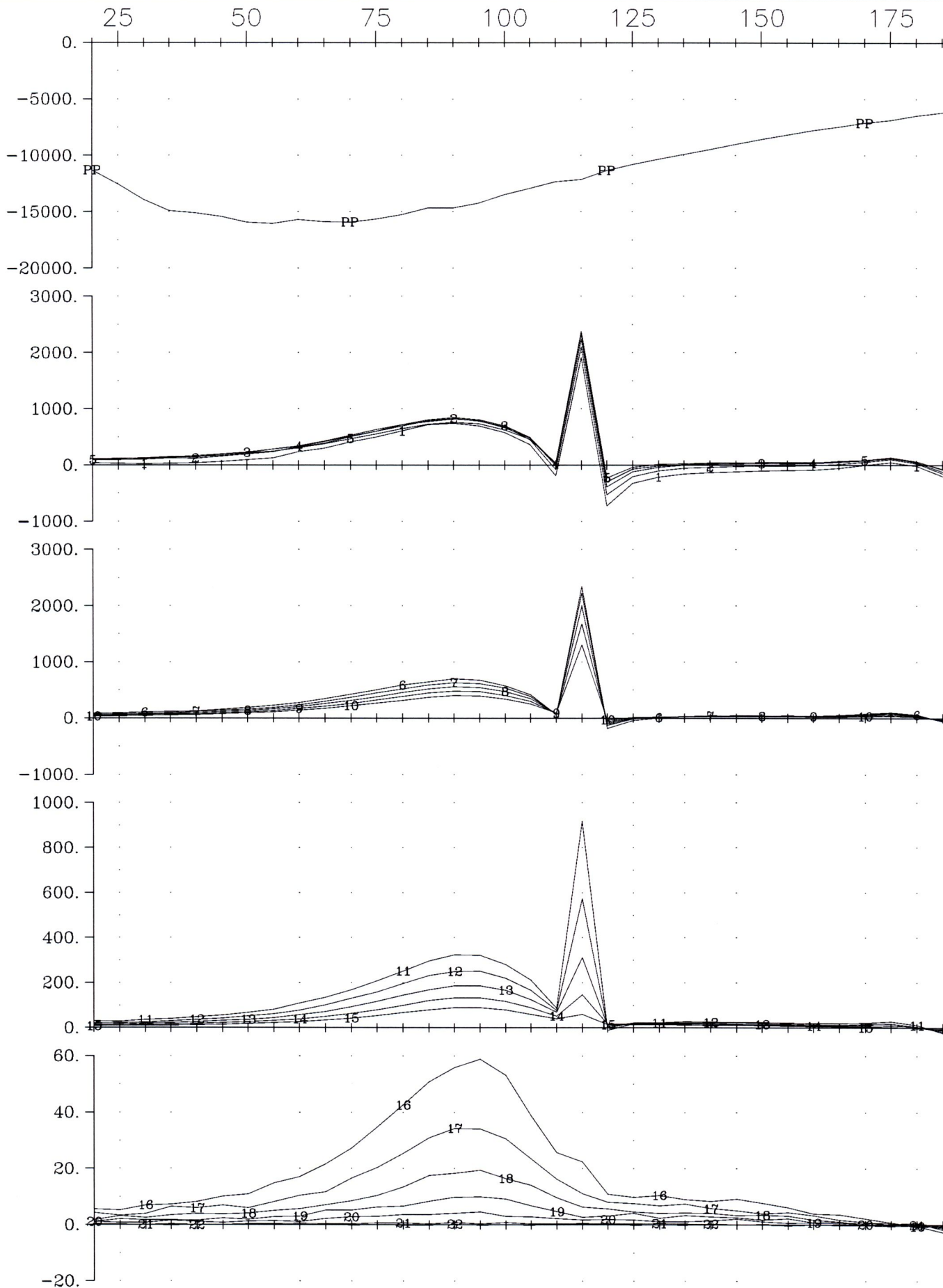
Primary Pulse
(nT/sec)

Channels 1 - 5
(nT/sec)

Channels 6 - 10
(nT/sec)

Channels 11 - 15
(nT/sec)

Channels 16 - 22
(nT/sec)



Northern Sun Mathu
Loop MATHU, Hole GM-16-03 Y Component
Crone Geophysics & Exploration Ltd.

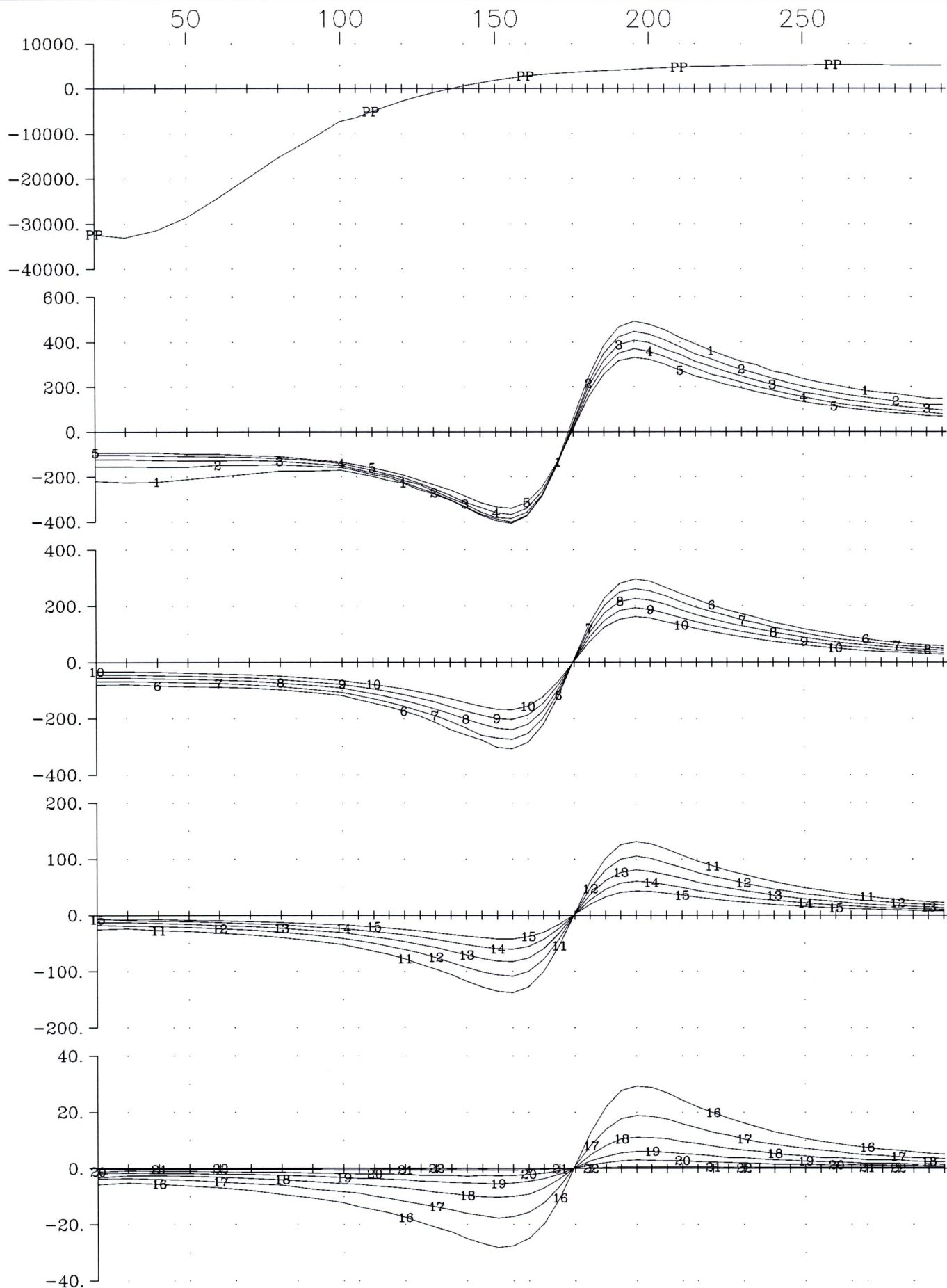
Primary Pulse
(nT/sec)

Channels 1 - 5
(nT/sec)

Channels 6 - 10
(nT/sec)

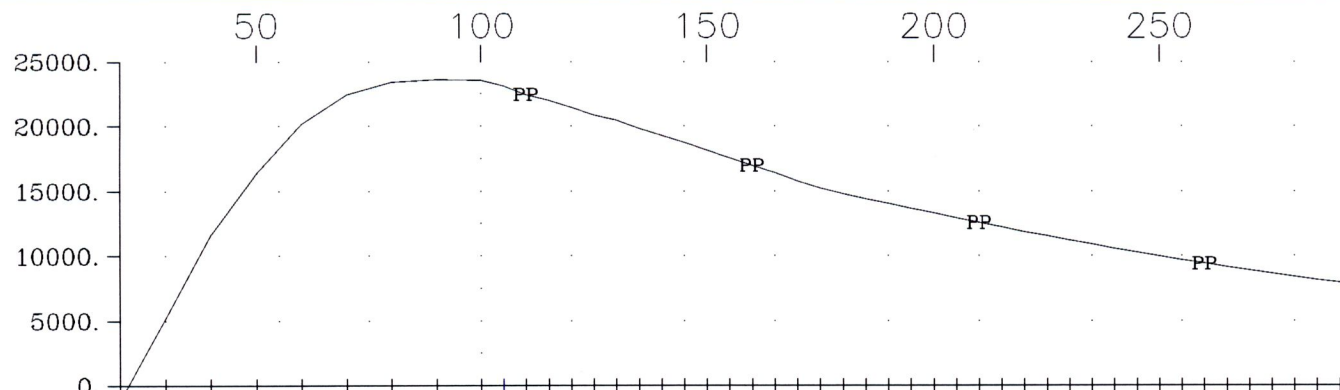
Channels 11 - 15
(nT/sec)

Channels 16 - 22
(nT/sec)

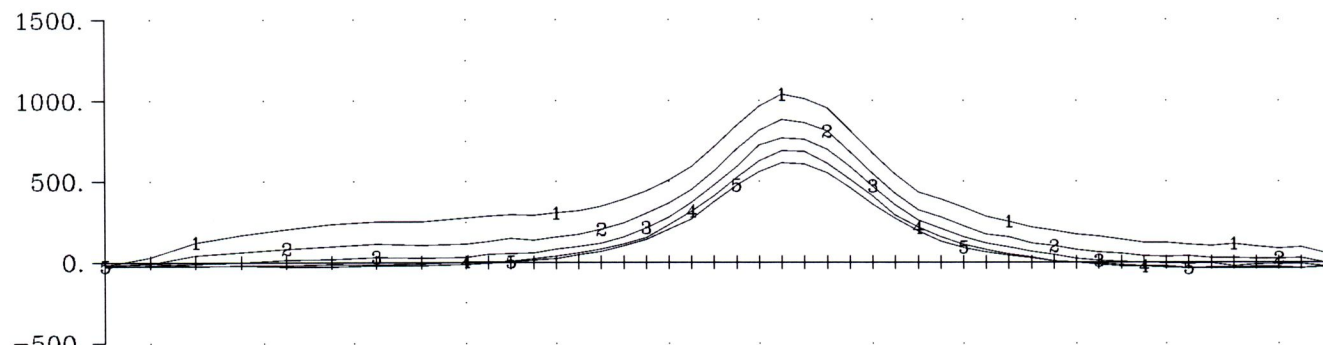


Northern Sun Mathu
Loop Mathu, Hole GM-16-06 Z Component
Crone Geophysics & Exploration Ltd.

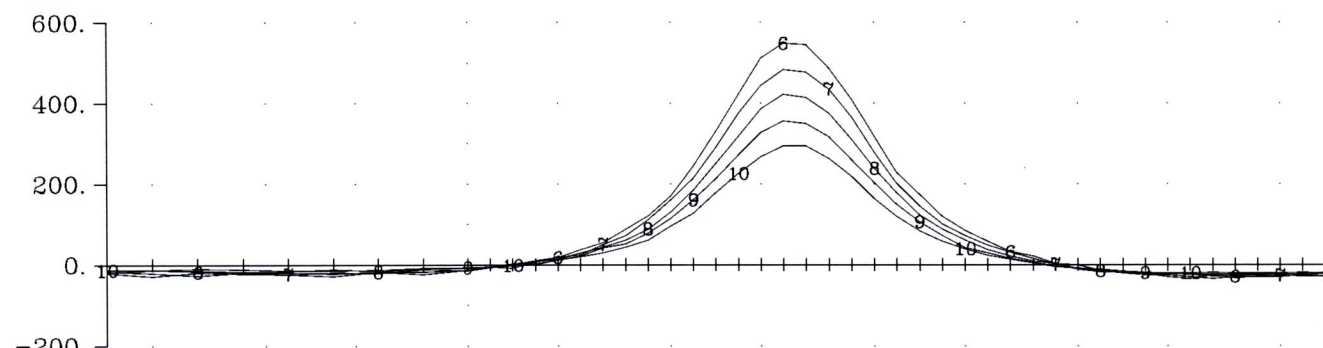
Primary Pulse
(nT/sec)



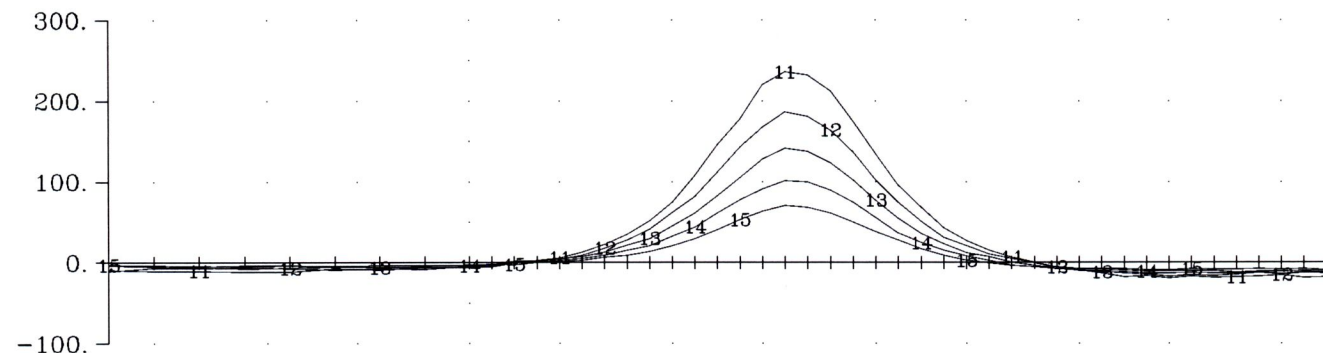
Channels 1 - 5
(nT/sec)



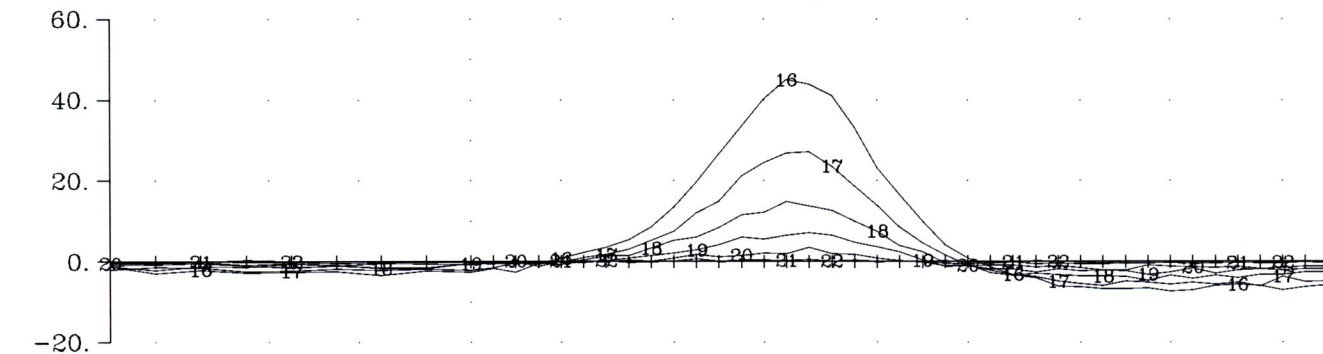
Channels 6 - 10
(nT/sec)



