00231 ADR 3D study at Brukunga

Integrated use of geological knowledge and the ADR geophysical results to build a 3D model of the sulphide mineralisation.

Executive Summary

- This report collects all the work completed during project 00231 using the dataset from Brukunga (in 2013 as part of project 00136). This report is internal, and will have a strong focus on the methodology, capturing the current aspect of the tools, as well as all the developments that have been accomplished for them during the project. The work was focused on three different tools:

1) **Sulphide identification using Weights of Evidence**: Carried out primarily by Lewis Lawrence after development by Simon Richards. It proved to be a very successful method in identifying the presence of high grade sulphide intervals in Brukunga, as well as in multiple other test locations. It's highly quantitative and straightforward from the raw data. It has shown excellent repeatability on close-by scans.

2) **Sulphide identification using Lithmetrics:** Carried out primarily by David Limmer. This method applied the combined fundamentals of lithmetrics and Weights of Evidence. Wile showing results that are not as precise as the WofE, this method has proved capable of approximating sulphide depths. The main difference with WofE is that this method firsts crunches the data thought an intense normalisation process. It has shown good repeatability in close-by scans.

3) **Structural mapping using Energy Mean Transect datasets:** Carried out primarily by Octavio Segura Delgado with support from Michael Robinson. This method was first carried out from the Stare Transect, proving that we can produce a very similar output to the one of project 00136. With the stare transect we can find the top of the mineralised sulphide bedding. It was then carried out with the P-Scan Transect, this one was very good at imaging the dips of the units, as well as the major a medium scale faults in the scanned area. These prognosis were done blind, and then validated using the Seismic line. The repeatability between the Stare and P-Scan is high, showing repeating features between both datasets.

- In conclusion, Adrok has developed a toolset capable of finding Sulphides based on a quantitative method calibrated with training sites from all over the globe, this has been refined and can now be utilised blind as an exploration tool. We have also developed our expertise at imagining the structure of the deposit, and can produce an interpretation of dips and faults from our Profile Scan data.

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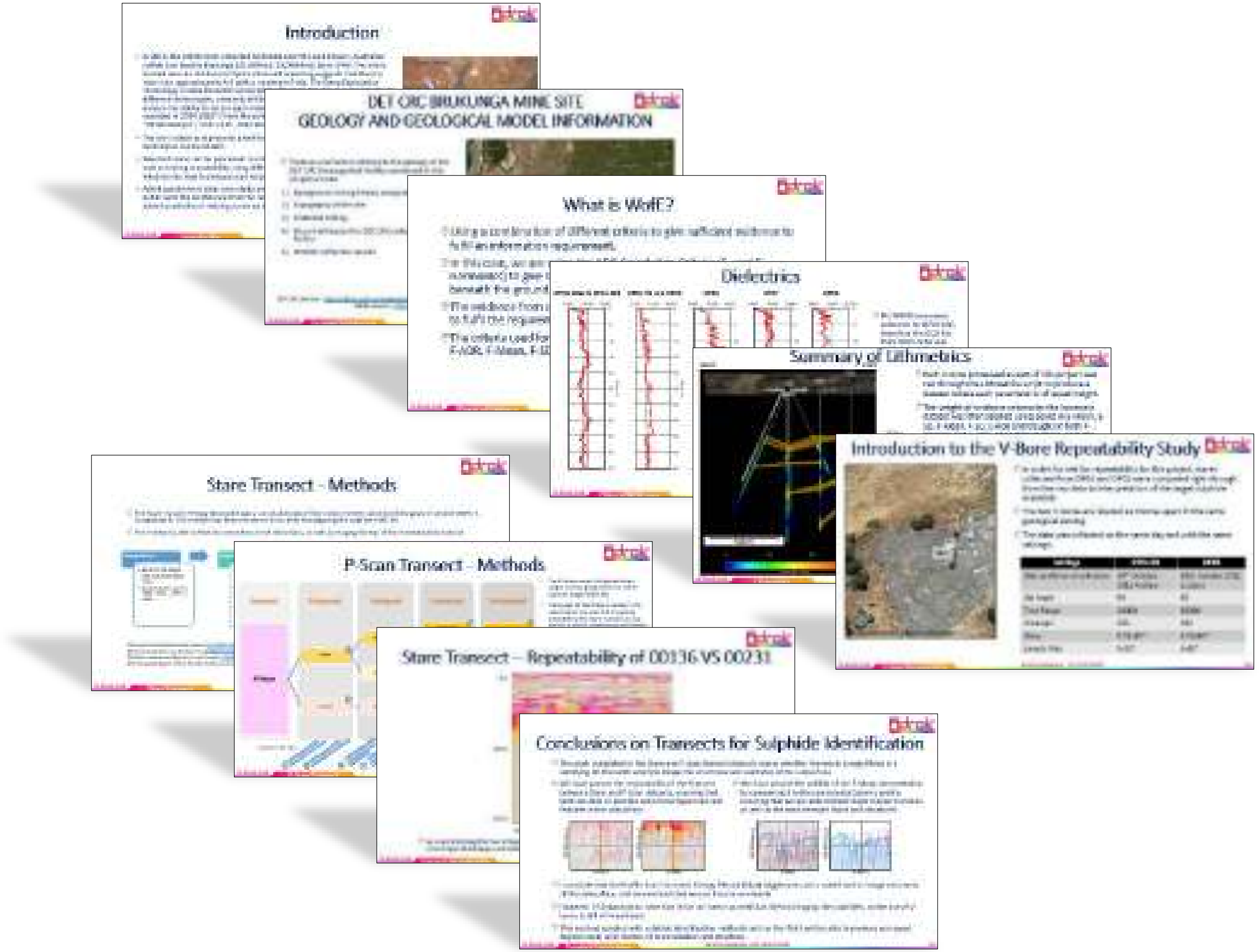

Introduction
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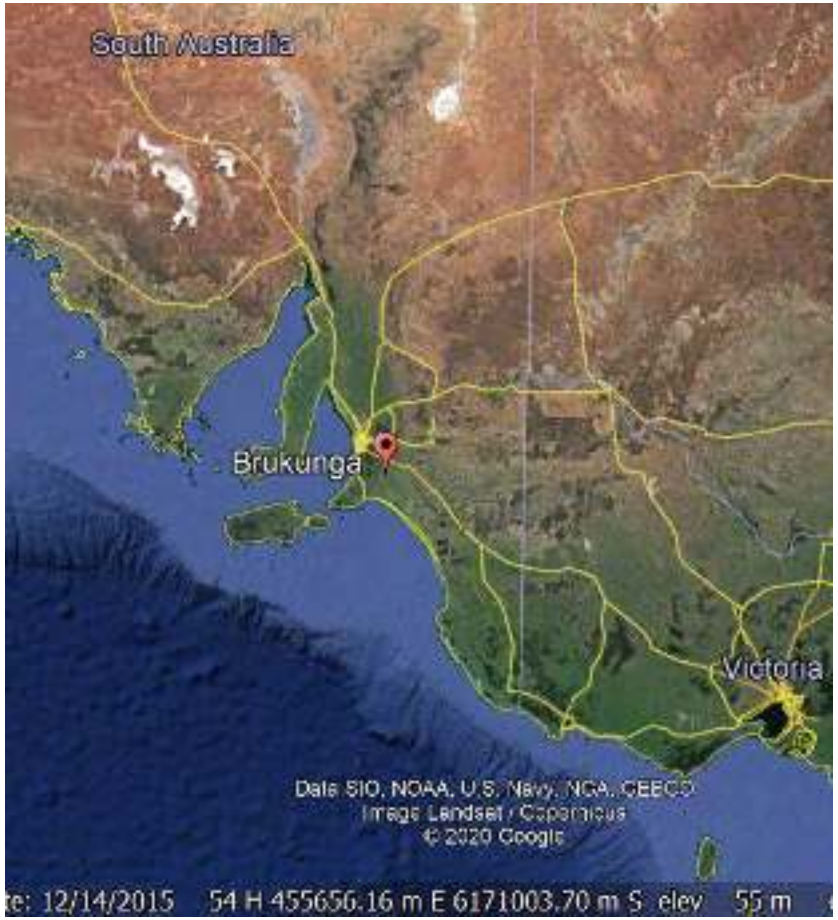
GEOLOGY AND GEOLOGICAL MODEL INFORMATION
What is WofE?
Dielectrics
Summary of Lithmetrics
Introduction to the V-Bore Repeatability Study
Stare Transect - Methods
P-Scan Transect - Methods
Stare Transect – Repeatability of 00136 VS 00231
Conclusions on Transects for Sulphide Identification

Introduction

- In 2013, the Adrok team collected ADR data over the well-known, Australian sulfide test locality Brukunga (311876mE, 6124664mS, Zone 54H). The site is located over an old disused Pyrite mine and reporting suggests that the ore zone runs approximately N-S with a moderate E-dip. The Deep Exploration Technology Crustal Research Center (DET-CRC) runs the site as a test locality for different technologies, primarily drilling. One of the attractive aspects of the areas is the ability to access open data relating to drill holes (collected and reported in 2014-2015*) from the central part of the test site (*Drill Hole – "DETBrukunga2"; Hillis et al., 2014 SEG special publication no.15 pp243-259).*
- The site is ideal as it presents a well-known area where new sulfide detection techniques can be trialed.
- Selected scans can be processed in order to gain an overview of the project as well as testing repeatability using different techniques and finally, to determine whether the new techniques can help better distinguish the sulfide zone.
- Adrok can derive a clear case study and re-presentation of results to the general public with the confidence that the results are correct, repeatable and with the added possibility of helping prove up the sulfide detection criteria.



From Project 00136 to Project 00231

- The original Adrok project number was 00136, was funded 100% by Adrok and performed 2012/2013.
- Data was collected during October/November 2012 and the final report produced by Adrok can be found:

  G:\00136 DetCRC 2020SR\Reports (external) (00136)\2013-11-20 final Brukunga_DET-CRC_Presentation BC
- An external presentation was presented, on Adrok's behalf, by Barrett Cameron to DET-CRC audience in Adelaide July 2013 can be found:

  G:\00136 DetCRC 2020SR\Reports (external) (00136)\From_RapidGeo_20131120

- This current project has been allocated Adrok project number **00231** and is another 100% Adrok funded R&D project.
- Timesheet *code "ER"* and constitutes training for UK based furloughed Adrokers.
- This is a training project that will be a great internal opportunity for:
  - Train Adrokers by providing practice of Adrok's data processing, interpretation and project management tools and workflows.
  - Showcase Adrok's state-of-the-art technology capabilities.
  - Test efficacy of ADR for finding subsurface sulphides.

Purpose and Goals

PURPOSE

To improve our Sulphide identification capabilities on legacy data by using our newest released tools and workflows.

Adrok will process 6 V-Bores (DP01, 01-60, 02, 06, 07 & 08) and the Transect Dataset.

GOALS

To impress Australian Mining Community with our improved capabilities and efficiency

To improve Adrokers expertise

OBJECTIVES

To produce public Case Studies for SR to market in Australia

To ground-truth the results with publicly available data.

To prove that Adrok can locate sulphides and trace them across V-Bores

To provide a sandbox scenario and try new processing and interpretation tools.

OSD to train LL on the basic stages and processes of Prince2 as the project advances.

How are we measuring success?

Do the drill depths of sulphide correspond to the interpreted sulphide?

Did we improve Accuracy and Certainty?
Did we reduce the amount of False Positives?
Did we increase the amount of True Positives?

Did we refine existing methods?
Did we create new techniques?
Was all of it documented?

Have the Prince2 stages been clear?
Has the project team been coordinated?

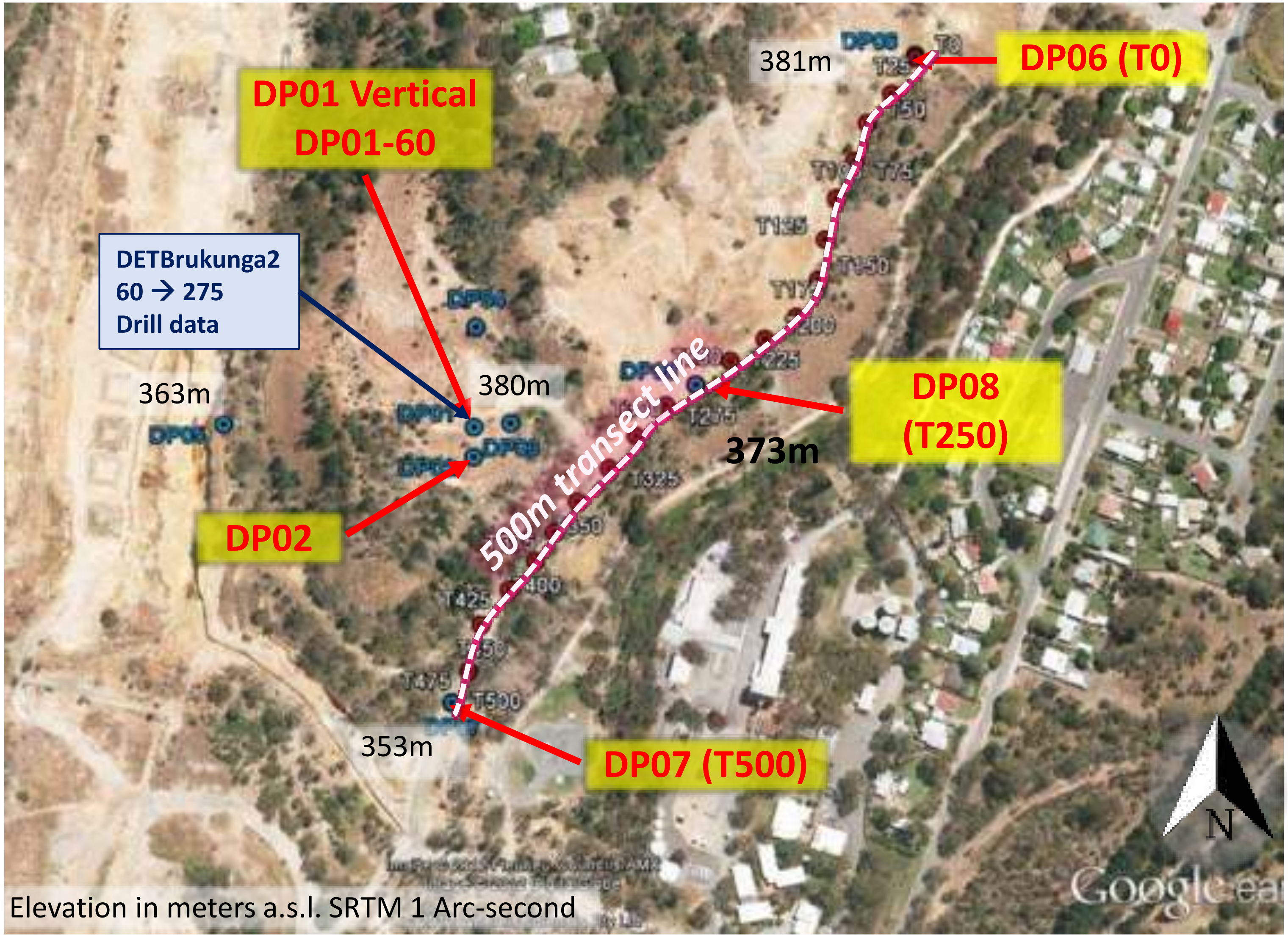
Tactical aims

1) Repeatability of selected scans using new processing methods.
2) Check the repeatability of DC measurements in all scans.
3) Process the results to obtain a full suite of results to compare with other sulfide projects.
4) Process the P-Scan & Stare transect images (either as whole PScan or broken into mini-Stares, or both if time permits) to show subsurface changes laterally along the main sulphide body zone.
5) Test sulfide discrimination and lithometrics criteria on defining the location of known sulfides.
6) Check for the depth offset observed on the old data.
7) Correlate new processed data with the original transect (Pscan) results showing positive sulfide detection.
8) Repeat processed filtered energy results presented in the cross section and find the processing workflow to achieve these results.
9) Input Seismic data to Adrok's model.

Adrok

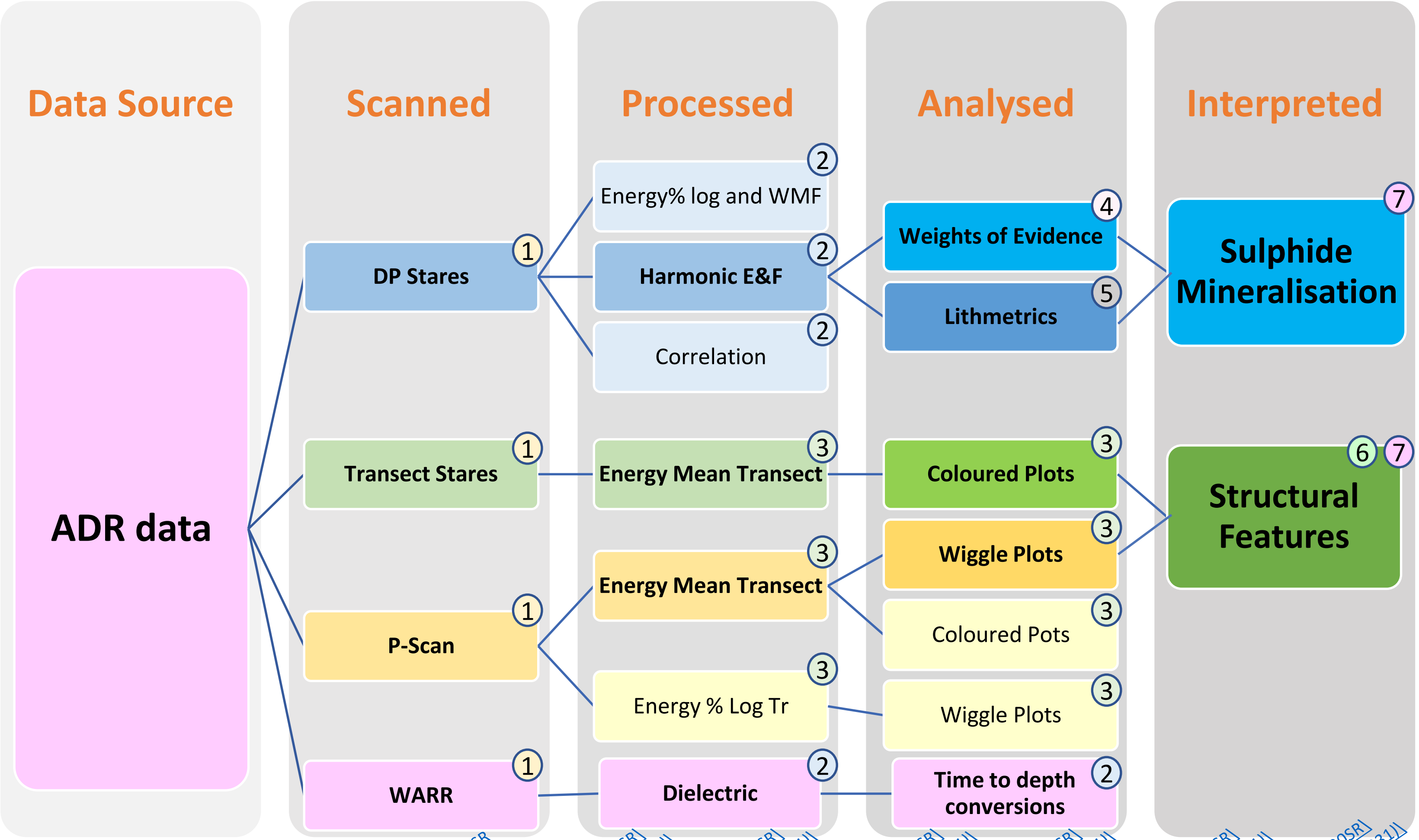
Data to be processed

1) **DP01 (Vertical & 60 degree to East and West) –** DP01 is aligned parallel to drill hole DETBrukunga2 from which we have the sulfide content as per publication on previous page. This will provide the mot detailed correlation with known sulfides so most emphasis should be placed on processing this scan.
2) **DP02 Vertical –** This scan is located parallel to DP01 and can be used for repeatability purposes.
3) **DP06 Vertical –** corresponds with the north eastern tip of the transect and lies at point T0 (i.e. the beginning of the transect).
4) **DP07 Vertical –** lies at the southwestern end of the transect at T500m and is the final scan of the transect.
5) **DP08 Vertical –** lies in the center of the transect and equivalent to point T250m which is mid-way along the transect.
6) **The "T" series of Stares** – Along the 500m transect line, stares were taken at every 25 metres (T0, T25, T50 … T450, T475, T500), for a total of 20 stares.
7) **The "TP1" series of Profile Scans –** Along the 500m transect line, 5 P-Scans of 100m length each were collected.



Elevation in meters a.s.l. SRTM 1 Arc-second

Data produced



Location of the data:

1 G:\00231 DetCRC 2020SR Data Collected (00136)

2 G:\00231 DetCRC 2020SR\ Internal Deliverables(00231)\ 00231 WF4 DP Stares Outputs

3 G:\00231 DetCRC 2020SR\ Internal Deliverables (00231)\ 00231 Transect Deliverables

4 G:\00231 DetCRC 2020SR\ Internal Deliverables (00231)\ WofE

5 G:\00231 DetCRC 2020SR\ Internal Deliverables (00231)\ 00231 Lithmetrics

6 G:\00231 DetCRC 2020SR\ Internal Deliverables (00231)\ 00231 WF5 Transect

7 G:\00231 DetCRC 2020SR\ Internal Deliverables (00231)\ 00231 00136 BRUKUNGA GEOSCIENCE ANALYST

- The diagram in this slide shows a summary view of the work completed, showing in bold letters the most successful items.
- A total of seven DP stares were used, as well as twenty Transect Stares and five 100m P-Scans.
- The combined efforts of the team and the datasets yielded very good prognosis of both Sulphide Mineralisation and Structural Features.

DET CRC BRUKUNGA MINE SITE
GEOLOGY AND GEOLOGICAL MODEL INFORMATION

- Features and factors relating to the geology of the DET CRC Brukunga test facility considered in this project include

1) Background mining history and geology of the site
2) Topography of the site
3) Historical drilling
4) Recent drilling by the DET CRC coiled tubing facility
5) SEISMIC reflection results

DET-CRC website - https://detcrc.com.au/programs/program-1/project-1-4/
SARIG website - https://map.sarig.sa.gov.au/

DET CRC BRUKUNGA MINE SITE
GEOLOGY AND GEOLOGICAL MODEL INFORMATION

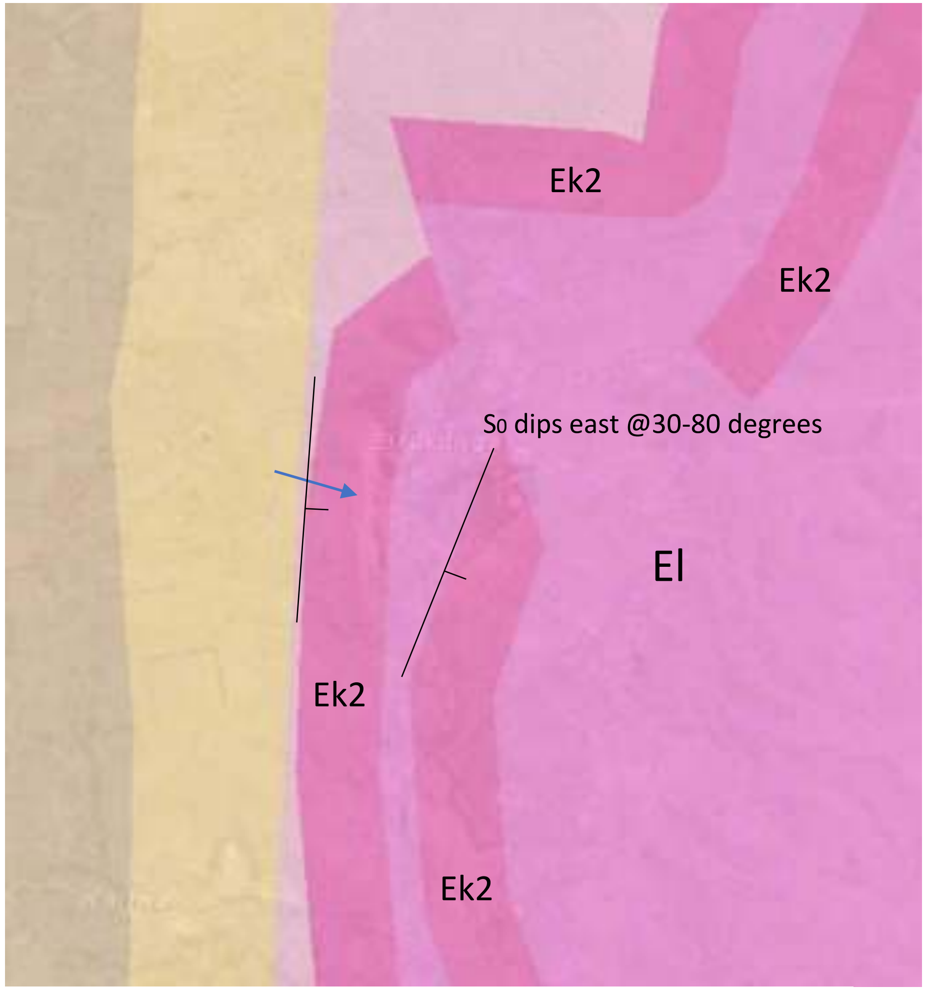
- Iron sulfide (pyrite minerals) was extracted from Brukunga from 1955 to 1972. The sulfur was the key ingredient for the production of sulfuric acid needed for the manufacture of superphosphate fertiliser. The superphosphate fertiliser was used to sustain the rapid expansion in agriculture that occurred in South Australia following World War II.
- The site is located within multiply deformed (folding and foliation development) metasediments of the Kanmantoo group to the east of Adelaide.
- In 2013, the site was used for testing of a new form of drilling referred to as coiled tube drilling. The DET CRC drill hole DETBrukunga2 referred throughout this project was the principal drill hole completed and contains the only deep geochemical/sulfide information in the area.
- The upper tens of meters is likely to be weathered, however, there was no specific reference to oxidation in the Nairne Pyrites historical drill holes, therefore, weathering may be less significant than first thought.

https://www.researchgate.net/figure/Location-of-the-Brukunga-Pyrite-Mine-and-key-site-features_fig8_237440173

DET CRC BRUKUNGA MINE SITE
GEOLOGY AND GEOLOGICAL MODEL INFORMATION

- The mine sits on the boundary between Early and middle Cambrian metasediments but little information exists on the group/formation descriptions at Brukunga. Rocktype descriptions are found mainly in drill core descriptions.

- According to multiple sources of information, including drill log structural intercepts, historical mining and cross sections in DET CRC reports, bedding dips to the east at an average of 60 degrees, however, as discussed below, the relative angle of bedding to drill hole axis indicated bedding dips as shallow as 40 degrees and up to 90 degrees which is reasonable given the complexity of folding of the Kanmantoo trough metasediments throughout South Australia.



Main unit	Stratigraphic name	GIS code	Parent nar	Parent symbol	Province	Age	Minage
Ek2	Unnamed GIS Unit - see description	E-ok----02	Kanmanto	Ek	KANMANTOO TROUGH (ADEL	CAMBRIAN	Cambrian, Middle
El	Bollaparudda Subgroup	E-okl	Kanmanto	Ek	KANMANTOO TROUGH (ADEL	CAMBRIAN	Cambrian, Early

DET CRC BRUKUNGA MINE SITE
GEOLOGY AND GEOLOGICAL MODEL INFORMATION

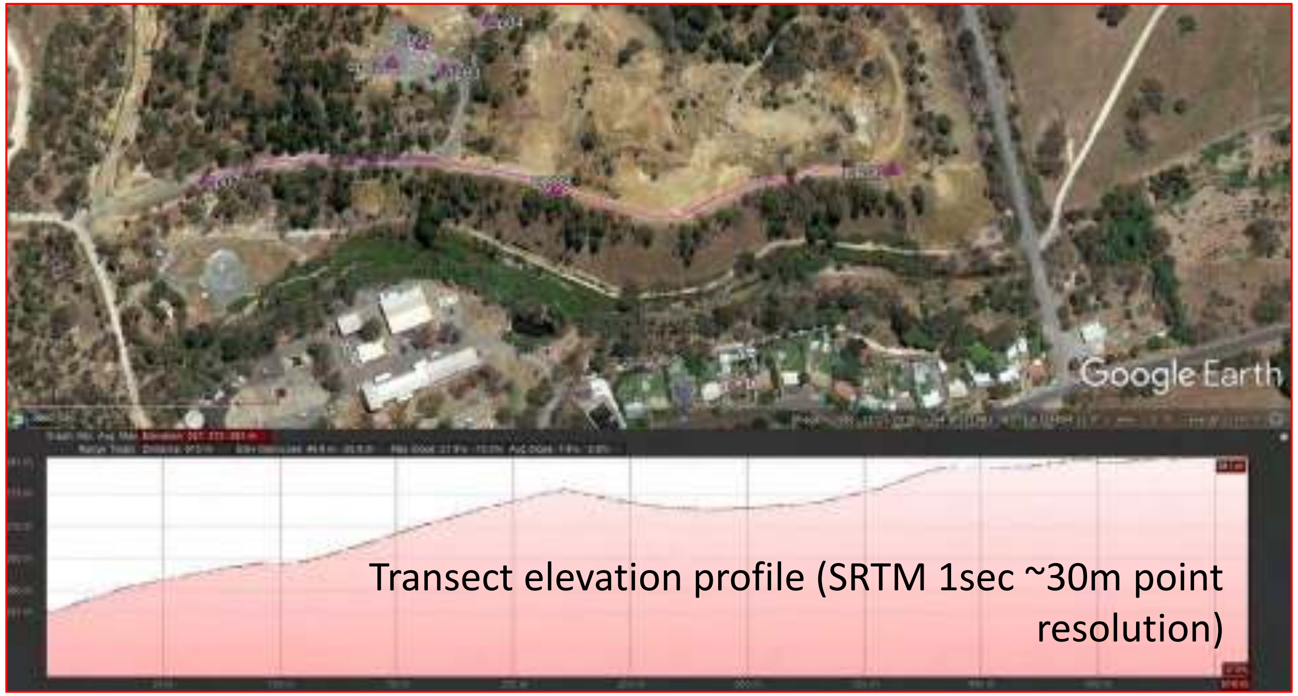
- Topography was modeled using 30m SRTM data extracted from google Earth using the point generation tool available at http://www.zonums.com/gmaps/terrain.php?action=sample
- Different densities of point were trialed in order to get a more "data rich" and smoother elevation model, however, the elevation pointset extracted from google is set on a regular 30x30m grid, therefore when loaded into geoscience analyst and a surface generated, the "blocky" appearance is retained. In order to maintain topographic correctness, the area used was populated with 2000 elevation point measurements which achieved a suitable outcome. The online topo point extraction tool allows the user to set the number of points. A smaller area requires fewer points whereas a larger area requires more points. The dataset has not been smoothed but work is in progress to determine the best method to do this prior to importing into Geoscience Analyst.
- A view of the 3D topographic model:

DET CRC BRUKUNGA MINE SITE
GEOLOGY AND GEOLOGICAL MODEL INFORMATION

Geoscience Analyst Model

Pointset, triangulation sfc which hosts the draped image are shown below

Other elevation test files are loaded into the model but the two highlighted are the ones used in this project.

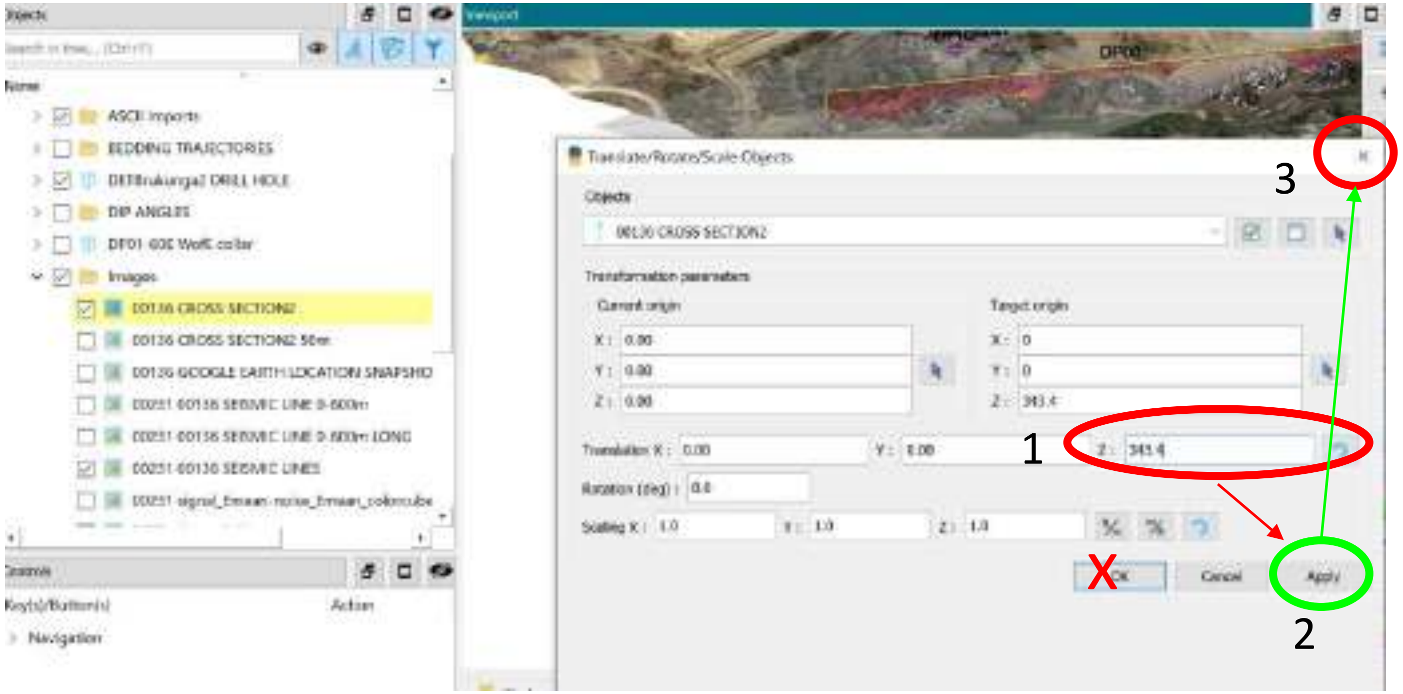


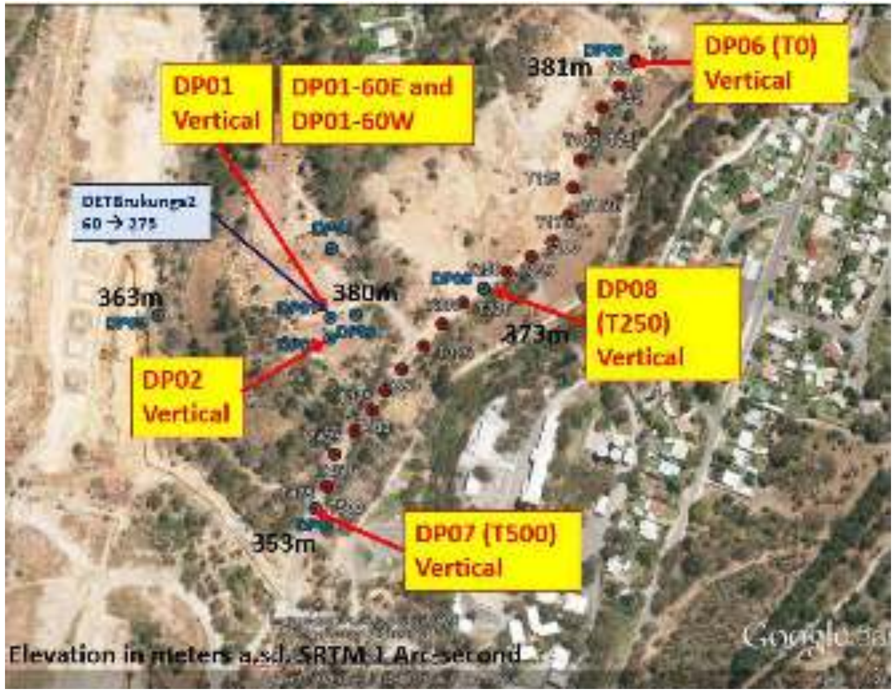
DET CRC BRUKUNGA MINE SITE
GEOLOGY AND GEOLOGICAL MODEL INFORMATION

- NOTE: IN ORDER TO CHANGE 0m TO THE CORRECT ELEVATION, RESULTS SHOULD BE MOVED IN THE Z- DIRECTION BY +383.4m.

1. To do this in G-Analyst, right mouse click on the object to be moved, select translate…from the pop up menu. The window shown below will appear with the object name in the top row. Type 384.4m in the Z: field as marked. Hit "APPLY" (2) and then the "X" (3) in the top right corner to close the window. DO NOT HIT OK.

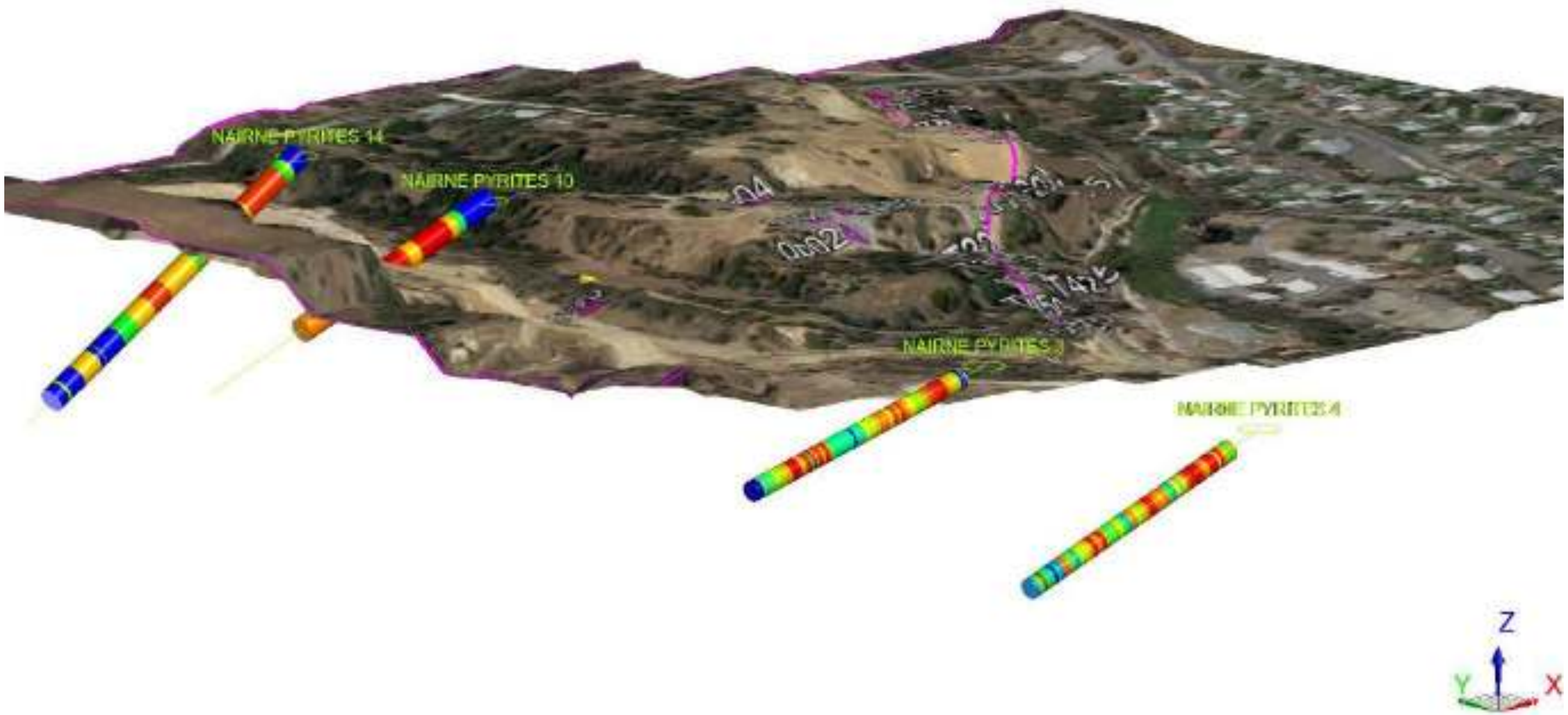
2. The object will shift up to match the project elevation. If the elevation is provided, the exact value given in the associated dataset can be used. 383.4 is the average elevation of the project if no other elevation data is provided.





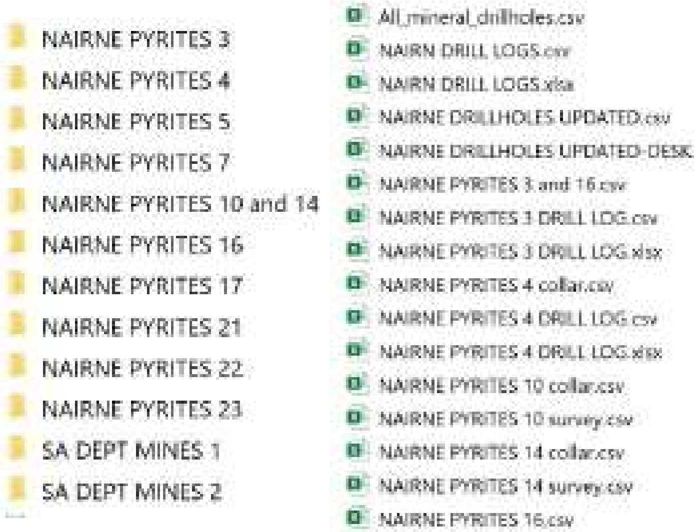
DET CRC BRUKUNGA MINE SITE
GEOLOGY AND GEOLOGICAL MODEL INFORMATION

- The Brukunga Pyrite mine was mined around 1955 but drilling was being carried out in 1951-53. Accordingly the topography at the time of drilling differed. As such, the drill collars located on SARIG (with associated elevations) are incorrect. Re-construction of the pre-mining terrain was carried out before final historical drill hole collar elevations were imported into Geoscience Analyst.

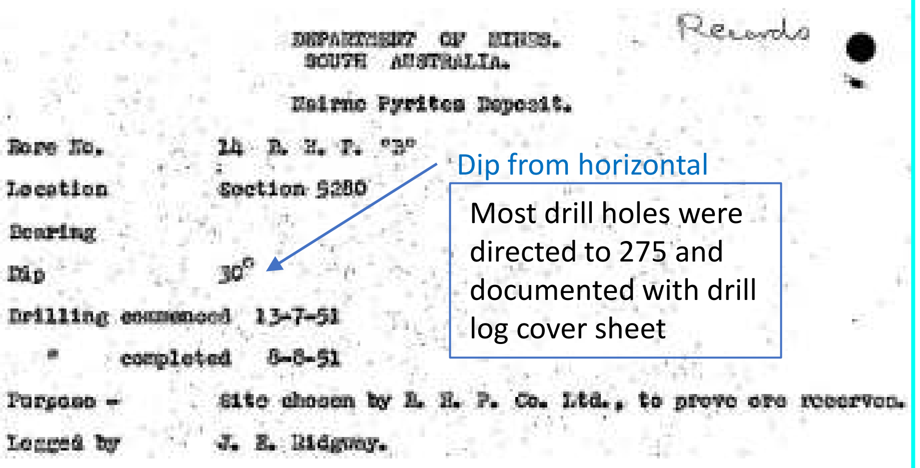


DET CRC BRUKUNGA MINE SITE
GEOLOGY AND GEOLOGICAL MODEL INFORMATION

- PDF or TIFF scans of drill log reports for drill holes in the vicinity of the ADR survey were downloaded from SARIG and saved into the folders relating to each hole. The data/results associated with each drill hole differed and the drill hole logging was completed by different geologists so many of the descriptions are different between different holes.
- Read with caution and be aware of the methods/mindset of geologists when they are logging.
- Bedding was noted in many of the drill logs and appears to be the principal (but not sole) factor concentrating pyrite. In particular the "greywacke" unit seems to be the pyrite bearing unit. More quartz-rich layers tend to not contain pyrite.
- Total sulfides (%) were recorded and extracted into various csv files for loading into Geoscience Analyst. Lithology was only logged for two drill holes (Nairn Pyrites 10 and 14).



An example of a PDF scan of historical drill log (Nairne Pyrites 14)


DEPARTMENT OF MINES.
SOUTH AUSTRALIA.

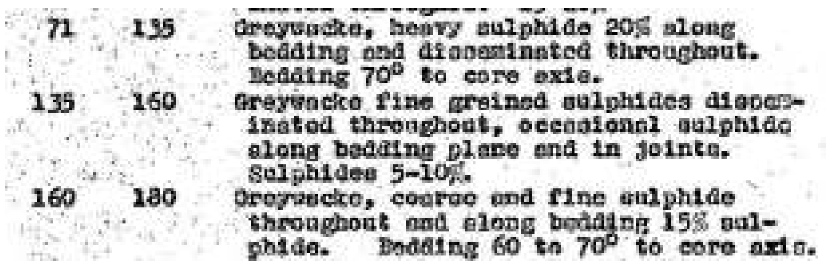
Records

Nairne Pyrites Deposit.

Bore No. 14 D. H. P. "3"
Location Section 5280
Bearing
Dip 30°
Drilling commenced 13-7-51
" completed 8-8-51
Purpose - Site chosen by B. H. P. Co. Ltd., to prove ore reserves.
Logged by J. E. Ridgway.

Dip from horizontal

Most drill holes were directed to 275 and documented with drill log cover sheet



From (ft)	To (ft)	Comments
71	135	Greywacke, heavy sulphide 20% along bedding and disseminated throughout. Bedding 70° to core axis.
135	160	Greywacke fine grained sulphides disseminated throughout, occasional sulphide along bedding plane and in joints. Sulphides 5-10%.
160	180	Greywacke, coarse and fine sulphide throughout and along bedding 15% sulphide. Bedding 60 to 70° to core axis.

Drilling carried out in ca.1950-1953
Mining ca. 1955

DET CRC BRUKUNGA MINE SITE
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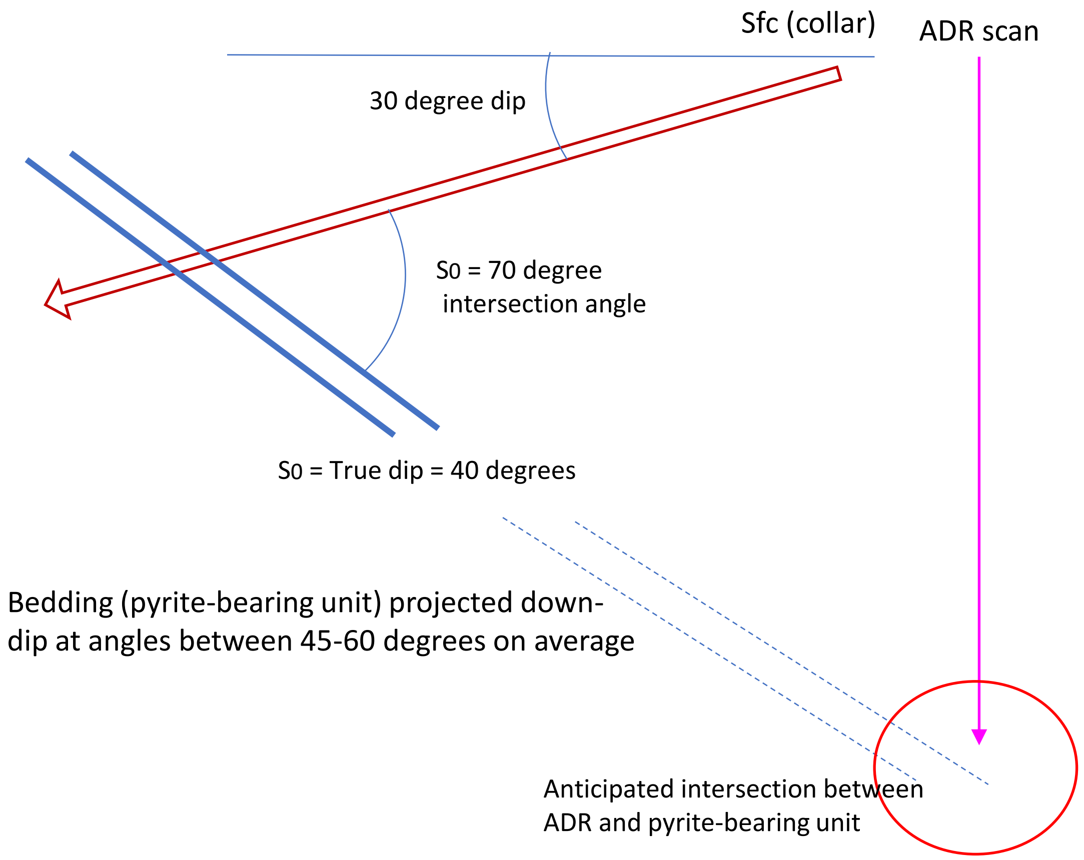
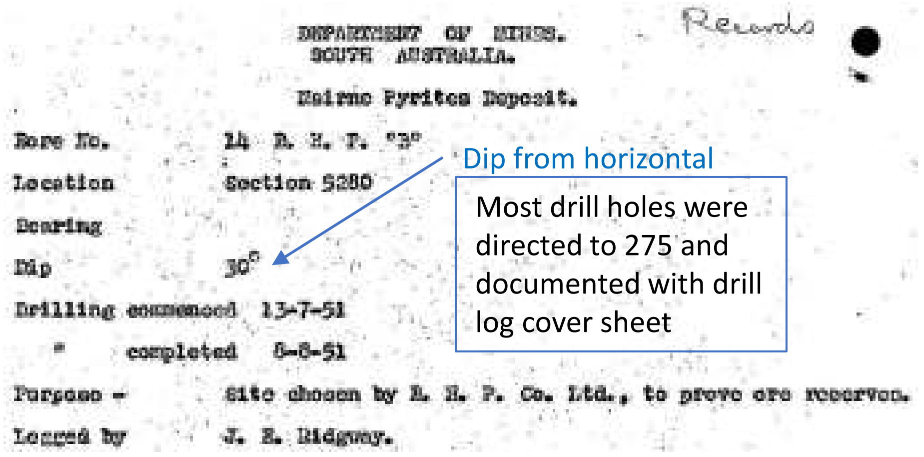
- Structural intercepts (principally bedding and drill core axis) were noted for most of the drill holes and it was determined that bedding is shallower in the north than the south. Bedding dips approximately 55-60 degrees east in the south and as shallow as 30-40 degrees to the east in the north of the area. Bedding is interpreted to flatten slightly with depth which is consistent with previous cross-sections. A best estimate reconstructed bedding surface has been generated in the geoscience Analyst model.



An example of a PDF scan of historical drill log (Nairne Pyrites 14)


DEPARTMENT OF MINES.
SOUTH AUSTRALIA.

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Bore No. 14 N. P. P. "3"
Location Section 5280
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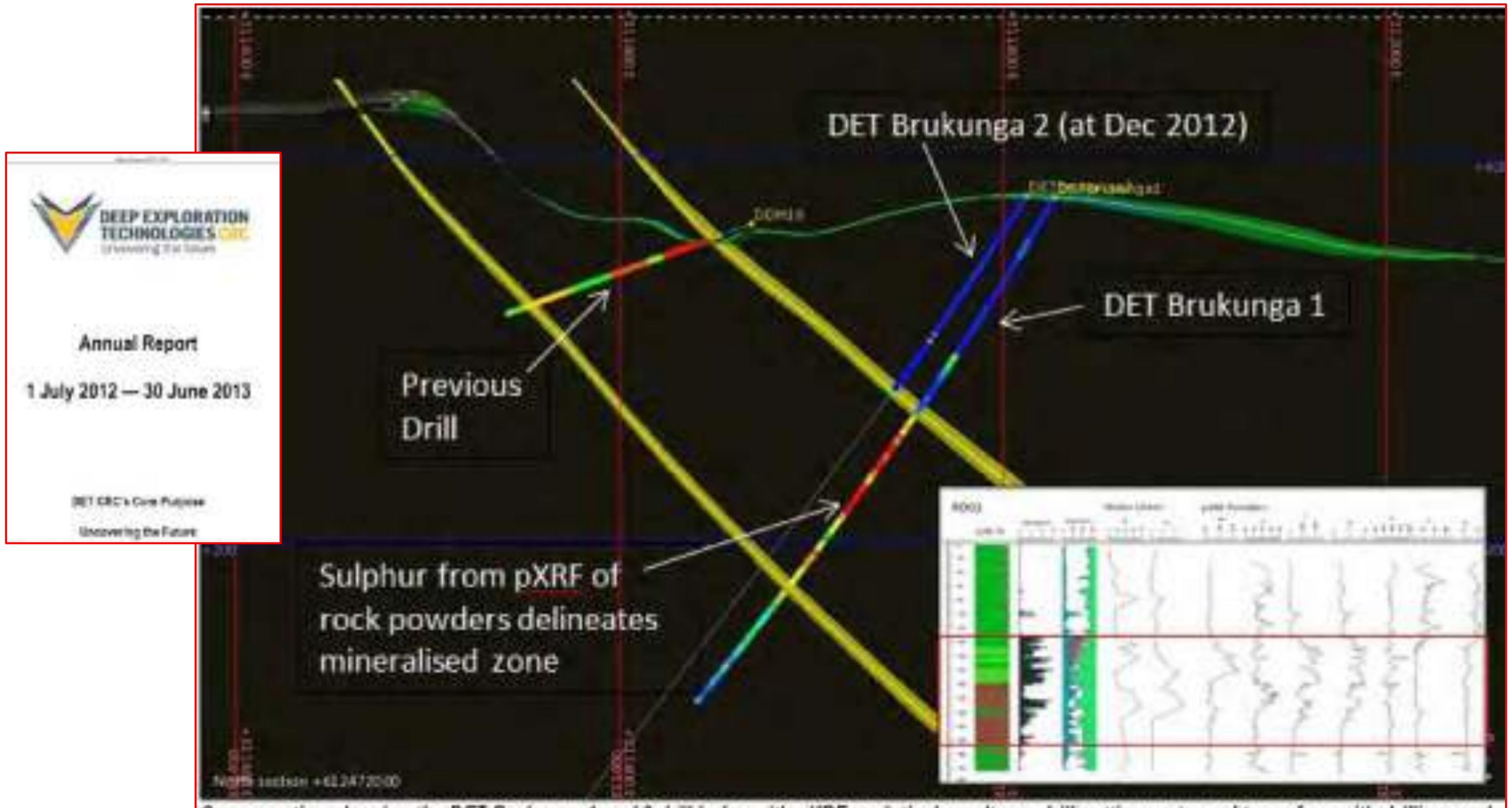
" completed 6-8-51
Purpose - Site chosen by N. P. P. Co. Ltd., to prove ore reserves.
Logged by J. E. Ridgway.

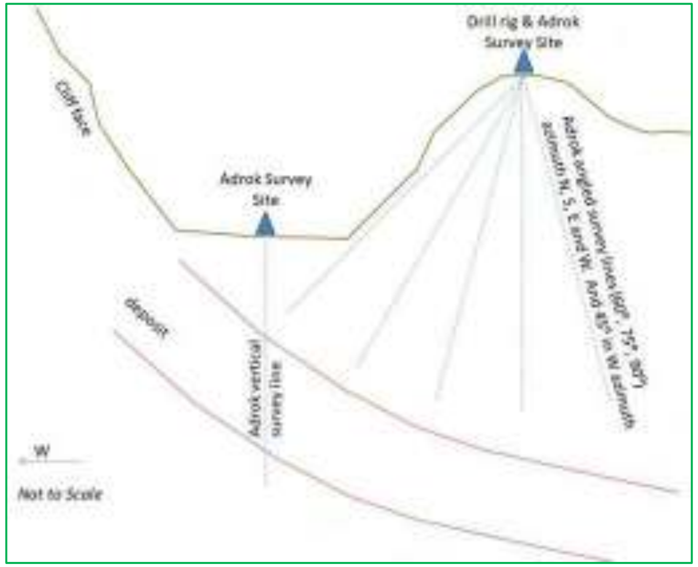
GEOLOGY AND GEOLOGICAL MODEL INFORMATION

BEDDING: Previous interpretations of curved/flattening bedding with increased depth



Cross-section showing the DET Brukunga 1 and 2 drill holes with pXRF analytical results on drill cuttings returned to surface with drilling mud.

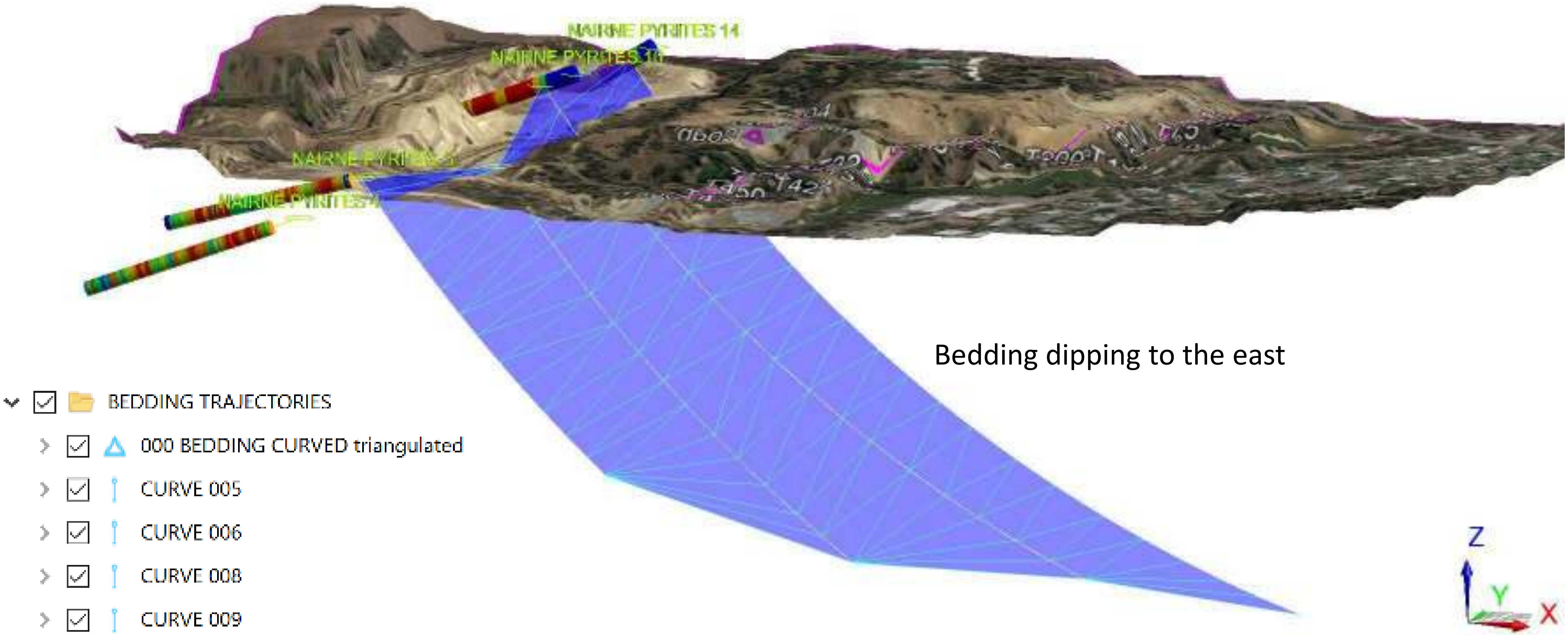
Showing progressively shallower dip in bedding to the right (East). View looking north



From previous ADR report

DET CRC BRUKUNGA MINE SITE
GEOLOGY AND GEOLOGICAL MODEL INFORMATION

- View looking North

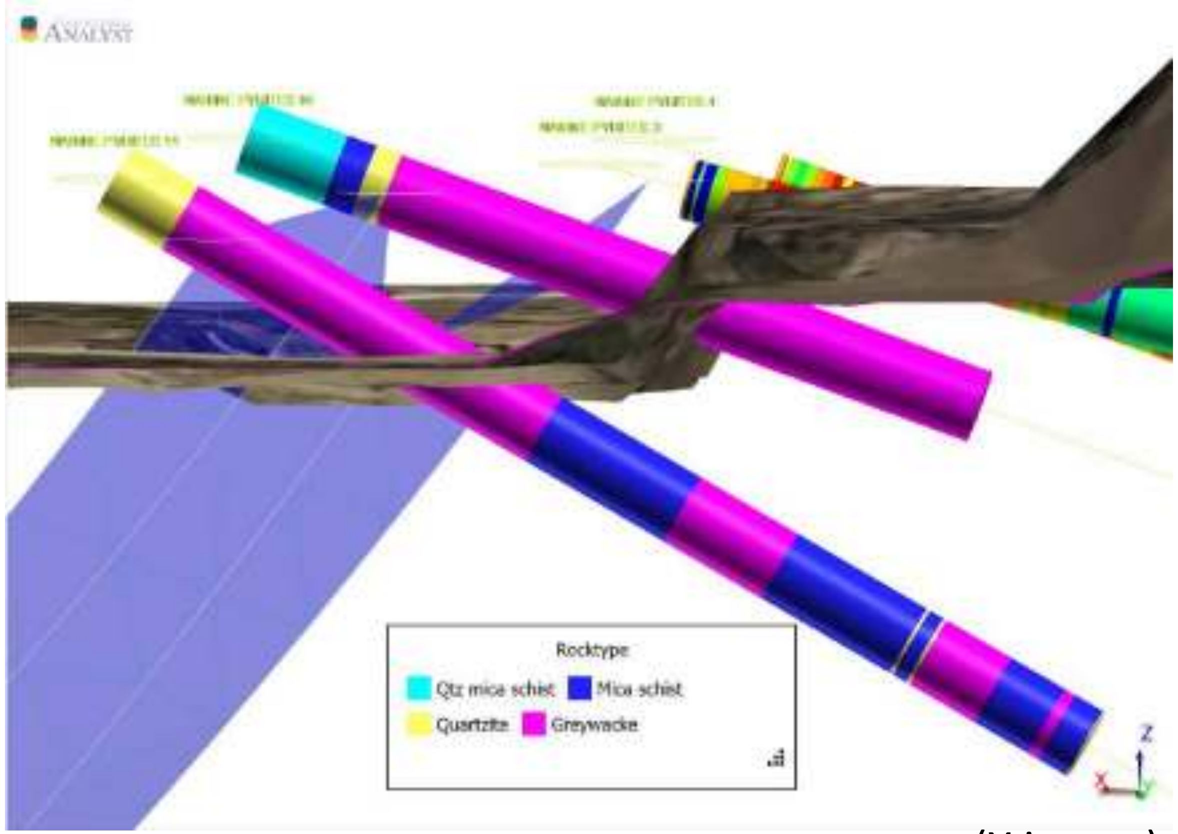


(Y is North)

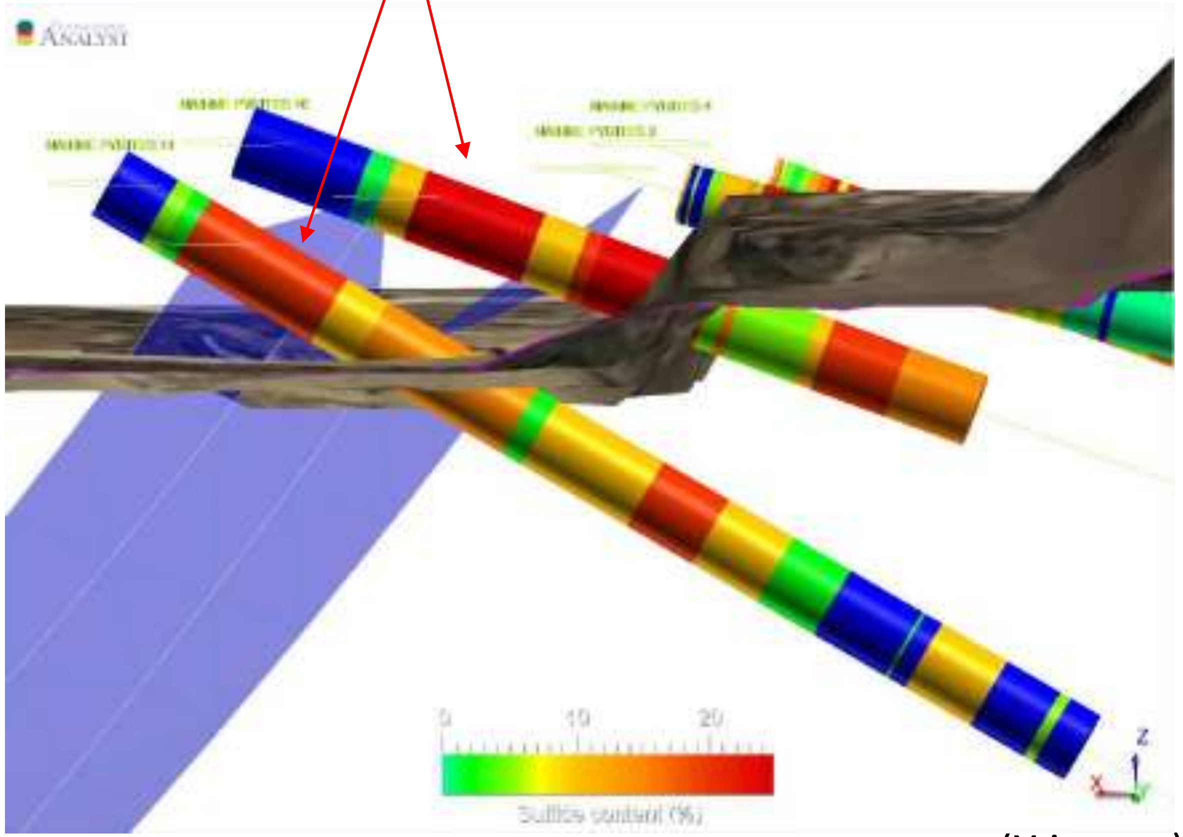
DET CRC BRUKUNGA MINE SITE
GEOLOGY AND GEOLOGICAL MODEL INFORMATION

- View looking South

Upper section (pyrite-rich) has been mined out



(X is east)



(X is east)

DET CRC BRUKUNGA MINE SITE
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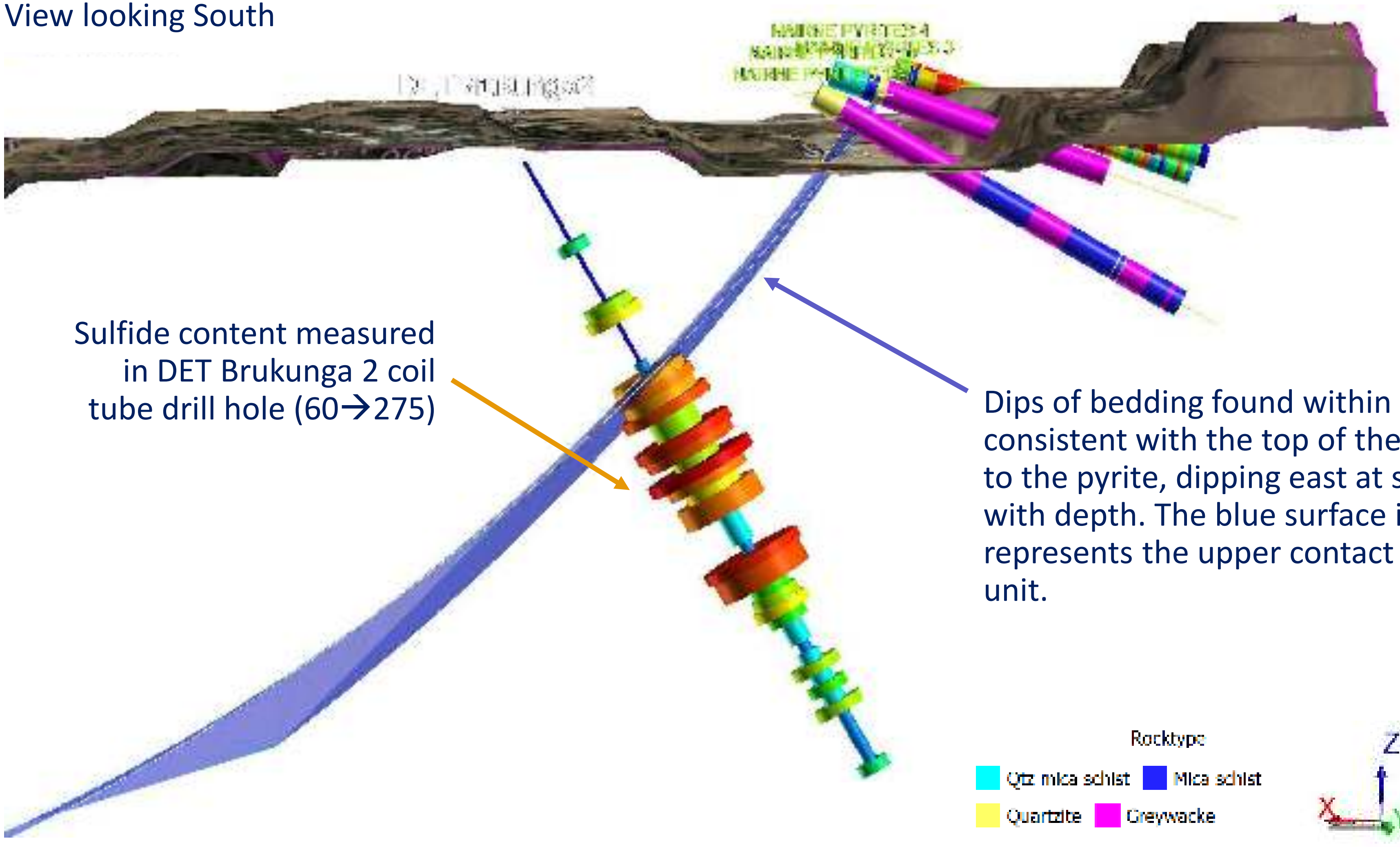
- View looking South



Sulfide content measured in DET Brukunga 2 coil tube drill hole (60→275)

Dips of bedding found within historical drilling are consistent with the top of the greywacke unit, also host to the pyrite, dipping east at slightly shallowing angles with depth. The blue surface in Geoscience Analyst represents the upper contact of the main Greywacke unit.

