PHASE 2 INITIAL BOREHOLE DRILLING AND TESTING AT IG BH04/05/06 IGNACE AREA

WP12 Data Report – Vertical Seismic Profiling for IG BH06

APM-REP-01332-0369 **November 2023**

WSP Canada Inc.

NUCLEAR WASTE MANAGEMENT ORGANIZATION
SOCIÉTÉ DE GESTION DES DÉCHETS NUCLÉAIRES

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REPORT

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Submitted to:

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WP12 DATA REPORT
VERTICAL SEISMIC PROFILING FOR IG_BH06

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1.0 INTRODUCTION

The Initial Borehole Drilling and Testing project in the Wabigoon Lake Ojibway Nation (WLON) – Ignace Area, Ontario is part of Phase 2 Geoscientific Preliminary Field Investigations of the Nuclear Waste Management Organization's (NWMO) Adaptive Phased Management Site Selection Phase. This project includes the drilling and testing of six deep boreholes at the Revell site, as well as additional on-going studies, located within the northern portion of the Revell batholith.

This project involves testing of deep borehole IG_BH04 and the drilling and testing of deep boreholes IG_BH05 and IG_BH06 in the Revell site within the identified Potential Repository Area (PRA) as shown on Figure 1. The work comprises a total of eleven work packages and was carried out by a team led by WSP Canada Inc. (WSP) on behalf of the NWMO. The IG_BH06 program is described in a Borehole Characterization Plan (BCP) for IG_BH06.

This data report describes the methodology, activities, and reporting for Work Package 12 (WP12): Vertical Seismic Profiling for IG_BH06 (Figure 1). This report follows a similar analysis approach as done for IG_BH04 and IG_BH05 (Golder and Vibrometric 2022, 2023) and describes the methodology, calibration/verification, acquisition, processing, and interpretation of the Vertical Seismic Profiling data. The geometry of this VSP is multi-offset, multi-azimuth. Information from this work package will target and image potential sub-horizontal reflectors (e.g., fracture zones and thin lithological units over the study area) and sub-vertical reflectors around the borehole.

The coordinates presented throughout this report are all presented in NAD83(CSRS), UTM Zone 15N, CGVD2013 Datum.

2.0 BACKGROUND INFORMATION

2.1 Geological Setting

The approximately 2.7-billion-year-old Revell batholith is located in the western part of the Wabigoon Sub-province of the Archean Superior Province. The batholith is roughly elliptical in shape trending northwest, is approximately 40 km in length, 15 km in width, and covers an area of approximately 455 km^2. Based on geophysical modelling, the batholith is approximately 2 km to 3 km thick through the center of the northern portion (SGL 2015). The batholith is surrounded by supracrustal rocks of the Raleigh Lake (to the north and east) and Bending Lake (to the southwest) greenstone belts (Figure 2).

IG_BH06 is located within an investigation area of approximately 19 km^2 in size, situated in the northern portion of the Revell batholith. Bedrock exposure in the area is generally very good due to minimal overburden, few water bodies, and relatively recent logging activities. Ground elevations generally range from 400 to 450 m above sea level. The ground surface broadly slopes towards the northwest as indicated by the flow direction of the main rivers in the area. Local water courses tend to flow to the southwest towards Mennin Lake (Figure 1).

Four main rock units are identified in the supracrustal rock group: mafic metavolcanic rocks, intermediate to felsic metavolcanic rocks, metasedimentary rocks, and mafic intrusive rocks (Figure 2). Sedimentation within the supracrustal rock assemblage was largely synvolcanic, although sediment deposition in the Bending Lake area may have continued past the volcanic period (Stone 2009; Stone 2010a; Stone 2010b). All supracrustal rocks are affected, to varying degrees, by penetrative brittle-ductile to ductile deformation under greenschist- to amphibolitefacies metamorphic conditions (Blackburn and Hinz 1996; Stone et al. 1998). In some locations, primary features, such as pillow basalt or bedding in sedimentary rocks are preserved, in other locations, primary relationships are completely masked by penetrative deformation. Uranium-lead (U-Pb) geochronological analysis of the supracrustal rocks produced ages that range between 2734.6 +/-1.1 Ma and 2725 +/-5 Ma (Stone et al. 2010). Three main suites of plutonic rock are recognized in the Revell batholith, including, from oldest to youngest: a Biotite Tonalite to Granodiorite suite, a Hornblende Tonalite to Granodiorite suite, and a Biotite Granite to Granodiorite suite (Figure 2) Plutonic rocks of the Biotite Tonalite to Granodiorite suite occur along the southwestern and northeastern margins of the Revell batholith. The principal type of rock within this suite is a white to grey, medium-grained, variably massive to foliated or weakly gneissic, biotite tonalite to granodiorite. One sample of foliated and medium-grained biotite tonalite produced a U-Pb age of 2734.2+/-0.8 Ma (Stone et al. 2010). The Hornblende Tonalite to Granodiorite suite occurs in two irregularly-shaped zones surrounding the central core of the Revell batholith. Rocks of the Hornblende Tonalite to Granodiorite suite range compositionally from tonalite through granodiorite to granite and also include significant proportions of quartz diorite and quartz monzodiorite. One sample of coarse-grained grey mesocratic hornblende tonalite produced a U-Pb age of 2732.3+/-0.8 Ma (Stone et al. 2010). Rocks of the Biotite Granite to Granodiorite suite underlie most of the northern, central and southern portions of the Revell batholith. Rocks of this suite are typically coarse-grained, massive to weakly foliated, and white to pink in colour. The Biotite Granite to Granodiorite suite ranges compositionally from granite through granodiorite to tonalite. A distinct potassium (K)-Feldspar Megacrystic Granite phase of the Biotite Granite to Granodiorite suite occurs as an oval-shaped body in the central portion of the Revell batholith (Figure 2). One sample of coarse-grained, pink, massive K-feldspar megacrystic biotite granite produced a U-Pb age of 2694.0+/-0.9 Ma (Stone et al. 2010).

The bedrock surrounding IG_BH06 is composed mainly of massive to weakly foliated felsic intrusive rocks that vary in composition between granodiorite and tonalite, and together form a relatively homogeneous intrusive complex. Bedrock identified as tonalite transitions gradationally into granodiorite and no distinct contact relationships between these two rock types are typically observed (SRK and Golder 2015; Golder and PGW 2017). Massive to weakly foliated granite is identified at the ground surface to the northwest of the feldspar-megacrystic granite. The granite is observed to intrude into the granodiorite-tonalite bedrock, indicating it is distinct from, and younger than, the intrusive complex (Golder and PGW 2017).

West-northwest trending mafic dykes interpreted from aeromagnetic data extend across the northern portion of the Revell batholith and into the surrounding greenstone belts. One mafic dyke occurrence, located to the northwest of IG_BH01, is approximately 15-20 m wide (Figure 2). All of these mafic dykes have a similar character and are interpreted to be part of the Wabigoon dyke swarm. One sample from the same Wabigoon swarm produced a U-Pb age of 1887+/-13 Ma (Stone et al. 2010), indicating that these mafic dykes are Proterozoic in age. It is assumed based on surface measurements that these mafic dykes are sub-vertical (Golder and PGW 2017).

Long, narrow valleys are located along the western and southern limits of the investigation area (Figure 1). These local valleys host creeks and small lakes that drain to the southwest and may represent the surface expression of structural features that extend into the bedrock. A broad valley is located along the eastern limits of the investigation area and hosts a more continuous, un-named water body that flows to the south. The linear and segmented nature of this waterbody’s shorelines may also represent the surface expression of structural features that extend into the bedrock.

Regional observations from mapping have indicated that structural features are widely spaced (typical 30 to 500 cm spacing range) and dominantly comprised of sub-vertical joints with two dominant orientations, northeast and northwest trending (Golder and PGW 2017). Interpreted bedrock lineaments generally follow these same dominant orientations in the northern portion of the Revell batholith (Figure 2) (DesRoches et al. 2018). Minor sub-horizontal joints have been observed with minimal alteration, suggesting they are younger and perhaps related to glacial unloading. One mapped regional-scale fault, the Washeibemaga Lake fault, trends east and is located to the west of the Revell batholith (Figure 2). Ductile lineaments, also shown on Figure 2, follow the trend of foliation mapped in the surrounding greenstone belts. Additional details of the lithological units and structures found at surface within the investigation area are reported in Golder and PGW (2017).

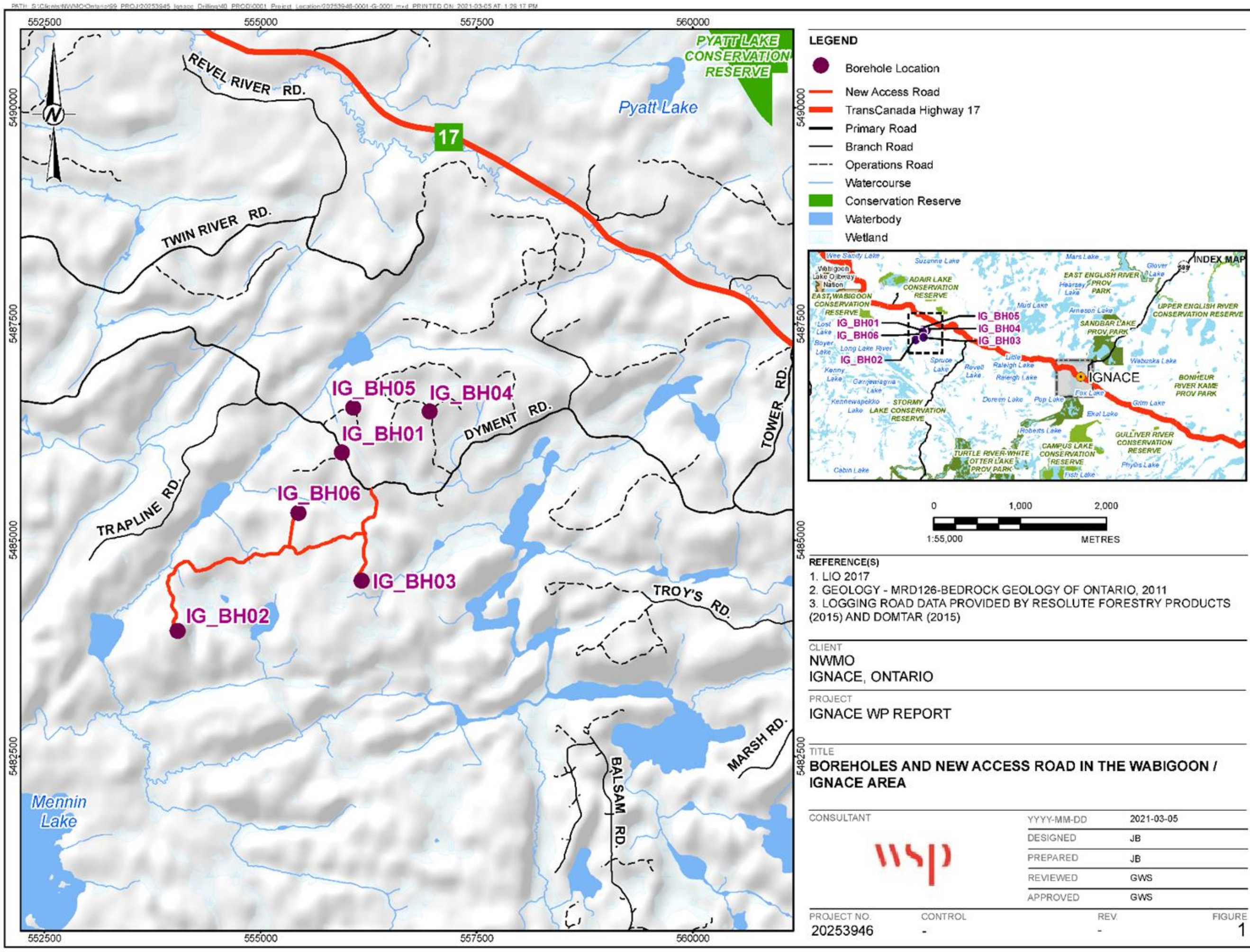


Figure 1: Location of IG_BH06 in relation to the Wabigoon-Ignace area.

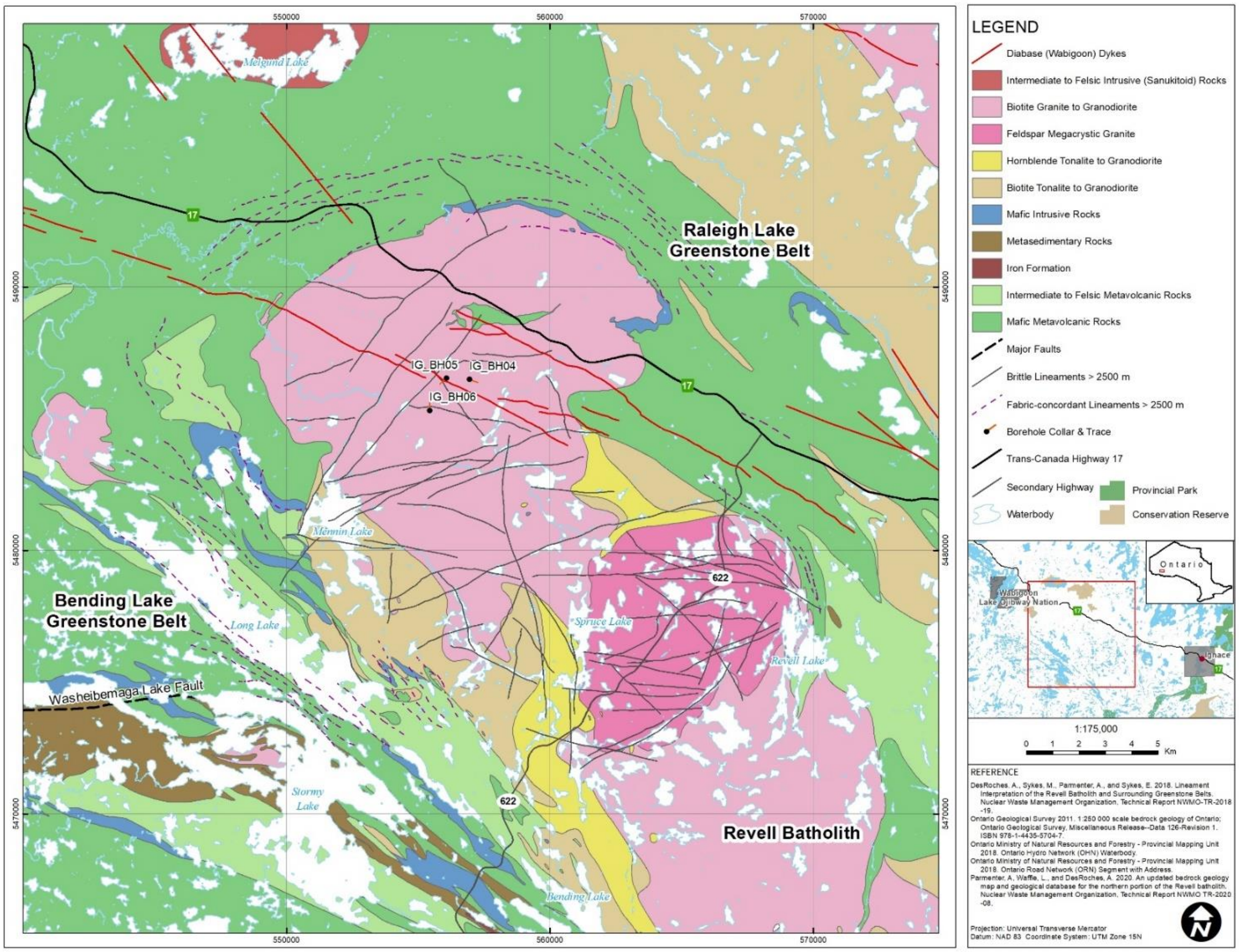


Figure 2: Geological setting and location of boreholes IG_BH04, IG_BH05, and IG_BH06 in the northern portion of the Revell batholith.

3.0 VERTICAL SEISMIC PROFILING FROM BOREHOLE IG_BH06

This section describes the multi-offset multi-azimuth Vertical Seismic Profiling (VSP) survey performed by Vibrometric in borehole IG_BH06 at the Revell site, Ontario, as well as the results obtained by processing and analyzing measured data. Data acquisition was done during January - February 2022. The locations of the borehole and of the shot points used for the VSP measurements are shown on Figure 7 to Figure 9, and summarized in Table 2 and Table 3.

The scope of the work presented here was to acquire, process, and interpret high-resolution vertical seismic profiles (VSP). This effort was designed to image potential reflectors (e.g., fracture zones and thin lithological units within the study area) with diverse dips from horizontal to vertical around the borehole. VSP results were correlated with available structural logs provided by the NWMO, as presented in Table 8.

The intended scope of the borehole and surface survey was to:

1) Collect 3D VSP data in one borehole to a maximum depth of ~1000 m;

2) Process seismic data by means of industry standard and proprietary seismic imaging techniques particularly adapted to hardrock; and

3) Interpret the main identified reflectors, i.e., position them in 3D, using all processed data and correlate them with the borehole lithological log (WP03) and lineaments identified in the vicinity of the borehole.

The VSP method provides a favorable geometry for mapping both steeply and gently dipping features that cut the borehole (Cosma et al. 2001b). Sub-vertical features not cutting the borehole can be mapped from surface to a depth of ½ to ¾ of the depth of the borehole. Sub-horizontal features can be mapped deep under the borehole, but with a lateral extent limited to ½ of the mean shot point offset. In the case of the VSP borehole IG_BH06 at the Revell site this means a maximum depth of about 500-750 m for the mapping of the sub-vertical and about 450m (depending on the azimuth) for the sub-horizontal features.

Receivers located in the bedrock reduce the loss of the higher frequencies due to near-surface signal absorption. For this reason, VSP is often preferred to surface seismic profiling, especially at sites where hard bedrock is covered by soft overburden.

4.0 LOGISTICS

The field crew and equipment were mobilized from Toronto to the Revell site area mid-January 2022. The crew consisted of four to five Vibrometric personnel and one WSP personnel, at various times during the survey, with one geophysicist and one field engineer on site at all times. Figure 1 presents the location on the map of the survey site, situated approximately 40 km west of the Town of Ignace, Ontario.

The VSP acquisition work was carried out in borehole IG_BH06, instrumented with 3-components digital geophones, which recorded seismic signals generated by a VIBSIST-3000 source, activated at 30 shot points distributed on surface around the borehole, as shown on the map on Figure 8. Survey details are presented in Section 5.0.

4.1 Field Equipment and Operations

Vibrometric supplied all the field equipment required for data acquisition. Some supporting infrastructure onsite (e.g., tent over the borehole collar and work area around the borehole, acquisition room, electrical power supply, etc.) was provided by WSP. Trail access and standby trail clearing/towing capacity was provided by the NWMO.

The following list presents the field equipment used to carry out the VSP investigation:

- VIBSIST-3000 seismic source;
- RD-XYZH 3-component seismic receivers with 1,000 m of multi-pair geophysical cable on a winch powered by an electric motor;
- Dummy probe;
- Tripod to place over the borehole;

- Depth encoder to measure depth of receivers;
- Field computer for data acquisition;
- Radios for transmission of pilot trigger signal from source to acquisition computer;
- Radios for audio communication between acquisition shelter and seismic source;
- Wooden stakes to mark VSP shot locations; and
- GPS to measure the coordinates of the source locations (NAD83 UTM Zone 15N, CGVD2013 Datum).

VSP data acquisition was performed in one field session, as described below:

Table 1: Daily Activities during the VSP Survey in IG_BH06.

Date	Day	Description of activity during the day
2022-01-20	Thursday	Move equipment to site / Standby
2022-01-21	Friday	Move equipment to site / Standby
2022-01-22	Saturday	VIBSIST-3000 moved from Ignace to site; Mark shot points
2022-01-23	Sunday	Standby
2022-01-24	Monday	Standby / Moved receivers and tools to site
2022-01-25	Tuesday	Move equipment into sea cans - Organizing/setting up acquisition - Moving winches under heated tent near borehole (Sunny -32°C to -25°C)
2022-01-26	Wednesday	Set up radio communications - Set up acquisition area - Assemble geophone chain - Test geophone chain on surface (Cloudy, -20°C to -12°C)
2022-01-27	Thursday	Confirm radio communication at all shot points - Lower geophones down borehole - Test geophone response below surface - Complete test points to evaluate signal with snow covered ground (Mostly sunny -20°C)
2022-01-28	Friday	Complete acquisition on Layout 1 and Layout 2 (Mostly sunny -25°C to -16°C)
2022-01-29	Saturday	Complete acquisition on Layout 3 and Layout 4 (Cloudy -17°C)
2022-01-30	Sunday	Complete acquisition on Layout 5, Layout 6 & Layout 7 (Mostly clouds -25° to -13°)
2022-01-31	Monday	Complete acquisition on Layout 8, Layout 9 & 10 shot points from Layout 10 (Mostly cloudy -11° to -6°C)
2022-02-01	Tuesday	Complete acquisition on 20 shot points on Layout 10, Layout 11 & 12 (Snow most of the day -18°C to -6°C)
2022-02-02	Wednesday	Complete acquisition on 20 shot points on Layout 13; Testing hammer, which deteriorated due to over freezing overnight (-38°C, sunny day -30°C to -22°C)
2022-02-03	Thursday	No work on site - Diagnose issue with seismic hammer in Ignace (Sunny -25°C to -10°C)
2022-02-04	Friday	No work on site – Work to repair the seismic hammer in Ignace (Sunny -23°C to -10°C)
2022-02-05	Saturday	No work on site – Work to repair the seismic hammer in Ignace (Sunny -32°C to -11°C)
2022-02-06	Sunday	No work on site – Repair the seismic hammer in Ignace (Sunny -25°C to -11°C)

Date	Day	Description of activity during the day
2022-02-07	Monday	Return hammer to site - Confirm functionality of the seismic source - Complete all 30 points for Layout 13, and 15 points for Layout 14 (Sunny -25°C to -11°C)
2022-02-08	Tuesday	Complete remaining 15 points for Layout 14 and Layout 15 - Remove geophones from borehole – Begin demob (Sunny -11°C to -3°C)
2022-02-09	Wednesday	Removed VIBSIST-3000 from site / Pack all equipment / Complete demob

4.2 Equipment

One VIBSIST-3000 time-distributed seismic source was used on the surface. A 12-level, 3-component digital geophone receiver tool, the RD-XYZH, was used in the borehole. A PC-based acquisition program was used to record the seismic data. Three-component profiles were collected from 30 shot points. Each profile consisted of 16 receiver layouts with 12 receivers in each layout, spaced at 5 m intervals between 80 m and 980 m depth as measured along the borehole.

4.2.1 The VIBSIST-3000 Seismic Source

The seismic source was the VIBSIST-3000, which is a multi-impact time-distributed seismic source based on the Swept Impact Seismic Technique (SIST), described in principle by Park et al. (1996) and technically elaborated and completed by Cosma and Enescu (2001).

The VIBSIST-3000 source uses a large-size hydraulic impact hammer, powered through a computer-controlled regulator that is mounted on an all-wheel drive/all-wheel steering 7-tonne tool carrier, as shown on Figure 3. The seismic source can handle topography at a reasonable speed while providing high energy and a stable source signature. The hydraulic hammer is capable of delivering 2500 – 3250 J/impact at 400-800 impacts/minute. At each shot point, the VIBSIST-3000 source was activated three times for a period of 20 seconds each, with the impact frequency being varied to generate a swept impact sequence. Each sweep contains ~100 impacts. Based on data inspection in the field, the number of sweep repetitions was sufficient to obtain high-quality seismic signal for the desired investigation depth.

The VIBSIST concept requires a pilot signal to be measured by a sensor placed on the source and this was conveyed by radio to the recording station and recorded together with the signals arriving from the receivers. The main role of the pilot signal is to record the actual time history and the energy of the impacts delivered to the ground by the source. High quality data were acquired from each shot location at all offsets.

Figure 3: The VIBSIST-3000 seismic source used for the VSP survey in IG_BH06. Shot point V94 (top), shot point V79 (bottom).

4.2.2 Downhole Seismic Receivers and Cable

A 3-component digital geophone chain was used for the VSP measurements. This is shown on Figure 4.
The RD-XYZH consists of up to 24 3-component modules spaced at 5 m intervals. The signal digitizing is done down-hole, within each module. For logistic reasons, the survey was carried out with 12 levels. The frequency band is from 14 to 500 Hz. The units are equipped with side arms for clamping, activated by DC motors.
The clamping control is independent for each unit.

Figure 4: Detail of the 3-component modules with clamping arms for the RD-XYZH geophone receiver system and pictures of the receiver installation and cable winch. Acquisition setup at borehole IG_BH06.

Survey Details

The VSP investigations were carried out in borehole IG_BH06. Three-component profiles were collected from 30 shot points spaced as evenly as possible around the borehole. Some of the shot points originally planned to be used were changed due to the terrain access issues and fire restrictions which precluded accessing some originally planned shot points with heavy equipment. The initial and actual survey layout are illustrated on Figure 5 and Figure 7, respectively. The green and orange place markers show the location of VSP sources for borehole IG_BH06 and the thick blue line shows the surface projection of the borehole. The field acquisition started on January 20, 2022, and was completed on February 09, 2022.

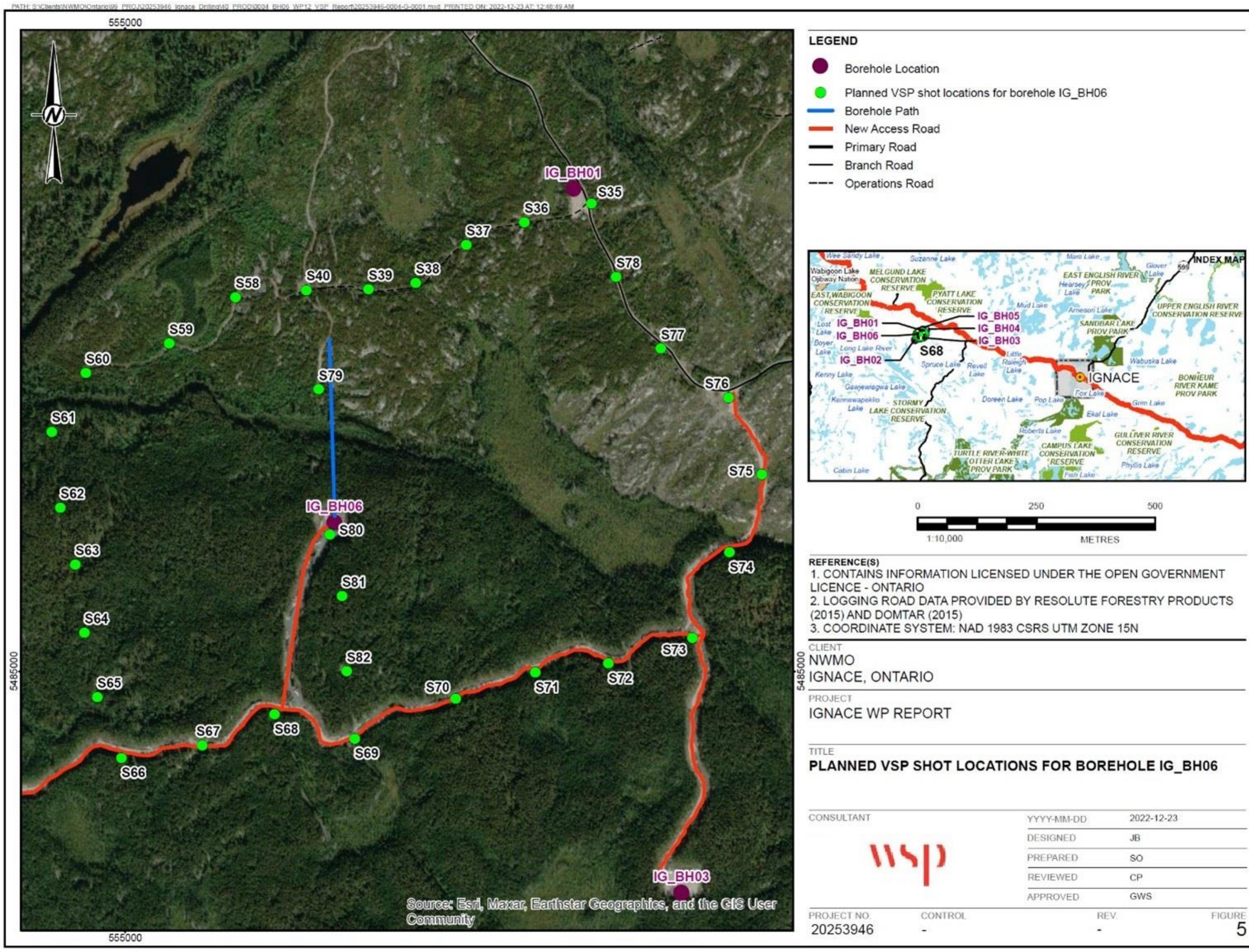


Figure 5: Location of borehole IG_BH06 and of the VSP shot points planned for data acquisition.

4.3 Borehole IG_BH06

Borehole IG_BH06 is inclined (dip -68° and azimuth 359°, approximately, see Figure 6) and the start and end positions of the borehole, in site coordinates, are given in Table 2. All coordinates shown in this report are reduced coordinates, obtained by subtracting 5480000 from the Northing and 550000 from the Easting coordinates, respectively. Top of the borehole is at Northing 5328.11 m, Easting 5440.35 m, and Elevation 417.74 m. Casing was installed to a depth of 70 m down the hole. The caliper log along the borehole, together with some qualitative considerations used to guide the usage of receivers down-hole are also shown on Figure 6.

Table 2: The Coordinates of borehole IG_BH06. All coordinates shown in this report are reduced coordinates, obtained by subtracting 5480000 on the Northing and 550000 on the Easting coordinates, respectively.

Borehole used for the VSP Survey	Coordinates of the first receiver			Coordinates of the last receiver		
	Northing Y (m)	Easting X (m)	Elevation Z (m)	Northing Y (m)	Easting X (m)	Elevation Z (m)
IG_BH06	5357.72	5439.76	343.35	5692.8	5433.2	-493.55

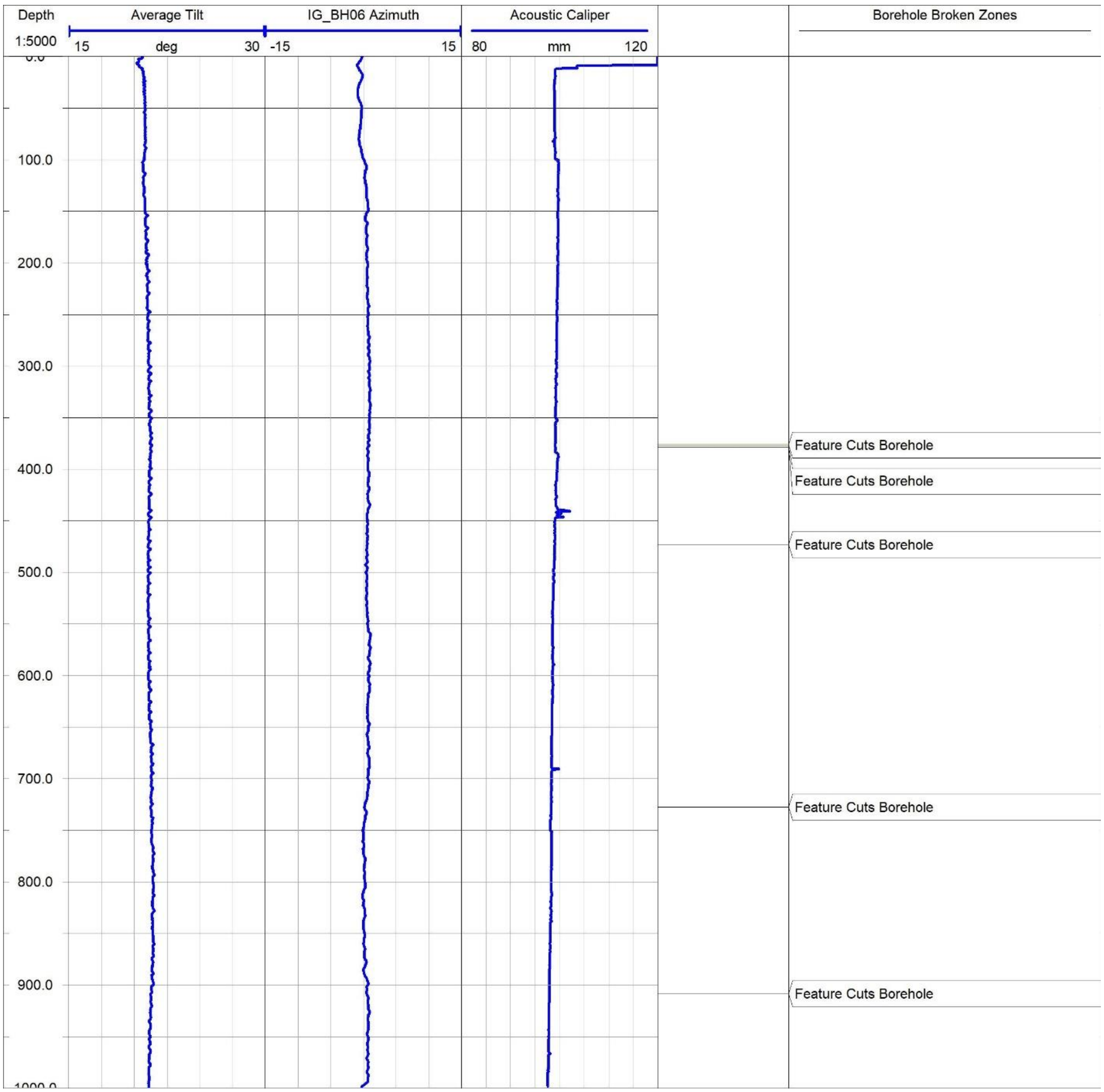


Figure 6: Orientation of borehole IG_BH06 with depth and Acoustic Caliper log together with a summary of zones where clamping of the geophones is to be avoided because of increased risk of instrument jam.

4.4 Survey Geometry

At each shot point, the VIBSIST-3000 source was activated for a period of 20 seconds, the impact frequency being varied from 3 Hz to 6 Hz to generate a swept impact sequence. Each sweep contained 95 to 100 impacts and was repeated three times. A pilot signal was measured by a sensor placed on the source plate and conveyed to the recording station by radio to be recorded on an additional channel, together with the signals arriving from the receivers.

The layout of the shot points is shown on Figure 7, Figure 8 and Figure 9 and their coordinates are given in Table 3. The zero-offset shot point (32 m away from the borehole top) is V90. The distances from the top of the borehole to shot points range from 32 to 906 m. The distances from shot points to the first receiver in the borehole range from 94.5 to 906 m. The distances from shot points to the deepest receivers in the borehole range from 905 to 1358 m.

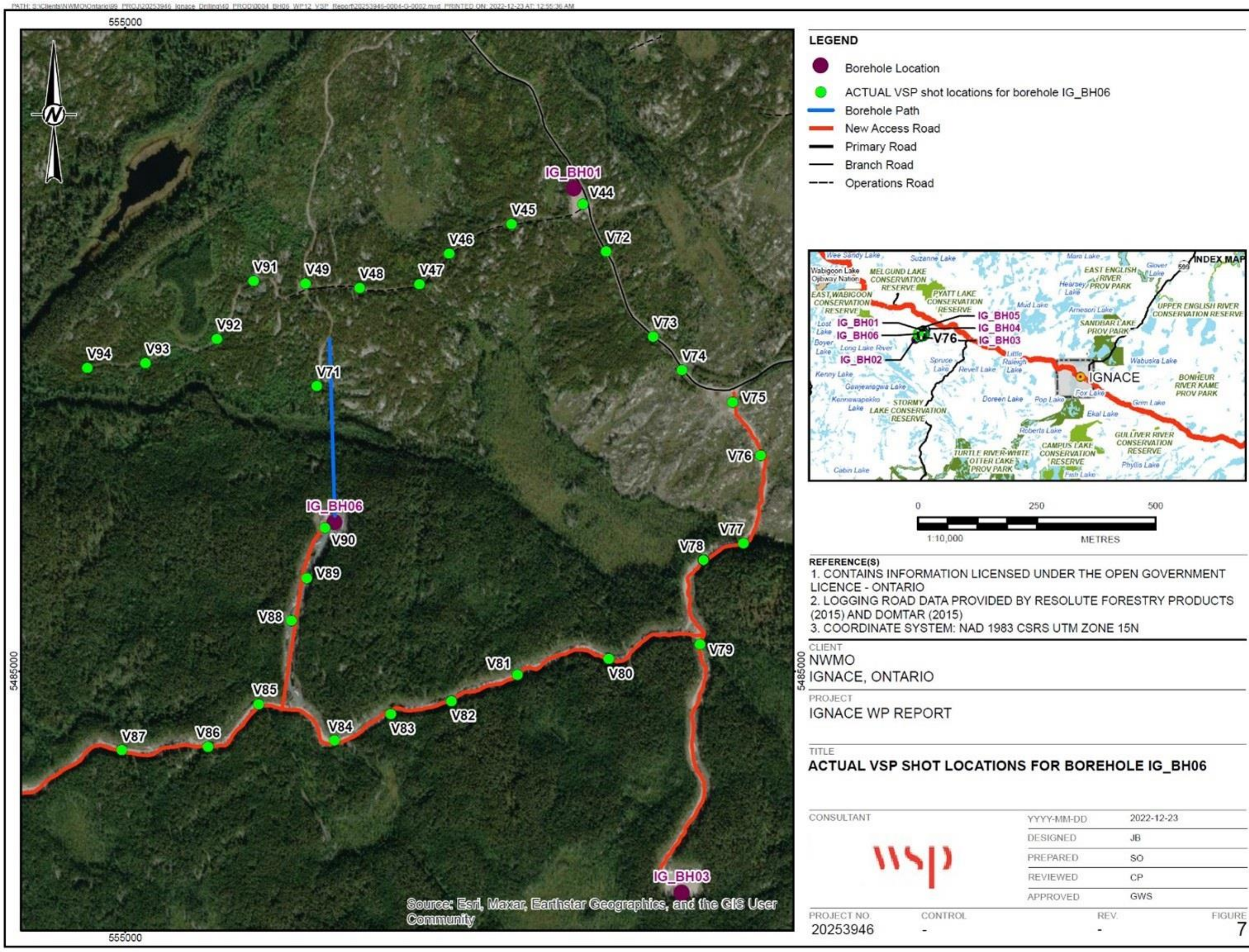


Figure 7: Location of borehole IG_BH06 and of the VSP shot points used for data acquisition.

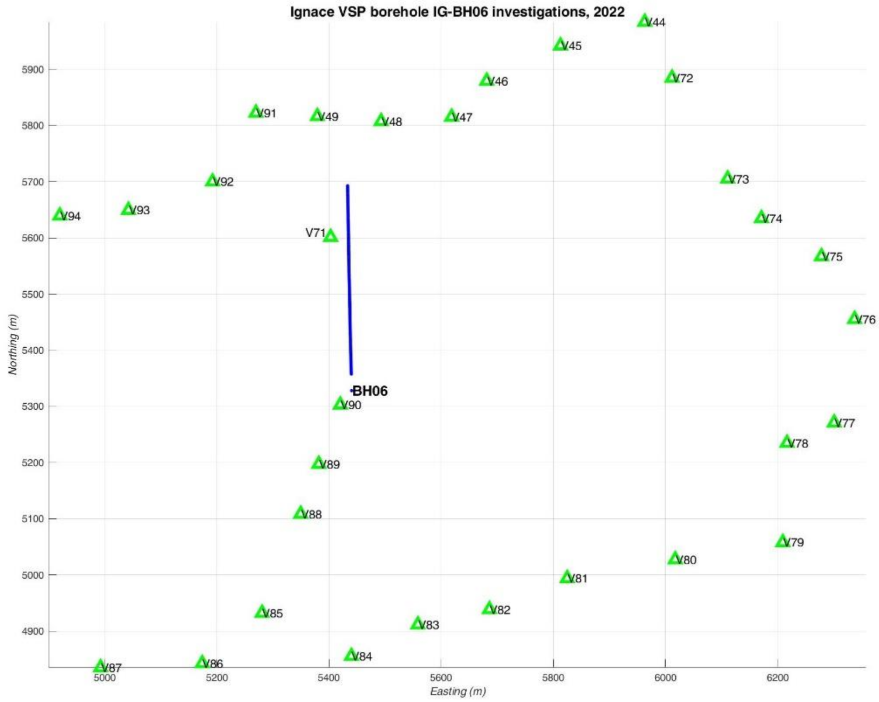


Figure 8: Top view of layout of the shot points used for the multi-offset VSP survey in borehole IG_BH06.

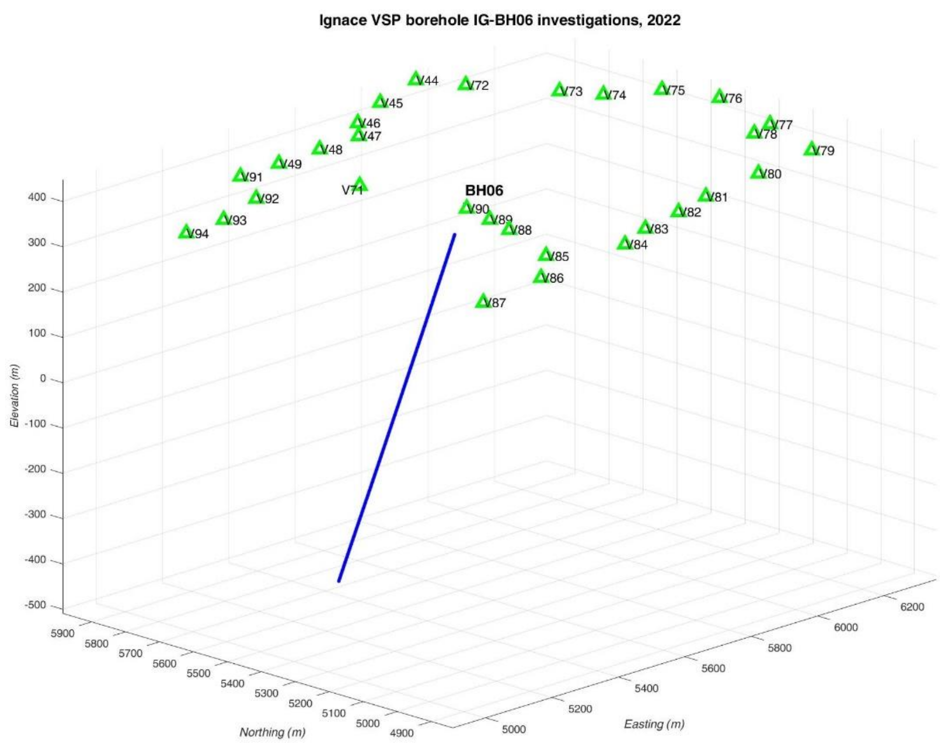


Figure 9: 3D view of layout of the shot points used for the multi-offset VSP survey in borehole IG_BH06. The location of the VSP receivers in borehole IG_BH06 are marked in blue.

Table 3: Reduced coordinates of the source positions for the VSP survey in IG_BH06. The zero-offset shot point (nearest to the borehole top) is printed bold.

Shot point	Northing (m)	Easting (m)	Elevation (m)	Distance from the shot point to the first receiver (m)	Distance from the shot point to the last receiver (m)
V44	5984.47	5963.04	428.93	820.95	1103.07
V45	5942.36	5812.82	422.23	698.00	1022.27
V46	5879.58	5681.32	420.65	580.23	965.51
V47	5815.52	5618.69	420.22	497.50	940.45
V48	5807.61	5492.96	420.85	459.61	923.51
V49	5816.63	5379.31	412.92	468.07	916.47
V71	5601.39	5402.89	406.05	254.29	904.74
V72	5884.92	6011.69	429.09	782.56	1105.81
V73	5705.48	6110.88	432.89	761.15	1147.91
V74	5634.94	6171.15	427.18	786.64	1181.38
V75	5567.10	6278.10	428.87	868.31	1257.19
V76	5455.33	6337.22	422.29	906.20	1308.59
V77	5271.00	6300.87	412.86	868.25	1323.76
V78	5234.94	6216.68	419.42	790.23	1287.24
V79	5057.99	6209.22	422.88	829.60	1358.32
V80	5027.47	6017.46	421.38	669.99	1273.23
V81	4993.96	5824.75	421.38	535.38	1216.05
V82	4938.67	5686.13	430.40	493.84	1219.17
V83	4911.53	5558.52	428.30	469.47	1214.86
V84	4855.45	5439.98	432.61	510.14	1248.59
V85	4932.23	5280.71	426.26	461.75	1203.23
V86	4842.48	5173.94	421.72	585.04	1275.92
V87	4835.12	4992.79	409.18	690.82	1320.79
V88	5108.47	5349.59	429.37	278.67	1095.54
V89	5197.36	5381.85	425.22	189.13	1045.10
V90	**5302.82**	**5420.18**	**417.75**	**94.51**	**991.32**
V91	5822.64	5269.77	407.72	499.19	925.12
V92	5700.28	5192.41	403.40	426.77	928.74
V93	5649.56	5042.40	401.56	496.44	977.66
V94	5639.61	4920.04	401.36	594.08	1032.97

Table 4: IG_BH06 Survey Parameters

Parameter	Description
Borehole Information	Casing depth: 70 m Dip: -68° Azimuth: 359° First receiver depth: 80 m Last receiver depth: 980 m
Geodetic Datum	NAD83(CSRS), UTM Zone 15N, CGVD2013 Datum
Source to Borehole Top Offset	Minimum: 32 m Maximum: 906 m
Source to Receiver Offset	Minimum: 94.5 m Maximum: 1358 m
Total Shot Points	30
Source Type	VIBSIST-3000 A multi-impact time-distributed seismic source
Source Sweep Time	20 seconds
Useful Frequency Bandwidth	50 to 250 Hz
Average Source Interval	100 m
Nominal Recorded Traces	3 sweeps per source location with approximately 100 impacts per sweep
Receiver Interval	5 m intervals between 80 m and 980 m depth. Collected in 16 levels with 12 receivers in each level.

4.5 Work Procedure and Quality Control

The VSP measurements were conducted in increments of 60 m with 12-level geophone string at a nominal station interval of 5 m. The station interval was adjusted to compensate for the actual cable elongation measured by comparing the reading of the depth encoder with preset cable markings. Measurements were done from 80.00 m to 981.58 m borehole depth from the top of the casing.

The data quality was controlled on screen immediately after acquiring a record. All shot-points were measured in one group, for which the geophone string was kept clamped to the borehole at the same depth. The last record of each day was repeated at the start of the next day to check the functioning of the clamping mechanism.

Daily Quality Control (DQC) Forms were filled out each day during the field program and submitted to NWMO with each daily field report. The DQC forms present each of the field checks and quality controls performed during the survey. They are provided for reference in Appendix A.

5.0 DATA PROCESSING

Reflecting interfaces associated with lithological contacts, faults or fracture zones can display strong to relatively weak seismic contrasts. Extensive processing is often needed to identify reflection events in the seismic profiles and to retrieve the information on the position of the reflectors.

The processing flow described below aims to suppress direct arrivals and improve the signal-to-noise ratio, so that the later events, e.g., reflections, become visible. As the reflection coefficients may be low, the reflectors cannot always be identified only by amplitude standout. Continuity and phase consistency throughout the profiles have been found to be sensitive indicators of the occurrence of reflections.

The processing flow used for the IG_BH06 VSP data is summarized below:

- Resampling from 1 ms to 500 μs
- Time stacking of the VIBSIST impact sequences
- Trace selection and sorting
- Adding the geometry information to the data files
- Data quality and frequency analysis
- Zero-phase band-pass filtering 50-250 Hz
- Component rotation: (X Y Z) to (R, T, Z)
- P- and S-wave arrival time picking and velocity computing
- Suppressing direct P- and S- wave arrivals
- Amplitude equalization
- Static corrections using tomographic reconstruction of velocities
- Spatial resampling to 2.5 m trace interval
- Image Point filtering and reflector enhancement
- Determining the positions of the reflectors multi-profile interactive interpretation.
- Migrating along the mean azimuths of the main interpreted reflectors

5.1 First Stage Processing of the VSP Data

5.1.1 Data Quality and Frequency Analysis

The data have been inspected for possible malfunctions of the measuring system, e.g., unusually high noise levels, possible errors in coordinates, time delays and trace order. The noise level was measured for reference at the beginning at each day. The depth of the geophone string in the borehole was verified by comparing the readings of the depth encoder with preset marks on the lead-in cable.

Following this, spectral analysis of the data has been done for all measured VSP profiles. Figure 10 displays the amplitude spectra for all three component profiles measured from shot point V71, which has a frequency response typical for the entire data group, although some shot points display lower frequency responses.

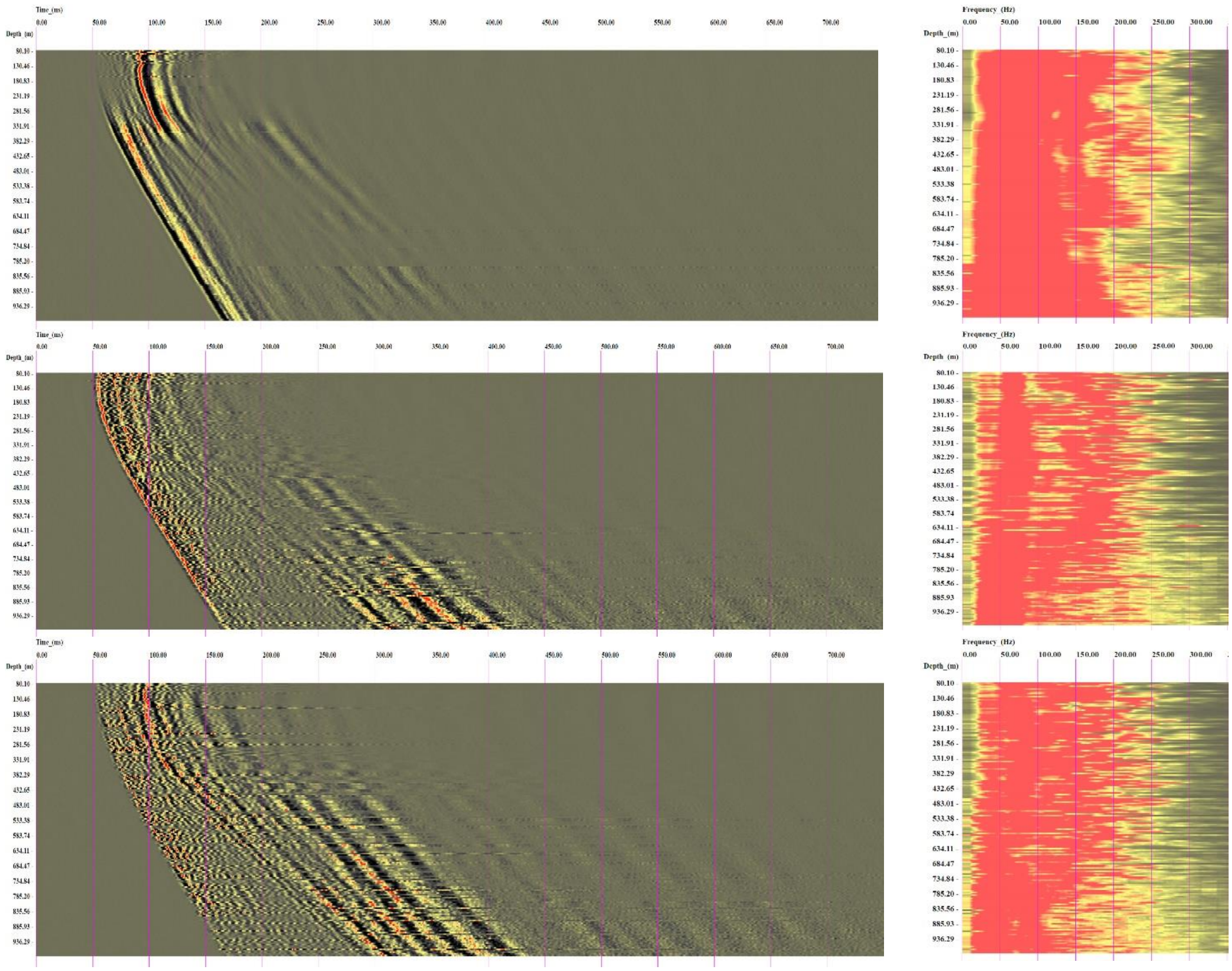


Figure 10: Spectra of the VSP data measured from IG_BH06 shot point V71 (right column). The vertical axis shows the depth along the borehole in metres. The horizontal axis shows time in ms (left) and the frequency in Hz (right). The useful seismic signal energy is contained in the 20 – 250 Hz band, as it appears in the right panel. The evaluation of the spectrum at this stage is meant to be overcovering. Shown are Axial, Z (top), Radial, R (middle), Transversal, T (bottom) components, normalized to trace.

The raw VSP Profiles acquired for IG_BH06 are presented in Appendix B.

5.1.2 Preconditioning of the Data Profiles

The overall frequency band of the P-waves was estimated to be 20 – 250 Hz (Figure 10). However, frequencies lower than 100 Hz were more actively contaminated by ground-roll and top rock-scattering. Following several tests with frequency panels, a zero-phase band-pass filter with spectral equalization from 50 to 250 Hz was chosen for filtering all data profiles.

Figure 11: Band pass filtered axial component (Z) profile from shot point V71.

The processed VSP profiles are presented in Appendix C.

5.1.3 Rotation of Transverse Components

The orientation of the transverse components (X and Y) is not set or determined during the measurements and the down-hole probes can rotate while changing position.

The rotation of the horizontal components is done computationally, assuming that the direct P wave is polarized along the source-receiver line. The X-Y trace pair is rotated so that after rotation the X-component acquires the most P-wave energy and becomes the “Radial” – R-component, while the Y-component contains the minimum of the P-wave energy becomes the “Transversal” – T-component. The Z-component remains directed along the borehole and it becomes the “Axial” component. Figure 12 to Figure 14 present the rotated components recorded in borehole IG_BH06 from shot point V71. The rotated components from all shot points are displayed in Appendix C.

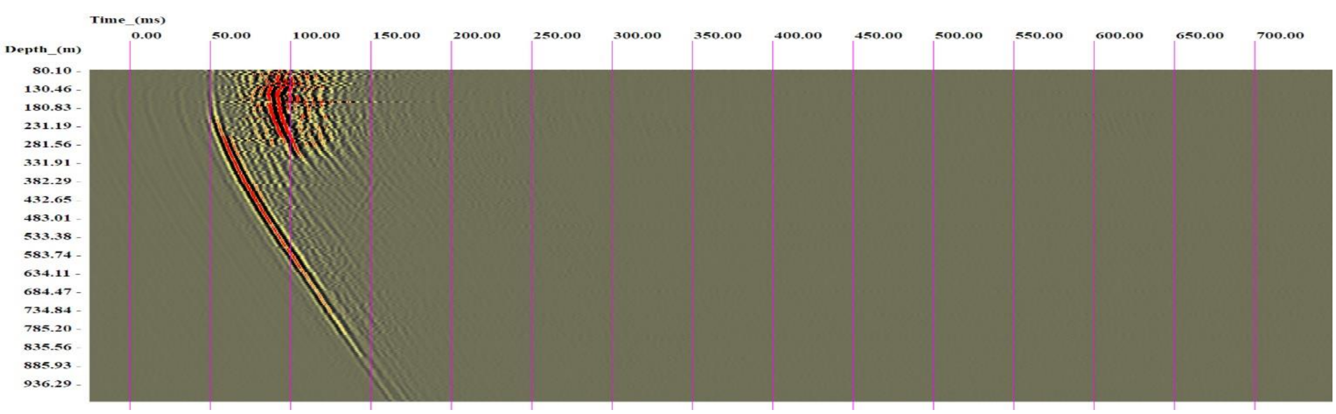


Figure 12: Axial (Z) VSP raw data profile, recorded in borehole IG_BH06, from shot V71. Profile normalized to value=100.

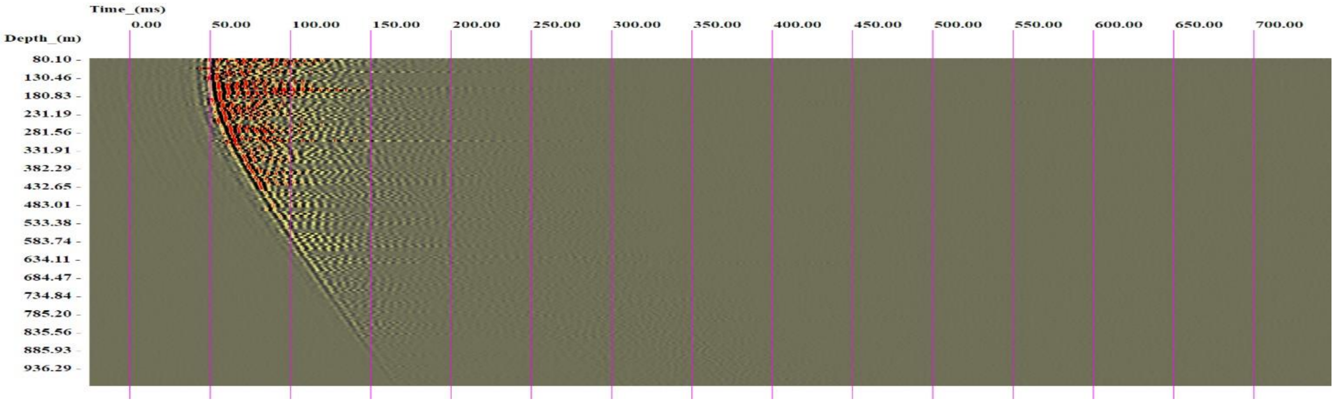


Figure 13: Rotated radial (R) VSP raw data profile, recorded in borehole IG_BH06, from shot V71. Profile normalized to value=100.

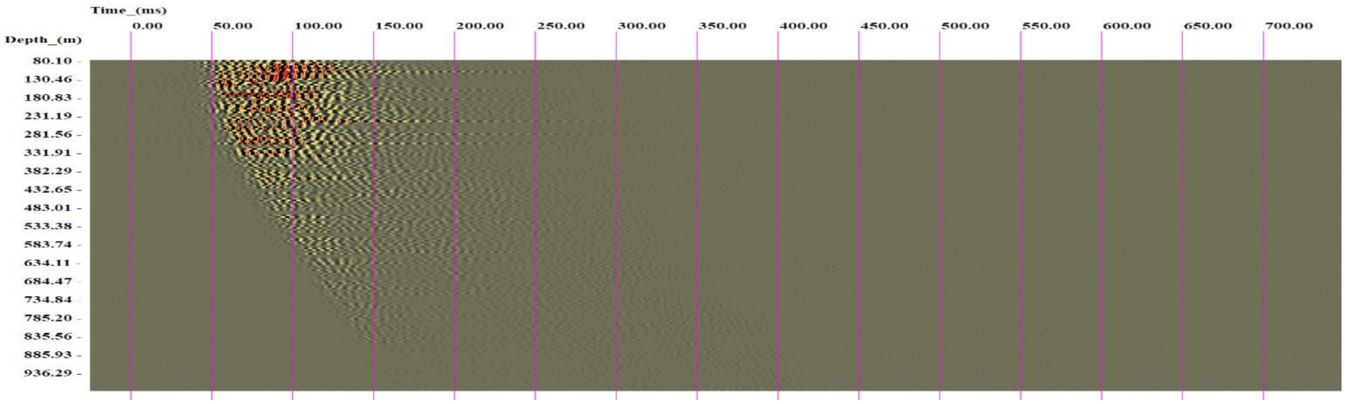


Figure 14: Rotated transversal (T) VSP raw data profile, recorded in borehole IG_BH06, from shot V71. Profile normalized to value=100.

5.1.4 Velocity Determinations

P and S wave first arrival times were picked for all shot gathers from rotated profiles, as the ones shown on Figure 12, Figure 13 and Figure 14. The smooth variation of the S-wave velocity vs. depth obtained by inverting all VSP data agrees well with the logging data. For the P-waves, the velocity log displays a slightly different depth pattern compared with the velocity curve derived by tomography (Figure 15). The values derived by tomographic inversion are representative for a significantly larger measurement scale than the log data (km vs. m) and are consistent with the velocity-depth functions determined for all the shot points as exemplified in Figure 17.

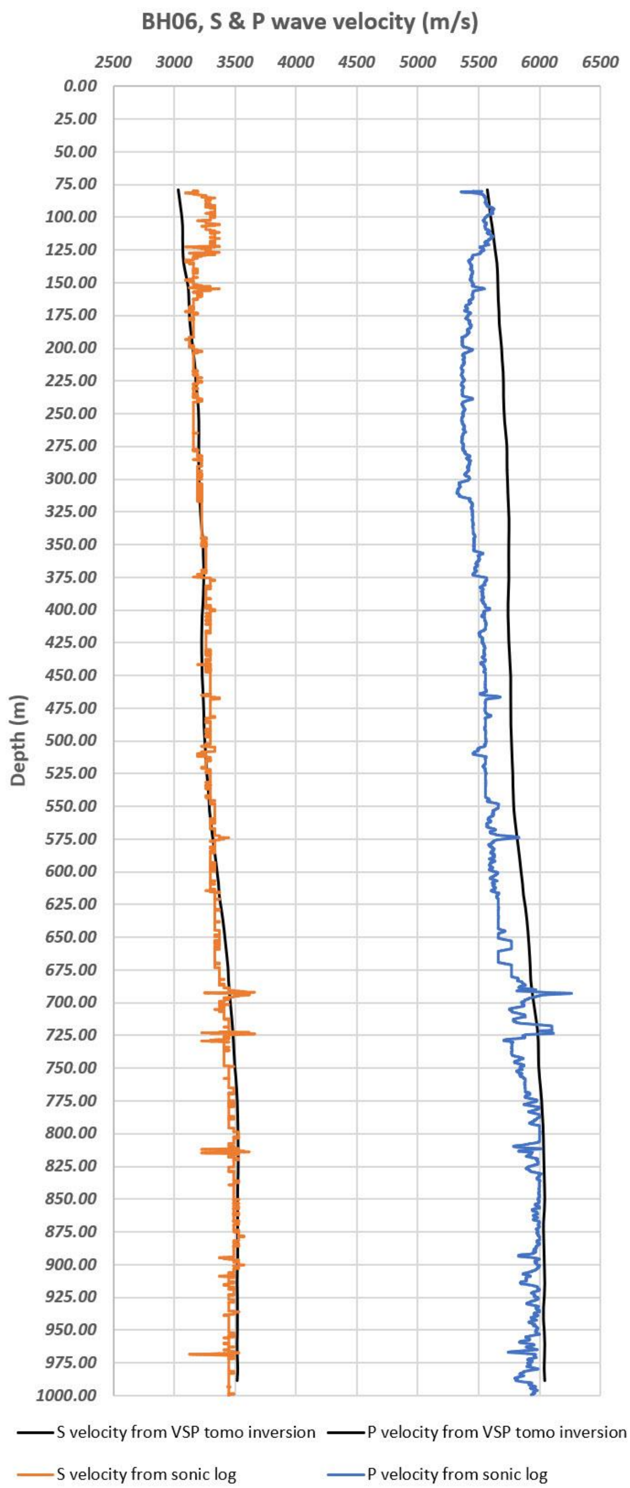


Figure 15: S- and P-wave velocity logs along borehole IG_BH06, derived from sonic logging and from tomographic inversion of VSP measured P & S waves first arrivals.

Tomographic reconstruction of the velocity field around the borehole was done using the picked first arrivals from all VSP shot points and the results are illustrated on Figure 16.

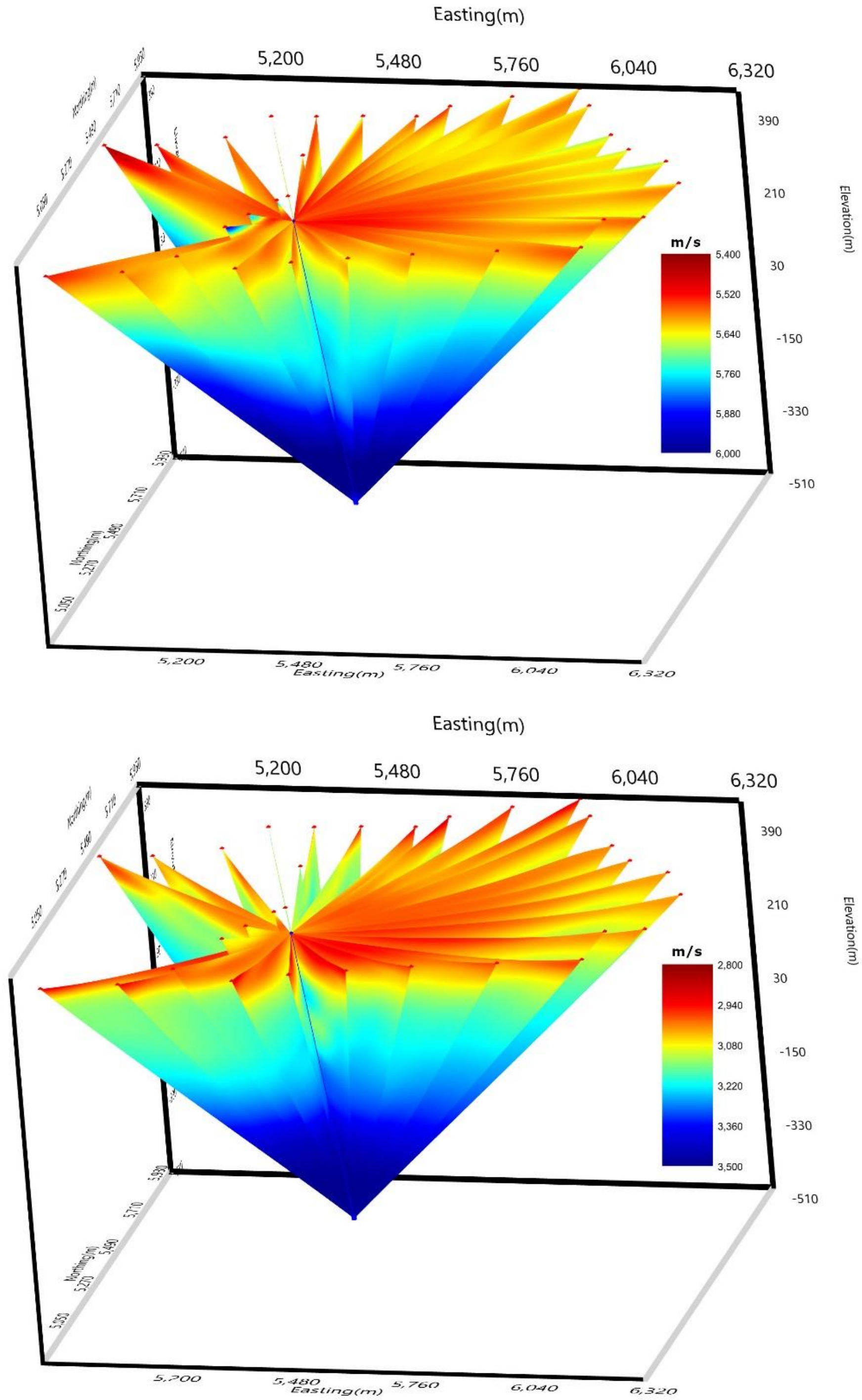
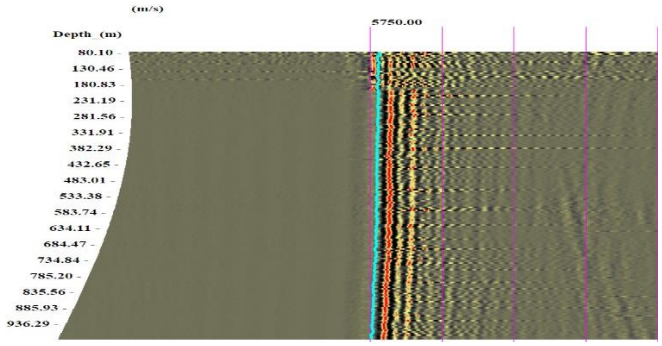
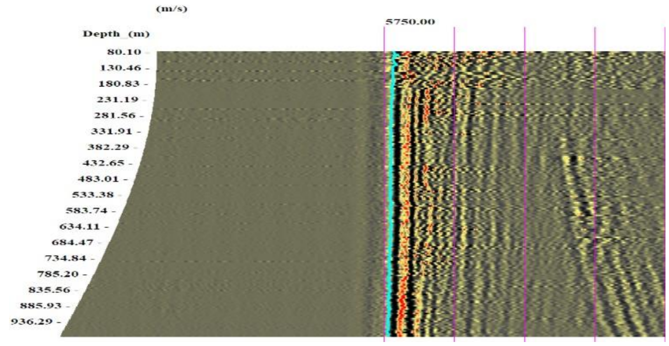


Figure 16: 3D view of the P-wave (top) and S-wave (bottom) velocity fields around boreholeIG_BH06, derived from tomographic inversion of VSP measured P & S first arrivals.

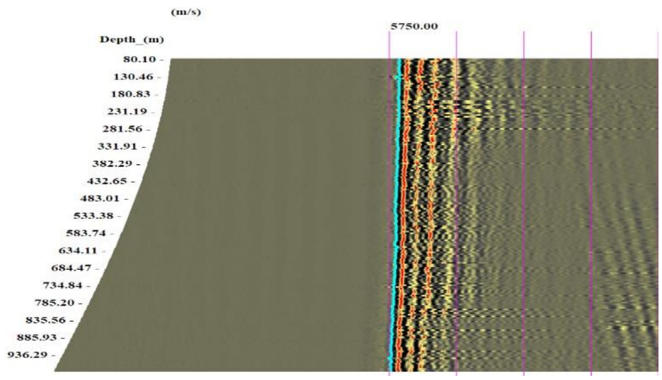
Figure 17 presents the picked arrival times on the R-component profiles from different shot points. By inspecting the reduced velocity plots for Vp=5750 m/s it appears that this velocity is appropriate for time-delay corrections amongst all VSP shot points and later removal of P wave direct arrivals.



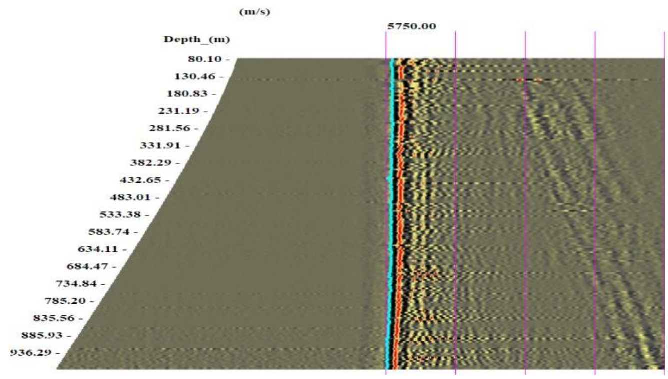
V44



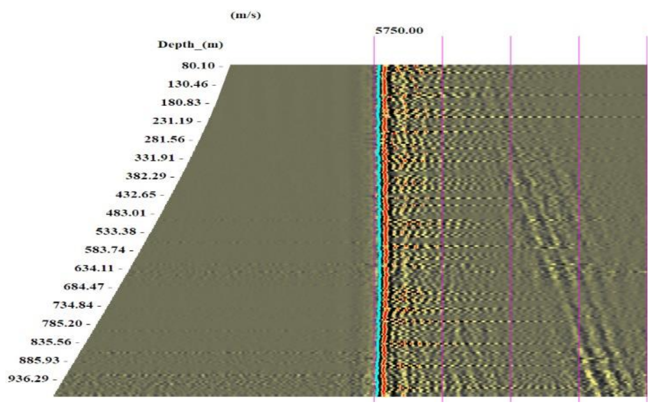
V74



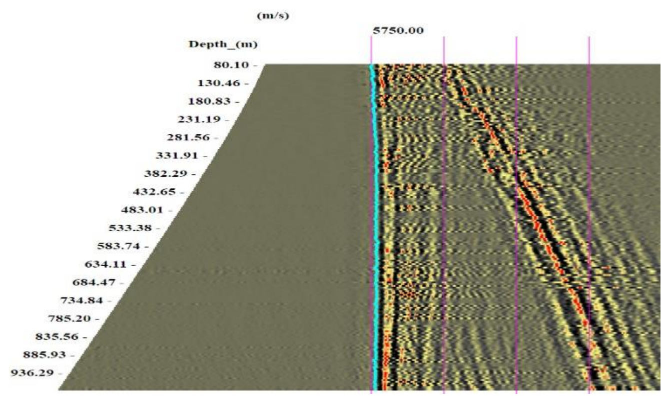
V78



V83



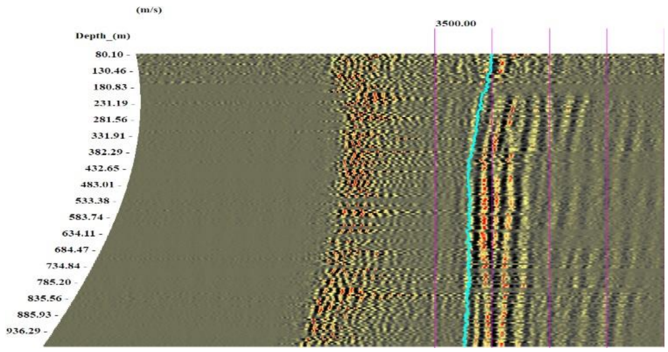
V85



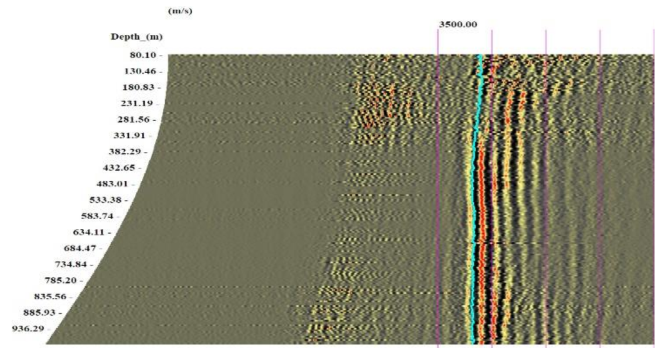
V88

Figure 17: Reduced velocity plots for profiles measured at different VSP shot points (V44, V74, V78, V83, V85 and V88). Vp=5750 m/s appears vertical. Picked P-wave arrival times are shown in blue and arrival times corresponding to the P-wave velocity derived by tomographic inversion are shown in light blue.

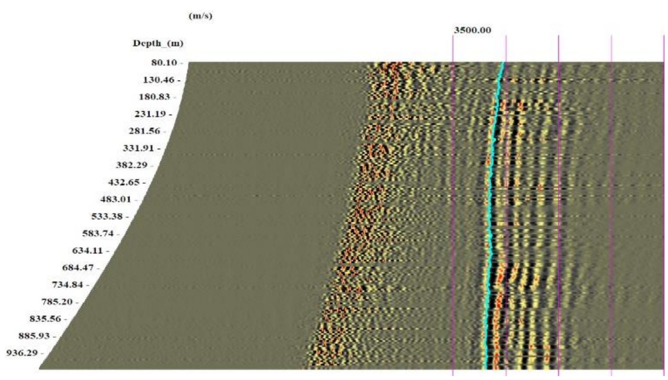
Figure 18 presents the picked arrival times on the T-component profiles from different shot points. By inspecting the reduced velocity plots for Vs=3350 m/s it appears that this velocity is appropriate for later removal of S-waves direct arrivals.



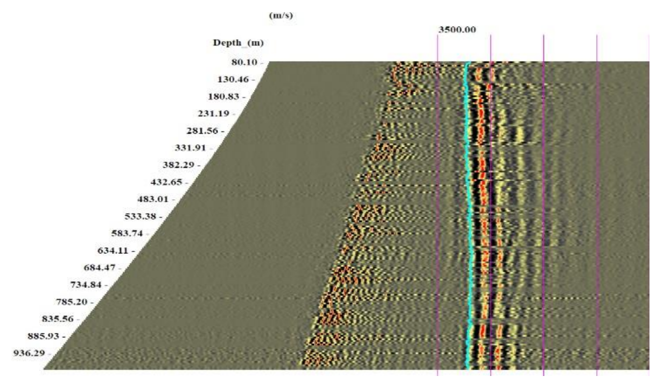
V44



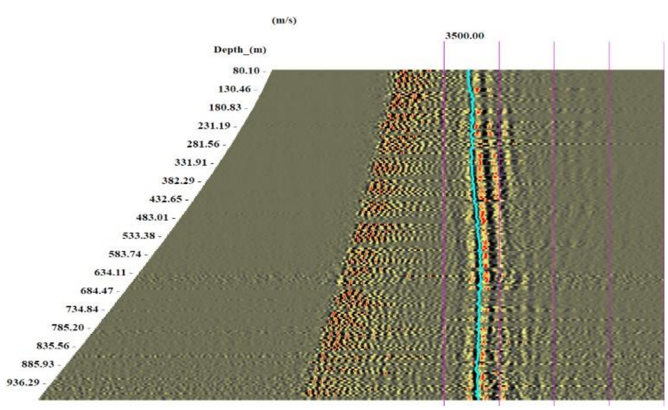
V74



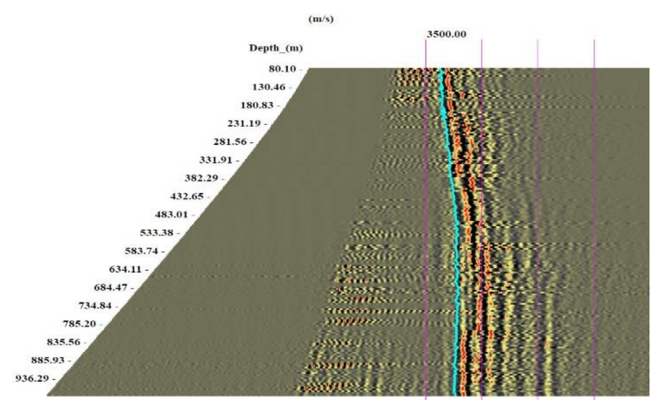
V78



V83



V85



V88

Figure 18: Reduced velocity plots for profiles measured at different VSP shot points (V44, V74, V78, V83, V85 and V88). Vs=3350 m/s appears vertical. Picked S-wave arrival times are shown in blue and arrival times corresponding to the S-wave velocity derived by tomographic inversion are shown in light blue.

5.1.5 Amplitude Compensation and Equalization

The signal levels were adjusted so that the average amplitudes of different traces and different parts of the same trace become comparable. Amplitude compensation (automatic gain control, or AGC) was performed to cancel the effects of geometrical spreading and attenuation and to reconstruct the original amplitude variations along the trace. With AGC, a variable gain operator is run along the records to increase the amplitude of later events assumed to have traveled along longer paths. The amplitude compensation for all three components was done with the same operator, so that the amplitude ratio among the components is conserved through the whole process. An inverse AGC operator is applied after median filtering, which restores the original amplitudes.

5.1.6 Suppression of Direct P-wave and S-waves and Static Corrections

The direct P-wave and S-wave wave fields were suppressed by means of variable slope 25-trace median filters applied along the P- and the S-first onset times, which corresponds to a +/- 60 m window along the borehole. Following several tests, this appeared to be the optimum filter length for the 50 Hz – 250 Hz frequency band used to enhance the P-wave content in the data conditioning phase presented above. The processing sequence is summarized in Table 5.

Table 5: Standard Processing Sequence for VSP Data

3-component AGC	Window 200 samples (100 ms)
Variable slope median	Slope: along picked S-wave arrivals Panel (traces) – 25 Window (samples) – 13
Band-pass filter	0-phase Butterworth Order of filter – 4 Low frequency limit (Hz) – 50 High frequency limit (Hz) – 250
Amplitude restore	Inverse AGC
3-component AGC	Window 200 samples (100 ms)
Variable slope median	Slope: along picked P-wave arrivals Panel (traces) – 25 Window (samples) – 13
Band-pass filter	0-phase Butterworth Order of filter – 4 Low frequency limit (Hz) – 50 High frequency limit (Hz) – 250
Amplitude restore	Inverse AGC
Time delay correction	Input times: picked P-wave arrivals Output times: modeled P-wave arrivals computed for constant velocity Vp=5750 m/s

Figure 19 to Figure 21 show the (Z R T) profiles where the direct P- and S-arrivals have been suppressed and static corrections applied, inferred by tomographic inversion (see Section 5.1.4), as described by the standard pre-processing sequence in Table 5.

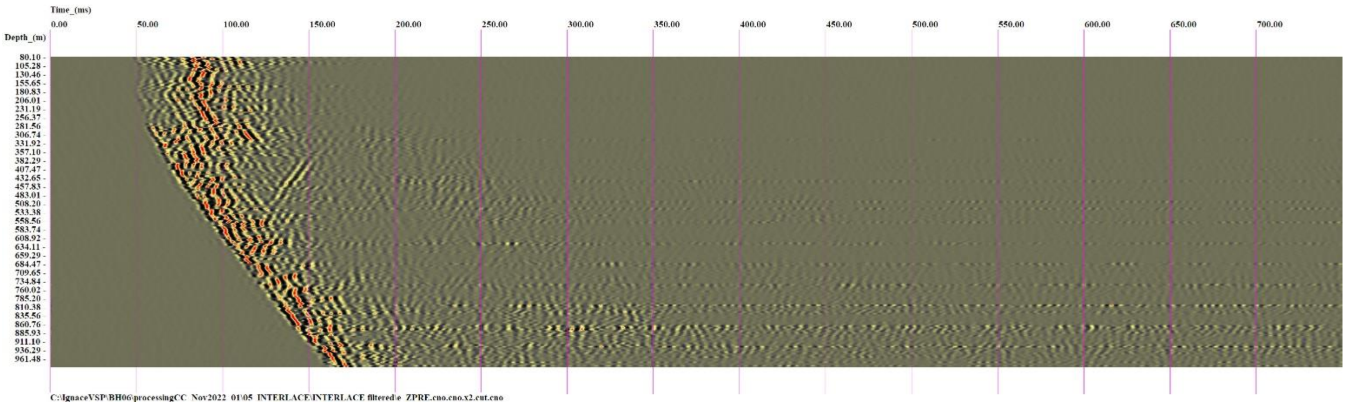


Figure 19: Profile (Z) shown on Figure 12, after removal of direct P- & S-wave fields and static corrections.

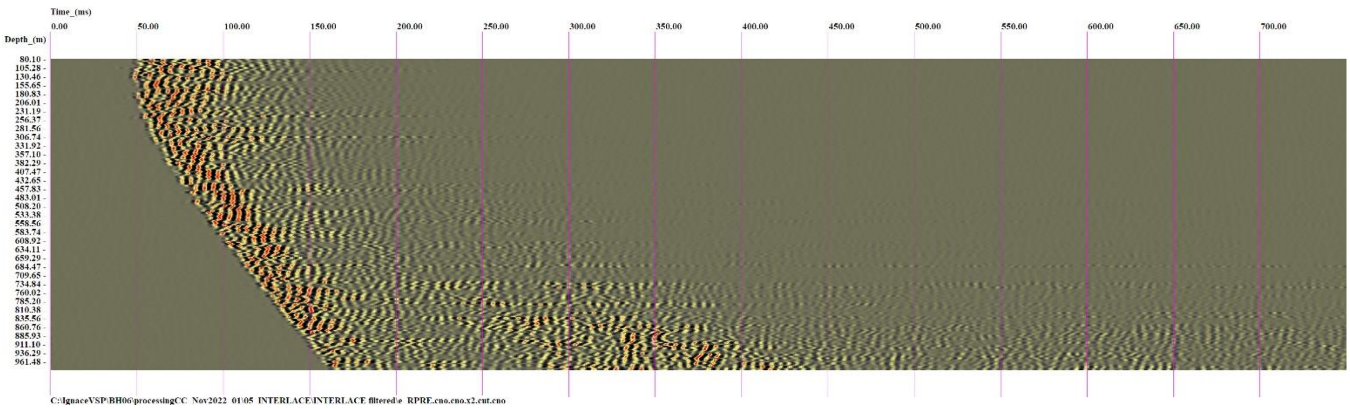


Figure 20: Profile (R) shown on Figure 13, after removal of direct P- & S-wave fields and static corrections.

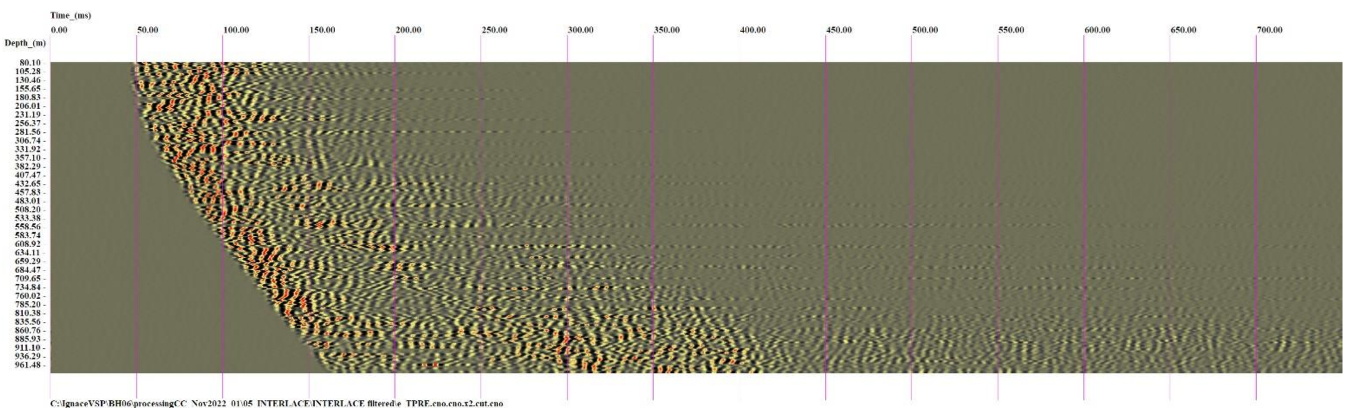


Figure 21: Profile (T) shown on Figure 14, after removal of direct P- & S-wave fields and static corrections.

5.2 Image Point Filtering and Reflector Enhancement in the Image Space for VSP Data

The second stage of the processing sequence focused on reflector enhancing by Image Point filtering. The procedure has been applied on data from all three components. Non-linear enhancement of reflected energy has also been used.

One of the properties of the Image Point transform and related filtering techniques is that, if the velocity field is correctly modeled, the coherent energy reflected by reflectors of any possible orientation adds in phase, producing well-defined maxima in the IP (Image Point) space (Cosma 1990; Cosma and Heikkinen 1996). This offers possibilities for advanced intricate processing, including polarization analysis, azimuth and dip filtering, as well as non-linear and neural network-based coherency-enhancement schemes.

Low energy, dipping P-wave reflectors are retrieved by IP-transform dip filtering and / or non-linear enhancement in the IP space, following the steps given in Table 6.

Table 6: Image Point Processing Sequence for VSP Data

A. Forward IP transform (see Appendix E for the definition of parameters)	Velocity (m/s) – 5750 Rho max (m) – 7000.00 Rho increment (m) – 5 Zita max (m) – 7000.00 Zita min (m) – 0.00 Zita increment (m) – 10
B. Inverse IP transform	Min cos slope – -0.1 Max cos slope – 1
C. Non-linear enhancement in IP space	
D. Inverse IP transform	Min cos slope – -1 Max cos slope – 1

The stages of the filtering process are exemplified on Figure 22 to Figure 27.

Up to Step B in Table 6, no additional enhancement scheme is being applied. However, the intrinsic filtering due to the IP transform can easily be noticed; non-coherent noise being strongly suppressed, as well as coherent trends produced by wave fields traveling with other velocities than the P-wave velocity field specified in the transform input (see Section 5.1.4). Coherent S-wave events were therefore eliminated at this stage.

By further processing, with non-linear enhancement of continuous reflectors in the IP space, up to Step D in Table 6, the coherent P-wave reflected energy appears more clearly, as it can be seen on Figure 25 to Figure 27.

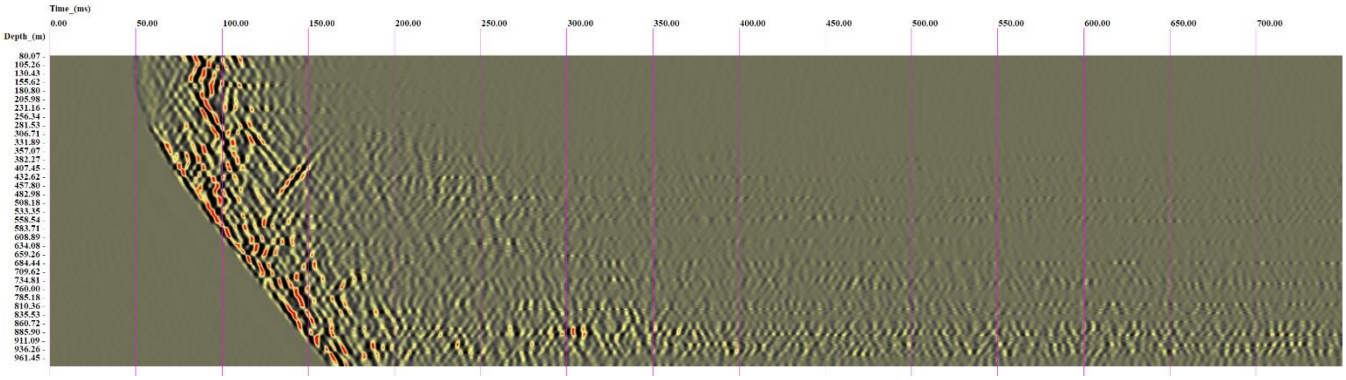


Figure 22: Profile (Z) on Figure 19, after filtering up to step B in Table 6. Normalized to trace.