Channels 11 - 15
(nT/sec)

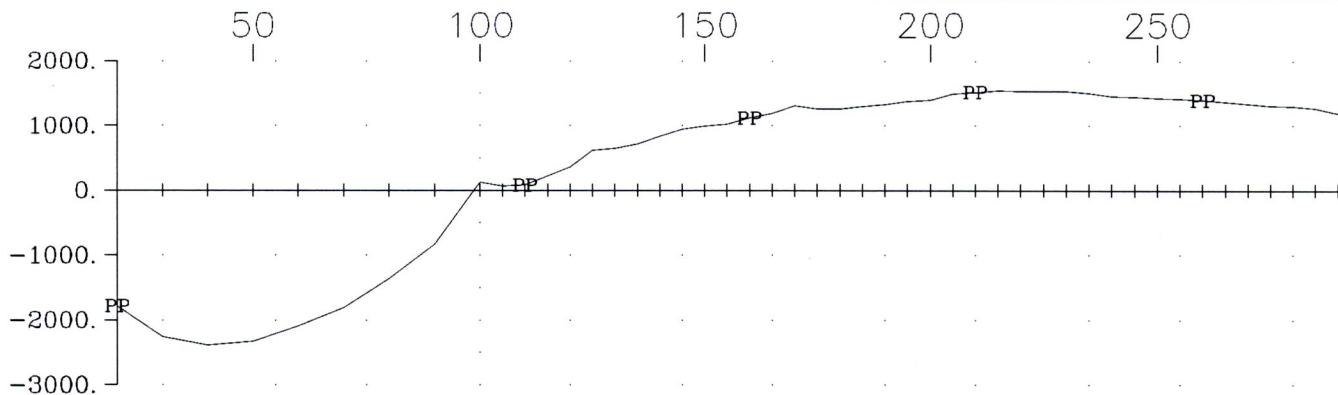


Channels 16 - 22
(nT/sec)

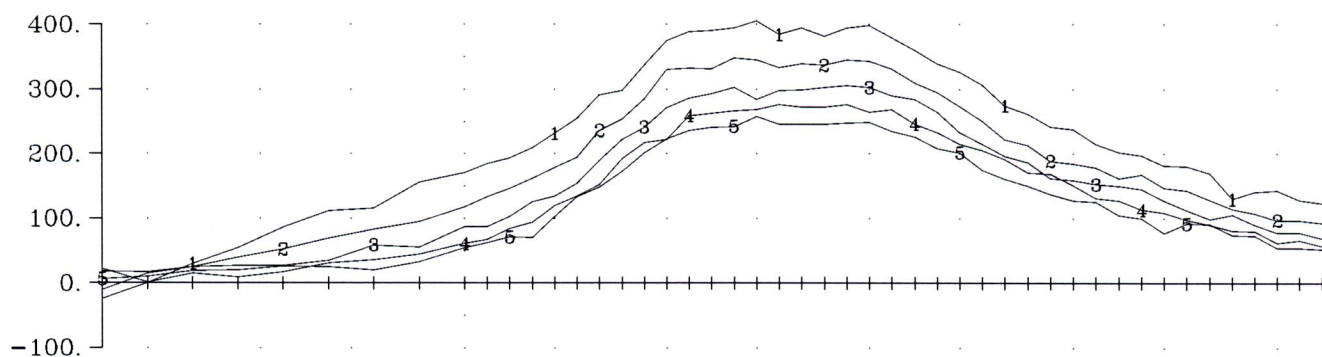


Northern Sun Mathu
Loop Mathu, Hole GM-16-06 X Component
Crone Geophysics & Exploration Ltd.

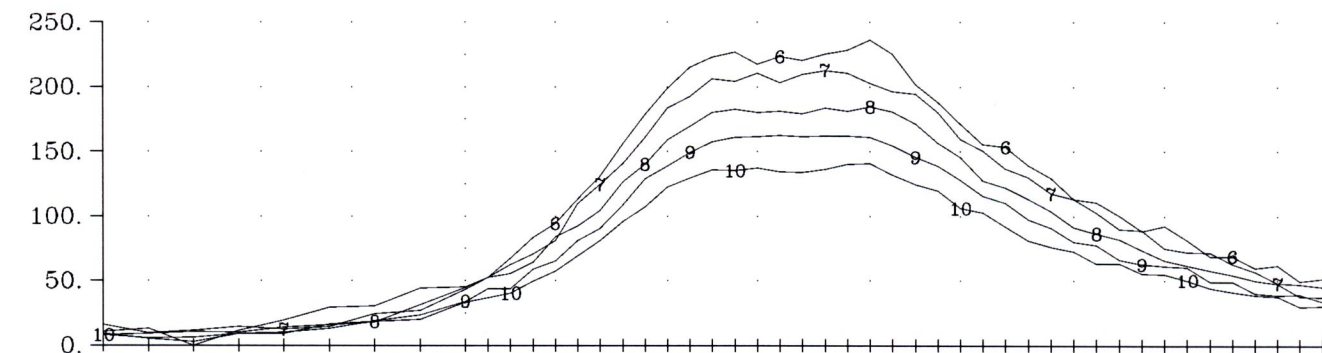
Primary Pulse
(nT/sec)



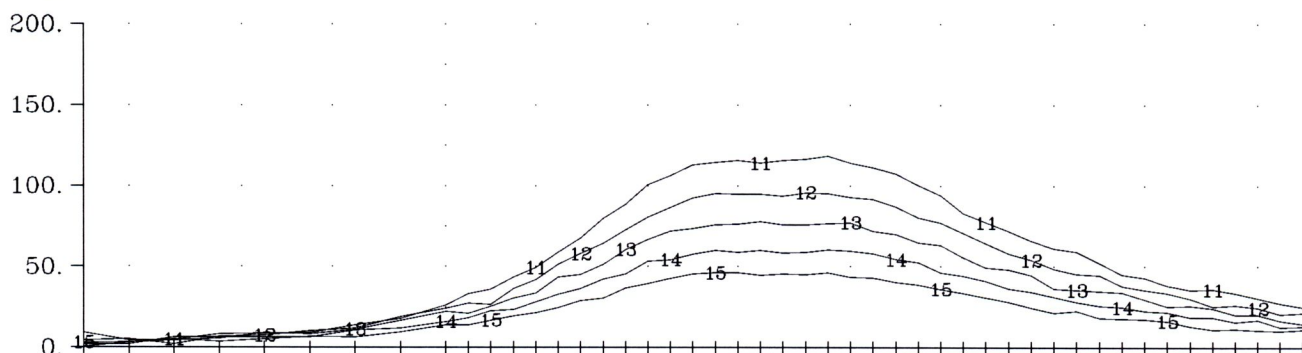
Channels 1 - 5
(nT/sec)



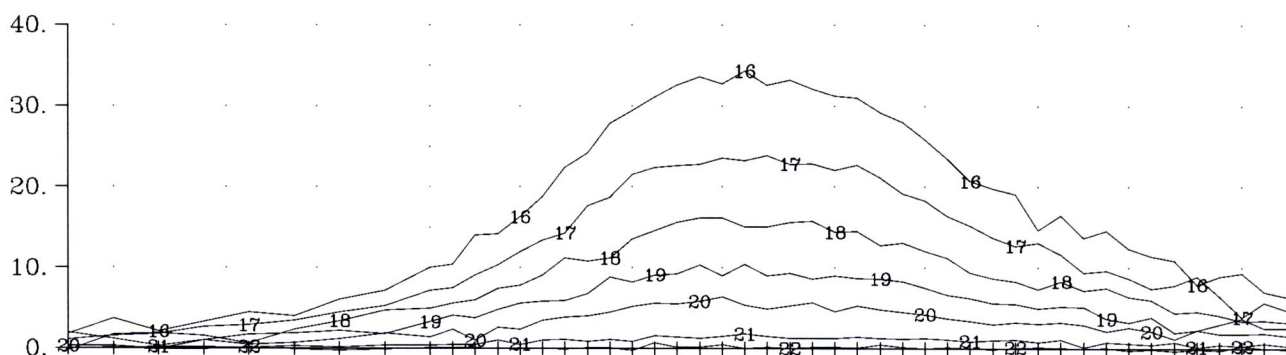
Channels 6 - 10
(nT/sec)



Channels 11 - 15
(nT/sec)



Channels 16 - 22
(nT/sec)



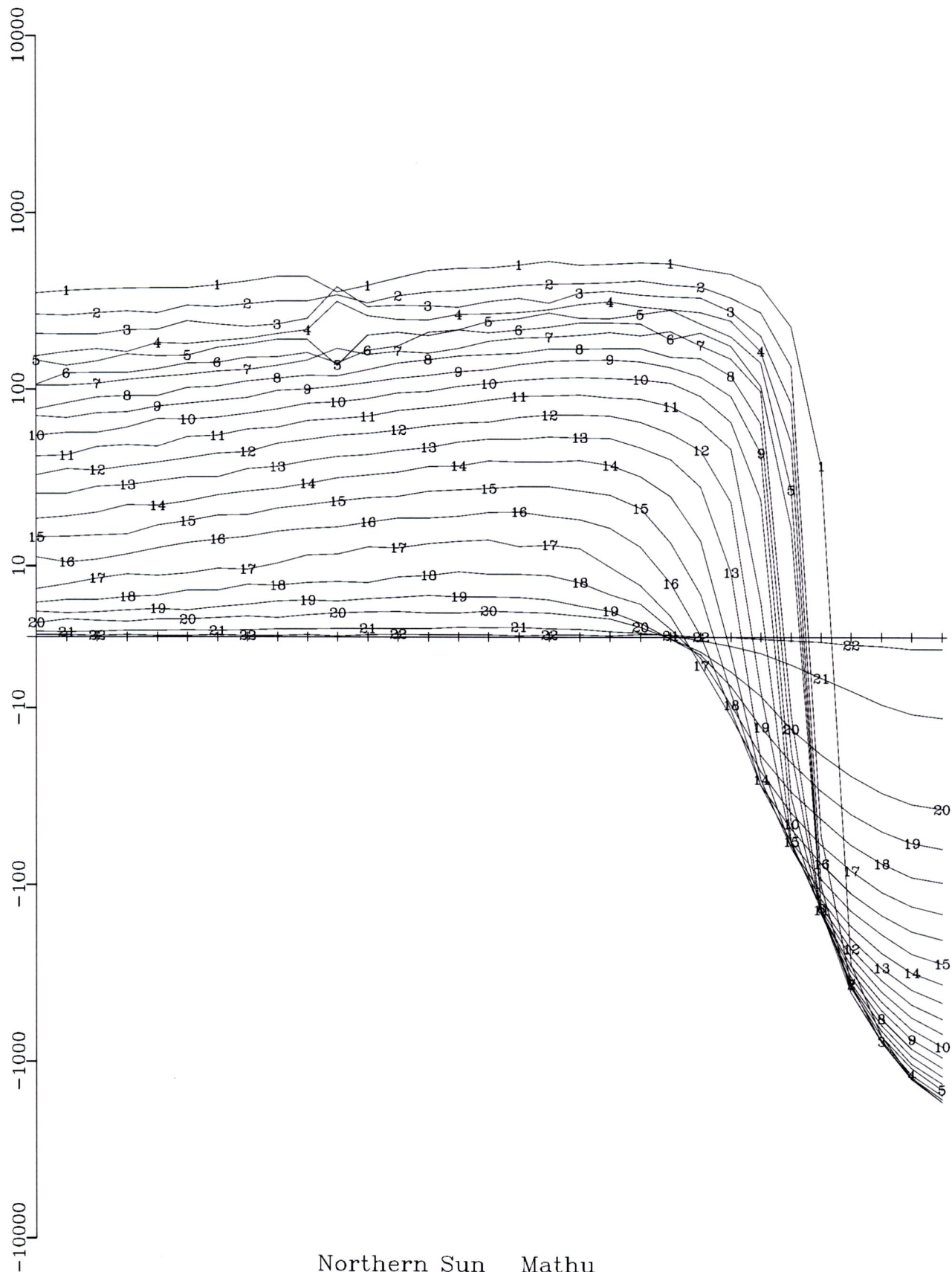
Northern Sun Mathu
Loop Mathu, Hole GM-16-06 Y Component
Crone Geophysics & Exploration Ltd.



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

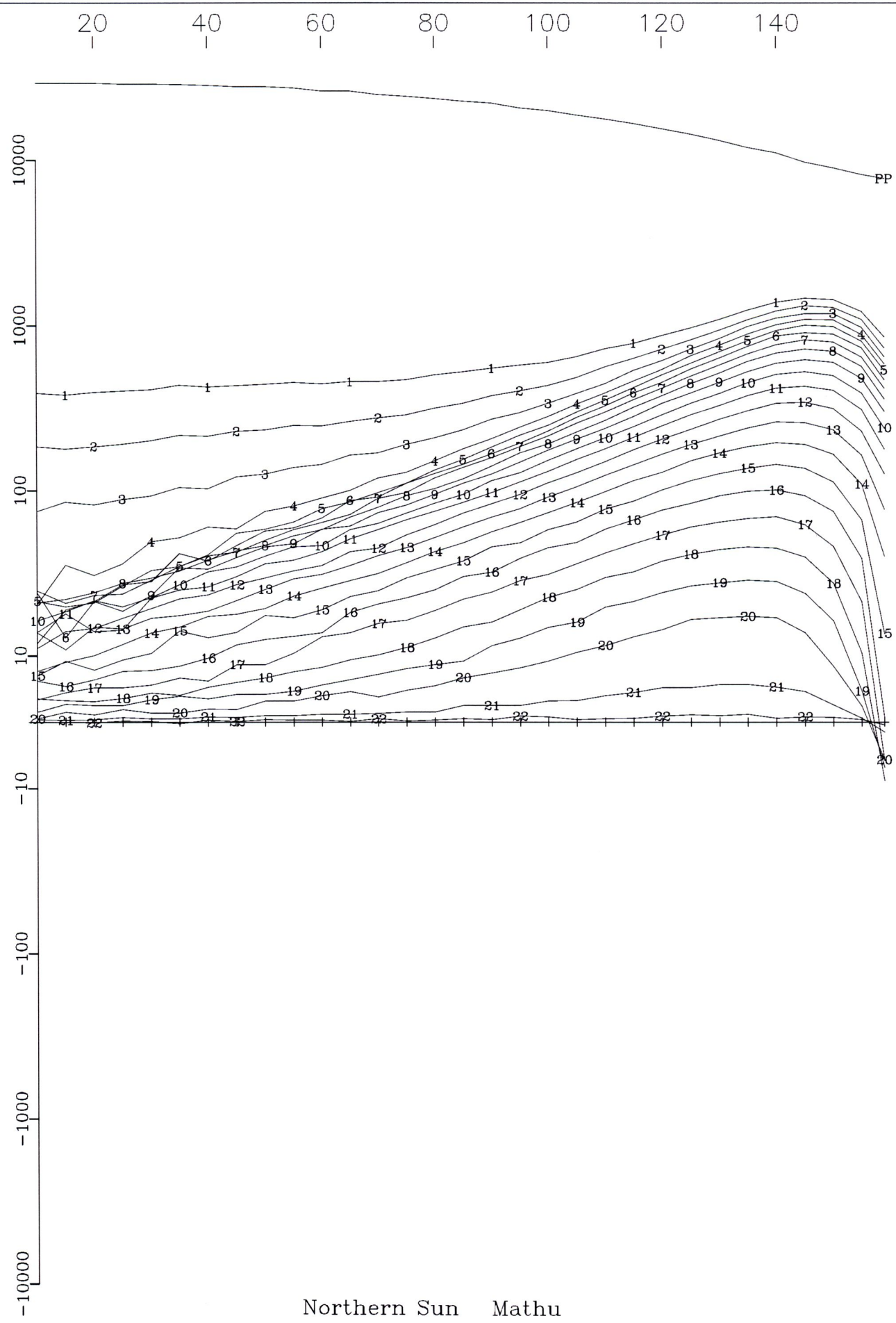


Primary Pulse and 22 Off-time Channels
(nT/sec)



