GEOPHYSICAL SEISMIC SURVEY FOR A PROPOSED FIXED DOCK, MARY RIVER PROJECT, MILNE INLET, NUNAVUT

Presented to:
Baffinland Iron Mines Corporation
2275 Upper Middle Road East, Suite 300,
Oakville, Ontario
L6H 0C3

Presented by:
Geophysics GPR International Inc.
6741 Columbus Road. Unit 14
Mississauga, Ontario
L5T 2G9

February 2014 T13615

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1. Introduction

Geophysics GPR International Inc. was requested by Baffinland Iron Mines Corporation to carry out a geophysical survey to aid in projection and planning of a proposed fixed dock for the Mary River Project, Milne Inlet, Nunavut. The aim of the investigation was to map the depth to bedrock and provide details of the overburden material.

Seismic profiles were collected approximately parallel with the shoreline as well as lines going from land perpendicularly out to sea (Figure 1). The start and end of line coordinates are outlined in Table 1.

Table 1: Profile Line UTM Coordinates and Chainage

Profile	UTM Start		UTM End		Chainage Start	Chainage End
A-A'	503251E	7976390N	503238E	7976742N	0+000	0+352.5
B-B'	503325E	7976422N	503312E	7976774N	0+000	0+352.5
C-C'	503091E	7976600N	503415E	7976740N	0+000	0+352.5
D-D'	503105E	7976568N	503430E	7976707N	0+000	0+352.5
E-E'	503114E	7976547N	503439E	7976686N	0+000	0+352.5

Geophysics GPR field personnel involved in this project and the dates that they were on-site are outlined in Table 2.

Employee	Title	Dates On-Site
Cameron Coatsworth	Field Supervisor	Nov. 26 to Dec. 5, 2013
Benoit Maille	Senior Tech	Nov. 26 to Dec. 5, 2013
Nicolas Beaulieu	Geophysicist	Nov. 26 to Dec. 5, 2013

Table 2: Geophysics GPR Field Personnel

The seismic reflection, refraction, TISAR and shear-wave velocity analysis methods were applied to collect the data along the alignments shown in Figure 1. Approximately 1.76 km of profiled data were collected.

The following report describes the survey design, the principles of the seismic methods, the methodology for interpreting the data and finally a culmination of the results in the form of interpreted bedrock profiles.

Figure 1: Approximate seismic profile orientations, Milne Inlet, Nunavut

2. Methodology

2.1. Positioning, Topography and Units of Measurement

The locations of the seismic profiles were oriented to encompass the area and to align with the design of the proposed fixed dock location.

The positioning data (northing and easting) were collected by Monteith & Sutherland Limited at the start and end of each line as well as every 15 m along the lines.

The GPS coordinates and field observations were then converted to project chainage based on site plans provided by Baffinland and Hatch.

The geophones were installed on the ice surface. The elevation of the geophones varied with the tides. Ice elevation data provided by Monteith & Sutherland Limited from December 2nd and 3rd indicate a range of approximate 0.9 m to -1.1 m over the course of the survey day. An average elevation of the geophones on the ice has been assumed to be 0 m.

The topography for the land portions of the Line A and B has been estimated using field observations and borehole elevation data.

All geophysical measurements were collected in SI units.

2.2. Seismic Methods

Seismic methods for geologic mapping involve measuring/recording the response of vibration sensors. Multiple techniques and methodologies are available for analysis of the data depending on the ultimate goal of the investigation. The profiles were collected using a standard stationary geophone arrangement. Several different seismic sources were applied including; propelled elastic generator (PEG) hammer, buffalo gun and explosives. After initial testing, it was determined that the buffalo gun and explosives were the most suitable sources for this particular site.

Several essentially independent techniques were used to analysis the resulting data; namely, seismic reflection, seismic refraction, TISAR and surface wave analysis.

Each of the seismic techniques has strengths and weaknesses primarily related to the depth of interest and local geology. After initial testing, it was determined that the seismic reflection method was likely going to be the primary methodology supplemented with seismic refraction and TISAR and surface wave analysis.

2.2.1. Seismic Reflection

Basic Theory

The seismic reflection method relies on measuring the transit time of an acoustic energy wave that travels from the energy source location to a reflective event (i.e. change in acoustic impedance) and back to a receiver (geophone). The fastest seismic waves are the compressional (P) or acoustic waves. Figure 2 is a basic geometric layout for reflection ray paths.

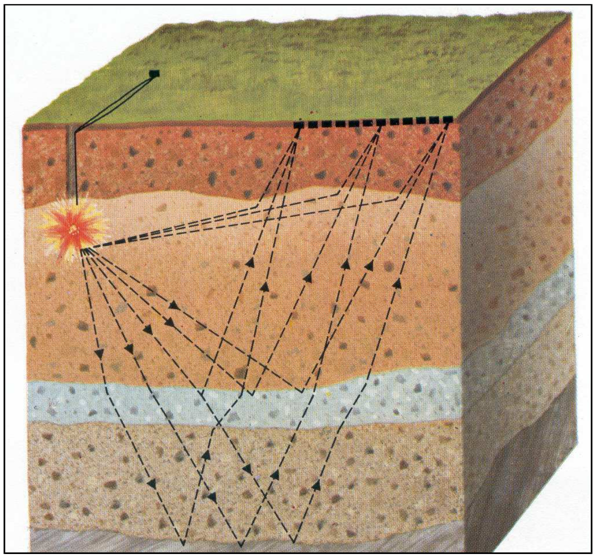


Figure 2: Simple Geometry of reflected pulse ray paths

Survey Design

A seismic spread consisted of 48 vibration monitoring devices (geophones) connected in line (spread) to a seismograph (ABEM Terraloc Pro) by connector cables. A seismic pulse (shot) is generated at a known location relative to the spread with a trigger system linked with the seismograph to begin the recording of the time-arrivals of the various seismic waves (shot record).

This investigation used 48 – 4.5 Hz geophones with a spacing between geophones of 7.5 m for a total individual profile length of 352.5 m.

The spacing between shots was 15 m with the shot inline with the seismic spread. Typically single shots were taken for each shot record, stacking was not needed to improve the signal to noise ratio.

The combination of geophone spacing and shot interval used for this investigation results in a varied-fold data set. Where fold refers to the multiplicity of the common-midpoint data. The highest fold was in the middle of the spread and decreased toward the ends.

The fold may be less for some shot gathers depending on geometry and individual geophone trace quality.

The seismic sources selected for this survey were devices called a “buffalo gun” and a “propelled elastic generator” (PEG). The “buffalo gun” was designed to fire a 12-gauge shotgun shell into a 5 cm diameter hole drilled through the ice. The PEG is a weight drop accelerated by elastic bands. The PEG was determined to be inadequate. It could not generate enough energy to transmit to the depths required of the geology. The “buffalo gun” source was determined to be the best option due to the prohibited use of explosives for the marine portion of this site.

Processing of Reflection Data

There are some common processing steps for every reflection data-set. These are purely mathematical or systematic steps that account for site conditions. There are also processing steps that serve to enhance the appearance of reflectors. Some of the more common steps include the removal of traces that are unusually noisy (trace kills) or correction of topography (statics corrections). In the processing sequence used for this project, there is flexibility in the order and the settings used in some optional processing steps.

It is important to note that there is no one correct processing sequence, as the processing steps and sequence are dependent on the geology and method of data collection. The following is a list of the processing steps and the order in which they were applied for this project.

1) Input seg2 data
2) time cut to 600 ms
3) trace editing (remove noisy traces)
4) Interpolation of removed traces
5) Gain correction
6) Filtering (bandpass and frequency-wave number)
7) Velocity Analysis
8) Normal move-out corrections
9) Common mid-point (CMP) Stacking
10) Time to depth conversion
11) Visual gain adjustments, horizontal filtering and contouring

Interpretation Method and Accuracy of Results

The reflection profile is essentially an image which must be interpreted. Without corroborating data, the true source or nature of a reflector can only be assumed. Interpretation of the data involves identifying reflectors and assigning a geologic context to them.

The two main sources of uncertainty in the results of a seismic reflection survey are in the velocity analysis and the assigning of reflectors to given geologic units.

2.2.2. Seismic Refraction

Basic Theory

The seismic refraction method relies on measuring the transit time of the wave that takes the shortest time to travel from the shot-point to each geophone. The fastest seismic waves are the compressional (P) or acoustic waves, where displaced particles oscillate in the direction of wave propagation. The energy that follows this first arrival, such as reflected waves, transverse (S) waves and resonance, is not considered under routine seismic refraction interpretation. Figure 3 illustrates the basic operating principle for refraction surveys.

Survey Design

The seismic spread setup utilized for seismic reflection was also used for seismic refraction. The seismic source was mainly buffalo gun. Explosives were used for the end and far shots on the land portion of the Line A and Line B.

This investigation used 48 – 4.5 Hz geophones with a spacing between geophones of 7.5 m for a total individual profile length of 352.5 m.

Typically, seven or more shots are executed per seismic spread; three to five shots within the profile to obtain the lateral velocity variation in the overburden and two shots on either side of the spread to provide the true velocity of the bedrock surface. The spacing between shots was generally every 45 m with the shot inline with the seismic spread. Typically single shots were taken for each shot record, stacking was not needed to improve the signal to noise ratio.

Interpretation Method and Accuracy of Results

Interpretation of the seismic data was primarily done using the critical distance method. Ideally, the Hawkins' method is the preferred method as it allows the computation of the rock depth to every geophone, information on the thickness of the various overburden layers, depth to bedrock and rock quality. At this particular site, the depth of the rock was greater than expected, performing a full Hawkins' interpretation would have required the use of explosives in the water which was not permissible. Accordingly the critical distance and partial Hawkins' method were employed.