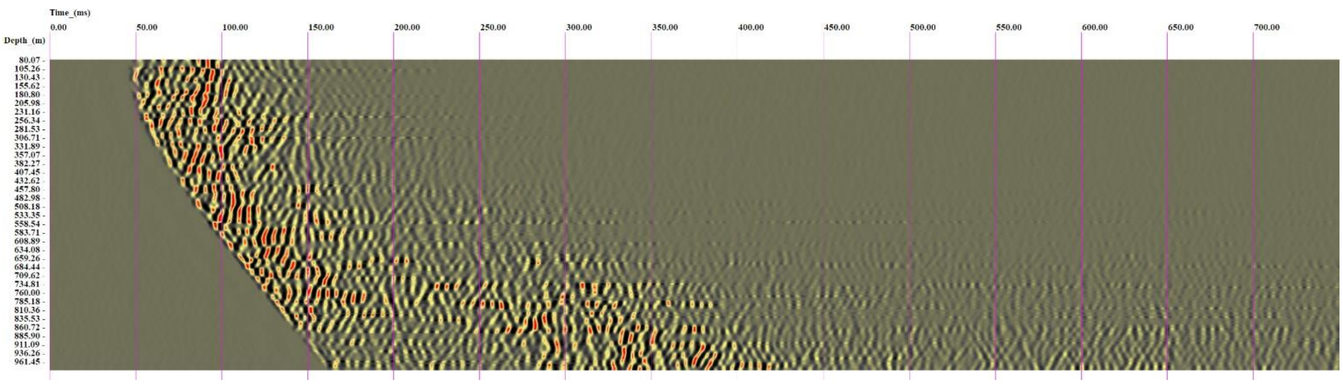


Figure 23: Profile (R) on Figure 20, after filtering up to step B in Table 6. Normalized to trace.

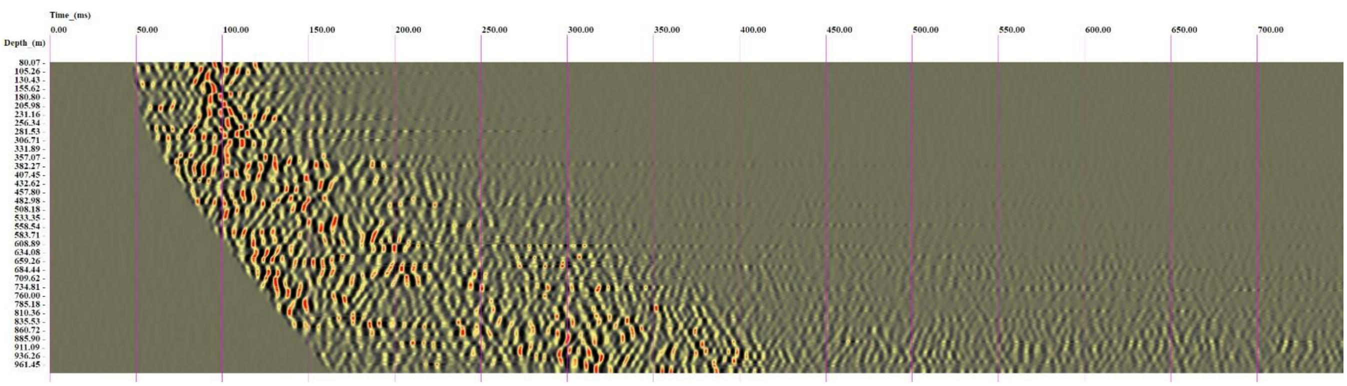


Figure 24: Profile (T) on Figure 21, after filtering up to step B in Table 6. Normalized to trace.

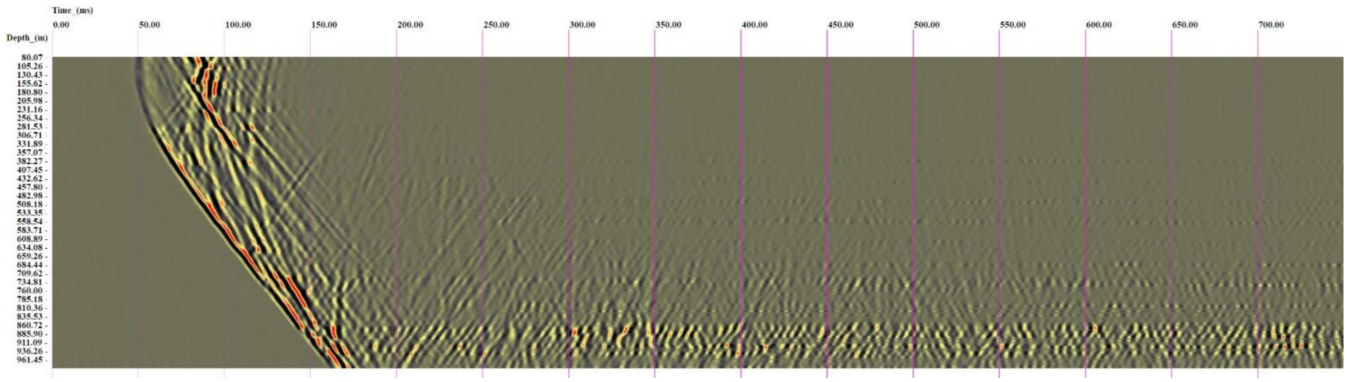


Figure 25: Profile (Z) on Figure 19, after filtering up to step D in Table 6. Normalized to trace.

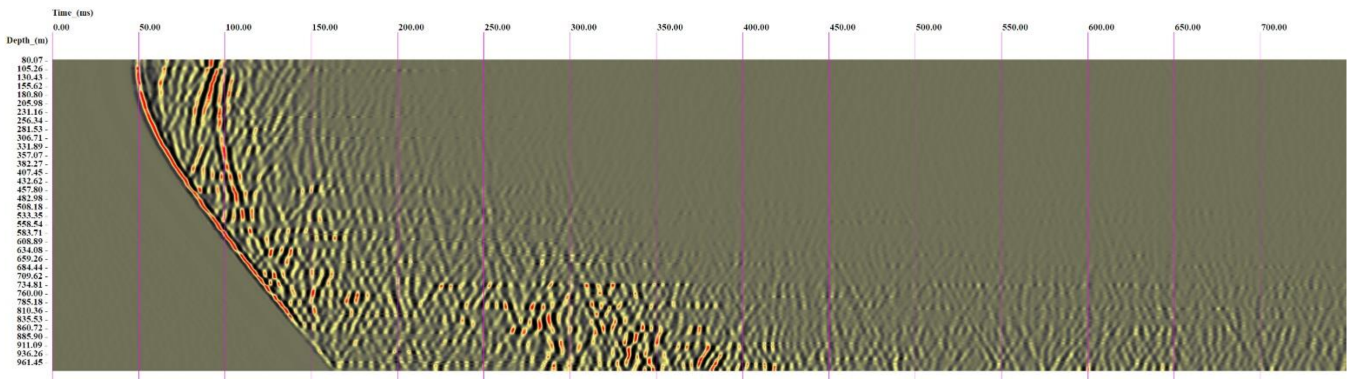


Figure 26: Profile (R) on Figure 20, after filtering up to step D in Table 6. Normalized to trace.

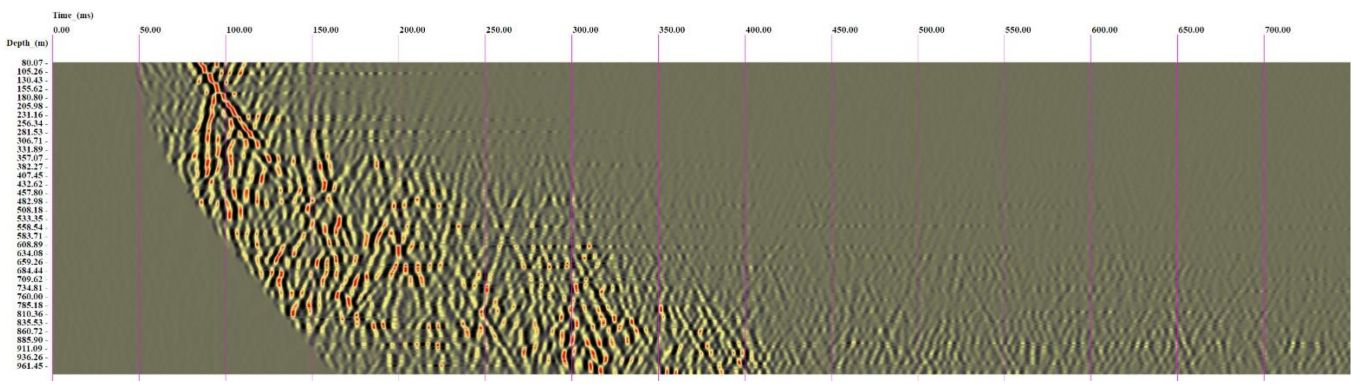


Figure 27: Profile (T) on Figure 21, after filtering up to step D in Table 6. Normalized to trace.

3D Image Point migration was performed on the data set, as discussed in further detail in Cosma et al. (2010). Migrated sections are illustrated in Appendix D, however, these were not used in the interpretation of the data.

6.0 DATA INTERPRETATION – 3D REFLECTORS LOCALIZATION AND 3D VSP MIGRATIONS

The interpretation phase consists, mainly, of computing the 3D locations and orientations of the reflectors, by using the coordinates of the shot points and the borehole and the velocity determined as part of the processing.

VSP shot gathers are 2D time-depth profiles and the image of a seismic reflector appears as a curved pattern of increased coherency. One approach to interpreting VSP profiles is to match hyperbolic travel time functions with coherent reflection events in the depth-time profiles. However, a full 3D target localization cannot be done from a single shot point because of the missing third dimension. Subsets of shot-gathers are processed together, and locations and orientations of the reflectors are computed by cross-fitting events observed in several profiles.

Reflector positions and orientations are computed from these and displayed in 3-D as reflection elements. An element extends between the computed reflection points corresponding to the given source and the first and the last receiver in the VSP array where the coherent hyperbolic pattern is observed. The width of the element is set approximately equal to the first Fresnel zone, given the position of the reflector relative to those and the dominant frequency of the event.

The results of the cross-fitting procedure are presented in Table 7 and illustrated on Figure 28 and in Appendix F. The interpreted reflectors are marked with same-color lines on the processed profiles and labeled with reflector numbers, as presented on the first column in Table 7. All coordinates shown in this report are reduced coordinates, obtained by subtracting 5480000 on the Northing and 550000 on the Easting coordinates, respectively.

The geometrical estimates were obtained by cross fitting amongst all the VSP processed profiles from borehole IG_BH06 only.

6.1 Interpretation of Seismic Reflectors from VSP Data

6.1.1 Event Picking

In a VSP profile, backscattered wave fronts arriving from various regions of the investigated volume can appear at similar times and tend to crowd the records. The Image Point (IP) techniques have been the key to resolve and identify intermingling events. In hard rock settings, the amplitude of an event is not by itself relevant, the classification of the reliability and relevance of the events being based on their continuity within each profile and persistence from profile to profile. This applies to events corresponding to features with a lateral extent equal to or larger than the typical distance between adjacent shot points, which has been in this case ~100 m.

6.1.2 Determining the Azimuth

As mentioned above, resolving the site geometry by multi-offset multi-azimuth VSP relies on the simultaneous interactive fitting among several profiles corresponding to different shot points.

The azimuth estimate is obtained by comparing profiles from several shot points. Theoretically, seven shot points, forming non-collinear triplets, are needed to ensure that a plane reflector of unlimited extent does not fall in the blind zone of at least three profiles. Subgroups are formed from the total number of shots to probe various regions of the rock volume.

The first column in Table 7 is the event number, which is the same as the label of the reflector curves shown in the profiles displayed on Figure 28 and in Appendix F. The width of the reflective elements shown in the 3-D plots of Figure 29 to Figure 32 is 100 m, which corresponds to +/- two mean wavelengths (Vp = 5750 m/s, f = 115 Hz).

The second column is the distance from the top of the hole and the reflector intersection with the hole (or its extension). This parameter is relevant for interpretation only for the reflectors actually intersecting the borehole. For the others, it is only a mathematical way of describing the position of the reflector relative to the borehole axis.

The dips of the reflectors given in the third column and dip directions in the fourth column were determined interactively, in several steps, seeking the best reflector fit among all VSP profiles.

In each profile, reflectors are qualitatively classified in three categories. Major events, appearing as well defined and continuous, belong to the first category (Visibility mark = 2, thicker line). The weaker reflectors, visible but overridden by stronger events of other orientations belong to the second category (Visibility mark = 1, thinner line). If the position and orientation of an event are determined from other profiles but the event does not appear as visible in the current profile, it is categorized as a third class (Visibility mark = 0, dashed line). The mean of the marks obtained in all profiles is then computed for each reflector. Reflectors obtaining mean mark larger than 1.0 (the absolute maximum being 2.0) are classified as certain (class I). Reflectors with mean marks between 0.5 and 1.0 are classified as probable (class II). The weak seismic structures with mean marks lower than 0.5 are classified as possible (class III). The fifth column presents the confidence class, as defined above.

The 3D position and orientation of a planar reflector are fully determined by the coordinates of the foot of the perpendicular descended on the plane from a local origin, in this case the top of the borehole. This representation is attractive computationally because small variations of the X, Y, Z coordinates produce equally small variations of the corresponding hyperbolic time-depth functions in the time-depth data profiles, which helps the interactive fitting amongst several profiles. A certain variability of the fit is to be expected because of local deviations from planarity.

A maximum variability in the fit of +/- half wavelength on each side of the predicted travel time function is considered to represent the same reflector. This variability is then expressed as “Depth”, “Dip” and “Dip Direction,” which are more intuitive parameters than the X, Y, Z coordinates of the point defined above.

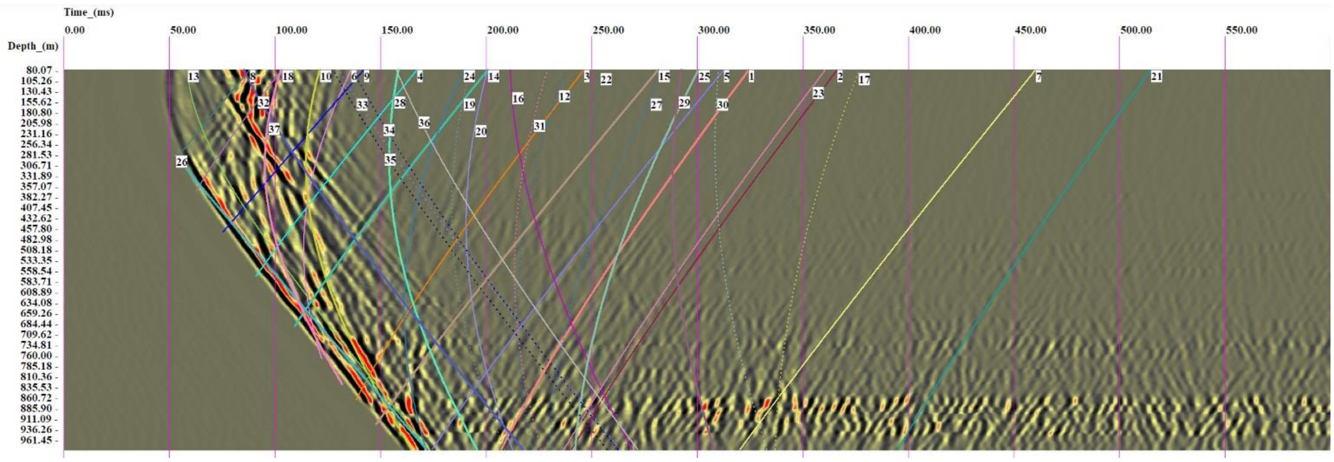
Columns 6 to 8 in Table 7 display the “Delta Depth”, “Delta Dip” and “Delta Dip Direction” values estimated for each reflector.

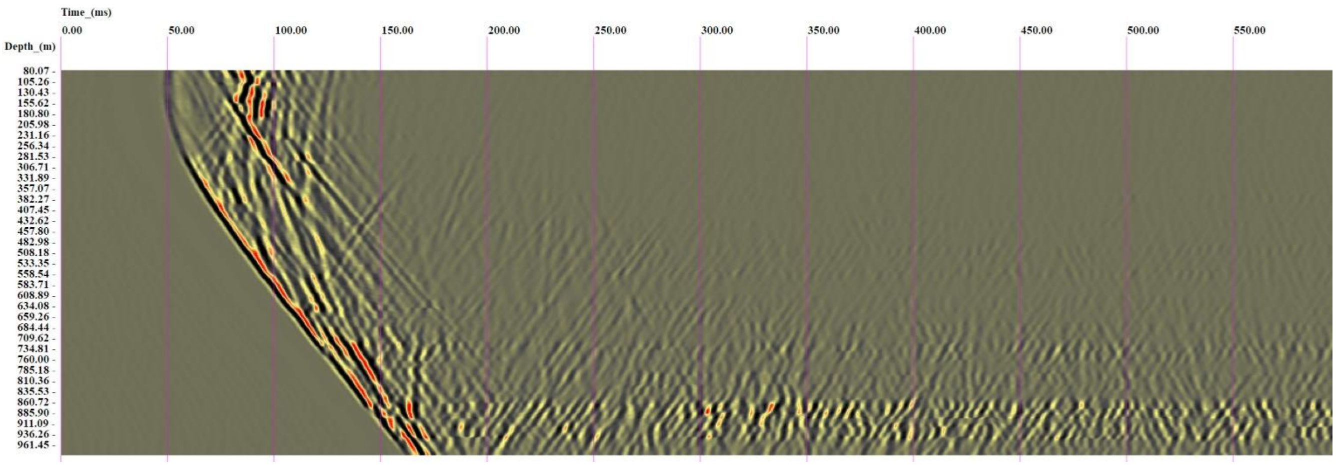
Note that “Delta Depth” values are very large for sub-vertical reflectors, as the “Depth” of intersection between the reflector and the axis of the borehole varies considerably for small variations in Dip or Dip Direction of such a reflector.

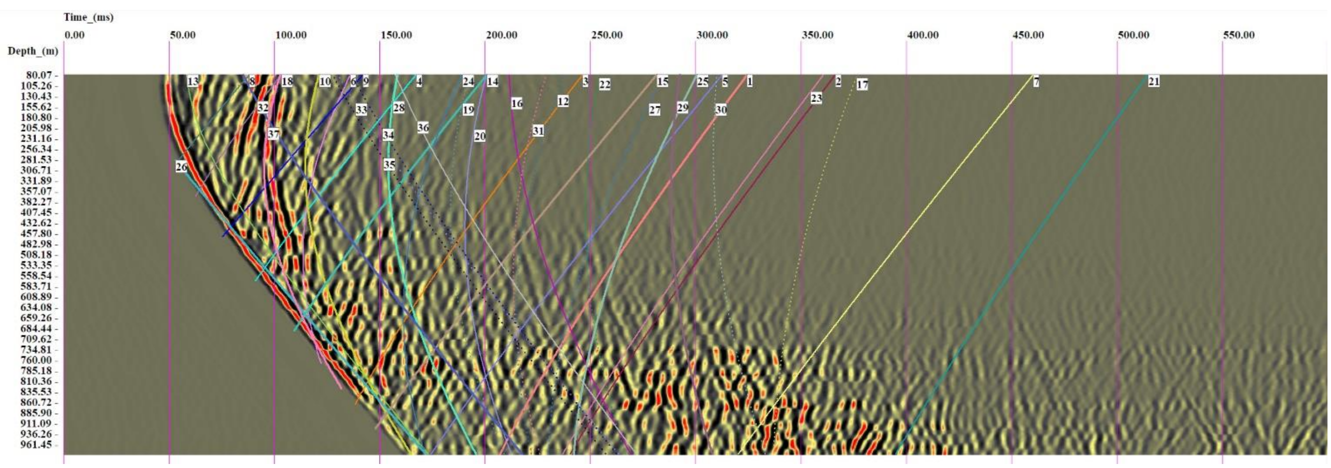
Conversely, “Delta Dip Direction” values can be large for sub-horizontal reflectors.

Columns 9 to 11 in Table 7 give the coordinates of the crux point that, together with the coordinates of the Origin chosen for interpretation, fully characterizes the reflector element. For all seismic data interpreted here the top of borehole IG_BH06 was chosen as the origin for interactive interpretation (Northing 5328.11 m; Easting 5440.35 m and Elevation 417.74 masl). Having a common origin facilitates further integration of interpreted reflectors, among several profiles measured from other boreholes or from surface.

The last column in Table 7 lists the shot points where each reflector was identified.


Time_(ms)
0.00 50.00 100.00 150.00 200.00 250.00 300.00 350.00 400.00 450.00 500.00 550.00
Depth_(m)
80.07 105.26 130.43 155.62 180.80 205.98 231.16 256.34 281.53 306.71 331.89 357.07 382.27 407.45 432.62 457.80 482.98 508.18 533.35 558.54 583.71 608.89 634.08 659.26 684.44 709.62 734.81 760.00 785.18 810.36 835.53 860.72 885.90 911.09 936.26 961.45


Time_(ms)
0.00 50.00 100.00 150.00 200.00 250.00 300.00 350.00 400.00 450.00 500.00 550.00
Depth_(m)
80.07 105.26 130.43 155.62 180.80 205.98 231.16 256.34 281.53 306.71 331.89 357.07 382.27 407.45 432.62 457.80 482.98 508.18 533.35 558.54 583.71 608.89 634.08 659.26 684.44 709.62 734.81 760.00 785.18 810.36 835.53 860.72 885.90 911.09 936.26 961.45


Time_(ms)
0.00 50.00 100.00 150.00 200.00 250.00 300.00 350.00 400.00 450.00 500.00 550.00
Depth_(m)
80.07 105.26 130.43 155.62 180.80 205.98 231.16 256.34 281.53 306.71 331.89 357.07 382.27 407.45 432.62 457.80 482.98 508.18 533.35 558.54 583.71 608.89 634.08 659.26 684.44 709.62 734.81 760.00 785.18 810.36 835.53 860.72 885.90 911.09 936.26 961.45

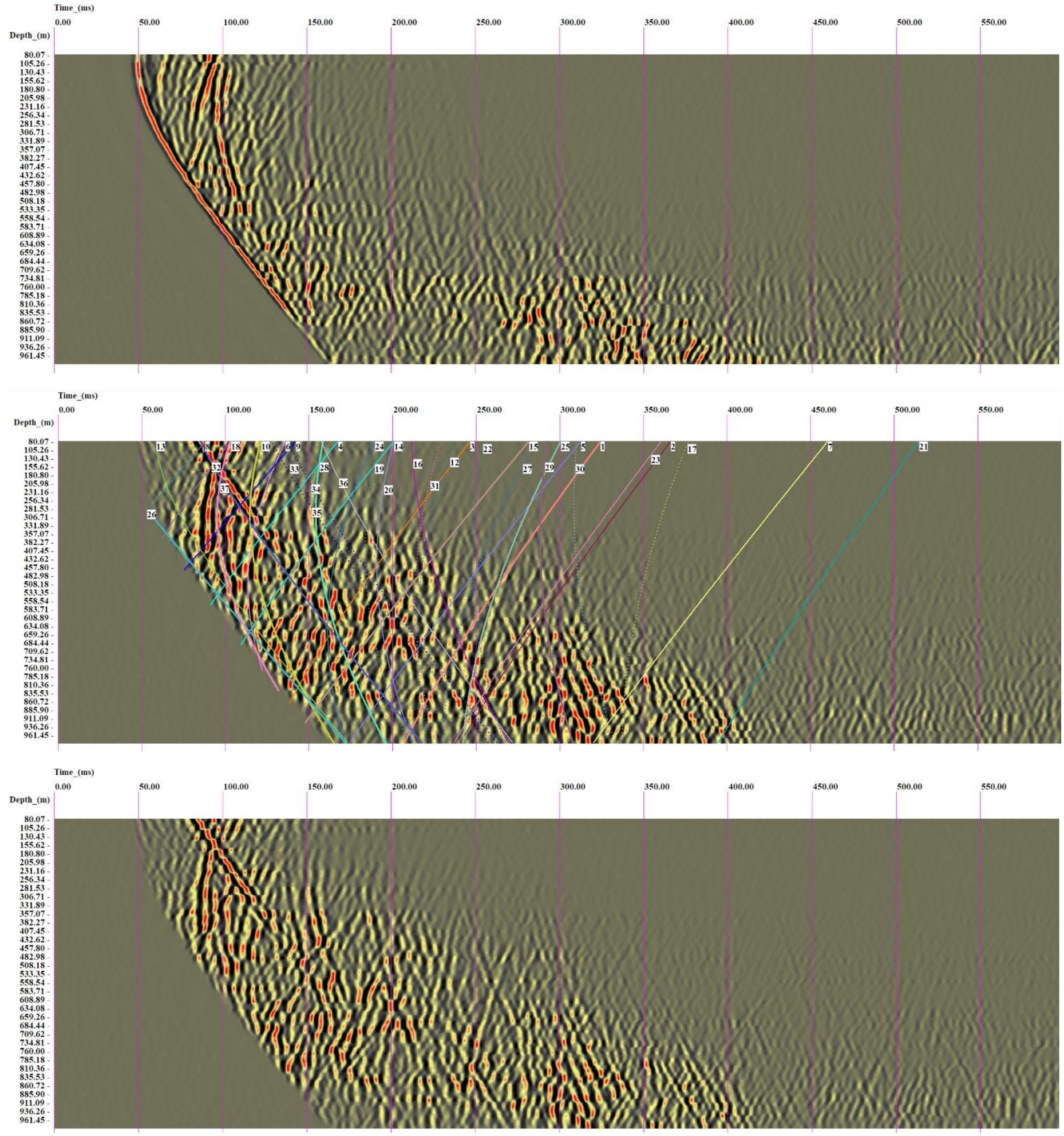


Figure 28: Axial (Z), Radial (R) and Transverse (T) components profiles from shot point V71, with interpreted reflectors (top) and without interpreted reflectors (bottom).

6.2 Reflectors Interpreted from the IG_BH06 VSP Data

Table 7: Parameters of Reflector Interfaces Interpreted from the VSP Data Acquired in Borehole IG_BH06.

Refl No.	Intersection Depth (m)	Dip (°)	Dip Dir (°)	Refl Class	Delta Depth (m)	Delta Dip (°)	Delta Dip Dir (°)	Northing Crux (m)	Easting Crux (m)	Elevation Crux (m)	Visible from shot point
1	1176.16	19.28	310.97	I	6.92	13.90	113.38	5126.22	5672.77	-463.49	44, 45, 48, 71, 72, 75, 76, 77, 78, 79, 80, 81, 82, 85, 91, 92, 46, 47, 49, 73, 74, 84, 86, 88, 89, 90, 93, 94
2	1284.67	17.00	305.00	I	6.89	15.28	108.68	5150.64	5693.80	-594.27	44, 45, 46, 48, 75, 76, 77, 78, 85, 47, 49, 71, 72, 74, 79, 80, 81, 82, 83, 84, 87, 89, 90, 91, 92, 93, 94
3	867.32	15.00	330.00	I	7.09	7.70	124.51	5170.15	5531.55	-262.98	44, 45, 48, 72, 79, 91, 46, 47, 49, 71, 73, 74, 75, 76, 77, 78, 80, 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 92, 93, 94
4	572.00	10.96	10.00	I	6.88	0.13	70.95	5237.92	5424.45	-55.20	48, 49, 91, 92, 93, 44, 45, 46, 47, 71, 73, 74, 75, 76, 77, 78, 79, 80, 81, 83, 87, 88, 89, 90, 94
5	1040.21	6.68	353.73	I	6.51	6.40	152.12	5222.58	5451.94	-490.09	44, 48, 49, 72, 74, 76, 79, 87, 91, 45, 46, 47, 71, 73, 75, 77, 78, 80, 81, 82, 83, 84, 85, 86, 88, 90, 92, 93, 94
6	770.00	47.21	321.81	I	15.64	3.58	111.87	5144.70	5584.60	201.66	45, 47, 49, 72, 74, 87, 88, 89, 90, 91, 94, 44, 46, 48, 71, 73, 85, 86, 92, 93
7	1516.10	17.00	265.00	I	6.34	11.14	69.71	5362.69	5835.63	-880.10	72, 74, 76, 44, 45, 46, 47, 48, 49, 71, 73, 75, 77, 78, 80, 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94
8	290.00	6.15	146.79	I	6.49	0.29	20.73	5352.98	5424.07	141.84	76, 78, 79, 80, 81, 82, 83, 84, 85, 86, 89, 90, 91, 92, 93, 94, 44, 45, 46, 47, 48, 49, 71, 72, 73, 74, 87, 88
9	466.00	5.22	146.33	I	6.38	1.32	2.04	5361.71	5417.97	-24.56	45, 47, 48, 81, 89, 91, 92, 44, 46, 49, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80, 82, 84, 85, 86, 87, 88, 90, 93, 94
10	1183.84	74.26	265.52	I	30.17	8.07	57.48	5352.34	5749.93	329.74	47, 49, 71, 83, 84, 85, 86, 88, 89, 90, 91, 93, 94, 46, 48, 87
11	-1000.03	71.00	316.00	I	6.85	0.77	0.44	5358.40	5411.10	432.24	75, 76, 77, 78, 80, 81, 82, 84, 85, 79, 83, 86, 88, 89

Table 7: Parameters of Reflector Interfaces Interpreted from the VSP Data Acquired in Borehole IG_BH06.

Refl No.	Intersection Depth (m)	Dip (°)	Dip Dir (°)	Refl Class	Delta Depth (m)	Delta Dip (°)	Delta Dip Dir (°)	Northing Crux (m)	Easting Crux (m)	Elevation Crux (m)	Visible from shot point
12	1720.00	50.14	328.30	II	19.93	26.97	20.74	4935.59	5682.78	32.48	48, 72, 82, 83, 86, 46, 73, 81, 84, 85, 87, 88, 89, 90, 91, 92, 93, 94
13	-295.00	74.96	260.46	II	10.92	22.25	30.38	5314.26	5357.91	440.21	49, 74, 77, 44, 45, 46, 47, 48, 71, 73, 75, 76, 78, 79, 80, 81, 82, 90
14	690.00	14.27	308.22	I	6.93	8.60	91.63	5239.54	5552.82	-145.12	46, 47, 48, 71, 80, 91, 44, 45, 49, 72, 73, 74, 75, 76, 77, 78, 79, 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 92, 93, 94
15	925.00	18.00	250.00	I	6.31	1.65	29.68	5418.05	5687.46	-391.64	45, 71, 72, 73, 91, 92, 44, 46, 47, 48, 49, 74, 75, 76, 77, 78, 79, 80, 81, 83, 84, 85, 86, 87, 88, 89, 90, 93, 94
16	-8032.35	72.27	54.20	II	63.41	5.88	75.83	5691.75	5944.55	616.53	78, 82, 84, 87, 88, 45, 47, 80, 81, 83, 85, 86, 89, 94
17	2549.64	79.13	145.31	III	13.55	0.78	21.69	6314.81	4757.39	187.26	44, 45, 48, 74, 75, 76, 77, 79, 80, 81, 83, 91, 92, 94
18	370.00	24.20	188.47	II	6.90	15.30	8.47	5477.63	5462.62	81.39	48, 79, 80, 87, 92, 46, 47, 49, 71, 72, 74, 75, 76, 78, 81, 82, 84, 85, 86, 91, 93, 94
19	2030.00	61.44	51.30	I	25.65	19.06	21.76	5055.36	5099.91	180.26	44, 73, 76, 81, 82, 88, 91, 93, 45, 48, 72, 74, 75, 77, 78, 79, 83, 84, 85, 89, 90
20	2000.00	86.06	140.25	III	20.90	85.00	39.75	5870.25	4989.49	369.16	46, 48, 49, 71, 73, 74, 75, 76, 77, 78, 79, 80, 89, 91, 94
21	1883.38	17.92	330.00	I	7.04	16.00	150.00	4935.09	5667.26	-985.65	44, 74, 76, 91, 45, 46, 47, 48, 49, 71, 72, 73, 75, 77, 78, 79, 80, 81, 83, 84, 85, 86, 87, 88, 89, 90, 92, 93, 94
22	3519.99	58.62	342.00	II	47.28	58.00	162.00	4814.41	5607.26	88.17	73, 89, 44, 48, 77, 78, 79, 80, 81, 82, 84, 85, 86, 87, 88, 92, 94
23	1276.43	13.99	352.84	II	7.06	11.00	166.27	5079.82	5471.54	-587.16	74, 85, 91, 44, 45, 46, 48, 49, 71, 72, 73, 75, 76, 77, 79, 80, 83, 84, 90, 92, 93, 94

Table 7: Parameters of Reflector Interfaces Interpreted from the VSP Data Acquired in Borehole IG_BH06.

Refl No.	Intersection Depth (m)	Dip (°)	Dip Dir (°)	Refl Class	Delta Depth (m)	Delta Dip (°)	Delta Dip Dir (°)	Northing Crux (m)	Easting Crux (m)	Elevation Crux (m)	Visible from shot point
24	1125.00	63.96	115.71	I	10.80	1.33	39.05	5572.77	4932.09	141.79	45, 46, 49, 72, 73, 74, 75, 91, 92, 93, 47, 48, 71, 76, 77, 78, 79, 81, 83, 84, 85, 87, 88, 94
25	1544.29	65.62	131.96	II	9.89	2.61	30.68	5906.01	4797.70	25.91	75, 94, 44, 45, 46, 48, 49, 73, 74, 80, 81, 91, 93
26	282.00	77.50	192.50	II	11.37	17.03	11.56	5476.80	5473.31	383.97	45, 46, 47, 71, 44, 49, 72, 74, 75, 76, 79, 80, 81, 87, 88, 89, 90, 92
27	1482.05	41.24	44.93	II	10.79	14.13	118.64	4962.86	5075.99	-170.75	87, 94, 44, 45, 47, 48, 49, 72, 73, 74, 75, 77, 79, 80, 85, 86, 88, 91, 92, 93
28	2229.98	61.95	330.00	I	65.83	27.01	12.71	5073.69	5587.24	260.91	46, 47, 48, 49, 72, 73, 85, 86, 87, 88, 89, 91, 93, 71, 74, 75, 90, 92, 94
29	5600.06	86.80	53.76	I	66.49	8.02	64.75	5862.58	6169.53	468.29	44, 46, 47, 48, 49, 71, 72, 73, 74, 75, 79, 80, 81, 82, 83, 84, 86, 88, 91, 92, 76, 77, 85, 87, 93, 94
30	10503.09	82.35	53.28	II	163.85	9.50	69.90	5893.44	6198.22	544.80	46, 48, 72, 80, 91, 73, 74, 75, 76, 79, 81, 82, 83, 84, 87, 92, 93, 94
31	1960.49	82.26	136.96	II	17.29	1.26	21.11	5894.92	4911.12	312.25	45, 48, 49, 72, 74, 78, 91, 93, 44, 73, 75, 76, 77, 79, 81, 82, 83, 86, 92, 94
32	-280.00	86.11	177.62	I	7.46	57.58	2.38	5206.88	5445.40	425.99	44, 46, 47, 49, 71, 76, 90, 91, 92, 48, 75
33	-380.00	76.90	187.20	I	2.66	55.55	5.00	5119.21	5413.99	466.75	44, 45, 46, 47, 48, 49, 72, 73, 75, 78, 79, 89, 91, 92, 93, 74, 77, 90, 94
34	-480.00	74.87	213.36	I	2.64	19.50	33.36	5119.79	5303.18	485.16	44, 45, 46, 48, 72, 73, 74, 75, 76, 77, 79, 82, 88, 91, 92, 47, 78, 80, 89, 90
35	-400.00	80.00	165.00	I	1.49	9.04	15.00	5131.41	5493.06	453.65	45, 46, 47, 48, 49, 89, 91, 93, 94, 44, 72, 76, 90, 92
36	-711.07	75.15	226.14	II	1.74	7.94	46.14	5098.63	5201.52	505.68	44, 45, 73, 74, 75, 76, 83, 84, 46, 72, 77, 78, 79, 82, 88
37	830.00	55.79	328.31	I	28.31	8.25	34.33	5177.80	5533.14	297.62	44, 45, 46, 47, 48, 49, 71, 72, 88, 89, 90, 93, 94, 73, 74, 91, 92

Table 7: Parameters of Reflector Interfaces Interpreted from the VSP Data Acquired in Borehole IG_BH06.

Refl No.	Intersection Depth (m)	Dip (°)	Dip Dir (°)	Refl Class	Delta Depth (m)	Delta Dip (°)	Delta Dip Dir (°)	Northing Crux (m)	Easting Crux (m)	Elevation Crux (m)	Visible from shot point
Crux origin = top of Hole IG_BH06								5328.11	5440.35	417.74	
Reflector Class				Coordinates translation: Northing +5480000 and Easting + 550000							
I	Strong										
II	Good										
III	Weak										

Figure 29 to Figure 31 show different views of all reflector elements interpreted from the seismic profiles measured in borehole IG_BH06. On these figures, the plot on the left displays the 3D reflector elements, while the plot on the right displays the interpreted reflector surfaces computed by 3D fitted interpolation through the elements corresponding to each reflector.

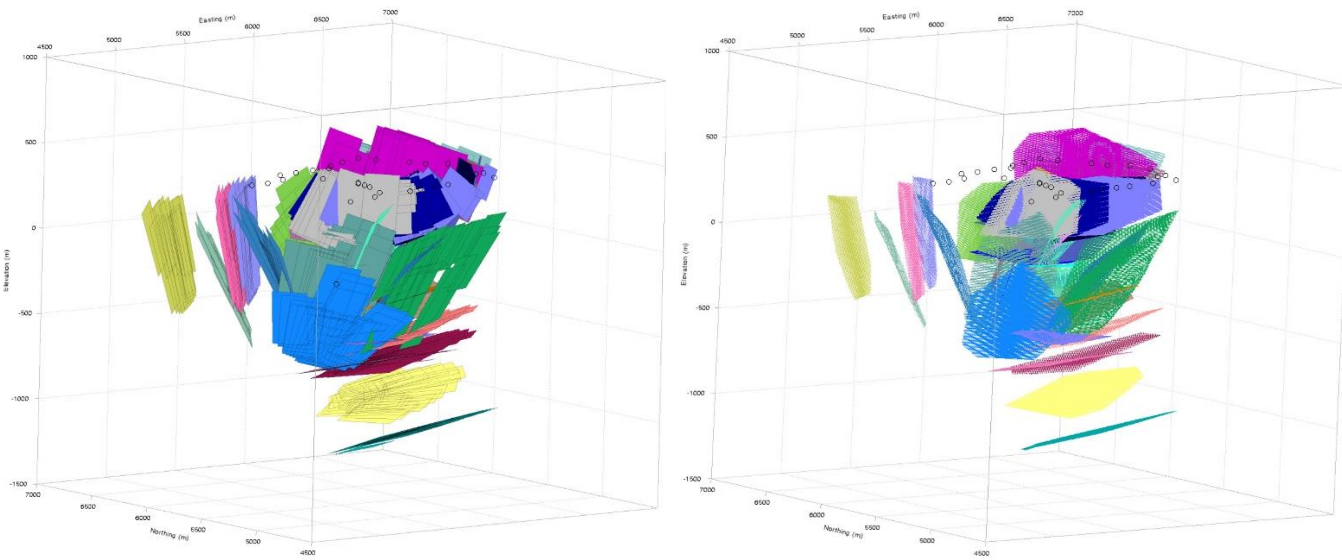


Figure 29: 3D view of all reflectors interpreted from all VSP data acquired from borehole IG_BH06.

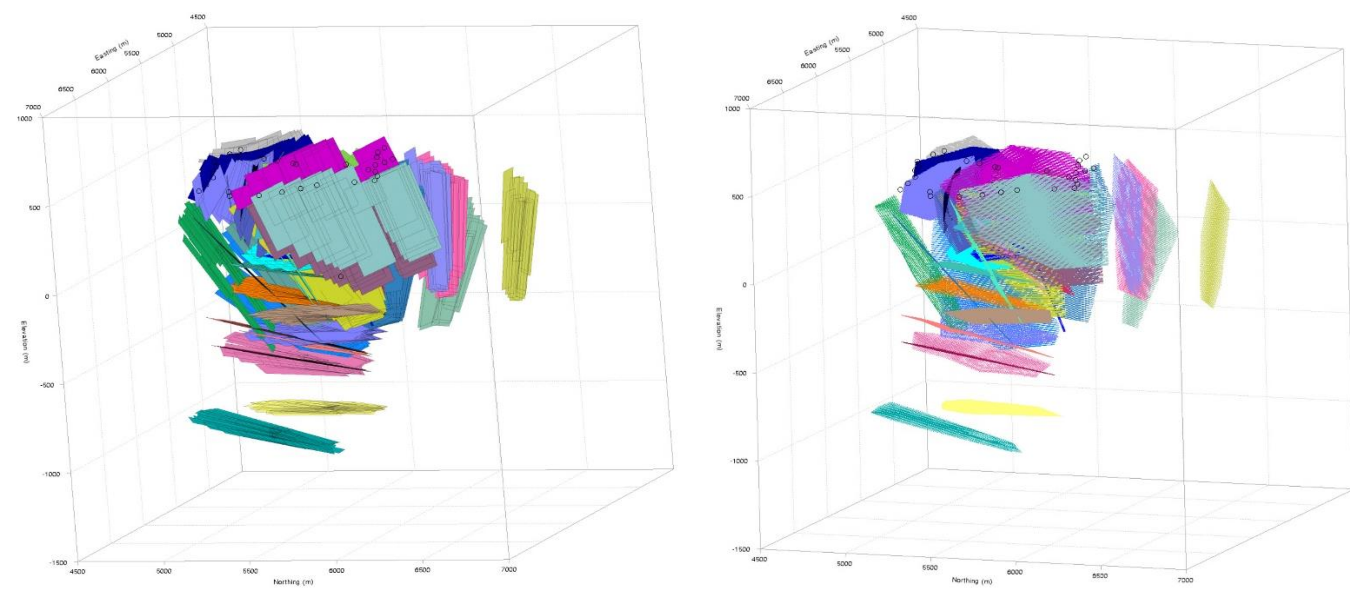


Figure 30: 3D view of all reflectors interpreted from all VSP data acquired from borehole IG_BH06.

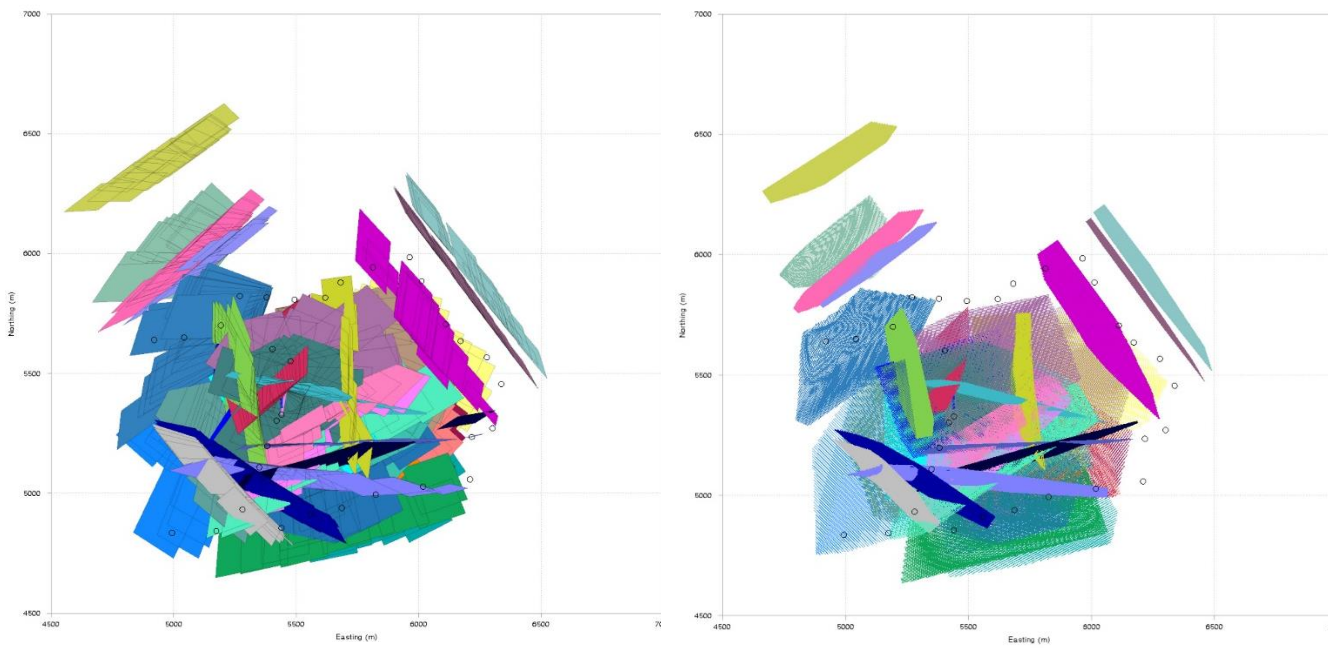


Figure 31: View from top of all reflector elements (left) and reflector surfaces (right) interpreted from all VSP data acquired from borehole IG_BH06.

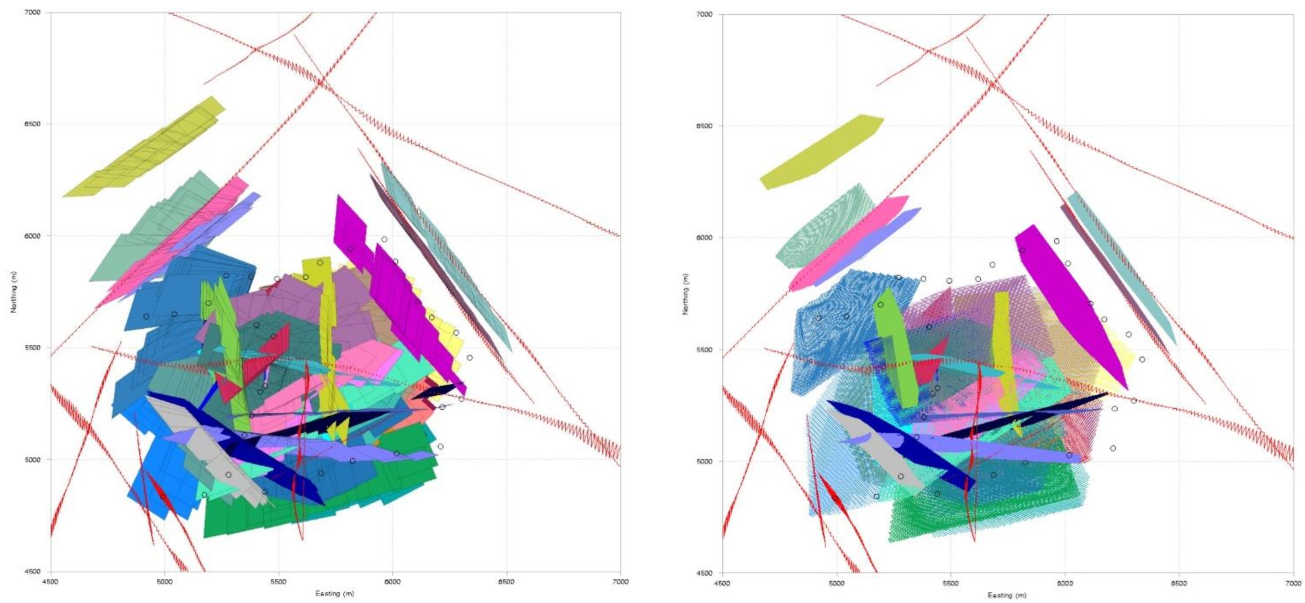


Figure 32: View from top of main site features (dykes and lineaments interpreted from surface are shown in red; provided by NWMO) together with all reflector elements (left) and reflector surfaces (right) interpreted from all VSP data acquired from borehole IG_BH06.

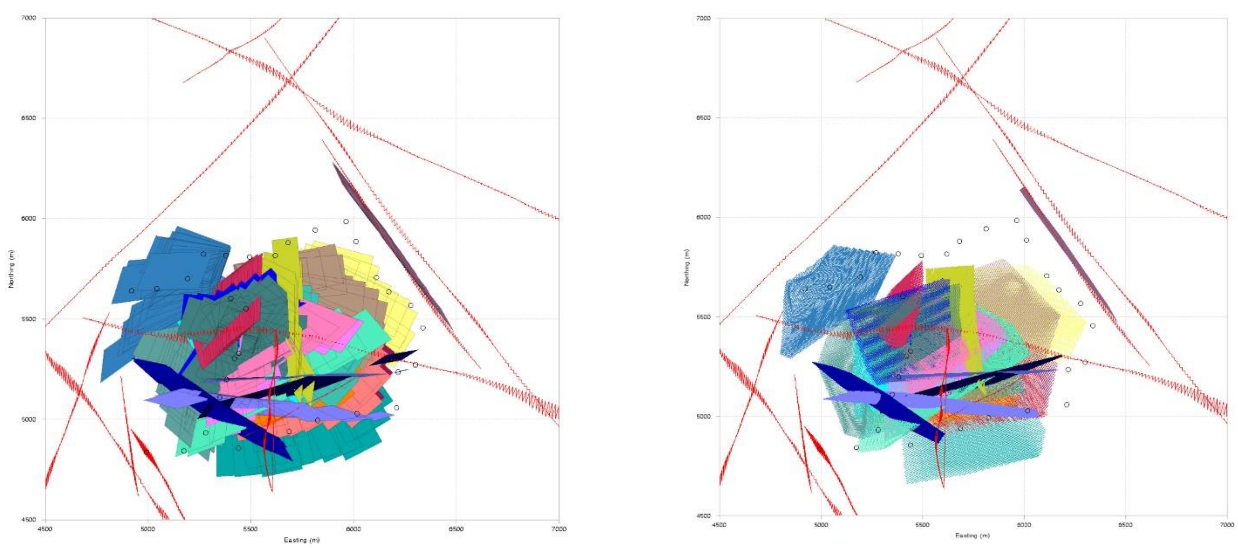


Figure 33: View from top of main site features (dykes and lineaments interpreted from surface are shown in red; provided by NWMO) together with reflector elements (left) and reflector surfaces (right) interpreted as strong reflectors (Class I) from all VSP data acquired from borehole IG_BH06.

Figure 34 illustrates the orientation distribution of the interpreted reflectors.

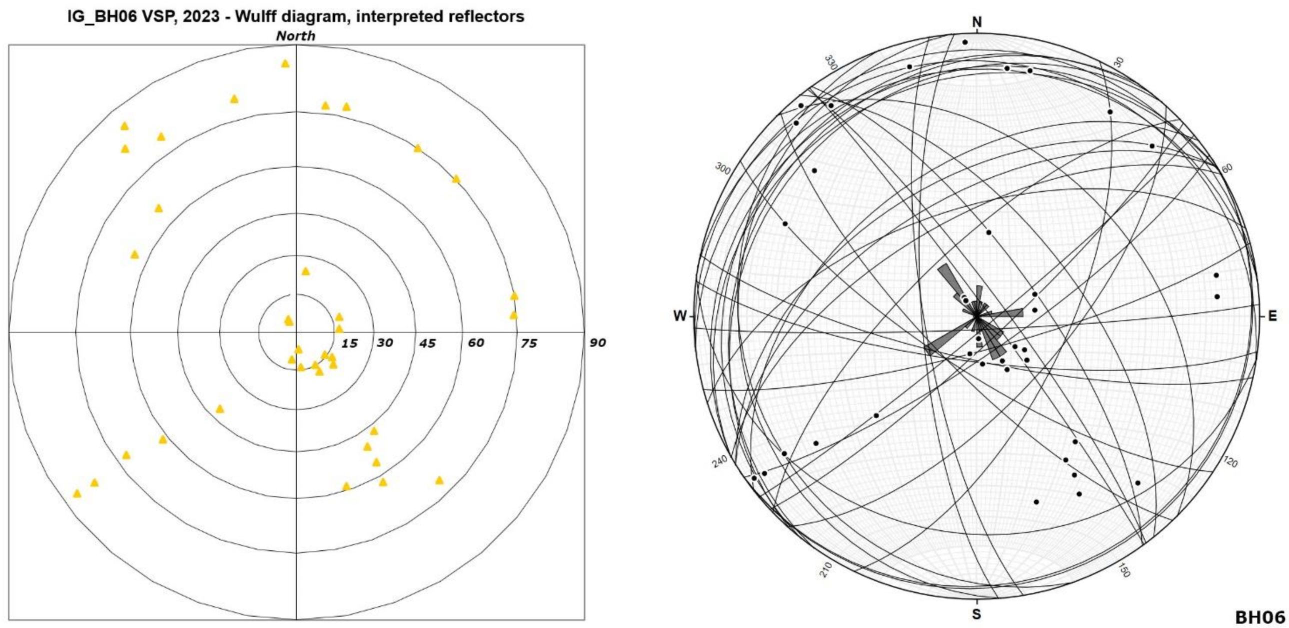


Figure 34: Left: Stereographic projection (Wulff diagram) of all reflectors interpreted from the VSP data measured in borehole IG_BH06. and Right: Rose diagram and Circular histogram.

Table 8: Reflector Interfaces Interpreted to Intersect Borehole IG_BH06.

Refl No.	Intersection Depth (m)	Dip (°)	Dip Dir (°)	Refl Class	Comments (with reference to the lithology log of borehole IG_BH06, WP03)
26	282.00	77.50	192.50	II	Fracture cuts borehole core at 284m
8	290.00	6.15	146.79	I	
18	370.00	24.20	188.47	II	Fractures cut borehole core at 371 – 373.7m
9	466.00	5.22	146.33	I	Feldspar-phyric Tonalite Dyke between 466 m and 467 m, minor Vp and Vs variation
4	572.00	10.96	10.00	I	Amphibolite between 572 m and 573 m, Vp variation
14	690.00	14.27	308.22	I	Amphibolite between 690 m and 692 m, Vp and Vs variation
6	770.00	47.21	321.81	I	Change in lithology as evident in change in spectral gamma response at 768 m
37	830.00	55.79	328.31	I	Amphibolite between 830 m and 830.75 m
3	867.32	15.00	330.00	I	Fracture cuts borehole core at 861.75m, Change in lithology? (light gray to dark gray)

Table 8: Reflector Interfaces Interpreted to Intersect Borehole IG_BH06.

Refl No.	Intersection Depth (m)	Dip (°)	Dip Dir (°)	Refl Class	Comments (with reference to the lithology log of borehole IG_BH06, WP03)
15	925.00	18.00	250.00	I	

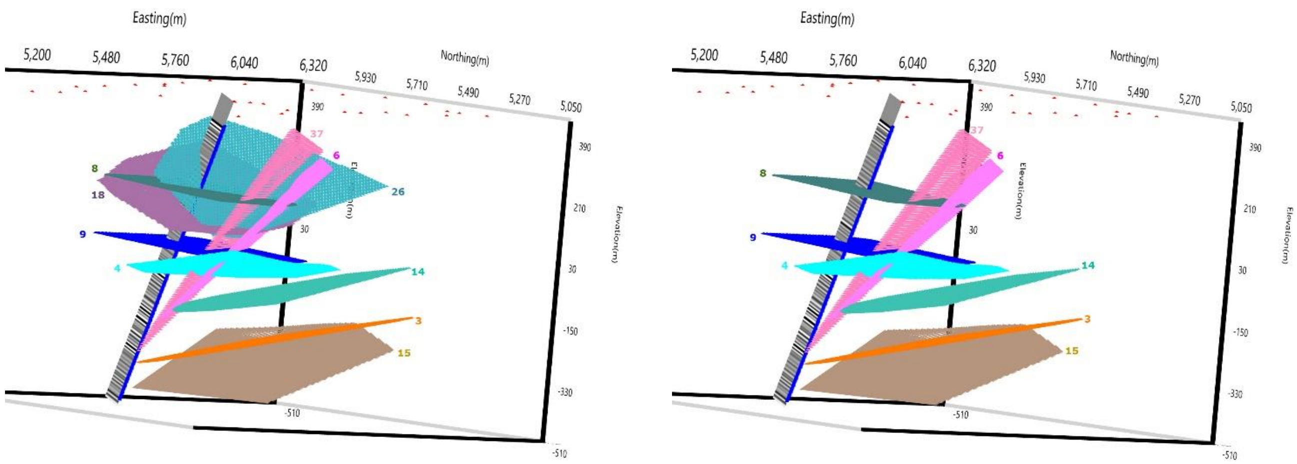


Figure 35: Left: 3D view of reflector surfaces interpreted from all VSP data acquired from borehole IG_BH06 and described in Table 8. Right: similar with the plot on the left, but showing only Class I reflectors.

The synthetic seismogram (see also Figure 42 and Figure 43) is illustrated in gray. Figure 35 presents the reflector interfaces interpreted as sub-vertical features that may be associated with lineaments mapped from surface. The lineaments numbers provided in Table 9 are defined and presented in DesRoches et al. (2021). The sub-vertical features are also shown in Appendix G.

Table 9: Reflector interfaces interpreted as sub-vertical features that may be associated with lineaments mapped from surface, as shown on Figure 32.

Refl No.	Intersection Depth (m)	Dip (°)	Dip Dir (°)	Refl Class	Comments (with reference to the lineaments, as provided by NWMO)
26	282.00	77.50	192.50	II	IFZ005
6	770.00	47.21	321.81	I	IFZ038
24	1125.00	63.96	115.71	I	IFZ010
10	1183.84	74.26	265.52	I	IFZ043
31	1960.49	82.26	136.96	II	IFZ004
17	2549.64	79.13	21.69	III	IFZ039
29	5600.06	86.80	64.75	I	IFZ030
30	10503.09	82.35	69.90	II	IFZ012

6.3 Physical Properties Derived from the VSP Data

P- and S-wave sonic logs and density logs were reported for borehole IG_BH06 by WSP in NWMO Report APM-REP-01332-0367 (WSP 2023). These are shown on Figure 36.

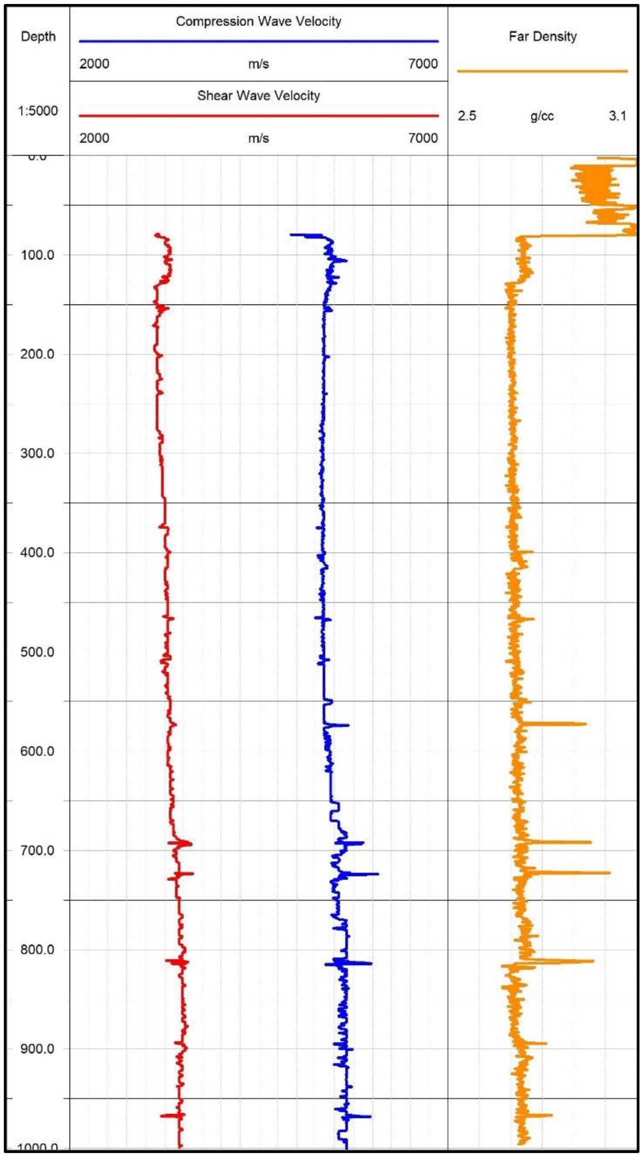


Figure 36: Borehole Seismic Velocity and Density Logs for IG_BH06.

The Shear and Young's moduli, as well as the Poisson ratio logs from the measured borehole logs are shown in Figure 37.

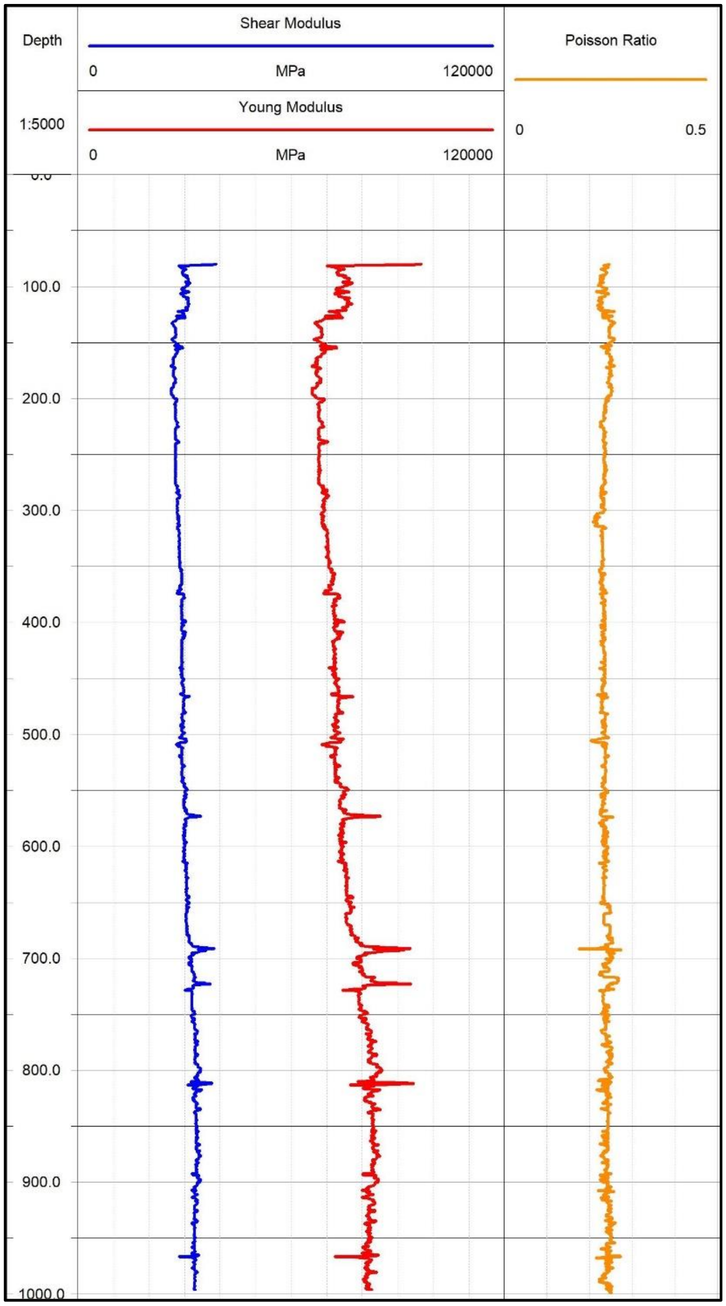


Figure 37: Borehole Shear and Young's moduli as well as the Poisson ratio logs for IG_BH06.

Shear and Young's moduli, as well as the Poisson ratio 3D distributions around the borehole were also computed from the 3D P- and S-wave velocity distributions, together with the density logs along the borehole.

The below formula was used to calculate the Poisson's Ratio log, according to the formula (ALT 2011):

$$Poisson's\ Ratio = \frac{\frac{1}{2}\left(\frac{dts}{dtc}\right)^2 - 1}{\left(\frac{dts}{dtc}\right)^2 - 1}$$

where:

$$dtc = Compression\ Wave\ Slowness\ \ (\mu s/sm)$$

$$dts = Shear\ Wave\ Slowness\ (\mu s/sm)$$

The calculated Poisson's Ratio was then used in conjunction with the Shear Modulus to generate the Young's Modulus, according to the formula:

$$Young's\ Modulus\ (MPa) = 2 \times \mu \times (1 + \nu)$$

where:

$$\mu = Shear\ Modulus\ (MPa)$$

$$\nu = Poisson's\ Ratio$$

The Bulk Modulus was calculated according to the formula:

$$Bulk\ Modulus\ (MPa) = \rho_b \times \left(\frac{1}{dtc^2} - \frac{4}{3 \times dts^2}\right)$$

where:

$$\rho_b = Bulk\ Density\ (g/cc)$$

Using the Near Density log in conjunction with the Shear Wave slowness log, the Shear Modulus was calculated according to the relationship (ALT 2011):

$$Shear\ Modulus\ (MPa) = \frac{\rho_b}{dts^2}$$

The 3D Shear modulus, Young's modulus, and Poisson ratio distributions are shown on Figure 38, Figure 39 and Figure 40.

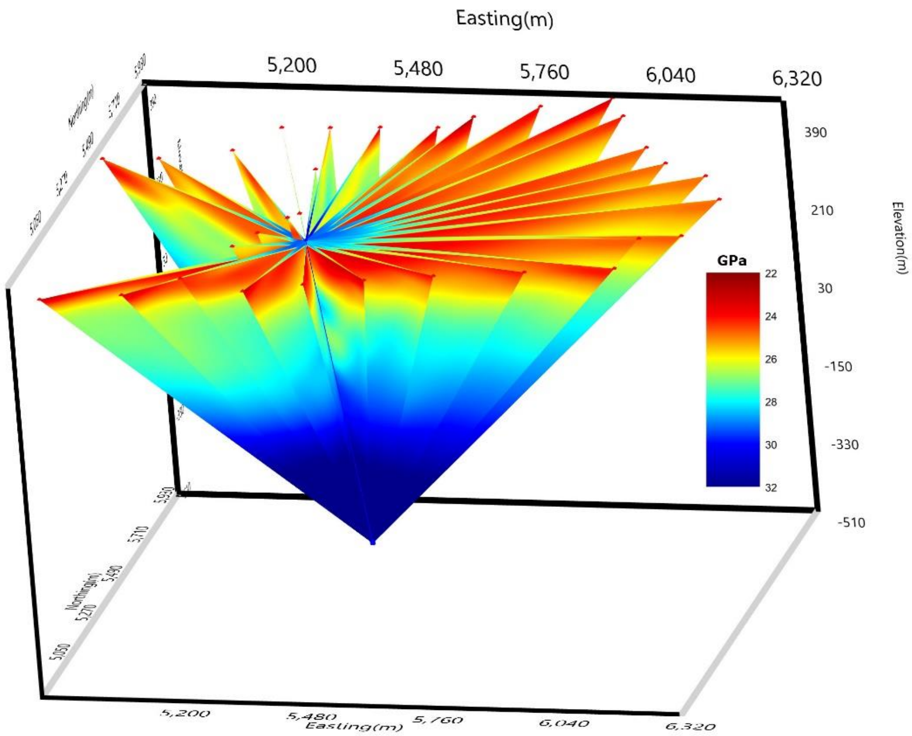


Figure 38: 3D Shear modulus distribution around borehole IG_BH06.

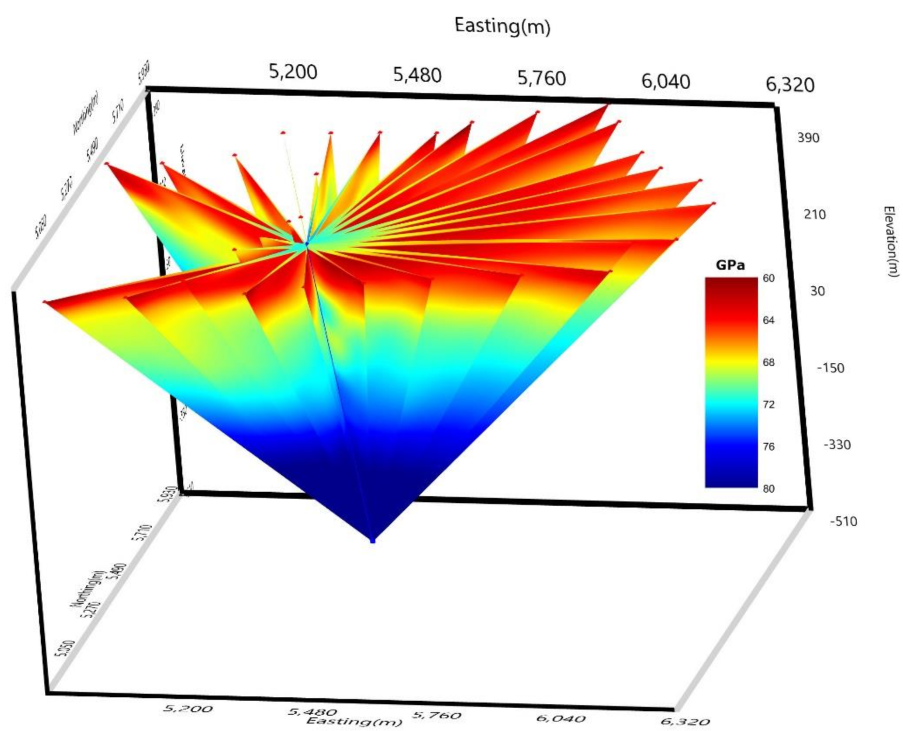


Figure 39: 3D Young's modulus distribution around borehole IG_BH06.

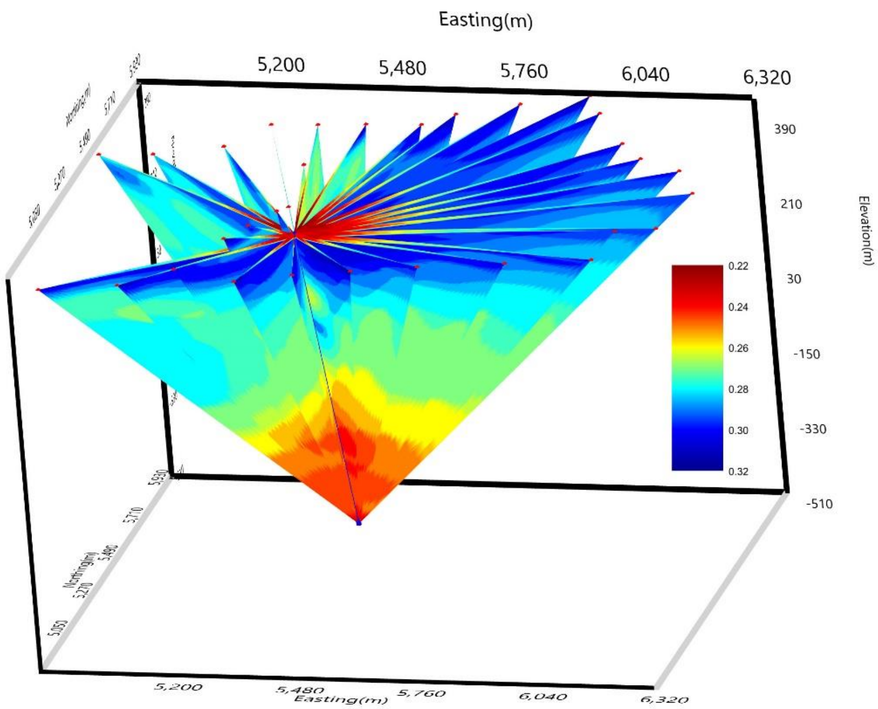


Figure 40: 3D Poisson ratio distribution around borehole IG_BH06.

6.4 Borehole Synthetics

A reflectivity log along the borehole was calculated from the logs shown on Figure 36 and it is shown on Figure 41, together with the reflectivity log used for generation of synthetics. For the later, the upper 100 m of the borehole reflectivity log was dismissed (highly attenuated) as it was measured in the casing.

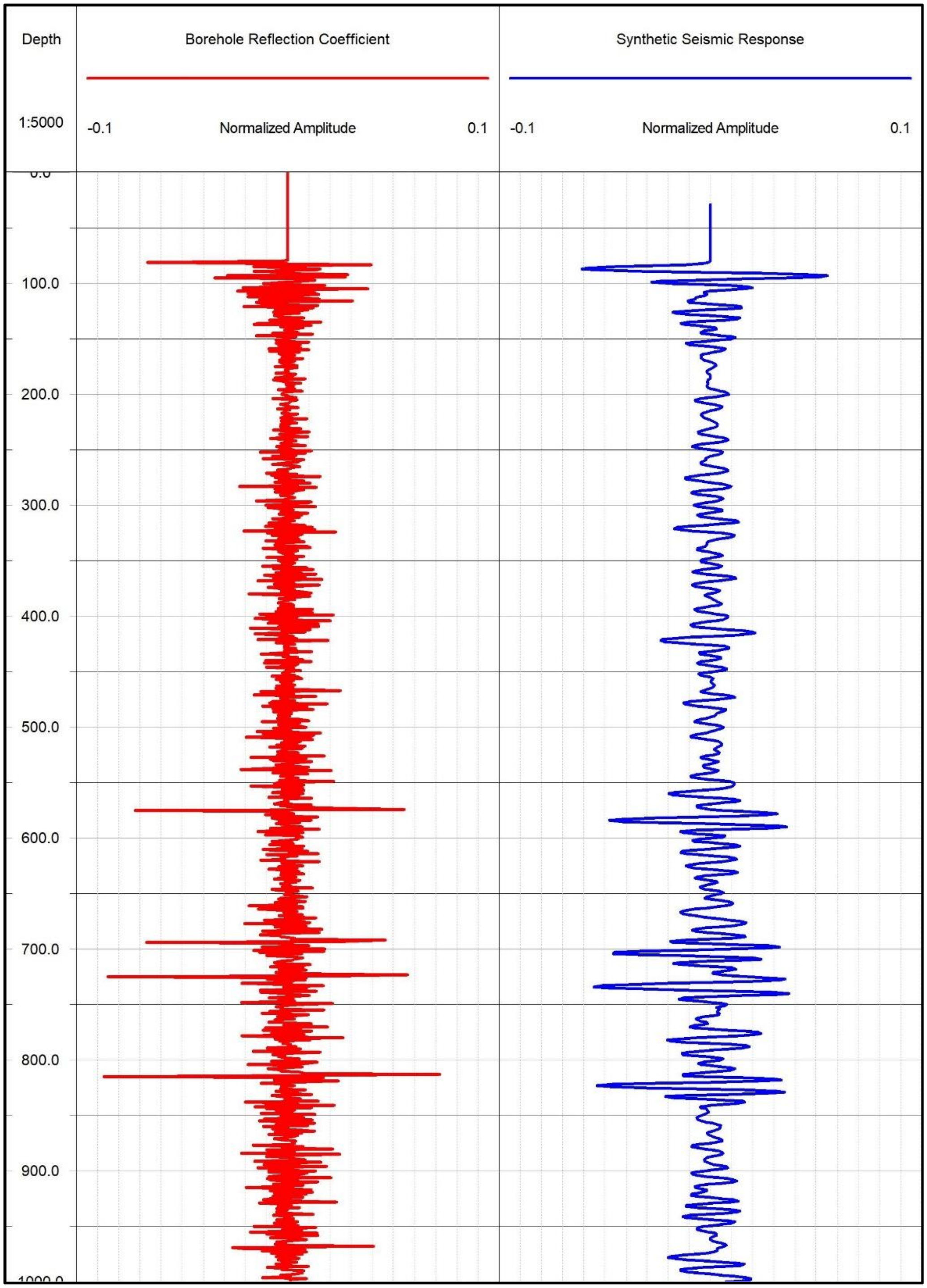


Figure 41: Borehole reflectivity log (left - red) used to calculate the synthetic seismic response along the borehole (right – blue), computed using the wavelet shown on Figure 42.

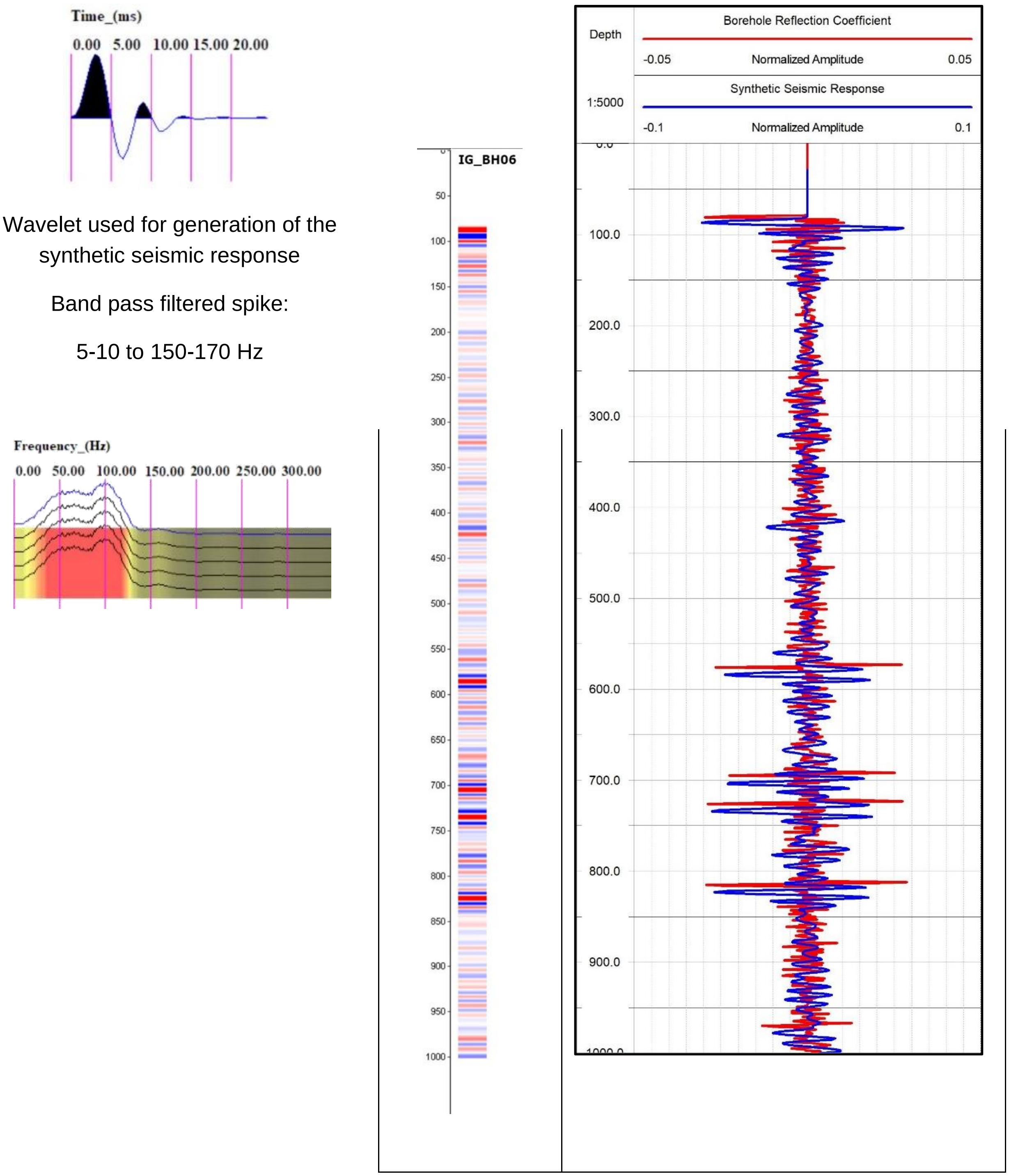


Figure 42: Wavelet used for generation of the synthetic seismic response along IG_BH06 together with its frequency spectra (left). The band used to derive the wavelet from a spike is narrower than the band used in the processing flow, in order to reflect the dominant frequency content of the measured data. The synthetic seismic response (middle) and the reflectivity log used for generation of synthetics (right). The blue curve in the plot on the right represents the synthetic seismic response along the borehole.

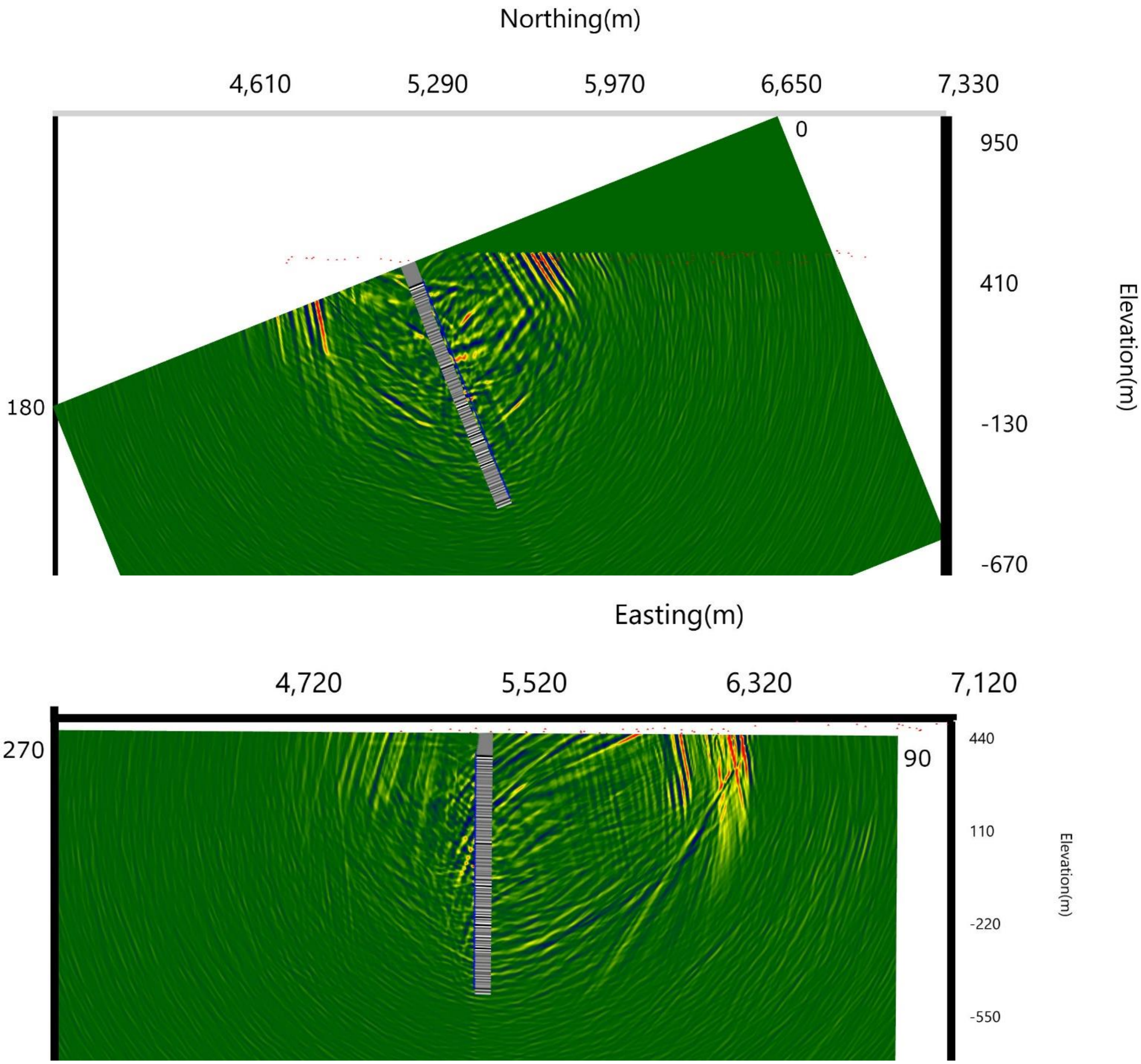


Figure 43: Synthetic seismogram (gray, same as shown in the middle column of Figure 42) and 3D IP migrations – Top: South-North sections and Bottom: West-East sections.

7.0 DISCUSSION

To map rock discontinuities by seismic, at least one dense array of measuring points is needed. For the IG_BH06 VSP survey, the dense array has been a line of 3-component geophone receivers spread in the borehole at 5 m intervals (see Section 4.2.2). With the dominant P-wave velocity slightly less than 6000 m/s (see Figure 15), and the frequency of the data being high cut at 250 Hz (see Figure 10), the theoretical minimum wavelength λ=V/f was 25 m. The geophone interval was therefore less than one fifth of the wavelength, sufficiently dense to prevent artifacts from being generated throughout the processing sequence described in Section 5.0. Phase-consistent events, appearing in the individual shot gathers must therefore be identified and treated as real seismic events, even when concentrations of crisscrossing coherent patterns may appear as noise.

The interpretation of the IG_BH06 VSP data resulted in a geometrical model of seismically significant rock discontinuities. Seismic reflectors with positions and orientations consistent with the current structural data for the site were identified. No attempt has been made at this time to infer the nature or texture of these features. Common rock discontinuities that these seismic features could represent are lithological contacts, dykes, faults and fracture zones.

The visibility of a lithological contact depends primarily on the impedance contrast between the adjacent units and possibly also on the alteration zone that may line the contact. Lithological contacts with an acoustic impedance contrast of more than 5-10% appear generally as outstanding continuous events and are relatively easy to recognize.

Faults, fracture zones and dykes are essentially two-dimensional features, with transverse dimensions much smaller than their lateral extent. The net acoustic impedance contrast is the combined effect of the closer and the further interface. The double, opposite transition of impedance and the variability of texture within the feature make the amplitude of the reflected wave field largely variable. Consequently, the visibility of faults, fracture zones and dykes as seismic reflectors is also largely variable, not only from feature to feature, but even from a region to another of the same feature. It is therefore to be expected that certain features have not equally high visibility in all shot gathers.

The implication is that the interpretation of seismic data from hard rock must rely primarily on phase and amplitude consistency rather than on amplitude magnitude. To follow the continuity of events across traces in the same profile and across profiles and thus make the interpretation possible, even illumination coverage and diversity of view angles are instrumental. An evenly spaced set of sources locations on the ground surface has initially been considered, the distance between two adjacent sources being approximately 200 m (see Figure 5). Larger distances between adjacent shots occurred in the actual layout, caused by accessibility limitations (see Figure 7). These gaps were, however, filled in the interpretation stage (see Section 6.0), by the images produced by other shots. Integrated processing and interpretation of multi-borehole VSP is bound to provide improved coverage and a more accurate non-ambiguous 3D target localization even with imperfect distributions of shots on surface.

7.1 How Accurately Can the Seismic Features be Mapped in 3D?

The IG_BH06 VSP survey produced indications of various site structures aligned with lineaments mapped in the area covered by the VSP survey and/or matching geological log in borehole IG_BH06. Other seismic features of similar extent and possibly similar relevance complete the geometrical model derived by VSP in borehole IG_BH06.

Characterizing these targets is a complex task, as besides merely detecting them (which has been done), one needs to compute their positions in space. This is definitely more than testing hypotheses regarding the existence of a given feature, with a given orientation, in a given region of the site volume. The following discussion attempts to show the complexity of the problem and produce guidelines for solving it.

On a locally planar reflector, the reflection points are distributed along a straight segment limited by the reflection points corresponding to the first and the last receiver in the receiver line. With offset sources, reflectors with equal dips but different azimuths are not covered symmetrically around the borehole. Figure 44 shows a volumetric reconstruction obtained from one shot point when the reflector dip is 60° and the dip direction is undetermined. The region between the source and the receivers and about two wavelengths around the borehole, appears as a blind zone, as reflections do not occur with the source and the receivers on opposite sides of a reflecting plane. The outer boundary of the coverage volume is determined by the investigation distance, which in the present case is about 1.5 km.

The imaging volume is quite complicated and is different for different dips. The ideal targets for VSP are features dipping 30º – 75º relative to the mean direction of the receiver array, i.e. to the borehole in the VSP case. Generally speaking, gently dipping reflectors are imaged close to the borehole and under it, while steeply dipping reflectors are imaged laterally, at depths smaller or comparable with the borehole depth.

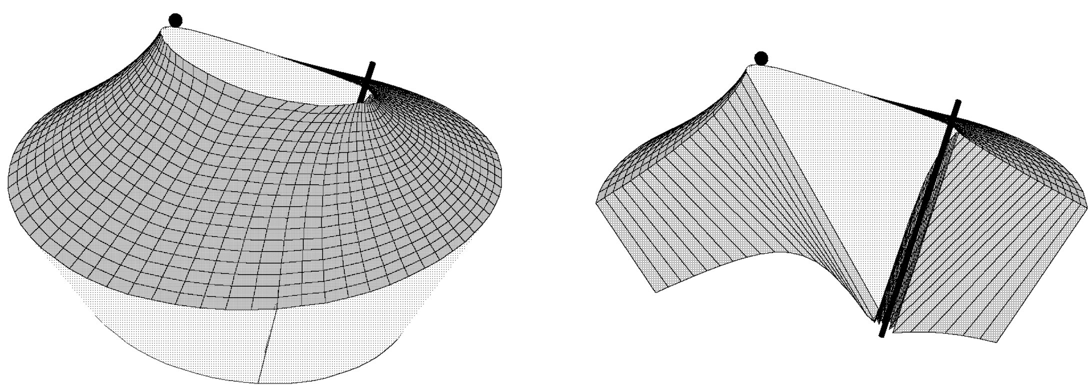


Figure 44: The volume covered from one shot point when the dip is fixed to 60°. Cut view of the coverage volume. The light grey region between the shot point and the receiver array depicts the blind zone (Cosma 2000).

Figure 45 illustrates how a site can be covered by 10 offsets, evenly distributed around the borehole top. One can note that some regions remain uncovered even with 10 shot points.

Whatever the spread of shot points, the actual mapping coverage of the VSP layout converges towards the borehole as depth increases. It is therefore preferable to perform measurements in more boreholes, to cover a larger area at depth.

To resolve this problem, VSP surveys are normally conducted in several boreholes, with each subsequent survey partly overlapping with the previous ones but also contributing with new information, from other regions of the site, until a quasi-complete and iteratively validated coverage is obtained.

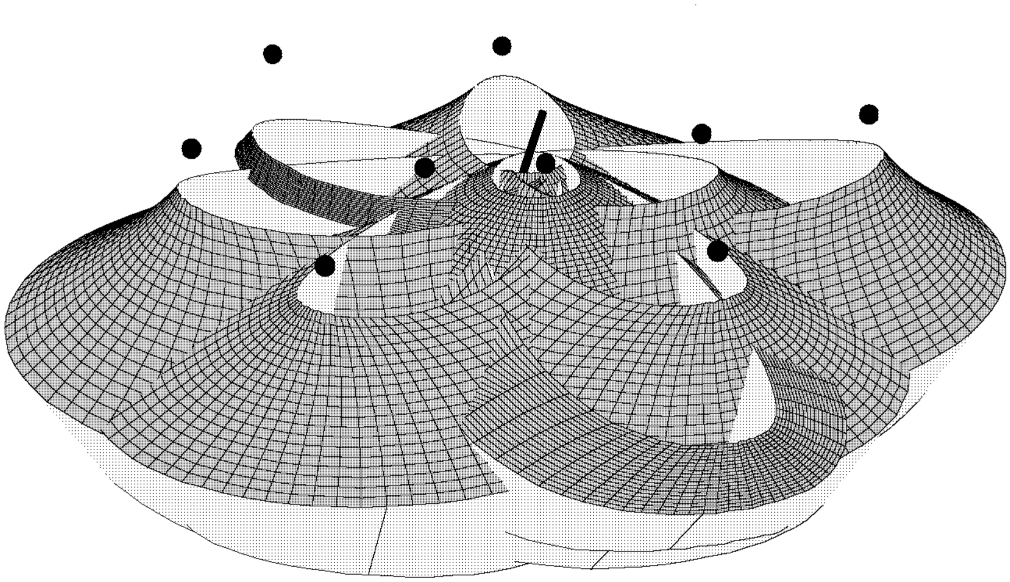


Figure 45: Volume covered from 10 shot points. The dip θ is 60° (Cosma 2000).