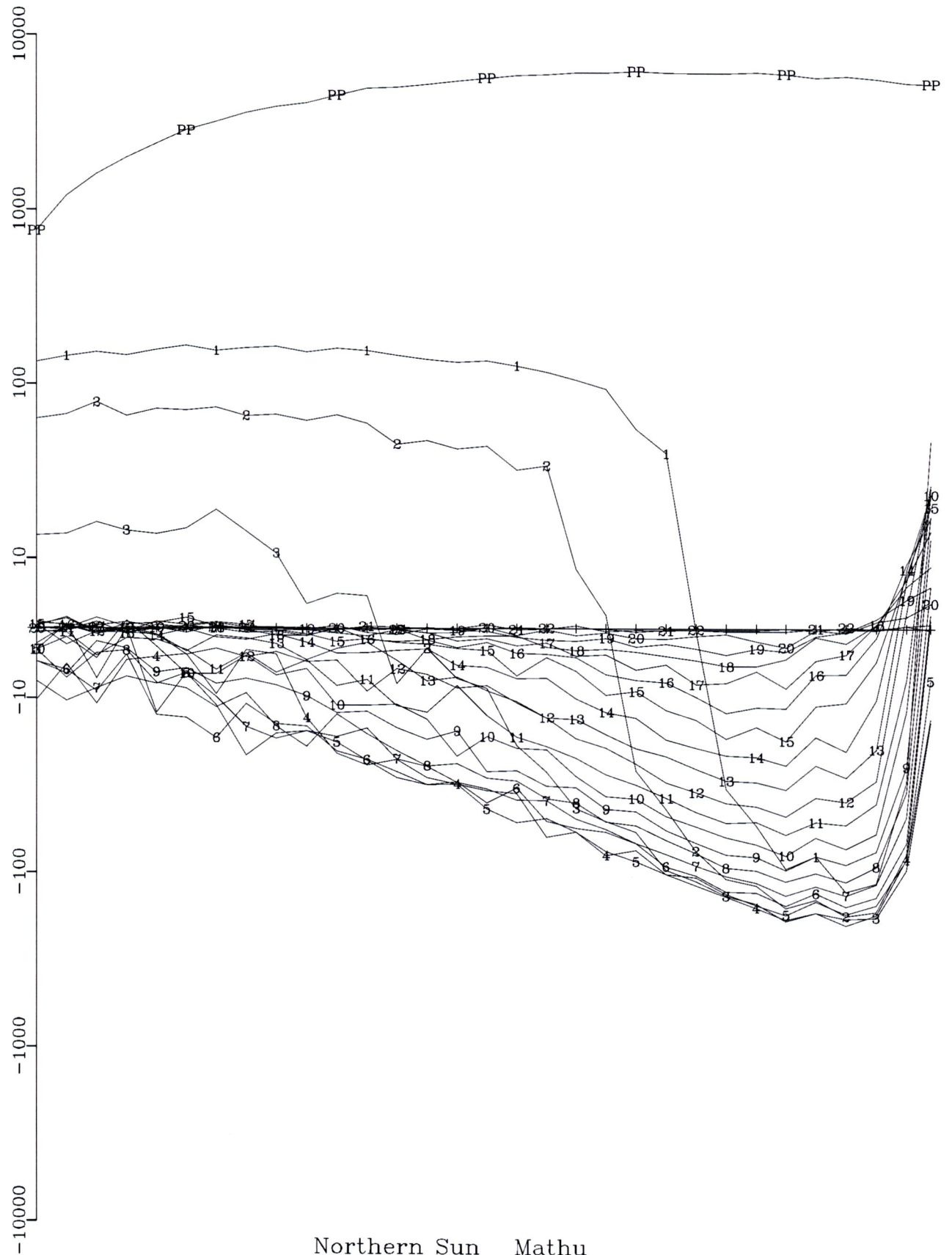
Northern Sun Mathu
Loop MATHU, Hole GM-16-01 Z Component
Crone Geophysics & Exploration Ltd.

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



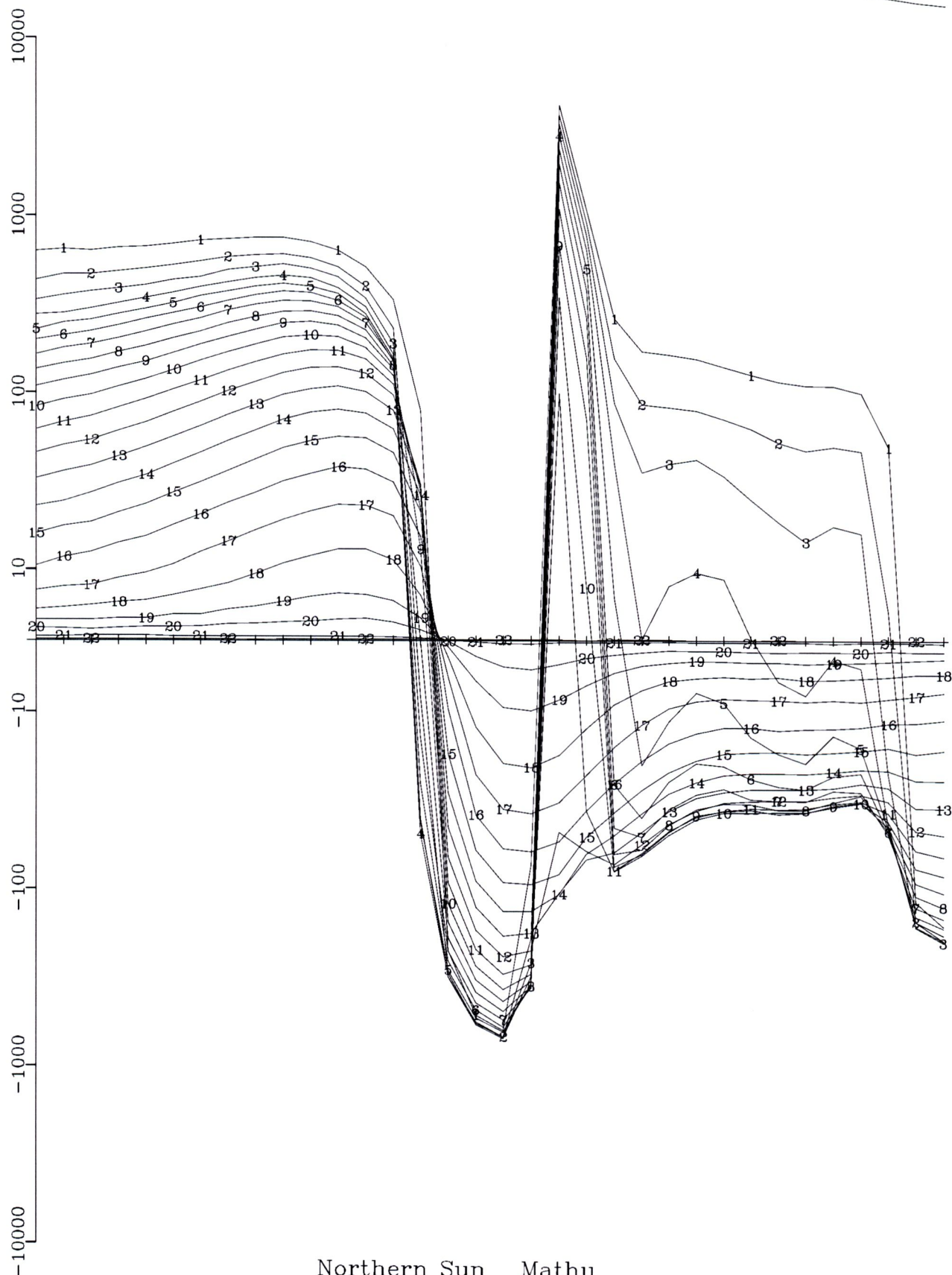
Northern Sun Mathu
Loop MATHU, Hole GM-16-01 X Component
Crone Geophysics & Exploration Ltd.

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



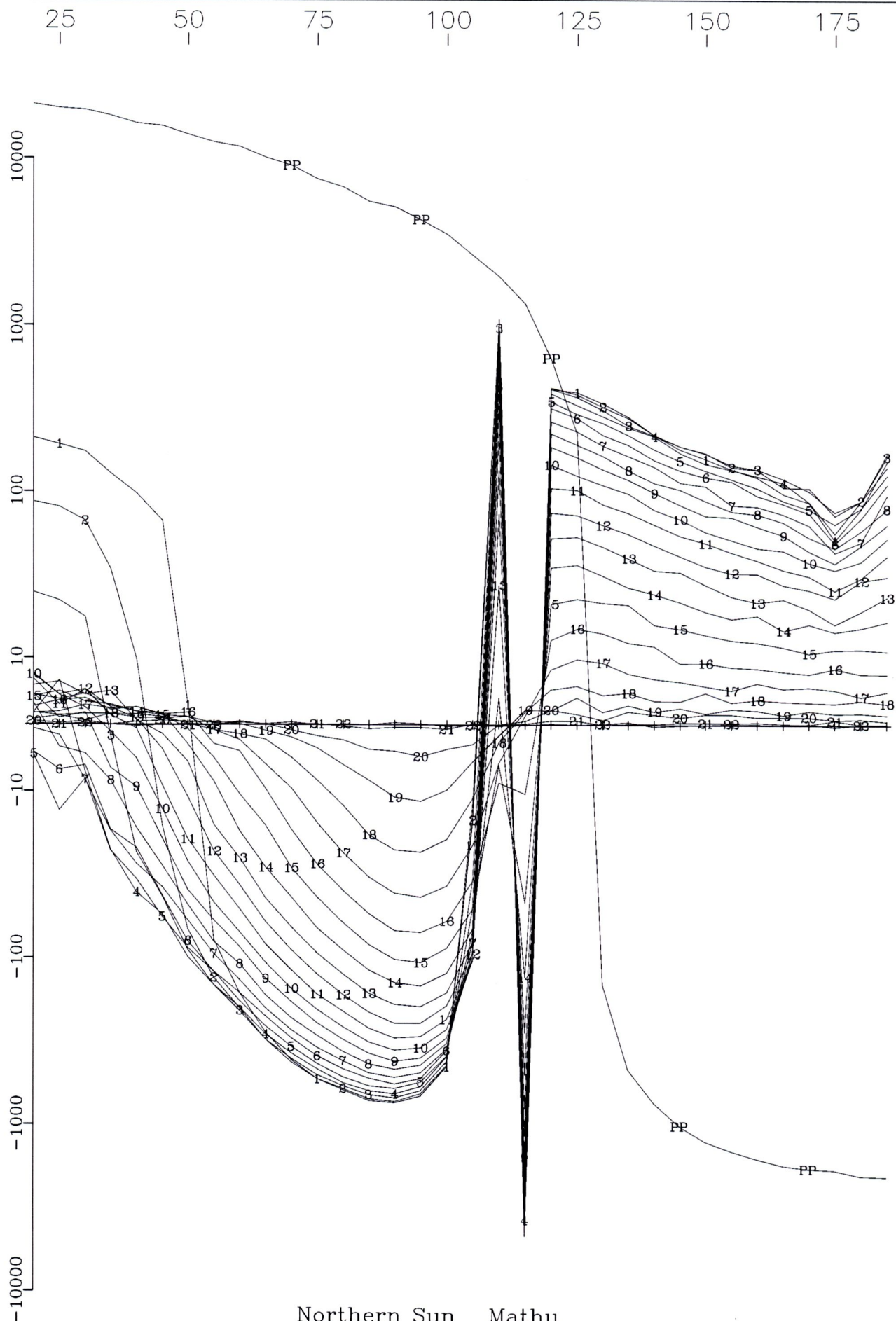
Northern Sun Mathu
Loop MATHU, Hole GM-16-01 Y Component
Crone Geophysics & Exploration Ltd.

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



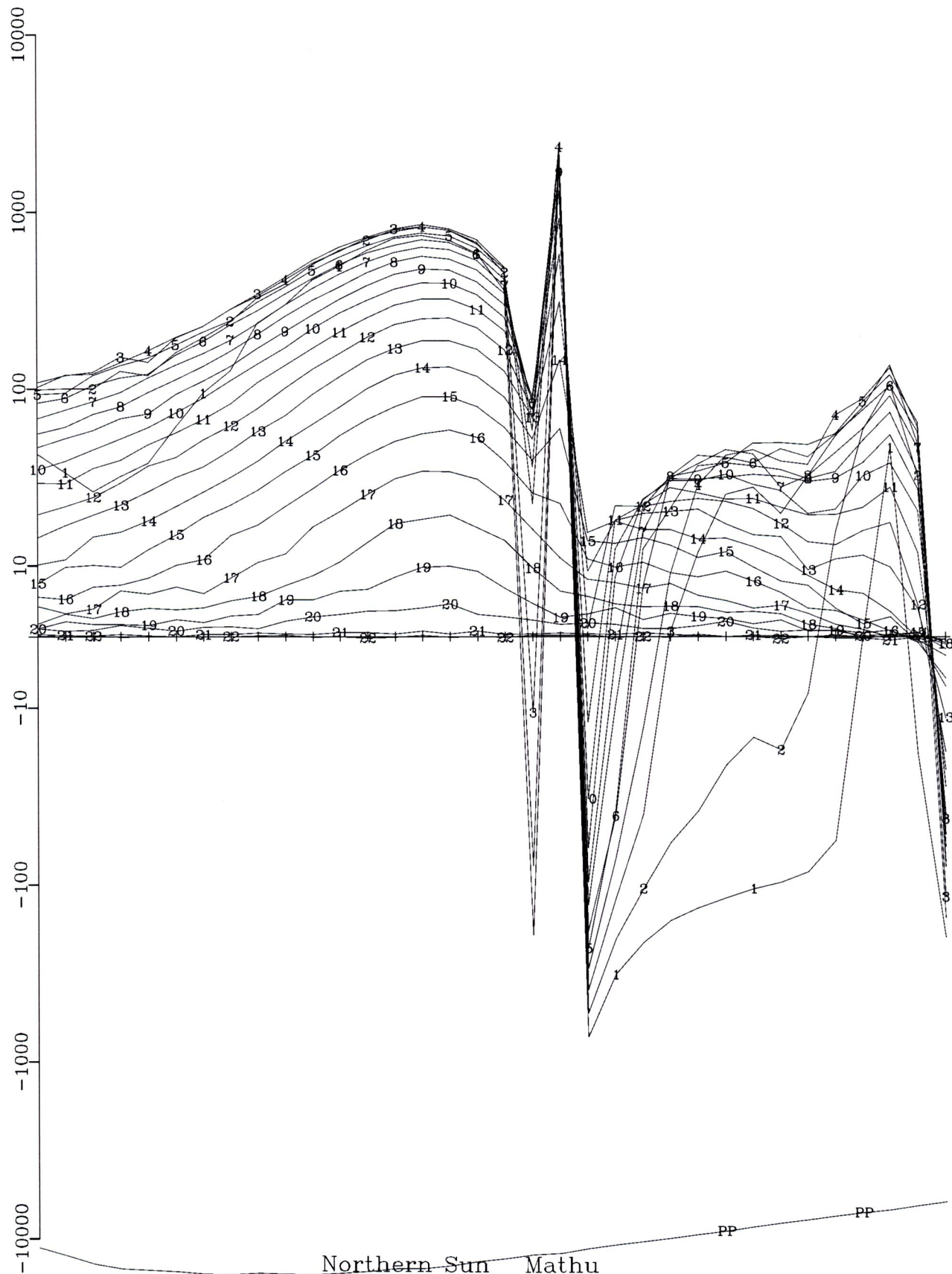
Northern Sun Mathu
Loop MATHU, Hole GM-16-03 Z Component
Crone Geophysics & Exploration Ltd.