(X is east)

DET CRC BRUKUNGA MINE SITE
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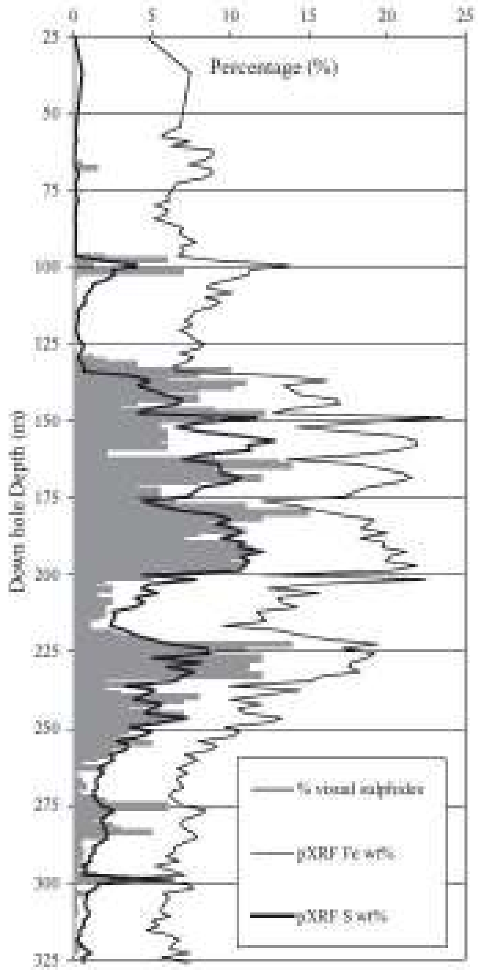


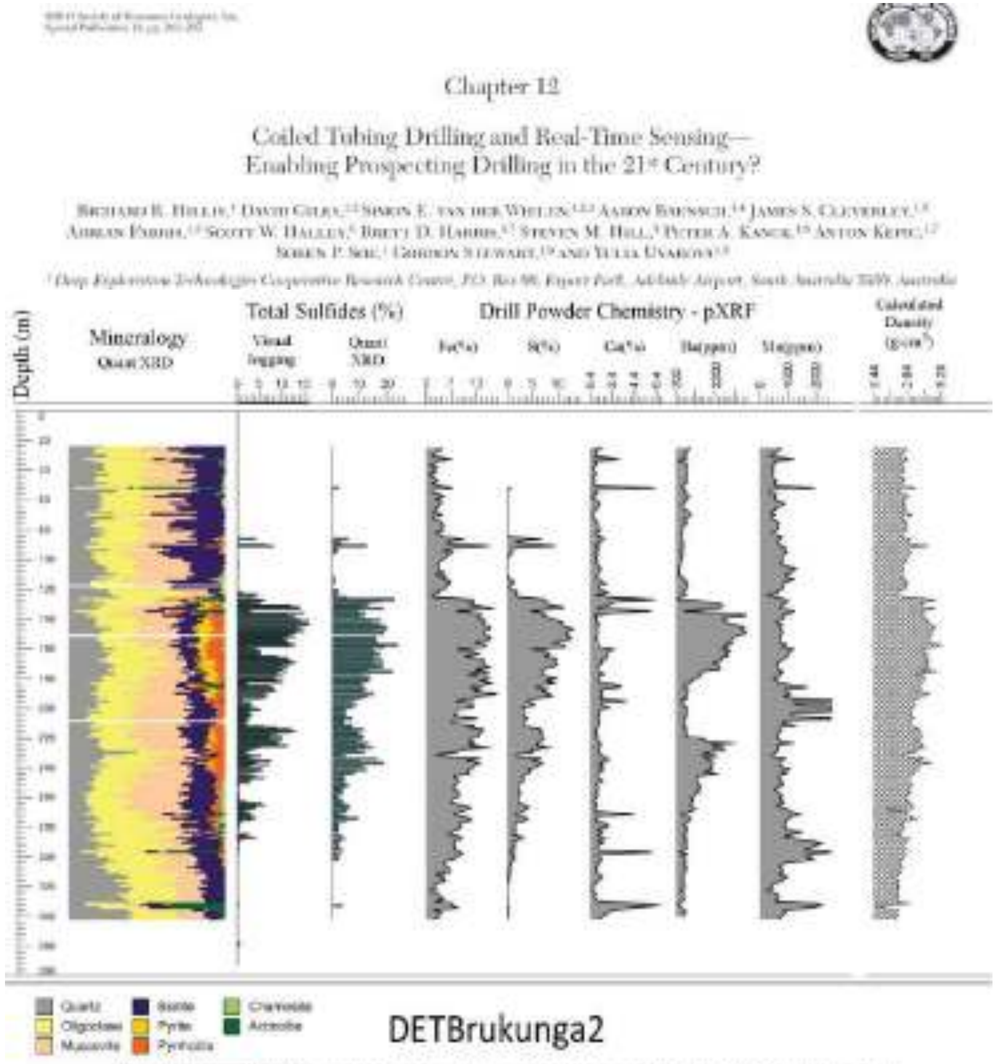
FIG. 8. Comparison of geologist's log of percent of visual sulfide in the core (gray bars) to portable XRF analysis of iron and sulfur in the rock powders sampled in the drill sump. These data are from a metamorphosed sandstone and shale sequence containing strata-bound sulfide mineralization at DET CRC's Brukunga Drilling Research and Training Facility. These analyses show that the depth fidelity of the rock powders is remarkably good with limited depth smearing.

DETBrukunga 2 coiled tubing drill hole

Drill hole collar info: 60 degrees → 275

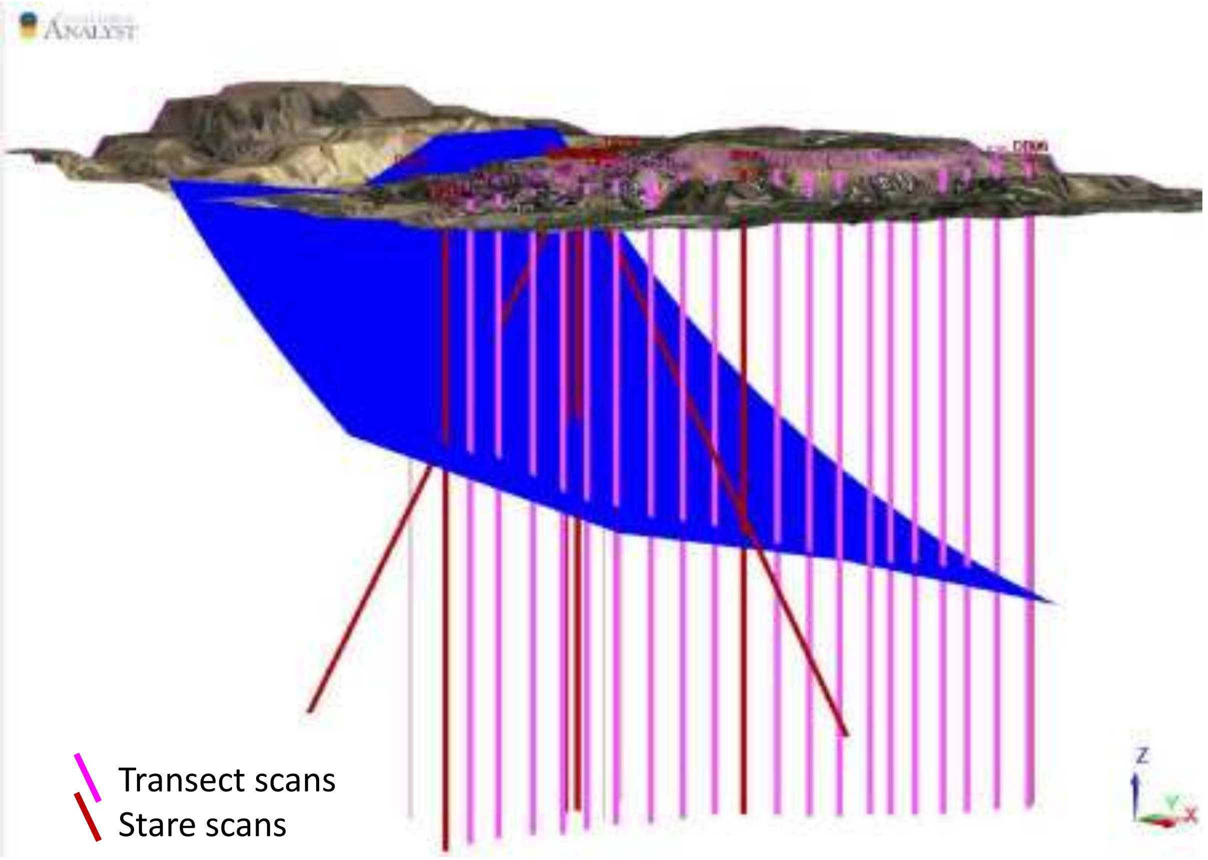
- P.252 Total sulfide content (%) were obtained from the visual log shown here. No digital information could be found on SARIG or from the DET CRC, therefore the values were tabulated into excel by directly reading the content (%) at depth intervals.

- Additional information can be seen on page 253. Different sulfide components together with other criteria r4ecorded for the drill core.

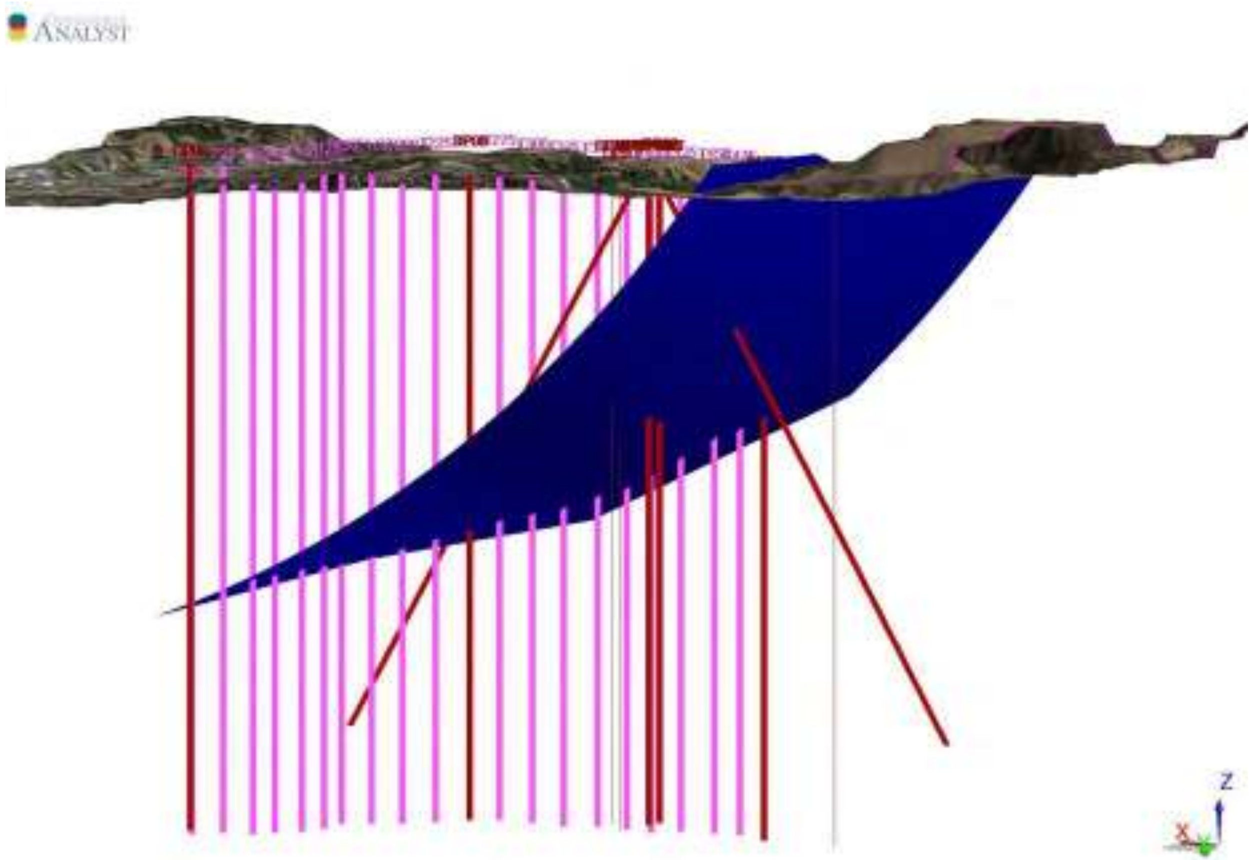


DET CRC BRUKUNGA MINE SITE
GEOLOGY AND GEOLOGICAL MODEL INFORMATION

- Progressively deeper intersection between bedding and ADR scans.
- Further north = deeper intersection with the host greywacke unit



View looking North



View looking South

DET CRC BRUKUNGA MINE SITE
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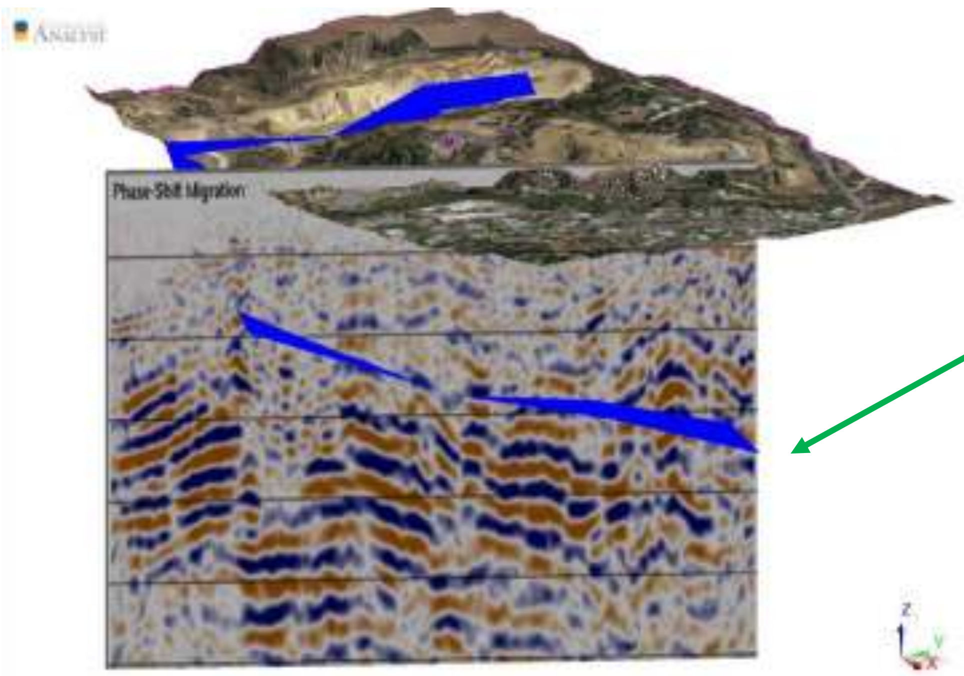
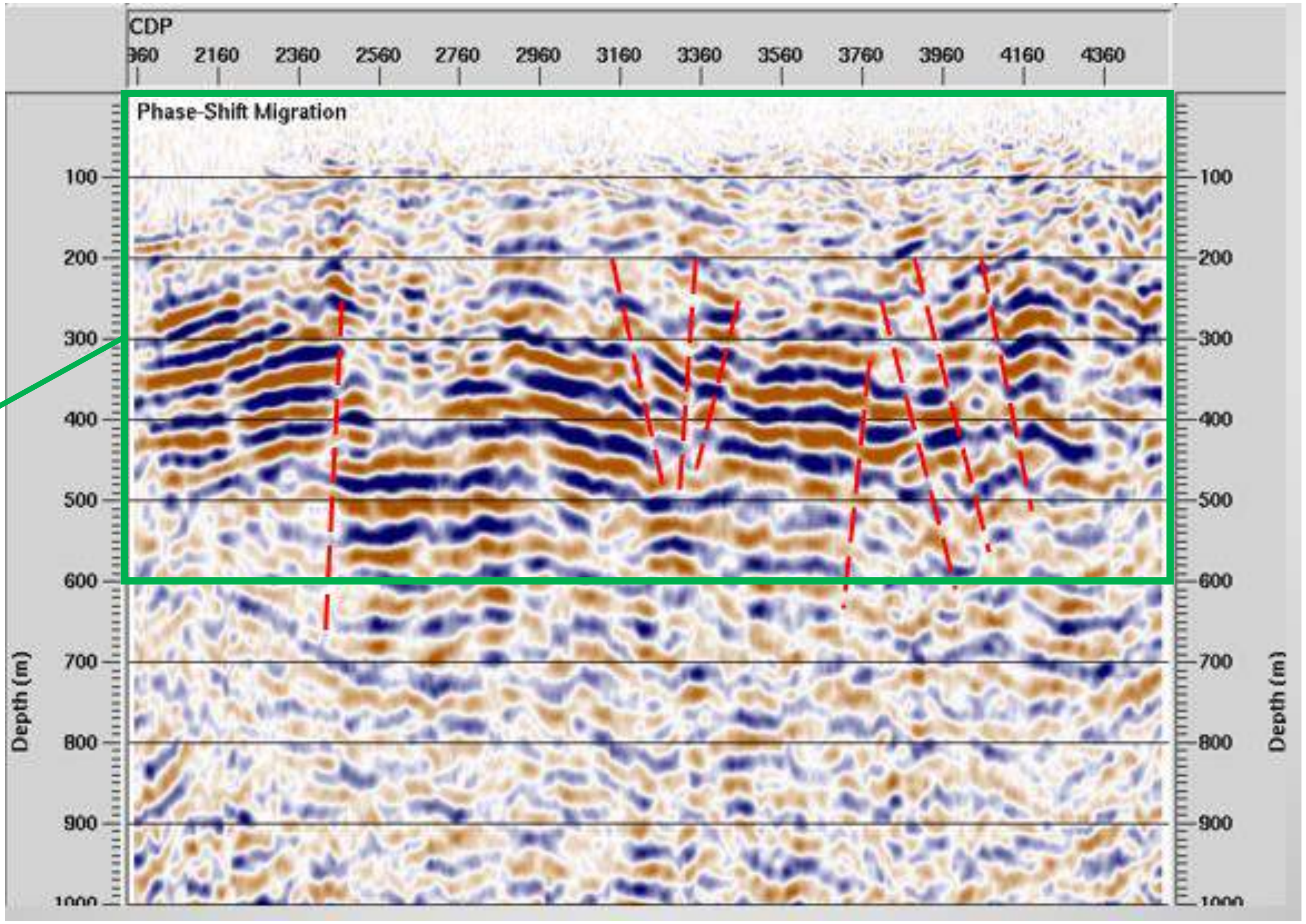
BrukungaSeismic_20131118





0-600m section seismic showing structurally interpreted bedding intersecting the seismic line progressively deeper to the north.

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- The seismic line was geo-referenced using:

1. The georeferenced seismic station map on the surface
2. Lining up the distance measurements
3. Adding start and finishing point
4. Ensuring distance = depth
5. Loading into geoscience analyst

- The line is not precisely along the curved path but it is sufficiently close to be accurate.

```
311692,6124298,0
312089,6124942,0
311692,6124298,-600
```

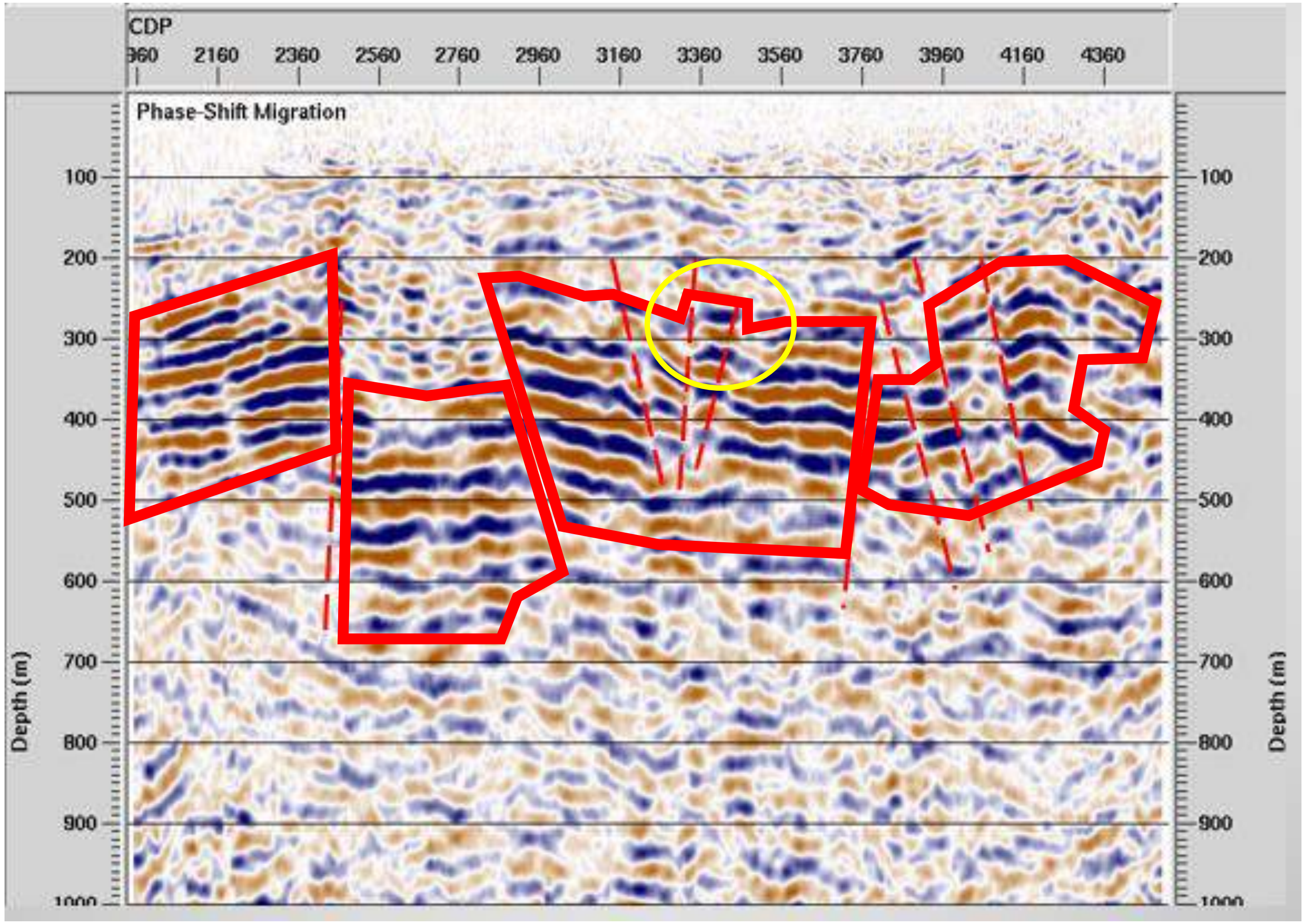
Seismic georeferenced coordinates
for the trimmed area shown in green.
*.csv file lies in "SEISMIC" folder with associated *.png

00231 00136 SEISMIC LINE 0-600m LONG.csv

00231 00136 SEISMIC LINE 0-600m LONG.PNG

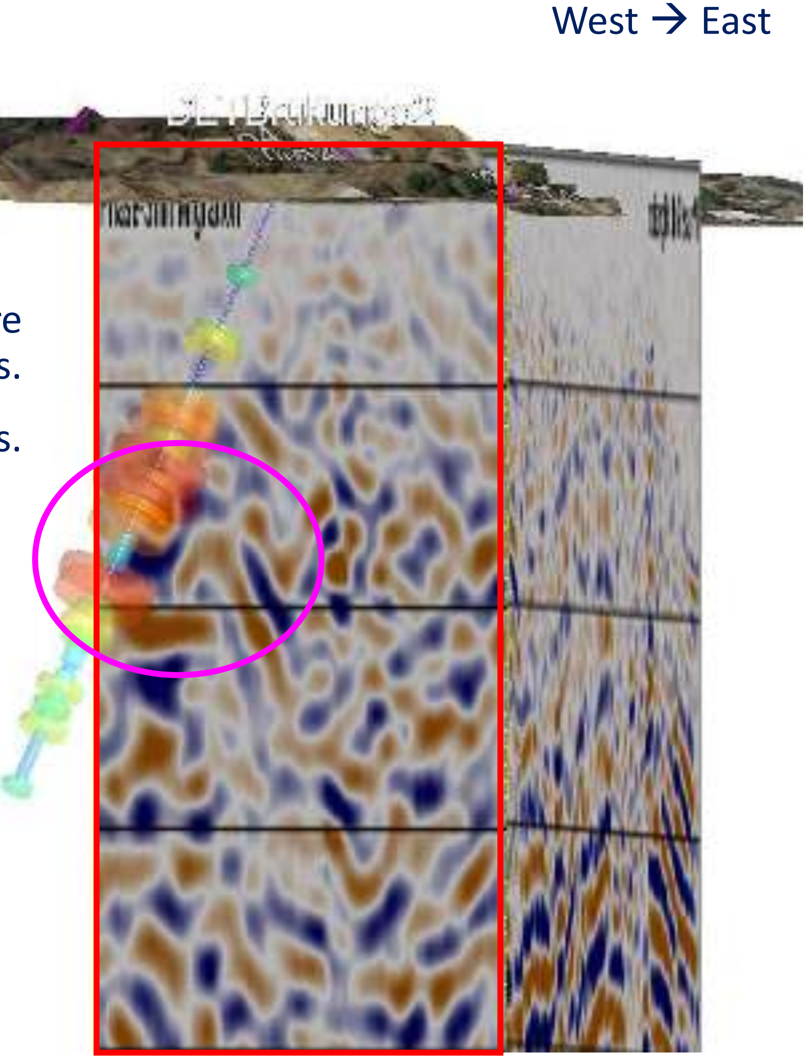
DET CRC BRUKUNGA MINE SITE
GEOLOGY AND GEOLOGICAL MODEL INFORMATION

- Potentially sulfide-bearing high Acoustic Impedance (AI) zone. Publications looking at AI in pyrite rich shales in the oil and gas industry show that added pyrite increases the AI. The section shown in the seismic results to the right are a potential indication for sulfides in the 200m-600m zone.
- A down-thrown block may represent a fault bound section of the Brukunga mine that had not been identified in drilling or mining.
- The area circled in yellow represents the down-dip projection of the mined sulfides (identified in historical drilling), the DETBrukunga2 sulfide zone.



DET CRC BRUKUNGA MINE SITE
GEOLOGY AND GEOLOGICAL MODEL INFORMATION

West → East



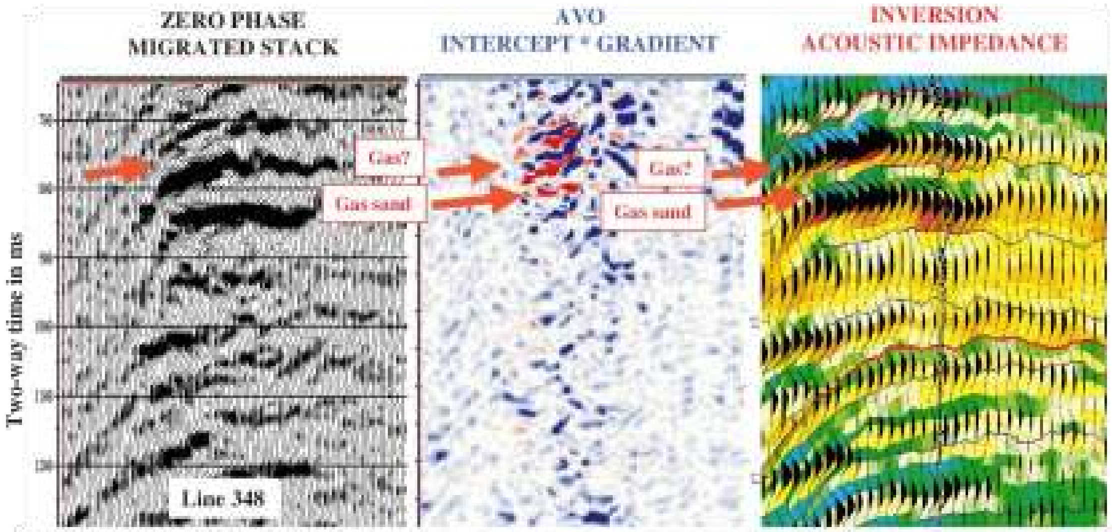
- High AI response in area where DETBrukunga 2 shows sulfides.
  - East-dipping reflectors.

Short E-W seismic line

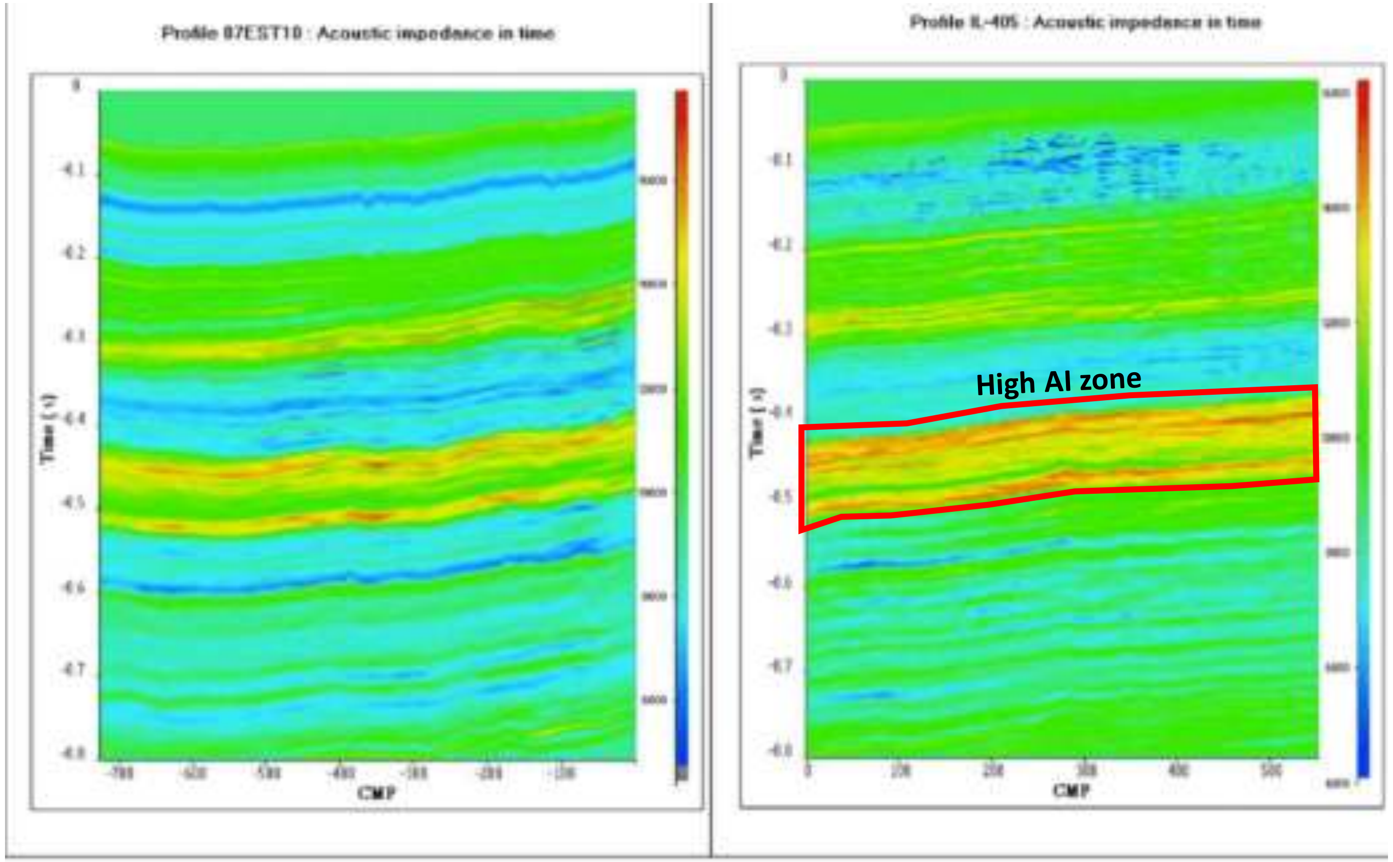
- Further information can be found in this ppt in the project folder under "From SashaZiramov". Attempts to contact Sasha at Curtin University in order to find any published interpretations have been unsuccessful.

DET CRC BRUKUNGA MINE SITE
GEOLOGY AND GEOLOGICAL MODEL INFORMATION

- An example of high Acoustic Impedance (AI) in seismic cross sections. The domain between 200 and 600m from Brukunga Seismic show evidence of high AI.



Mari, J. & Yven, Béatrice. (2013). The application of high-resolution 3D seismic data to model the distribution of mechanical and hydrogeological properties of a potential host rock for the deep storage of radioactive waste in France. Marine and Petroleum Geology. 53. 10.1016/j.marpetgeo.2013.10.014.



Acoustic impedance sections in time. Left: 07EST10 seismic line, Right: IL 405 seismic line. For each section, the vertical axis is the time axis, the horizontal axis the CMP number axis. The acoustic impedance values are expressed in g/cm 3 $m/s. Each seismic section has its own color scale ranging from blue to red. The lowest values of impedance are in blue, the highest values in red.

What is WofE?

- Using a combination of different criteria to give sufficient evidence to fulfil an information requirement.
- In this case, we are using the ADR Correlation Criteria (E- and F-Harmonics) to give sufficient evidence to accurately locate sulphides beneath the ground.
- The evidence from one single criteria, e.g., F-Gamma, is not sufficient to fulfil the requirement, therefore, a combination of criteria is used.
- The criteria used for the Sulphide WofE Identification are F-Gamma, F-ADR, F-Mean, F-SD, E-ADR, E-Mean and E-SD.

Evolution of WofE for Sulphide Identification

1. Correlation Criteria determined from drill hole comparisons in project 00219. F-Gamma, F-ADR, F-Mean, F-SD, E-Gamma, E-ADR, E-Mean, E-SD and E-Log to be used.

2. Correlation Criteria using the Circles Method to find 4 most significant peaks/troughs. *Refer to "Correlation Criteria Explanation" document.*

3. Changes made to the Circles method. Red circles for energy logs and Blue for frequency logs. Circle size reduced to ½ size due to only ~300m zone to be interpreted.

4. New quantitative method using sorting and formulas in Excel. CSV output generated for Geoscience Analyst Model. *Refer to "Creating a new WofE result v1" document.*

5. Testing carried out for Different Depth's of Influence, Criteria and Chart Outputs across previous projects. Stacked Bar Charts provide a criteria-sensitive view of the results.

6. High F-Mean, High E-ADR & Low E-ADR picked out as the 3 strongest criteria for sulphide detection. Final outputs created *Refer to "Creating a new WofE result v2" document.*

ADR Correlation Criteria

- The ADR Correlation Criteria for sulphide identification have been chosen based on comparisons and typecasting from project 00219 site BB008.
- This site is parallel to drill hole BBDD0054 which has high grade sulphides (up to 70% Pyrite).
- ADR data was compared to this assay data to generate the ADR Correlation Criteria for sulphides (right).
- We have not been able to correlate E-Gamma, F-Corr charts or DC with sulphides so these are not included. E-log is also not included but an be used to detect boundaries

Correlation criteria

F-Charts
Low F-Gamma
High F-ADR
High F-SD
Step change in F-Mean (high F-Mean)

E-Charts
High E-Mean
Low E-Log
High E-SD
E-ADR (high &/or Low)
Transition ←→ E-Gamma

F-Corr charts
Peak in 5-10 MHz + no peak in 1-5MHz
(intensity of peak corresponding to % sulfides

DC (Dielectrics)
Change from high variability from SD to low variability.

Red – key criteria
Orange – in development

1

ADR Correlation Criteria

- Based on the experiments in project 00219, 7 criteria have been taken forward into the ADR Correlation Criteria as potential sulphide identifiers.
- High responses in F-ADR, F-Mean, F-SD, E-ADR, E-Mean and E-SD.
- Low response in F-Gamma.
- Low E-Log was originally used as a criteria for sulphide detection, however, this has since been removed from the correlation criteria and used comparatively as a boundary indicator.
- We expect a combination of these criteria to be able to accurately locate sulphide zones.

Correlation criteria

F-Charts

Low F-Gamma
High F-ADR
High F-Mean
High F-SD

E-Charts

Transition ←→ E-Gamma
High &/or Low E-ADR
High E-Mean
High E-SD
Low E-Log

2

WofE using the Circles Method

- The first method that was used to produce the WofE was the "Circles Method". This was a good test to compare with existing drill hole data.
- F- and E-Charts were imported into Inkscape to be aligned and scaled.
- Upper 200m removed due to noise (May not be the case for other projects).
- Each plot of results has min and max values. In theory, significant changes in mineralogy should also produce a significant response in the ADR results. Accordingly, this process focusses around delineating the zone(s) that demonstrate the greatest number of significant variables in multiple datasets (E- and F- results).
- The top 4 peaks (or troughs, depending on the criteria) are identified and highlighted using the pre-scaled circles provided (bottom right).
- The size of the circle represents the depth of influence (DOI) and is proportional to the WofE value. A larger circle represents a greater WofE value.
- The largest peak is given a value of 4 and a greater DOI (larger circle size) and each next lower peak is reduced in value and DOI from 3 to 2 to 1. Large or double peaks are given 2x value and represented by a bold (2pt) circle, but not twice the DOI.

Correlation criteria

F-Charts

Low F-Gamma

High F-ADR

High F-Mean

High F-SD

E-Charts

Transition ←→ E-Gamma

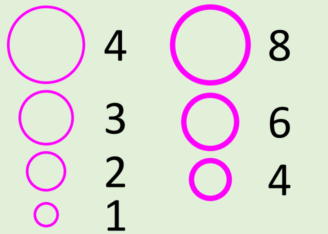
High &/or Low E-ADR

High E-Mean

High E-SD

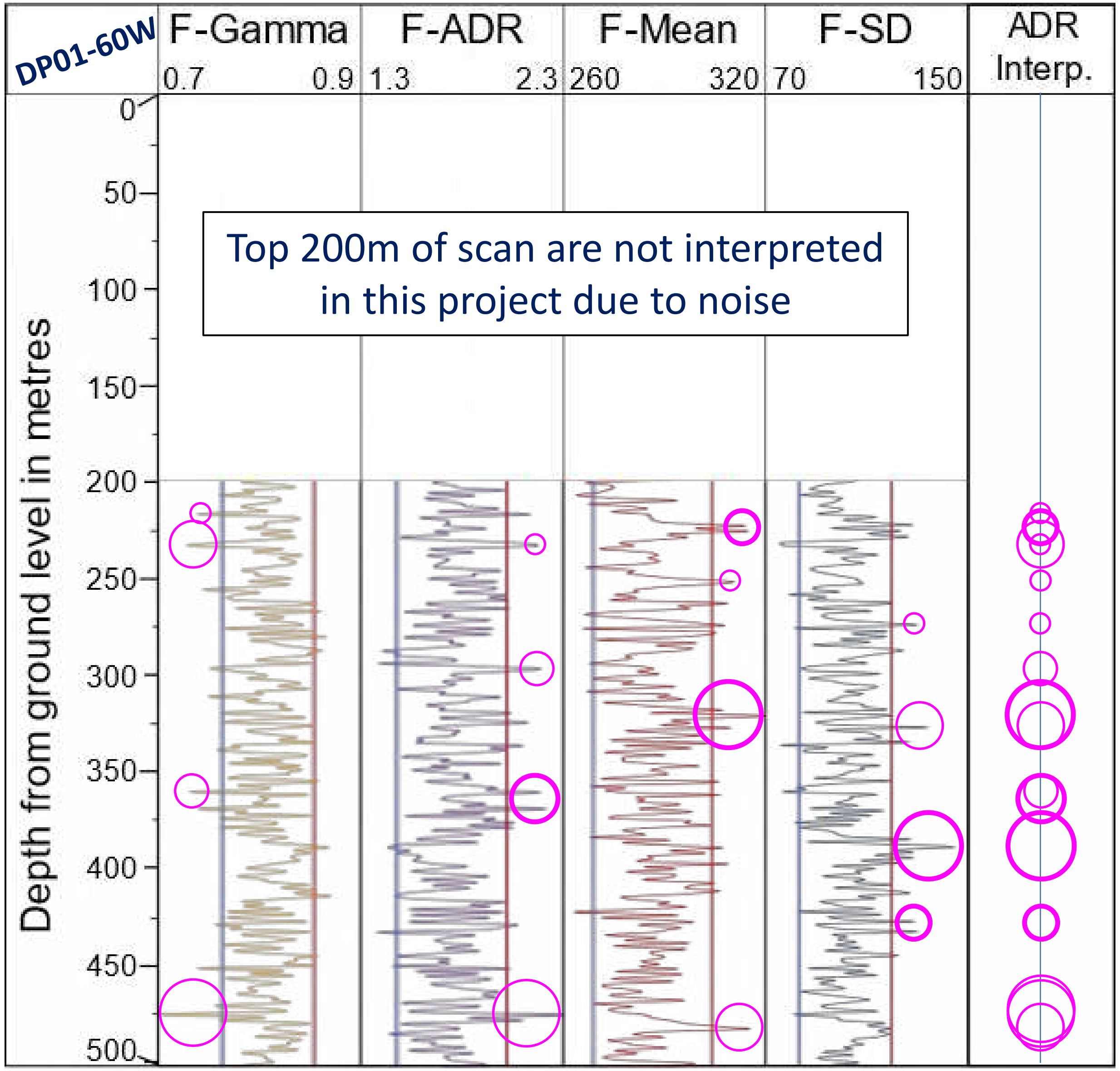
Low E-Log

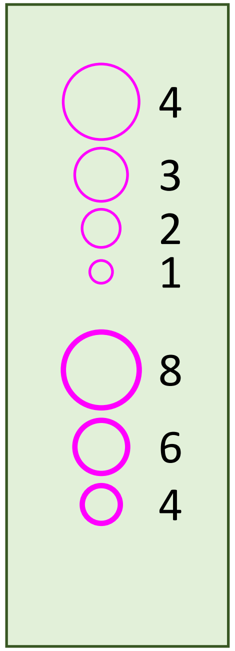
Pre-Scaled Cirlces. Circle size increased to 2pt size in the case of a large or double peak



Click the adjacent hyperlink for detailed methods

Circles Method v1: F-Charts





Correlation criteria

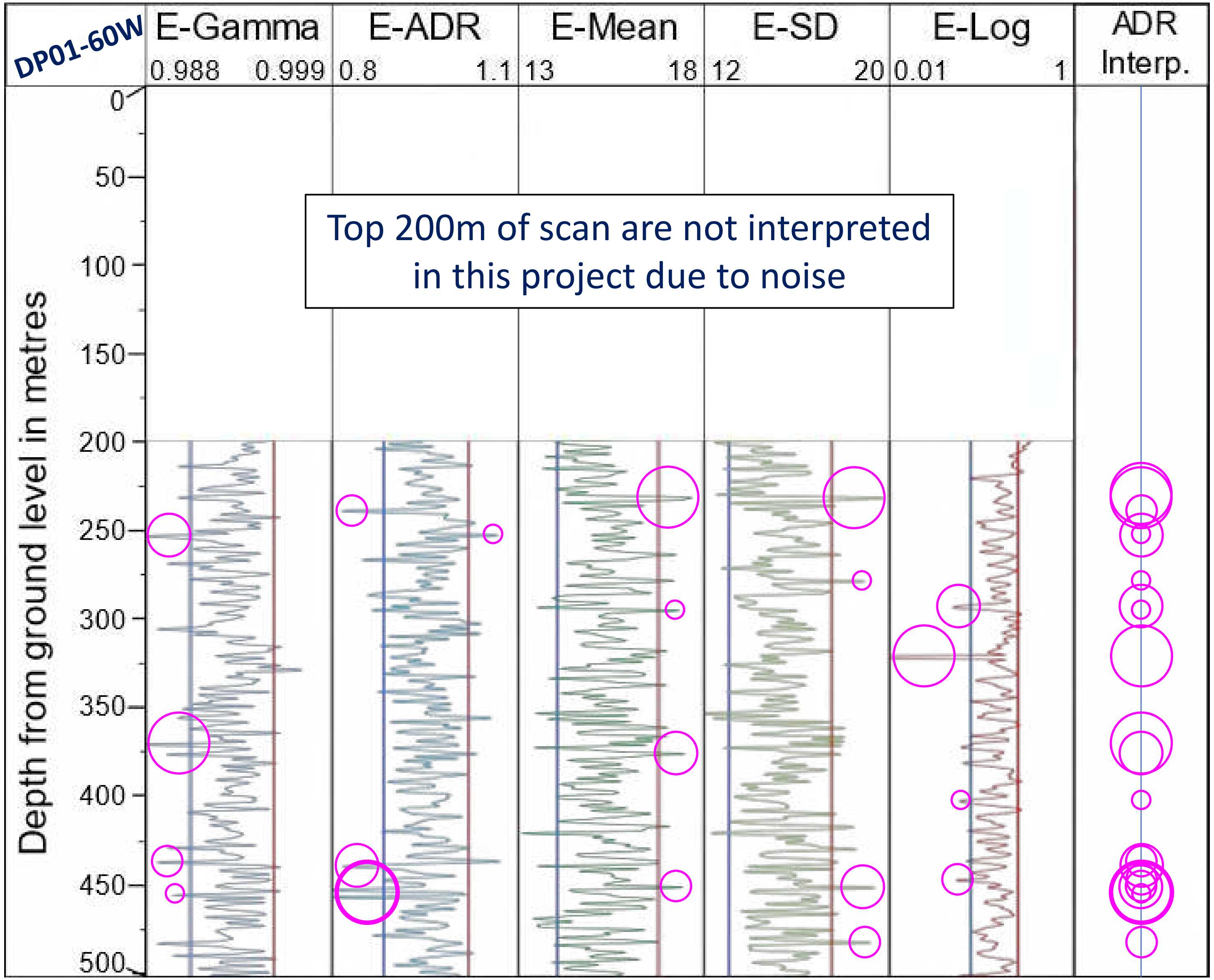
F-Charts
Low F-Gamma
High F-ADR
High F-Mean
High F-SD

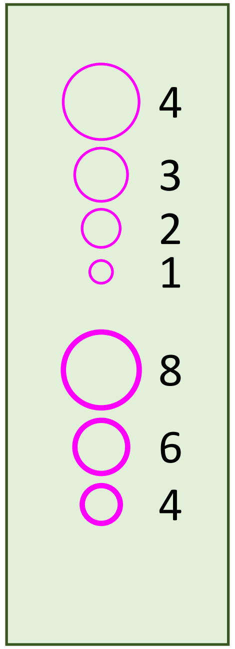
E-Charts
Transition ←→ E-Gamma
High &/or Low E-ADR
High E-Mean
High E-SD
Low E-Log

- Each chart will have 4 different sized circles indicating the 4 most significant peaks/troughs.
- Bold (2pt) circles applied to large or double peaks.
- All circles from the four F-Charts are collated in a final ADR Interpretation column to be taken forward into the combined results.

2

Circles Method v1: E-Charts





Correlation criteria

F-Charts

Low F-Gamma
High F-ADR
High F-Mean
High F-SD

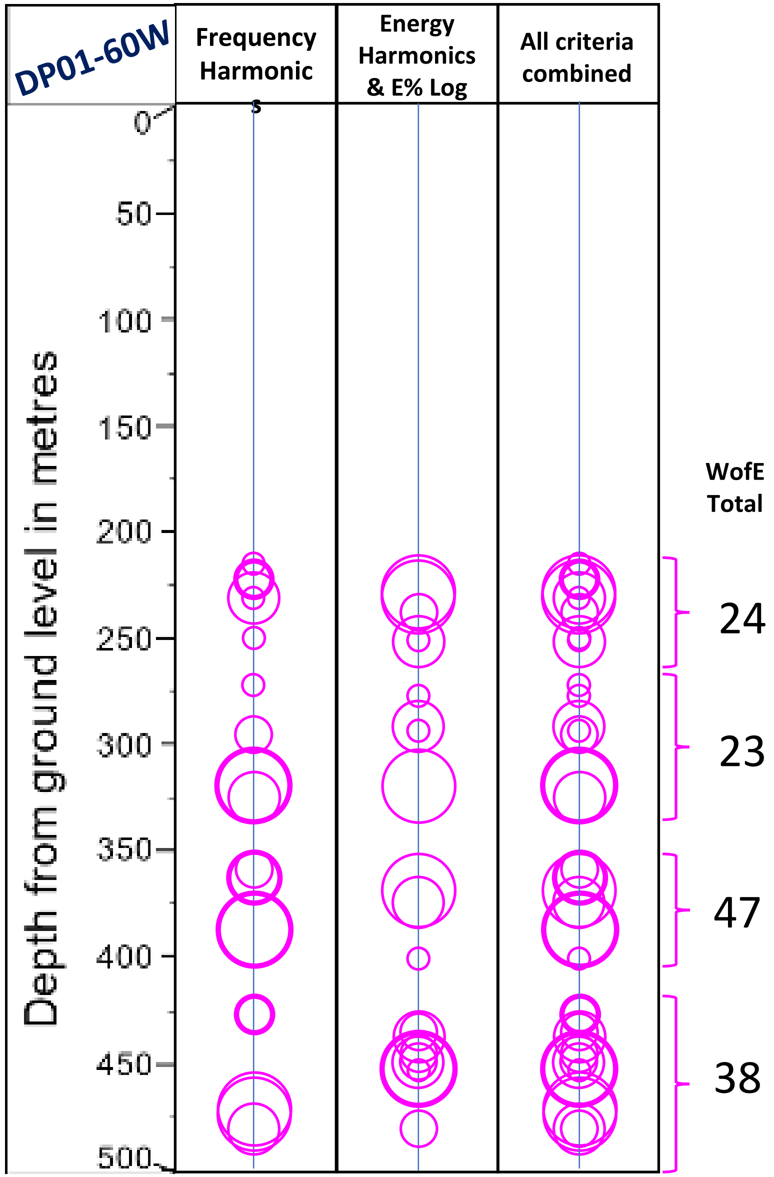
E-Charts

Transition ←→ E-Gamma
High &/or Low E-ADR
High E-Mean
High E-SD
Low E-Log

- Each chart will have 4 different sized circles indicating the 4 most significant peaks/troughs.
- Bold (2pt) circles applied to large or double peaks.
- All circles from the five E-Charts are collated in a final ADR Interpretation column to be taken forward into the combined results.

Circles Method v1: Combined Results

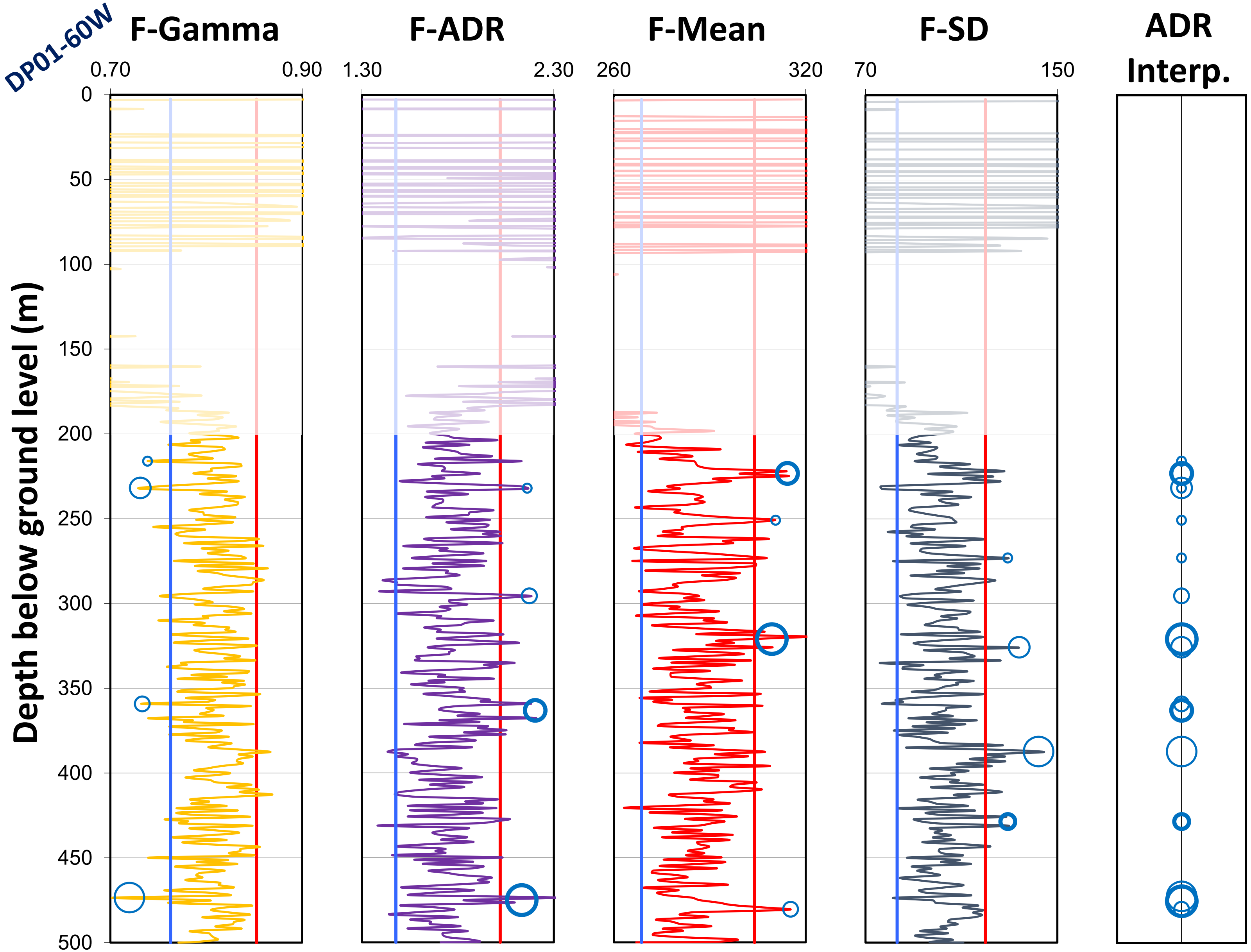
2



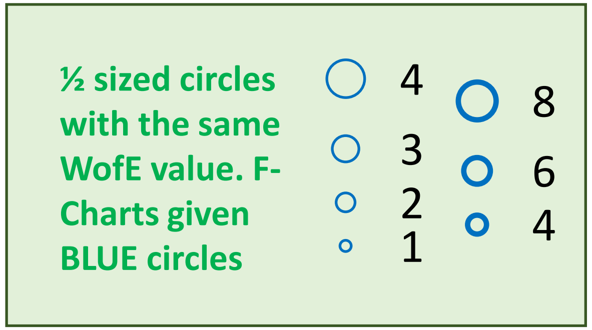
- Both sets of results (Frequency results and Energy results) are combined into a final Combined Criteria column and aligned vertically.
- Once aligned, the density (i.e. clustering) of points is taken as approximately equal to the significance and number of changes in the ADR data.
- The values of each circle can be added where they overlap in different clusters.
- As seen here in DP01-60W, there are 4 clustered zones with WofE totals ranging from 23 to 47.
- Due to the noise in the top 200m, there is only 300m worth of scan that can be interpreted. This has led to over-clustering of the circles, making it difficult to pinpoint any mineralisation zones accurately.
- In the combined criteria column, there is also no way of discriminating between Frequency and Energy circles.
- Following this analysis, the circles method was adapted to improve interpretations.

Circles Method v2: F-Charts

3

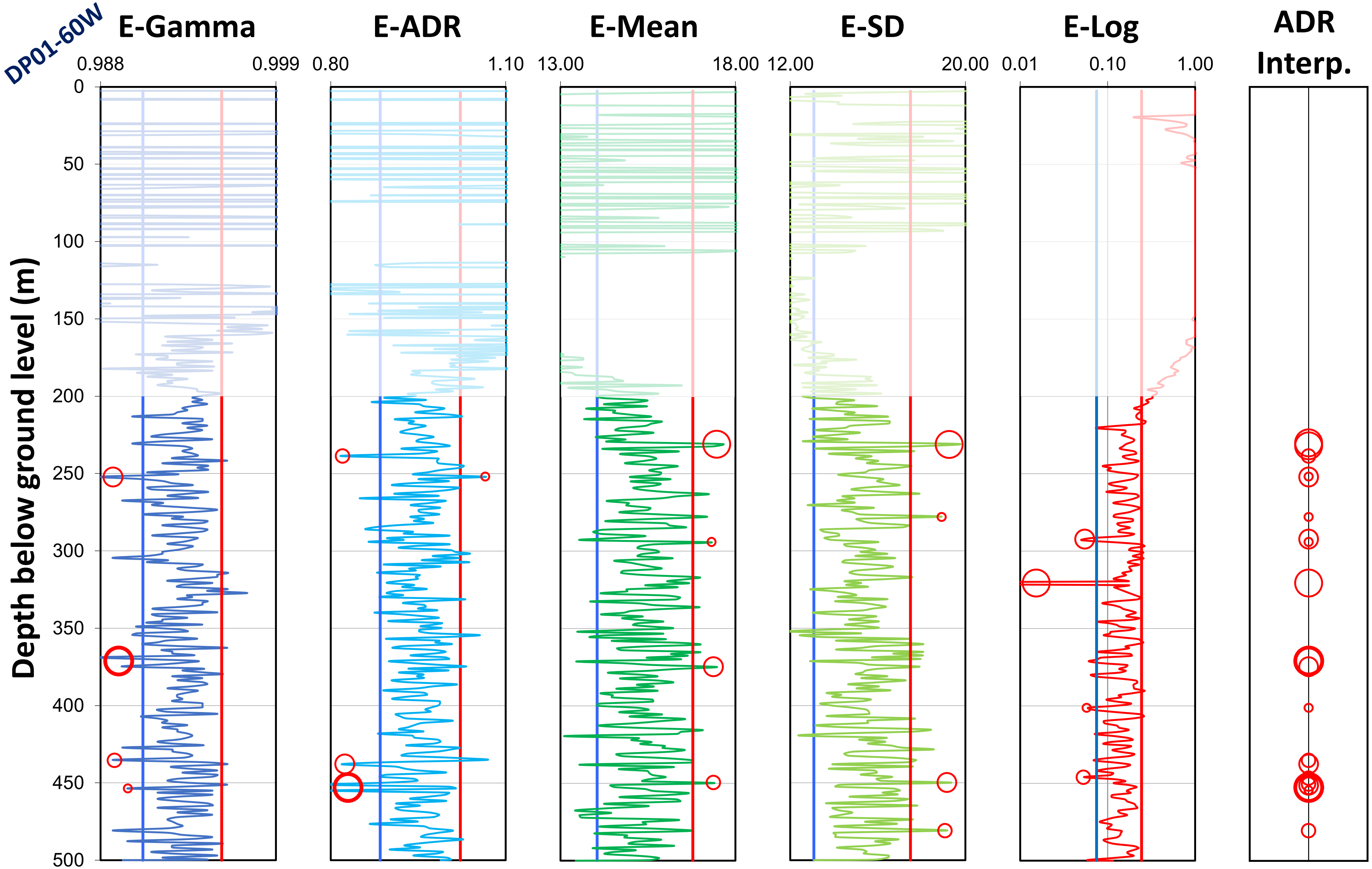


- Formatting of the charts is changed. Inkscape no longer used, instead charts are imported directly from Excel and aligned within PowerPoint using a template.
- Top 200m "noise" is faded out and not interpreted.
- To reduce over-clustering in the 300m section, circles are reduced in size by ½.
- F-Charts given blue circles and E-Charts given red circles to discriminate between the two in the combined results column.
- Process of identifying peaks and applying circles is the same as previous.

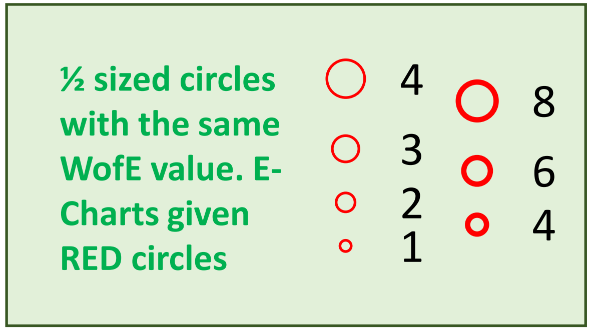


Circles Method v2: E-Charts

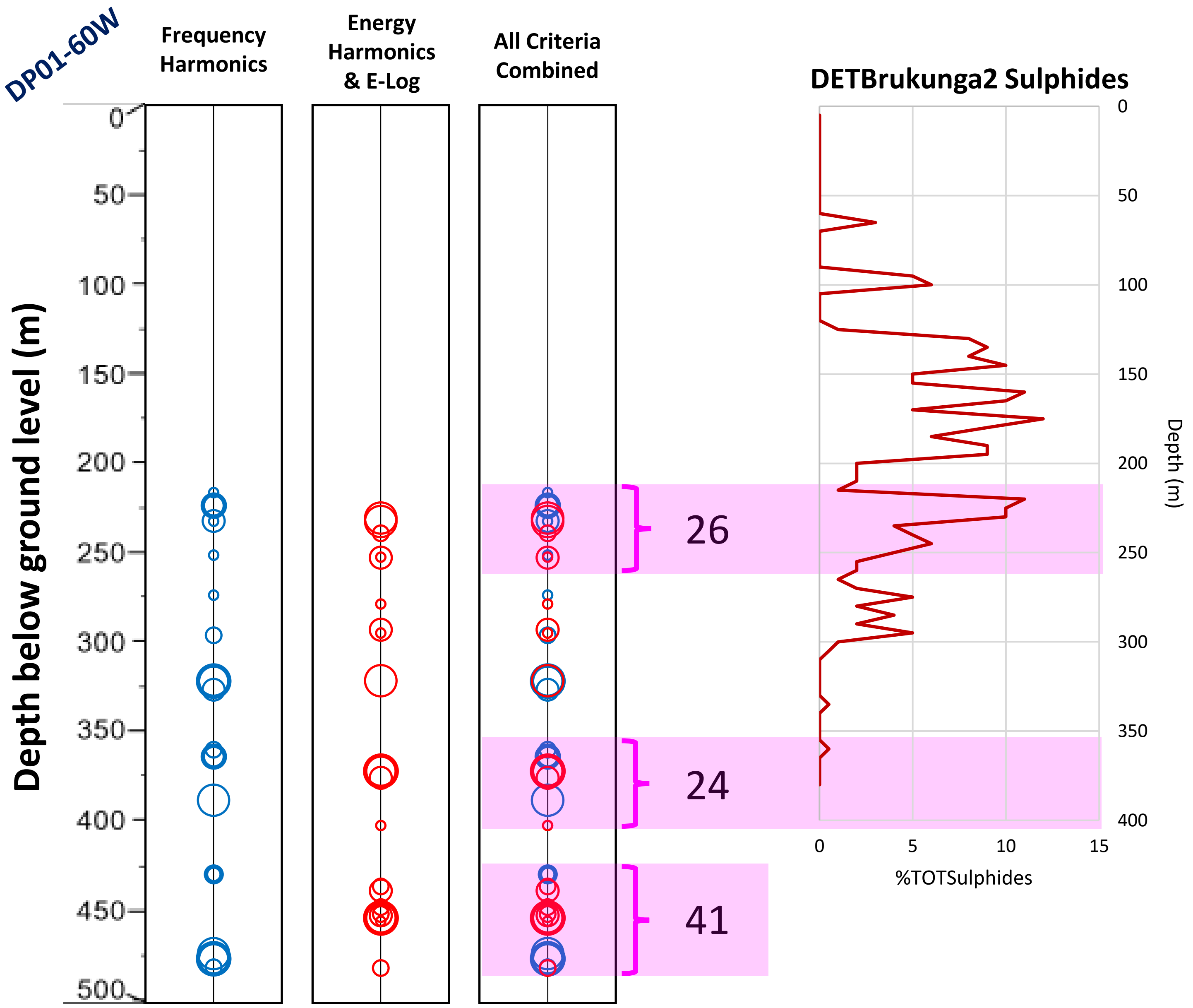
3



- To reduce over-clustering in the 300m section, circles are reduced in size by ½.
- F-Charts given blue circles and E-Charts given red circles to discriminate between the two in the combined results column.
- Process of identifying peaks and applying circles is the same as previous.



Circles Method v2: Combined Results



- After the adjustments that were made to the Circles Method, DP01-60W now shows 3 clustered zones with WofE totals ranging from 24 to 41.
- The depths of these zones and their respective WofE totals are similar to the results from the previous version of the Circles Method, however, there is less visual over-clustering and there is 1 less zone.
- Unfortunately, in the drill hole DETBrukunga2, the bulk of the sulphides are situated within the top 200m. We are unable to interpret this section of our data. We also do not have drill hole data below 400m.
- Despite this, the major peak below 200m is picked out very well by the WofE. The correlation of other minor peaks in sulphides is less clear.
- A more quantifiable method of presenting the WofE data could provide clearer results .

Quantitative WofE Method v1

- In order to generate a more quantifiable set of WofE results that can also be easily imported into the Geoscience Analyst 3D Model, a new method using sorting and formulas in Excel was produced.
- At this stage, E-Gamma and E-Log were removed from the Correlation Criteria due to poor signal correspondence to sulphides.
- The user is required to set-up 3 Excel Worksheets.
- The first is used to clip and sort the Raw E- and F- Harmonics in order to pick out the 4 most significant peaks/troughs, depending on the Correlation Criteria.
- The second sheet requires the user to enter WofE values from 4-1 at the depths corresponding to the 4 most significant peaks (i.e., the largest peak is given a WofE value of 4). A depth of influence (DOI) is then applied to each WofE value. A 50m DOI is given to WofE value 4, 40m to WofE value 3, 20m to WofE value 2 & 10m to WofE value 1. The WofE across each criteria is then totalled at each 1m interval.
- The final sheet requires the data to be organised into a format that can be imported into Geoscience Analyst, for comparisons with the 3D Model.
- A chart displaying the WofE values with depth can also be generated for analysis and comparisons with existing drill sites or other ADR scans.

Correlation criteria

F-Charts

Low F-Gamma

High F-ADR

High F-Mean

High F-SD

E-Charts

High &/or Low E-ADR

High E-Mean

High E-SD

Click the below hyperlink for detailed methods for this version.

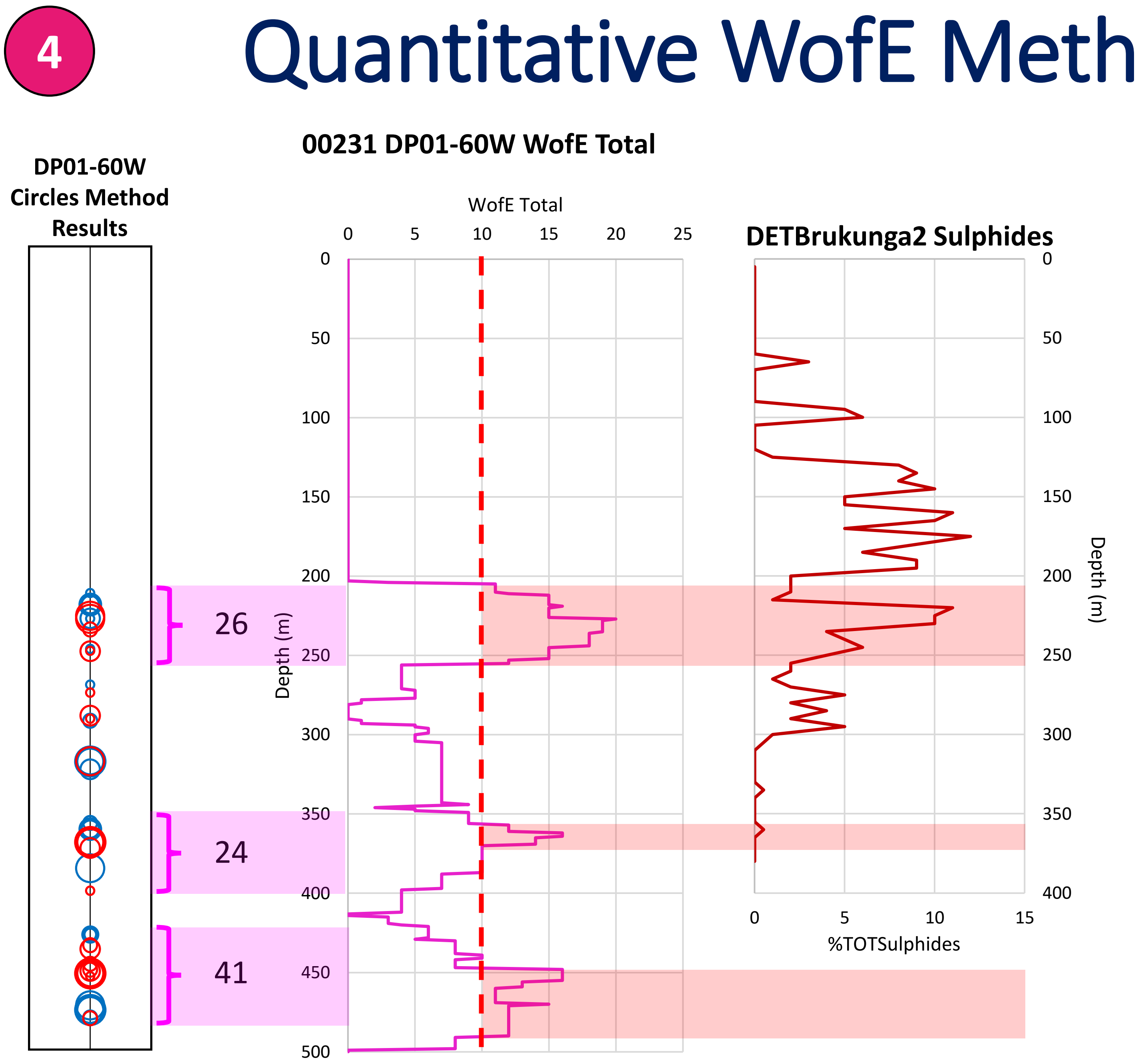

DRAFT/TRIAL WORKFLOW FOR

CREATING A NEW WofE RESULT

FROM HARMONIC E- AND F- DATA FOR IMPORTING AND INTERPRETATION IN GEOSCIENCE ANALYST

Version 1.0 SWR 26-05-2020

Quantitative WofE Method v1: Results



- The output from the Quantitative WofE Method (middle) correlates very well with the Circles Method (left) whilst also providing a more accurate and quantifiable view of the results.
- If a cut-off WofE total value of 10 is given for sulphides, there is very good correlation with the drill hole data from DETBrukunga2.
- Unfortunately wecannot compare against the top 200m, however, we have a strong response in the WofE between 200-250m, correlating with the major large peak from the drill site.
- The smaller WofE peak at 360-370m also correlates with a small peak in %TOTSulphides from DETBrukunga2.
- The smaller peaks between 270-300m are not identified by the WofE.
- The WofE suggests that there are also sulphides present between 450-500m, however, we do not have any drill hole data for these depths.

WofE Testing

- At this stage of the WofE evolution, the results from the WofE are satisfying, however, with some tweaking of the methods and testing of different variables, the WofE tool can be improved and taken to the next level.
- 8 different ADR scans from previous projects (see table) were used with their respective drill hole data to test the WofE technique.
- The Depth of Influence was altered to observe the visual changes in the final WofE results.
- Other criteria/parameters were tested, e.g., using **both** High E-ADR and Low E-ADR responses in the Correlation Criteria.
- Stacked Bar charts generated from the WofE, with different coloured bars assigned to each criteria. This made it possible to differentiate between each criteria in the final results, to determine which criteria are the best at picking out sulphides.