7.2 Recommendations for Further Analysis of the IG_BH06 VSP Data

Looking at the example of interpreted shot gathers from Figure 28 can be misleading on at least two counts. Firstly, the number of interpreted events is strikingly large. Secondly, the correspondence between the lines representing the computed time functions and the coherent patterns underneath is not crystal clear in all cases. One must note that although only one shot profile is shown as an example, the time functions for events were inferred from several profiles and components (see also Appendix F). This explains the occasional slight misfit, as the theoretical extrapolation as a planar mathematical object of a reflector interpreted and confirmed in one profile does not necessarily fit exactly when ported to a different profile and extrapolation over large distances can produce fit variations. This issue is solved locally, by analyzing subsets of close by shot profiles.

This brings forward the question of the actual resolution of a coherent event fitting a time function. Indeed, +/- ¼ cycle at 200 Hz and 6000 m/s corresponds to ~ +/- 10 m. Assigning locally a velocity of 5750 m/s instead of, e.g. 6000 m/s, over a distance of 1000 m, which is theoretically possible but unlikely, considering the velocity corrections performed according to tomographic inversions, would generate a positioning error of ~40 m.

A variation of 1º of the dip or strike of a distant reflector can lead to a predicted intersection depth with the borehole offset by tens or even hundreds of metres, if the reflector dips closely to parallel with respect to the borehole. Conversely, for reflectors nearly perpendicular to the borehole, the prediction depth offset is insignificant. A reliable way to evaluate the seismic predictions of reflector positions is as the variability along the normal direction to the best fit reflector plane, the expected precision being ~ +/- 10 m.

The orientation and positioning of reflector elements and surfaces generated by seismics can further be refined by comparing them with the site geological and structural model.

8.0 REFERENCES

ALT (Advanced Logic Technology), 2011. WellCAD User Manual Section 4.1.8 Computing Rock Mechanical Parameters.

Cosma, C., 1990. Seismic Imaging Techniques Applied to Rock Engineering. Invited paper. Proceedings of The 1st SEGJ International Symposium on Geotomography, Tokyo, Japan.

Cosma, C., Heikkinen, P.J. and Keskinen, J., 1994a. Development of seismic investigation techniques, Part I: Coverage analysis of VSP surveys. TVO, Helsinki. Work report PATU-94-02e.

Cosma, C., Heikkinen, P.J. and Keskinen, J., 1994b. Development of seismic investigation techniques, Part II: Site coverage of VSP surveys in Romuvaara, borehole KR2. TVO, Helsinki. Work report PATU -94-03e.

Cosma, C., 1995. Characterisation of subsurface structures by remote sensing. Keynote address. Proceedings of th[e] 1st International Congress on Rock Mechanics (ISRM), Tokyo, Japan.

Cosma, C. and Heikkinen, P., 1996. Seismic Investigations for the Final Disposal of Spent Nuclear Fuel in Finland. Journal of Applied Geophysics vol. 35, pp. 151–157.

Cosma, C., 2000. Contributions to the study of the structure of the rockmass by seismic tomography. Ph.D. Thesis, University of Bucharest, 173 pages.

Cosma, C., Heikkinen, P.J., Keskinen, J. and Enescu, N., 2001a. VSP in Crystalline Rocks – from Downhole Velocity Profiling to 3-D Fracture Mapping. International Journal of Rock Mechanics and Mining Sciences, vol. 38, no. 6, pp ….

Cosma, C., Olsson, O., Keskinen, J. and Heikkinen, P.J., 2001b. Seismic characterisation of fracturing at the Äspö Hard Rock Laboratory, from the kilometre scale to the meter scale. International Journal of Rock Mechanics and Mining Sciences, vol. 38, 6, pp.

Cosma, C. and Enescu, N., 2001c. Characterization of Fractured Rock in the Vicinity of Tunnels by the Swept Impact Seismic Technique. International Journal of Rock Mechanics and Mining Sciences, vol. 38, no. 6, pp. 815 – 821.

Cosma, C., Enescu, N. and Keskinen, J. 2002a. Vertical Seismic Profiling from KLX-02, Laxemar, 2000. SKB Technical Document, TD-02-02.

Cosma, C. and Enescu, N., 2002b. Multi-Azimuth VSP Methods for Fractured Rock Characterization, the 5th ISRM Conference, Toronto.

Cosma, C., P. Heikkinen, J. Keskinen, 2003. Multi-azimuth VSP for Rock Characterization of Deep Nuclear Waste Disposal Sites in Finland. Hardrock Seismic Exploration, 01/2003: pages 207-226, ISBN: 978-1-56080-114-6, DOI:10.1190/1.9781560802396.ch14

Cosma, C., L. Balu and N. Enescu, 2010. 3D VSP Migration by Image Point Transform. Geophysics, vol. 75, no. 3 _May-June 2010_; P. S121–S130 10.1190/1.3396316.

DesRoches, A., Sykes, M., Parmenter, A. and Sykes, E., 2018. Lineament Interpretation of the Revell Batholith and Surrounding Greenstone Belts (Nuclear Waste Management Organization). No. NWMO-TR-2018-19.

DesRoches, A.J., Waffle, L., Parmenter, A. 2021. 3D Site-scale geological model in the Revell Batholith: Model Version 1.0. Report Number: NWMO-TR-2021-12. June 2021.

Golder (Golder Associates Ltd.) and Vibrometric (Vibrometric Canada Ltd.)., 2022. Phase 2 Initial Borehole Drilling and Testing at IG_BH04/05/06 Ignace Area WP12 Data Report – Vertical Seismic Profiling for IG_BH04. NWMO Report Number: APM-REP-01332-0284.

Golder and Vibrometric, 2023. Phase 2 Initial Borehole Drilling and Testing at IG_BH04/05/06 Ignace Area WP12 Data Report – Vertical Seismic Profiling for IG_BH05. NWMO Report Number: APM-REP-01332-0368.

Golder, 2021. Phase 2 Initial Borehole Drilling and Testing at IG_BH04/05/06, Ignace Area – Borehole Characterization Plan for IG_BH06. NWMO Report Number: APM-REP-01332-0275

Golder and PGW (Paterson Grant and Watson Ltd.), 2017. Phase 2 Geoscientific Preliminary Assessment, Geological Mapping, Township of Ignace and Area, Ontario.

Heikkinen, P.J. and Cosma, C., 1994. Development of seismic investigation techniques. Part III: Fast 3D-modeling of VSP surveys. TVO site investigations, Work report PATU-94-04e.

Heikkinen, P.J., Cosma, C. and Keskinen, J., 1995. Development of Seismic Investigation Techniques: Anisotropy in VSP Measurements. Work Report PATU-95-58e.

Park, C.B., Miller, R.D., Steeples, D.W. and Black, R.A. 1996. Swept Impact Seismic Technique (SIST). Geophysics, vol. 61, no. 6, pp.1789 – 1803.

Schweigert, J., and Schulte, B. W., 2019. What is the value of a VSP and why it should be modeled? Recorder, Vol. 44, No. 05, Sep 2019.

SGL (Sander Geophysics Limited), 2015. Phase 2 Geoscientific Preliminary Assessment, Acquisition, Processing and Interpretation of High-Resolution Airborne Geophysical Data, Township of Ignace, Ontario. Prepared for Nuclear Waste Management Organization (NWMO). NWMO Report Number: APM-REP-06145-0002.

SRK (SRK Consulting, Inc). and Golder, 2015. Phase 2 Geoscientific Preliminary Assessment, Observation of General Geological Features, Township of Ignace, Ontario. Prepared for Nuclear Waste Management Organization. NWMO Report Number: APM-REP-06145-0004.

Stone, D., 2009. Geology of the Bending Lake Area, Northwestern Ontario; in Summary of Field Work and Other Activities 2009. Ontario Geological Survey. Open File Report 6240.

Stone, D., 2010a. Geology of the Stormy Lake Area, Northwestern Ontario; in Summary of Field Work and Other Activities 2010. Ontario Geological Survey, Open File Report 6260.

Stone, D., 2010b. Precambrian geology of the central Wabigoon Subprovince area, northwestern Ontario. Ontario Geological Survey, Open File Report 5422.

Stone, D., Halle, J. and Chaloux, E., 1998. Geology of the Ignace and Pekagoning Lake Areas, Central Wabigoon Subprovince; in Summary of Field Work and Other Activities 1998, Ontario Geological Survey, Misc. Paper 169.

Stone, D., Davis, D.W., Hamilton, M.A. and Falcon, A., 2010. Interpretation of 2009 Geochronology in the Central Wabigoon Subprovince and Bending Lake Areas, Northwestern Ontario, in Summary of Field Work and Other Activities 2010, Ontario Geological Survey, Open File Report 6260

Wood, G., O'Dowd, C., Cosma, C., Enescu, N., 2012. An interpretation of surface and borehole seismic surveys for mine planning at the Millennium uranium deposit, northern Saskatchewan, Canada. Geophysics 10/2012; 77(5). DOI:10.1190/GEO2011-0488.1

WSP Canada Inc., 2023. Phase 2 Initial Borehole Drilling and Testing at IG_BH04/05/06 Ignace Area WP05 Data Report – Geophysical Well Logging for IG_BH06. Prepared for Nuclear Waste Management Organization. NWMO Report Number: APM-REP-01332-0367.

Wyatt, K.D. and Wyatt, S.B., 1984. Determining subsurface structure using vertical seismic profiling. In: Toksoz, M.N. and Stewart, R.R., Eds, Vertical Seismic Profiling: Advanced concepts, Geophysical Press.

APPENDIX A

Daily Quality Control Forms

WP12 Data Quality Confirmation (DQC) Form			
Document No.: *20253946-6120-220128*	Original Date: *28 Jan 2022*	Developed By: *Nicoleta Enescu*	GOLDER MEMBER OF WSP
Revision No.: *R0*	Revision Date: *N/A*	Authorized By: *Christopher Phillips*	

TO:	Mostafa Khorshidi	**Date:**	*220128*
	Maria Sánchez-Rico Castejón	**Work Package:**	WP12 – VSP Profiling
	Sarah Hirschorn		
CC:	George Schneider		
		Distributed By:	Email

Record Number: 20253946-6120-220128

IGBH_06, IGNACE, ONTARIO

Acquisition depth interval: L1 (80 – 135 m) and L2 (140 – 195m)

Staff: Cristian Vasile

Start time: 10:30 am **Finish time: 6:45 pm**

Shot location(s): All 30 shot locations for levels at 70m and 130m

Prepared by: Nicoleta Enescu

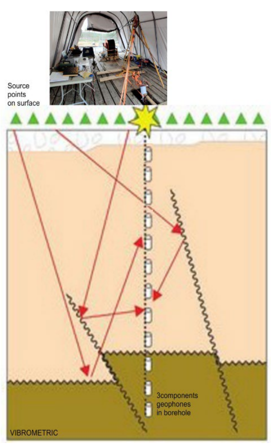
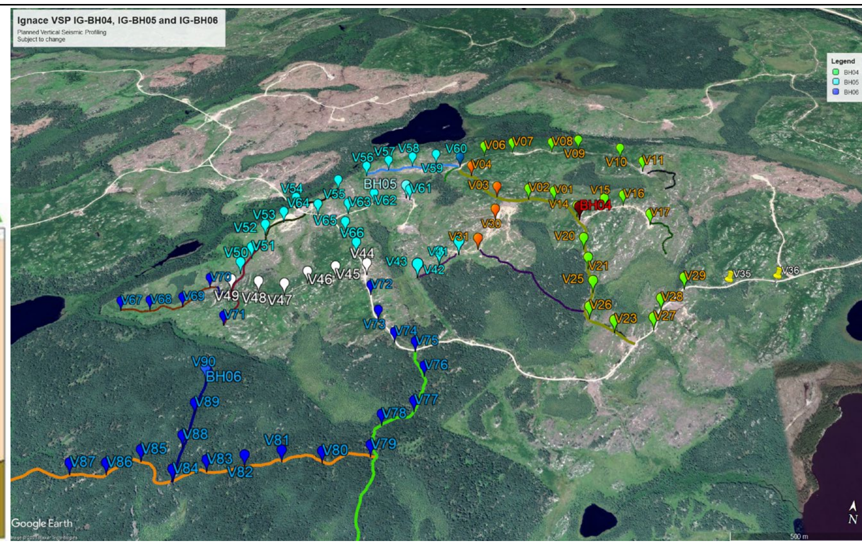
Verified by: Christopher Phillips

Usage notes:

- Complete one form per field day
- Office forms will be complete as processing packages/tasks are completed and will include supporting documentation
- Complete all header information (above)
- Delete unused tables (below) and fully populate those that remain
- Form is divided into A through O tables and field and processing tasks

FIELD

A	Winch and Depth Counter
Calibrated by measuring and marking the cable every 100 m before insertion in the borehole. Verifying these distances using the depth counter. Discrepancies are adjusted by changing the depth value on the depth counter to match the cable mark.	
Results	At cable mark 50m, depth counter reads 50m. At 70.00m the depth counter read 70.03m. At 130m the depth counter read 130.16m
Settings applied	

B	Tool Assembly	
Schematic		
Results of checks.	All good	

E	Equipment Calibration/Function Checklist	OK	Maintenance
Geophones			
	Geophone used (RD or R):	RD	
	Testing at ground surface performed before insertion in the borehole:		
	Level of electrical disturbance	OK	
	Water tightness	OK	
	Operation of side arm clamp	OK	
	Verification of noise level and real seismic signal in each component	OK	

E Equipment Calibration/Function Checklist	OK	Maintenance
Winch Motor and transmission Controller Brake Ground anchors	All OK	
Cable Borehole collar level mark Overnight clamp	All OK	
Depth counter	OK	
Radio check	OK	
Acquisition computer Computer Acquisition Software Data Analysis Software	OK OK OK	
Power source	OK	
Access vehicle	OK	
Geophones calibration certificate verification: Technical ID Signature Date Validity period Location	_X_ _X_ _X_ _X_ _X_	
Depth counter calibration certificate verification: Technical ID Signature Date Validity period Location	Calibration shown in Table A	

F Decontamination	
Verification of equipment decontamination before insertion into borehole	Yes

G Dummy Probe Run	
Done before insertion of geophones into borehole	Complete to 998m mbgs on January 25, 2022

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H	Geophone Testing in Borehole
Clamping location verified	Yes
Level of electrical disturbance	None
Operation of the side arm clamp	Good
Verification of noise in each component	Done, file Noise_0070__21_60001.dlc
Verification of real seismic signal in each component	Done, file V_BH6_0070__21_00001.dlc

I	Shot
Confirmation of shot point ID with receiver staff	Yes
Data acquisition sampling rate confirmed at 1 ms	Yes

J Field Data – Review and Verification

Depth of zero mark	Shot ID	Data File	Comment/Verified (fitness for use)
70	V90	V_BH6_0070__21_00013	**All ok**
		V_BH6_0070__21_00014	
		V_BH6_0070__21_00015	
70	V89	V_BH6_0070__21_00016	
		V_BH6_0070__21_00017	
		V_BH6_0070__21_00018	
70	V88	V_BH6_0070__21_00019	
		V_BH6_0070__21_00020	
		V_BH6_0070__21_00021	
70	V87	V_BH6_0070__21_00022	
		V_BH6_0070__21_00023	
		V_BH6_0070__21_00024	
70	V86	V_BH6_0070__21_00025	
		V_BH6_0070__21_00026	

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J	Field Data – Review and Verification		
		V_BH6_0070__21_00027	
70	V85	V_BH6_0070__21_00028	
		V_BH6_0070__21_00029	
		V_BH6_0070__21_00030	
70	V84	V_BH6_0070__21_00031	
		V_BH6_0070__21_00032	
		V_BH6_0070__21_00033	
70	V83	V_BH6_0070__21_00034	
		V_BH6_0070__21_00035	
		V_BH6_0070__21_00036	
70	V82	V_BH6_0070__21_00037	
		V_BH6_0070__21_00038	
		V_BH6_0070__21_00039	
70	V81	V_BH6_0070__21_00040	
		V_BH6_0070__21_00041	
		V_BH6_0070__21_00042	
70	V80	V_BH6_0070__21_00043	
		V_BH6_0070__21_00044	
		V_BH6_0070__21_00045	
70	V79	V_BH6_0070__21_00046	
		V_BH6_0070__21_00047	
		V_BH6_0070__21_00048	

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J	Field Data – Review and Verification		
70	V78	V_BH6_0070__21_00049	
		V_BH6_0070__21_00050	
		V_BH6_0070__21_00051	
70	V77	V_BH6_0070__21_00052	
		V_BH6_0070__21_00053	
		V_BH6_0070__21_00054	
70	V76	V_BH6_0070__21_00055	
		V_BH6_0070__21_00056	
		V_BH6_0070__21_00057	
70	V75	V_BH6_0070__21_00058	
		V_BH6_0070__21_00059	
		V_BH6_0070__21_00060	
70	V74	V_BH6_0070__21_00061	
		V_BH6_0070__21_00062	
		V_BH6_0070__21_00063	
70	V73	V_BH6_0070__21_00064	
		V_BH6_0070__21_00065	
		V_BH6_0070__21_00066	
70	V72	V_BH6_0070__21_00067	
		V_BH6_0070__21_00068	
		V_BH6_0070__21_00069	
70	V44	V_BH6_0070__21_00070	

J	Field Data – Review and Verification		
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		V_BH6_0070__21_00072	
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		V_BH6_0070__21_00074	
		V_BH6_0070__21_00075	
70	V46	V_BH6_0070__21_00076	
		V_BH6_0070__21_00077	
		V_BH6_0070__21_00078	
70	V47	V_BH6_0070__21_00079	
		V_BH6_0070__21_00080	
		V_BH6_0070__21_00081	
70	V48	V_BH6_0070__21_00082	
		V_BH6_0070__21_00083	
		V_BH6_0070__21_00084	
70	V49	V_BH6_0070__21_00085	
		V_BH6_0070__21_00086	
		V_BH6_0070__21_00087	
70	V71	V_BH6_0070__21_00088	
		V_BH6_0070__21_00089	
		V_BH6_0070__21_00090	
70	V91	V_BH6_0070__21_00091	
		V_BH6_0070__21_00092	

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J	Field Data – Review and Verification		
		V_BH6_0070__21_00093	
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		V_BH6_0070__21_00095	
		V_BH6_0070__21_00096	
70	V93	V_BH6_0070__21_00097	
		V_BH6_0070__21_00098	
		V_BH6_0070__21_00099	
70	V94	V_BH6_0070__21_00100	
		V_BH6_0070__21_00101	
		V_BH6_0070__21_00102	
130	V94	V_BH6_0130__21_00103	**All ok**
		V_BH6_0130__21_00104	
		V_BH6_0130__21_00105	
130	V93	V_BH6_0130__21_00106	
		V_BH6_0130__21_00107	
		V_BH6_0130__21_00108	
130	V92	V_BH6_0130__21_00109	
		V_BH6_0130__21_00110	
		V_BH6_0130__21_00111	
130	V91	V_BH6_0130__21_00112	
		V_BH6_0130__21_00113	

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J	Field Data – Review and Verification		
		V_BH6_0130__21_00114	
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		V_BH6_0130__21_00117	
130	V49	V_BH6_0130__21_00118	
		V_BH6_0130__21_00119	
		V_BH6_0130__21_00120	
130	V48	V_BH6_0130__21_00121	
		V_BH6_0130__21_00122	
		V_BH6_0130__21_00123	
130	V47	V_BH6_0130__21_00124	
		V_BH6_0130__21_00125	
		V_BH6_0130__21_00126	
130	V46	V_BH6_0130__21_00127	
		V_BH6_0130__21_00128	
		V_BH6_0130__21_00129	
130	V45	V_BH6_0130__21_00130	
		V_BH6_0130__21_00131	
		V_BH6_0130__21_00132	
130	V44	V_BH6_0130__21_00133	
		V_BH6_0130__21_00134	
		V_BH6_0130__21_00135	

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J	Field Data – Review and Verification		
130	V72	V_BH6_0130__21_00136	
		V_BH6_0130__21_00137	
		V_BH6_0130__21_00138	
130	V73	V_BH6_0130__21_00139	
		V_BH6_0130__21_00140	
		V_BH6_0130__21_00141	
130	V74	V_BH6_0130__21_00142	
		V_BH6_0130__21_00143	
		V_BH6_0130__21_00144	
130	V75	V_BH6_0130__21_00145	
		V_BH6_0130__21_00146	
		V_BH6_0130__21_00147	
130	V76	V_BH6_0130__21_00148	
		V_BH6_0130__21_00149	
		V_BH6_0130__21_00150	
130	V77	V_BH6_0130__21_00151	
		V_BH6_0130__21_00152	
		V_BH6_0130__21_00153	
130	V78	V_BH6_0130__21_00154	
		V_BH6_0130__21_00155	
		V_BH6_0130__21_00156	
130	V79	V_BH6_0130__21_00157	

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J	Field Data – Review and Verification		
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130	V80	V_BH6_0130__21_00160	
		V_BH6_0130__21_00161	
		V_BH6_0130__21_00162	
130	V81	V_BH6_0130__21_00163	
		V_BH6_0130__21_00164	
		V_BH6_0130__21_00165	
130	V82	V_BH6_0130__21_00166	
		V_BH6_0130__21_00167	
		V_BH6_0130__21_00168	
130	V83	V_BH6_0130__21_00169	
		V_BH6_0130__21_00170	
		V_BH6_0130__21_00171	
130	V84	V_BH6_0130__21_00172	
		V_BH6_0130__21_00173	
		V_BH6_0130__21_00174	
130	V85	V_BH6_0130__21_00175	
		V_BH6_0130__21_00176	
		V_BH6_0130__21_00177	
130	V86	V_BH6_0130__21_00178	
		V_BH6_0130__21_00179	

J	Field Data – Review and Verification		
		V_BH6_0130__21_00180	
130	V87	V_BH6_0130__21_00181	
		V_BH6_0130__21_00182	
		V_BH6_0130__21_00183	
130	V88	V_BH6_0130__21_00184	
		V_BH6_0130__21_00185	
		V_BH6_0130__21_00186	
130	V89	V_BH6_0130__21_00187	
		V_BH6_0130__21_00188	
		V_BH6_0130__21_00189	
130	V90	V_BH6_0130__21_00190	
		V_BH6_0130__21_00191	
		V_BH6_0130__21_00192	

K Field Issues	
Observed damage (note here as-needed additional detail on Daily Report items)	*corrective action (e.g. repair, component replacement)* *N/A*

L File Control					
Data File	**Date Time**	**Depth Range**	**Staff**	**Software**	**Parameters/Settings**
V_BH6_0070__21_00013		80 – 135m	Cristian Vasile	VIPS5.11	1ms sample rate. 3 records of 20 seconds each
V_BH6_0070__21_00014					
V_BH6_0070__21_00015					

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L	**File Control**				
V_BH6_0070__21_00016					
V_BH6_0070__21_00017					
V_BH6_0070__21_00018					
V_BH6_0070__21_00019					
V_BH6_0070__21_00020					
V_BH6_0070__21_00021					
V_BH6_0070__21_00022					
V_BH6_0070__21_00023					
V_BH6_0070__21_00024					
V_BH6_0070__21_00025					
V_BH6_0070__21_00026					
V_BH6_0070__21_00027					
V_BH6_0070__21_00028					
V_BH6_0070__21_00029					
V_BH6_0070__21_00030					
V_BH6_0070__21_00031					
V_BH6_0070__21_00032					
V_BH6_0070__21_00033					
V_BH6_0070__21_00034					
V_BH6_0070__21_00035					
V_BH6_0070__21_00036					
V_BH6_0070__21_00037					

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L File Control					
V_BH6_0070__21_00038					
V_BH6_0070__21_00039					
V_BH6_0070__21_00040					
V_BH6_0070__21_00041					
V_BH6_0070__21_00042					
V_BH6_0070__21_00043					
V_BH6_0070__21_00044					
V_BH6_0070__21_00045					
V_BH6_0070__21_00046					
V_BH6_0070__21_00047					
V_BH6_0070__21_00048					
V_BH6_0070__21_00049					
V_BH6_0070__21_00050					
V_BH6_0070__21_00051					
V_BH6_0070__21_00052					
V_BH6_0070__21_00053					
V_BH6_0070__21_00054					
V_BH6_0070__21_00055					
V_BH6_0070__21_00056					
V_BH6_0070__21_00057					
V_BH6_0070__21_00058					
V_BH6_0070__21_00059					

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L File Control					
V_BH6_0070__21_00060					
V_BH6_0070__21_00061					
V_BH6_0070__21_00062					
V_BH6_0070__21_00063					
V_BH6_0070__21_00064					
V_BH6_0070__21_00065					
V_BH6_0070__21_00066					
V_BH6_0070__21_00067					
V_BH6_0070__21_00068					
V_BH6_0070__21_00069					
V_BH6_0070__21_00070					
V_BH6_0070__21_00071					
V_BH6_0070__21_00072					
V_BH6_0070__21_00073					
V_BH6_0070__21_00074					
V_BH6_0070__21_00075					
V_BH6_0070__21_00076					
V_BH6_0070__21_00077					
V_BH6_0070__21_00078					
V_BH6_0070__21_00079					
V_BH6_0070__21_00080					
V_BH6_0070__21_00081					

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L **File Control**					
V_BH6_0070__21_00082					
V_BH6_0070__21_00083					
V_BH6_0070__21_00084					
V_BH6_0070__21_00085					
V_BH6_0070__21_00086					
V_BH6_0070__21_00087					
V_BH6_0070__21_00088					
V_BH6_0070__21_00089					
V_BH6_0070__21_00090					
V_BH6_0070__21_00091					
V_BH6_0070__21_00092					
V_BH6_0070__21_00093					
V_BH6_0070__21_00094					
V_BH6_0070__21_00095					
V_BH6_0070__21_00096					
V_BH6_0070__21_00097					
V_BH6_0070__21_00098					
V_BH6_0070__21_00099					
V_BH6_0070__21_00100					
V_BH6_0070__21_00101					
V_BH6_0070__21_00102					

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L File Control					
V_BH6_0130__21_00103		140 – 195m	Cristian Vasile	VIPS5.11	1ms sample rate. 3 records of 20 seconds each
V_BH6_0130__21_00104					
V_BH6_0130__21_00105					
V_BH6_0130__21_00106					
V_BH6_0130__21_00107					
V_BH6_0130__21_00108					
V_BH6_0130__21_00109					
V_BH6_0130__21_00110					
V_BH6_0130__21_00111					
V_BH6_0130__21_00112					
V_BH6_0130__21_00113					
V_BH6_0130__21_00114					
V_BH6_0130__21_00115					
V_BH6_0130__21_00116					
V_BH6_0130__21_00117					
V_BH6_0130__21_00118					
V_BH6_0130__21_00119					
V_BH6_0130__21_00120					
V_BH6_0130__21_00121					
V_BH6_0130__21_00122					
V_BH6_0130__21_00123					
V_BH6_0130__21_00124					

L File Control					
V_BH6_0130__21_00125					
V_BH6_0130__21_00126					
V_BH6_0130__21_00127					
V_BH6_0130__21_00128					
V_BH6_0130__21_00129					
V_BH6_0130__21_00130					
V_BH6_0130__21_00131					
V_BH6_0130__21_00132					
V_BH6_0130__21_00133					
V_BH6_0130__21_00134					
V_BH6_0130__21_00135					
V_BH6_0130__21_00136					
V_BH6_0130__21_00137					
V_BH6_0130__21_00138					
V_BH6_0130__21_00139					
V_BH6_0130__21_00140					
V_BH6_0130__21_00141					
V_BH6_0130__21_00142					
V_BH6_0130__21_00143					
V_BH6_0130__21_00144					
V_BH6_0130__21_00145					
V_BH6_0130__21_00146					

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L	**File Control**				
V_BH6_0130__21_00147					
V_BH6_0130__21_00148					
V_BH6_0130__21_00149					
V_BH6_0130__21_00150					
V_BH6_0130__21_00151					
V_BH6_0130__21_00152					
V_BH6_0130__21_00153					
V_BH6_0130__21_00154					
V_BH6_0130__21_00155					
V_BH6_0130__21_00156					
V_BH6_0130__21_00157					
V_BH6_0130__21_00158					
V_BH6_0130__21_00159					
V_BH6_0130__21_00160					
V_BH6_0130__21_00161					
V_BH6_0130__21_00162					
V_BH6_0130__21_00163					
V_BH6_0130__21_00164					
V_BH6_0130__21_00165					
V_BH6_0130__21_00166					
V_BH6_0130__21_00167					
V_BH6_0130__21_00168					

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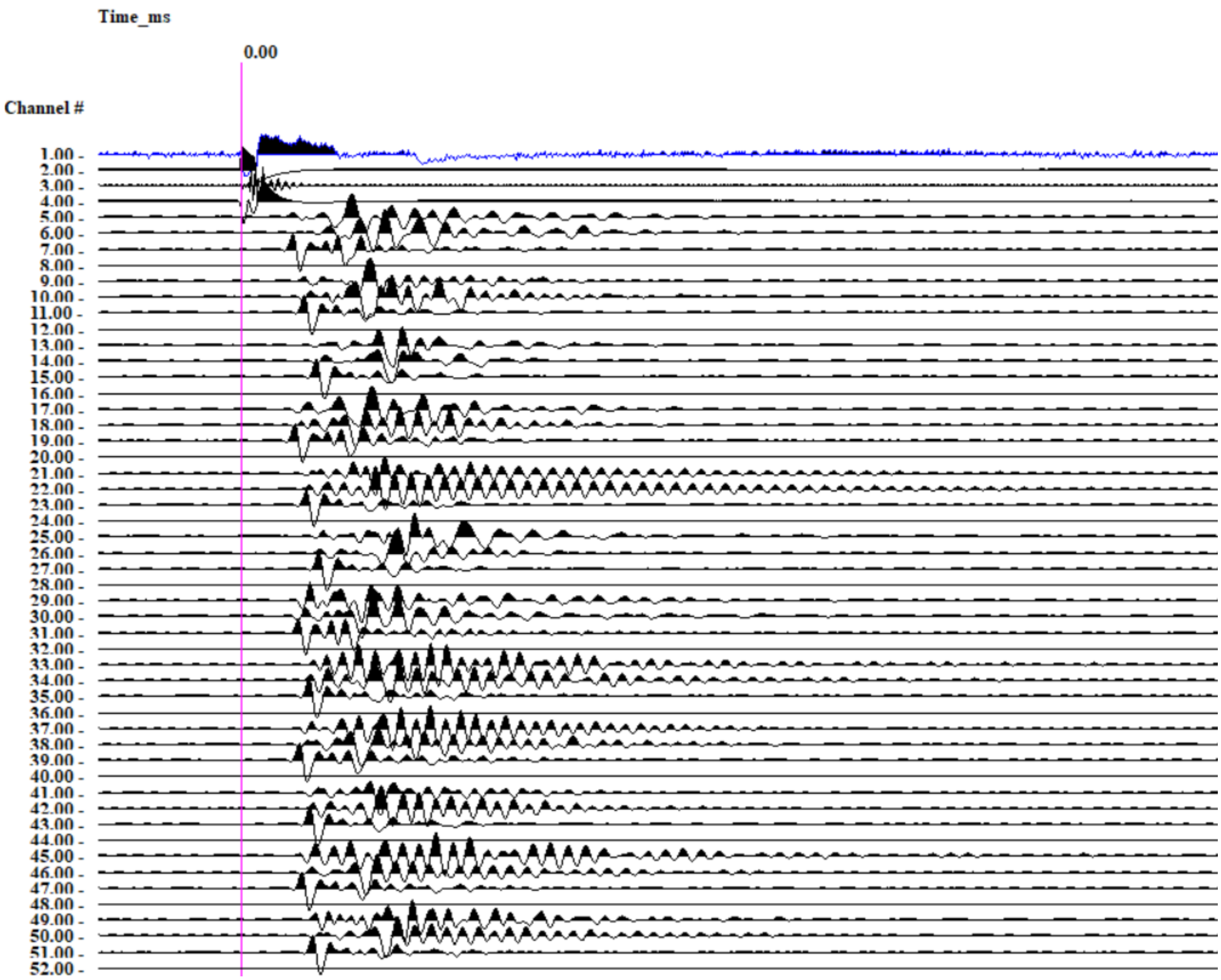
L File Control					
V_BH6_0130__21_00169					
V_BH6_0130__21_00170					
V_BH6_0130__21_00171					
V_BH6_0130__21_00172					
V_BH6_0130__21_00173					
V_BH6_0130__21_00174					
V_BH6_0130__21_00175					
V_BH6_0130__21_00176					
V_BH6_0130__21_00177					
V_BH6_0130__21_00178					
V_BH6_0130__21_00179					
V_BH6_0130__21_00180					
V_BH6_0130__21_00181					
V_BH6_0130__21_00182					
V_BH6_0130__21_00183					
V_BH6_0130__21_00184					
V_BH6_0130__21_00185					
V_BH6_0130__21_00186					
V_BH6_0130__21_00187					
V_BH6_0130__21_00188					
V_BH6_0130__21_00189					
V_BH6_0130__21_00190					

L File Control					
V_BH6_0130__21_00191					
V_BH6_0130__21_00192					



V90_L1

VIBROMETRIC

Vibrometric Seismic Source Checklist

Engine Off Checks	OK	Maintenance
Leaks – Fuel, Hydraulic Oil, Engine Oil or Radiator Coolant	✓✓	
Tires – Condition and Pressure	✓	
Hydraulic Hoses, Mast Chains, Cables and Stops – Check Visually	✓	
Safety Warnings – Attached (Refer to Parts Manual for Location)	✓	
Battery – Check Water/Electrolyte Level and Charge	✓	
Hydraulic Fluid Level – Check Level	✓	
Engine Oil Level – Dipstick	✓	
Transmission Fluid Level – Dipstick	✓	
Radiator Coolant – Check Level	✓	
Operator's Manual – In Container	✓	
Nameplate – Attached and Information Matches Model, Serial Number and Attachments	✓	
Seat Belt – Functioning Smoothly	✓	
Hood Latch – Adjusted and Securely Fastened	✓	
Brake Fluid – Check Level	✓	
Seismic Vibrator Check Screws, Cables, Hoses	✓	
Fuel level	✓	
Lights check	✓	
Engine On Checks	OK	Maintenance
Accelerator or Direction Control Pedal – Functioning Smoothly	✓	
Service Brake – Functioning Smoothly	✓	
Parking Brake – Functioning Smoothly	✓	
Steering Operation – Functioning Smoothly	✓	
Drive Control – Forward/Reverse – Functioning Smoothly	✓	
Arm Tilt Control – Forward and Back – Functioning Smoothly	✓	
Hoist (Seismic Source) and Lowering Control – Functioning Smoothly	✓	
Testing the sweep – Operation		
Horn and Lights – Functioning	✓	
Cab (if equipped) – Heater, Defroster, Wipers – Functioning	✓	
Gauges: Ammeter, Engine Oil Pressure, Hour Meter, Fuel Level, Temperature, Instrument Monitors – Functioning	✓	
Controller check | Trigger sensor on impact plate check		
Impact plate check | Radio check	✓	
Source type	✓	

Jan 28 / 22 [signature]

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O Sign-Off		
Prepared	*Jon Crawford*	*January 28, 2022*
Reviewed	*Nicoleta Enescu*	*January 28, 2022*
Approved	*Christopher Phillips*	*January 28, 2022*

WP12 Data Quality Confirmation (DQC) Form			GOLDER MEMBER OF WSP
Document No.: *20253946-6120-220128*	Original Date: *29 Jan 2022*	Developed By: *Nicoleta Enescu*	
Revision No.: *R0*	Revision Date: *N/A*	Authorized By: *Christopher Phillips*	

TO:	Mostafa Khorshidi	**Date:**	*220129*
	Maria Sánchez-Rico Castejón	**Work Package:**	WP12 – VSP Profiling
	Sarah Hirschorn		
CC:	George Schneider		
		Distributed By:	Email

Record Number: 20253946-6120-220129

IGBH_06, IGNACE, ONTARIO

Acquisition depth interval: L3 (200 – 255 m) and L4 (260 – 315m)

Staff: Cristian Vasile

Start time: 10:00 am **Finish time: 6:00 pm**

Shot location(s): All 30 shot locations for levels at 190m and 250m

Prepared by: Nicoleta Enescu

Verified by: Christopher Phillips

Usage notes:

- Complete one form per field day
- Office forms will be complete as processing packages/tasks are completed and will include supporting documentation
- Complete all header information (above)
- Delete unused tables (below) and fully populate those that remain
- Form is divided into A through O tables and field and processing tasks

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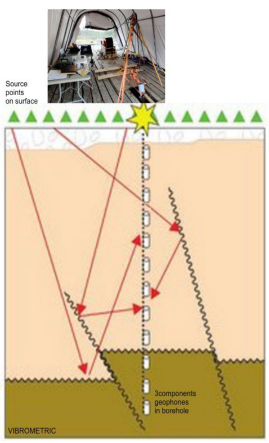
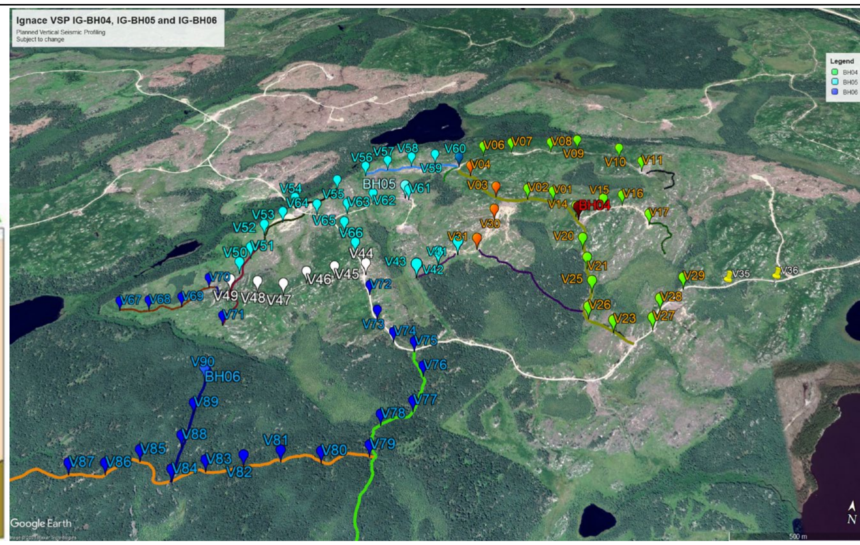
FIELD

A	Winch and Depth Counter
Calibrated by measuring and marking the cable every 100 m before insertion in the borehole. Verifying these distances using the depth counter. Discrepancies are adjusted by changing the depth value on the depth counter to match the cable mark.	
Results	At cable mark 190m, depth counter reads 190.05m. At 250.00m the depth counter read 250.2m.
Settings applied	

B	Tool Assembly
Schematic	 
Results of checks.	All good

E	Equipment Calibration/Function Checklist	OK	Maintenance
Geophones			
	Geophone used (RD or R):	RD	
	Testing at ground surface performed before insertion in the borehole:		
	Level of electrical disturbance	OK	
	Water tightness	OK	
	Operation of side arm clamp	OK	
	Verification of noise level and real seismic signal in each component	OK	

E Equipment Calibration/Function Checklist	OK	Maintenance
Winch Motor and transmission Controller Brake Ground anchors	All OK	
Cable Borehole collar level mark Overnight clamp	All OK	
Depth counter	OK	
Radio check	OK	
Acquisition computer Computer Acquisition Software Data Analysis Software	OK OK OK	
Power source	OK	
Access vehicle	OK	
Geophones calibration certificate verification: Technical ID Signature Date Validity period Location	_X_ _X_ _X_ _X_ _X_	
Depth counter calibration certificate verification: Technical ID Signature Date Validity period Location	Calibration shown in Table A	

F Decontamination	
Verification of equipment decontamination before insertion into borehole	Yes

G Dummy Probe Run	
Done before insertion of geophones into borehole	Complete to 998m mbgs on January 25, 2022

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H	**Geophone Testing in Borehole**
Clamping location verified	Yes
Level of electrical disturbance	None
Operation of the side arm clamp	Good
Verification of noise in each component	Done, file Noise_0070__21_60003.dlc
Verification of real seismic signal in each component	Done, file V_BH6_0130__21_00195.dlc

I	**Shot**
Confirmation of shot point ID with receiver staff	Yes
Data acquisition sampling rate confirmed at 1 ms	Yes

J Field Data – Review and Verification

Depth of zero mark	**Shot ID**	**Data File**	**Comment/Verified** (fitness for use)
190	V90	V_BH6_0190__21_00196	**All ok**
		V_BH6_0190__21_00197	
		V_BH6_0190__21_00198	
190	V89	V_BH6_0190__21_00199	
		V_BH6_0190__21_00200	
		V_BH6_0190__21_00201	
190	V88	V_BH6_0190__21_00202	
		V_BH6_0190__21_00203	
		V_BH6_0190__21_00204	
190	V87	V_BH6_0190__21_00205	
		V_BH6_0190__21_00206	
		V_BH6_0190__21_00207	
190	V86	V_BH6_0190__21_00208	
		V_BH6_0190__21_00209	

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J	Field Data – Review and Verification		
		V_BH6_0190__21_00210	
190	V85	V_BH6_0190__21_00211	
		V_BH6_0190__21_00212	
		V_BH6_0190__21_00213	
190	V84	V_BH6_0190__21_00214	
		V_BH6_0190__21_00215	
		V_BH6_0190__21_00216	
190	V83	V_BH6_0190__21_00217	
		V_BH6_0190__21_00218	
		V_BH6_0190__21_00219	
190	V82	V_BH6_0190__21_00220	
		V_BH6_0190__21_00221	
		V_BH6_0190__21_00222	
190	V81	V_BH6_0190__21_00223	
		V_BH6_0190__21_00224	
		V_BH6_0190__21_00225	
190	V80	V_BH6_0190__21_00226	
		V_BH6_0190__21_00227	
		V_BH6_0190__21_00228	
190	V79	V_BH6_0190__21_00229	
		V_BH6_0190__21_00230	
		V_BH6_0190__21_00231	

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J	Field Data – Review and Verification		
190	V78	V_BH6_0190__21_00232	
		V_BH6_0190__21_00233	
		V_BH6_0190__21_00234	
190	V77	V_BH6_0190__21_00235	
		V_BH6_0190__21_00236	
		V_BH6_0190__21_00237	
190	V76	V_BH6_0190__21_00238	
		V_BH6_0190__21_00239	
		V_BH6_0190__21_00240	
190	V75	V_BH6_0190__21_00241	
		V_BH6_0190__21_00242	
		V_BH6_0190__21_00243	
190	V74	V_BH6_0190__21_00244	
		V_BH6_0190__21_00245	
		V_BH6_0190__21_00246	
		V_BH6_0190__21_90245	
		V_BH6_0190__21_90246	
190	V73	V_BH6_0190__21_00247	
		V_BH6_0190__21_00248	
		V_BH6_0190__21_00249	
190	V72	V_BH6_0190__21_00250	
		V_BH6_0190__21_00251	

J	Field Data – Review and Verification		
		V_BH6_0190__21_00252	
190	V44	V_BH6_0190__21_90253	
		V_BH6_0190__21_90254	
		V_BH6_0190__21_90255	
		V_BH6_0190__21_90256	
		V_BH6_0190__21_00253	
		V_BH6_0190__21_00254	
		V_BH6_0190__21_00255	
190	V45	V_BH6_0190__21_00256	
		V_BH6_0190__21_00257	
		V_BH6_0190__21_00258	
190	V46	V_BH6_0190__21_00259	
		V_BH6_0190__21_00260	
		V_BH6_0190__21_00261	
190	V47	V_BH6_0190__21_00262	
		V_BH6_0190__21_00263	
		V_BH6_0190__21_00264	
190	V48	V_BH6_0190__21_00265	
		V_BH6_0190__21_00266	
		V_BH6_0190__21_00267	
190	V49	V_BH6_0190__21_00268	
		V_BH6_0190__21_00269	

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J	Field Data – Review and Verification		
		V_BH6_0190__21_00270	
190	V71	V_BH6_0190__21_00271	
		V_BH6_0190__21_00272	
		V_BH6_0190__21_00273	
190	V91	V_BH6_0190__21_00274	
		V_BH6_0190__21_00275	
		V_BH6_0190__21_00276	
190	V92	V_BH6_0190__21_00277	
		V_BH6_0190__21_00278	
		V_BH6_0190__21_00279	
190	V93	V_BH6_0190__21_00280	
		V_BH6_0190__21_00281	
		V_BH6_0190__21_00282	
190	V94	V_BH6_0190__21_00283	
		V_BH6_0190__21_00284	
		V_BH6_0190__21_00285	
250	V94	V_BH6_0250__21_00286	**All ok**
		V_BH6_0250__21_00287	
		V_BH6_0250__21_00288	
250	V93	V_BH6_0250__21_00289	
		V_BH6_0250__21_00290	

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J	Field Data – Review and Verification		
		V_BH6_0250__21_00291	
250	V92	V_BH6_0250__21_00292	
		V_BH6_0250__21_00293	
		V_BH6_0250__21_00294	
250	V91	V_BH6_0250__21_00295	
		V_BH6_0250__21_00296	
		V_BH6_0250__21_00297	
250	V71	V_BH6_0250__21_00298	
		V_BH6_0250__21_00299	
		V_BH6_0250__21_00300	
250	V49	V_BH6_0250__21_00301	
		V_BH6_0250__21_00302	
		V_BH6_0250__21_00303	
250	V48	V_BH6_0250__21_00304	
		V_BH6_0250__21_00305	
		V_BH6_0250__21_00306	
250	V47	V_BH6_0250__21_00307	
		V_BH6_0250__21_00308	
		V_BH6_0250__21_00309	
250	V46	V_BH6_0250__21_00310	
		V_BH6_0250__21_00311	
		V_BH6_0250__21_00312	

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J	Field Data – Review and Verification		
250	V45	V_BH6_0250__21_00313	
		V_BH6_0250__21_00314	
		V_BH6_0250__21_00315	
250	V44	V_BH6_0250__21_00316	
		V_BH6_0250__21_00317	
		V_BH6_0250__21_00318	
250	V72	V_BH6_0250__21_00319	
		V_BH6_0250__21_00320	
		V_BH6_0250__21_00321	
250	V73	V_BH6_0250__21_00322	
		V_BH6_0250__21_00323	
		V_BH6_0250__21_00324	
250	V74	V_BH6_0250__21_00325	
		V_BH6_0250__21_00326	
		V_BH6_0250__21_00327	
250	V75	V_BH6_0250__21_00328	
		V_BH6_0250__21_00329	
		V_BH6_0250__21_00330	
250	V76	V_BH6_0250__21_00331	
		V_BH6_0250__21_00332	
		V_BH6_0250__21_00333	
250	V77	V_BH6_0250__21_00334	

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J	Field Data – Review and Verification		
		V_BH6_0250__21_00335	
		V_BH6_0250__21_00336	
250	V78	V_BH6_0250__21_00337	
		V_BH6_0250__21_00338	
		V_BH6_0250__21_00339	
250	V79	V_BH6_0250__21_00340	
		V_BH6_0250__21_00341	
		V_BH6_0250__21_00342	
250	V80	V_BH6_0250__21_00343	
		V_BH6_0250__21_00344	
		V_BH6_0250__21_00345	
250	V81	V_BH6_0250__21_00346	
		V_BH6_0250__21_00347	
		V_BH6_0250__21_00348	
250	V82	V_BH6_0250__21_00349	
		V_BH6_0250__21_00350	
		V_BH6_0250__21_00351	
250	V83	V_BH6_0250__21_00352	
		V_BH6_0250__21_00353	
		V_BH6_0250__21_00354	
250	V84	V_BH6_0250__21_00355	
		V_BH6_0250__21_00356	

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J	Field Data – Review and Verification		
		V_BH6_0250__21_00357	
250	V85	V_BH6_0250__21_00358	
		V_BH6_0250__21_00359	
		V_BH6_0250__21_00360	
250	V86	V_BH6_0250__21_00361	
		V_BH6_0250__21_00362	
		V_BH6_0250__21_00363	
250	V87	V_BH6_0250__21_00364	
		V_BH6_0250__21_00365	
		V_BH6_0250__21_00366	
250	V88	V_BH6_0250__21_00367	
		V_BH6_0250__21_00368	
		V_BH6_0250__21_00369	
250	V89	V_BH6_0250__21_00370	
		V_BH6_0250__21_00371	
		V_BH6_0250__21_00372	
250	V90	V_BH6_0250__21_00373	
		V_BH6_0250__21_00374	
		V_BH6_0250__21_00375	

K	Field Issues
Observed damage (note here as-needed additional detail on Daily Report items)	*corrective action (e.g. repair, component replacement)* *N/A*

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L File Control					
Data File	**Date Time**	**Depth Range**	**Staff**	**Software**	**Parameters/Settings**
V_BH6_0190__21_00196		80 – 135m	Cristian Vasile	VIPS5.11	1ms sample rate. 3 records of 20 seconds each
V_BH6_0190__21_00197					
V_BH6_0190__21_00198					
V_BH6_0190__21_00199					
V_BH6_0190__21_00200					
V_BH6_0190__21_00201					
V_BH6_0190__21_00202					
V_BH6_0190__21_00203					
V_BH6_0190__21_00204					
V_BH6_0190__21_00205					
V_BH6_0190__21_00206					
V_BH6_0190__21_00207					
V_BH6_0190__21_00208					
V_BH6_0190__21_00209					
V_BH6_0190__21_00210					
V_BH6_0190__21_00211					
V_BH6_0190__21_00212					
V_BH6_0190__21_00213					
V_BH6_0190__21_00214					
V_BH6_0190__21_00215					

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L File Control					
V_BH6_0190__21_00216					
V_BH6_0190__21_00217					
V_BH6_0190__21_00218					
V_BH6_0190__21_00219					
V_BH6_0190__21_00220					
V_BH6_0190__21_00221					
V_BH6_0190__21_00222					
V_BH6_0190__21_00223					
V_BH6_0190__21_00224					
V_BH6_0190__21_00225					
V_BH6_0190__21_00226					
V_BH6_0190__21_00227					
V_BH6_0190__21_00228					
V_BH6_0190__21_00229					
V_BH6_0190__21_00230					
V_BH6_0190__21_00231					
V_BH6_0190__21_00232					
V_BH6_0190__21_00233					
V_BH6_0190__21_00234					
V_BH6_0190__21_00235					
V_BH6_0190__21_00236					
V_BH6_0190__21_00237					

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L File Control					
V_BH6_0190__21_00238					
V_BH6_0190__21_00239					
V_BH6_0190__21_00240					
V_BH6_0190__21_00241					
V_BH6_0190__21_00242					
V_BH6_0190__21_00243					
V_BH6_0190__21_00244					
V_BH6_0190__21_00245					
V_BH6_0190__21_00246					
V_BH6_0190__21_90245					
V_BH6_0190__21_90246					
V_BH6_0190__21_00247					
V_BH6_0190__21_00248					
V_BH6_0190__21_00249					
V_BH6_0190__21_00250					
V_BH6_0190__21_00251					
V_BH6_0190__21_00252					
V_BH6_0190__21_90253					
V_BH6_0190__21_90254					
V_BH6_0190__21_90255					
V_BH6_0190__21_90256					
V_BH6_0190__21_00253					

L File Control					
V_BH6_0190__21_00254					
V_BH6_0190__21_00255					
V_BH6_0190__21_00256					
V_BH6_0190__21_00257					
V_BH6_0190__21_00258					
V_BH6_0190__21_00259					
V_BH6_0190__21_00260					
V_BH6_0190__21_00261					
V_BH6_0190__21_00262					
V_BH6_0190__21_00263					
V_BH6_0190__21_00264					
V_BH6_0190__21_00265					
V_BH6_0190__21_00266					
V_BH6_0190__21_00267					
V_BH6_0190__21_00268					
V_BH6_0190__21_00269					
V_BH6_0190__21_00270					
V_BH6_0190__21_00271					
V_BH6_0190__21_00272					
V_BH6_0190__21_00273					
V_BH6_0190__21_00274					
V_BH6_0190__21_00275					

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L File Control					
V_BH6_0190__21_00276					
V_BH6_0190__21_00277					
V_BH6_0190__21_00278					
V_BH6_0190__21_00279					
V_BH6_0190__21_00280					
V_BH6_0190__21_00281					
V_BH6_0190__21_00282					
V_BH6_0190__21_00283					
V_BH6_0190__21_00284					
V_BH6_0190__21_00285					
V_BH6_0250__21_00286		140 – 195m	Cristian Vasile	VIPS5.11	1ms sample rate. 3 records of 20 seconds each
V_BH6_0250__21_00287					
V_BH6_0250__21_00288					
V_BH6_0250__21_00289					
V_BH6_0250__21_00290					
V_BH6_0250__21_00291					
V_BH6_0250__21_00292					
V_BH6_0250__21_00293					
V_BH6_0250__21_00294					
V_BH6_0250__21_00295					
V_BH6_0250__21_00296					

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L File Control					
V_BH6_0250__21_00297					
V_BH6_0250__21_00298					
V_BH6_0250__21_00299					
V_BH6_0250__21_00300					
V_BH6_0250__21_00301					
V_BH6_0250__21_00302					
V_BH6_0250__21_00303					
V_BH6_0250__21_00304					
V_BH6_0250__21_00305					
V_BH6_0250__21_00306					
V_BH6_0250__21_00307					
V_BH6_0250__21_00308					
V_BH6_0250__21_00309					
V_BH6_0250__21_00310					
V_BH6_0250__21_00311					
V_BH6_0250__21_00312					
V_BH6_0250__21_00313					
V_BH6_0250__21_00314					
V_BH6_0250__21_00315					
V_BH6_0250__21_00316					
V_BH6_0250__21_00317					
V_BH6_0250__21_00318					

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L **File Control**					
V_BH6_0250__21_00319					
V_BH6_0250__21_00320					
V_BH6_0250__21_00321					
V_BH6_0250__21_00322					
V_BH6_0250__21_00323					
V_BH6_0250__21_00324					
V_BH6_0250__21_00325					
V_BH6_0250__21_00326					
V_BH6_0250__21_00327					
V_BH6_0250__21_00328					
V_BH6_0250__21_00329					
V_BH6_0250__21_00330					
V_BH6_0250__21_00331					
V_BH6_0250__21_00332					
V_BH6_0250__21_00333					
V_BH6_0250__21_00334					
V_BH6_0250__21_00335					
V_BH6_0250__21_00336					
V_BH6_0250__21_00337					
V_BH6_0250__21_00338					
V_BH6_0250__21_00339					
V_BH6_0250__21_00340					

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L	**File Control**				
V_BH6_0250__21_00341					
V_BH6_0250__21_00342					
V_BH6_0250__21_00343					
V_BH6_0250__21_00344					
V_BH6_0250__21_00345					
V_BH6_0250__21_00346					
V_BH6_0250__21_00347					
V_BH6_0250__21_00348					
V_BH6_0250__21_00349					
V_BH6_0250__21_00350					
V_BH6_0250__21_00351					
V_BH6_0250__21_00352					
V_BH6_0250__21_00353					
V_BH6_0250__21_00354					
V_BH6_0250__21_00355					
V_BH6_0250__21_00356					
V_BH6_0250__21_00357					
V_BH6_0250__21_00358					
V_BH6_0250__21_00359					
V_BH6_0250__21_00360					
V_BH6_0250__21_00361					
V_BH6_0250__21_00362					

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L File Control					
V_BH6_0250__21_00363					
V_BH6_0250__21_00364					
V_BH6_0250__21_00365					
V_BH6_0250__21_00366					
V_BH6_0250__21_00367					
V_BH6_0250__21_00368					
V_BH6_0250__21_00369					
V_BH6_0250__21_00370					
V_BH6_0250__21_00371					
V_BH6_0250__21_00372					
V_BH6_0250__21_00373					
V_BH6_0250__21_00374					
V_BH6_0250__21_00375					

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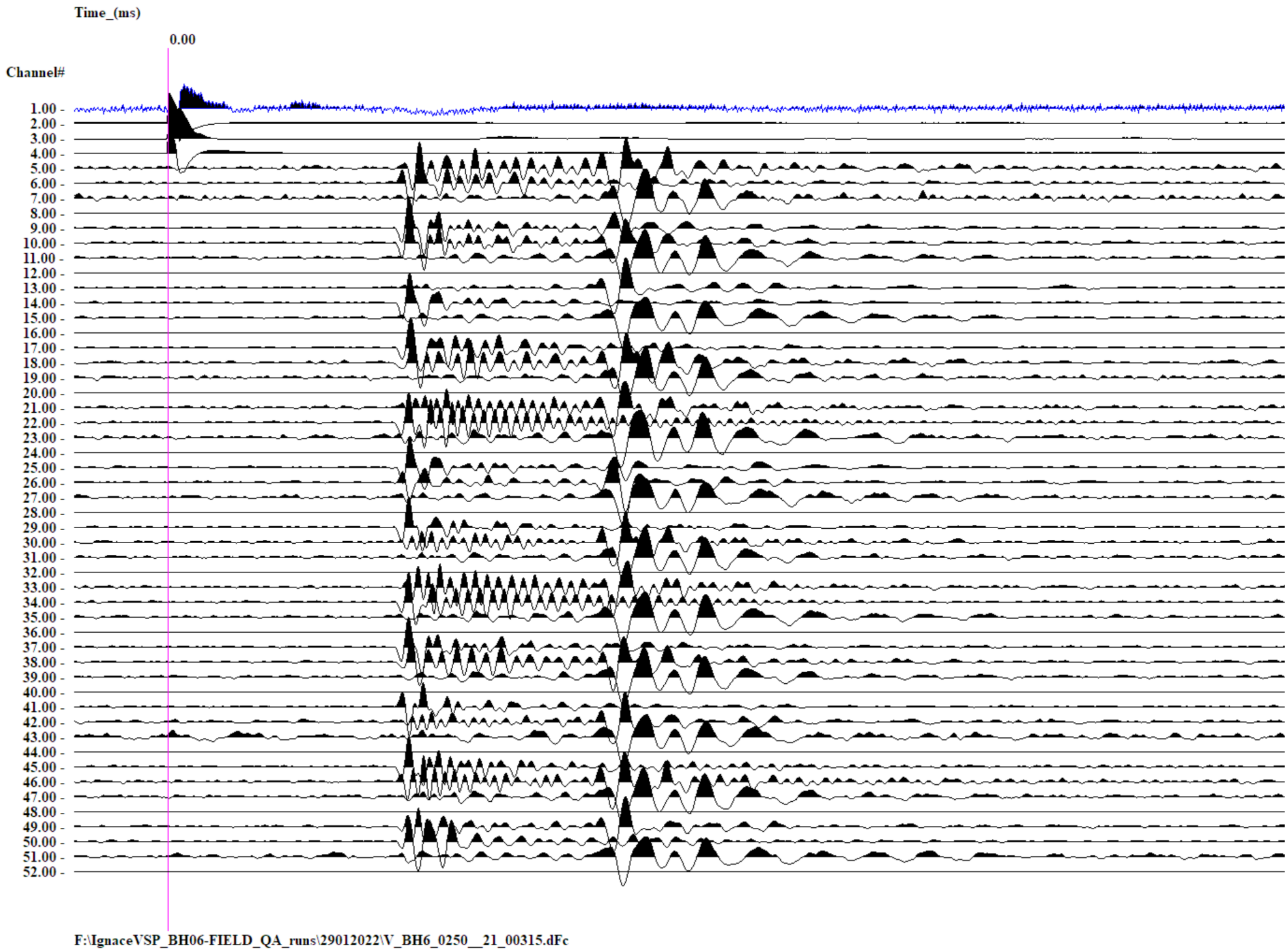

Time_(ms)
0.00
Channel#
F:\IgnaceVSP_BH06-FIELD_QA_runs\29012022\V_BH6_0250__21_00315.dFc

V45_L4

VIBROMETRIC

Vibrometric Seismic Source Checklist

Engine Off Checks	OK	Maintenance
Leaks – Fuel, Hydraulic Oil, Engine Oil or Radiator Coolant	✓	
Tires – Condition and Pressure	✓	
Hydraulic Hoses, Mast Chains, Cables and Stops – Check Visually	✓	
Safety Warnings – Attached (Refer to Parts Manual for Location)	✓	
Battery – Check Water/Electrolyte Level and Charge	✓	
Hydraulic Fluid Level – Check Level	✓	
Engine Oil Level – Dipstick	✓	
Transmission Fluid Level – Dipstick	✓	
Radiator Coolant – Check Level	✓	
Operator's Manual – In Container	✓	
Nameplate – Attached and Information Matches Model, Serial Number and Attachments	✓	
Seat Belt – Functioning Smoothly	✓	
Hood Latch – Adjusted and Securely Fastened	✓	
Brake Fluid – Check Level	✓	
Seismic Vibrator Check Screws, Cables, Hoses	✓	
Fuel level	✓	
Lights check	✓	
Engine On Checks	**OK**	**Maintenance**
Accelerator or Direction Control Pedal – Functioning Smoothly	✓	
Service Brake – Functioning Smoothly	✓	
Parking Brake – Functioning Smoothly	✓	
Steering Operation – Functioning Smoothly	✓	
Drive Control – Forward/Reverse – Functioning Smoothly	✓	
Arm Tilt Control – Forward and Back – Functioning Smoothly	✓	
Hoist (Seismic Source) and Lowering Control – Functioning Smoothly	✓	
Testing the sweep – Operation		
Horn and Lights – Functioning	✓	
Cab (if equipped) – Heater, Defroster, Wipers – Functioning	✓	
Gauges: Ammeter, Engine Oil Pressure, Hour Meter, Fuel Level, Temperature, Instrument Monitors – Functioning	✓	
Controller check | Trigger sensor on impact plate check		
Impact plate check | Radio check	✓	
Source type	✓	

[signature] JAN 29/2022

O Sign-Off		
Prepared	*Jon Crawford*	*January 29, 2022*
Reviewed	*Nicoleta Enescu*	*January 29, 2022*
Approved	*Christopher Phillips*	*January 29, 2022*

TO:	Mostafa Khorshidi	**Date:**	*220130*
	Maria Sánchez-Rico Castejón	**Work Package:**	WP12 – VSP Profiling
	Sarah Hirschorn		
CC:	George Schneider		
		Distributed By:	Email

Record Number: 20253946-6120-220130

IGBH_06, IGNACE, ONTARIO

Acquisition depth interval: L5 (320 – 375 m), L6 (380 – 435m) and L7 (440 – 495m)

Staff: Cristian Vasile

Start time: 10:00 am Finish time: 5:30 pm

Shot location(s): All 30 shot locations for levels at 310m, 370m and 430m

Prepared by: Nicoleta Enescu

Verified by: Christopher Phillips

Usage notes:

- Complete one form per field day
- Office forms will be complete as processing packages/tasks are completed and will include supporting documentation
- Complete all header information (above)
- Delete unused tables (below) and fully populate those that remain
- Form is divided into A through O tables and field and processing tasks

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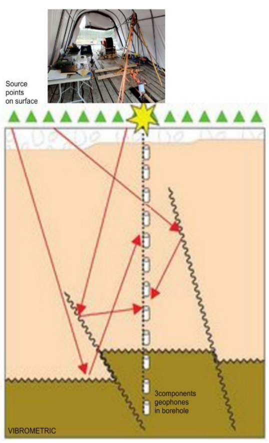
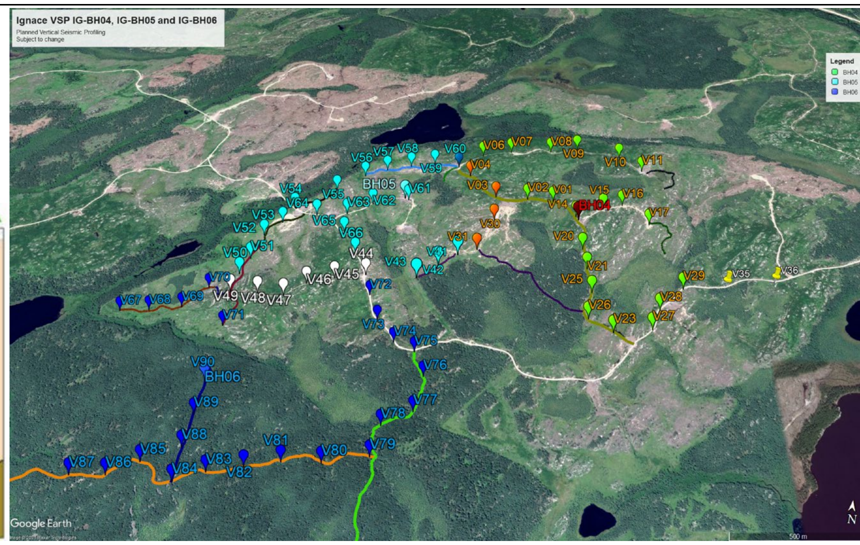
FIELD

A Winch and Depth Counter	
Calibrated by measuring and marking the cable every 100 m before insertion in the borehole. Verifying these distances using the depth counter. Discrepancies are adjusted by changing the depth value on the depth counter to match the cable mark.	
Results	At cable mark 310m, depth counter reads 310.08m. At 370.00m the depth counter read 369.94m. At 430.00m the depth counter read 430.1m.
Settings applied	

B Tool Assembly	
Schematic	 
Results of checks.	All good

E Equipment Calibration/Function Checklist	OK	Maintenance
Geophones Geophone used (RD or R):	RD	
Testing at ground surface performed before insertion in the borehole:		
Level of electrical disturbance	OK	
Water tightness	OK	
Operation of side arm clamp	OK	
Verification of noise level and real seismic signal in each component	OK	

E	Equipment Calibration/Function Checklist	OK	Maintenance
Winch Motor and transmission Controller Brake Ground anchors		All OK	
Cable Borehole collar level mark Overnight clamp		All OK	
Depth counter		OK	
Radio check		OK	
Acquisition computer Computer Acquisition Software Data Analysis Software		OK OK OK	
Power source		OK	
Access vehicle		OK	
Geophones calibration certificate verification: Technical ID Signature Date Validity period Location		_X_ _X_ _X_ _X_ _X_	
Depth counter calibration certificate verification: Technical ID Signature Date Validity period Location		Calibration shown in Table A	

F	Decontamination
Verification of equipment decontamination before insertion into borehole	Yes

G	Dummy Probe Run
Done before insertion of geophones into borehole	Complete to 998m mbgs on January 25, 2022

H Geophone Testing in Borehole	
Clamping location verified	Yes
Level of electrical disturbance	None
Operation of the side arm clamp	Good
Verification of noise in each component	Done, file Noise_0070__21_60004.dlc
Verification of real seismic signal in each component	Done, file V_BH6_0310__21_00384.dlc

I Shot	
Confirmation of shot point ID with receiver staff	Yes
Data acquisition sampling rate confirmed at 1 ms	Yes

J Field Data – Review and Verification

Depth of zero mark	**Shot ID**	**Data File**	**Comment/Verified** (fitness for use)
310	V90	V_BH6_0310__21_00376	**All ok**
		V_BH6_0310__21_00377	
		V_BH6_0310__21_00378	
310	V89	V_BH6_0310__21_00379	
		V_BH6_0310__21_00380	
		V_BH6_0310__21_00381	
310	V88	V_BH6_0310__21_00382	
		V_BH6_0310__21_00383	
		V_BH6_0310__21_00384	
310	V88	V_BH6_0310__21_00385	
		V_BH6_0310__21_00386	
		V_BH6_0310__21_00387	
310	V87	V_BH6_0310__21_00388	
		V_BH6_0310__21_00389	

J	Field Data – Review and Verification		
		V_BH6_0310__21_00390	
310	V86	V_BH6_0310__21_00391	
		V_BH6_0310__21_00392	
		V_BH6_0310__21_00393	
310	V85	V_BH6_0310__21_00394	
		V_BH6_0310__21_00395	
		V_BH6_0310__21_00396	
310	V84	V_BH6_0310__21_00397	
		V_BH6_0310__21_00398	
		V_BH6_0310__21_00399	
310	V83	V_BH6_0310__21_00400	
		V_BH6_0310__21_00401	
		V_BH6_0310__21_00402	
310	V82	V_BH6_0310__21_00403	
		V_BH6_0310__21_00404	
		V_BH6_0310__21_00405	
310	V81	V_BH6_0310__21_00406	
		V_BH6_0310__21_00407	
		V_BH6_0310__21_00408	
310	V80	V_BH6_0310__21_00409	
		V_BH6_0310__21_00410	
		V_BH6_0310__21_00411	

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J	Field Data – Review and Verification		
310	V79	V_BH6_0310__21_00412	
		V_BH6_0310__21_00413	
		V_BH6_0310__21_00414	
310	V78	V_BH6_0310__21_00415	
		V_BH6_0310__21_00416	
		V_BH6_0310__21_00417	
310	V77	V_BH6_0310__21_00418	
		V_BH6_0310__21_00419	
		V_BH6_0310__21_00420	
310	V76	V_BH6_0310__21_00421	
		V_BH6_0310__21_00422	
		V_BH6_0310__21_00423	
310	V75	V_BH6_0310__21_00424	
		V_BH6_0310__21_00425	
		V_BH6_0310__21_00426	
310	V74	V_BH6_0310__21_00427	
		V_BH6_0310__21_00428	
		V_BH6_0310__21_00429	
310	V73	V_BH6_0310__21_00430	
		V_BH6_0310__21_00431	
		V_BH6_0310__21_00432	
310	V72	V_BH6_0310__21_00433	

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J	Field Data – Review and Verification		
		V_BH6_0310__21_00434	
		V_BH6_0310__21_00435	
310	V44	V_BH6_0310__21_00436	
		V_BH6_0310__21_00437	
		V_BH6_0310__21_00438	
310	V45	V_BH6_0310__21_00439	
		V_BH6_0310__21_00440	
		V_BH6_0310__21_00441	
310	V46	V_BH6_0310__21_00442	
		V_BH6_0310__21_00443	
		V_BH6_0310__21_00444	
310	V47	V_BH6_0310__21_00445	
		V_BH6_0310__21_00446	
		V_BH6_0310__21_00447	
310	V48	V_BH6_0310__21_00448	
		V_BH6_0310__21_00449	
		V_BH6_0310__21_00450	
310	V49	V_BH6_0310__21_00451	
		V_BH6_0310__21_00452	
		V_BH6_0310__21_00453	
310	V71	V_BH6_0310__21_00454	
		V_BH6_0310__21_00455	

J	Field Data – Review and Verification		
		V_BH6_0310__21_00456	
310	V91	V_BH6_0310__21_00457	
		V_BH6_0310__21_00458	
		V_BH6_0310__21_00459	
310	V92	V_BH6_0310__21_00460	
		V_BH6_0310__21_00461	
		V_BH6_0310__21_00462	
310	V93	V_BH6_0310__21_00463	
		V_BH6_0310__21_00464	
		V_BH6_0310__21_00465	
310	V94	V_BH6_0310__21_00466	
		V_BH6_0310__21_00467	
		V_BH6_0310__21_00468	
370	V94	V_BH6_0370__21_00469	**All ok**
		V_BH6_0370__21_00470	
		V_BH6_0370__21_00471	
370	V93	V_BH6_0370__21_00472	
		V_BH6_0370__21_00473	
		V_BH6_0370__21_00474	
370	V92	V_BH6_0370__21_00475	
		V_BH6_0370__21_00476	

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J	Field Data – Review and Verification		
		V_BH6_0370__21_00477	
370	V91	V_BH6_0370__21_00478	
		V_BH6_0370__21_00479	
		V_BH6_0370__21_00480	
370	V71	V_BH6_0370__21_00481	
		V_BH6_0370__21_00482	
		V_BH6_0370__21_00483	
370	V49	V_BH6_0370__21_00484	
		V_BH6_0370__21_00485	
		V_BH6_0370__21_00486	
370	V48	V_BH6_0370__21_00487	
		V_BH6_0370__21_00488	
		V_BH6_0370__21_00489	
370	V47	V_BH6_0370__21_00490	
		V_BH6_0370__21_00491	
		V_BH6_0370__21_00492	
370	V46	V_BH6_0370__21_00493	
		V_BH6_0370__21_00494	
		V_BH6_0370__21_00495	
370	V45	V_BH6_0370__21_00496	
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		V_BH6_0370__21_00498	

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J	Field Data – Review and Verification		
370	V44	V_BH6_0370__21_00499	
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370	V72	V_BH6_0370__21_00502	
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		V_BH6_0370__21_00504	
370	V73	V_BH6_0370__21_00505	
		V_BH6_0370__21_00506	
		V_BH6_0370__21_00507	
370	V74	V_BH6_0370__21_00508	
		V_BH6_0370__21_00509	
		V_BH6_0370__21_00510	
370	V75	V_BH6_0370__21_00511	
		V_BH6_0370__21_00512	
		V_BH6_0370__21_00513	
370	V76	V_BH6_0370__21_00514	
		V_BH6_0370__21_00515	
		V_BH6_0370__21_00516	
370	V77	V_BH6_0370__21_00517	
		V_BH6_0370__21_00518	
		V_BH6_0370__21_00519	
370	V78	V_BH6_0370__21_00520	

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J	Field Data – Review and Verification		
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370	V79	V_BH6_0370__21_00523	
		V_BH6_0370__21_00524	
		V_BH6_0370__21_00525	
370	V80	V_BH6_0370__21_00526	
		V_BH6_0370__21_00527	
		V_BH6_0370__21_00528	
370	V81	V_BH6_0370__21_00529	
		V_BH6_0370__21_00530	
		V_BH6_0370__21_00531	
370	V82	V_BH6_0370__21_00532	
		V_BH6_0370__21_00533	
		V_BH6_0370__21_00534	
370	V83	V_BH6_0370__21_00535	
		V_BH6_0370__21_00536	
		V_BH6_0370__21_00537	
370	V84	V_BH6_0370__21_00538	
		V_BH6_0370__21_00539	
		V_BH6_0370__21_00540	
370	V85	V_BH6_0370__21_00541	
		V_BH6_0370__21_00542	

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J	Field Data – Review and Verification		
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370	V86	V_BH6_0370__21_00544	
		V_BH6_0370__21_00545	
		V_BH6_0370__21_00546	
370	V87	V_BH6_0370__21_00547	
		V_BH6_0370__21_00548	
		V_BH6_0370__21_00549	
370	V88	V_BH6_0370__21_00550	
		V_BH6_0370__21_00551	
		V_BH6_0370__21_00552	
370	V89	V_BH6_0370__21_00553	
		V_BH6_0370__21_00554	
		V_BH6_0370__21_00555	
370	V90	V_BH6_0370__21_00556	
		V_BH6_0370__21_00557	
		V_BH6_0370__21_00558	
430	V90	V_BH6_0430__21_00559	**All ok**
		V_BH6_0430__21_00560	
		V_BH6_0430__21_00561	
430	V89	V_BH6_0430__21_00562	
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J	Field Data – Review and Verification		
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430	V87	V_BH6_0430__21_00568	
		V_BH6_0430__21_00569	
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430	V86	V_BH6_0430__21_00571	
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430	V84	V_BH6_0430__21_00577	
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		V_BH6_0430__21_00579	
430	V83	V_BH6_0430__21_00580	
		V_BH6_0430__21_00581	
		V_BH6_0430__21_00582	
430	V82	V_BH6_0430__21_00583	
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J	Field Data – Review and Verification		
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		V_BH6_0430__21_00588	
430	V80	V_BH6_0430__21_00589	
		V_BH6_0430__21_00590	
		V_BH6_0430__21_00591	
430	V79	V_BH6_0430__21_00592	
		V_BH6_0430__21_00593	
		V_BH6_0430__21_00594	
430	V78	V_BH6_0430__21_00595	
		V_BH6_0430__21_00596	
		V_BH6_0430__21_00597	
430	V77	V_BH6_0430__21_00598	
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		V_BH6_0430__21_00600	
430	V76	V_BH6_0430__21_00601	
		V_BH6_0430__21_00602	
		V_BH6_0430__21_00603	
430	V75	V_BH6_0430__21_00604	
		V_BH6_0430__21_00605	
		V_BH6_0430__21_00606	
430	V74	V_BH6_0430__21_00607	

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J	Field Data – Review and Verification		
		V_BH6_0430__21_00608	
		V_BH6_0430__21_00609	
430	V73	V_BH6_0430__21_00610	
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		V_BH6_0430__21_00612	
430	V72	V_BH6_0430__21_00613	
		V_BH6_0430__21_00614	
		V_BH6_0430__21_00615	
430	V44	V_BH6_0430__21_00616	
		V_BH6_0430__21_00617	
		V_BH6_0430__21_00618	
430	V45	V_BH6_0430__21_00619	
		V_BH6_0430__21_00620	
		V_BH6_0430__21_00621	
430	V46	V_BH6_0430__21_00622	
		V_BH6_0430__21_00623	
		V_BH6_0430__21_00624	
430	V47	V_BH6_0430__21_00625	
		V_BH6_0430__21_00626	
		V_BH6_0430__21_00627	
430	V48	V_BH6_0430__21_00628	
		V_BH6_0430__21_00629	

J	Field Data – Review and Verification		
		V_BH6_0430__21_00630	
430	V49	V_BH6_0430__21_00631	
		V_BH6_0430__21_00632	
		V_BH6_0430__21_00633	
430	V71	V_BH6_0430__21_00634	
		V_BH6_0430__21_00635	
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430	V91	V_BH6_0430__21_00637	
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430	V93	V_BH6_0430__21_00643	
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		V_BH6_0430__21_00645	
430	V94	V_BH6_0430__21_00646	
		V_BH6_0430__21_00647	
		V_BH6_0430__21_00648	

K	Field Issues
Observed damage (note here as-needed additional detail on Daily Report items)	*corrective action (e.g. repair, component replacement)* *N/A*

L	**File Control**				
Data File	**Date Time**	**Depth Range**	**Staff**	**Software**	**Parameters/Settings**
V_BH6_0310__21_00376		320 – 375m	Cristian Vasile	VIPS5.11	1ms sample rate. 3 records of 20 seconds each
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V_BH6_0310__21_00378					
V_BH6_0310__21_00379					
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L	**File Control**				
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L **File Control**					
V_BH6_0310__21_00418					
V_BH6_0310__21_00419					
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L **File Control**					
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L File Control					
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V_BH6_0310__21_00466					
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V_BH6_0310__21_00468					
V_BH6_0370__21_00469		380 – 435m	Cristian Vasile	VIPS5.11	1ms sample rate. 3 records of 20 seconds each
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L File Control					
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L File Control					
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L File Control					
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L	**File Control**				
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V_BH6_0430__21_00559		440 – 495m	Cristian Vasile	VIPS5.11	1ms sample rate. 3 records of 20 seconds each
V_BH6_0430__21_00560					
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L	**File Control**				
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L **File Control**					
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L File Control					
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L File Control					
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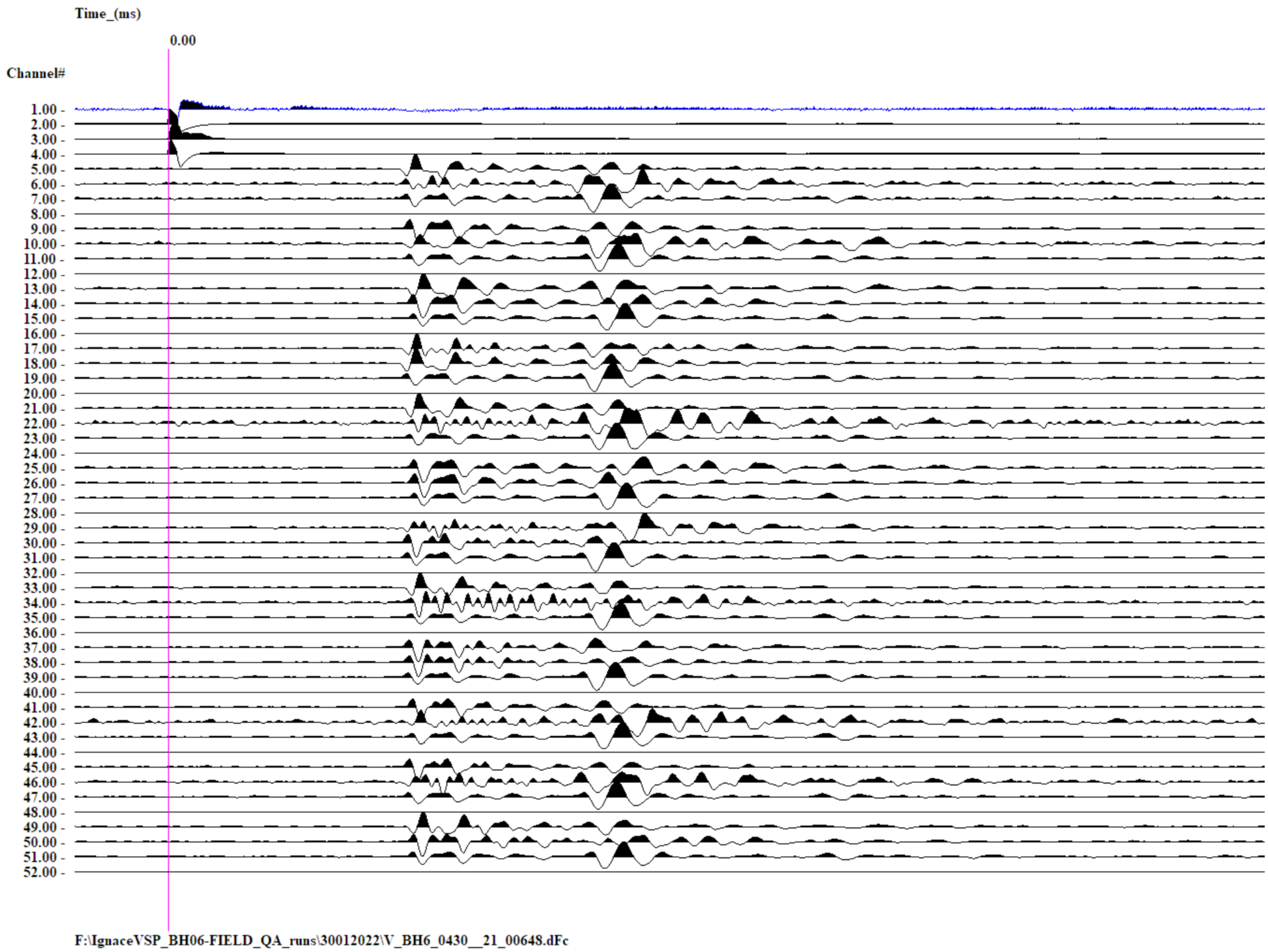
V_BH6_0430__21_00648					



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F:\IgnaceVSP_BH06-FIELD_QA_runs\30012022\V_BH6_0430__21_00648.dFc

V94_L7

VIBROMETRIC

Vibrometric Seismic Source Checklist

Engine Off Checks	OK	Maintenance
Leaks – Fuel, Hydraulic Oil, Engine Oil or Radiator Coolant	✓	
Tires – Condition and Pressure	✓	
Hydraulic Hoses, Mast Chains, Cables and Stops – Check Visually	✓	
Safety Warnings – Attached (Refer to Parts Manual for Location)	✓	
Battery – Check Water/Electrolyte Level and Charge	✓	
Hydraulic Fluid Level – Check Level	✓	
Engine Oil Level – Dipstick	✓	
Transmission Fluid Level – Dipstick	✓	
Radiator Coolant – Check Level	✓	
Operator's Manual – In Container	✓	
Nameplate – Attached and Information Matches Model, Serial Number and Attachments	✓	
Seat Belt – Functioning Smoothly	✓	
Hood Latch – Adjusted and Securely Fastened	✓	
Brake Fluid – Check Level	✓	
Seismic Vibrator Check Screws, Cables, Hoses	✓	
Fuel level	✓	
Lights check	✓	
Engine On Checks	**OK**	**Maintenance**
Accelerator or Direction Control Pedal – Functioning Smoothly	✓	
Service Brake – Functioning Smoothly	✓	
Parking Brake – Functioning Smoothly	✓	
Steering Operation – Functioning Smoothly	✓	
Drive Control – Forward/Reverse – Functioning Smoothly	✓	
Arm Tilt Control – Forward and Back – Functioning Smoothly	✓	
Hoist (Seismic Source) and Lowering Control – Functioning Smoothly	✓	
Testing the sweep – Operation		
Horn and Lights – Functioning	✓	
Cab (if equipped) – Heater, Defroster, Wipers – Functioning	✓	
Gauges: Ammeter, Engine Oil Pressure, Hour Meter, Fuel Level, Temperature, Instrument Monitors – Functioning	✓	
Controller check | Trigger sensor on impact plate check		
Impact plate check | Radio check	✓	
Source type	✓	

JAN 30/22

O **Sign-Off**		
Prepared	*Jon Crawford*	*January 30, 2022*
Reviewed	*Nicoleta Enescu*	*January 30, 2022*
Approved	*Christopher Phillips*	*January 30, 2022*

TO:	Mostafa Khorshidi	**Date:**	*220131*
	Maria Sánchez-Rico Castejón	**Work Package:**	WP12 – VSP Profiling
	Sarah Hirschorn		
CC:	George Schneider		
		Distributed By:	Email

Record Number: 20253946-6120-220131

IGBH_06, IGNACE, ONTARIO

Acquisition depth interval: L8 (500 – 555 m), L9 (560 – 615m) and L10 (620 – 675m)

Staff: Cristian Vasile

Start time: 09:15 am **Finish time: 4:45 pm**

Shot location(s): All 30 shot locations for levels at 490m, 550m and 10 shot locations at 610m

Prepared by: Nicoleta Enescu

Verified by: Christopher Phillips

Usage notes:

- Complete one form per field day
- Office forms will be complete as processing packages/tasks are completed and will include supporting documentation
- Complete all header information (above)
- Delete unused tables (below) and fully populate those that remain
- Form is divided into A through O tables and field and processing tasks

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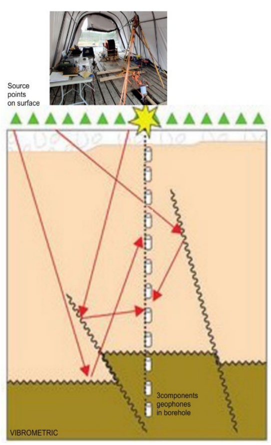
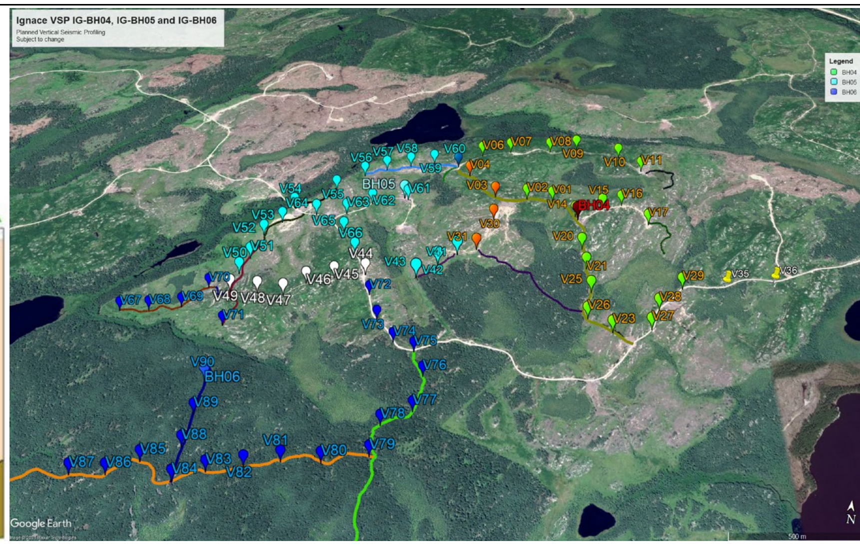
FIELD

A	Winch and Depth Counter
Calibrated by measuring and marking the cable every 100 m before insertion in the borehole. Verifying these distances using the depth counter. Discrepancies are adjusted by changing the depth value on the depth counter to match the cable mark.	
Results	At cable mark 490m, depth counter reads 489.98m. At 550.00m the depth counter read 549.93m. At 610.00m the depth counter read 609.98m.
Settings applied	

B	Tool Assembly
Schematic	 
Results of checks.	All good

E	Equipment Calibration/Function Checklist	OK	Maintenance
Geophones			
	Geophone used (RD or R):	RD	
	Testing at ground surface performed before insertion in the borehole:		
	Level of electrical disturbance	OK	
	Water tightness	OK	
	Operation of side arm clamp	OK	
	Verification of noise level and real seismic signal in each component	OK	

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E Equipment Calibration/Function Checklist	OK	Maintenance
Winch Motor and transmission Controller Brake Ground anchors	All OK	
Cable Borehole collar level mark Overnight clamp	All OK	
Depth counter	OK	
Radio check	OK	
Acquisition computer Computer Acquisition Software Data Analysis Software	OK OK OK	
Power source	OK	
Access vehicle	OK	
Geophones calibration certificate verification: Technical ID Signature Date Validity period Location	_X_ _X_ _X_ _X_ _X_	
Depth counter calibration certificate verification: Technical ID Signature Date Validity period Location	Calibration shown in Table A	

F Decontamination	
Verification of equipment decontamination before insertion into borehole	Yes

G Dummy Probe Run	
Done before insertion of geophones into borehole	Complete to 998m mbgs on January 25, 2022

H	**Geophone Testing in Borehole**
Clamping location verified	Yes
Level of electrical disturbance	None
Operation of the side arm clamp	Good
Verification of noise in each component	Done, file Noise_0070__21_60005.dlc
Verification of real seismic signal in each component	Done, file V_BH6_0490__21_00651.dlc

I	**Shot**
Confirmation of shot point ID with receiver staff	Yes
Data acquisition sampling rate confirmed at 1 ms	Yes

J Field Data – Review and Verification

Depth of zero mark	**Shot ID**	**Data File**	**Comment/Verified** (fitness for use)
490	V90	V_BH6_0490__21_00652	**All ok**
		V_BH6_0490__21_00653	
		V_BH6_0490__21_00654	
490	V89	V_BH6_0490__21_00655	
		V_BH6_0490__21_00656	
		V_BH6_0490__21_00657	
490	V88	V_BH6_0490__21_00658	
		V_BH6_0490__21_00659	
		V_BH6_0490__21_00660	
490	V87	V_BH6_0490__21_00661	
		V_BH6_0490__21_00662	
		V_BH6_0490__21_00663	
490	V86	V_BH6_0490__21_00664	
		V_BH6_0490__21_00665	