A full description of the strengths and limitations of the refraction seismic method is presented in Appendix A.

The seismic refraction method typically allows the determination of the bedrock profile with a precision of 10% or better for depths greater than 10 m and a precision of 1 m for depths less than 10 m. The precision in the determination of rock velocities is plus or minus 3%.

The two most significant problem areas for refraction mapping are the "hidden" layer and effect of velocity inversions.

A "hidden" layer or "blind zone" is a stratigraphic layer that is not possible to discern from the arrival time data due to insufficient velocity variation or thickness. The unknown presence of a hidden layer has the effect of making the interpreted bedrock depth too shallow. The presence of a "hidden" layer is typically revealed through borehole or test-pit data and calculations can be made to compensate for the presence of such a layer.

Velocity inversions occur when the velocity does not increase with depth. The velocity inversion can result from the presence of a low or high velocity layer. Refractions from low-velocity layers cannot be determined from the arrival time data. The unknown presence of a low velocity layer has the effect of making the interpreted depths deeper than actual depths.

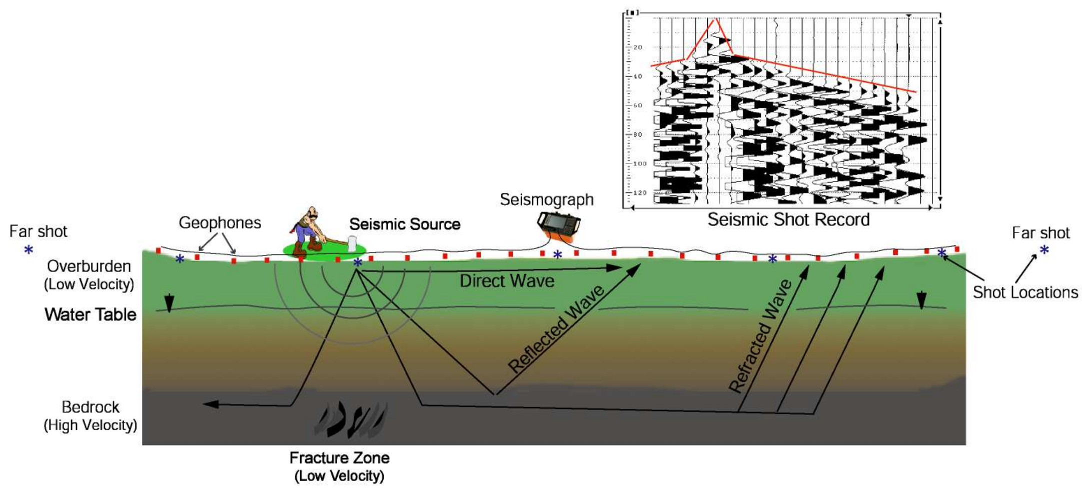


Figure 3: Seismic Refraction Operating Principle

2.2.3. Seismic Resonance (TISAR)

Basic Theory

The seismic resonance, or *TISAR (Testing & Imaging using Seismic Acoustic Resonance),* method is based on the frequency analysis of seismic records. It considers the seismic resonance within the signal. The method was originally developed for geological sub-surface profiling (1 to 15 m deep); however it has been shown to be effective for ranges smaller than 0.1 m for testing of concrete/asphalt structures, as well as for deep (100 m) geological investigations. Figure 4 is a combination figure showing applications for the method and a small sample of an output that is interpreted for geologic contacts.

The method uses the information from an induced seismic signal in the frequency domain instead of the direct time domain as with classic seismic reflection. For both methods, however, the principal physical parameter involved remains the acoustic impedance contrast, which is the product of the seismic velocity and the volumetric mass of the investigated materials. At the interface between two materials with different acoustic impedance, the seismic signal is partially reflected back to the surface. Under specific conditions, the repetition of such reflections leads to the build-up of a resonance signal, whose frequency is related to the depth of the interface and the seismic velocity of the upper material. The resonance frequency is inversely proportional to the reflection time. The first advantage of the use of frequencies instead of reflection times is the amplitude and the repetitive signal, which is less sensitive to the ambient noise and produces a resolution that increases with shallow depths. The second advantage of using resonance frequencies is the ability to resolve very thin layers (contrary to standard reflection).

Survey Design

The seismic spread setup utilized for seismic reflection and seismic refraction was also used for TISAR. A buffalo gun was used as the primary energy source. The buffalo gun was a good energy source for the resonance survey. The TISAR data was primarily used to supplement the reflection data in the shallow on-land portions.

Interpretation Method and Accuracy of Results

The seismic resonance method requires adequate geological models and seismic velocities. These parameters are typically derived from seismic refraction measurements. The accuracy of the depths of TISAR reflectors is related to the accuracy of the layer velocities and thicknesses of the geological model. It may be possible that velocities vary by approximately 10% or more resulting in a similar variation in depth to a given reflector. Layer thicknesses estimated in the model could vary by a few metres resulting in variations of 20 to 30% in the resonance reflector depth. Resonance has the advantage of a vertical resolution that cannot be obtained from conventional seismic methods.

TISAR resonators can occur from geologic contacts, fractures and/or voids. As with seismic reflection and ground penetrating radar, the true nature/source of the resonators cannot be certain. Interpretation involves identifying trends in the relative amplitude of resonators.

The use of the word “relative” is the operative word. The vibration response of each geophone is normalized to itself and then a gain curve is applied to the entire geophone spread to compensate for the decrease in signal amplitude with depth (this is similar to ground radar). The gain curves are kept similar between profiles; however, changes in near surface geology and the resulting geophone coupling and hammer signal amplitude and frequency requires individual adjustment of the gain curves for each profile. Accordingly, discretion must be used when comparing the relative amplitudes of the resonators between profiles and depths.

The same colour palette (blue through violet) has been applied in all the data sets presented in this report. The TISAR values are unitless. The blue has “relatively” little or no acoustic impedance contrast when compared to the red within an entire data set. A geologic contact such as a fracture should appear in yellow to red unless there is a stronger contact such as a larger void within the data set in which case a subtle stratigraphic contact may not be visible.

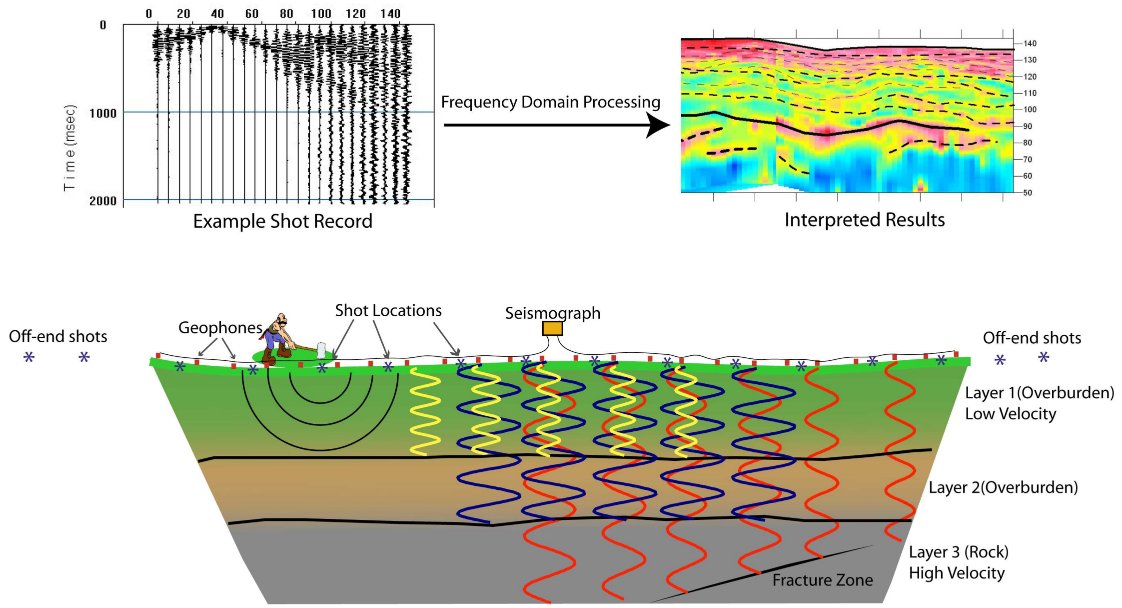


Figure 4: TISAR operating principle.

2.2.4. Multichannel Analysis of Surface Waves (MASW)

Basic Theory

The Multi-channel Analysis of Surface Waves (MASW) is a seismic method used to evaluate the shear-wave velocities of subsurface materials through the analysis of the dispersion properties of Rayleigh surface waves (“ground roll”). The dispersion properties are measured as a change in phase velocity with frequency. Surface wave energy will decay exponentially with depth. Lower frequency surface waves will travel deeper and thus be more influenced by deeper velocity layering than the shallow higher frequency waves. Inversion of the Rayleigh wave dispersion curve yields a shear-wave (V_s) velocity depth profile (sounding). Figure 5 outlines the basic operating procedure for the MASW method. Figure 6 is an example image of a typical MASW record and resulting 1D V_s model. A more detailed description of the method can be found in the paper *Multi-channel Analysis of Surface Waves,* Park, C.B., Miller, R.D. and Xia, J. Geophysics, Vol. 64, No. 3 (May-June 1999); P. 800–808.