List of ADR Scans used for WofE Testing:

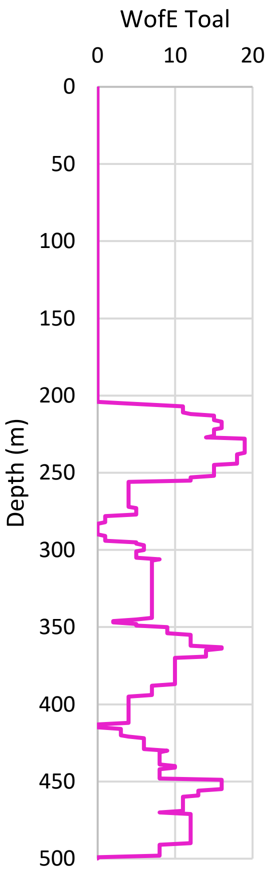
Project #	Hole Name
00193	ORE (H3)
00218	AN810 (H1)
00218	AN944 (H3)
00219	BB008 (H1)
00219	BB004 (H2)
00219	MY003 (H4
00219	TN005 (H6)
00231	DP01-60W

WofE Testing: Depth of Influence

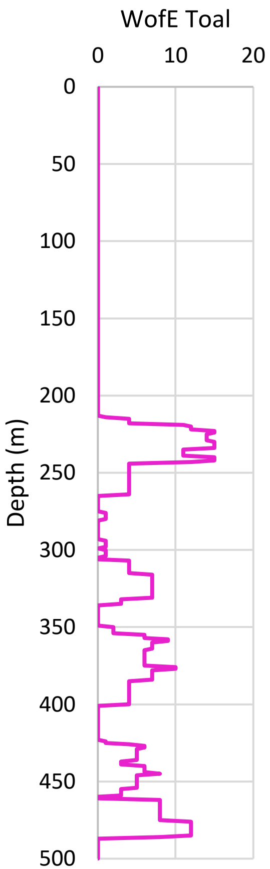
- The original Depth's of Influence are 10m, 20m, 40m and 50m buffer zones for WofE1, WofE2, WofE3 and WofE4, respectively.
- These depths were assigned based on the assumed average thickness of disseminated sulphides from projects 00231 (ADR scan DP01-60W, drill hole DETBrukunga2) and 00219 (ADR scan BB008, drill hole BBDD054).
- As seen in the adjacent charts, when the Depth of Influence's for the WofE are reduced, the most significant peaks remain, whilst there is visible a reduction in the "False Positives".

Note: The four numbers in brackets at the end of the chart title refer to the Depth of Influence for the 4 most significant peaks (WofE1, WofE2, WofE3, WofE4)

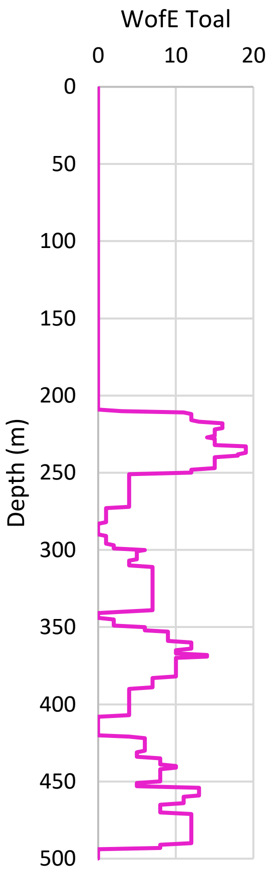
00231 DP01-60W WofE Total (10, 20, 40, 50)



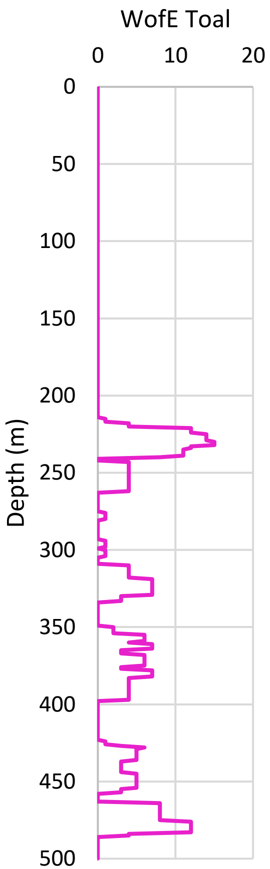
00231 DP01-60W WofE Total (5, 10, 20, 25)



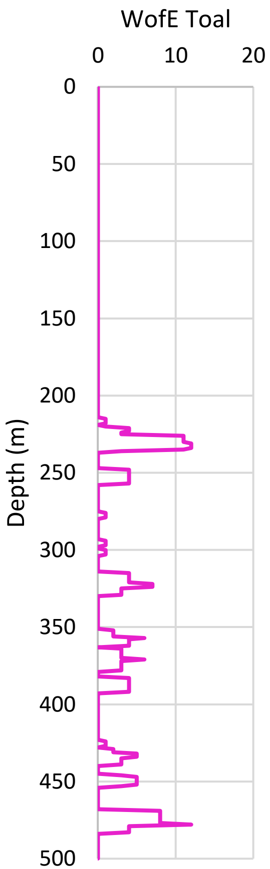
00231 DP01-60W WofE Total (10, 20, 30, 40)



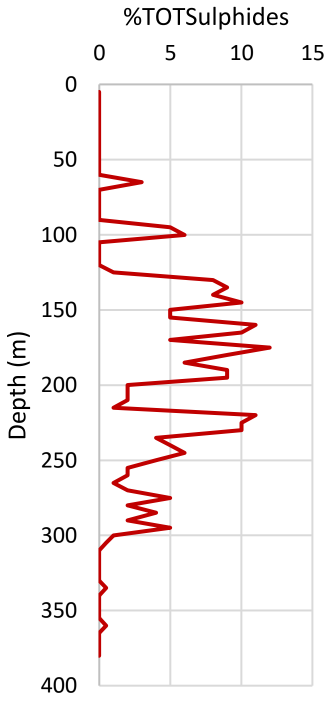
00231 DP01-60W WofE Total (5, 10, 15, 20)



00231 DP01-60W WofE Total (4, 6, 8, 10)

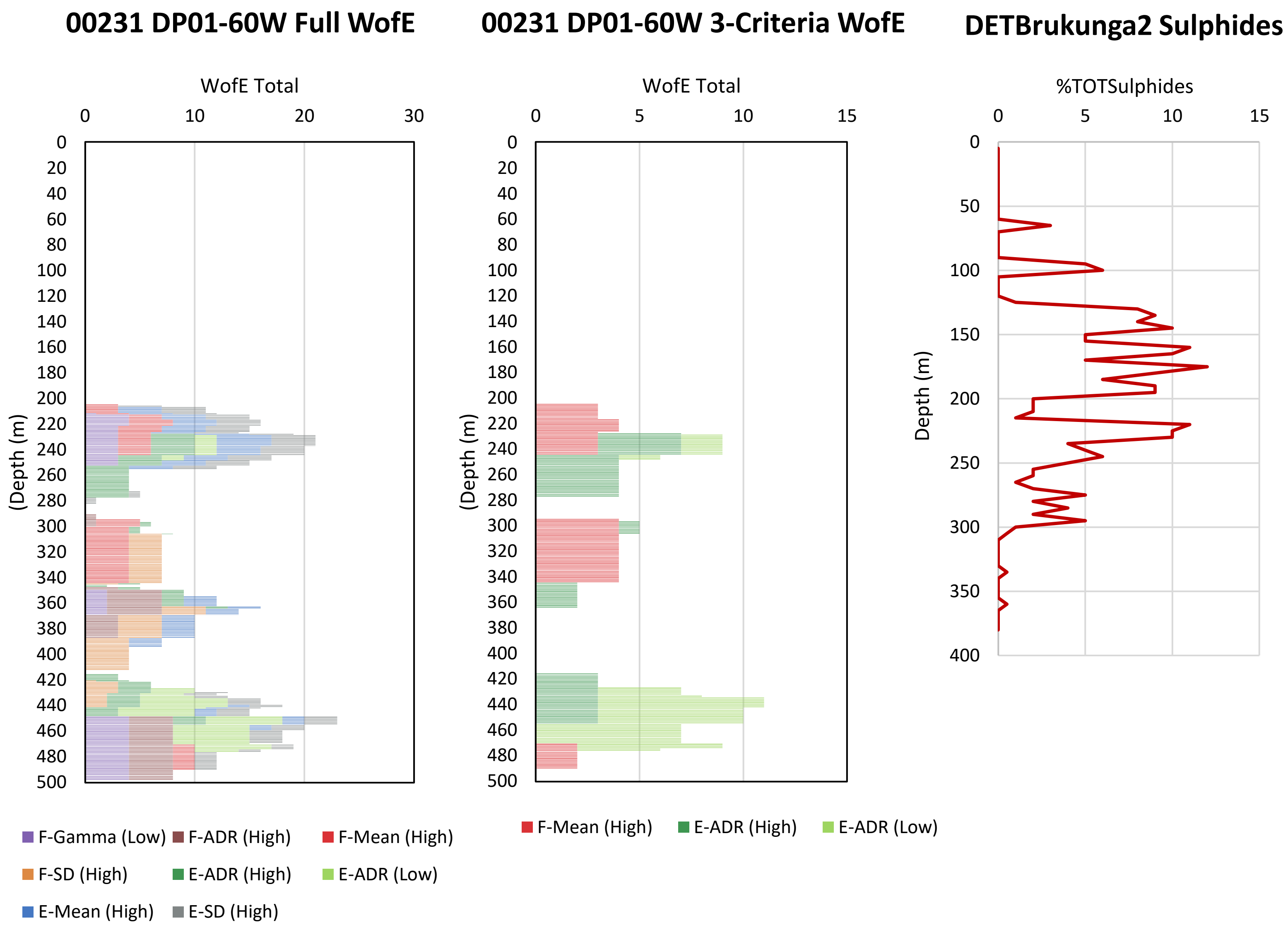


DETBrukunga2 Sulphides



6

WofE Stacked Bar Charts



- Low E-ADR was added to the Sulphide Correlation Criteria, as well as already having High E-ADR.
- Stacked Bar Charts generated for each of the ADR Test Scans.
- After analysis of each criteria within the stacked bar charts for each Test Scan, 3 Criteria stood out as the strongest Sulphide indicators.
- These are High F-Mean, High E-ADR & Low-E-ADR.
- A combination of looking at the WofE for these 3 criteria, as well as the combined results, stand as a very strong tool for Sulphide identification.

6 WofE Methodolgy

The following 7 slides detail the methodology for generating WofE results from Harmonic E- and F- data for interpretation and importing in Geoscience Analyst.

Preparation

The WofE results can be completed upon the completion of Workflow 5.1

If you haven't already, set up a WofE folder for the project and create subfolders for each V-Bore that you WofE results for.

Within the specific V-Bore folder, you will need copies of the following 5 templates:

- 00###_HoleName_WofE_Harmonics
- 00###_HoleName_WofE_Criteria
- 00###_HoleName_WofE_GSA Output (Full)
- 00###_HoleName_WofE_GSA Output (3-Criteria)
- 00###_HoleName_WofE_GSA Output (Enhanced)

These template can be found here:
G:\Training\WofE\Templates

Rename these files based on the project and V-Bore that you're working on.

You will also need a copy of the "ADR_Results" Spreadsheet (Workflow 5.1 Deliverable) for the respective V-Bore.

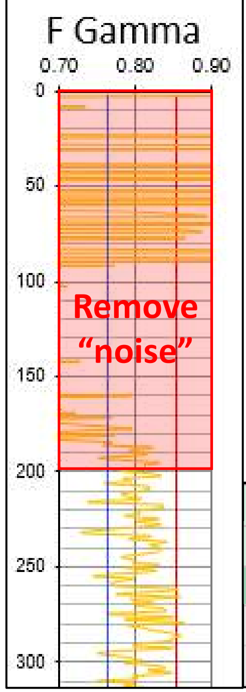
WofE Harmonics Worksheet (1/2)

1) Open the “ADR_Results” Spreadsheet for this V-Bore. Also, open the “WofE_Harmonics” Worksheet. In the first Sheet, named Harmonics, Row 1 should be populated with 8 colour coded criteria, each with their own depth column.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
1	DEPTH	FGAMMA (Low)	DEPTH	FADR (High)	DEPTH	FMEAN (High)	DEPTH	FSD (High)	DEPTH	EADR (High)	DEPTH	EADR (Low)	DEPTH	EMEAN (High)	DEPTH	ESD (High)
2																

2) Extract the Depth, F-Gamma tot, F-ADR tot, F-Mean tot, F-SD tot, E-Mean tot, E-ADR tot and E-SD tot from the “ADR_Results” Spreadsheet and paste into their respective columns. Each result set should be associated with its OWN depth column.

	A	B	C	D
1	DEPTH	FGAMMA (Low)	DEPTH	FADR (High)
2	2.62	1	2.62	0.748090909
3	4.3	0.104181818	4.3	17.61690909
4	5.75	0.161181818	5.75	24.49527273
5	7.07	0.199090909	7.07	16.99772727
6	8.43	0.733272727	8.43	1.688090909
7	9.83	0.029909091	9.83	62.59290909



3) Once all of the datasets are in together, remove the top "noise" which may include the top 200m of data. This will remove any erroneous datapoints and remove the "skew" of results in the upper part of the scan.

148	196.87	0.811272727
14	Delete	.812909091
150	199.62	0.782272727
151	201.03	0.819636364
152	202.42	0.832454545

4) Once the noise is removed, each of the pairs of data (depth + ADR result) can be sorted according to the correlation criteria from LARGET TO SMALLEST (High) or SMALLEST TO LARGEST (Low). Be sure to use "custom sort" in Excel and select sort by data column, for example F-Gamma.

Note, the criteria highlighted below is currently in use (16/07/2020).

Correlation criteria

F-Charts
Low F-Gamma
High F-ADR
High F-Mean
High F-SD

E-Charts
High E-ADR
Low E-ADR
High E-Mean
High E-SD

Column		Sort On	Order
Sort by	FGAMMA (Low)	Cell Values	Smallest to Largest

WofE Harmonics Worksheet (2/2)

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
1	DEPTH	FGAMMA (Low)	DEPTH	FADR (High)	DEPTH	FMEAN (High)	DEPTH	FSD (High)	DEPTH	EADR (High)	DEPTH	EADR (Low)	DEPTH	EMEAN (High)	DEPTH	ESD (High)
2	473.56	0.701545455	473.56	2.315272727	319.40	319.9611818	387.57	144.4222727	252.1	1.0665625	451.18	0.7784375	230.77	17.5284375	230.77	19.51625
3	232.32	0.731636364	367.63	2.200000000	224.85	314.7318182	325.95	134.0409091	435.21	1.0659375	454.57	0.7925	174.83	17.4604375	449.9	19.3403125
4	359.18	0.732545455	359.18	2.181636364	480.8	314.4734545	431.07	129.3585455	354.42	1.055625	238.62	0.816875	449.9	17.39375	480.8	19.1534375
5	216.07	0.739	295.56	2.181	221.92	313.9797273	425.82	128.639	301.89	1.038125	437.98	0.81875	232.32	17.3090625	277.82	18.918125
6	44[illegible].9	0.729363636	23[illegible].32	2.161181818	25[illegible].62	310.3325455	27[illegible].43	126.3009091	30[illegible].30	1.0370875	26[illegible].58	0.8496875	29[illegible].22	17.2803125	42[illegible].45	18.5070125

Harmonics

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
1	FGAMMA (Low)		FADR (High)		FMEAN (High)		FSD (High)		EADR (High)		EADR (Low)		EMEAN (High)		ESD (High)	
2	Depth	WofE	Depth	WofE	Depth	WofE	Depth	WofE	Depth	WofE	Depth	WofE	Depth	WofE	Depth	WofE
3		4		4		4		4		4		4		4		4
4		3		3		3		3		3		3		3		3
5		2		2		2		2		2		2		2		2
6		1		1		1		1		1		1		1		1

WofE Top 4

5) Copy and Paste the top 4 Depth's from each Criteria in the Harmonics Sheet into their respective columns in the WofE Top 4 Sheet. These 4 depths represent the top 4 peaks/troughs for each criteria. The top 4 peaks are given WofE values from 4 to 1 (largest peak has WofE value of 4).

6) Put the "WofE_Harmonics" Worksheet onto your second screen and open the "WofE_Criteria" Worksheet.

WofE Criteria Worksheet (1/3)

7) In the first Sheet, named **WofE Data**, the depth column is currently set at 1m intervals from 0-1000m. If your scan doesn't have a depth of 1000m, clip the depth column or add to it. Enter the V-Bore name in the 'HOLE ID' Column and populate down to the end depth.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD	AE	AF	AG	AH
1			FGAMMA (Low)				FADR (High)				FMEAN (High)				FSD (High)				EADR (High)				EADR (Low)				EMEAN (High)				ESD (High)			
2	HOLE ID	DEPTH	WofE 1	WofE 2	WofE 3	WofE 4	WofE 1	WofE 2	WofE 3	WofE 4	WofE 1	WofE 2	WofE 3	WofE 4	WofE 1	WofE 2	WofE 3	WofE 4	WofE 1	WofE 2	WofE 3	WofE 4	WofE 1	WofE 2	WofE 3	WofE 4	WofE 1	WofE 2	WofE 3	WofE 4	WofE 1	WofE 2	WofE 3	WofE 4
3		0																																

8) With both spreadsheets open, scroll to the depth corresponding to the WofE value, and enter that value.
Example: In the "WofE_Harmonics" Worksheet, F-Gamma has a WofE value of 4 at 474m depth.
In the "WofE_Criteria" Worksheet, scroll to this depth and manually enter "4" in the 'FGAMMA WofE 4' column at a depth of 474m.
Enter a "3" at 232m in the 'FGAMMA WofE 3' column, and so on.
For each result/criteria, there should be a single value from 1-4 in the corresponding columns WofE 1 to WofE 4 at the respective depths.
Repeat this for all eight results sets.

	A	B
1	FGAMMA (Low)	
2	Depth	WofE
3	473.56	4
4	232.32	3
5	359.18	2
6	216.07	1

WofE_Harmonics

	A	B	C	D	E	F
1			FGAMMA (Low)			
2	HOLE ID	DEPTH	WofE 1	WofE 2	WofE 3	WofE 4
476	DP01-60W	473				
477	DP01-60W	474				4
478	DP01-60W	475				
479	DP01-60W	476				

WofE_Criteria

9) In order to give the values a Depth of Influence (DOI), navigate to a value such as 474m depth in column 'FGAMMA WofE 4'. Here we need to assign the value of 4 to the cells 25m above and below the current cell that has a value of 4. Copy the value 4 so that a total of 50 cells (equivalent to 50m) are filled. This gives a buffer zone of 25m up and down from the inserted value (principal peak or trough in that dataset).

WofE 4 = DOI 50m (25 cells above and below)
WofE 3 = DOI 40m (20 cells above and below)
WofE 2 = DOI 20m (10 cells above and below)
WofE 1 = DOI 10m (5 cells above and below)

See over the page for an example.

WofE Criteria Worksheet (2/3)

9) The table will end up looking mostly empty with a collection of columns with cells filled with either 1, 2, 3, 4. ***QAQC:*** Each set of 4 columns (WofE 1-4) should have a total sum of `Sum: 370`.

	A	B	O	P	Q	R	S	T	U	V	W	X	Y	Z
1			FSD (High)				EADR (High)				EADR (Low)			
2	HOLE ID	DEPTH	WofE 1	WofE 2	WofE 3	WofE 4	WofE 1	WofE 2	WofE 3	WofE 4	WofE 1	WofE 2	WofE 3	WofE 4
419	DP01-60W	416							3					
420	DP01-60W	417							3					
421	DP01-60W	418							3					
422	DP01-60W	419							3					
423	DP01-60W	420							3					
424	DP01-60W	421	1						3					
425	DP01-60W	422	1	2					3					
426	DP01-60W	423	1	2					3					
427	DP01-60W	424	1	2					3					
428	DP01-60W	425	1	2					3					
429	DP01-60W	426	1	2					3					
430	DP01-60W	427	1	2					3					4
431	DP01-60W	428	1	2					3					4
432	DP01-60W	429	1	2					3					4
433	DP01-60W	430	1	2					3					4
434	DP01-60W	431		2					3					4
435	DP01-60W	432		2					3					4
436	DP01-60W	433		2					3		1			4
437	DP01-60W	434		2					3		1			4
438	DP01-60W	435		2					3		1		3	4
439	DP01-60W	436		2					3		1		3	4
440	DP01-60W	437		2					3		1		3	4
441	DP01-60W	438		2					3		1		3	4
442	DP01-60W	439		2					3		1		3	4
443	DP01-60W	440		2					3		1		3	4
444	DP01-60W	441		2					3		1		3	4
445	DP01-60W	442							3		1		3	4
446	DP01-60W	443							3				3	4
447	DP01-60W	444							3				3	4
448	DP01-60W	445							3				3	4
449	DP01-60W	446							3				3	4
450	DP01-60W	447							3				3	4
451	DP01-60W	448							3				3	4
452	DP01-60W	449							3				3	4
453	DP01-60W	450							3				3	4
454	DP01-60W	451							3				3	4
455	DP01-60W	452							3				3	4
456	DP01-60W	453							3				3	4
457	DP01-60W	454							3				3	4
458	DP01-60W	455							3				3	4
459	DP01-60W	456											3	4
460	DP01-60W	457											3	4

10) If any of the top 4 peaks are close to the maximum depth of the V-Bore, there is a chance that WofE values have spilled below the max depth. Scroll to the bottom of the table and delete any WofE values that are below the maximum depth for your V-Bore.

11) There are 3 'WofE TOTALS' columns at the end of the table. The formulas have already been setup in the first row of each totals column. You simply need to double-click on the "Fill Handle" (green box in the lower right corner of the selected cell) in each of the 3 total's cells that contain formulas.

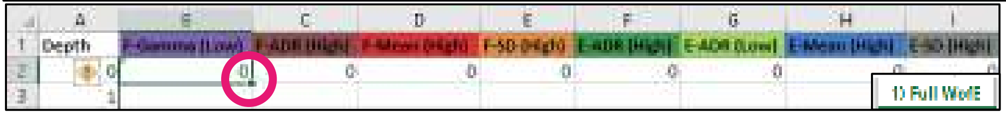
Full WofE = Total of all WofE from all 8 criteria. `=SUM(C3:AH3)`
3-Criteria WofE = Total of all WofE from 3 selected criteria (High F-Mean, High E-ADR & Low E-ADR). `=SUM(K3:N3,S3:V3,W3:Z3)`
3-Criteria Enhanced WofE = Total of all WofE from all 8 criteria, with 2x WofE values for the 3 selected criteria. `=SUM(AI3:AJ3)`

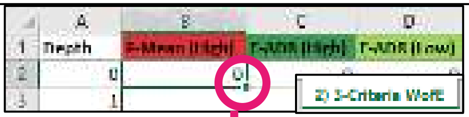
	A	B	AI	AJ	AK
1			WofE TOTALS		
2	HOLE ID	DEPTH	Full WofE	3-Criteria WofE	3-Criteria Enhanced WofE
3	DP01-60W	0	0	0	0
4	DP01-60W	1			

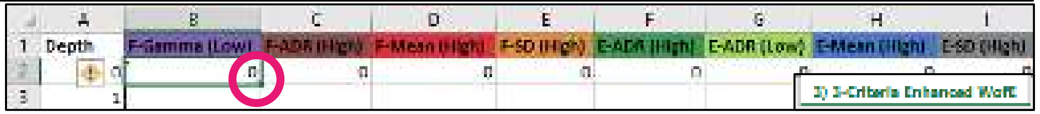
WofE Criteria Worksheet (3/3)

12) Next, we will be working in the 3 other sheets: 1) Full WofE , 2) 3-Criteria WofE & 3) 3-Criteria Enhanced WofE , in order to generate Stacked Bar Charts to be interpreted. As was completed in step **7)**, clip the depth columns in each of these 3 sheets to the depths of the V-Bore (if they are not 1000m scans).

13) In these 3 sheets, the columns represent the total WofE values for each set of results/criteria (e.g., SUM of WofE 1-4 in F-Gamma (High)). The formulas for these sums have already been entered in the first row (depth 0m). Similar to what was completed in step **11)**, double-click on the "Fill Handle" in each of the selected cells to fill out each of the 3 tables.

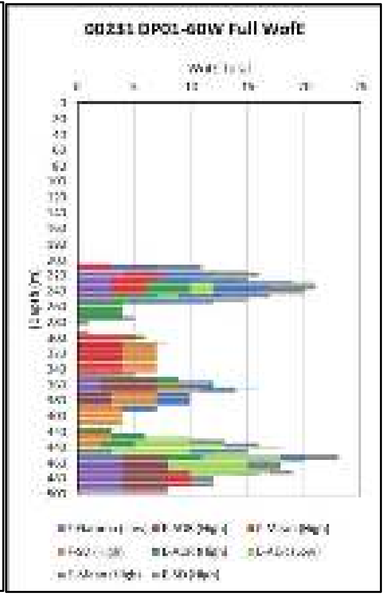






14) The next step is generating the Stacked Bar Charts.
a) First, create a stacked bar chart with the WofE data in the sheet: Click within the data, then: "Insert" > "Recommended Charts" > "All Charts" > "Bar" > "Stacked Bar" > Select the 2nd chart > "OK".
b) "Right-Click" and "Copy" the Template Chart that is in the current sheet.
c) Click on the bar chart that you have just created > Click the "Home" tab > Under 'Clipboard' click the arrow beneath 'Paste' > "Paste special" > check "Formats" > "OK".
d) Edit the chart title and scale/align the bar chart as desired.
e) Repeat these steps for the 2 other sheets.

15) The final charts should look like this (example is for Full WofE, each of the 3 charts will look different). The stacked bar chart plots WofE Values against Depth. The colours represent each of the Correlation Criteria. Peaks in the WofE Total should indicate sulphides. The 3-Criteria (High F-Mean, High F-ADR & Low E-ADR) should be the strongest sulphide indicators, therefore the 3-Criteria WofE and 3-Criteria Enhanced WofE charts should be primarily used for interpretation.



WofE GSA Output Worksheet

16) Now, move the "WofE_Criteria" worksheet to your second screen and open one of the "WofE_GSA Output" Worksheets. The purpose of this worksheet is to produce a .CSV file that can be read into Geoscience Analyst (GSA) for interpretation.

17) Copy and paste the HOLE ID and Depth columns in "WofE_Criteria" Worksheet (WofE Data sheet) and paste them into the HOLE ID and DEPTH FROM columns in "WofE_GSA Output" Worksheet.

	A	B
1		
2	HOLE ID	DEPTH
3	DP01-60W	0
4	DP01-60W	1

WofE_Criteria

	A	B	C	D
1	HOLE ID	DEPTH FROM	DEPTH TO	WofE Total
2			1	
3				
4				

WofE_GSA Output

18) The DEPTH TO column needs to be filled with DEPTH FROM + 1. The simple formula has already been entered into the first row. You simply need to double-click on the "Fill Handle" to populate the rest of this column to the V-Bore max depth. This creates a 1m interval for each of the WofE values which is easier to display and visualize in Geoscience Analyst.

	A	B	C	D
1	HOLE ID	DEPTH FROM	DEPTH TO	WofE Total
2	DP01-60W	0	1	
3	DP01-60W	1		
4	DP01-60W	2		

WofE_GSA Output

19) The data that you will enter into the WofE Totals column will depend on which of the 3 "WofE_GSA Output" Worksheets you are working in (Full WofE, 3-Criteria WofE or 3-Criteria Enhanced WofE). These all relate to the 3 totals columns in the "WofE_Criteria" Worksheet. Choose which total you want to use, copy the column and paste it into the relevant "WofE_GSA Output" Worksheet. Make sure you paste as values to ensure that you don't copy across the formulas.

	A	B	AI	AJ	AK
1				TOTALS	
2	HOLE ID	DEPTH	Full WofE	3-Criteria WofE	3-Criteria Enhanced WofE
3	DP01-60W	0	? 0	? 0	? 0
4	DP01-60W	1	0	0	0

WofE_Criteria

	A	B	C	D
1	HOLE ID	DEPTH FROM	DEPTH TO	WofE Total
2	DP01-60W	0	1	
3	DP01-60W		2	
4	DP01-60W		3	

Paste Options:

Values (V)

WofE_GSA Output

20) Repeat for all 3 "WofE_GSA Output" Worksheets. Finally, For each Output, create a master .CSV file for the project. Copy across all of the data from the GSA_Output Worksheets from each V-Bore. This format can now be imported into Geoscience Analyst to view the WofE for each V-Bore in a project.

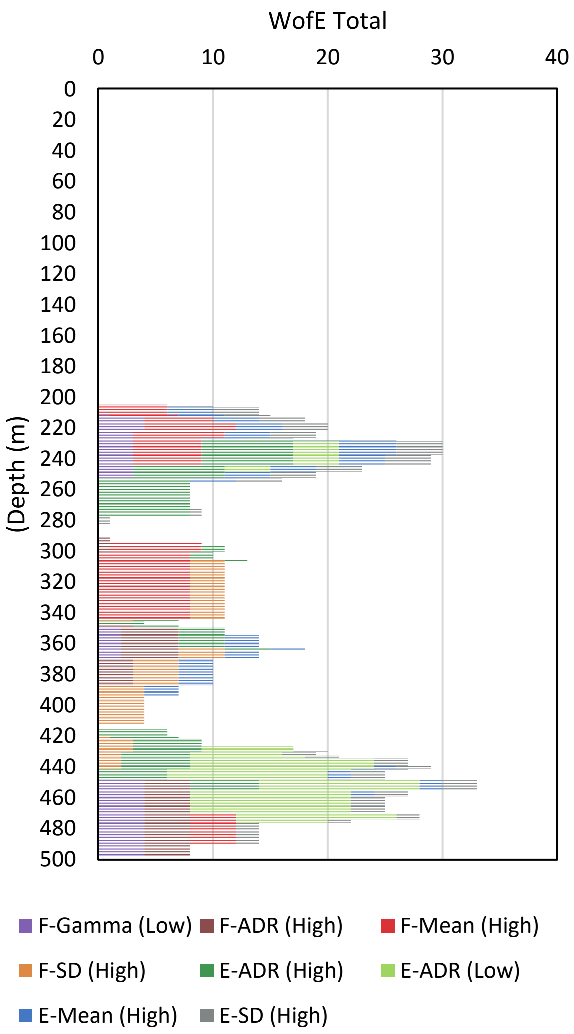
WofE Results

- There are 2 forms of outputs from the WofE results.
- The first is the Stacked Bar Charts which can be used for site by site analysis and interpretation, as well as comparison with the drill hole data.
- The second output is the .CSV files that can be imported into the Geoscience Analyst 3D Model. This gives a more project-wide perspective of the WofE results, allowing more detailed interpretations to be made.

- For this project, 2 of the Stacked Bar Chart Outputs have been taken forward for interpretation. These are the 3-Criteria WofE and 3-Criteria Enhanced WofE Charts due to our confidence in the ability of F-Mean (High) and E-ADR (high & Low) to accurately detect sulphides.
- The following 7 slides will display both of these Stacked Bar Charts for the 7 V-Bores for this project. Direct interpretations of sulphide zones are made using the 3-Criteria WofE chart with a cut-off/baseline WofE value of 5. The 3-Criteria Enhanced WofE chart is adjacent, as a visual comparison to the other correlation criteria.
- DP01-60W is parallel to the drill hole, DETBrukunga2, therefore, this site can be compared directly to the training data.

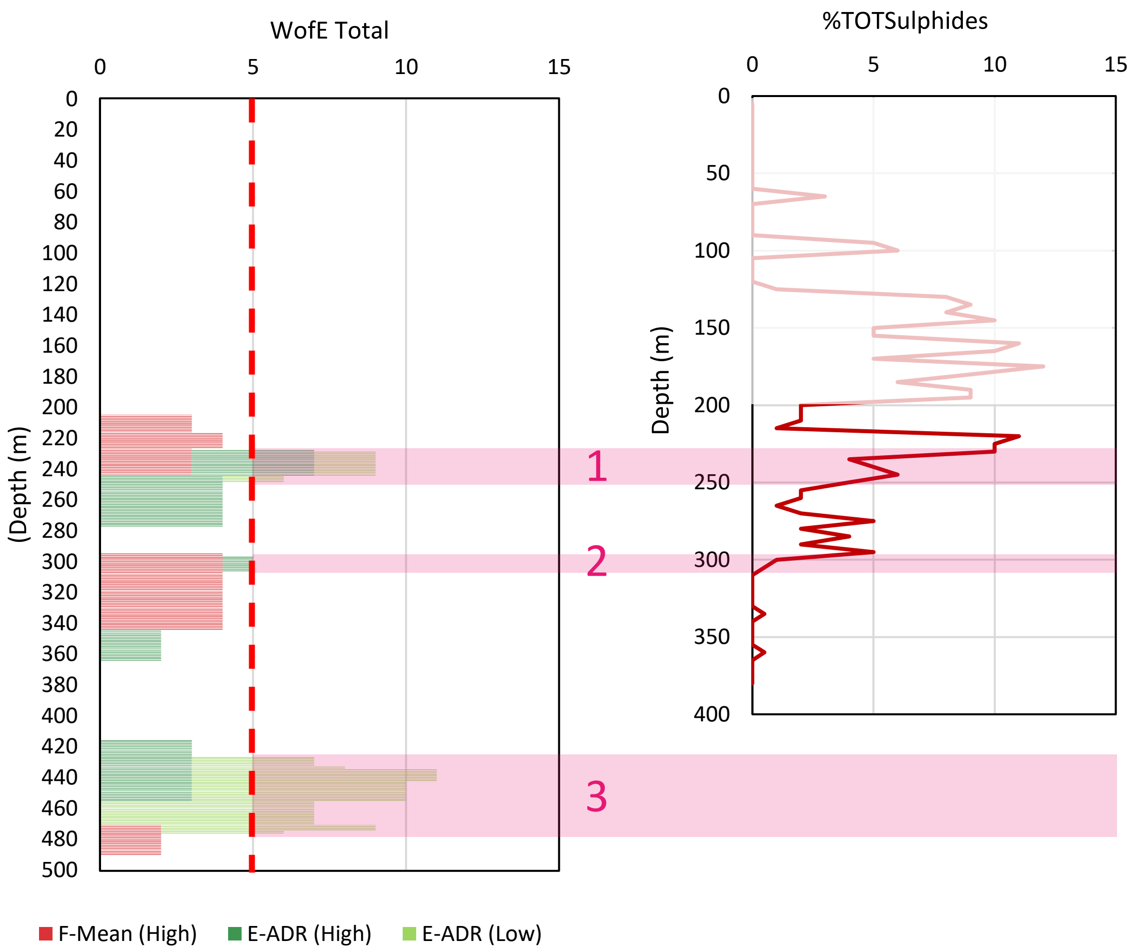
WofE Results: DP01-60W

00231 DP01-60W 3-Criteria Enhanced WofE



00231 DP01-60W 3-Criteria WofE

DETBrukunga2 Sulphides



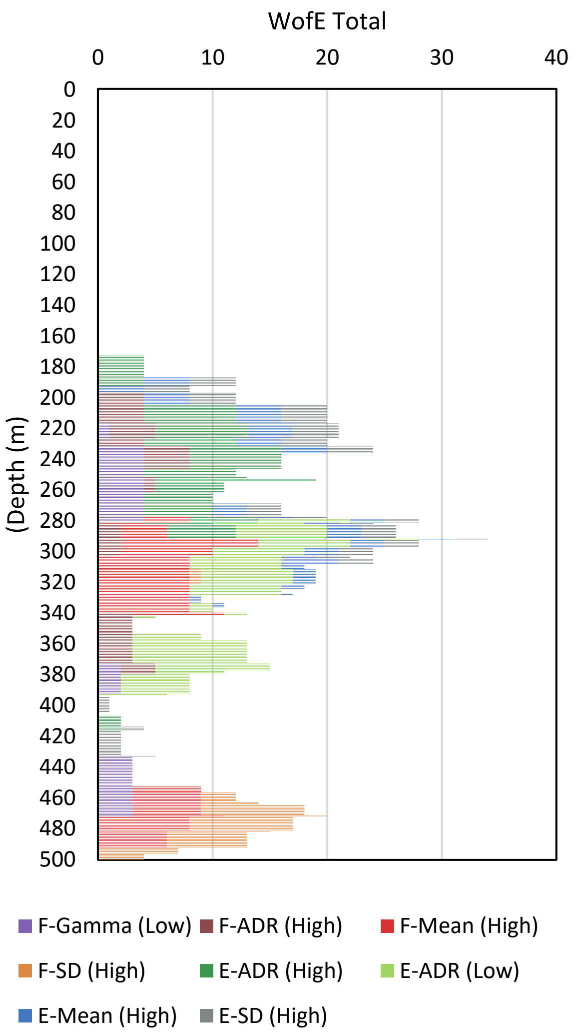
Baseline for Sulphides = WofE Total 5

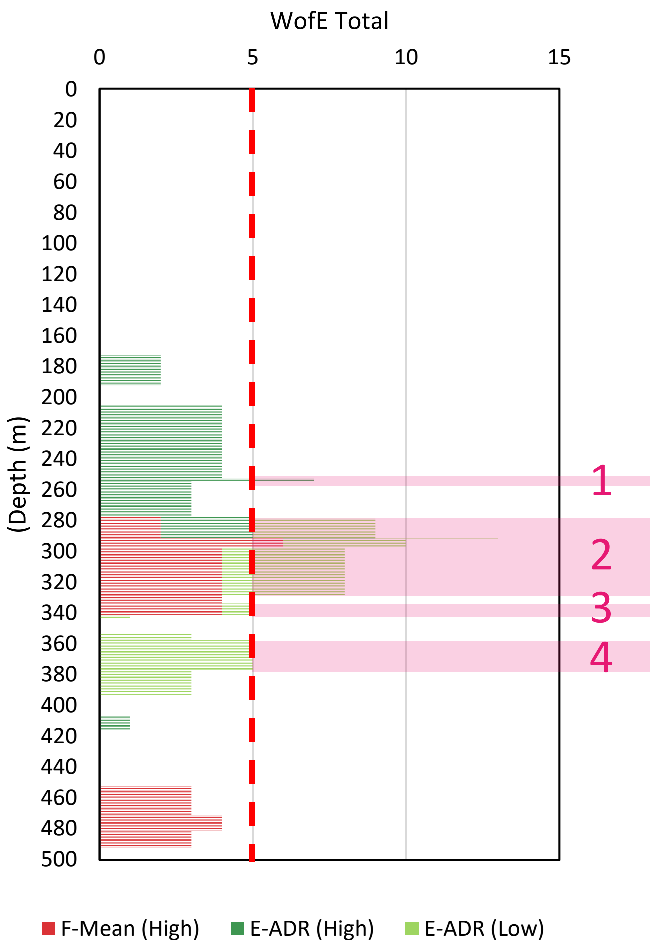
- DP01-60W is parallel to drill hole DETBrukunga2, which contains %TOTSulphides data from 0-400m.
- Targets 1 and 2 correlate well with the sulphides between 220-250m and 260-300m respectively.
- High-confidence in the deeper target 3, however, no training data at depths below 400m.

DP01-60W WofE Sulphide Targets:

Target #	Depth From (m)	Depth To (m)
1	228	248
2	297	306
3	427	476

WofE Results: DP01-60E





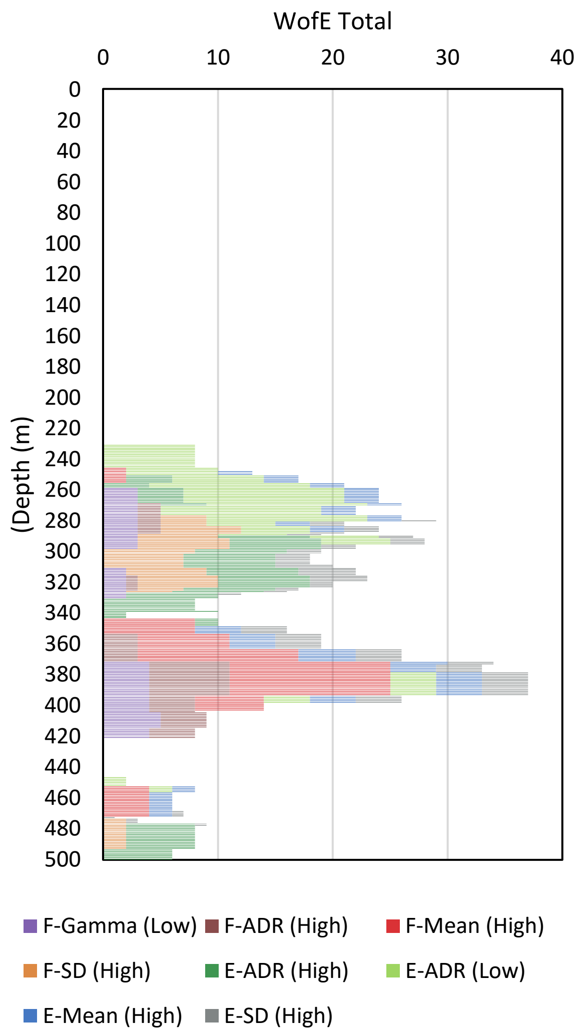
Baseline for Sulphides = WofE Total 5

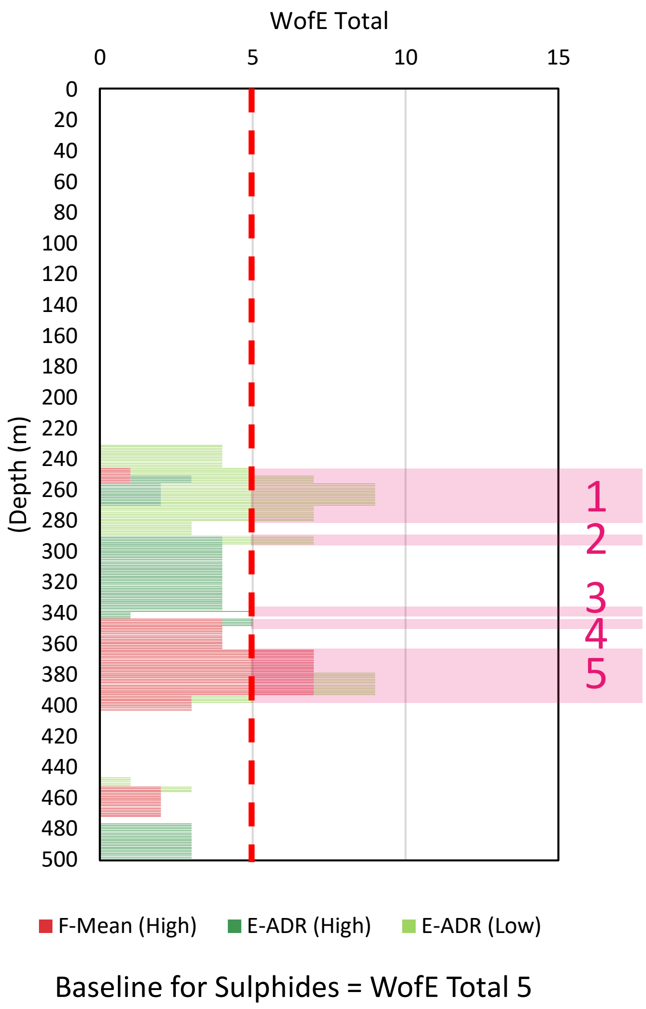
- DP01-60E has 4 targets that are clustered between 250-400m.
- Target 2 has the highest WofE values (up to 13) and meets all 3 of the selected criteria, hence, it is the highest confidence target.
- There is a clustering of WofE Values in the 3-Criteria Enhanced chart between 200-340m.

DP01-60E WofE Sulphide Targets:

Target #	Depth From (m)	Depth To (m)
1	253	254
2	278	328
3	334	341
4	358	377

WofE Results: DP01-90



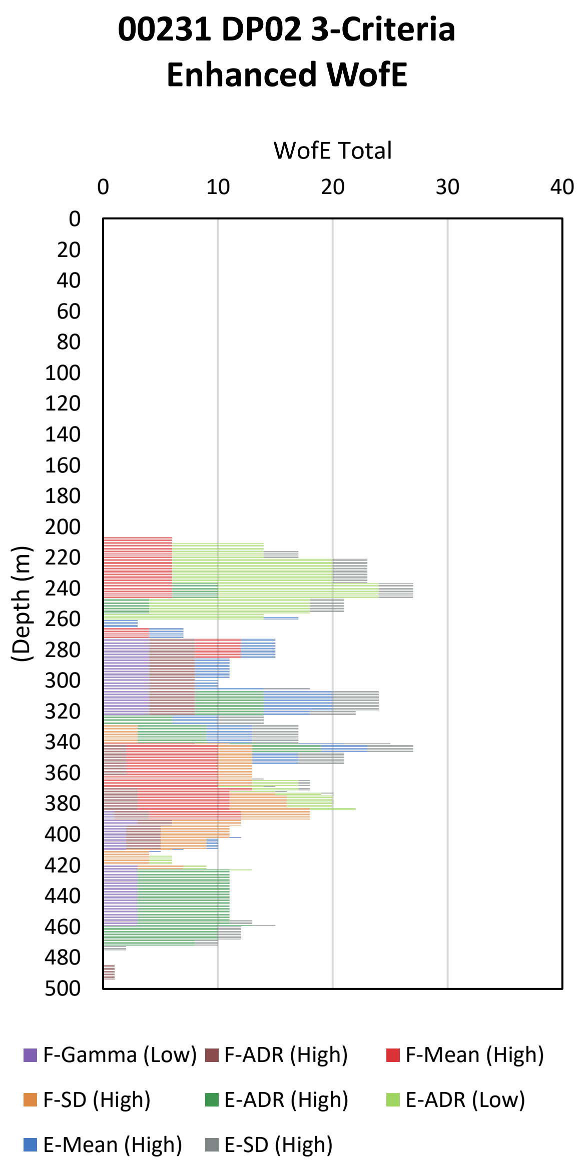


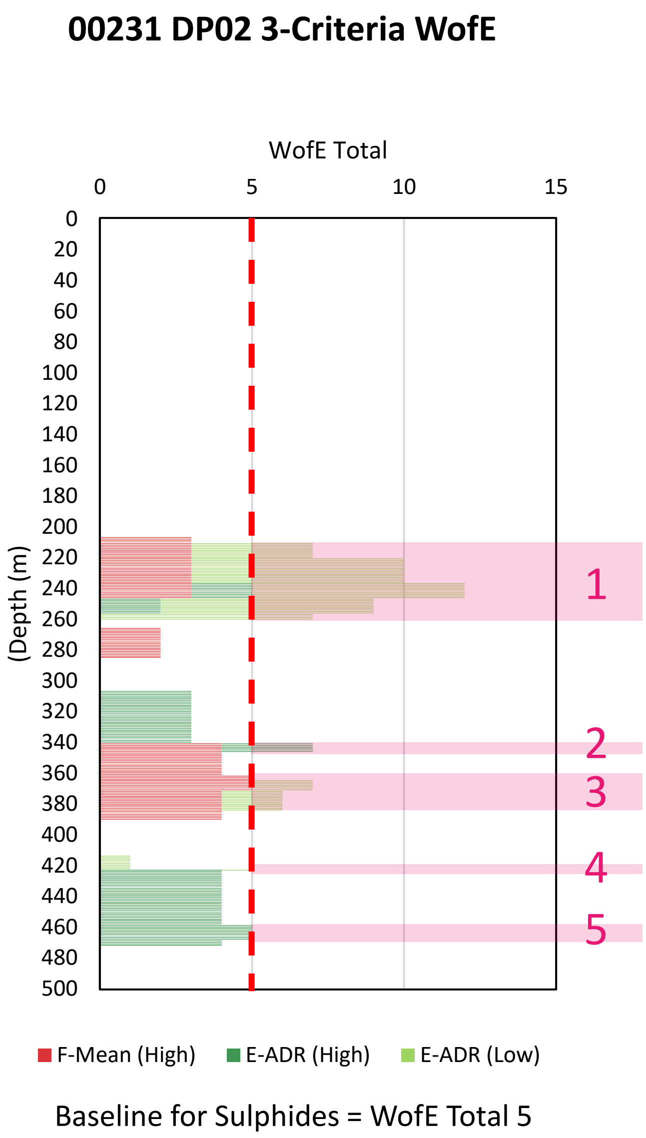
- DP01-90 has 5 targets. 2 main sulphide zones can be picked out between 240-300m (targets 1 and 2) and 340-400m (targets 3,4 and 5).
- The 3-Criteria Enhanced chart shows 2 main clusters of WofE values between 230-340m and 350-400m, correlating to the 2 defined sulphide zones in the 3-Criteria chart.

DP01-90 WofE Sulphide Targets:

Target #	Depth From (m)	Depth To (m)
1	246	280
2	290	295
3	339	339
4	344	348
5	364	398

WofE Results: DP02





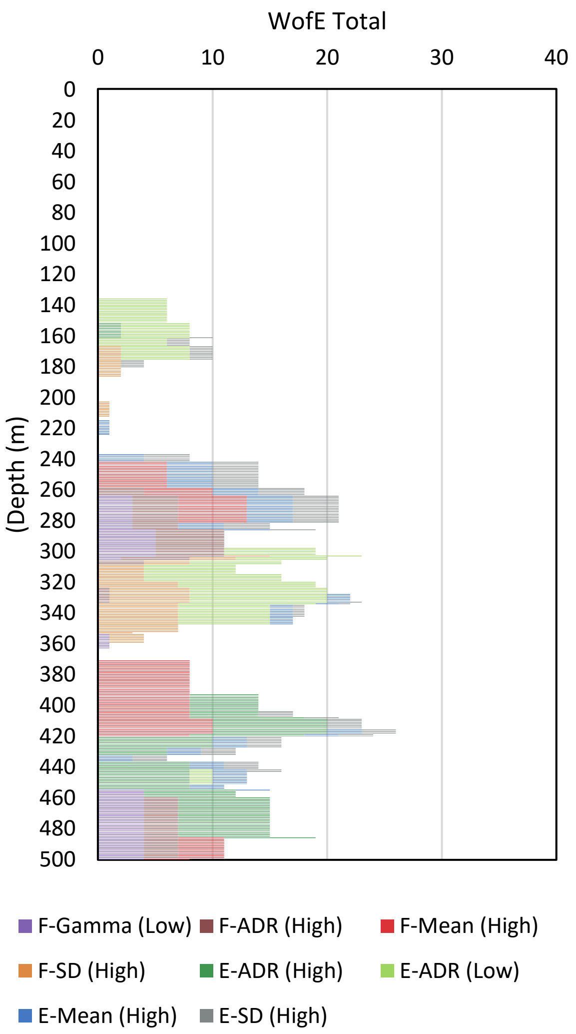
- DP02 has 5 targets. Target 1 is the primary target with the highest WofE value (up to 12). It has also matched with all 3 of the selected criteria.
- DP02 is parallel and close in proximity to DP01-90. DP02 Target 1 correlates well with targets 1 and 2 in DP01-90. DP02 Targets 2 and 3 correlate to targets 3, 4 and 5 in DP01-90.

DP02 WofE Sulphide Targets:

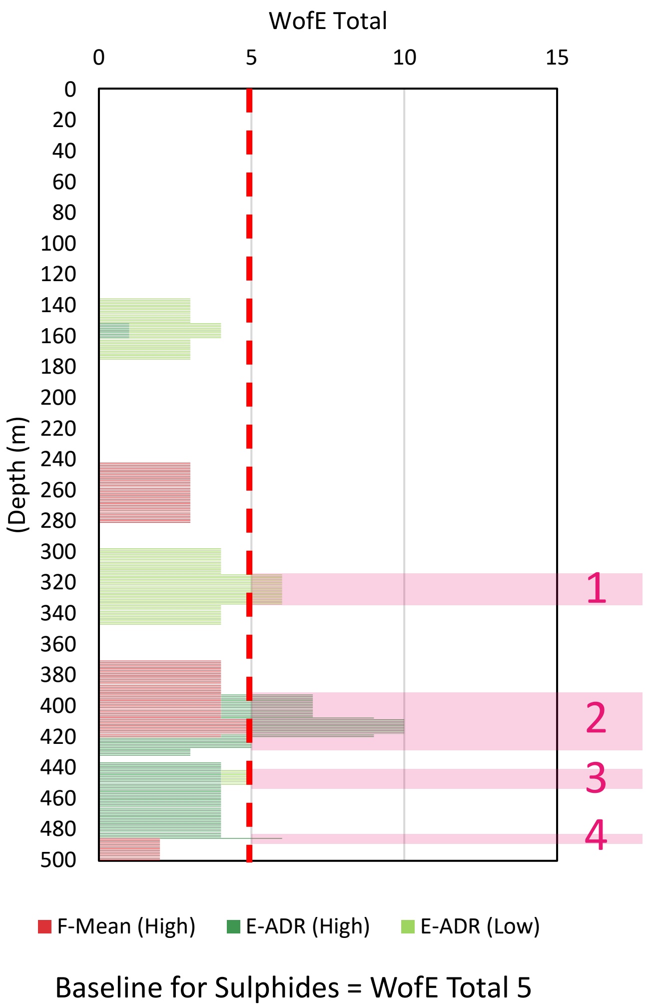
Target #	Depth From (m)	Depth To (m)
1	211	260
2	341	346
3	362	384
4	423	423
5	459	468

WofE Results: DP06

00231 DP06 3-Criteria Enhanced WofE



00231 DP06 3-Criteria WofE

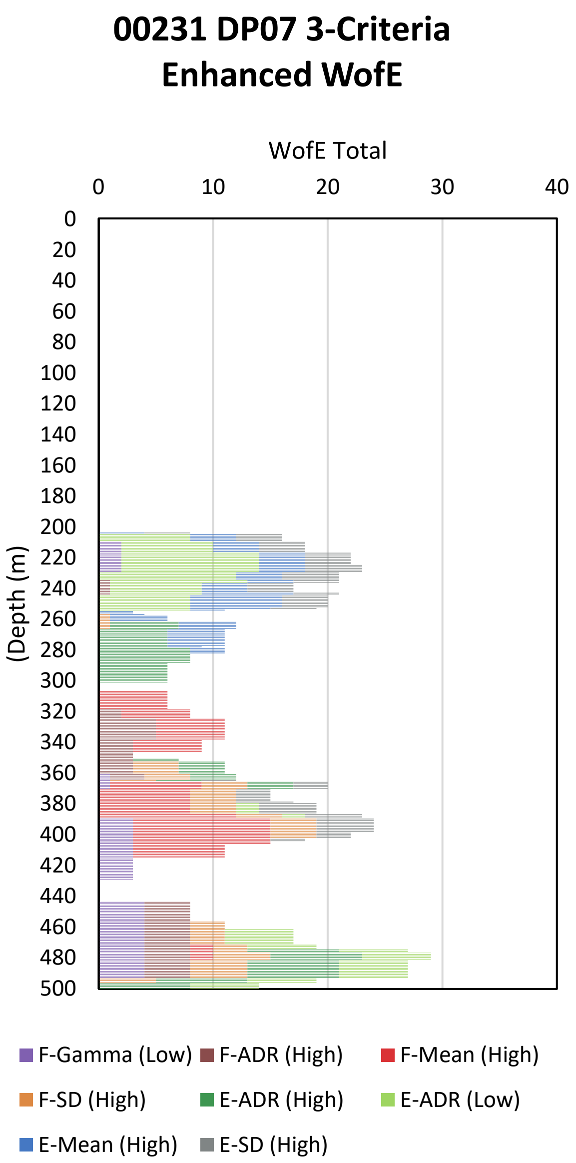


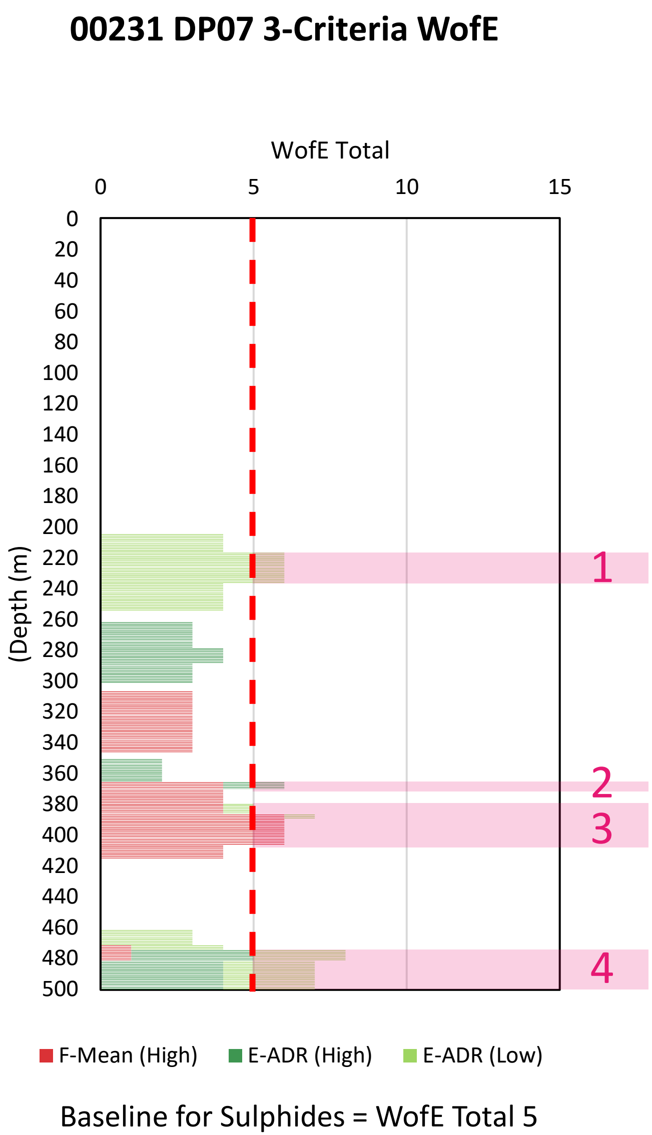
- DP06 has 4 targets that are all at depths greater than 300m. This is the only scan without a target between 200-300m.
- None of the sulphide targets in DP06 meet all 3 of the selected criteria, however, target 2 does have a high WofE value, up to 10.

DP06 WofE Sulphide Targets:

Target #	Depth From (m)	Depth To (m)
1	315	334
2	393	427
3	442	451
4	486	486

WofE Results: DP07





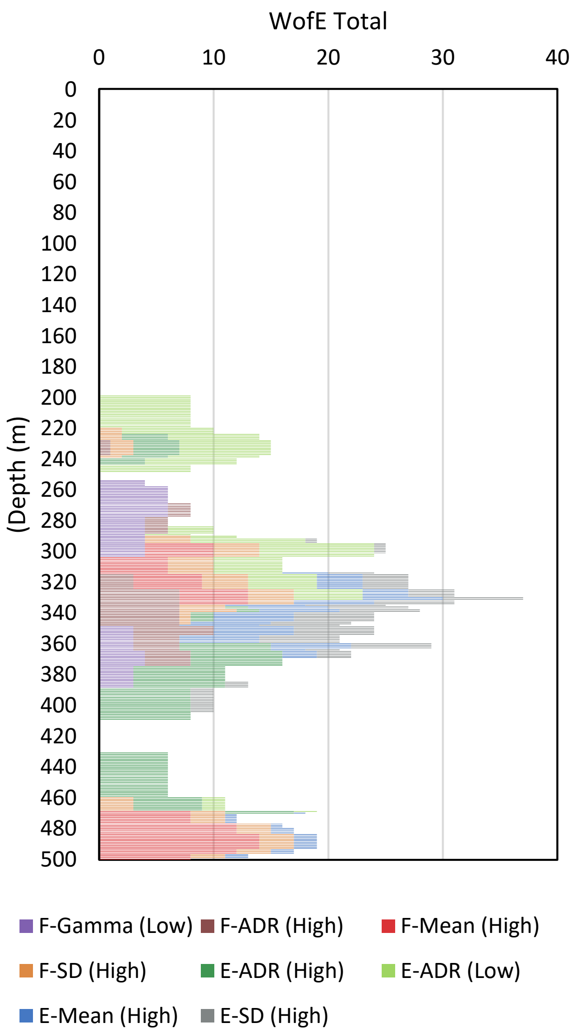
- DP07 has 4 targets that are spread across 3 potential sulphide zones, with targets 2 and 3 being very close.
- These zones also correlate with clustered WofE values in the 3-Criteria Enhanced chart.
- *Target 4 has an end depth of 500m due to the end depth of the scan. It is likely that this target ends deeper than 500m.

DP07 WofE Sulphide Targets:

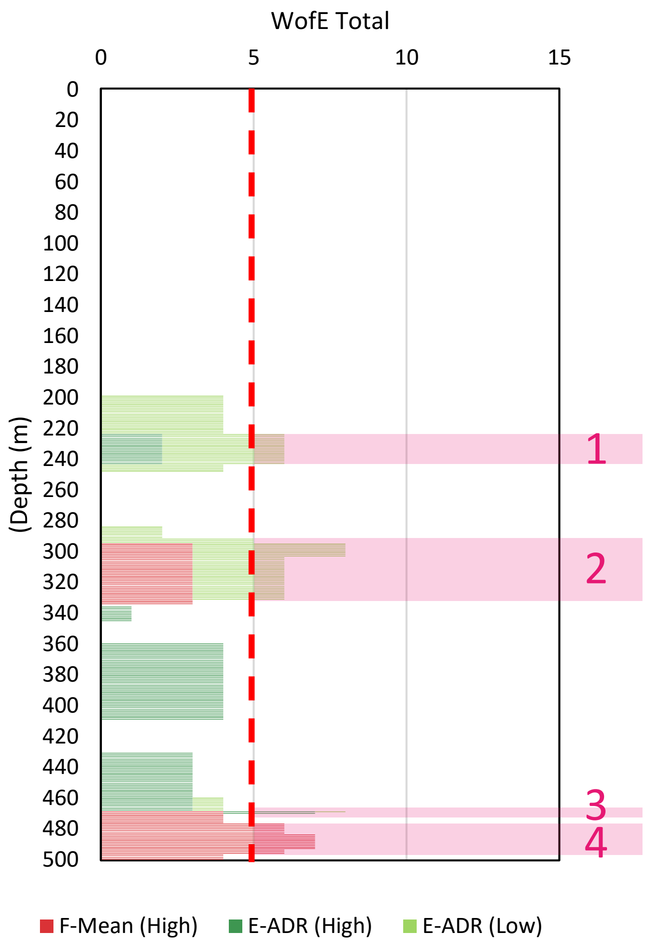
Target #	Depth From (m)	Depth To (m)
1	217	236
2	366	370
3	387	406
4	475	500*

WofE Results: DP08

00231 DP08 3-Criteria Enhanced WofE



00231 DP08 3-Criteria WofE



Baseline for Sulphides = WofE Total 5

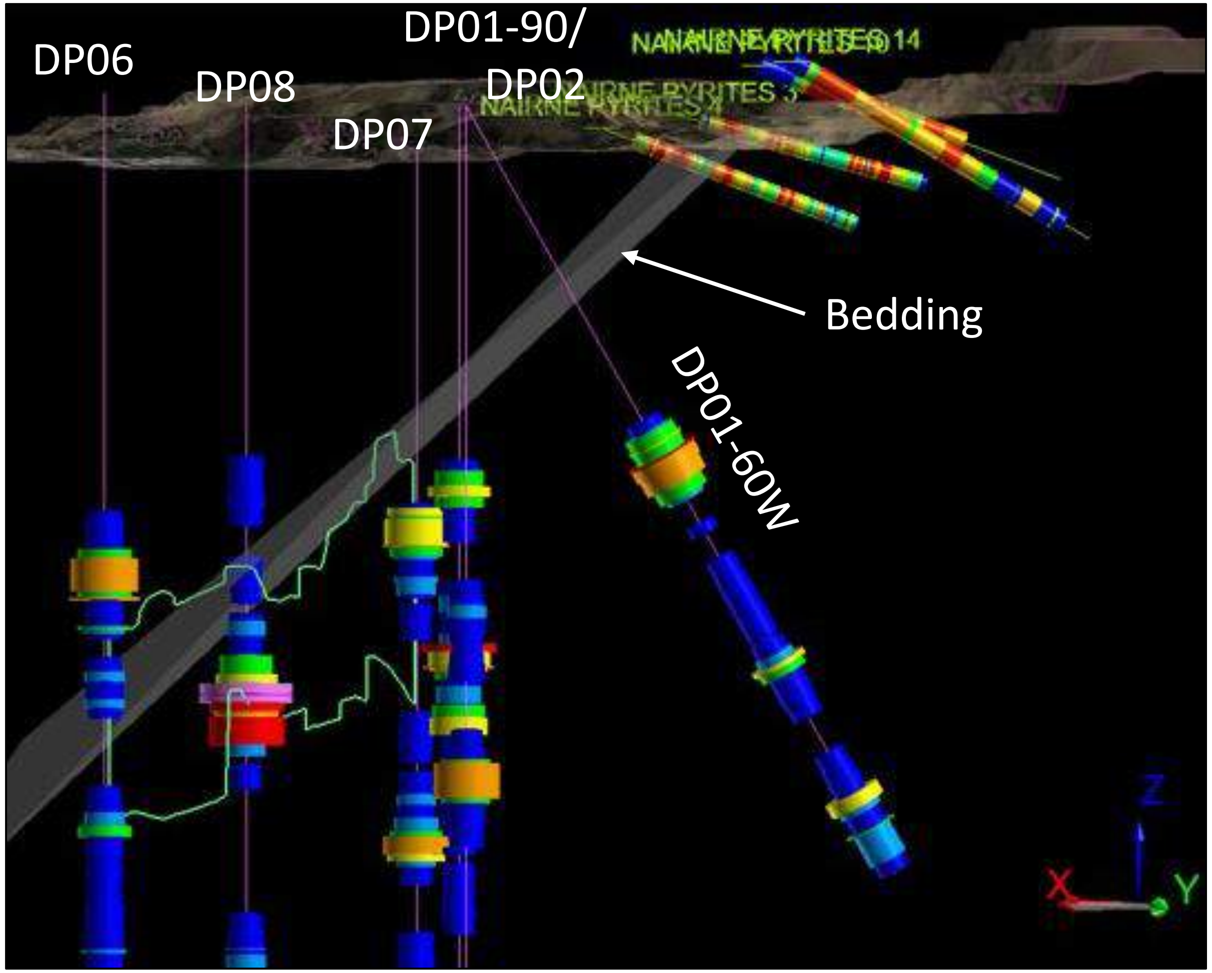
- DP08 also has 4 targets spread into 3 potential sulphide zones, with targets 3 and 4 being very close.
- The 3-Criteria Enhanced chart has clustering of WofE values between 300-400m, correlating with target 2 from the 3-Criteria chart.

DP08 WofE Sulphide Targets:

Target #	Depth From (m)	Depth To (m)
1	224	243
2	292	331
3	469	470
4	477	496

WofE Results Combined:

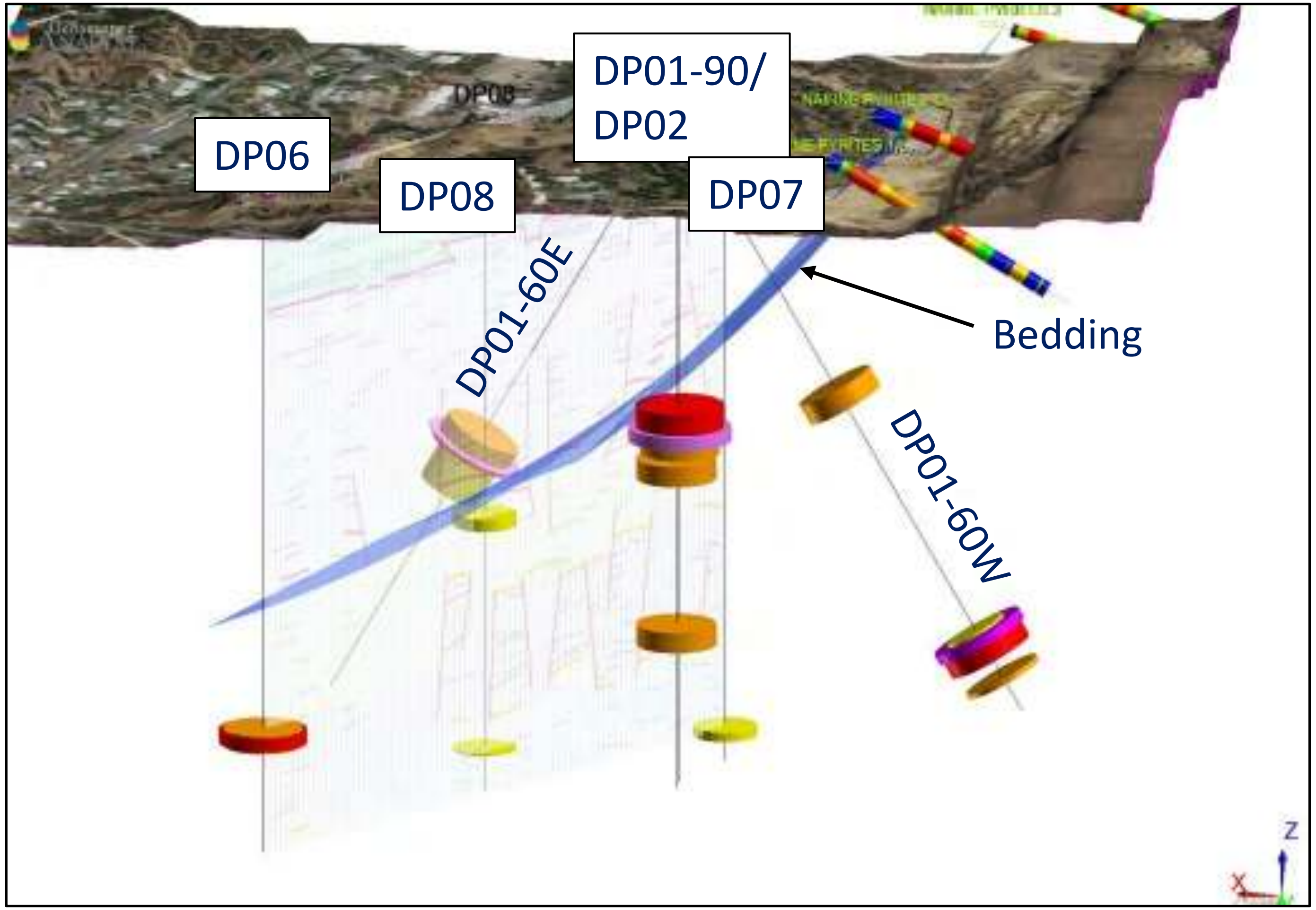
Full WofE 3D Model:



- The 3D Model in Geoscience Analyst provides a combined view of all 7 V-Bores.
- In the Full WofE 3D Model, high WofE values are represented by warmer colours (green, yellow, orange and red) and lower values represented by colder colours (blue).
- If we take the geological bedding into account, there is good correlation between each of the scans to form an inferred sulphide zone.
- Dp08 has a really strong signal towards the base of the sulphide zone.
- Most of the scans have high WofE zones at greater depths than the main sulphide zone. There is likely to be a deeper sulphide zone that has not been drilled.

WofE Results Combined:

3-Criteria WofE 3D Model:



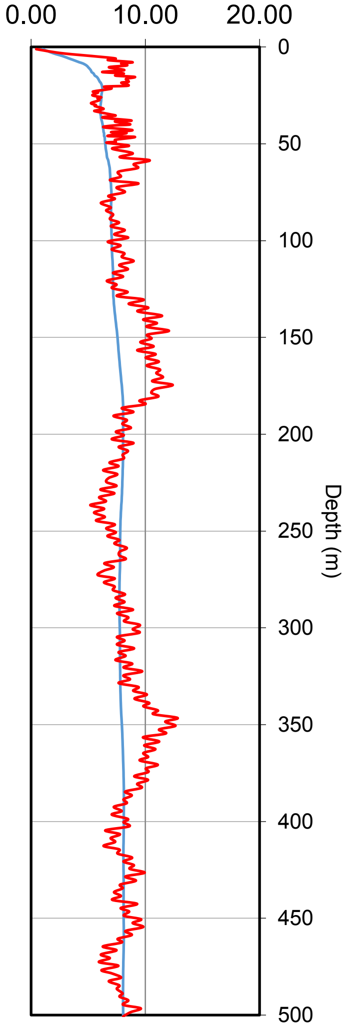
- The 3D Model in Geoscience Analyst provides a combined view of all 7 V-Bores.
- The 3-Criteria Model gives a more accurate view of the potential sulphide zones as the “noise” from the less effective criteria is removed.
- Again, most of the scans pick up on the main sulphide zone between 200-300m depth.
- This model also emphasises the presence of some deeper sulphides.