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J	Field Data – Review and Verification		
		V_BH6_0490__21_00666	
490	V85	V_BH6_0490__21_00667	
		V_BH6_0490__21_00668	
		V_BH6_0490__21_00669	
490	V84	V_BH6_0490__21_00670	
		V_BH6_0490__21_00671	
		V_BH6_0490__21_00672	
490	V83	V_BH6_0490__21_00673	
		V_BH6_0490__21_00674	
		V_BH6_0490__21_00675	
490	V82	V_BH6_0490__21_00676	
		V_BH6_0490__21_00677	
		V_BH6_0490__21_00678	
490	V81	V_BH6_0490__21_00679	
		V_BH6_0490__21_00680	
		V_BH6_0490__21_00681	
490	V80	V_BH6_0490__21_00682	
		V_BH6_0490__21_00683	
		V_BH6_0490__21_00684	
490	V79	V_BH6_0490__21_00685	
		V_BH6_0490__21_00686	
		V_BH6_0490__21_00687	

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J	Field Data – Review and Verification		
490	V78	V_BH6_0490__21_00688	
		V_BH6_0490__21_00689	
		V_BH6_0490__21_00690	
490	V77	V_BH6_0490__21_00691	
		V_BH6_0490__21_00692	
		V_BH6_0490__21_00693	
490	V76	V_BH6_0490__21_00694	
		V_BH6_0490__21_00695	
		V_BH6_0490__21_00696	
490	V75	V_BH6_0490__21_00697	
		V_BH6_0490__21_00698	
		V_BH6_0490__21_00699	
490	V74	V_BH6_0490__21_00700	
		V_BH6_0490__21_00701	
		V_BH6_0490__21_00702	
490	V73	V_BH6_0490__21_00703	
		V_BH6_0490__21_00704	
		V_BH6_0490__21_00705	
490	V72	V_BH6_0490__21_00706	
		V_BH6_0490__21_00707	
		V_BH6_0490__21_00708	
490	V44	V_BH6_0490__21_00709	

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J	Field Data – Review and Verification		
		V_BH6_0490__21_00710	
		V_BH6_0490__21_00711	
490	V45	V_BH6_0490__21_00712	
		V_BH6_0490__21_00713	
		V_BH6_0490__21_00714	
490	V46	V_BH6_0490__21_00715	
		V_BH6_0490__21_00716	
		V_BH6_0490__21_00717	
490	V47	V_BH6_0490__21_00718	
		V_BH6_0490__21_00719	
		V_BH6_0490__21_00720	
490	V48	V_BH6_0490__21_00721	
		V_BH6_0490__21_00722	
		V_BH6_0490__21_00723	
490	V49	V_BH6_0490__21_00724	
		V_BH6_0490__21_00725	
		V_BH6_0490__21_00726	
490	V71	V_BH6_0490__21_00727	
		V_BH6_0490__21_00728	
		V_BH6_0490__21_00729	
490	V91	V_BH6_0490__21_00730	
		V_BH6_0490__21_00731	

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J	Field Data – Review and Verification		
		V_BH6_0490__21_00732	
490	V92	V_BH6_0490__21_00733	
		V_BH6_0490__21_00734	
		V_BH6_0490__21_00735	
490	V93	V_BH6_0490__21_00736	
		V_BH6_0490__21_00737	
		V_BH6_0490__21_00738	
490	V94	V_BH6_0490__21_00739	
		V_BH6_0490__21_00740	
		V_BH6_0490__21_00741	
550	V94	V_BH6_0550__21_00742	**All ok**
		V_BH6_0550__21_00743	
		V_BH6_0550__21_00744	
550	V93	V_BH6_0550__21_00745	
		V_BH6_0550__21_00746	
		V_BH6_0550__21_00747	
550	V92	V_BH6_0550__21_00748	
		V_BH6_0550__21_00749	
		V_BH6_0550__21_00750	
550	V91	V_BH6_0550__21_00751	
		V_BH6_0550__21_00752	

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J	Field Data – Review and Verification		
		V_BH6_0550__21_00753	
550	V71	V_BH6_0550__21_00754	
		V_BH6_0550__21_00755	
		V_BH6_0550__21_00756	
550	V49	V_BH6_0550__21_00757	
		V_BH6_0550__21_00758	
		V_BH6_0550__21_00759	
550	V48	V_BH6_0550__21_00760	
		V_BH6_0550__21_00761	
		V_BH6_0550__21_00762	
550	V47	V_BH6_0550__21_00763	
		V_BH6_0550__21_00764	
		V_BH6_0550__21_00765	
550	V46	V_BH6_0550__21_00766	
		V_BH6_0550__21_00767	
		V_BH6_0550__21_00768	
550	V45	V_BH6_0550__21_00769	
		V_BH6_0550__21_00770	
		V_BH6_0550__21_00771	
550	V44	V_BH6_0550__21_00772	
		V_BH6_0550__21_00773	
		V_BH6_0550__21_00774	

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J	Field Data – Review and Verification		
550	V72	V_BH6_0550__21_00775	
		V_BH6_0550__21_00776	
		V_BH6_0550__21_00777	
550	V73	V_BH6_0550__21_00778	
		V_BH6_0550__21_00779	
		V_BH6_0550__21_00780	
550	V74	V_BH6_0550__21_00781	
		V_BH6_0550__21_00782	
		V_BH6_0550__21_00783	
550	V75	V_BH6_0550__21_00784	
		V_BH6_0550__21_00785	
		V_BH6_0550__21_00786	
550	V76	V_BH6_0550__21_00787	
		V_BH6_0550__21_00788	
		V_BH6_0550__21_00789	
550	V77	V_BH6_0550__21_00790	
		V_BH6_0550__21_00791	
		V_BH6_0550__21_00792	
550	V78	V_BH6_0550__21_00793	
		V_BH6_0550__21_00794	
		V_BH6_0550__21_00795	
550	V79	V_BH6_0550__21_00796	

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J	Field Data – Review and Verification		
		V_BH6_0550__21_00797	
		V_BH6_0550__21_00798	
550	V80	V_BH6_0550__21_00799	
		V_BH6_0550__21_00800	
		V_BH6_0550__21_00801	
550	V81	V_BH6_0550__21_00802	
		V_BH6_0550__21_00803	
		V_BH6_0550__21_00804	
550	V82	V_BH6_0550__21_00805	
		V_BH6_0550__21_00806	
		V_BH6_0550__21_00807	
550	V83	V_BH6_0550__21_00808	
		V_BH6_0550__21_00809	
		V_BH6_0550__21_00810	
550	V84	V_BH6_0550__21_00811	
		V_BH6_0550__21_00812	
		V_BH6_0550__21_00813	
550	V85	V_BH6_0550__21_00814	
		V_BH6_0550__21_00815	
		V_BH6_0550__21_00816	
550	V86	V_BH6_0550__21_00817	
		V_BH6_0550__21_00818	

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J	Field Data – Review and Verification		
		V_BH6_0550__21_00819	
550	V87	V_BH6_0550__21_00820	
		V_BH6_0550__21_00821	
		V_BH6_0550__21_00822	
550	V88	V_BH6_0550__21_00823	
		V_BH6_0550__21_00824	
		V_BH6_0550__21_00825	
550	V89	V_BH6_0550__21_00826	
		V_BH6_0550__21_00827	
		V_BH6_0550__21_00828	
550	V90	V_BH6_0550__21_00829	
		V_BH6_0550__21_00830	
		V_BH6_0550__21_00831	
610	V90	V_BH6_0610__21_00832	**All ok**
		V_BH6_0610__21_00833	
		V_BH6_0610__21_00834	
610	V89	V_BH6_0610__21_00835	
		V_BH6_0610__21_00836	
		V_BH6_0610__21_00837	
610	V88	V_BH6_0610__21_00838	
		V_BH6_0610__21_00839	

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J	Field Data – Review and Verification		
		V_BH6_0610__21_00840	
610	V87	V_BH6_0610__21_00841	
		V_BH6_0610__21_00842	
		V_BH6_0610__21_00843	
610	V86	V_BH6_0610__21_00844	
		V_BH6_0610__21_00845	
		V_BH6_0610__21_00846	
610	V85	V_BH6_0610__21_00847	
		V_BH6_0610__21_00848	
		V_BH6_0610__21_00849	
610	V84	V_BH6_0610__21_00850	
		V_BH6_0610__21_00851	
		V_BH6_0610__21_00852	
610	V83	V_BH6_0610__21_00853	
		V_BH6_0610__21_00854	
		V_BH6_0610__21_00855	
610	V82	V_BH6_0610__21_00856	
		V_BH6_0610__21_00857	
		V_BH6_0610__21_00858	
610	V81	V_BH6_0610__21_00859	
		V_BH6_0610__21_00860	
		V_BH6_0610__21_00861	

K Field Issues	
Observed damage (note here as-needed additional detail on Daily Report items)	*corrective action (e.g. repair, component replacement)* *N/A*

L File Control

Data File	Date Time	Depth Range	Staff	Software	Parameters/Settings
V_BH6_0490__21_00652		500 – 555m	Cristian Vasile	VIPS5.11	1ms sample rate. 3 records of 20 seconds each
V_BH6_0490__21_00653					
V_BH6_0490__21_00654					
V_BH6_0490__21_00655					
V_BH6_0490__21_00656					
V_BH6_0490__21_00657					
V_BH6_0490__21_00658					
V_BH6_0490__21_00659					
V_BH6_0490__21_00660					
V_BH6_0490__21_00661					
V_BH6_0490__21_00662					
V_BH6_0490__21_00663					
V_BH6_0490__21_00664					
V_BH6_0490__21_00665					
V_BH6_0490__21_00666					
V_BH6_0490__21_00667					
V_BH6_0490__21_00668					

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L File Control					
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V_BH6_0490__21_00672					
V_BH6_0490__21_00673					
V_BH6_0490__21_00674					
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L File Control					
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V_BH6_0490__21_00712					

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L File Control					
V_BH6_0490__21_00735					
V_BH6_0490__21_00736					
V_BH6_0490__21_00737					
V_BH6_0490__21_00738					
V_BH6_0490__21_00739					
V_BH6_0490__21_00740					
V_BH6_0490__21_00741					
V_BH6_0550__21_00742		560 – 615m	Cristian Vasile	VIPS5.11	1ms sample rate. 3 records of 20 seconds each
V_BH6_0550__21_00743					
V_BH6_0550__21_00744					
V_BH6_0550__21_00745					
V_BH6_0550__21_00746					
V_BH6_0550__21_00747					
V_BH6_0550__21_00748					
V_BH6_0550__21_00749					
V_BH6_0550__21_00750					
V_BH6_0550__21_00751					
V_BH6_0550__21_00752					
V_BH6_0550__21_00753					
V_BH6_0550__21_00754					
V_BH6_0550__21_00755					

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L File Control					
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V_BH6_0550__21_00759					
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V_BH6_0550__21_00761					
V_BH6_0550__21_00762					
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V_BH6_0550__21_00767					
V_BH6_0550__21_00768					
V_BH6_0550__21_00769					
V_BH6_0550__21_00770					
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V_BH6_0550__21_00777					

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L File Control					
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V_BH6_0550__21_00794					
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V_BH6_0550__21_00797					
V_BH6_0550__21_00798					
V_BH6_0550__21_00799					

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L File Control					
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V_BH6_0550__21_00808					
V_BH6_0550__21_00809					
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V_BH6_0550__21_00813					
V_BH6_0550__21_00814					
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V_BH6_0550__21_00818					
V_BH6_0550__21_00819					
V_BH6_0550__21_00820					
V_BH6_0550__21_00821					

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L **File Control**					
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V_BH6_0550__21_00827					
V_BH6_0550__21_00828					
V_BH6_0550__21_00829					
V_BH6_0550__21_00830					
V_BH6_0550__21_00831					
V_BH6_0610__21_00832		440 – 495m	Cristian Vasile	VIPS5.11	1ms sample rate. 3 records of 20 seconds each
V_BH6_0610__21_00833					
V_BH6_0610__21_00834					
V_BH6_0610__21_00835					
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V_BH6_0610__21_00837					
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V_BH6_0610__21_00841					
V_BH6_0610__21_00842					

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L File Control					
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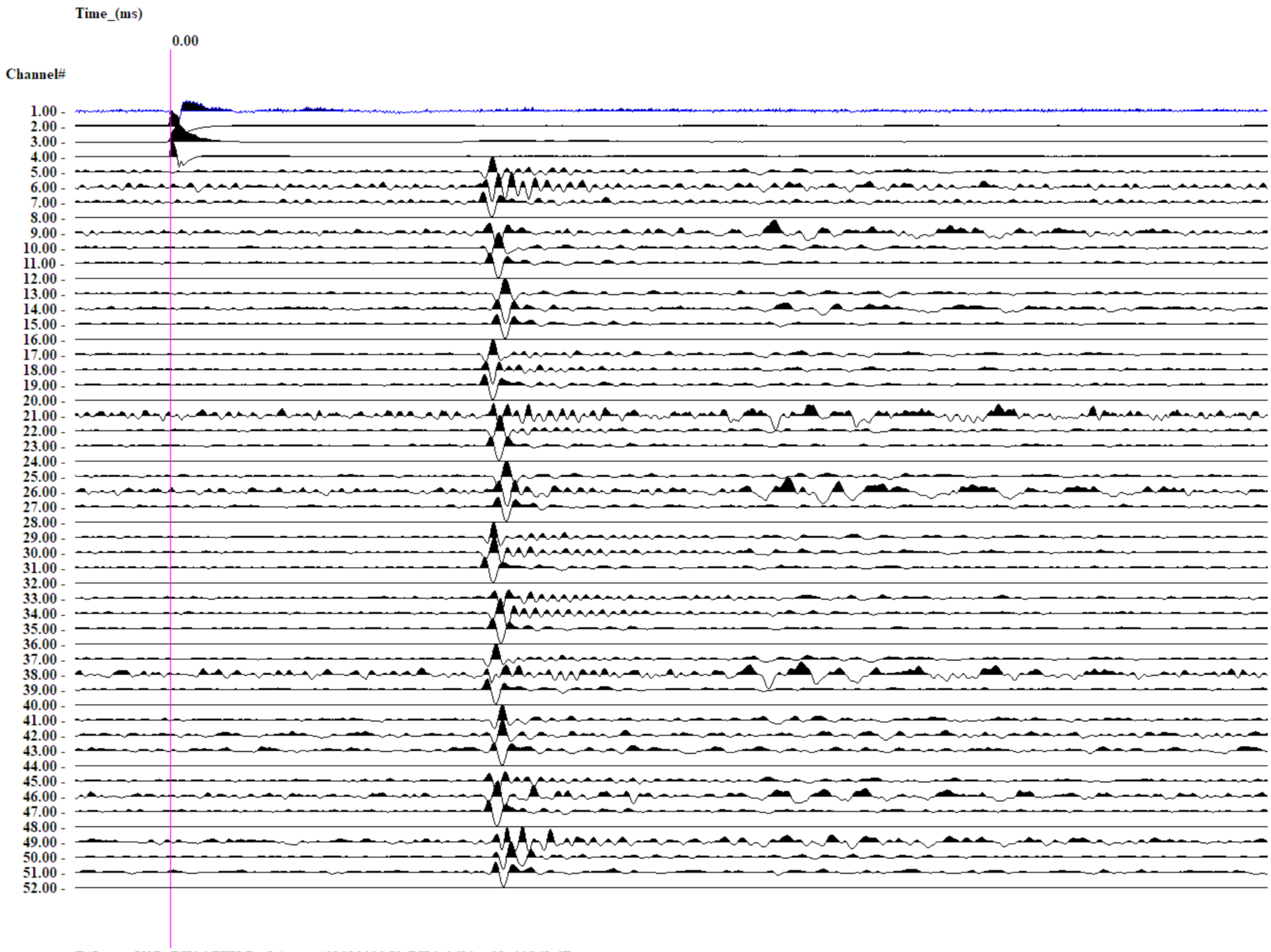
V_BH6_0610__21_00861					



F:\IgnaceVSP_BH06-FIELD_QA_runs\31012022\V_BH6_0610__21_00861.dFc

V81_L10

WP12 Data Quality Confirmation (DQC) Form		
Document No.: *20253946-6120-220128*	Original Date: *31 Jan 2022*	Developed By: *Nicoleta Enescu*
Revision No.: *R0*	Revision Date: *N/A*	Authorized By: *Christopher Phillips*

GOLDER
MEMBER OF WSP

VIBROMETRIC

Vibrometric Seismic Source Checklist

Engine Off Checks	OK	Maintenance
Leaks – Fuel, Hydraulic Oil, Engine Oil or Radiator Coolant	✓	
Tires – Condition and Pressure	✓	
Hydraulic Hoses, Mast Chains, Cables and Stops – Check Visually	✓	
Safety Warnings – Attached (Refer to Parts Manual for Location)	✓	
Battery – Check Water/Electrolyte Level and Charge	✓	
Hydraulic Fluid Level – Check Level	✓	
Engine Oil Level – Dipstick	✓	
Transmission Fluid Level – Dipstick	✓	
Radiator Coolant – Check Level	✓	
Operator's Manual – In Container	✓	
Nameplate – Attached and Information Matches Model, Serial Number and Attachments	✓	
Seat Belt – Functioning Smoothly	✓	
Hood Latch – Adjusted and Securely Fastened	✓	
Brake Fluid – Check Level	✓	
Seismic Vibrator Check Screws, Cables, Hoses	✓	
Fuel level	✓	
Lights check	✓	
Engine On Checks	**OK**	**Maintenance**
Accelerator or Direction Control Pedal – Functioning Smoothly	✓	
Service Brake – Functioning Smoothly	✓	
Parking Brake – Functioning Smoothly	✓	
Steering Operation – Functioning Smoothly	✓	
Drive Control – Forward/Reverse – Functioning Smoothly	✓	
Arm Tilt Control – Forward and Back – Functioning Smoothly	✓	
Hoist (Seismic Source) and Lowering Control – Functioning Smoothly	✓	
Testing the sweep – Operation		
Horn and Lights – Functioning	✓	
Cab (if equipped) – Heater, Defroster, Wipers – Functioning	✓	
Gauges: Ammeter, Engine Oil Pressure, Hour Meter, Fuel Level, Temperature, Instrument Monitors – Functioning	✓	
Controller check | Trigger sensor on impact plate check		
Impact plate check | Radio check	✓	
Source type	✓	

JAN 31/22 B MORIN

O Sign-Off		
Prepared	*Jon Crawford*	*January 31, 2022*
Reviewed	*Nicoleta Enescu*	*January 31, 2022*
Approved	*Christopher Phillips*	*January 31, 2022*

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WP12 Data Quality Confirmation (DQC) Form		
Document No.: *20253946-6120-220128*	Original Date: *01 Feb 2022*	Developed By: *Nicoleta Enescu*
Revision No.: *R0*	Revision Date: *N/A*	Authorized By: *Christopher Phillips*

TO:	Mostafa Khorshidi	**Date:**	*220201*
	Maria Sánchez-Rico Castejón	**Work Package:**	WP12 – VSP Profiling
	Sarah Hirschorn		
CC:	George Schneider		
		Distributed By:	Email

Record Number: 20253946-6120-220201

IGBH_06, IGNACE, ONTARIO

Acquisition depth interval: L10 (620 – 675m), L11 (680 – 735 m) and L12 (740 – 795m)

Staff: Cristian Vasile

Start time: 09:00 am Finish time: 5:30 pm

Shot location(s): All 30 shot locations for levels at 610m, 670m and 730m

Prepared by: Nicoleta Enescu

Verified by: Christopher Phillips

Usage notes:

- Complete one form per field day
- Office forms will be complete as processing packages/tasks are completed and will include supporting documentation
- Complete all header information (above)
- Delete unused tables (below) and fully populate those that remain
- Form is divided into A through O tables and field and processing tasks

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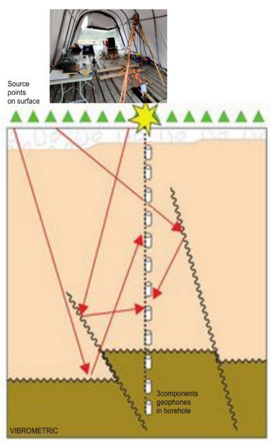
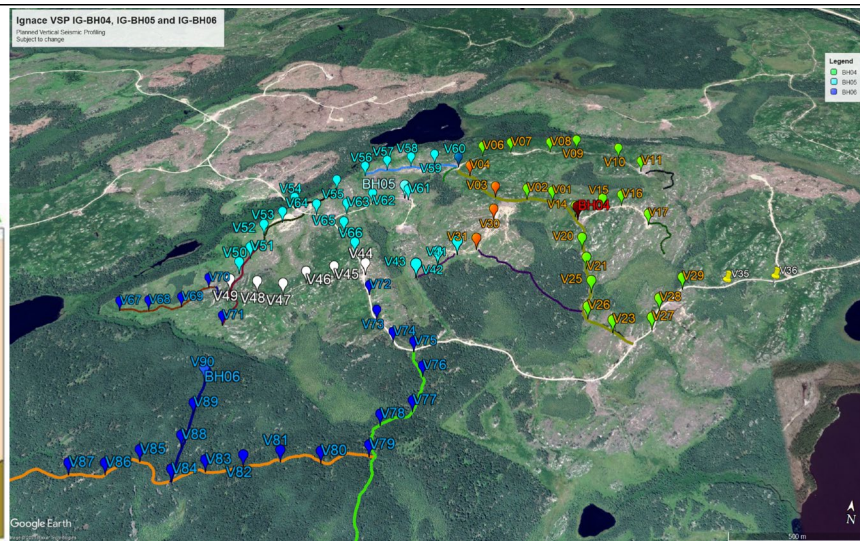
FIELD

A	Winch and Depth Counter
Calibrated by measuring and marking the cable every 100 m before insertion in the borehole. Verifying these distances using the depth counter. Discrepancies are adjusted by changing the depth value on the depth counter to match the cable mark.	
Results	At cable mark 610m, depth counter reads 609.98m. At 670.00m the depth counter read 669.98m. At 730.00m the depth counter read 730.08m.
Settings applied	

B	Tool Assembly
Schematic	 
Results of checks.	All good

E	Equipment Calibration/Function Checklist	OK	Maintenance
Geophones			
	Geophone used (RD or R):	RD	
	Testing at ground surface performed before insertion in the borehole:		
	Level of electrical disturbance	OK	
	Water tightness	OK	
	Operation of side arm clamp	OK	
	Verification of noise level and real seismic signal in each component	OK	

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E Equipment Calibration/Function Checklist	OK	Maintenance
Winch Motor and transmission Controller Brake Ground anchors	All OK	
Cable Borehole collar level mark Overnight clamp	All OK	
Depth counter	OK	
Radio check	OK	
Acquisition computer Computer Acquisition Software Data Analysis Software	OK OK OK	
Power source	OK	
Access vehicle	OK	
Geophones calibration certificate verification: Technical ID Signature Date Validity period Location	_X_ _X_ _X_ _X_ _X_	
Depth counter calibration certificate verification: Technical ID Signature Date Validity period Location	Calibration shown in Table A	

F Decontamination	
Verification of equipment decontamination before insertion into borehole	Yes

G Dummy Probe Run	
Done before insertion of geophones into borehole	Complete to 998m mbgs on January 25, 2022

H	Geophone Testing in Borehole
Clamping location verified	Yes
Level of electrical disturbance	None
Operation of the side arm clamp	Good
Verification of noise in each component	Done, file Noise_0070__21_60006.dlc
Verification of real seismic signal in each component	Done, file V_BH6_0610__21_00862.dlc

I	Shot
Confirmation of shot point ID with receiver staff	Yes
Data acquisition sampling rate confirmed at 1 ms	Yes

J Field Data – Review and Verification			
Depth of zero mark	**Shot ID**	**Data File**	**Comment/Verified** (fitness for use)
610	V81	V_BH6_0610__21_00862	**All ok**
		V_BH6_0610__21_00863	
		V_BH6_0610__21_00864	
610	V80	V_BH6_0610__21_00865	
		V_BH6_0610__21_00866	
		V_BH6_0610__21_00867	
610	V79	V_BH6_0610__21_00868	
		V_BH6_0610__21_00869	
		V_BH6_0610__21_00870	
610	V78	V_BH6_0610__21_00871	
		V_BH6_0610__21_00872	
		V_BH6_0610__21_00873	
610	V77	V_BH6_0610__21_00874	
		V_BH6_0610__21_00875	

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J	Field Data – Review and Verification		
		V_BH6_0610__21_00876	
610	V76	V_BH6_0610__21_00877	
		V_BH6_0610__21_00878	
		V_BH6_0610__21_00879	
610	V75	V_BH6_0610__21_00880	
		V_BH6_0610__21_00881	
		V_BH6_0610__21_00882	
610	V74	V_BH6_0610__21_00883	
		V_BH6_0610__21_00884	
		V_BH6_0610__21_00885	
610	V73	V_BH6_0610__21_00886	
		V_BH6_0610__21_00887	
		V_BH6_0610__21_00888	
610	V72	V_BH6_0610__21_00889	
		V_BH6_0610__21_00890	
		V_BH6_0610__21_00891	
610	V44	V_BH6_0610__21_00892	
		V_BH6_0610__21_00893	
		V_BH6_0610__21_00894	
610	V45	V_BH6_0610__21_00895	
		V_BH6_0610__21_00896	
		V_BH6_0610__21_00897	

J	Field Data – Review and Verification		
610	V46	V_BH6_0610__21_00898	
		V_BH6_0610__21_00899	
		V_BH6_0610__21_00900	
610	V47	V_BH6_0610__21_00901	
		V_BH6_0610__21_00902	
		V_BH6_0610__21_00903	
610	V48	V_BH6_0610__21_00904	
		V_BH6_0610__21_00905	
		V_BH6_0610__21_00906	
610	V49	V_BH6_0610__21_00907	
		V_BH6_0610__21_00908	
		V_BH6_0610__21_00909	
610	V71	V_BH6_0610__21_00910	
		V_BH6_0610__21_00911	
		V_BH6_0610__21_00912	
610	V91	V_BH6_0610__21_00913	
		V_BH6_0610__21_00914	
		V_BH6_0610__21_00915	
610	V92	V_BH6_0610__21_00916	
		V_BH6_0610__21_00917	
		V_BH6_0610__21_00918	
610	V93	V_BH6_0610__21_00919	

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J	Field Data – Review and Verification		
		V_BH6_0610__21_00920	
		V_BH6_0610__21_00921	
610	V94	V_BH6_0610__21_00922	
		V_BH6_0610__21_00923	
		V_BH6_0610__21_00924	
670	V94	V_BH6_0670__21_00925	**All ok**
		V_BH6_0670__21_00926	
		V_BH6_0670__21_00927	
670	V93	V_BH6_0670__21_00928	
		V_BH6_0670__21_00929	
		V_BH6_0670__21_00930	
670	V92	V_BH6_0670__21_00931	
		V_BH6_0670__21_00932	
		V_BH6_0670__21_00933	
670	V91	V_BH6_0670__21_00934	
		V_BH6_0670__21_00935	
		V_BH6_0670__21_00936	
670	V71	V_BH6_0670__21_00937	
		V_BH6_0670__21_00938	
		V_BH6_0670__21_00939	
670	V49	V_BH6_0670__21_00940	

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J	Field Data – Review and Verification		
		V_BH6_0670__21_00941	
		V_BH6_0670__21_00942	
670	V48	V_BH6_0670__21_00943	
		V_BH6_0670__21_00944	
		V_BH6_0670__21_00945	
670	V47	V_BH6_0670__21_00946	
		V_BH6_0670__21_00947	
		V_BH6_0670__21_00948	
670	V46	V_BH6_0670__21_00949	
		V_BH6_0670__21_00950	
		V_BH6_0670__21_00951	
670	V45	V_BH6_0670__21_00952	
		V_BH6_0670__21_00953	
		V_BH6_0670__21_00954	
670	V44	V_BH6_0670__21_00955	
		V_BH6_0670__21_00956	
		V_BH6_0670__21_00957	
670	V72	V_BH6_0670__21_00958	
		V_BH6_0670__21_00959	
		V_BH6_0670__21_00960	
670	V73	V_BH6_0670__21_00961	
		V_BH6_0670__21_00962	

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J	Field Data – Review and Verification		
		V_BH6_0670__21_00963	
670	V74	V_BH6_0670__21_00964	
		V_BH6_0670__21_00965	
		V_BH6_0670__21_00966	
670	V75	V_BH6_0670__21_00967	
		V_BH6_0670__21_00968	
		V_BH6_0670__21_00969	
670	V76	V_BH6_0670__21_00970	
		V_BH6_0670__21_00971	
		V_BH6_0670__21_00972	
670	V77	V_BH6_0670__21_00973	
		V_BH6_0670__21_00974	
		V_BH6_0670__21_00975	
670	V78	V_BH6_0670__21_00976	
		V_BH6_0670__21_00977	
		V_BH6_0670__21_00978	
670	V79	V_BH6_0670__21_00979	
		V_BH6_0670__21_00980	
		V_BH6_0670__21_00981	
670	V80	V_BH6_0670__21_00982	
		V_BH6_0670__21_00983	
		V_BH6_0670__21_00984	

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J	Field Data – Review and Verification		
670	V81	V_BH6_0670__21_00985	
		V_BH6_0670__21_00986	
		V_BH6_0670__21_00987	
670	V82	V_BH6_0670__21_00988	
		V_BH6_0670__21_00989	
		V_BH6_0670__21_00990	
670	V83	V_BH6_0670__21_00991	
		V_BH6_0670__21_00992	
		V_BH6_0670__21_00993	
670	V84	V_BH6_0670__21_00994	
		V_BH6_0670__21_00995	
		V_BH6_0670__21_00996	
670	V85	V_BH6_0670__21_00997	
		V_BH6_0670__21_00998	
		V_BH6_0670__21_00999	
670	V86	V_BH6_0670__21_01000	
		V_BH6_0670__21_01001	
		V_BH6_0670__21_01002	
670	V87	V_BH6_0670__21_01003	
		V_BH6_0670__21_01004	
		V_BH6_0670__21_01005	
670	V88	V_BH6_0670__21_01006	

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J	Field Data – Review and Verification		
		V_BH6_0670__21_01007	
		V_BH6_0670__21_01008	
670	V89	V_BH6_0670__21_01009	
		V_BH6_0670__21_01010	
		V_BH6_0670__21_01011	
670	V90	V_BH6_0670__21_01012	
		V_BH6_0670__21_01013	
		V_BH6_0670__21_01014	
730	V90	V_BH6_0730__21_01015	**All ok**
		V_BH6_0730__21_01016	
		V_BH6_0730__21_01017	
730	V89	V_BH6_0730__21_01018	
		V_BH6_0730__21_01019	
		V_BH6_0730__21_01020	
730	V88	V_BH6_0730__21_01021	
		V_BH6_0730__21_01022	
		V_BH6_0730__21_01023	
730	V87	V_BH6_0730__21_01024	
		V_BH6_0730__21_01025	
		V_BH6_0730__21_01026	
730	V86	V_BH6_0730__21_01027	

J	Field Data – Review and Verification		
		V_BH6_0730__21_01028	
		V_BH6_0730__21_01029	
730	V85	V_BH6_0730__21_01030	
		V_BH6_0730__21_01031	
		V_BH6_0730__21_01032	
730	V84	V_BH6_0730__21_01033	
		V_BH6_0730__21_01034	
		V_BH6_0730__21_01035	
730	V83	V_BH6_0730__21_01036	
		V_BH6_0730__21_01037	
		V_BH6_0730__21_01038	
730	V82	V_BH6_0730__21_01039	
		V_BH6_0730__21_01040	
		V_BH6_0730__21_01041	
730	V81	V_BH6_0730__21_01042	
		V_BH6_0730__21_01043	
		V_BH6_0730__21_01044	
730	V80	V_BH6_0730__21_01045	
		V_BH6_0730__21_01046	
		V_BH6_0730__21_01047	
730	V79	V_BH6_0730__21_01048	
		V_BH6_0730__21_01049	

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J	Field Data – Review and Verification		
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		V_BH6_0730__21_01052	
		V_BH6_0730__21_01053	
730	V77	V_BH6_0730__21_01054	
		V_BH6_0730__21_01055	
		V_BH6_0730__21_01056	
730	V76	V_BH6_0730__21_01057	
		V_BH6_0730__21_01058	
		V_BH6_0730__21_01059	
730	V75	V_BH6_0730__21_01060	
		V_BH6_0730__21_01061	
		V_BH6_0730__21_01062	
730	V74	V_BH6_0730__21_01063	
		V_BH6_0730__21_01064	
		V_BH6_0730__21_01065	
730	V73	V_BH6_0730__21_01066	
		V_BH6_0730__21_01067	
		V_BH6_0730__21_01068	
730	V72	V_BH6_0730__21_01069	
		V_BH6_0730__21_01070	
		V_BH6_0730__21_01071	

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J	Field Data – Review and Verification		
730	V44	V_BH6_0730__21_01072	
		V_BH6_0730__21_01073	
		V_BH6_0730__21_01074	
730	V45	V_BH6_0730__21_01075	
		V_BH6_0730__21_01076	
		V_BH6_0730__21_01077	
730	V46	V_BH6_0730__21_01078	
		V_BH6_0730__21_01079	
		V_BH6_0730__21_01080	
730	V47	V_BH6_0730__21_01081	
		V_BH6_0730__21_01082	
		V_BH6_0730__21_01083	
730	V48	V_BH6_0730__21_01084	
		V_BH6_0730__21_01085	
		V_BH6_0730__21_01086	
730	V49	V_BH6_0730__21_01087	
		V_BH6_0730__21_01088	
		V_BH6_0730__21_01089	
730	V71	V_BH6_0730__21_01090	
		V_BH6_0730__21_01091	
		V_BH6_0730__21_01092	
730	V91	V_BH6_0730__21_01093	

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J	Field Data – Review and Verification		
		V_BH6_0730__21_01094	
		V_BH6_0730__21_01095	
730	V92	V_BH6_0730__21_01096	
		V_BH6_0730__21_01097	
		V_BH6_0730__21_01098	
730	V93	V_BH6_0730__21_01099	
		V_BH6_0730__21_01100	
		V_BH6_0730__21_01101	
730	V94	V_BH6_0730__21_01102	
		V_BH6_0730__21_01103	
		V_BH6_0730__21_01104	

K Field Issues	
Observed damage (note here as-needed additional detail on Daily Report items)	*corrective action (e.g. repair, component replacement)* *N/A*

L File Control

Data File	Date Time	Depth Range	Staff	Software	Parameters/Settings
V_BH6_0610__21_00862		620 – 675m	Cristian Vasile	VIPS5.11	1ms sample rate. 3 records of 20 seconds each
V_BH6_0610__21_00863					
V_BH6_0610__21_00864					
V_BH6_0610__21_00865					
V_BH6_0610__21_00866					

L File Control					
V_BH6_0610__21_00867					
V_BH6_0610__21_00868					
V_BH6_0610__21_00869					
V_BH6_0610__21_00870					
V_BH6_0610__21_00871					
V_BH6_0610__21_00872					
V_BH6_0610__21_00873					
V_BH6_0610__21_00874					
V_BH6_0610__21_00875					
V_BH6_0610__21_00876					
V_BH6_0610__21_00877					
V_BH6_0610__21_00878					
V_BH6_0610__21_00879					
V_BH6_0610__21_00880					
V_BH6_0610__21_00881					
V_BH6_0610__21_00882					
V_BH6_0610__21_00883					
V_BH6_0610__21_00884					
V_BH6_0610__21_00885					
V_BH6_0610__21_00886					
V_BH6_0610__21_00887					
V_BH6_0610__21_00888					

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L File Control					
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V_BH6_0610__21_00892					
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V_BH6_0610__21_00894					
V_BH6_0610__21_00895					
V_BH6_0610__21_00896					
V_BH6_0610__21_00897					
V_BH6_0610__21_00898					
V_BH6_0610__21_00899					
V_BH6_0610__21_00900					
V_BH6_0610__21_00901					
V_BH6_0610__21_00902					
V_BH6_0610__21_00903					
V_BH6_0610__21_00904					
V_BH6_0610__21_00905					
V_BH6_0610__21_00906					
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V_BH6_0610__21_00908					
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V_BH6_0610__21_00910					

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L File Control					
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V_BH6_0610__21_00917					
V_BH6_0610__21_00918					
V_BH6_0610__21_00919					
V_BH6_0610__21_00920					
V_BH6_0610__21_00921					
V_BH6_0610__21_00922					
V_BH6_0610__21_00923					
V_BH6_0610__21_00924					
V_BH6_0670__21_00925		680 – 735m	Cristian Vasile	VIPS5.11	1ms sample rate. 3 records of 20 seconds each
V_BH6_0670__21_00926					
V_BH6_0670__21_00927					
V_BH6_0670__21_00928					
V_BH6_0670__21_00929					
V_BH6_0670__21_00930					
V_BH6_0670__21_00931					

L File Control					
V_BH6_0670__21_00932					
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L File Control					
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L File Control					
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V_BH6_0670__21_00985					
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V_BH6_0670__21_01005					
V_BH6_0670__21_01006					
V_BH6_0670__21_01007					
V_BH6_0670__21_01008					
V_BH6_0670__21_01009					
V_BH6_0670__21_01010					
V_BH6_0670__21_01011					
V_BH6_0670__21_01012					
V_BH6_0670__21_01013					
V_BH6_0670__21_01014					
V_BH6_0730__21_01015		740 – 795m	Cristian Vasile	VIPS5.11	1ms sample rate. 3 records of 20 seconds each
V_BH6_0730__21_01016					
V_BH6_0730__21_01017					
V_BH6_0730__21_01018					

L File Control					
V_BH6_0730__21_01019					
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V_BH6_0730__21_01022					
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V_BH6_0730__21_01024					
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L	**File Control**				
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L	**File Control**				
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L File Control					
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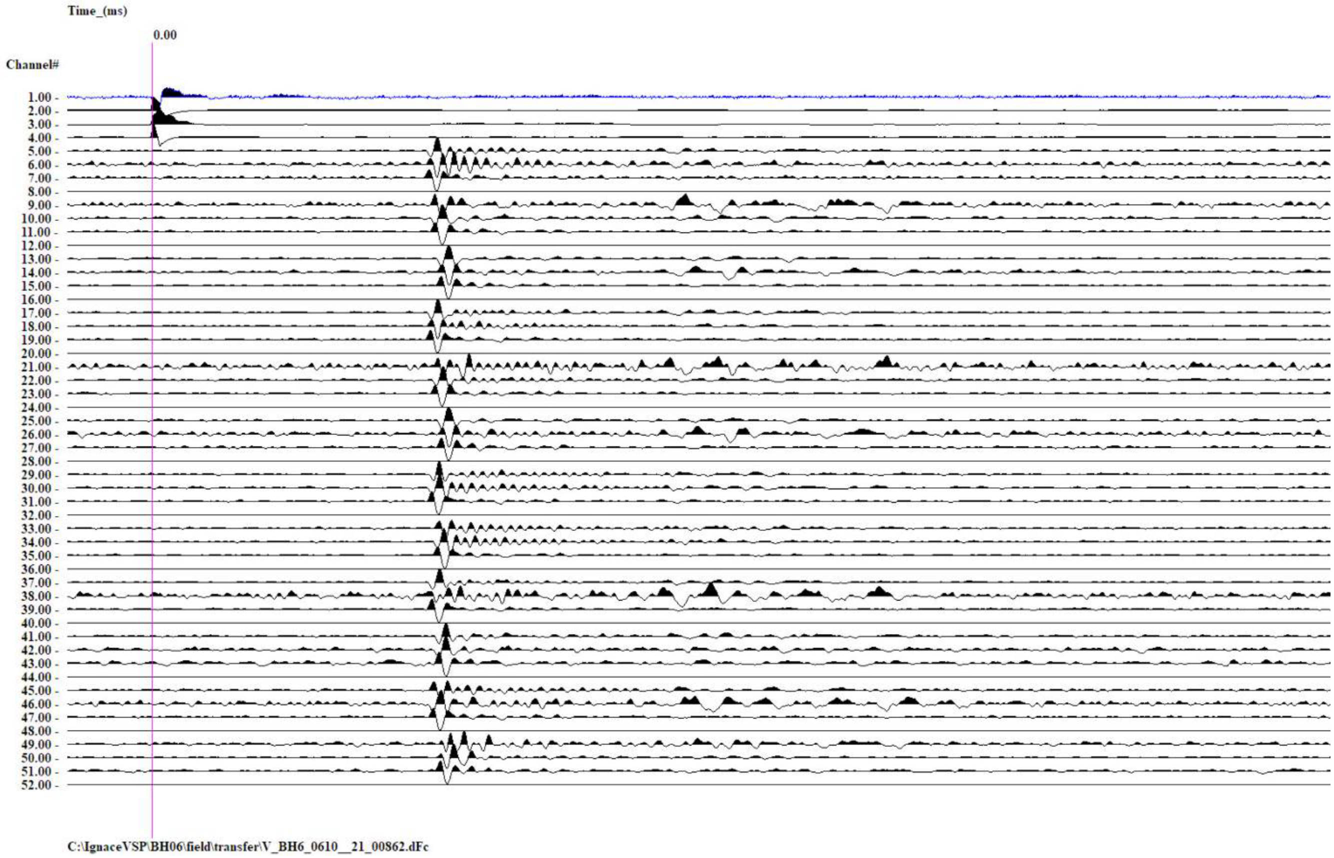
V_BH6_0730__21_01104					



Time_(ms)
0.00
Channel#
C:\IgnaceVSP\BH06\field\transfer\V_BH6_0610__21_00862.dFc

V81_L10

VIBROMETRIC

Vibrometric Seismic Source Checklist

Engine Off Checks	OK	Maintenance
Leaks – Fuel, Hydraulic Oil, Engine Oil or Radiator Coolant	✓	
Tires – Condition and Pressure	✓	
Hydraulic Hoses, Mast Chains, Cables and Stops – Check Visually	✓	
Safety Warnings – Attached (Refer to Parts Manual for Location)	✓	
Battery – Check Water/Electrolyte Level and Charge	✓	
Hydraulic Fluid Level – Check Level	✓	
Engine Oil Level – Dipstick	✓	
Transmission Fluid Level – Dipstick	✓	
Radiator Coolant – Check Level	✓	
Operator's Manual – In Container	✓	
Nameplate – Attached and Information Matches Model, Serial Number and Attachments	✓	
Seat Belt – Functioning Smoothly	✓	
Hood Latch – Adjusted and Securely Fastened	✓	
Brake Fluid – Check Level	✓	
Seismic Vibrator Check Screws, Cables, Hoses	✓	
Fuel level	✓	
Lights check	✓	
Engine On Checks	**OK**	**Maintenance**
Accelerator or Direction Control Pedal – Functioning Smoothly	✓	
Service Brake – Functioning Smoothly	✓	
Parking Brake – Functioning Smoothly	✓	
Steering Operation – Functioning Smoothly	✓	
Drive Control – Forward/Reverse – Functioning Smoothly	✓	
Arm Tilt Control – Forward and Back – Functioning Smoothly	✓	
Hoist (Seismic Source) and Lowering Control – Functioning Smoothly	✓	
Testing the sweep – Operation		
Horn and Lights – Functioning	✓	
Cab (if equipped) – Heater, Defroster, Wipers – Functioning	✓	
Gauges: Ammeter, Engine Oil Pressure, Hour Meter, Fuel Level, Temperature, Instrument Monitors – Functioning	✓	
Controller check | Trigger sensor on impact plate check		
Impact plate check | Radio check	✓	
Source type	✓	

O	**Sign-Off**	
Prepared	*Jon Crawford*	*February 01, 2022*
Reviewed	*Nicoleta Enescu*	*February 01, 2022*
Approved	*Christopher Phillips*	*February 01, 2022*

TO:	Mostafa Khorshidi	**Date:**	*220207*
	Maria Sánchez-Rico Castejón	**Work Package:**	WP12 – VSP Profiling
	Sarah Hirschorn		
CC:	George Schneider		
		Distributed By:	Email

Record Number: 20253946-6120-220207

IGBH_06, IGNACE, ONTARIO

Acquisition depth interval: all L13 (800 – 855m), 15 shots at L14 (860 – 915 m)

Staff: Cristian Vasile

Start time: 01:00 pm **Finish time: 5:30 pm**

Shot location(s): All 30 shot locations for level at 790m, and 15 shot locations for level at 850m

Prepared by: Nicoleta Enescu

Verified by: Christopher Phillips

Usage notes:

- Complete one form per field day
- Office forms will be complete as processing packages/tasks are completed and will include supporting documentation
- Complete all header information (above)
- Delete unused tables (below) and fully populate those that remain
- Form is divided into A through O tables and field and processing tasks

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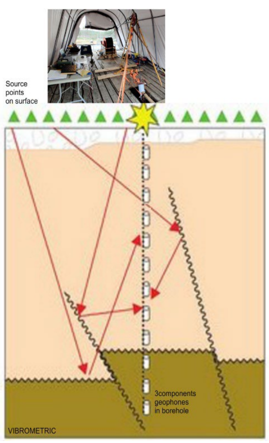
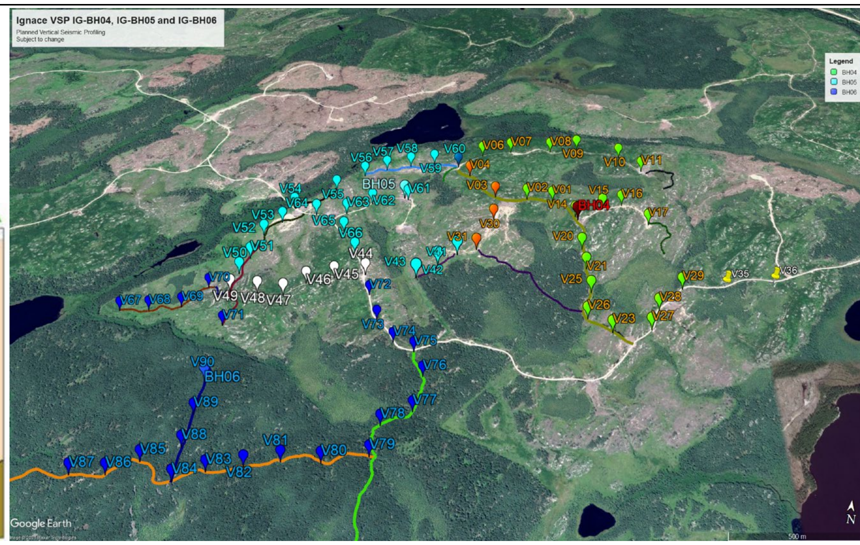
FIELD

A	Winch and Depth Counter
Calibrated by measuring and marking the cable every 100 m before insertion in the borehole. Verifying these distances using the depth counter. Discrepancies are adjusted by changing the depth value on the depth counter to match the cable mark.	
Results	At cable mark 790m, depth counter reads 790.05m. At 850.00m the depth counter read 850.00m.
Settings applied	

B	Tool Assembly
Schematic	 
Results of checks.	All good

E	Equipment Calibration/Function Checklist	OK	Maintenance
Geophones			
	Geophone used (RD or R):	RD	
	Testing at ground surface performed before insertion in the borehole:		
	Level of electrical disturbance	OK	
	Water tightness	OK	
	Operation of side arm clamp	OK	
	Verification of noise level and real seismic signal in each component	OK	

E Equipment Calibration/Function Checklist	**OK**	**Maintenance**
Winch Motor and transmission Controller Brake Ground anchors	All OK	
Cable Borehole collar level mark Overnight clamp	All OK	
Depth counter	OK	
Radio check	OK	
Acquisition computer Computer Acquisition Software Data Analysis Software	OK OK OK	
Power source	OK	
Access vehicle	OK	
Geophones calibration certificate verification: Technical ID Signature Date Validity period Location	_X_ _X_ _X_ _X_ _X_	
Depth counter calibration certificate verification: Technical ID Signature Date Validity period Location	Calibration shown in Table A	

F Decontamination	
Verification of equipment decontamination before insertion into borehole	Yes

G Dummy Probe Run	
Done before insertion of geophones into borehole	Complete to 998m mbgs on January 25, 2022

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H	**Geophone Testing in Borehole**
Clamping location verified	Yes
Level of electrical disturbance	None
Operation of the side arm clamp	Good
Verification of noise in each component	Done, file Noise_0070__21_60009.dlc and Noise_0070__21_60010.dlc
Verification of real seismic signal in each component	Done, files V_BH6_0730__21_01165.dlc V_BH6_0730__21_01166.dlc, V_BH6_0730__21_01167.dlc

I	**Shot**
Confirmation of shot point ID with receiver staff	Yes
Data acquisition sampling rate confirmed at 1 ms	Yes

J	**Field Data – Review and Verification**		
Depth of zero mark	**Shot ID**	**Data File**	**Comment/Verified** (fitness for use)
730	V90	V_BH6_0730__21_01165	**All ok**
		V_BH6_0730__21_01166	
		V_BH6_0730__21_01167	
790	V90	V_BH6_0790__21_01168	**All ok**
		V_BH6_0790__21_01169	
		V_BH6_0790__21_01170	
790	V89	V_BH6_0790__21_01171	
		V_BH6_0790__21_01172	
		V_BH6_0790__21_01173	
790	V88	V_BH6_0790__21_01174	
		V_BH6_0790__21_01175	

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J	Field Data – Review and Verification		
		V_BH6_0790__21_01176	
790	V87	V_BH6_0790__21_01177	
		V_BH6_0790__21_01178	
		V_BH6_0790__21_01179	
790	V86	V_BH6_0790__21_01180	
		V_BH6_0790__21_01181	
		V_BH6_0790__21_01182	
790	V85	V_BH6_0790__21_01183	
		V_BH6_0790__21_01184	
		V_BH6_0790__21_01185	
790	V84	V_BH6_0790__21_01186	
		V_BH6_0790__21_01187	
		V_BH6_0790__21_01188	
790	V83	V_BH6_0790__21_01189	
		V_BH6_0790__21_01190	
		V_BH6_0790__21_01191	
790	V82	V_BH6_0790__21_01192	
		V_BH6_0790__21_01193	
		V_BH6_0790__21_01194	
790	V81	V_BH6_0790__21_01195	
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J	Field Data – Review and Verification		
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790	V79	V_BH6_0790__21_01201	
		V_BH6_0790__21_01202	
		V_BH6_0790__21_01203	
790	V78	V_BH6_0790__21_01204	
		V_BH6_0790__21_01205	
		V_BH6_0790__21_01206	
790	V77	V_BH6_0790__21_01207	
		V_BH6_0790__21_01208	
		V_BH6_0790__21_01209	
790	V76	V_BH6_0790__21_01210	
		V_BH6_0790__21_01211	
		V_BH6_0790__21_01212	
790	V75	V_BH6_0790__21_01213	
		V_BH6_0790__21_01214	
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790	V74	V_BH6_0790__21_01216	
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		V_BH6_0790__21_01218	
790	V73	V_BH6_0790__21_01219	

J	Field Data – Review and Verification		
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		V_BH6_0790__21_01221	
790	V72	V_BH6_0790__21_01222	
		V_BH6_0790__21_01223	
		V_BH6_0790__21_01224	
790	V44	V_BH6_0790__21_01225	
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		V_BH6_0790__21_01227	
790	V45	V_BH6_0790__21_01228	
		V_BH6_0790__21_01229	
		V_BH6_0790__21_01230	
790	V46	V_BH6_0790__21_01231	
		V_BH6_0790__21_01232	
		V_BH6_0790__21_01233	
790	V47	V_BH6_0790__21_01234	
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		V_BH6_0790__21_01236	
790	V48	V_BH6_0790__21_01237	
		V_BH6_0790__21_01238	
		V_BH6_0790__21_01239	
790	V49	V_BH6_0790__21_01240	
		V_BH6_0790__21_01241	

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J	**Field Data – Review and Verification**		
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790	V71	V_BH6_0790__21_01243	
		V_BH6_0790__21_01244	
		V_BH6_0790__21_01245	
790	V91	V_BH6_0790__21_01246	
		V_BH6_0790__21_01247	
		V_BH6_0790__21_01248	
790	V92	V_BH6_0790__21_01249	
		V_BH6_0790__21_01250	
		V_BH6_0790__21_01251	
790	V93	V_BH6_0790__21_01252	
		V_BH6_0790__21_01253	
		V_BH6_0790__21_01254	
790	V94	V_BH6_0790__21_01255	
		V_BH6_0790__21_01256	
		V_BH6_0790__21_01257	
850	V94	V_BH6_0850__21_01258	**All ok**
		V_BH6_0850__21_01259	
		V_BH6_0850__21_01260	
850	V93	V_BH6_0850__21_01261	
		V_BH6_0850__21_01262	

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J	**Field Data – Review and Verification**		
		V_BH6_0850__21_01263	
850	V92	V_BH6_0850__21_01264	
		V_BH6_0850__21_01265	
		V_BH6_0850__21_01266	
850	V91	V_BH6_0850__21_01267	
		V_BH6_0850__21_01268	
		V_BH6_0850__21_01269	
850	V71	V_BH6_0850__21_01270	
		V_BH6_0850__21_01271	
		V_BH6_0850__21_01272	
850	V49	V_BH6_0850__21_01273	
		V_BH6_0850__21_01274	
		V_BH6_0850__21_01275	
850	V48	V_BH6_0850__21_01276	
		V_BH6_0850__21_01277	
		V_BH6_0850__21_01278	
850	V47	V_BH6_0850__21_01279	
		V_BH6_0850__21_01280	
		V_BH6_0850__21_01281	
850	V46	V_BH6_0850__21_01282	
		V_BH6_0850__21_01283	
		V_BH6_0850__21_01284	

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J	Field Data – Review and Verification		
850	V45	V_BH6_0850__21_01285	
		V_BH6_0850__21_01286	
		V_BH6_0850__21_01287	
850	V44	V_BH6_0850__21_01288	
		V_BH6_0850__21_01289	
		V_BH6_0850__21_01290	
850	V72	V_BH6_0850__21_01291	
		V_BH6_0850__21_01292	
		V_BH6_0850__21_01293	
850	V73	V_BH6_0850__21_01294	
		V_BH6_0850__21_01295	
		V_BH6_0850__21_01296	
850	V74	V_BH6_0850__21_01297	
		V_BH6_0850__21_01298	
		V_BH6_0850__21_01299	
850	V75	V_BH6_0850__21_01300	
		V_BH6_0850__21_01301	
		V_BH6_0850__21_01302	

K	Field Issues
Observed damage (note here as-needed additional detail on Daily Report items)	*corrective action (e.g. repair, component replacement)* *N/A*

L	**File Control**				
Data File	**Date Time**	**Depth Range**	**Staff**	**Software**	**Parameters/Settings**
V_BH6_0790__21_01168		800 – 855m	Cristian Vasile	VIPS5.11	1ms sample rate. 3 records of 20 seconds each
V_BH6_0790__21_01169					
V_BH6_0790__21_01170					
V_BH6_0790__21_01171					
V_BH6_0790__21_01172					
V_BH6_0790__21_01173					
V_BH6_0790__21_01174					
V_BH6_0790__21_01175					
V_BH6_0790__21_01176					
V_BH6_0790__21_01177					
V_BH6_0790__21_01178					
V_BH6_0790__21_01179					
V_BH6_0790__21_01180					
V_BH6_0790__21_01181					
V_BH6_0790__21_01182					
V_BH6_0790__21_01183					
V_BH6_0790__21_01184					
V_BH6_0790__21_01185					
V_BH6_0790__21_01186					
V_BH6_0790__21_01187					
V_BH6_0790__21_01188					

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L File Control					
V_BH6_0790__21_01189					
V_BH6_0790__21_01190					
V_BH6_0790__21_01191					
V_BH6_0790__21_01192					
V_BH6_0790__21_01193					
V_BH6_0790__21_01194					
V_BH6_0790__21_01195					
V_BH6_0790__21_01196					
V_BH6_0790__21_01197					
V_BH6_0790__21_01198					
V_BH6_0790__21_01199					
V_BH6_0790__21_01200					
V_BH6_0790__21_01201					
V_BH6_0790__21_01202					
V_BH6_0790__21_01203					
V_BH6_0790__21_01204					
V_BH6_0790__21_01205					
V_BH6_0790__21_01206					
V_BH6_0790__21_01207					
V_BH6_0790__21_01208					
V_BH6_0790__21_01209					
V_BH6_0790__21_01210					

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L File Control					
V_BH6_0790__21_01211					
V_BH6_0790__21_01212					
V_BH6_0790__21_01213					
V_BH6_0790__21_01214					
V_BH6_0790__21_01215					
V_BH6_0790__21_01216					
V_BH6_0790__21_01217					
V_BH6_0790__21_01218					
V_BH6_0790__21_01219					
V_BH6_0790__21_01220					
V_BH6_0790__21_01221					
V_BH6_0790__21_01222					
V_BH6_0790__21_01223					
V_BH6_0790__21_01224					
V_BH6_0790__21_01225					
V_BH6_0790__21_01226					
V_BH6_0790__21_01227					
V_BH6_0790__21_01228					
V_BH6_0790__21_01229					
V_BH6_0790__21_01230					
V_BH6_0790__21_01231					
V_BH6_0790__21_01232					

L File Control					
V_BH6_0790__21_01233					
V_BH6_0790__21_01234					
V_BH6_0790__21_01235					
V_BH6_0790__21_01236					
V_BH6_0790__21_01237					
V_BH6_0790__21_01238					
V_BH6_0790__21_01239					
V_BH6_0790__21_01240					
V_BH6_0790__21_01241					
V_BH6_0790__21_01242					
V_BH6_0790__21_01243					
V_BH6_0790__21_01244					
V_BH6_0790__21_01245					
V_BH6_0790__21_01246					
V_BH6_0790__21_01247					
V_BH6_0790__21_01248					
V_BH6_0790__21_01249					
V_BH6_0790__21_01250					
V_BH6_0790__21_01251					
V_BH6_0790__21_01252					
V_BH6_0790__21_01253					
V_BH6_0790__21_01254					

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L **File Control**					
V_BH6_0790__21_01255					
V_BH6_0790__21_01256					
V_BH6_0790__21_01257					
V_BH6_0850__21_01258		860 – 915m	Cristian Vasile	VIPS5.11	1ms sample rate. 3 records of 20 seconds each
V_BH6_0850__21_01259					
V_BH6_0850__21_01260					
V_BH6_0850__21_01261					
V_BH6_0850__21_01262					
V_BH6_0850__21_01263					
V_BH6_0850__21_01264					
V_BH6_0850__21_01265					
V_BH6_0850__21_01266					
V_BH6_0850__21_01267					
V_BH6_0850__21_01268					
V_BH6_0850__21_01269					
V_BH6_0850__21_01270					
V_BH6_0850__21_01271					
V_BH6_0850__21_01272					
V_BH6_0850__21_01273					
V_BH6_0850__21_01274					
V_BH6_0850__21_01275					

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L File Control					
V_BH6_0850__21_01276					
V_BH6_0850__21_01277					
V_BH6_0850__21_01278					
V_BH6_0850__21_01279					
V_BH6_0850__21_01280					
V_BH6_0850__21_01281					
V_BH6_0850__21_01282					
V_BH6_0850__21_01283					
V_BH6_0850__21_01284					
V_BH6_0850__21_01285					
V_BH6_0850__21_01286					
V_BH6_0850__21_01287					
V_BH6_0850__21_01288					
V_BH6_0850__21_01289					
V_BH6_0850__21_01290					
V_BH6_0850__21_01291					
V_BH6_0850__21_01292					
V_BH6_0850__21_01293					
V_BH6_0850__21_01294					
V_BH6_0850__21_01295					
V_BH6_0850__21_01296					
V_BH6_0850__21_01297					

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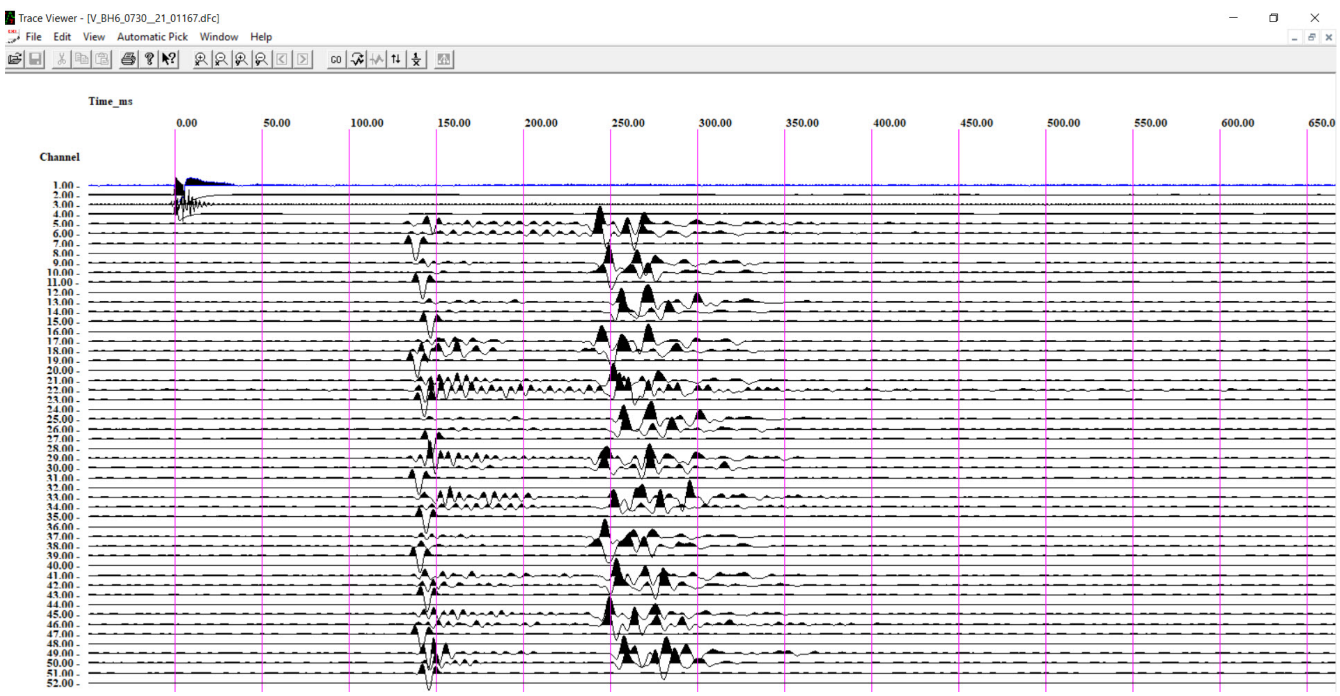
L File Control					
V_BH6_0850__21_01298					
V_BH6_0850__21_01299					
V_BH6_0850__21_01300					
V_BH6_0850__21_01301					
V_BH6_0850__21_01302					



Test shot at depth 730, V90

The energy is the same as before. Also frequency-wise the VIBSIST-3000 works as before.

WP12 Data Quality Confirmation (DQC) Form			
Document No.: *20253946-6120-220207*	Original Date: *07 Feb 2022*	Developed By: *Nicoleta Enescu*	GOLDER MEMBER OF WSP
Revision No.: *R0*	Revision Date: *N/A*	Authorized By: *Christopher Phillips*	

VIBROMETRIC

Vibrometric Seismic Source Checklist

Engine Off Checks	OK	Maintenance
Leaks – Fuel, Hydraulic Oil, Engine Oil or Radiator Coolant	✓	
Tires – Condition and Pressure	✓	
Hydraulic Hoses, Mast Chains, Cables and Stops – Check Visually	✓	
Safety Warnings – Attached (Refer to Parts Manual for Location)	✓	
Battery – Check Water/Electrolyte Level and Charge	✓	
Hydraulic Fluid Level – Check Level	✓	
Engine Oil Level – Dipstick	✓	
Transmission Fluid Level – Dipstick	✓	
Radiator Coolant – Check Level	✓	
Operator's Manual – In Container	✓	
Nameplate – Attached and Information Matches Model, Serial Number and Attachments	✓	
Seat Belt – Functioning Smoothly	✓	
Hood Latch – Adjusted and Securely Fastened	✓	
Brake Fluid – Check Level	✓	
Seismic Vibrator Check Screws, Cables, Hoses	✓	
Fuel level	✓	
Lights check	✓	
Engine On Checks	**OK**	**Maintenance**
Accelerator or Direction Control Pedal – Functioning Smoothly	✓	
Service Brake – Functioning Smoothly	✓	
Parking Brake – Functioning Smoothly	✓	
Steering Operation – Functioning Smoothly	✓	
Drive Control – Forward/Reverse – Functioning Smoothly	✓	
Arm Tilt Control – Forward and Back – Functioning Smoothly	✓	
Hoist (Seismic Source) and Lowering Control – Functioning Smoothly	✓	
Testing the sweep – Operation	✓	
Horn and Lights – Functioning	✓	
Cab (if equipped) – Heater, Defroster, Wipers – Functioning	✓	
Gauges: Ammeter, Engine Oil Pressure, Hour Meter, Fuel Level, Temperature, Instrument Monitors – Functioning	✓	
Controller check | Trigger sensor on impact plate check		
Impact plate check | Radio check	✓	
Source type	✓	

Feb 7 2022 B Moran

O Sign-Off		
Prepared	*Jon Crawford*	*February 07, 2022*
Reviewed	*Nicoleta Enescu*	*February 07, 2022*
Approved	*Christopher Phillips*	*February 07, 2022*

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TO:	Mostafa Khorshidi	**Date:**	*220208*
	Maria Sánchez-Rico Castejón	**Work Package:**	WP12 – VSP Profiling
	Sarah Hirschorn		
CC:	George Schneider		
		Distributed By:	Email

Record Number: 20253946-6120-220208

IGBH_06, IGNACE, ONTARIO

Acquisition depth interval: 15 shots at L14 (860 – 915 m) and all L15 (920 – 975m),

Staff: Cristian Vasile

Start time: 08:30 am **Finish time: 1:15 pm**

Shot location(s): 15 shot locations for level at 850m and all 30 shot locations for level at 910m

Prepared by: Nicoleta Enescu

Verified by: Chris Phillips

Usage notes:

- Complete one form per field day
- Office forms will be complete as processing packages/tasks are completed and will include supporting documentation
- Complete all header information (above)
- Delete unused tables (below) and fully populate those that remain
- Form is divided into A through O tables and field and processing tasks

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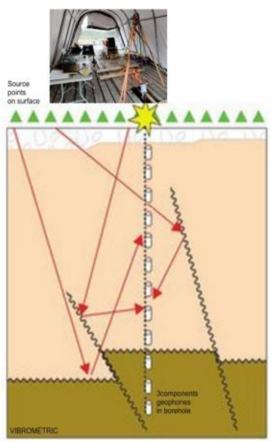
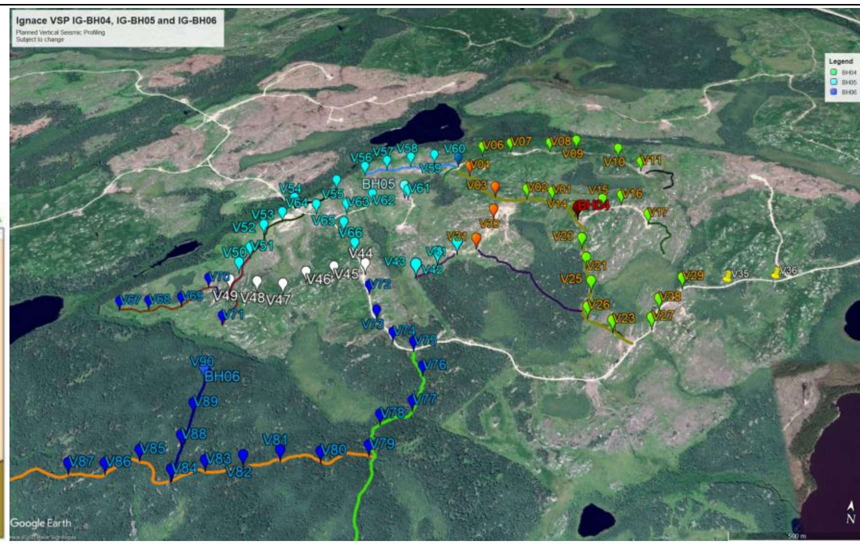
FIELD

A Winch and Depth Counter	
Calibrated by measuring and marking the cable every 100 m before insertion in the borehole. Verifying these distances using the depth counter. Discrepancies are adjusted by changing the depth value on the depth counter to match the cable mark.	
Results	At 850.00m the depth counter read 850.00m. At cable mark 910m, depth counter reads 910.00m.
Settings applied	

B Tool Assembly	
Schematic	(see figures below)
Results of checks.	All good





E Equipment Calibration/Function Checklist	OK	Maintenance
Geophones		
Geophone used (RD or R):	RD	
Testing at ground surface performed before insertion in the borehole:		
Level of electrical disturbance	OK	
Water tightness	OK	
Operation of side arm clamp	OK	
Verification of noise level and real seismic signal in each component	OK	

E Equipment Calibration/Function Checklist	OK	Maintenance
Winch Motor and transmission Controller Brake Ground anchors	All OK	
Cable Borehole collar level mark Overnight clamp	All OK	
Depth counter	OK	
Radio check	OK	
Acquisition computer Computer Acquisition Software Data Analysis Software	OK OK OK	
Power source	OK	
Access vehicle	OK	
Geophones calibration certificate verification: Technical ID Signature Date Validity period Location	_X_ _X_ _X_ _X_ _X_	
Depth counter calibration certificate verification: Technical ID Signature Date Validity period Location	Calibration shown in Table A	

F Decontamination	
Verification of equipment decontamination before insertion into borehole	Yes

G Dummy Probe Run	
Done before insertion of geophones into borehole	Complete to 998m mbgs on January 25, 2022

H Geophone Testing in Borehole	
Clamping location verified	Yes
Level of electrical disturbance	None
Operation of the side arm clamp	Good
Verification of noise in each component	Done, file Noise_0070__21_60012.dlc
Verification of real seismic signal in each component	Done, file V_BH6_0850__21_01303.dlc

I Shot	
Confirmation of shot point ID with receiver staff	Yes
Data acquisition sampling rate confirmed at 1 ms	Yes

J Field Data – Review and Verification

Depth of zero mark	**Shot ID**	**Data File**	**Comment/Verified** (fitness for use)
850	V75	V_BH6_0850__21_01303	**All ok**
		V_BH6_0850__21_01304	
		V_BH6_0850__21_01305	
850	V76	V_BH6_0850__21_01306	**All ok**
		V_BH6_0850__21_01307	
		V_BH6_0850__21_01308	
850	V77	V_BH6_0850__21_01309	
		V_BH6_0850__21_01310	
		V_BH6_0850__21_01311	
850	V78	V_BH6_0850__21_01312	
		V_BH6_0850__21_01313	
		V_BH6_0850__21_01314	
850	V79	V_BH6_0850__21_01315	

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J	Field Data – Review and Verification		
		V_BH6_0850__21_01316	
		V_BH6_0850__21_01317	
850	V80	V_BH6_0850__21_01318	
		V_BH6_0850__21_01319	
		V_BH6_0850__21_01320	
850	V81	V_BH6_0850__21_01321	
		V_BH6_0850__21_01322	
		V_BH6_0850__21_01323	
850	V82	V_BH6_0850__21_01324	
		V_BH6_0850__21_01325	
		V_BH6_0850__21_01326	
850	V83	V_BH6_0850__21_01327	
		V_BH6_0850__21_01328	
		V_BH6_0850__21_01329	
850	V84	V_BH6_0850__21_01330	
		V_BH6_0850__21_01331	
		V_BH6_0850__21_01332	
850	V85	V_BH6_0850__21_01333	
		V_BH6_0850__21_01334	
		V_BH6_0850__21_01335	
850	V86	V_BH6_0850__21_01336	
		V_BH6_0850__21_01337	

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J	**Field Data – Review and Verification**		
		V_BH6_0850__21_01338	
850	V87	V_BH6_0850__21_01339	
		V_BH6_0850__21_01340	
		V_BH6_0850__21_01341	
850	V88	V_BH6_0850__21_01342	
		V_BH6_0850__21_01343	
		V_BH6_0850__21_01344	
850	V89	V_BH6_0850__21_01345	
		V_BH6_0850__21_01346	
		V_BH6_0850__21_01347	
850	V90	V_BH6_0850__21_01348	
		V_BH6_0850__21_01349	
		V_BH6_0850__21_01350	
910	V90	V_BH6_0910__21_01351	**All ok**
		V_BH6_0910__21_01352	
		V_BH6_0910__21_01353	
910	V89	V_BH6_0910__21_01354	
		V_BH6_0910__21_01355	
		V_BH6_0910__21_01356	
910	V88	V_BH6_0910__21_01357	
		V_BH6_0910__21_01358	

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J	Field Data – Review and Verification		
		V_BH6_0910__21_01359	
910	V87	V_BH6_0910__21_01360	
		V_BH6_0910__21_01361	
		V_BH6_0910__21_01362	
910	V86	V_BH6_0910__21_01363	
		V_BH6_0910__21_01364	
		V_BH6_0910__21_01365	
910	V85	V_BH6_0910__21_01366	
		V_BH6_0910__21_01367	
		V_BH6_0910__21_01368	
910	V84	V_BH6_0910__21_01369	
		V_BH6_0910__21_01370	
		V_BH6_0910__21_01371	
910	V83	V_BH6_0910__21_01372	
		V_BH6_0910__21_01373	
		V_BH6_0910__21_01374	
910	V82	V_BH6_0910__21_01375	
		V_BH6_0910__21_01376	
		V_BH6_0910__21_01377	
910	V81	V_BH6_0910__21_01378	
		V_BH6_0910__21_01379	
		V_BH6_0910__21_01380	

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J	Field Data – Review and Verification		
910	V80	V_BH6_0910__21_01381	
		V_BH6_0910__21_01382	
		V_BH6_0910__21_01383	
910	V79	V_BH6_0910__21_01384	
		V_BH6_0910__21_01385	
		V_BH6_0910__21_01386	
910	V78	V_BH6_0910__21_01387	
		V_BH6_0910__21_01388	
		V_BH6_0910__21_01389	
910	V77	V_BH6_0910__21_01390	
		V_BH6_0910__21_01391	
		V_BH6_0910__21_01392	
910	V76	V_BH6_0910__21_01393	
		V_BH6_0910__21_01394	
		V_BH6_0910__21_01395	
910	V75	V_BH6_0910__21_01396	
		V_BH6_0910__21_01397	
		V_BH6_0910__21_01398	
910	V74	V_BH6_0910__21_01399	
		V_BH6_0910__21_01400	
		V_BH6_0910__21_01401	
910	V73	V_BH6_0910__21_01402	

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J	Field Data – Review and Verification		
		V_BH6_0910__21_01403	
		V_BH6_0910__21_01404	
910	V72	V_BH6_0910__21_01405	
		V_BH6_0910__21_01406	
		V_BH6_0910__21_01407	
910	V44	V_BH6_0910__21_01408	
		V_BH6_0910__21_01409	
		V_BH6_0910__21_01410	
910	V45	V_BH6_0910__21_01411	
		V_BH6_0910__21_01412	
		V_BH6_0910__21_01413	
910	V46	V_BH6_0910__21_01414	
		V_BH6_0910__21_01415	
		V_BH6_0910__21_01416	
910	V47	V_BH6_0910__21_01417	
		V_BH6_0910__21_01418	
		V_BH6_0910__21_01419	
910	V48	V_BH6_0910__21_01420	
		V_BH6_0910__21_01421	
		V_BH6_0910__21_01422	
910	V49	V_BH6_0910__21_01423	
		V_BH6_0910__21_01424	

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J	**Field Data – Review and Verification**		
		V_BH6_0910__21_01425	
910	V71	V_BH6_0910__21_01426	
		V_BH6_0910__21_01427	
		V_BH6_0910__21_01428	
910	V91	V_BH6_0910__21_01429	
		V_BH6_0910__21_01430	
		V_BH6_0910__21_01431	
910	V92	V_BH6_0910__21_01432	
		V_BH6_0910__21_01433	
		V_BH6_0910__21_01434	
910	V93	V_BH6_0910__21_01435	
		V_BH6_0910__21_01436	
		V_BH6_0910__21_01437	
910	V94	V_BH6_0910__21_01438	
		V_BH6_0910__21_01439	
		V_BH6_0910__21_01440	

K	**Field Issues**
Observed damage (note here as-needed additional detail on Daily Report items)	*corrective action (e.g. repair, component replacement)* *N/A*

L	**File Control**				
Data File	**Date Time**	**Depth Range**	**Staff**	**Software**	**Parameters/Settings**

L	**File Control**				
V_BH6_0850__21_01306		860 – 915m	Cristian Vasile	VIPS5.11	1ms sample rate. 3 records of 20 seconds each
V_BH6_0850__21_01307					
V_BH6_0850__21_01308					
V_BH6_0850__21_01309					
V_BH6_0850__21_01310					
V_BH6_0850__21_01311					
V_BH6_0850__21_01312					
V_BH6_0850__21_01313					
V_BH6_0850__21_01314					
V_BH6_0850__21_01315					
V_BH6_0850__21_01316					
V_BH6_0850__21_01317					
V_BH6_0850__21_01318					
V_BH6_0850__21_01319					
V_BH6_0850__21_01320					
V_BH6_0850__21_01321					
V_BH6_0850__21_01322					
V_BH6_0850__21_01323					
V_BH6_0850__21_01324					
V_BH6_0850__21_01325					
V_BH6_0850__21_01326					
V_BH6_0850__21_01327					

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L **File Control**					
V_BH6_0850__21_01328					
V_BH6_0850__21_01329					
V_BH6_0850__21_01330					
V_BH6_0850__21_01331					
V_BH6_0850__21_01332					
V_BH6_0850__21_01333					
V_BH6_0850__21_01334					
V_BH6_0850__21_01335					
V_BH6_0850__21_01336					
V_BH6_0850__21_01337					
V_BH6_0850__21_01338					
V_BH6_0850__21_01339					
V_BH6_0850__21_01340					
V_BH6_0850__21_01341					
V_BH6_0850__21_01342					
V_BH6_0850__21_01343					
V_BH6_0850__21_01344					
V_BH6_0850__21_01345					
V_BH6_0850__21_01346					
V_BH6_0850__21_01347					
V_BH6_0850__21_01348					
V_BH6_0850__21_01349					

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L **File Control**					
V_BH6_0850__21_01350					
V_BH6_0910__21_01351		920 – 975m	Cristian Vasile	VIPS5.11	1ms sample rate. 3 records of 20 seconds each
V_BH6_0910__21_01352					
V_BH6_0910__21_01353					
V_BH6_0910__21_01354					
V_BH6_0910__21_01355					
V_BH6_0910__21_01356					
V_BH6_0910__21_01357					
V_BH6_0910__21_01358					
V_BH6_0910__21_01359					
V_BH6_0910__21_01360					
V_BH6_0910__21_01361					
V_BH6_0910__21_01362					
V_BH6_0910__21_01363					
V_BH6_0910__21_01364					
V_BH6_0910__21_01365					
V_BH6_0910__21_01366					
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V_BH6_0910__21_01368					
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V_BH6_0910__21_01370					

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V_BH6_0910__21_01377					
V_BH6_0910__21_01378					
V_BH6_0910__21_01379					
V_BH6_0910__21_01380					
V_BH6_0910__21_01381					
V_BH6_0910__21_01382					
V_BH6_0910__21_01383					
V_BH6_0910__21_01384					
V_BH6_0910__21_01385					
V_BH6_0910__21_01386					
V_BH6_0910__21_01387					
V_BH6_0910__21_01388					
V_BH6_0910__21_01389					
V_BH6_0910__21_01390					
V_BH6_0910__21_01391					
V_BH6_0910__21_01392					

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L File Control					
V_BH6_0910__21_01393					
V_BH6_0910__21_01394					
V_BH6_0910__21_01395					
V_BH6_0910__21_01396					
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V_BH6_0910__21_01398					
V_BH6_0910__21_01399					
V_BH6_0910__21_01400					
V_BH6_0910__21_01401					
V_BH6_0910__21_01402					
V_BH6_0910__21_01403					
V_BH6_0910__21_01404					
V_BH6_0910__21_01405					
V_BH6_0910__21_01406					
V_BH6_0910__21_01407					
V_BH6_0910__21_01408					
V_BH6_0910__21_01409					
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V_BH6_0910__21_01412					
V_BH6_0910__21_01413					
V_BH6_0910__21_01414					

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L File Control					
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V_BH6_0910__21_01436					

L File Control					
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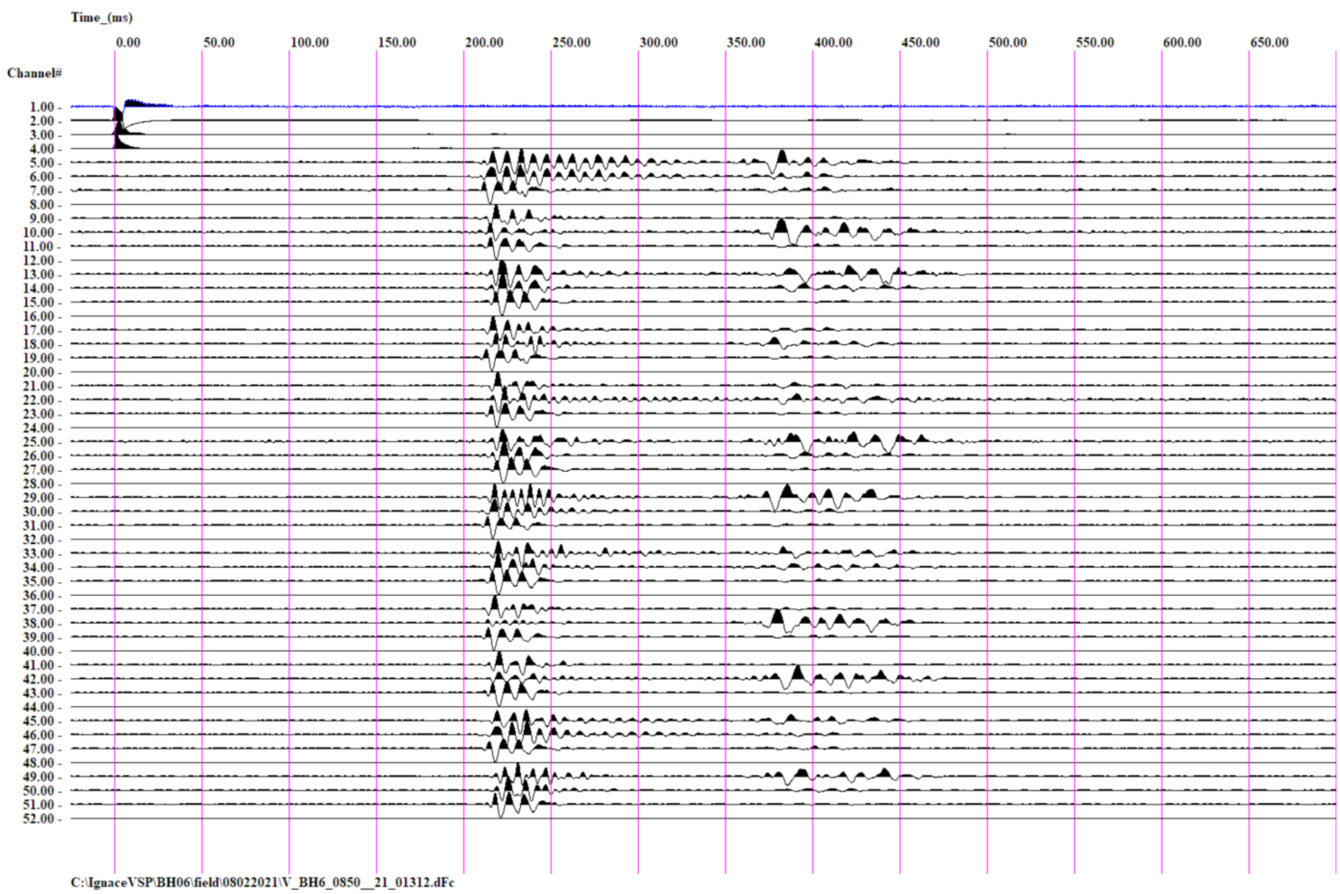
V_BH6_0910__21_01440					



Test shot at depth 850, V78

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VIBROMETRIC

Vibrometric Seismic Source Checklist

Engine Off Checks	OK	Maintenance
Leaks – Fuel, Hydraulic Oil, Engine Oil or Radiator Coolant	✓	
Tires – Condition and Pressure	✓	
Hydraulic Hoses, Mast Chains, Cables and Stops – Check Visually	✓	
Safety Warnings – Attached (Refer to Parts Manual for Location)	✓	
Battery – Check Water/Electrolyte Level and Charge	✓	
Hydraulic Fluid Level – Check Level	✓	
Engine Oil Level – Dipstick	✓	
Transmission Fluid Level – Dipstick	✓	
Radiator Coolant – Check Level	✓	
Operator's Manual – In Container	✓	
Nameplate – Attached and Information Matches Model, Serial Number and Attachments	✓	
Seat Belt – Functioning Smoothly	✓	
Hood Latch – Adjusted and Securely Fastened	✓	
Brake Fluid – Check Level	✓	
Seismic Vibrator Check Screws, Cables, Hoses	✓	
Fuel level	✓	
Lights check	✓	

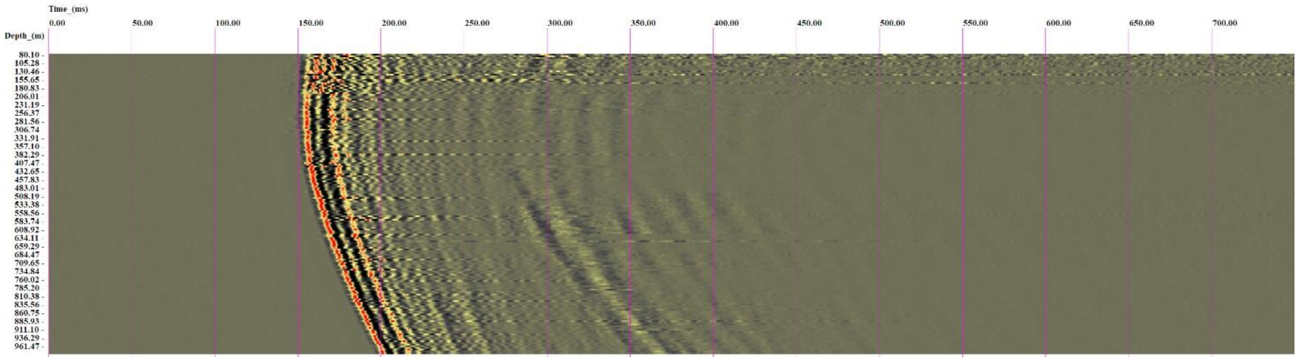
Engine On Checks	OK	Maintenance
Accelerator or Direction Control Pedal – Functioning Smoothly	✓	
Service Brake – Functioning Smoothly	✓	
Parking Brake – Functioning Smoothly	✓	
Steering Operation – Functioning Smoothly	✓	
Drive Control – Forward/Reverse – Functioning Smoothly	✓	
Arm Tilt Control – Forward and Back – Functioning Smoothly	✓	
Hoist (Seismic Source) and Lowering Control – Functioning Smoothly	✓	
Testing the sweep – Operation		
Horn and Lights – Functioning	✓	
Cab (if equipped) – Heater, Defroster, Wipers – Functioning	✓	
Gauges: Ammeter, Engine Oil Pressure, Hour Meter, Fuel Level, Temperature, Instrument Monitors – Functioning	✓	
Controller check | Trigger sensor on impact plate check		
Impact plate check | Radio check	✓	
Source type	✓	

Feb 8/22 B Morin

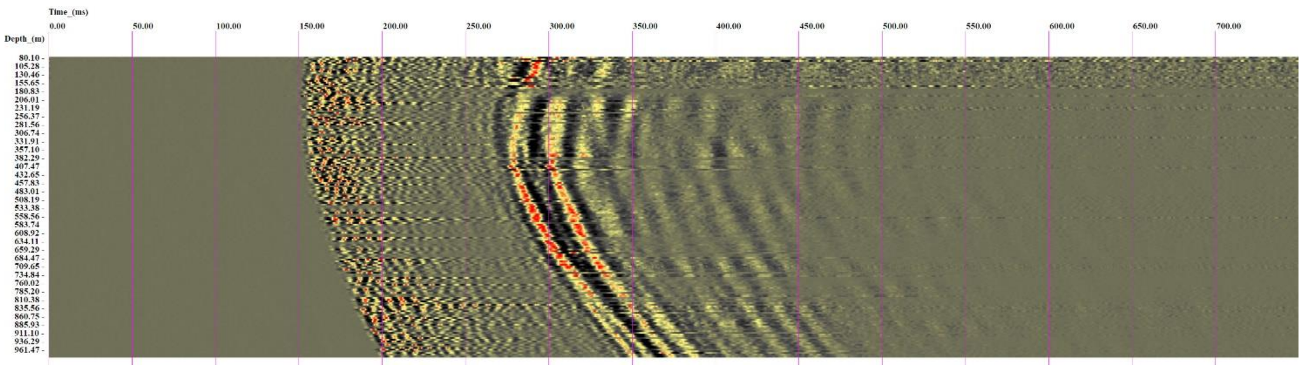
O	**Sign-Off**	
Prepared	*Jon Crawford*	*February 08, 2022*
Reviewed	*Nicoleta Enescu*	*February 08, 2022*
Approved	*Christopher Phillips*	*February 08, 2022*

APPENDIX B

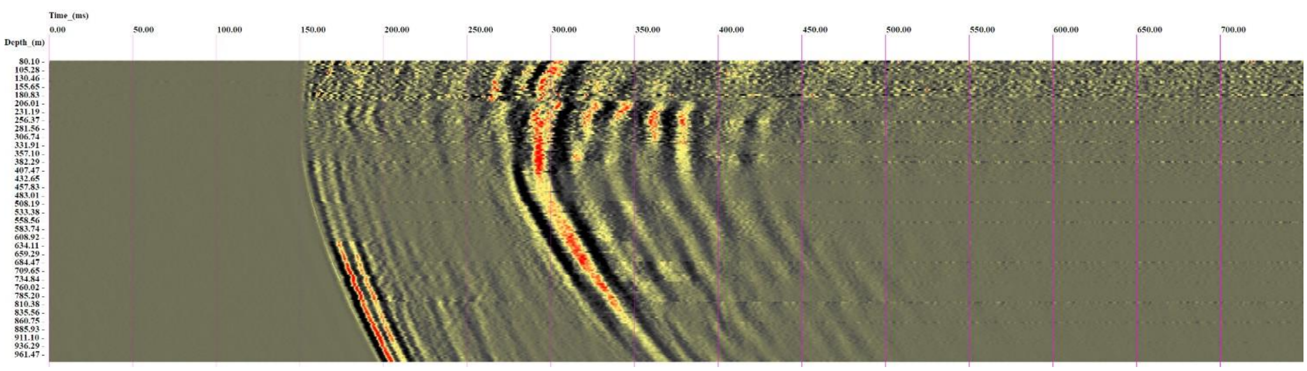
Raw VSP Profiles Acquired from Borehole IG_BH06