Survey Design

The geometry of an MASW survey is similar to that of a seismic refraction investigation (i.e. 12 or more geophones in a linear array). The fundamental principle involves intentionally generating an acoustic wave at the surface and digitally recording the surface waves from the moment of source impact with a linear series of geophones on the surface. This is referred to as an “active source” method. Unlike the reflection method, which produces a data point beneath each geophone, the shear-wave depth profile is the average of the bulk area within the entirety of the geophone spread.

Interpretation Method and Accuracy of Results

The main processing sequence involves plotting, picking, and 1-D inversion of the MASW shot records using the SeisimagerSW™ software package. The results of the inversion process are inherently non-unique and the final model must be judged geologically realistic. The inversion modelling also assumes that all layering is flat/horizontal and laterally uniform.

Typically the accuracy of the shear-wave velocities modelled from the MASW method is on the order of +/- 10 to 15% for overburden material. The estimated error is typically higher for shear-wave velocities within rock formations.

At this particular site, the geology was not ideal for MASW soundings. The permafrost, ice and water layers will complicate the dispersion images. The method also assumes that the geology is laterally homogenous. The most suitable profile for MASW analysis was SL-E as the water depth was relatively shallow and uniform; however, analysis of the dispersion images for SL-D and SL-C appear to yield reasonable results. Ideally for marine MASW surveys, the geophones/hydrophones are placed on or as close as possible to the sea-floor.

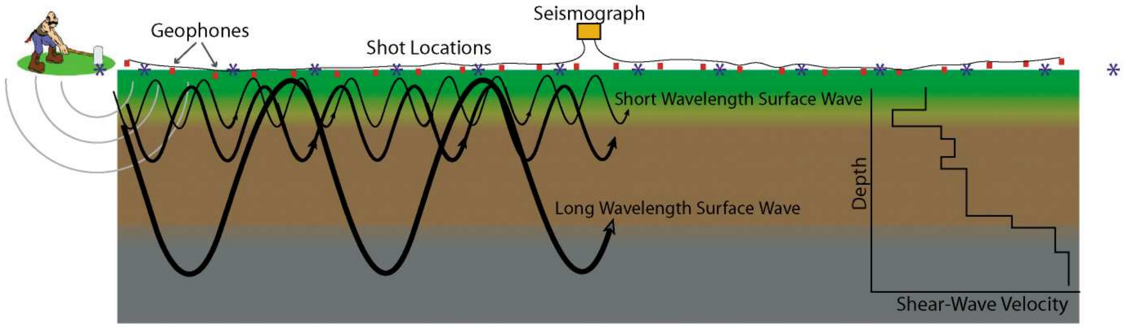


Figure 5: MASW Operating Principle

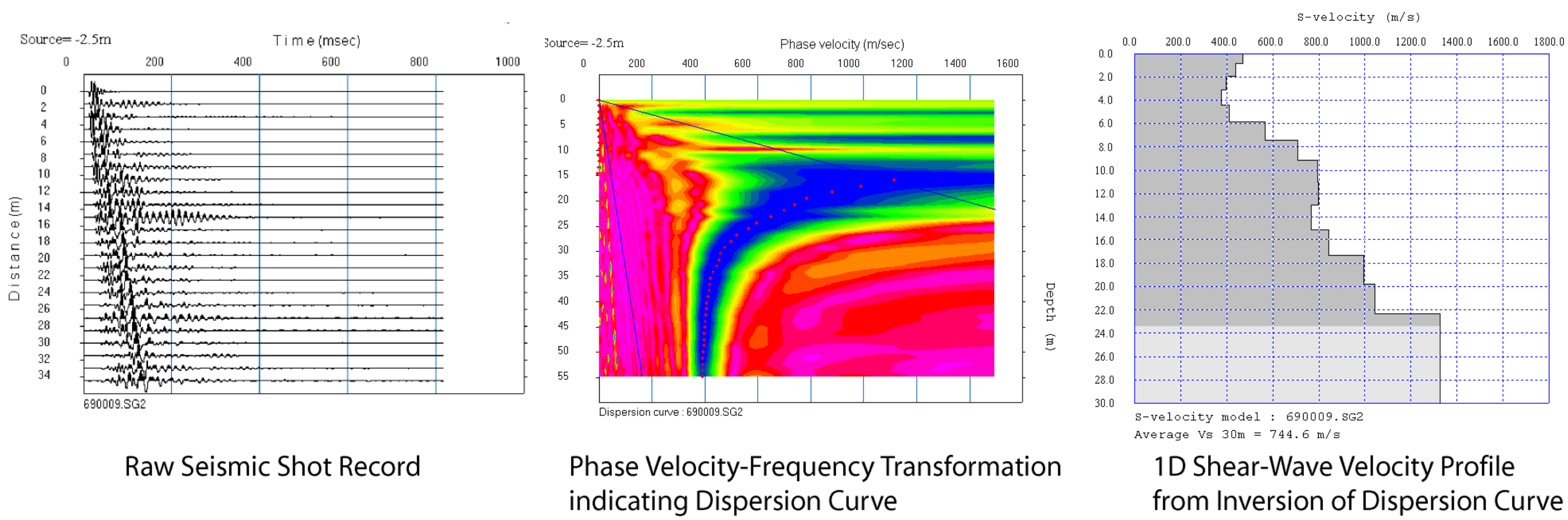


Figure 6: Example of a typical MASW shot record, phase velocity/frequency curve and resulting 1D shear-wave velocity model.

3. Results

The combined results of the seismic reflection, refraction, TISAR and MASW interpretations are presented in Appendix C in the form of interpreted cross-sections (Drawing T13615_A1). The interpreted contacts are based on the combined results of the shear-wave modelling, reflection images, critical distance calculations and borehole data.

The overall quality of the seismic records was very good.

Initial testing indicated that the seismic reflection method was most suitable to this particular site.

The primary objective of the survey was to identify the top of rock. It has been represented by a thick red line from the reflection interpretation and a magenta line based on the refraction analysis. Additional overburden contacts interpreted from the reflection and TISAR images are indicated by blue and grey lines respectively.

S-wave velocities can be used as an indicator of overburden types and bedrock competence. Appendix A contains a table of soil and rock classification based on S-wave velocities. MASW shear-wave data were analyzed for SL-C, SL-D and SL-E. The shear-wave models have been overlain on the cross-sections of drawing T13615_A1. As discussed above, the conditions for MASW analysis were not ideal at this particular site. The S-wave velocities determined through the MASW method are modelled velocities as opposed to true velocities measured using standard in-situ measuring methodology. The modelled velocities are typically within +/-10 to 15% of the true velocities of the overburden material; however, the added complications of the ice/water layers and multiple dispersion modes likely increase this error for this particular survey.

The seismic reflection and resonance (TISAR) data are primarily imaging tools. Alone, the methods do not provide indications of the material type. In addition, a velocity must be applied to convert the vertical scale of the images to a depth scale. The velocity can be estimated by correlation with borehole data. Interpretation of the data involves visually identifying reflector trends and corroborating with borehole data.

Interpretation of the seismic reflection data has identified 6 layers based on relatively stronger reflectors. These 6 layers have very good correlation at the intersection points of the seismic lines. The identification of the layers does not necessarily indicate uniform material within the layer. Gradual changes or thin layers may not generate a clear detectable reflection.

Relatively weaker reflectors have also been identified. The correlation of the weaker reflectors between the seismic profiles has not been systemically analyzed.

Comparison with the borehole logs suggest the following summaries for the defined overburden layers:

Layer 1: Layer 1 the upper most layer and represents materials from the sea floor to an elevation of approximately -10 m (onshore) to -32 m (offshore at SL-C). Offshore, in the vicinity of Line C, and based on borehole BH-13-09, this layer is interpreted as loose silty sand. Towards the shore there appears to be an increase in coarser grained materials; however the layer remains loose (BH-13-05 and MASW data). At the shoreline, boreholes indicate that this layer is fully (BH-13-01) to partially frozen (BH-13-02).

MASW S-wave velocities were modelled to be between 175 to 250 m/s for this layer.

Layer 2: Layer 2 is defined by a strong upper reflector. Borehole 13-09, along SL-C, suggests that this layer is characterized by compact silt and sand. Boreholes along SL-D indicate the layer is dominated by relatively uniform compact sand. Boreholes along SL-E indicate predominately compact sand (BH-13-08) with some silt and gravel layers (BH-14-13 and BH-13-11).

MASW S-wave velocities were modelled to be between 175 to 275 m/s for this layer.

Layer 3: The top of Layer 3 is best defined along SL-D.

BH-14-07b indicates primarily sand with some gravel and silt layers. The SPT N-Values are higher than the overlying layers.

BH-14-06 indicates more silt content than BH-14-07b.

BH-14-05C indicates primarily dense to very dense sand with some silt layers. As with BH-14-07b, the SPT N-Values are higher than the overlying layers.

BH-13-05b indicates very loose sand. This conflicts with the nearby BH-14-05C.

BH-13-09 intersects with the top of Layer 3 on SL-C. There is no sample logging; however, the DCPT indicates an increase (followed by a decrease) in blows near the top of Layer 3.

BH-14-13 along SL-E extends into the top of this layer and indicates sand and gravel for the upper 7 m.

No boreholes on-shore extend to this layer.

MASW S-wave velocities were modelled to be between 250 to 375 m/s for this layer.

Layer 4: The top of layer 4 is well defined along SL-C; however there are no boreholes that extend to it along the line nor along SL-E. Along SL-D BH-13-05B, BH-14-05C, BH-14-06 and BH-14-07B extend into this interpreted layer at an elevation of approximately -53 m. The boreholes indicate primarily dense to very dense sand.

MASW S-wave velocities were modelled to be between 400 to 460 m/s for this layer.

No on-shore boreholes extended into this interpreted layer.