WofE Conclusions:

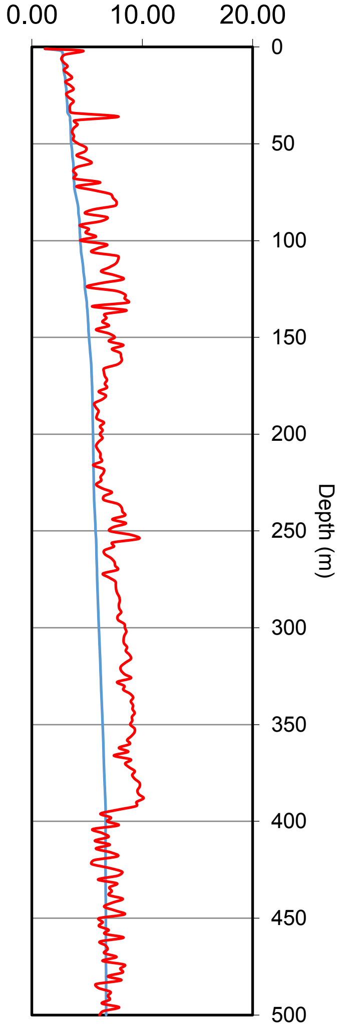
- The WofE technique has evolved and improved in leaps and bounds throughout project 00231. After hours of testing and fine tuning the tools, our latest version of outputs has the potential to accurately locate sulphides.
- The 3 selected criteria (High F-Mean, High E-ADR & Low E-ADR) correlate strongly with sulphides from DETBrukunga2. These criteria have also been successful in test comparisons with training data in project 00219 (00135 & 00138).
- For project 00231 we do not have the detailed measurements above 200m. We know from DETBrukunga2 that the majority of the sulphides are shallower than 200m so we cannot check all of the sulphides. However, the locations where we do have a high response in the WofE seem to correlate very well with sulphides.
- The bedding in the region dips and also shallows towards the East. The high WofE responses also follow this eastwards trend.
- All of the V-Bores also give high WofE responses at depths >400m, suggesting that there is also a deeper sulphide zone that has not yet been drilled.

Dielectrics

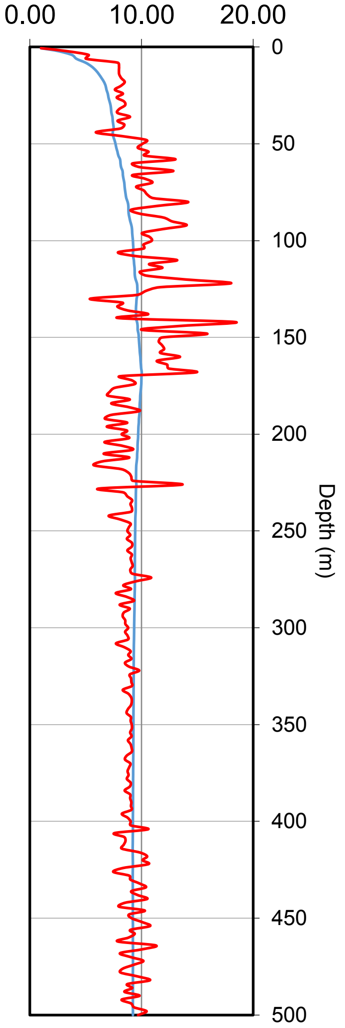
DP01-60W & DP01-60E



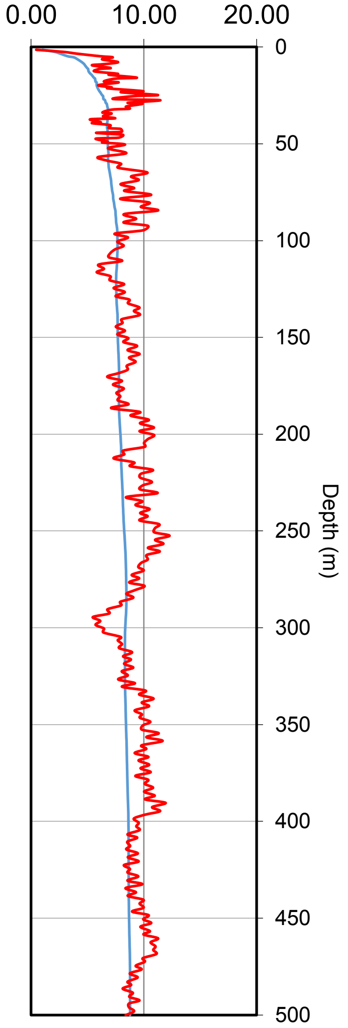
DP01-90 and DP02



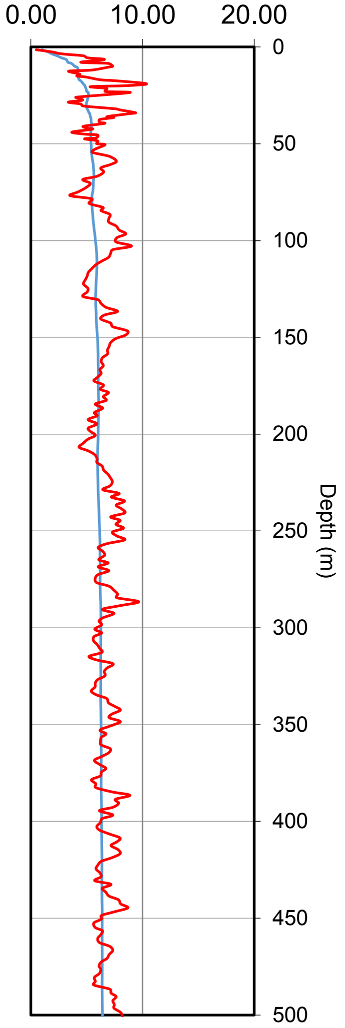
DP06



DP07

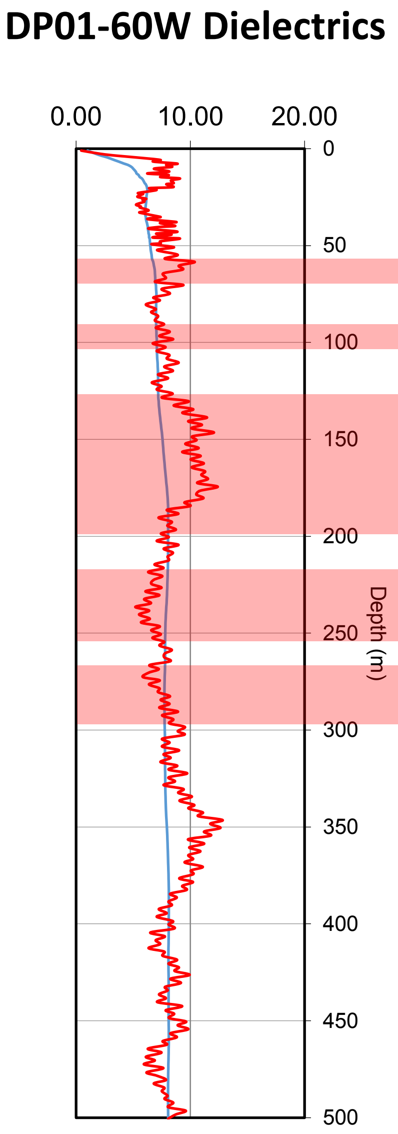


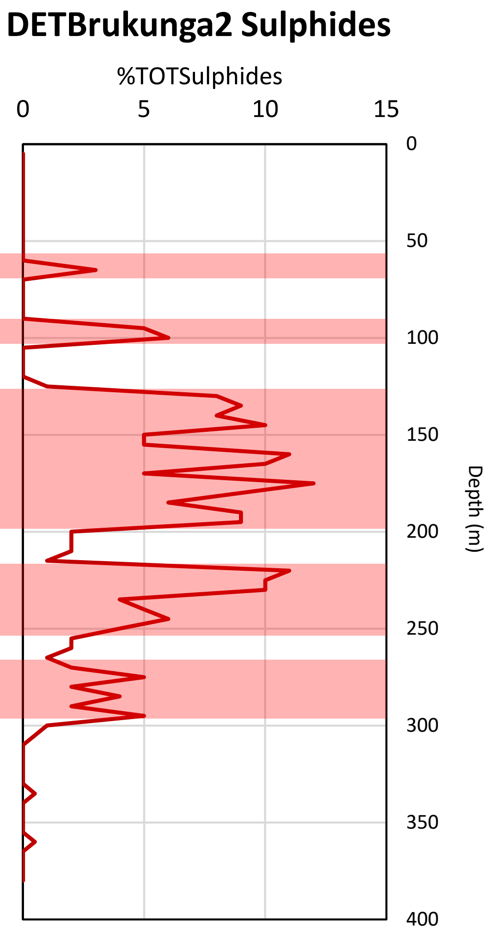
DP08



- No WARR scans were collected for DP01-60E, therefore the DCO file from DP01-60W was used, hence, they have the same Dielectric curve.
- No WARR scans were collected for DP02, therefore the DCO files from DP01-90 was used as they two scans are close in proximity, hence, they have the same Dielectric curve.

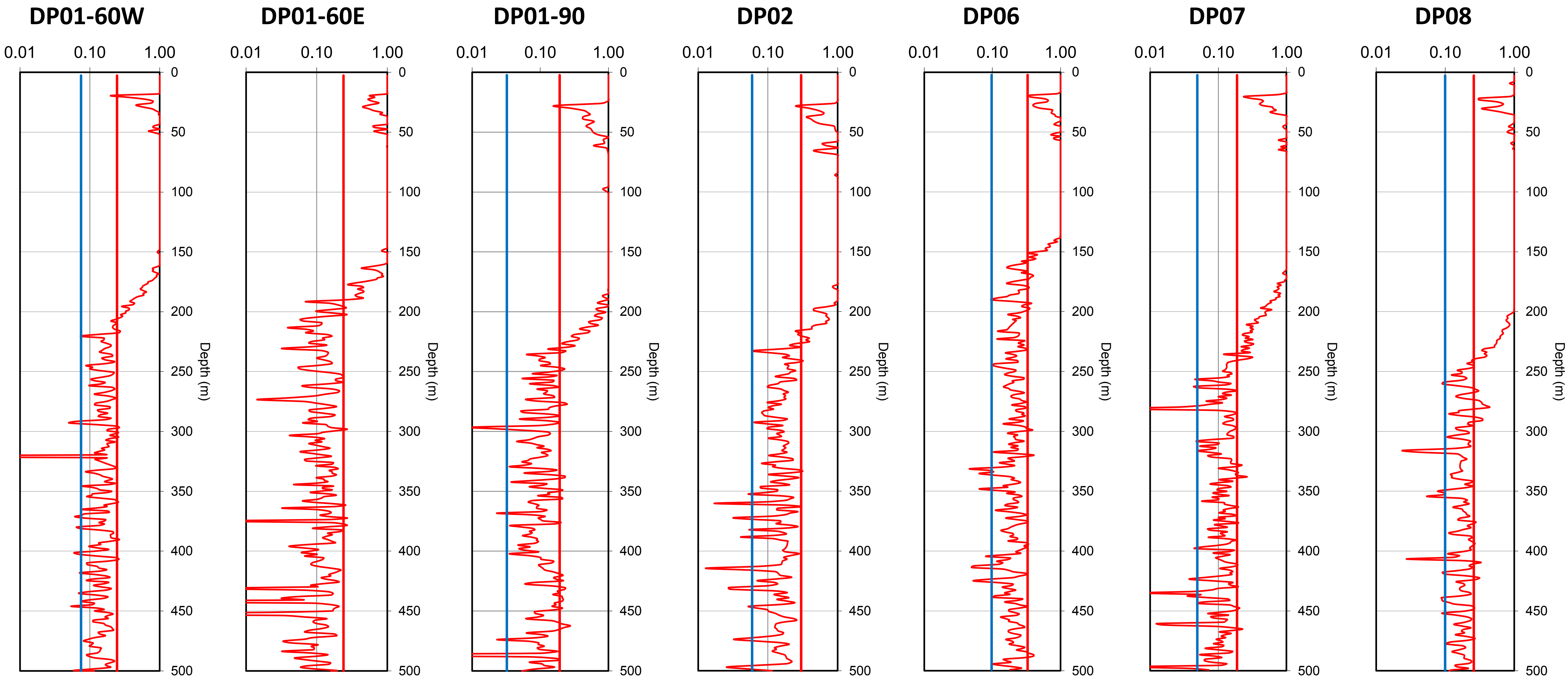
Dielectrics





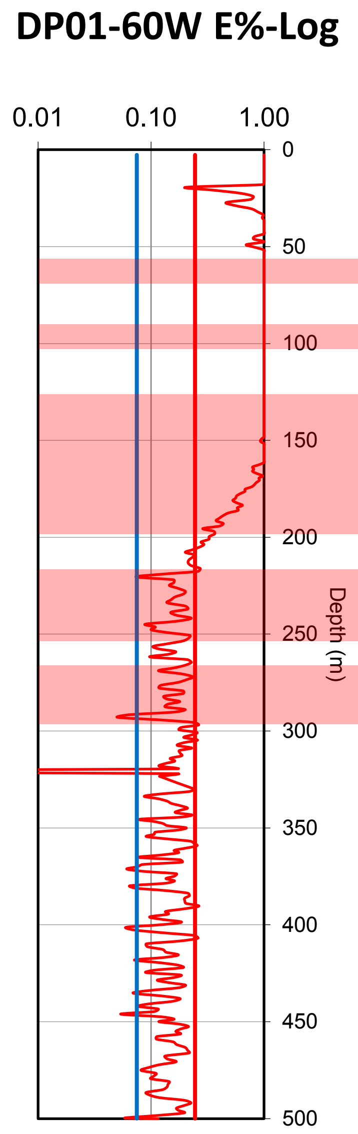
- In the training site, DP01-60W, there is no clear correlation between the DC and the %TOTSulphides in DETBrukunga2.
- There is a higher DC between 125-200m, correlating with the high %TOTSulphides in DETBrukunga2, however, there are no other DC responses in the other areas with high % TOTSulphides.
- The running theory is that the DC of sulphides is high compared with that of siliceous host-rocks. There is not a consistently high or low response associated with the DC and sulphides in this project.
- There may be some correlation between a change in the DC and a trough in the E%-Log.

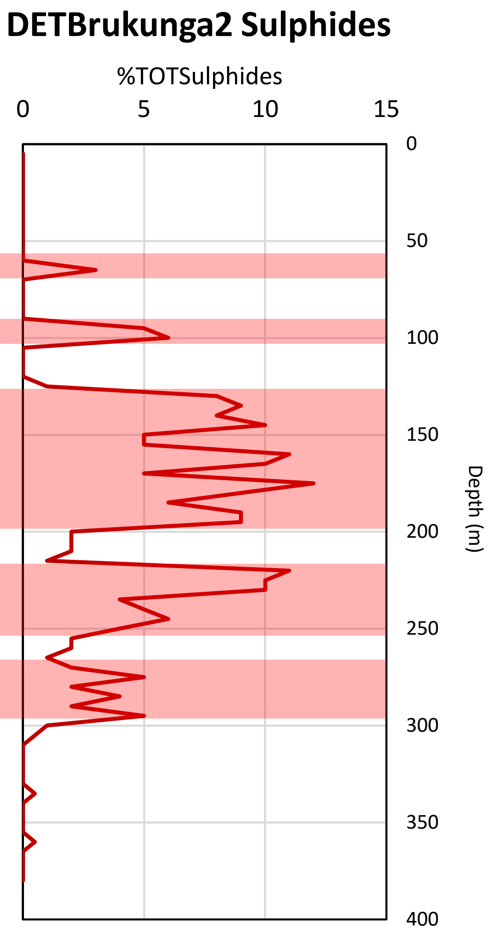
E%-Logs



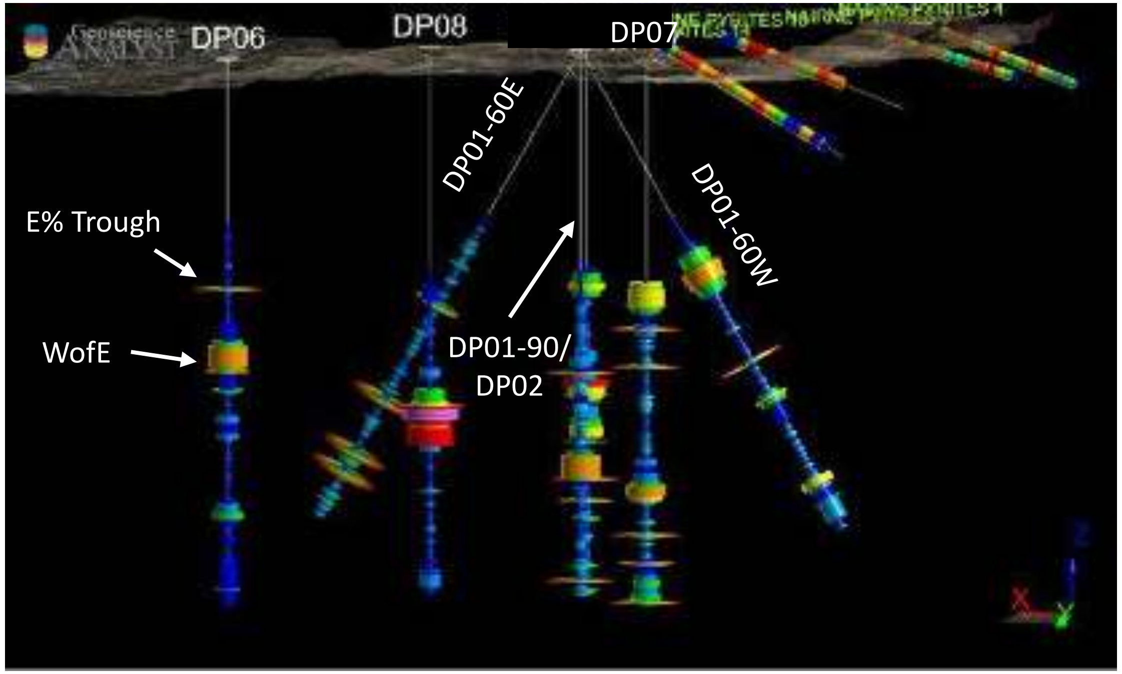
DP01-60W
DP01-60E
DP01-90
DP02
DP06
DP07
DP08
0.01
0.10
1.00
0
50
100
150
200
250
300
350
400
450
500
Depth (m)

E%-Logs

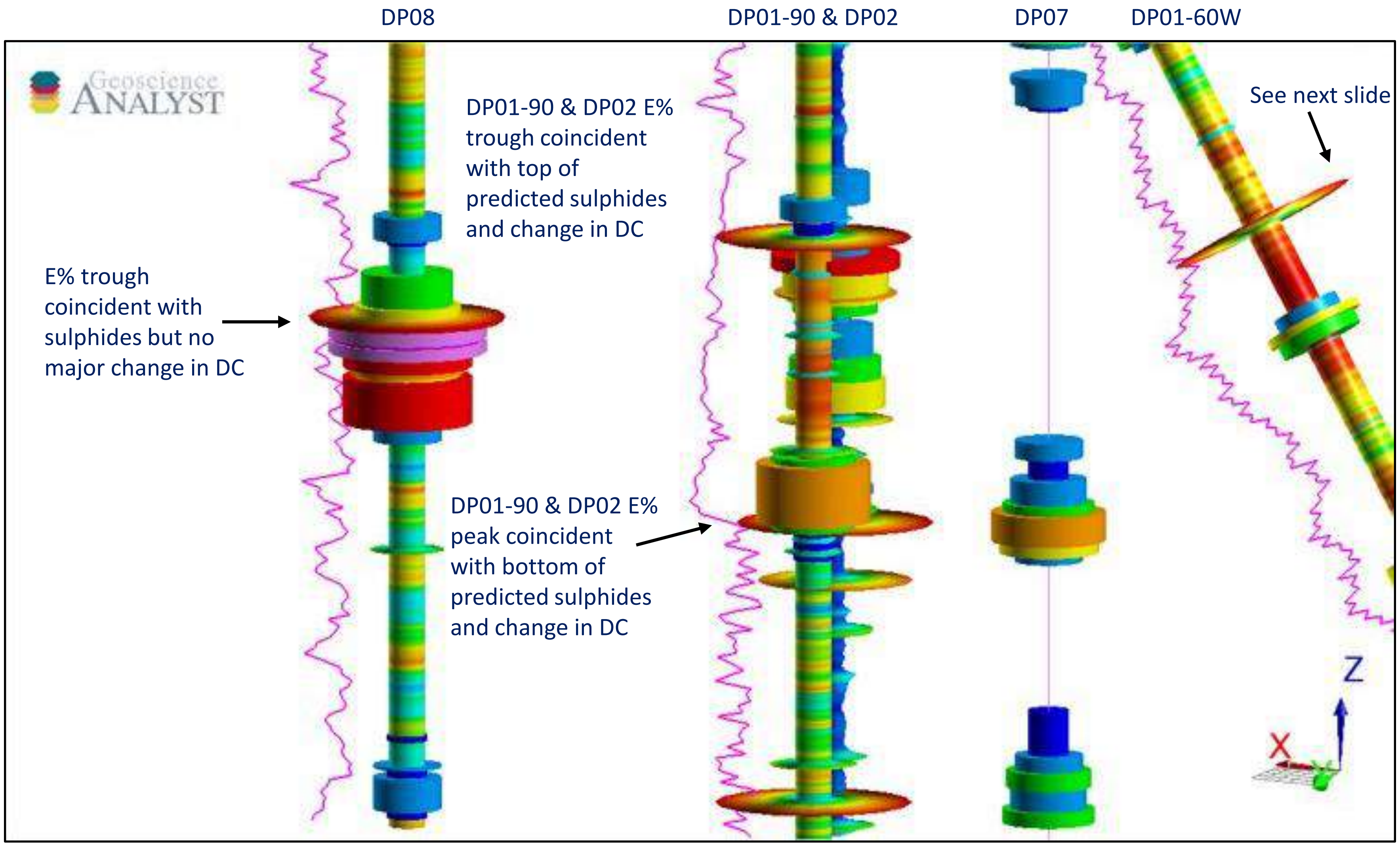




- In the training site, DP01-60W, there is no correlation between the E%-Log and the %TOTSulphides at DETBrukunga2.
- In the Geoscience Analyst model (below), troughs in the E% have been added as thin disks in relation to the Full WofE.
- In some cases, there is an E% trough coincident with sulphides but this correlation is inconsistent.
- There may be some correlation between a change in the DC and a trough in the E%-Log.



E%-Logs and Dielectrics

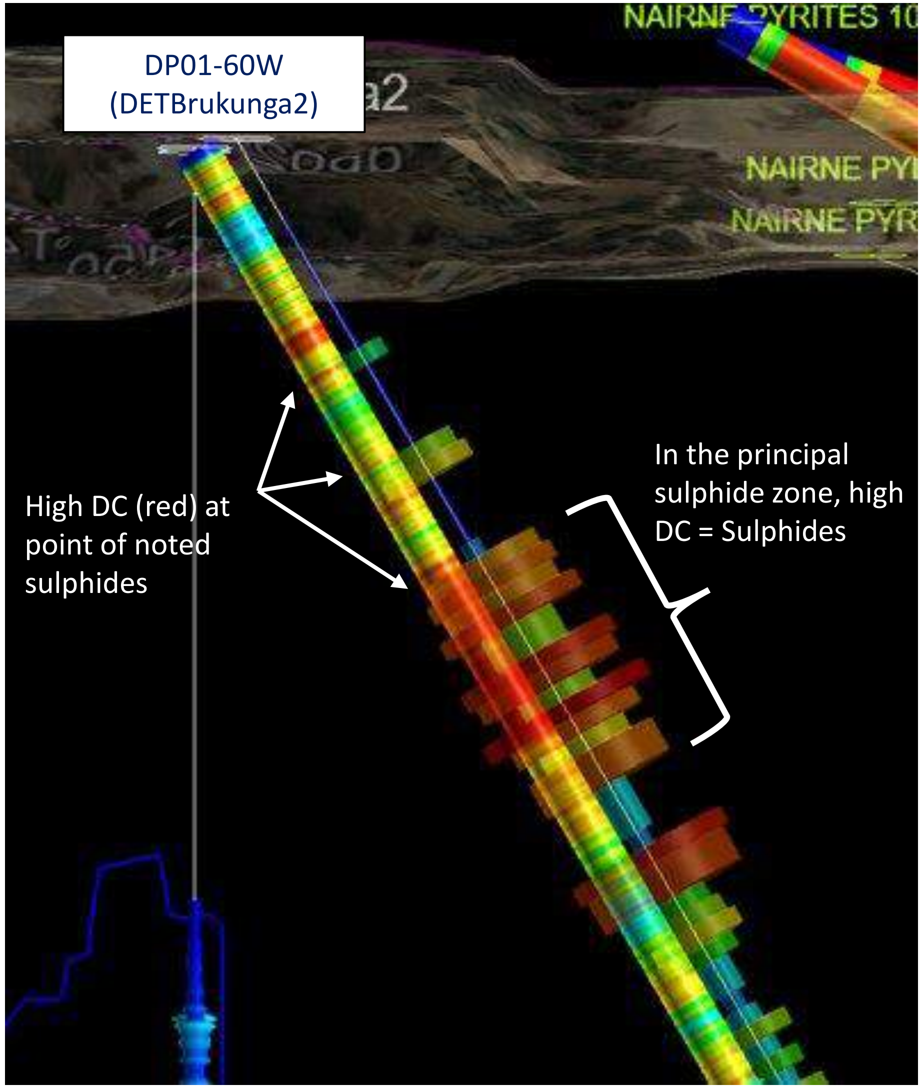


- In many cases, the E% trough (discs) pick up changes in DC as we have proposed from other projects. In particular, low to high DC is imaged.

E%-Logs and Dielectrics

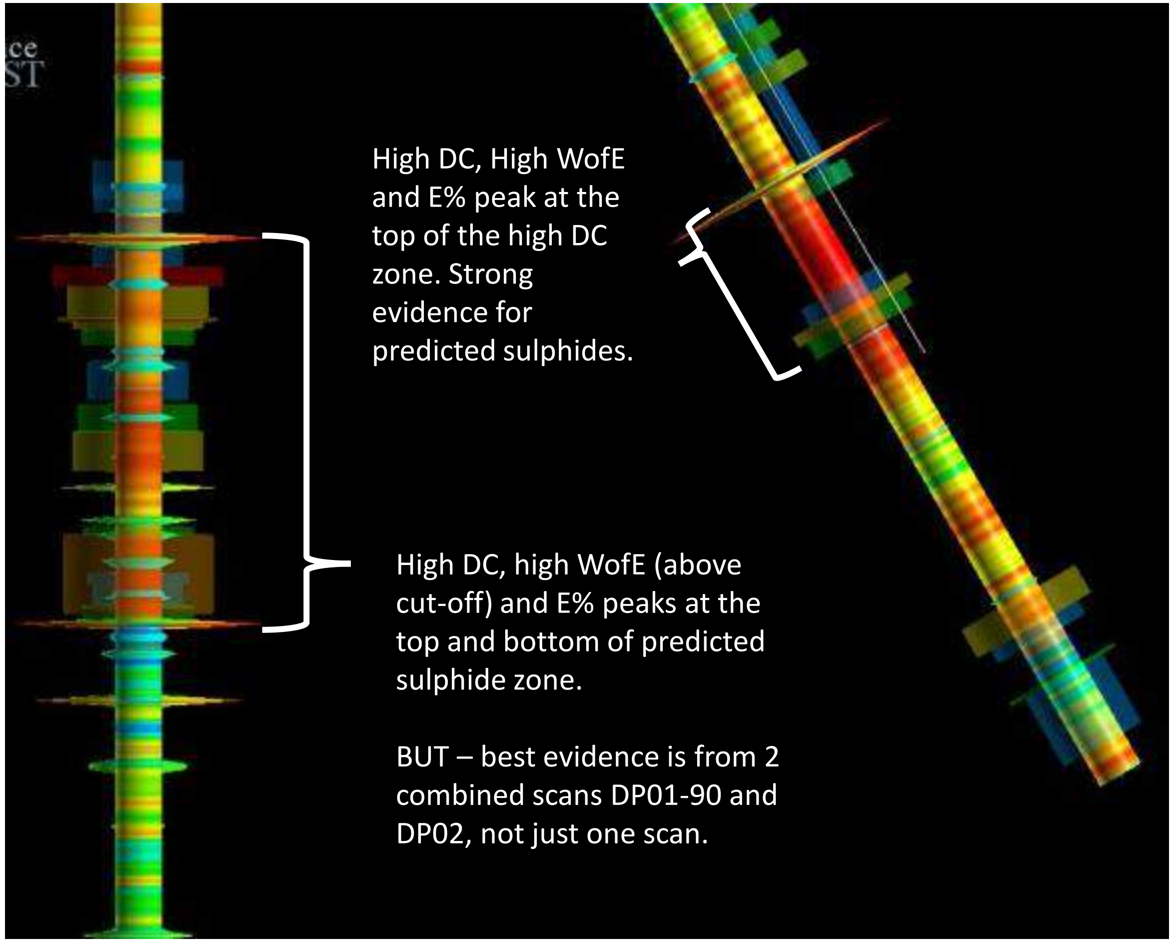
DC = Solid Column (no scaling)

Sulphide% = Variable width, scaled and semi-transparent column

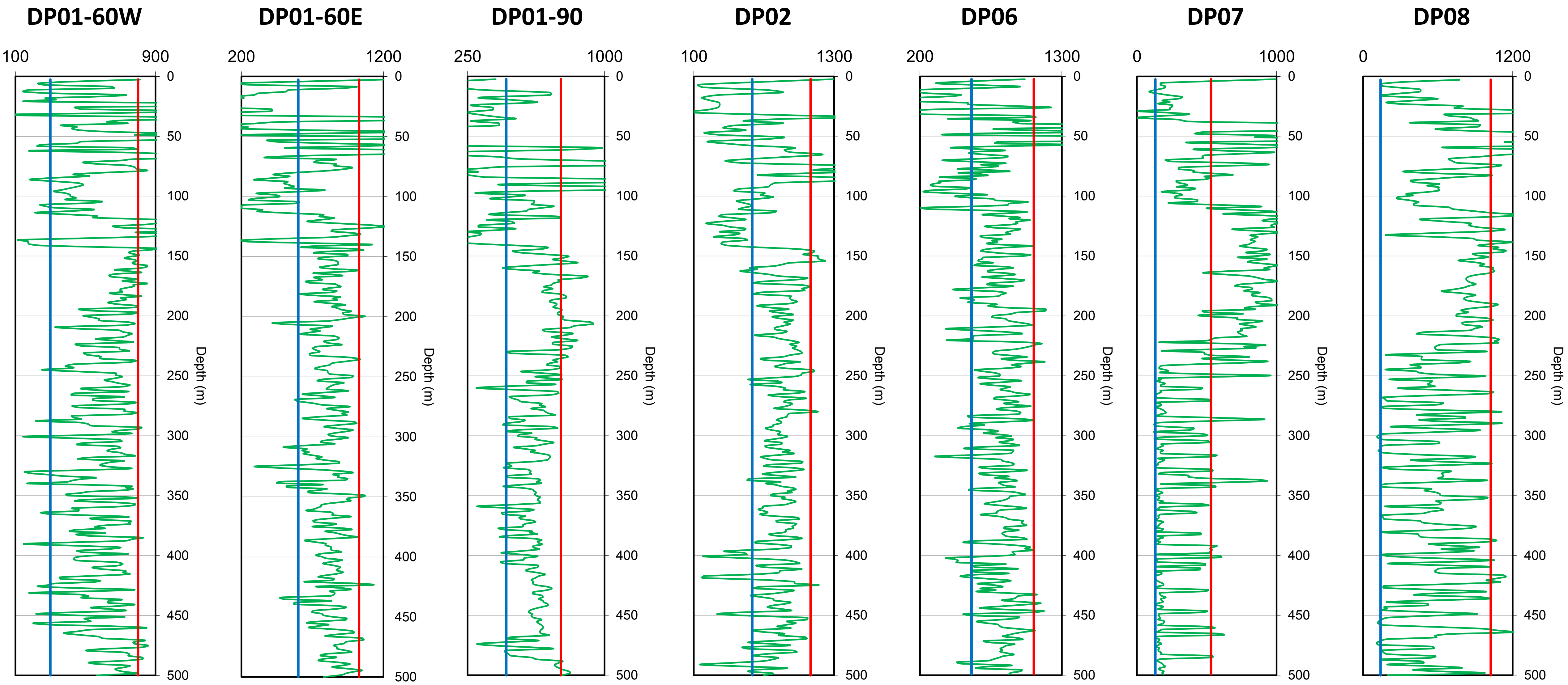


DP01-90 & DP02

DP01-60W lower zone (below logging)

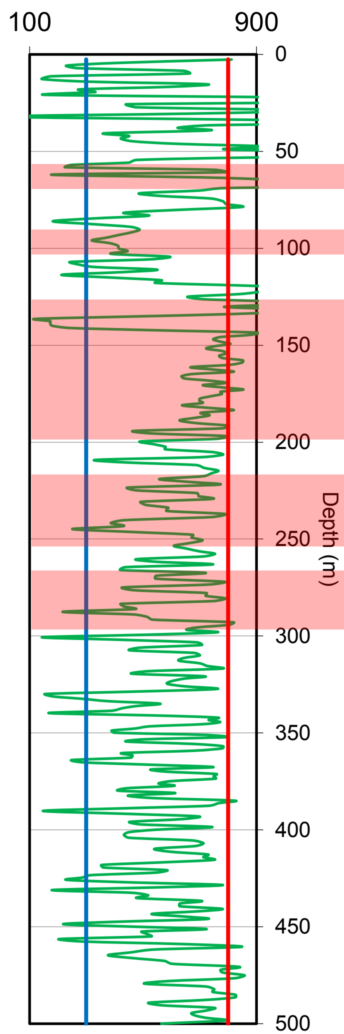


WMF

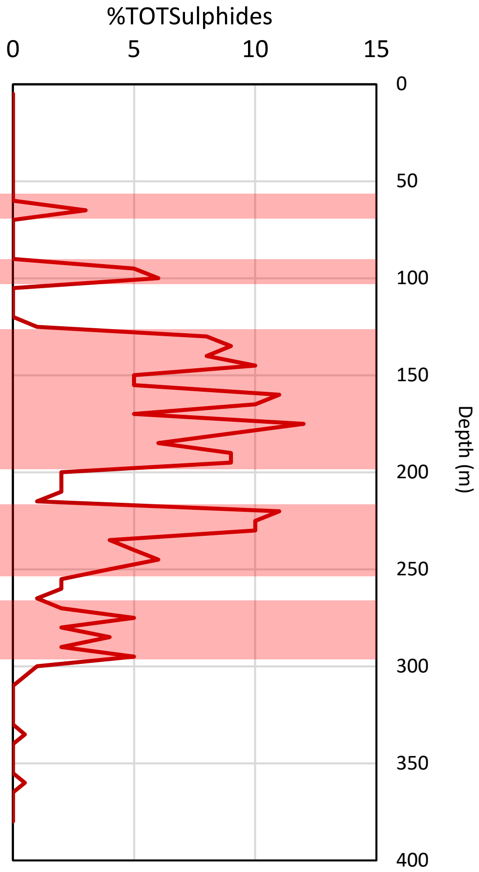

DP01-60W
100
900
DP01-60E
200
1200
DP01-90
250
1000
DP02
100
1300
DP06
200
1300
DP07
0
1000
DP08
0
1200
0
50
100
150
200
250
300
350
400
450
500
Depth (m)

WMF

DP01-60W WMF

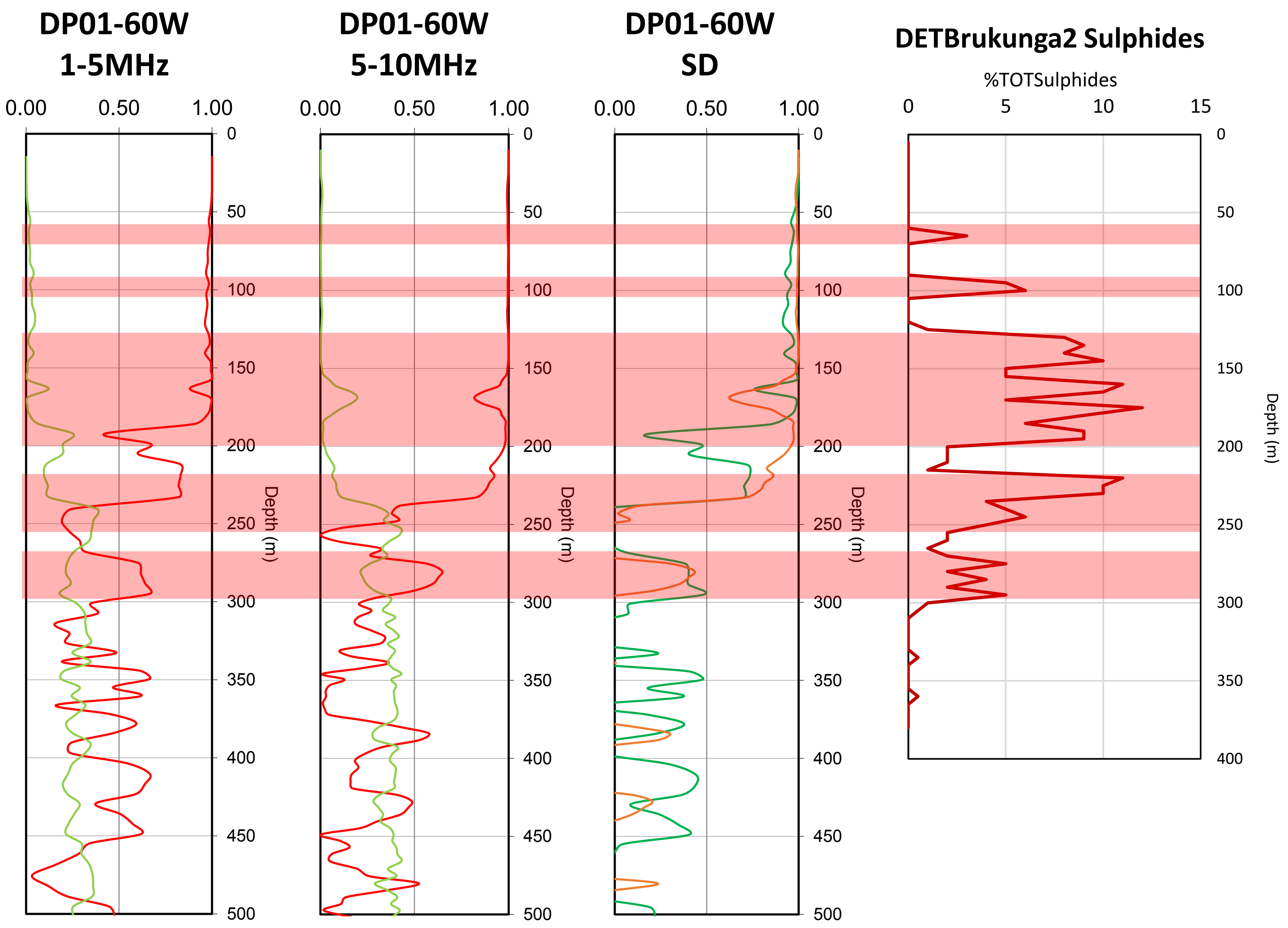


DETBrukunga2 Sulphides



- There is no visual correlation between the WMF and the %TOTSulphides at DETBrukunga2.
- The WMF has not been used with any degree of certainty throughout project 00231.

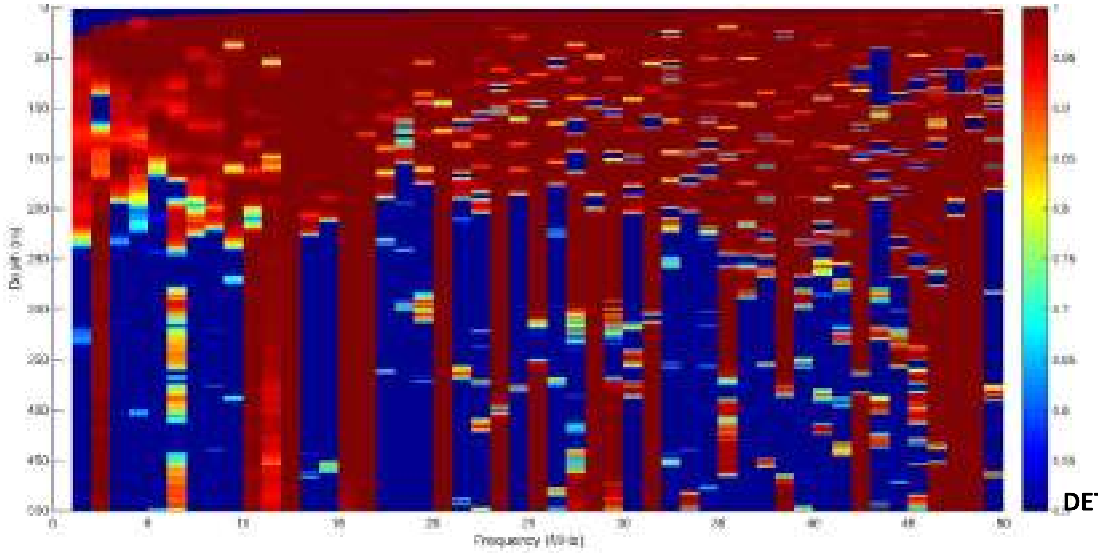
Correlation 1-5MHz and 5-10MHz



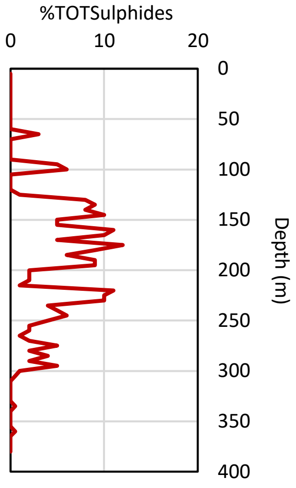
- Adrok's previous ideas about the Frequency Correlation charts is that a combination of a peak in the 5-10MHz + no peak in the 1-5MHz should be indicative of sulphides (intensity of peak corresponding to & sulphides).
- This Correlation Criteria has not been met in DP01-60W at areas of know sulphide mineralisation.

Correlation 1-50MHz

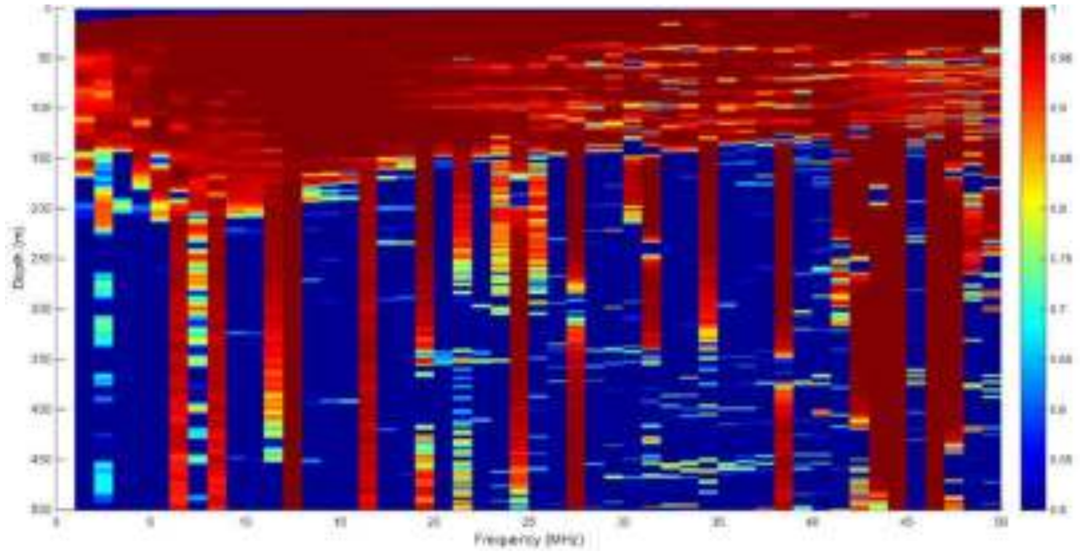
DP01-60W Corr above SD v Depth (m) (BW 1MHz)



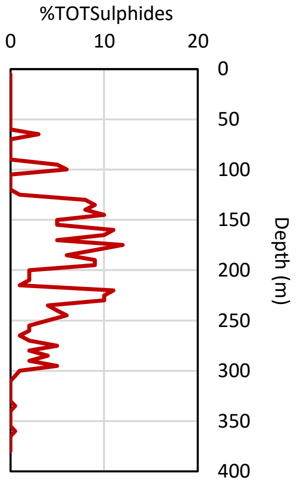
DETBrukunga2 Sulphides



DP01-60W Corr above SD v Depth (m) (BW 5MHz)



DETBrukunga2 Sulphides

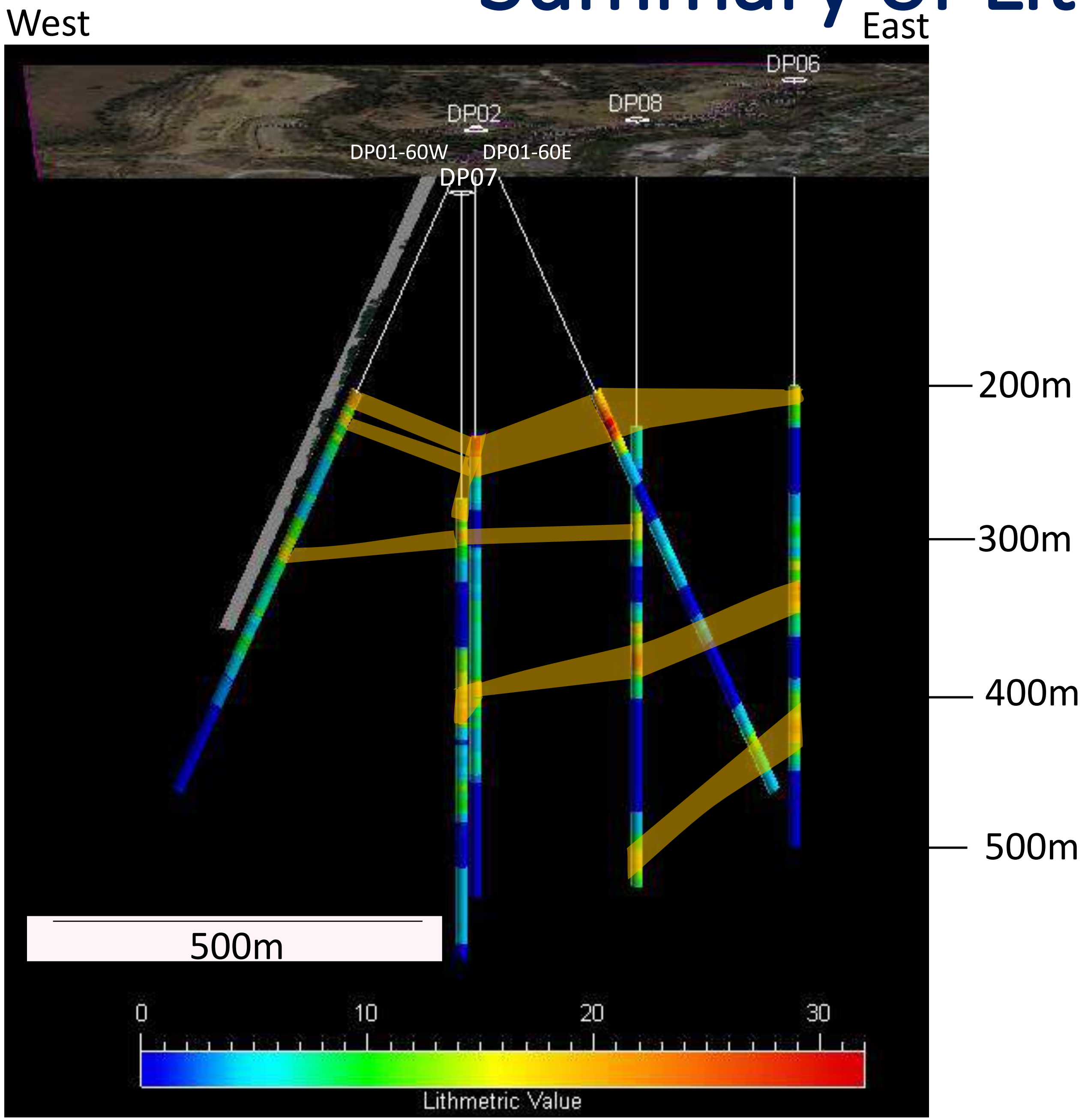


- No clear sulphide relationships found with the 1-50MHz Correlation at both 1MHz and 5MHz bins

Individual Parameters Conclusions

- In some cases, the Dielectrics are high in areas of sulphide mineralisation, however, this is not conclusive throughout the project due to the lack of any consistently high response in the DC related o sulphides.
- The E%-Logs have not been able to directly identify sulphides, however, they have been able to detect strong boundaries between 2 different materials. This has given some strong E% troughs at the top and base of predicted sulphide zones.
- The E%-Log can be used as a good tool to constrain the top and base of high-grade sulphides. E% troughs can also be indicators of rock boundaries and faults.
- In many cases, the E% troughs pick up changes in DC as we have proposed from other projects. In particular, low to high DC is imaged.
- WMF and F-Correlation (1-5MHz, 5-10MHz & 1-50MHz) charts have shown no strong relationships with the true and predicted sulphide zones in this project.

Summary of Lithmetrics



- Each V-bore processed as part of this project was ran through the Lithmetrics script to produce a dataset where each parameter is of equal weight.
- The weight of evidence criteria for the harmonic dataset was then applied using peaks in E-Mean, E-SD, F-Mean, F-SD, E-ADR and troughs in both F-Gamma and E-ADR. The totals of these were the final values used to quantify the presence of sulphides.
- A threshold value of 15 was set for the presence of sulphides. This shows a good match with the training data at DP01-60W at approximately 200-225m below ground level.
- This feature can be traced from west to east across the survey area.
- Lithmetric values above 15 are also seen running east to west at 300m and 400m suggesting the presence of sulphides below the depth of the drill data.

Introduction

- This section covers the Lithmetrics analysis of the ADR results.
- The report documents the history of Lithmetrics analysis from the work carried out on Project 00219 to the latest assessment completed during July 2020.
- Lithmetrics is a process of normalising each parameter recorded in the ADR spreadsheet so that each parameter has an equal weighting.
- By looking at each parameter and comparing it with the training data, we can combine parameters with similar responses to the training it is hoped that we can produce a downhole signature that we can apply to the V-bores where no training data is available.

History of Lithmetrics for Project 00231

Flow diagram (pre-weight of evidence)

Before the current report, this flow diagram outlines all the steps previously covered by the Lithmetrics workflow. Many of these have since been altered or removed.
The current workflow will be presented in Slide 15.

Completed ADR spreadsheet

Normalise processed data and creation of common depth points using LithMetrics_v100 script.

Calculate the median for each parameter.

Subtract value from the median.

Compare each parameter with the training data.

Add parameters with peaks that correspond to the material of interest to create lithmetric. Subtract troughs that correspond to the material of interest. Experiment with different calculations.

Verification of created Lithmetrics against training data.

If results are poor go back, review and refine.

Timeline of Previous Lithmetrics Work

16th June 2020

- Calculated Lithmetrics which showed promised for 00219 V-bores tested on training V-bore DP01-60W and DP01-90. All of these were based on subtractions of normalised values from the medians...\00231 Lithmetrics\Archive\00231 Lithmetrics Results_v0.1

19th June 2020

- After sharing this with the G&G Team, a new lithmetric was created. This was called ‘Pyrite 2’ and produced many false positives. ...\00231 Lithmetrics\Archive\00231 Lithmetrics Results_v0.1

24th June 2020

- After further feedback the Correlation datasets were discontinued as it was decided this relates to other geological characteristics. The focus was now only harmonics and the E-log. Data re-extracted from 200m instead of 100m. ...\00231 Lithmetrics\Archive\00231 Lithmetrics Results_v0.2

26th June 2020

- Several different iterations were tested called Pyrite 3 to Pyrite 3g. A threshold value of zero was used and this data was directly compared to the drill hole data in Geoscience Analyst. Pyrite 3g showed the most promise...\00231 Lithmetrics\Archive\00231 Lithmetrics Results_v0.3_Lithmetrics_v0.1

3rd July 2020

- Pyrite 3g converted to a quantitative dataset. This still suggested multiple false positives. Different thresholds tested but reducing the threshold removed some of the true positives. Increasing the threshold created further false positives W:\00231 DetCRC 2020SR\Internal Deliverables (00231)\00231 Lithmetrics\Archive Lithmetrics_v0.2.

6th July 2020 to present

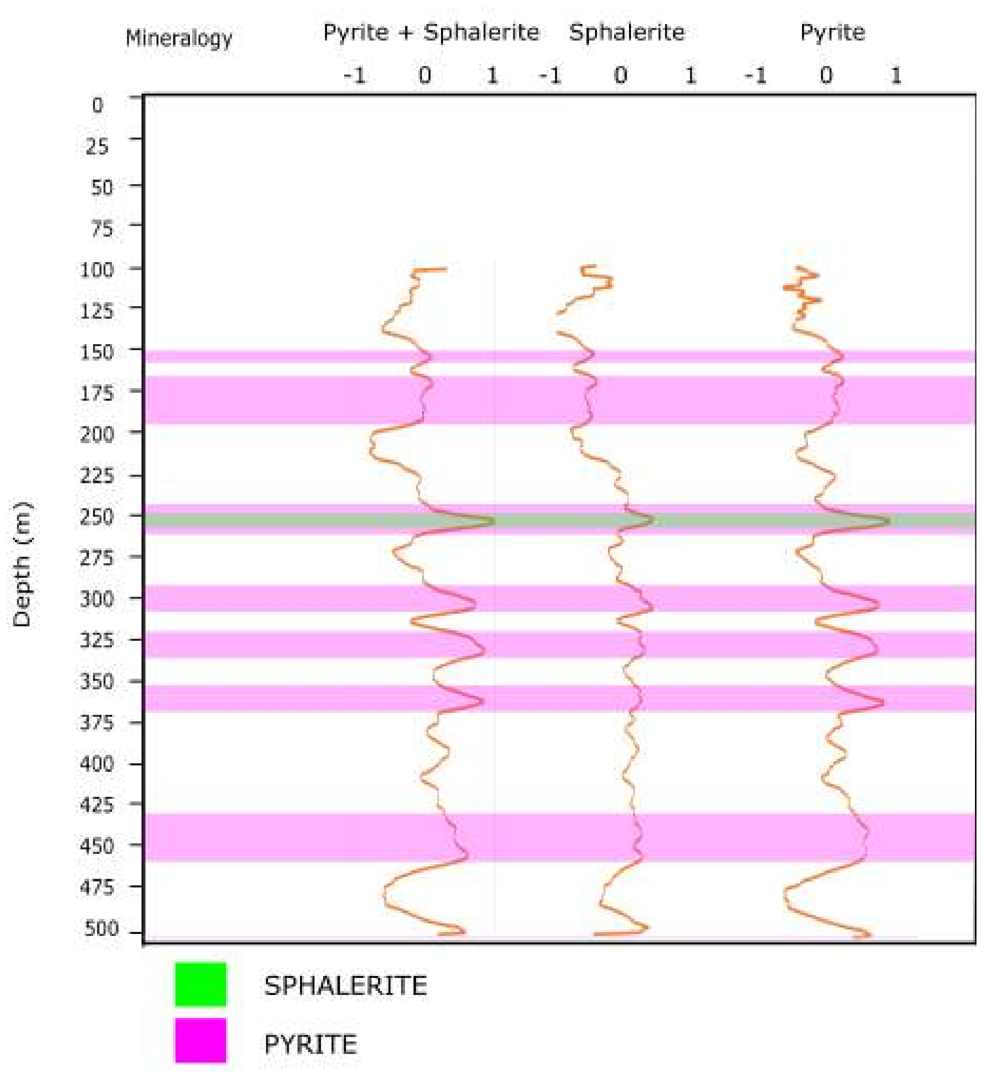
- The weight of evidence criteria was tested on the normalised data, a new threshold value was devised and the findings of these results are presented in this report W:\00231 DetCRC 2020SR\Internal Deliverables (00231)\00231 Lithmetrics Lithmetrics_v0.3.

Deviations from the median method

Depth (m)	Depth (ft)	E-Mean MA3	Median	Difference to Median
200	656.168	0	0.31885	-0.318848
201	659.449	0.034571	0.31885	-0.284277
		Parameter (normalised 0-1)	Median for full each parameter dataset	Median subtracted from parameter

- The top 200m is cropped from the dataset because of beam saturation. In some of the early tests, only the top 100m was cropped.
- The median is calculated for each parameter.
- The differences from the median are then calculated for each depth interval.
- Lithmetrics are created by adding peaks in parameters at identical depth to the target material and subtracting troughs in parameters at identical depths that also correspond to the target material.
- Data range for parameters were limited to -1 to + 1 to identify peaks in parameters with a smaller range.

Calculated Lithmetrics from Project 00219



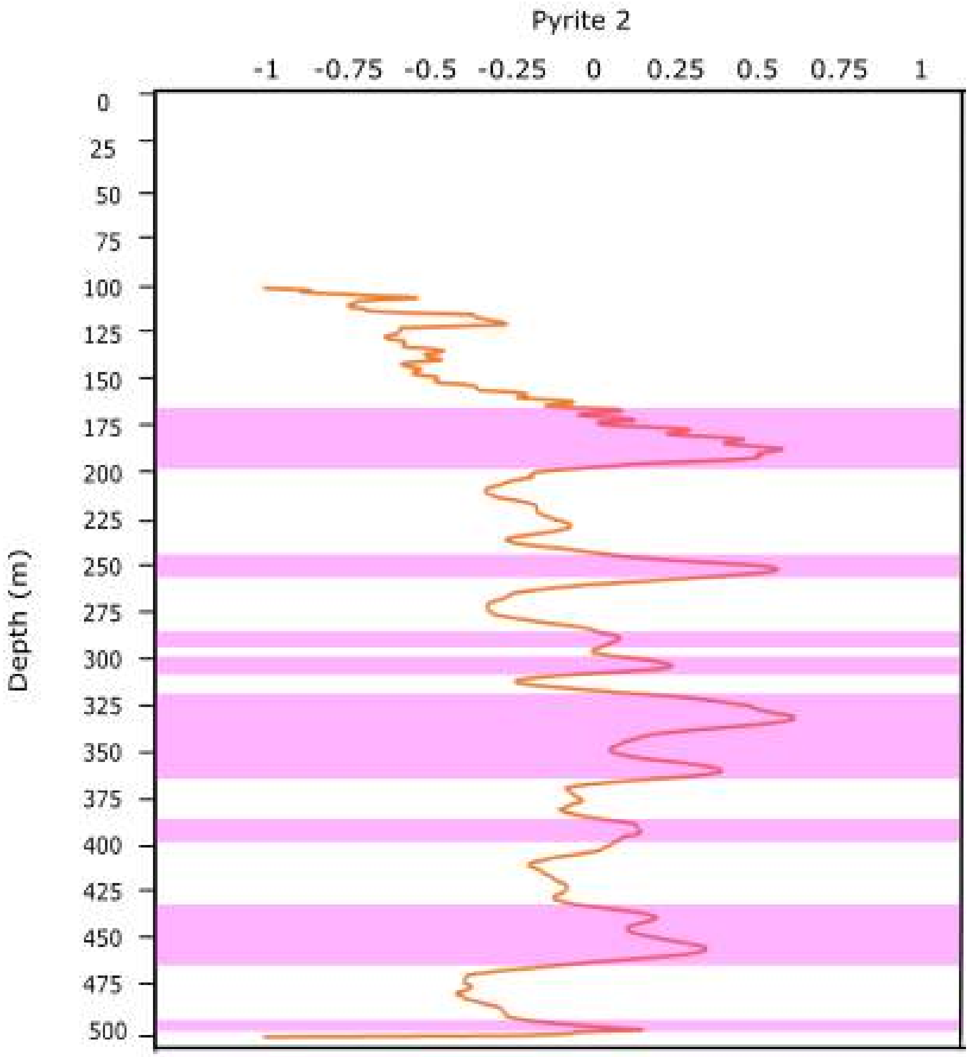
Lithmetrics Test Pyrite + Sphalerite Difference from the Median (SD 1-5 + WMF + Corr 5-10)-(Corr 1-5 + E-log + SD 5-10).

Lithmetrics Test Sphalerite Difference from the Median (WMF + SD 1-5+ E-Mean +E-SD)-(E-log + SD 5-10).

Lithmetrics Test Pyrite Difference from the Median (SD 1-5+ WMF + Corr 5-10)-(E-SD+Corr 1-5+E-Mean + E-SD).

- The same metrics applied to the three 00219 holes were applied to DP01.
- Some positive feedback received from SR for the Pyrite lithmetric.
- However, WMF, E-SD and E-Mean all have low to moderate variance and shouldn't really be considered in the final lithmetric.
- A revised lithmetric is now presented which considers these findings.

DP01-60W Revised after all factors considered



Pyrite 2
Peaks SD 1-5, F-Gamma, Corr 5-10, E-Gamma

Troughs SD 5-10, F-SD

Difference from the Median Metric Excel Calculation
(SD 1-5 + F-Gamma + Corr 5-10 + E-Gamma)-(SD 5-10+ F-SD)

- The Pyrite 2 Lithmetric is a simplified version of the Pyrite Lithmetric. This discards many of the low variance parameters such as WMF but still uses F-SD because this parameter had some positive matches in the V-bores tested in Project 00219.
- The Pyrite 2 Lithmetric implies multiple sulphide zones below 250m, especially between 325-360m and 430-460m which need exploring.
- There is too much beam saturation between 100-200m producing false positives for sulphides between 170-200m.

DP01 Normalised Plots

Variance	Parameter
0.137 **(Highest)**	E-log
0.127	SD 5-10
0.110	Corr 5-10
0.092	SD 1-5
0.086	F-Gamma
0.085	E-Gamma
0.078	F-ADR
0.060	Corr 1-5
0.038	Ray DC
0.022	WMF
0.020	BW Harmonics
0.019	E-ADR
0.018	F-SD
0.008	NMO DC
0.007	F-Mean
0.002	E-Mean
0.001 **(Lowest)**	E-SD

Correlation criteria

F-Charts
Low F-Gamma
High F-ADR
High F-SD
Step change in F-Mean (high F-Mean)

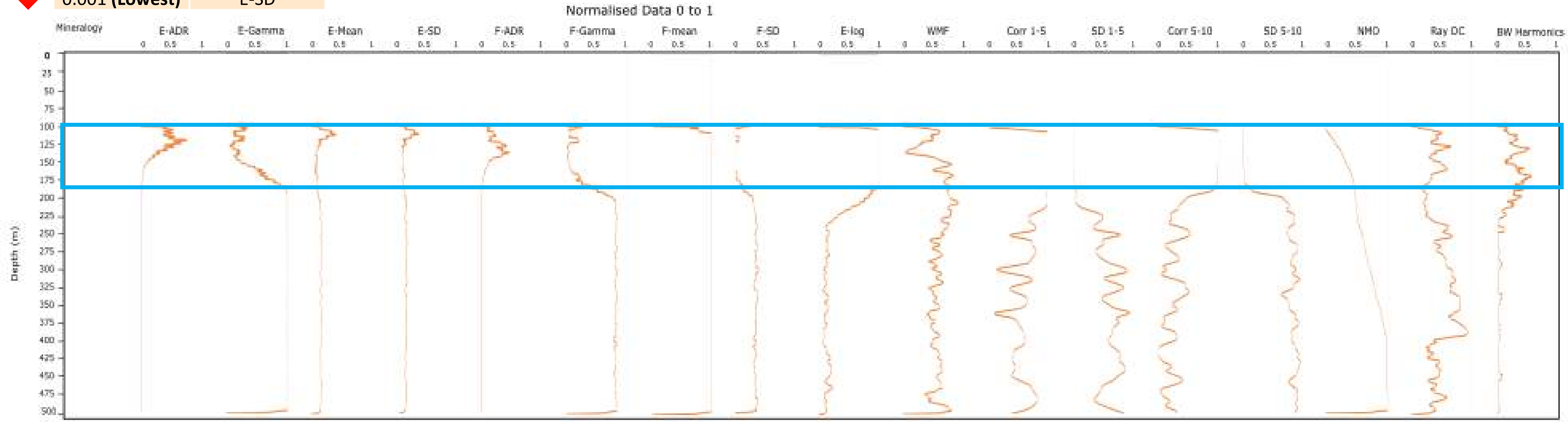
E-Charts
High E-Mean
Low E-Log
High E-SD
E-ADR (high &/or Low)
Transition ←→ E-Gamma

F-Corr charts
Peak in 5-10 MHz + no peak in 1-5MHz (intensity of peak corresponding to % sulfides

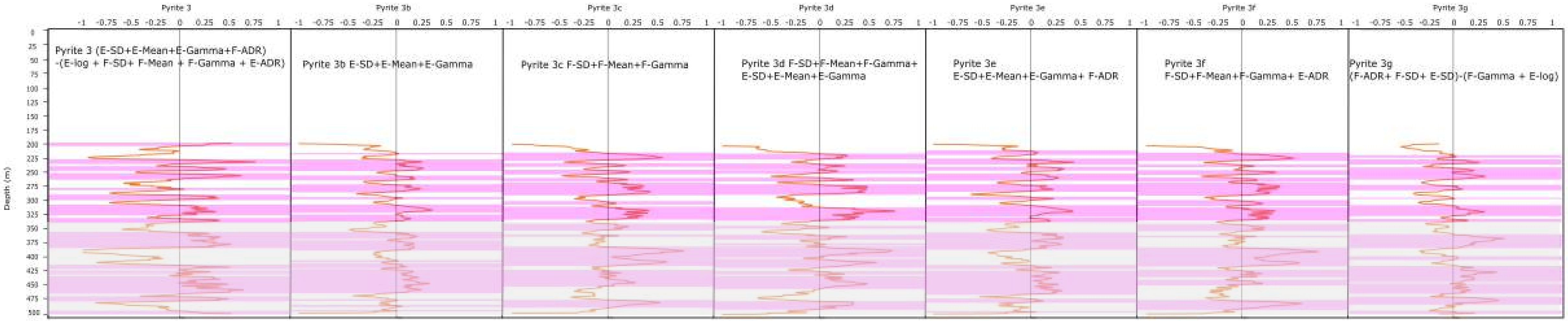
DC (Dielectrics)
Change from high variability from SD to low variability.

Red – key criteria
Orange – In development

- The E-log has the most variance and shows a positive trend but this could because of beam saturation between 100-200m.
- The Correlation and SD 1-5 and 5-10 plots together with E-Gamma and F-Gamma also show high variance. But the Correlation is not thought to relate to sulphides. The harmonics will be used for designing a new lithmetric for this data.
- In contrast the parameters that show the least variance are E-Mean, F-Mean, NMO DC and E-SD. These will not be considered for designing a new metric for this data.

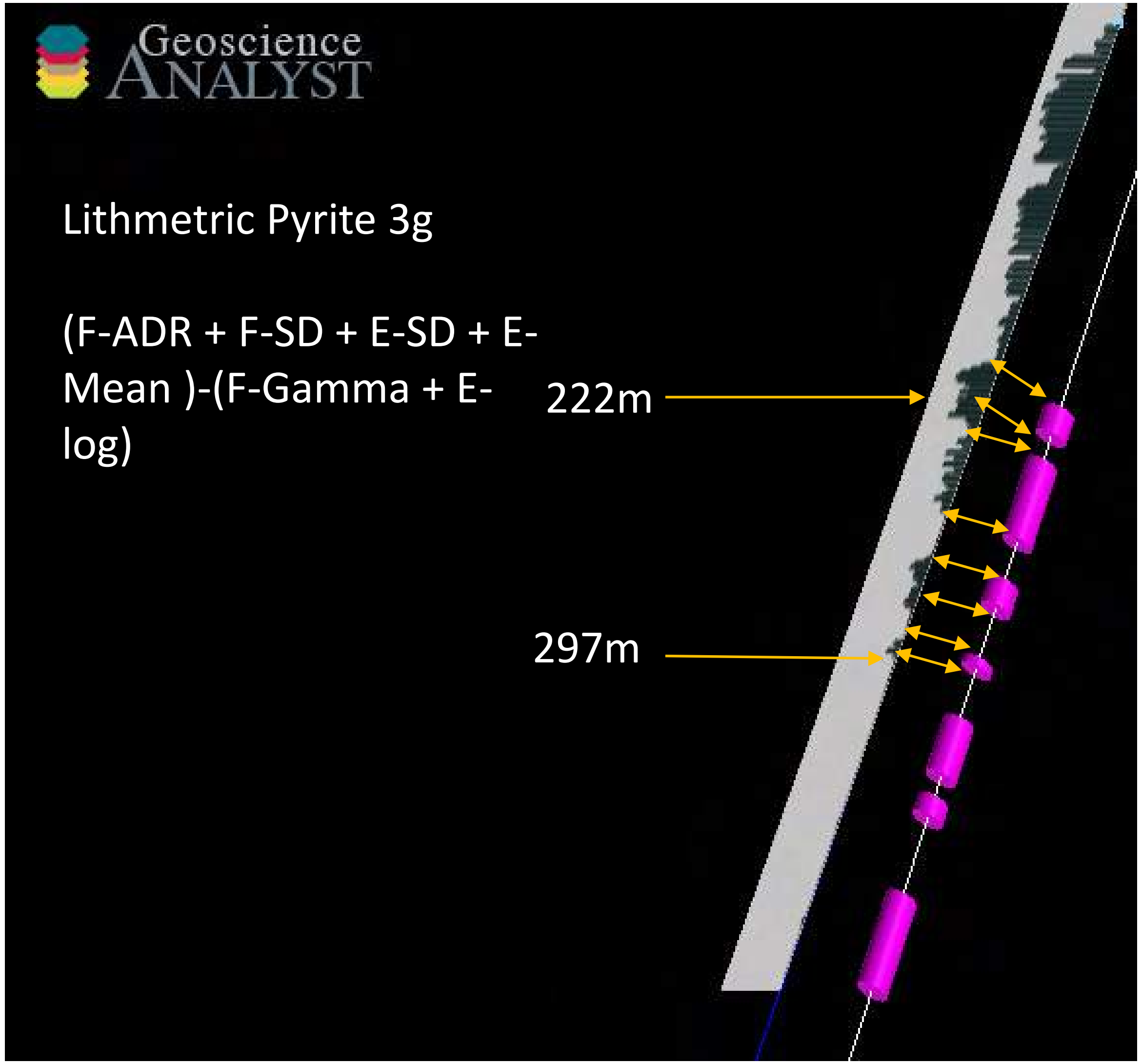


DP01-60W Training site

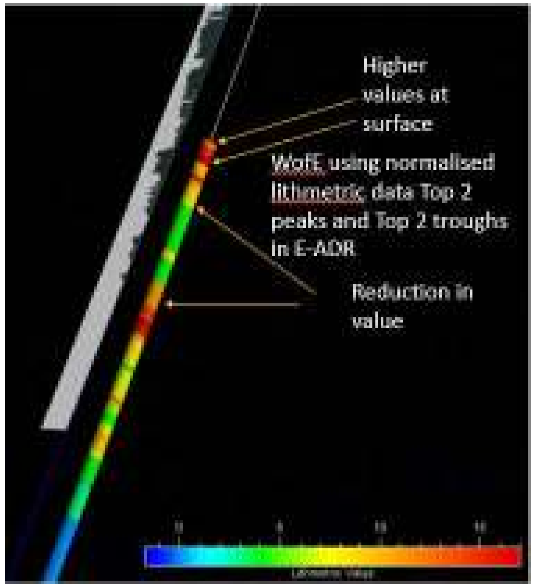


- In these examples the data was cropped from 200m instead of 100m. The approach for creating Lithmetrics remained unchanged, although the focus was purely on the eight harmonics and the e-log as these showed promise in the early development of the weight of evidence procedure.
- Seven different Lithmetrics were created, all of which appear to over estimate the presence of sulphides.
- All lithmetrics apart from Pyrite 3 suggest mineralisation below 200m rather then at 200m.
- These were tested against the training data in Slide 12 with the most promising result Pyrite 3g discussed in detail.

