# PHASE 2 INITIAL BOREHOLE DRILLING AND TESTING, IGNACE AREA

## *WP05 Data Report – Geophysical Well Logging and Interpretation for Upper 100 m of IG_BH04*

**APM-REP-01332-0289** **September 2021**

**Wood Plc.**

NUCLEAR WASTE MANAGEMENT ORGANIZATION
SOCIÉTÉ DE GESTION DES DÉCHETS NUCLÉAIRES

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# Phase 2 Initial Borehole Drilling and Testing, Ignace Area

# WP05 Data Report – Geophysical Well Logging and Interpretation for Upper 100 m of IG_BH04. APM-REP-01332-0289

Project Number: SCB1912026
Document Number: SCB1912026-REP-016 R1
NWMO Document Number: APM-REP-01332-0289

Prepared for:

**Nuclear Waste Management Organization**

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September 2021

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|---|---|---|
| Prepared by: | Pamela Patraskovic<br>Project Manager, DGI | Date:<br>29 September 2021 |
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| Reviewed by: | Martin Rawlings<br>Data Validation Officer | Date:<br>29 September 2021 |
| Approved by: | Simon Gautrey<br>Project Manager | Date:<br>29 September 2021 |

## Document Revision History

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| R0 | 2020-04-14 | Issued for Review |
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## Third-party disclaimer

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# 1.0 Introduction

## 1.1 Project Overview

DGI Geoscience Inc. (DGI) was contracted by Wood to obtain downhole geophysical information for their client, Nuclear Waste Management Organization (NWMO), on borehole IG_BH04. The Initial Borehole Drilling and Testing project at Ignace, Ontario was part of Phase 2 Geoscientific Preliminary Field Investigations of the NWMO's Adaptive Phased Management (APM) Site Selection Phase. Work by DGI was completed in accordance with the Work Package (WP) 05 Test Plan for IG_BH04, submitted by Wood and approved by NWMO (SCB1912026-PLN-013 I04). The geophysical logging is intended to provide high-quality, high-resolution profiles of a number of rock properties. These will ultimately be used to help assess the local thickness of potentially suitable rock units, the geophysical properties of the rock units at depth, and the presence and types of structural features at depth.

As detailed in the workplan (SCB1912026-PLN-013 I04), in the event of significant groundwater flow in the upper 100 metres, DGI would be mobilized in advance of the completion of the borehole to acquire a subset of parameters on the first 100 metres of data. This situation was encountered during drilling in November 2019 and DGI was mobilized to Site.

The scope of work for the survey of the first 100 metres included: acoustic televiewer, optical televiewer, and natural gamma. Downhole probes utilized were quick link (QL) probes, allowing for natural gamma to be acquired simultaneously with the main parameter for improved depth accuracy.

# 2.0 Survey Details

## 2.1 Location

IG_BH04 is located near Ignace, Ontario, approximately 250 km northwest of Thunder Bay, ON. Figure 1 illustrates Site location and borehole location.

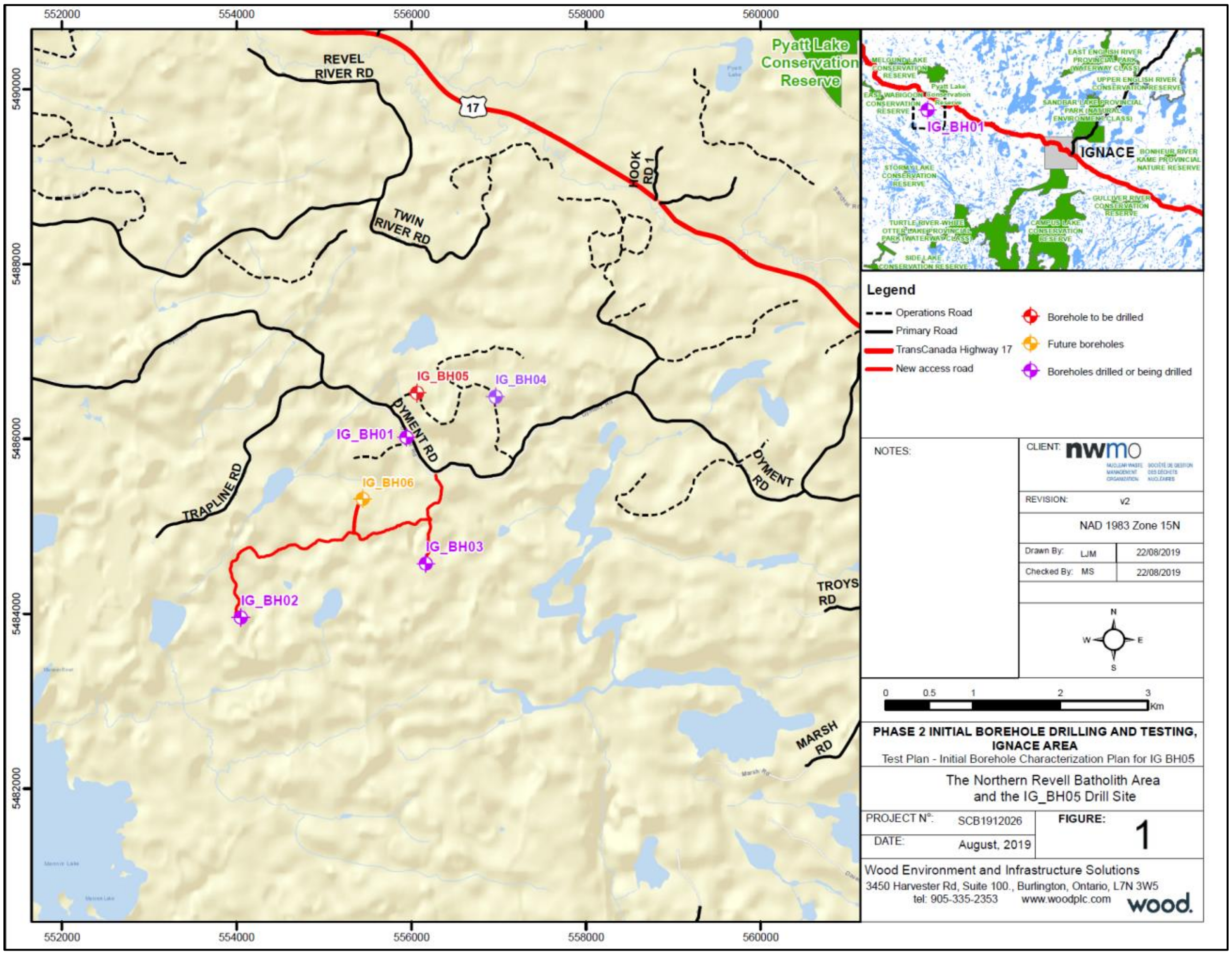


**Figure 1: Ignace Borehole Site Locations**

## 2.2 Personnel

Wood WP05 Lead: Simon Gautrey (replaced by Kevin Beattie March 2020)

**DGI Project Manager**

Alejandro Rojas (replaced by Pamela Patraskovic June 2020)

**DGI Field Personnel**

Jared Smith (Field Team Leader)
Alexi Parinov (Field Technician)

**DGI Data Analysts**

Roxanne Leblanc (Senior Data Analyst)
Steve Reese (Data Analyst)

## 2.3 Logistics and Operations

DGI completed equipment preparation and bench testing prior to mobilizing the crew and equipment to the project Site. Probes and associated running gear were determined to be in good working condition and passed both DGI's established quality control criteria and the additional quality control criteria outlined in the Test Plan (SCB1912026-PLN-013 I04). The equipment preparation and testing phase was overseen by DGI's Technical Assets Manager, Andrew Torgerson, and DGI's Senior Data Analyst, Roxanne Leblanc.

Equipment and personnel commenced mobilization from Barrie, ON on 25 November 2019. DGI arrived in Ignace on 27 November. Upon meeting with the onsite Wood representative, it was determined that the drilling was still in progress and the borehole was not yet available for survey. DGI was on standby waiting for the conclusion of the drilling until 29 November. Data acquisition commenced on 30 November and took one shift to complete. During the execution of the surveys, DGI operators carried out the survey equipment set up as outlined in the Test Plan (SCB1912026-PLN-013 I04). DGI demobilized from Site on 1 December after confirmation was received from DGI's Senior Data Analyst that data acquired meet the required criteria for data quality.

DGI was on Site from 27 November to 1 December. The work was completed with zero lost time incidences and zero incidents requiring First Aid.

# 3.0 Acquisition Parameters

Acoustic televiewer, optical televiewer, and natural gamma probes were deployed by DGI on borehole IG_BH04. Acquisition parameters used by DGI were consistent with the requirements outlined in the Test Plan (SCB1912026-PLN-013 I04). Table 1 summarizes the probes used during data acquisition and sections 3.1 through 3.3 detail the theory of operation.

**Table 1: Geophysical Probes Deployed in IG_BH04**

| Probe | Manufacturer | Serial Number | Vertical Sample Rate | Horizontal Sample Rate | Logging Direction |
|---|---|---|---|---|---|
| Acoustic Televiewer | ALT | 182903 | 2 mm | 288 ppt | Up |
| Optical Televiewer | ALT | 170709 | 2 mm | 900 ppt | Up |
| Natural Gamma | MSI | 6568 | 5 cm | n/a | Up |

## 3.1 Acoustic Televiewer

The Advanced Logic Technology (ALT) QL40 ABI-2G acoustic televiewer probe, also known as the acoustic borehole imager (ABI), sends out a series of high frequency sonic pulses that are reflected off a rotating mirror. It then receives the echo of those pulses from the borehole wall. By analyzing the amplitude of the echo relative to the original pulse, as well as the time delay between the original pulse and the echo, the ABI generates a series of thin slices of data which it stacks and translates into a pair of continuous images, the Amplitude log and the Travel Time log. Because of varying acoustic impedance between the borehole fluid and the wall rock, the wall rocks and minerals absorb or reflect different amounts of the original sonic pulse that hits them, thus the ABI's Amplitude log shows an image of the varying "hardness/reflectivity" of the borehole wall (along with fluid impacts); these differences are plotted using a colour scale. A fracture/joint, for example, will absorb more of the acoustic signal than the smooth formation. As a result, the fracture/joint will present itself in the acoustic amplitude log as a low amplitude feature. The ABI's Travel Time log is an image plotting the differences in echo delay; for example, an open fracture or void into which the sonic pulse had to travel farther before being reflected will appear in contrast to the nearer borehole wall. Using an assumed constant fluid velocity, the travel time of the pulses can be converted into a distance, meaning the ABI's Travel Time log can be converted into an Acoustic Caliper log, showing the calculated diameter of the borehole.

In order to translate the travel time of each pulse into distance and properly analyze the strength of the pulse echoes, the ABI can only be run in water. Because the ABI does not use an optical camera, the borehole fluid may be murky without adversely impacting the acoustic image quality. Additionally, because of the geometry of the reflections of the pulses, the ABI must be well centered in the borehole. Specialized centralizers are affixed to the ABI to improve centralization of the probe while logging.

Acoustic televiewer data was acquired using ALT's ABI SN 182903.

## 3.2 Optical Televiewer

The Advanced Logic Technology (ALT) QL40 OBI-2G optical televiewer probe, also known as the optical borehole imager (OBI), is a sophisticated camera which records images of the borehole wall by focusing down using a 360° wide angle lens and illuminating the borehole wall with an array of LEDs. Thin slices of images are stacked up to form one long continuous 24-bit RGB true colour image of the unwrapped borehole wall. Because the image is a 2-dimensional unwrapped cylinder, planar features (e.g., fractures) intersecting the borehole at an angle appear sinusoidal in the OBI image log.

OBI logs are useful for observing layering, banding, foliation, fractures, voids, and veins in addition to obtaining information on visual characteristics such as oxidation staining, mineral infilling, and alteration. The probe also contains a three-axis magnetometer, an inclinometer, and a three-axis accelerometer that records the azimuth and the tilt of the hole as well as the roll of the probe inside the hole. Because the OBI uses LED lights for illumination, it requires a transparent medium to see through, being either air or clear water. Muddy or murky water can obscure the lens and prevent a clear image so flushing of the borehole at the end of drilling is recommended to improve the clarity of the fluid. The OBI log is run up from the bottom of the borehole to maintain a more constant tension on the wireline and thus a consistent logging speed. A set of specialized centralizers for HQ sized boreholes are affixed to the OBI probe to maintain centralization of the probe while logging.

Optical televiewer data was acquired using ALT's OBI SN 170709.

## 3.3 Natural Gamma

The Mount Sopris QL40 GAM natural gamma probe provides a measurement, recorded in counts per second (CPS), proportional to the natural radioactivity of the formation. The sample volume for the gamma log is typically material within a 25 to 30 cm radius. In crystalline rock, the gamma log is used principally for lithologic identification based on presence of minerals with natural radioactivity.

The natural gamma probe uses a scintillation sodium iodide crystal to measure the incoming natural gamma radiation from the borehole wall. The gamma-emitting radioisotopes that naturally occur in geologic materials include Potassium 40 and nuclides in the Thorium 232 and Uranium 238 decay series. Potassium 40 occurs within potassium minerals including potassium feldspars. Thorium 232 is typically associated with biotite, sphene, zircon, and other heavy minerals. Uranium 238 is typically associated with granitoid rocks with uranium mineralization.

Natural gamma data was acquired using MSI's GR SN6568.

# 4.0 Data Processing

## 4.1 Data Processing Comments

Data was reviewed for quality control and quality assurance by DGI field operators in real time and the survey day. Raw data from the field was uploaded by field technicians at the end of the shift and reviewed by DGI's data analysts for verification that depth discrepancy, data repeatability, and errors were within the tolerance limits specified in the Test Plan (SCB1912026-PLN-013 I04).. After quality control verification was completed, data analysts merged the required survey runs to create a continuous downhole profile, then interpolated and filtered the data and calculated and applied the required depth corrections.

### 4.1.1 Data Interpolation and Noise Filtering

Data was interpolated to remove null values that were logged using a linear interpolation algorithm. A moving average filter with a filter width of 3 fiducials was subsequently applied to non-RGB logs to reduce noise.

### 4.1.2 Depth Correction and Verification

Downhole logs were referenced to ground level as described in the Test Plan (SCB1912026-PLN-013 I04). Probes were connected to the wireline and lowered into the casing until the top of the cable head was flush with the top of the casing. Field technicians recorded (1) the initial depth at which the probe was levelled at surface prior to starting the data recording and (2) the final depth at surface after data acquisition was completed. Data analysts calculated the magnitude and direction of the depth shift by subtracting the initial and final values. The run was considered valid if the magnitude of the shift was within the tolerance specified in the Test Plan (SCB1912026-PLN-013 I04). Runs were determined by DGI to be within tolerance limits.

After the linear depth shift was applied to the data set, the cable stretch was calculated for each probe using the methodology outlined in the Test Plan (SCB1912026-PLN-013 I04). The required wireline stretch coefficient was provided by the wireline manufacturer and the probe weight was measured by DGI. The corrected depth was determined from the measured depth using the following equation:

$$D_c = D + \frac{(W \cdot D) + (0.03412 \cdot D^2)}{45{,}360}$$

where:

$$D_c = Corrected\ Depth\ (m)$$

$$D = Measured\ Depth\ (m)$$

$$W = Suspended\ Weight\ (kg) = \ Probe\ Weight\ (kg) + 10.4\frac{D}{304.8}$$

The depth values provided for the final data are the corrected depth values in metres.

A natural gamma subsection was added to each probe, providing a common data reference point across the data sets as an additional verification method. This could be used to resolve depth discrepancy issues, if encountered. The depths of the runs were within the quality control tolerance limits specified by in the Test Plan (SCB1912026-PLN-013 I04), so the natural gamma was not required to resolve depth discrepancy.

Following the application of the cable stretch correction to the acoustic and optical data sets, the two data sets were additionally depth matched to each other. To do this, the parameter with the best zero (i.e., least depth discrepancy) was identified and the second data set was shifted to match. For the data acquired on IG_BH04, the optical televiewer data had the best zero and the acoustic televiewer was matched to the optical televiewer by using features common on both RGB logs. The depth matching points used for this are detailed in Table 2.

**Table 2: Anchor Points for Depth Matching**

| Original Depth (m) | Final Depth (m) |
|---|---|
| 16.4975 | 16.5235 |
| 20.6505 | 20.6725 |
| 30.4525 | 30.4815 |
| 32.5945 | 32.6255 |
| 36.5545 | 36.5925 |
| 42.0715 | 42.1115 |
| 42.9365 | 42.9745 |
| 58.2325 | 58.2685 |
| 65.4995 | 65.5395 |
| 72.6805 | 72.7185 |
| 79.8455 | 79.8985 |

## 4.2 Client Deliverables

Data is provided separately from this report. The data package includes final data, preliminary data, QAQC sheets, raw data, and tool files.