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



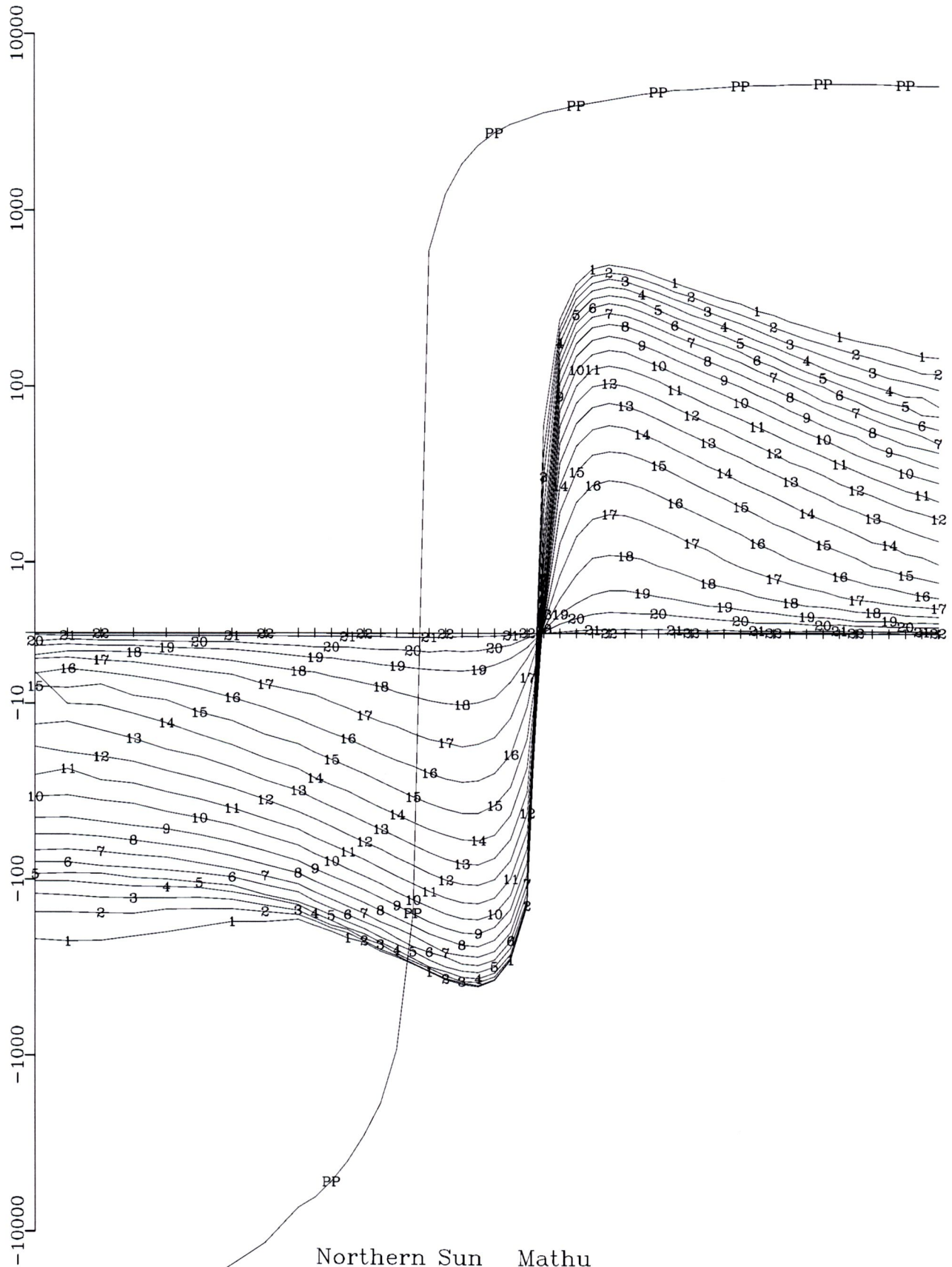
Northern Sun Mathu
Loop MATHU, Hole GM-16-03 X Component
Crone Geophysics & Exploration Ltd.

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

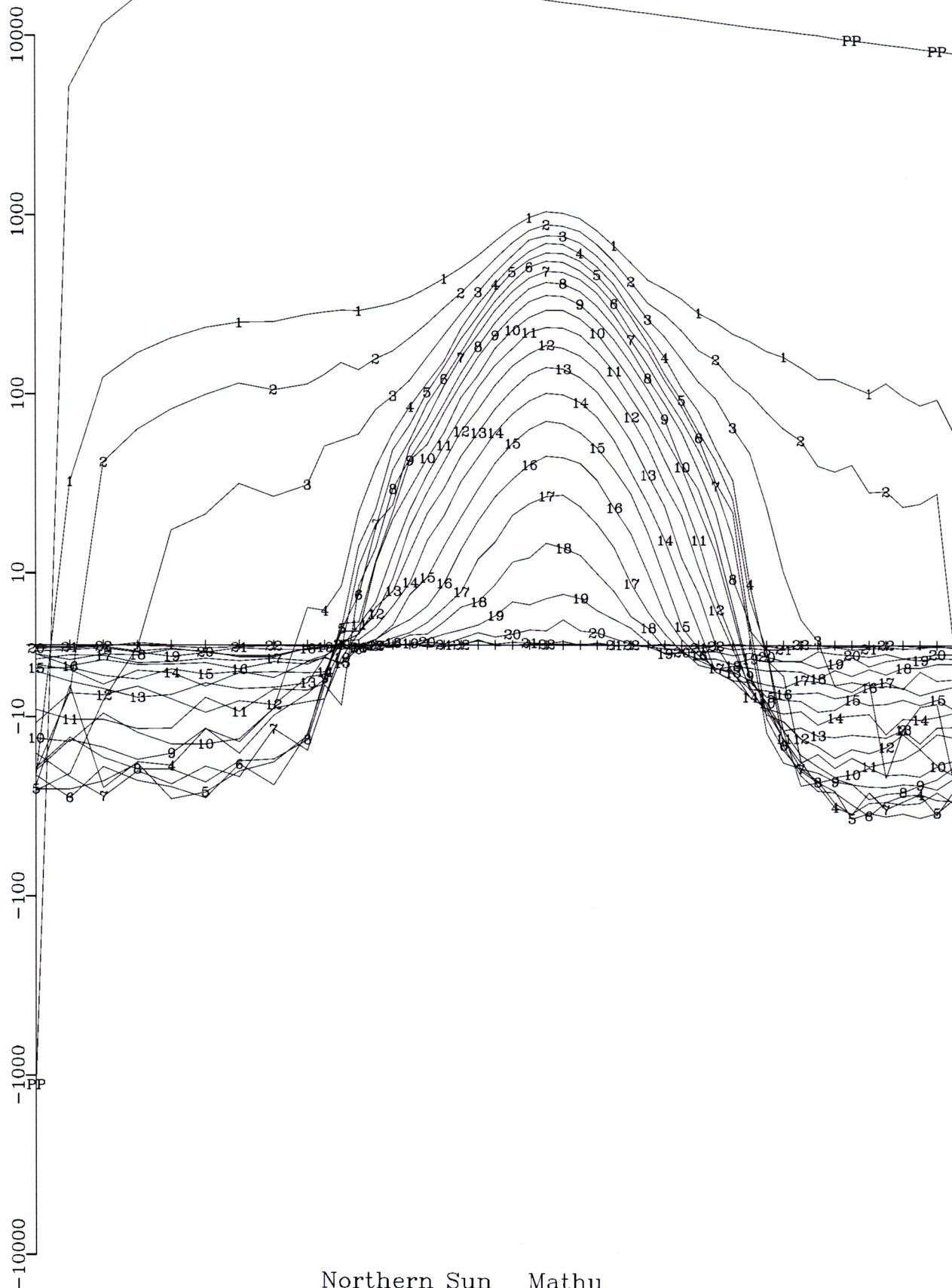


Northern Sun Mathu
Loop MATHU, Hole GM-16-03 Y Component
Crone Geophysics & Exploration Ltd.

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

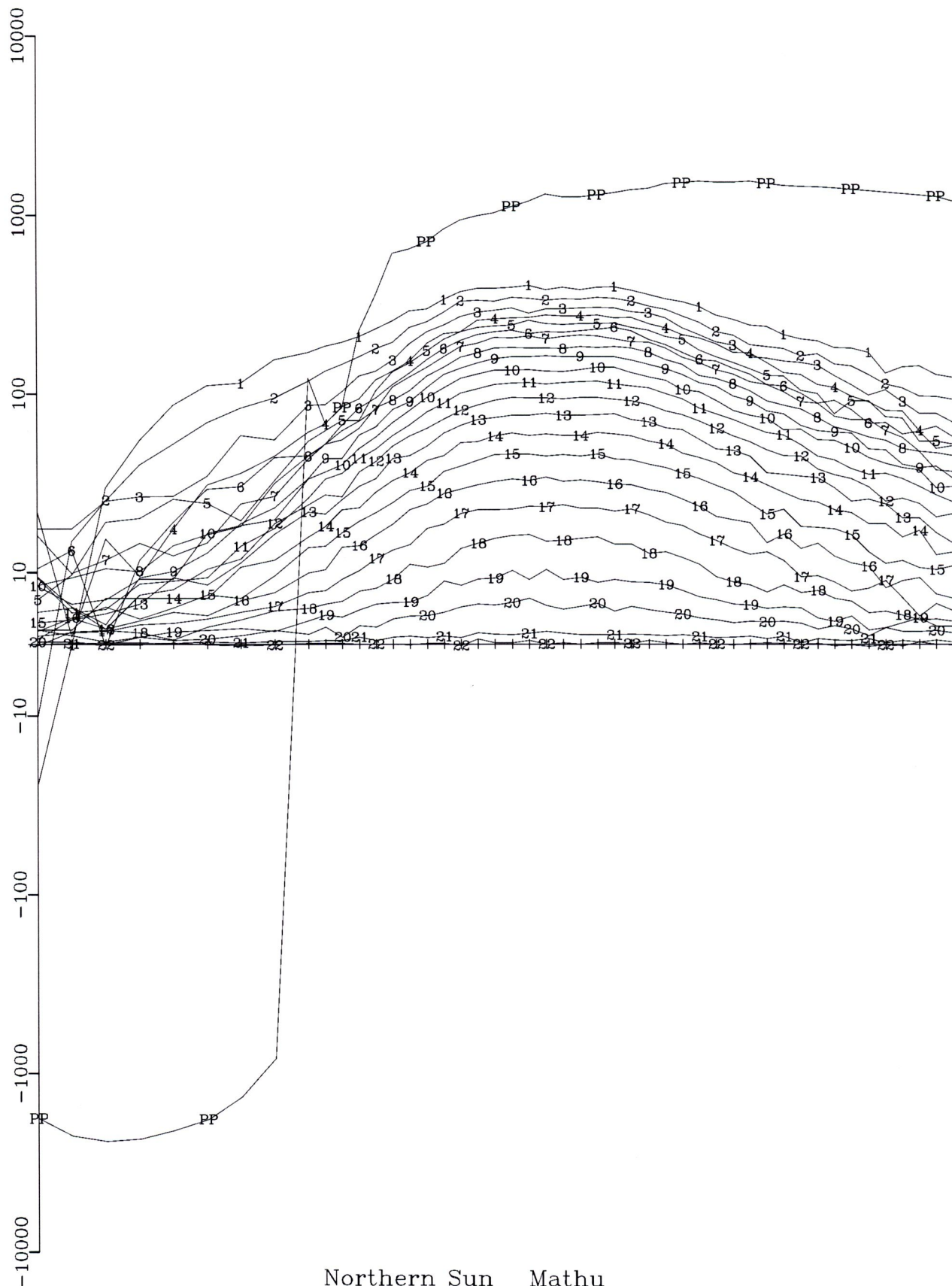


Primary Pulse and 22 Off-time Channels
(nT/sec)



Northern Sun Mathu
Loop Mathu, Hole GM-16-06 X Component
Crone Geophysics & Exploration Ltd.

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



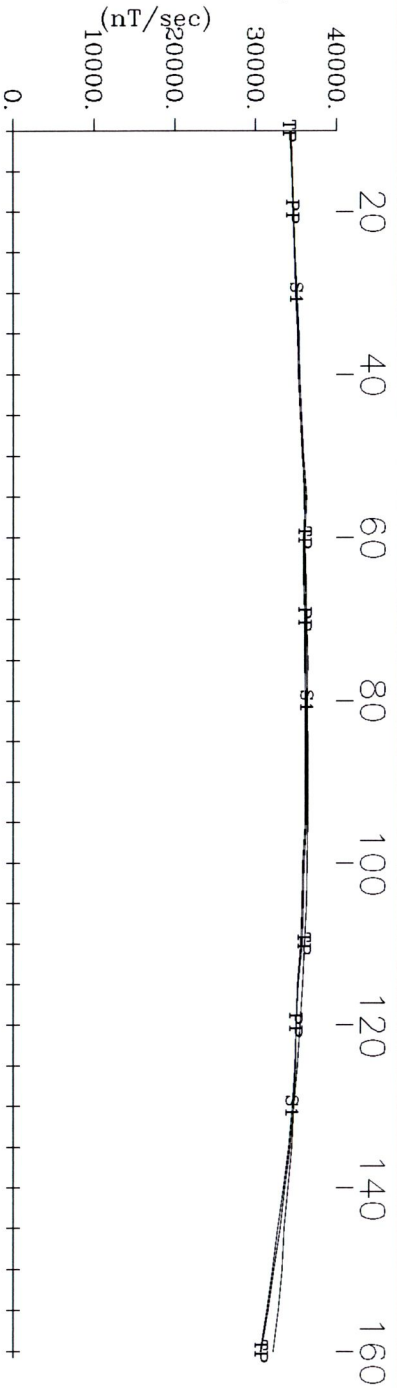
Northern Sun Mathu
Loop Mathu, Hole GM-16-06 Y Component
Crone Geophysics & Exploration Ltd.