DP01-60W Training site



- The Pyrite 3g lithmetric adds together all the strong peak parameters from the weight of evidence method and subtracts the strong trough parameters thought to be associated with sulphides.
- There are regular matches between the lithmetric Pyrite 3g and the known mineralisation between 200-300m.
- This lithmetric still suggests excess pyrite below 350m.
- Shallower mineralisation is observed in the drill data above 200m is not observed in the lithmetric because of the beam saturation.
- This approach will need further refining but is progress on the original pyrite 2 lithmetric which produced more false positives and also failed to identify some of the sulphides in depth associated with sulphides.



Summary of tested Lithmetrics

- This table summaries all the examples of Lithmetrics tested using the difference from the median method on the training V-bores and the weight of evidence method tested against every V-bore.
- None of the difference from the median examples perfectly pick out the sulphides but Pyrite 3g matches well between 200-300m.
- We'll now discuss an alternative approach which removes many of these false positives and provides a quantitative valuation of the presence of sulphides called weight of evidence. An example of one of the two tests using the weight of evidence method is shown in the figure on the left.

Lithmetric Name	Calculation	Success	Reasons
Pyrite 2	(SD1-5+F-Gamma+Corr5-10+E-Gamma)-(SD 5-10+ F-SD)	No	Multiple false positives, correlation parameters not thought to relate to sulphides
Pyrite 3	(E-SD+E-Mean+E-Gamma+F-ADR)-(F-SD+F-Mean+F-Gamma+E-ADR)	No	Multiple false positives, matches with training data rare
Pyrite 3b	E-SD+E-Mean+E-Gamma	No	Multiple false positives, matches with training data rare
Pyrite 3c	F-SD+F-Mean+F-Gamma	No	Multiple false positives, matches with training data rare
Pyrite 3d	F-SD+F-Mean+F-Gamma+E-SD+E-Mean+E-Gamma	No	Multiple false positives, matches with training data rare and not consistent
Pyrite 3e	E-SD+E-Mean+E-Gamma+F-ADR	No	Multiple false positives, matches with training data rare
Pyrite 3f	F-SD+F-Mean+F-Gamma+E-ADR	No	Multiple false positives, matches with training data rare
Pyrite 3g	(F-ADR+F-SD+E-SD)-(F-Gamma+ E-log)	Somewhat	Some good matches between 200-300m but also some false positives below this.
WofE Peaks E-ADR	Peaks in E-ADR + E-Mean+ E-SD+ F-Mean+ F-SD+ trough in F-Gamma	Yes	Reduced false positives below 300m, values similar to % sulphide
WofE Peaks & Troughs E-ADR	**Peaks in E-ADR + E-Mean+ E-SD+ F-Mean+ F-SD+ trough in F-Gamma + trough in E-ADR**	**Yes**	**Slight increase in response to sulphides. False positives still reduced, values similar to % sulphide**

Methodology

Flow diagram (post weight of evidence)

Completed ADR spreadsheet

Normalise processed data and creation of common depth points using LithMetrics_v100 script. Data output with top 200m removed.

Select 7 harmonic parameters.

Complete weight of evidence for peaks (E-ADR, E-Mean, E-SD, F-Mean, F-SD and troughs (F-Gamma, E-ADR). Test different variations if initial results are poor.

Compare each parameter with the training data quantitatively. Set threshold value.

If results are poor go back, review and refine.

If results are good, continue

Run for all other V-bores.

Weight of Evidence Method

Data sorted by value either high or low. (see third note)

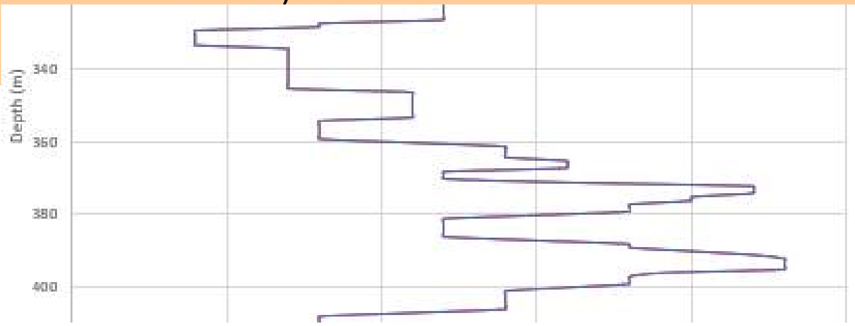
Depth (m)	Depth (ft)	F-ADR MA
397	1302.493	0.603223
396	1299.213	0.602662

Depth (m)	F-Mean				F-ADR			
370		2	3	4				
371		2	3	4				
372	1	2	3	4	1			4
373	1	2	3	4	1			4
374	1	2	3	4	1			4
375	1		3	4	1			4
376	1		3	4	1			4
377			3	4				4
378			3	4				4
379			3	4				4
380				4				4
381				4				4
382				4				4
383				4				4
384				4				4
385				4				4
386				4				4
387				4			3	4
388				4			3	4
389				4			3	4
390				4		2	3	4
391				4		2	3	4
392				4		2	3	4
393				4		2	3	4
394				4		2	3	4
395				4		2	3	4
396						2	3	4

Top 4 peaks

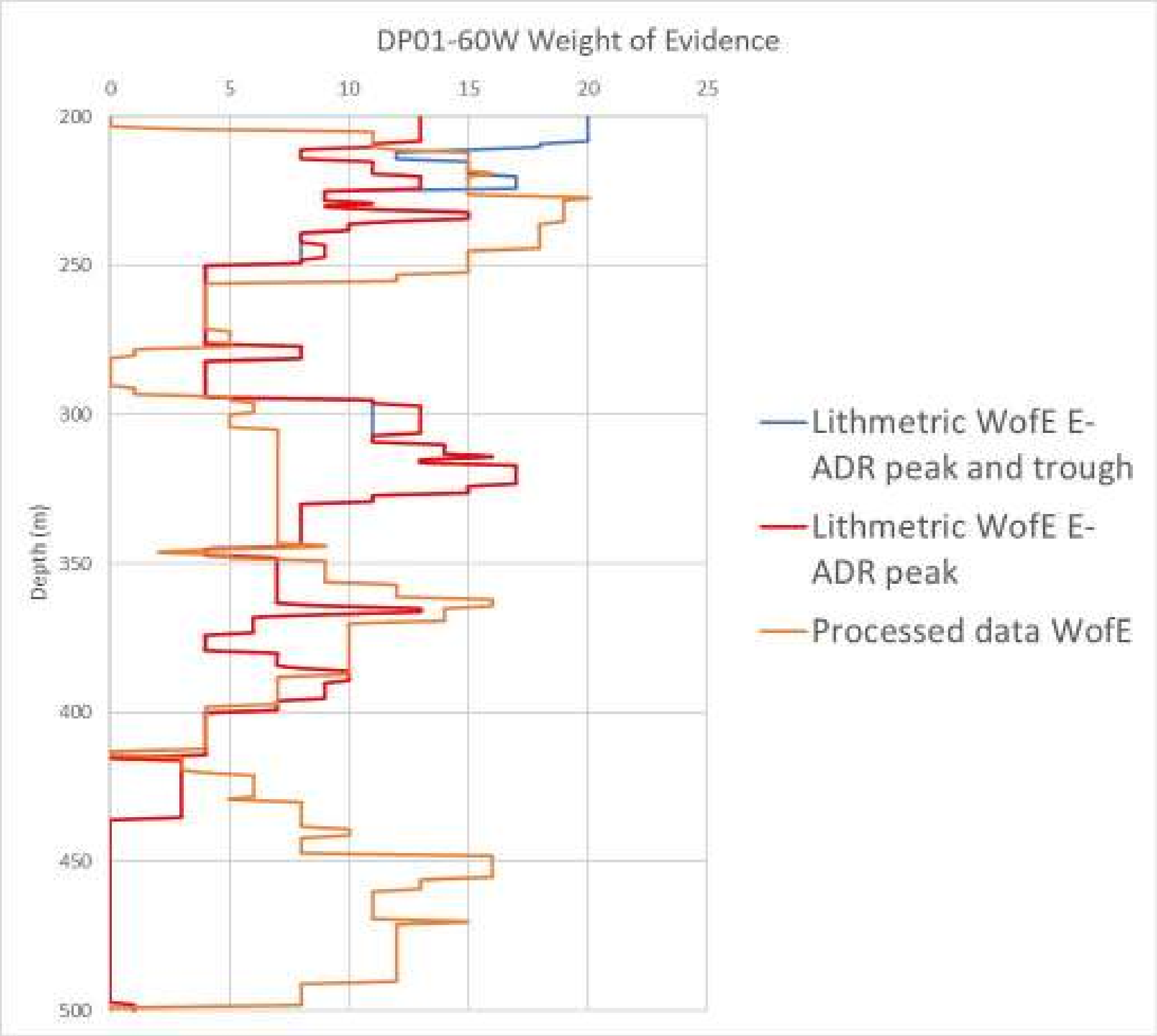
4 = place values 25m above and below = buffer of 25m either side of the peak in the value.
3 = 20 cells above and below (20m buffer on either side)
2 = 10 cells above and below (10m buffer on either side)
1 = 5 cells above and below (5m buffer on either side)

Totals added and graph plotted. A csv output for Geoscience Analyst created.



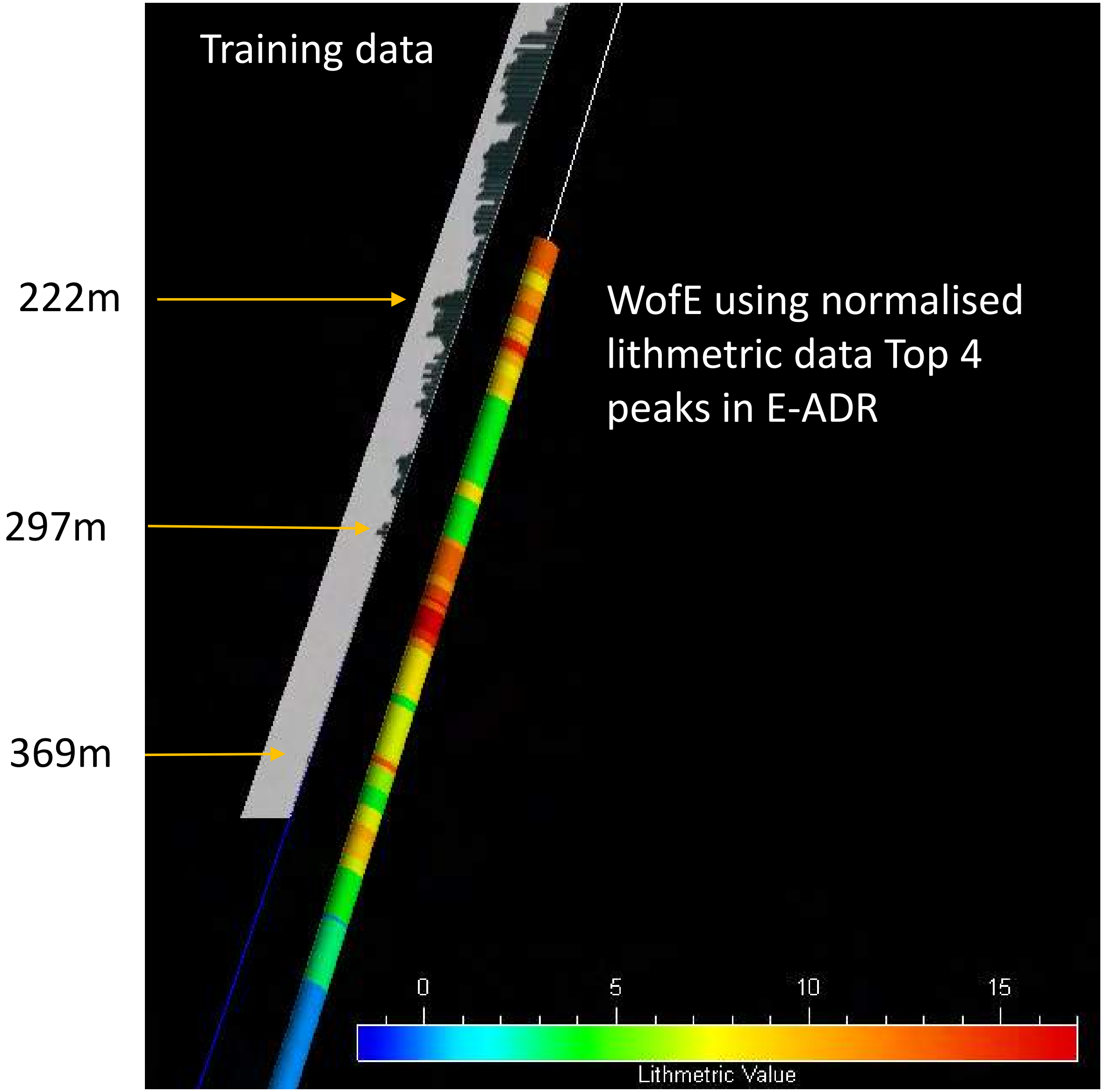
- This uses the same normalised data used for the difference from the median method. This a relatively quick approach taking 1.5-2 hours per V-bore, compared to a full day for the zonation method and uses specific parameters rather than the full data suite. The approach is also more quantitative than zonation or the difference from the median method.
- Run the Lithmetrics_v100 script as before and paste the data into the moving average spreadsheet, but only the harmonics data. Create separate tabs for each of the parameters listed below. Copy the data and sort into high or low parameter values.
- The parameters used are Low F-Gamma, High F-ADR, High F-Mean, High F-SD, High E-Mean, High E-SD and High or Low values for E-ADR (as these show promise in the non-normalised data. The top 4 peaks or troughs for each of the parameters above was weighted from 4 to 1 with the exception of E-ADR where the top two peaks were weighted 3 and 4 and the top two troughs were also given a weighted value of 3 and 4.
- All the values were then added together, to produce the final value at each depth interval.
- Values of 15 or greater are considered mineral zones as these are similar to the percentage values for sulphides present in the rocks.
- This gives a value more similar to the estimated percentage of sulphides from the training data than the difference from the median method.

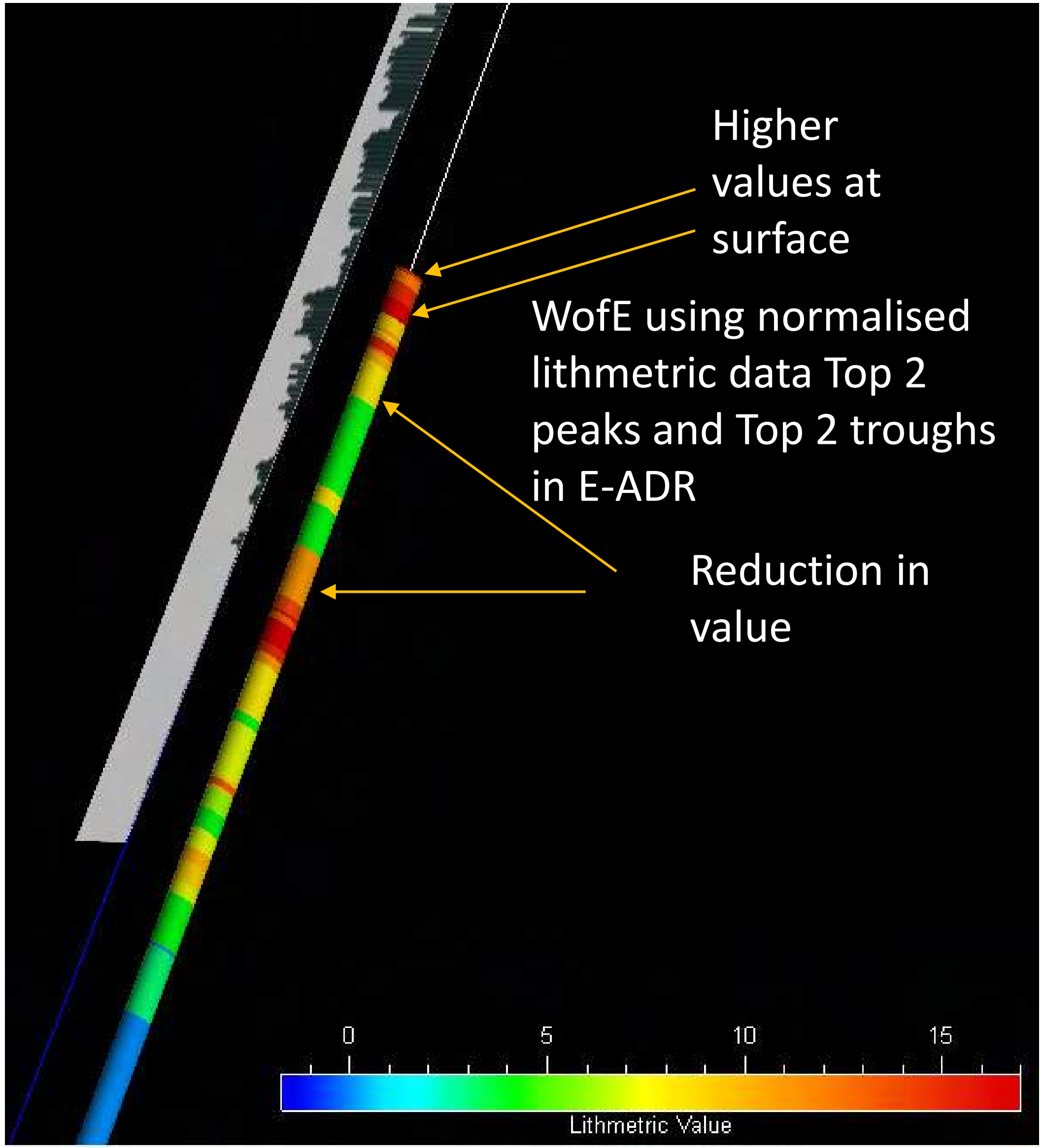
DP01-60W Lithmetrics Weight of Evidence



- Two sets of results are shown. The red line uses weighted peak values of 1 to 4 for E-ADR. The blue line uses weighted peak values of 3 and 4 and weighted trough values of 3 and 4. The orange line is the weight of evidence data processed without using the normalised data from the Lithmetrics script.
- Both sets of Lithmetrics data indicate potential sulphides at 325m which is not seen in the processed data.
- Both methods still show some values above 10 below 350m but this is greatly reduced using the Lithmetrics method compared to the none normalised Weight of Evidence dataset. Furthermore, none of these values are above or at the threshold value of 15.
- When using troughs for E-ADR there is an increase in values between 200m-225m above the threshold value of 15.
- E-ADR peaks and troughs for lithmetrics will now be compared with the training data for DP01-60W.

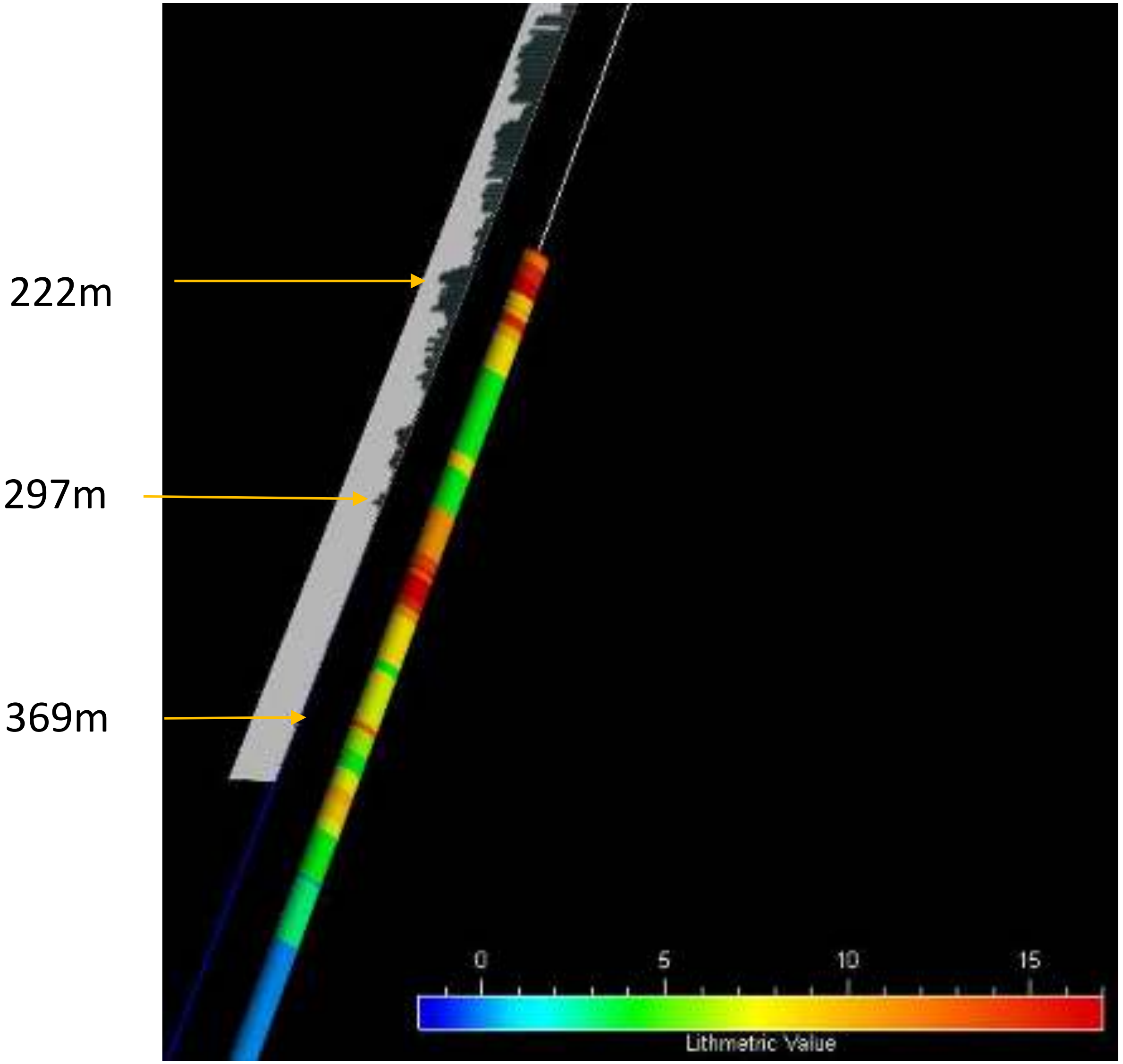
DP01-60W Comparison with training data





- When the two approaches are compared there is a slight improvement in the results if E-ADR peaks and troughs are used instead of just E-ADR peaks.

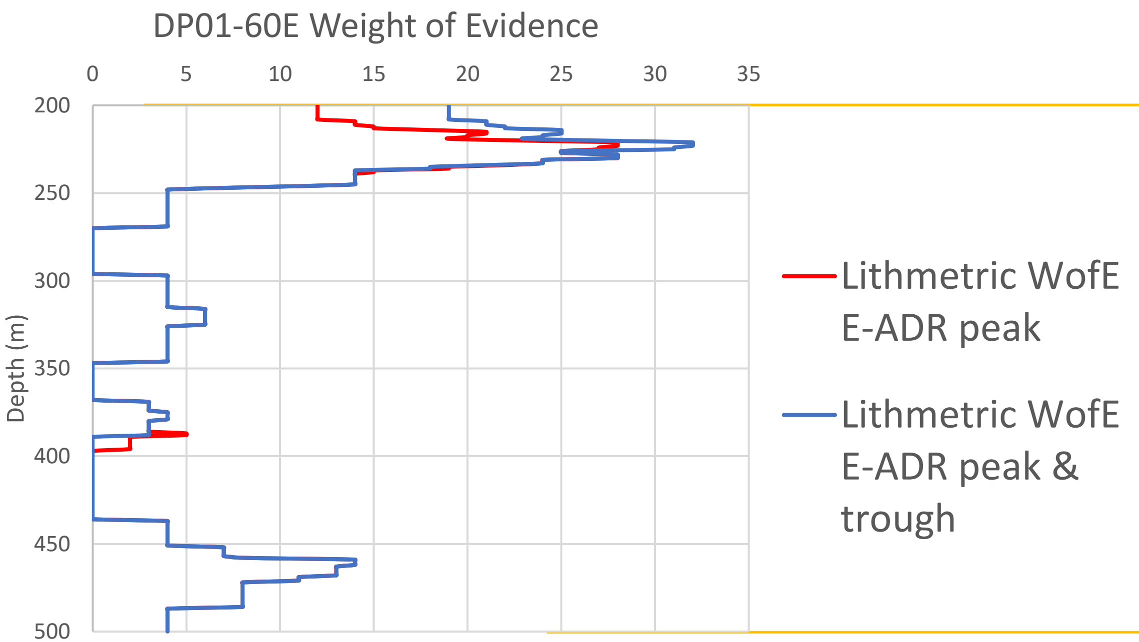
DP01-60W Training site E-ADR peaks and troughs

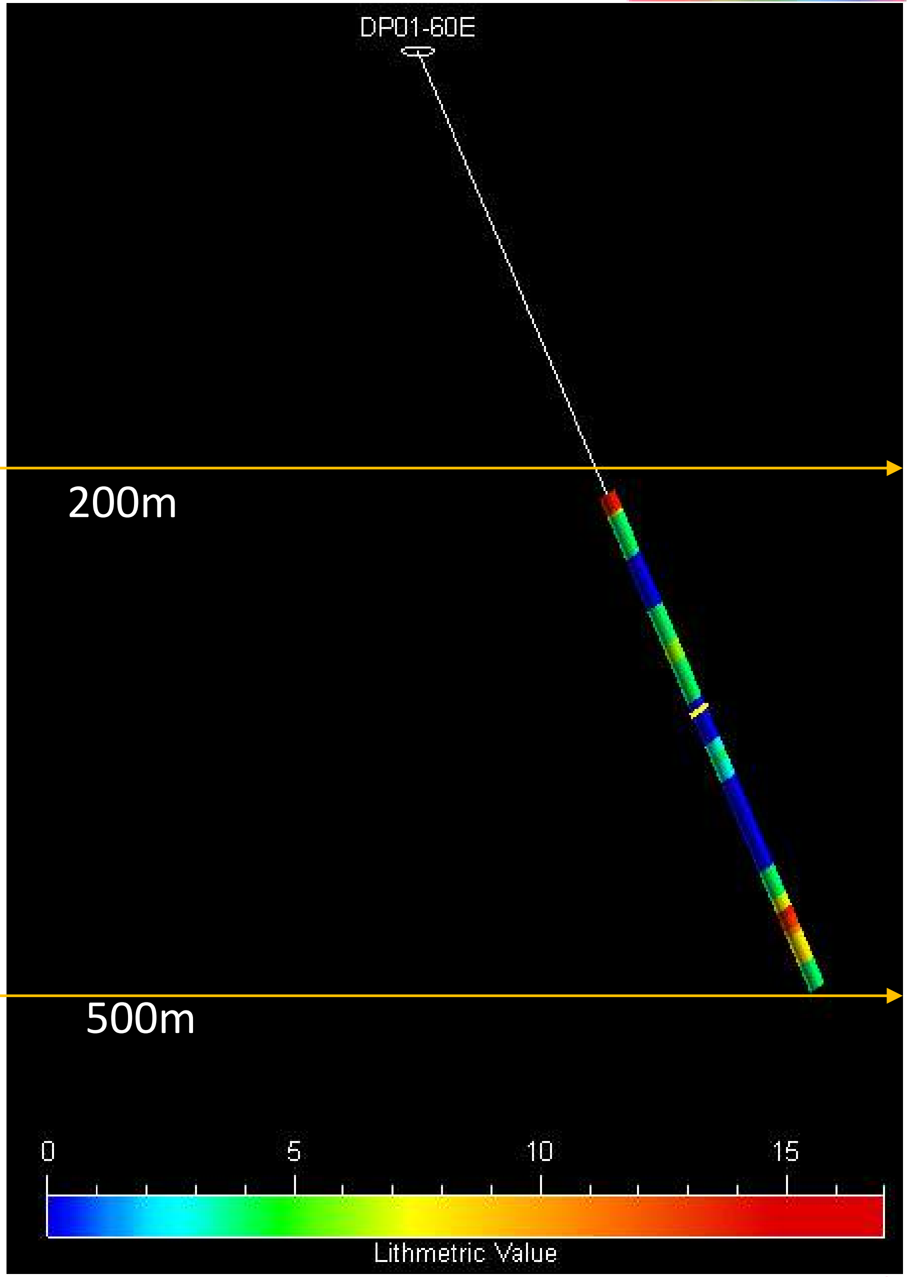


- The weight of evidence method adds about 30 minutes to the data analysis but removes some false positives at depth compared to the difference from the median method.
- The key mineral zone is clearly picked out at 200-230m.
- This lithmetric still suggests moderate values below 325m but this is reduced when only peaks in E-ADR are considered. Also below the end of the drill data, the values drop off to close to zero.
- Shallower mineralisation observed in the drill data above 200m is not observed in the lithmetric because of the beam saturation.

DP01-60E Lithmetrics Weight of Evidence

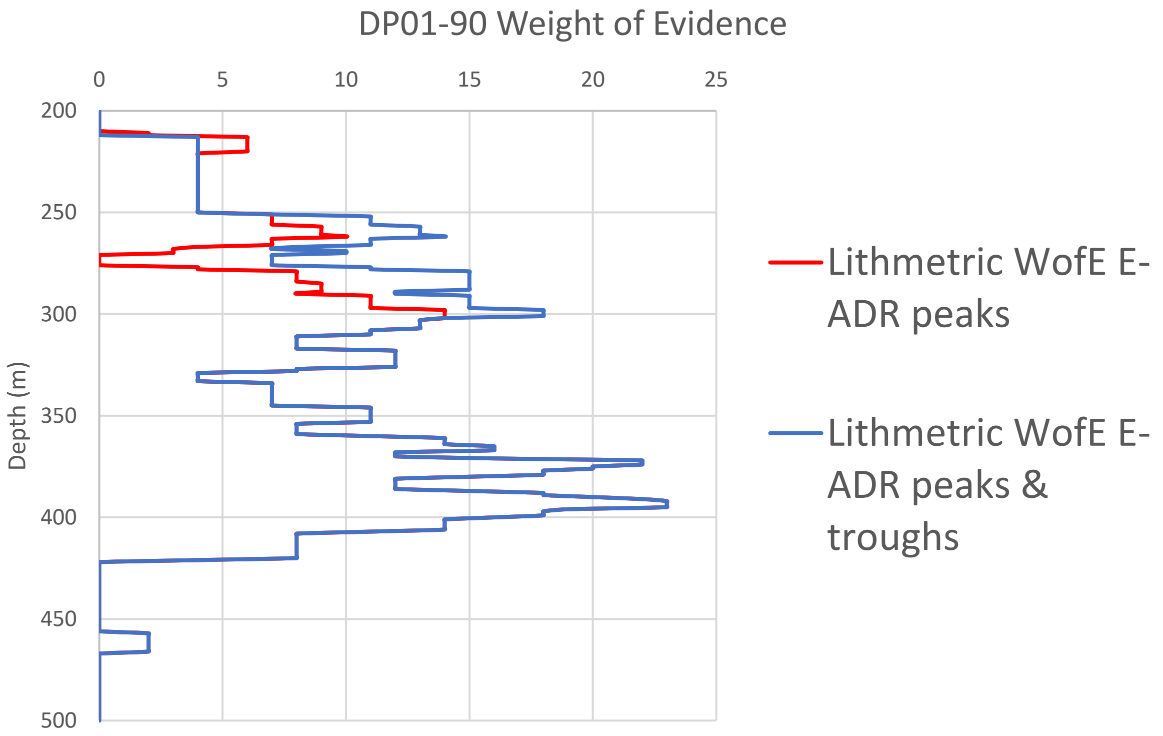
- The sulphide mineral zone can be defined as occurring between 200-240m.
- The sulphide zone is larger by approximately 10m when both troughs and peaks in E-ADR are taken into account.
- The area which appears red in the Geoscience Analyst model at 455m is below the threshold value of 15.

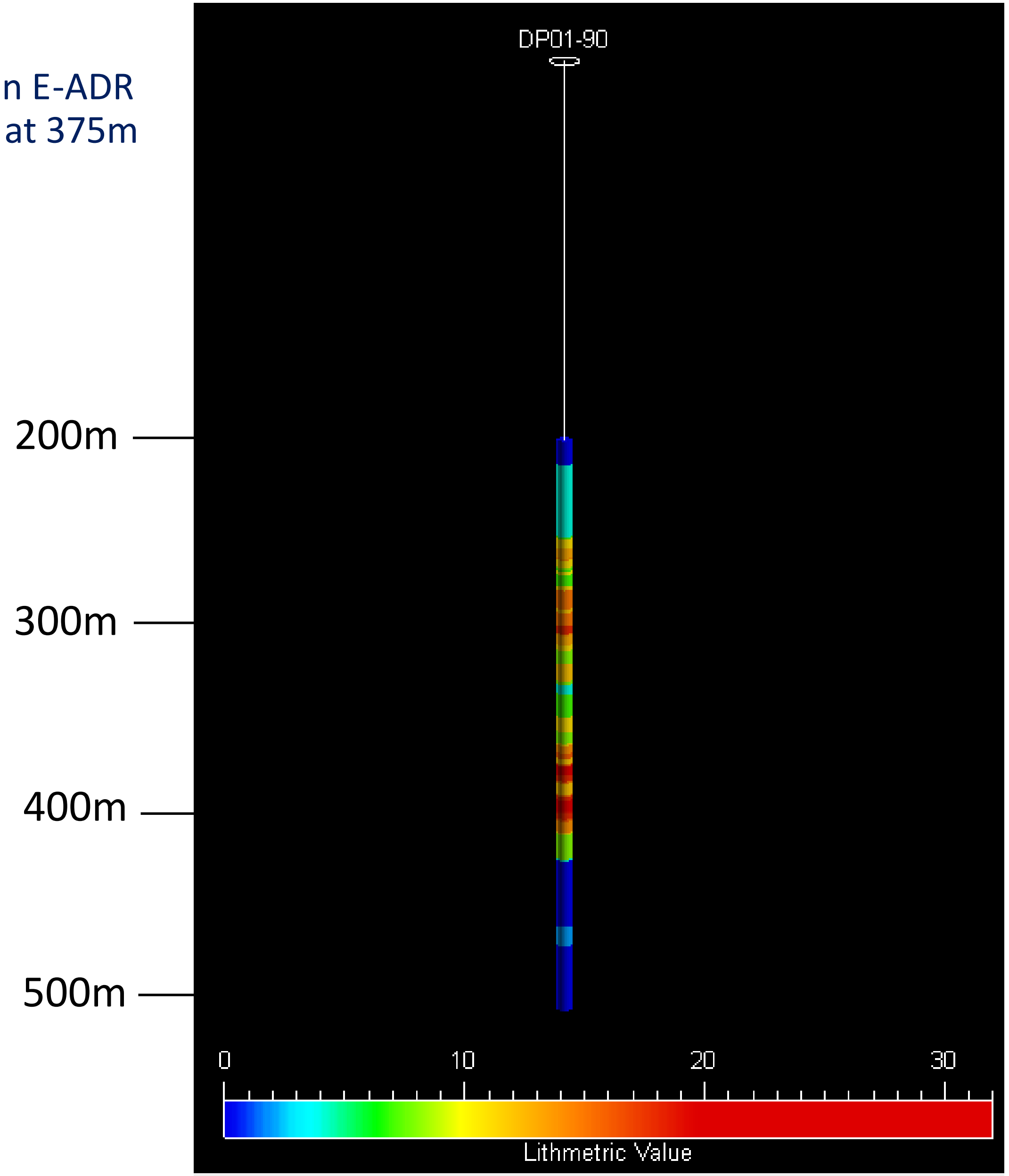




DP01-90 Lithmetrics Weight of Evidence

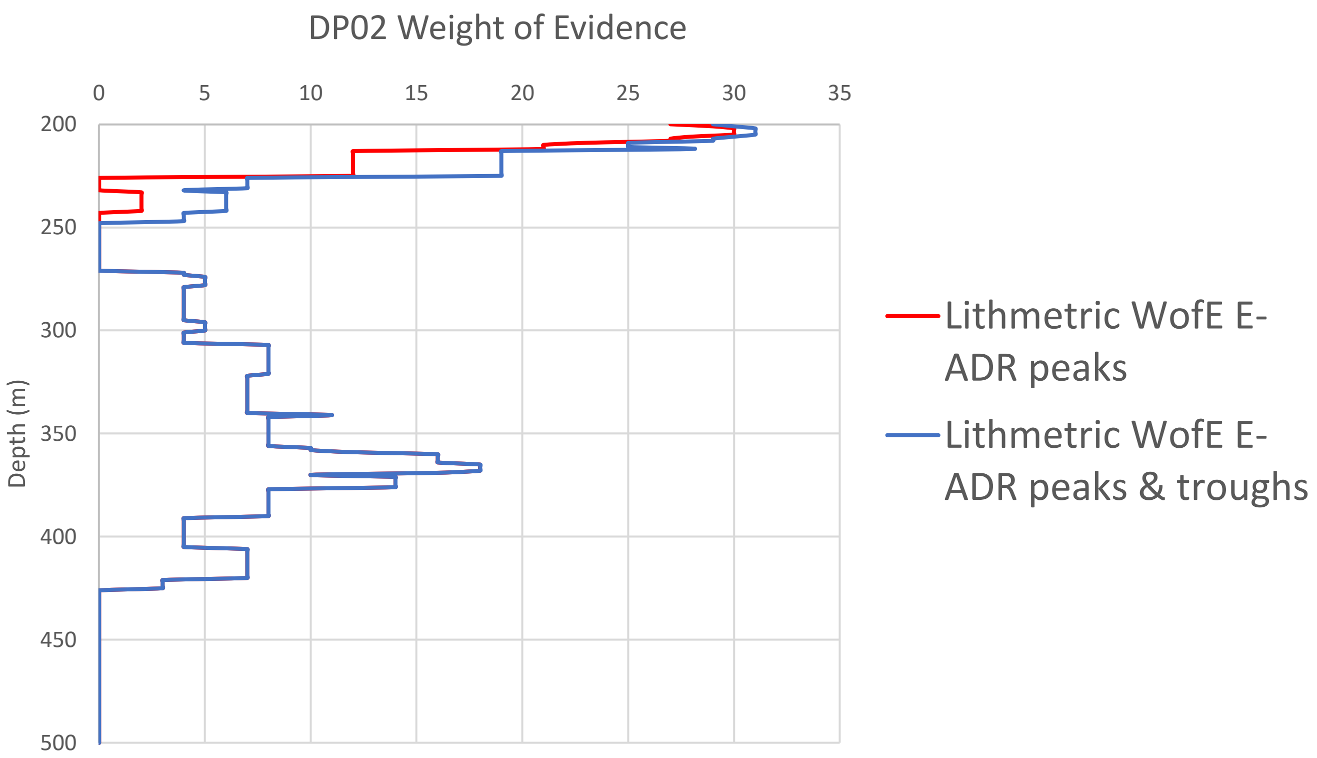
- Using a threshold value of 15 three sulphide zones are picked out by both peaks in E-ADR and peaks and troughs in E-ADR methods. The first is at 275-300m, the second is at 375m and the third is at 390m.
- The peaks and trough method also identifies a sulphide zone at 300m.

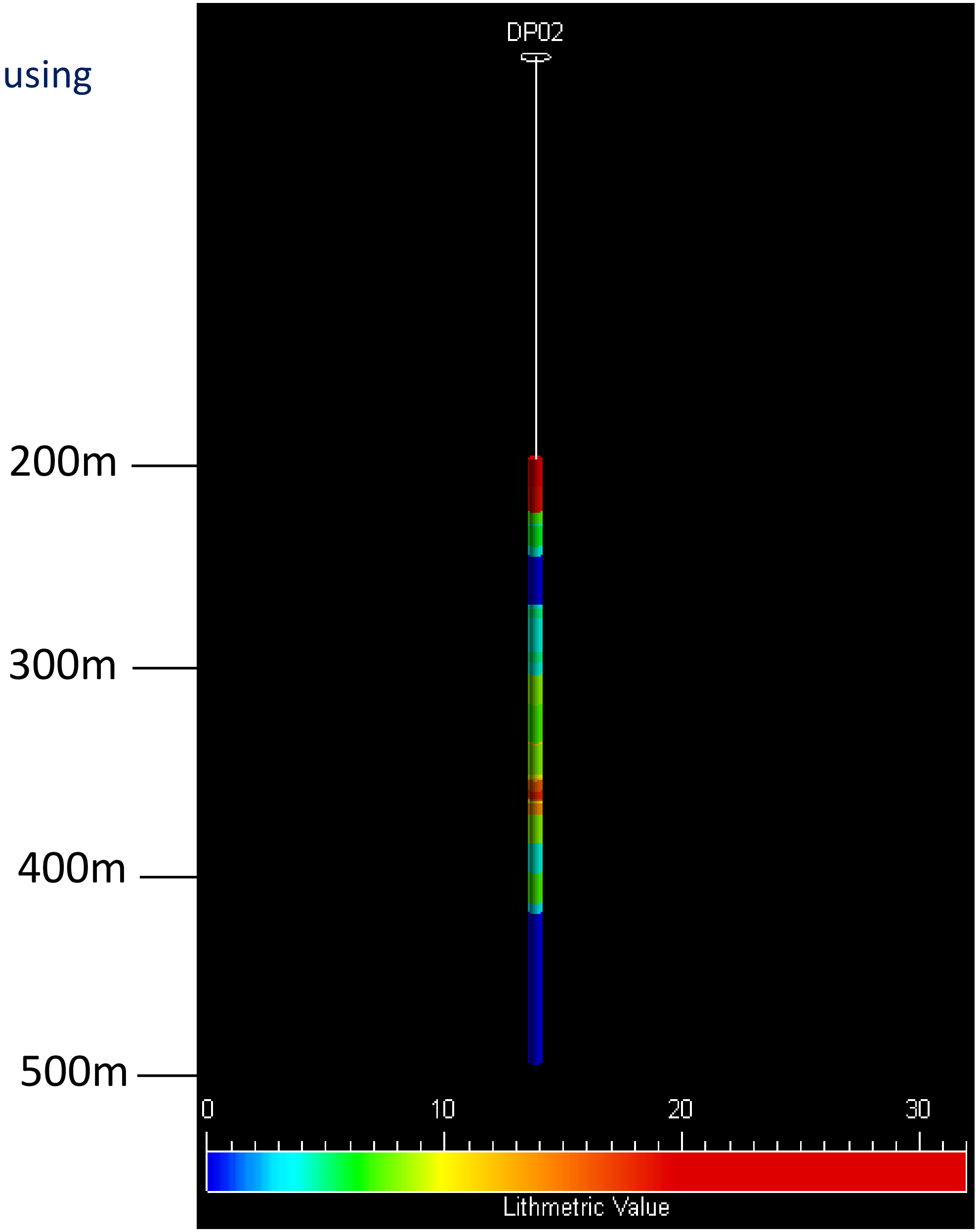




DP02 Lithmetrics Weight of Evidence

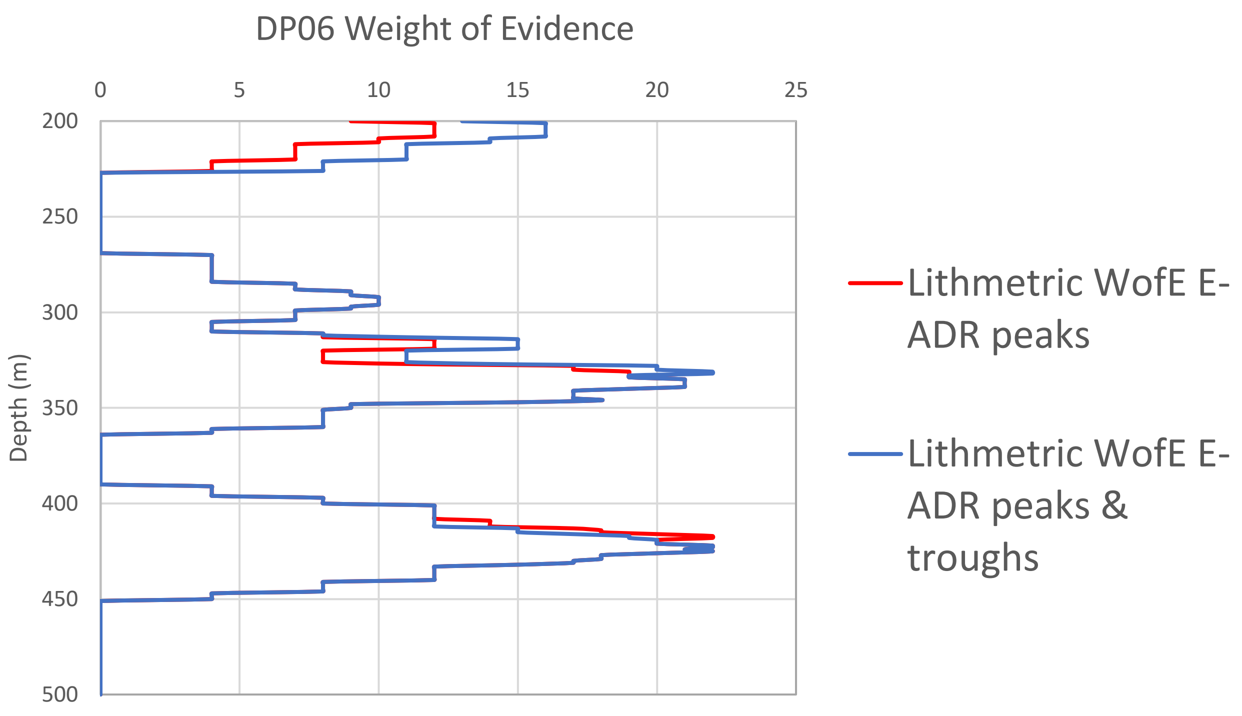
- Using a threshold value of 15 two sulphide zones are identified at 200m and at 360m using both peaks in E-ADR and peaks and troughs in E-ADR.
- The zone at 200m is 15m thicker when peaks and troughs in E-ADR are used.

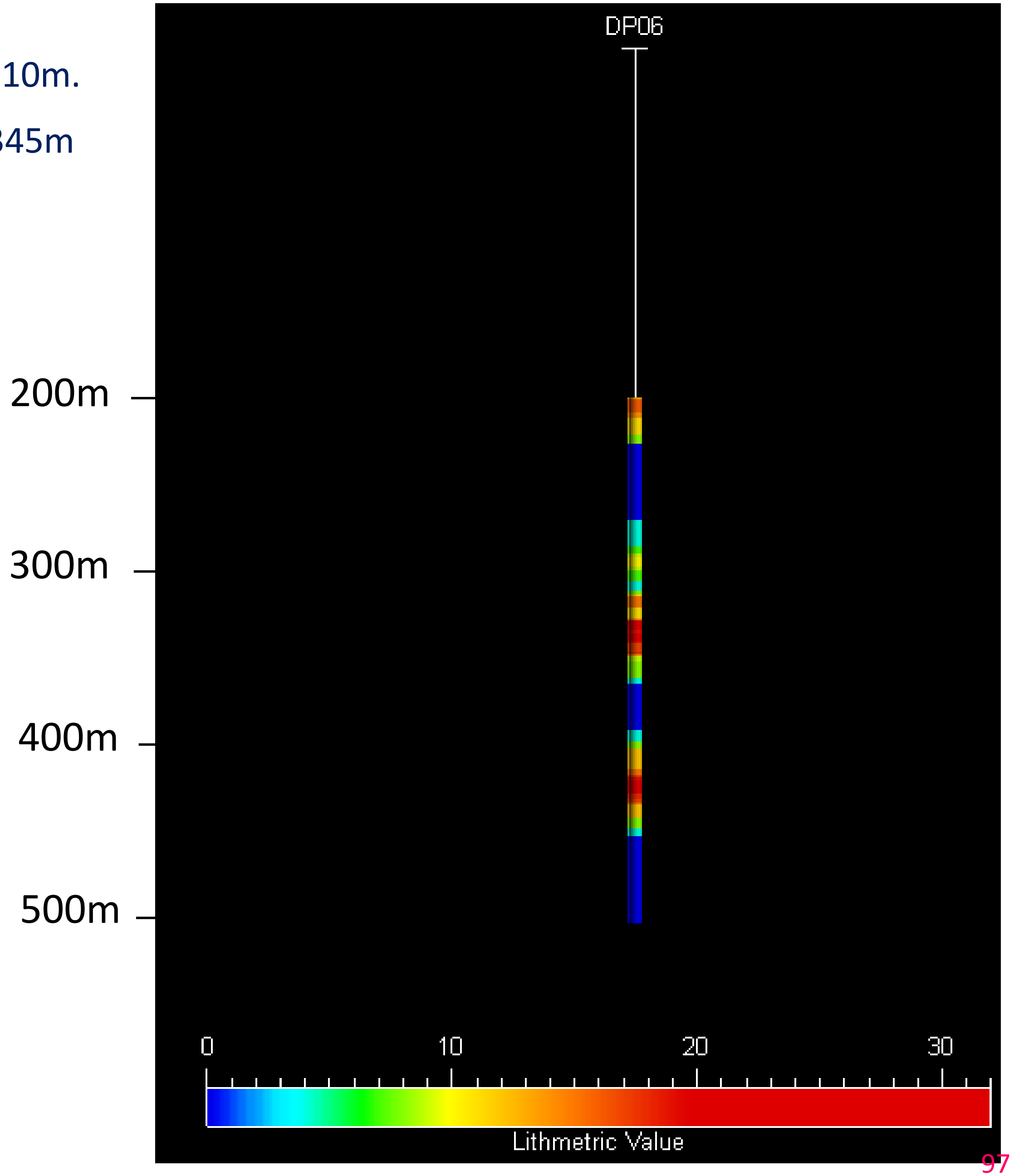




DP06 Lithmetrics Weight of Evidence

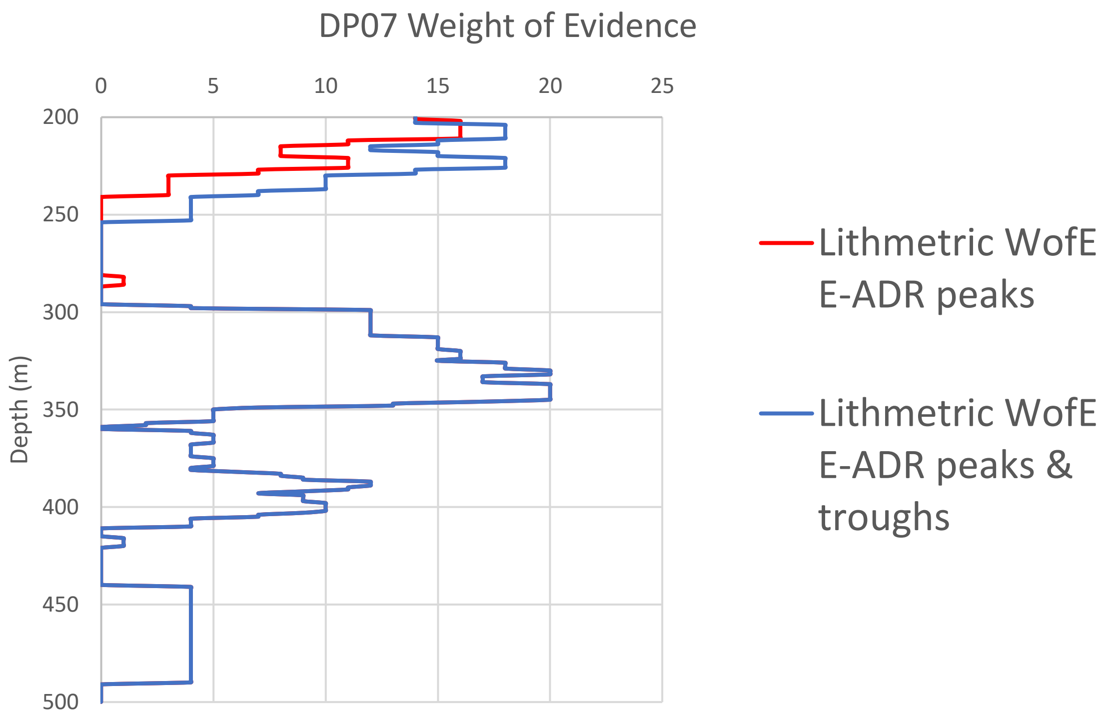
- The peaks and troughs in E-ADR approach picks out a sulphide zone at 200-210m.
- Both peaks and peaks and troughs methods pick out sulphide zones at 325-345m and at 425m.

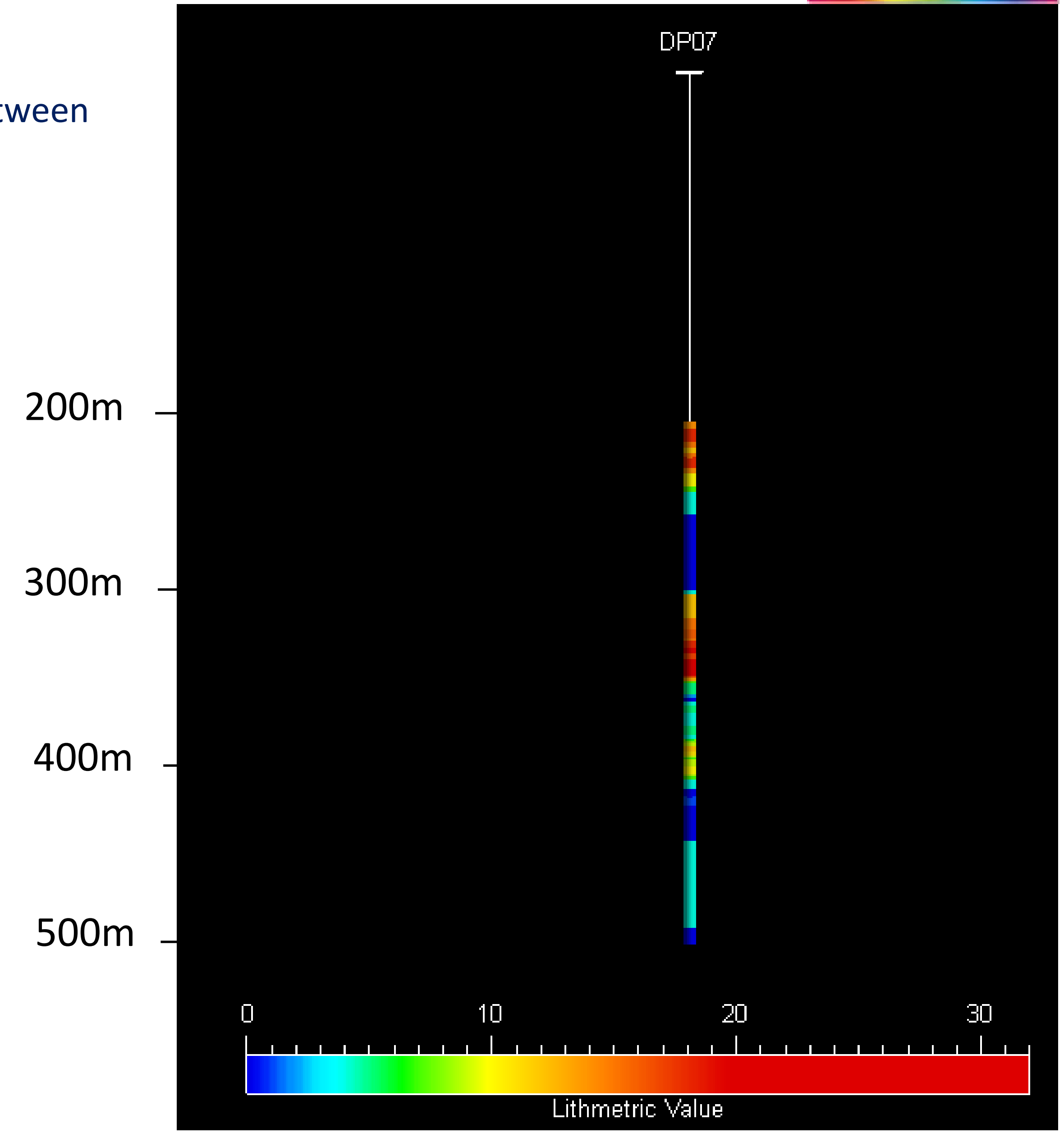




DP07 Lithmetrics Weight of Evidence

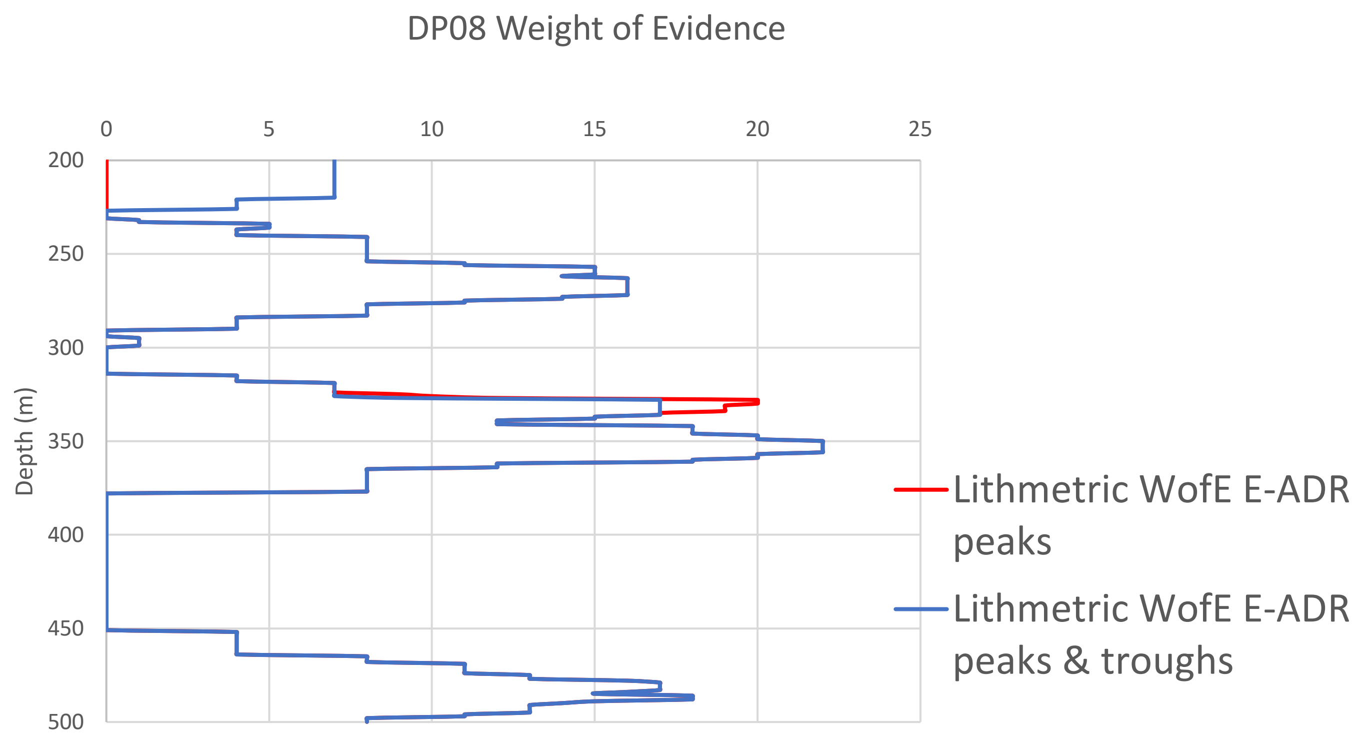
- E-ADR peaks and troughs approach identifies a potential mineral zone between 200-225m.
- A second mineral zone is identified between 330-350m.

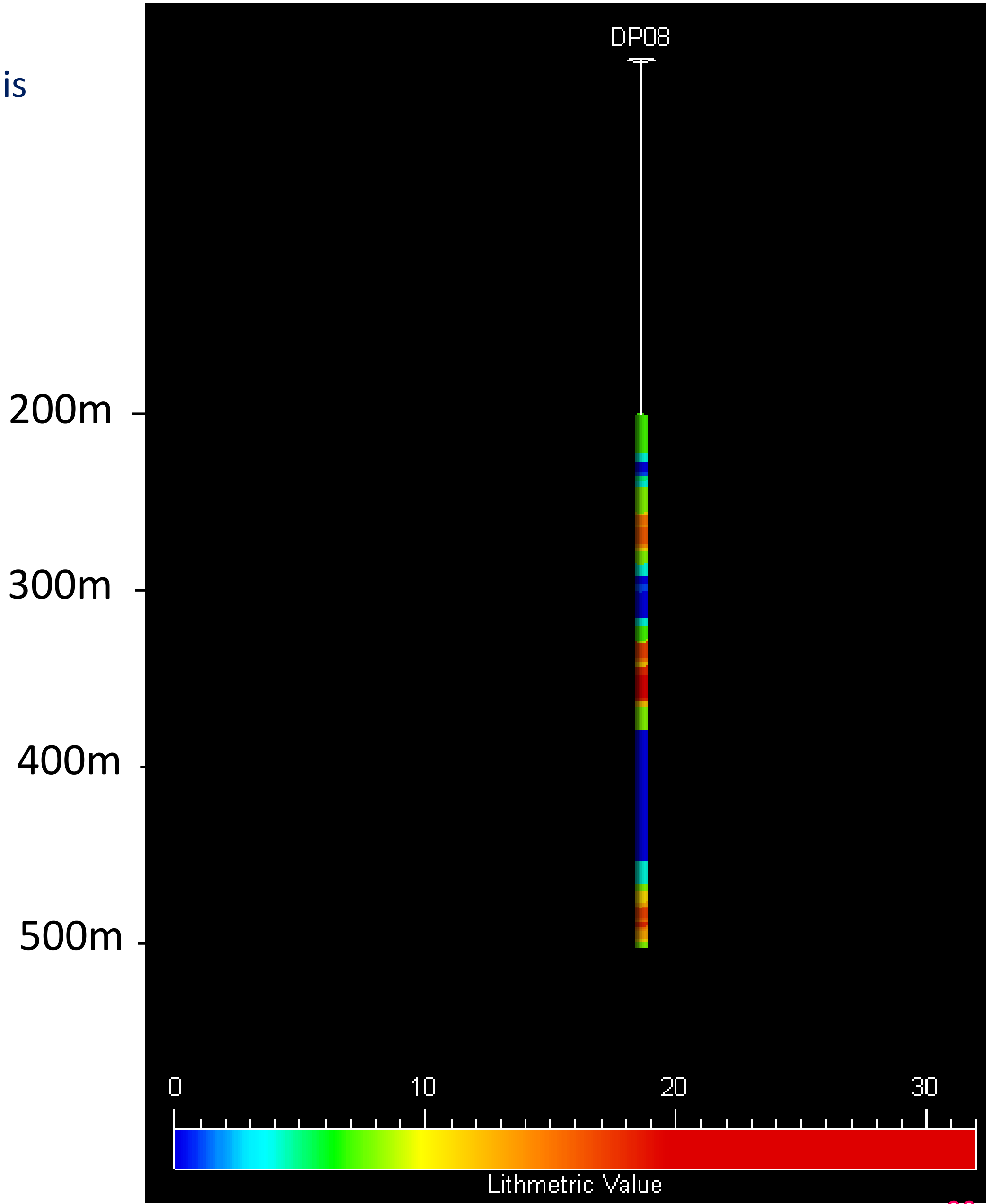




DP08 Lithmetrics Weight of Evidence

- E-ADR peaks and troughs identifies three potential mineral zones. The first zone is between 260-270m. The second zone is between 330-355m and a third mineral zone is seen at 480m.

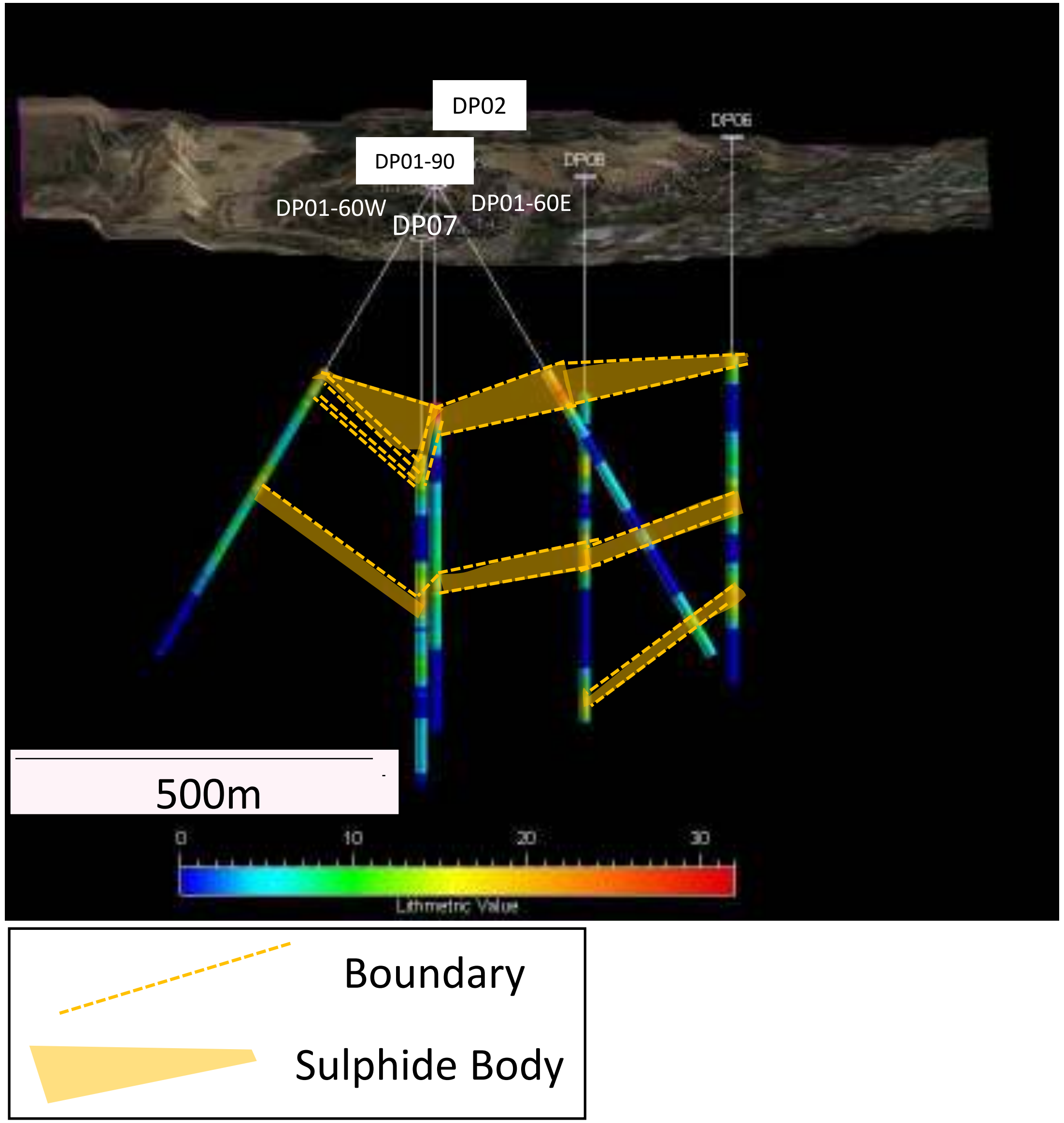




Geoscience Analyst Model

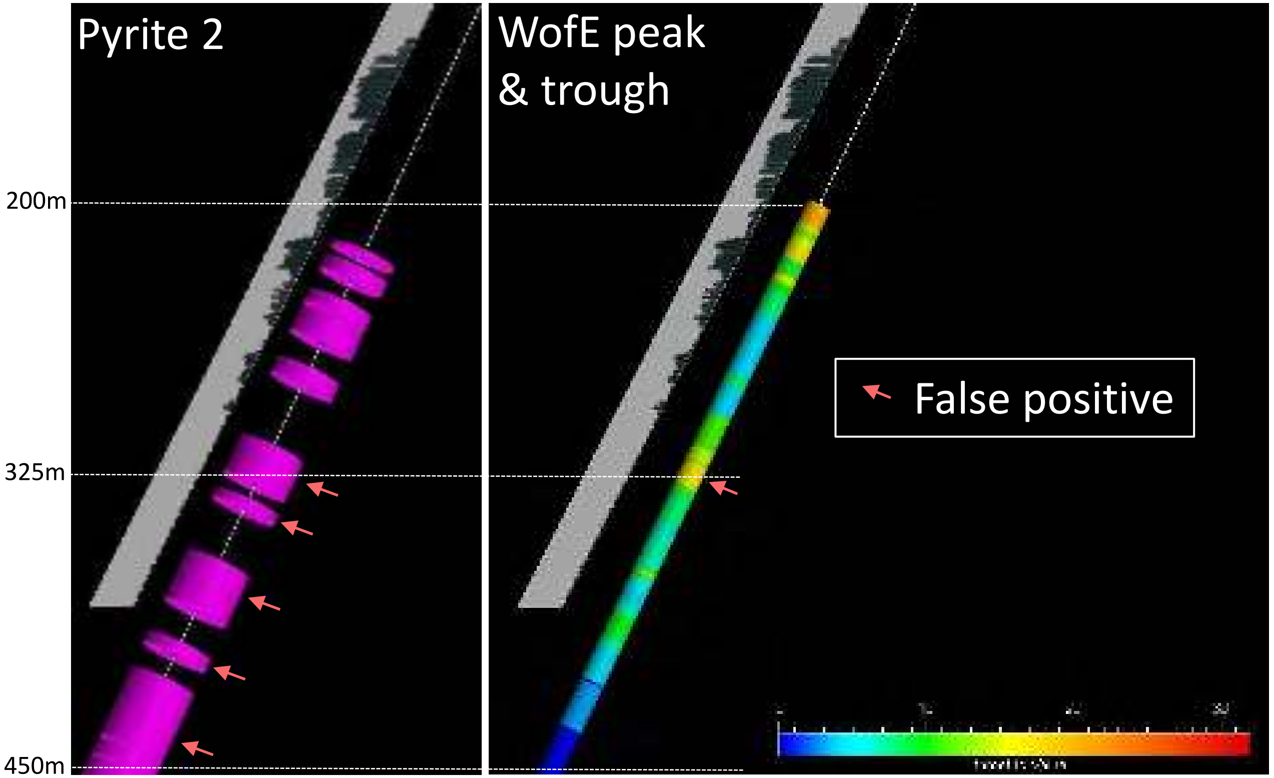
West

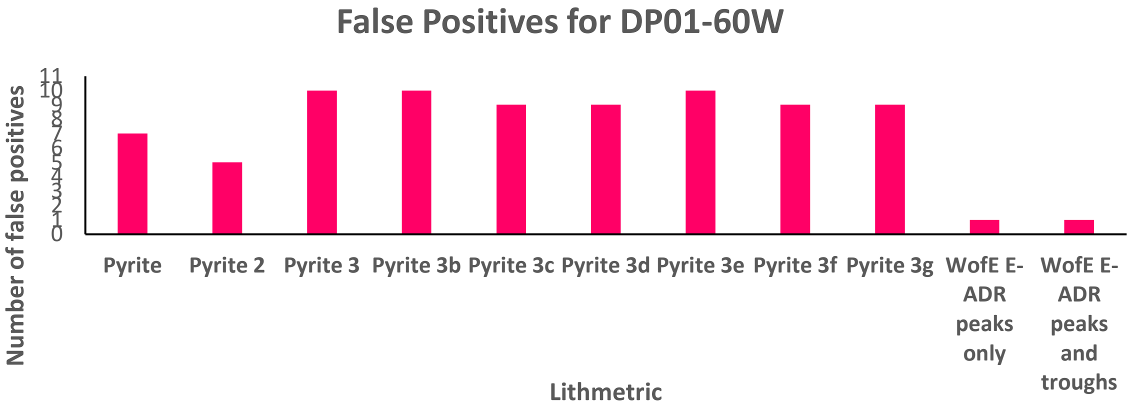
East



- When all the sites are combined, a sulphide body is identified around 200m which can be tracked west to east and also to the south in DP07. It could also be located in DP08. However, if this is the case it would be present above 200m and covered by the beam saturated zone.
- The sulphide body is especially clear in the two angled stares DP01-60E and DP01-60W.
- If a threshold value of 15 is used this would imply further mineral zones orientated in a similar direction (north-east to south-west) at approximately 300m below ground level.