**Final Data**

IG-BH04_NM_BHOrientation_ATV.xlsx
IG-BH04_NM_BHOrientation_OTV.xlsx
IG-BH04_WP05_ATVOTV_AZIMUTH-021219_Final.las
IG-BH04_WP05_ATVOTV_CALIPER-021219_Final.las
IG-BH04_WP05_ATVOTV_GR-021219_Final.las
IG-BH04_WP05_ATVOTV_MAGFIELD-021219_Final.las
IG-BH04_WP05_ATVOTV_REFLECTIVITY-021219_Final.las
IG-BH04_WP05_ATVOTV_TILT-021219_Final.las
IG-BH04_WP05_ATVOTV_WINTIME-021219_Final.las

IG-BH04_WP05_ATVOTV-021219_Final.pdf
IG-BH04_WP05_ATVOTV-021219_Final.wcl
IG-BH04_WP05_FeatureAnalysis_121819.xlsx
IG-BH04_WP05_SchmidtPlot_AllFeatures_121819.pdf

**Preliminary Data**

IG-BH04_WP05_ATVOTV_AZIMUTH-021219_Draft1.las
IG-BH04_WP05_ATVOTV_CALIPER-021219_Draft1.las
IG-BH04_WP05_ATVOTV_GR-021219_Draft1.las
IG-BH04_WP05_ATVOTV_MAGFIELD-021219_Draft1.las
IG-BH04_WP05_ATVOTV_REFLECTIVITY-021219_Draft1.las
IG-BH04_WP05_ATVOTV_TILT-021219_Draft1.las
IG-BH04_WP05_ATVOTV_WINTIME-021219_Draft1.las
IG-BH04_WP05_ATVOTV-021219_Draft1.pdf
IG-BH04_WP05_ATVOTV-021219_Draft1.WCL
IG-BH04_WP05_DepthMatch.txt

**QAQC Sheets**

IG-BH04_WP05_DGI-RGS_ATV-021219.docx
IG-BH04_WP05_DGI-RGS_OTV-021219.docx

**Raw Data**

IG-BH04_WP05_ATVGR_d1_113019.tfd
IG-BH04_WP05_ATVGR_d3_113019.tfd
IG-BH04_WP05_ATVGR_PostEastAzimuth_113019.tfd
IG-BH04_WP05_ATVGR_PostNorthAzimuth_113019.tfd
IG-BH04_WP05_ATVGR_PostRoll_113019.tfd
IG-BH04_WP05_ATVGR_PostSouthAzimuth_113019.tfd
IG-BH04_WP05_ATVGR_PostTiltHorizontal_113019.tfd
IG-BH04_WP05_ATVGR_PostTiltVertical_113019.tfd
IG-BH04_WP05_ATVGR_PostWestAzimuth_113019.tfd
IG-BH04_WP05_ATVGR_PreEastAzimuth_113019.tfd
IG-BH04_WP05_ATVGR_PreNorthAzimuth_113019.tfd
IG-BH04_WP05_ATVGR_PreRoll_113019.tfd
IG-BH04_WP05_ATVGR_PreSouthAzimuth_113019.tfd
IG-BH04_WP05_ATVGR_PreTiltHorizontal_113019.tfd
IG-BH04_WP05_ATVGR_PreTiltVertical_113019.tfd
IG-BH04_WP05_ATVGR_PreWestAzimuth_113019.tfd
IG-BH04_WP05_ATVGR_u2_113019.tfd
IG-BH04_WP05_ATVGR_u4_113019.tfd
IG-BH04_WP05_OTVGR_d1_113019.tfd
IG-BH04_WP05_OTVGR_d3_113019.tfd
IG-BH04_WP05_OTVGR_PreEastAzimuth_113019.tfd
IG-BH04_WP05_OTVGR_PreNorthAzimuth_113019.tfd
IG-BH04_WP05_OTVGR_PreRoll_113019.tfd

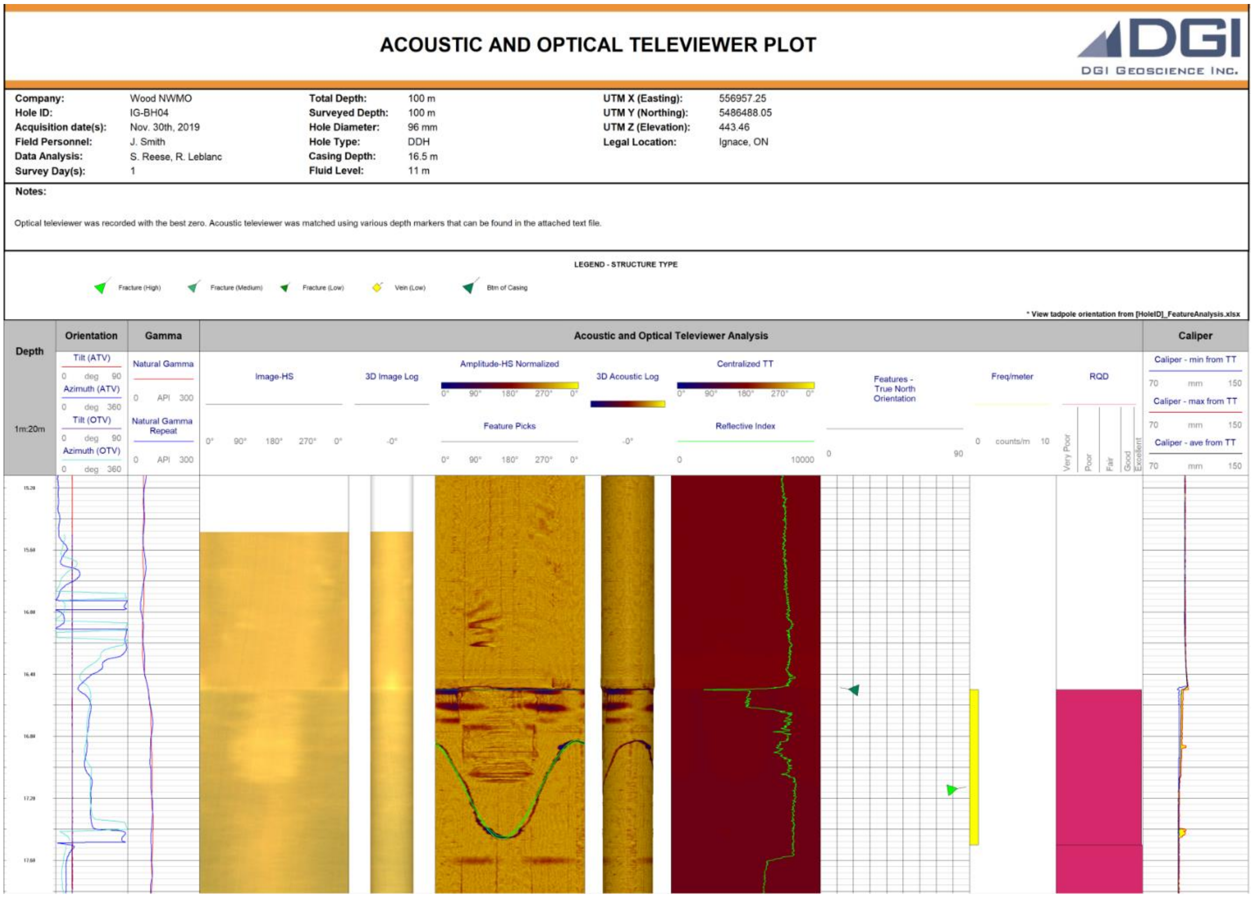
IG-BH04_WP05_OTVGR_PreSouthAzimuth_113019.tfd
IG-BH04_WP05_OTVGR_PreTiltHorizontal_113019.tfd
IG-BH04_WP05_OTVGR_PreTiltVertical_113019.tfd
IG-BH04_WP05_OTVGR_PreWestAzimuth_113019.tfd
IG-BH04_WP05_OTVGR_u2_113019.tfd
IG-BH04_WP05_OTVGR_u4_113019.tfd

**Tool Files**

QL40-ABI2G-182903.sub
QL40-GR-6568.sub
QL40-OBI2G-170709.sub

## 4.3 Acoustic and Optical Televiewer – Final Data

The final acoustic and optical televiewer plot provided by DGI is shown in Figure 2. This includes televiewer tilt and azimuth, borehole wall images acquired by the televiewer probes, picked borehole features, fracture frequency, and RQD and synthetic caliper calculated from the acoustic televiewer. Additionally, the gamma acquired with the televiewers is shown. Final data was provided as a continuous log downhole in WellCAD and PDF (Appendix A) format *(IG-BH04_WP05_ATVOTV-021219_Final.pdf and IG-BH04_WP05_ATVOTV-021219_Final.wcl).*



ACOUSTIC AND OPTICAL TELEVIEWER PLOT

| | | | | | |
|---|---|---|---|---|---|
| **Company:** | Wood NWMO | **Total Depth:** | 100 m | **UTM X (Easting):** | 556957.25 |
| **Hole ID:** | IG-BH04 | **Surveyed Depth:** | 100 m | **UTM Y (Northing):** | 5486488.05 |
| **Acquisition date(s):** | Nov. 30th, 2019 | **Hole Diameter:** | 96 mm | **UTM Z (Elevation):** | 443.46 |
| **Field Personnel:** | J. Smith | **Hole Type:** | DDH | **Legal Location:** | Ignace, ON |
| **Data Analysis:** | S. Reese, R. Leblanc | **Casing Depth:** | 16.5 m | | |
| **Survey Day(s):** | 1 | **Fluid Level:** | 11 m | | |

**Notes:**

Optical televiewer was recorded with the best zero. Acoustic televiewer was matched using various depth markers that can be found in the attached text file.

Figure 2: Acoustic and optical televiewer composite plot: final processed data

The following describes the logs present in the plot:

A. Tilt and Azimuth

Both the acoustic and optical televiewer contain a built-in, high precision deviation sensor that measures the borehole tilt and azimuth during data acquisition.

**Tilt:** inclination of the borehole measured from the vertical axis. Tilt = 0 degrees corresponds to a vertical borehole; Tilt = 90 degrees indicates a horizontal borehole.

**Azimuth:** the raw probe azimuth is represented with respect to magnetic north**,** plotted from 0 to 360 degrees. Note that the azimuth is influenced by magnetics.

B. 3D Acoustic and Image Logs

For visual reference, the unwrapped acoustic and optical images are also plotted in WellCAD as 3D logs. These logs are a three-dimensional outside view of the borehole wall.

## C. Acoustic Televiewer Logs

### Amplitude Normalized

Amplitude of the returned pulse with a high pass normalization filter applied. Highs (orange) represent regions where the formation is smooth or more acoustically reflective, while lows (blue) represent regions where the acoustic signal is being preferentially absorbed by the formation. These regions of absorption typically are the result of fractures present in the formation.

### Reflective Index

The median of the acoustic amplitude log per vertical sample interval. This value is indicative of relative rock hardness. As with the amplitude log, low values indicated high absorption/low reflectivity while highs indicate a low absorption/high reflectivity.

### Centralized TT

The travel time log filtered and corrected for centralization. Highs indicate that there are open fractures/joints present.

### Synthetic Caliper Logs

Using the centralized travel time log, the two-way travel time, the probe radius, and an assumed fluid velocity of 1450 m/s, DGI produced a synthetic caliper log by computing a radius value for each recorded travel time data point along the borehole path. Opposite radius values are then added to get the calculated borehole caliper result. This value is displayed as the minimum, maximum, and average value for each vertical interval resulting in three acoustic caliper logs (min, max, and average).

## D. Televiewer Rock Quality Designation and Fracture Frequency

DGI generates a Televiewer Rock Quality Designation (RQD) and a Fracture Frequency log for each borehole. This data is displayed in the WellCAD plot as well as exported to Excel format. Both measurements are calculated using the following feature pick classes:

Fracture (High)
Fracture (Medium)
Fracture (Low)

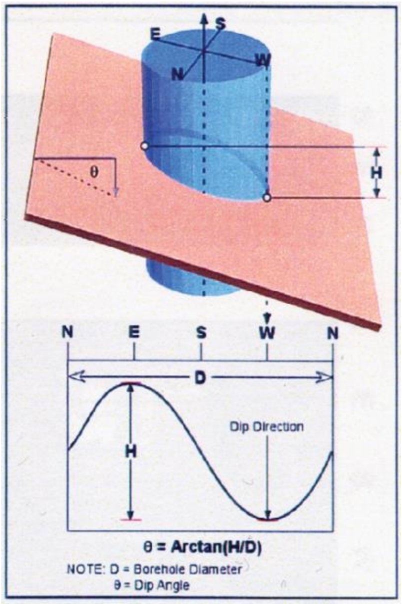
**Freq/m:** Fracture frequency per 1 m; the number of occurrences per metre.

**Televiewer Rock Quality Designation (RQD):** a measure of the drill core quality or intensity of fracturing. This is measured as a percentage of drill core in length of 0.1 metres and is derived from the televiewer feature picks. The RQD was provided at an interval of every 1 m.

| RQD | Description |
|---|---|
| 0-25% | Very Poor |
| 25-50% | Poor |
| 50-75% | Fair |

| RQD | Description |
|---|---|
| 75-90% | Good |
| 90-100% | Excellent |

### 4.3.1 Data Processing – Televiewer Feature Classification and Orientation



Planar geological features appear in the unwrapped acoustic and optical televiewer images as sinusoidal waves. From this, the dip and dip direction were determined as follows:

**Dip:** amplitude of the sinusoid

**Dip Direction:** radial position of the sine wave minimum

These picked features were provided to the client oriented to true north orientation (this includes correction to true dip as this borehole is inclined). Please note, ABI and OBI imagery are presented oriented to high side. To correct the feature picks to true north orientation, DGI used the tilt and azimuth information collected by the televiewer probes, along with the magnetic declination at Site (-1.43 degrees). The magnetic declination was determined using the Natural Resources Canada website using the following location: Latitude: 49.50° North, Longitude: 92.25° West.

Feature picks were plotted in WellCAD both in projection view (“Feature Picks” Log) and as tadpoles (“Features – True North Orientation” Log).

### 4.3.2 Data Processing – Televiewer Classification Scheme

The picking criteria established in the Test Plan (SCB1912026-PLN-013 I04) is detailed in Figure 3. Planar geological features were assigned a feature class based on this criteria. Each class is described by a confidence designation (Low, Medium, High).

Only a subset of the features listed in Figure 3 were observed in the data. These include:

Fracture (High)
Fracture (Medium)
Fracture (Low)
Vein (Low)

| Code: | Structural Description: |
|---|---|
| Fol-H | Foliation (High) |
| Fol-M | Foliation (Medium) |
| Fol-L | Foliation (Low) |
| Cleav-H | Cleavage (High) |
| Cleav-M | Cleavage (Medium) |
| Cleav-L | Cleavage (Low) |
| Schist-H | Schistosity (High) |
| Schist-M | Schistosity (Medium) |
| Schist-L | Schistosity (Low) |
| Gneiss-H | Gneissosity (High) |
| Gneiss-M | Gneissosity (Medium) |
| Gneiss-L | Gneissosity (Low) |
| F-H | Fracture (High) |
| F-M | Fracture (Medium) |
| F-L | Fracture (Low) |
| V-H | Vein (High) |
| V-M | Vein (Medium) |
| V-L | Vein (Low) |
| FAP-H | Fold Axial Plane (High) |
| FAP-M | Fold Axial Plane (Medium) |
| FAP-L | Fold Axial Plane (Low) |
| SZBD-H | Shear Zone - Brittle-Ductile (High) |
| SZBD-M | Shear Zone - Brittle-Ductile (Medium) |
| SZBD-L | Shear Zone - Brittle-Ductile (Low) |
| SZD-H | Shear Zone - Ductile (High) |
| SZD-M | Shear Zone - Ductile (Medium) |
| SZD-L | Shear Zone - Ductile (Low) |
| Myl-H | Mylonite (High) |
| Myl-M | Mylonite (Medium) |
| Myl-L | Mylonite (Low) |
| IPS-H | Igneous Primary Structure (High) |
| IPS-M | Igneous Primary Structure (Medium) |
| IPS-L | Igneous Primary Structure (Low) |
| 0 | Btm of Casing |

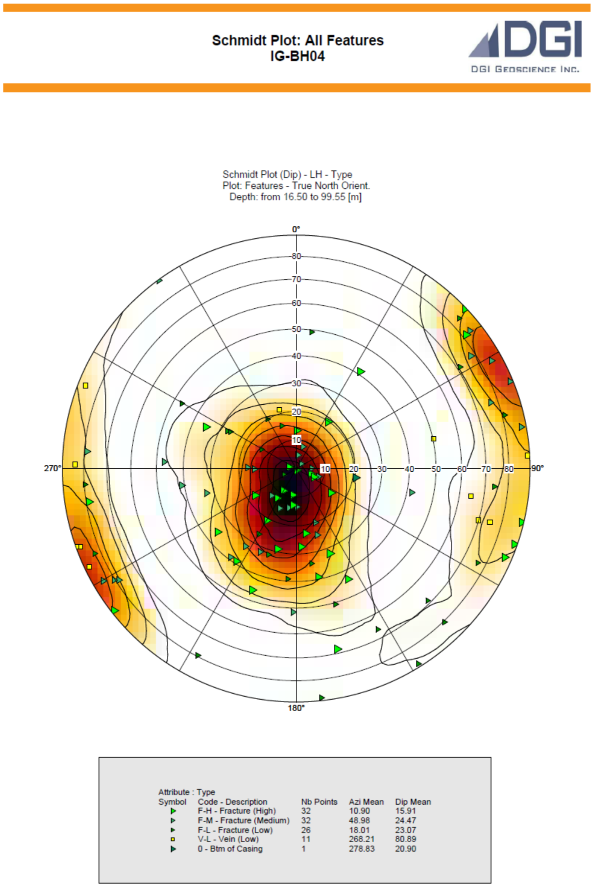
**Figure 3: Acoustic and optical televiewer feature classification scheme**

### 4.3.3 Data Processing – Data Visualization and Export

Data was provided visualized in a Schmidt plot (IG-BH04_WP05_SchmidtPlot_AllFeatures_121819.pdf) and exported in Excel format (IG-BH04_WP05_FeatureAnalysis_121819.xlsx, IG-BH04_NM_BHOrientation_ATV.xlsx and IG-BH04_NM_BHOrientation_OTV.xlsx).

The Schmidt plot provided as part of the deliverable package is shown in Figure 4. The Schmidt plot generated is a polar projection in the southern hemisphere. Features in the surveyed section of IG_BH04 are included.

The true dip and true north dip direction of each feature was exported to Excel. Figure 5 illustrates the columns included in the Feature Analysis export file. Additionally, the tilt and azimuth channels for both the acoustic and optical televiewer probes were exported with reference to magnetic north orientation (IG-BH04_NM_BHOrientation_ATV.xlsx and IG-BH04_NM_BHOrientation_OTV.xlsx).