Layer 5: A single borehole (BH-14-07b) extends to the top of Layer 5 at an elevation of -66 m. The borehole indicates dense sand with trace silt, less dense than the material immediately overlying it.

MASW S-wave velocities were modelled to be between 460 to 600 m/s for this layer.

Layer 6: MASW S-wave velocities were modelled to be between 525 to 760 m/s for this layer indicating the potential for dense sediments.

No boreholes extend to layer 6.

4. Conclusions & Recommendations

A total of approximately 1.76 km of seismic data were collected along five profiles in the vicinity of the proposed fixed dock, Mary River Project, Milne Inlet, Nunavut (Figure 1).

The data are presented in the form of cross-sectional figures in drawing T13615_A1.

Bedrock depths have been interpreted from a combination of seismic reflection and refraction data. The interpreted bedrock elevation ranged from approximately 90 to 140 m below sea-level. There was no borehole data available to corroborate the bedrock depth. P-wave velocities in the order of 3900 to 5100 m/s suggest the bedrock is competent.

Interpretation of the reflection data identifies 6 overburden layers overlying the bedrock based on relatively stronger, continuous reflectors. Borehole data for 16 boreholes were provided by Hatch Ltd. to aid in the interpretation of the seismic data. Brief descriptions of the bulk layer properties based on borehole data have been provided above. The reader is referred to the geotechnical report by Hatch Ltd. for the analysis of borehole and geotechnical data.

Interpretation of the TISAR data identifies a number of resonators that could represent geologic overburden contacts. In general the TISAR method provides a higher resolution than the seismic reflection method. The TISAR contacts are interpreted to represent the various sand/gravel contacts identified in the borehole logs. As mentioned above, the TISAR data requires an accurate velocity model. At this particular site, due to the permafrost, assumptions had to be made regarding the velocity model. Variations in the thickness or seismic velocity of the permafrost layers will have a large effective in the overall accuracy of the interpreted results.

The velocity model, and thus interpreted images, for the on-shore portions are likely less accurate than the off-shore profiles. This is due to the irregularly/discontinuous frozen soil as indicated in BH-13-01/b, BH-13-02 and BH-14-12. The combined TISAR and reflection images for SL-A and SL-B do suggest however, that the geologic layers interpreted off-shore, can be interpreted continuing on-shore.

Line SL-E was the most suitable data set for MASW processing due to the shallow water and unfrozen sediments. The frozen ground on/near the shore created a large velocity inversion and contrast at surface, which does not allow adequate frequency dispersion. The water was shallow for SL-E and the sediments unfrozen. Lines SL-C and SL-D had deep water and unfrozen sediments. The overall accuracy of the shear-wave velocity measurements is not certain due to water depths and ice.

Shear strength data can be more reliably measured in marine conditions using data collected with hydrophones on or near the water bottom and a seismic source such as an air gun. On-shore, intrusive, e.g. downhole, methods can accurately measure the shear-wave velocity beneath the permafrost.

Processing and interpretation of the seismic data was performed by Ben McClement, P.Eng. and Olivier Létourneau. This report has been written by Milan Situm, P.Geo. and reviewed by Ben McClement, P.Eng.

Ben McClement, P.Eng.
Geophysicist

Milan Situm, P.Geo.
Manager

APPENDIX A

SEISMIC EQUIPMENT AND METHODOLOGY FACT SHEETS

TERRALOC PRO FEATURES

Terraloc Pro - Your guarantee for high-quality fieldwork

A STAND-ALONE SEISMOGRAPH, RUGGED FOR DEMANDING ENVIRONMENTS:
A self-contained instrument, designed to cope with rough field conditions.

VERSATILE & FUTURE-PROOF: You don't know what your next job will demand, with the Terraloc Pro you are equipped to successfully take on a wide range of seismic surveys.

SAVES VALUABLE FIELD TIME: Terraloc Pro offers built-in diagnostics and remote management as well as vendor assisted support over the net.

HIGH QUALITY DATA: Don't compromise, return from the field with superior data, Terraloc Pro delivers top class performance.

SECURE INVESTMENT: Terraloc Pro is a product for the future, it allows for add-on of new functionality and seamless expansion.

The ABEM Terraloc line of seismographs has a long and well-known reputation for ease of use and reliability under the toughest field conditions. With this brand new Terraloc Pro instrument, ABEM has stretched the specification and incorporated several new features. Well working software functionality has been inherited from its predecessor in order to save time and effort for the user. All together, this new instrument is a high quality product, designed to meet demanding field requirements.

A

General

No. of channels	12, 24 and 48
Additional channels	Easily obtained by linking two or more units together
Up-hole channel	Yes, 2 additional independent
Sampling rate (selectable)	100 sps – 50 ksps (20 µs - 10 ms)
Record length (selectable)	Up to 480 k samples / ch. equivalent to: 5,1 ms - 80 min
Pre-trig record (selectable)	0 – 100 % of record length
Delay time	Up to 2 minutes
Stacking	32 bits, up to 999 impacts
Unstack	Remove last shot from stack
Trigger inputs	Trigger coil, make/break, geophone, TTL
A/D converter resolution	24 bits
Dynamic range	(theoretical / measured) 144 dB / >120 dB
Input voltage range (selectable)	0,5 Vpp, 5 Vpp, 12,5 Vpp
Input gain (selectable)	0 dB, 12 dB, 24 dB, 36 dB, 48 dB
Input impedance (selectable)	3 kΩ, 20 kΩ, 20 MΩ
Frequency range	DC to 20 kHz
Total harmonic distortion	0,0005%
Crosstalk	-120 dB
Noise monitor	Amplitude
Anti-alias filters	Set automatically based on sampling rate
Connectors	NK-27 / KPT 55
GPS	Yes

Post recording features

Digital filters	Band-, low-, high- pass band-reject, remove DC offset
Spectrum analysis	Any single trace, FFT analysis
Velocity Analysis	On-screen analysis of refractor velocity
First arrivals picking	Automatic or manual Times can be saved with record
Pre-stack correlation	Yes, cross correlation with reference or any other ch.

Processor, RAM and hard disk

Processor	Low power Intel Atom, 1,6 GHz
Operating System	Windows XP Pro
Internal RAM	2GB (DDR SO-DIMM module)
Hard disk capacity	100 GB or greater
Display	8,4" Active TFT LCD, full colour, daylight visible, 800x600 res.
External display port	VGA output
I / O port	3 x USB 2.0 ports
Network interfaces	1 x IEEE 802.3 TP-10/100/1000 RJ-45 IP 67 2 x TP-10/100 KPT 08 WLAN antenna

Power	10 – 34 V DC external power 12 V internal battery
Power consumption	30/60 W (man/acq)
Ambient temp (operating)	-20 to + 55 °C
Ambient temp (storage)	-30 to + 70 °C
Casing	Rugged Al alloy, meets IEC IP 66
Weight, 24 channels	10 kg
Weight, 48 channels	11 kg
Dimensions (W x L x H)	39 x 21 x 32 cm

To order, please specify

Terraloc Pro, 12 CHANNEL UNIT	33 7000 12
Terraloc Pro, 24 CHANNEL UNIT	33 7000 14
Terraloc Pro, 48 CHANNEL UNIT	33 7000 16

Each unit includes:

- **Terraloc Pro instrument (of chosen type)**
- **Reference manual**
- **Trigger cable 250 m on reel, Office power supply (charger), Trigger coil, Accessories & Tools kit**
- **Windows XP compatible USB keyboard and mouse**
- **Software SeisTW and sample records**
- **Transport case (plywood)**

Field Accessories (ordered separately)

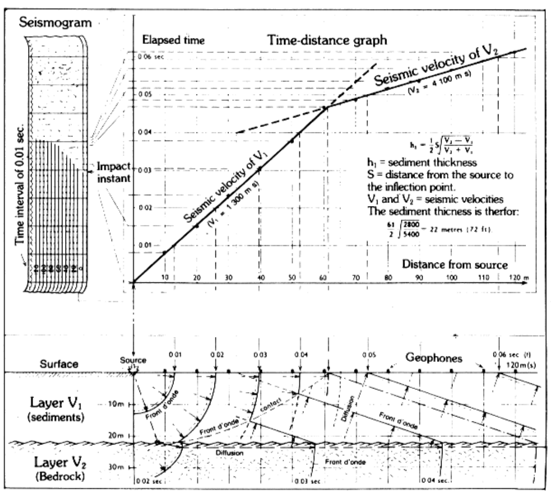
Seismic cable 24 take-outs at 5 m	36 0001 96
Extension cable 160 m (for 24 take-out cable)	36 0001 97
Seismic cable 12 take-outs at 12.5 m	36 0001 26
Extension cable, 160 m (for 12 take-out cable)	36 0001 28
(other cable configurations also available)	
Portable reel	38 3001 52
10 Hz vertical geophone	39 1000 61
10 Hz horizontal geophone	39 1000 93
4.5 Hz vertical geophone	39 1000 63
4.5 Hz horizontal geophone	39 1000 64
4.5 Hz 3-D geophone	39 1000 85
100 Hz vertical geophone (land)	39 1000 77
100 Hz vertical geophone (marsh)	39 1000 78
Shock plate	33 0010 18
Hi-voltage CB 20 VA shotbox	39 9000 23

GEOPHYSICS G P R INTERNATIONAL INC.

SEISMIC REFRACTION

Seismic refraction consists of recording the length of time taken for an artificially provoked surface vibration to propagate through the earth. By processing the data, the seismic velocities and depths of the underlying rock layers can be determined. These velocities are characteristic of the nature and quality of the bedrock; a fissured, fractured or sheared rock will be characterized by reduced seismic velocities.