Conclusions





- The Lithmetrics technique has gone through several iterations throughout this project initiating from the difference to the median method to a weight of evidence approach. The latter is a relatively quick method taking 1.5-2 hours per V-bore from running the script to creating a Geoscience Analyst input. This is reduced from a full day for the zonation method and uses seven specific parameters rather than the full ADR dataset.
- From analysing the drill data at DP01-60W, the weight of evidence method reduces the number of false positives from as high as ten to just one. A strong response is seen at the target depth for sulphides.
- The most effective method for applying the normalised lithmetrics dataset is using the weight of evidence approach. Specifically using both peaks and troughs in E-ADR rather than just peaks in E-ADR is better because this further enhances true positives without increasing false positives.
- The weight of evidence approach is also more quantitative than the difference from the median method as the values more closely relate to the sulphide weight percent values estimated from the training data (e.g. 0-30) rather than an arbitrary range of -1 to 1.

Introduction to the V-Bore Repeatability Study

- In order for test for repeatability for this project, stares collected from DP01 and DP02 were compared right through from the raw data to interpretation of the target sulphide materials.
- The two V-bores are located 11 metres apart in the same geological setting.
- The data was collected on the same day and with the same settings.

Settings	DP01-90	DP02
Date and time of collection	30th October 2012 4:39am	30th October 2012 6:23am
Dip Angle	90	90
Time Range	20000	20000
Chainage	500	500
Delay	$9.92x10^{-6}$	$9.92x10^{-6}$
Sample Rate	$5x10^{9}$	$5x10^{9}$

Methodology for the 1D Repeatability assessment

A step by step workflow for all the steps covered in this report

Compare Raw Data with the Correlation mehtod

↓

Stare processing for Correlation, Harmonics, WMF, E-log & Bandwidth Harmonics
For DP01-90 and DP02 using a merged stare and identical processing

→

10 point moving average calculated for each parameter

↓

Mean, Min, Max, Standard Deviation calculated for each parameter from 200-500m depth. Range calculated.

→ **Semi-Quantitative and Quantitative Comparison of Processed data**

↓

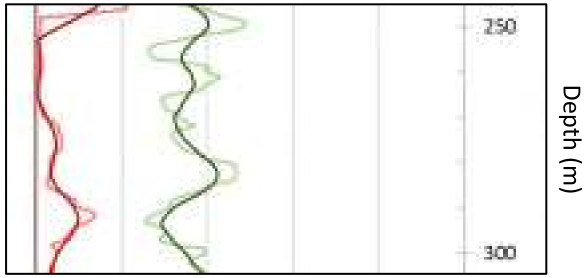
Compilation of WofE and Lithmetrics results for DP0190 & DP02

→ **Semi-Quantitative comparison of Lithmetric Results**

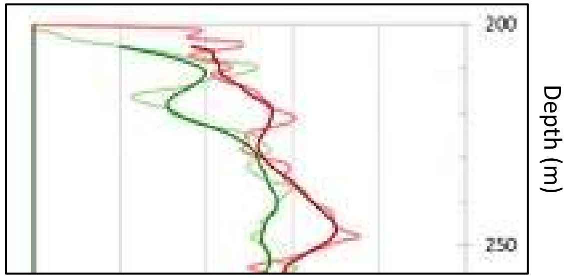
Semi-Quantitative Assessment

- In order to look at the differences in the profiles of the graphs producing during processing. A similarity index was created.
- This looks at the profiles of the data at 50m intervals from 200-500m and gives a value between 0 and 3 depending on whether the profiles go in the same direction or going in the opposite direction. The values are not important as long as the peaks and troughs are seen at the same depths.
- This methodology was used for both the trend assessment of the Processed data and the Lithmetric Results.

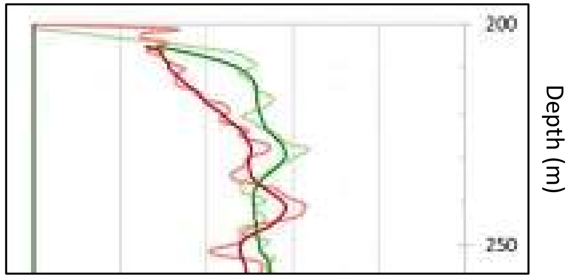
Similarity	Sim. Index	Criteria
No similarity	0	Peaks correspond with troughs for the entire 50m section.
Less than 50% similarity	1	Peaks will correspond with peaks and troughs will correspond with troughs for less than 50% of the 50m section.
More than 50% similarity	2	Peaks will correspond with peaks and troughs will correspond with troughs for more than 50% of the 50m section.
100% similarity	3	Peaks will correspond with peaks and troughs will correspond with troughs for 100% of the 50m section.



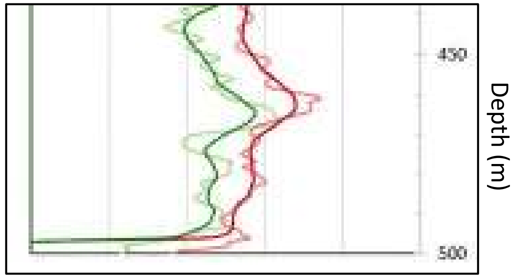
Example for similarity index value of 0



Example for similarity index value of 1



Example for similarity index value of 2

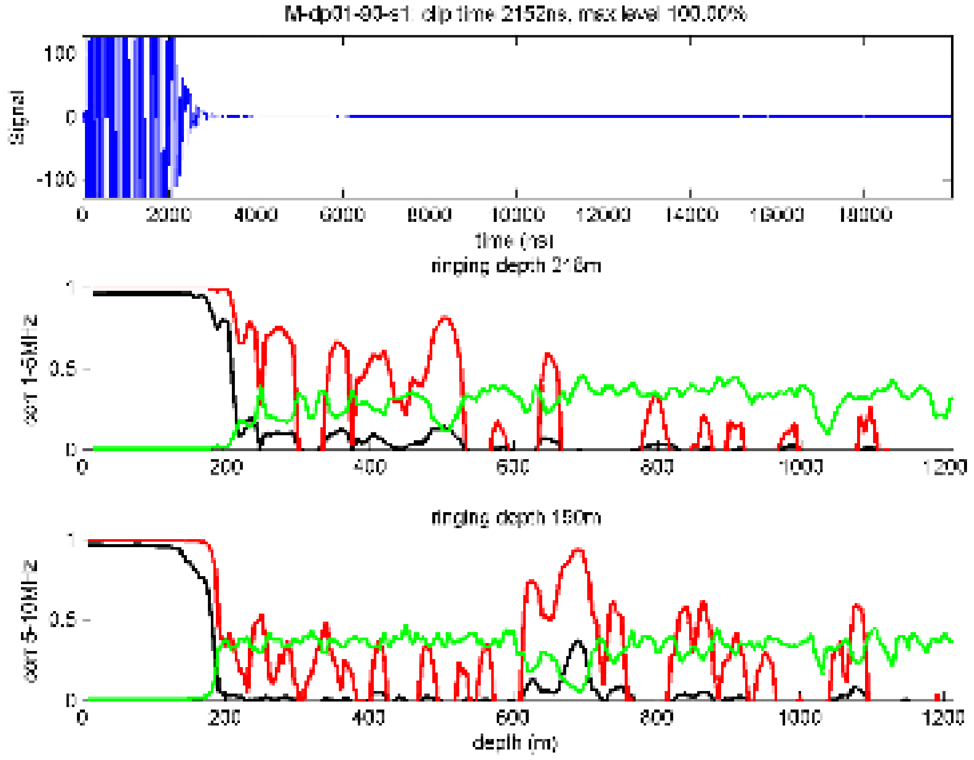


Example for similarity index value of 3

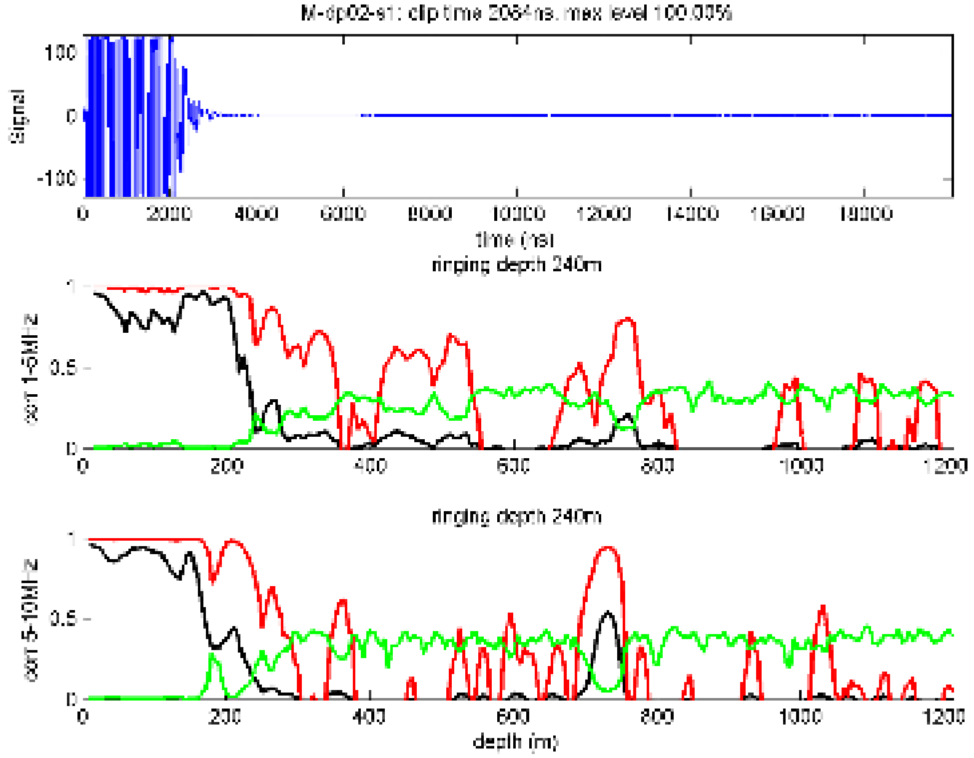
Raw Data Comparisons

- For both V-bores, two stares (S1 and S2) were merged together in order to improve the quality of the data.

DP01-90



DP02



- When the data was ran through the QAQC software, similar peaks and troughs can be identified, especially in the 5-10MHz correlation at 700m and between 200-600m in the 1-5MHz frequency range.

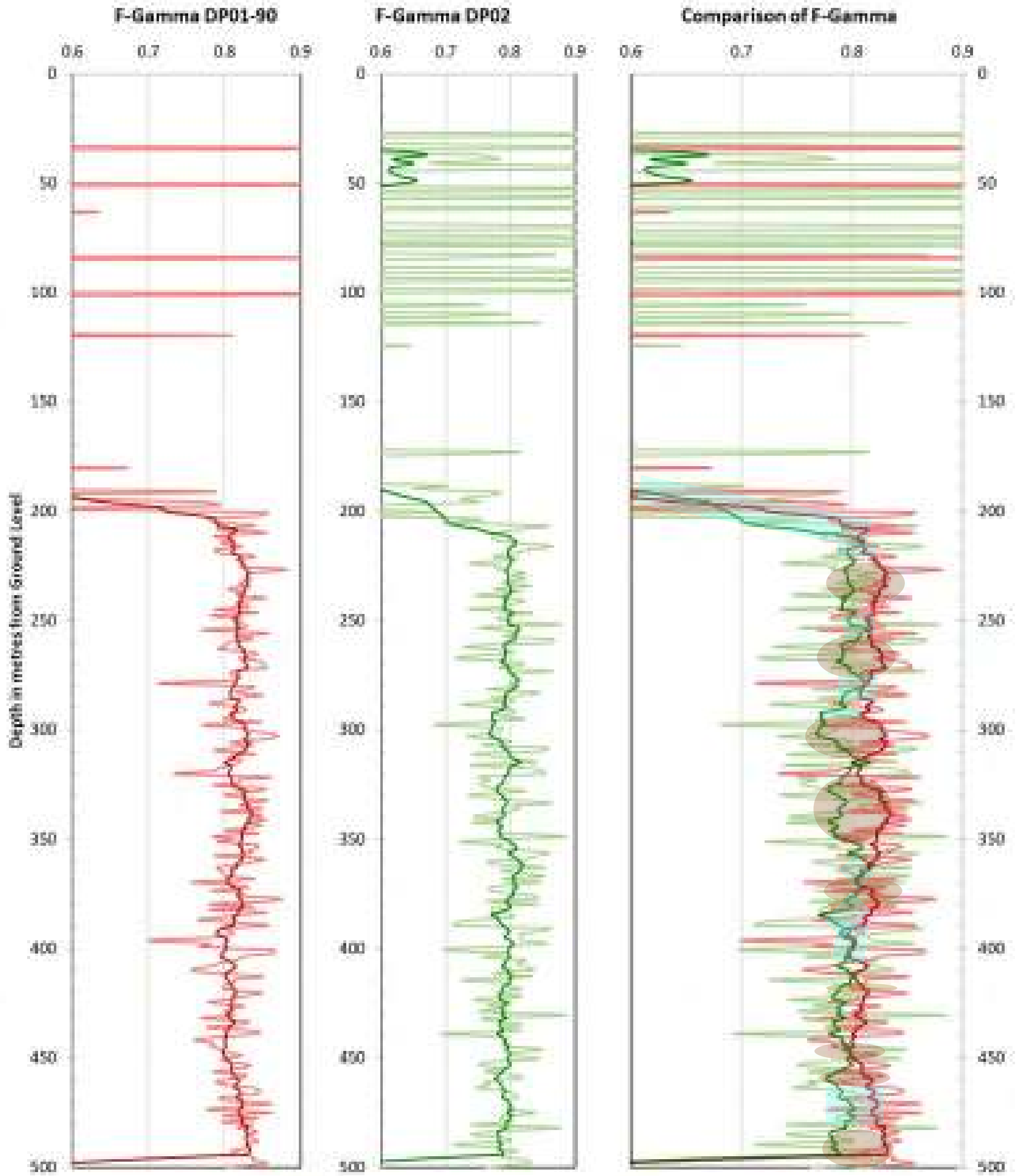
Processed Data

- For both V-bores DP01-90 and DP02 E-logs, correlation, harmonics (E-ADR, E-Gamma, E-Mean, E-SD, F-ADR, F-Gamma, F-Mean, F-SD) and Bandwidth harmonics were processed using the current G&G workflows. The same dielectric were used for both DP01-90 and DP02 because the V-bores are so close to each other

Parameter	Processing DP01-90	Processing DP02
E-log and Weighted Mean Frequency	X3 smooth, data output at 128 pixels. Depth converted using DCO file. RadamaticV3 used.	X3 smooth, data output at 128 pixels. Depth converted using DCO file. RadamaticV3 used.
Harmonics	Time zero subtracted, data extracted at 128 pixels. Depth converted using DCO file. RadamaticV3 used.	Time zero subtracted, data extracted at 128 pixels. Depth converted using DCO file. RadamaticV3 used.
Correlation Method	1-5MHz and 5-10MHz extracted from the merged stare using CalcCorrections script.	1-5MHz and 5-10MHz extracted from the merged stare using CalcCorrections script.
Bandwidth Harmonics	Time zero subtracted Vertical Correction, subimage to 500m, split to 10 subimages before Bandwidth harmonics extracted at 128 pixels, using Radamatic 2.63 and Radamatic.	Time zero subtracted Vertical Correction, subimage to 500m, split to 10 subimages before Bandwidth harmonics extracted at 128 pixels, using Radamatic 2.63 and Radamatic.

- In order to compare the processed results a 10 point moving average was produced for each parameter and plotted alongside each other. Minimum, Maximum, Mean, Range and Standard Deviation were also calculated from 200-500m removing noise from the dataset.

F-Gamma



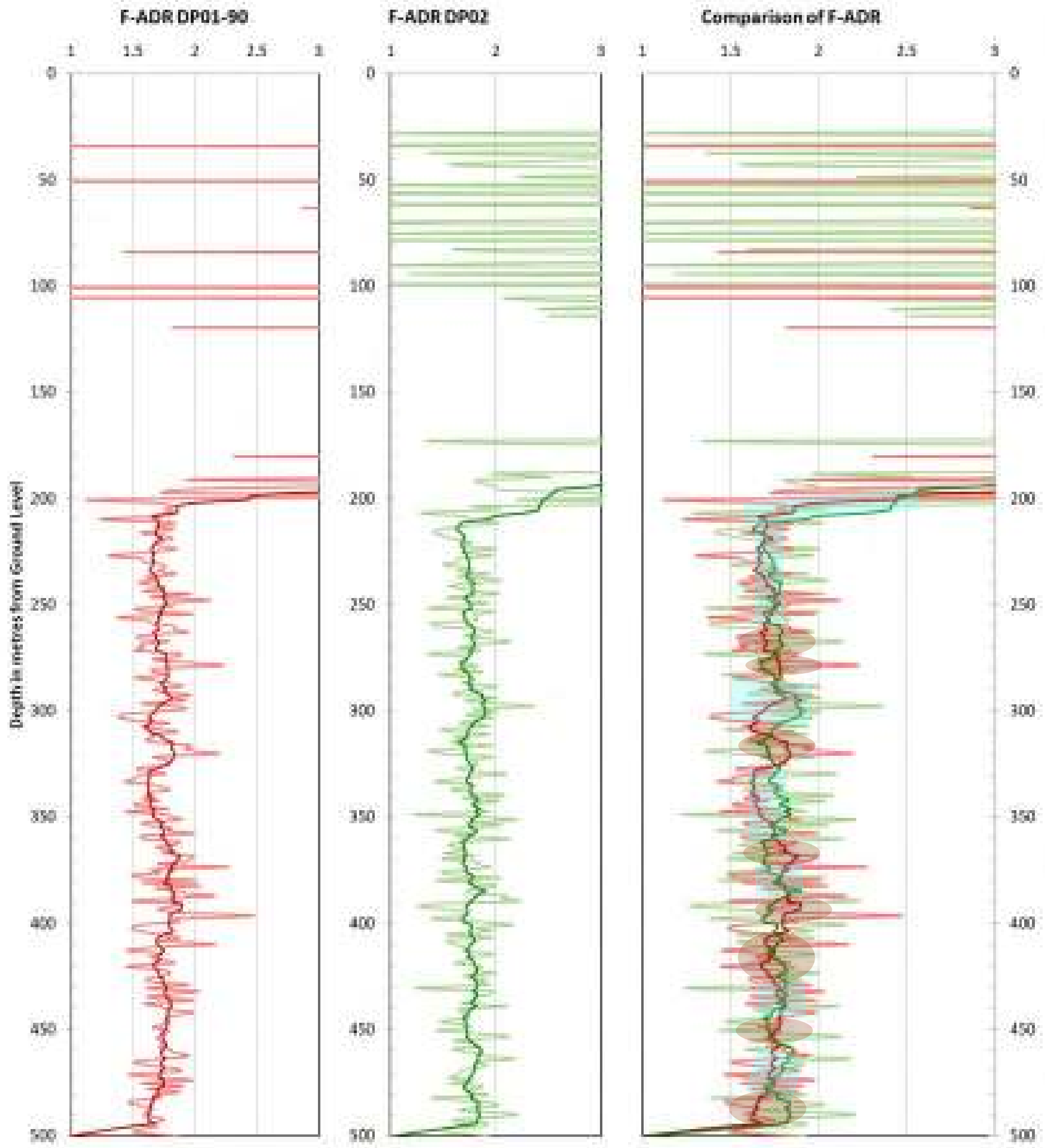
- There are differences in trends through most of the section between 200-500m and the only area where the trend similarity index is greater than 1 is between 350-450.
- Between 360-370m F-Gamma values are both close to 0.8 and show a slight negative trend. Between 380-420m, the trends are also closely matched, although values for DP02 drop more steeply to 0.75 compared to 0.82 for DP01-90.
- Statistically the results are similar except the minimum and standard deviation with the standard deviation values doubled to 0.36 from 0.18 in DP02 and the minimum values are 0.17 less in DP02 compared to DP01-90.

Similar
Different

Interval	Trend similarity
200-250m	1
250-300m	1
300-350m	1
350-400m	2
400-450m	2
450-500m	1

Statistics 200-500m	DP01-90	DP02
Mean	0.82	0.79
Max	0.88	0.89
Min	0.70	0.53
Standard Dev.	0.18	0.36
Range	0.03	0.04

F-ADR



- Between 200-250m the trend similarity index has a value of 3 although values for DP02 are higher than DP01-90 by approximately 0.1.
- A trend similarity index of 2 is seen between 300-350m again with values for DP02 greater by 0.1-0.2.
- Statistically there are differences, especially in the maximum where DP02 has a value greater by 1.45 than DP01-90 and the standard deviation DP02 has a value greater by 1.41 than DP01-90. For the remaining statistics the difference in value between DP01-90 and DP02 is less than 0.3.

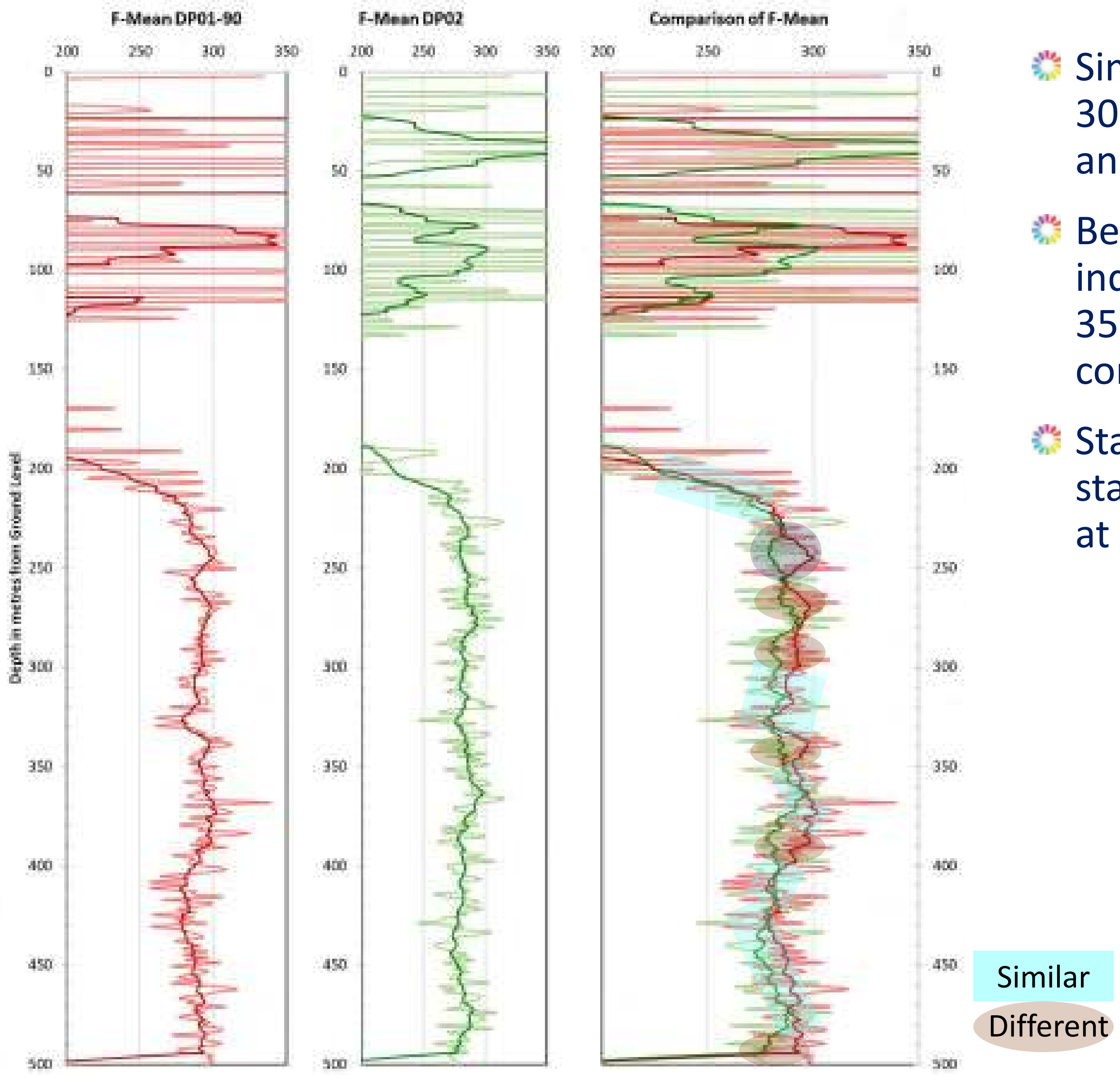
Similar

Different

Interval	Trend similarity
200-250m	3
250-300m	1
300-350m	2
350-400m	1
400-450m	1
450-500m	2

Statistics 200-500m	DP01-90	DP02
Mean	1.73	1.77
Max	2.48	3.93
Min	1.17	1.22
Standard Dev.	1.30	2.71
Range	0.18	0.26

F-Mean

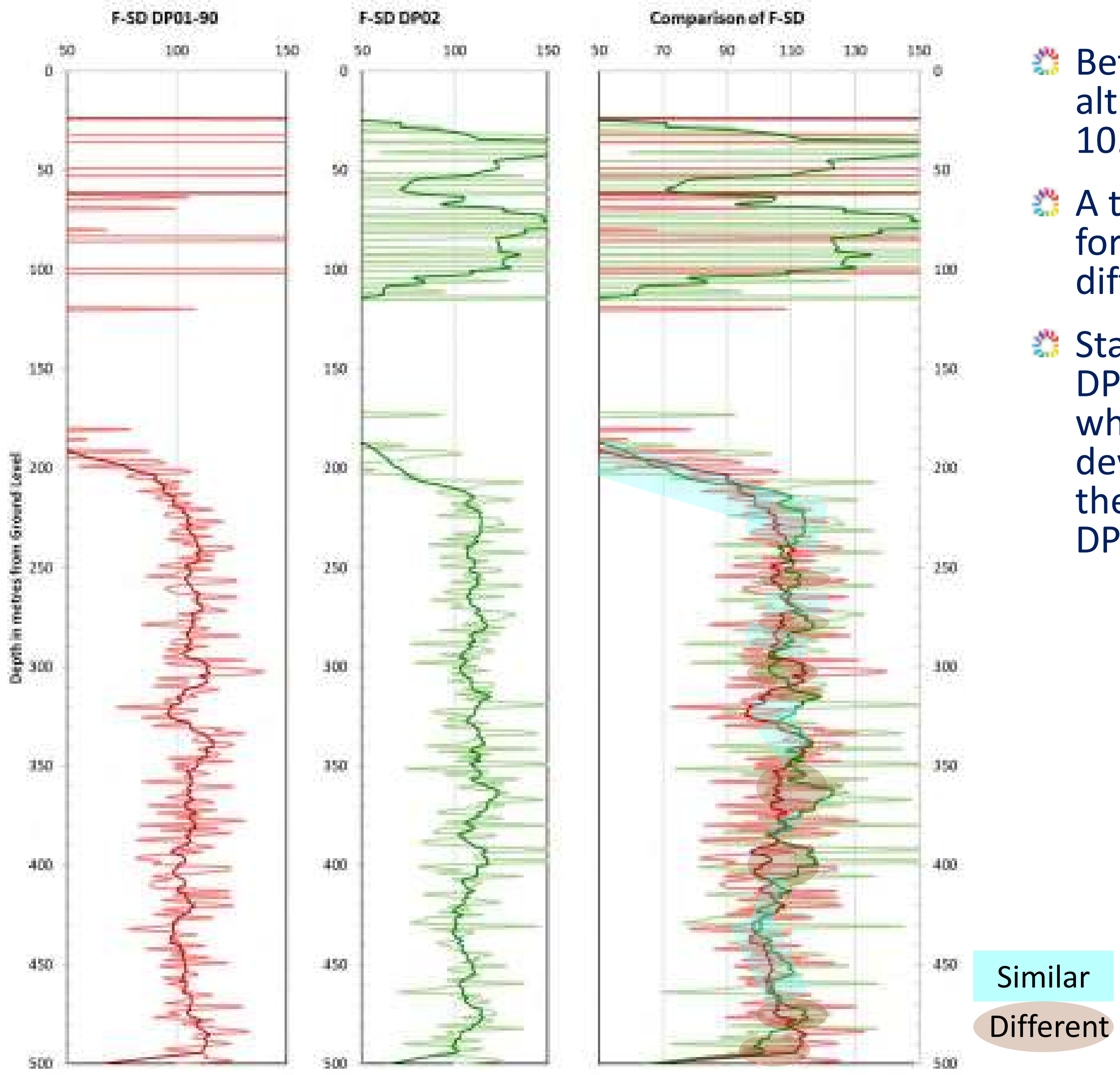


- Similar trends are seen from 200-220m but then between 220-300m, the trends are different with values decreasing for DP02 and increasing in DP01-90.
- Below 300m, the trends are more similar, and the trend similarity index increases from 1 to 2 The only exception is between 340-350m where values in DP01-90 increase by approximately 40 in contrast to an increase by 10 in DP02.
- Statistically the results are similar especially the mean, range and standard deviation. However, the maximum and minimum values at DP01-90 are both larger than at DP02 by 24.52 and 22.39.

Interval	Trend similarity
200-250m	1
250-300m	1
300-350m	1
350-400m	2
400-450m	2
450-500m	2

Statistics 200-500m	DP01-90	DP02
Mean	288.72	281.32
Max	339.07	314.55
Min	215.59	193.32
Standard Dev.	123.48	121.24
Range	15.28	16.20

F-SD

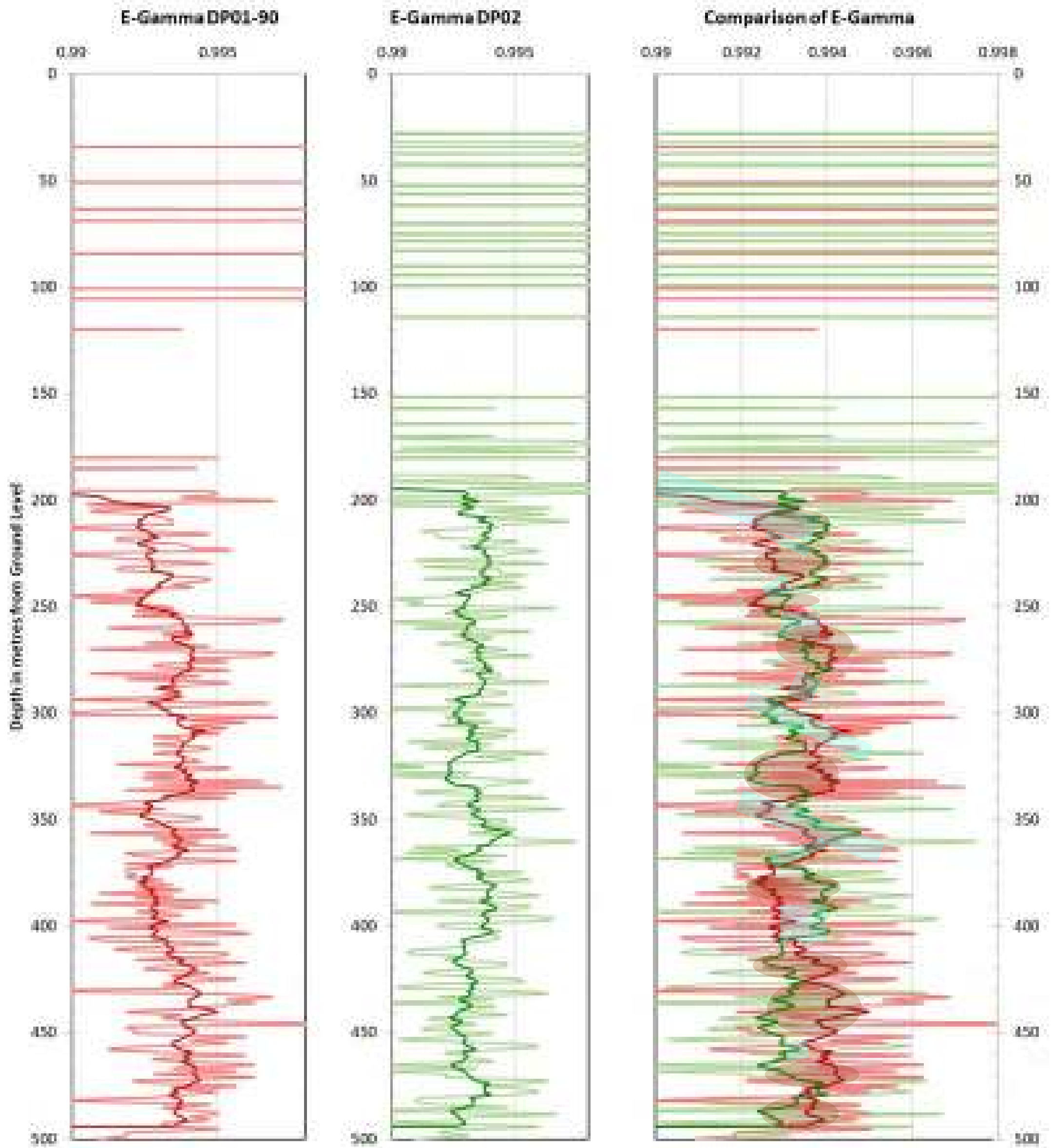


- Between 200-250m the trend similarity index has a value of 3 although values for DP02 are higher than DP01-90 by approximately 10.
- A trend similarity index of 2 is seen between 300-350m with values for DP02 greater by as much as 40. Between 400-450 this drops to a difference of 10 again DP02 has the greater values.
- Statistically there are differences, especially in the maximum where DP02 has a value greater by 31.23 than DP01-90, the minimum where DP01-90 has a greater value by 29.98 and the standard deviation where DP02 has a value greater by 61.21 than DP01-90. For the remaining statistics the difference in value between DP01-90 and DP02 is less than 5.5.

Interval	Trend similarity
200-250m	3
250-300m	1
300-350m	2
350-400m	1
400-450m	2
450-500m	1

Statistics 200-500m	DP01-90	DP02
Mean	105.46	108.68
Max	139.33	170.56
Min	72.85	42.87
Standard Dev.	66.48	127.69
Range	12.45	17.99

E-Gamma



Similar

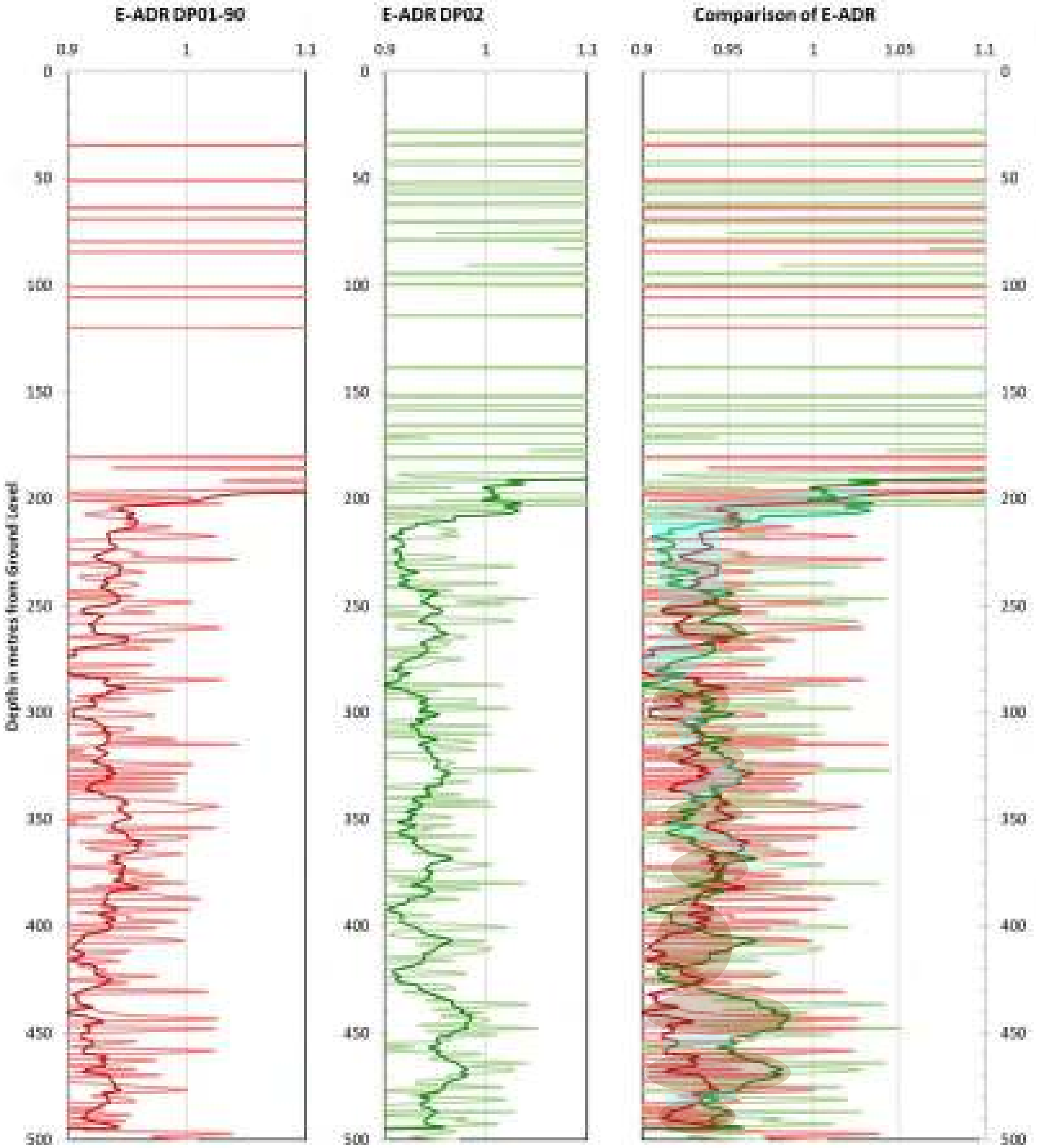
Different

- Similar trends are seen from 240-260m, with the range of values larger for DP01-90 by 0.002.
- 370-400m shows high trend similarity although the values for DP02 are greater by 0.003
- Statistically the results are similar. The maximum values from both visits is 1 and the difference in both minimum values and standard deviation values between both visits is 0.06. The largest different in values is the range. DP01-90 values are 0.15 greater than DP02.

Interval	Trend similarity
200-250m	2
250-300m	1
300-350m	1
350-400m	2
400-450m	1
450-500m	1

Statistics 200-500m	DP01-90	DP02
Mean	0.78	0.91
Max	1.00	1.00
Min	0.02	0.08
Standard Dev.	0.98	0.92
Range	0.35	0.20

E-ADR



- The interval between 200-250m has a trend similarity index of 3 with values for DP01-90 greater than DP02 by 0.3-0.4.
- Below 250m the only interval with a trend similarity index greater than 1 is 300-350m where values for DP02 are greater than DP01-90 by 0.25.
- The statistics show high similarity. The range for both DP01-90 and DP02 has an identical value of 0.06 and for the mean and minimum values DP02 has a greater but by no more than 0.05. The biggest difference in the statistics is the minimum which is 0.29 high in DP02 than DP01-90.

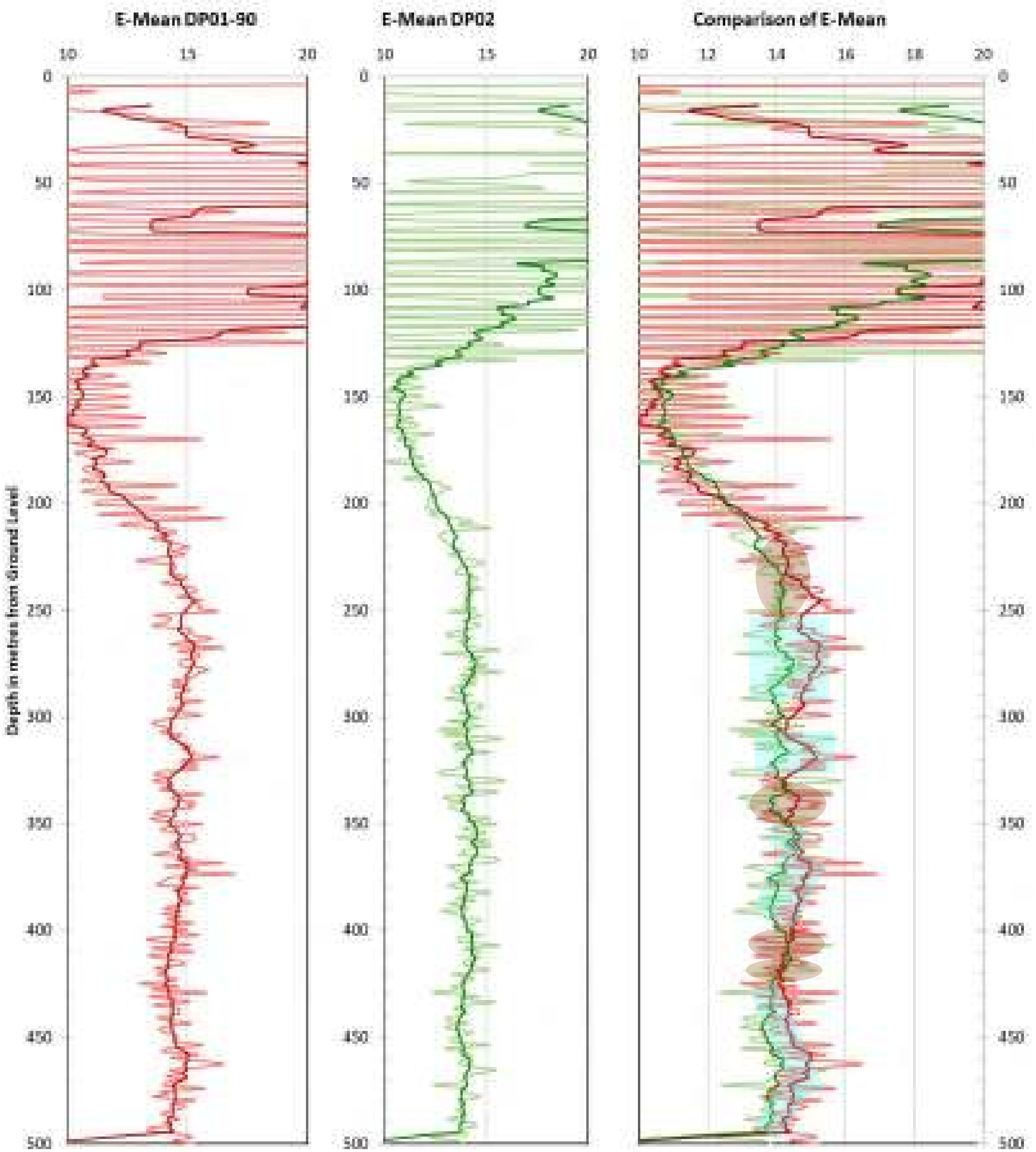
Similar

Different

Interval	Trend similarity
200-250m	3
250-300m	1
300-350m	2
350-400m	1
400-450m	1
450-500m	1

Statistics 200-500m	DP01-90	DP02
Mean	0.93	0.94
Max	1.04	1.33
Min	0.75	0.80
Standard Dev.	0.29	0.53
Range	0.06	0.06

E-Mean



- Between 250-350m the trend similarity index is 3. DP01-90 values are greater than DP02 values by approximately 1.
- A trend similarity index value of 3 is also seen at 350-400m. The values are greater for DP01-90 than DP02 by approximately 1.5. This is also true between 450-500m.
- Statistically the results are similar. The difference in the mean, minimum and range values are all less than 1. With the exception of the minimum value DP01-90 values are the highest.

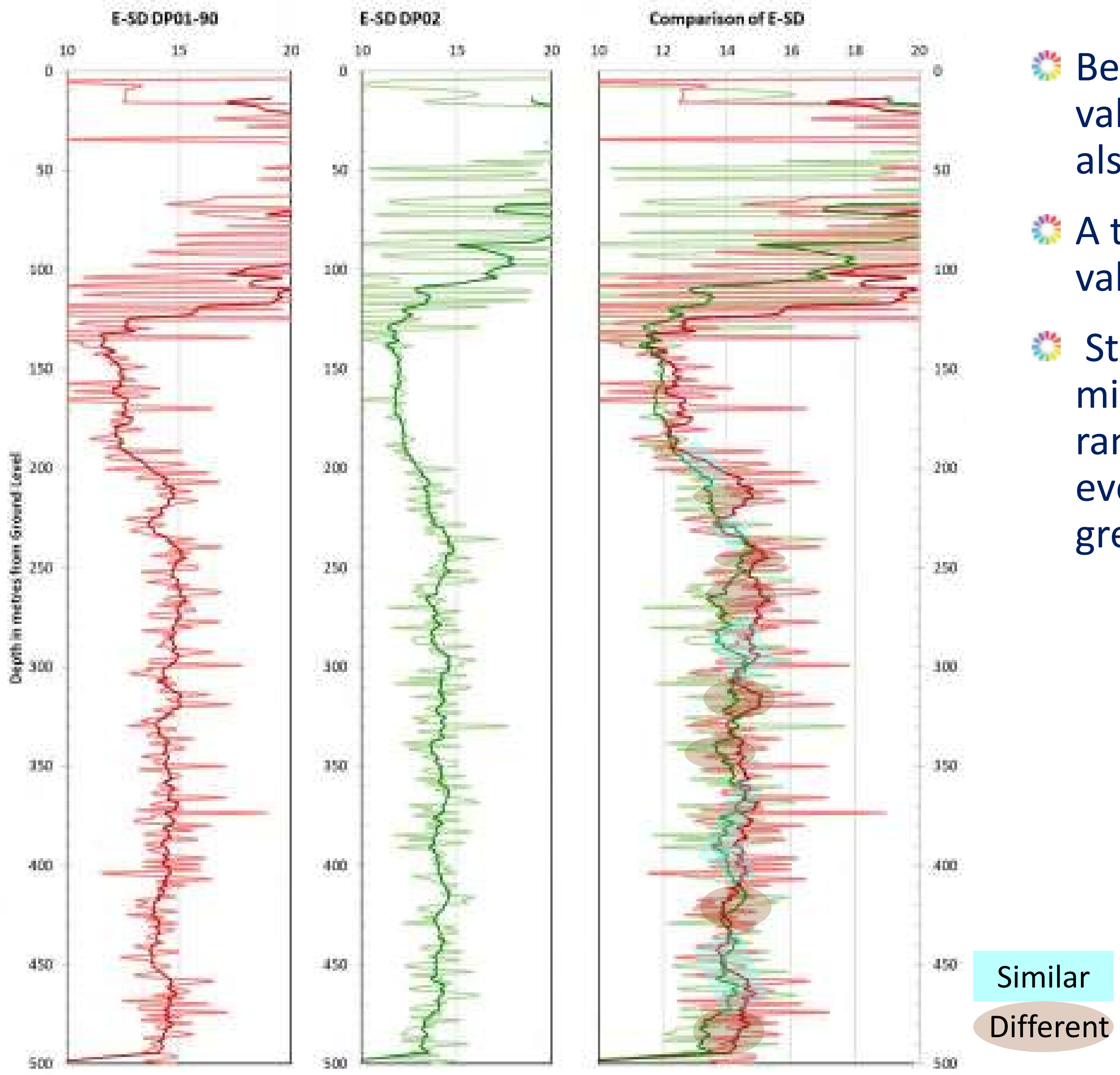
Similar

Different

Interval	Trend similarity
200-250m	1
250-300m	3
300-350m	2
350-400m	3
400-450m	2
450-500m	3

Statistics 200-500m	DP01-90	DP02
Mean	14.54	13.98
Max	16.94	15.91
Min	11.15	12.01
Standard Dev.	5.79	3.90
Range	0.81	0.75

E-SD

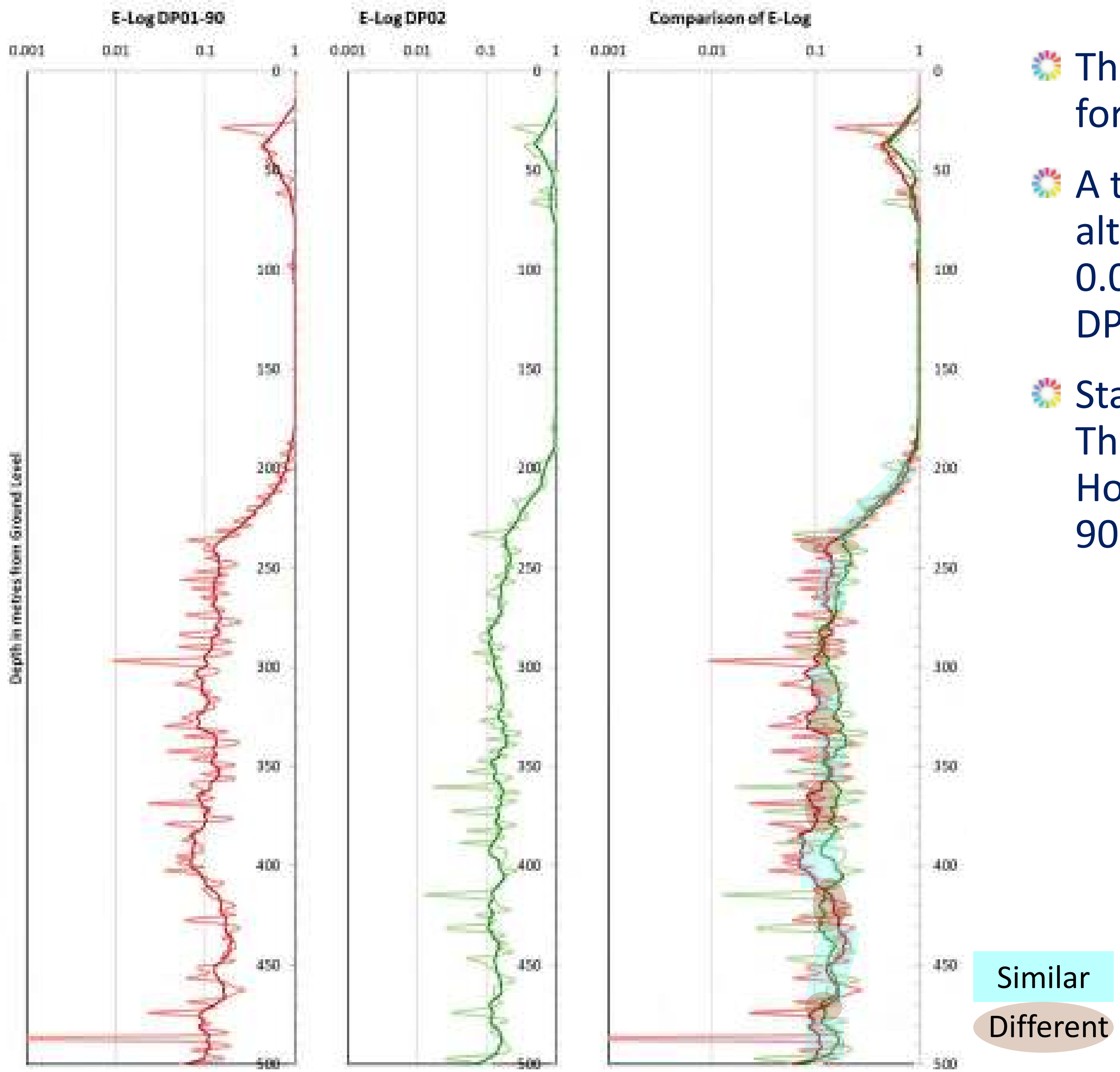


- Between 200-250m the trend similarity index is 2. DP01-90 values are greater than DP02 values by a maximum of 2. This is also true of the 250-300m interval.
- A trend similarity index value of 3 is also seen at 400-450m. The values are greater for DP02 than DP01-90 by approximately 0.25.
- Statistically the results are similar. The difference in the mean, minimum and standard deviation values are all less than 1. The range value of 1.10 is identical for both DP01-90 and DP02. For every statistic apart from the range values for DP01-90 are greater than DP02.

Interval	Trend similarity
200-250m	2
250-300m	2
300-350m	1
350-400m	2
400-450m	3
450-500m	1

Statistics 200-500m	DP01-90	DP02
Mean	14.47	14.00
Max	18.94	17.61
Min	11.58	11.04
Standard Dev.	7.36	6.56
Range	1.10	1.10

E-log

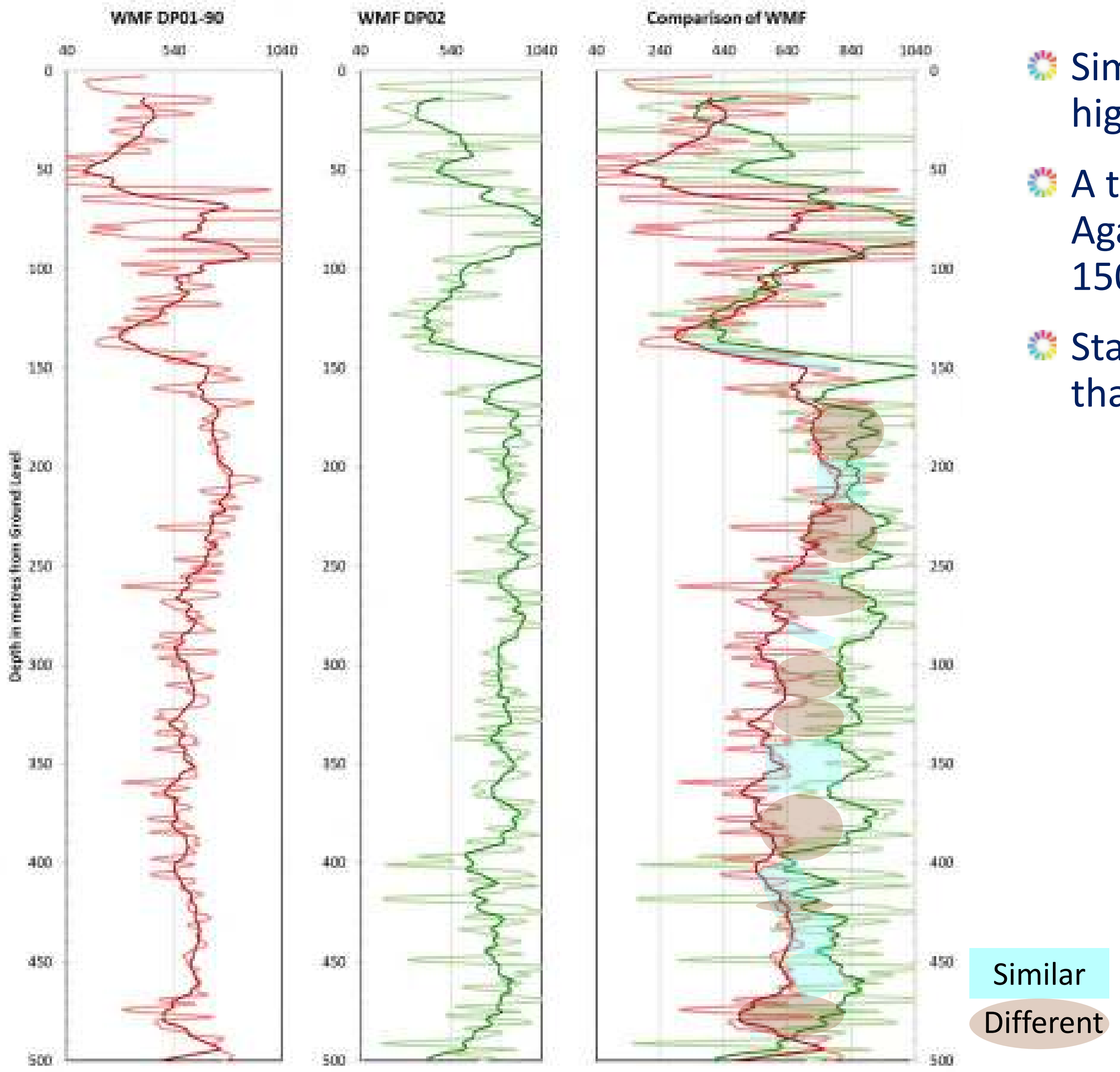


- The trend similarity index of 2 occurs between 200-300m. Values for DP02 are greater by approximately 0.01
- A trend similarity index of 2 is also seen between 400-500m although initially the values for DP01-90 are higher than DP02 by 0.05. However below 460m the values for DP02 are higher than DP01-90 by 0.06
- Statistically the results are similar especially the mean and range. The minimum values are 0.00 for both DP01-90 and DP02 However, the maximum and standard deviation values at DP01-90 are both larger than at DP02 by 0.16.

Interval	Trend similarity
200-250m	2
250-300m	2
300-350m	1
350-400m	1
400-450m	2
450-500m	2

Statistics 200-500m	DP01-90	DP02
Mean	0.15	0.18
Max	0.91	0.75
Min	0.00	0.00
Standard Dev.	0.91	0.75
Range	0.13	0.12

WMF

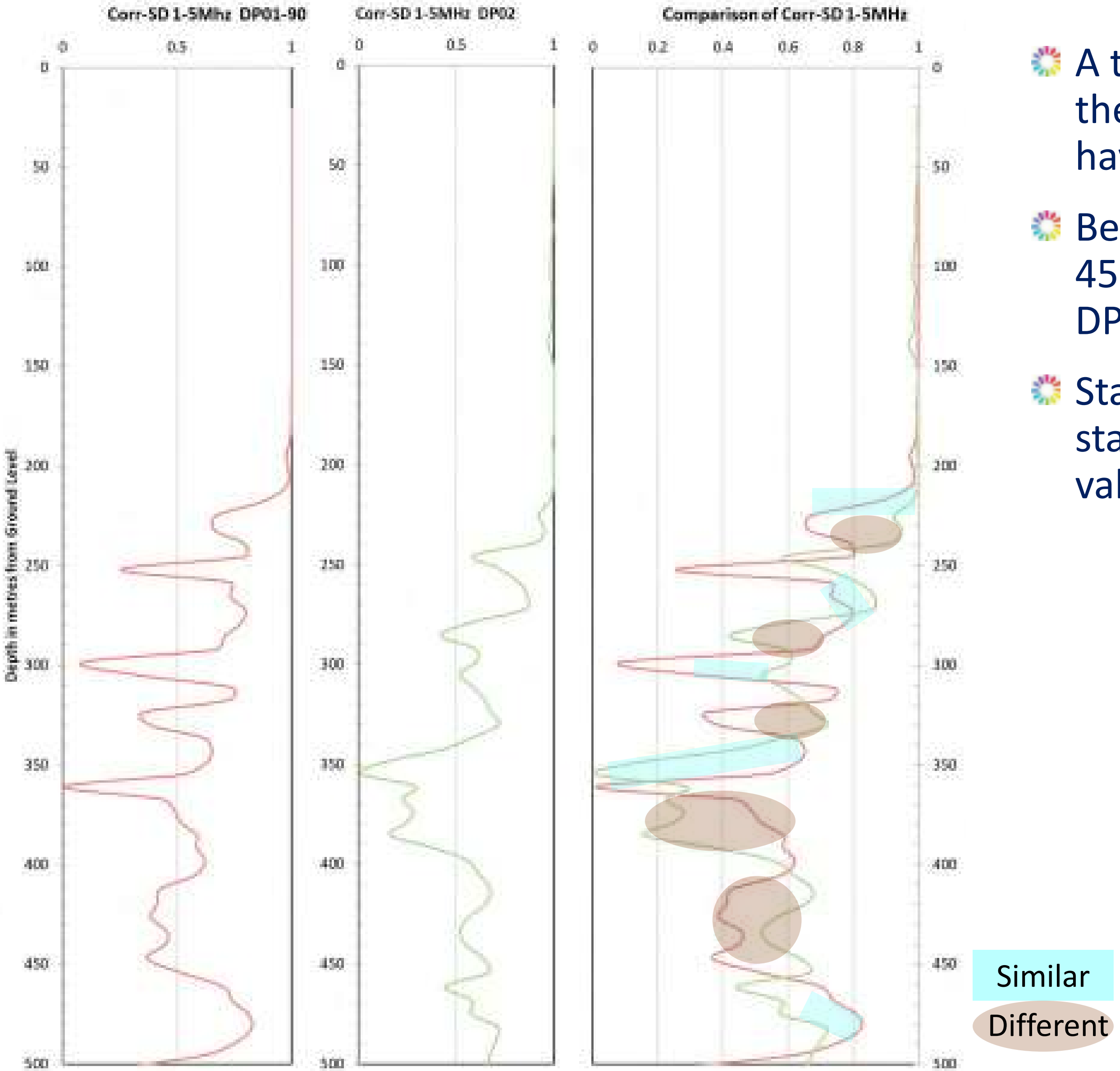


- Similar trends are seen from 250-300m but DP02 values are higher than DP01-90 by approximately 120.
- A trend similarity index of 2 is also seen between 400-450m. Again the DP02 values are higher than DP01-90 by approximately 150
- Statistically only the range show a difference in values of less than 100 and DP02 values are higher than DP01-90 by 61.82.

Interval	Trend similarity
200-250m	1
250-300m	2
300-350m	1
350-400m	1
400-450m	2
450-500m	1

Statistics 200-500m	DP01-90	DP02
Mean	618.80	815.18
Max	937.10	1162.48
Min	297.84	152.22
Standard Dev.	639.26	1010.26
Range	110.75	172.57

Corr-SD 1-5MHz

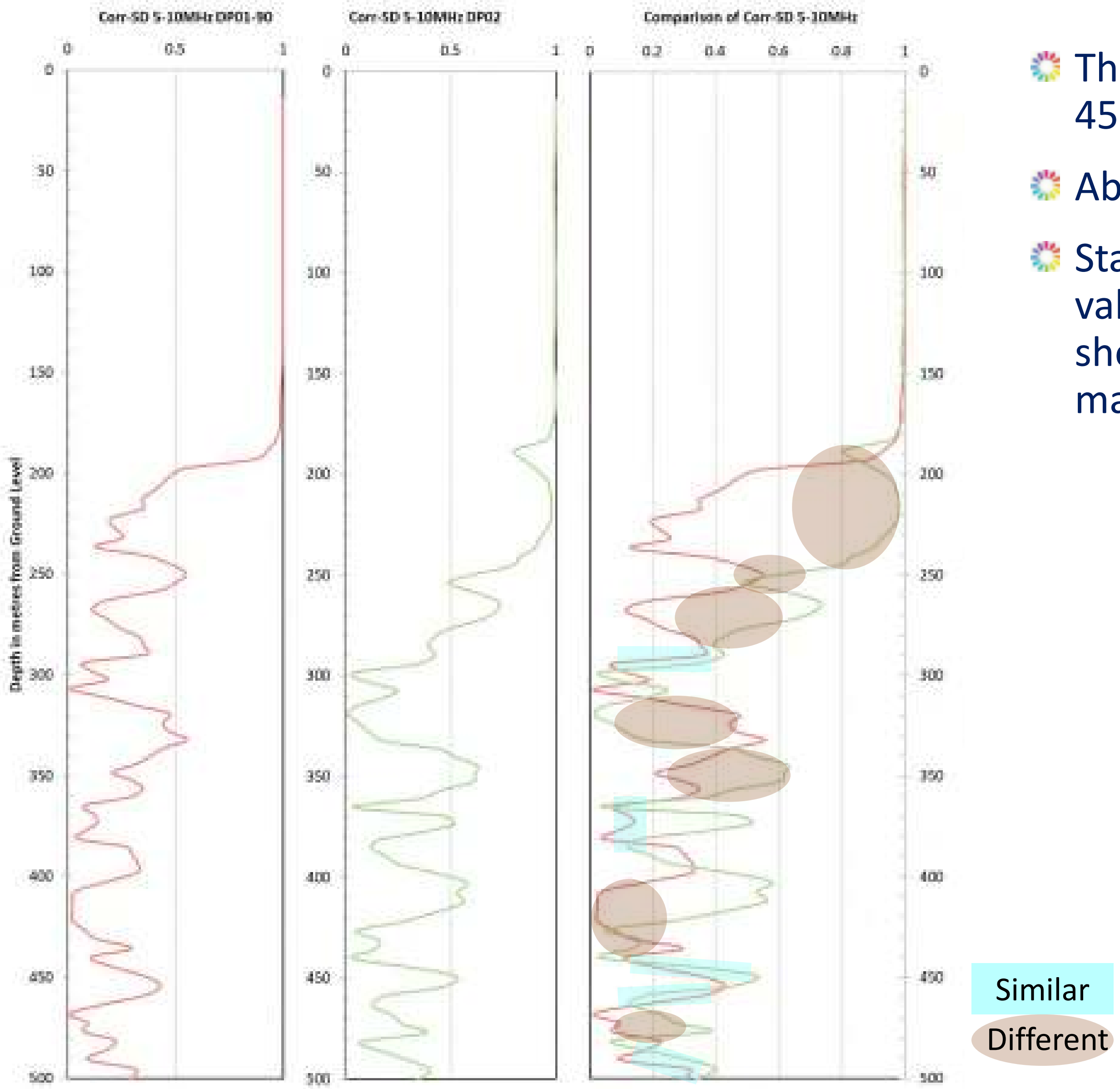


- A trend similarity index of 2 is present from 200-350m, although there are different occasions when either DP01-90 and DP02 have the highest values.
- Below 350m, a trend similarity index of 2 is also seen between 450-500m. This the time the values for DP01-90 are greater than DP02 by 0.15
- Statistically all the results are similar. The largest difference in statistics is 0.05 seen in the minimum value. DP02 minimum values are greater than DP01-90.

Interval	Trend similarity
200-250m	2
250-300m	2
300-350m	2
350-400m	1
400-450m	1
450-500m	2

Statistics 200-500m	DP01-90	DP02
Mean	0.36	0.39
Max	0.98	1.00
Min	-0.38	-0.33
Standard Dev.	1.35	1.32
Range	0.30	0.32

Corr-SD 5-10MHz

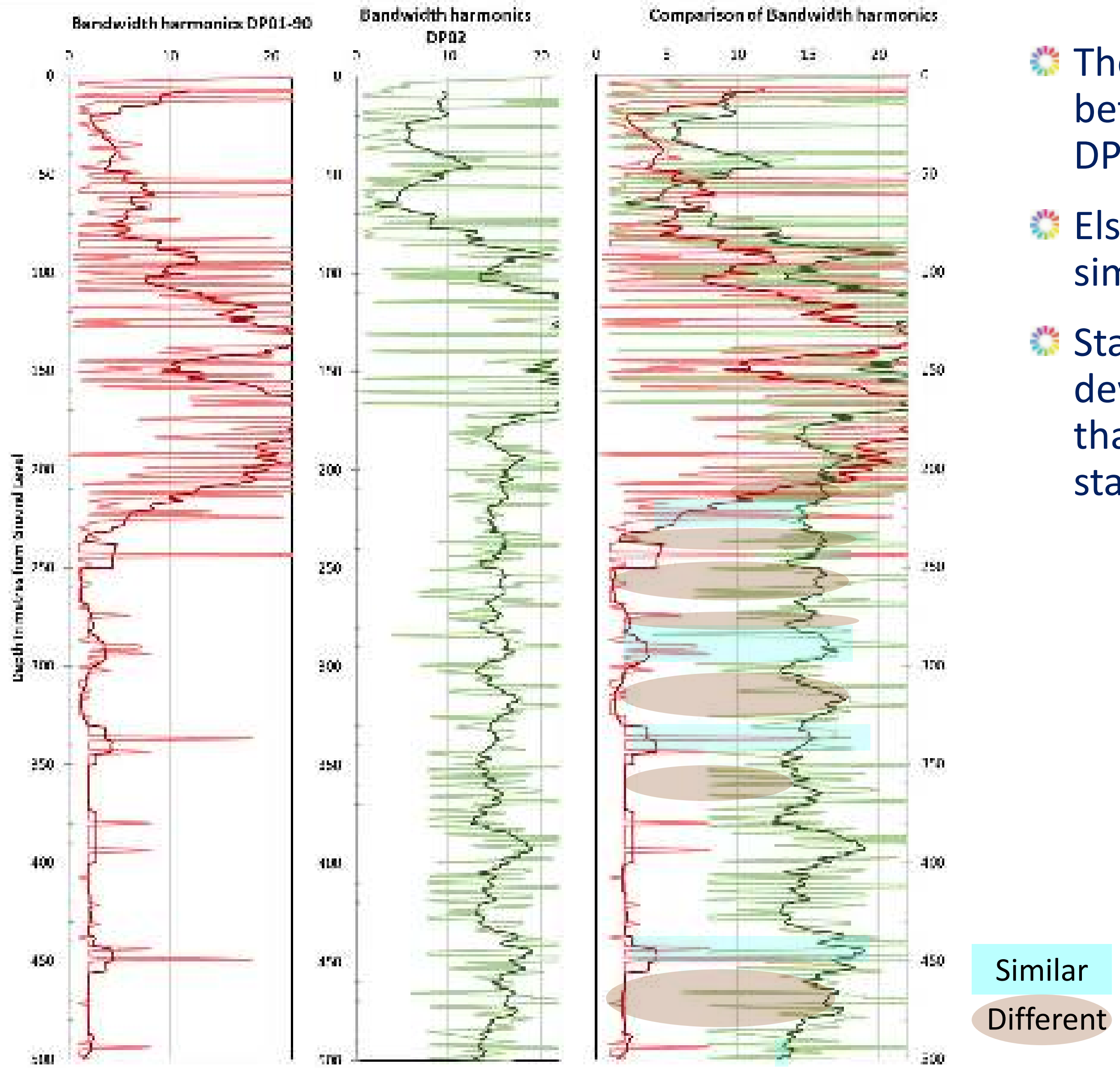


- The only interval with a trend similarity index of 2 is between 450-500m with values for DP02 higher than DP01-90 by 0.01.
- Above 450m the trend similarity index never exceeds 1.
- Statistically the minimum values are very similar with DP01-90 values greater than 0.02 than DP02. The rest of the statistics show some more differences by as much as 0.67 for the maximum values.