Radial component

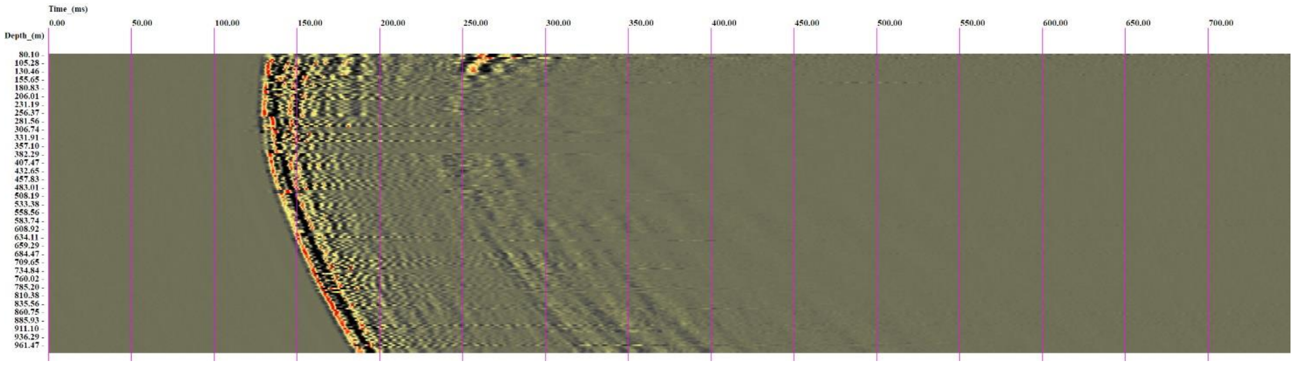


Transversal component

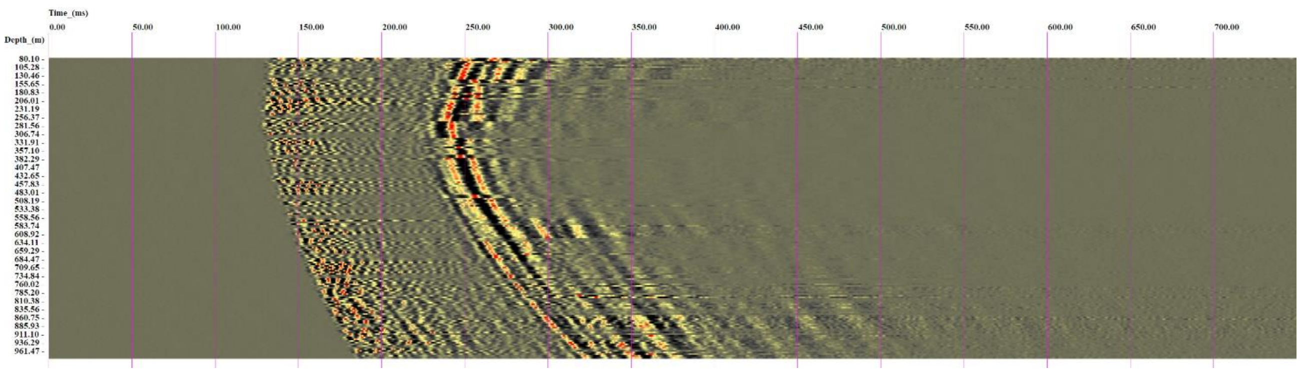


Axial component

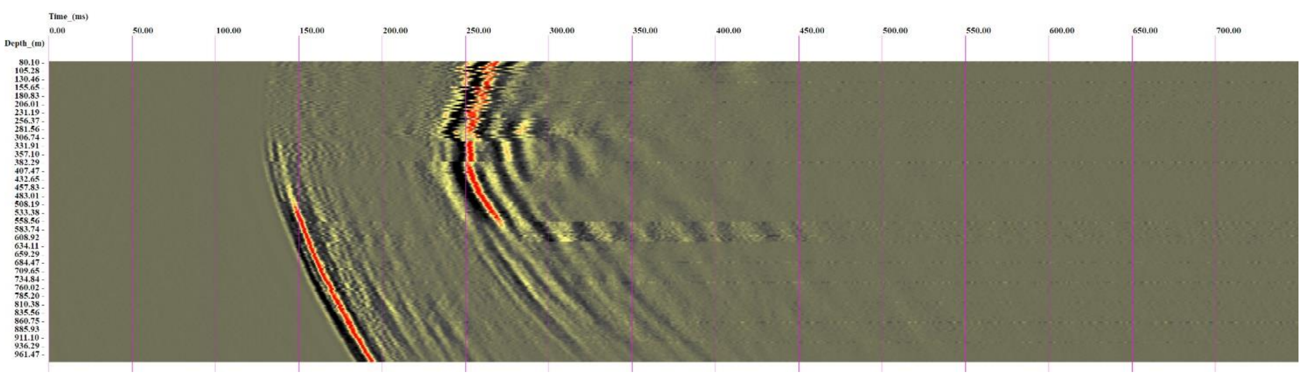
Figure 1. IG_BH06 VSP, Shot V44



Radial component

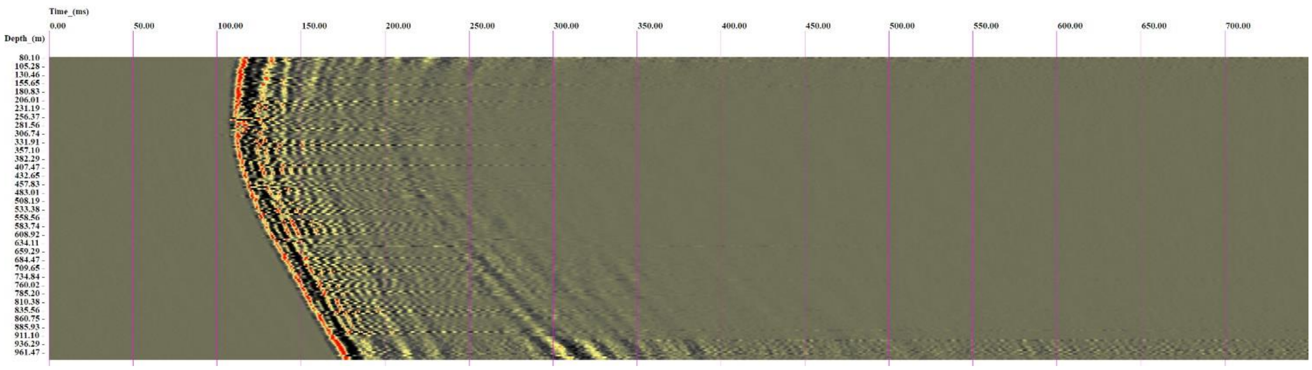


Transversal component

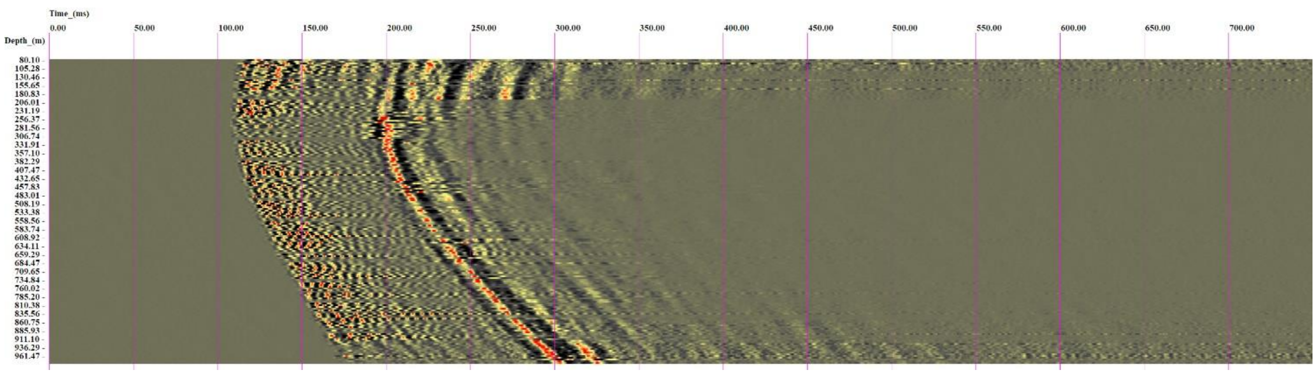


Axial component

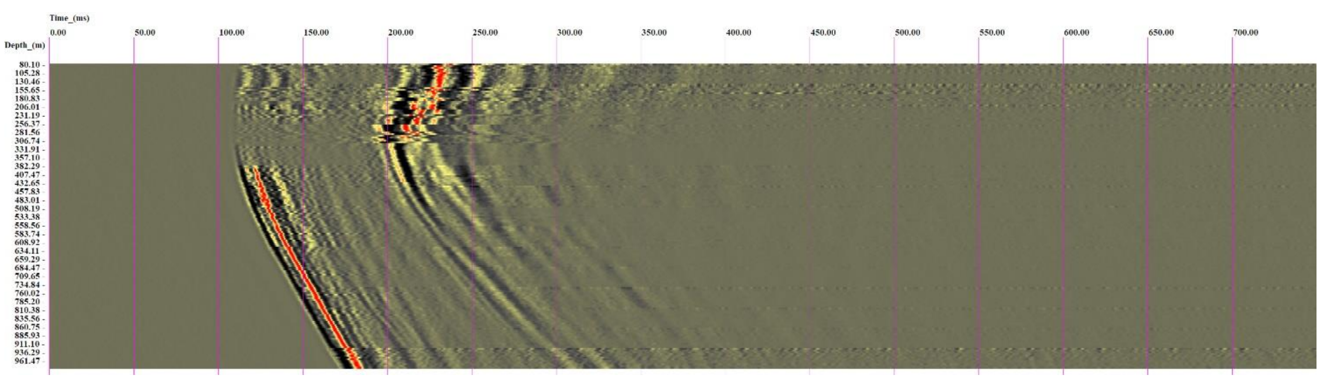
Figure 2. IG_BH06 VSP, Shot V45



Radial component

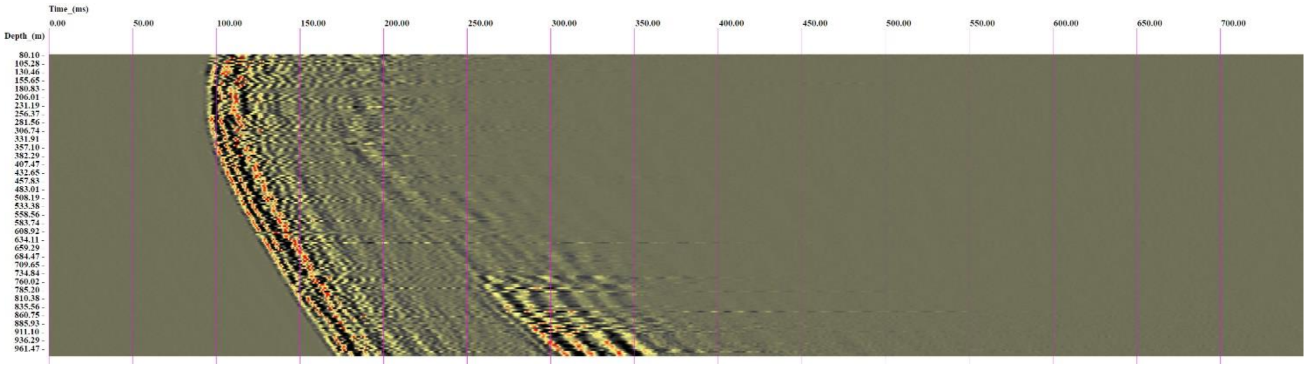


Transversal component

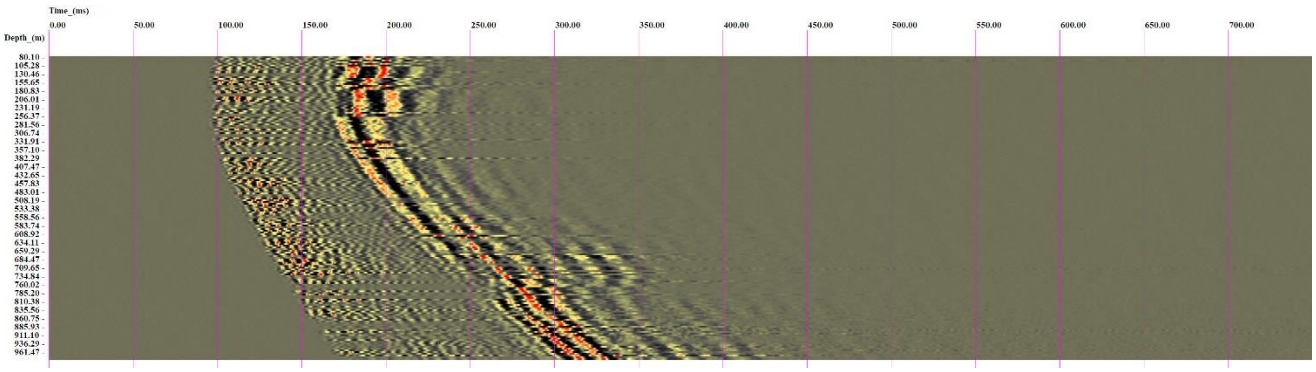


Axial component

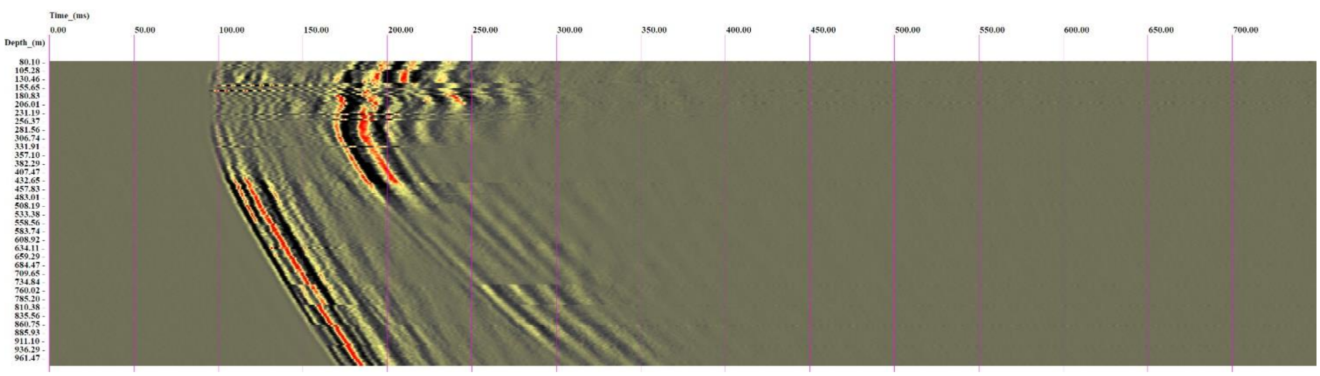
Figure 3. IG_BH06 VSP, Shot V46



Radial component

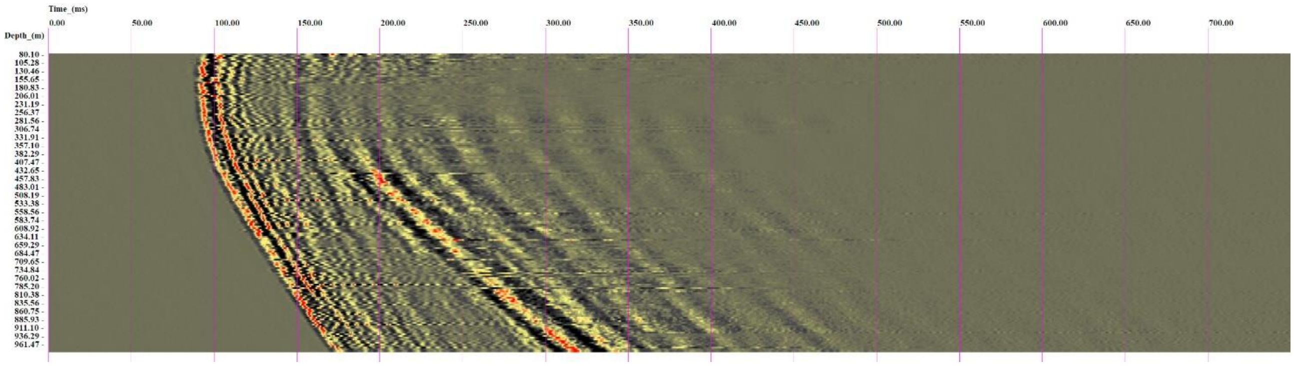


Transversal component

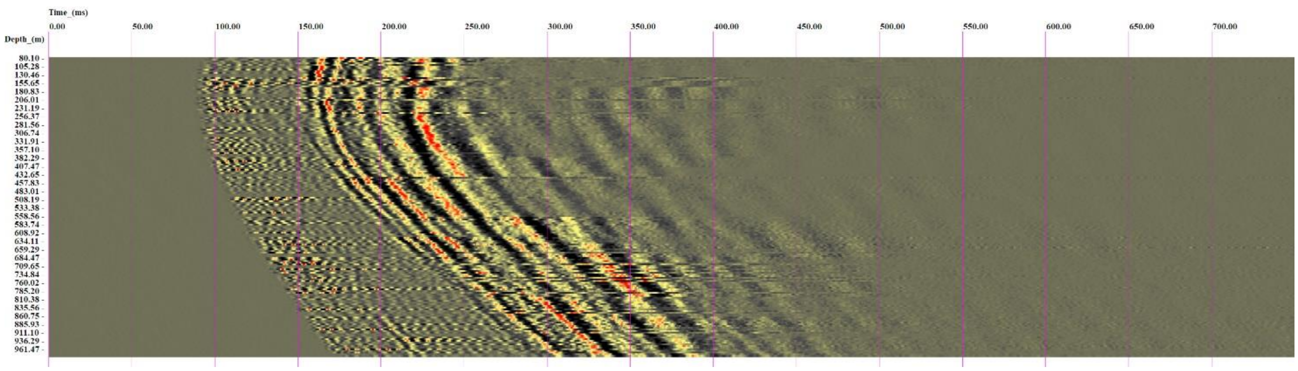


Axial component

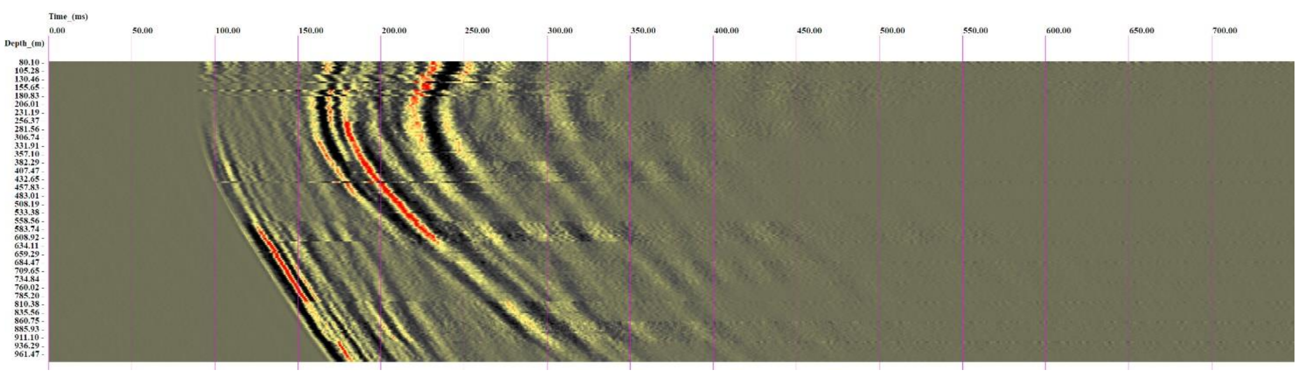
Figure 4. IG_BH06 VSP, Shot V47



Radial component

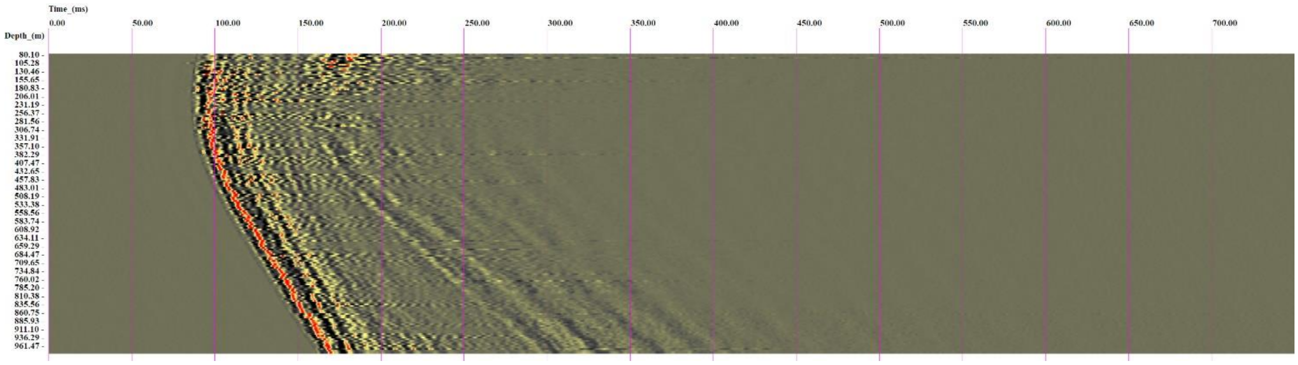


Transversal component

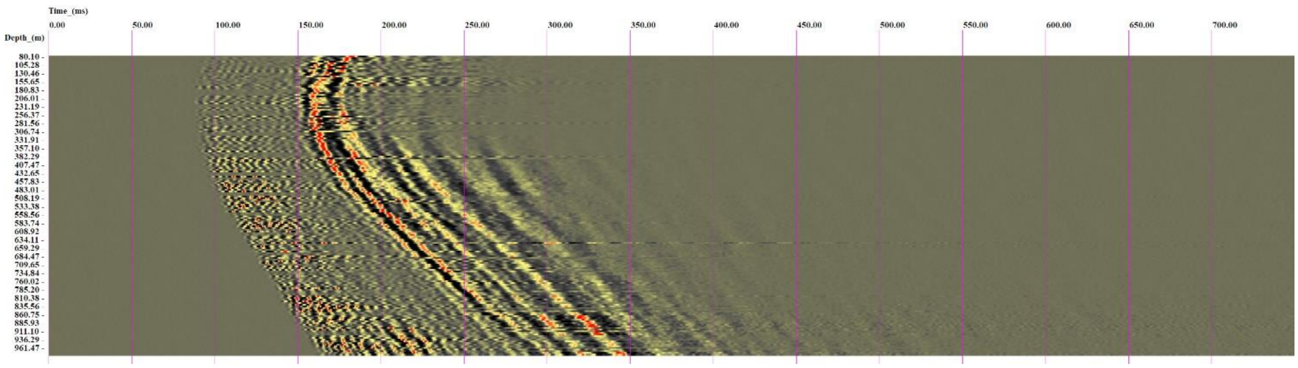


Axial component

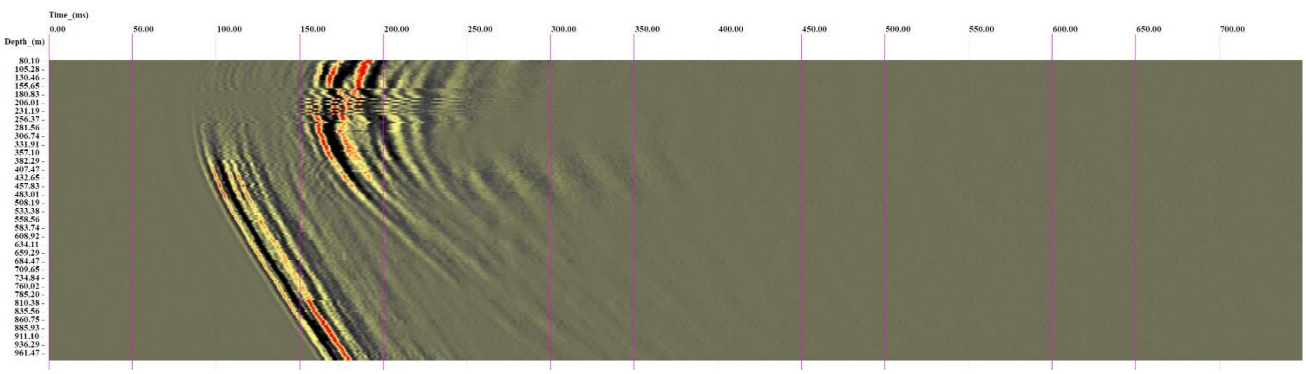
Figure 5. IG_BH06 VSP, Shot V48



Radial component

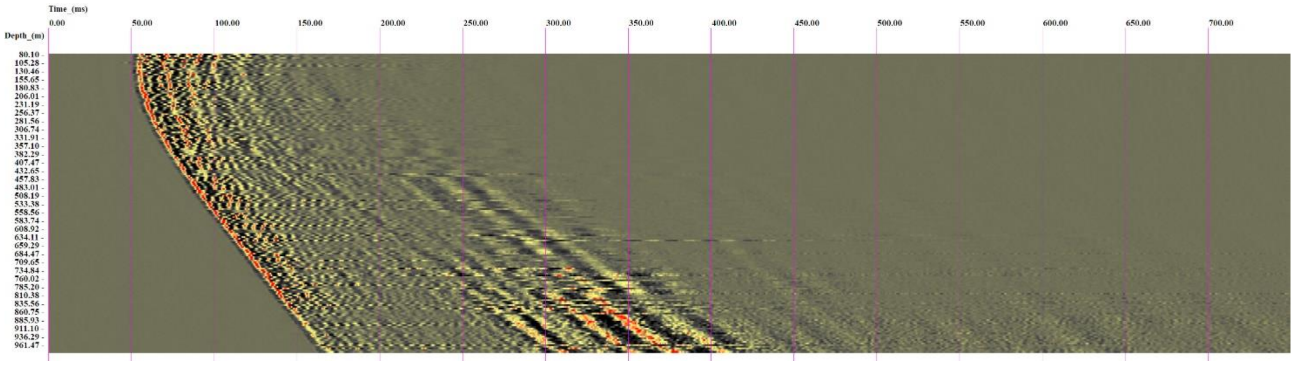


Transversal component

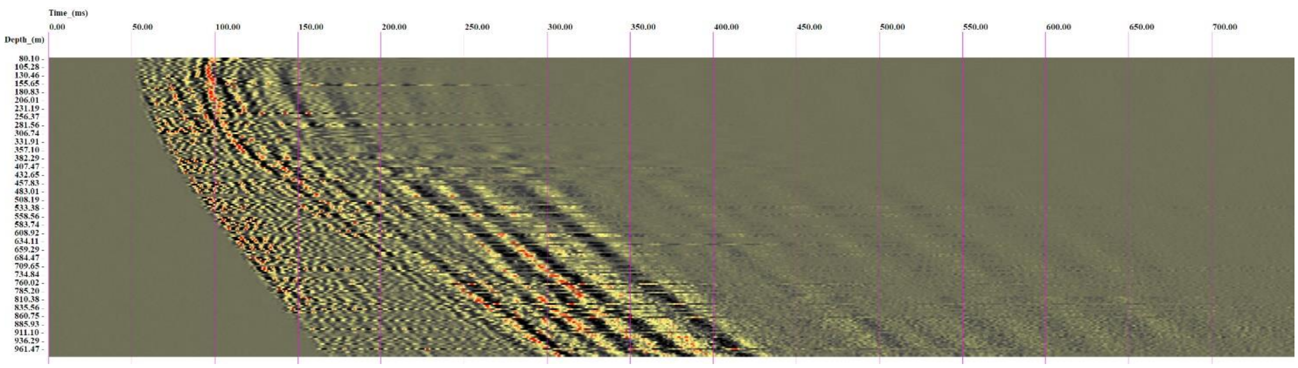


Axial component

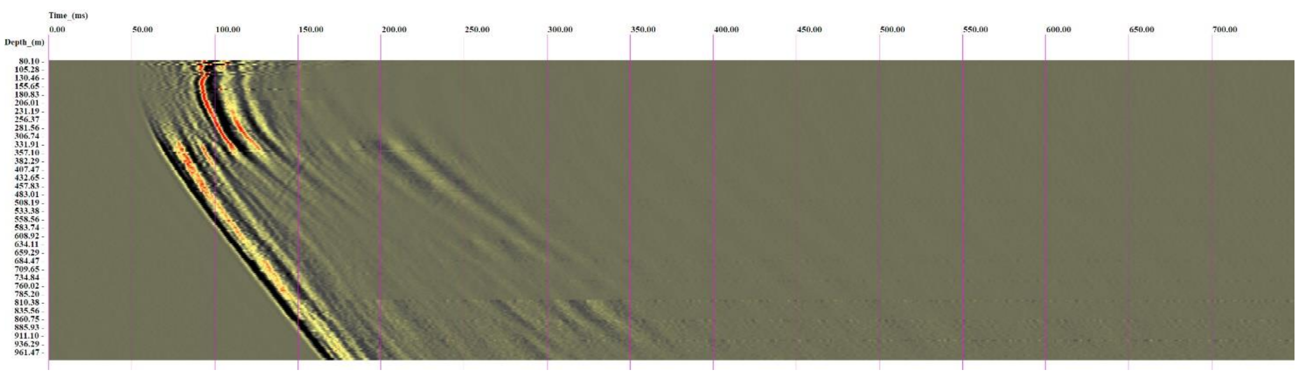
Figure 6. IG_BH06 VSP, Shot V49



Radial component

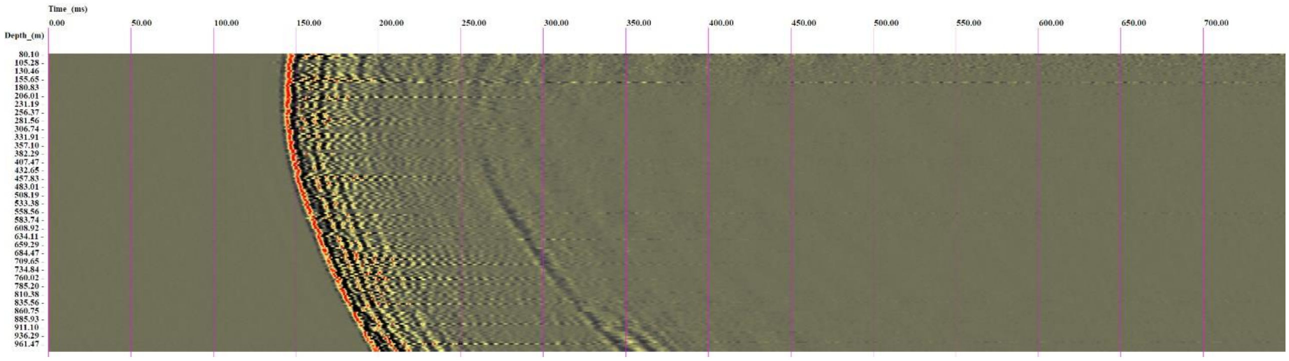


Transversal component

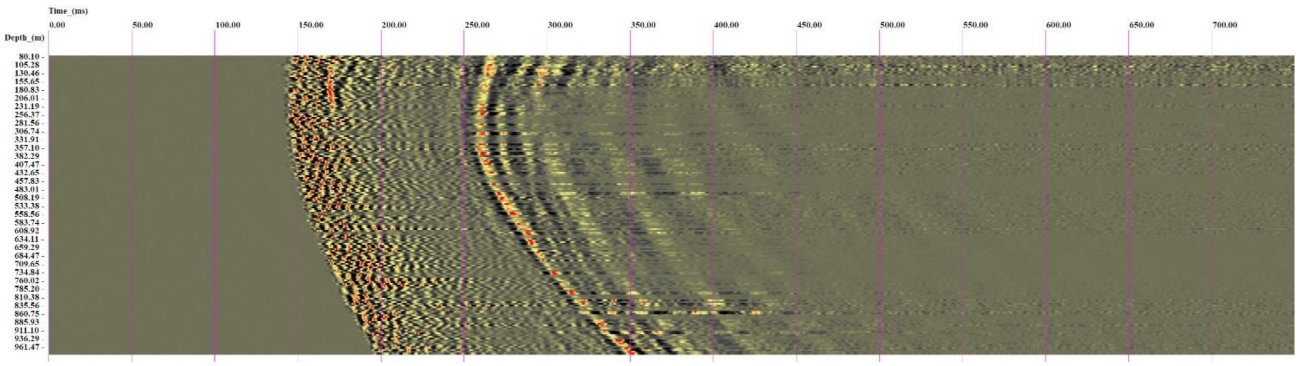


Axial component

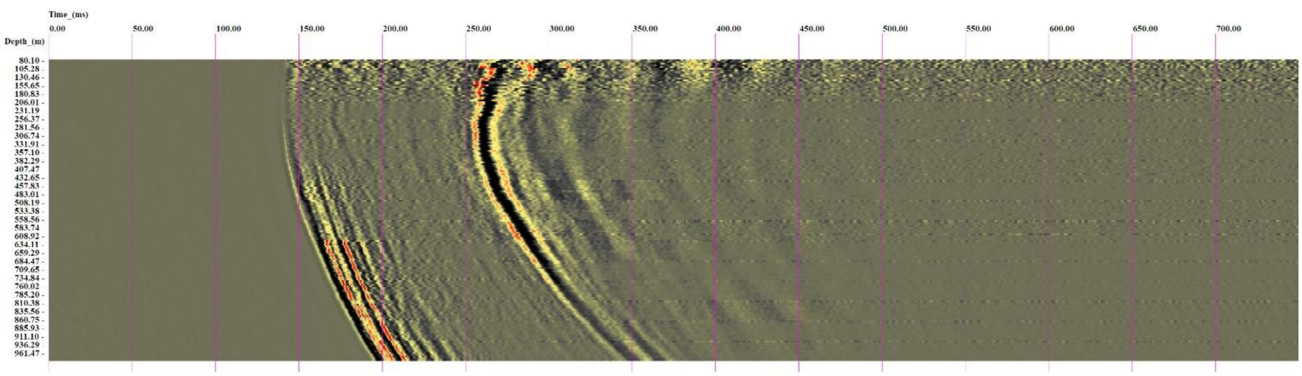
Figure 7. IG_BH06 VSP, Shot V71



Radial component

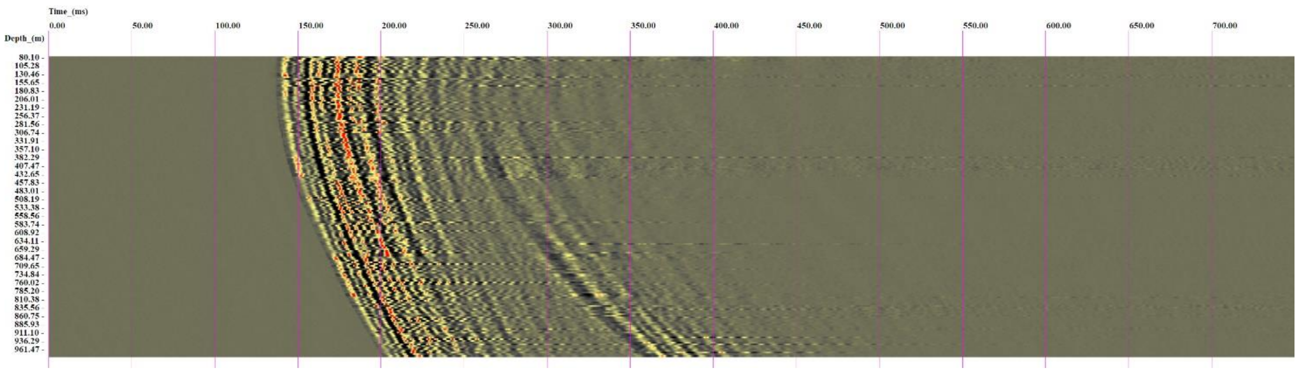


Transversal component

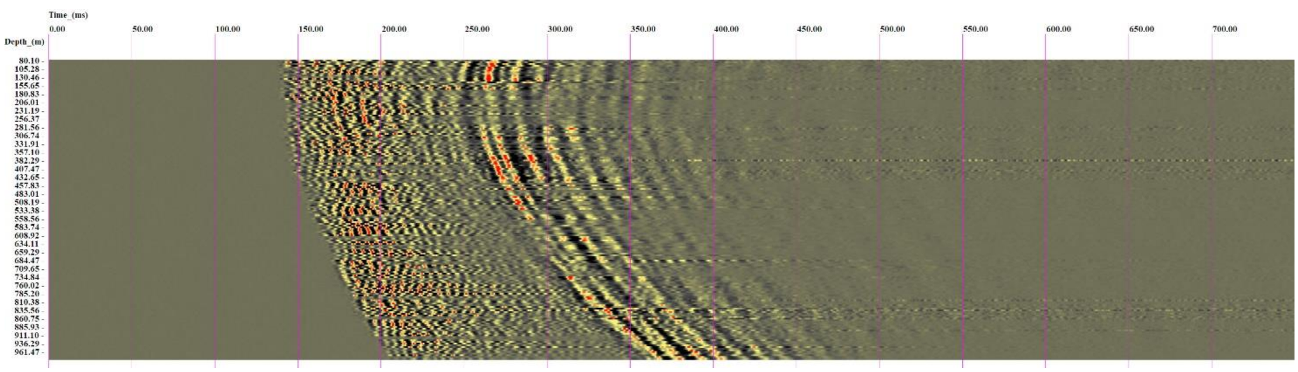


Axial component

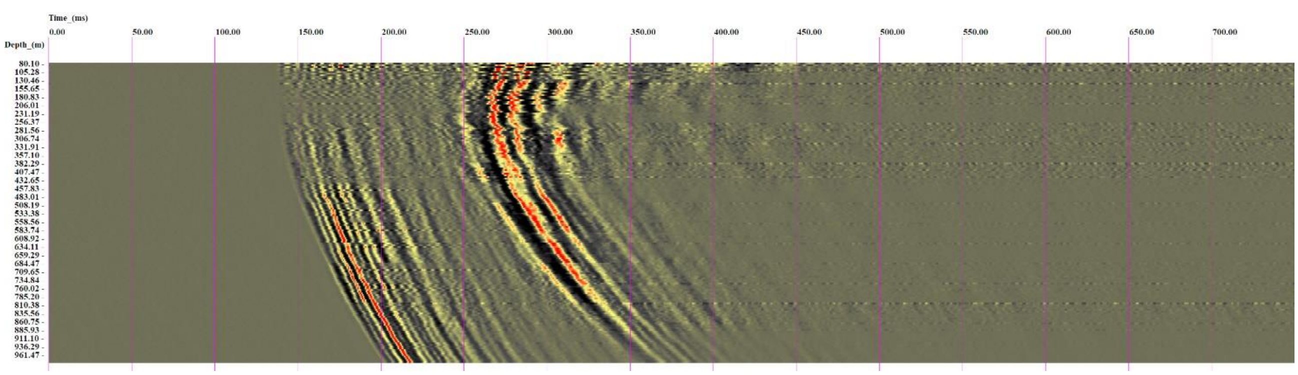
Figure 8. IG_BH06 VSP, Shot V72



Radial component

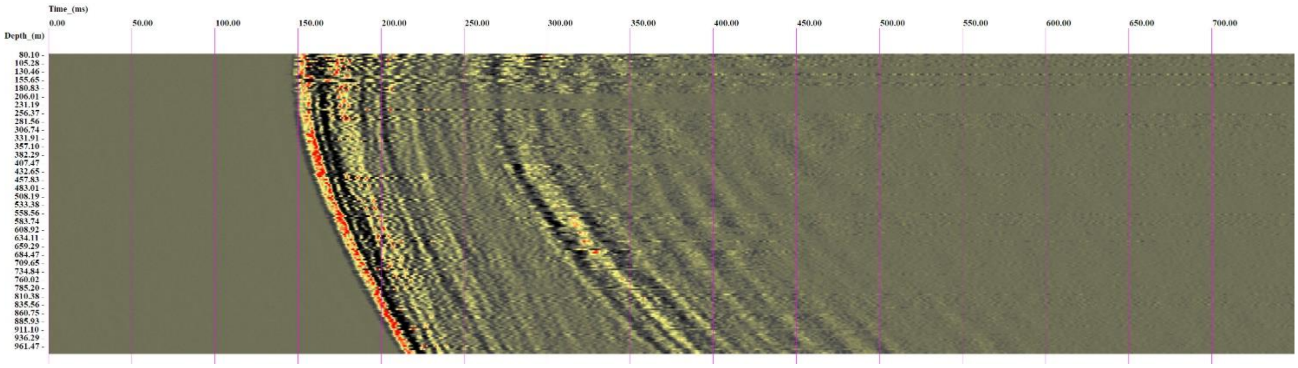


Transversal component

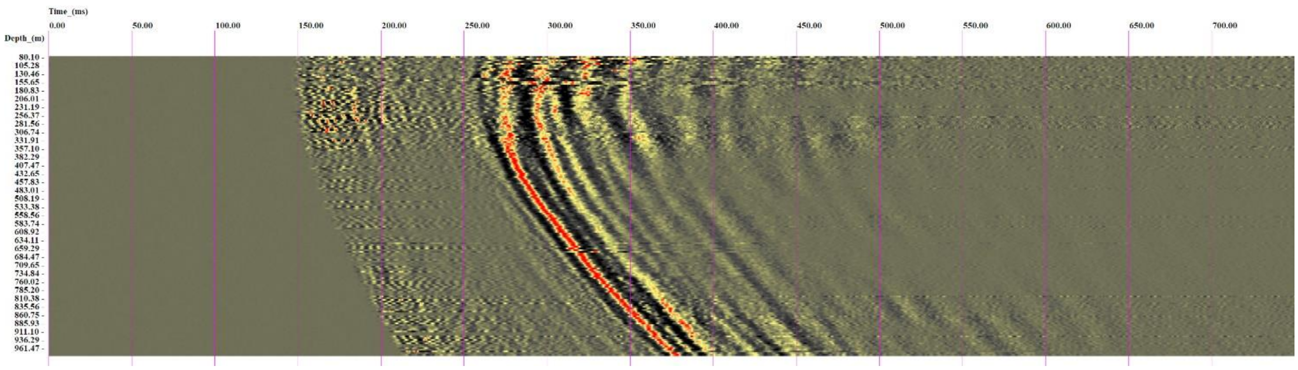


Axial component

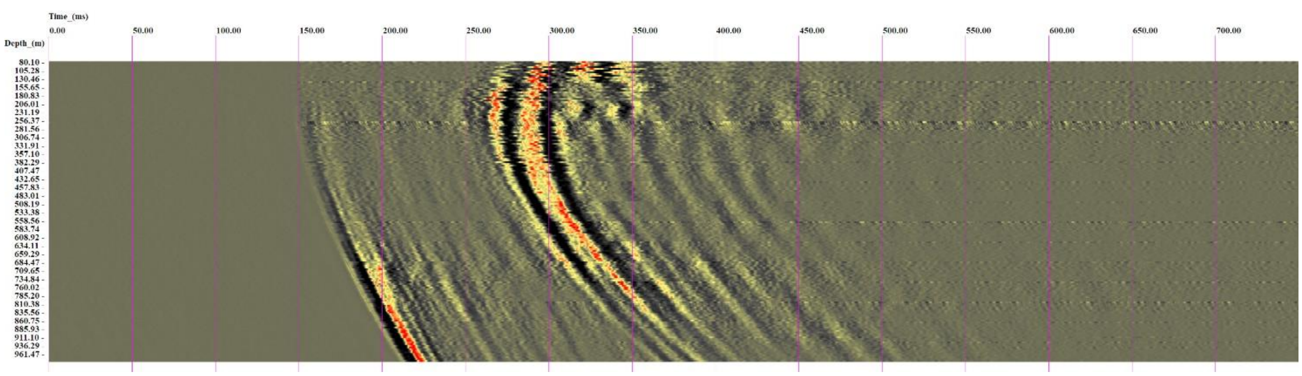
Figure 9. IG_BH06 VSP, Shot V73



Radial component

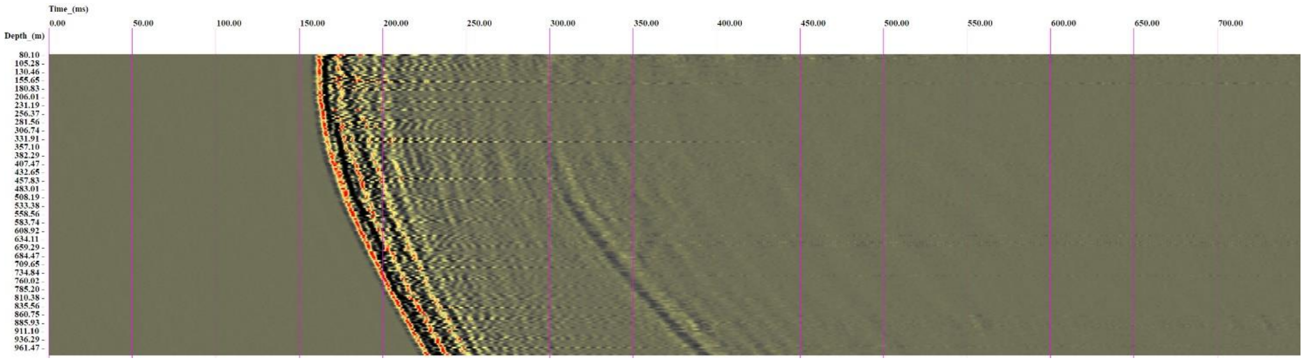


Transversal component

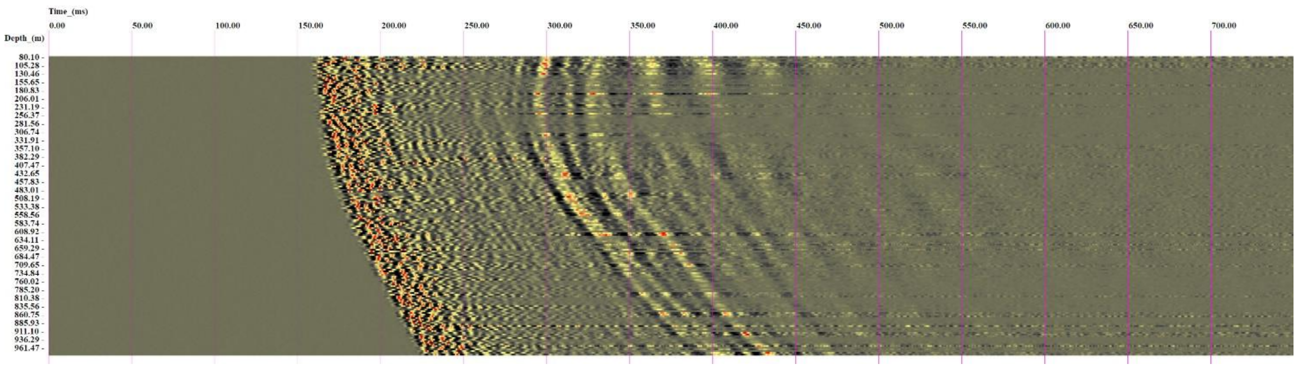


Axial component

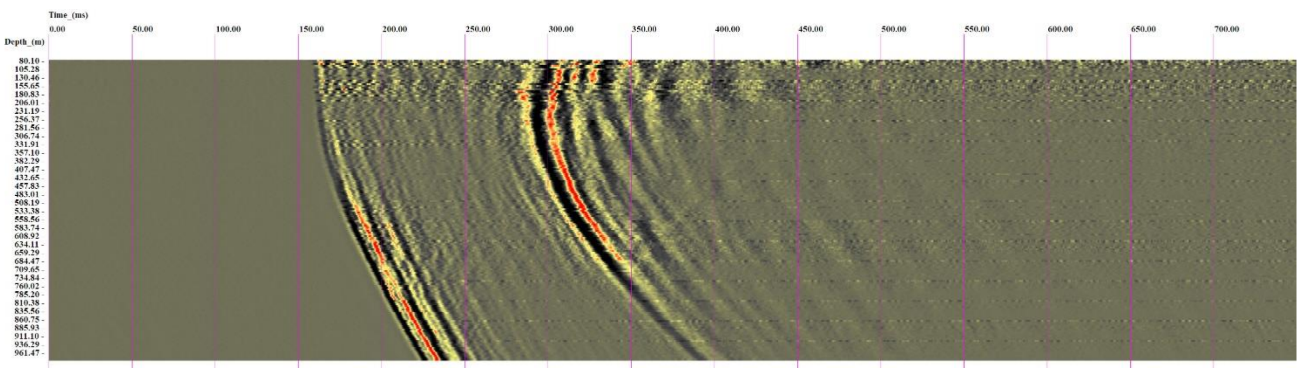
Figure 10. IG_BH06 VSP, Shot V74



Radial component

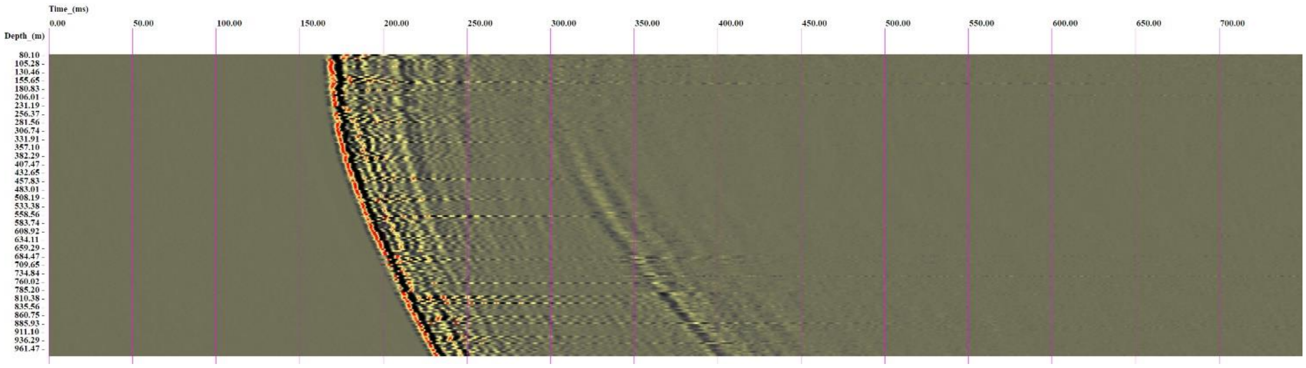


Transversal component

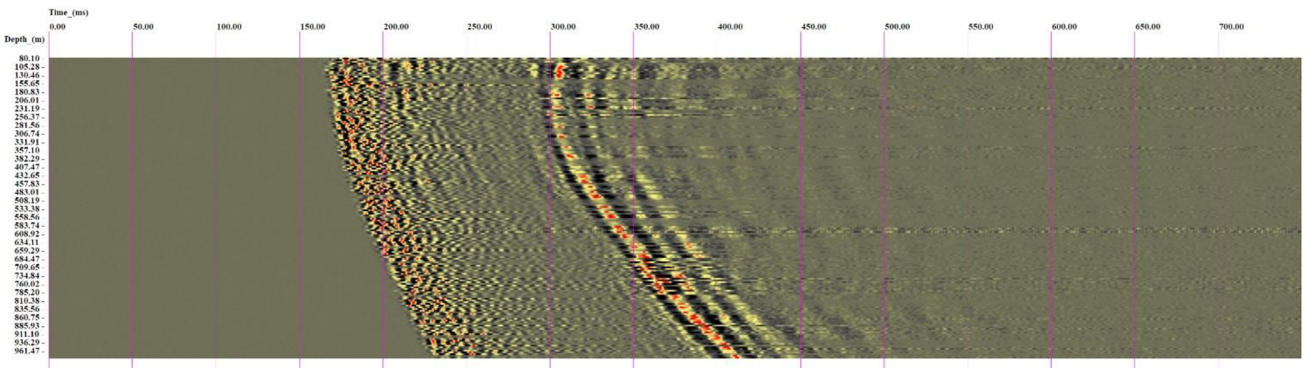


Axial component

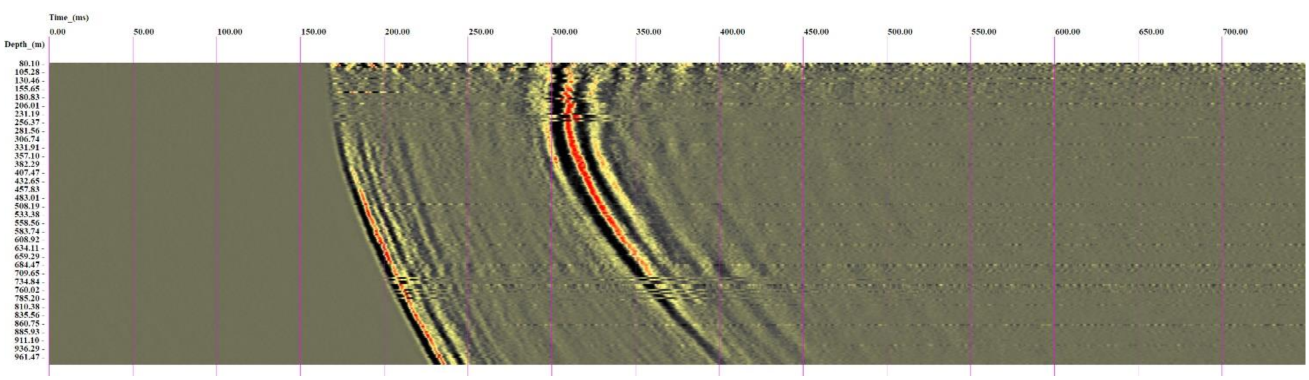
Figure 11. IG_BH06 VSP, Shot V75



Radial component

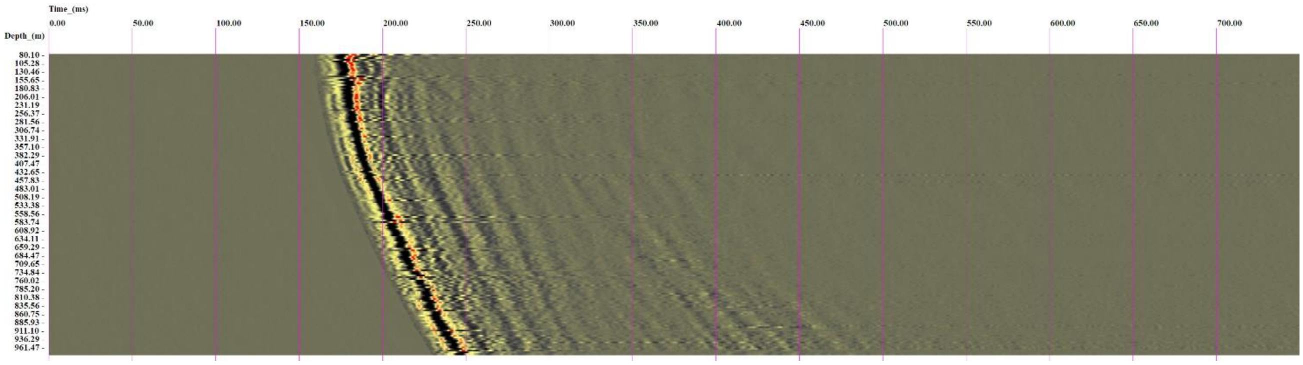


Transversal component

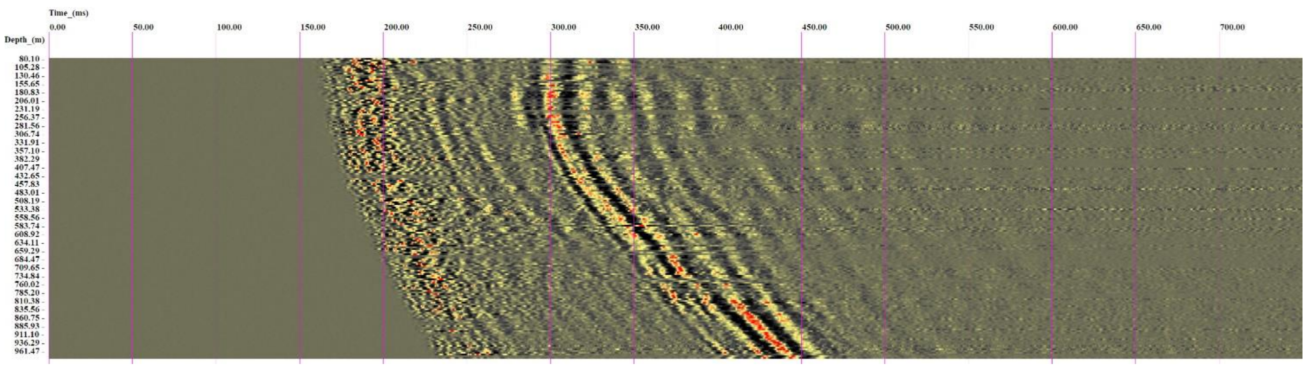


Axial component

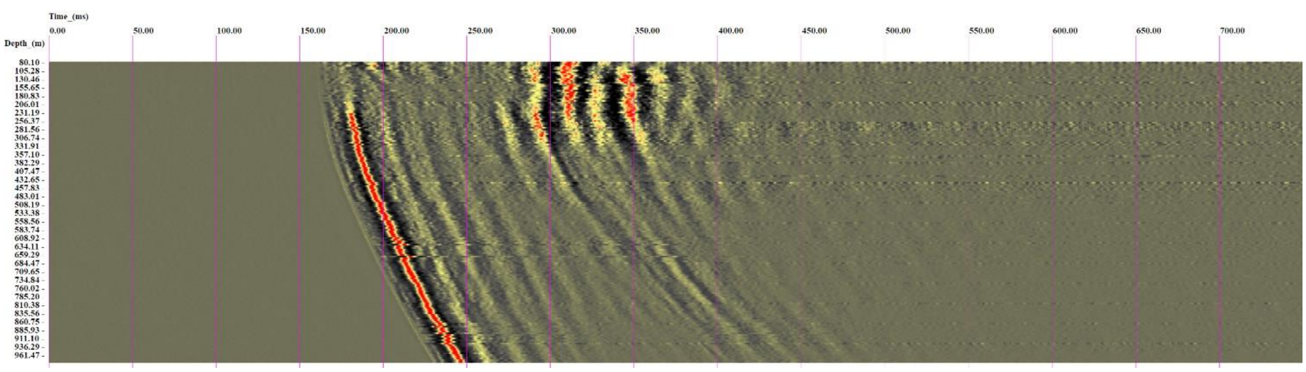
Figure 12. IG_BH06 VSP, Shot V76



Radial component

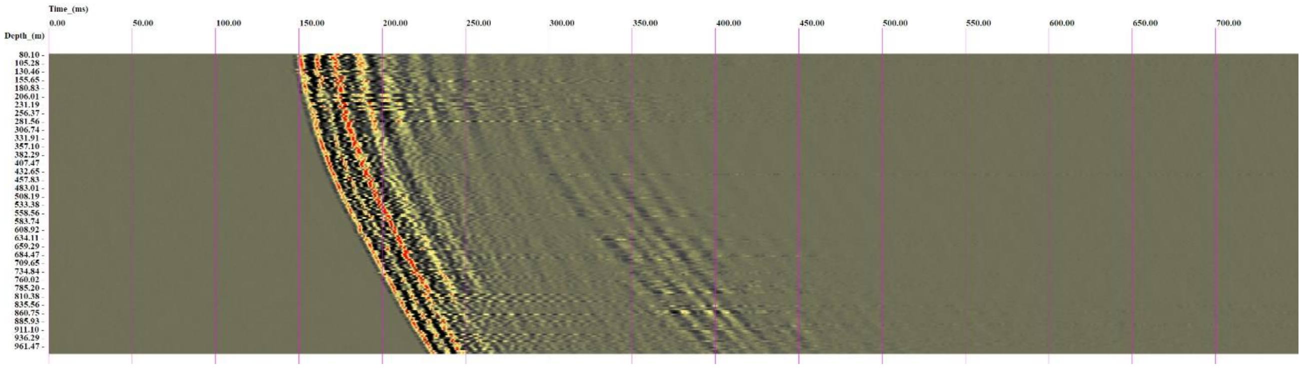


Transversal component

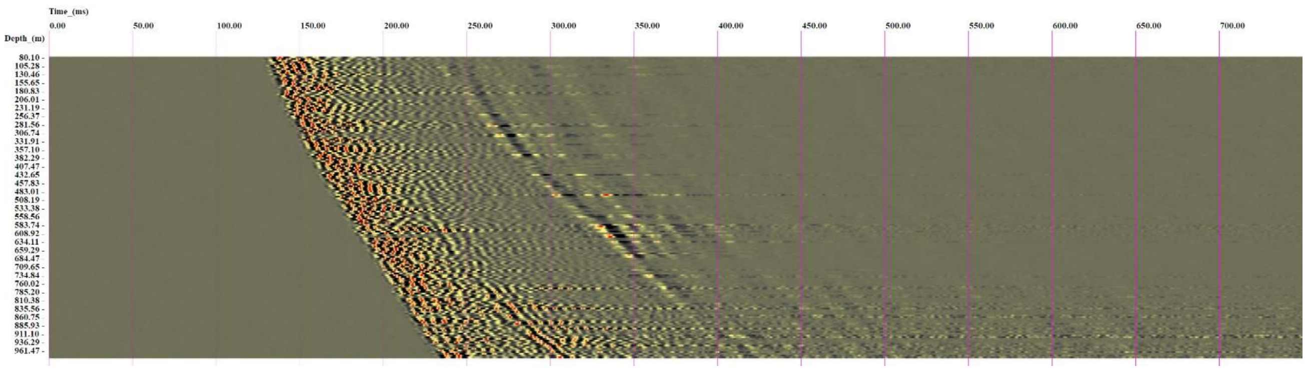


Axial component

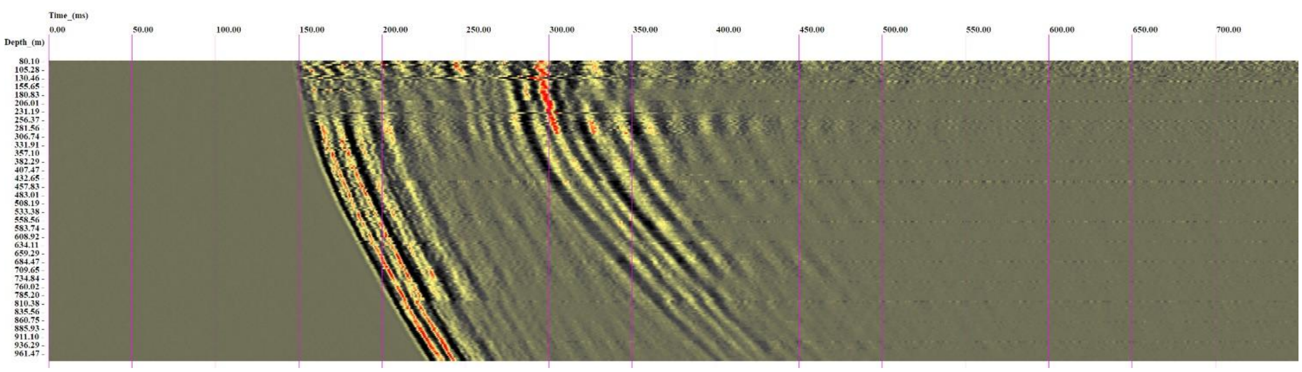
Figure 13. IG_BH06 VSP, Shot V77



Radial component

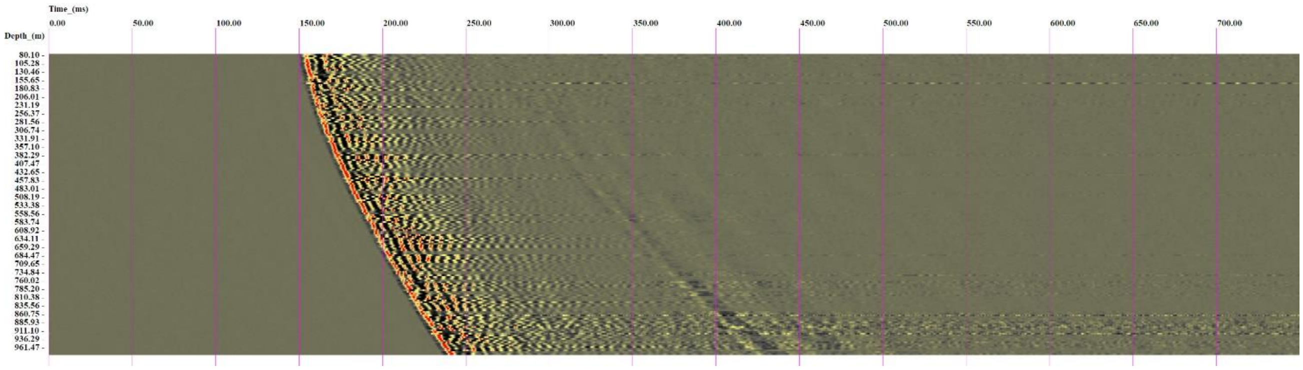


Transversal component

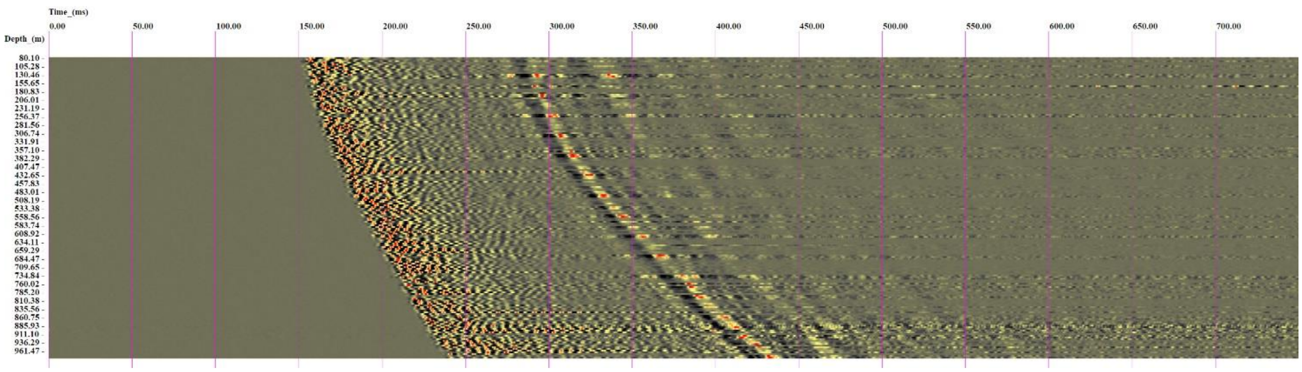


Axial component

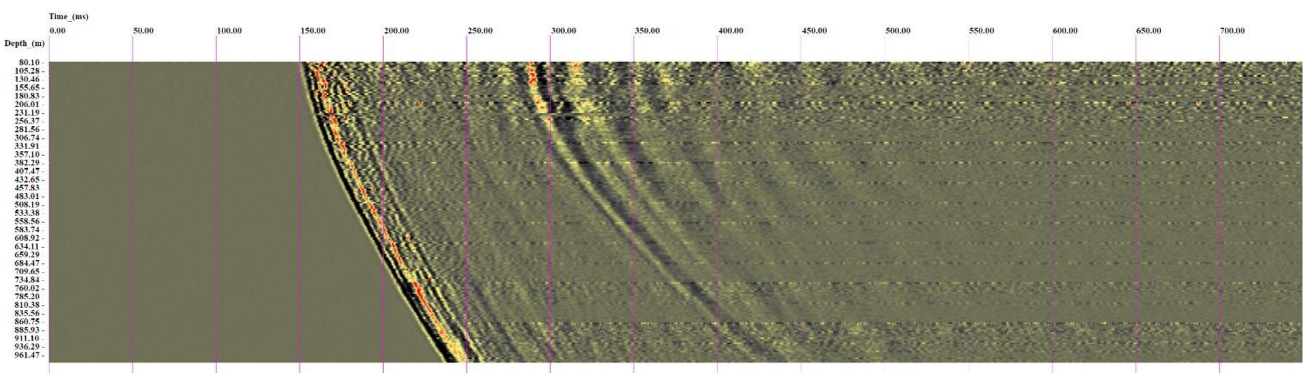
Figure 14. IG_BH06 VSP, Shot V78



Radial component

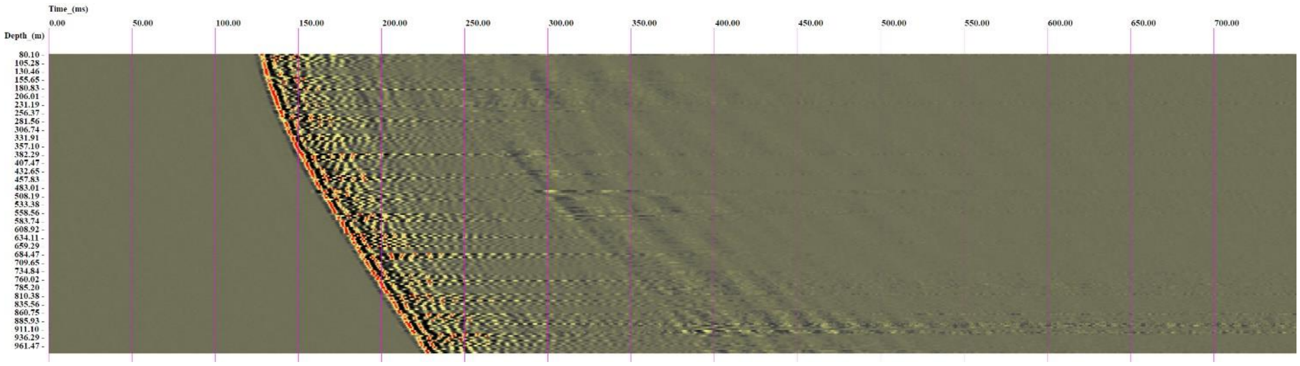


Transversal component

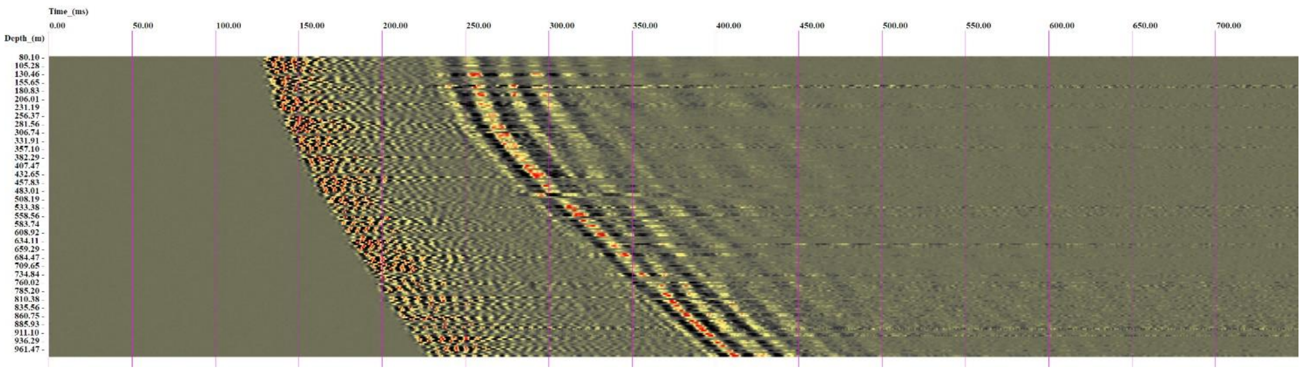


Axial component

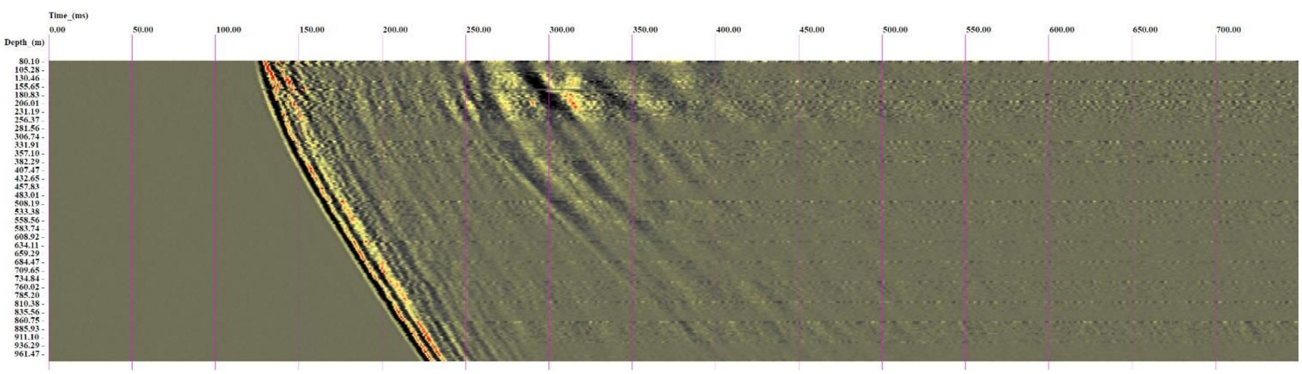
Figure 15. IG_BH06 VSP, Shot V79



Radial component