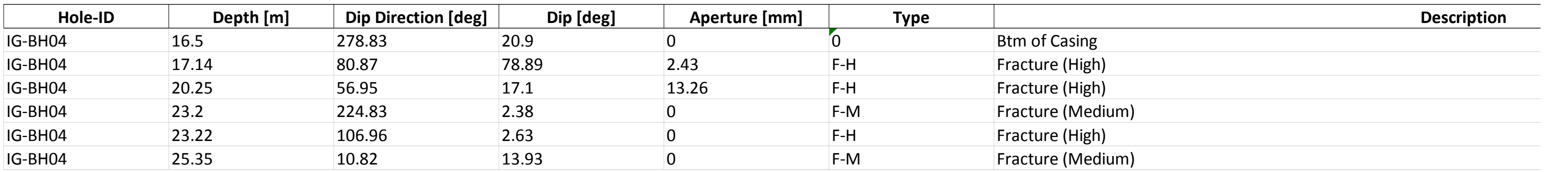

**Schmidt Plot: All Features**
**IG-BH04**

Schmidt Plot (Dip) - LH - Type
Plot: Features - True North Orient.
Depth: from 16.50 to 99.55 [m]

Attribute : Type

| Symbol | Code - Description | Nb Points | Azi Mean | Dip Mean |
|---|---|---|---|---|
| ▶ | F-H - Fracture (High) | 32 | 10.90 | 15.91 |
| ▶ | F-M - Fracture (Medium) | 32 | 48.98 | 24.47 |
| ▶ | F-L - Fracture (Low) | 26 | 18.01 | 23.07 |
| □ | V-L - Vein (Low) | 11 | 268.21 | 80.89 |
| ▶ | 0 - Btm of Casing | 1 | 278.83 | 20.90 |

**Figure 4: Feature picks in IG_BH04, Schmidt plot**



| Hole-ID | Depth [m] | Dip Direction [deg] | Dip [deg] | Aperture [mm] | Type | Description |
|---|---|---|---|---|---|---|
| IG-BH04 | 16.5 | 278.83 | 20.9 | 0 | 0 | Btm of Casing |
| IG-BH04 | 17.14 | 80.87 | 78.89 | 2.43 | F-H | Fracture (High) |
| IG-BH04 | 20.25 | 56.95 | 17.1 | 13.26 | F-H | Fracture (High) |
| IG-BH04 | 23.2 | 224.83 | 2.38 | 0 | F-M | Fracture (Medium) |
| IG-BH04 | 23.22 | 106.96 | 2.63 | 0 | F-H | Fracture (High) |
| IG-BH04 | 25.35 | 10.82 | 13.93 | 0 | F-M | Fracture (Medium) |

**Figure 5: Data export of feature picks, IG_BH04**

# 5.0 Quality Control

DGI employed a rigorous QA/QC process to ensure deployed equipment function appropriately. Standard Operating Procedures (SOP) were developed over three key stages: pre-mobilization, on-Site, and post-project. Adherence to SOPs at each stage enabled early detection and resolution when issues were encountered. Prevention is the goal, but identification and contingency plans are equally important when unforeseen challenges occasionally arise.

DGI has established a baseline for probes and parameters at the Geologic Survey of Canada's (GSC) Bells Corners Calibration Facility near Ottawa, Canada. The GSC calibration borehole is well understood with detailed core analysis and published papers in support of results. Repeated acquisition of data at this facility has enabled the development of a baseline for each probe's individual functionality based on expected geophysical signatures. DGI has developed a calibration data set, using the GSC facility, to create field calibration procedures that supplement manufacturer recommendations.

To expand the quality and breadth of calibration procedures, DGI has established an additional calibration borehole. DGI has leveraged proven baselines from the GSC Calibration Facility for each probe and parameter by transferring calibration to our own calibration borehole in Levack, Ontario. The exceptional geology of the Levack borehole provides geophysical signatures with extensive variance; well supported by documented drilling data, core analysis, and lab assay. The Levack calibration borehole enables our equipment to be checked for nominal function, calibration, and performance in an environment approximating a project site. Our full calibration infrastructure enables DGI to conduct an auditable logging process for each project from pre-mobilization through to project completion.

Once equipment was mobilized to Site, QA/QC measures were in place to such that field personnel had confidence in equipment functionality. SOPs were defined based on the specific suite of geophysical probes, Site conditions, and overall goals of the client's project. Each geophysical probe had unique measures in place that may include:

- On-Site calibrations to correct for regional variance and/or borehole size;
- Bench tests conducted in the field to verify probes meet baseline values;
- Calibration checks, recorded before and after each survey, if applicable; and
- Transferred calibration enabling establishment of an on-Site calibration borehole with representative geology for long-term projects, if applicable.

DGI operators followed the QA/QC standards defined in the Test Plan (SCB1912026-PLN-013 I04) for the data acquisition of the parameters. Specifically, as per the Test Plan the OBI and ABI operational testing was completed in the field (i.e., no calibration) and operational bench testing of the natural gamma probe was conducted prior to mobilization (i.e., no calibration). DGI operators verified data repeatability and data consistency by collecting repeat runs for each parameter surveyed. The QA/QC runs were at least 10% of the total depth of each survey. Following data acquisition, DGI's senior data analyst further reviewed the data for quality assurance. The optical televiewer image acquired was cloudy due to the fluid in the borehole. However, it was determined that there was no means to improve this image quality at the time. On future data acquisition attempts, DGI recommends additional flushing of the borehole to improve the optical image as the optical image quality is dependant on water clarity. Other data quality standards outlined in the Test Plan (SCB1912026-PLN-013 I04) were met and both the DGI Project Manager and the on-site Wood representative signed off on the data acquired prior to the field crew demobilizing from Site. Please find the Daily Report issued for 30 November 2019 (the day of data collection) in Appendix B and the ABI (ATV) and OBI (OTV) Data QA/QC Record Sheets in Appendix C. Appendix C also includes the data quality control sign-off sheet as provided by DGI data analysts to the Wood representative after the survey was completed.

# 6.0 Conclusions

DGI Geoscience successfully acquired acoustic televiewer, optical televiewer, and natural gamma on IG_BH04 in Ignace, Ontario. The field work occurred between 27 November and 1 December 2019 with no incidents or lost time. The geophysical information derived from the downhole surveys will assist in the characterization of the subsurface at NWMO's area of study. Deliverables have been provided along with this report. Data has been quality assured by DGI's strict quality control procedures. Work was complete in accordance with the standards laid out in the Test Plan (SCB1912026-PLN-013 I04).

# Appendix A

# Continuous Downhole Log of Final Data

# ACOUSTIC AND OPTICAL TELEVIEWER PLOT

DGI GEOSCIENCE INC.

| | | | | | |
|---|---|---|---|---|---|
| **Company:** | Wood NWMO | **Total Depth:** | 100 m | **UTM X (Easting):** | 556957.25 |
| **Hole ID:** | IG-BH04 | **Surveyed Depth:** | 100 m | **UTM Y (Northing):** | 5486488.05 |
| **Acquisition date(s):** | Nov. 30th, 2019 | **Hole Diameter:** | 96 mm | **UTM Z (Elevation):** | 443.46 |
| **Field Personnel:** | J. Smith | **Hole Type:** | DDH | **Legal Location:** | Ignace, ON |
| **Data Analysis:** | S. Reese, R. Leblanc | **Casing Depth:** | 16.5 m | | |
| **Survey Day(s):** | 1 | **Fluid Level:** | 11 m | | |

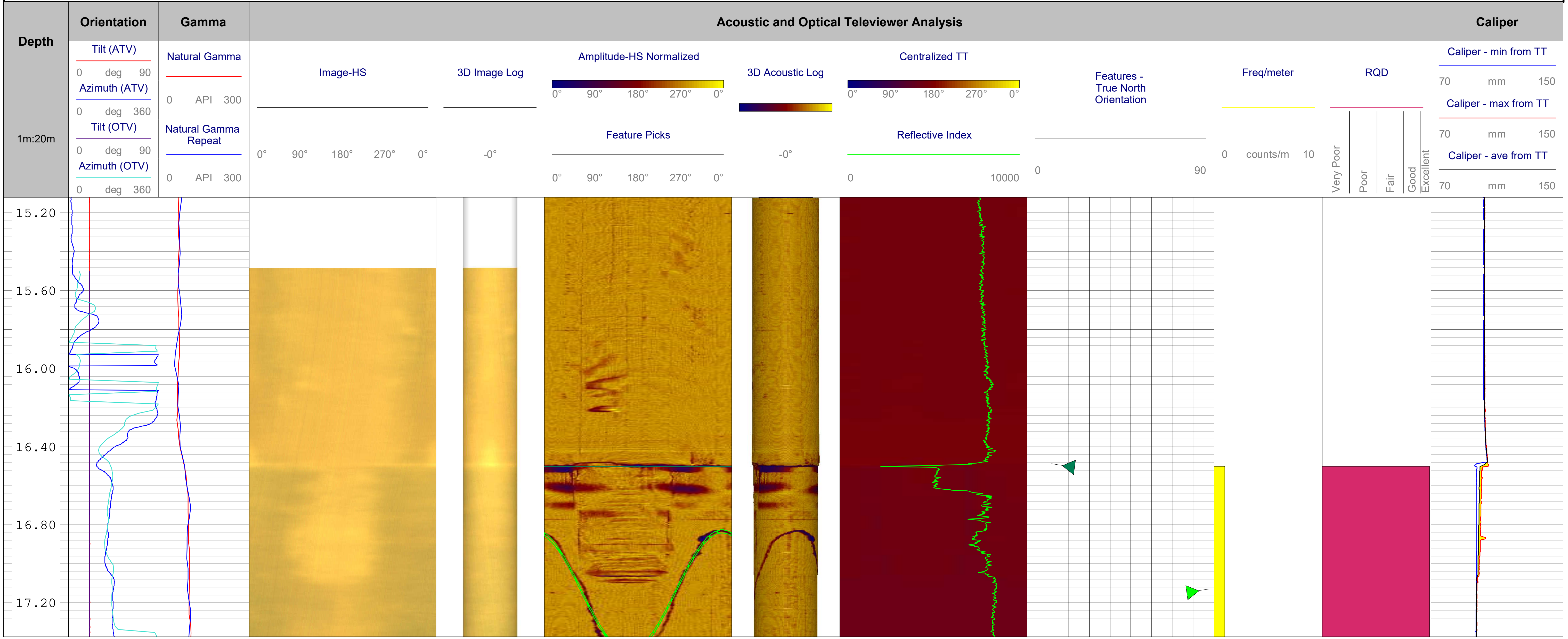
**Notes:**

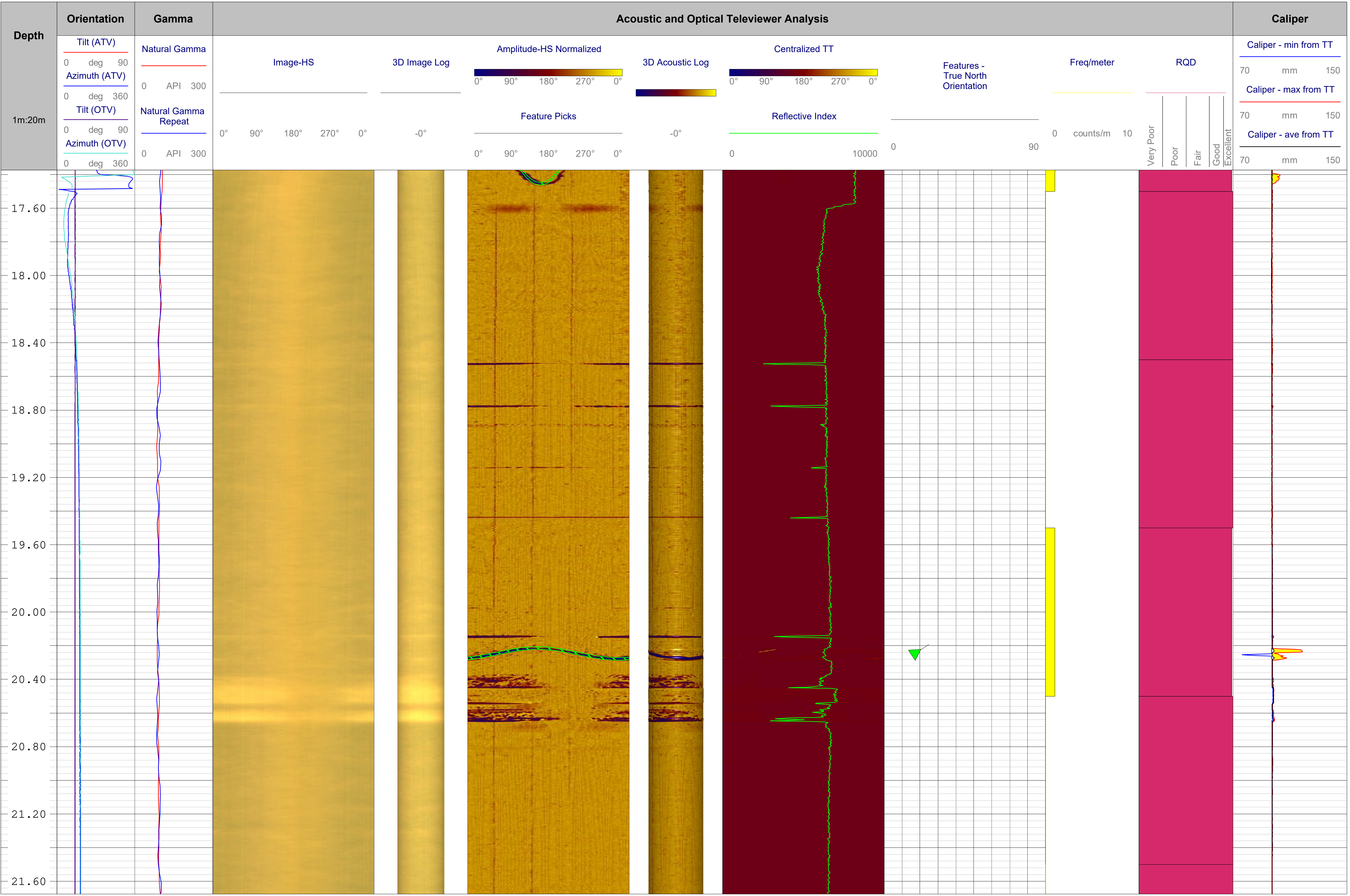
Optical televiewer was recorded with the best zero. Acoustic televiewer was matched using various depth markers that can be found in the attached text file.

**LEGEND - STRUCTURE TYPE**

Fracture (High)    Fracture (Medium)    Fracture (Low)    Vein (Low)    Btm of Casing