Interval	Trend similarity
200-250m	0
250-300m	1
300-350m	1
350-400m	1
400-450m	1
450-500m	2

Statistics 200-500m	DP01-90	DP02
Mean	-0.11	0.11
Max	0.30	0.97
Min	-0.38	-0.40
Standard Dev.	0.68	1.37
Range	0.17	0.40

Bandwidth Harmonics

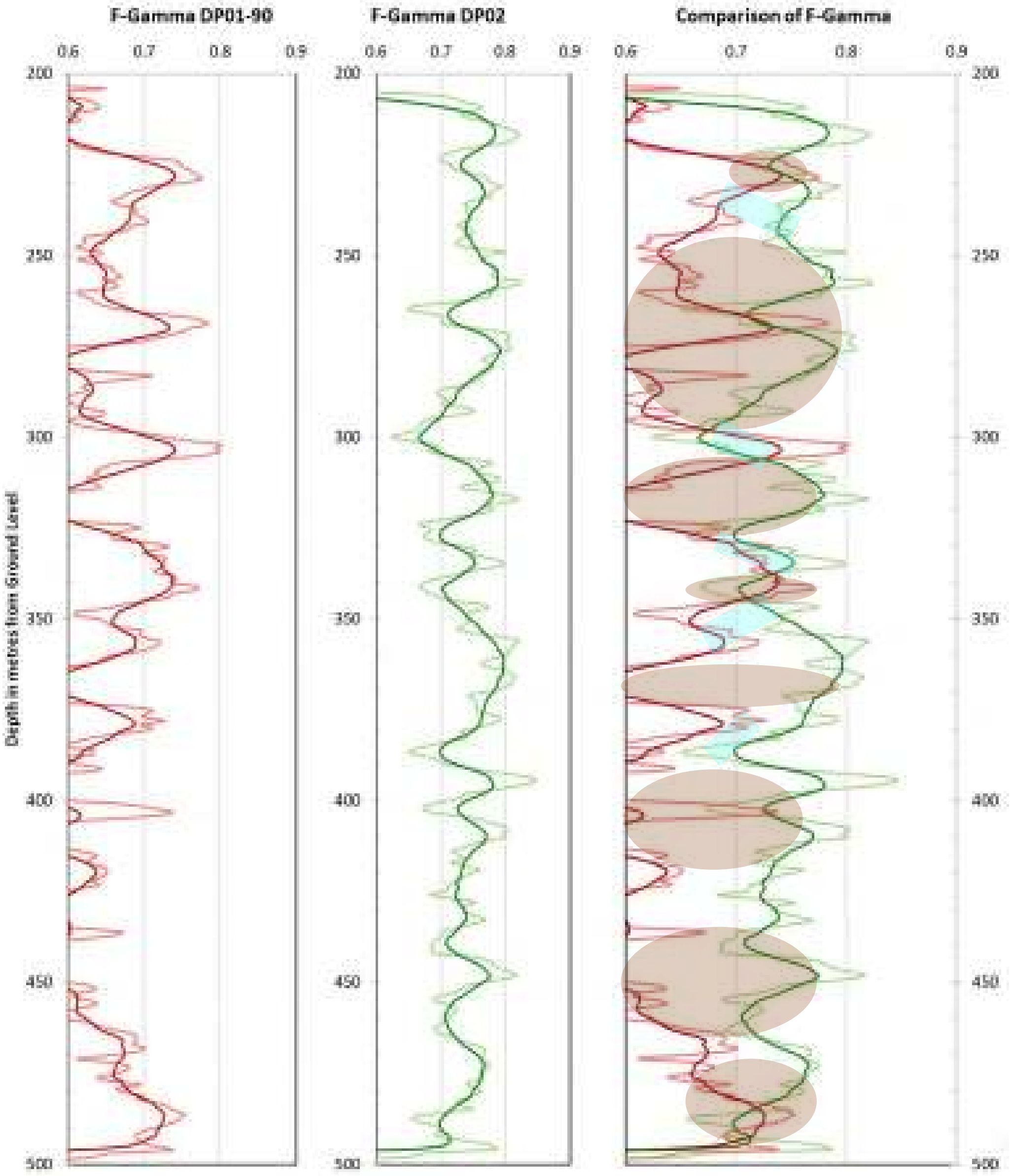


- The only interval with a trend similarity index greater than 1 is between 350-400m and even in this interval values for DP02 than DP01-90 are greater by approximately 11.
- Elsewhere the similarity index remains at 1 indicating little similarity in the down hole patterns in DP01-90 and DP02.
- Statistically the results show some similarity. The standard deviation values are identical and the DP02 values are greater than DP01-90 for every other statistic. However for every statistics apart from the mean, the difference is less than 3.

Interval	Trend similarity
200-250m	1
250-300m	1
300-350m	1
350-400m	2
400-450m	1
450-500m	1

Statistics 200-500m	DP01-90	DP02
Mean	3.18	15.15
Max	32.00	35.00
Min	1.00	4.00
Standard Dev.	31.00	31.00
Range	4.79	5.08

F-Gamma Lithmetric



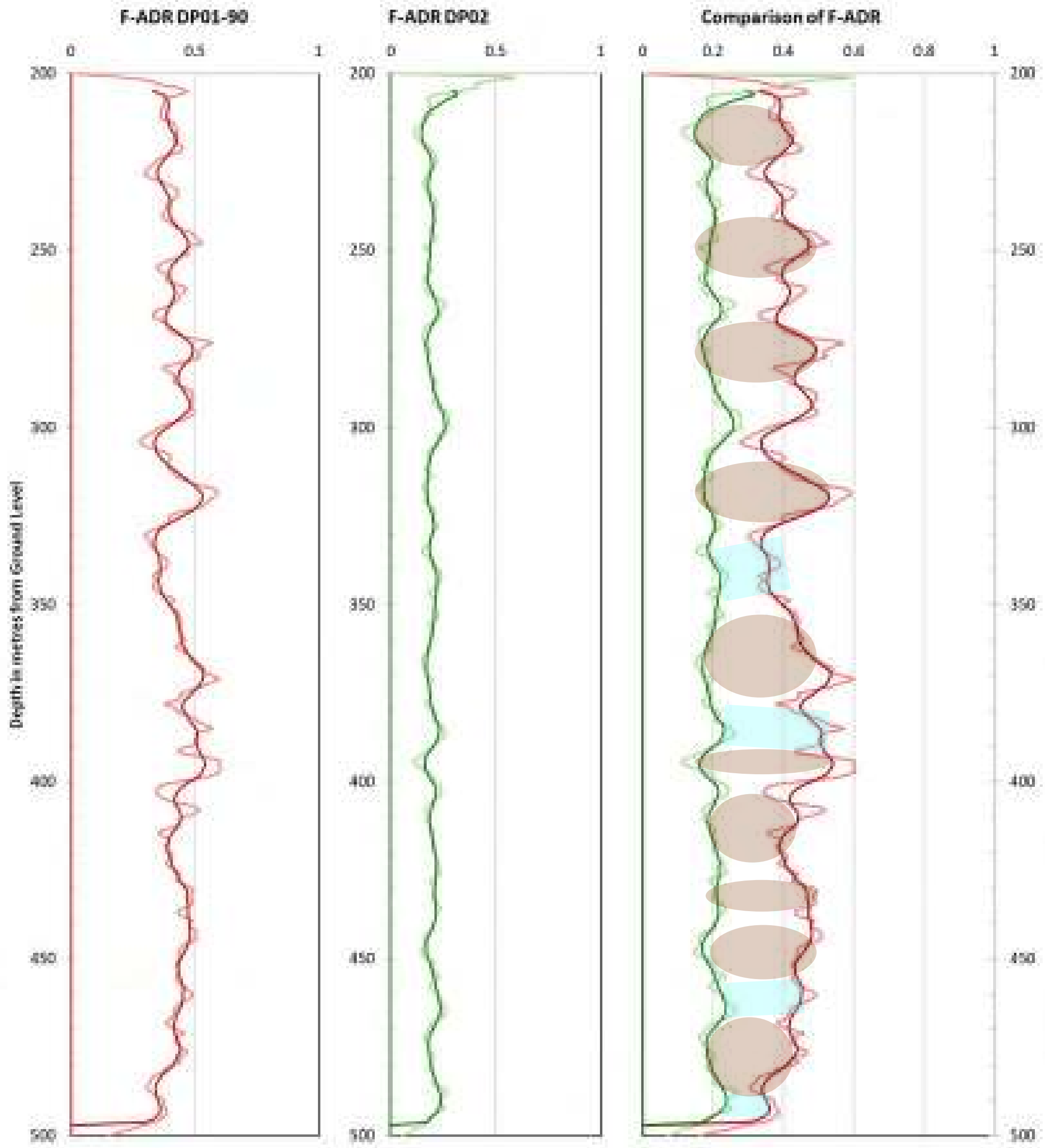
- The trend similarity index has a value of 2 between 200-250m. Values are greater in DP02 than DP01-90 by approximately 0.18
- A trend similarity index of 2 is also seen between 300-350m. The values for DP02 are greater than DP01-90 by 0.1
- Statistically the results are similar. The minimum and range values are identical, while the standard deviation and maximum values are 0.05 greater for DP02 than DP01-90.

Interval	Trend similarity
200-250m	2
250-300m	1
300-350m	2
350-400m	1
400-450m	1
450-500m	1

Similar
Different

Statistics 200-500m	DP01-90	DP02
Mean	0.64	0.73
Max	0.80	0.85
Min	0.00	0.00
Standard Dev.	0.80	0.85
Range	0.09	0.09

F-ADR Lithmetric



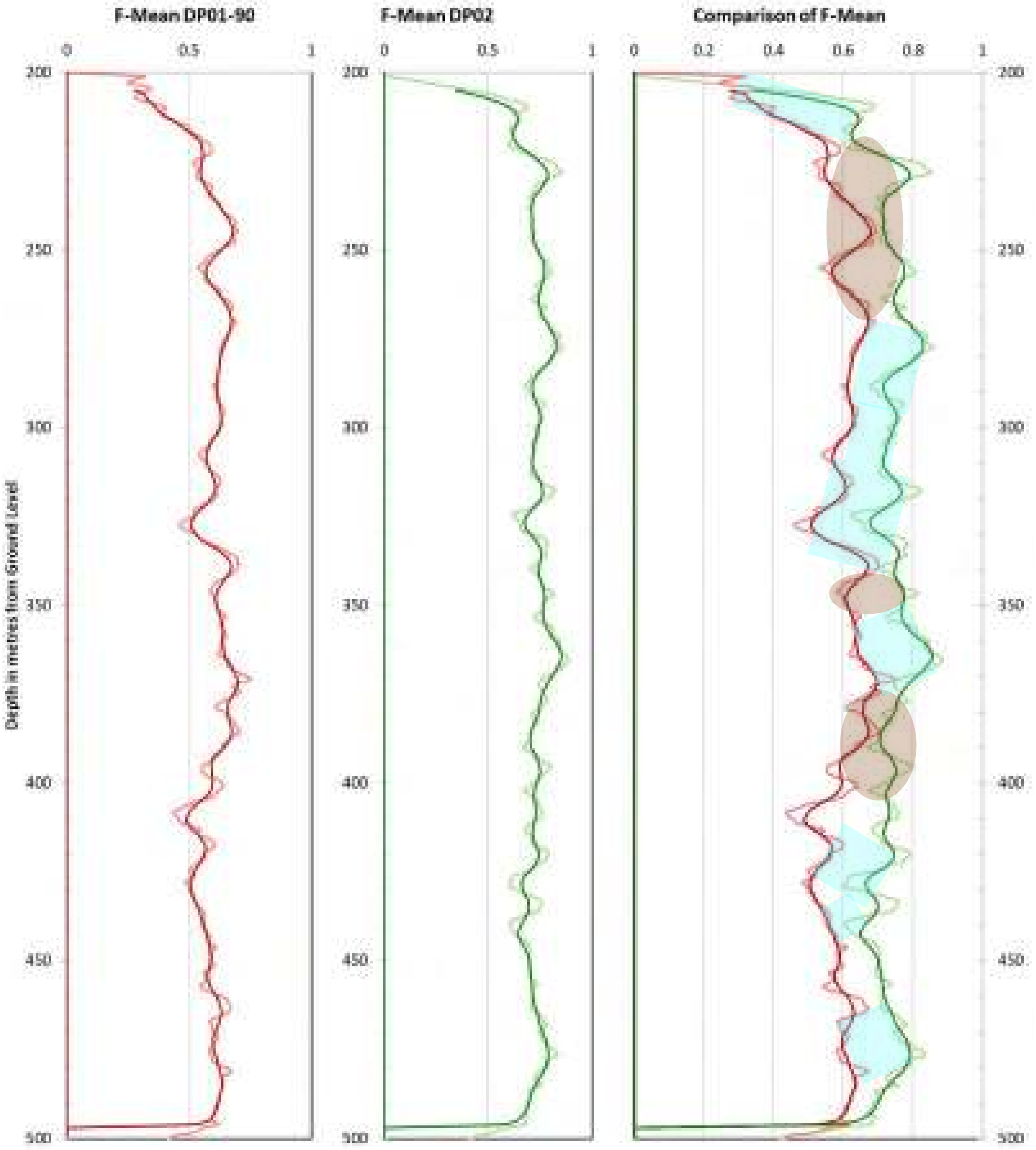
Similar
Different

- The trend similarity index never exceeds 1 down V-bore.
- Values for DP01-90 are consistently higher than DP02 by at least 0.2.
- Statistically there are some similarities. The minimum values are identical for DP01-90 and DP02. The maximum and standard deviation values are 0.02 higher DP01-90 than DP02 and the range values are 0.03 higher in DP01-90 than DP02.

Interval	Trend similarity
200-250m	1
250-300m	1
300-350m	1
350-400m	1
400-450m	1
450-500m	1

Statistics 200-500m	DP01-90	DP02
Mean	0.42	0.20
Max	0.60	0.58
Min	0.00	0.00
Standard Dev.	0.60	0.58
Range	0.08	0.05

F-Mean Lithmetric



- A trend similarity index of 2 is seen between 250-300m. DP02 values are greater than DP01-90 by approximately 0.2
- Below 400m a trend similarity index of 2 is also seen. Again DP02 values are greater than DP01-90 by approximately 0.2
- Statistically the results are similar. The minimum value is identical and the range value for DP02 is only 0.02 greater than for DP01-90. Larger discrepancies are seen in the mean, maximum and standard deviation. Again DP02 values are larger than DP01-90.

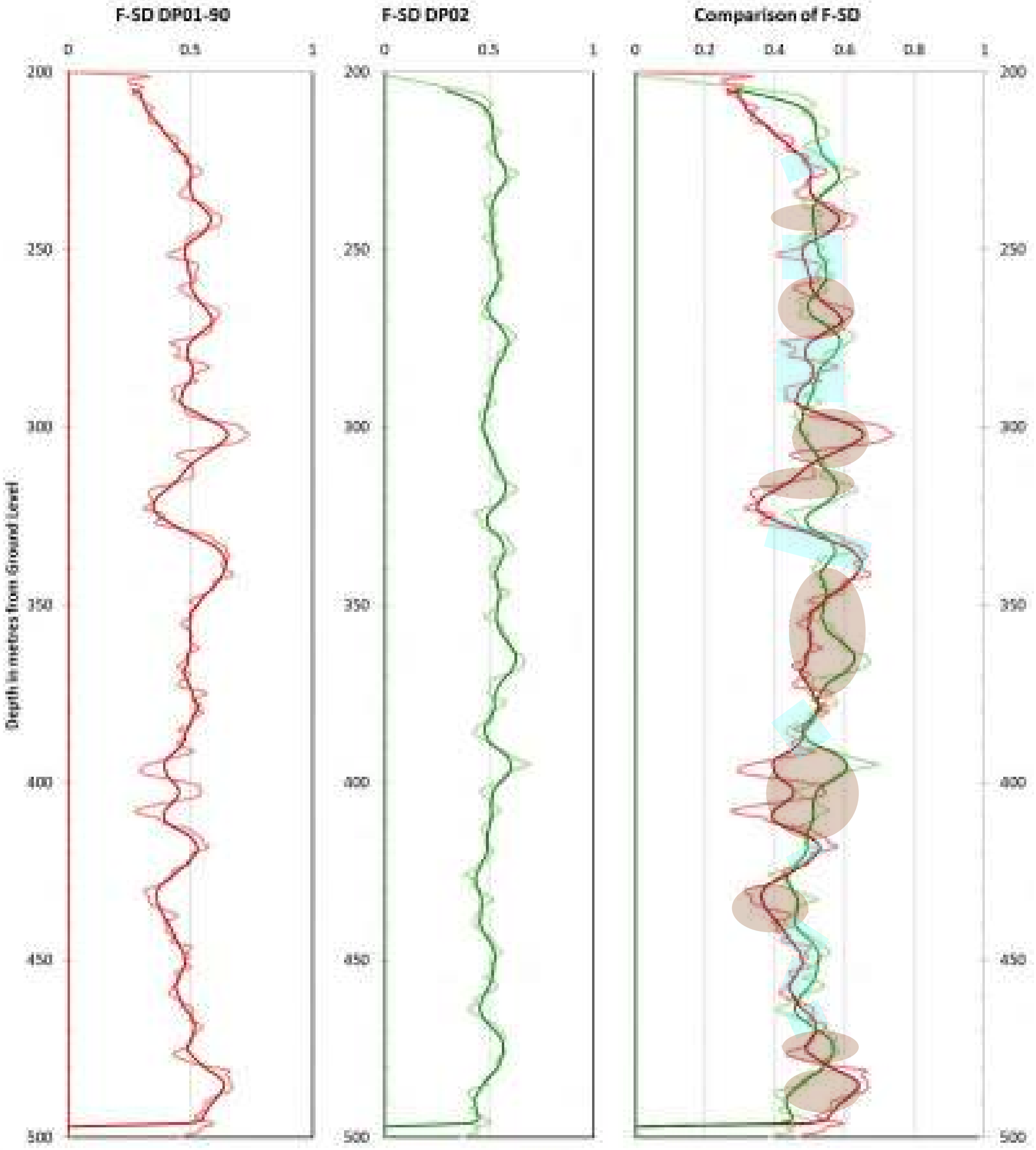
Similar

Different

Interval	Trend similarity
200-250m	1
250-300m	2
300-350m	1
350-400m	1
400-450m	2
450-500m	2

Statistics 200-500m	DP01-90	DP02
Mean	0.59	0.72
Max	0.75	0.89
Min	0.00	0.00
Standard Dev.	0.75	0.89
Range	0.09	0.11

F-SD Lithmetric



Similar

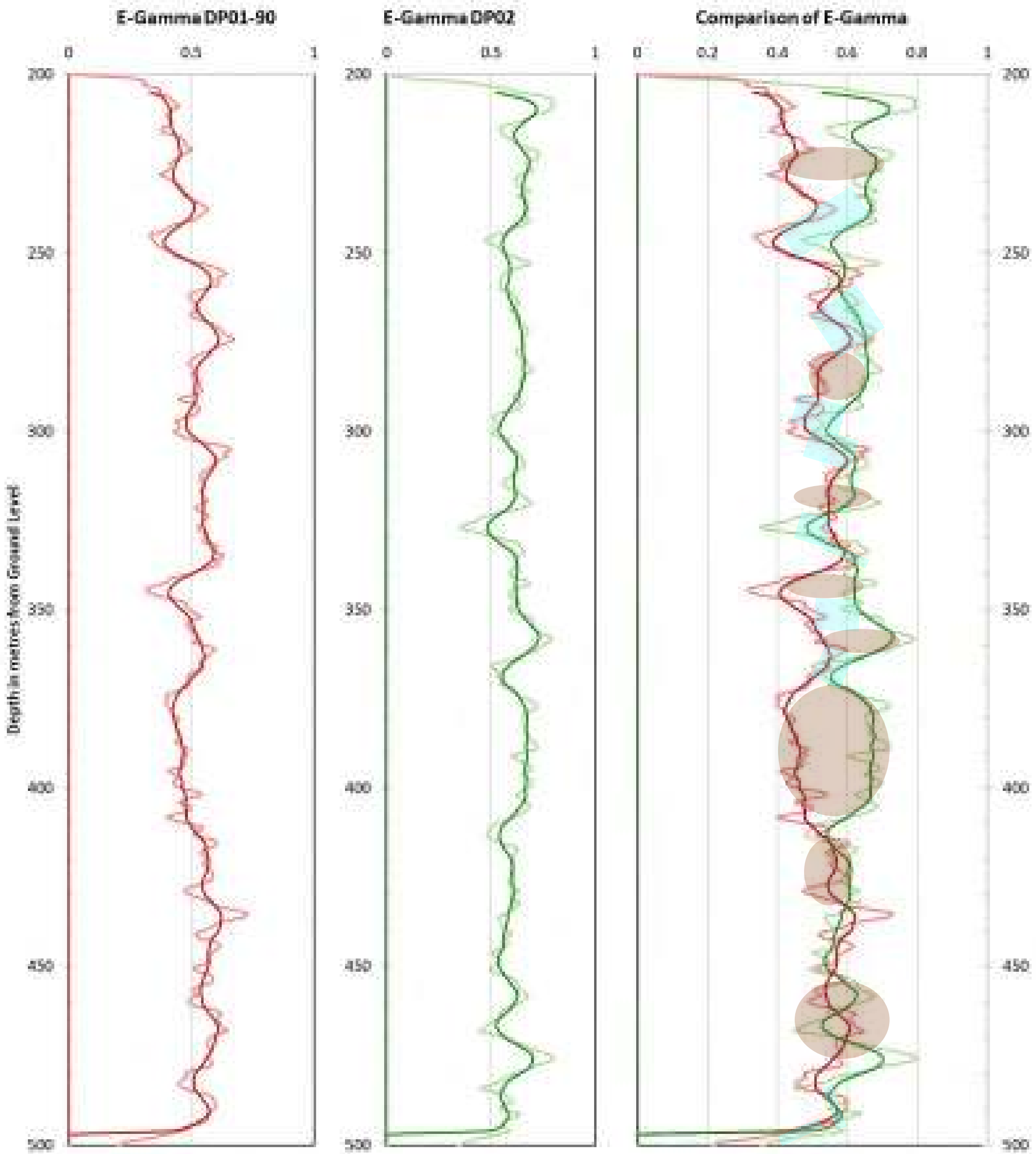
Different

- Between 200-300m the trend similarity index is 2. DP02 values are greater than DP01-90 by as high as 0.2 but is as low as 0.05 at 250m.
- Below 300m the trend similarity index never exceeds 1.
- The statistics are similar. The minimum levels are identical. Maximum values and standard deviation values at DP01-90 are greater by 0.04 than DP02. The range values for DP01-90 are greater by 0.02 than DP02.

Interval	Trend similarity
200-250m	2
250-300m	2
300-350m	1
350-400m	1
400-450m	1
450-500m	1

Statistics 200-500m	DP01-90	DP02
Mean	0.48	0.51
Max	0.74	0.70
Min	0.00	0.00
Standard Dev.	0.74	0.70
Range	0.10	0.08

E-Gamma Lithmetric

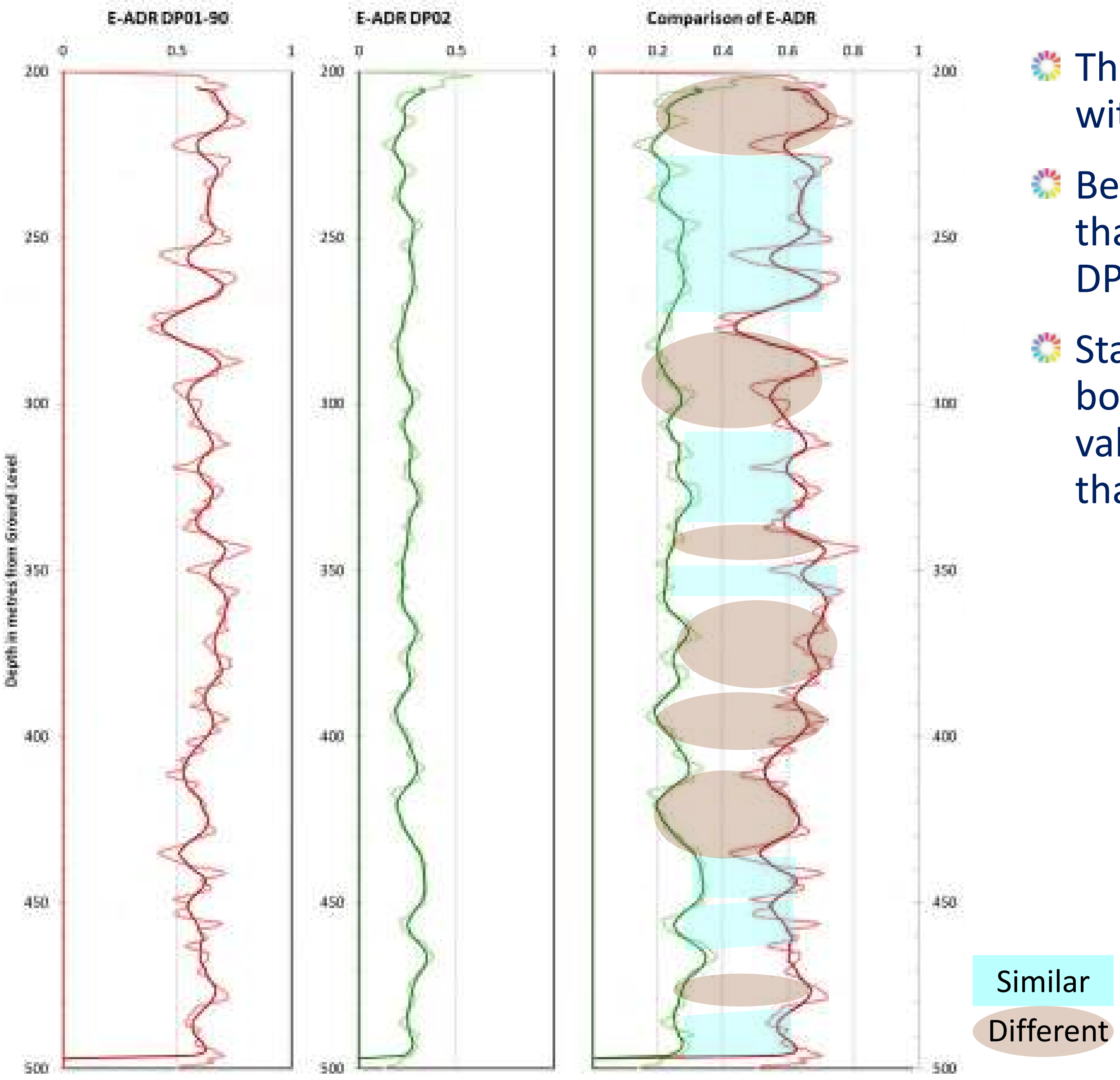


- A trend similarity index of 2 is seen between 200-250m. DP02 values are approximately 0.2 greater than in DP01-90.
- Below 250m the trend similarity index remains at 1. Generally DP02 values are greater than DP01-90, although the difference in values between 420-450m is almost 0.
- Statistically the results are similar. The minimum values from both visits is 0 and the difference in both maximum values and standard deviation values between both visits is 0.07. The difference in mean values is greater in DP02 by DP01-90 than 0.1.

Interval	Trend similarity
200-250m	2
250-300m	1
300-350m	1
350-400m	1
400-450m	1
450-500m	1

Statistics 200-500m	DP01-90	DP02
Mean	0.51	0.61
Max	0.73	0.80
Min	0.00	0.00
Standard Dev.	0.73	0.80
Range	0.09	0.10

E-ADR Lithmetric

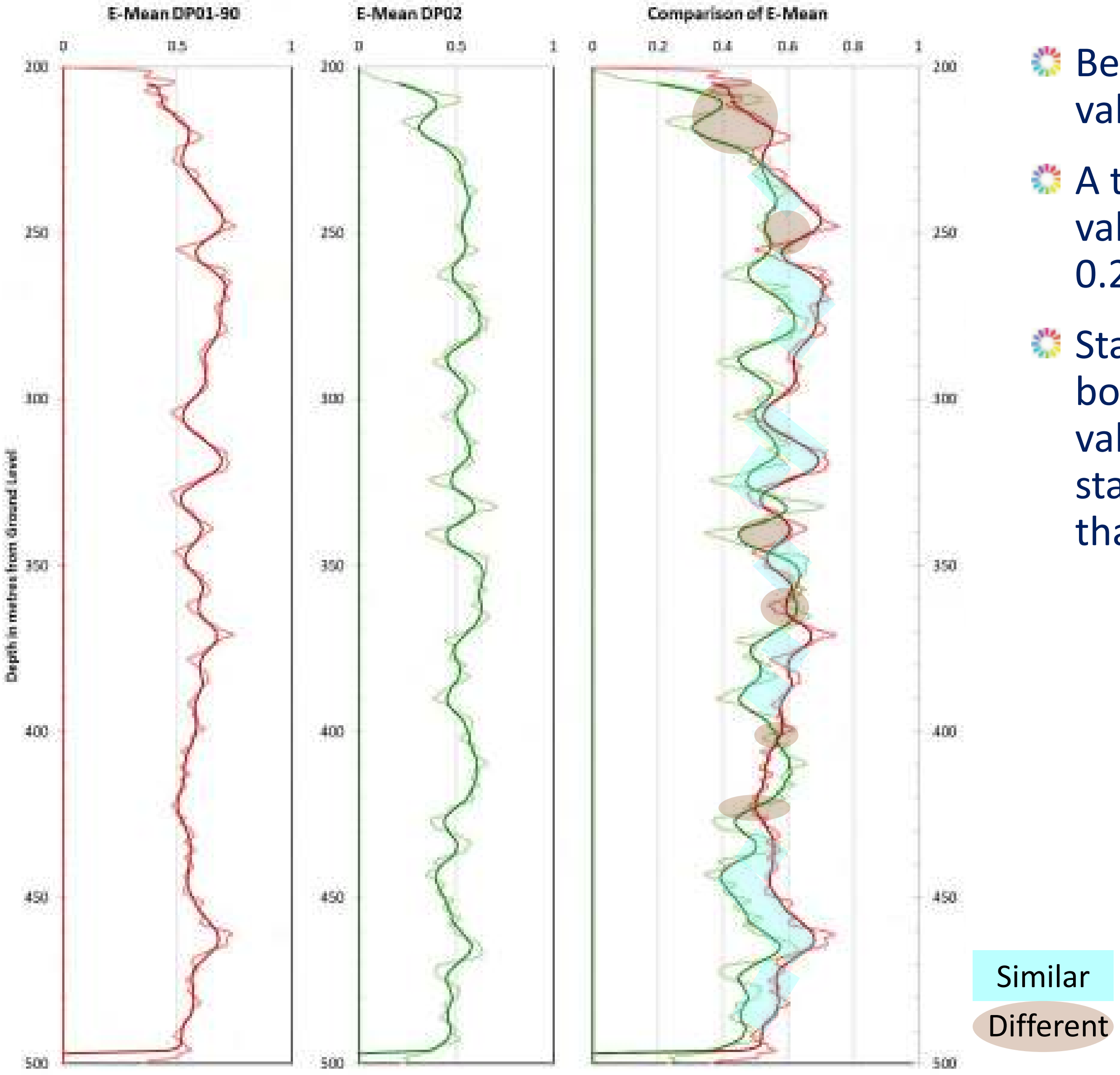


- The interval between 200-250m has a trend similarity index of 2 with values for DP01-90 greater than DP02 by 0.4-0.5.
- Below 250m the only interval with a trend similarity index greater than 1 is 300-350m where values for DP01-90 are greater than DP02 by 0.4.
- Statistically the results are similar. The minimum values from both visits is 0 and the difference in range is 0.04 with DP01-90 values greater than DP02. The remaining statistics are greater than by more than 0.3.

Interval	Trend similarity
200-250m	2
250-300m	1
300-350m	2
350-400m	1
400-450m	1
450-500m	1

Statistics 200-500m	DP01-90	DP02
Mean	0.62	0.26
Max	0.81	0.57
Min	0.00	0.00
Standard Dev.	0.81	0.57
Range	0.10	0.06

E-Mean Lithmetric

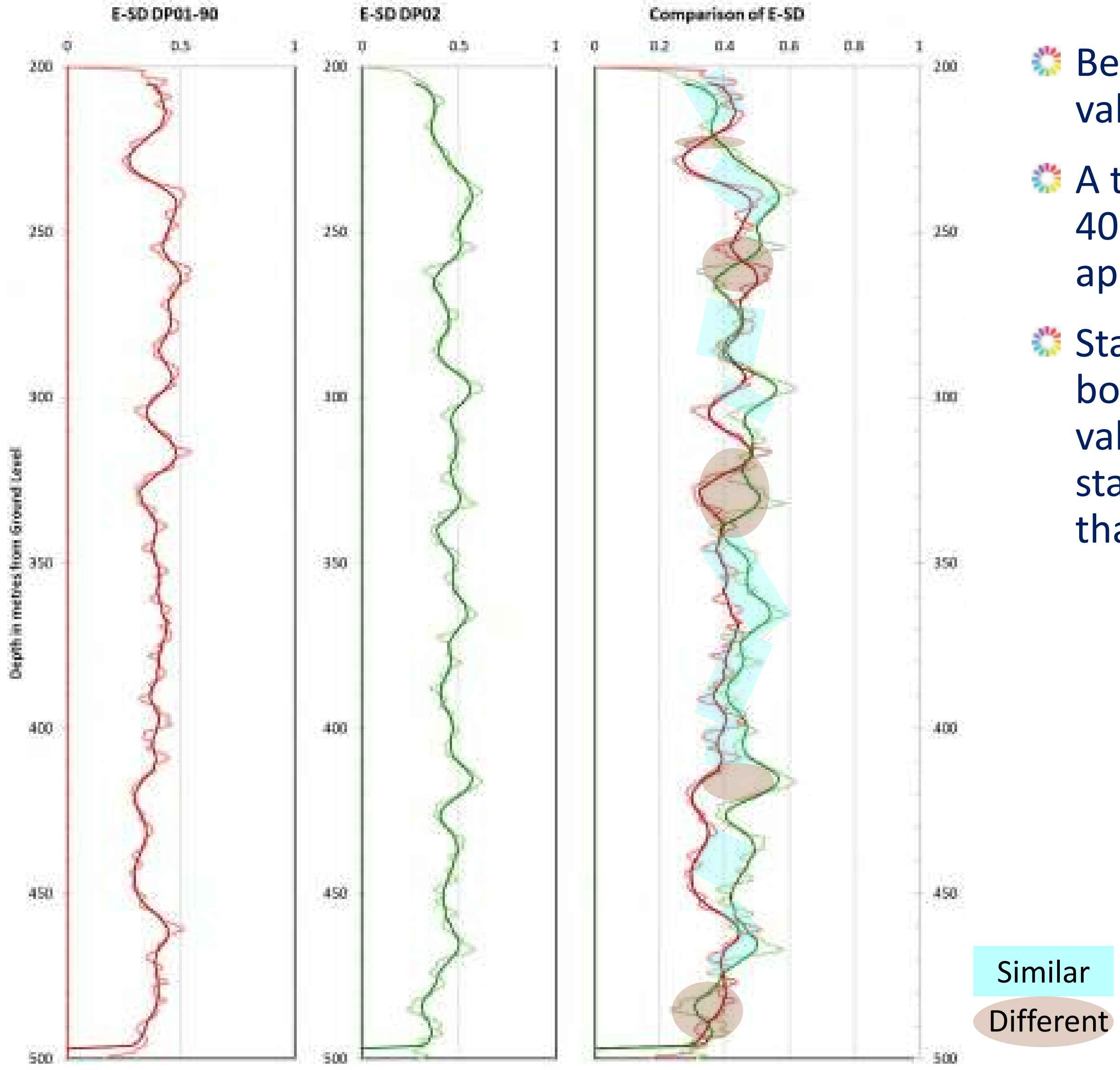


- Between 250-300m the trend similarity index is 3. DP01-90 values are greater than DP02 values by approximately 0.1-0.2.
- A trend similarity index value of 3 is also seen at 450-500m. The values are greater for DP01-90 than DP02 by approximately 0.1-0.2.
- Statistically the results are similar. The minimum values from both visits is 0 and the difference in range is 0.02 with DP02 values greater than DP01-90. The difference in maximum and standard deviation values is 0.04, with DP01-90 values greater than DP02.

Interval	Trend similarity
200-250m	1
250-300m	3
300-350m	2
350-400m	2
400-450m	1
450-500m	3

Statistics 200-500m	DP01-90	DP02
Mean	0.58	0.50
Max	0.76	0.71
Min	0.00	0.00
Standard Dev.	0.76	0.71
Range	0.09	0.11

E-SD Lithmetric

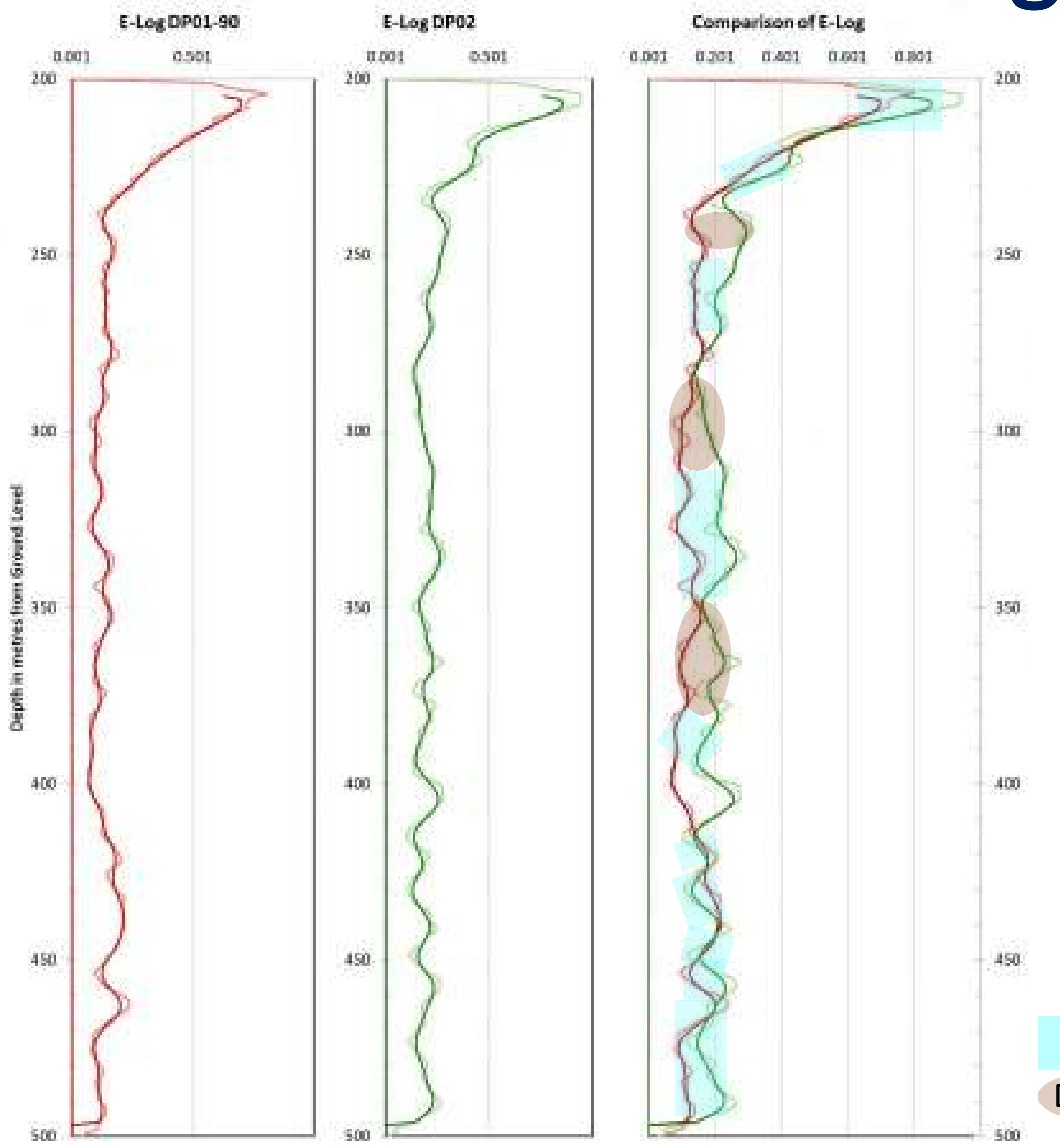


- Between 200-300m the trend similarity index is at least 2.DP02 values are usually greater by 0.05-0.1
- A trend similarity index value of 3 is also seen between 350-400m. The values are greater for DP02 than DP01-90 by approximately 0.1.
- Statistically the results are similar. The minimum values from both visits is 0 and the difference in range is 0.02 with DP02 values greater than DP01-90. The difference in maximum and standard deviation values is 0.08, with DP01-90 values greater than DP02.

Interval	Trend similarity
200-250m	2
250-300m	2
300-350m	1
350-400m	3
400-450m	2
450-500m	1

Statistics 200-500m	DP01-90	DP02
Mean	0.39	0.44
Max	0.54	0.62
Min	0.00	0.00
Standard Dev.	0.54	0.62
Range	0.07	0.09

E-log Lithmetric



- The trend similarity index of 2 occurs between 200-350m. Values for DP02 are greater than DP01-90 by approximately 0.03-0.1
- A trend similarity index of 3 is also seen between 450-500m. Usually DP02 values are higher than DP01-90 by approximately 0.01.
- Statistically the results are similar especially the range where DP02 values are 0.01 greater than DP01-90. The minimum values are 0.00 for both DP01-90 and DP02 However, the maximum and standard deviation values at DP02 are both larger than at DP01-90 by 0.14.

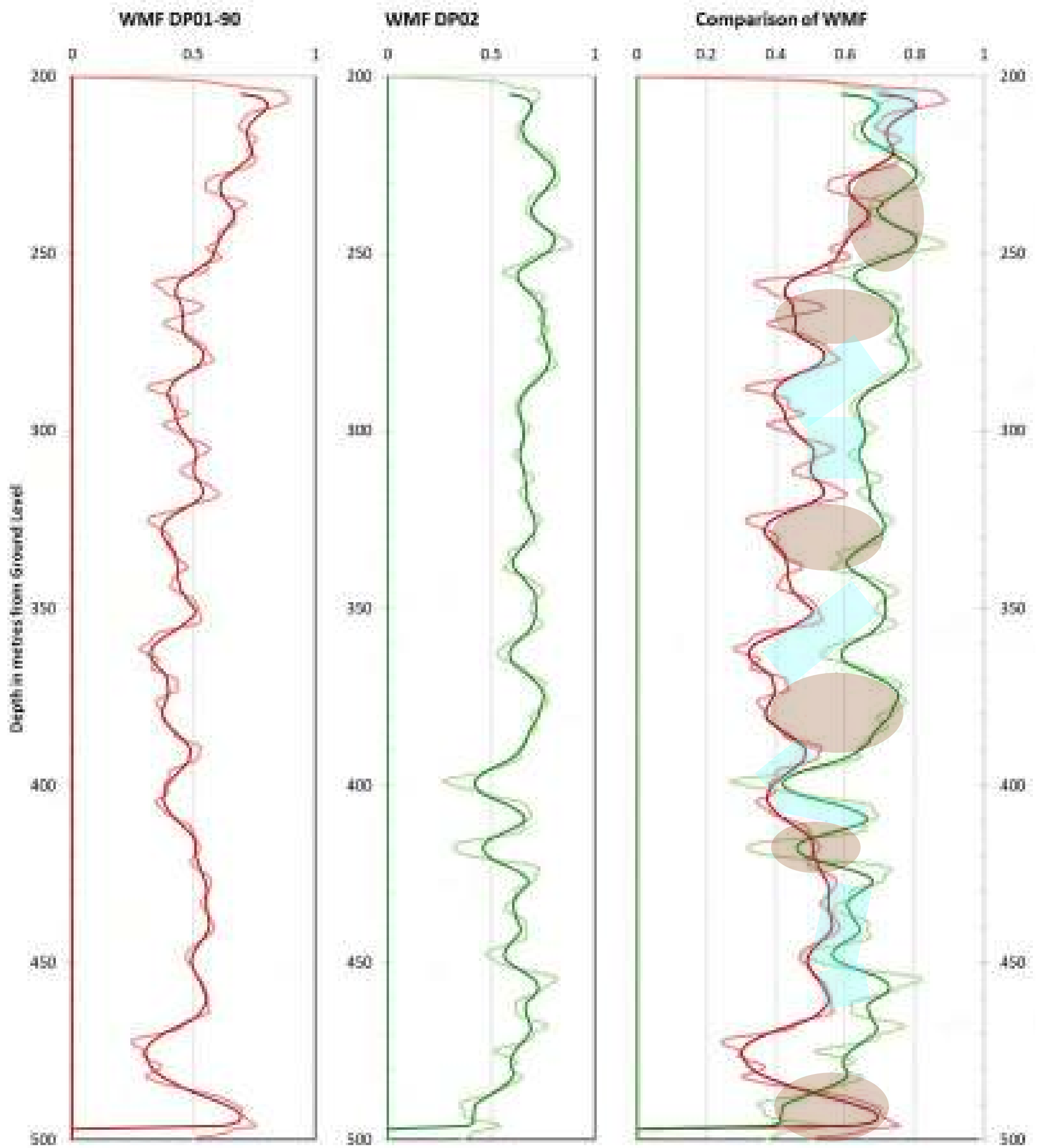
Similar

Different

Interval	Trend similarity
200-250m	2
250-300m	2
300-350m	2
350-400m	1
400-450m	2
450-500m	3

Statistics 200-500m	DP01-90	DP02
Mean	0.17	0.23
Max	0.80	0.94
Min	0.00	0.00
Standard Dev.	0.80	0.94
Range	0.13	0.14

WMF Lithmetric

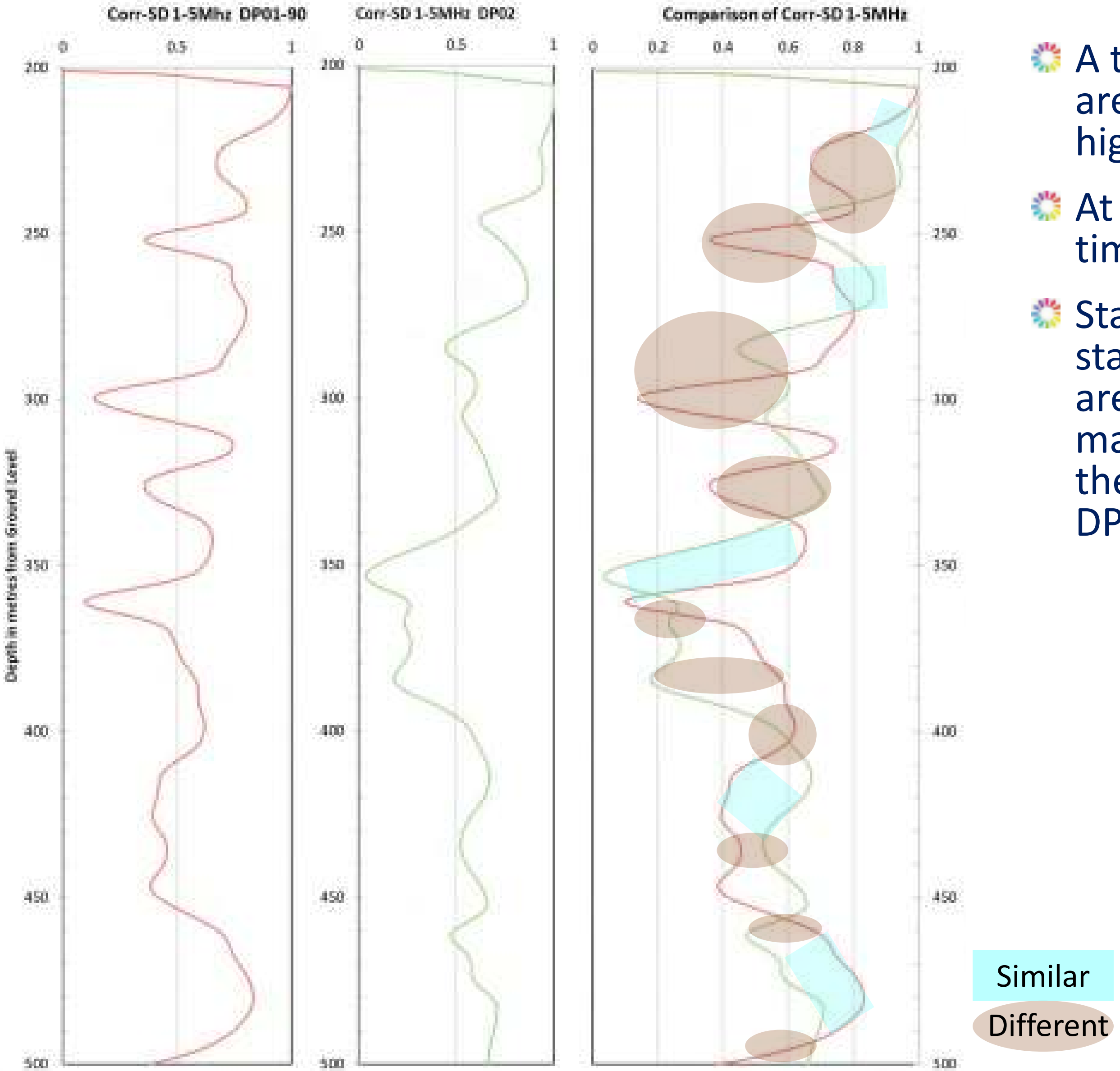


- The trend similarity index of 2 occurs between 250-300m. Values for DP02 are greater than DP01-90 by approximately 0.02
- A trend similarity index of 2 is also seen between 400-450m. Usually DP02 values are higher than DP01-90 by approximately 0.04.
- Statistically the results are similar especially the range where DP01-90 values are 0.01 greater than DP02. The minimum values are 0.00 for both DP01-90 and DP02 However, the maximum and standard deviation values at DP01-90 are both larger than at DP02 by 0.01.

Interval	Trend similarity
200-250m	1
250-300m	2
300-350m	1
350-400m	1
400-450m	2
450-500m	1

Statistics 200-500m	DP01-90	DP02
Mean	0.50	0.65
Max	0.89	0.88
Min	0.00	0.00
Standard Dev.	0.89	0.88
Range	0.13	0.12

Corr-SD 1-5MHz Lithmetric

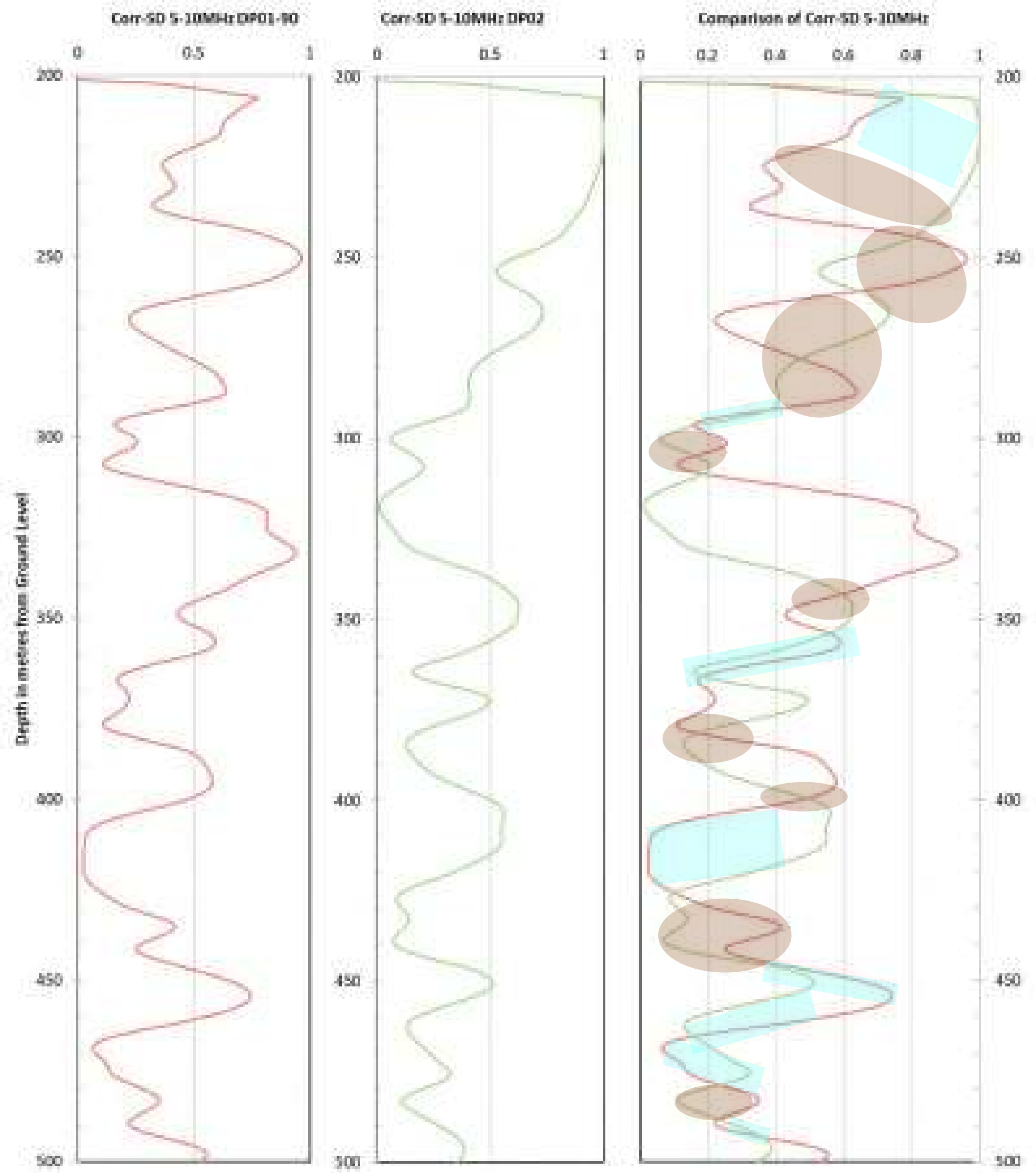


- A trend similarity index of 2 is seen at 250-300m, although there are different occasions when either DP01-90 and DP02 have the highest values.
- At 450-500m, a trend similarity index of 2 is also seen This the time the values for DP01-90 are usually than DP02 by 0.1.
- Statistically the results are similar. The largest difference in statistics is 0.1 seen in the minimum value. DP02 minimum values are greater than DP01-90. The difference in the mean and maximum values are 0.01. DP01-90 mean values are greater than the DP02 value. The DP02 maximum value is greater than the DP01-90 value.

Interval	Trend similarity
200-250m	1
250-300m	2
300-350m	1
350-400m	1
400-450m	1
450-500m	2

Statistics 200-500m	DP01-90	DP02
Mean	0.03	0.02
Max	0.99	1.00
Min	-0.83	-0.93
Standard Dev.	1.82	1.93
Range	0.38	0.46

Corr-SD 5-10MHz Lithmetric



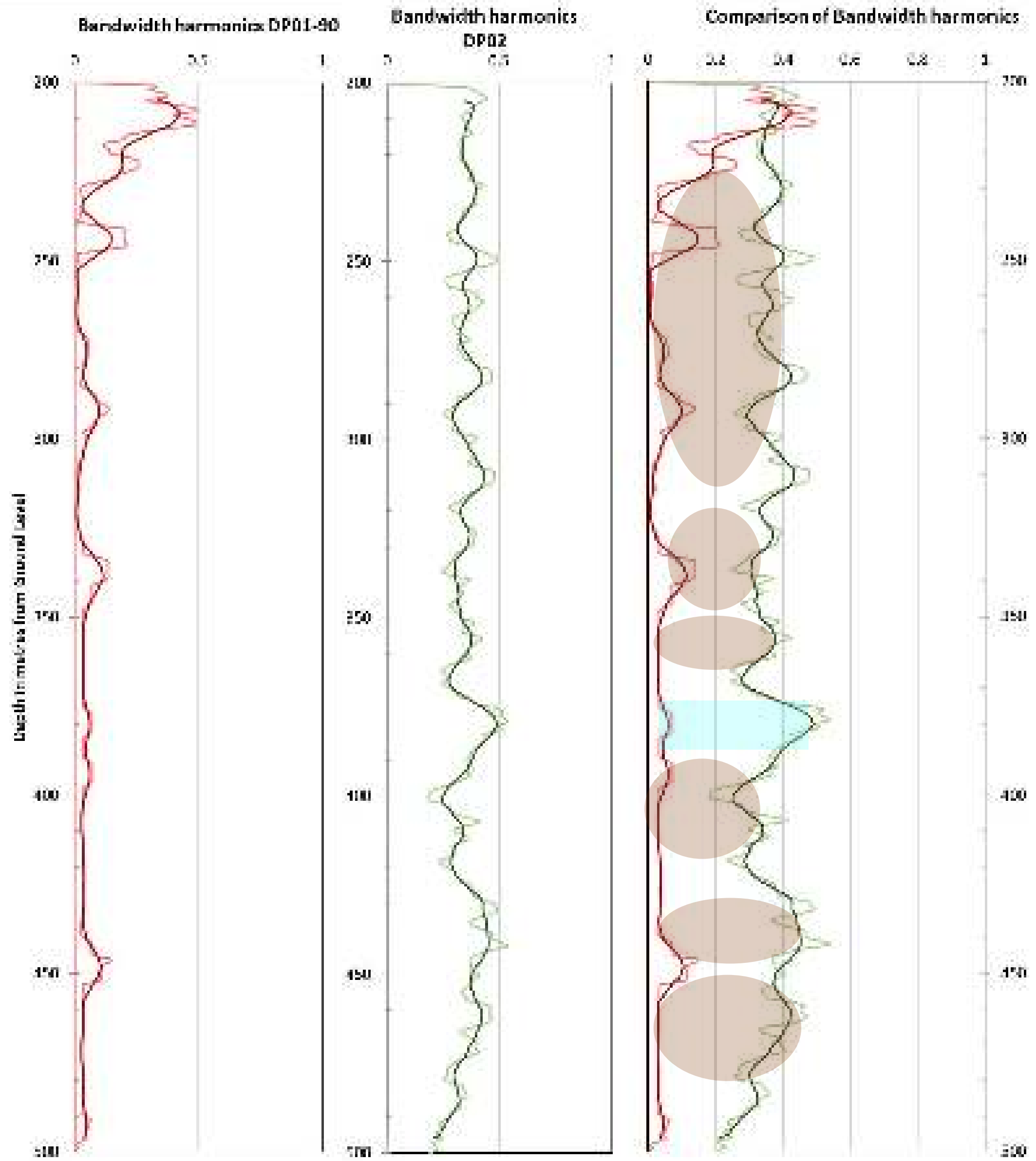
- A trend similarity index of 2 is seen between 350-400m. The V-bore with the higher value changes over the interval.
- Between 450-500m the trend similarity index is also 2. Values for DP01-90 are usually higher than DP02 by approximately 0.1
- Statistically there are differences. The statistic with the smallest difference is the mean. The DP02 mean is 0.08 higher than DP01-90. The only other statistic with a difference with less than 0.1 is the minimum. Values for DP01-90 are 0.09 greater than DP02.

Similar
Different

Interval	Trend similarity
200-250m	1
250-300m	1
300-350m	1
350-400m	2
400-450m	1
450-500m	2

Statistics 200-500m	DP01-90	DP02
Mean	-0.18	-0.26
Max	0.84	1.00
Min	-0.82	-0.91
Standard Dev.	1.67	1.91
Range	0.40	0.55

Bandwidth Harmonics Lithmetric



- There are no intervals with a similarity index value greater than 1 and values for DP02 are consistently greater than DP01-90 apart from 210-220m.

- Statistically the results show some similarity. The minimum values are identical. For the remaining statistics only the mean has a difference greater than 0.4. In all statistics apart from the minimum and range values for DP02 are greater than DP01-90.

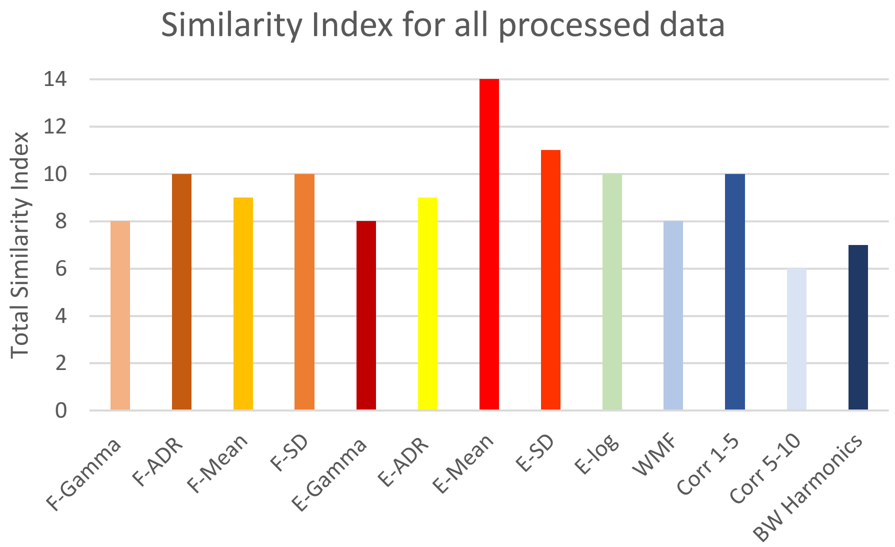
Similar

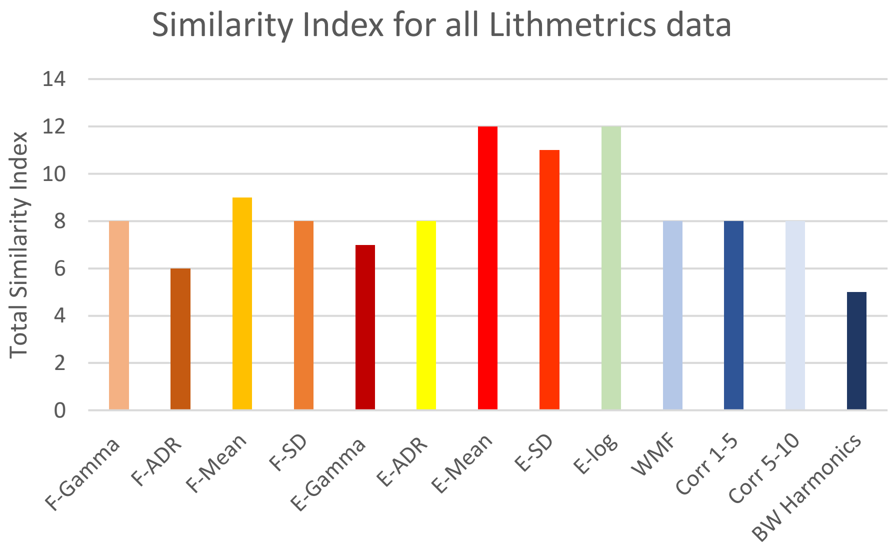
Different

Interval	Trend similarity
200-250m	1
250-300m	0
300-350m	1
350-400m	1
400-450m	1
450-500m	1

Statistics 200-500m	DP01-90	DP02
Mean	0.07	0.35
Max	0.50	0.54
Min	0.00	0.00
Standard Dev.	0.50	0.54
Range	0.09	0.07

Repeatability of processed data

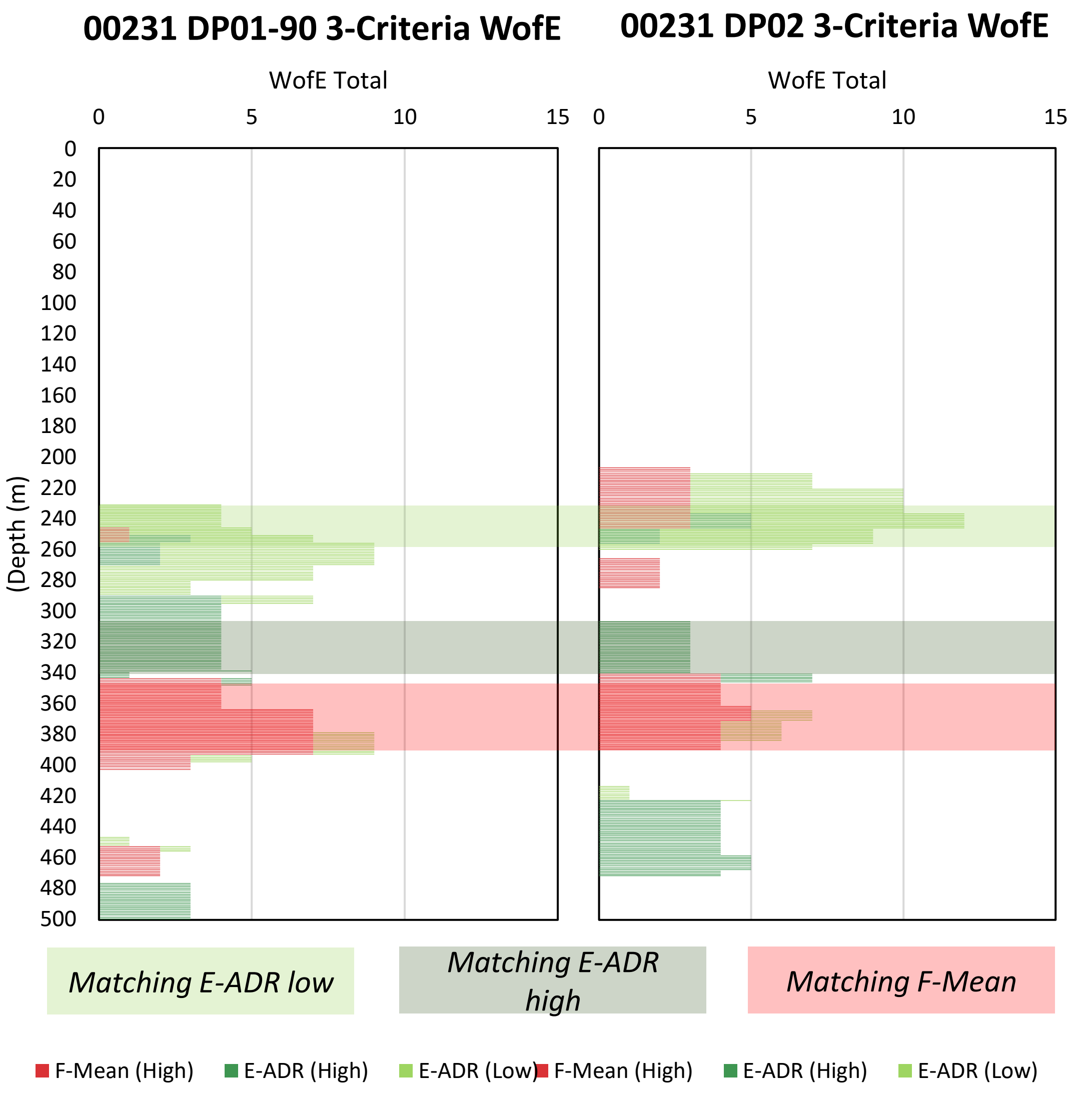




The similarity index is a measure of the symmetry between scans at each 50m depth interval.

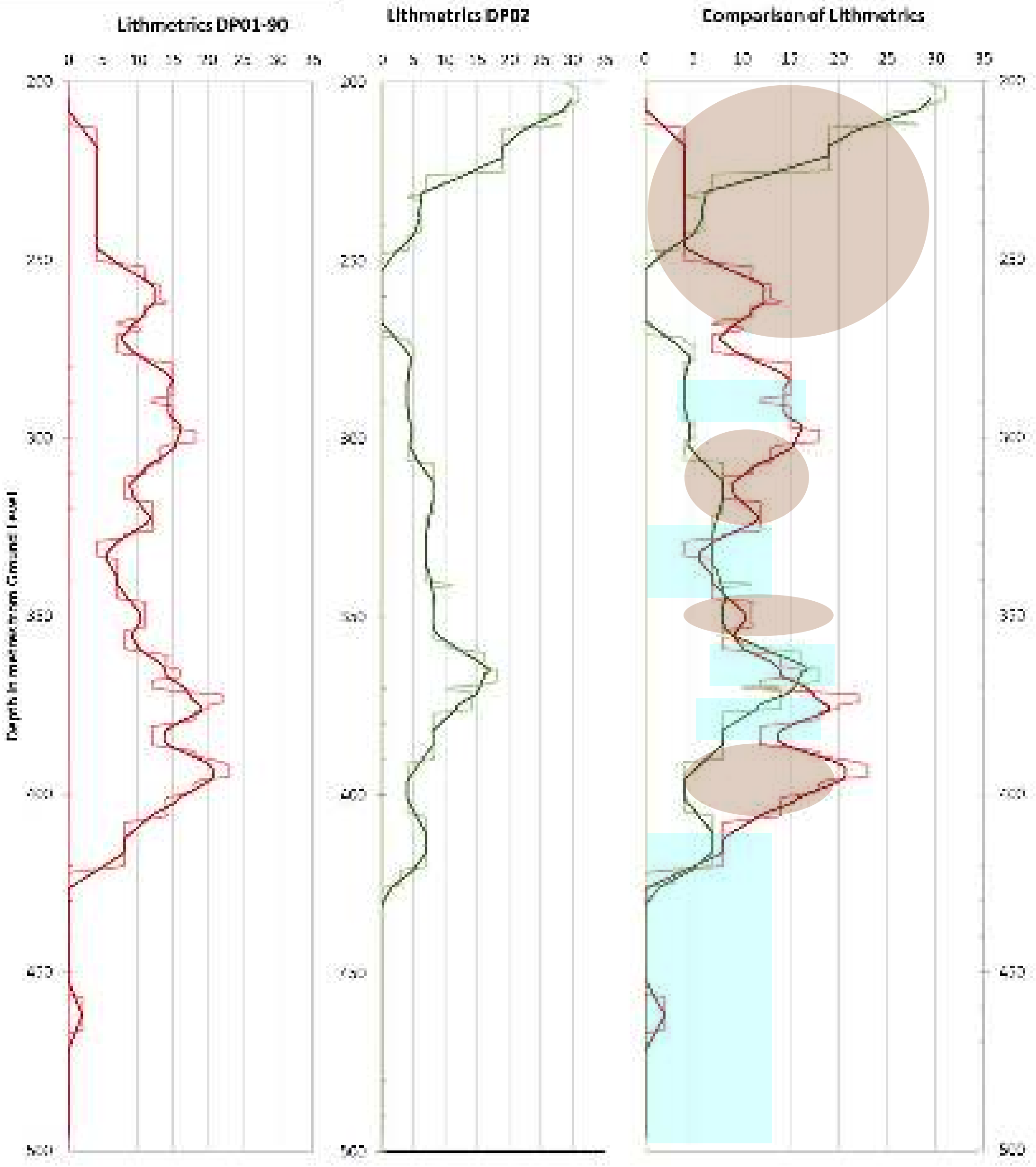
- The similarity index has been totalled for both sets of processed data.
- For both sets of processed the E-Mean has the highest similarity index and many of the harmonic parameters have moderate to high similarity with values of 8 or higher. In contrast the correlation 5-10 MHz and bandwidth harmonic parameters have the lowest similarity index with values between 6 and 7. This is interesting because the final interpretation was completed using the harmonic parameters.
- The lithmetrics similarity index shows a similar pattern to the standard data processing similarity index. Although similarity values are lower for some of the harmonic parameters such as F-ADR and E-Mean, the bandwidth harmonics has the lowest similarity. The correlation values at both 1-5 and 5-10 MHz are now almost identical to the harmonics.