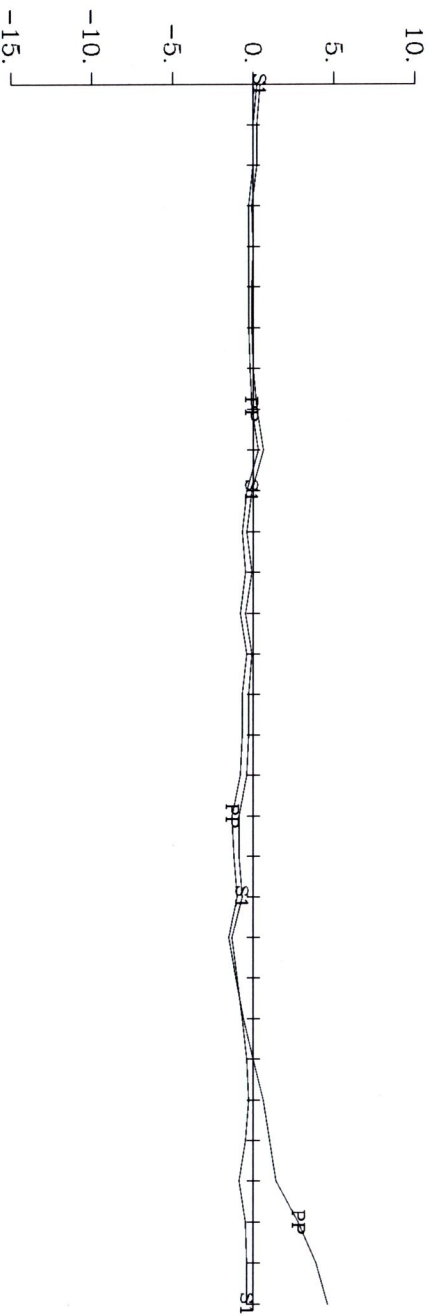
Appendix 4: Step Response Data Profiles



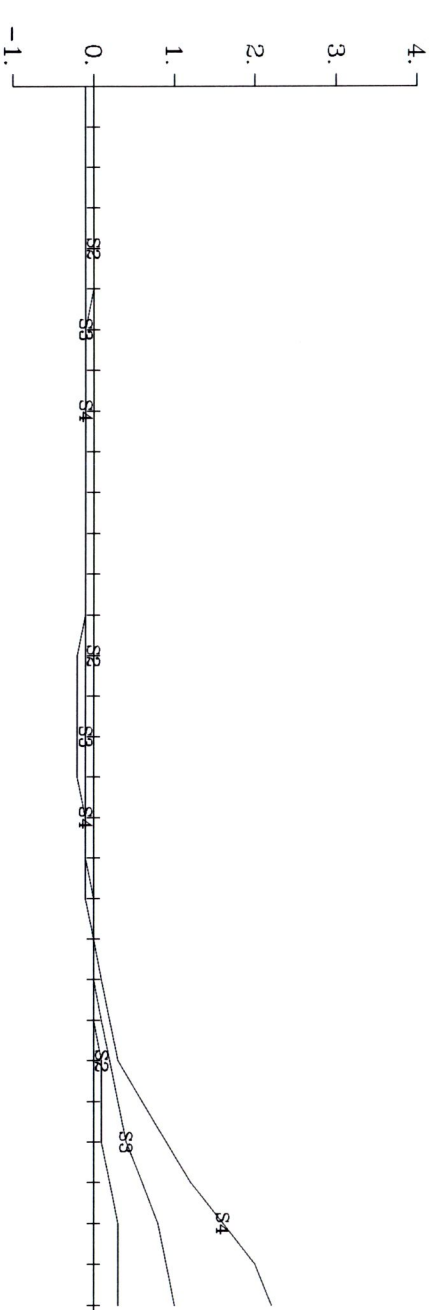
TP = Theoretical Primary
 PP = Last Ramp Channel
 S1 = Calculated Step Ch.1



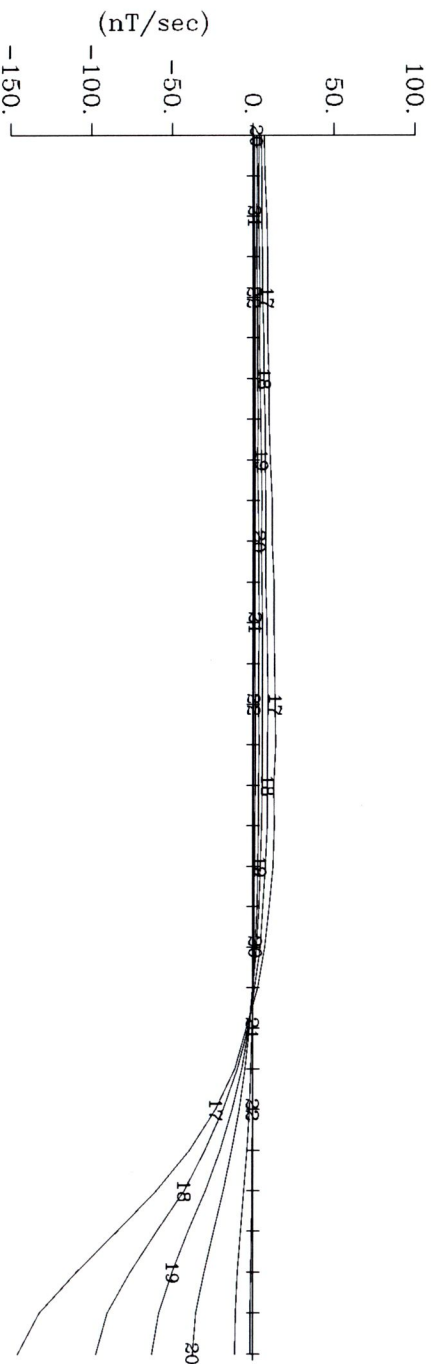
Deviation from TP.
 (% Total Theoretical)



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

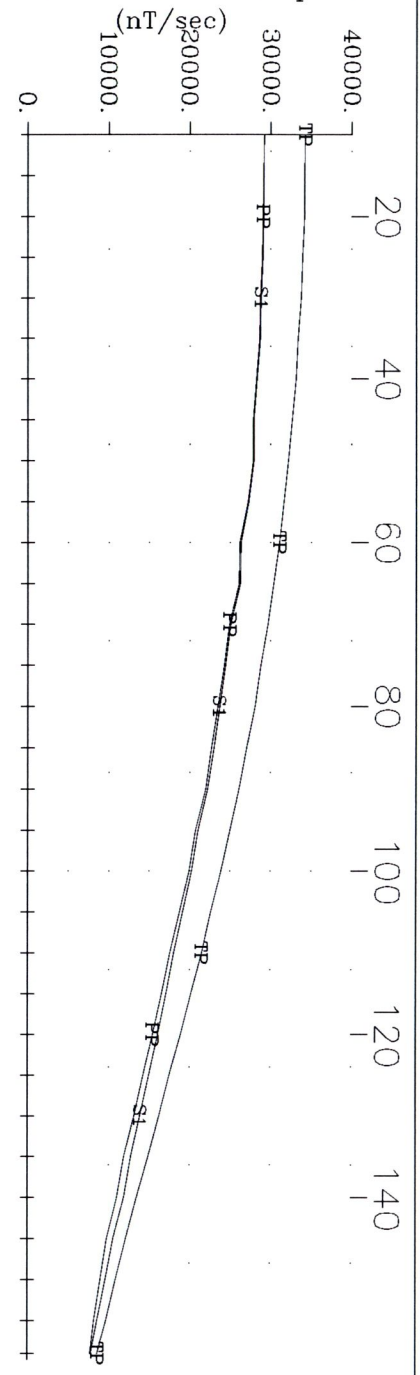


Pulse EM Off-time
 Channels 17-22

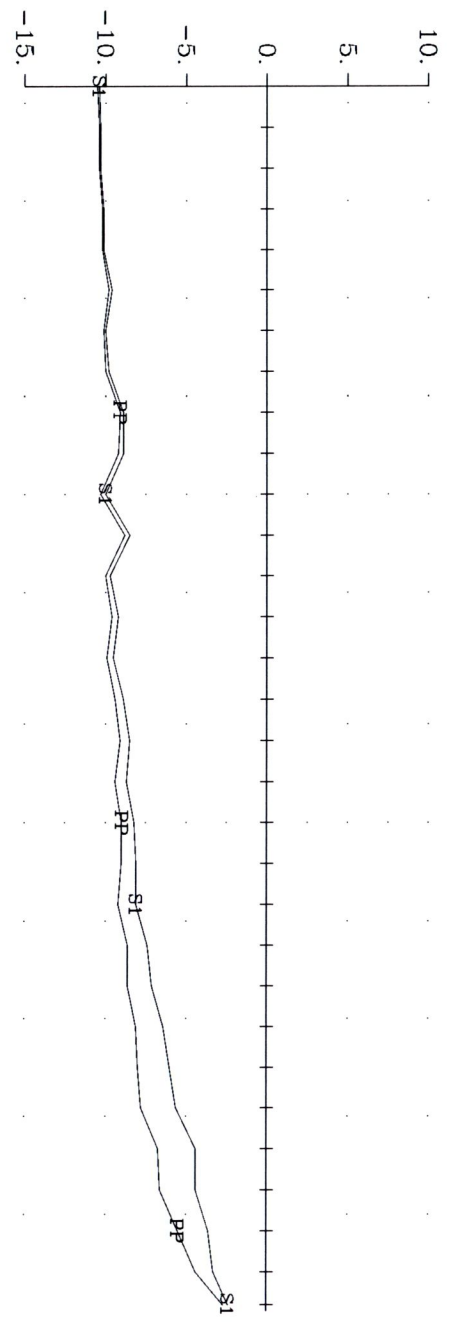


Northern Sun Mathu
 Loop MATHU, Hole GM-16-01 Z Component
 Crone Geophysics & Exploration Ltd.

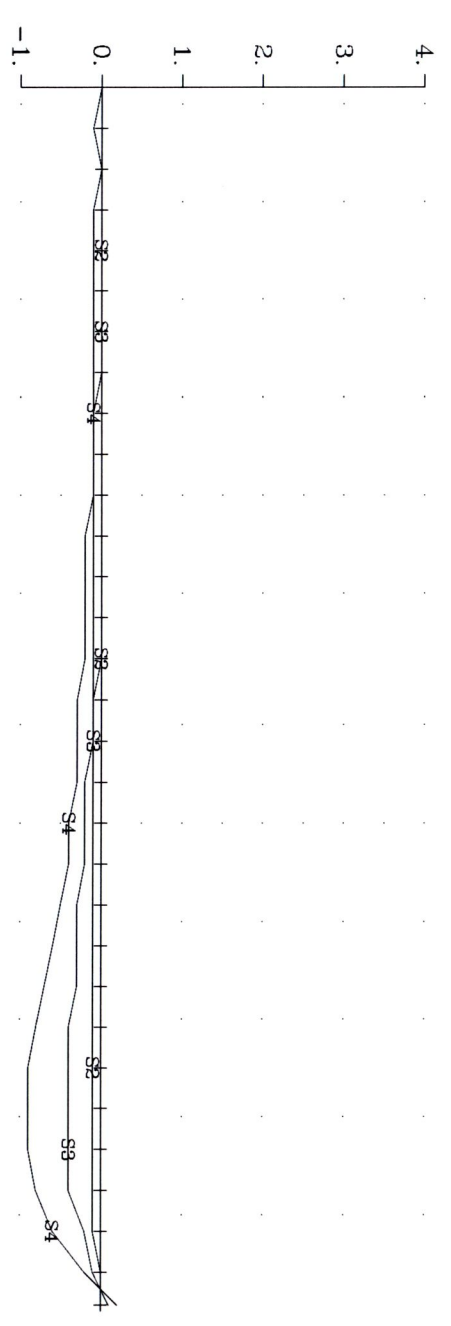
TP = Theoretical Primary
 PP = Last Ramp Channel
 S1 = Calculated Step Ch.1



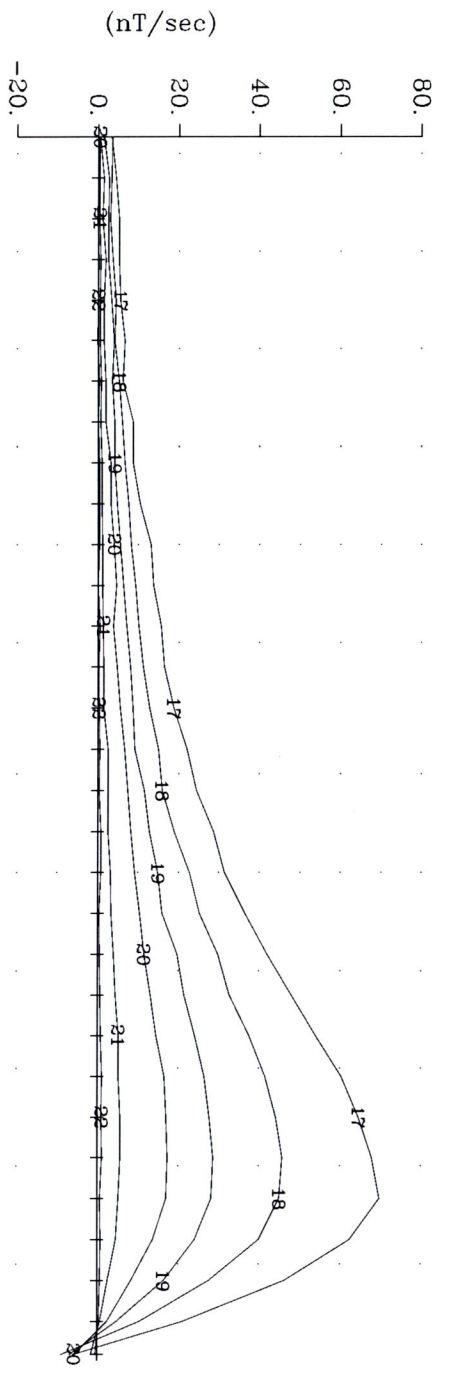
Deviation from TP.
 (% Total Theoretical)