* View tadpole orientation from [HoleID]_FeatureAnalysis.xlsx

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Tilt (OTV)
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Azimuth (OTV)
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Gamma
Natural Gamma
0 API 300
Natural Gamma Repeat
0 API 300
Acoustic and Optical Televiewer Analysis
Image-HS
0° 90° 180° 270° 0°
3D Image Log
-0°
Amplitude-HS Normalized
0° 90° 180° 270° 0°
Feature Picks
0° 90° 180° 270° 0°
3D Acoustic Log
-0°
Centralized TT
0° 90° 180° 270° 0°
Reflective Index
0 10000
Features - True North Orientation
0 90
Freq/meter
0 counts/m 10
RQD
Very Poor
Poor
Fair
Good
Excellent
Caliper
Caliper - min from TT
70 mm 150
Caliper - max from TT
70 mm 150
Caliper - ave from TT
70 mm 150
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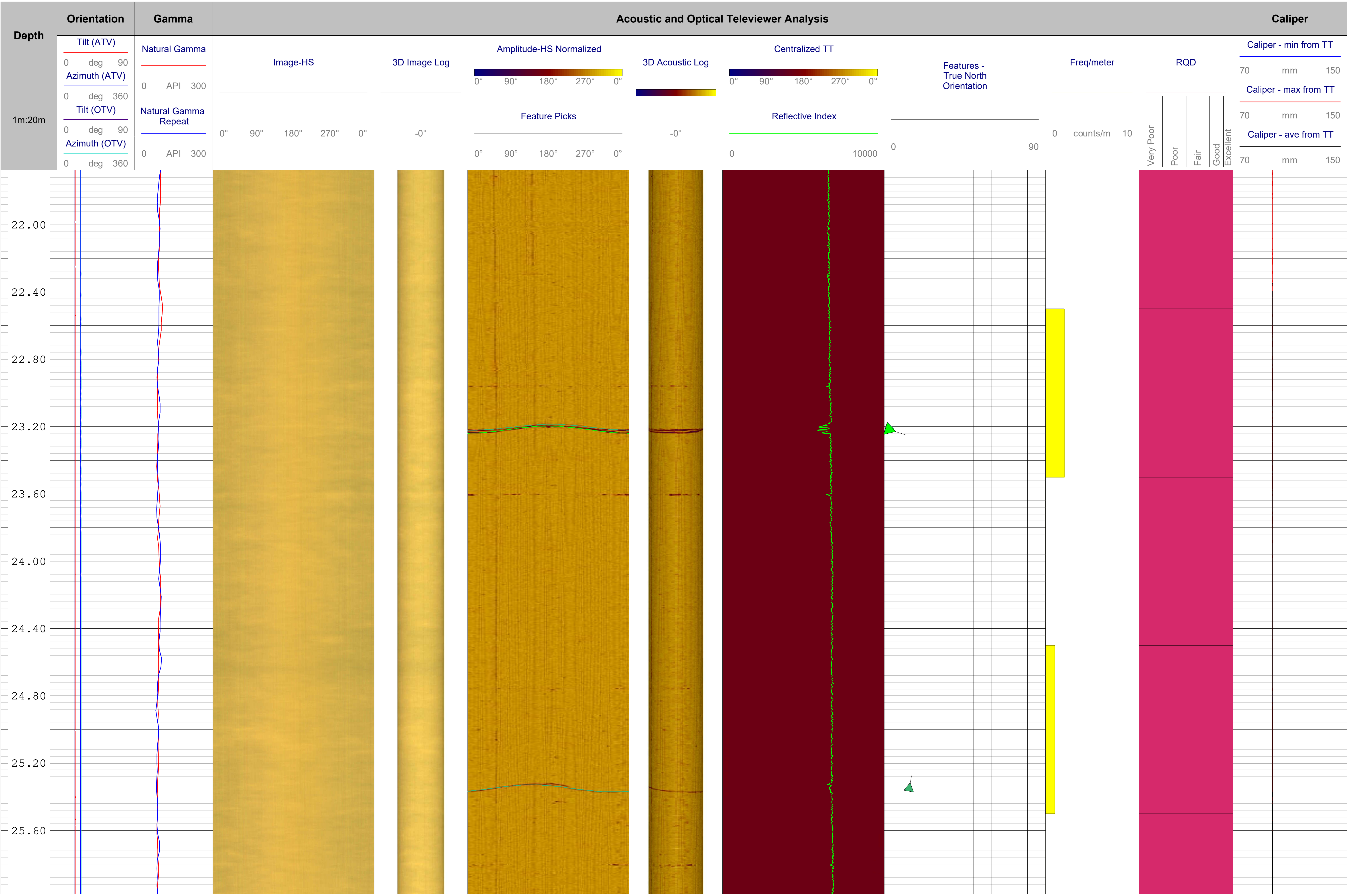
18.00
18.40
18.80
19.20
19.60
20.00
20.40
20.80
21.20
21.60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Gamma
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0 API 300
Natural Gamma Repeat
0 API 300
Acoustic and Optical Televiewer Analysis
Image-HS
0° 90° 180° 270° 0°
3D Image Log
-0°
Amplitude-HS Normalized
0° 90° 180° 270° 0°
Feature Picks
0° 90° 180° 270° 0°
3D Acoustic Log
-0°
Centralized TT
0° 90° 180° 270° 0°
Reflective Index
0 10000
Features - True North Orientation
0 90
Freq/meter
0 counts/m 10
RQD
Very Poor
Poor
Fair
Good
Excellent
Caliper
Caliper - min from TT
70 mm 150
Caliper - max from TT
70 mm 150
Caliper - ave from TT
70 mm 150
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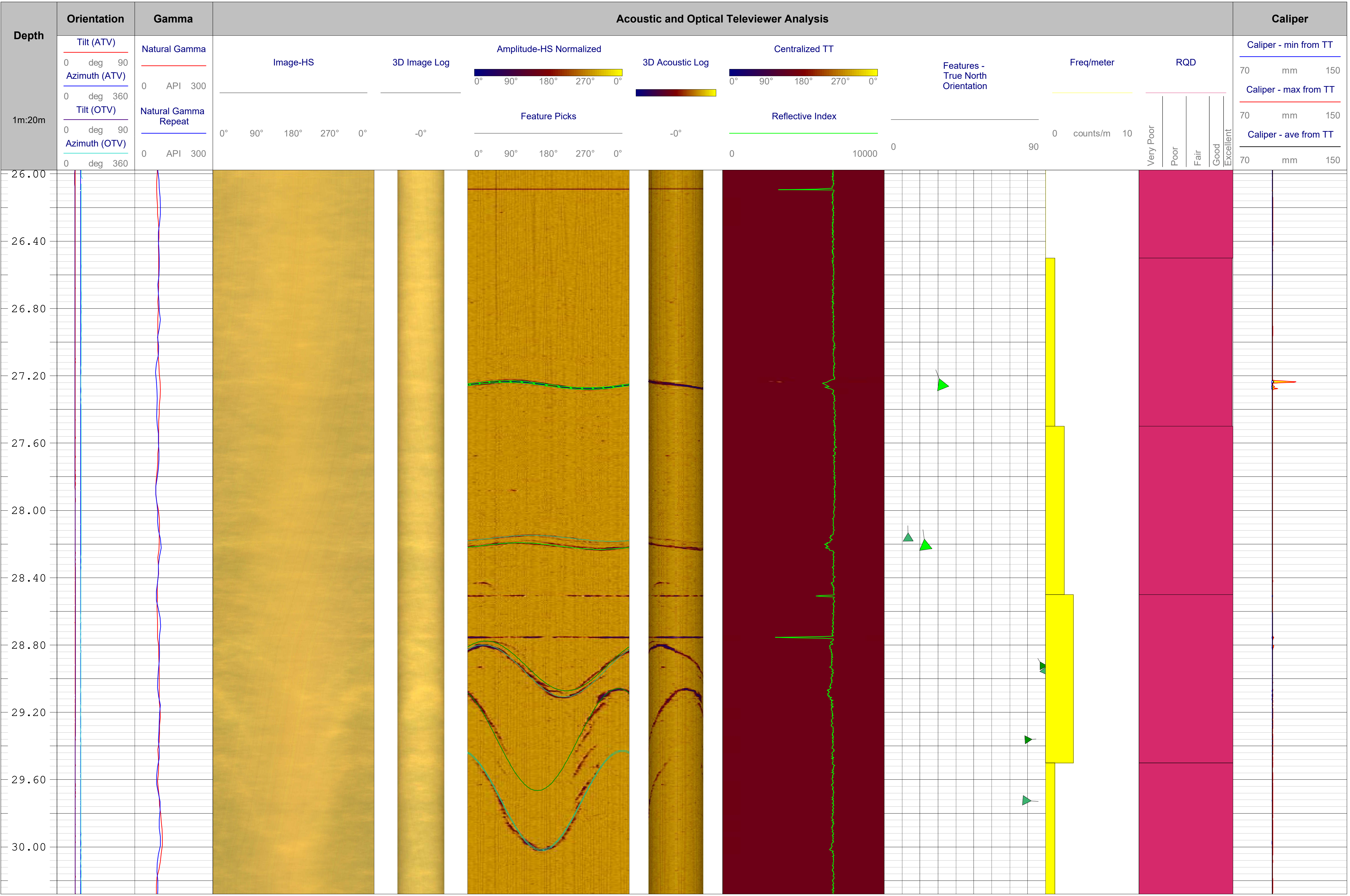
24.40
24.80
25.20
25.60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0 API 300
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3D Acoustic Log
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Reflective Index
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Freq/meter
0 counts/m 10
RQD
Very Poor
Poor
Fair
Good
Excellent
Caliper
Caliper - min from TT
70 mm 150
Caliper - max from TT
70 mm 150
Caliper - ave from TT
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27.20
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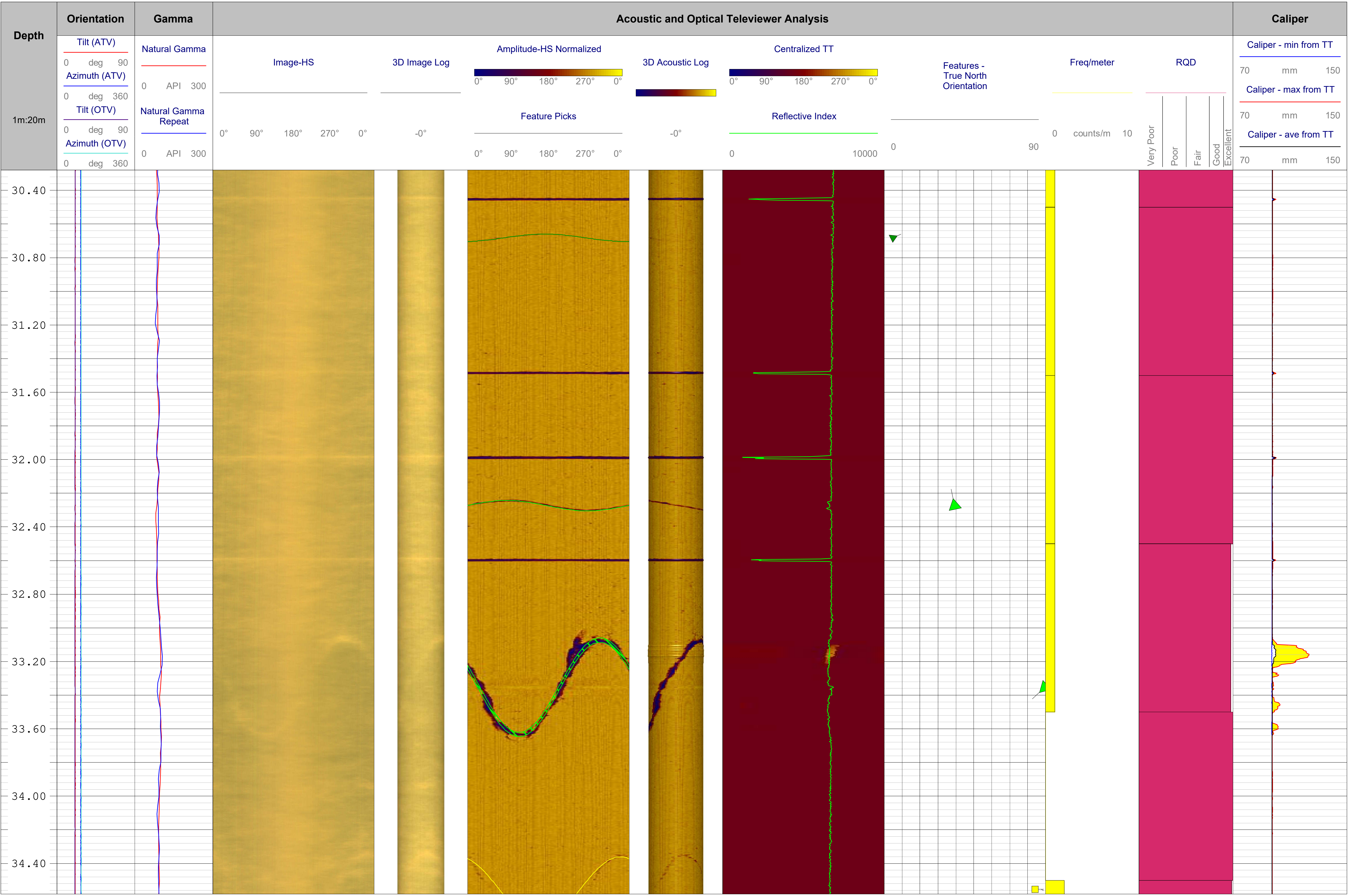
29.20
29.60
30.00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Caliper - min from TT
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Caliper - max from TT
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Caliper - ave from TT
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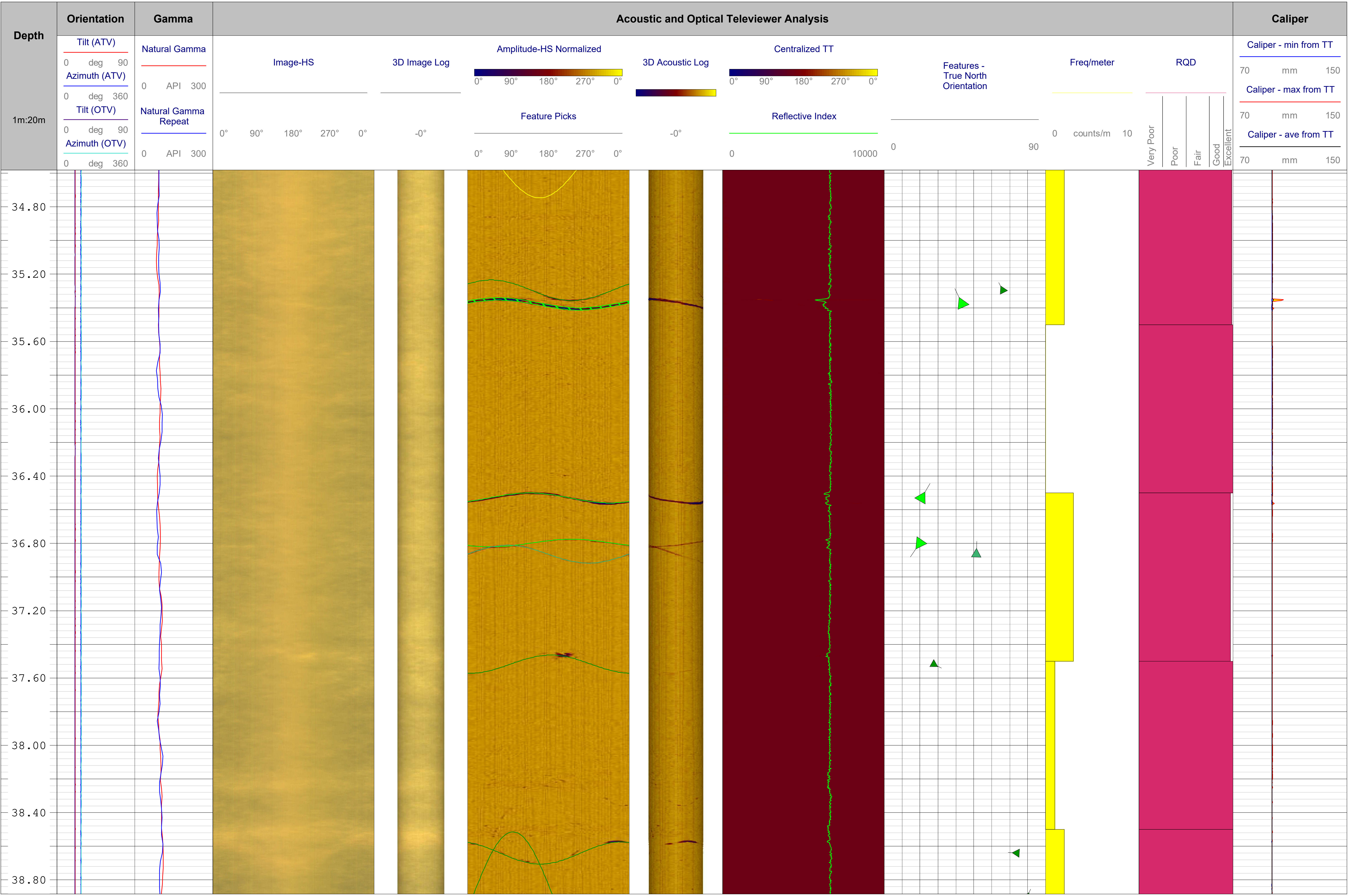
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Freq/meter
0 counts/m 10
RQD
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Poor
Fair
Good
Excellent
Caliper
Caliper - min from TT
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Caliper - max from TT
70 mm 150
Caliper - ave from TT
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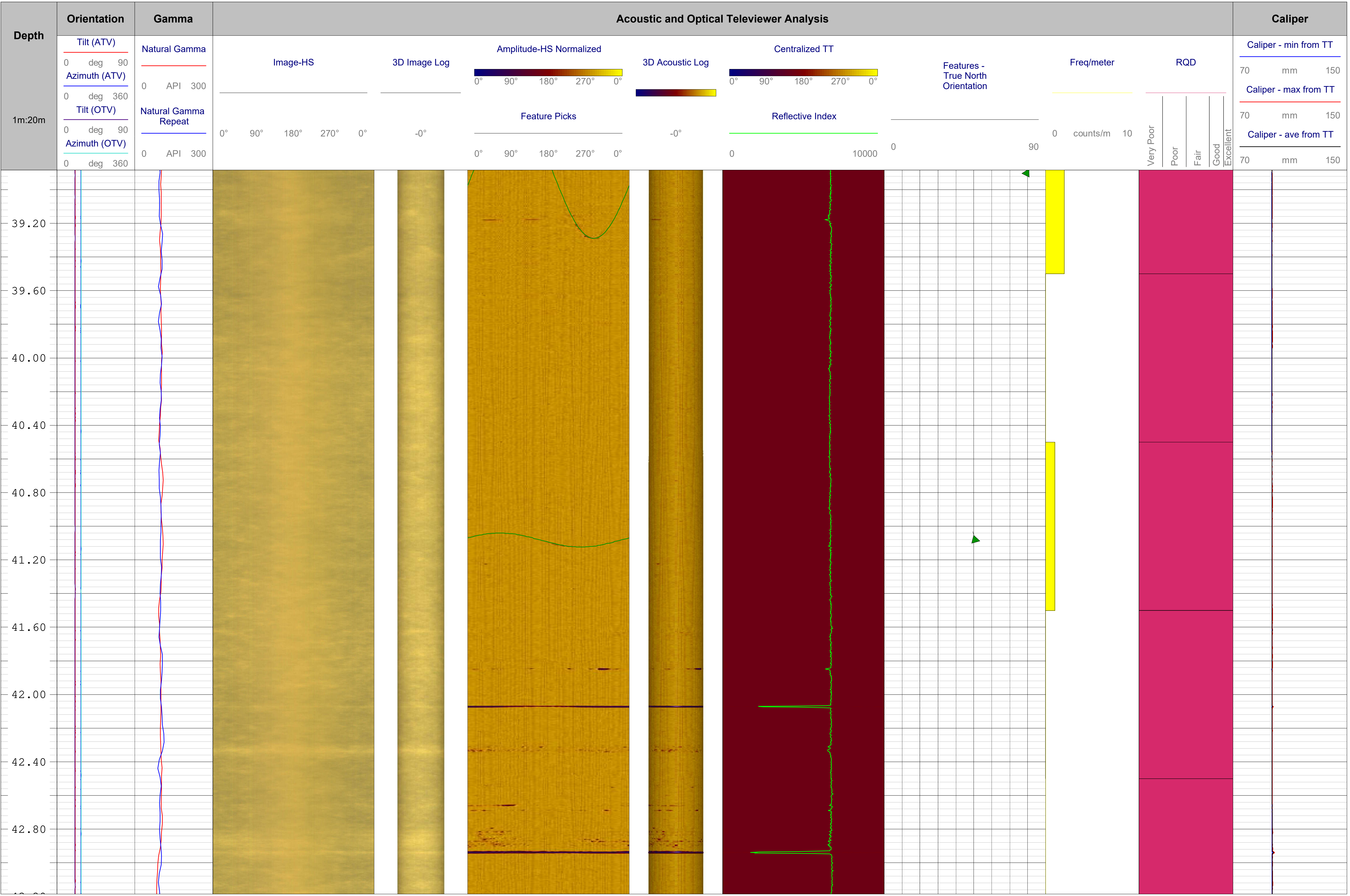
38.00
38.40
38.80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3D Acoustic Log
-0°
Centralized TT
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Reflective Index
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Features - True North Orientation
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Freq/meter
0 counts/m 10
RQD
Very Poor
Poor
Fair