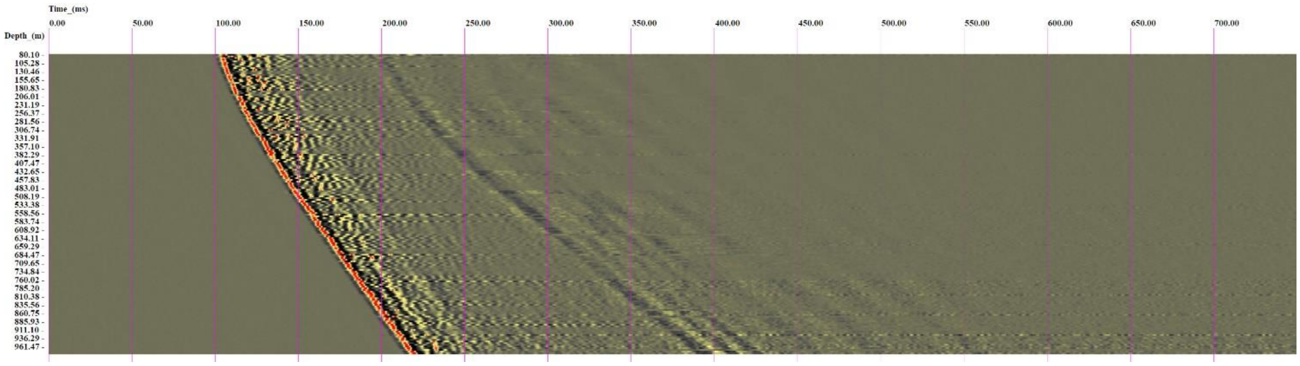


Transversal component

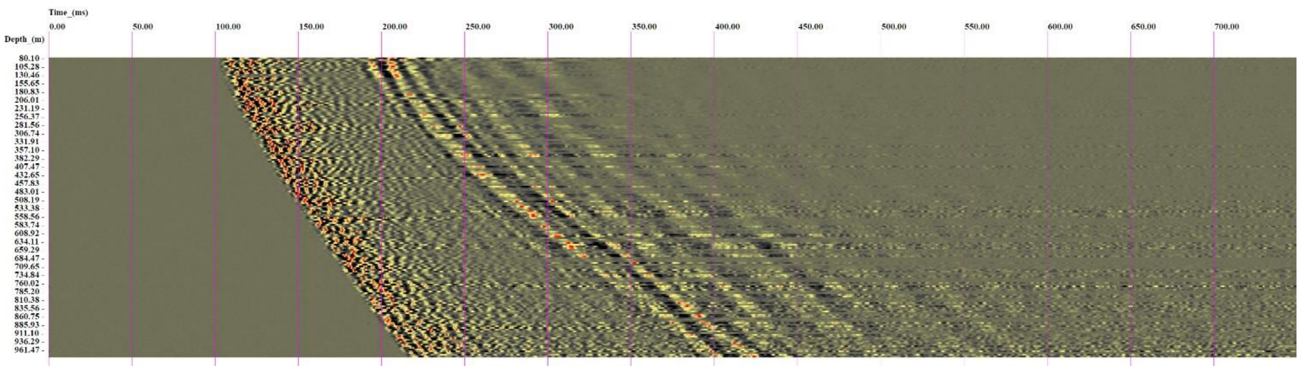


Axial component

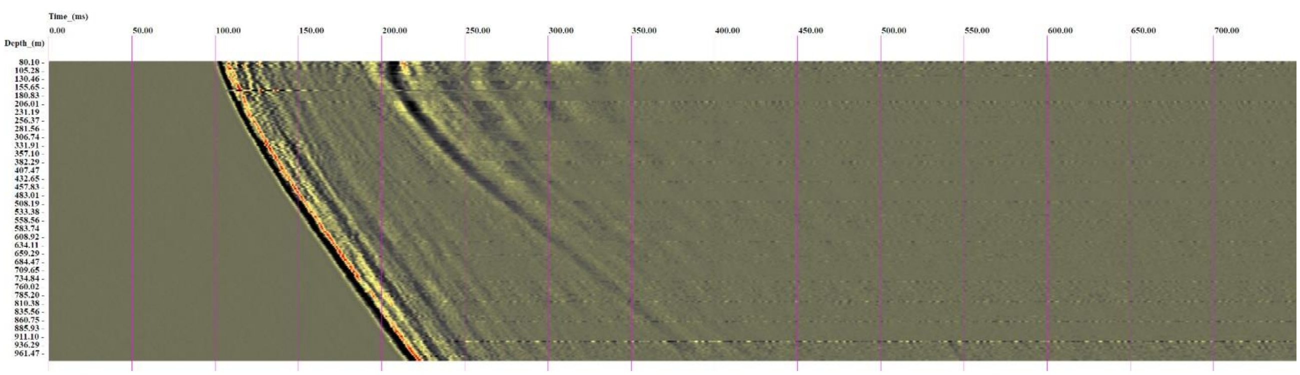
Figure 16. IG_BH06 VSP, Shot V80



Radial component

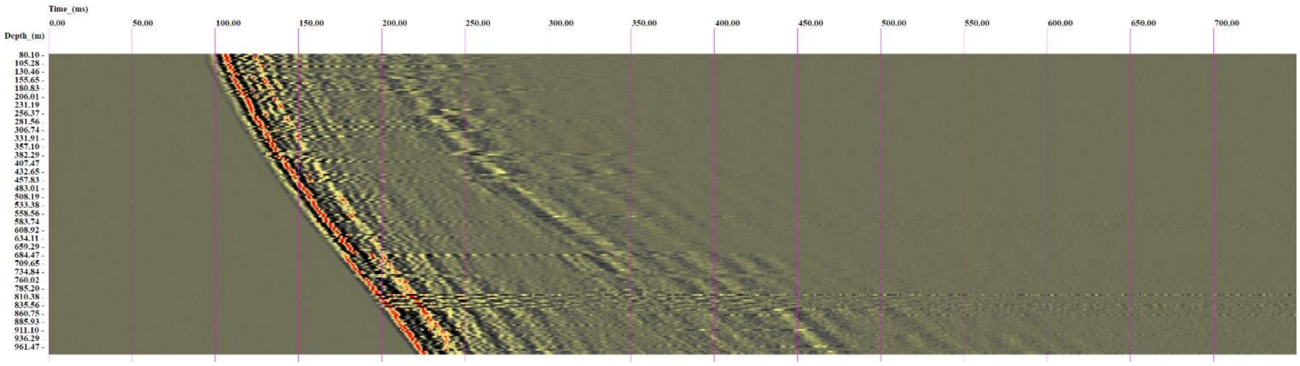


Transversal component

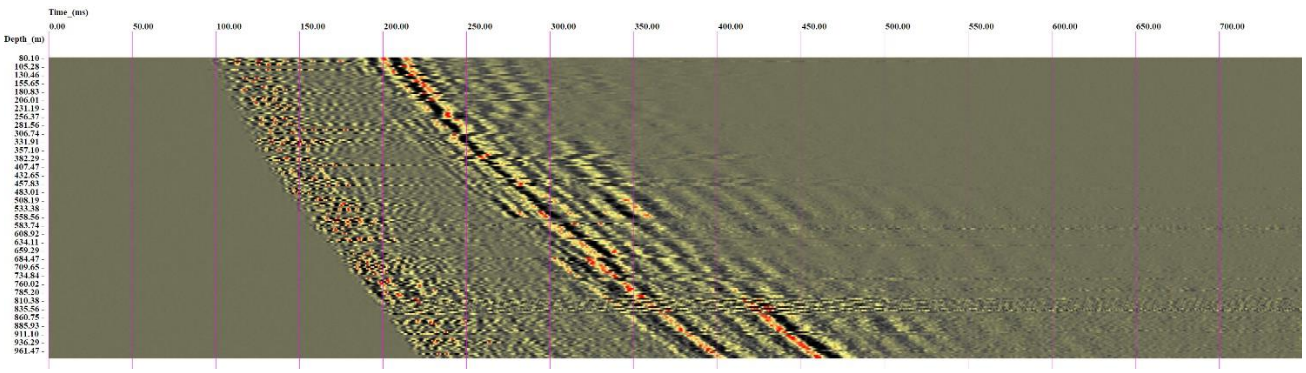


Axial component

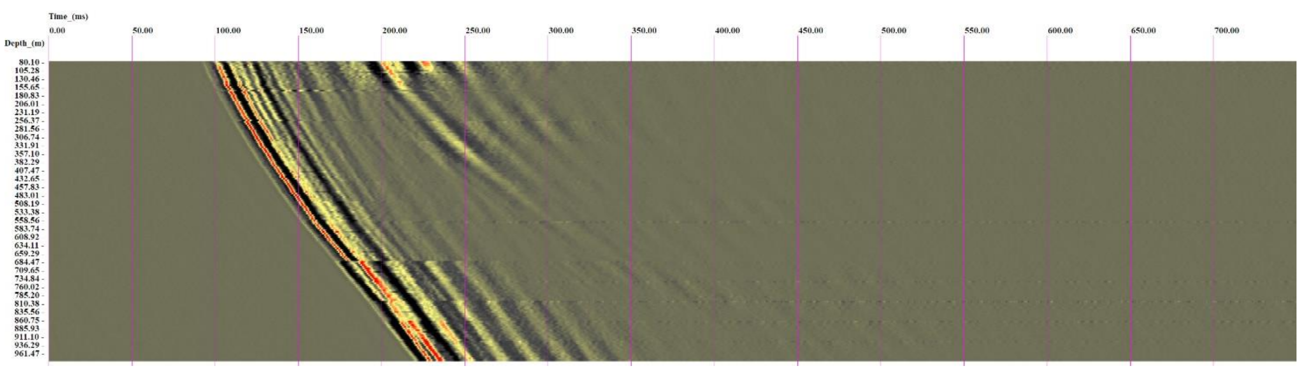
Figure 17. IG_BH06 VSP, Shot V81



Radial component

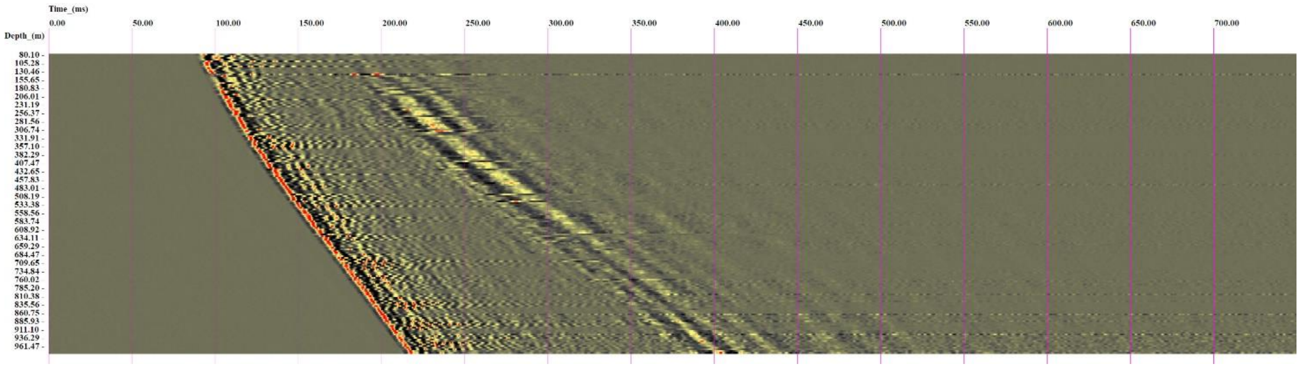


Transversal component

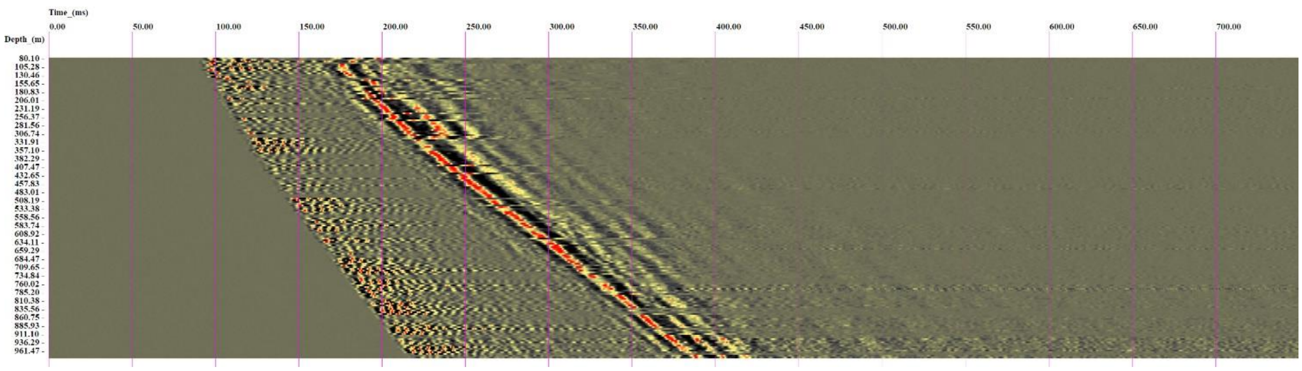


Axial component

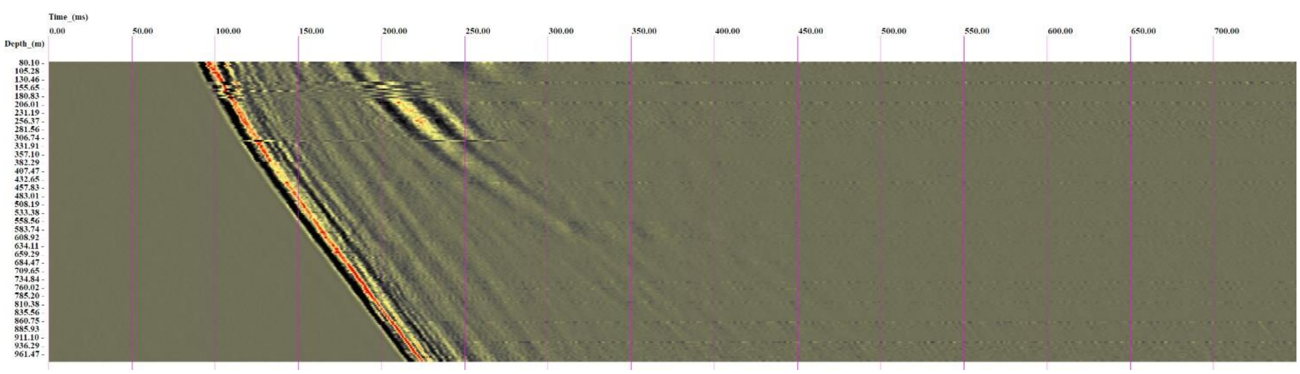
Figure 18. IG_BH06 VSP, Shot V82



Radial component

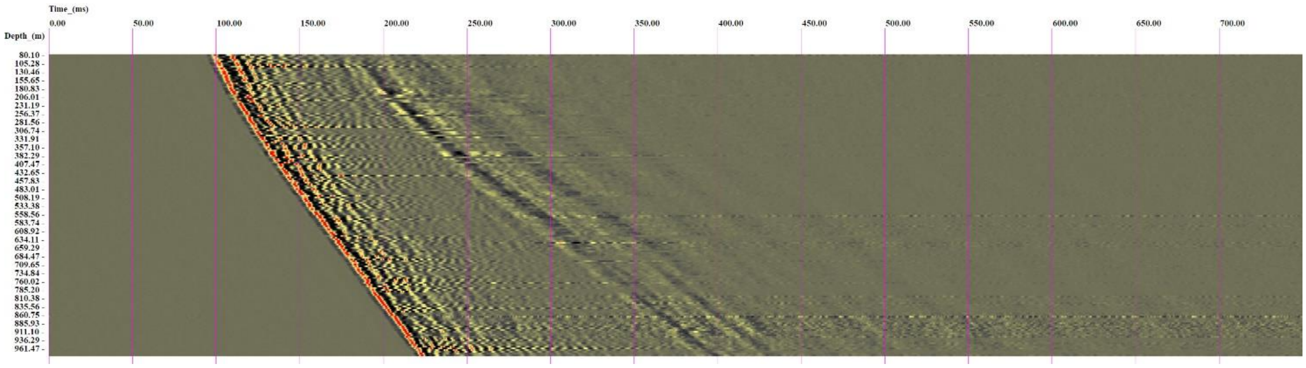


Transversal component

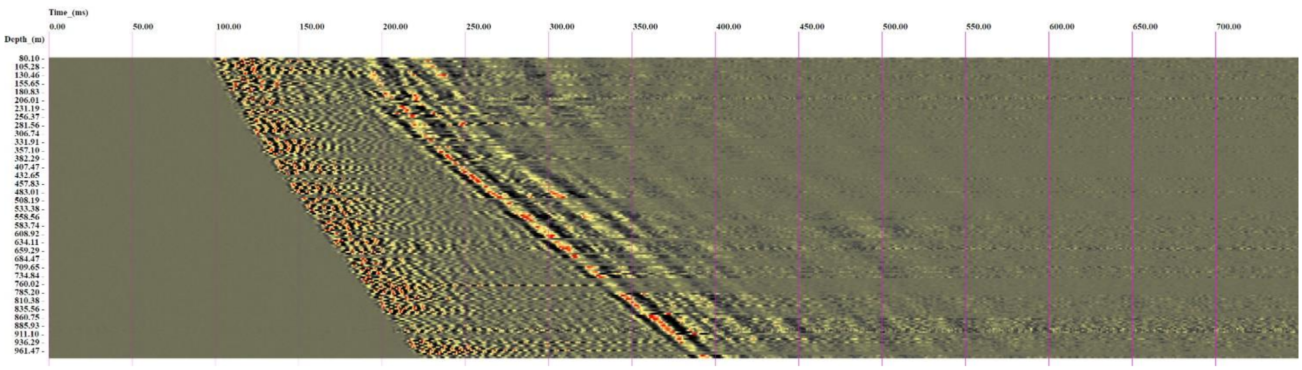


Axial component

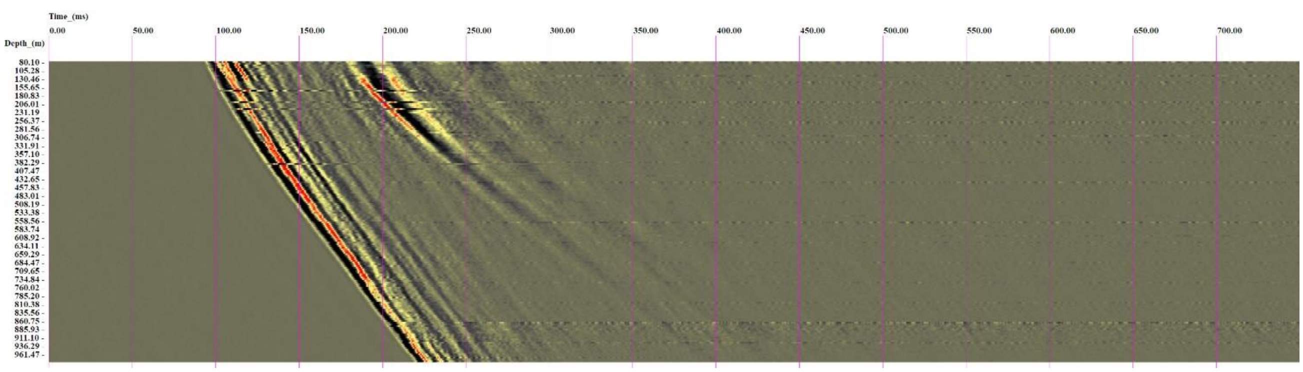
Figure 19. IG_BH06 VSP, Shot V83



Radial component

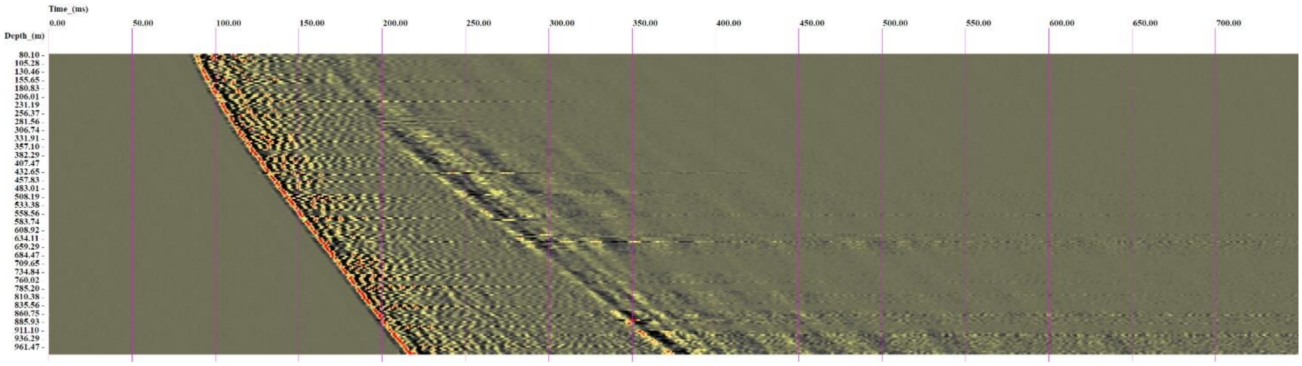


Transversal component

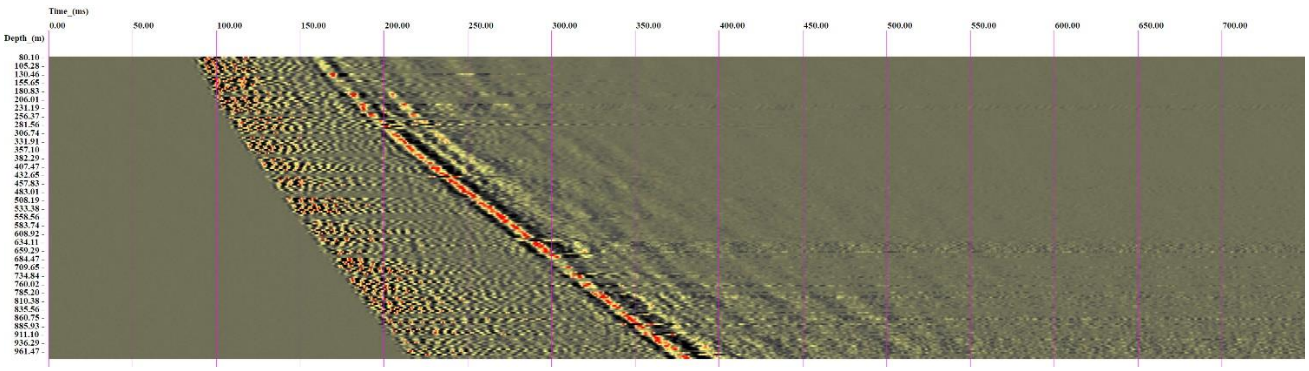


Axial component

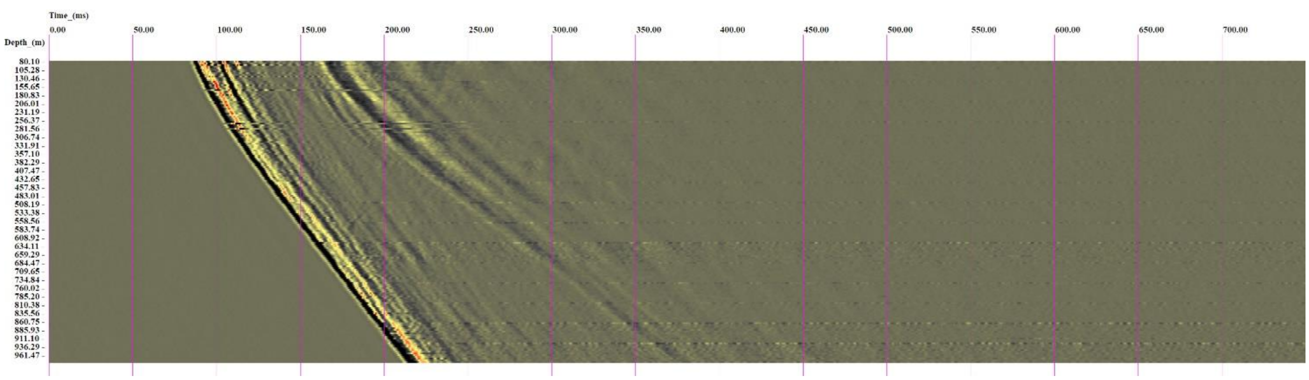
Figure 20. IG_BH06 VSP, Shot V84



Radial component

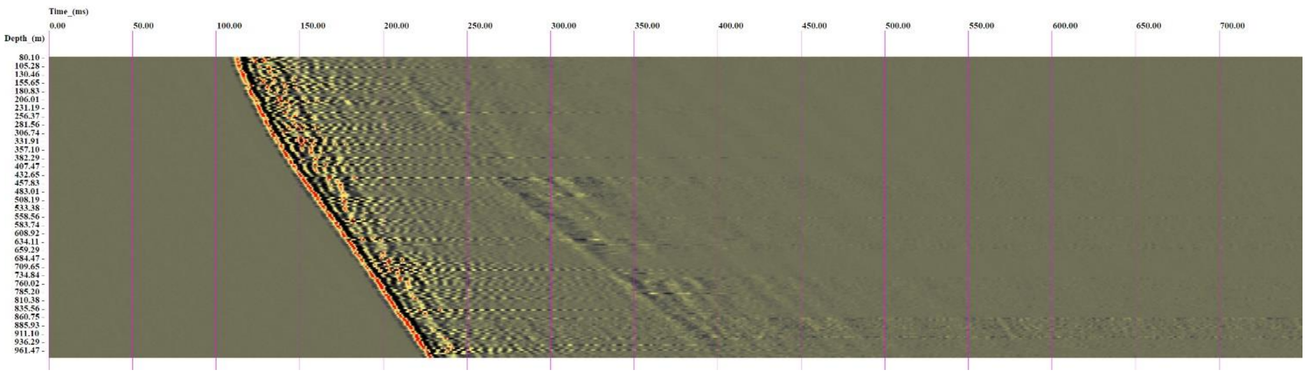


Transversal component

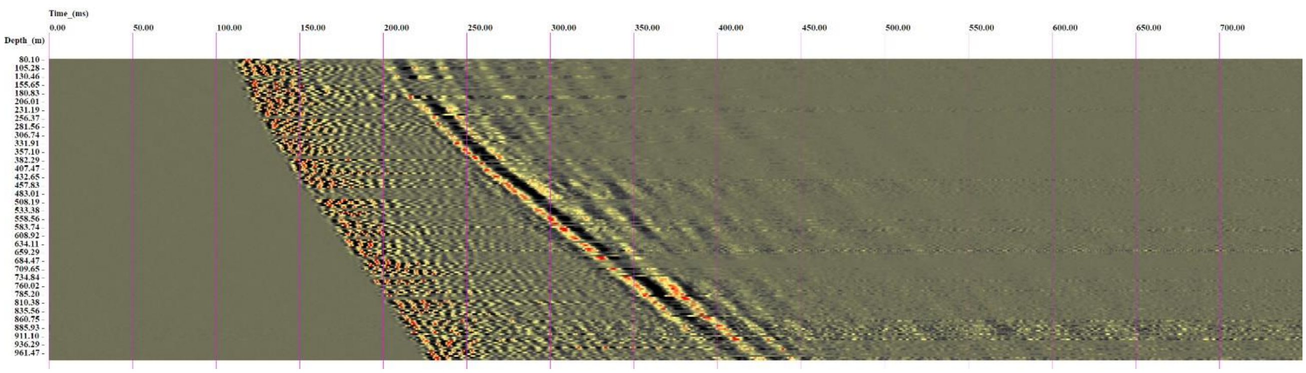


Axial component

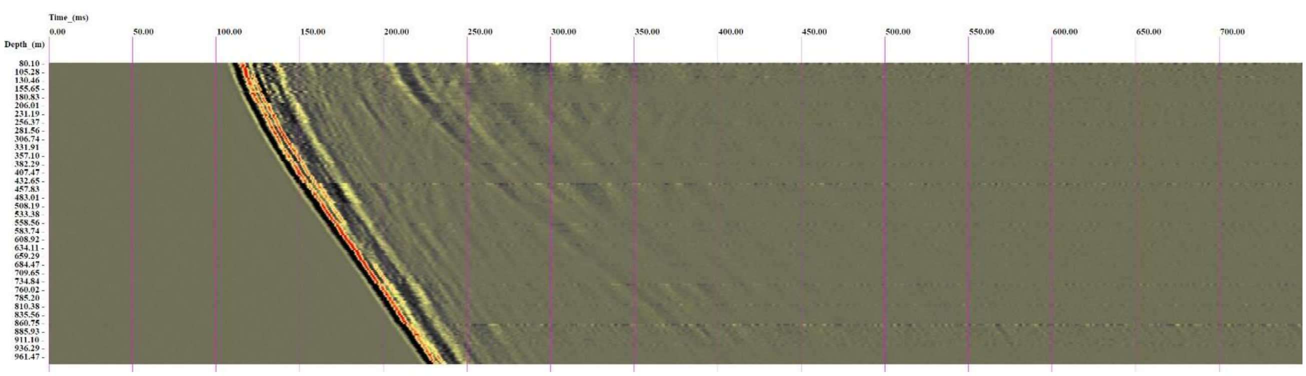
Figure 21. IG_BH06 VSP, Shot V85



Radial component

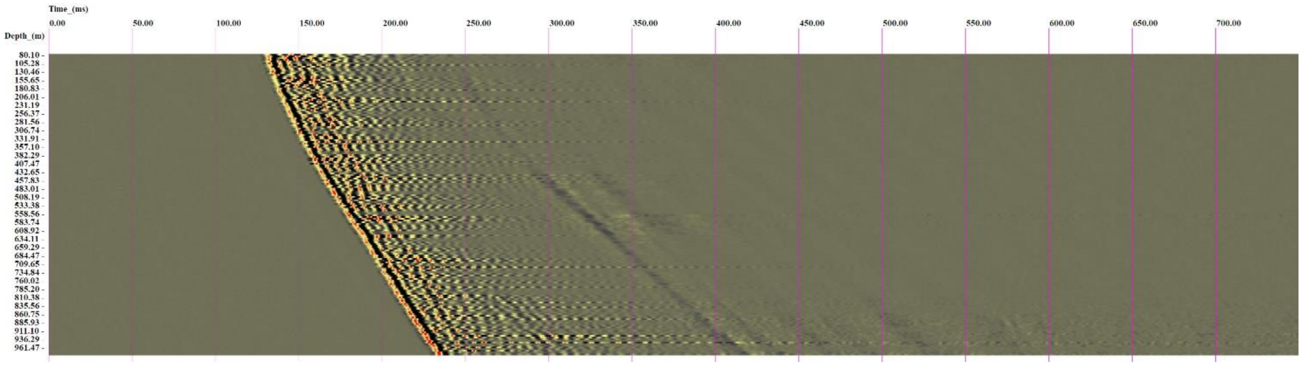


Transversal component

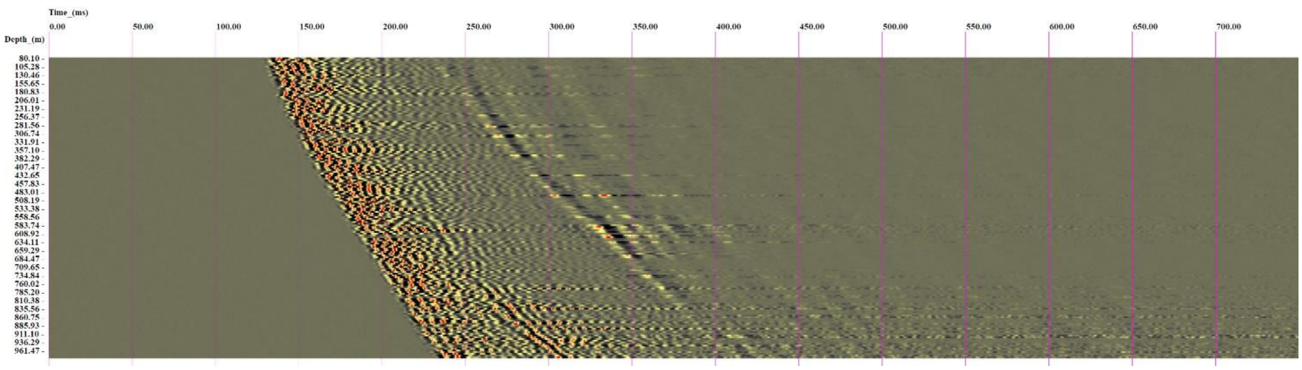


Axial component

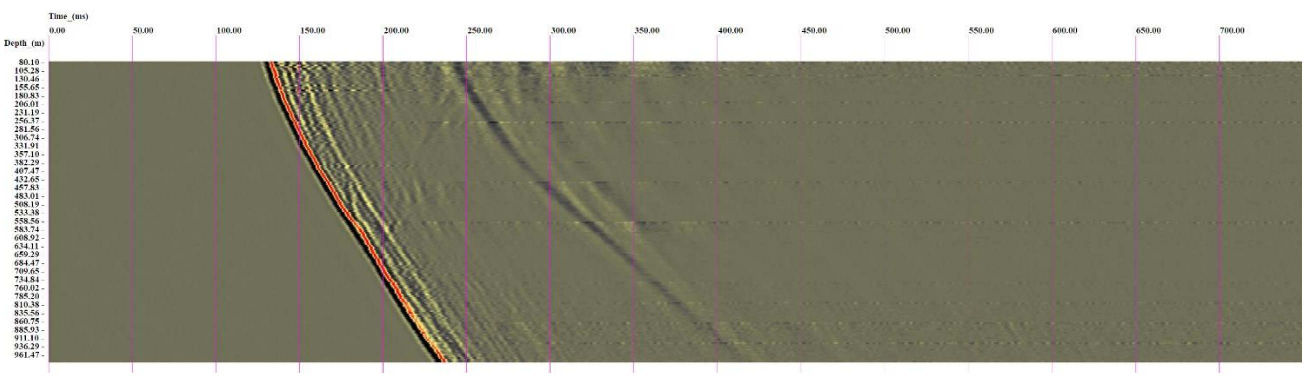
Figure 22. IG_BH06 VSP, Shot V86



Radial component

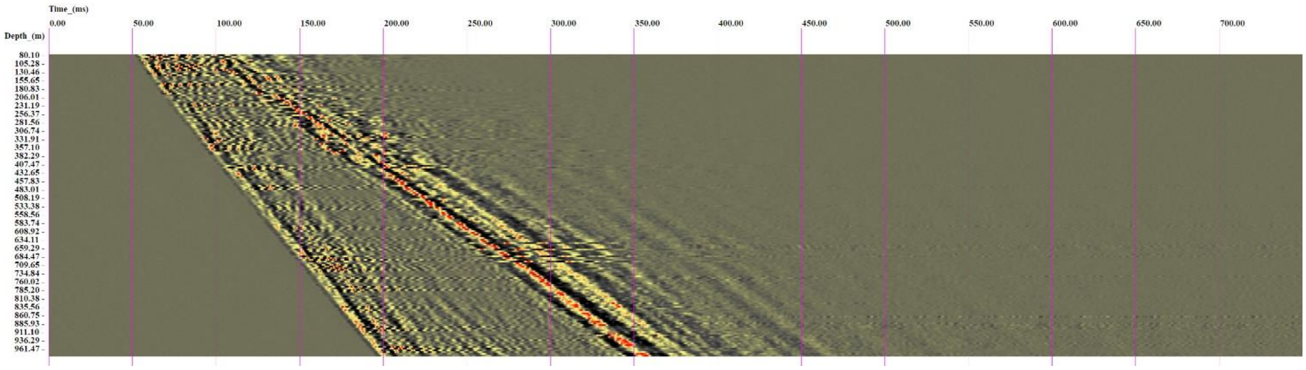


Transversal component

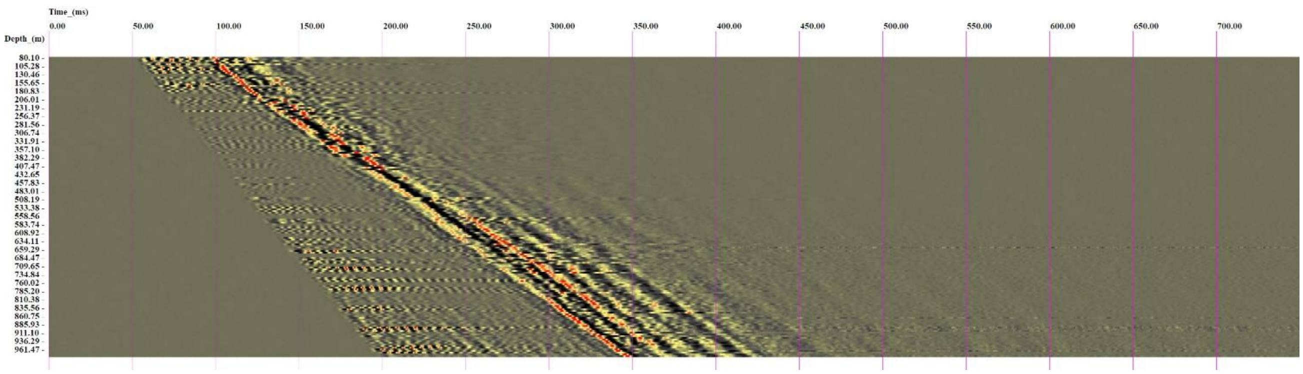


Axial component

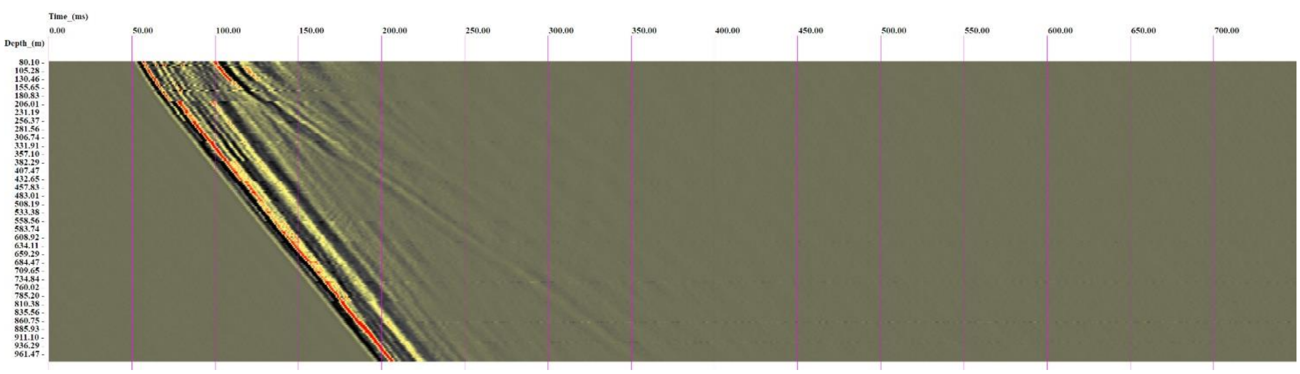
Figure 23. IG_BH06 VSP, Shot V87



Radial component

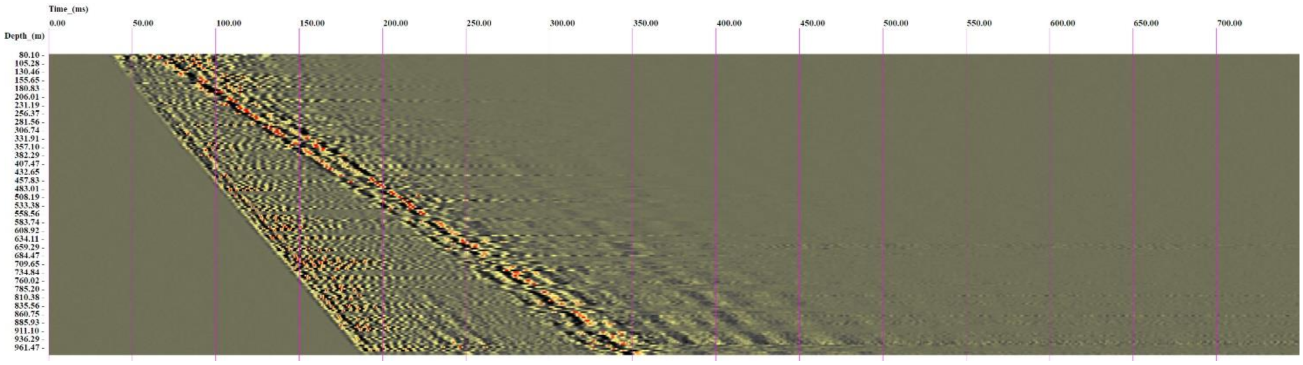


Transversal component

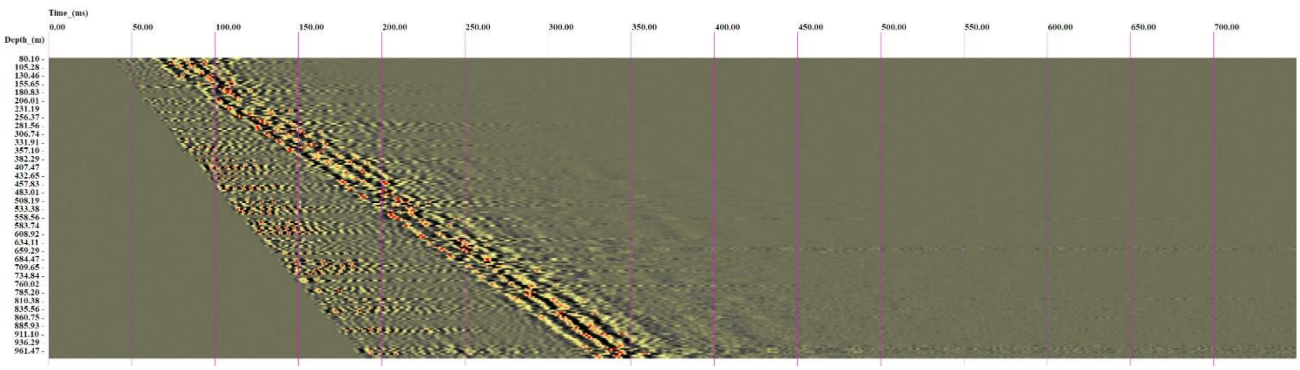


Axial component

Figure 24. IG_BH06 VSP, Shot V88



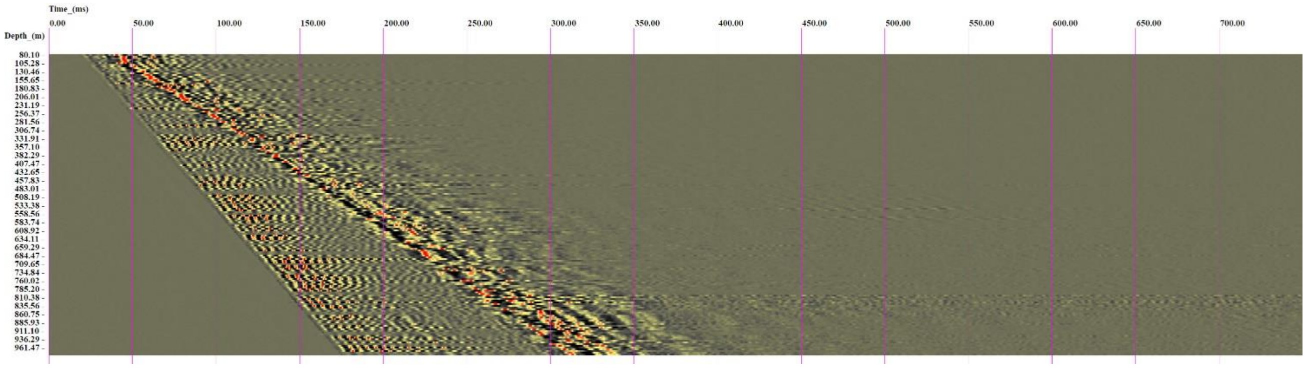
Radial component



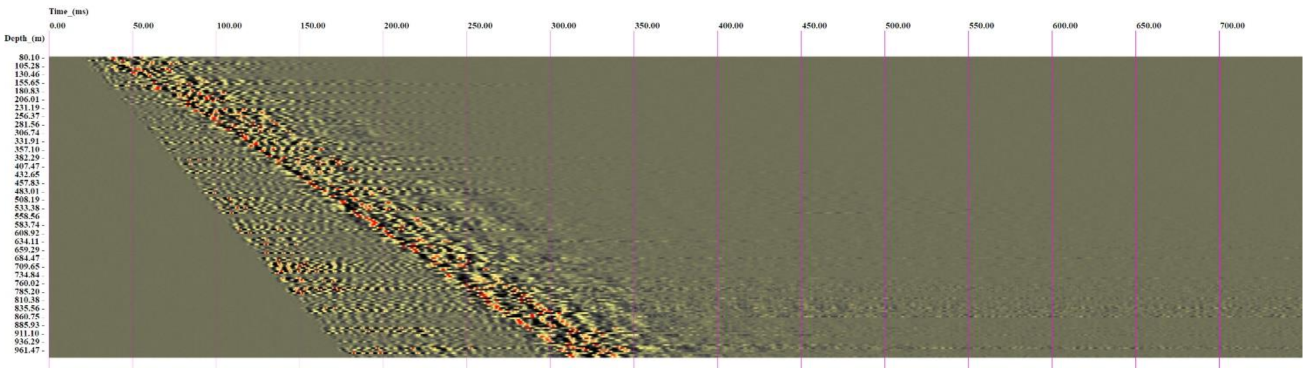
Transversal component

Axial component

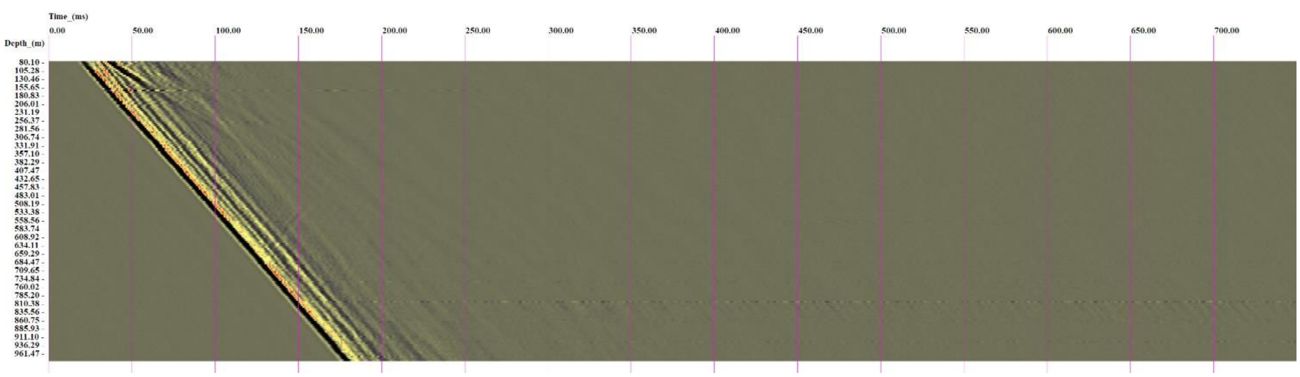
Figure 25. IG_BH06 VSP, Shot V89



Radial component

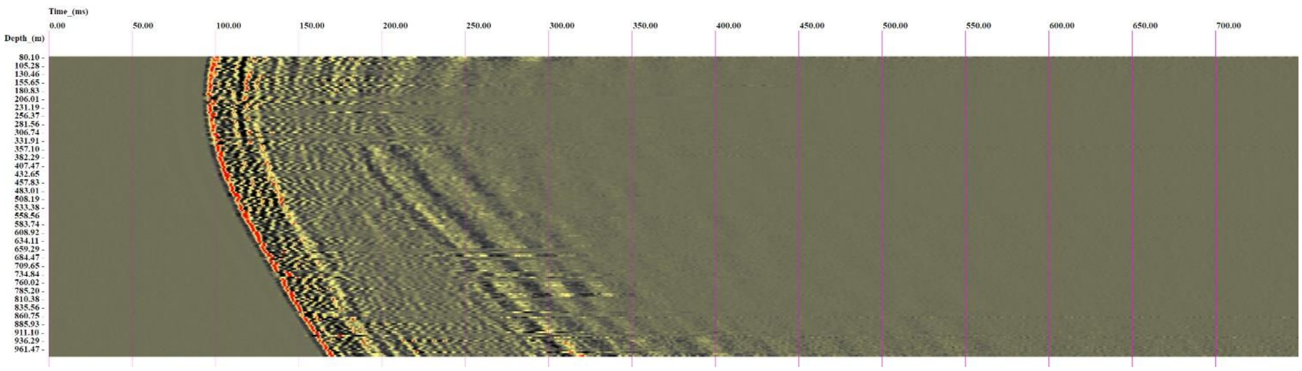


Transversal component

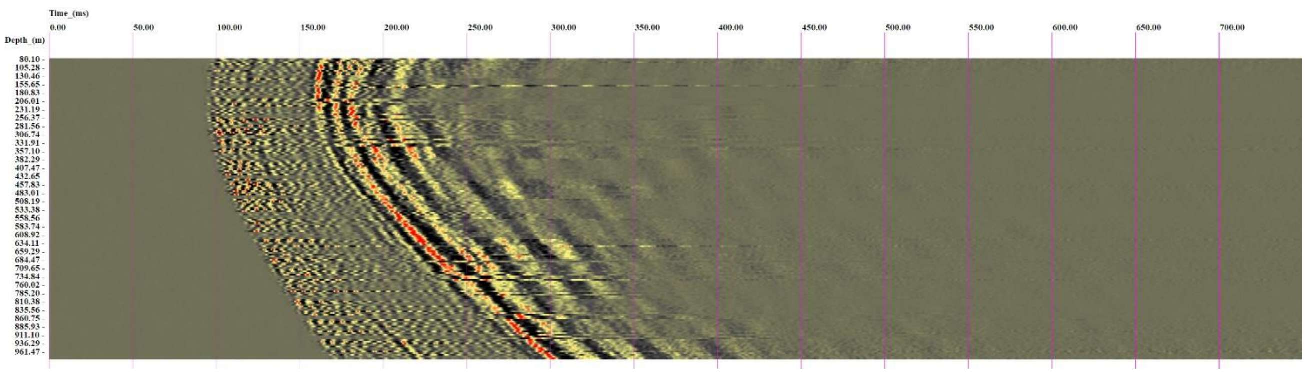


Axial component

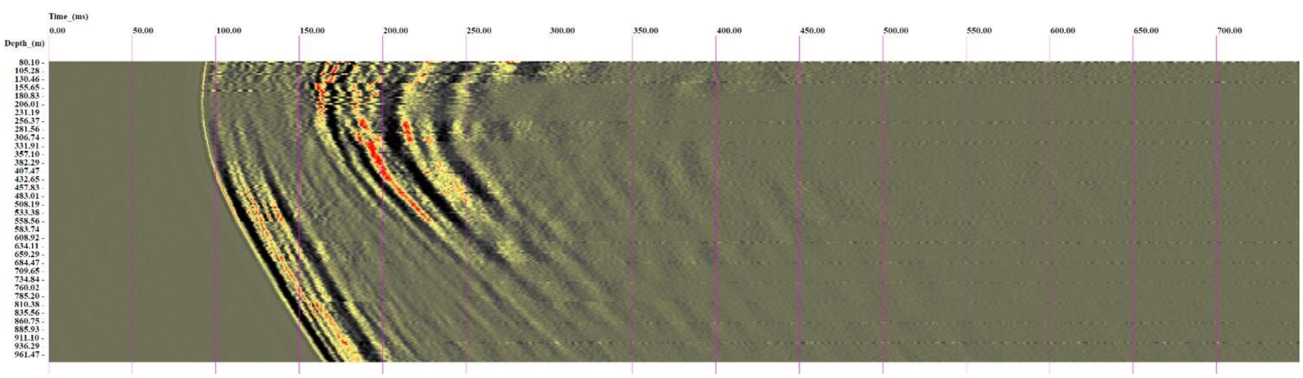
Figure 26. IG_BH06 VSP, Shot V90



Radial component

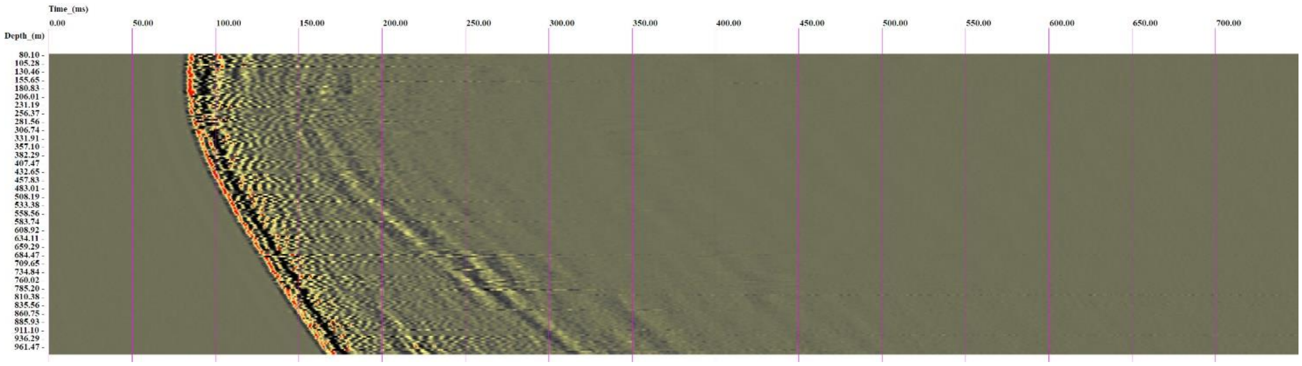


Transversal component

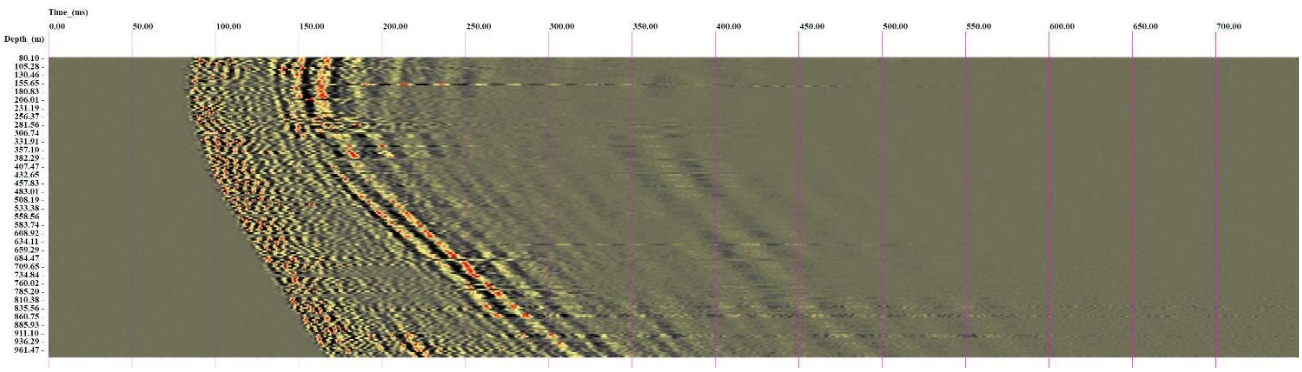


Axial component

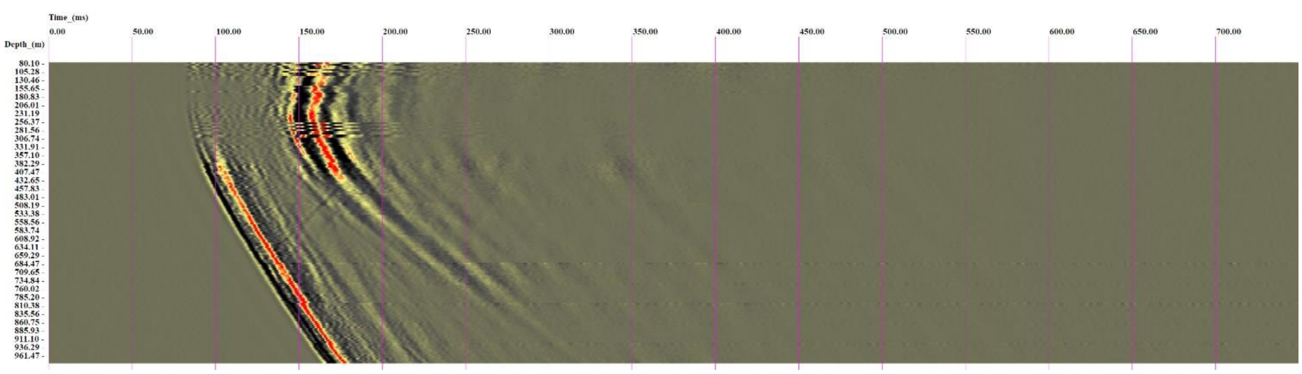
Figure 27. IG_BH06 VSP, Shot V91



Radial component

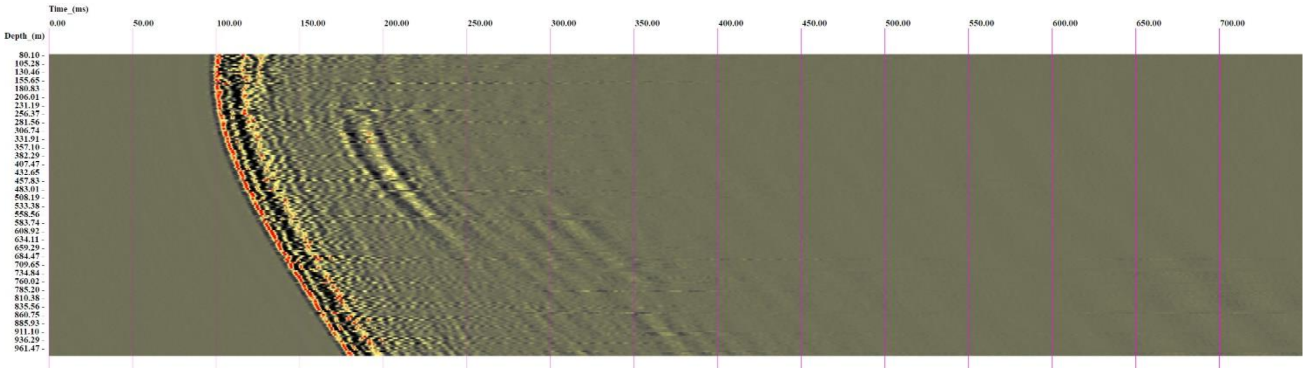


Transversal component

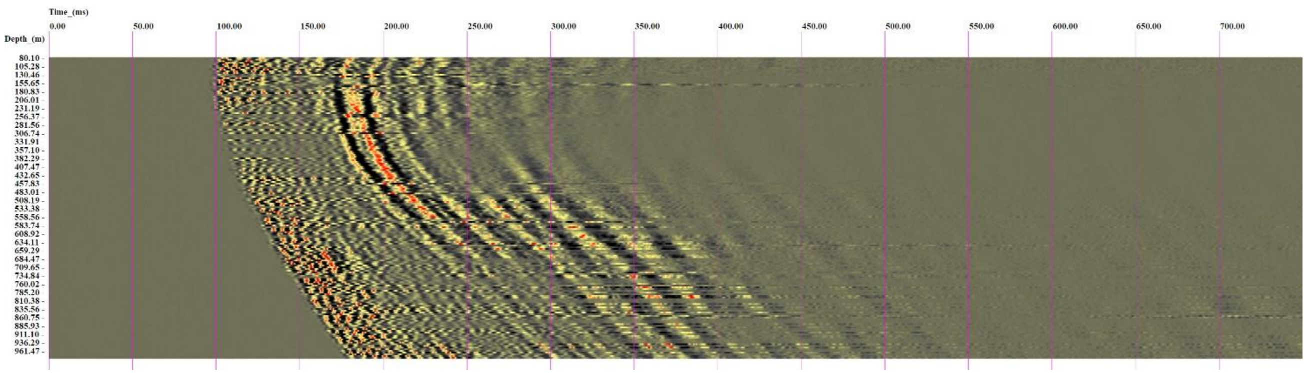


Axial component

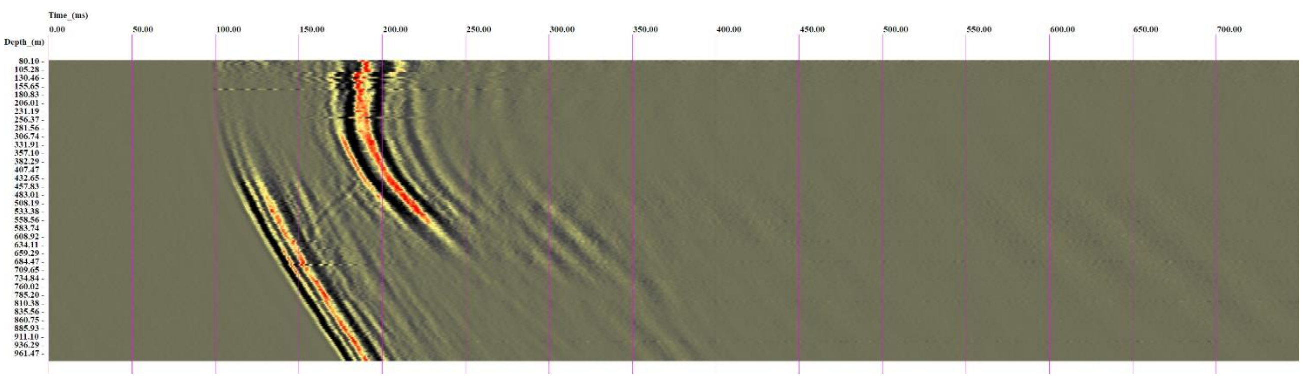
Figure 28. IG_BH06 VSP, Shot V92



Radial component

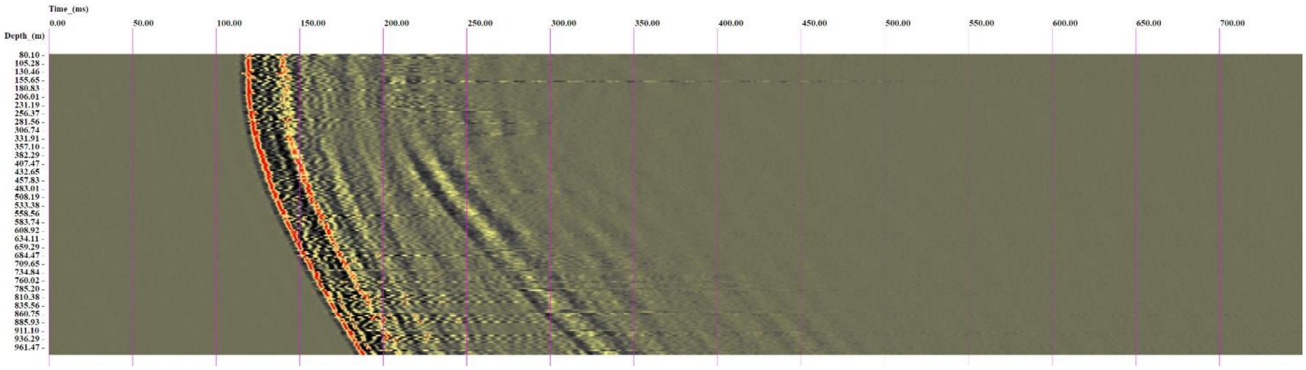


Transversal component

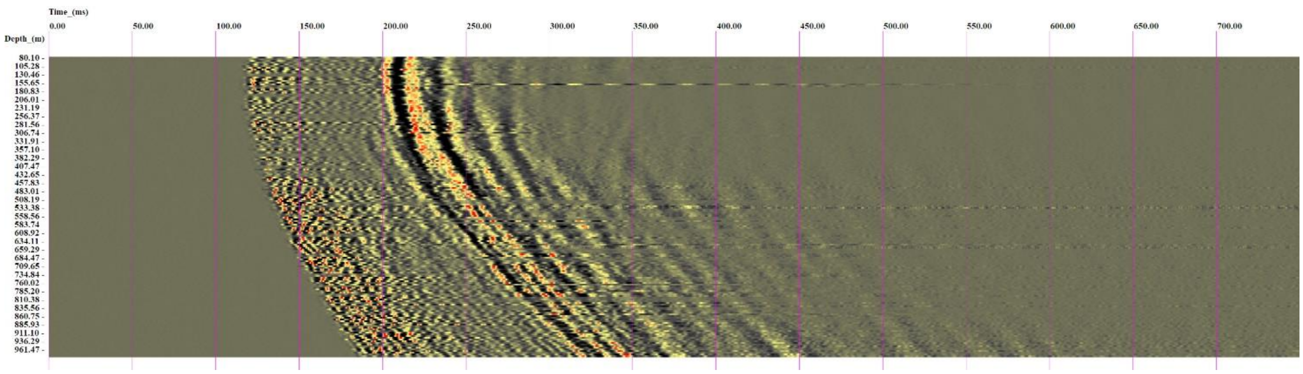


Axial component

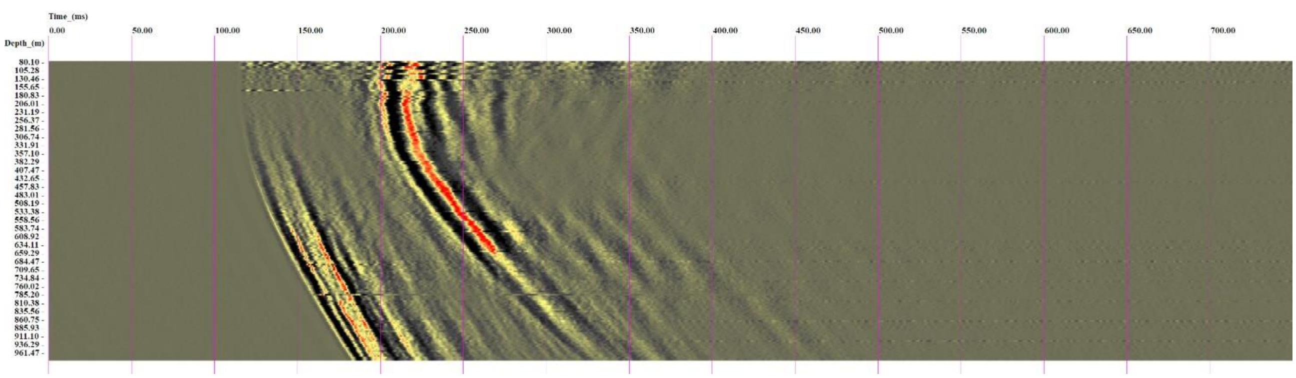
Figure 29. IG_BH06 VSP, Shot V93



Radial component



Transversal component

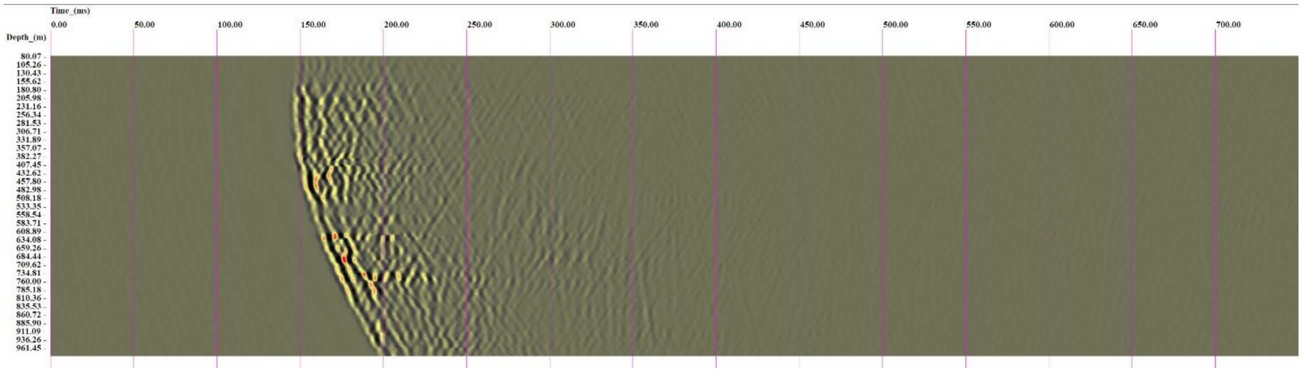


Axial component

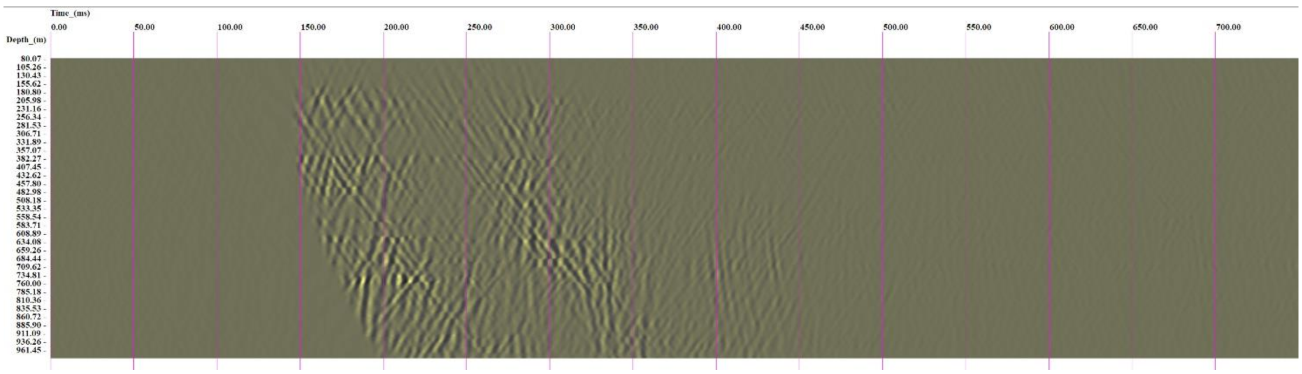
Figure 30. IG_BH06 VSP, Shot V94

APPENDIX C

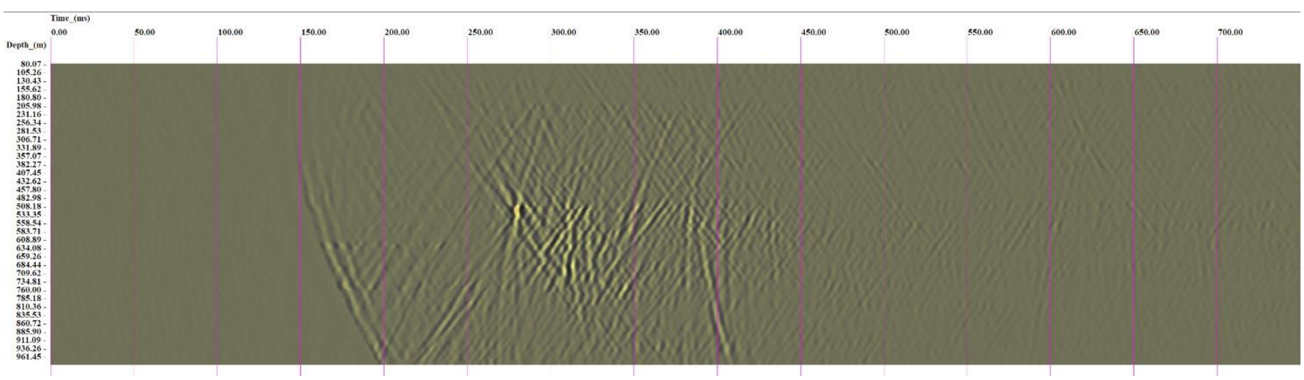
Processed VSP Profiles from Borehole IG_BH06