The method is generally used to obtain a better geological analysis of the sub-surface and to determine the following characteristics: the quality, profile and depth of bedrock, its nature, degree of alteration and any other physical contrasts. Seismic refraction ensures that maximum information may be gained from geological field work, and that direct investment costs (drilling, excavation), will be reduced.



PRINCIPLE OF SEISMIC REFRACTION

FEATURES

- Precise determination of soil thickness .
- Precise determination of the seismic velocities (rock type and quality).
- Localization and identification of geological units.
- Detailed analysis of soil.
- Year-round use.
- Sea and land surveys (above and below ground).
- Great accessibility possible to rough terrain and remote regions.

AREAS OF APPLICATION

Civil Engineering/Mining Exploration - Exploitation/Petroleum and Gas Sectors/ Geotechnology/Geology/ Hydrology.

- Identification of faults, fractures, shear zones.
- Detection of rock differences (veins, dykes, cavities, etc.).
- Determination of rock topography.
- Evaluation of volume of soil present or to be excavated.
- Excellent complement to geological mapping.
- Recognition of geophysical anomalies such as VLF, gravimetry, etc.
- Drill site selection, better target identification.
- Evaluation of the size, thickness and condition of surface shafts (mining exploitation).
- Mass Rock Quality Determination (MRQD).
- Detection of rock irregularities and breaks.
- Hydrogeology (detection of water tables, veins, reservoirs).
- Excellent complement to any geological analysis.

AREAS OF APPLICATION

Civil Engineering/Mining Exploration - Exploitation/Petroleum and Gas Sectors/ Geotechnology/Geology/ Hydrology.

- Identification of faults, fractures, shear zones.
- Detection of rock differences (veins, dykes, cavities, etc.).
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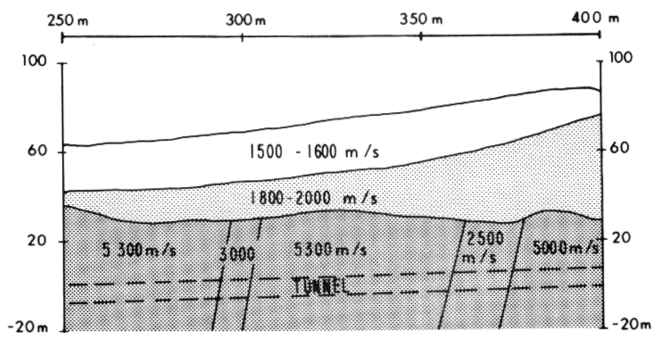
- Recognition of geophysical anomalies such as VLF, gravimetry, etc.
- Drill site selection, better target identification.
- Evaluation of the size, thickness and condition of surface shafts (mining exploitation).
- Mass Rock Quality Determination (MRQD).
- Detection of rock irregularities and breaks.
- Hydrogeology (detection of water tables, veins, reservoirs).
- Excellent complement to any geological analysis.

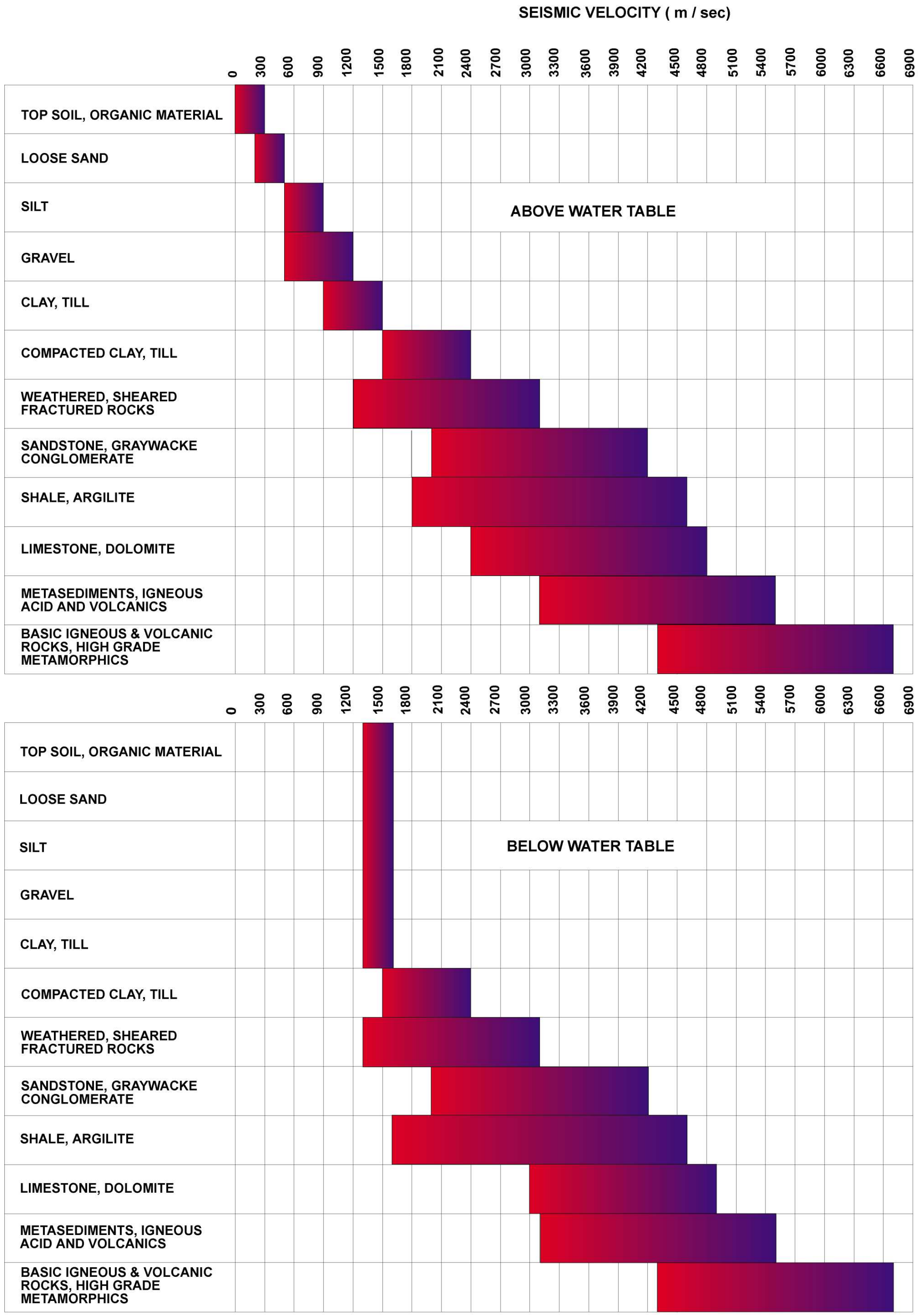


Interpretation results of a seismic profile

ADDITIONAL REMARKS

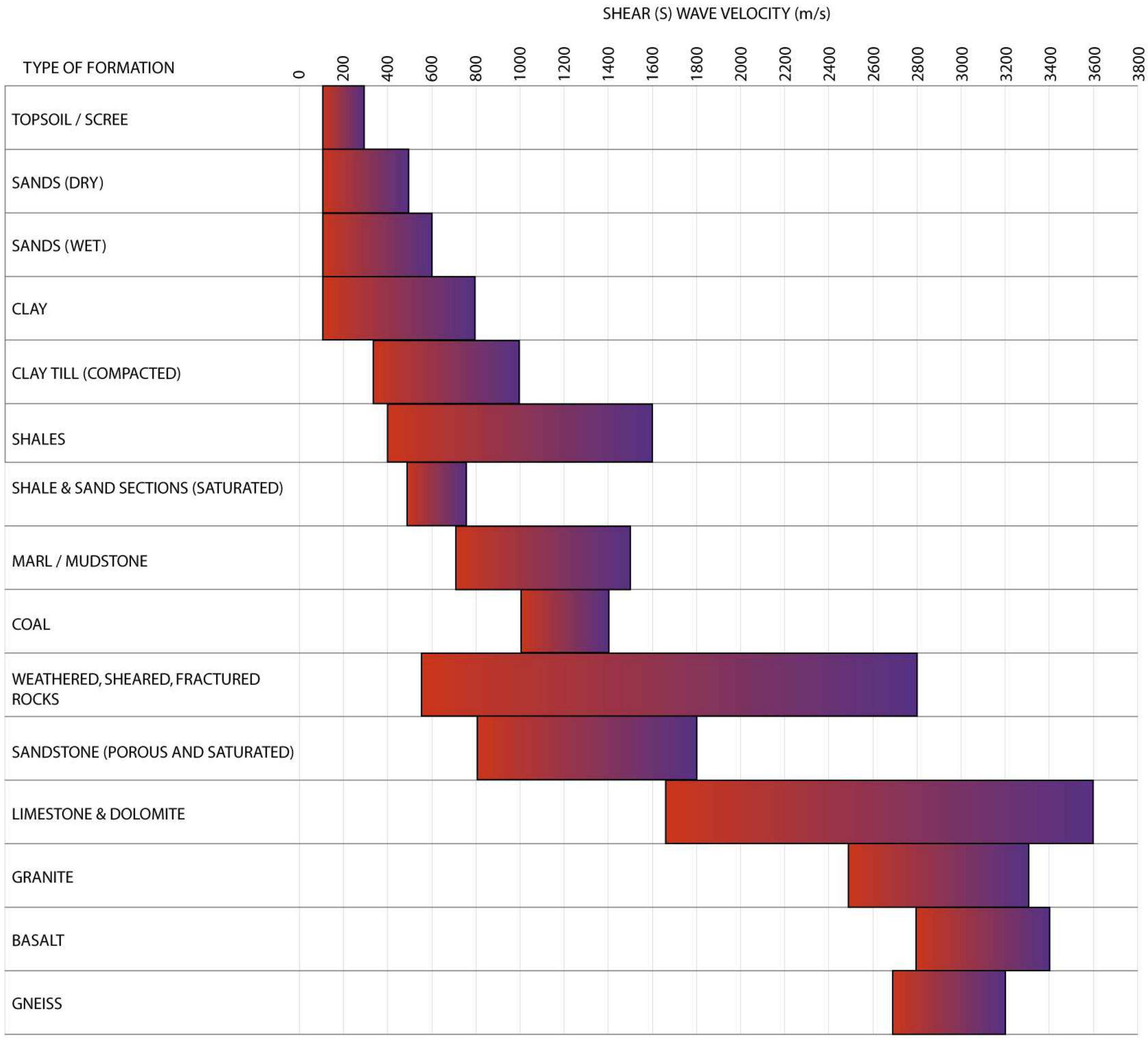
Geophysics GPR International Inc. has been recognized for the past fifteen years as a leader in both the application and the development of seismic methods. Seismic refraction is currently used in both civil and mining engineering; the use of lighter high-performance equipment and better tomographical interpretation of the results have contributed to its growing popularity.