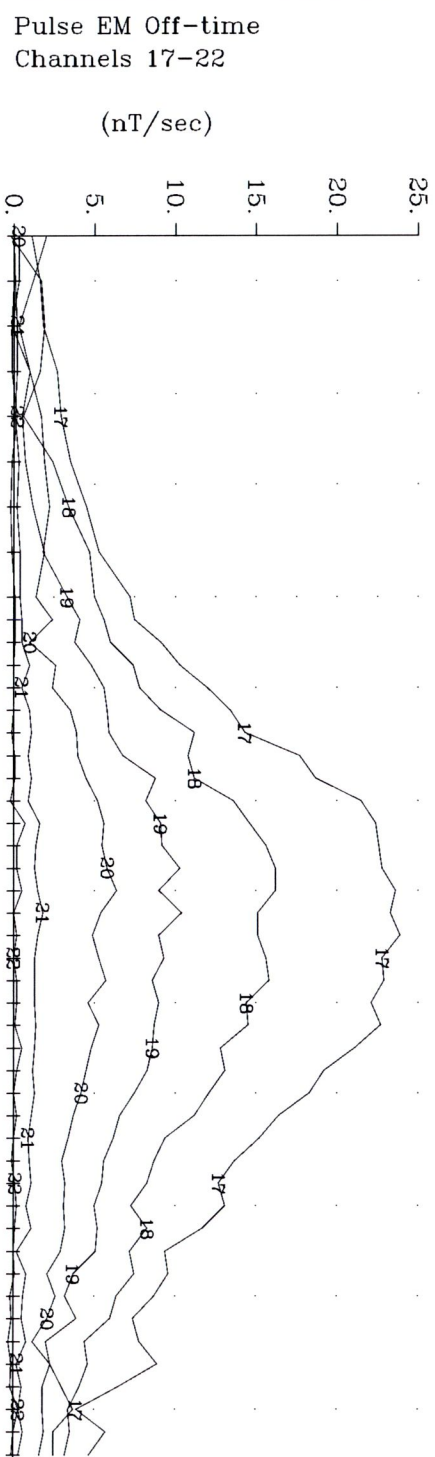
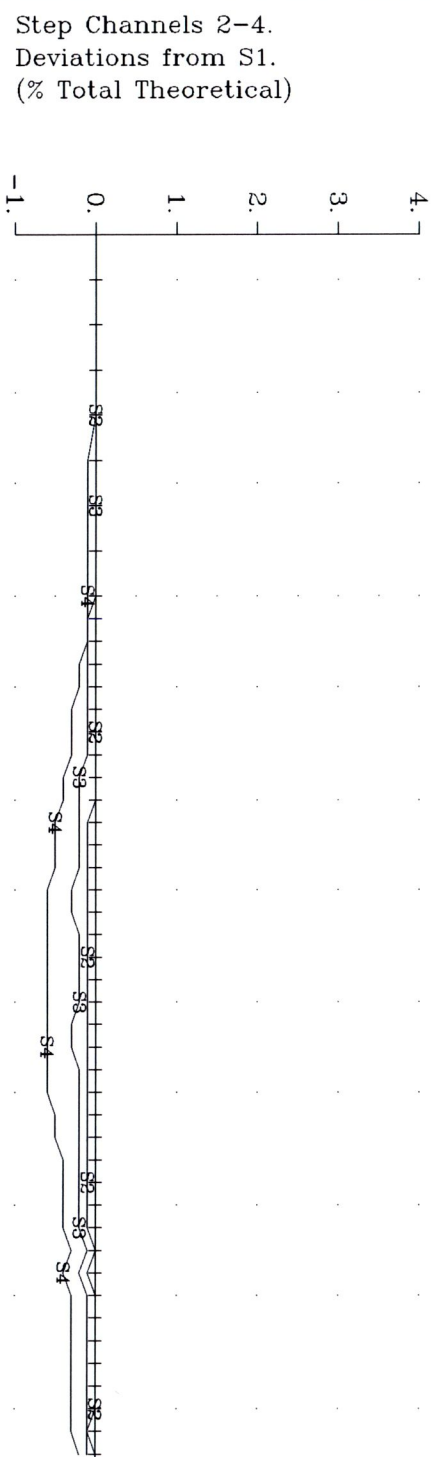
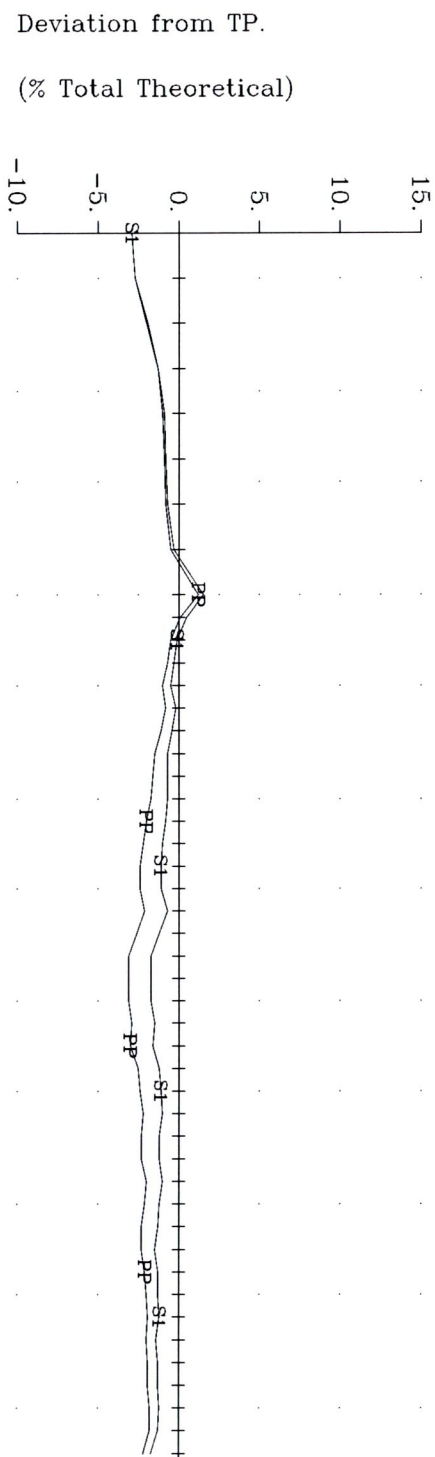
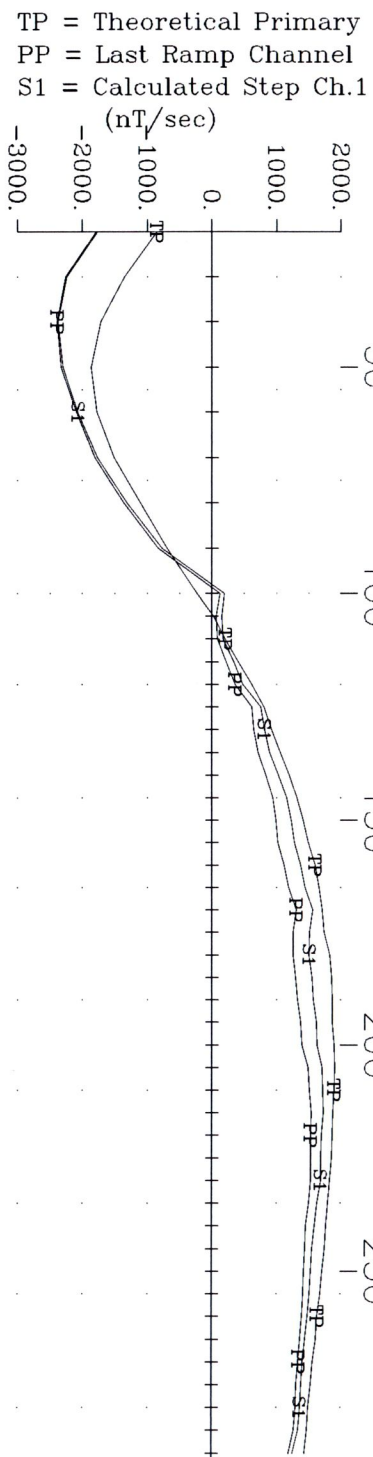
Step Channels 2-4.
 Deviations from S1.
 (% Total Theoretical)



Pulse EM Off-time
 Channels 17-22

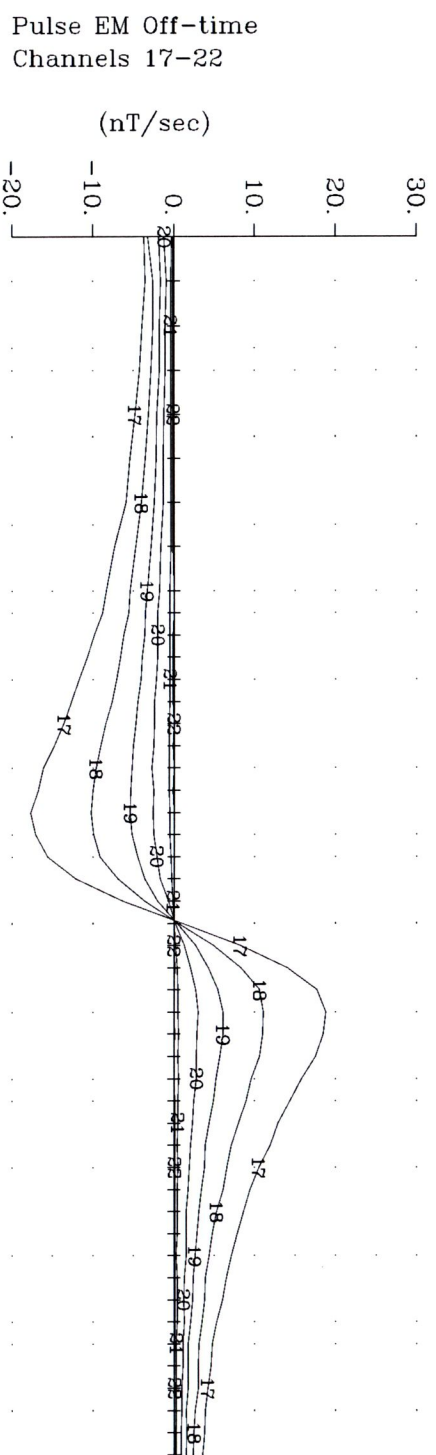
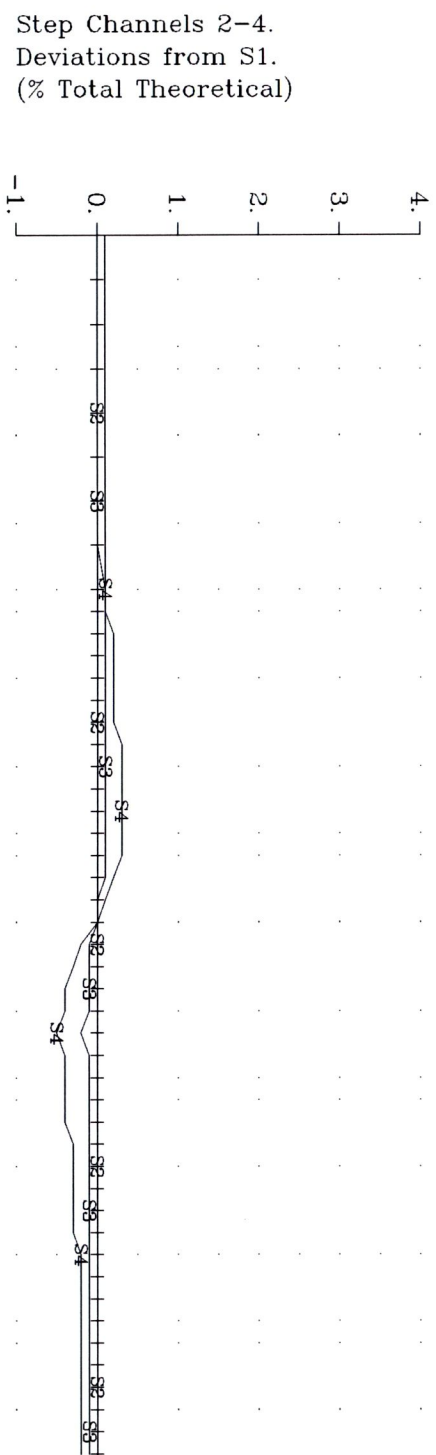
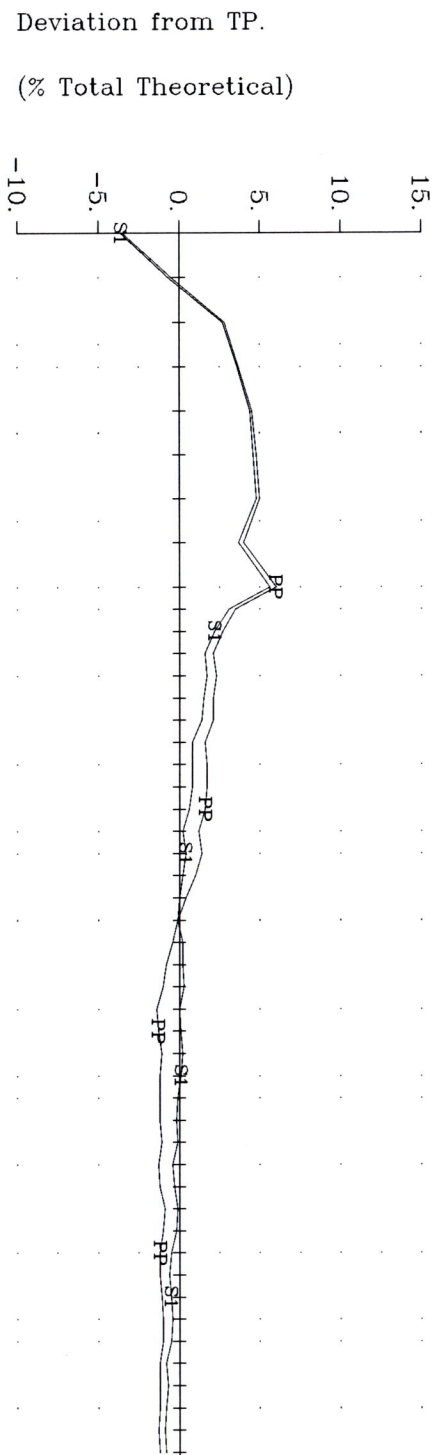
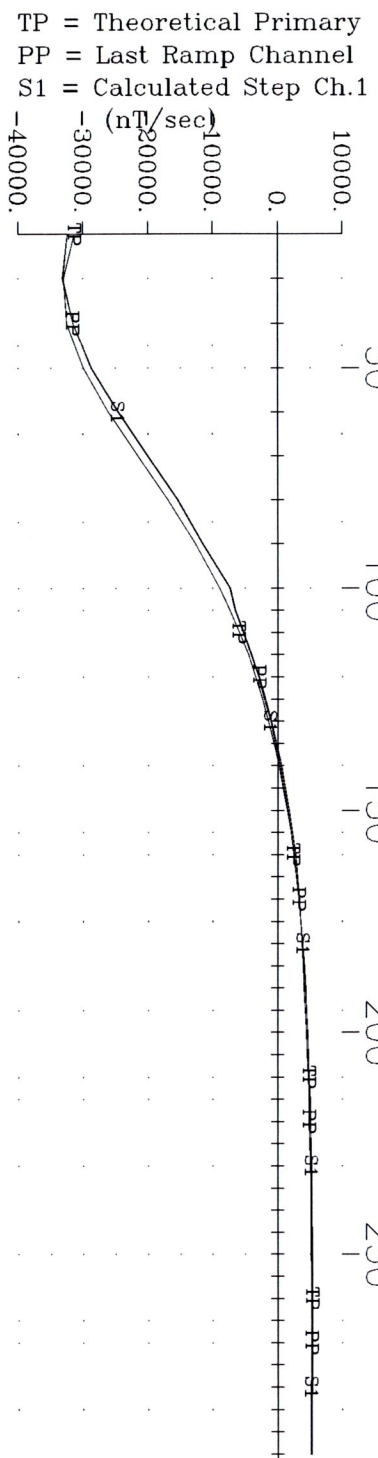


Northern Sun Mathu
 Loop MATHU, Hole GM-16-01 X Component
 Crone Geophysics & Exploration Ltd.