Good
Excellent
Caliper
Caliper - min from TT
70 mm 150
Caliper - max from TT
70 mm 150
Caliper - ave from TT
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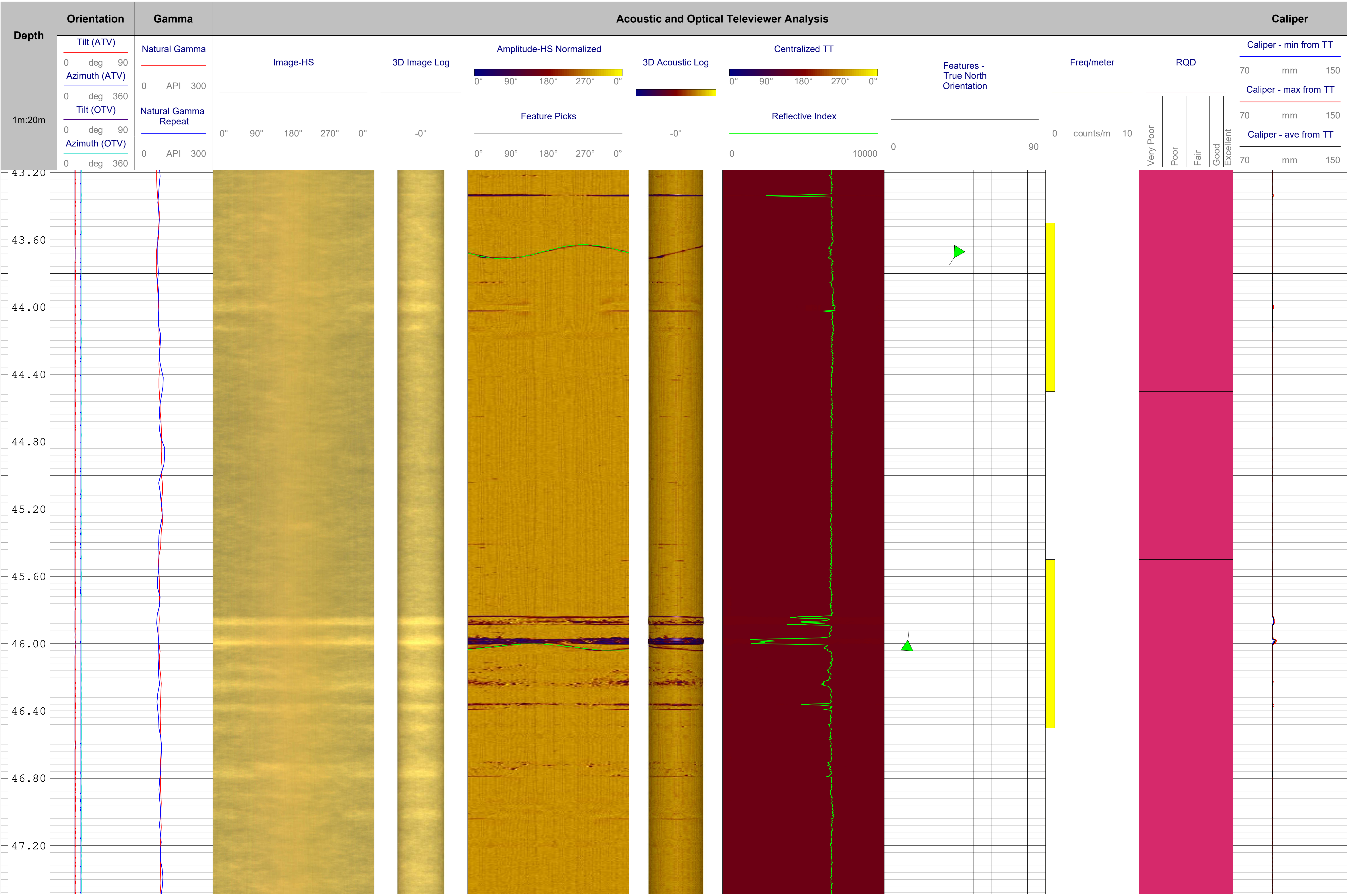
42.40
42.80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Freq/meter
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RQD
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Poor
Fair
Good
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Caliper
Caliper - min from TT
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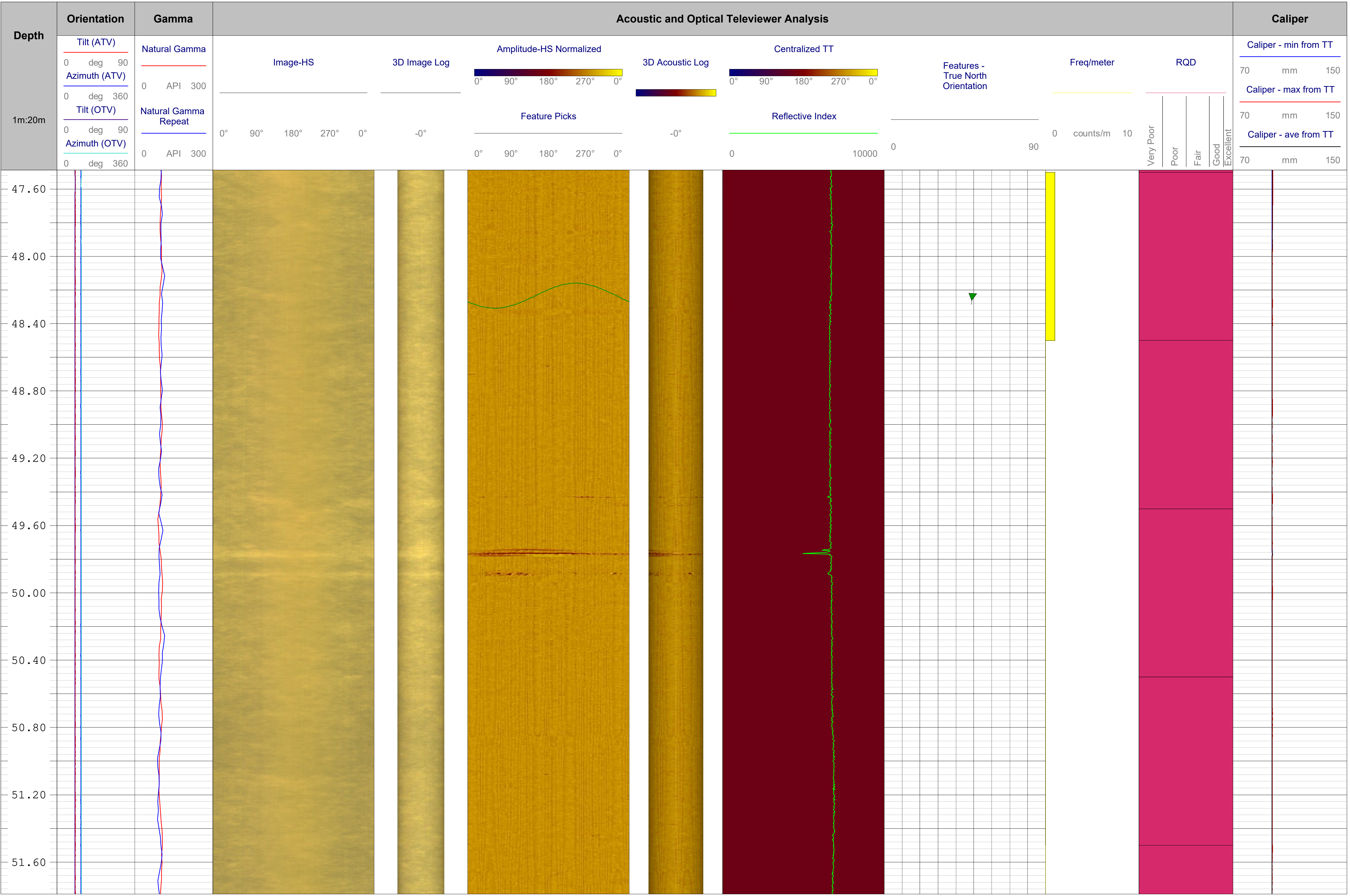
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RQD
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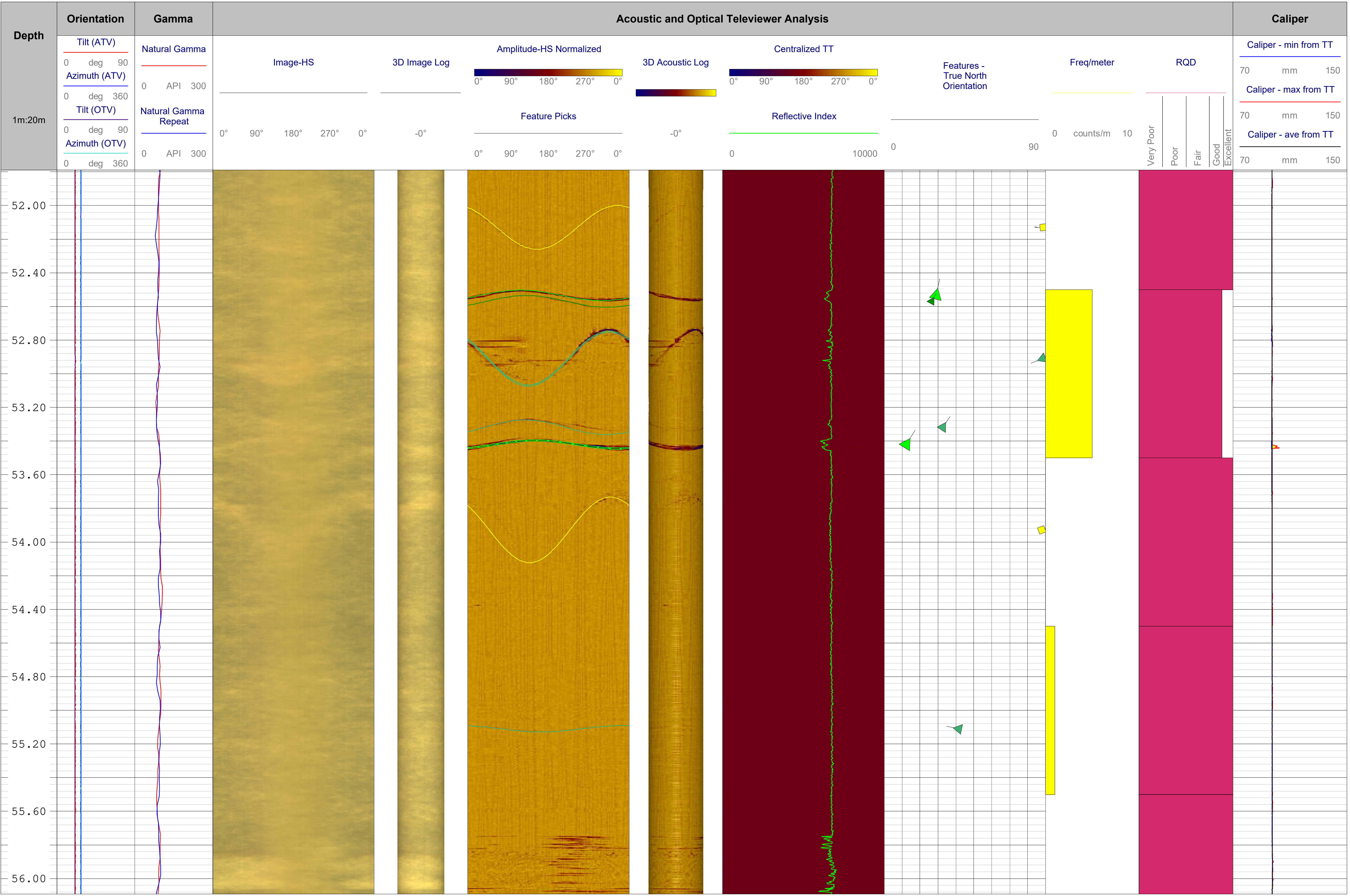
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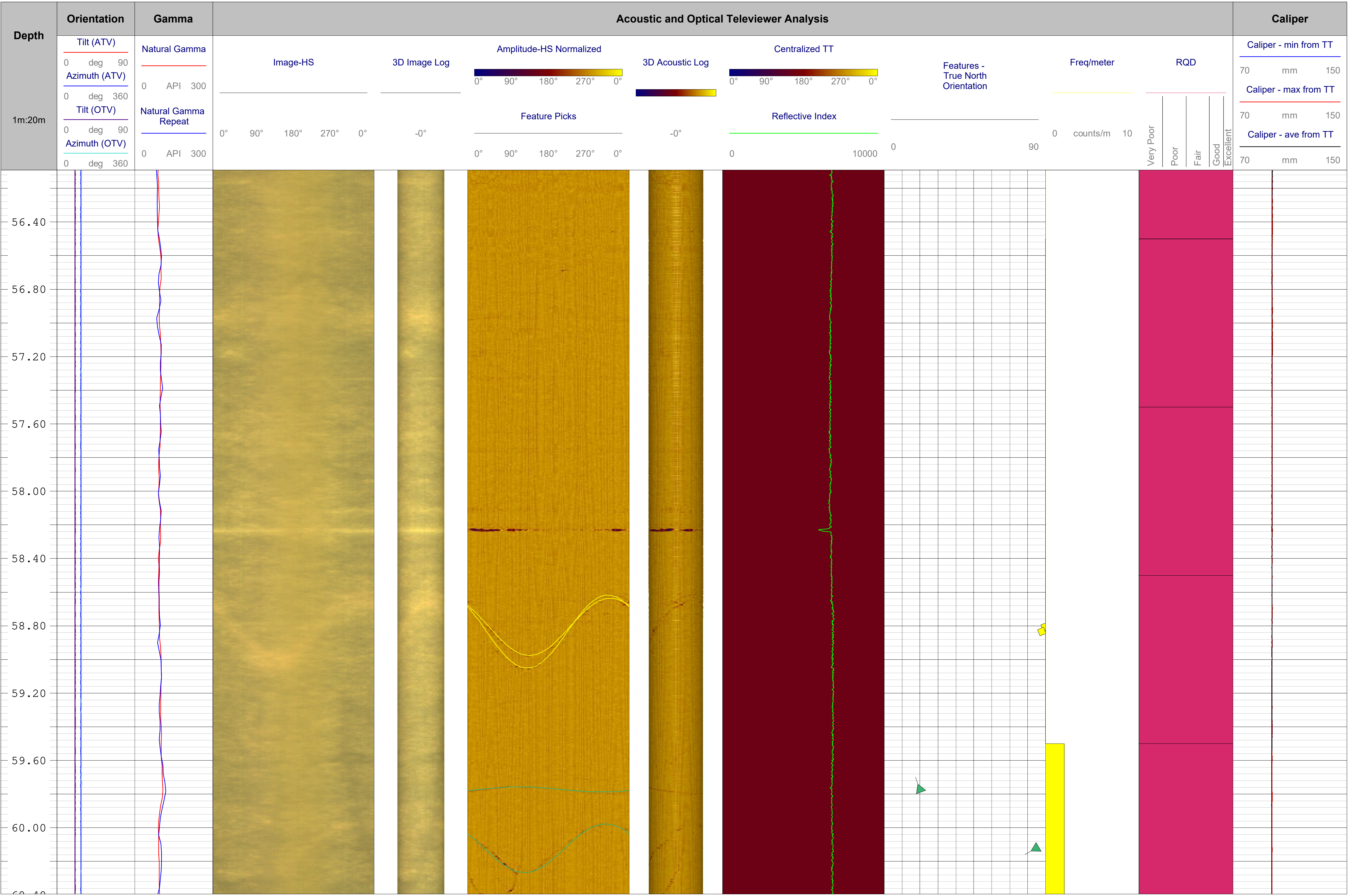
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Good
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Caliper
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70 mm 150
Caliper - max from TT
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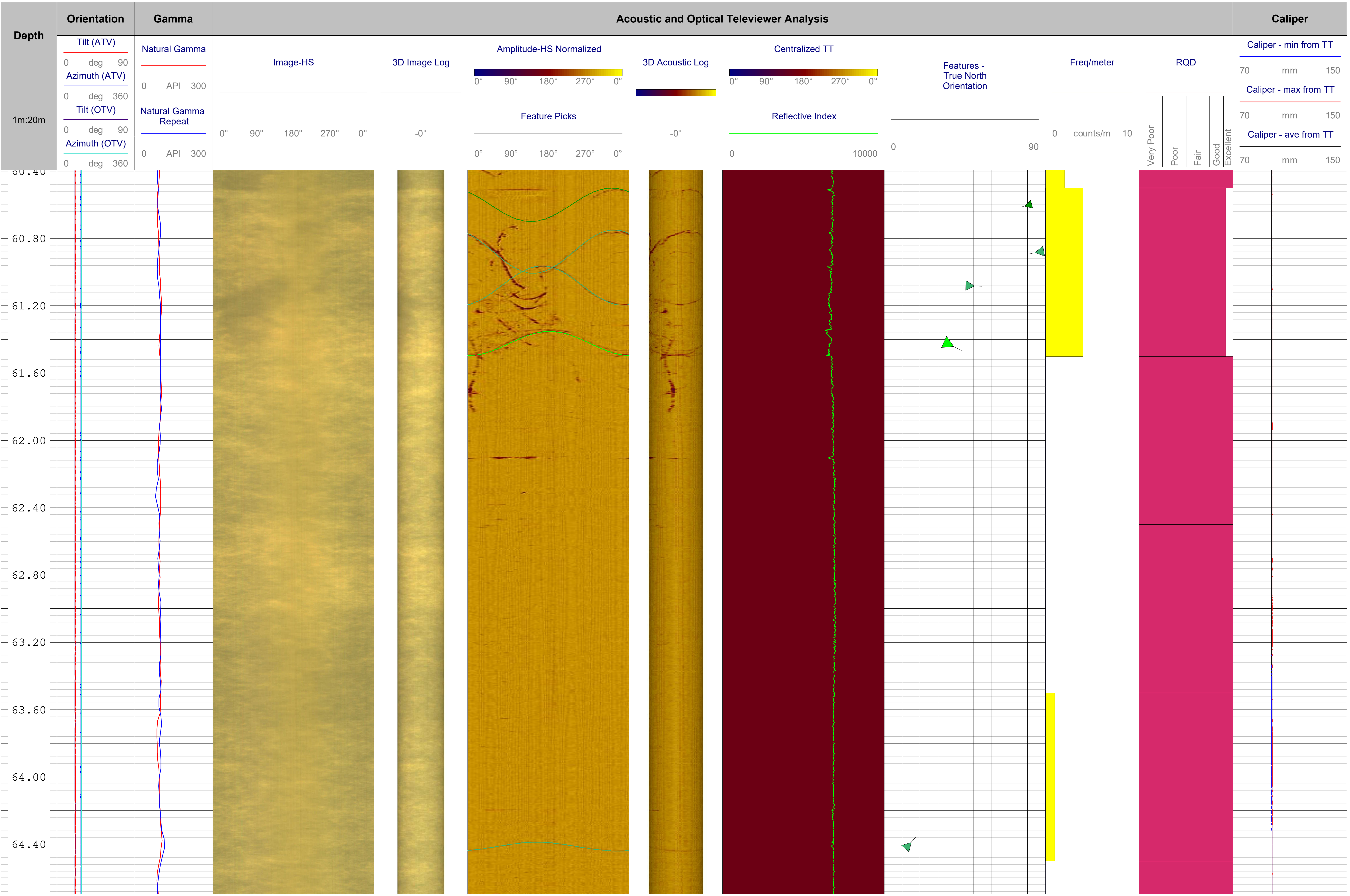
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Caliper - max from TT
70 mm 150
Caliper - ave from TT
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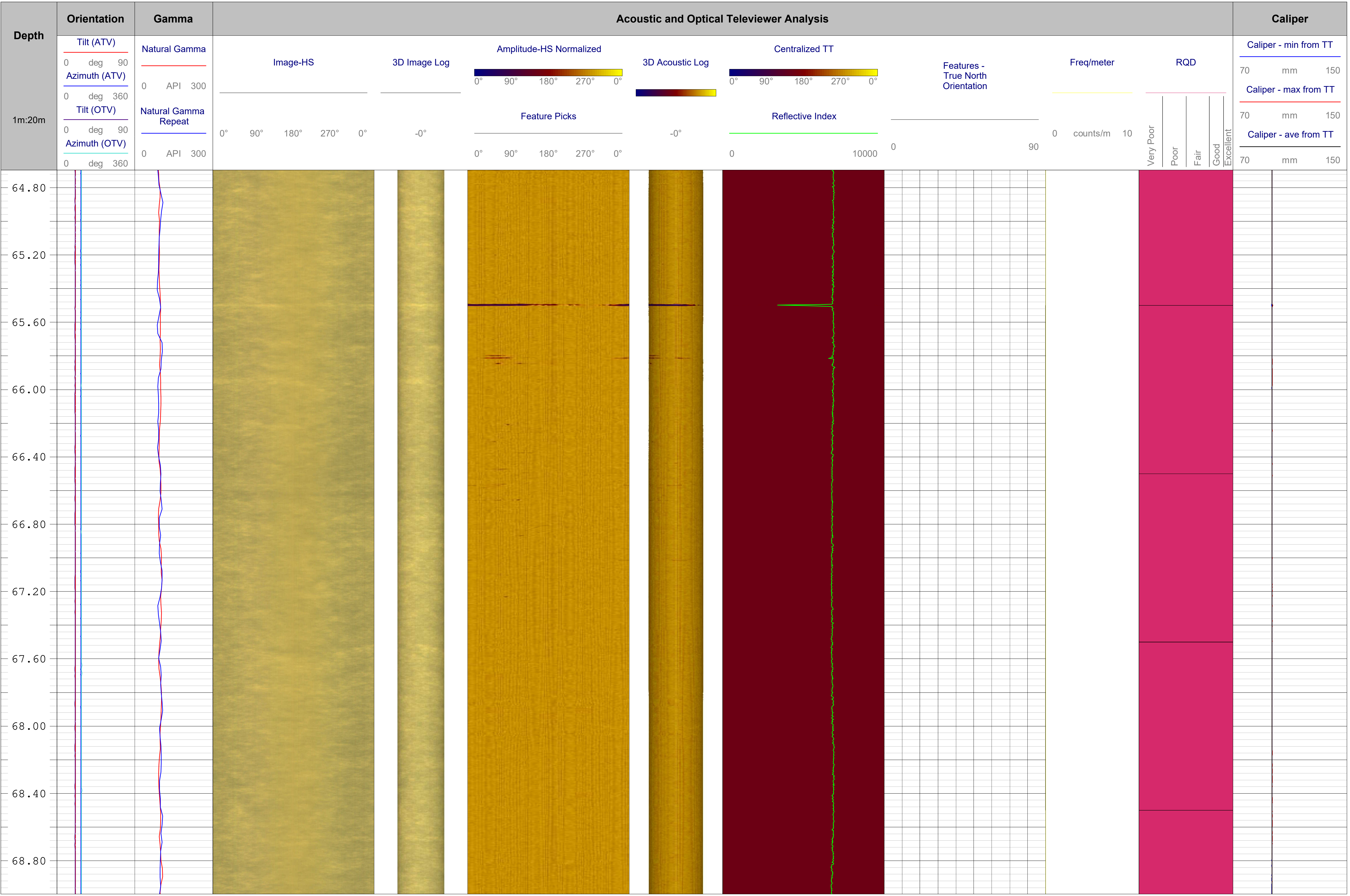
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Features - True North Orientation
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RQD
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Poor
Fair
Good
Excellent
Caliper
Caliper - min from TT
70 mm 150
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70 mm 150
Caliper - ave from TT
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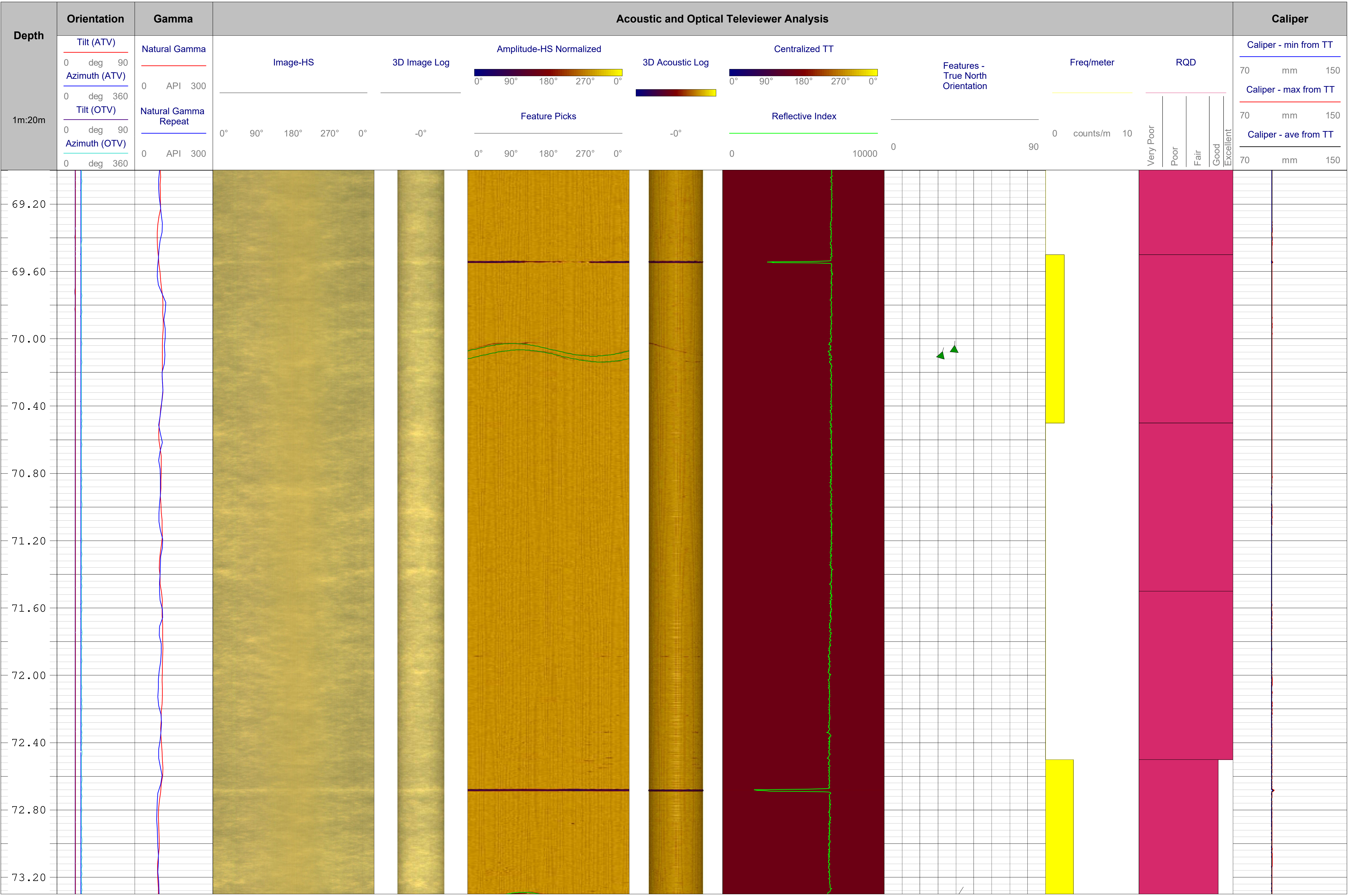
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Gamma
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0 API 300
Natural Gamma Repeat
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Acoustic and Optical Televiewer Analysis
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0° 90° 180° 270° 0°
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Amplitude-HS Normalized
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Feature Picks
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Centralized TT
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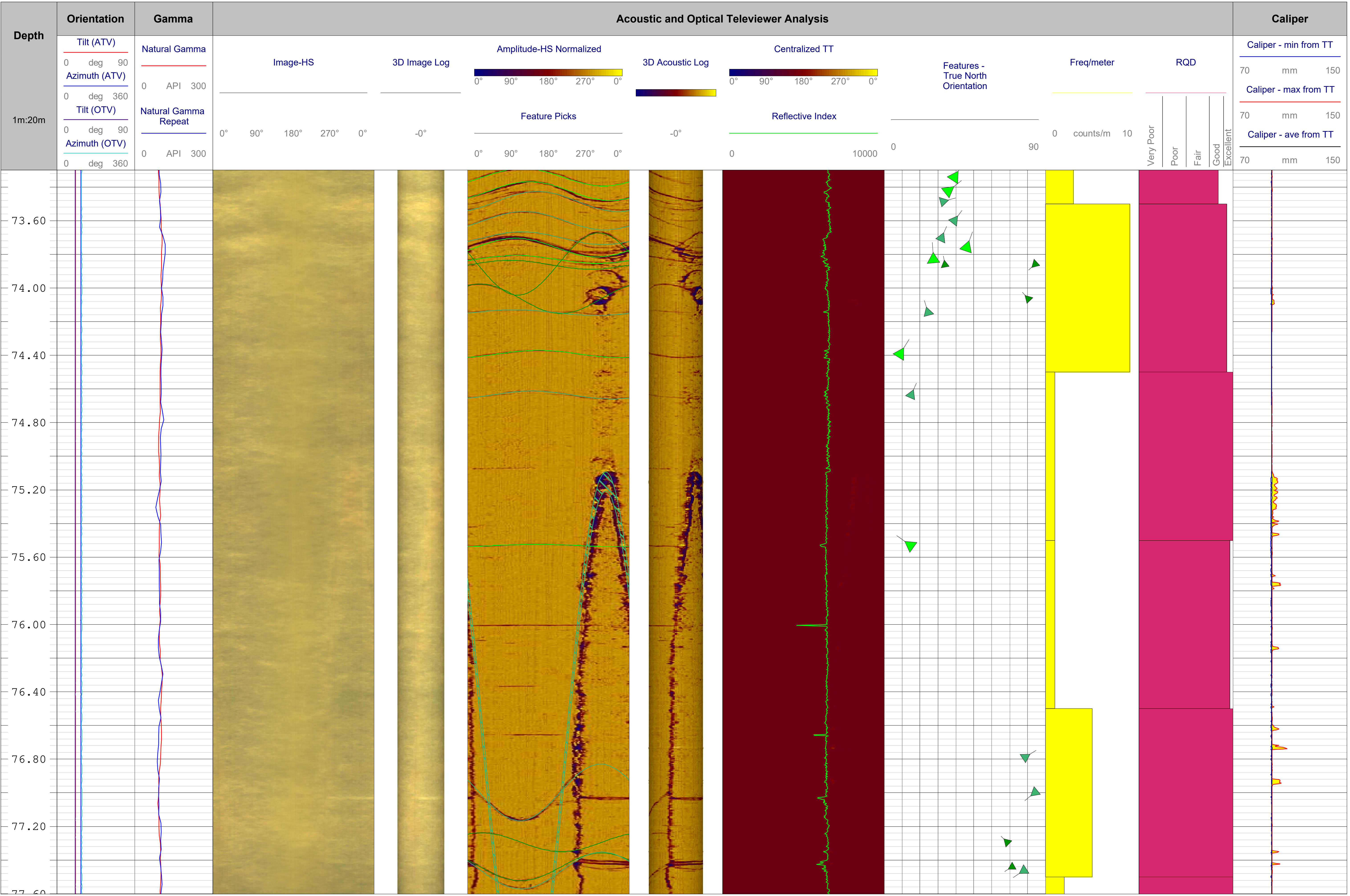
Reflective Index
0 10000
Features - True North Orientation
0 90
Freq/meter
0 counts/m 10
RQD
Very Poor
Poor
Fair
Good
Excellent
Caliper
Caliper - min from TT
70 mm 150
Caliper - max from TT
70 mm 150
Caliper - ave from TT
70 mm 150
69.20
69.60
70.00
70.40
70.80
71.20
71.60
72.00
72.40
72.80
73.20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Orientation
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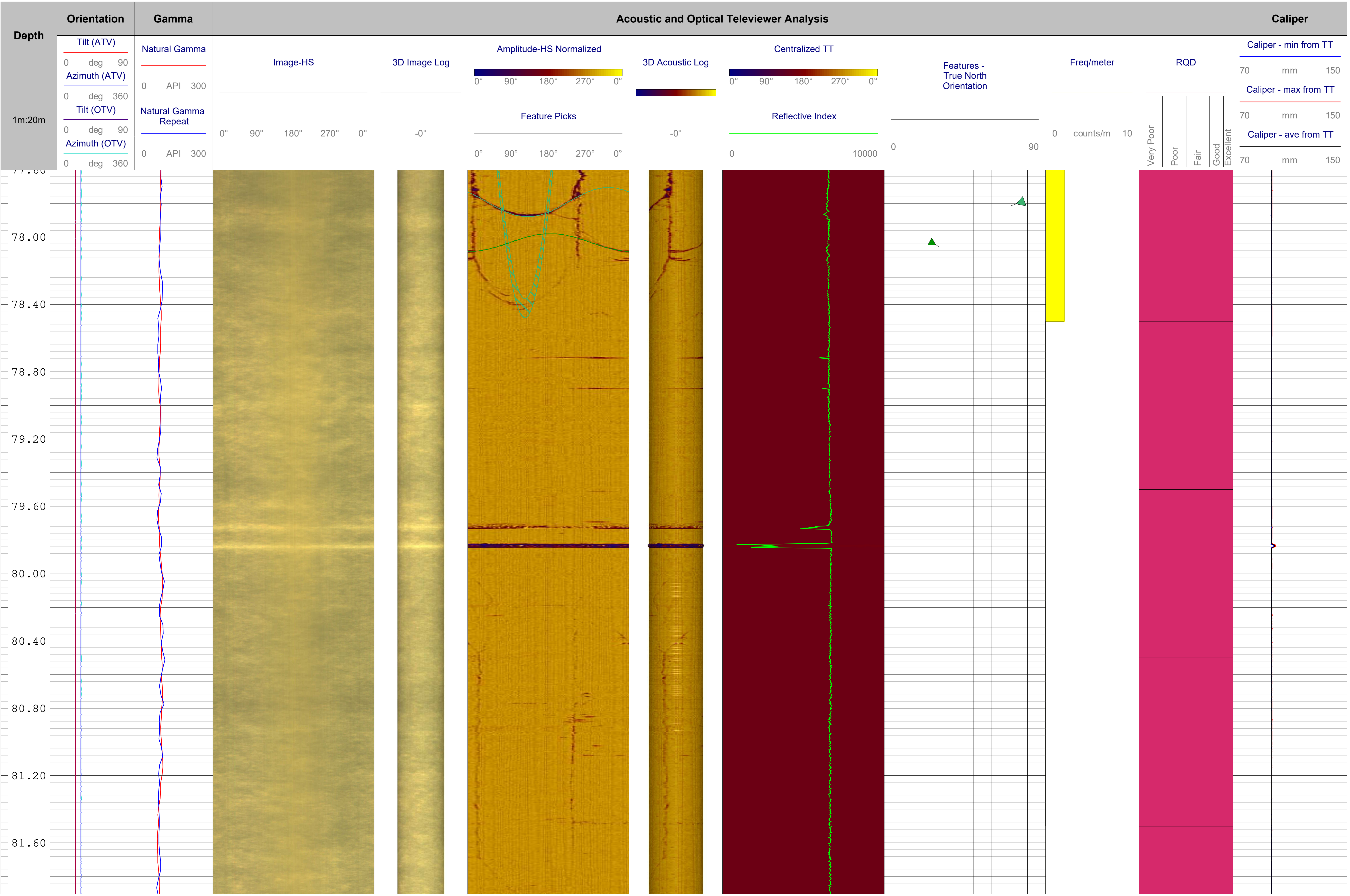
0 deg 90
Azimuth (ATV)
0 deg 360
Tilt (OTV)
0 deg 90
Azimuth (OTV)
0 deg 360
Gamma
Natural Gamma
0 API 300
Natural Gamma Repeat
0 API 300
Acoustic and Optical Televiewer Analysis
Image-HS
0° 90° 180° 270° 0°
3D Image Log
-0°
Amplitude-HS Normalized
0° 90° 180° 270° 0°
Feature Picks
0° 90° 180° 270° 0°
3D Acoustic Log
-0°
Centralized TT
0° 90° 180° 270° 0°
Reflective Index
0 10000
Features - True North Orientation
0 90
Freq/meter
0 counts/m 10
RQD