GEOPHYSICS G P R INTERNATIONAL INC.



SOIL AND ROCK CLASSIFICATION
BASED ON SEISMIC VELOCITIES

A



Typical rock velocities, Based on Bourbie, Coussy and Zinszner, Acoustics of Porous Media, 1987
with modifications by Geophysics GPR. Rev A.1 July 2011

APPENDIX B

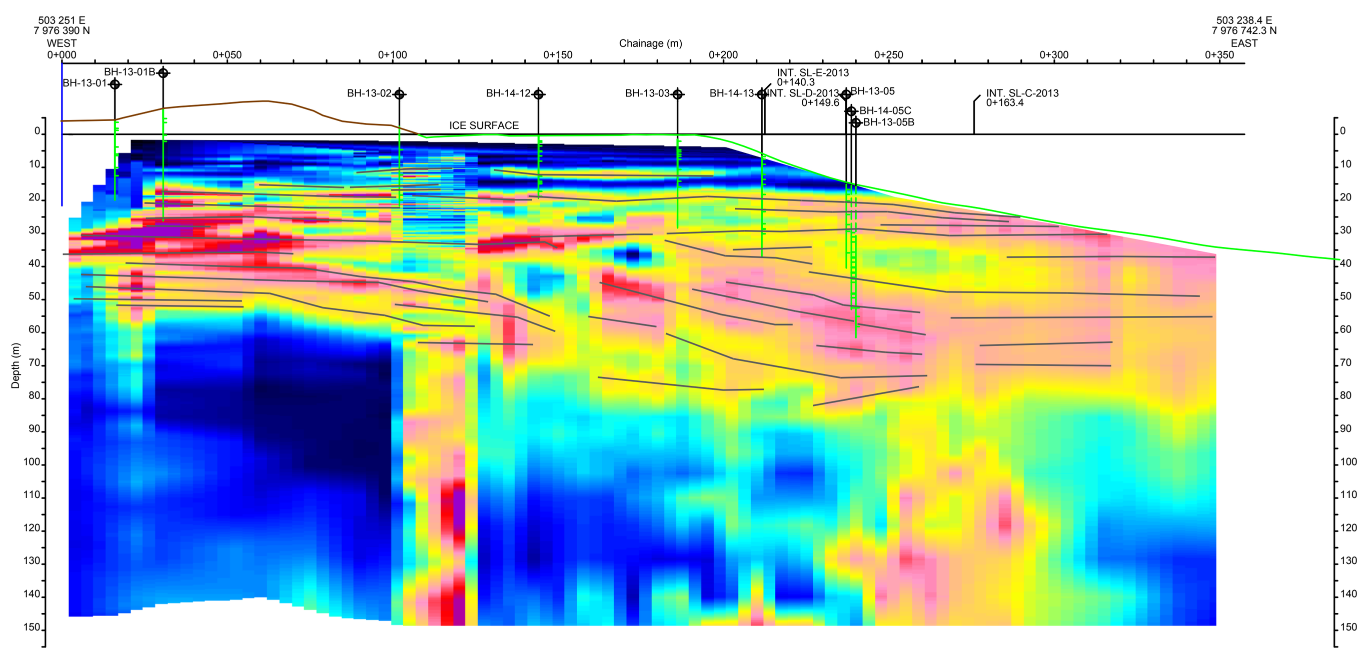
SITE PHOTOS

Photo 1: Seismic line setup with buffalo gun

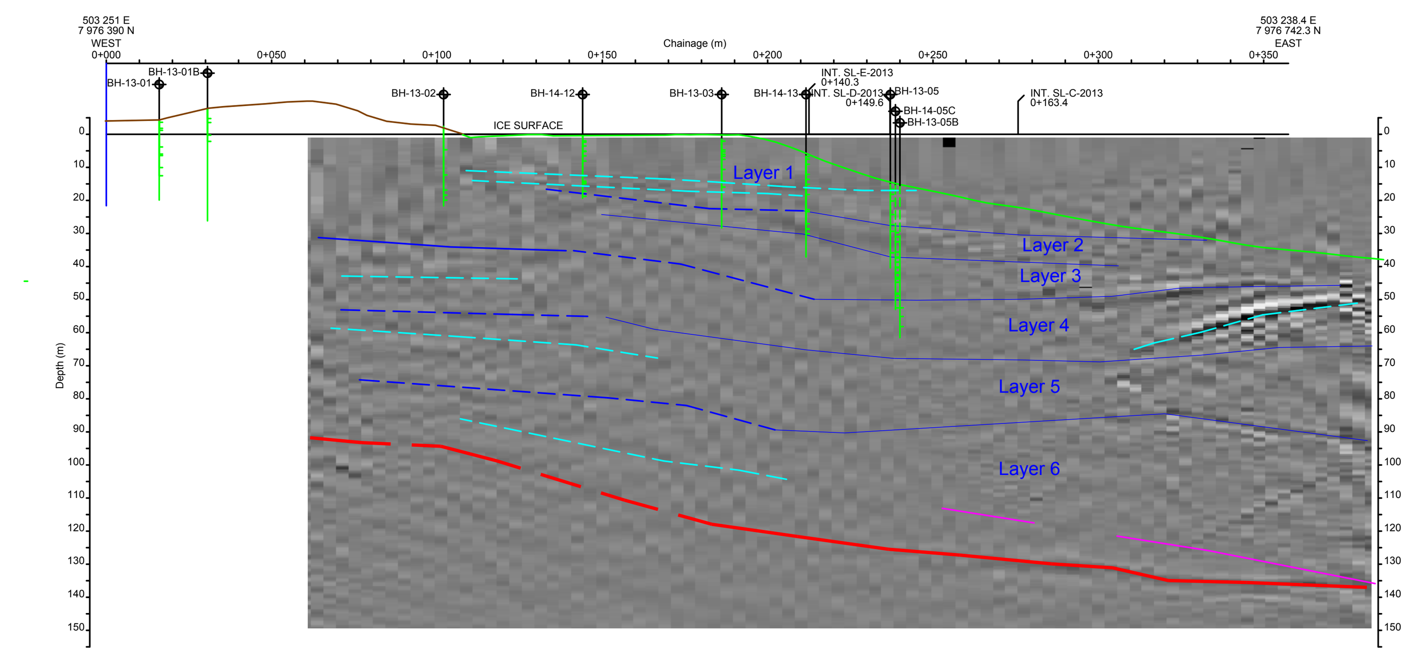
Photo 2: Seismic line setup, with seismograph shelter