Radial component

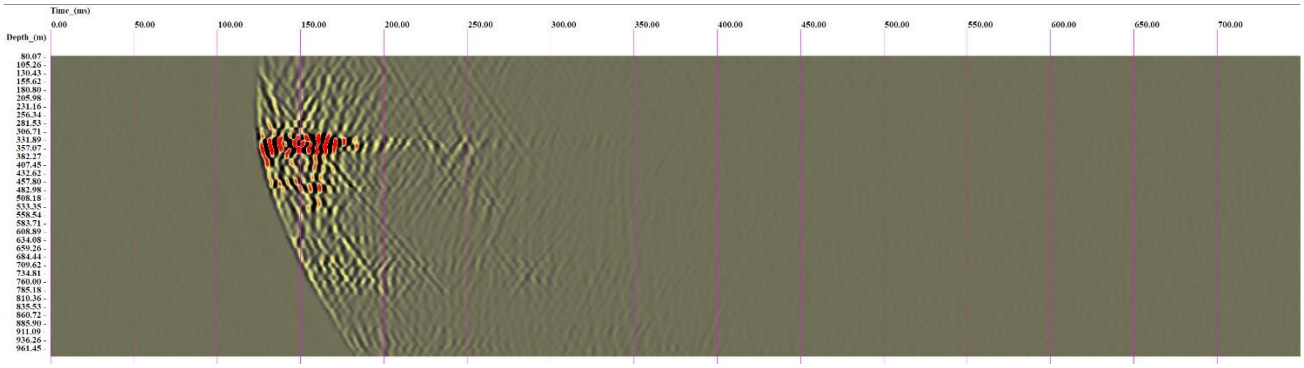


Transversal component

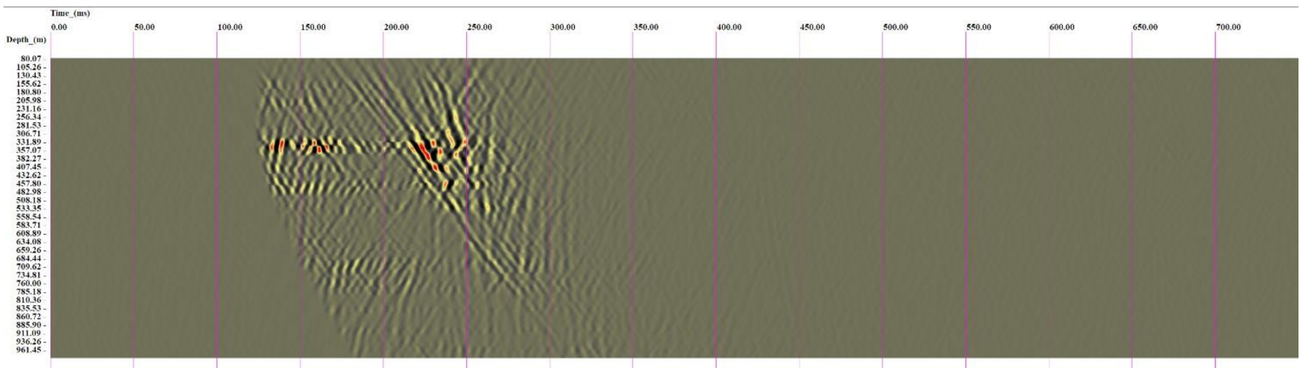


Axial component

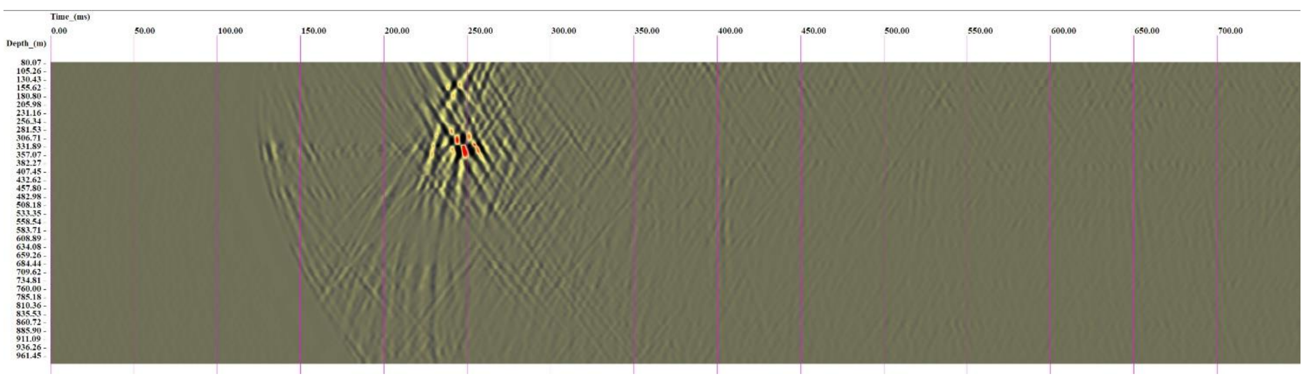
Figure 1. IG_BH06 VSP, Shot V44



Radial component

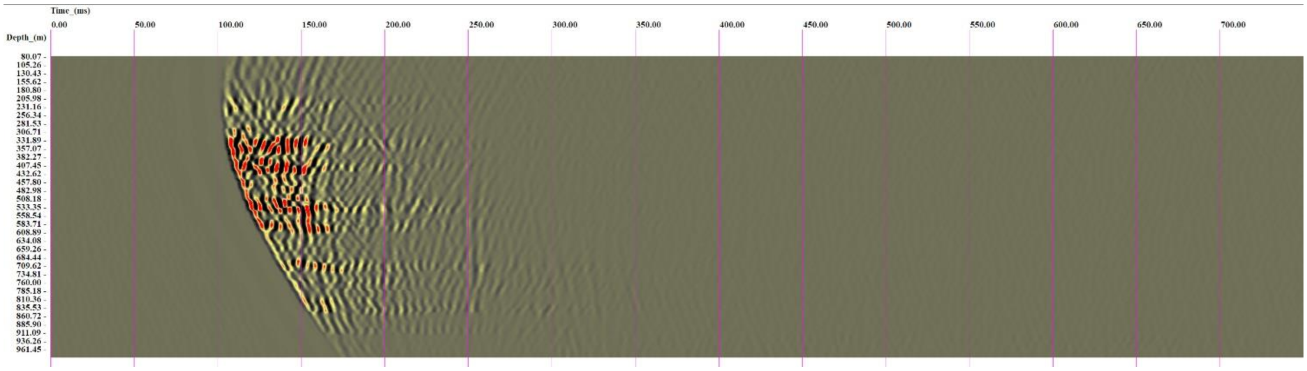


Transversal component

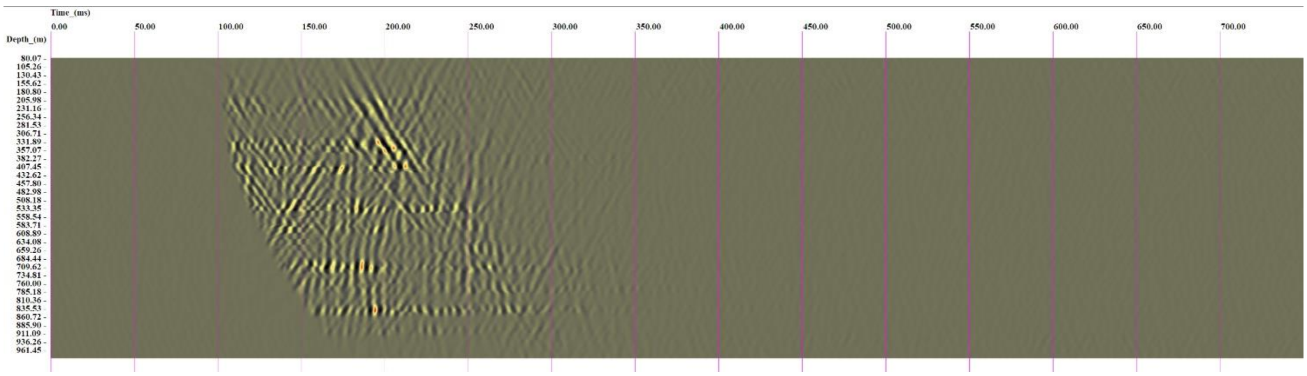


Axial component

Figure 2. IG_BH06 VSP, Shot V45



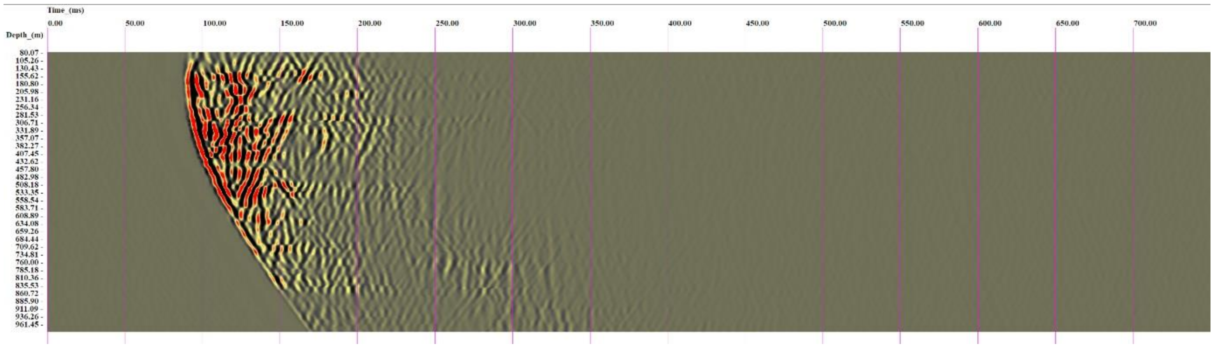
Radial component



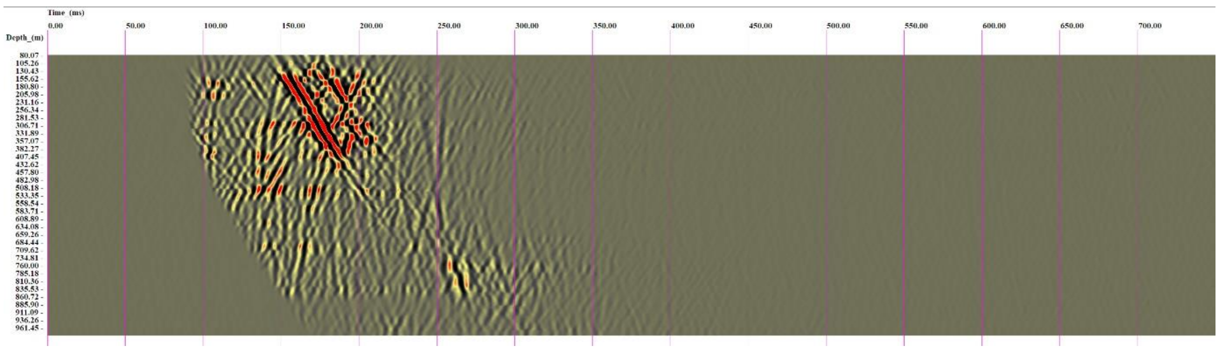
Transversal component

Axial component

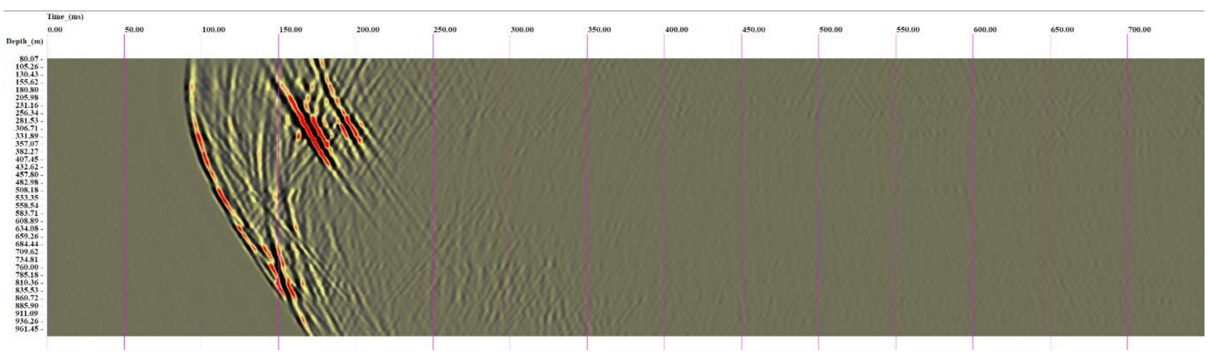
Figure 3. IG_BH06 VSP, Shot V46



Radial component

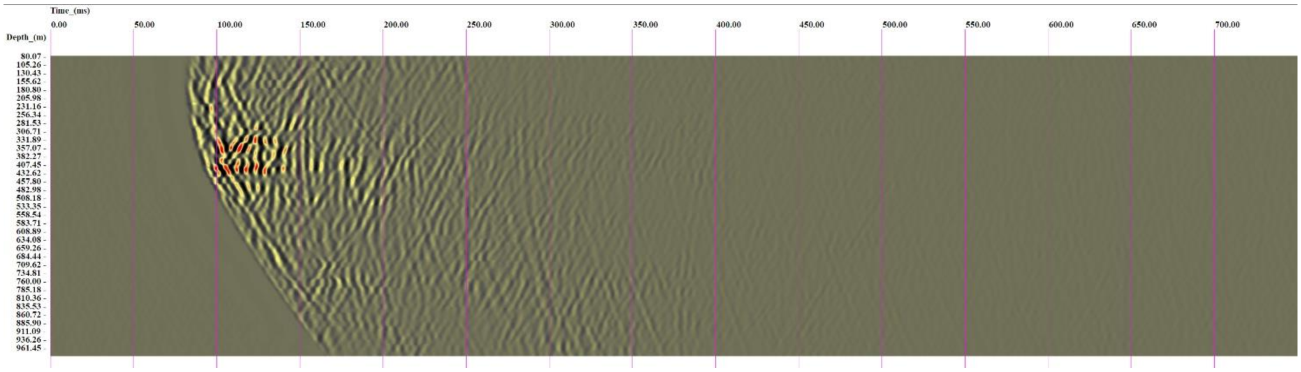


Transversal component

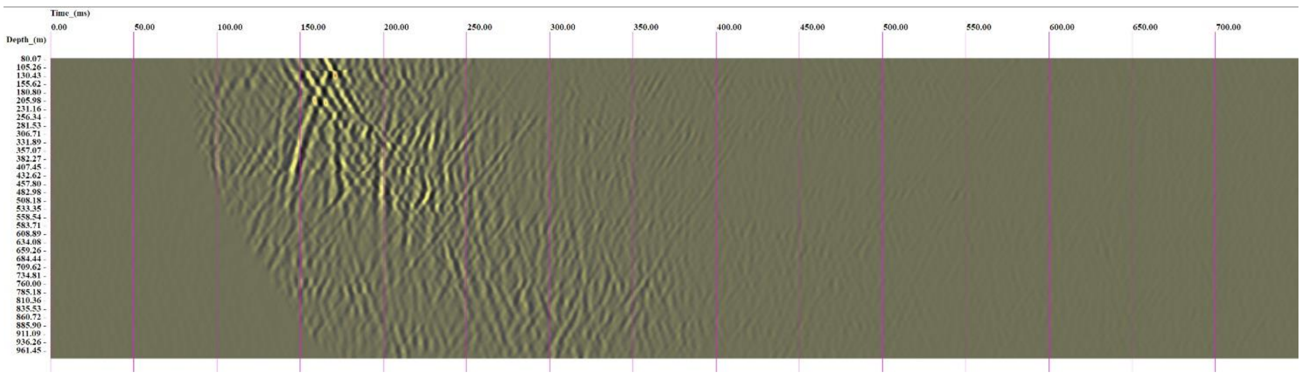


Axial component

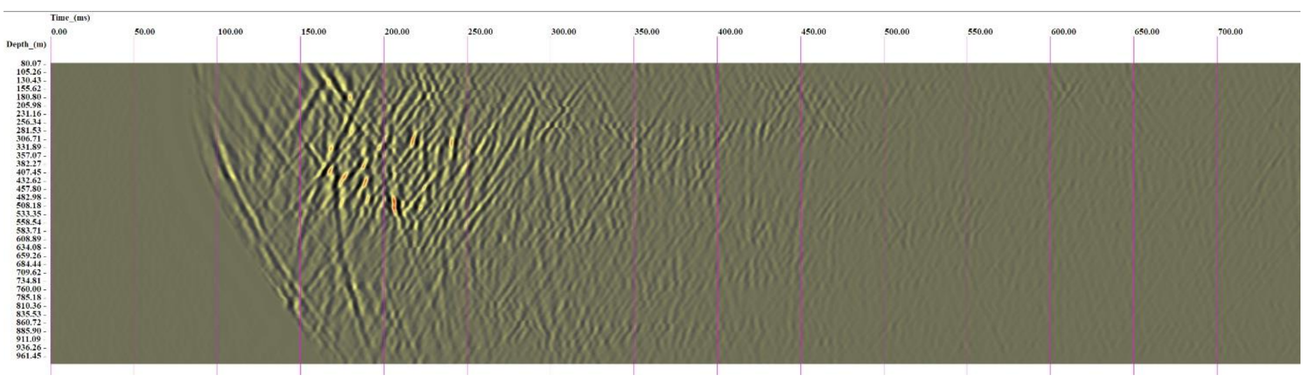
Figure 4. IG_BH06 VSP, Shot V47



Radial component

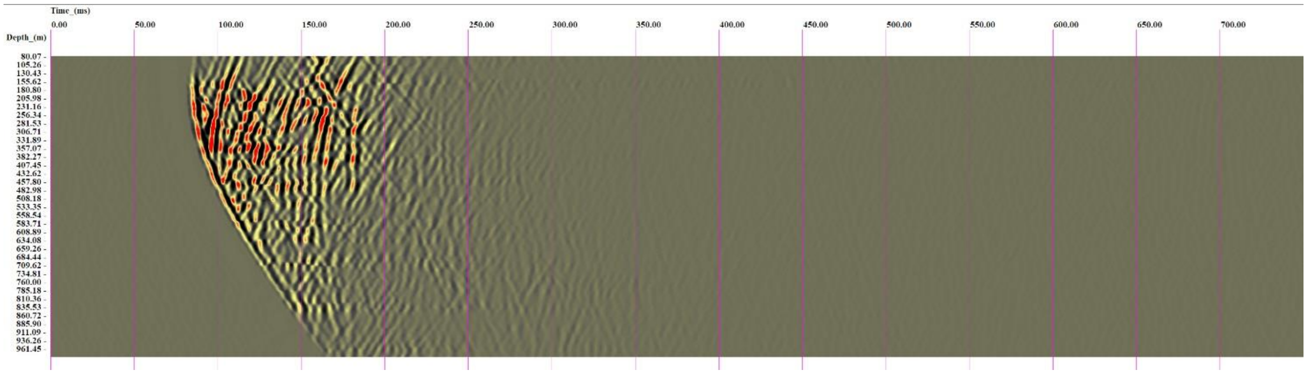


Transversal component

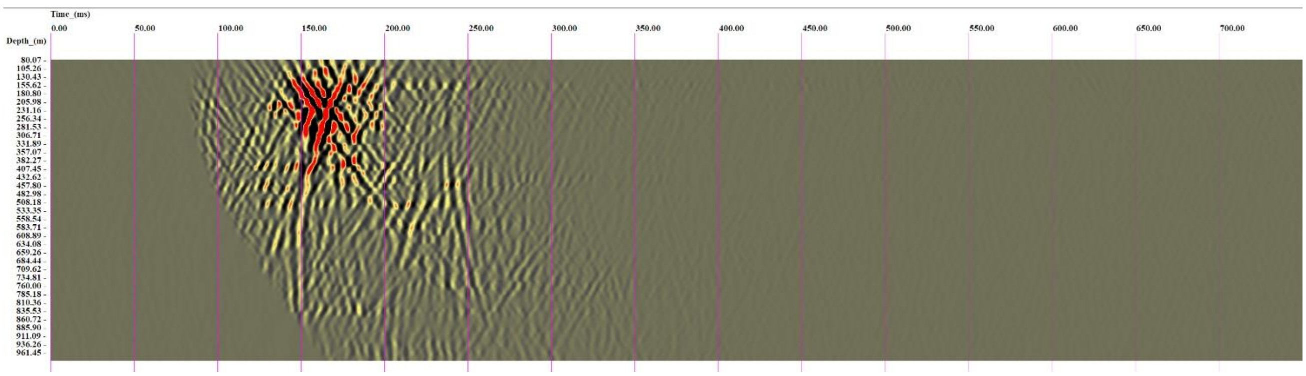


Axial component

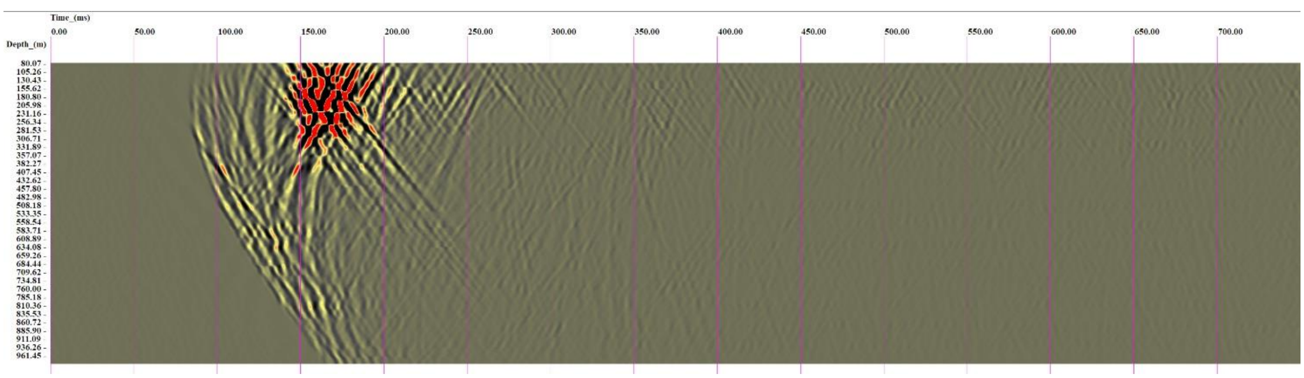
Figure 5. IG_BH06 VSP, Shot V48



Radial component

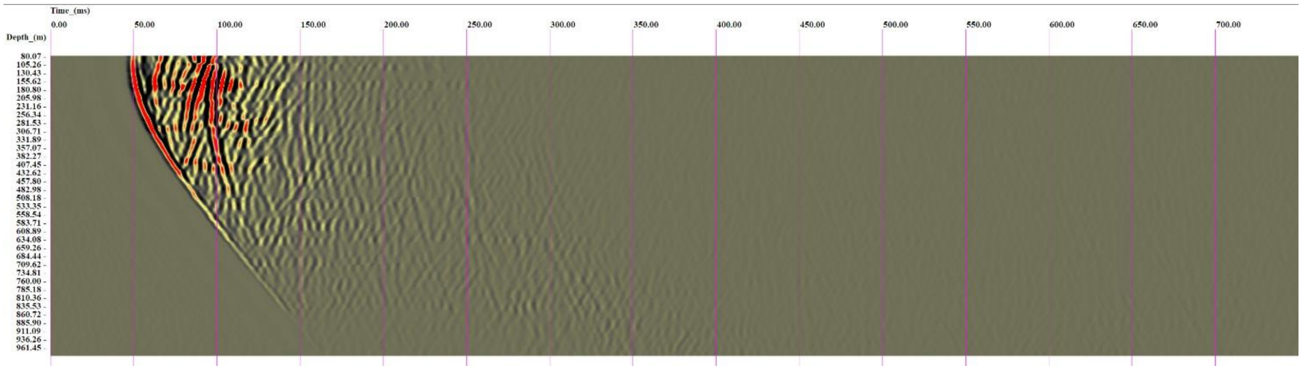


Transversal component

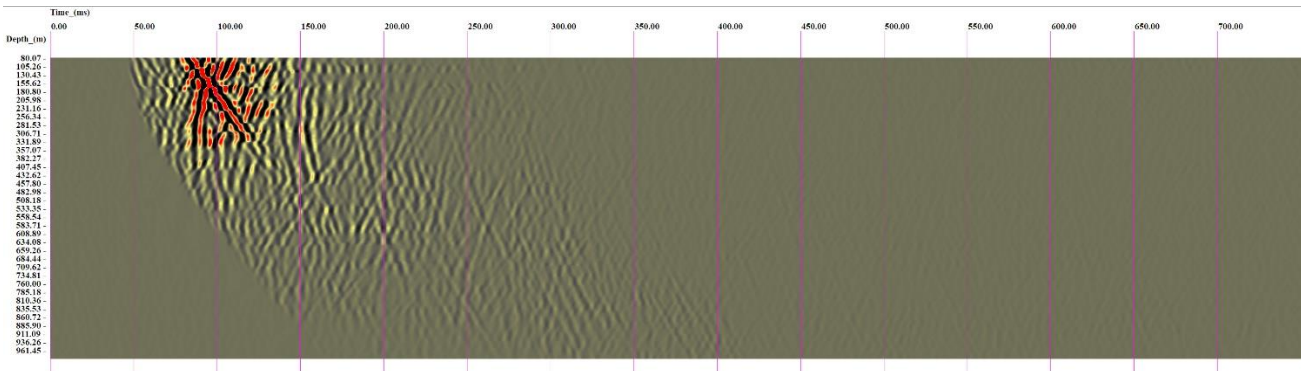


Axial component

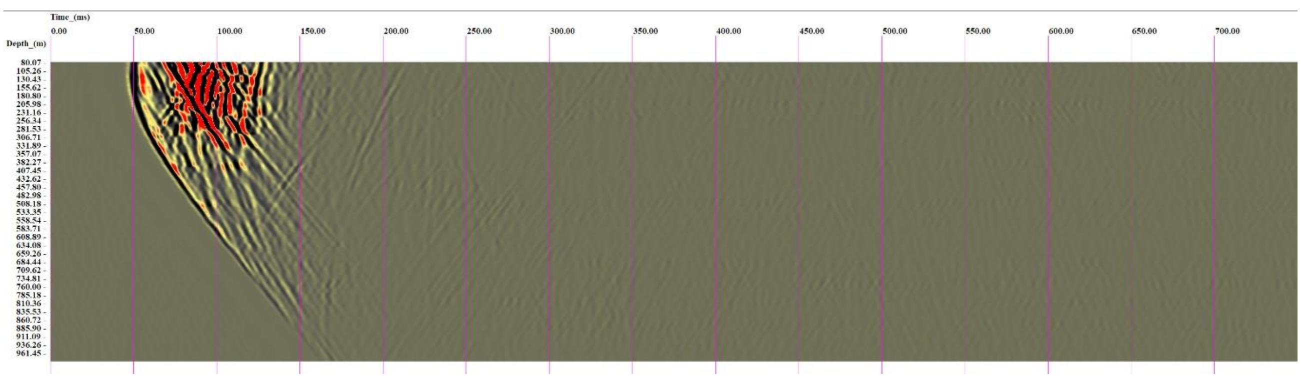
Figure 6. IG_BH06 VSP, Shot V49



Radial component

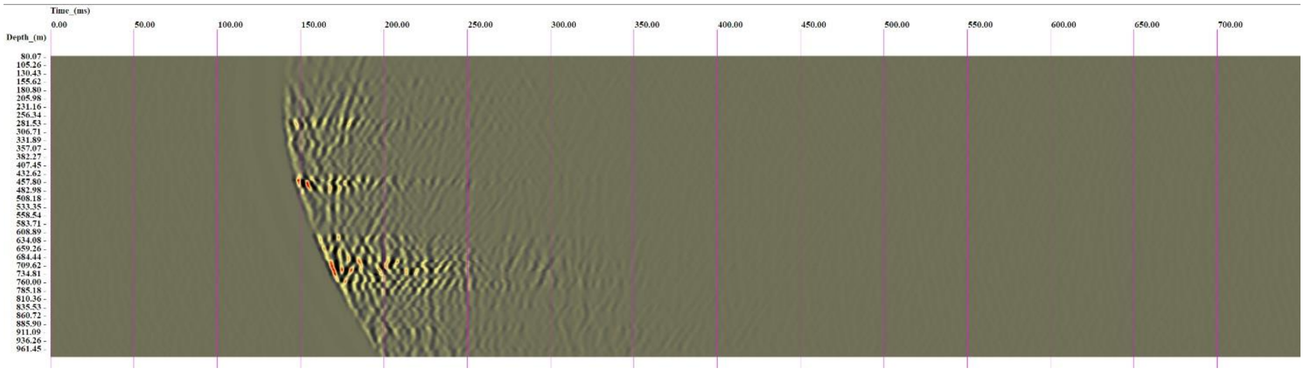


Transversal component

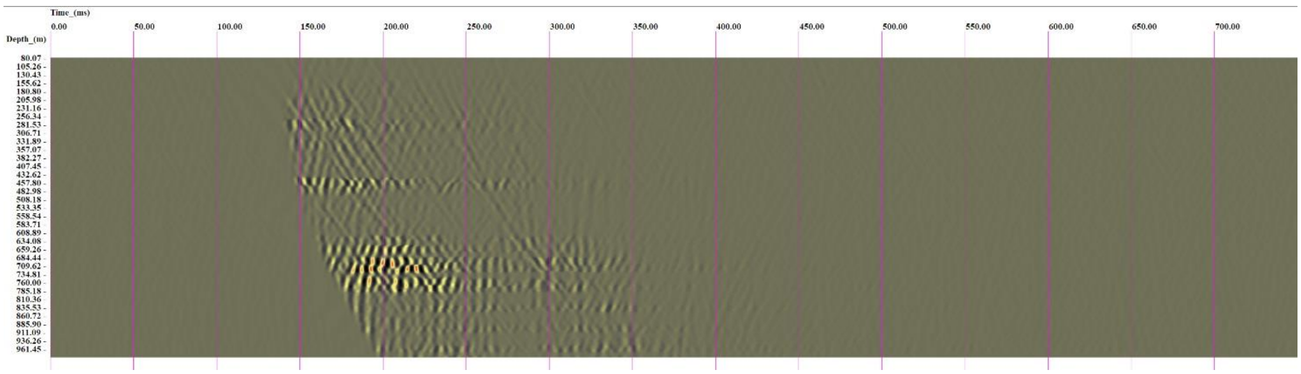


Axial component

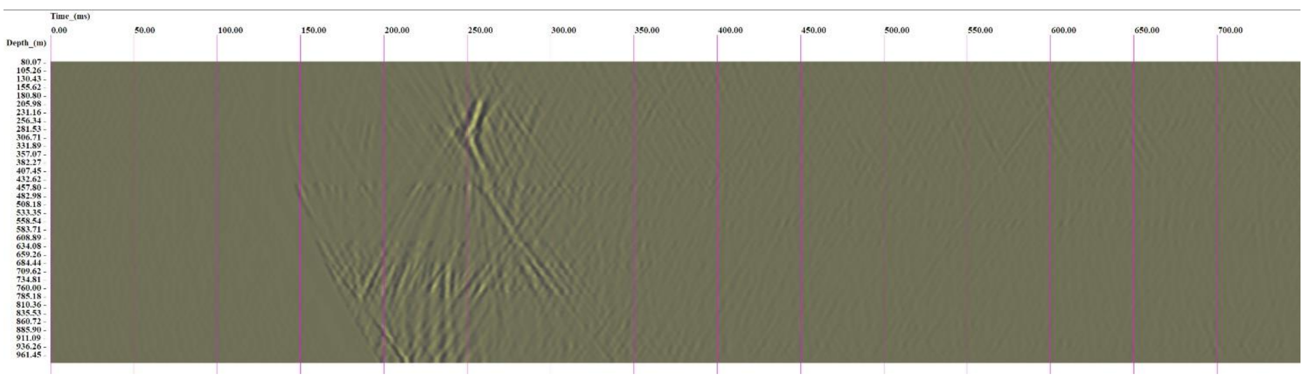
Figure 7. IG_BH06 VSP, Shot V71



Radial component

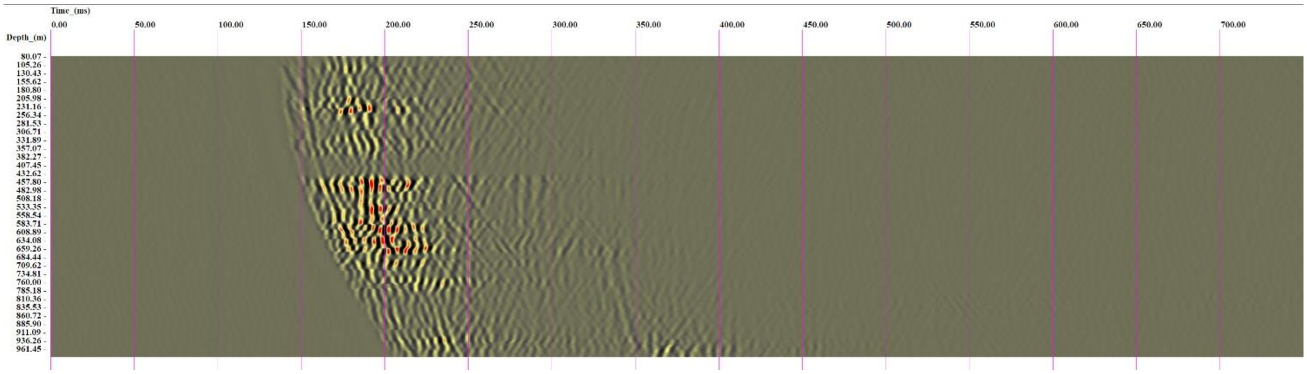


Transversal component

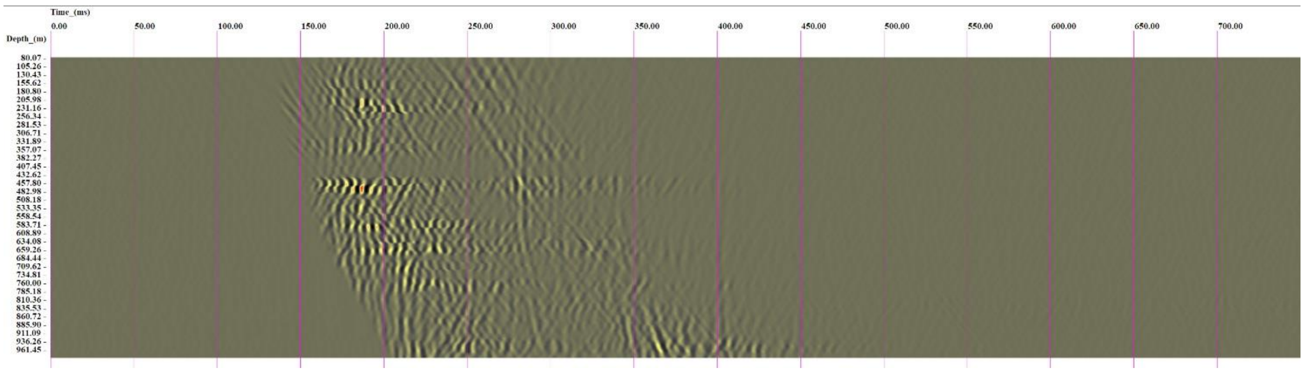


Axial component

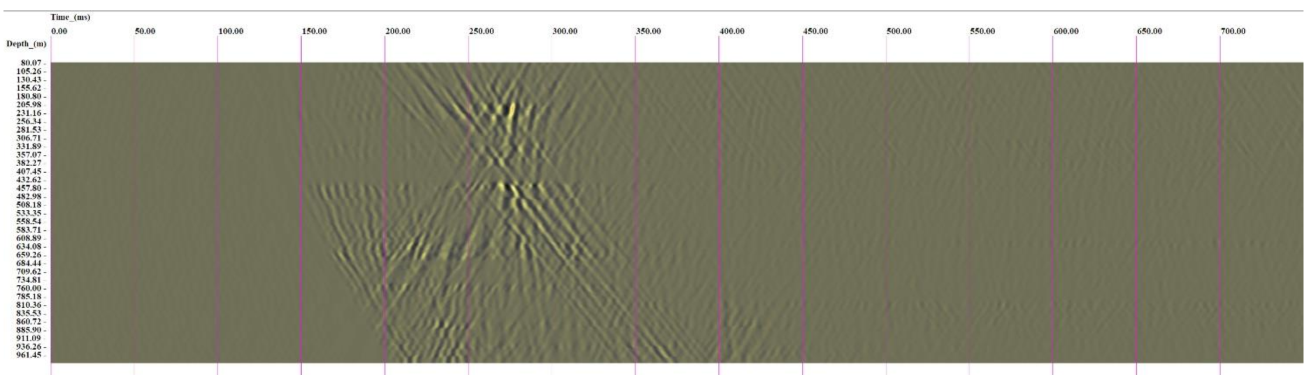
Figure 8. IG_BH06 VSP, Shot V72



Radial component

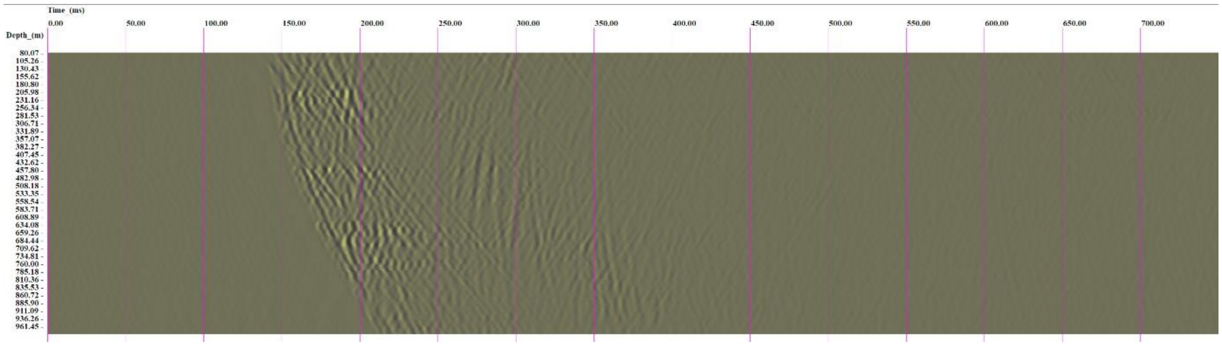


Transversal component

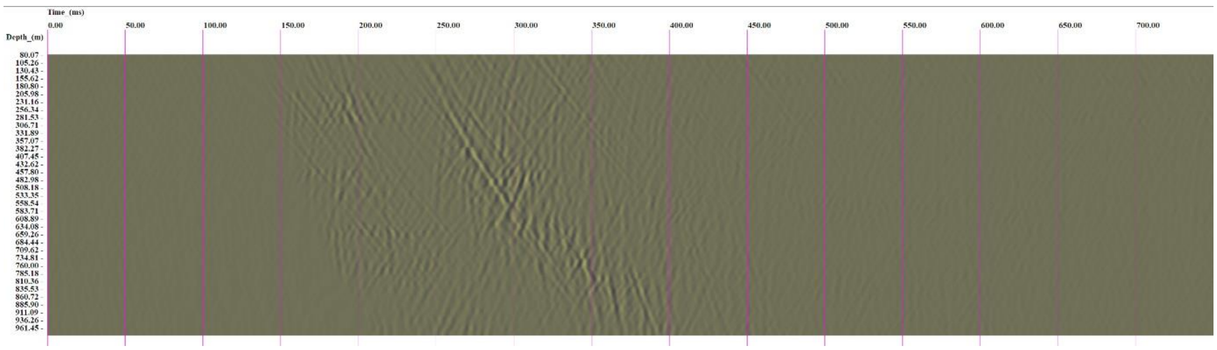


Axial component

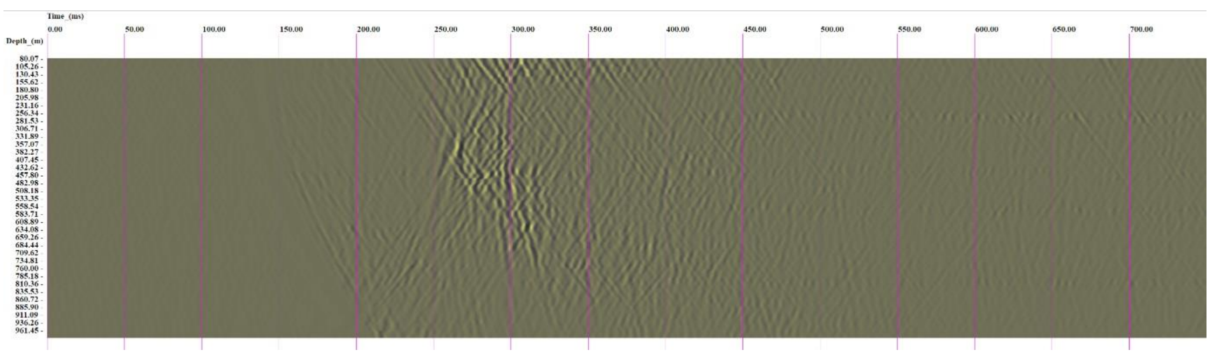
Figure 9. IG_BH06 VSP, Shot V73



Radial component

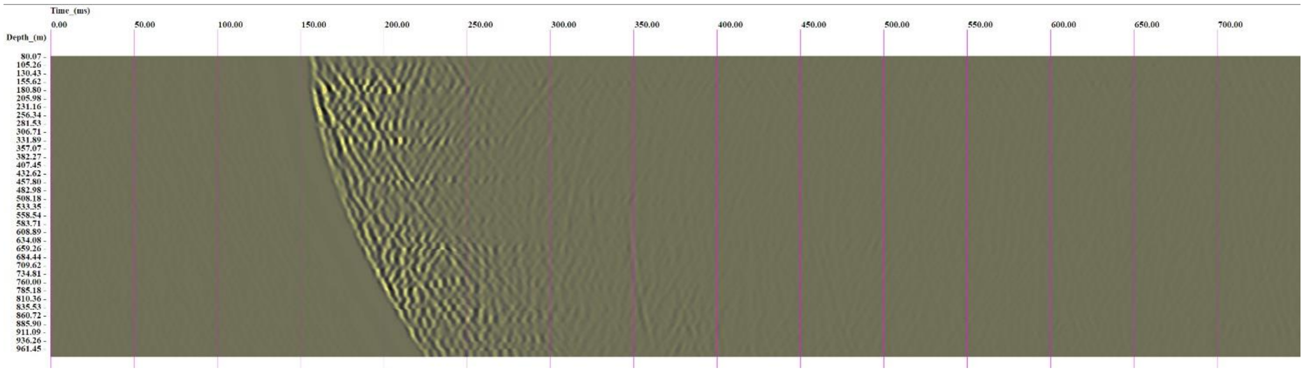


Transversal component

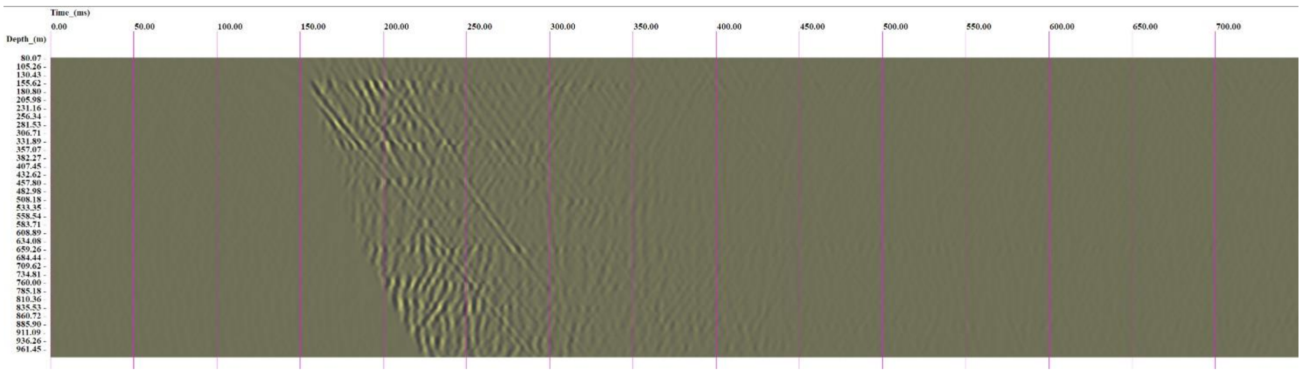


Axial component

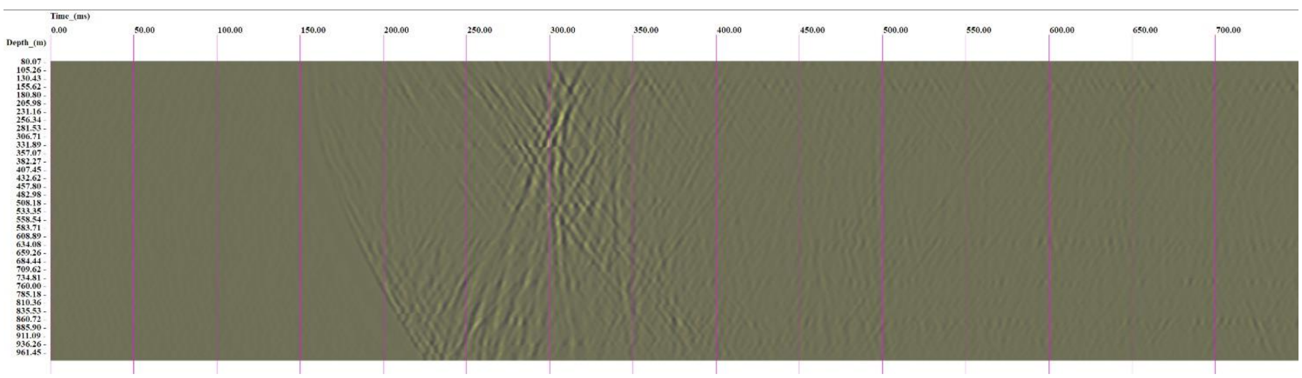
Figure 10. IG_BH06 VSP, Shot V74



Radial component

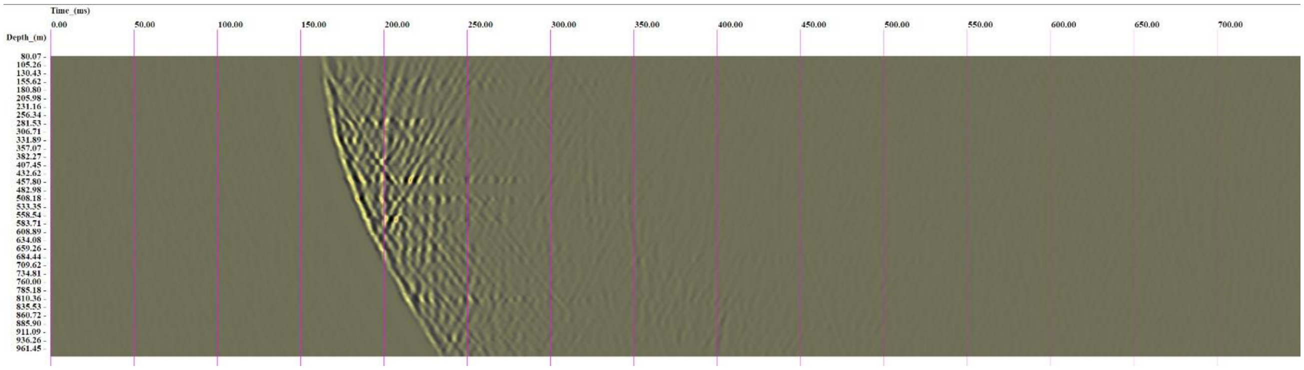


Transversal component

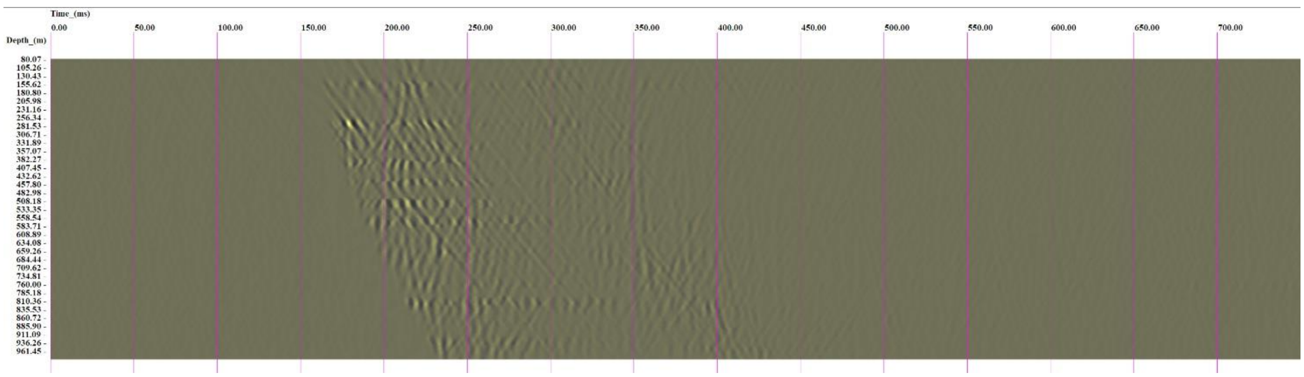


Axial component

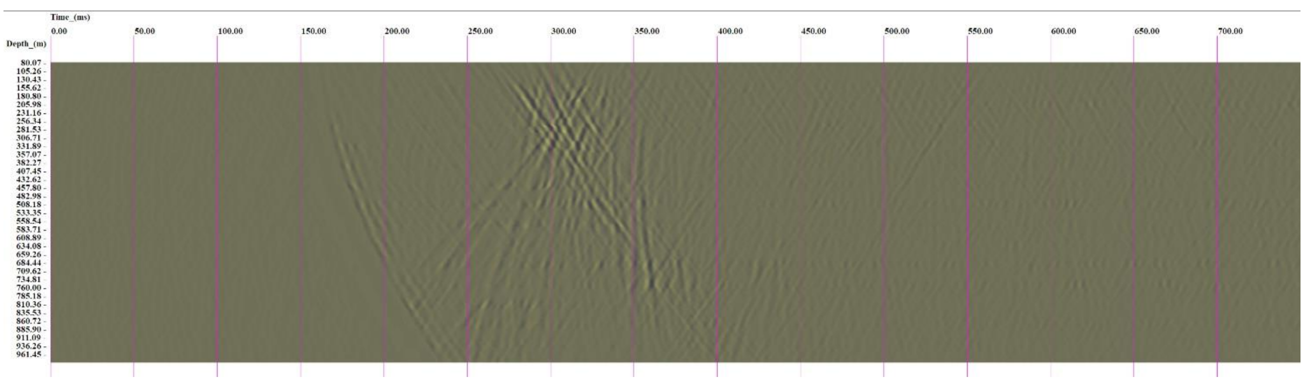
Figure 11. IG_BH06 VSP, Shot V75



Radial component

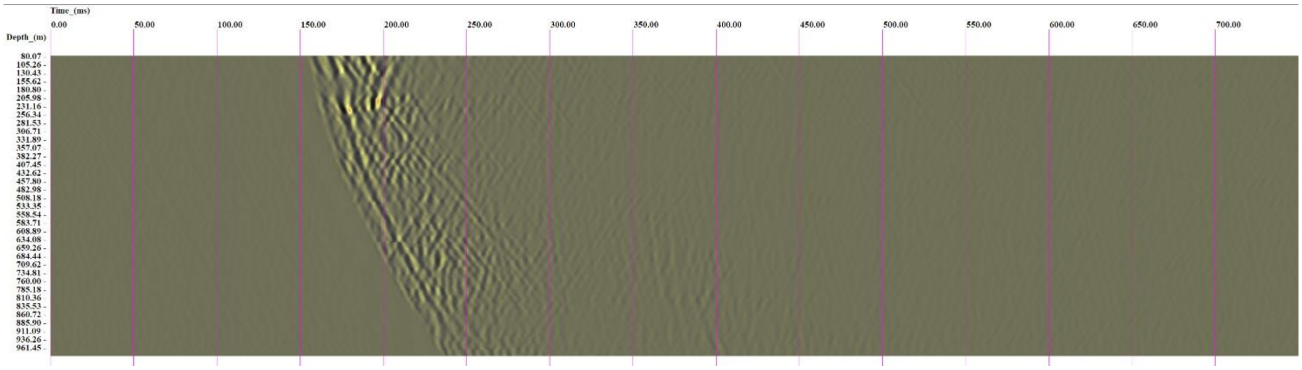


Transversal component

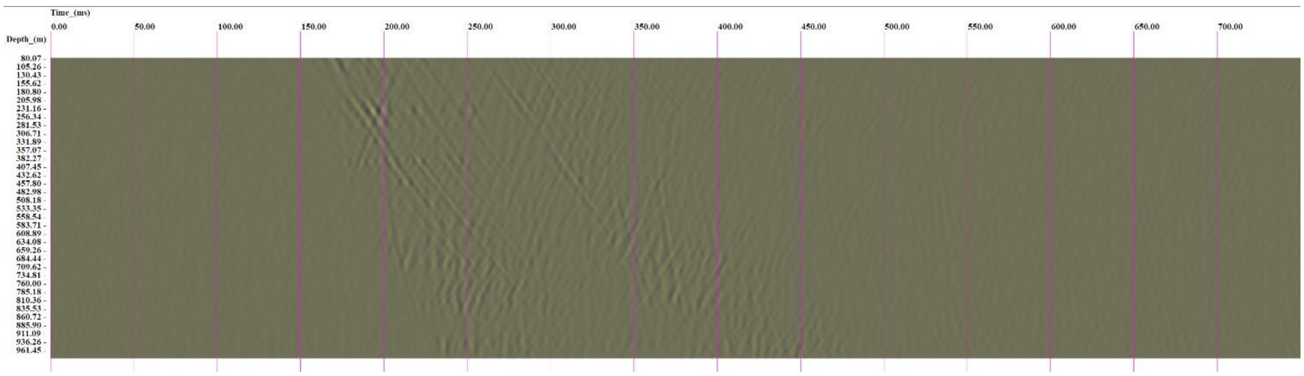


Axial component

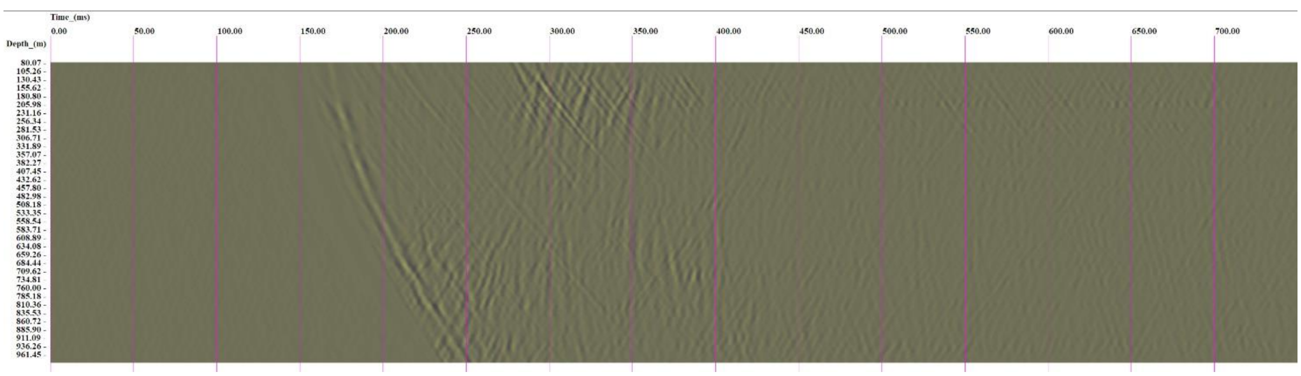
Figure 12. IG_BH06 VSP, Shot V76



Radial component

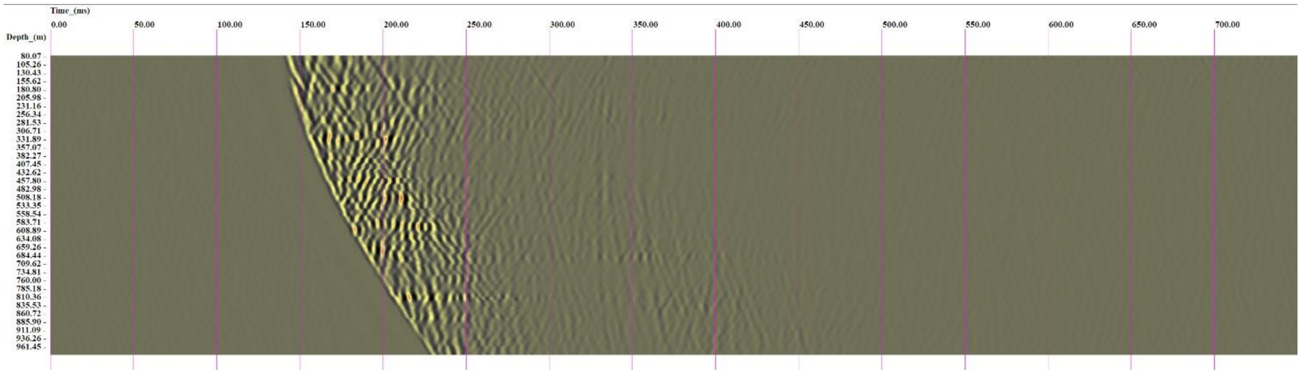


Transversal component

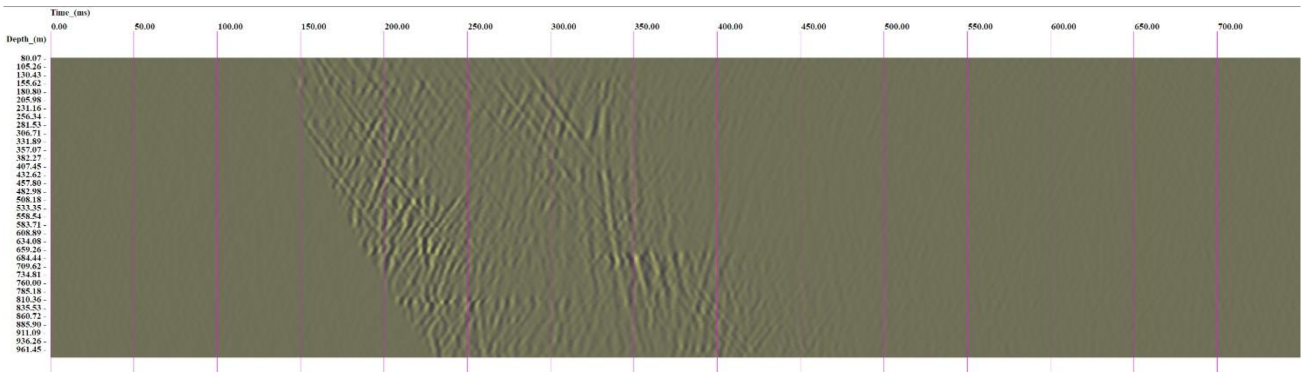


Axial component

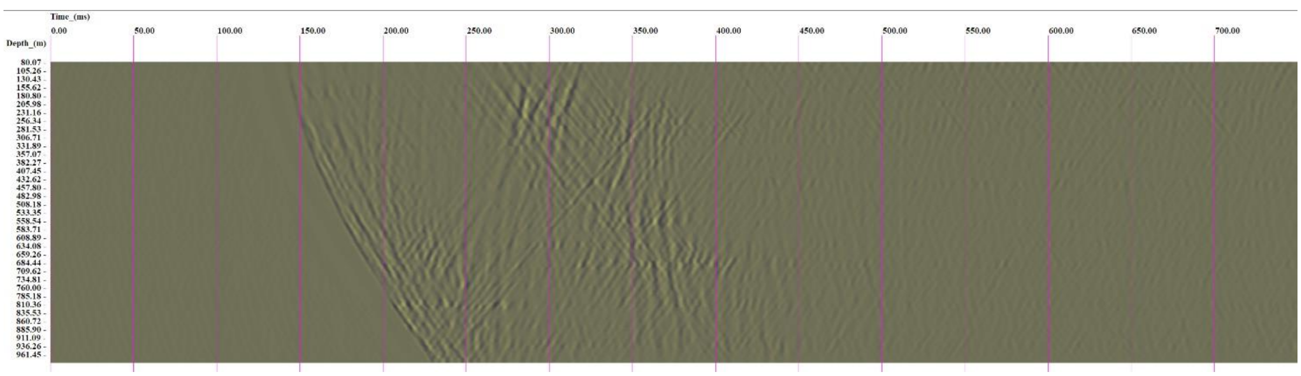
Figure 13. IG_BH06 VSP, Shot V77



Radial component

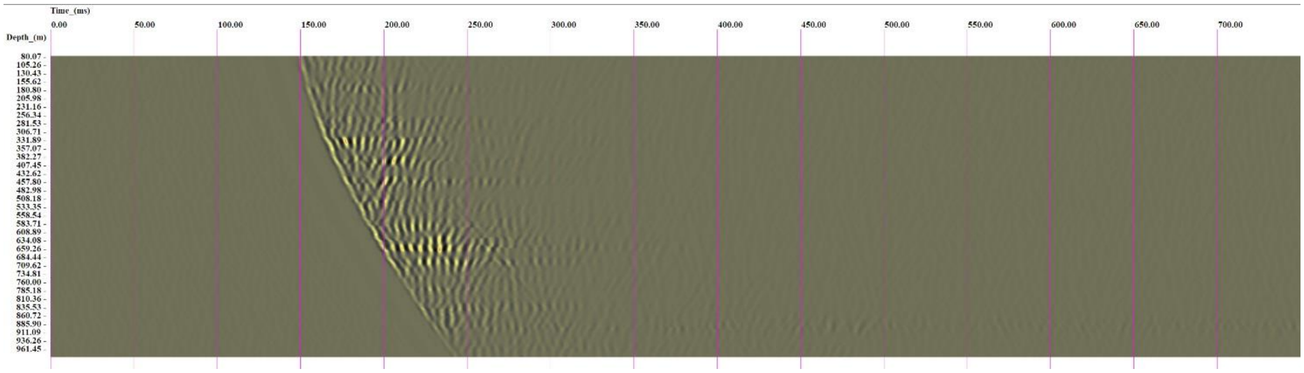


Transversal component

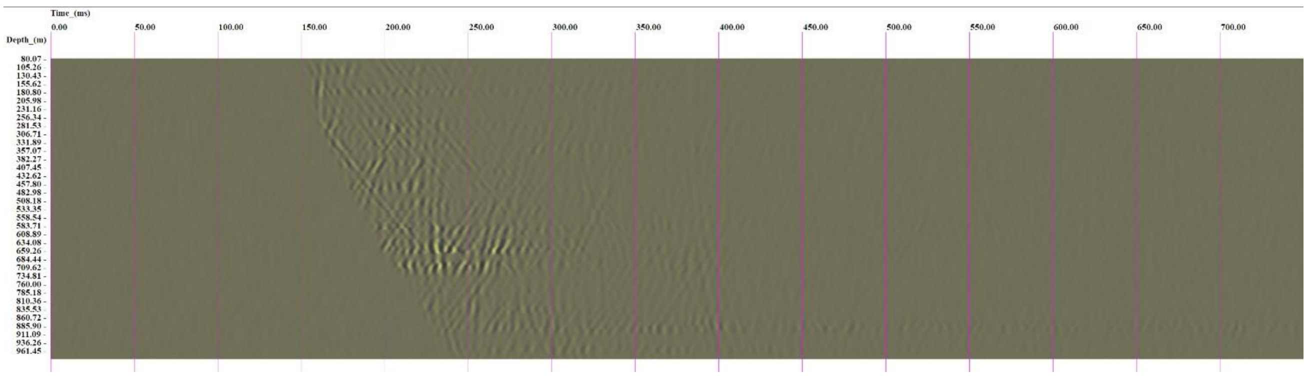


Axial component

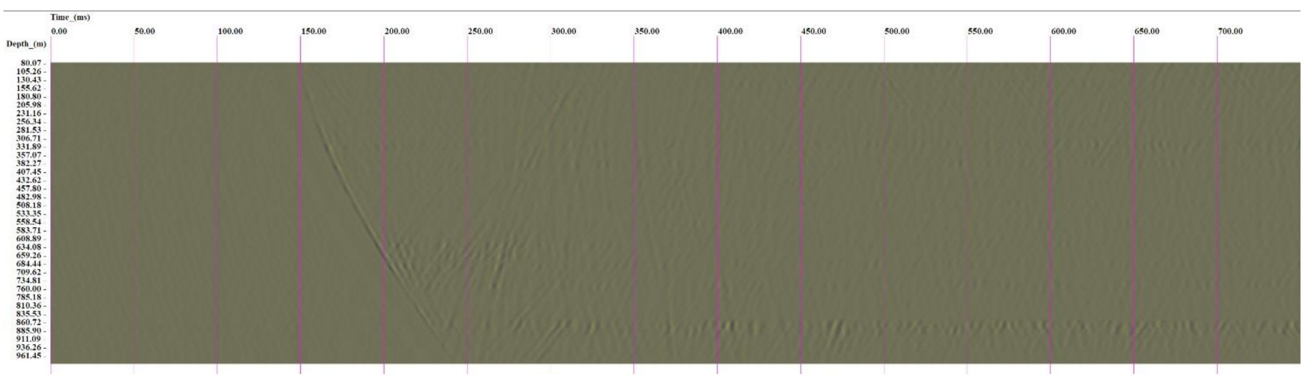
Figure 14. IG_BH06 VSP, Shot V78



Radial component

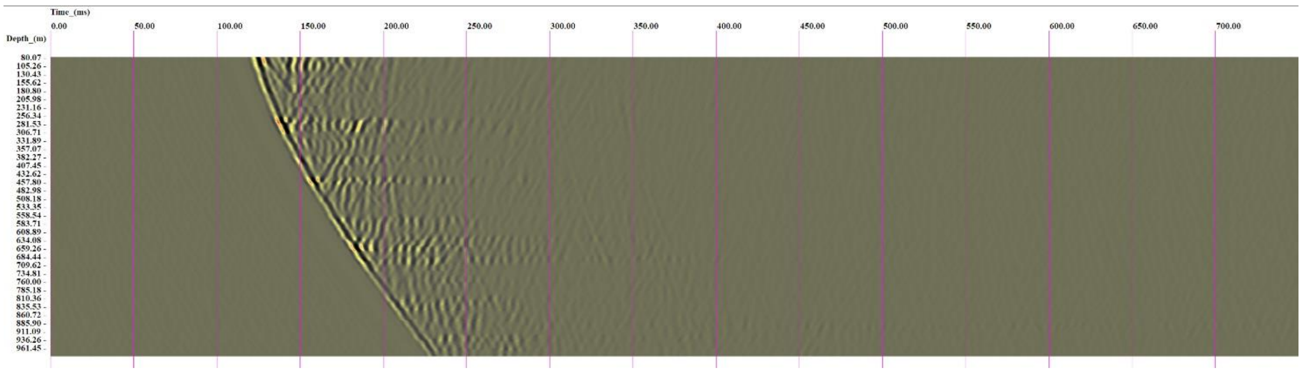


Transversal component

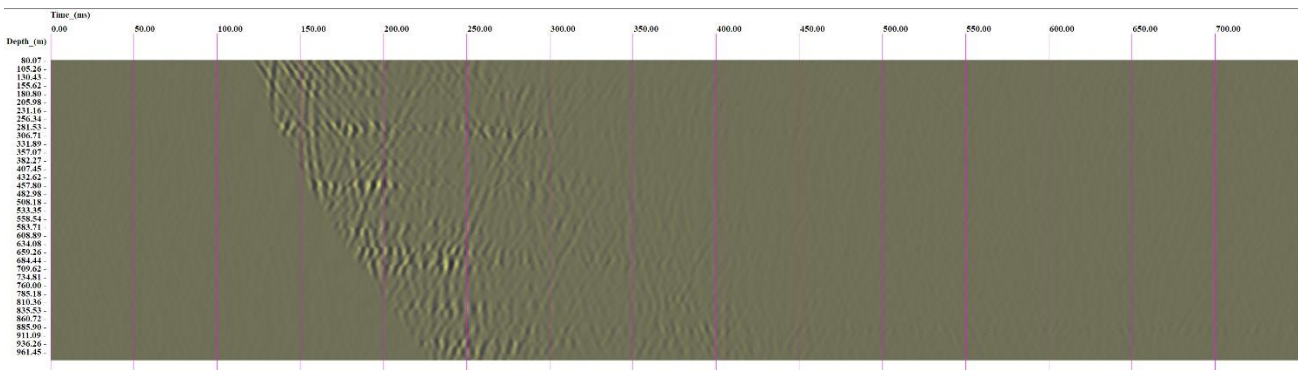


Axial component

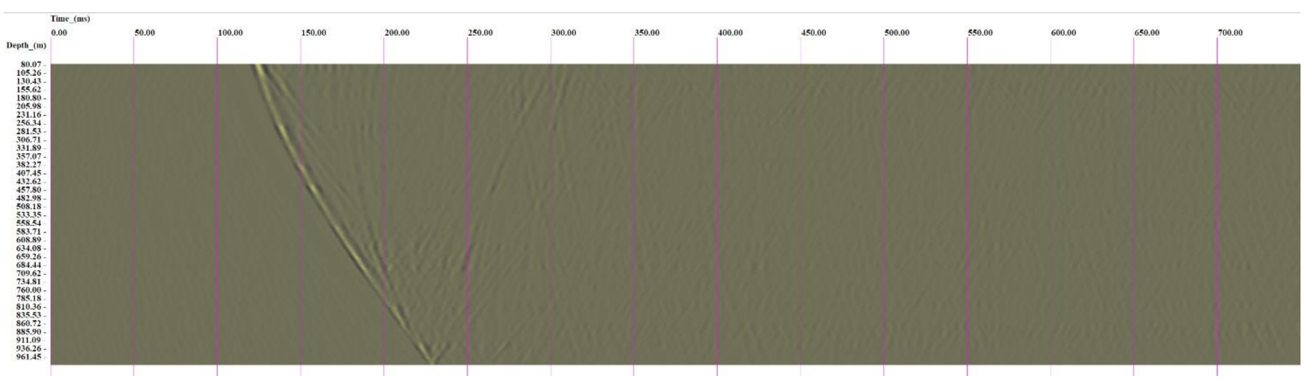
Figure 15. IG_BH06 VSP, Shot V79



Radial component

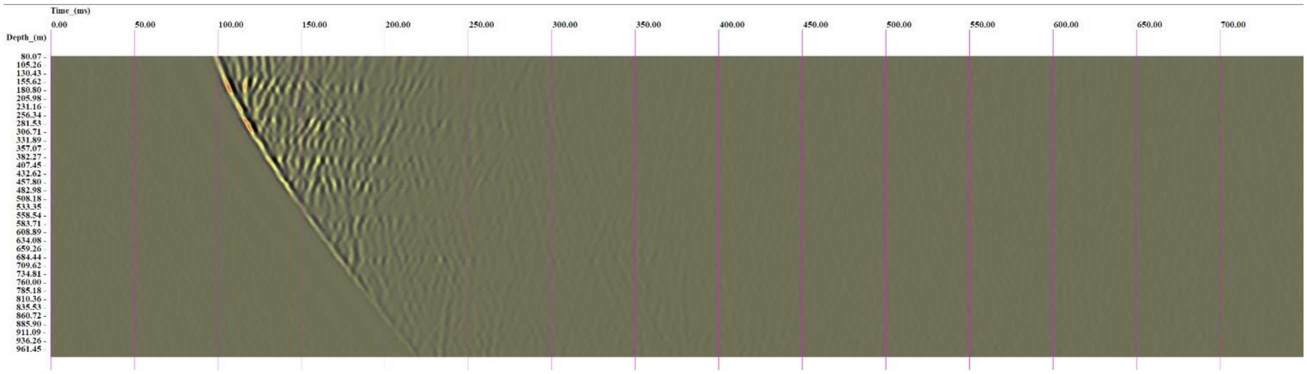


Transversal component

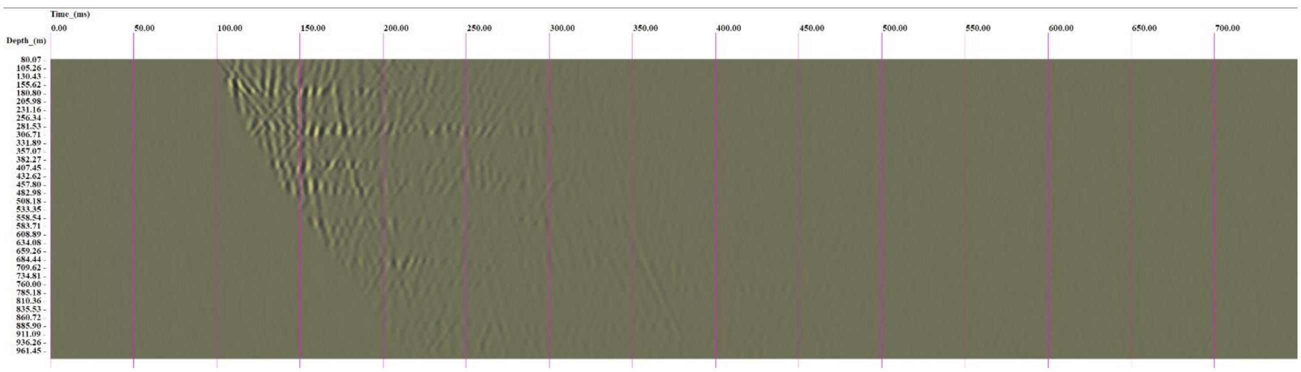


Axial component

Figure 16. IG_BH06 VSP, Shot V80



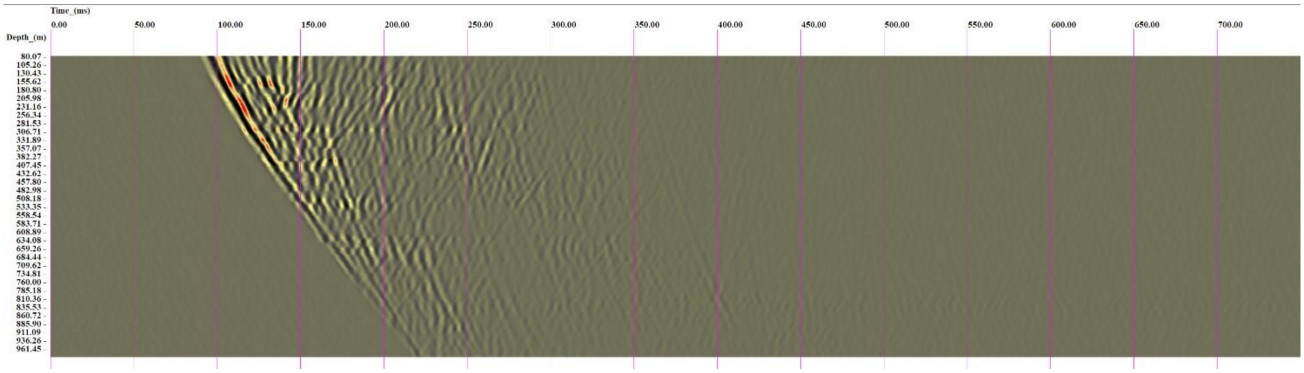
Radial component



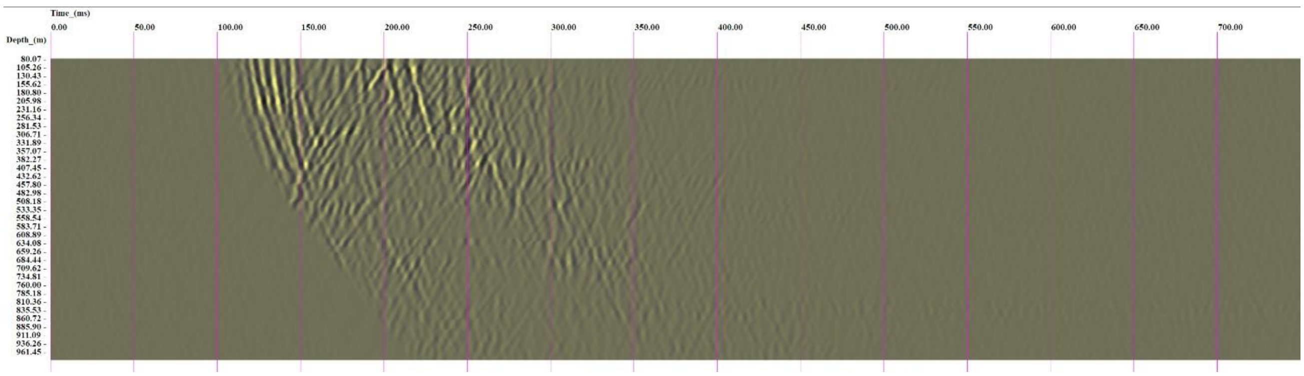
Transversal component

Axial component

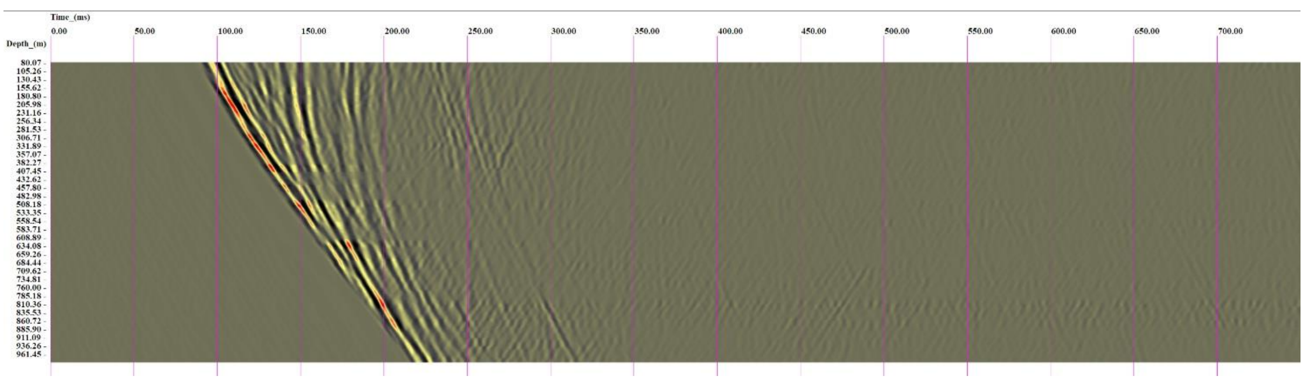
Figure 17. IG_BH06 VSP, Shot V81



Radial component

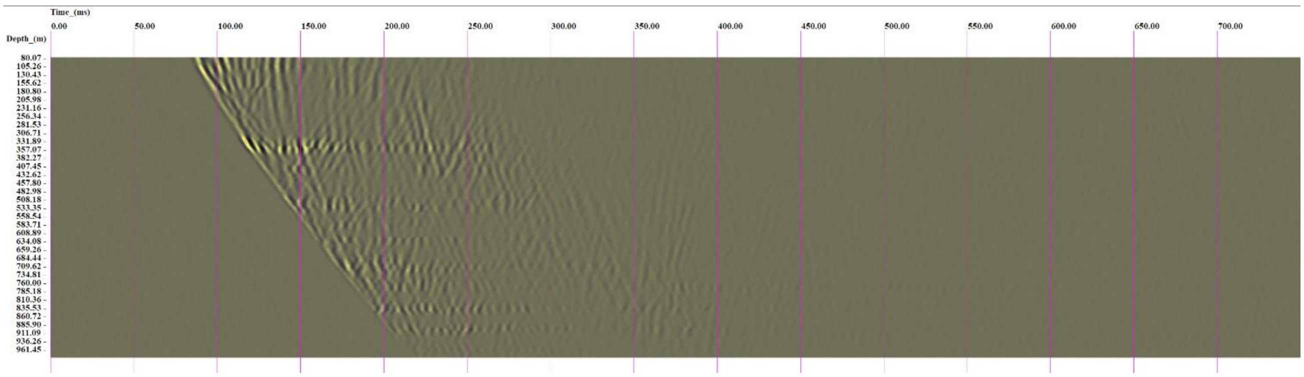


Transversal component

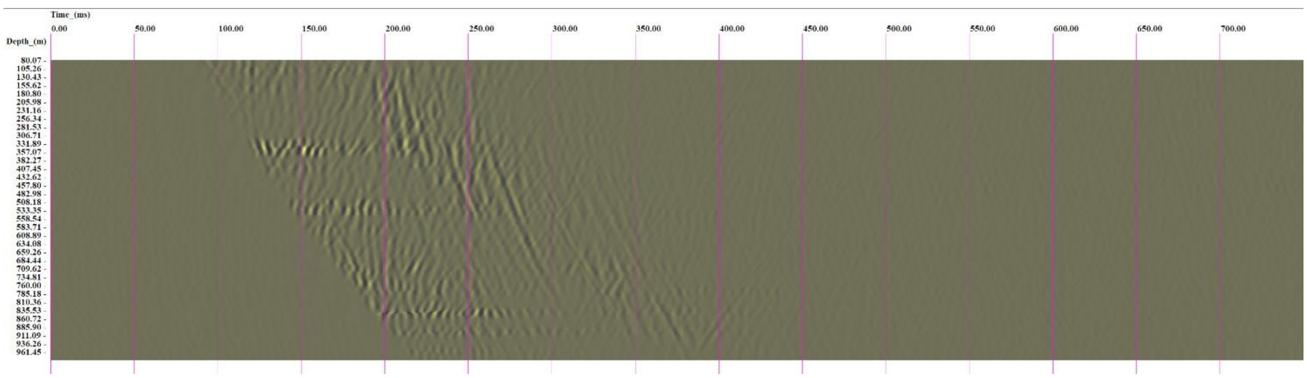


Axial component

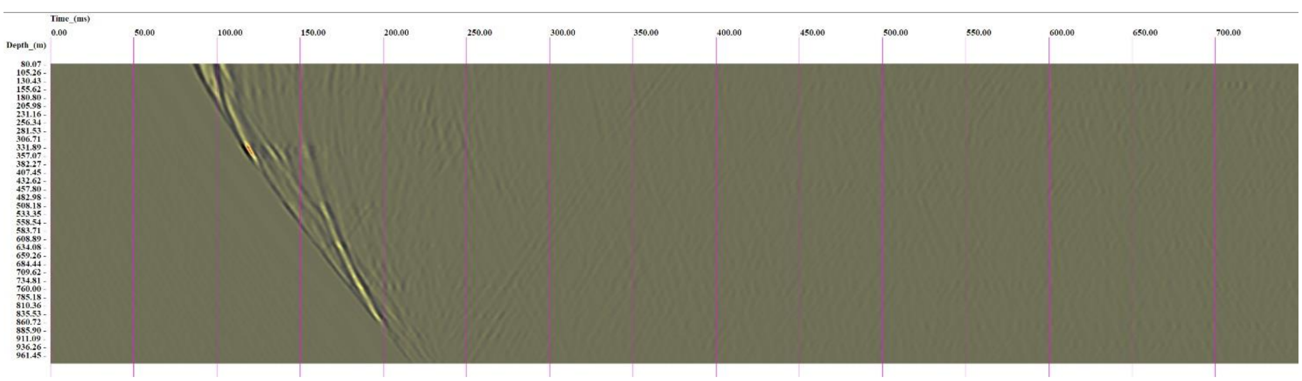
Figure 18. IG_BH06 VSP, Shot V82



Radial component

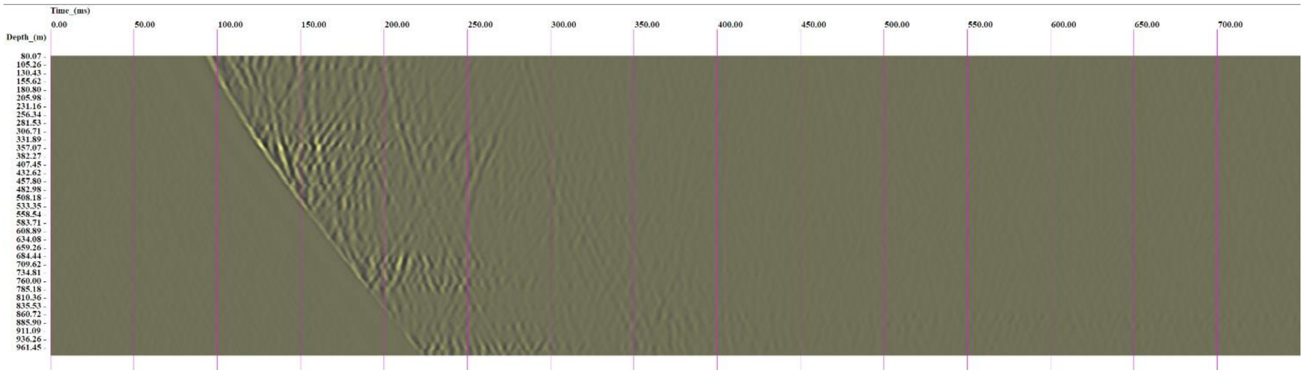


Transversal component

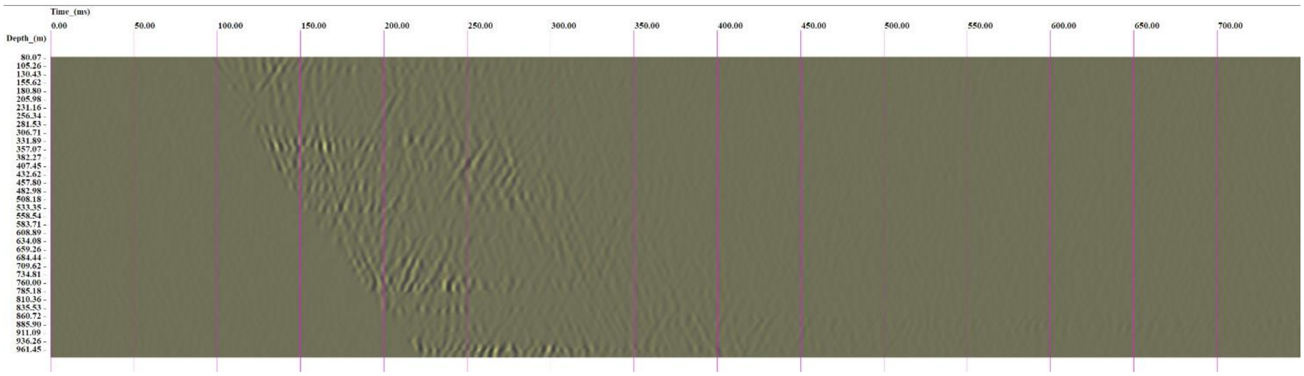


Axial component

Figure 19. IG_BH06 VSP, Shot V83



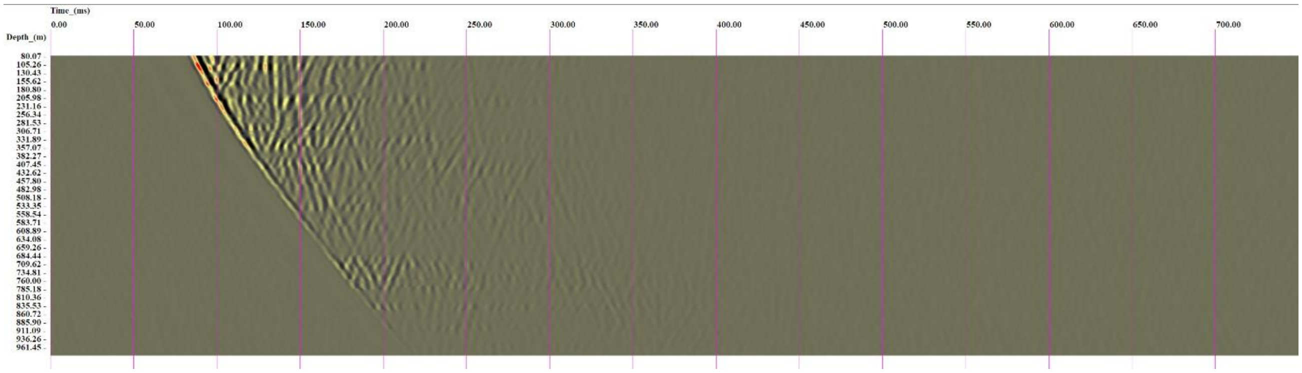
Radial component



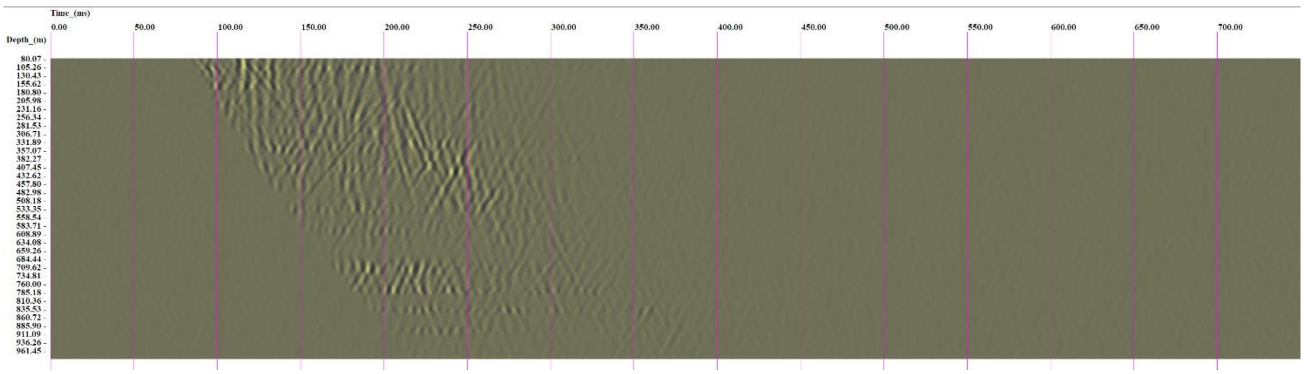
Transversal component

Axial component

Figure 20. IG_BH06 VSP, Shot V84



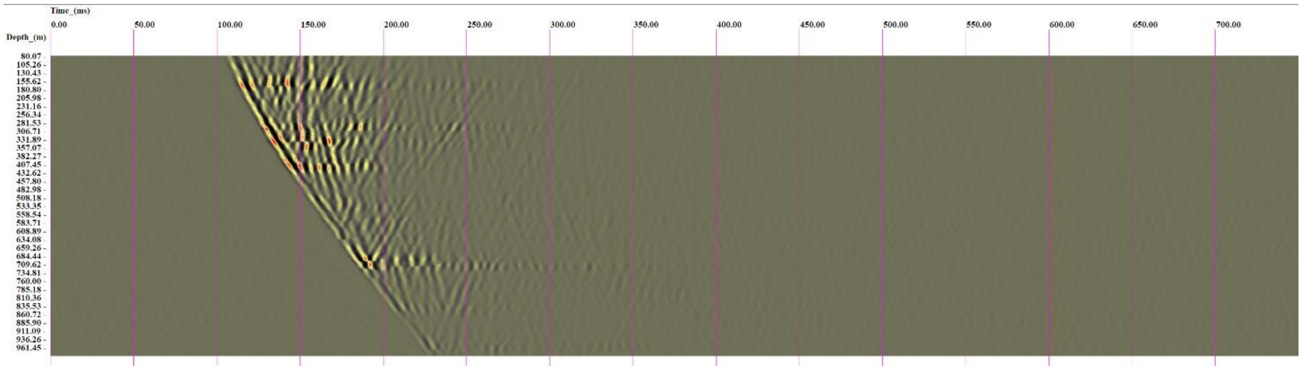
Radial component



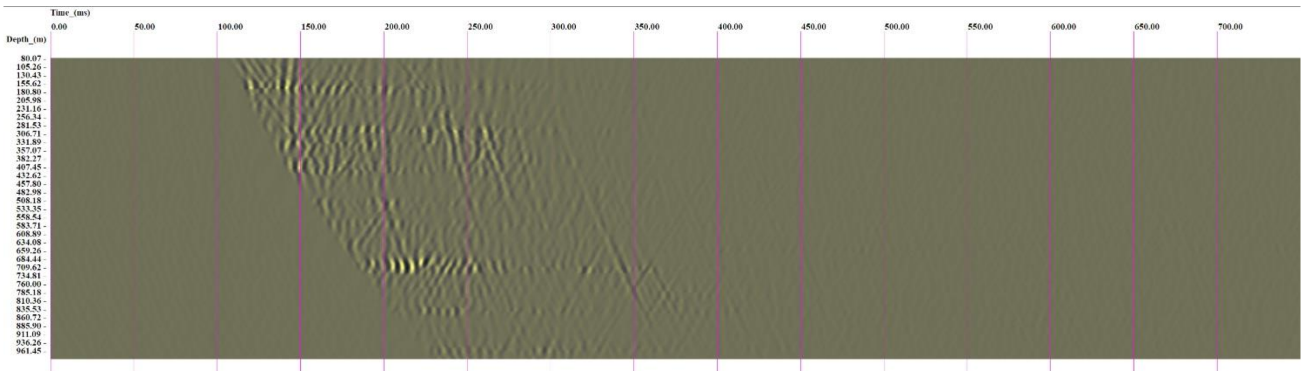
Transversal component

Axial component

Figure 21. IG_BH06 VSP, Shot V85



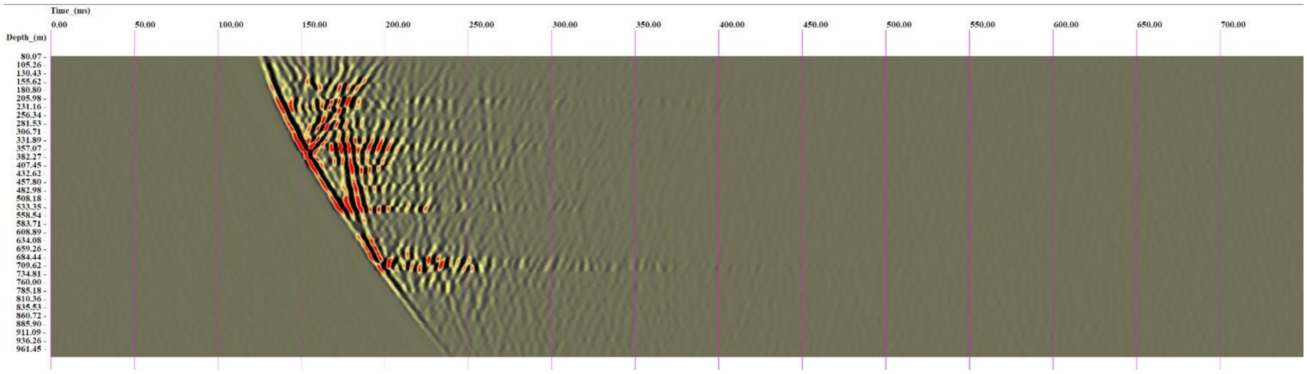
Radial component



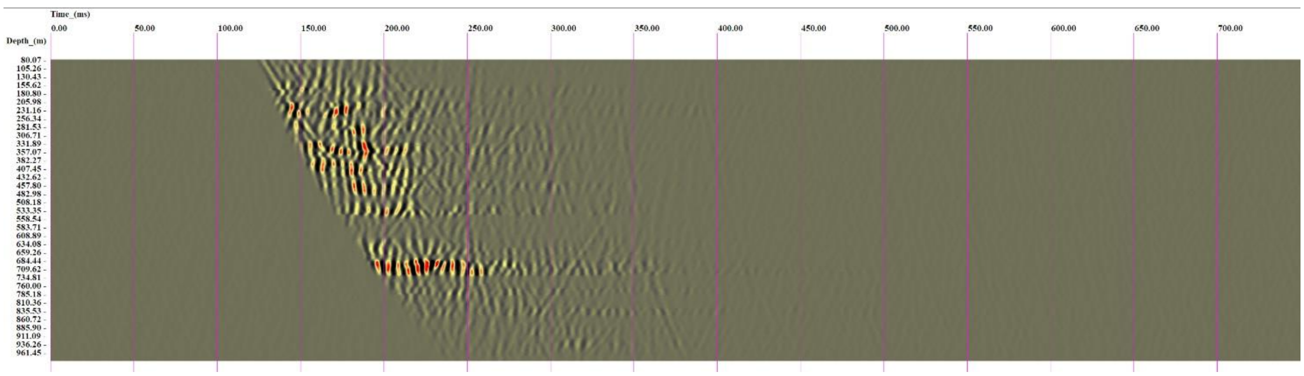
Transversal component

Axial component

Figure 22. IG_BH06 VSP, Shot V86



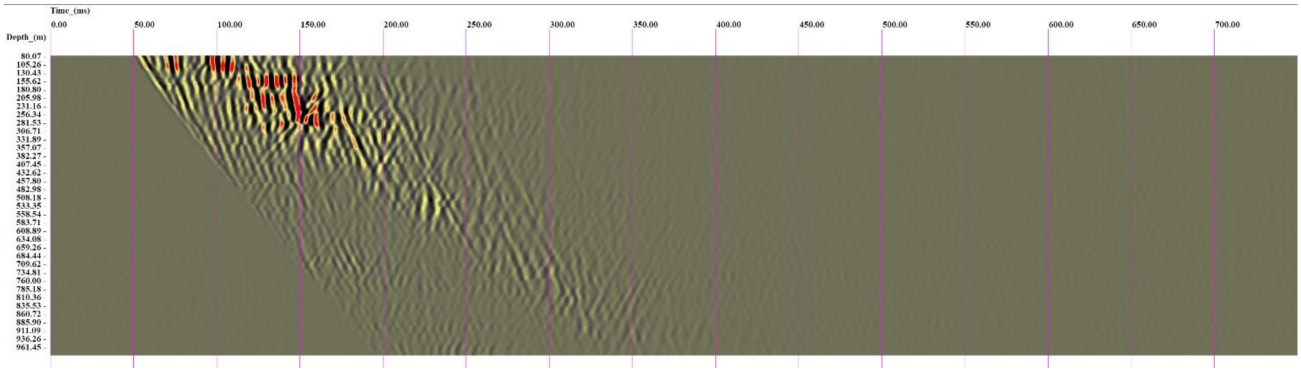
Radial component



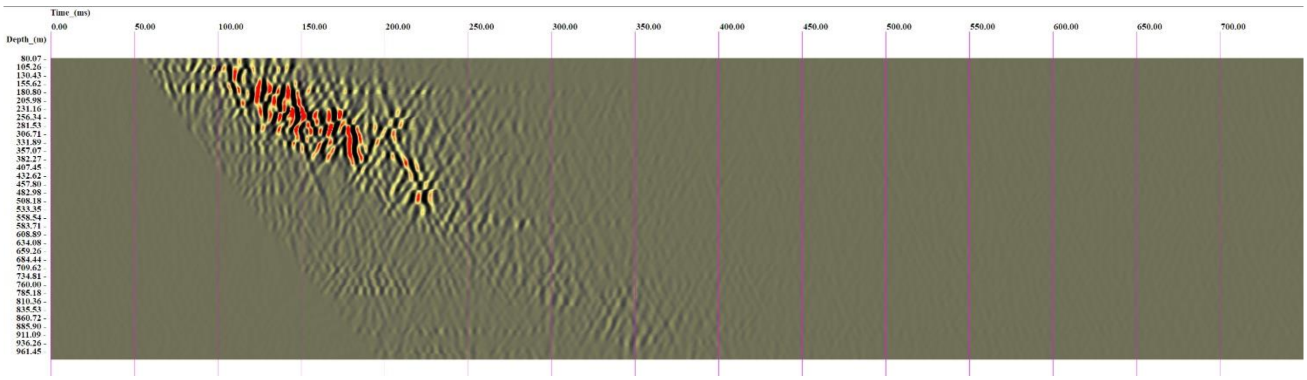
Transversal component

Axial component

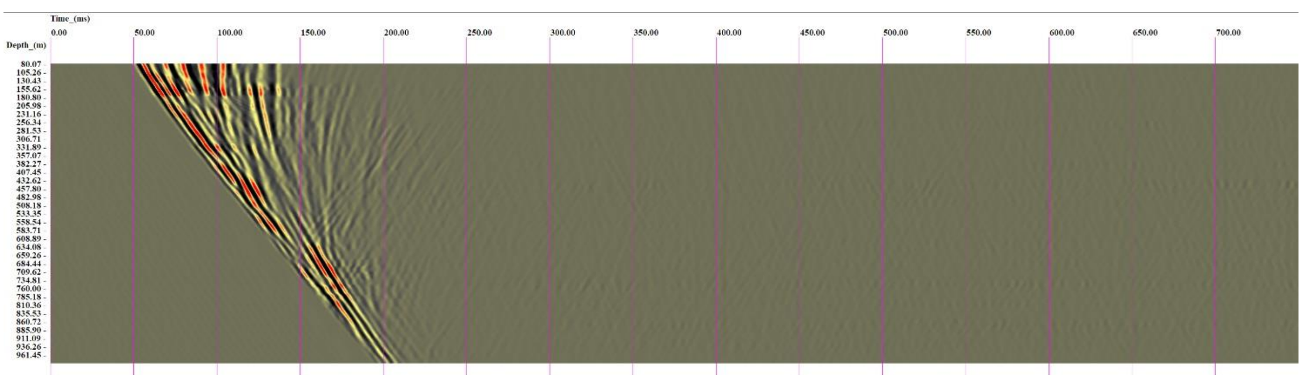
Figure 23. IG_BH06 VSP, Shot V87



Radial component

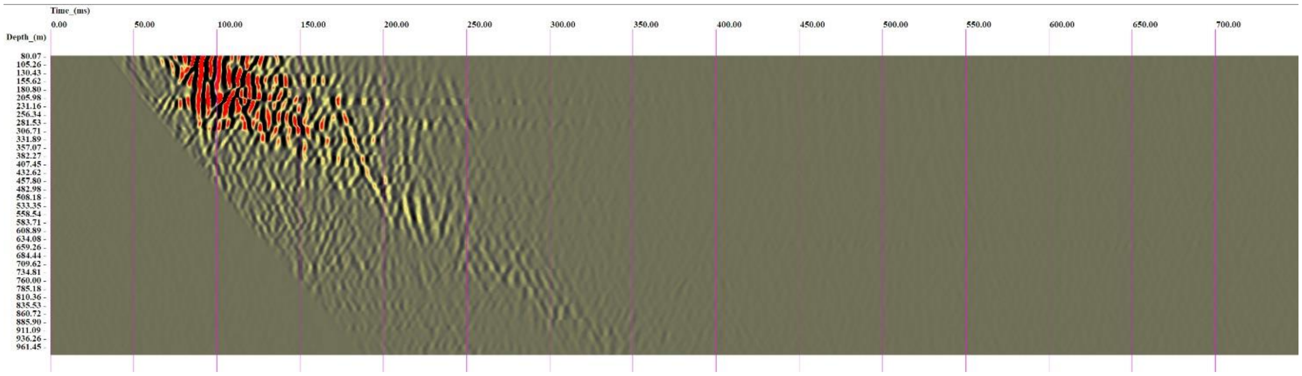


Transversal component

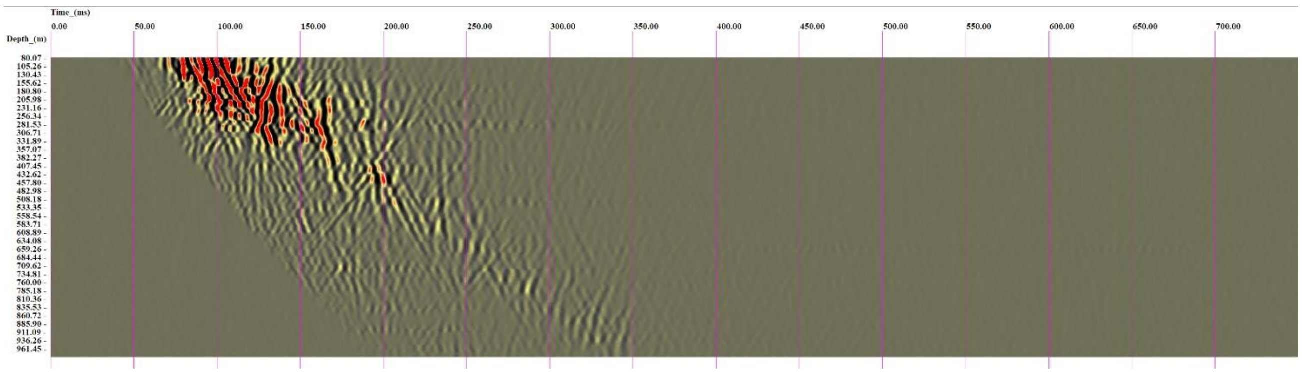


Axial component

Figure 24. IG_BH06 VSP, Shot V88



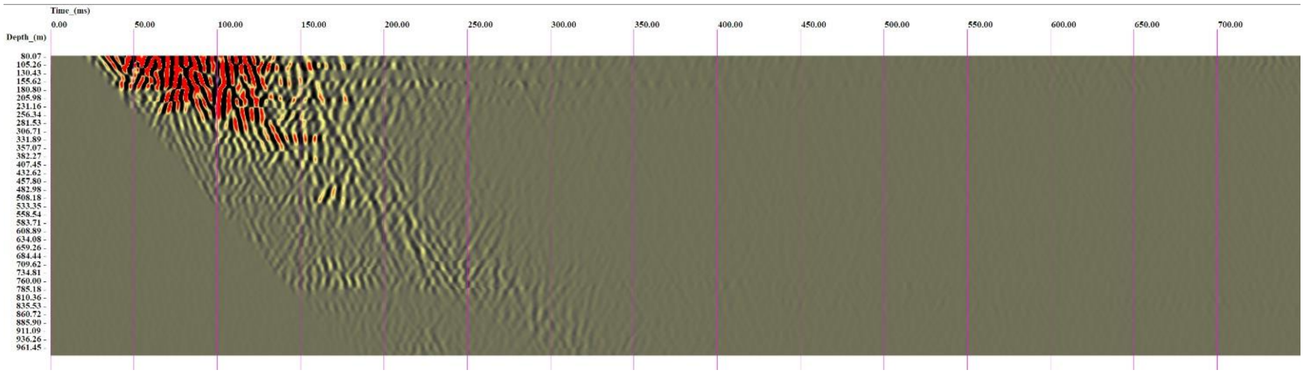
Radial component



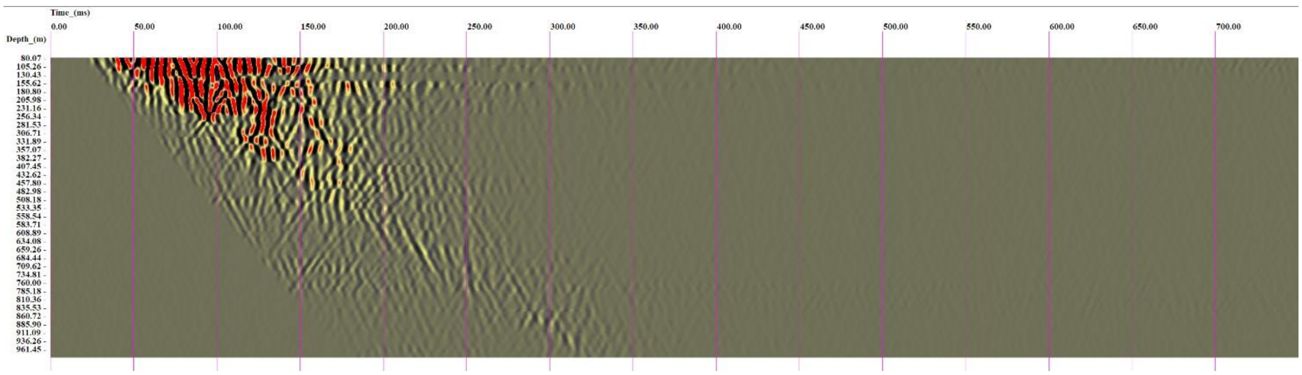
Transversal component

Axial component

Figure 25. IG_BH06 VSP, Shot V89



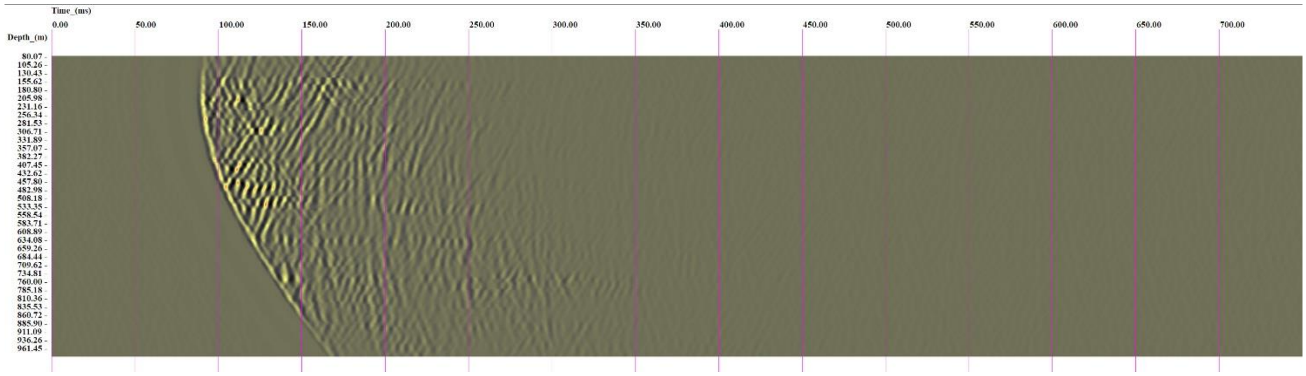
Radial component



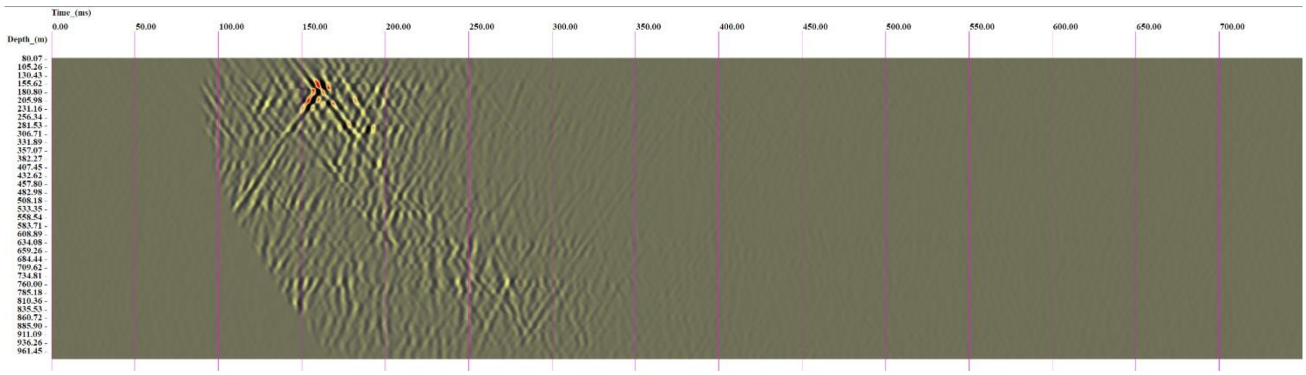
Transversal component

Axial component

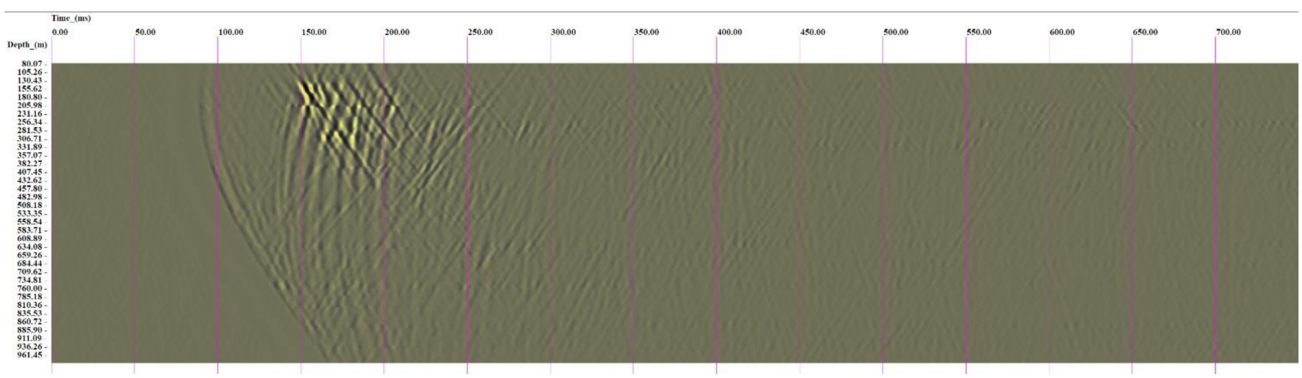
Figure 26. IG_BH06 VSP, Shot V90



Radial component

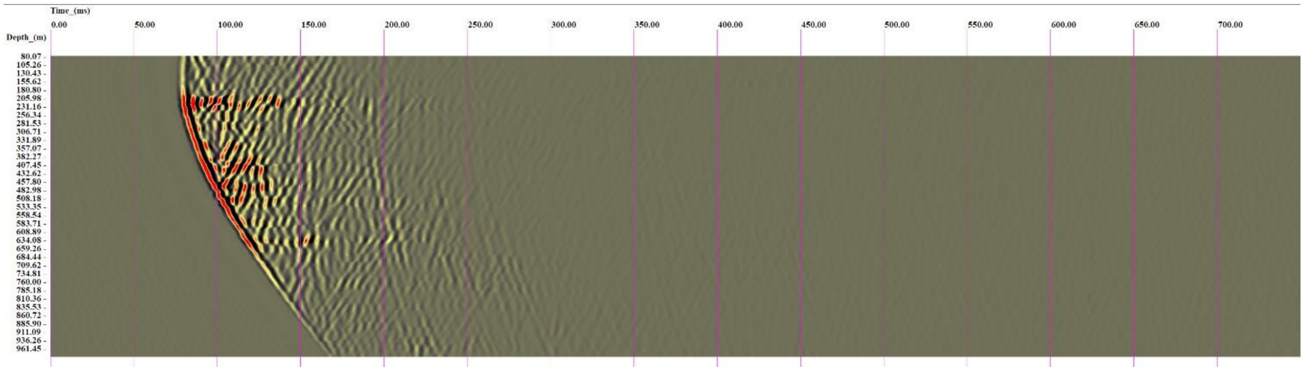


Transversal component

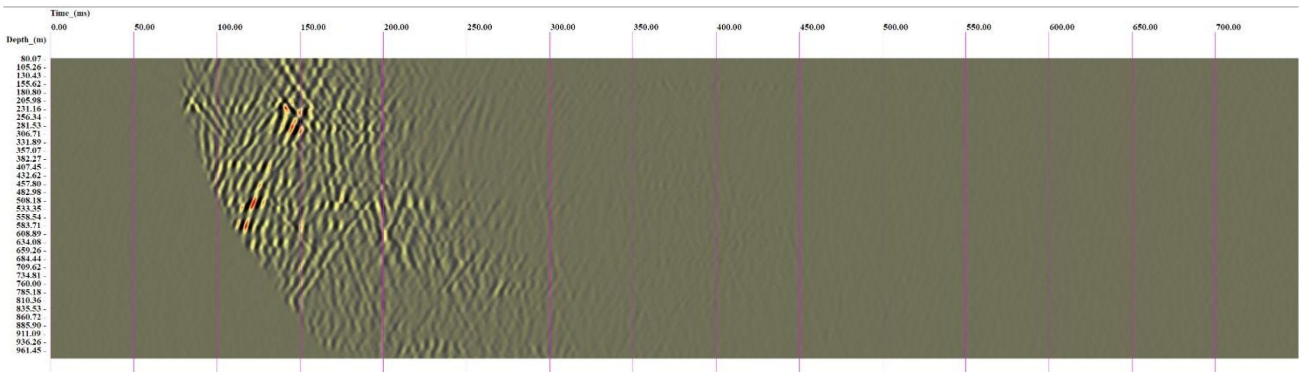


Axial component

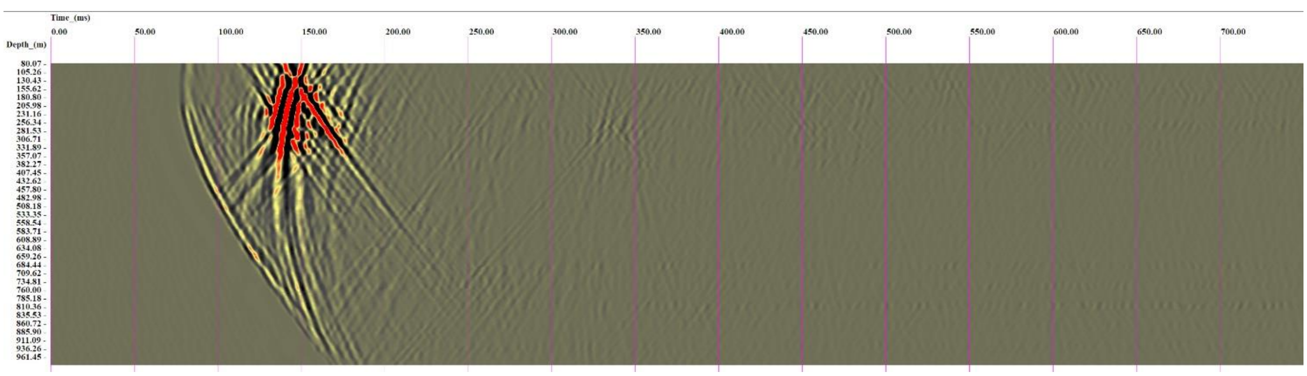
Figure 27. IG_BH06 VSP, Shot V91



Radial component

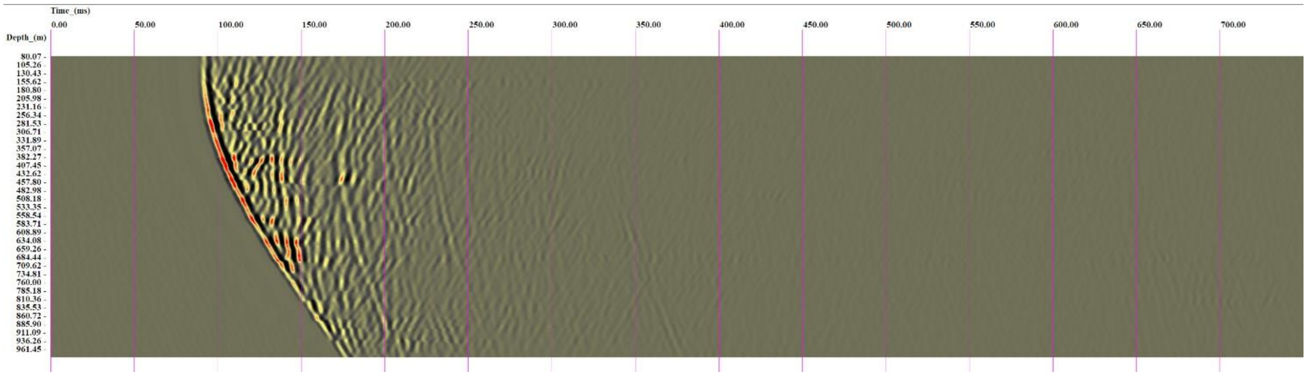


Transversal component

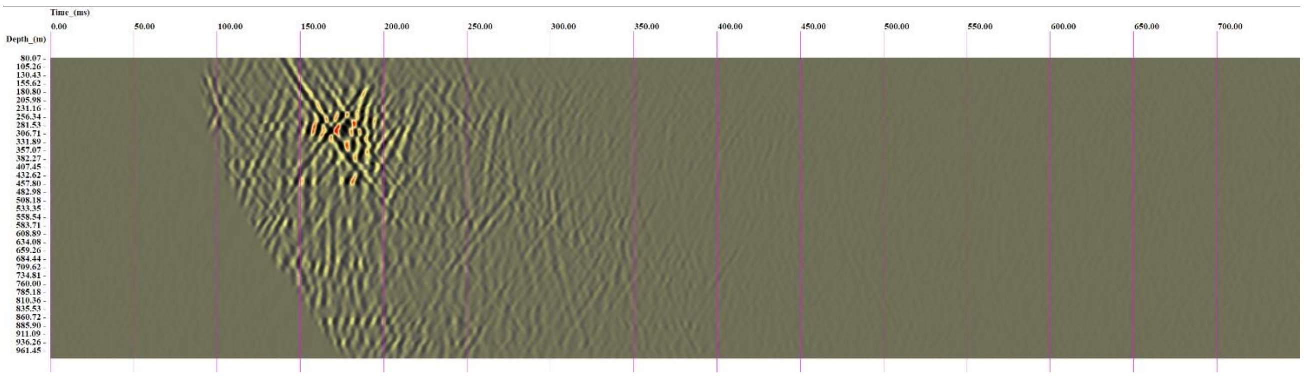


Axial component

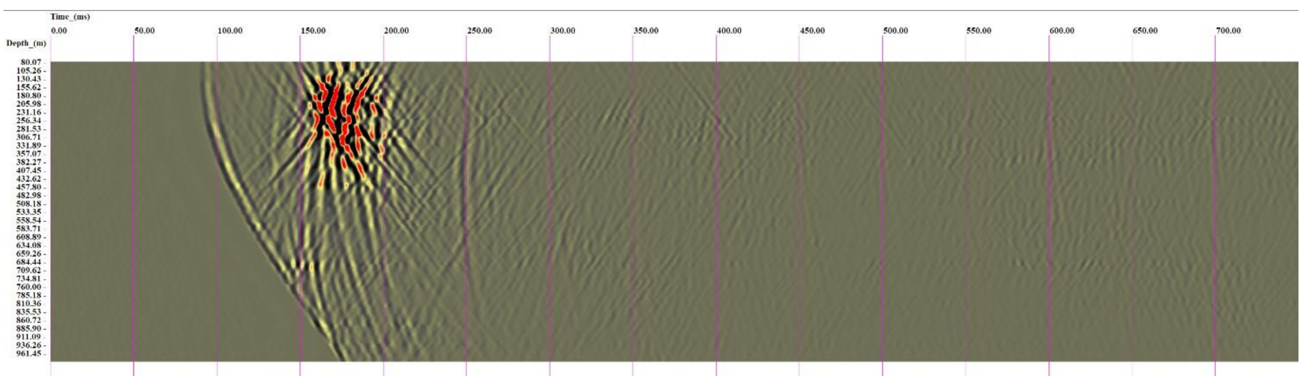
Figure 28. IG_BH06 VSP, Shot V92



Radial component

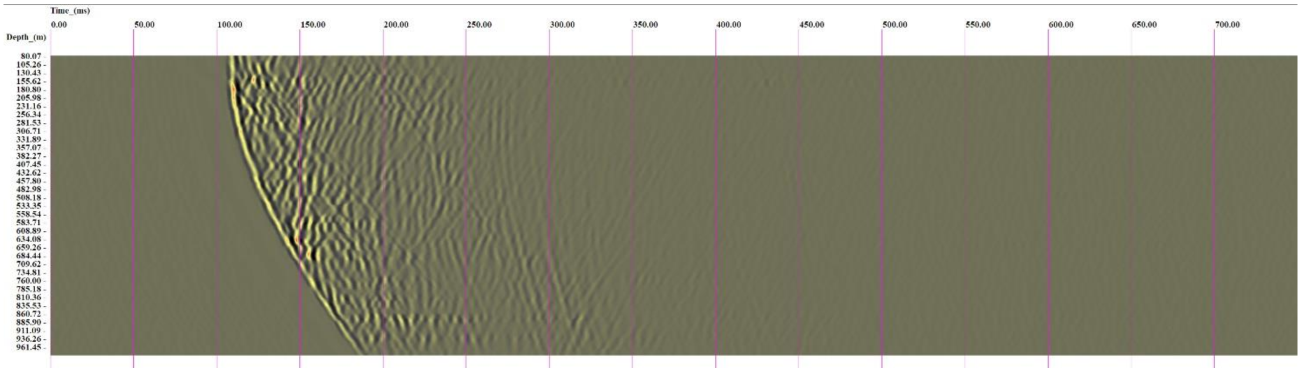


Transversal component

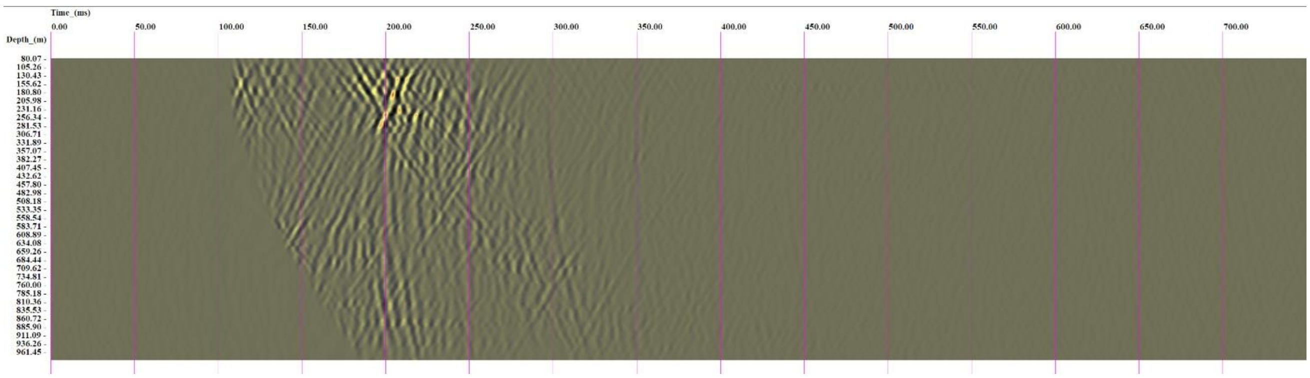


Axial component

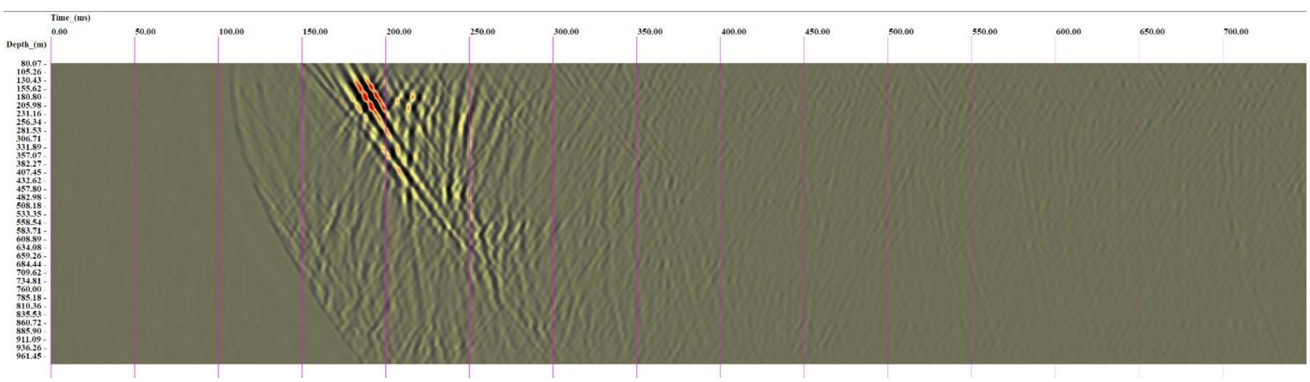
Figure 29. IG_BH06 VSP, Shot V93



Radial component



Transversal component

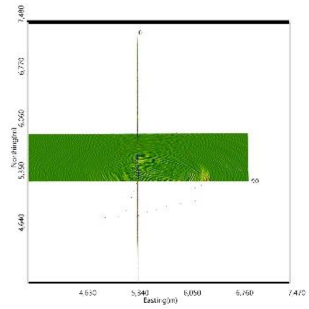


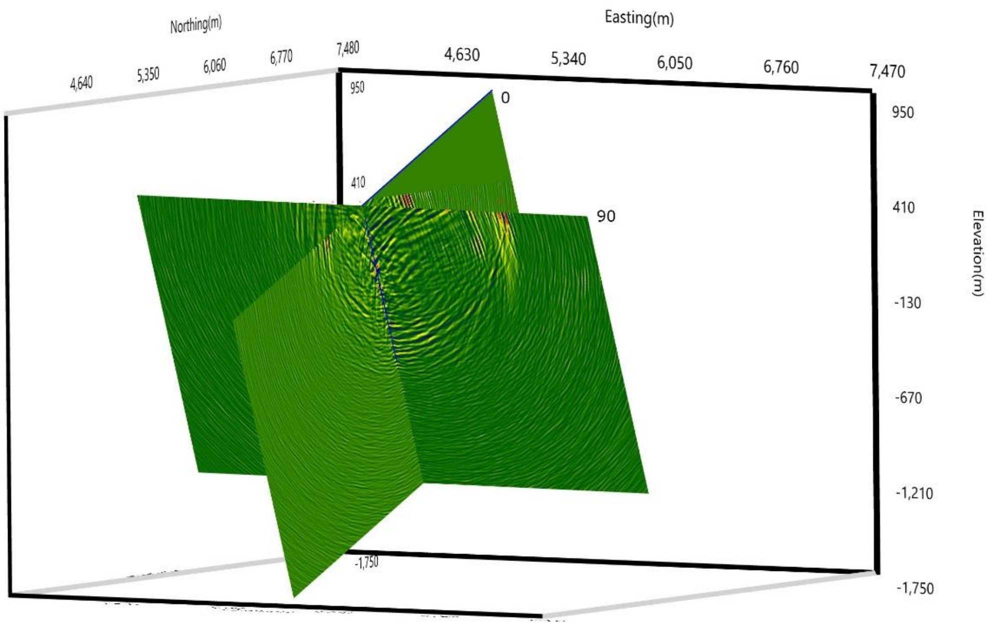
Axial component

Figure 30. IG_BH06 VSP, Shot V94

APPENDIX D

3D Image Point Migrations from Borehole IG_BH06





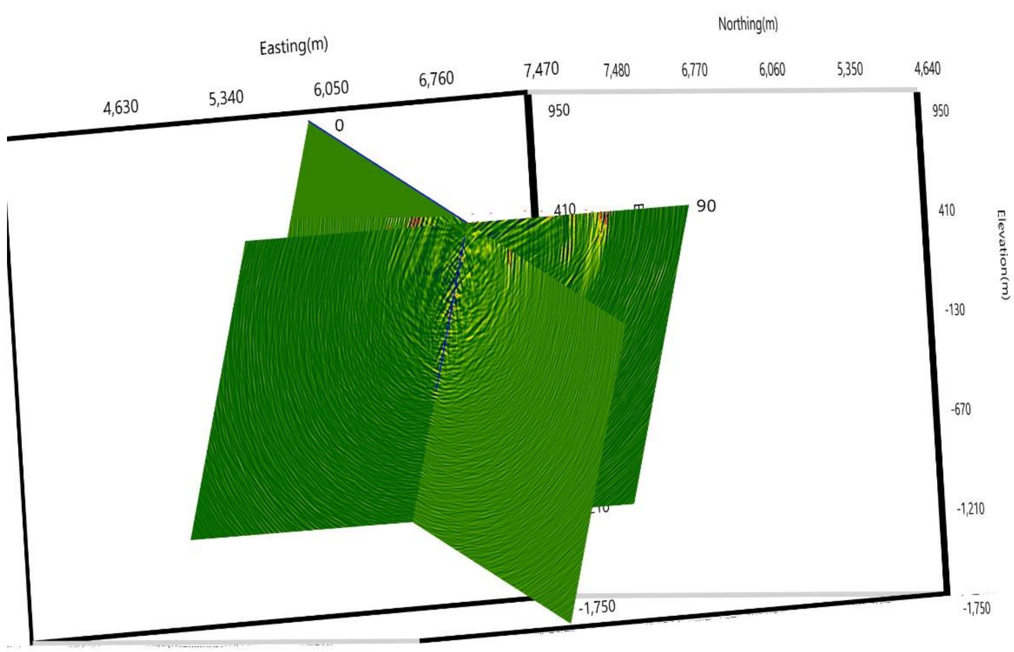


Figure 1. 3D Image Point migrated profiles, N-S (0º - 180º) and E-W (90º - 270º) cross sections around borehole IG_BH06. Azimuth 0º is at North.