Very Poor
Poor
Fair
Good
Excellent
Caliper
Caliper - min from TT
70 mm 150
Caliper - max from TT
70 mm 150
Caliper - ave from TT
70 mm 150
73.60
74.00
74.40
74.80
75.20
75.60
76.00
76.40
76.80
77.20
77.60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Azimuth (OTV)
0 deg 360
Gamma
Natural Gamma
0 API 300
Natural Gamma Repeat
0 API 300
Acoustic and Optical Televiewer Analysis
Image-HS
0° 90° 180° 270° 0°
3D Image Log
-0°
Amplitude-HS Normalized
0° 90° 180° 270° 0°
Feature Picks
0° 90° 180° 270° 0°
3D Acoustic Log
-0°
Centralized TT
0° 90° 180° 270° 0°
Reflective Index
0 10000
Features - True North Orientation
0 90
Freq/meter
0 counts/m 10
RQD
Very Poor
Poor
Fair
Good
Excellent
Caliper
Caliper - min from TT
70 mm 150
Caliper - max from TT
70 mm 150
Caliper - ave from TT
70 mm 150
78.00
78.40
78.80
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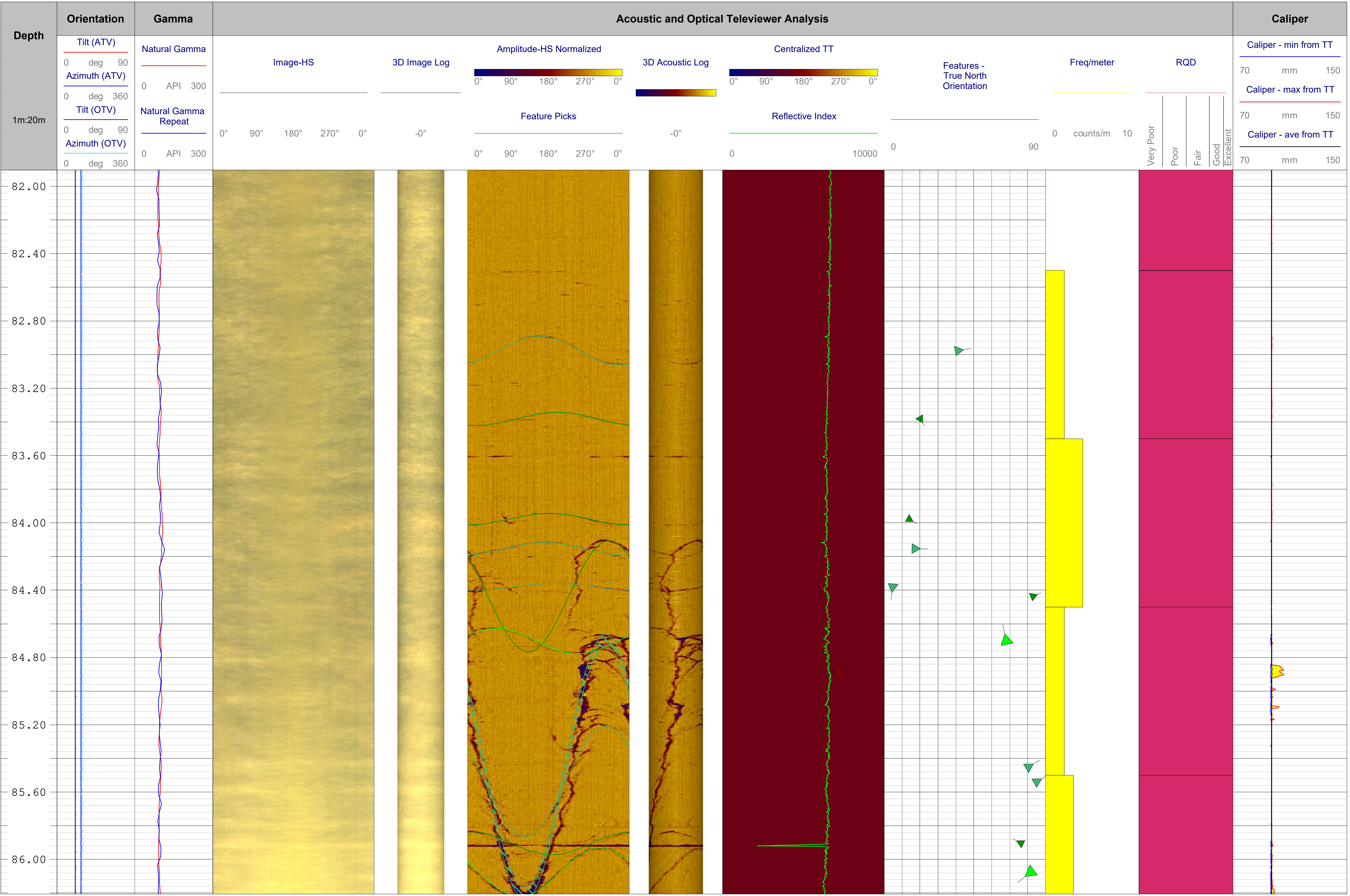
80.40
80.80
81.20
81.60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Orientation
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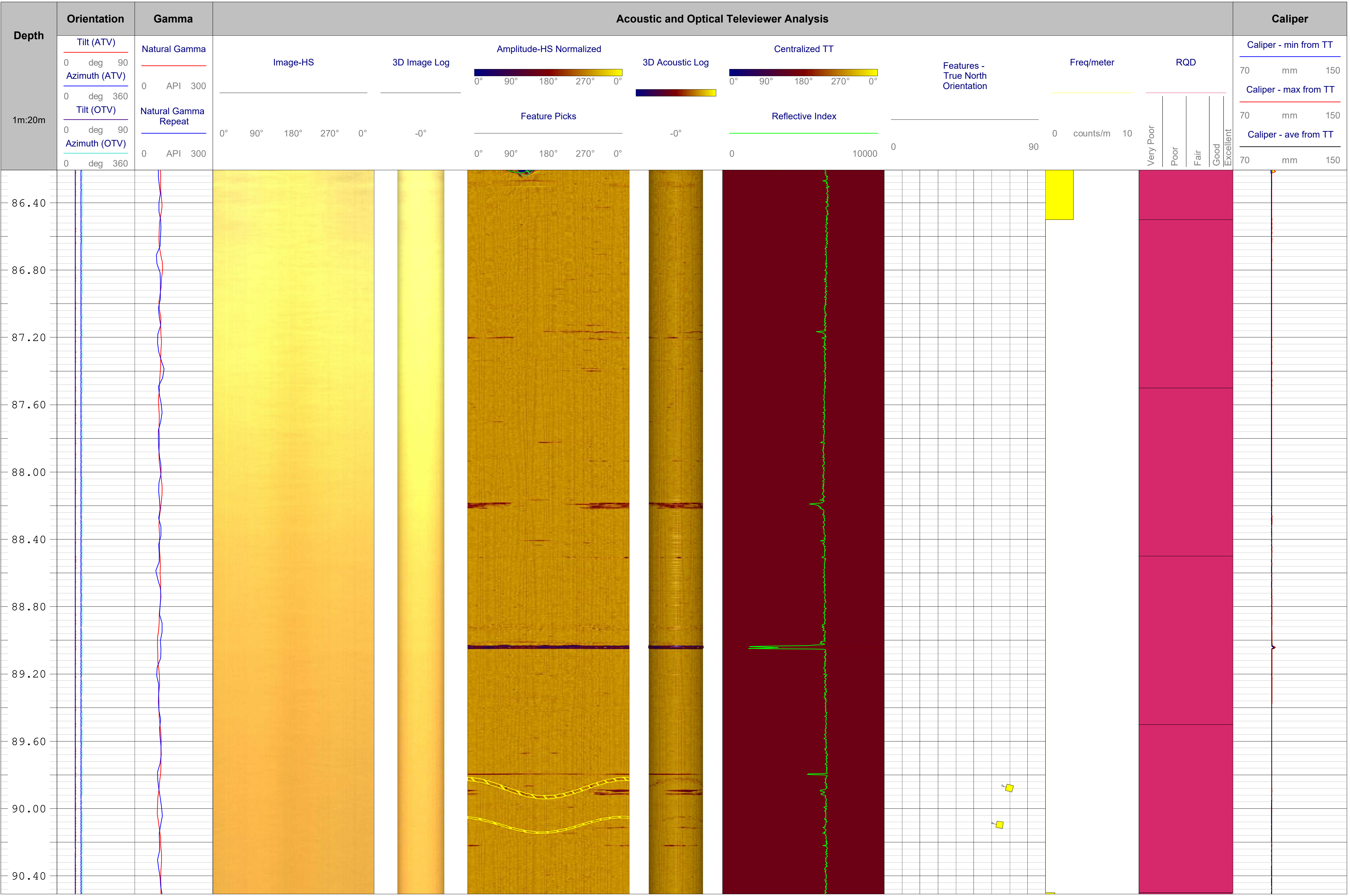
Azimuth (ATV)
0 deg 360
Tilt (OTV)
0 deg 90
Azimuth (OTV)
0 deg 360
Gamma
Natural Gamma
0 API 300
Natural Gamma Repeat
0 API 300
Acoustic and Optical Televiewer Analysis
Image-HS
0° 90° 180° 270° 0°
3D Image Log
-0°
Amplitude-HS Normalized
0° 90° 180° 270° 0°
Feature Picks
0° 90° 180° 270° 0°
3D Acoustic Log
-0°
Centralized TT
0° 90° 180° 270° 0°
Reflective Index
0 10000
Features - True North Orientation
0 90
Freq/meter
0 counts/m 10
RQD
Very Poor
Poor
Fair
Good
Excellent
Caliper
Caliper - min from TT
70 mm 150
Caliper - max from TT
70 mm 150
Caliper - ave from TT
70 mm 150
82.00
82.40
82.80
83.20
83.60
84.00
84.40
84.80
85.20
85.60
86.00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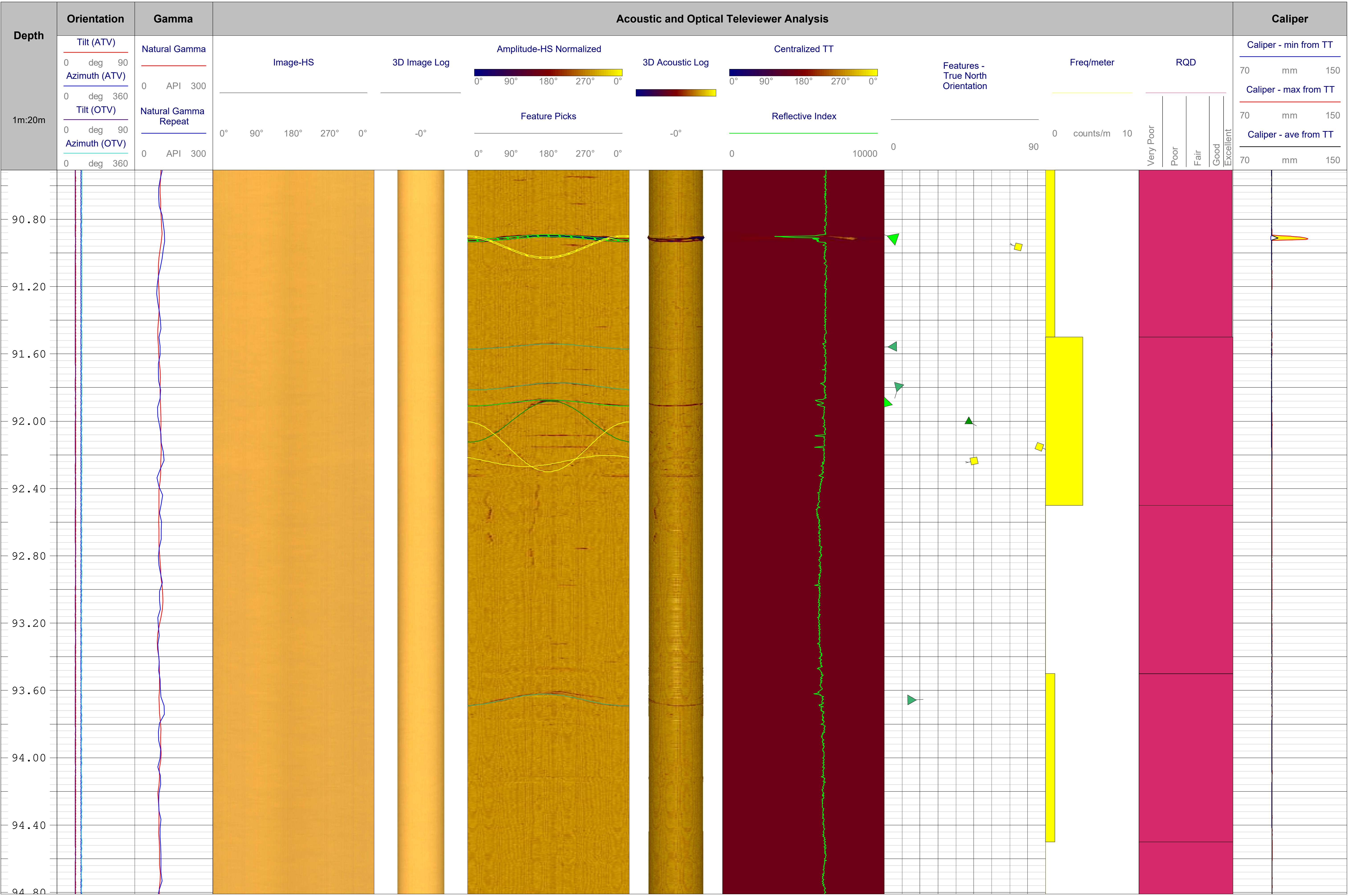
Azimuth (ATV)
0 deg 360
Tilt (OTV)
0 deg 90
Azimuth (OTV)
0 deg 360
Gamma
Natural Gamma
0 API 300
Natural Gamma Repeat
0 API 300
Acoustic and Optical Televiewer Analysis
Image-HS
0° 90° 180° 270° 0°
3D Image Log
-0°
Amplitude-HS Normalized
0° 90° 180° 270° 0°
Feature Picks
0° 90° 180° 270° 0°
3D Acoustic Log
-0°
Centralized TT
0° 90° 180° 270° 0°
Reflective Index
0 10000
Features - True North Orientation
0 90
Freq/meter
0 counts/m 10
RQD
Very Poor
Poor
Fair
Good
Excellent
Caliper
Caliper - min from TT
70 mm 150
Caliper - max from TT
70 mm 150
Caliper - ave from TT
70 mm 150
86.40
86.80
87.20
87.60
88.00
88.40
88.80
89.20
89.60
90.00
90.40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Orientation
Tilt (ATV)
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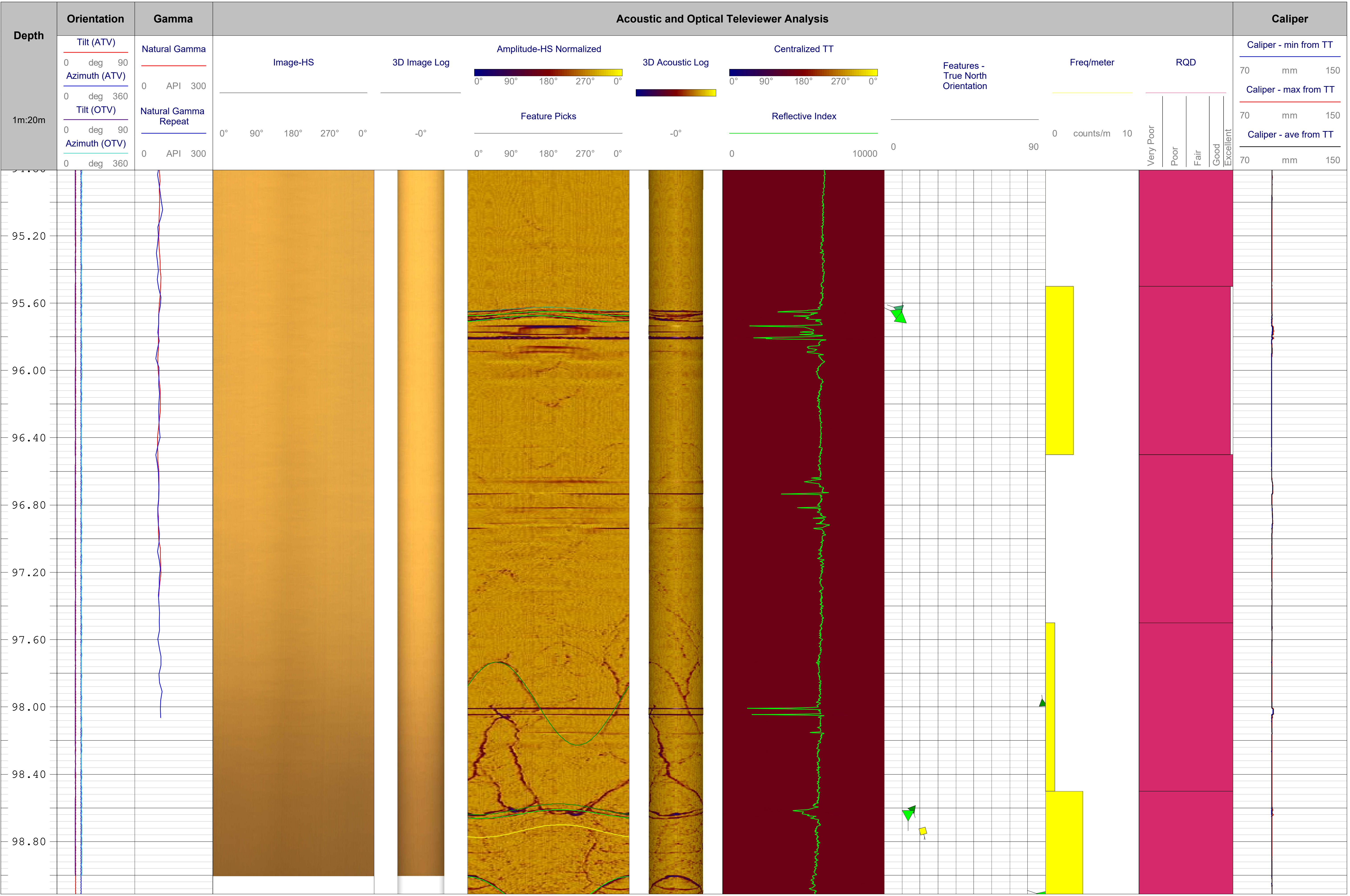
Azimuth (ATV)
0 deg 360
Tilt (OTV)
0 deg 90
Azimuth (OTV)
0 deg 360
Gamma
Natural Gamma
0 API 300
Natural Gamma Repeat
0 API 300
Acoustic and Optical Televiewer Analysis
Image-HS
0° 90° 180° 270° 0°
3D Image Log
-0°
Amplitude-HS Normalized
0° 90° 180° 270° 0°
Feature Picks
0° 90° 180° 270° 0°
3D Acoustic Log
-0°
Centralized TT
0° 90° 180° 270° 0°
Reflective Index
0 10000
Features - True North Orientation
0 90
Freq/meter
0 counts/m 10
RQD
Very Poor
Poor
Fair
Good
Excellent
Caliper
Caliper - min from TT
70 mm 150
Caliper - max from TT
70 mm 150
Caliper - ave from TT
70 mm 150
90.80
91.20
91.60
92.00
92.40
92.80
93.20
93.60
94.00
94.40
94.80