APPENDIX C

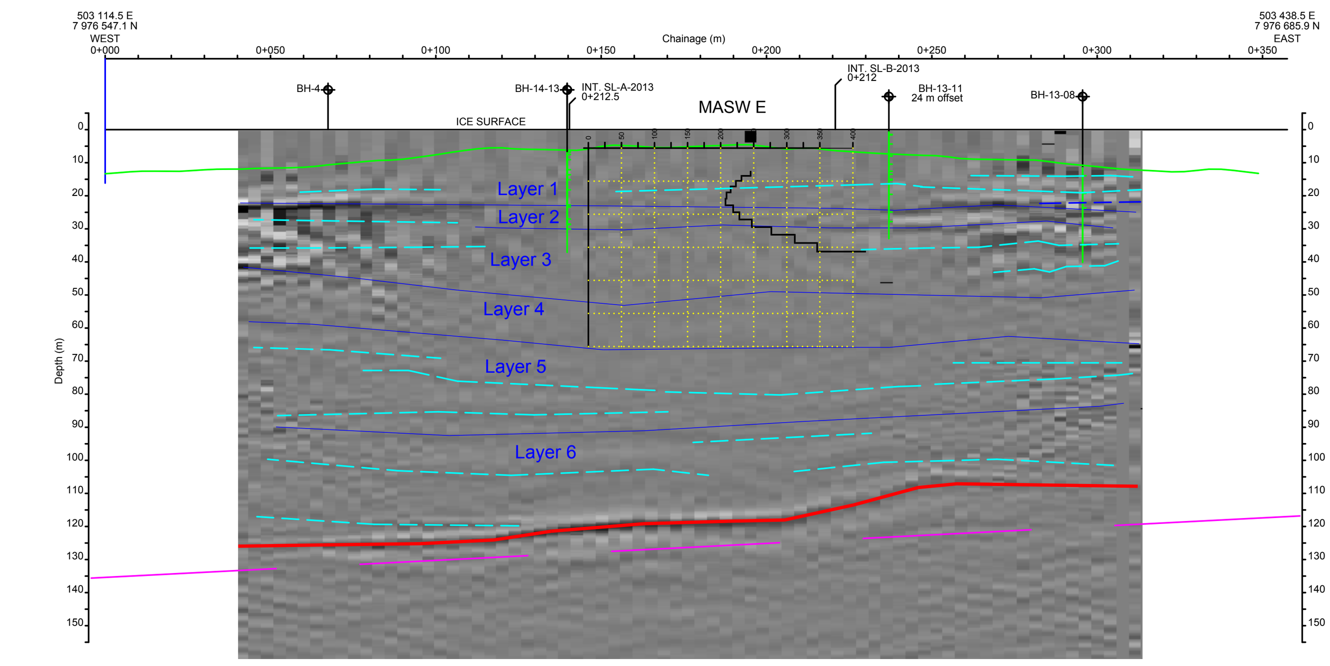
DRAWING T13615_A1



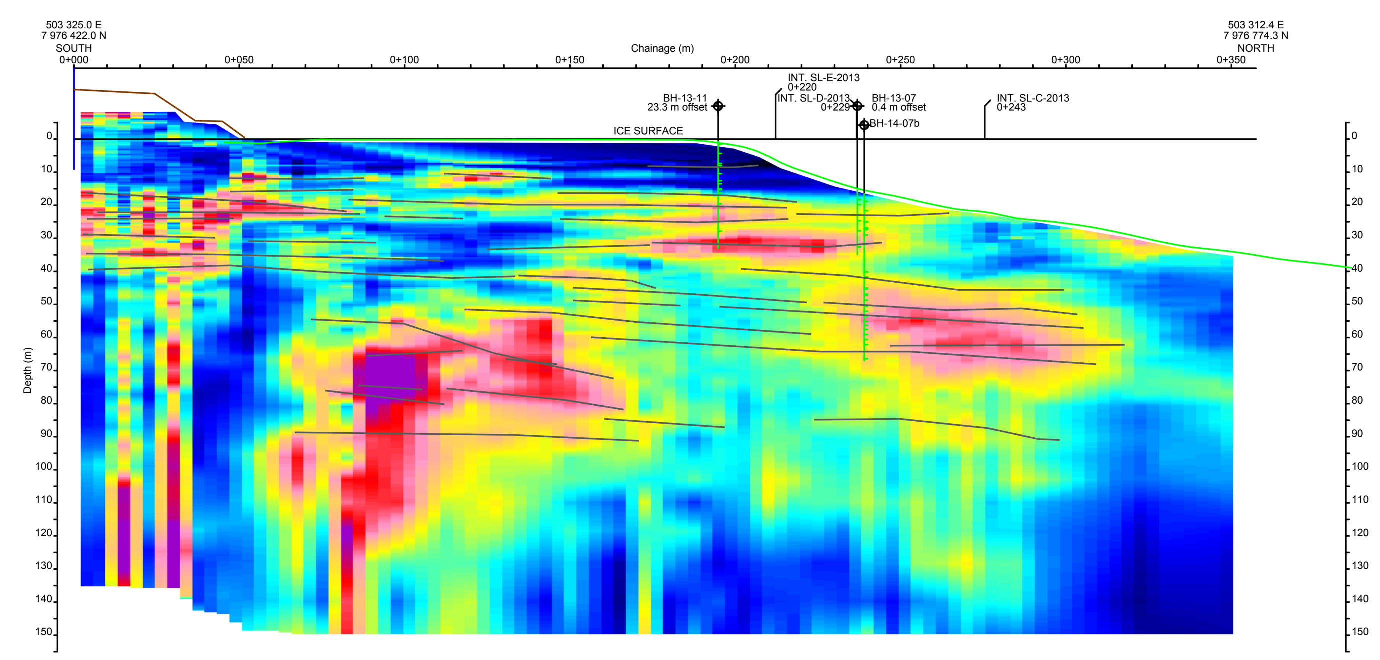
SL-A-2013
(TISAR)



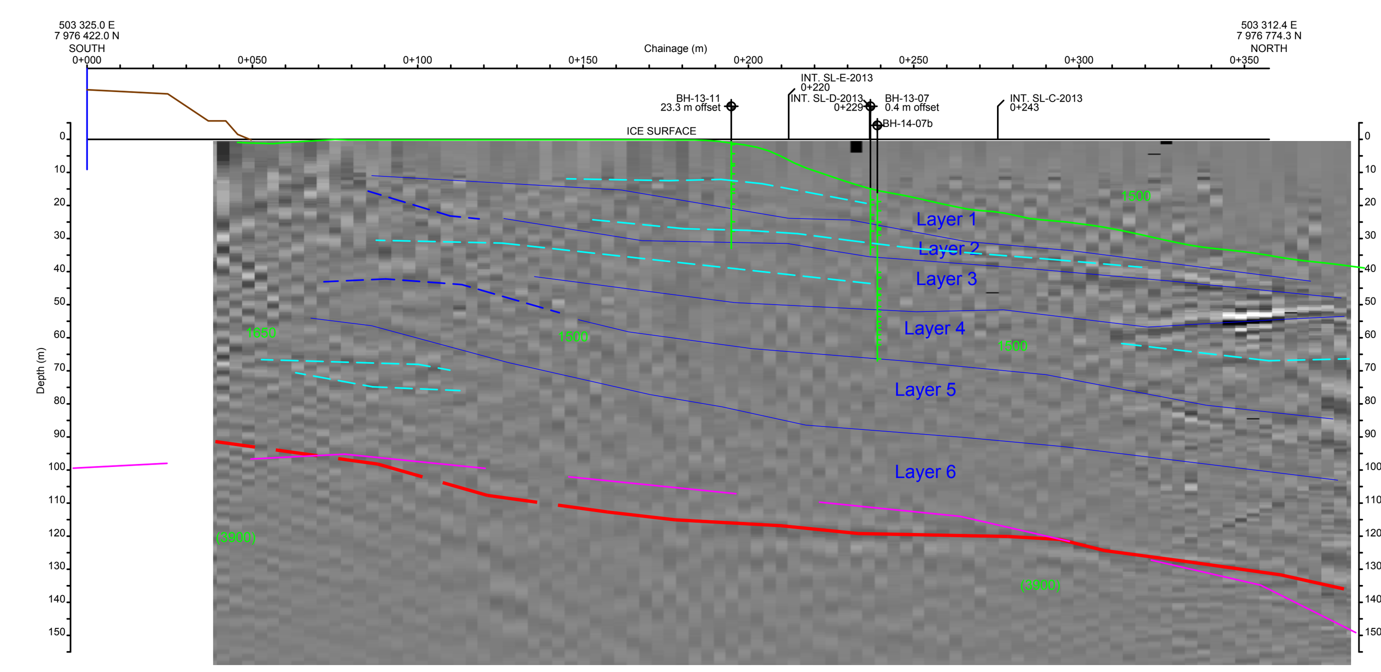
SL-A-2013
(Reflection and Refraction)



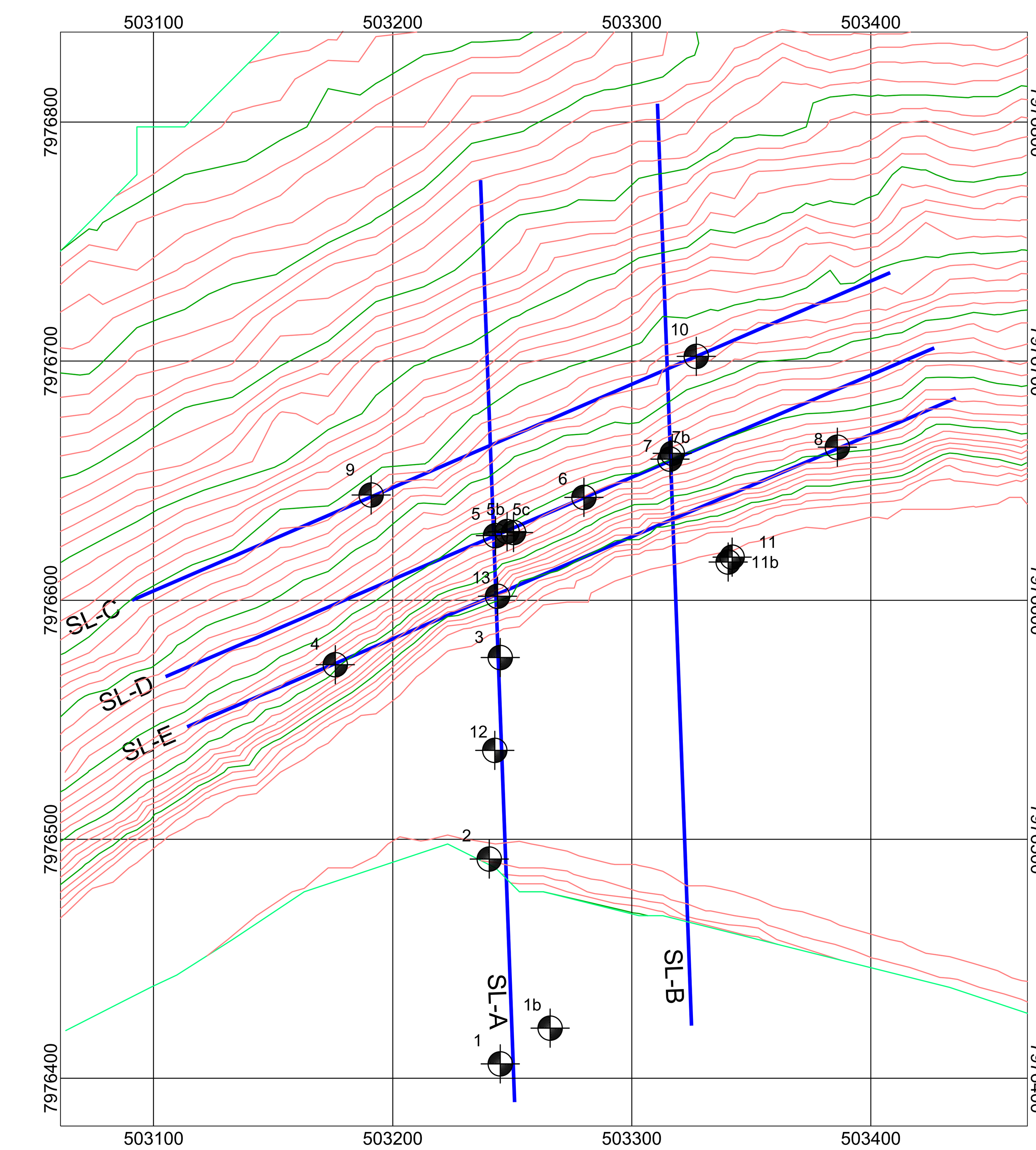
SL-E-2013
(Reflection and Refraction)