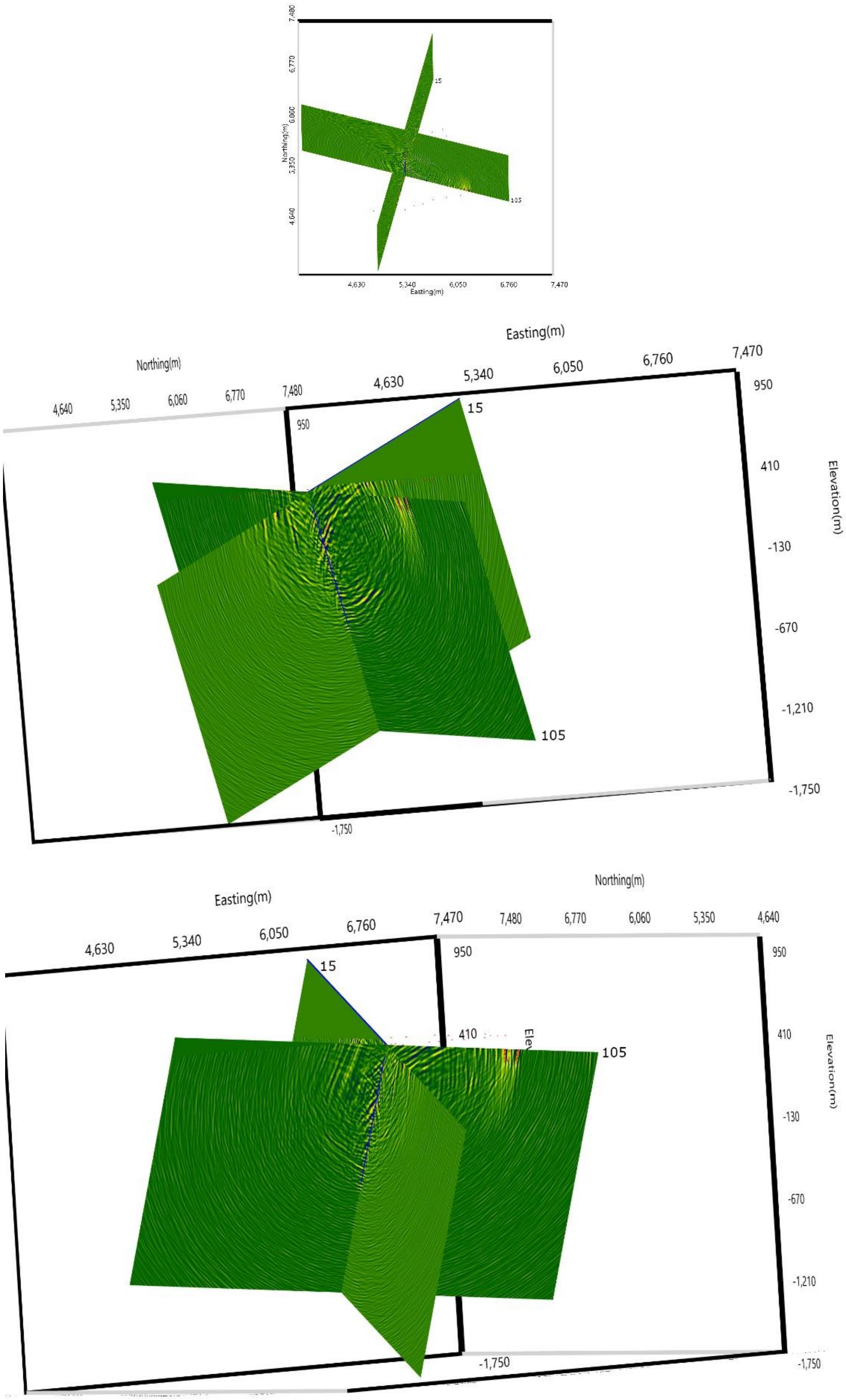


Figure 2. 3D Image Point migrated profiles, 15º - 195º and 105º - 285º cross sections around borehole IG_BH06. Azimuth 0º is at North.

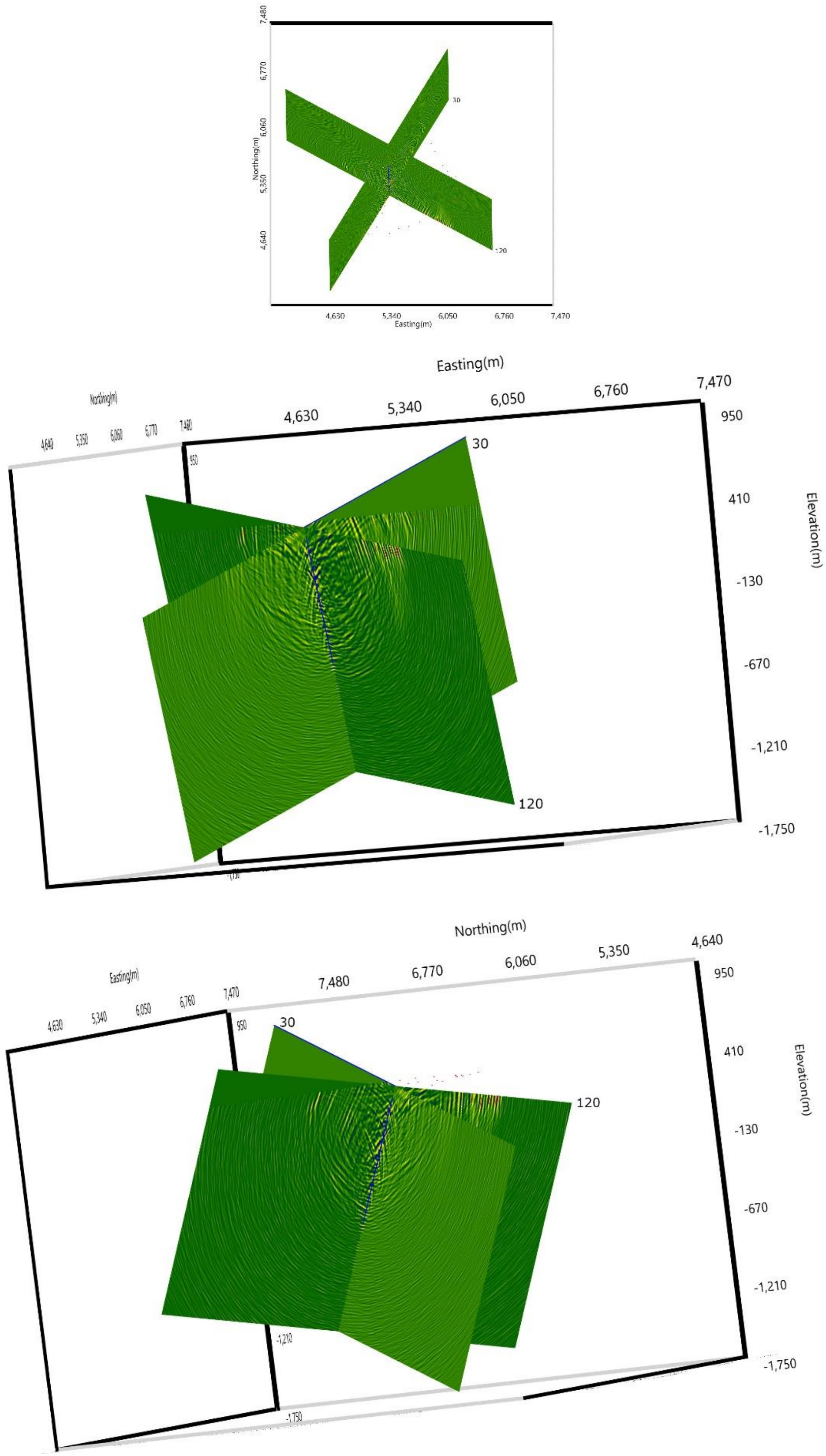


Figure 3. 3D Image Point migrated profiles, 30º - 210º and 120º - 300º cross sections around borehole IG_BH06. Azimuth 0º is at North.

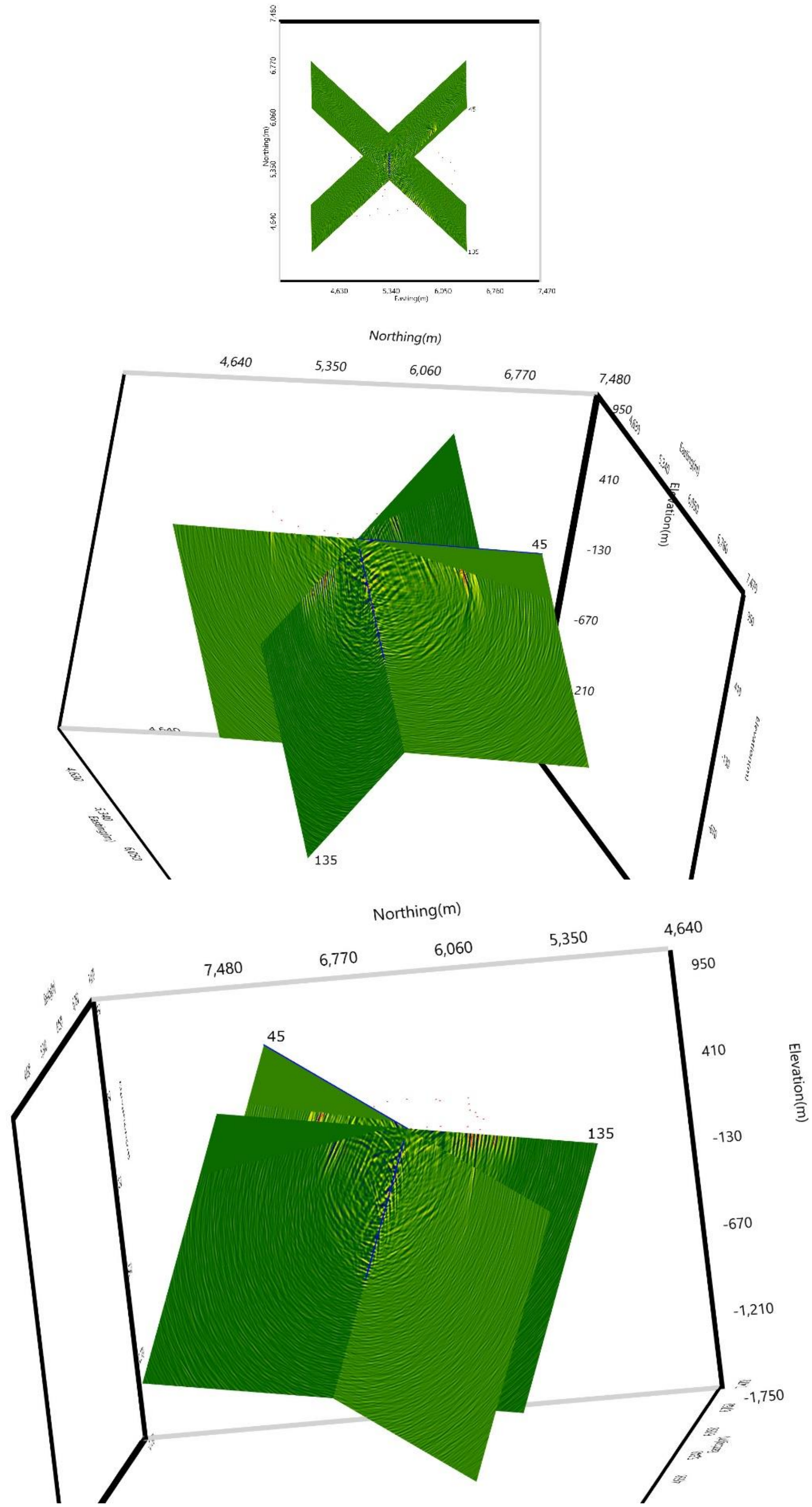


Figure 4. 3D Image Point migrated profiles, 45º - 225º and 135º - 315º cross sections around borehole IG_BH06. Azimuth 0º is at North.

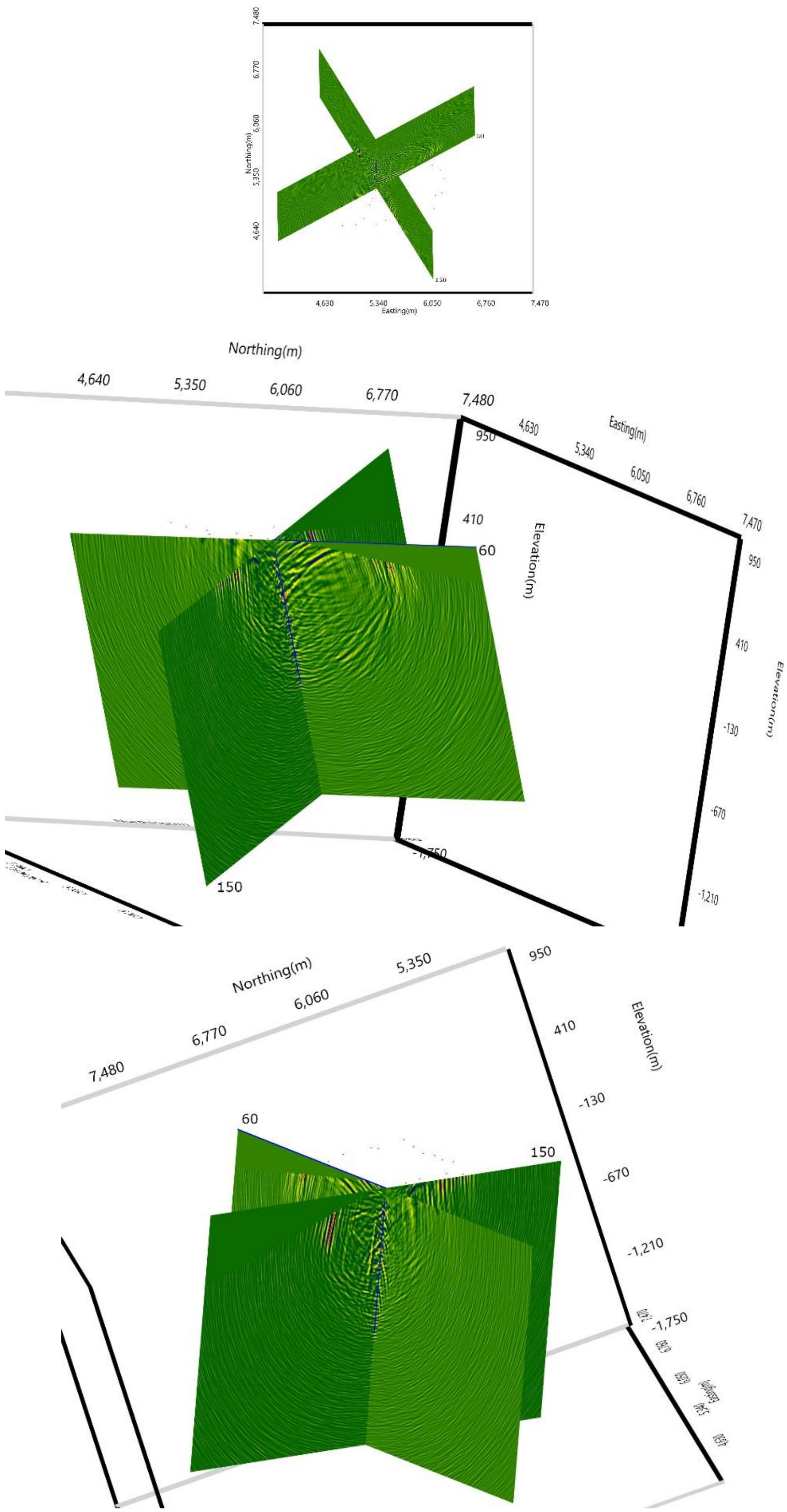


Figure 5. 3D Image Point migrated profiles, 60º - 240º and 150º - 330º cross sections around borehole IG_BH06. Azimuth 0º is at North.

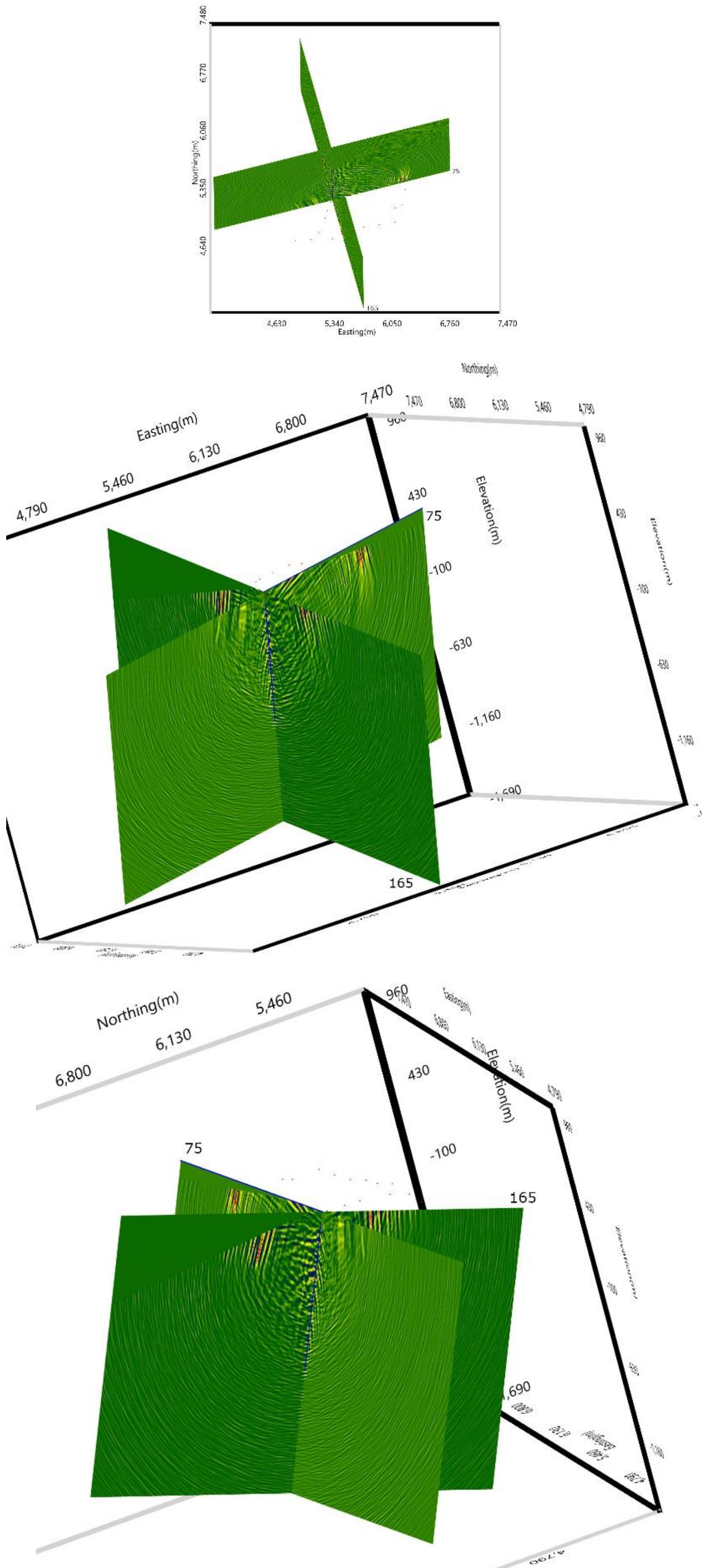


Figure 6. 3D Image Point migrated profiles, 75º - 255º and 165º - 345º cross sections around borehole IG_BH06. Azimuth 0º is at North.

APPENDIX E

Image Space Transform

The reflecting interfaces in the rock mass are generally from lithological contacts but can also be from faults, fracture zones and dissolution features. Those reflections from faults and fracture zones usually display relatively weak seismic characters and extensive processing is needed to obtain information on the position of the reflectors from the seismic profiles.

It is necessary to improve the signal-to-noise ratio, so that the later events (e.g. reflections) become visible. As the reflection coefficients are expected to be low, the reflectors cannot usually be identified by amplitude contrast. Phase consistency is a more sensitive indicator.

The Image Point transform is a technique developed for both filtering and interpretation of VSP profiles. Like the τ-*p* method, it is based on the Radon-transform, but while in the τ-*p* transform the traces are stacked along straight paths across the section, in the Image Point transform the stacking is done along paths lining up with travel times corresponding to possible real reflectors. This gives to the Image Point transform two advantages: the signal coherence can be used as effectively as possible to enhance the weak reflections and the transformed section in Image Point Space can be directly used as an interpretation tool, to estimate the strength and position of the reflectors. The approach permits the determination of both the 3-D position and local orientation of the observed reflectors. The physical meaning of the procedure is that each reflection event can be considered as being produced by an "image source" from which the signal propagates to each receiver on a direct path, much like the mirror effect in optics. The mirror on which the image source is formed is a reflecting rock feature, e.g. a fracture zone, as shown in *Figure A-1*.

The Image Point transform of a depth-time profile g(z,t) is obtained by stacking along paths, all possible values of ζ and ρ, i.e. to all possible orientations of the reflecting planes.

The direct transform is expressed as:

$$\Gamma(\zeta,\rho) = \int_{z_{\min}}^{z_{\max}} (t_r(\zeta,\rho;z))dz$$

The function $t_r(\zeta,\rho;z)$ gives the travel times corresponding to the planar reflector specified by ρ and ζ , to the detector at the depth z:

$$t_r = \sqrt{\rho^2 + z^2 \text{-} 2z\zeta}/\mathrm{c}$$

where

$$\rho = \sqrt{\zeta^2 + \xi^2}$$

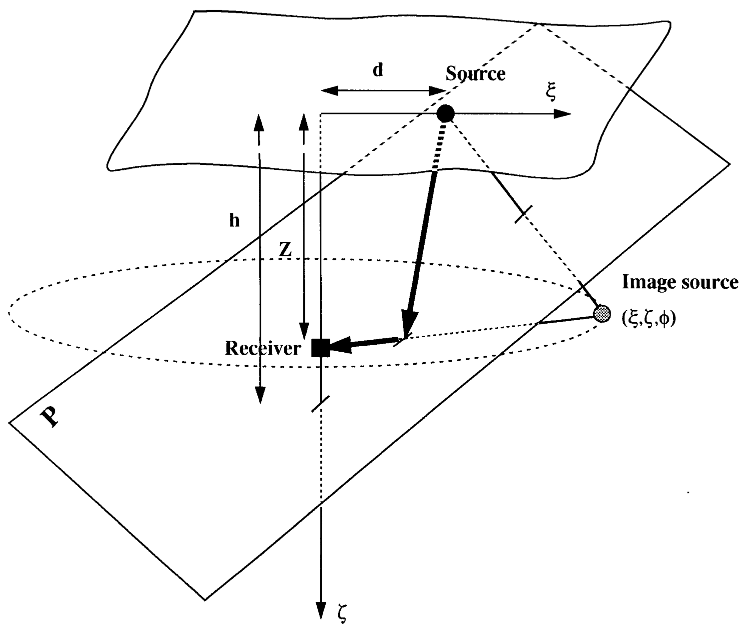


Figure A-1. **Schematic presentation of the Image Point Transform**.

The inverse transform has the following expression:

$$g(z',t') = \frac{d}{dt'} H \int_{\zeta_1}^{\zeta_2} \Gamma\big(\zeta, \rho = \rho_r(z',t';\zeta)\big) d\zeta$$

where

$$\rho_r = \sqrt{c^2 t^2 - z^2 + 2z\zeta}$$

The derivation and the Hilbert transform H restore the original signal shape.

In the Image Point transform, coherent reflection events collapse to points. Therefore, the signal coherence can be used as effectively as possible to enhance the weak reflections.

Within a certain range for the propagation velocity c, only real reflectors produce coherent patterns along their integration paths. Therefore, the inverse transform from the Image Point space to the depth-time space always leads to a filtered version of the reflection profile.

With the Image Point method, two of the three parameters defining the 3-D position of a reflector can be determined. The reflectors with image points located on a circle perpendicular to the borehole generate equal travel times to all detectors. In order to determine uniquely the 3D position and orientation of a reflector, means should be found to estimate the dip direction. An effective method is to use polarisation analysis.

The reflected signals do not stack constructively along the image point integration path if the reflector is not a plane. This problem is solved by dividing the time-depth section into several overlapping panels, each containing a subset of the traces. For each panel, the Image Point transform is computed independently.

APPENDIX F

Interpretation of Seismic Reflectors from IG_BH06 VSP Data

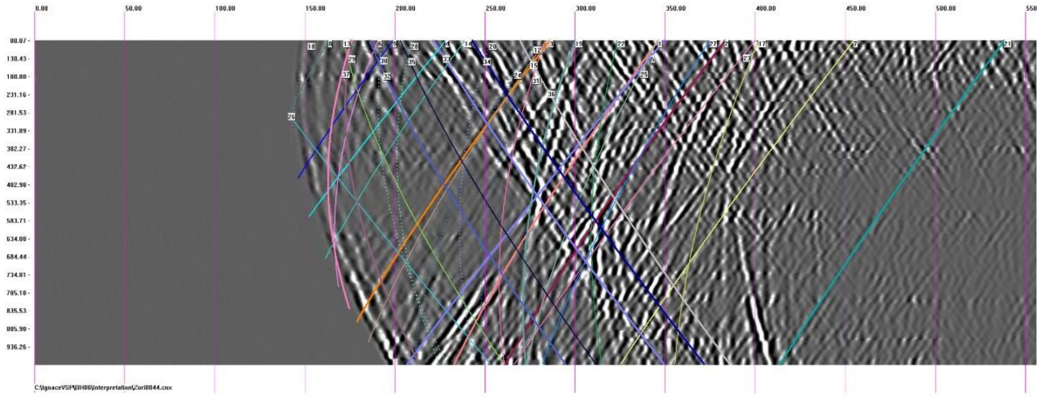


Figure 1. Axial component profile from V44.

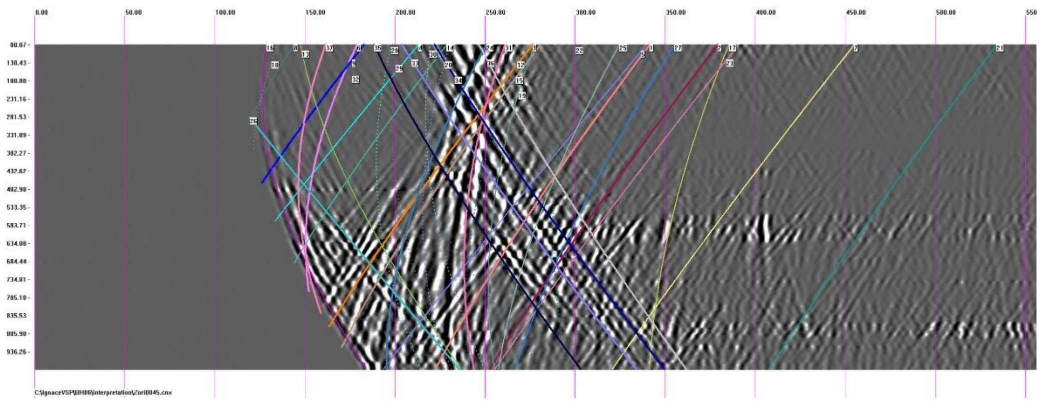


Figure 2. Axial component profile from V45.

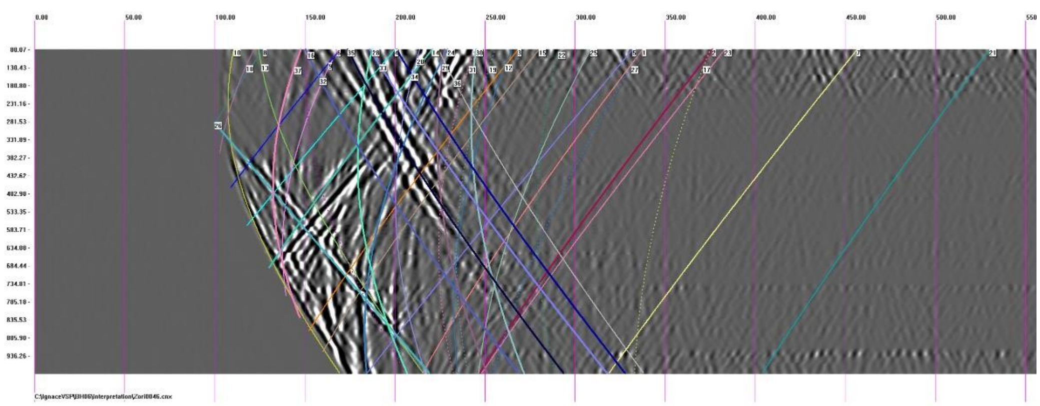


Figure 3. Axial component profile from V46.

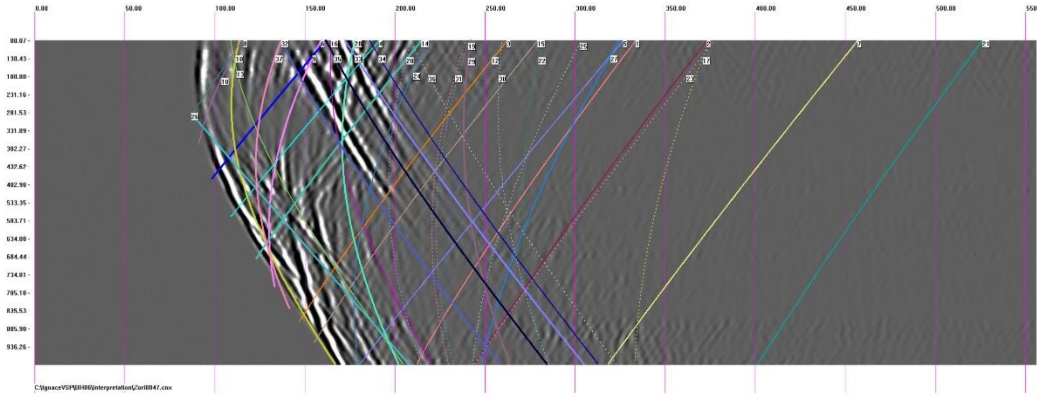


Figure 4. Axial component profile from V47.

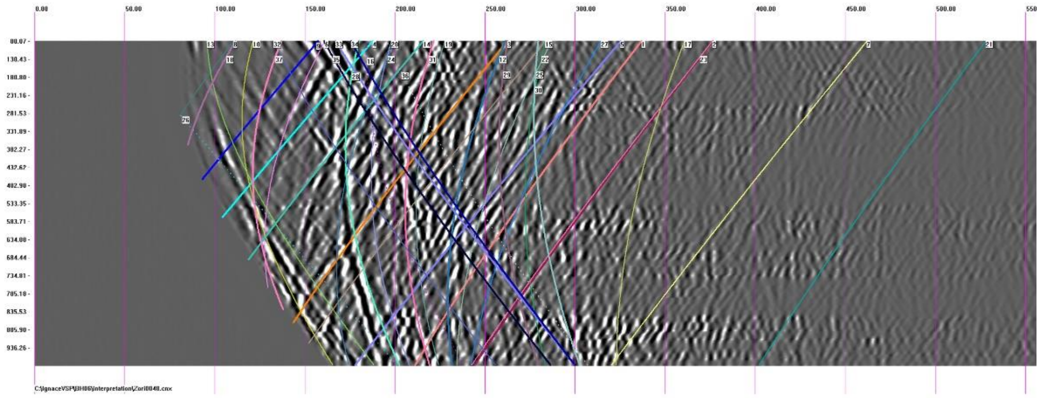


Figure 5. Axial component profile from V48.

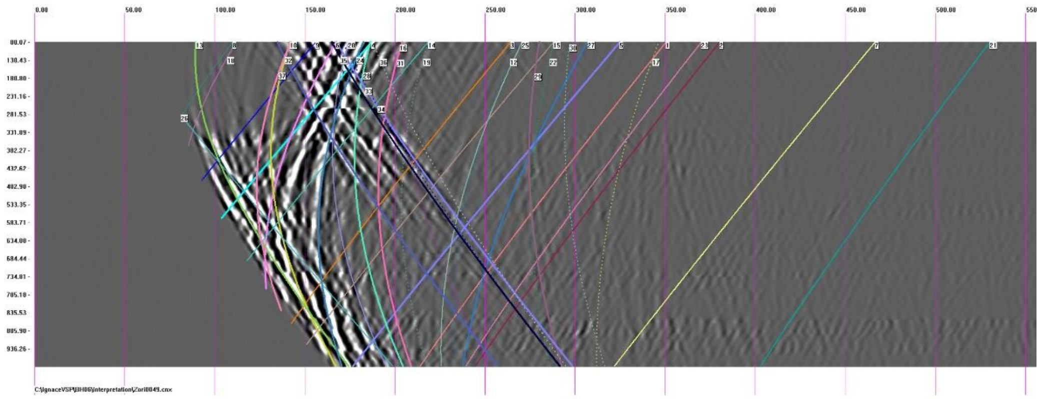


Figure 6. Axial component profile from V49.

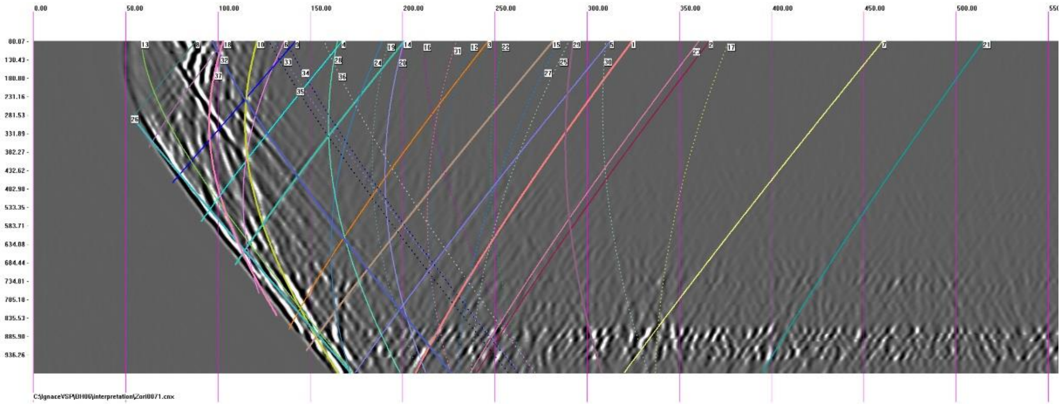


Figure 7. Axial component profile from V71.

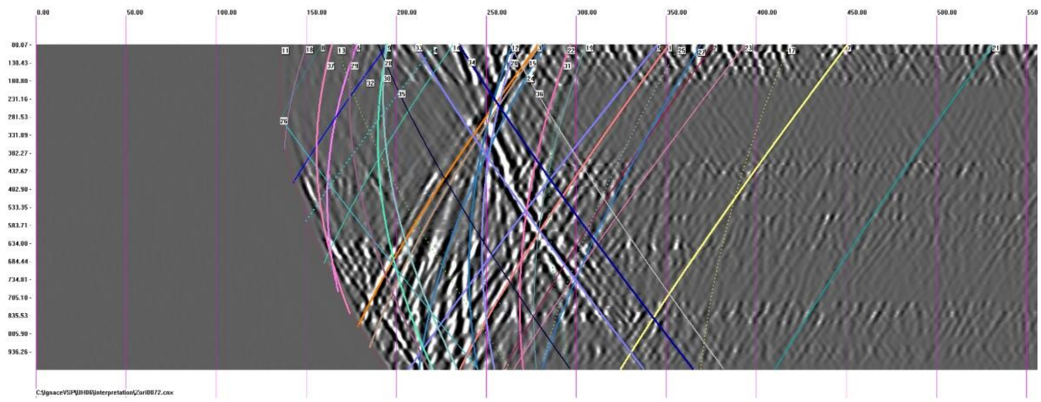


Figure 8. Axial component profile from V72.

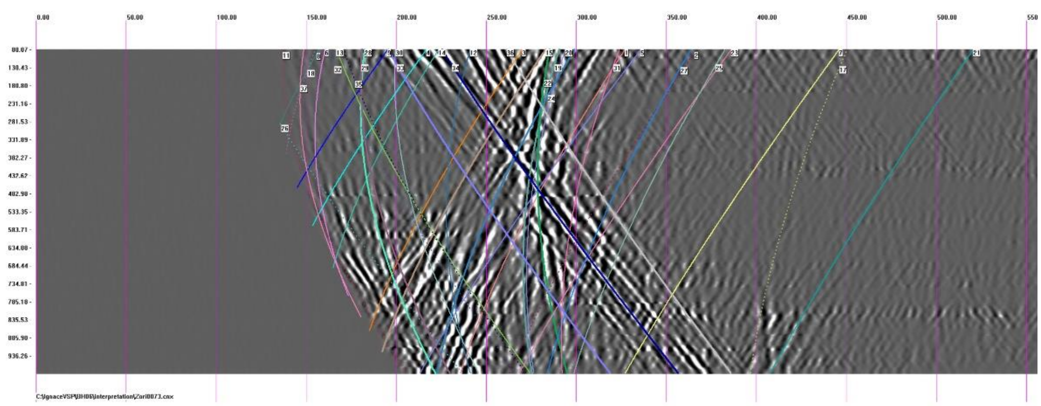


Figure 9. Axial component profile from V73.

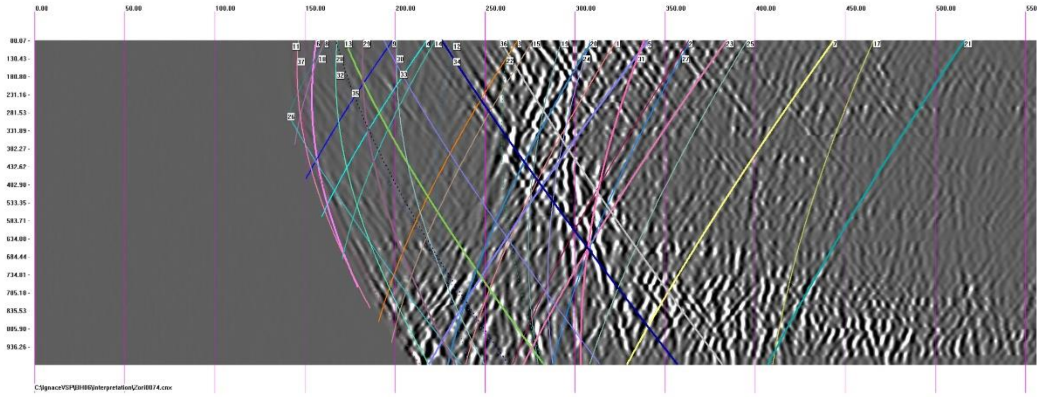


Figure 10. Axial component profile from V74.

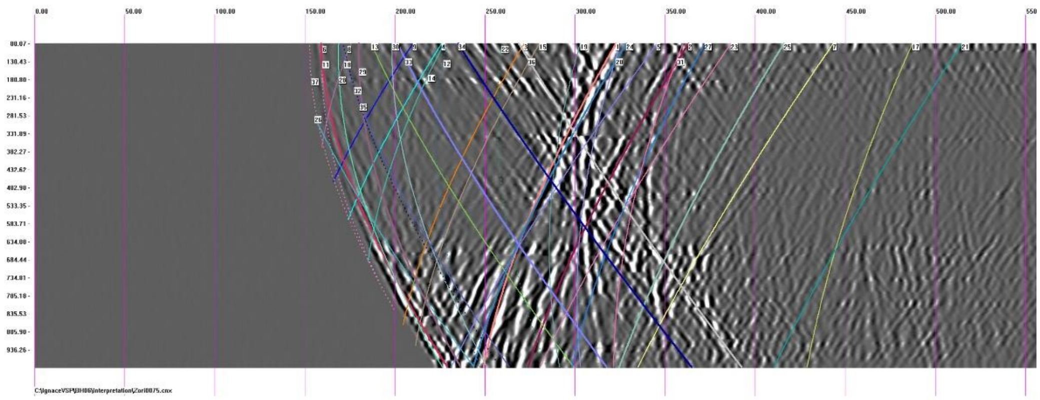


Figure 11. Axial component profile from V75.

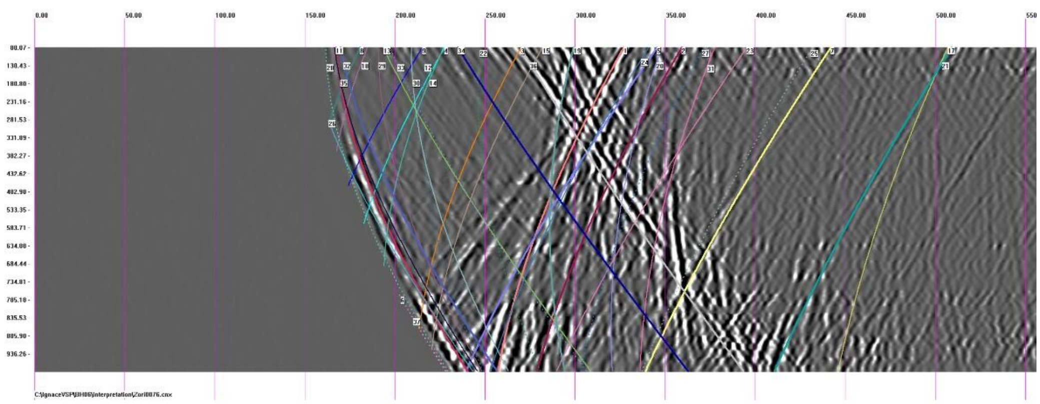


Figure 12. Axial component profile from V76.

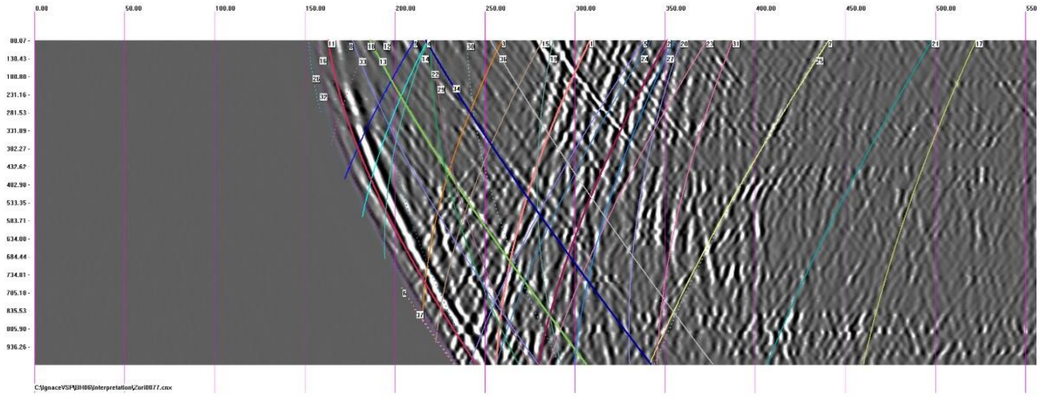


Figure 13. Axial component profile from V77.

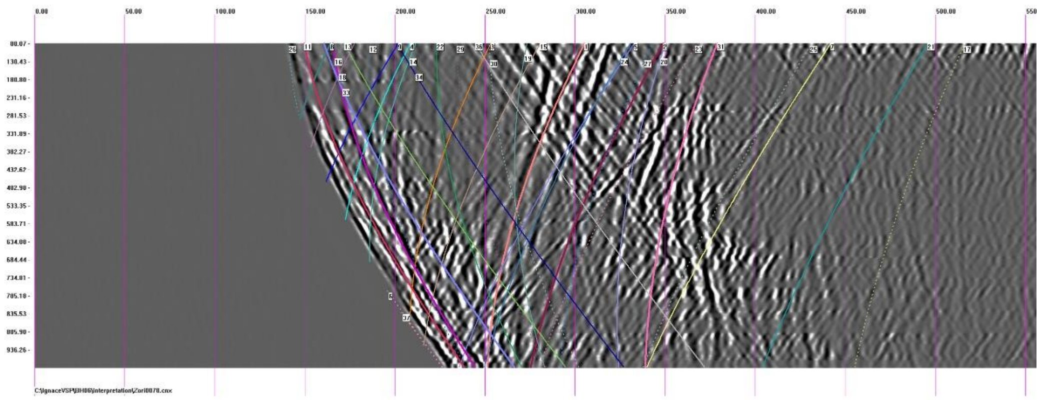


Figure 14. Axial component profile from V78.

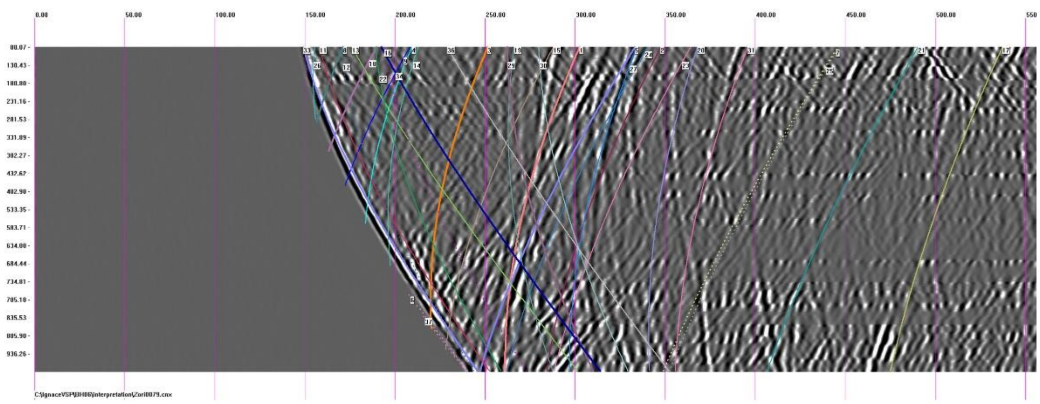


Figure 15. Axial component profile from V79.

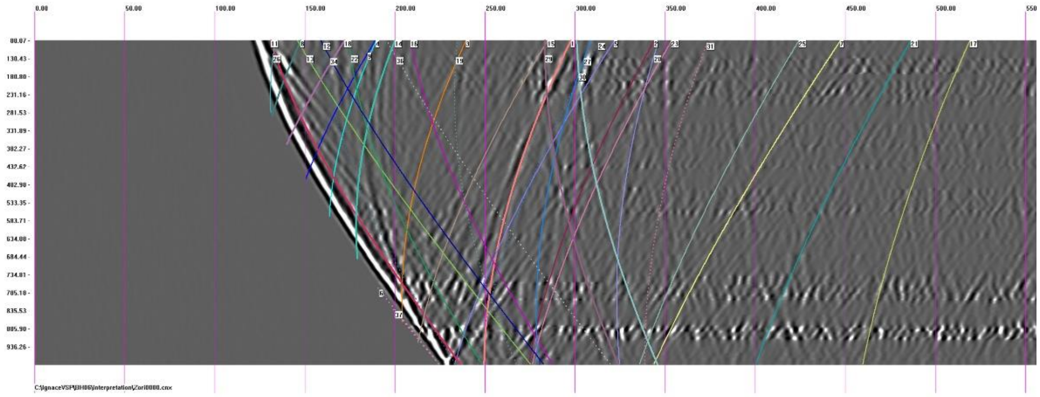


Figure 16. Axial component profile from V80.

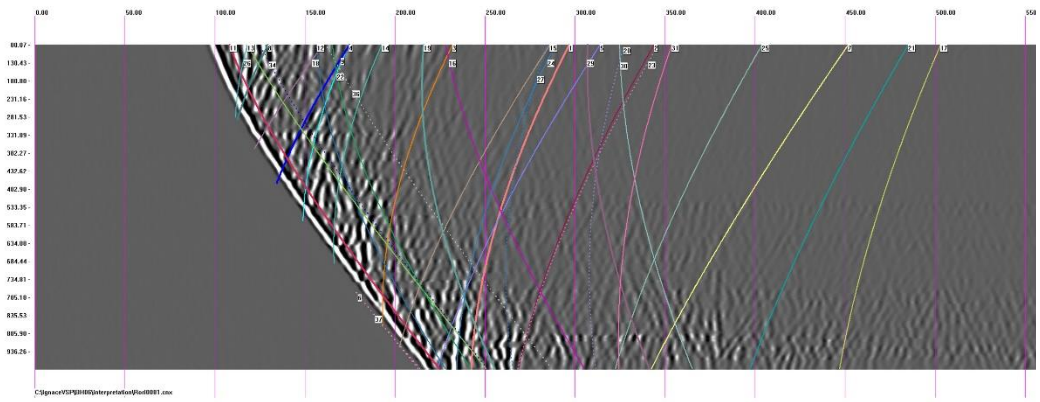


Figure 17. Axial component profile from V81.

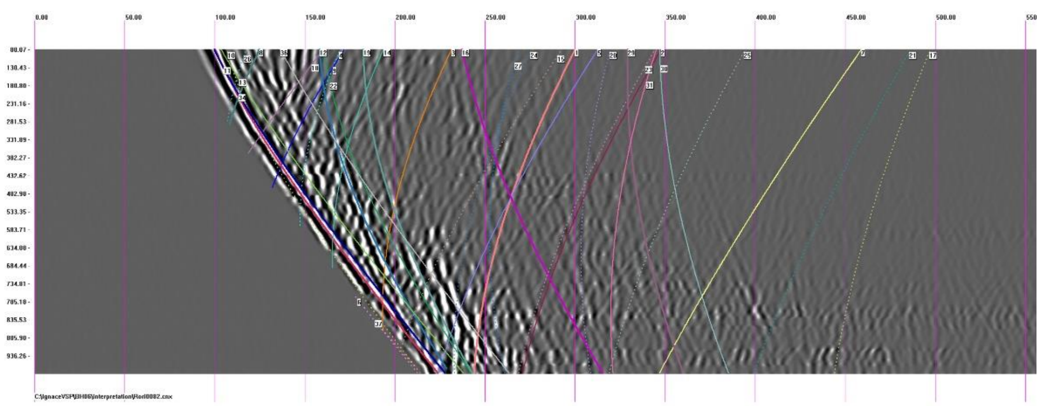


Figure 18. Axial component profile from V82.

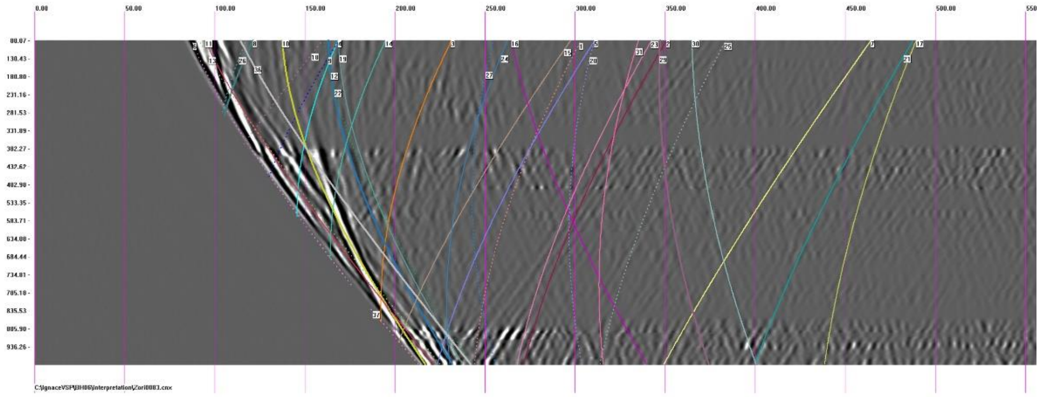


Figure 19. Axial component profile from V83.

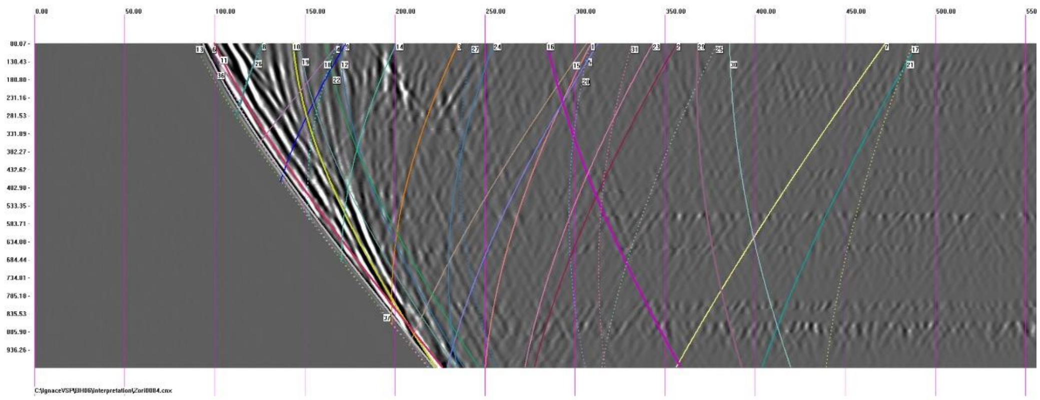


Figure 20. Axial component profile from V84.

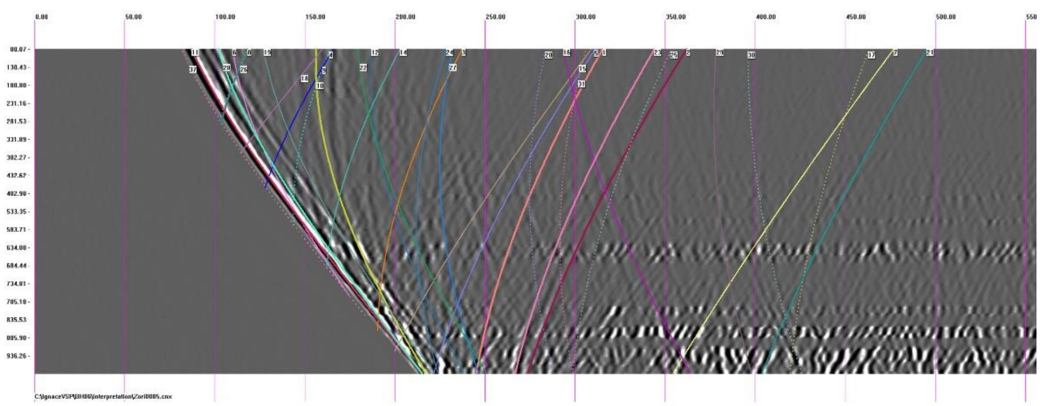


Figure 21. Axial component profile from V85.

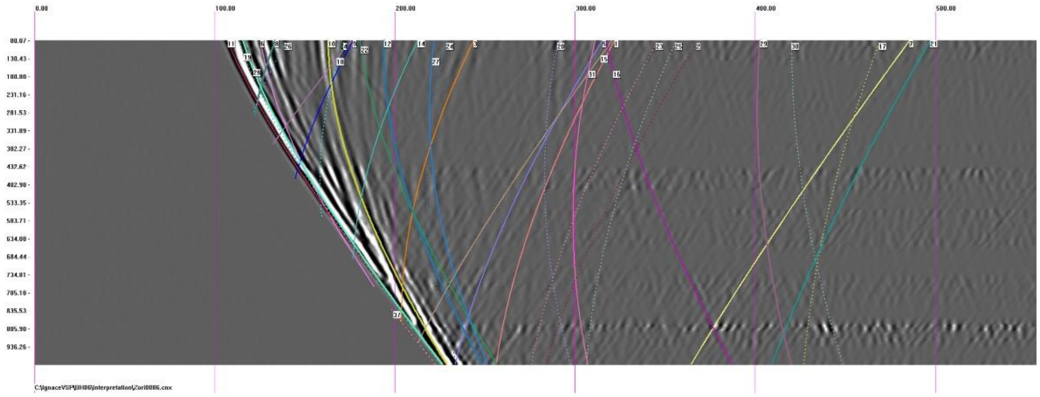


Figure 22. Axial component profile from V86.

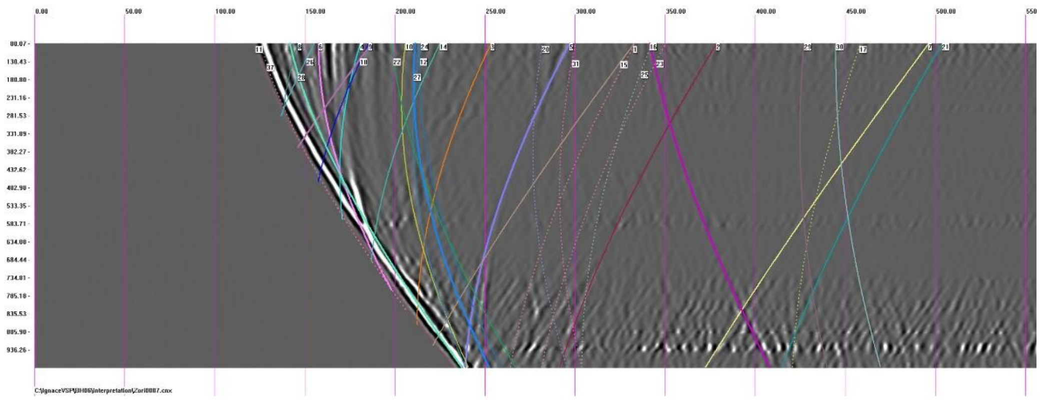


Figure 23. Axial component profile from V87.

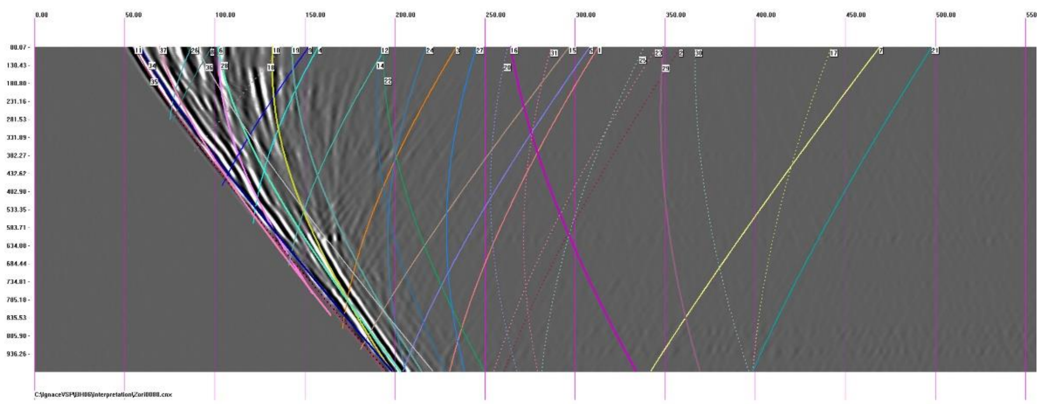


Figure 24. Axial component profile from V88.

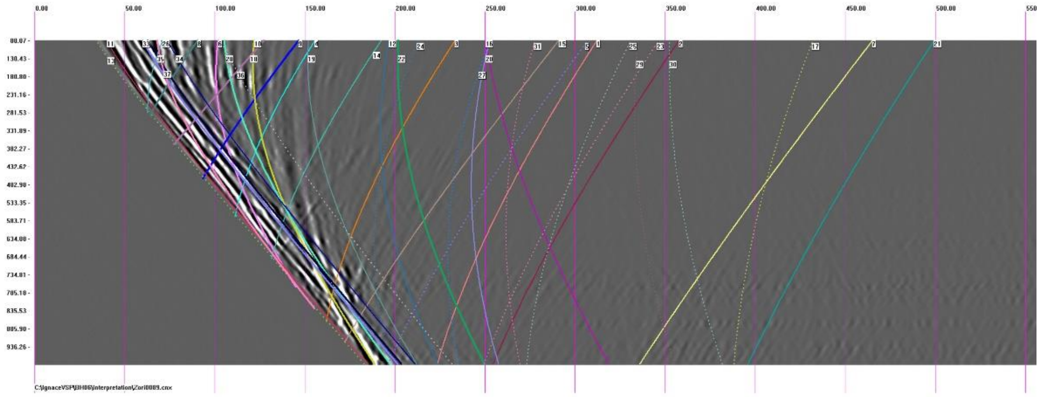


Figure 25. Axial component profile from V89.

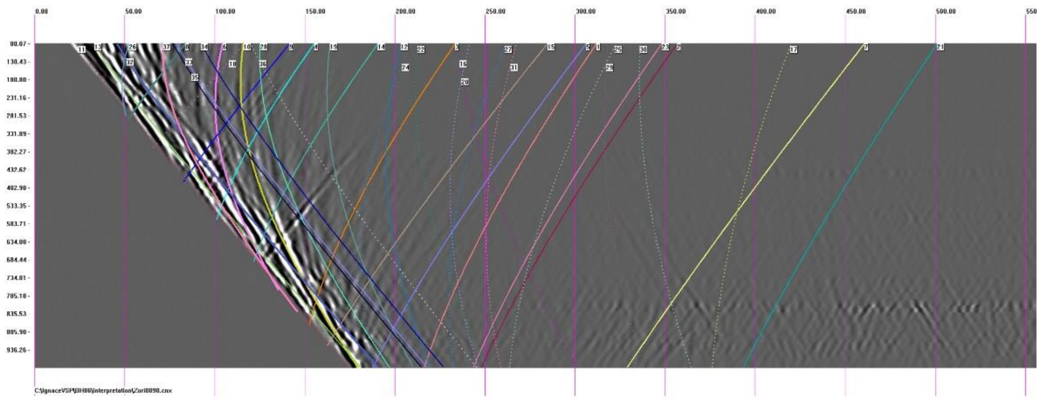


Figure 26. Axial component profile from V90.

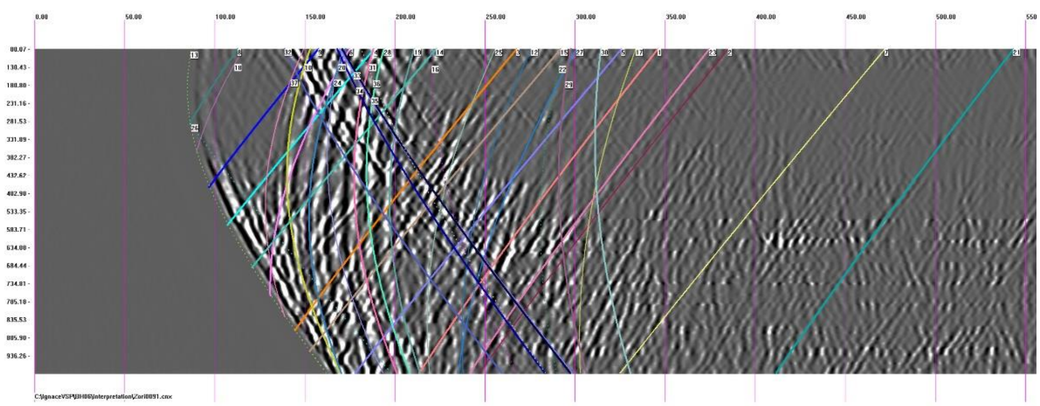


Figure 27. Axial component profile from V91.

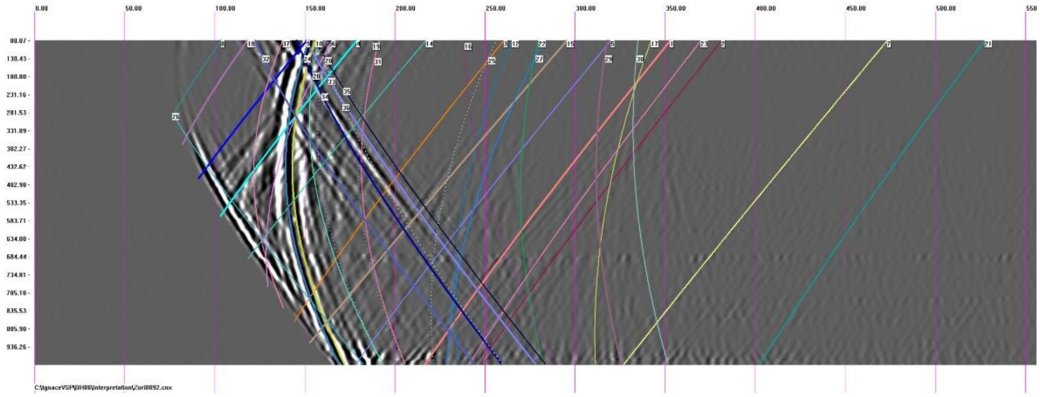


Figure 28. Axial component profile from V92.

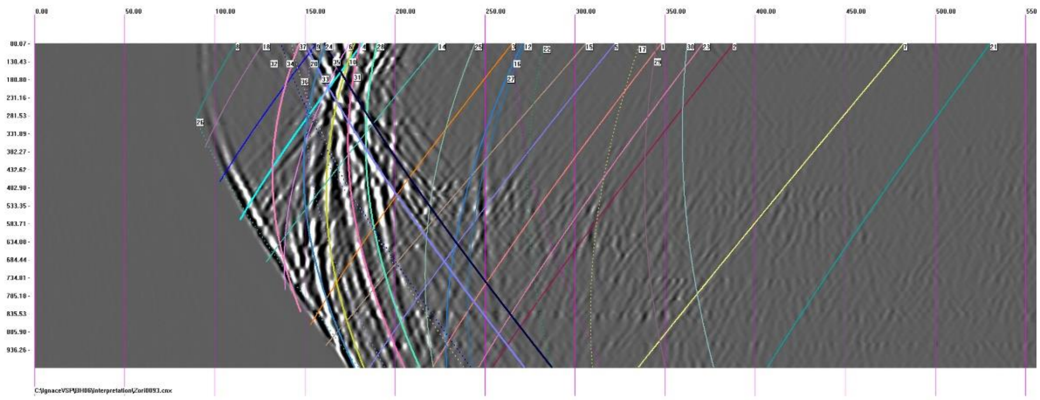


Figure 29. Axial component profile from V93.

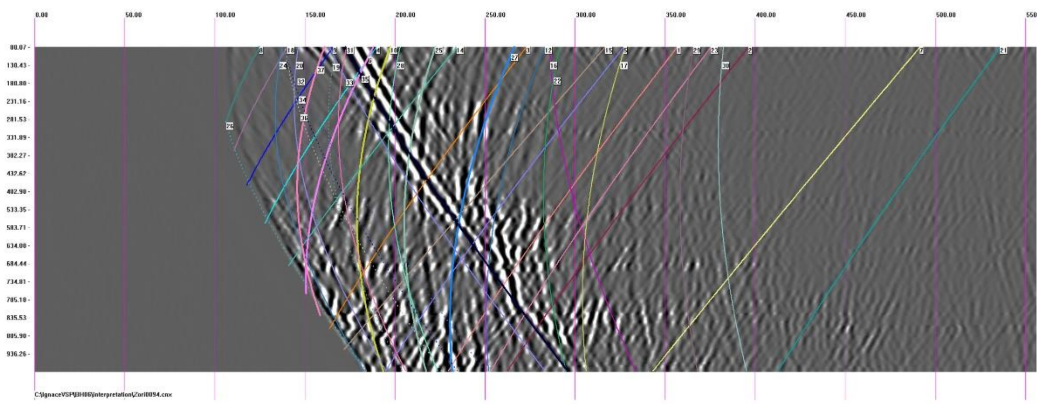


Figure 30. Axial component profile from V94.

APPENDIX G

Interpreted Steeply Dipping Seismic Reflectors Possibly Associated with Lineaments Mapped from Surface

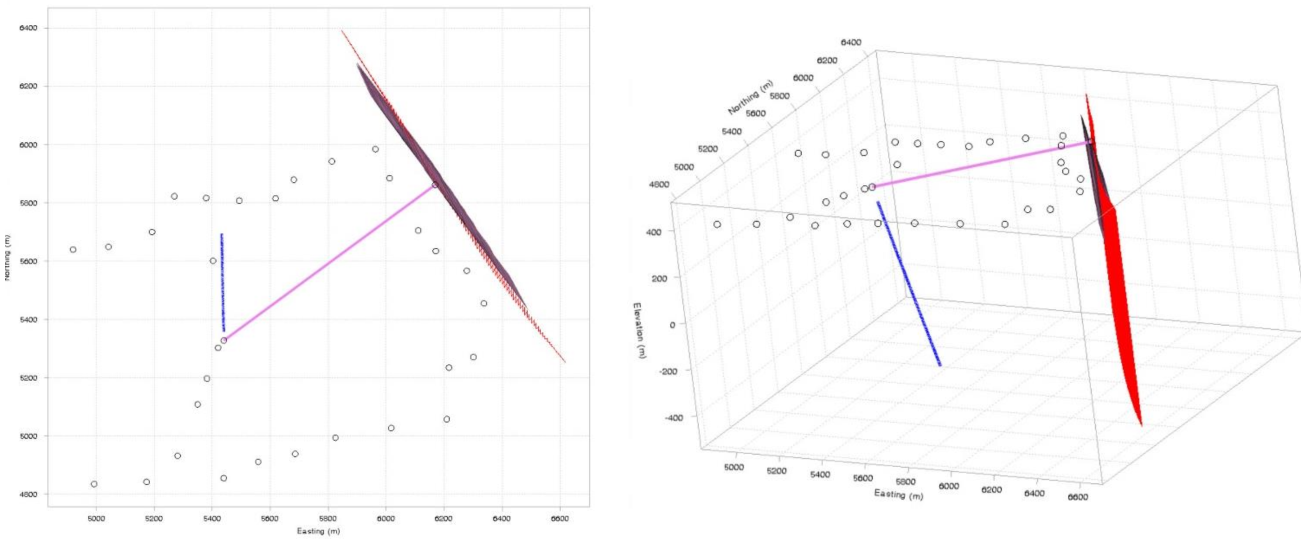


Figure 1. Reflector elements for Refl. No. 29, together with lineament IFZ030 mapped from surface.

Left: view from above, Right: 3D view.

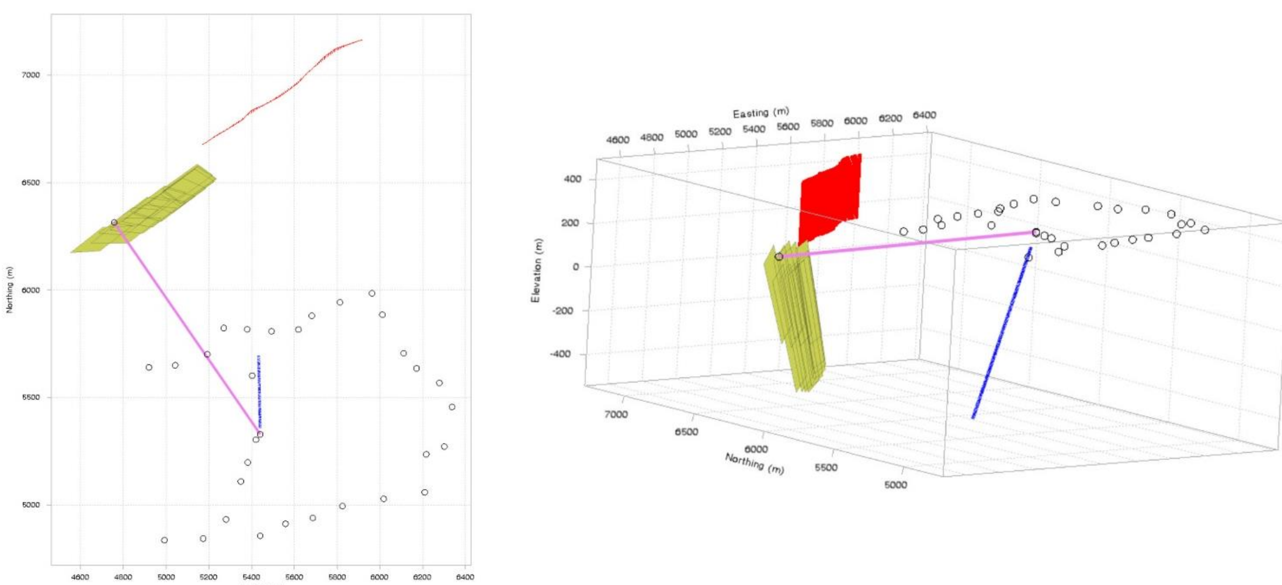


Figure 2. Reflector elements for Refl. No. 17, together with lineament IFZ039 mapped from surface.

Left: view from above, Right: 3D view.

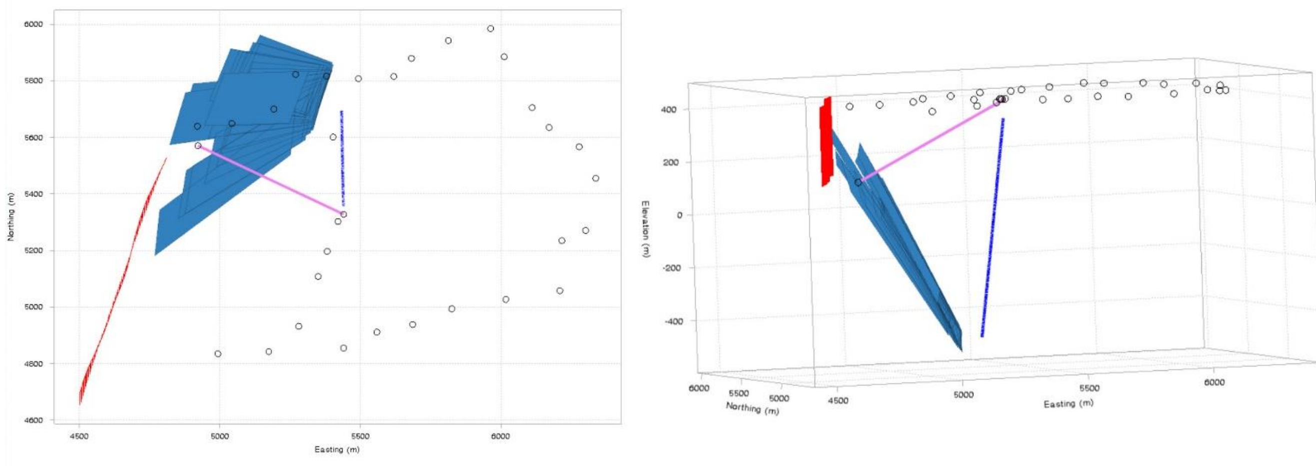


Figure 3. Reflector elements for Refl. No. 24, together with lineament IFZ010 mapped from surface.

Left: view from above, Right: 3D view.

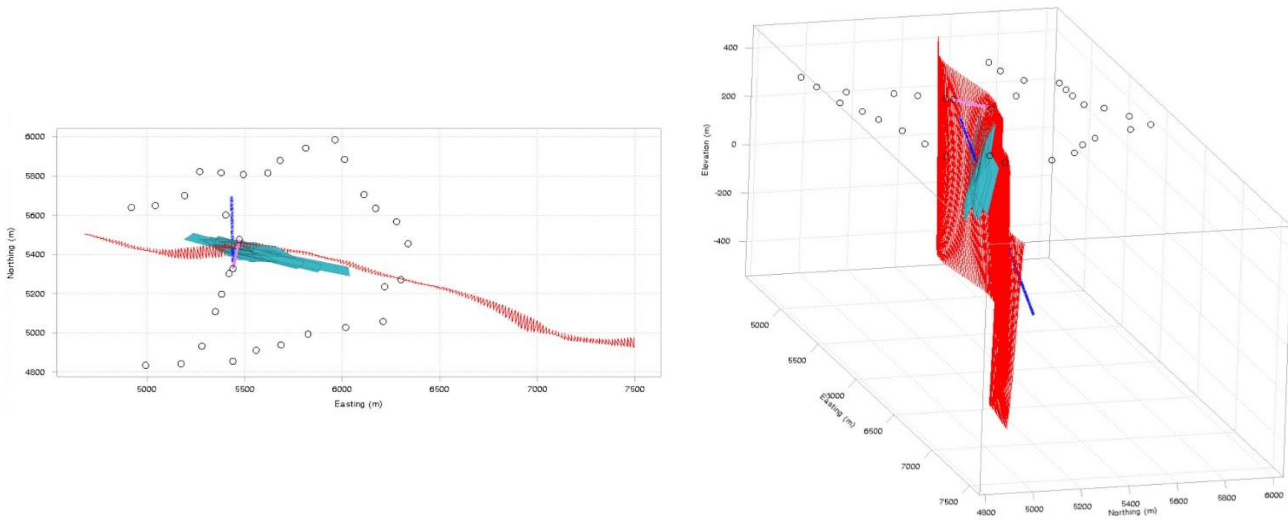


Figure 4. Reflector elements for Refl. No. 26, together with lineament IFZ005 mapped from surface.

Left: view from above, Right: 3D view.

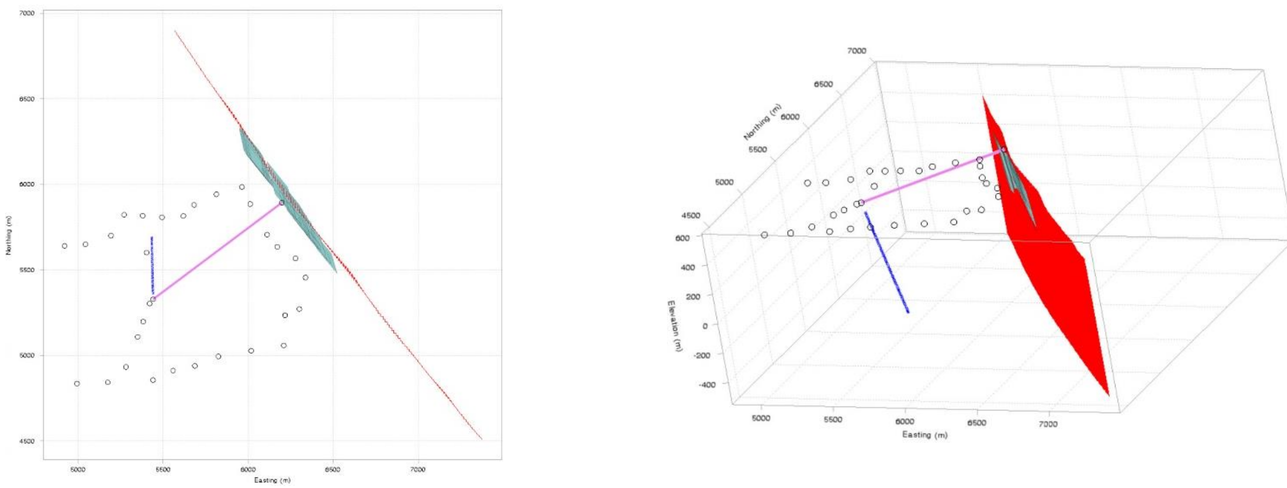


Figure 5. Reflector elements for Refl. No. 30, together with lineament IFZ012 mapped from surface.

Left: view from above, Right: 3D view.

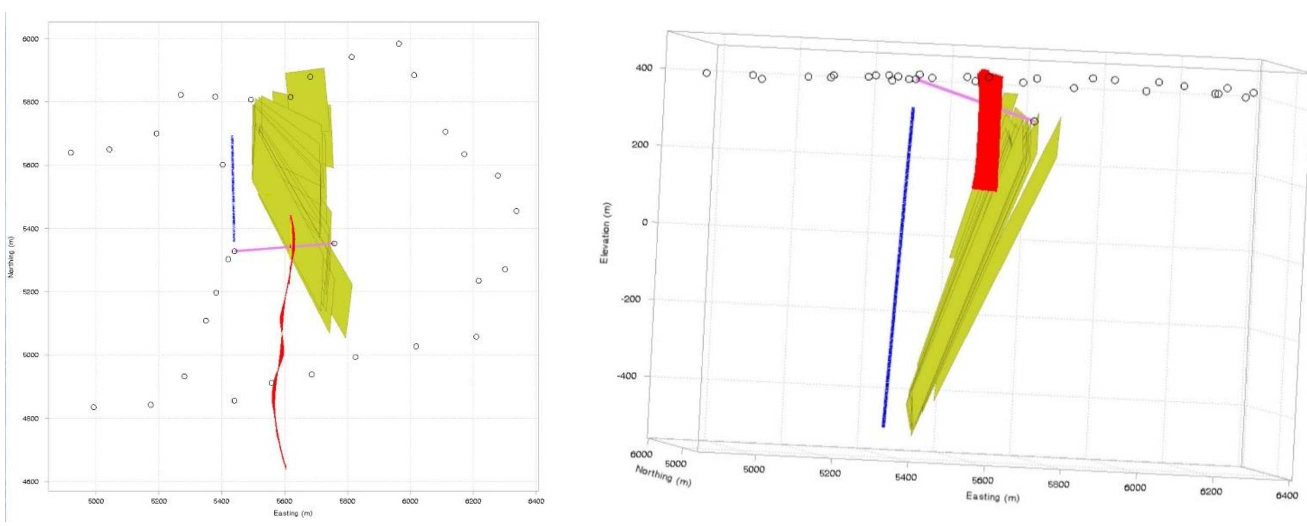


Figure 6. Reflector elements for Refl. No. 10, together with lineament IFZ043 mapped from surface.

Left: view from above, Right: 3D view.

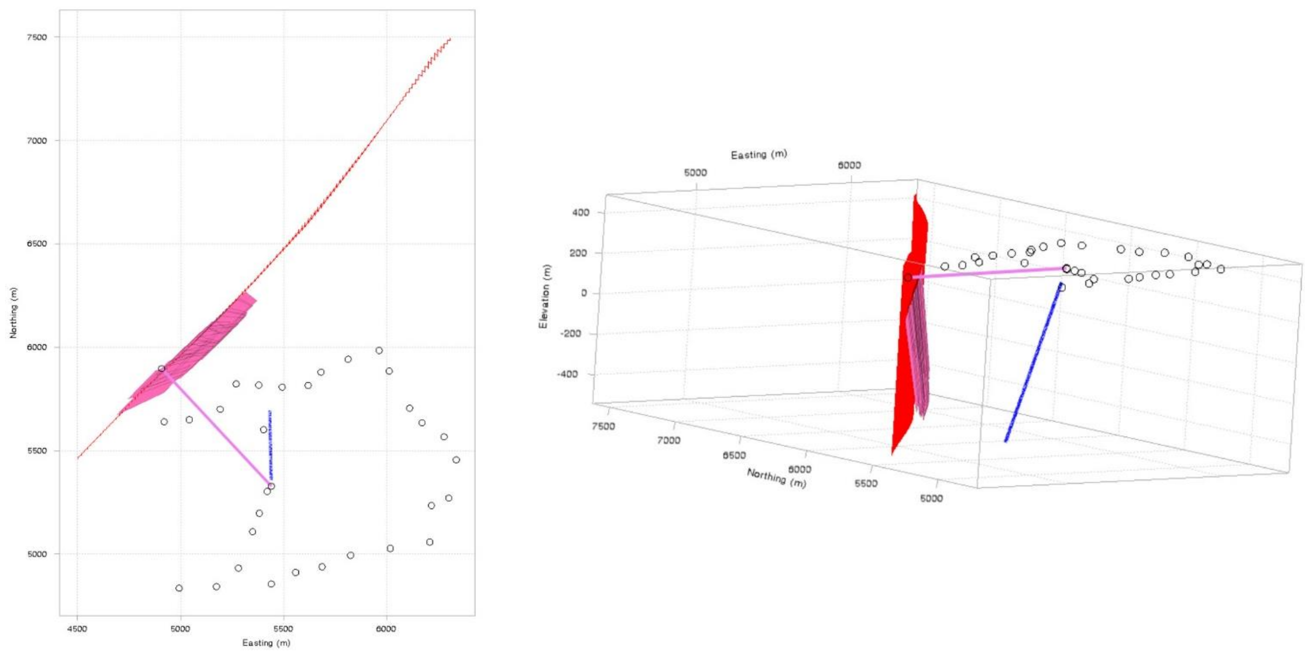


Figure 7. Reflector elements for Refl. No. 31, together with lineament IFZ004 mapped from surface. Left: view from above, Right: 3D view.

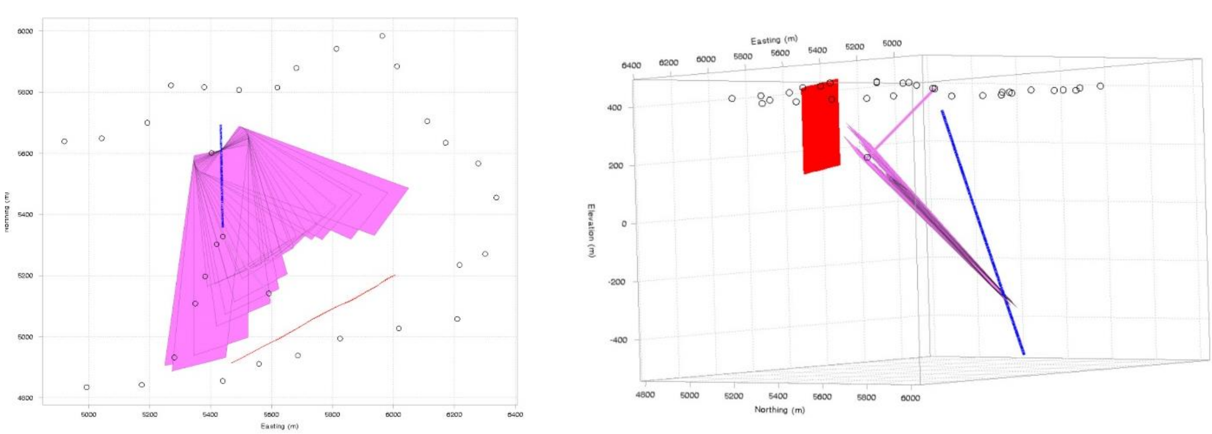


Figure 8. Reflector elements for Refl. No. 06, together with lineament IFZ038 mapped from surface. Left: view from above, Right: 3D view.