Depth
1m:20m
Orientation
Tilt (ATV)
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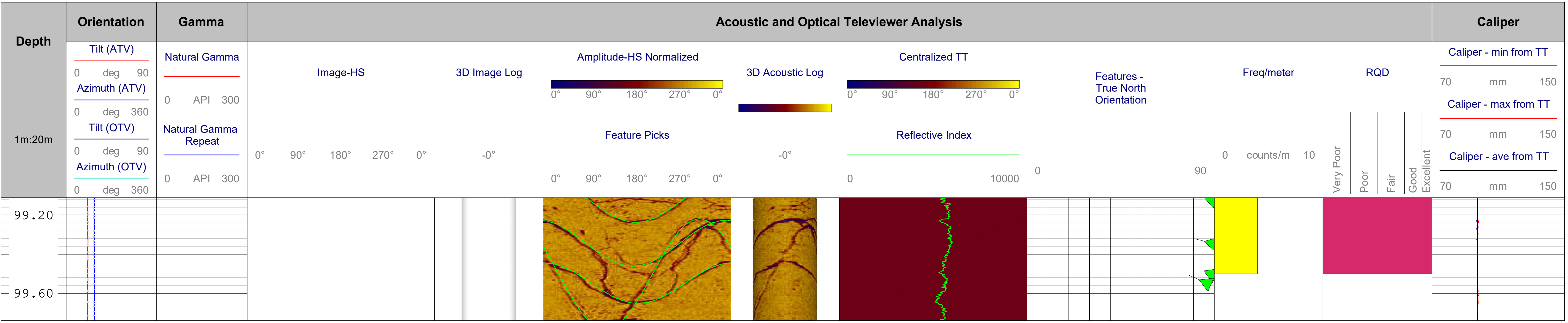
Azimuth (ATV)
0 deg 360
Tilt (OTV)
0 deg 90
Azimuth (OTV)
0 deg 360
Gamma
Natural Gamma
0 API 300
Natural Gamma Repeat
0 API 300
Acoustic and Optical Televiewer Analysis
Image-HS
0° 90° 180° 270° 0°
3D Image Log
-0°
Amplitude-HS Normalized
0° 90° 180° 270° 0°
Feature Picks
0° 90° 180° 270° 0°
3D Acoustic Log
-0°
Centralized TT
0° 90° 180° 270° 0°
Reflective Index
0 10000
Features - True North Orientation
0 90
Freq/meter
0 counts/m 10
RQD
Very Poor
Poor
Fair
Good
Excellent
Caliper
Caliper - min from TT
70 mm 150
Caliper - max from TT
70 mm 150
Caliper - ave from TT
70 mm 150
95.20
95.60
96.00
96.40
96.80
97.20
97.60
98.00
98.40
98.80