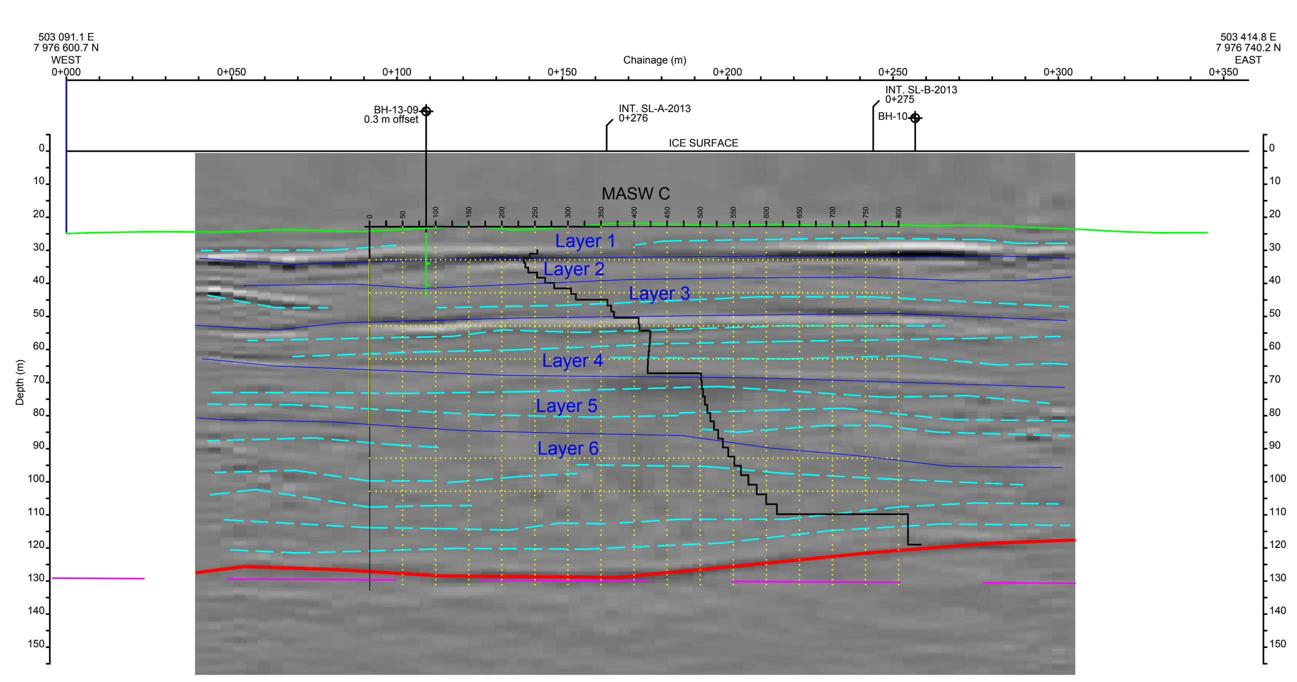
SL-B-2013
(TISAR)



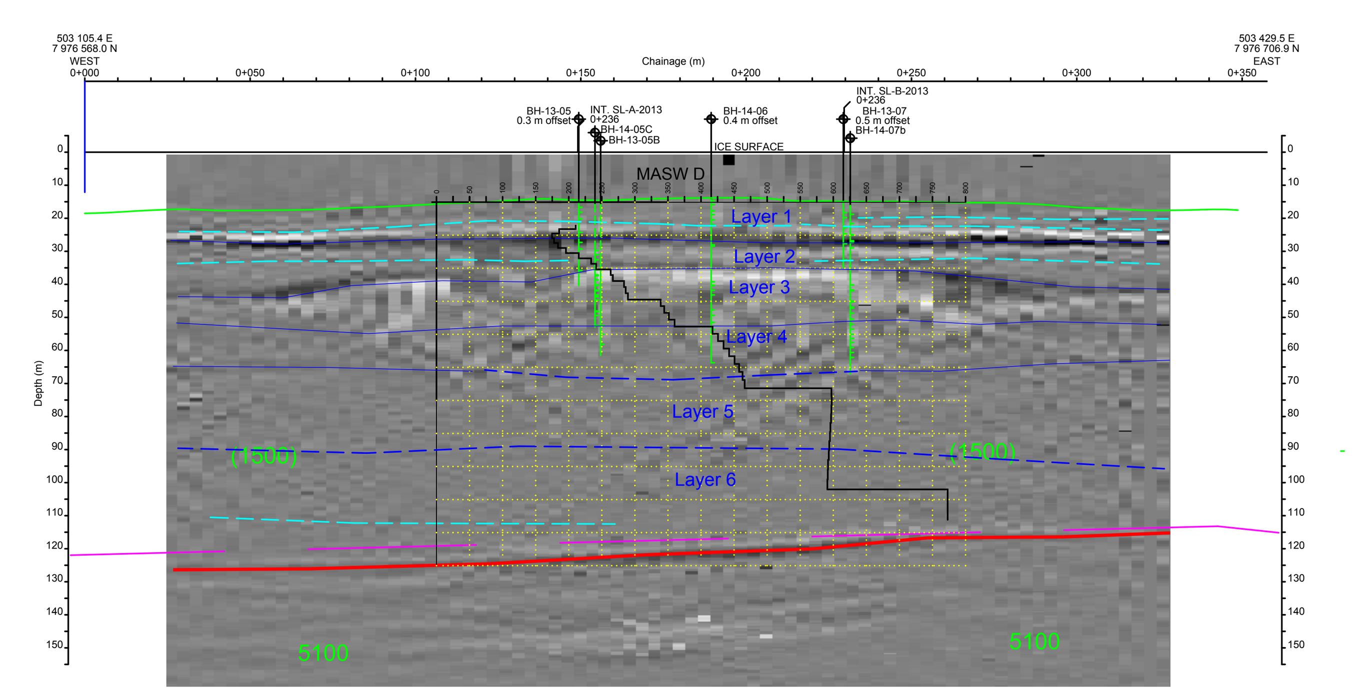
SL-B-2013
(Reflection and Refraction)



PLAN VIEW MAP WITH BATHYMETRY CONTOURS



SL-C-2013
(Reflection and Refraction)



SL-D-2013
(Reflection and Refraction)

LEGEND

- Interpreted Bedrock from Reflection data
- Interpreted Bedrock from Refraction data
- Interpreted Overburden Reflector (stronger)
- Interpreted Overburden Reflector (weaker)
- (1500) Seismic Refraction Velocity
- Interpreted Overburden Resonator (TISAR)
- Bathymetry Profile
- Topography Profile
- Geotechnical Borehole (Hatch)

No	NOTES
1	THE GEOPHYSICAL SURVEY WAS EXECUTED BY GEOPHYSICS GPR INTERNATIONAL INC. DECEMBER, 2013
2	COORDINATE SYSTEM: NAD83 UTM ZONE 17N
3	BATHYMETRY DATA, AND BOREHOLE DATA PROVIDED BY HATCH LTD.
4	REFER TO THE FULL REPORT FOR A DISCUSSION OF METHODLOGY, RESULTS, ACCURICIES AND LIMITATIONS
5	
6	

No	DATE	MODIFICATIONS	GPR APP.
1	Feb 10, 2014	Minor adjustments to layer interpretation at intersection points of lines Added interpretation for weaker seismic reflectors and MASW S-wave Profiles	
2	Feb 28, 2014	Minor formating/labeling changes	

GEOPHYSICS GPR INTERNATIONAL INC.

DESSINÉ PAR / DRAWN BY	RBM
VERIFIÉ PAR / CHECKED BY	B.McClement, P. Eng.
APPROUVÉ PAR / APPROVED BY	M. Situm, P. Geo.
# CONTRAT / CONTRACT #	T-13615
DATE	February 28, 2014
ÉCHELLE / SCALE	AS SHOWN
# DESSIN / DRAWING #	T13615_A1

CLIENT: BAFFINLAND IRON MINES CORP.

PROJET / PROJECT: MARY RIVER PROJECT
MILNE INLET, NUNAVUT

TITRE / TITLE: GEOPHYSICAL SEISMIC INVESTIGATION
INTERPRETED SEISMIC PROFILES