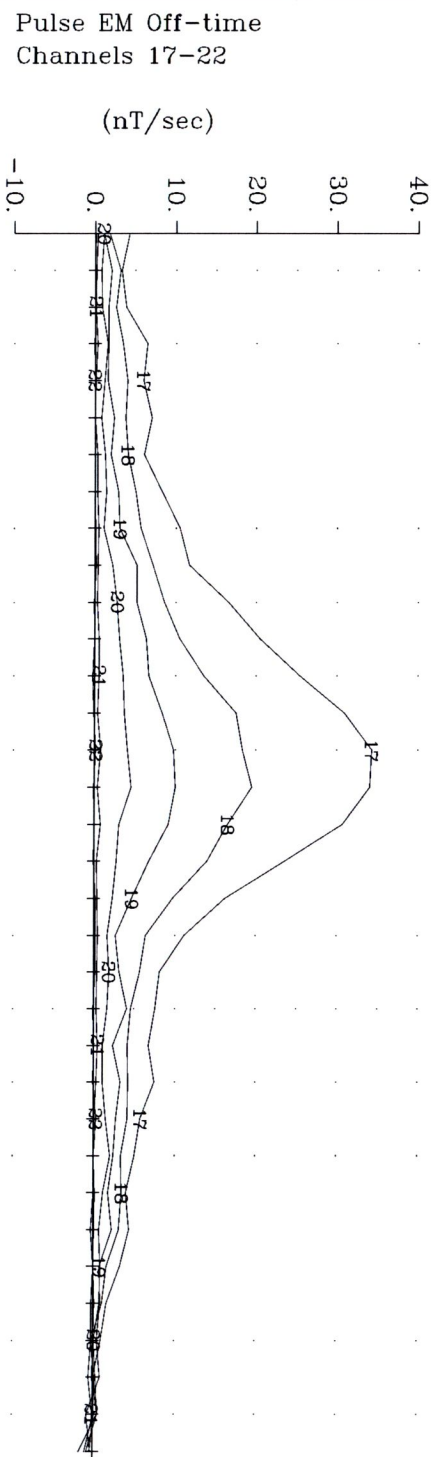
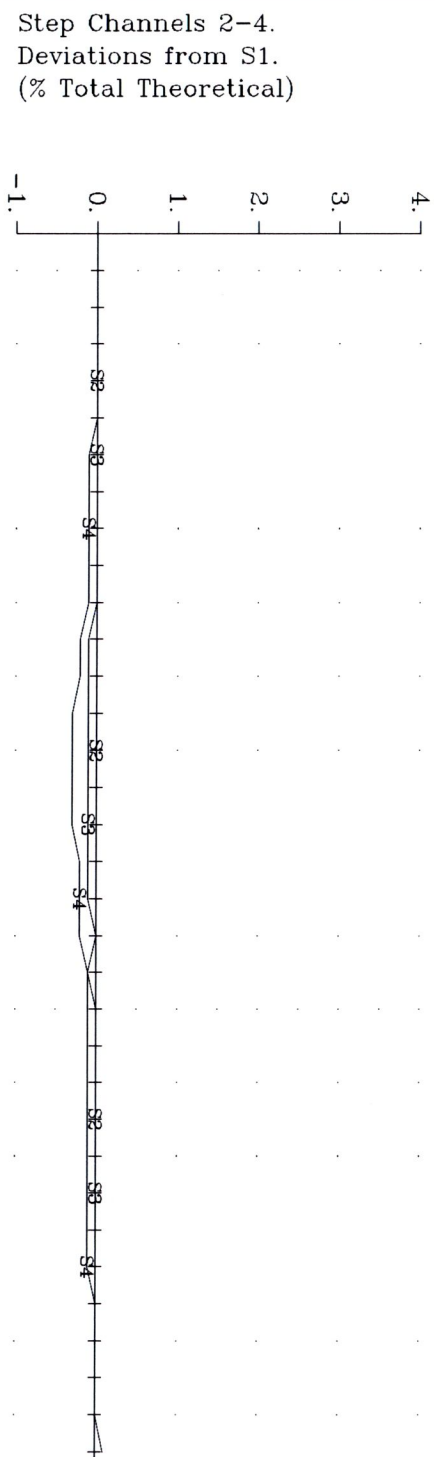
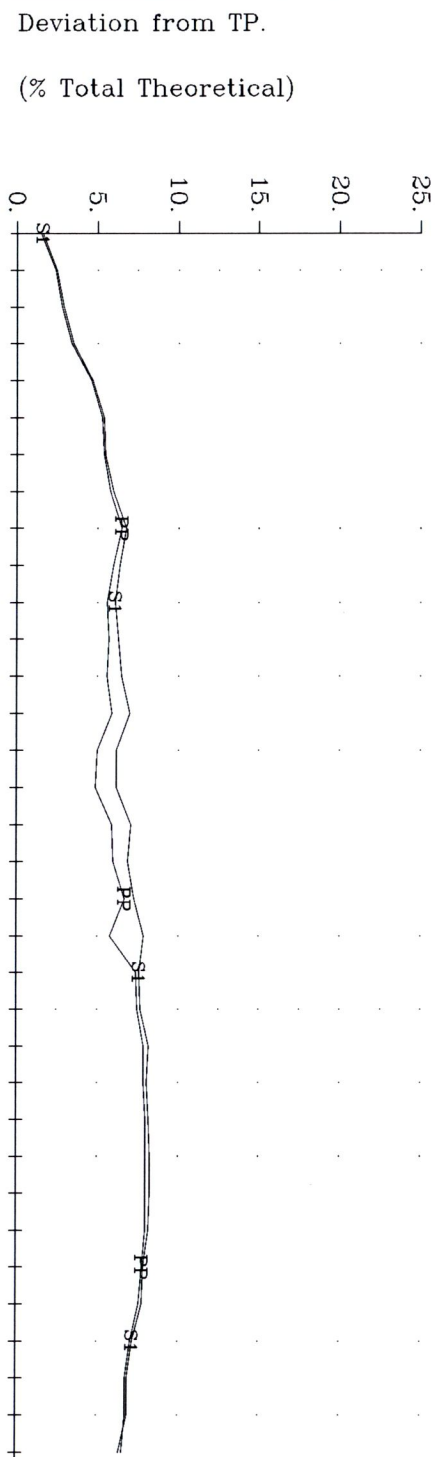
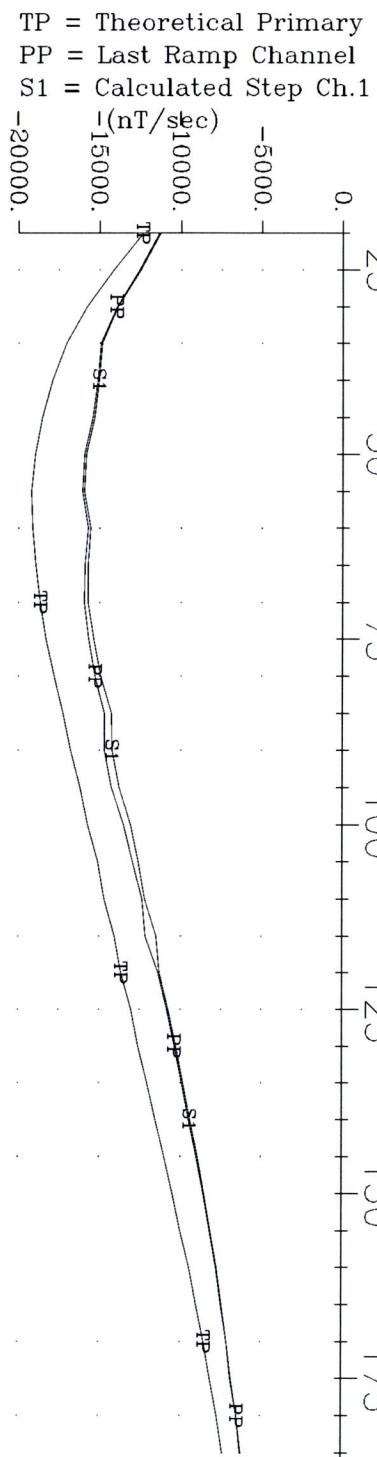


Northern Sun Mathu
 Loop Mathu, Hole GM-16-06 Y Component
 Crone Geophysics & Exploration Ltd.

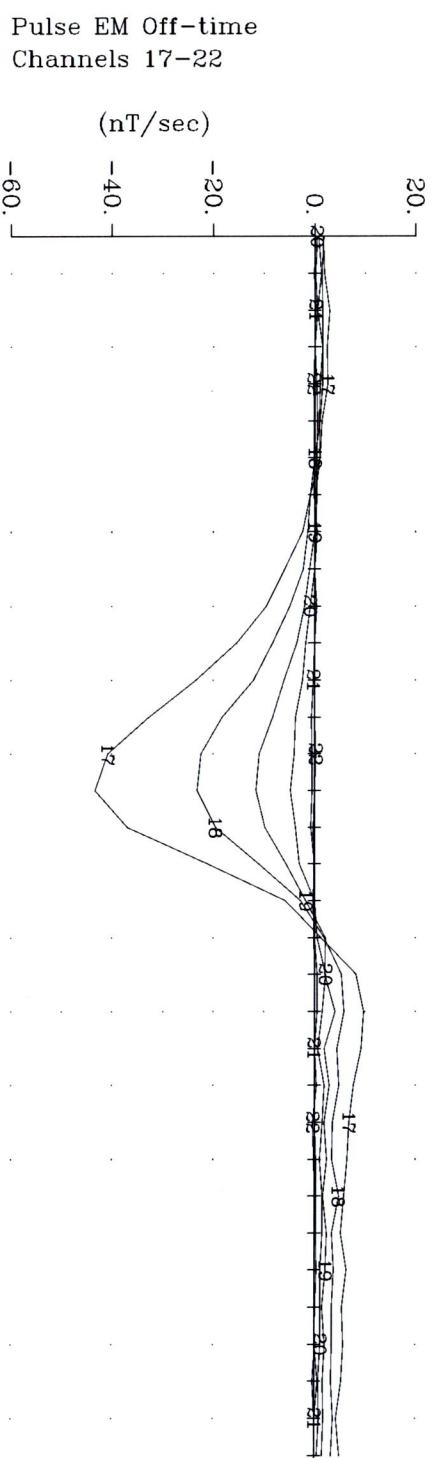
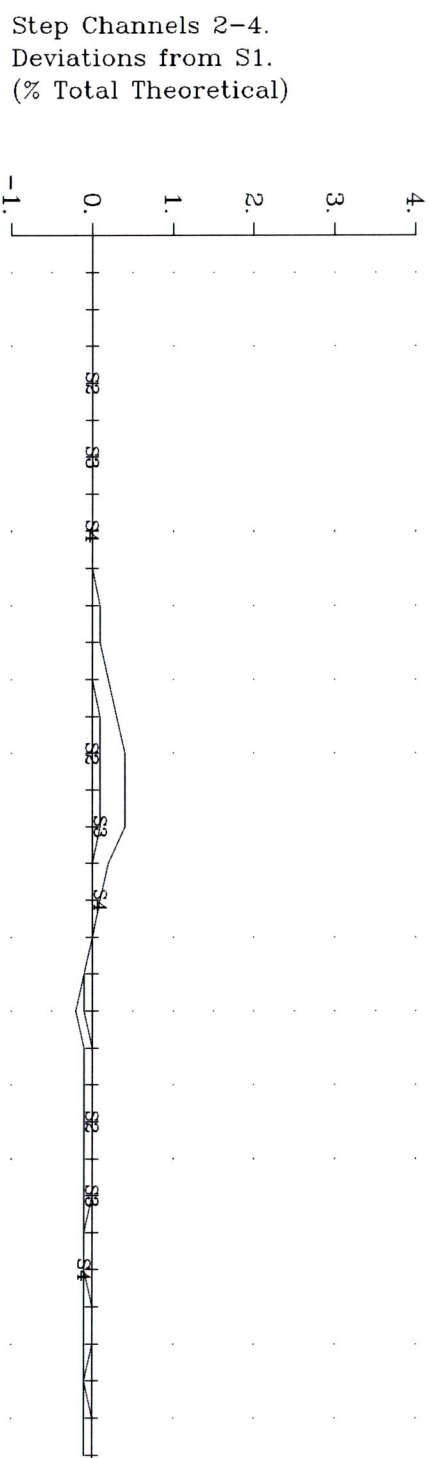
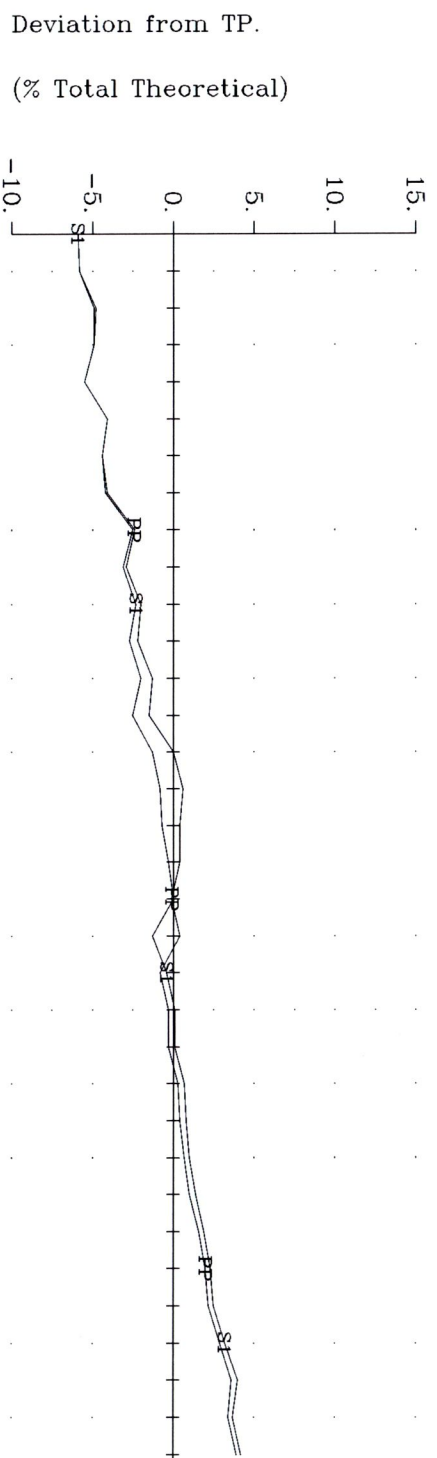
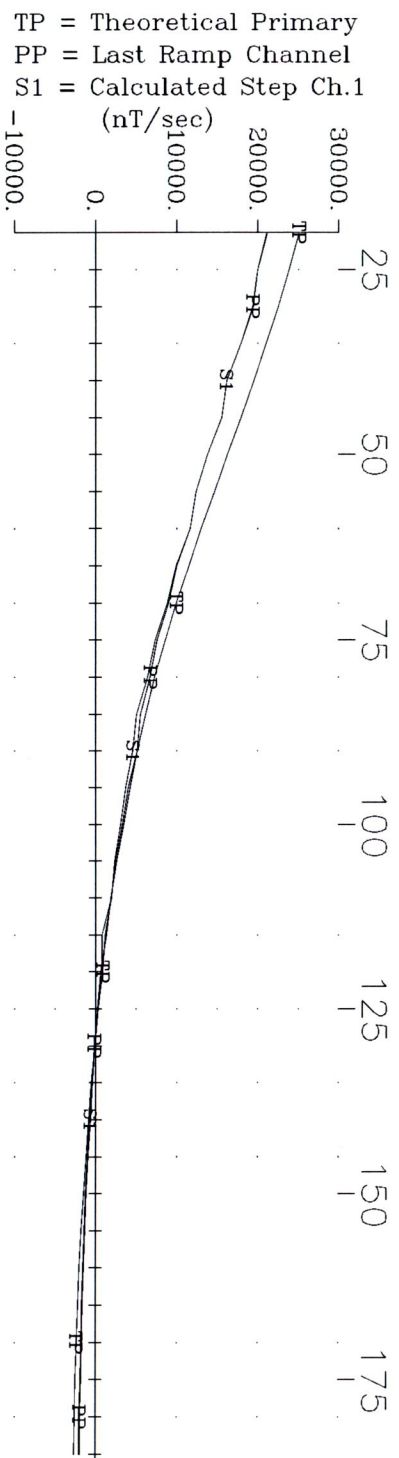
Northern Sun Mathu
Loop Mathu, Hole GM-16-06 X Component
Crone Geophysics & Exploration Ltd.