Depth
1m:20m
Orientation
Tilt (ATV)
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Azimuth (ATV)
0 deg 360
Tilt (OTV)
0 deg 90
Azimuth (OTV)
0 deg 360
Gamma
Natural Gamma
0 API 300
Natural Gamma Repeat
0 API 300
Acoustic and Optical Televiewer Analysis
Image-HS
0° 90° 180° 270° 0°
3D Image Log
-0°
Amplitude-HS Normalized
0° 90° 180° 270° 0°
Feature Picks
0° 90° 180° 270° 0°
3D Acoustic Log
-0°
Centralized TT
0° 90° 180° 270° 0°
Reflective Index
0 10000
Features - True North Orientation
0 90
Freq/meter
0 counts/m 10
RQD
Very Poor
Poor
Fair
Good
Excellent
Caliper
Caliper - min from TT
70 mm 150
Caliper - max from TT
70 mm 150
Caliper - ave from TT
70 mm 150
99.20
99.60

# Appendix B

## 30 November 2019 Daily Report

## WP02 & WP03 TEST PLAN- SITE INFRASTRUCTURE AND ACCESS ROAD CONSTRUCTION
## IGNACE, ONTARIO

**Record Number: SCB1912026-FOR-051** 191130

**Prepared by:** Martin Little

**Distributed By:** Adam Coulson (WP02 Lead) and Eliane Cabot (WP03 Lead)

**Start Date / Time: 191130 / 7:00 am** **End Date / Time: 191201 / 7:00 am**

**Weather:**

-11 Degrees C partly clouds Day Shift, -14 Degrees C and clear Night Shift

**Health, Safety and Environment incidents**

Total number that occurred during this reporting period: __0__

## Summary of Work Conducted

*Note: All depths are in metres down-hole unless otherwise stated.*

<table>
<tr><th>Work Package and Task</th><th colspan="2">In this reporting period (Y/N)</th><th colspan="6">Description</th></tr>
<tr><td>WP01 Site Infrastructure</td><td colspan="2">Y</td><td colspan="6">MCL completed sandbagging of fence installment.</td></tr>
<tr><td rowspan="3">WP02 Drilling</td><td rowspan="2">Y</td><td rowspan="2">Day</td><td>From:</td><td>95.17 m</td><td>To:</td><td>101.20 m</td><td>Total:</td><td>6.03 m</td></tr>
<tr><td colspan="6">Advance HQ3 95.17 m to 98.20 m (CR038)<br>Advance HQ3 98.20 m to 101.20 m (CR039)<br>Pull one rod<br>Flush Hole (Vac Truck) for preparation of DGI Downhole Survey<br>Pull All rods</td></tr>
<tr><td>N</td><td>Night</td><td>From:</td><td>- m</td><td>To:</td><td>- m</td><td>Total:</td><td>- m</td></tr>
</table>

**Summary of Work Conducted**

*Note: All depths are in metres down-hole unless otherwise stated.*

| **Work Package and Task** | **In this reporting period (Y/N)** | **Description** |
|---|---|---|
| | | DGI Downhole Survey<br>Ream hole to 11 m |
| WP03 Core Logging / Photography / Sampling | | Log and photograph CR038 from 95.17 m to 98.20 m<br>Log and photograph CR039 from 98.20 m to 101.20 m<br>Gyro Calibration<br>Gyro Measurement<br>Source Water Sampling (to be shipped on Dec 1 2019)<br>Drill Fluid Sampling |

**Summary of Work Conducted**

*Note: All depths are in metres down-hole unless otherwise stated.*

| **Work Package and Task** | **In this reporting period (Y/N)** | **Description** |
|---|---|---|
| WP05 Geophysical Logging | Y | DGIS Downhole Survey – 1.34m (effective 15.2m because of the HWT casing) to 99.8m with an accuracy of +/-4 cm, which is within the tolerance (ASDE was 1.38 m from a start of 1.34 m). Accumulation of drill cuttings in the last meter of the hole rendered the imaged to cloudy to continue.<br>Set up and Calibration<br>Acoustic Televiewer Survey<br>Optical Televiewer Survey |
| WP06 Hydraulic Testing | N | |
| WP07 Opportunistic Groundwater Sampling | N | |
| WP08 Well Sealing | N | |
| WP09 Instrumentation | N | |
| WP12 Vertical Seismic Profiling | N | |

**Summary of Work Conducted**

*Note: All depths are in metres down-hole unless otherwise stated.*

| Work Package and Task | In this reporting period (Y/N) | Description |
|---|---|---|
| Other (specify) | N | |

**Technical (other than Work Package work detailed above)**

| Approximate start and end times | Task Performed |
|---|---|
| n/a | n/a |

**Next 24 hours' activities planned**

Install HWT Casing to 100.77 m (provisional)

**Workers on Site (Consultant, Subs)**

| Name | Company | Position | Shift Worked | Hours on Site |
|---|---|---|---|---|
| Martin Little | Wood | Site Supervisor | Day | 12 |
| Michael Anderson | Wood | Drill Supervisor | Day | 12 |
| Cynthia Lane | Wood | Core Logger | Day | 12 |
| Neil Davidson | Major | Drill Foreman | Day | 11 |

**Workers on Site (Consultant, Subs)**

| **Name** | **Company** | **Position** | **Shift Worked** | **Hours on Site** |
|---|---|---|---|---|
| Jonathan Bowering | Major | Driller | Day | 12 |
| Graham Meyer | Major | Driller Helper | Day | 12 |
| Jared Smith | DGI | Supervisor | Day | 15.75 |
| Alexei Parinov | DGI | Technician | Day | 15.75 |
| Shady Hashem | Wood | Construction Manager | Day | 3.25 |
| Jack McKay | NWS | Driver | Day | 2 |
| Mario Bianchin | Wood | WP07 Lead | Day | 12 |
| Andrew Lee | Wood | WP07 Sampling | Day | 12 |
| Derek Grandbois | MCL | Supervisor | Day | 0.25 |
| Braeden Hinds | MCL | Labour | Day | 0.25 |
| Jason Boucha | MCL | Labour | Day | 4.75 |
| Jimmy Trunchon | Major | Driller | Night | 12 |
| Kory D'Entremont | Major | Driller Helper | Night | 12 |
| Frank Grivich | Wood | Drill Supervisor | Night | 12 |
| Sepehr Rahimi | Wood | Core Logger | Night | 12 |

| **Visitors on Site (NWMO, WLON, Community Members, MNRF, others)** | | | | |
|---|---|---|---|---|
| **Name** | **Affiliation** | **Purpose** | **Shift Present** | **Hours on Site** |
| Elise Leroux | NWMO | WP01 to WP10 | Day | 7 |

| **Quality Assurance** | |
|---|---|
| **Test Conducted** | **Reference Documentation** |
| DQC Core Logging, Photography, and Sampling | IG_BH04_WP03_Daily_ DQC_191130_Day_R0 |
| DQC Daily Drill Record | IG_BH04_WP02_DQC_Daily_Drill_Record_191130_R0 |
| Deviation Cal. Check | IG_BH04_WP02_DQC_Dev_Cal_Check_CR039_191130_R0 |
| CR038 Drill Record | IG_BH04_WP02_DQC_Drill_Record_Form_CR038_191130_R0 |
| CR039 Drill Record | IG_BH04_WP02_DQC_Drill_Record_Form_CR039_191130_R0 |
| Borehole Survey Tracking | IG_BH04_WP02_DQC_Borehole_Survey_191130_R0 |
| DQC Fluid Sample List | IG_BH04_WP02 DQC Fluid_Samples_List_R0 |

| **Equipment Calibrations** | |
|---|---|
| **Calibration Conducted** | **Reference Documentation** |
| Daily Instrument Calibration Check | IG_BH04_WP02_DQC_Daily_Cal_Form_191130_R0 |

**Samples Collected**

| **Sample Type** *(e.g., rock core, drill water, etc.)* | **Sample Name** | **Number of Bottles / Boxes / Cores** | **Purpose** *(e.g., archive, porewater, aqueous extraction, etc.)* | **Sampled For** *(e.g., lab name, NWMO)* |
|---|---|---|---|---|
| Drill Water | IG_BH04_DW_001 | 12 | Archive | NWMO |

**Samples Shipped**

| **Sample Name** | **Shipped by** | **Shipped to** | **Tracking Number** |
|---|---|---|---|
| n/a | n/a | n/a | n/a |

**Health and Safety**

Safety share: Communication, Many different processes scheduled for today, much movement around site, Discuss tasks, hazards, and work plan areas with everyone to avoid disruption to work flow.  Ensure SOP's are reviewed and followed if needed.

AHA for GeoMechanical Assessment Via Diamond Drilling, Unloading / Electrical / Water, Downhole Survey, Water Sampling

**Environmental**

[n/a]

## Loss of Process

Tight site constraints.

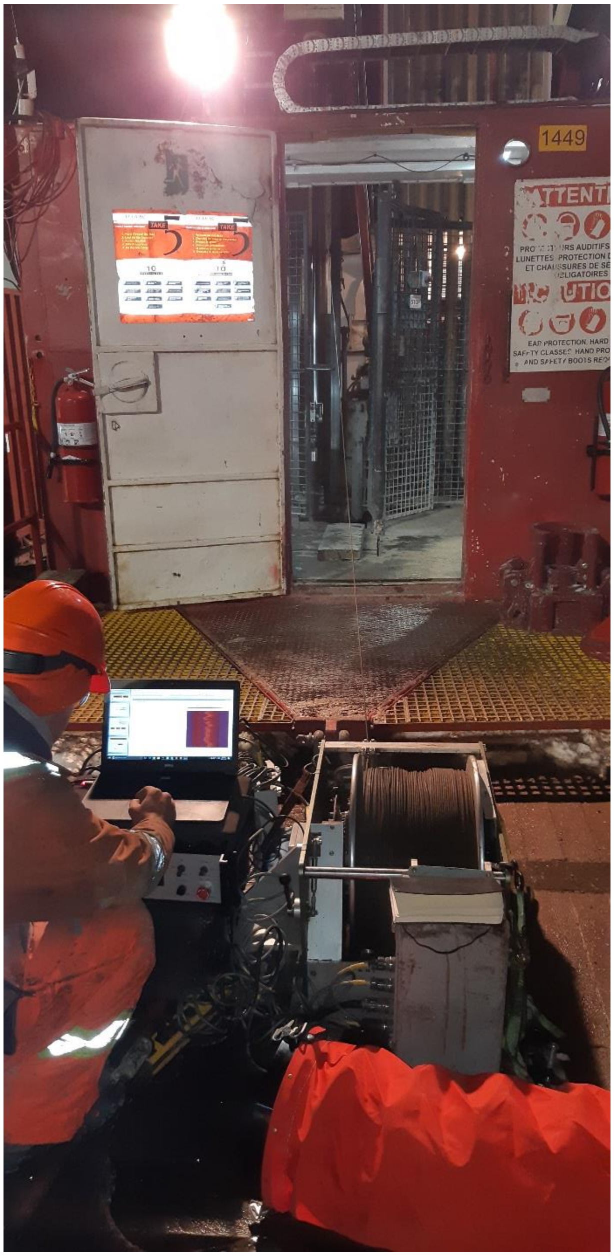
Non Functional Waste Water Tank on site requires scheduling of vac trucks for removal of waste water from BH-04

WP01 still in progress

## Photographs

Photograph 1. Verifying passage down hole is clear of obstruction.

Photograph 2. ATV on drill deck prior to deployment.



Photograph 3. ATV survey being conducted on drill deck.

Photograph 4. HWT casings.

Photograph 5. Reaming bit and core barrel.

Photograph 6. Reaming bit.

# Appendix C

# ABI (ATV) and OBI (OTV) Data QA/QC Record Sheets and the Signed Off Data Acquisition Form

# Data QA/QC Record Sheet - ATV

Project: ___L-576 Wood - Mississauga NWMO______

Client: ___Wood – Mississauga NWMO____________

Date: _____11/30/2019__________________________

Reviewed by: ___Roxanne Leblanc__________________

| **PARAMETER: ATV (Acoustic Televiewer)** | |
|---|---|
| **Probe (model/sn)** | ABI 2G 182903 |
| **Source (sn)** | N/A |
| | |
| **Survey File Name:** | IG-BH04_WP05_ATVGR_u4_113019.tfd |
| **Depth Start zero** | 1.34 |
| **Depth Start data** | 100.00 |
| **Depth End Data** | 15.35 |
| **Depth End Zero** | 1.38 |
| **Data Point Errors (%)** | 0.034 |
| | |
| **Survey File Name:** | IG-BH04_WP05_ATVGR_u2_113019.tfd |
| **Depth Start zero** | 1.34 |
| **Depth Start data** | 80.06 |
| **Depth End Data** | 69.99 |
| **Depth End Zero** | 1.38 |
| **Data Point Errors (%)** | 0.04 |
| | |
| **QA/QC File Name** | IG-BH04_WP05_ATVGR_d1_113019.tfd |
| **Depth Start zero** | 1.34 |
| **Depth Start data** | 1.34 |
| **Depth End Data** | 80.06 |
| **Depth End Zero** | 1.38 |
| **Data Point Errors (%)** | 0.06 |

| | |
|---|---|
| **QA/QC File Name** | IG-BH04_WP05_ATVGR_d3_113019.tfd |
| **Depth Start zero** | 1.34 |
| **Depth Start data** | 69.99 |
| **Depth End Data** | 100.00 |
| **Depth End Zero** | 1.38 |
| **Data Point Errors (%)** | 0.00 |
| | |
| **Data Repeats (Survey vs QA/QC)** | [✓ Yes] \| No |
| **Depth Shift Acceptable (Start Zero vs End Zero)** | [✓ Yes] \| No |
| **Data points errors below 1%** | [✓ Yes] \| No |

**Comments:**

In order to match the acoustic televiewer to the optical televiewer, DGI uses a depth matching method. DGI will take the televiewer that records the best zero and will use that as a reference log. Then a series of depth points are selected downhole and matched to the other televiewer. Attached is a text file containing these depth matches.

# Data QA/QC Record Sheet - OTV

Project: ___L-576 Wood - Mississauga NWMO______

Client: ___Wood – Mississauga NWMO____________

Date: _____11/30/2019_________________________

Reviewed by: ___Roxanne Leblanc_________________

| | |
|---|---|
| **PARAMETER: OTV (Optical Televiewer)** | |
| **Probe (model/sn)** | OTV 2G 170709 |
| **Source (sn)** | N/A |
| | |
| **Survey File Name:** | IG-BH04_WP05_OTVGR_u4_113019.tfd |
| **Depth Start zero** | 1.19 |
| **Depth Start data** | 99.08 |
| **Depth End Data** | 15.53 |
| **Depth End Zero** | 1.20 |
| **Data Point Errors (%)** | 0.075 |
| | |
| **Survey File Name:** | IG-BH04_WP05_OTVGR_u2_113019.tfd |
| **Depth Start zero** | 1.19 |
| **Depth Start data** | 90.86 |
| **Depth End Data** | 79.54 |
| **Depth End Zero** | 1.20 |
| **Data Point Errors (%)** | 0.00 |
| | |
| **QA/QC File Name** | IG-BH04_WP05_OTVGR_d1_113019.tfd |
| **Depth Start zero** | 1.19 |
| **Depth Start data** | 1.19 |
| **Depth End Data** | 90.86 |
| **Depth End Zero** | 1.20 |
| **Data Point Errors (%)** | 0.00 |

| | |
|---|---|
| **QA/QC File Name** | IG-BH04_WP05_OTVGR_d3_113019.tfd |
| **Depth Start zero** | 1.19 |
| **Depth Start data** | 79.54 |
| **Depth End Data** | 99.08 |
| **Depth End Zero** | 1.20 |
| **Data Point Errors (%)** | 0.00 |
| | |
| **Data Repeats (Survey vs QA/QC)** | [✓ Yes] \| No |
| **Depth Shift Acceptable (Start Zero vs End Zero)** | [✓ Yes] \| No |
| **Data points errors below 1%** | [✓ Yes] \| No |

**Comments:**

In order to match the acoustic televiewer to the optical televiewer, DGI uses a depth matching method. DGI will take the televiewer that records the best zero and will use that as a reference log. Then a series of depth points are selected downhole and matched to the other televiewer. Optical televiewer quality is poor due to fluid clarity.

Based on IG-BH04 DGI Data QA/QC Record Sheets for ATV and OTV (above), the Project Manager (Alejandro Rojas) and Senior Data Analyst (Roxanne Leblanc) certify that all data was acquired in accordance with WP05 and passes quality control. The crew at site is authorized to demobilize from site.

______________________
Alejandro Rojas
Project Manager

Roxanne Leblanc
______________________
Roxanne Leblanc
Senior Data Analyst