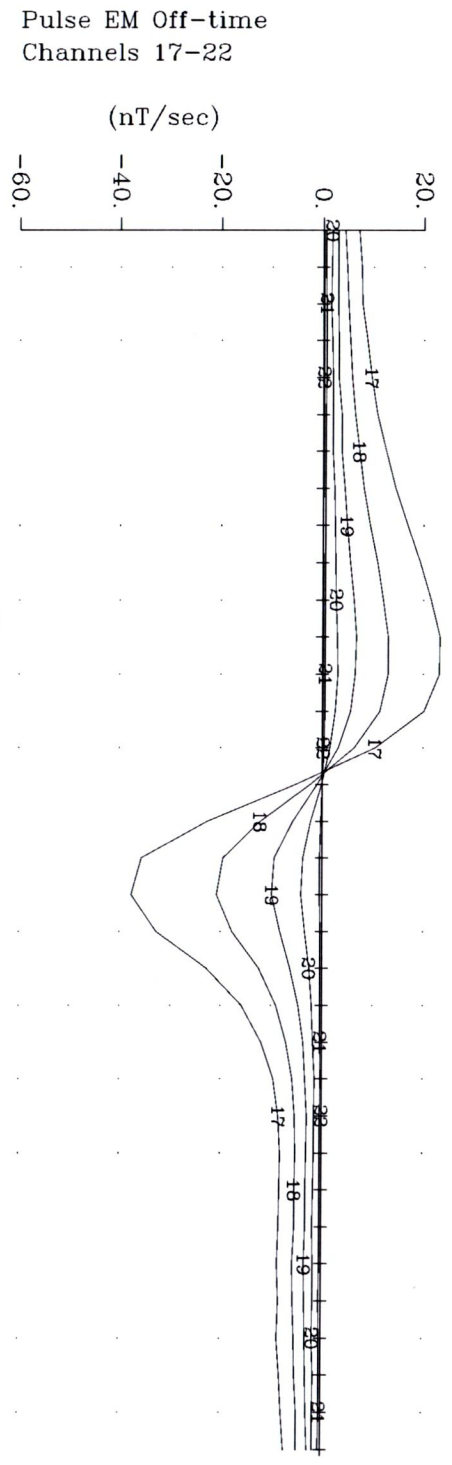
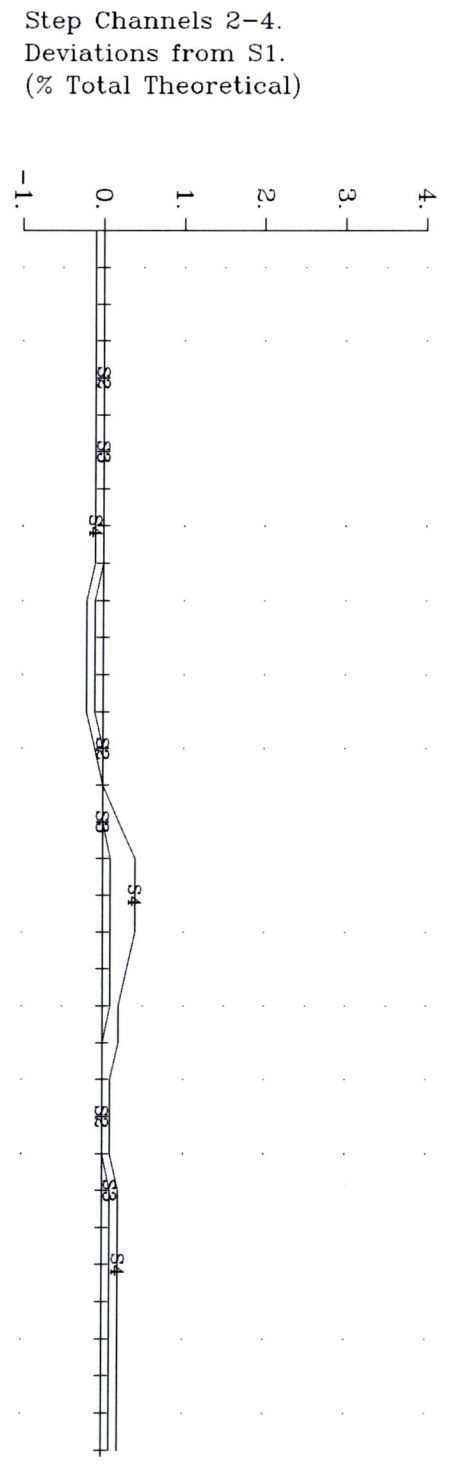
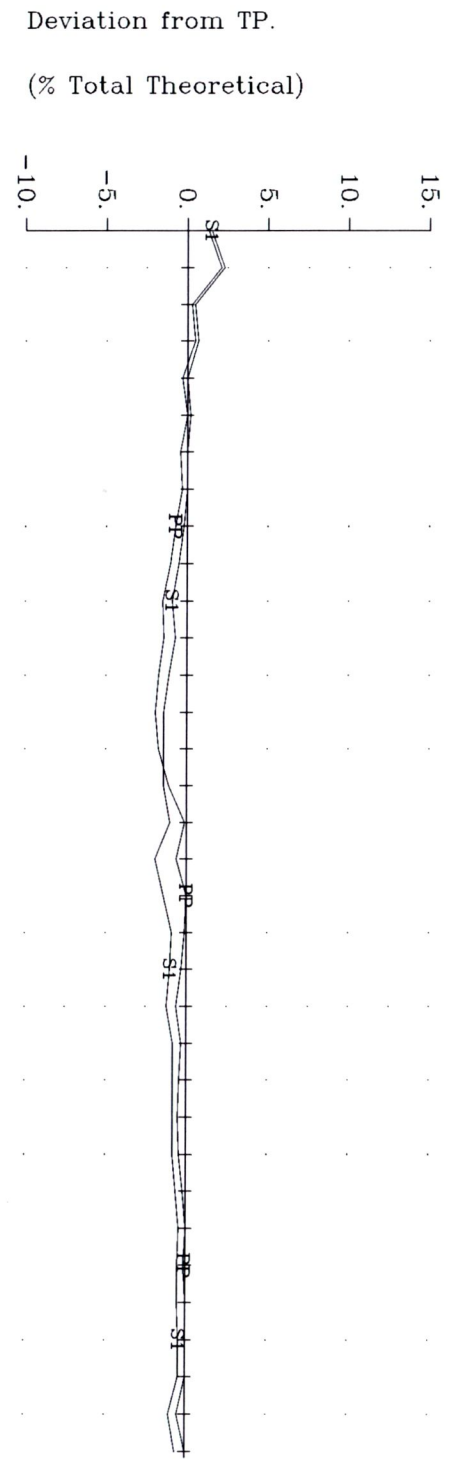
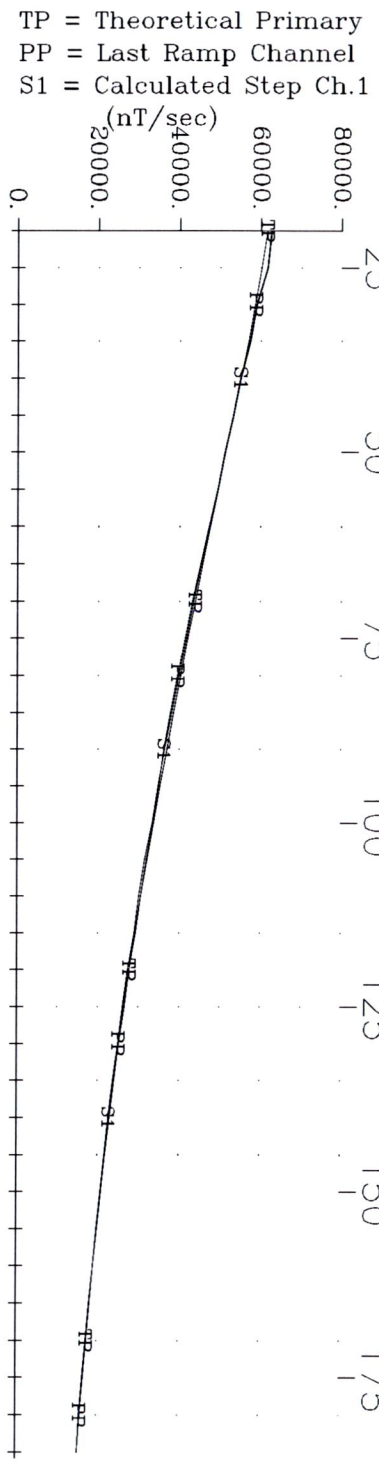
Northern Sun Mathu
 Loop Mathu, Hole GM-16-06 Z Component
 Crone Geophysics & Exploration Ltd.



Northern Sun Mathu
Loop MATHU, Hole GM-16-03 Y Component
Crone Geophysics & Exploration Ltd.

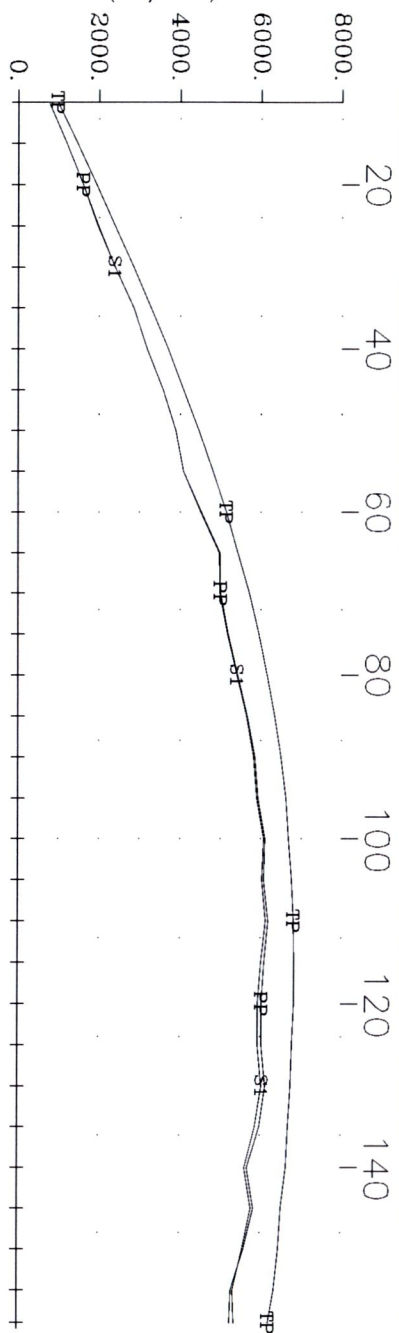


Northern Sun Mathu
Loop MATHU, Hole GM-16-03 X Component
Crone Geophysics & Exploration Ltd.

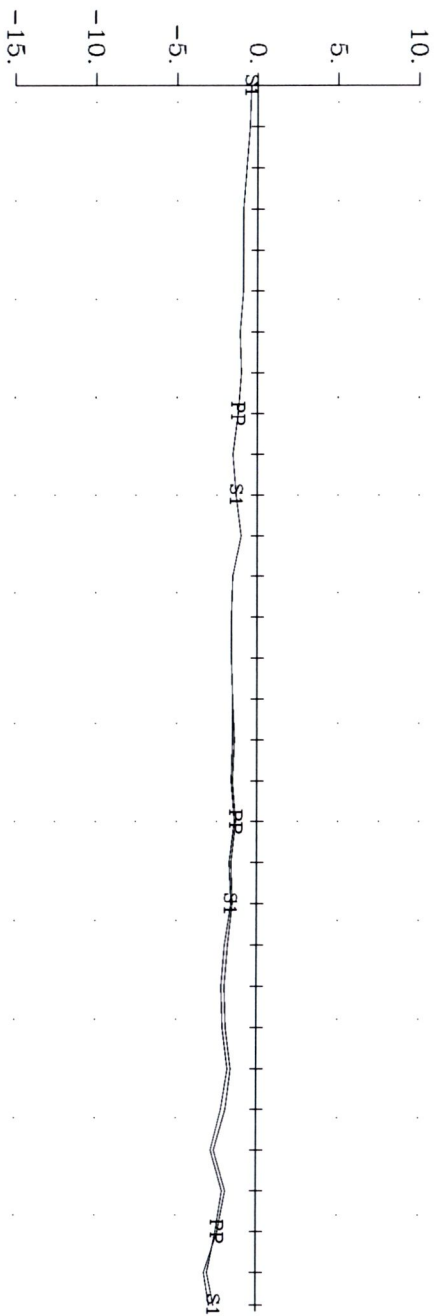


Northern Sun Mathu
 Loop MATHU, Hole GM-16-03 Z Component
 Crone Geophysics & Exploration Ltd.

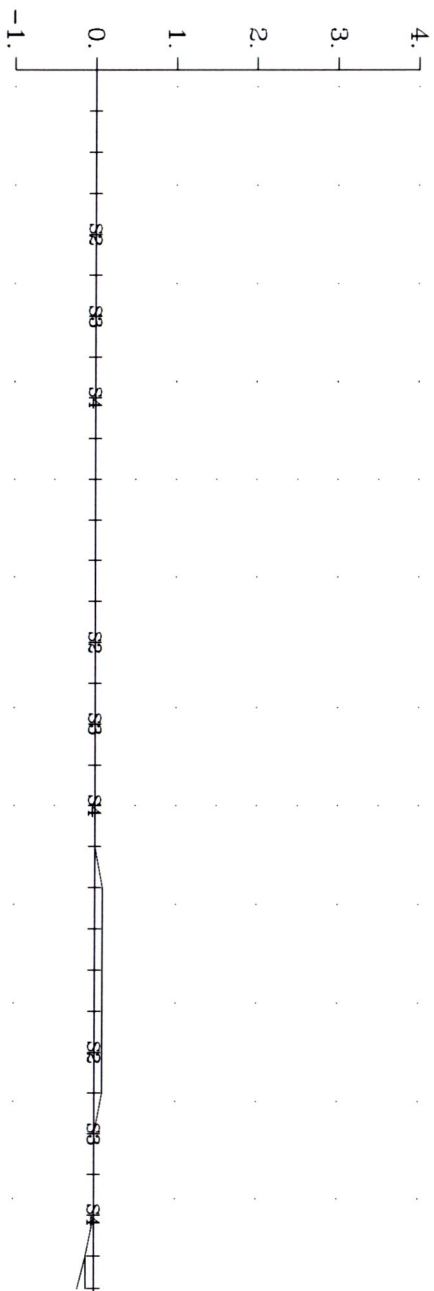
TP = Theoretical Primary
 PP = Last Ramp Channel
 S1 = Calculated Step Ch.1
 (nT/sec)



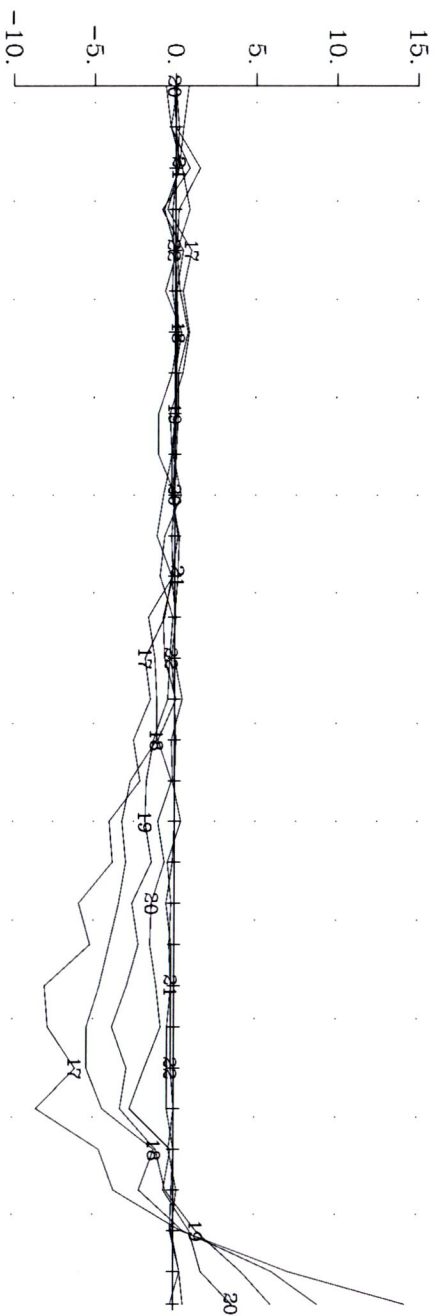
Deviation from TP.
 (% Total Theoretical)



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



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



Northern Sun Mathu
 Loop MATHU, Hole GM-16-01 Y Component
 Crone Geophysics & Exploration Ltd.