Repeatability of WofE Results



- The weight of evidence analysis focussed on high values for F-Mean and both high values and low E-ADR values.
- Lows and Highs in E-ADR are seen in both DP01-90 and DP02 between 240-260m, although there is a difference in value of approximately of 3 for E-ADR lows and 1 for E-ADR highs.
- Between 350-390m F-Mean value are seen in both DP01-90 and DP02. The values are higher by 2-3 in DP01-90 than DP02.
- Also within the same interval, lows in E-ADR are seen in both between 370-390m. Values of 3 are seen in both DP01-90 and DP02.
- The results show good repeatability in the area between 230-260m and 350-390m.

Repeatability of Lithmetric Results



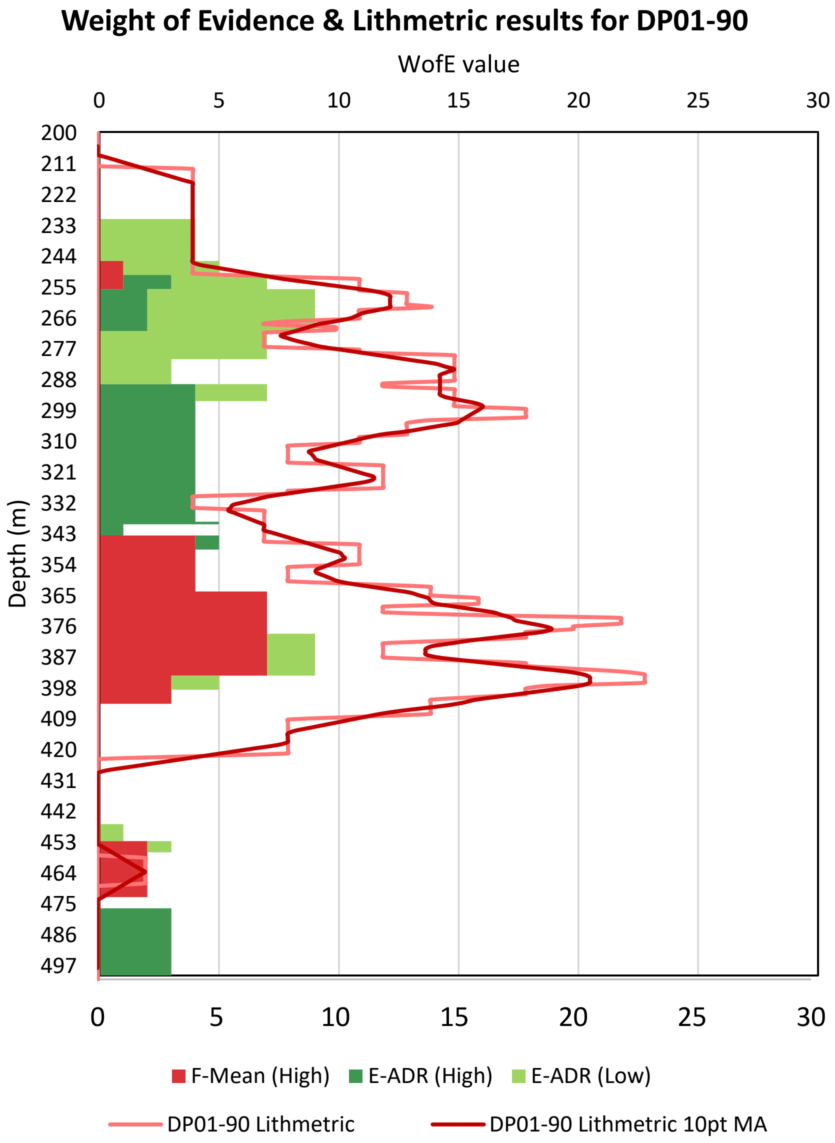
- The weight of evidence criteria for lithmetrics used all the harmonic parameters apart from F-Gamma has a threshold similarity index of 0 between 200-250m but this increases to 3 between 400-500m .
- Below 350m the patterns are virtually identical, although the values at DP01-90 are greater than at DP02 by between 5-10.
- In terms of statistics both only the standard deviations show a value difference in value of less than 1 with DP02 values greater than DP01-90. The minimum values are both identical .
- Overall the results are promising with the similarity index increasing with depth from 0 to 3. Also the values below 420m show a difference of less than 2. The total trend similarity is 11. This equal or above many of the highest similarity values recorded.

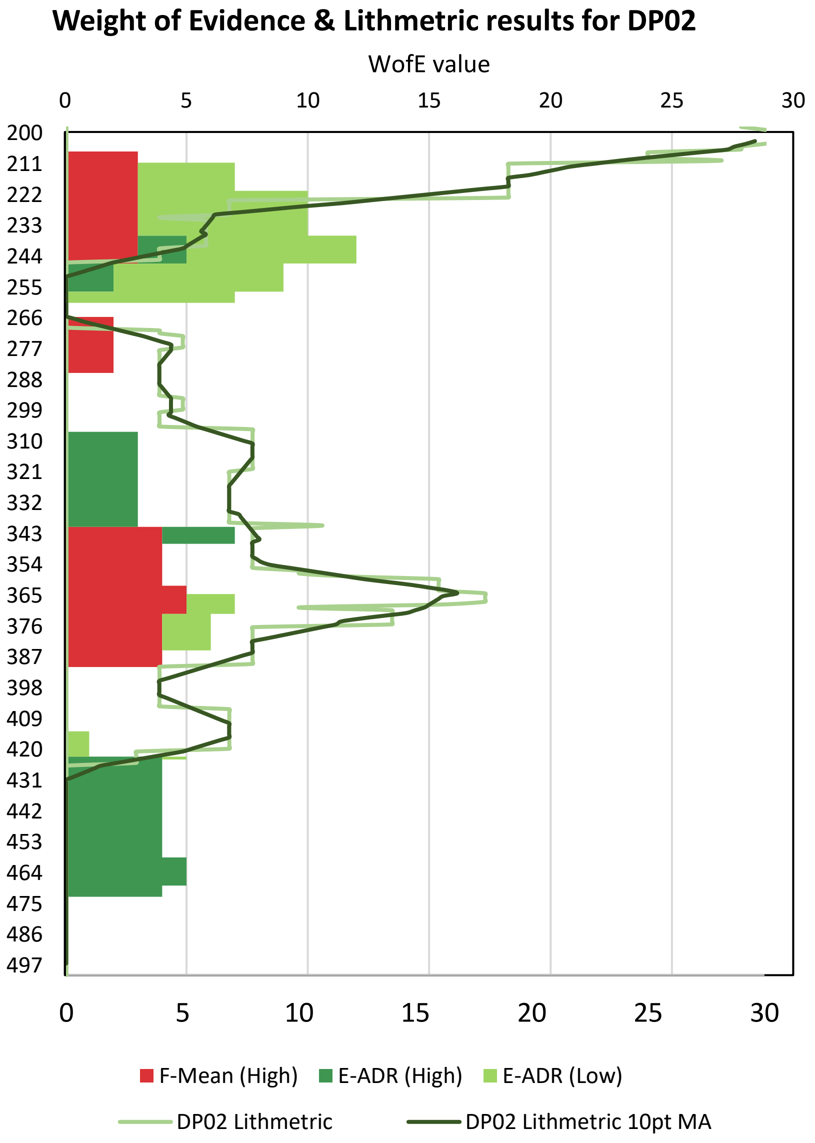
Interval	Trend similarity
200-250m	0
250-300m	1
300-350m	2
350-400m	2
400-450m	3
450-500m	3

Statistics 200-500m	DP01-90	DP02
Mean	7.41	6.20
Max	23.00	31.00
Min	0.00	0.00
Standard Dev.	6.36	6.99
Range	23.00	31.00

Similar
Different

Conclusions of the Repeatability Study





- A thorough examination of the raw data, data processing and data analysis reveals similarity in the results of DP01-90 and DP02.
- Similarity is greatest between 340-420m where both the weight of evidence and lithmetrics values increase. These values are as much as three times greater using the lithmetric criteria than the weight of evidence criteria. Below 420m, lithmetrics values are close to zero.
- The largest data differences are between 200-220m where more evidence for sulphides is seen in both the weight of evidence and lithmetrics in DP02 than DP01-90. The same beam saturation depth of 200m was used for both lithmetrics and weight of evidence. From looking at the data an increase in the beam saturation depth used in DP02 by approximately 20m would improve the repeatability of the results.

Stare Transect - Methods

- The Stare Transect Energy Mean plot was a successful output from project 00136, and one of the goals of project 00231 is to replicate it. This method has been chosen to do so after investigating the data from 00136.
- This method is able to find discontinuities in the subsurface, as well as imaging the top of the mineralisation interval.

Transect Stares

- Both for the Signal (SII) and Noise (SOI) scans.
- 21 directories named n000, n025… n475 to n500.

Processing

- All Energy and Frequency harmonics extracted.
- Settings were 16384 pixel windows at 128 pixel steps.
- Completed with Radamatic 3.2.

Analysis

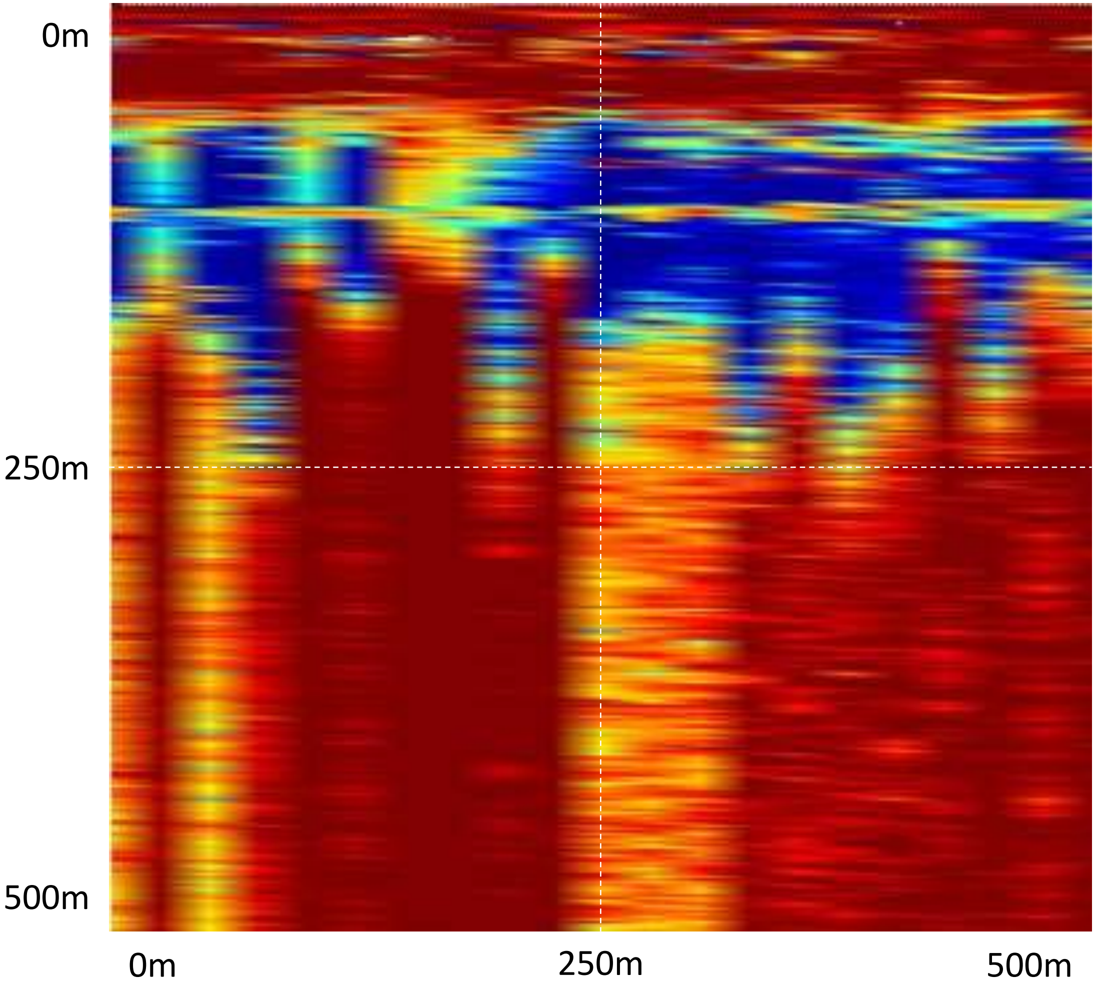
- Compilation of the E-Mean data with script “plotharms231_000”.
- Plotting of the data using “plot231” to create suf plot of datasets, using Er=7 for time-depth conversion.

Interpretation

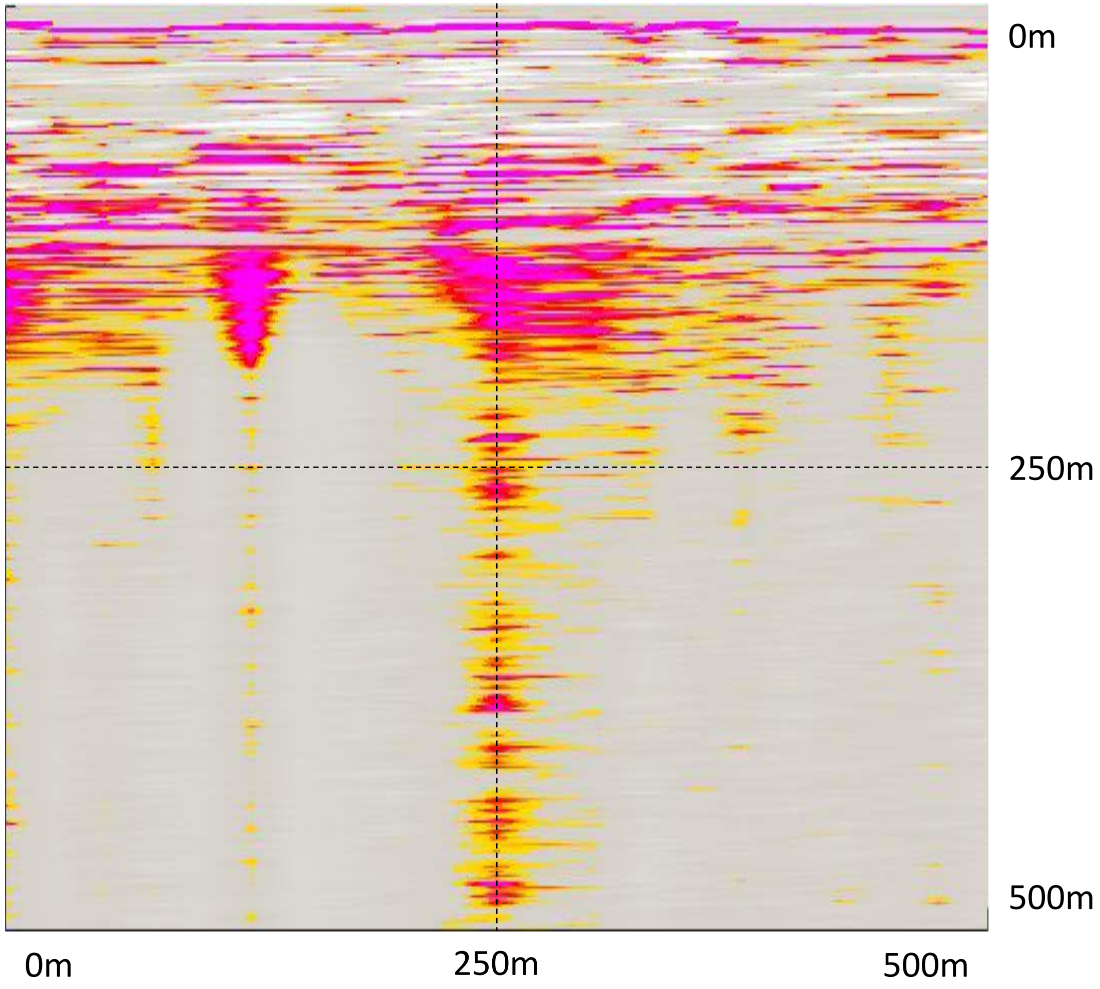
- The results were compared to the Seismic profile coincidental with the data.

The raw scanned data can be found in G:\00231 DetCRC 2020SR\Data Collected (00136)\Transect_Stare
The processed data can be found in G:\00231 DetCRC 2020SR\V-Bores (00231)\Transect_Stare
The final outputs and figures can be found in G:\00231 DetCRC 2020SR\Internal Deliverables (00231)\00231 Transect Deliverables\Stare Transect.
The integrated figure within the 3D model can be found in G:\00231 DetCRC 2020SR\Internal Deliverables (00231)\00231 00136 BRUKUNGA GEOSCIENCE ANALYST

Stare Transect - Results

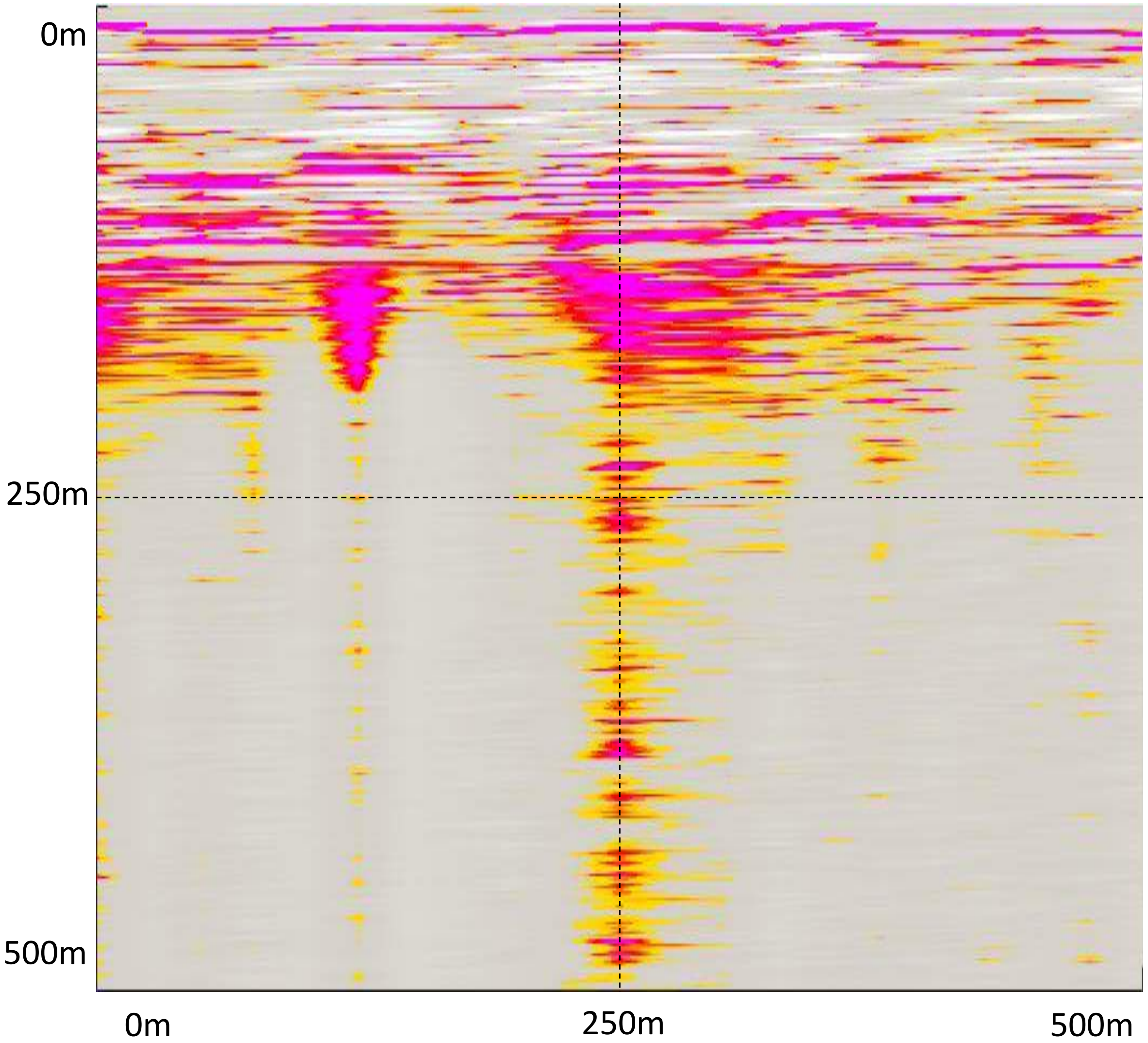


- Energy Mean (Signal-Noise) image created from 21 stare stations during project 00136.

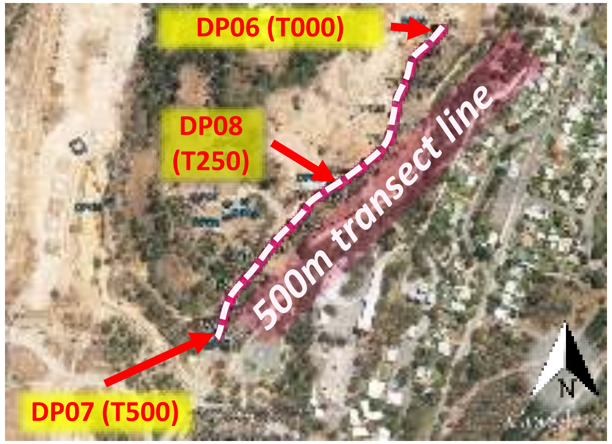


- Energy Mean (Signal-Noise) image created from 21 stare stations during project 00231.

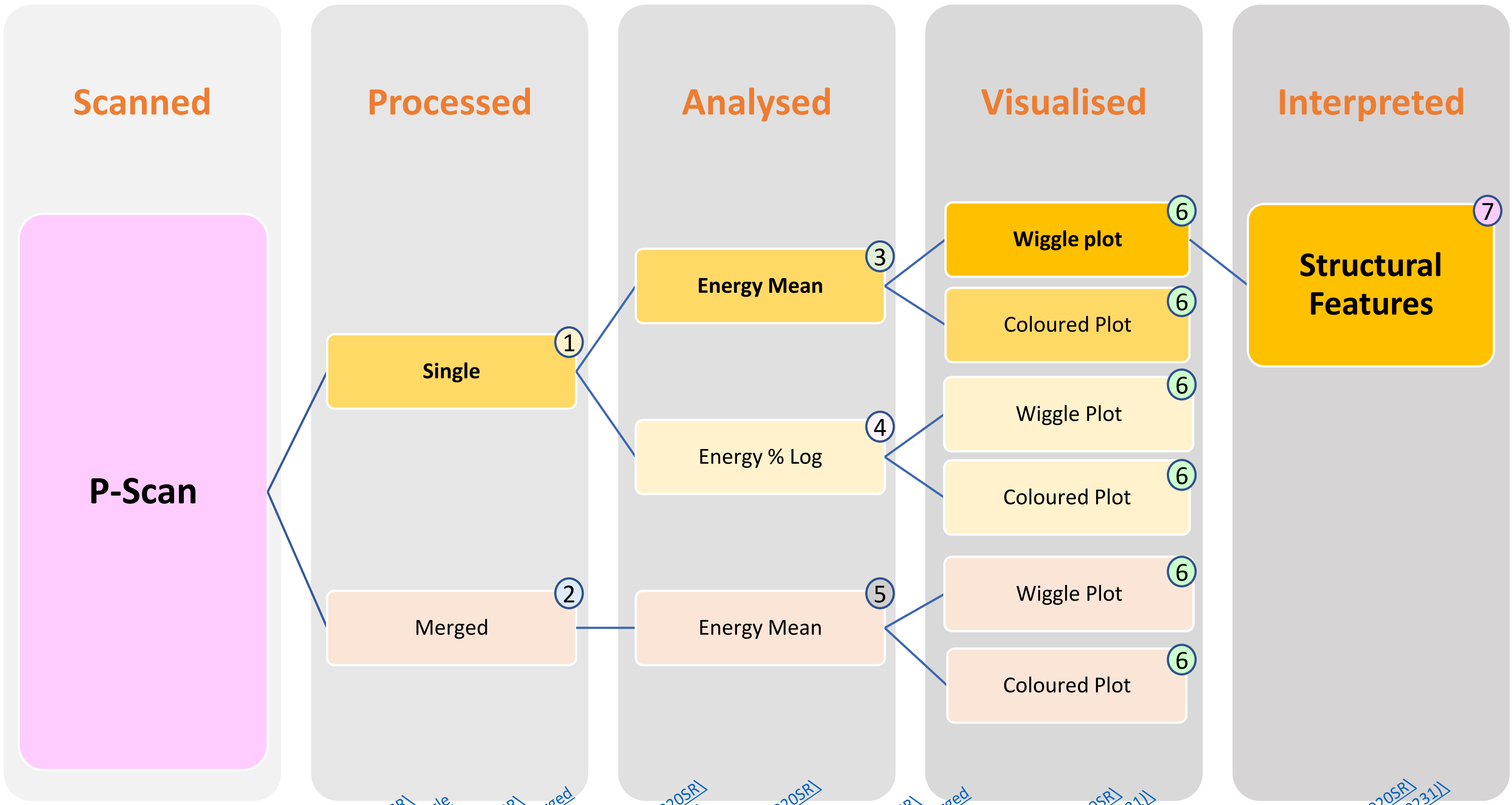
Stare Transect - Conclusions



- The final output from this process was a high resolution image that was then incorporated into the 3D model (see later in the presentation.
- We can now produce this style of Stare Transect reliably, and use it for creating 2D sections based on 1D scans.



P-Scan Transect - Methods



Location of the data:

1. G:\00231 DetCRC 2020SR\ V-Bores (00231)\P-Scan\Single
2. G:\00231 DetCRC 2020SR\ V-Bores (00231)\P-Scan\Merged
3. G:\00231 DetCRC 2020SR\ V-Bores (00231)\P-Scan\ Single\Harmonics
4. G:\00231 DetCRC 2020SR\ V-Bores (00231)\ P-Scan\Single\E-Logs
5. G:\00231 DetCRC 2020SR\ V-Bores (00231)\P-Scan\Merged
6. G:\00231 DetCRC 2020SR\ Internal Deliverables (00231)\ 00231 WF5 Transect
7. G:\00231 DetCRC 2020SR\ Internal Deliverables (00231)\ 00231 00136 BRUKUNGA GEOSCIENCE ANALYST

- The P-Scans were first joined into a single .tra file, going from five 100m scans to single 500m file.
- The target of the P-Scan transect is to resemble or improve the imagining provided by the Stare transect, so we aim for a similar processing path, hence the preference for Energy Mean.
- After trying both the Single and Merged versions of the extracted Energy Mean, the single provided better contrast and overall data.
- For visualisation and interpretation, the most interesting visuals are provided by the wiggle plots, which retain much more visual data than the coloured plots for interpretation.
- The interpretation technique, very much resembles seismic horizon picking (more on that later).
- The P-Scans yielded a great structural imaging tool that picks up on the major boundaries and faults.

P-Scan Transect – The chosen method

Scanned

P-Scan

Processed

Single

Using Radamativ v3.2 the 5 P-Scans were first horizontally rectified and then joined into a single P-Scan of 4586 traces.

Using Radamatic v3.2 the larger image was spilt into 5m intervals (of chainage).

Analysed

Energy Mean

Using Radamativ v3.2 batch processing options, the Harmonic parameters of each interval were extracted. For depth conversion, we used the closest possible WARR.

Visualised

Wiggle plot

Using Matlab scrip harmonicSurfGenerator_v100 we con produce the wiggle plots.

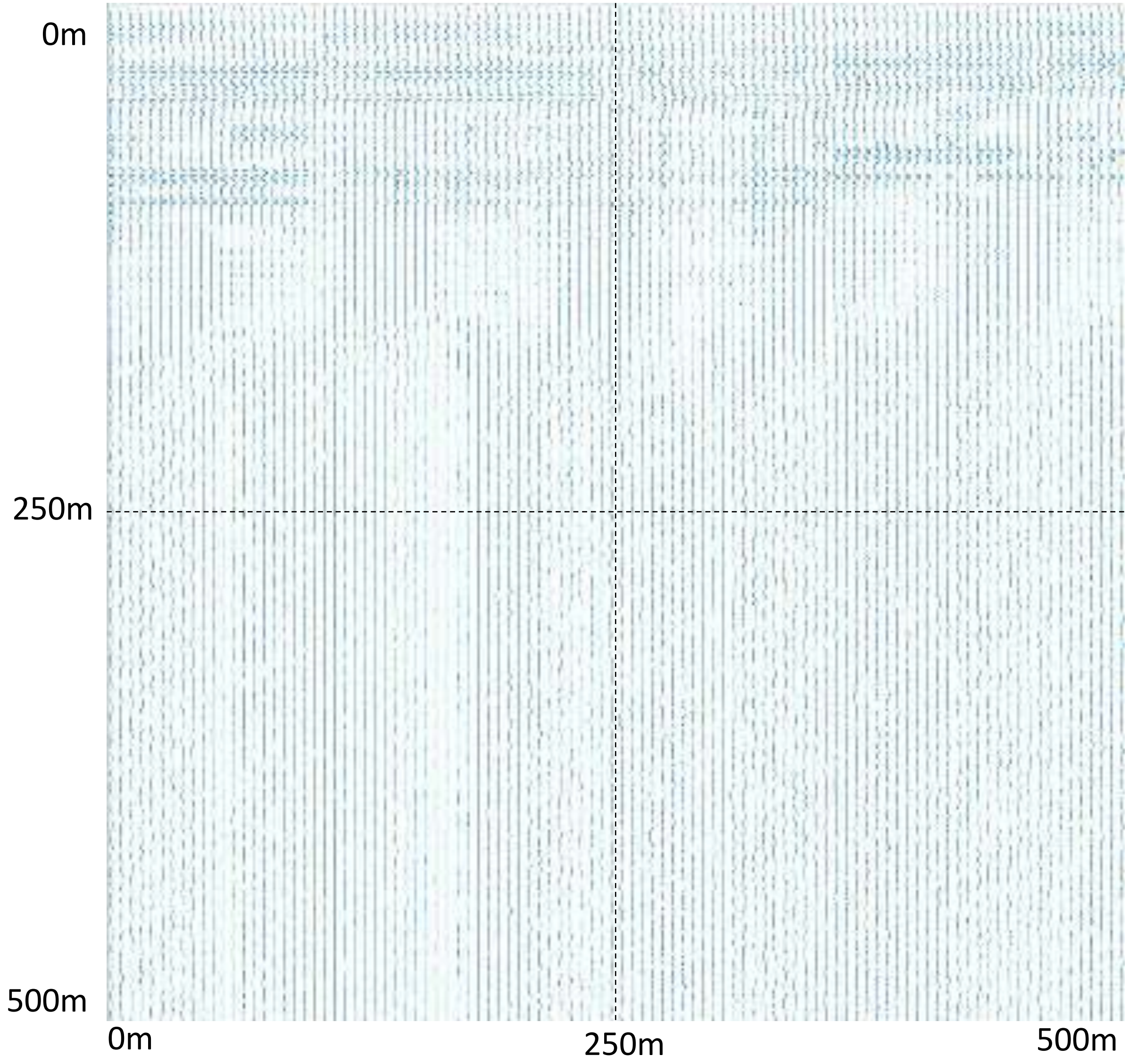
Interpreted

Structural Features

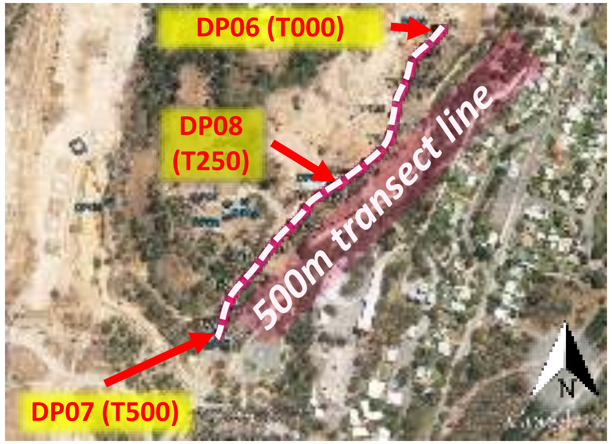
Using Inkscape or any other image editing with transparencies and layer capabilities, we can now interpret the output.
Detailed instructions follow.

- The diagram in this slide, presents the specific steps taken to produce the final deliverable.
- Following this steps will ensure repeatability.

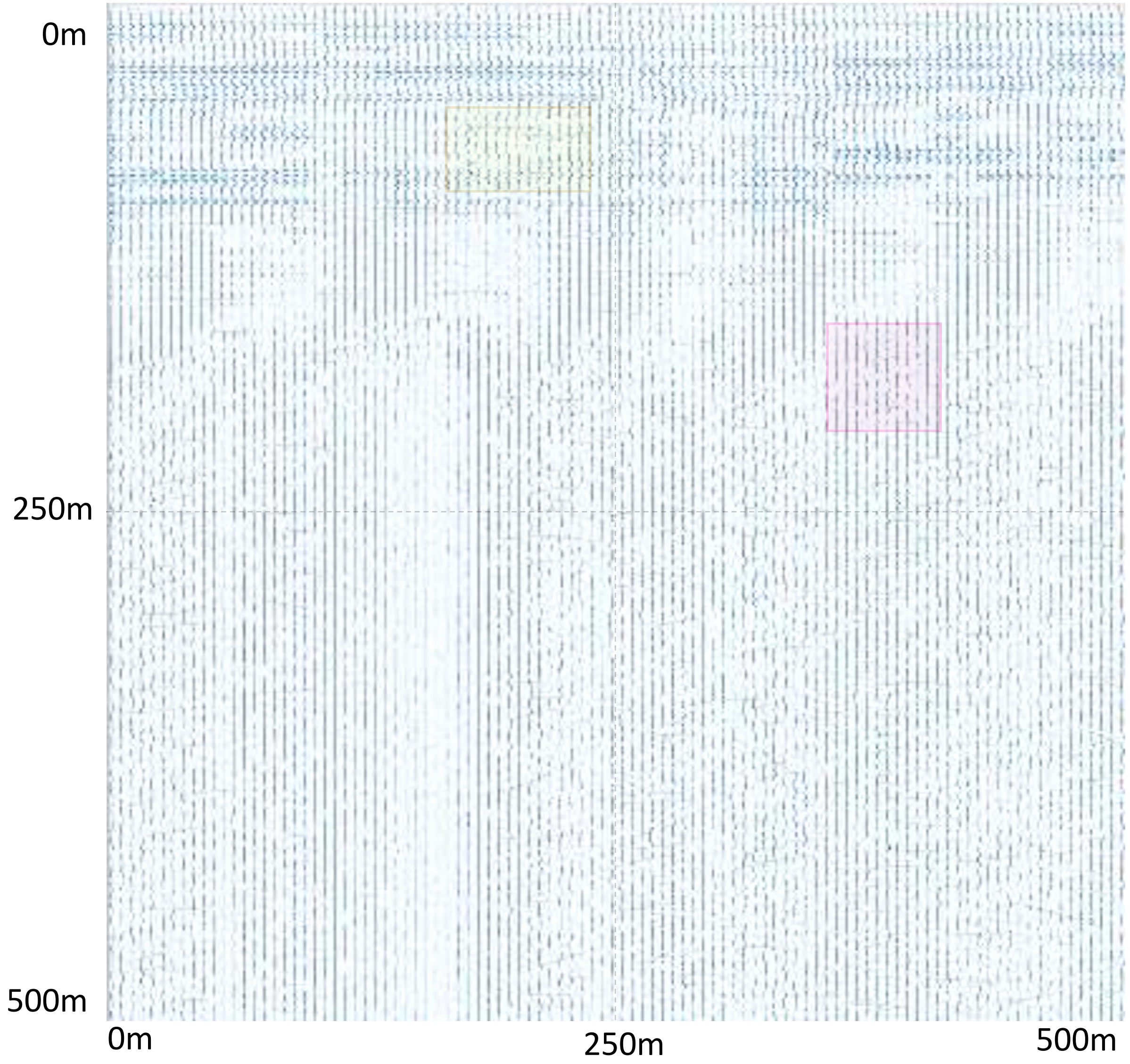
P-Scan Transect – Energy Mean wiggle plot



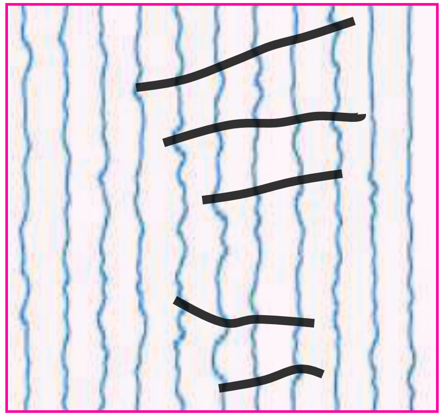
- This figure shows 100 wiggle tracks, each one calculated from 45 to 55 traces, out of the total almost 5000 traces collected in the 500m of profile scan.
- The transect runs from NE to SW, following a road southwards from the mined out pit.
- The attribute shown is the Energy Mean of the SII scan, higher in peaks and lower in troughs, with values typically between 5 and 15.
- The depth correction applied is dynamic, according to the closest possible WARR:
  - 0 to 150m uses DP06.
  - 155 to 350 uses DP08.
  - 355 to 500 uses DP07.

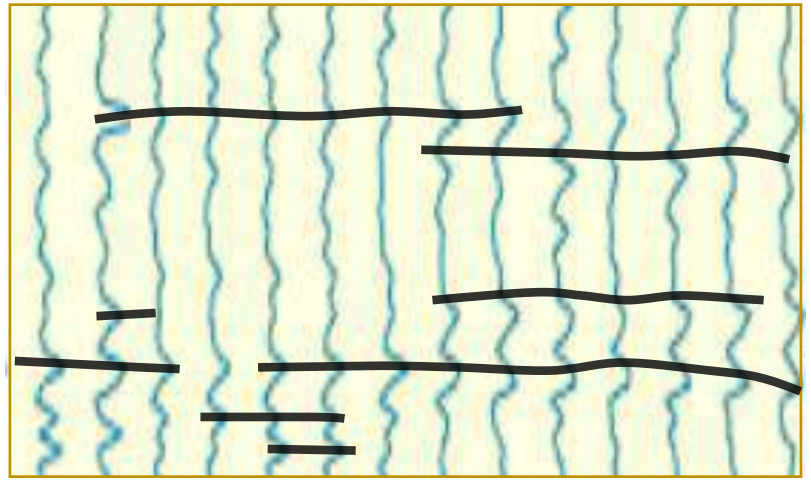


P-Scan Transect – Horizon Picking

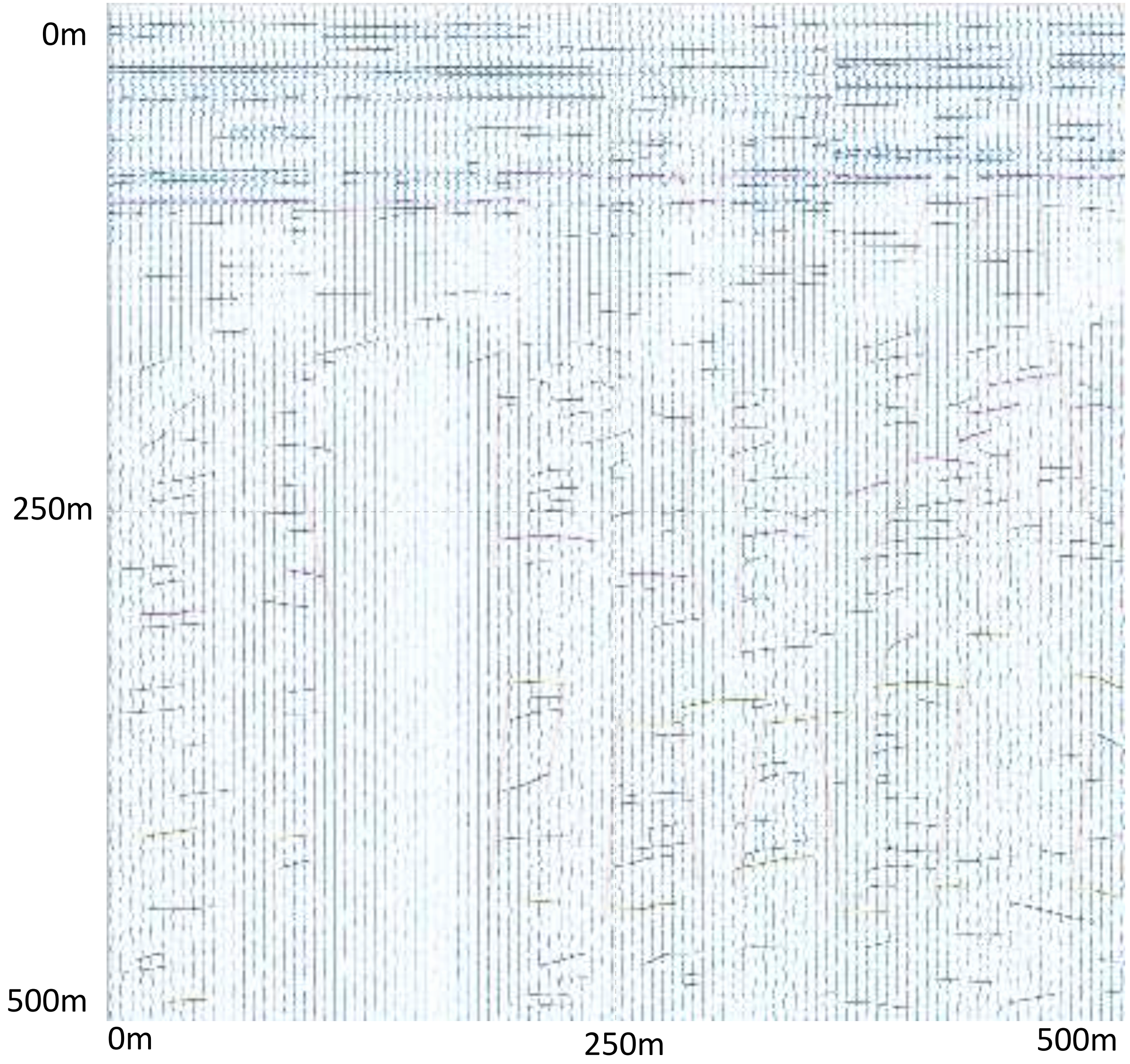


- This figure shows the first step of the interpretation process.
- The interpreter will focus on lateral trends between at least three tracks (15m), following these features.
    1. The main priority is lateral continuity of traces with similar peaks or troughs.
    2. Its important to notice the change in intensity, to detect anomalies or interruptions.
    3. While following the horizon laterally, try to detect similar features above and below to strengthen confidence.

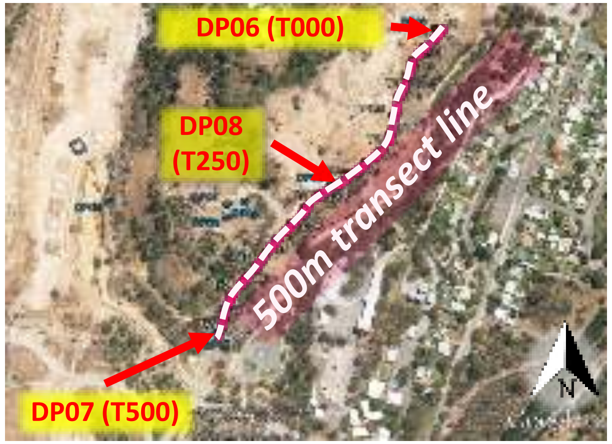




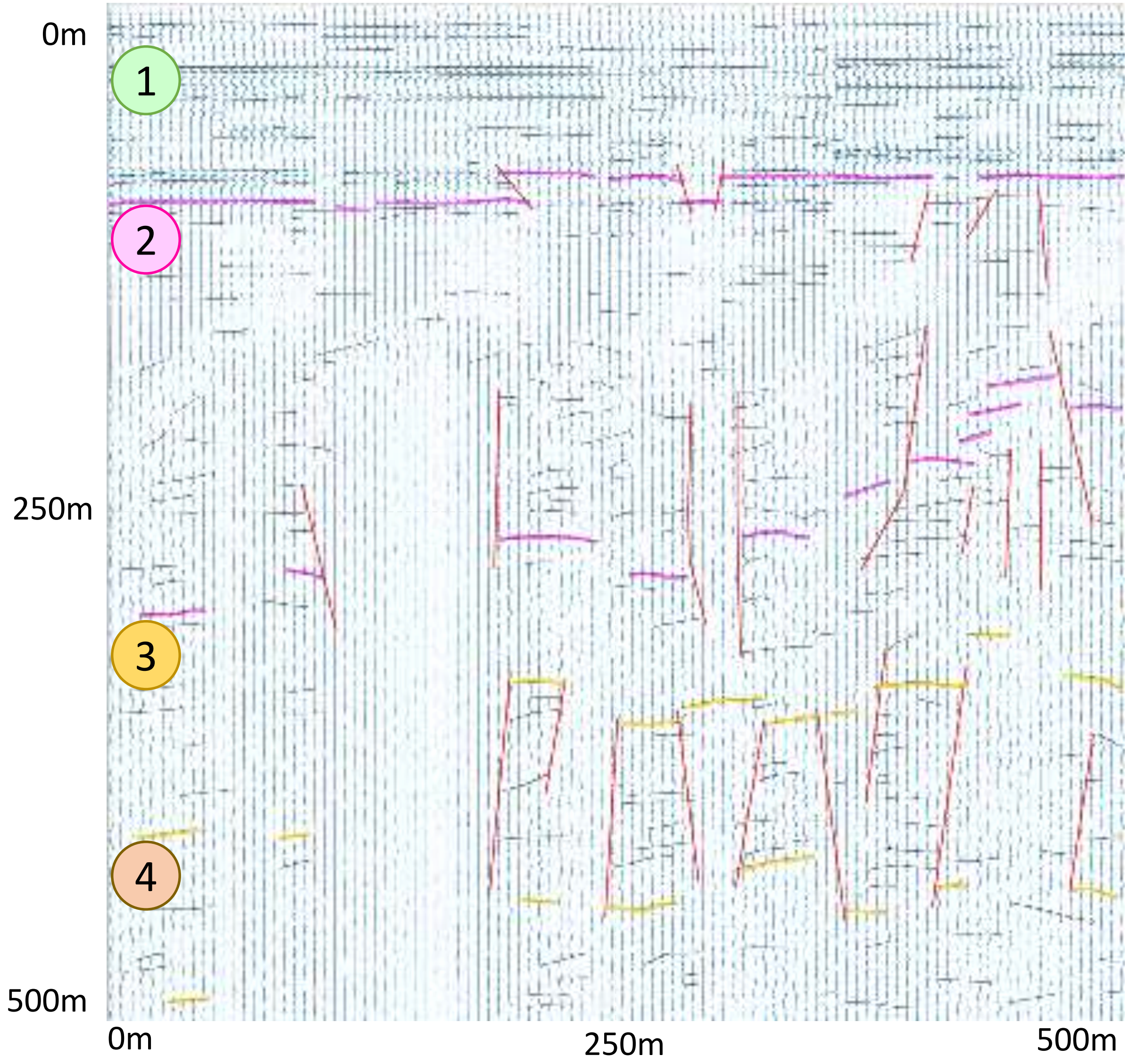
P-Scan Transect – Initial interpretation



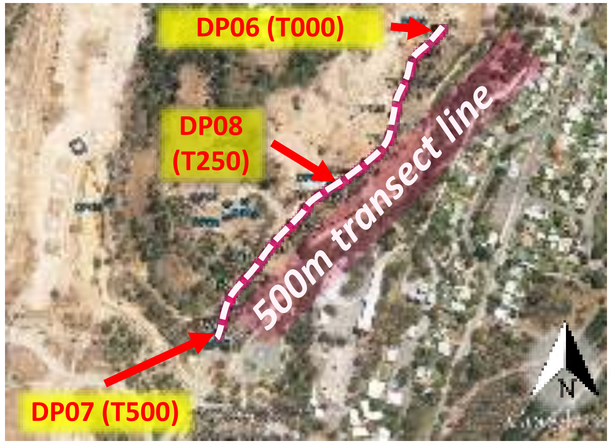
- This figure shows the second step of the interpretation process.
- The interpreter will focus on identifying relationships between laterally trackable groups of horizons.
  1. The main priority is lateral continuity of horizons with similar attribute values (remarkable peaks or troughs).
  2. The dip and relative position to other groups is also considered.
  3. Then, each of these marker horizons are marked with pairs of colours to indicate potential units.



P-Scan Transect – Completed interpretation



- This figure shows the last step of the interpretation process.
- The interpreter will determine and produce observation on Energy defined units according to the characteristics of the horizons and traces within. In this case, these are the descriptions:

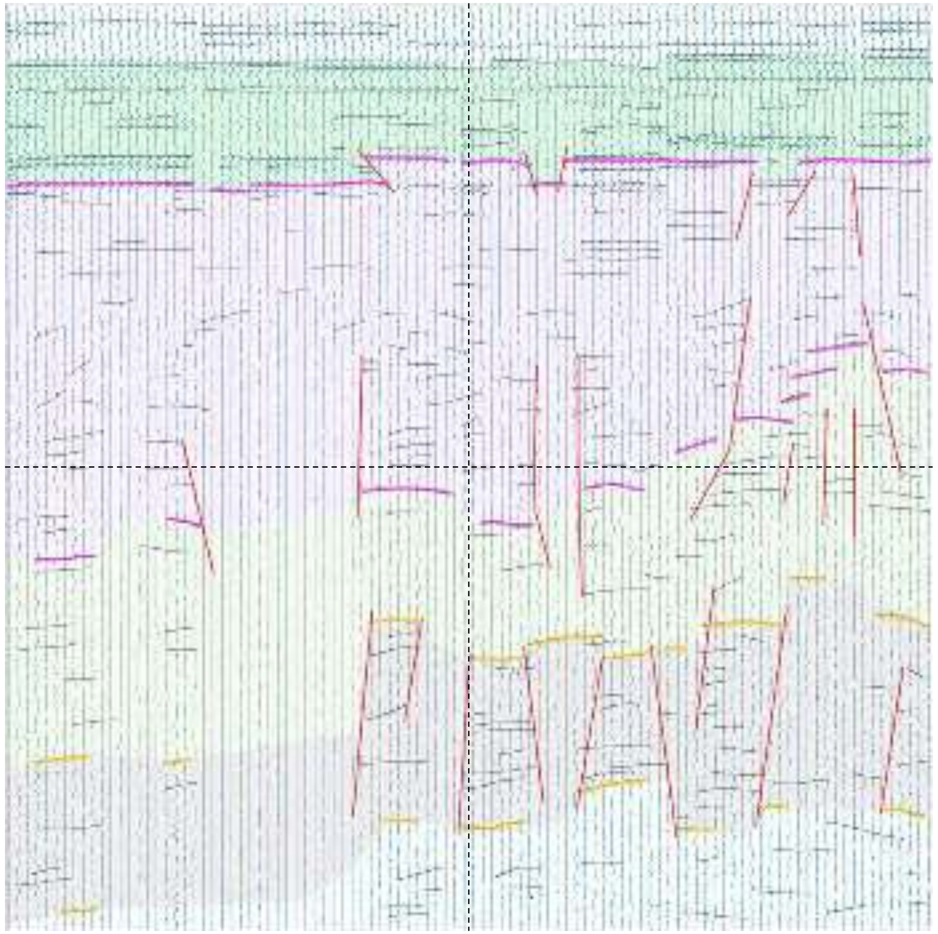


P-Scan Transect – Validation with Seismic

0m

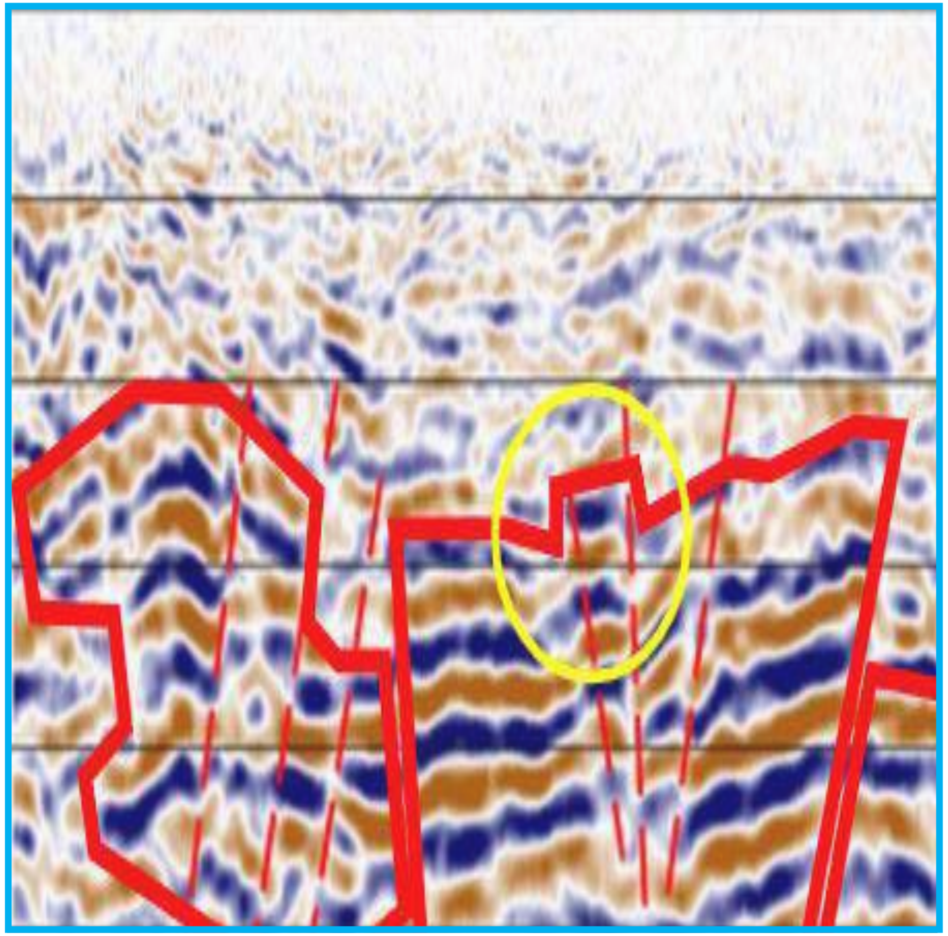
250m

500m

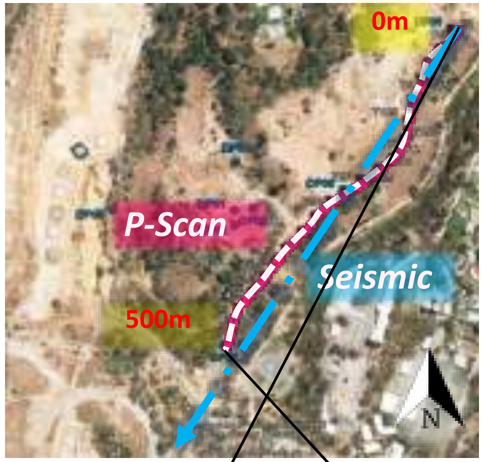


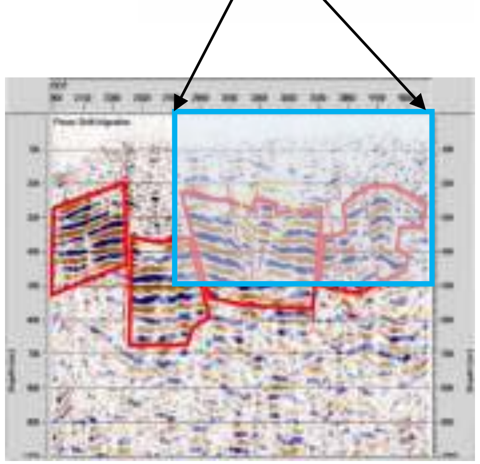
0m 250m 500m

Approximated 0-500m



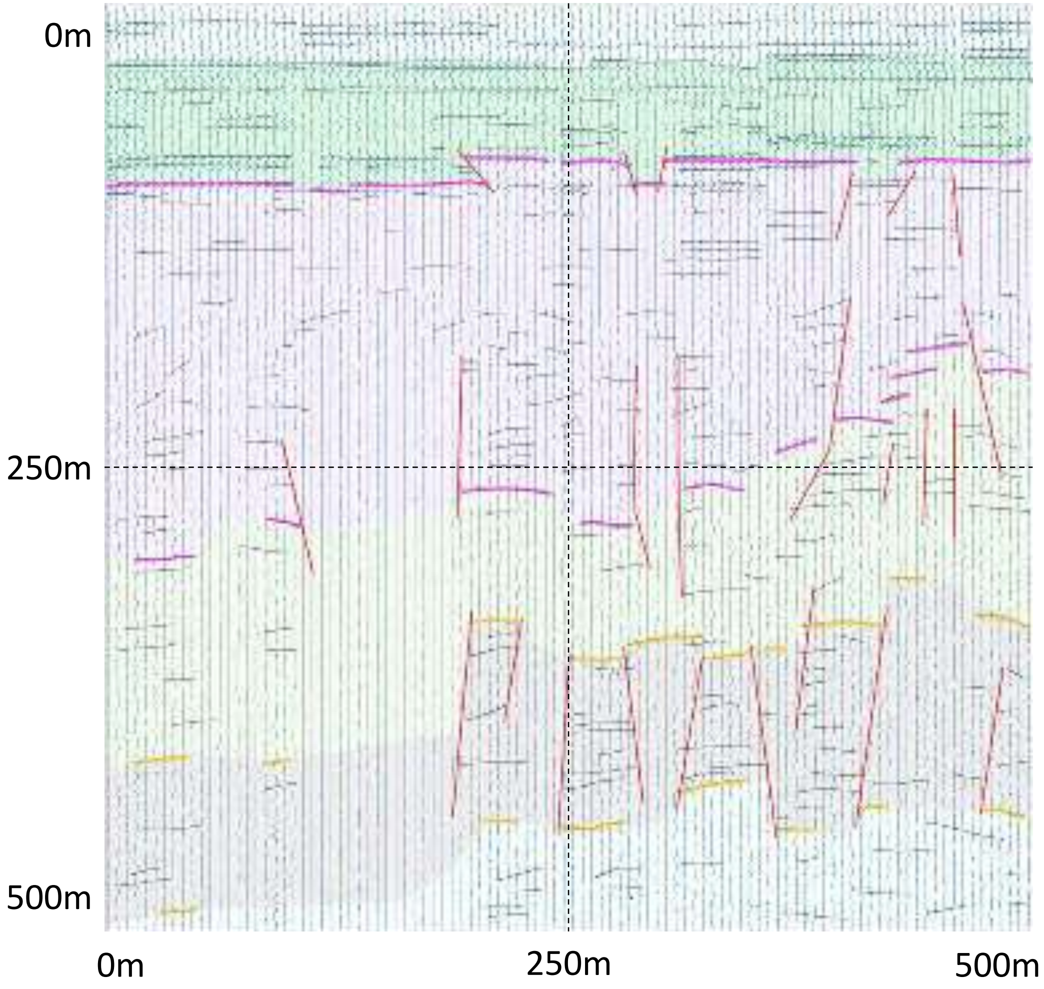
Approximated chainage coincidence

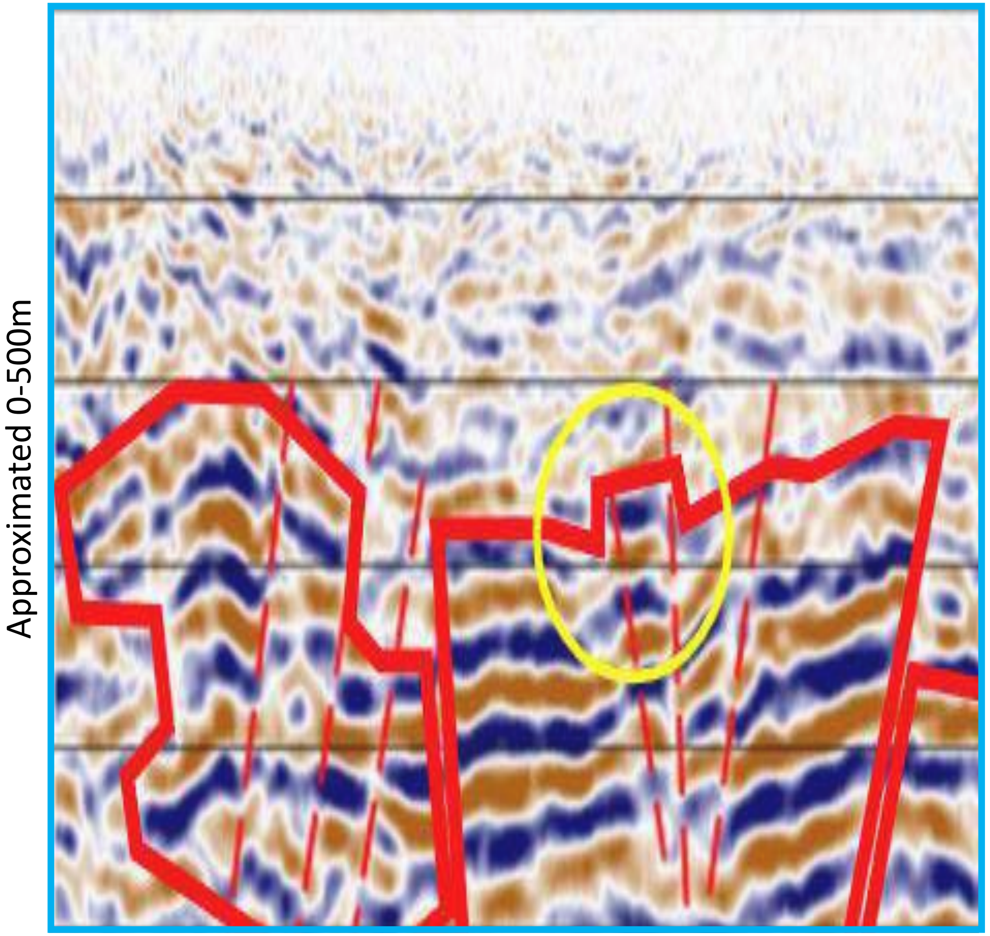




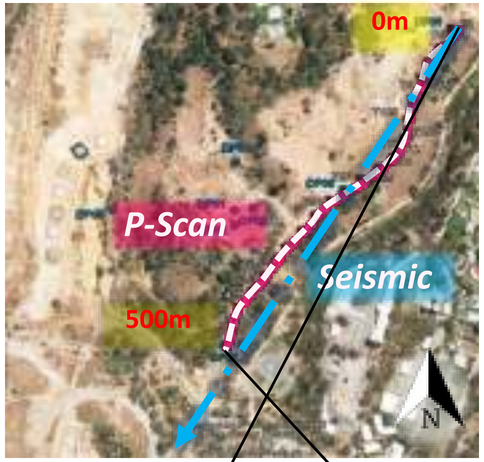
- Side by side view of the interpreted Energy Mean Transect, interpreted by Octavio Delgado and the corresponding approximate section of the Seismic image, interpreted by Simon Richards. On the right, the relative positions of the transect and the seismic profile are shown, as well as the whole seismic profile, and the corresponding area.

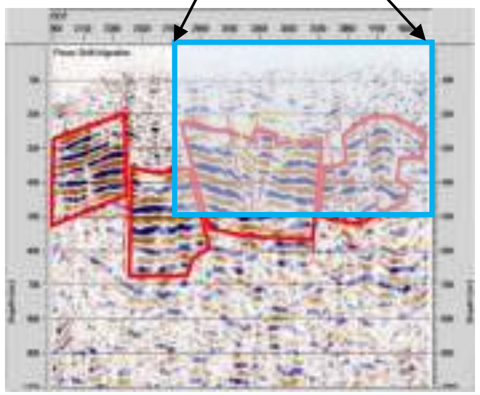
P-Scan Transect – Validation with Seismic



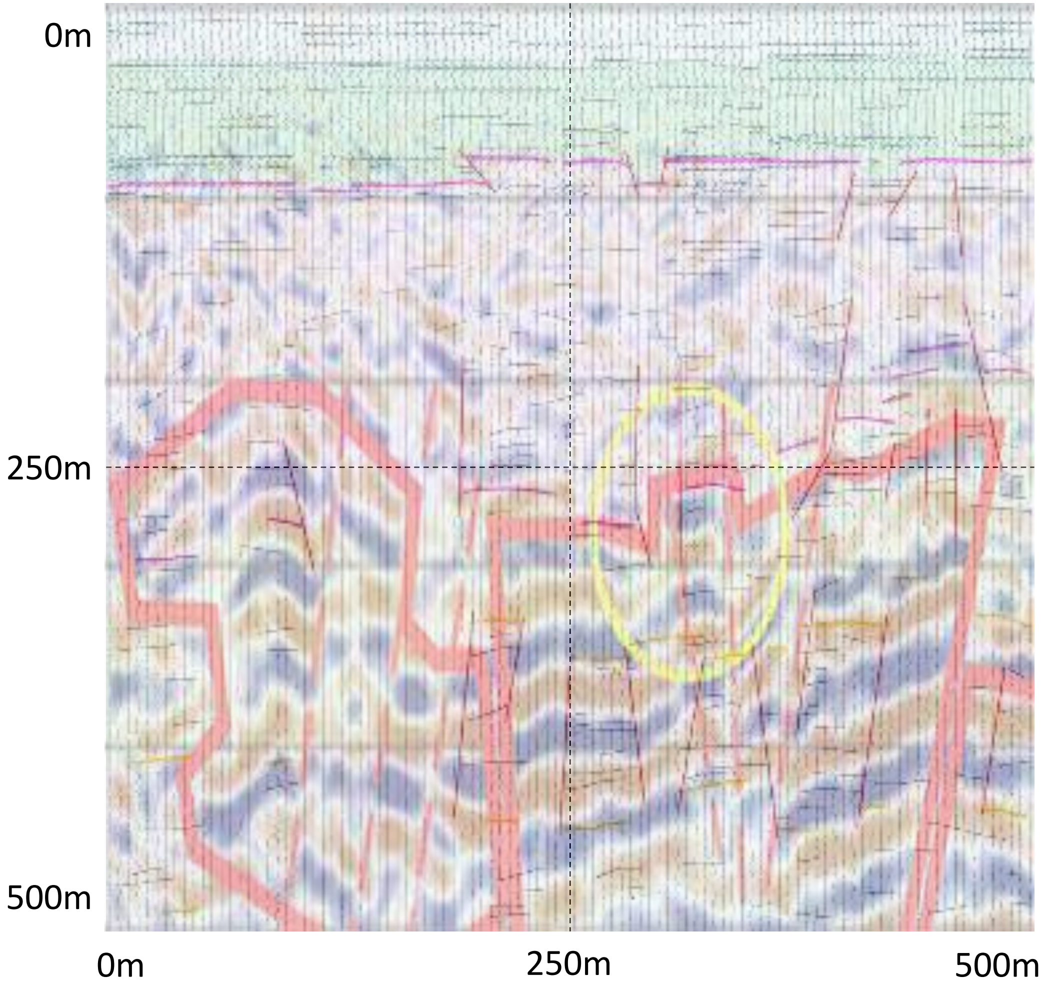


Approximated chainage coincidence





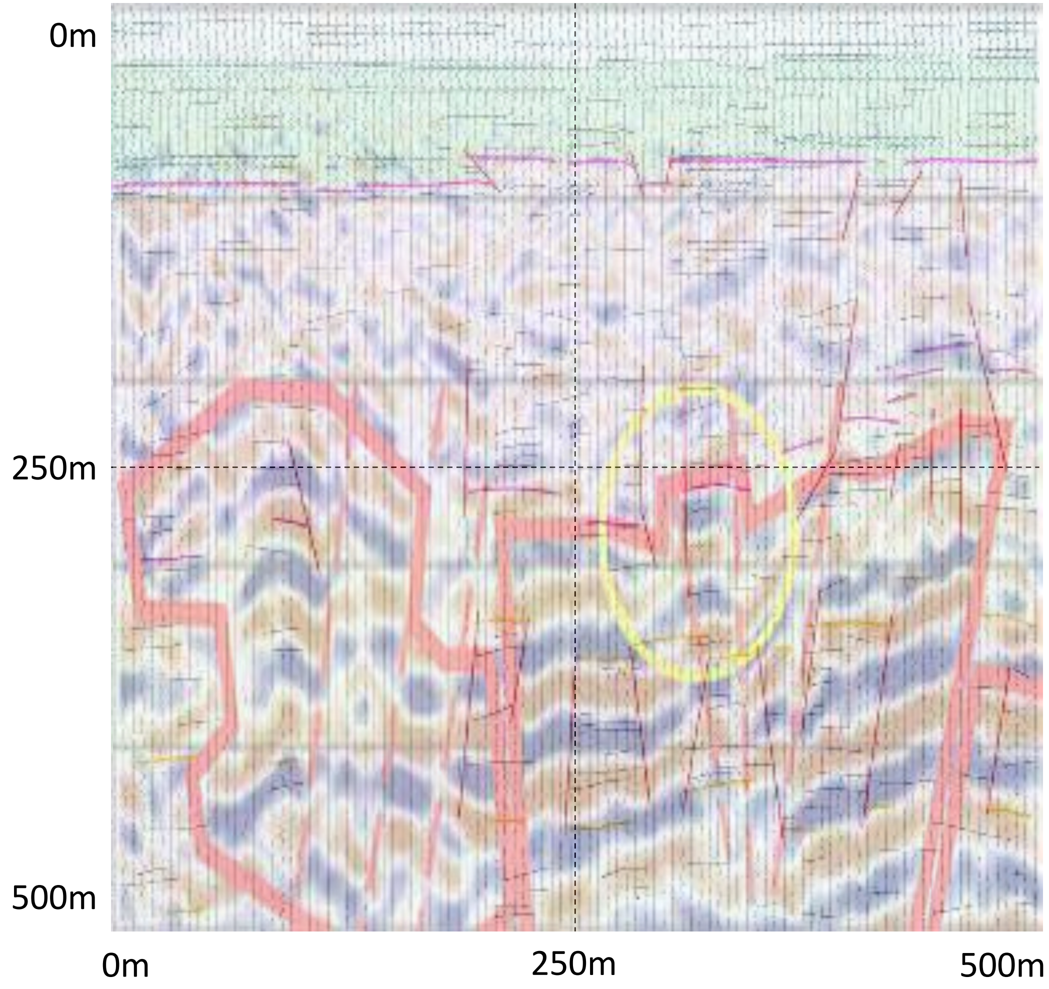
P-Scan Transect – Validation with Seismic



Approximated chainage coincidence 0-500m

- Overlay of the seismic profile onto the E-Mean transect.
- Firstly, the not so good:
  - The first observation is that the two readings operate at different scales, the E-mean works at a metric scale, while the seismic is best at decametric features, this is to be expected, due to the difference in data density.
  - Secondly, it appears as though seismic impedance and E-Mean are not immediately tied together, in the sense that areas with higher impedance don't necessarily correlate with areas more densely populated, or vice versa. This is to be expected, as those are two different physical parameters.
  - Lastly, the seismic scan shows a definitive increase in responses around the mineralised area, while the E-Mean does not show any major indication of the mineralisation.

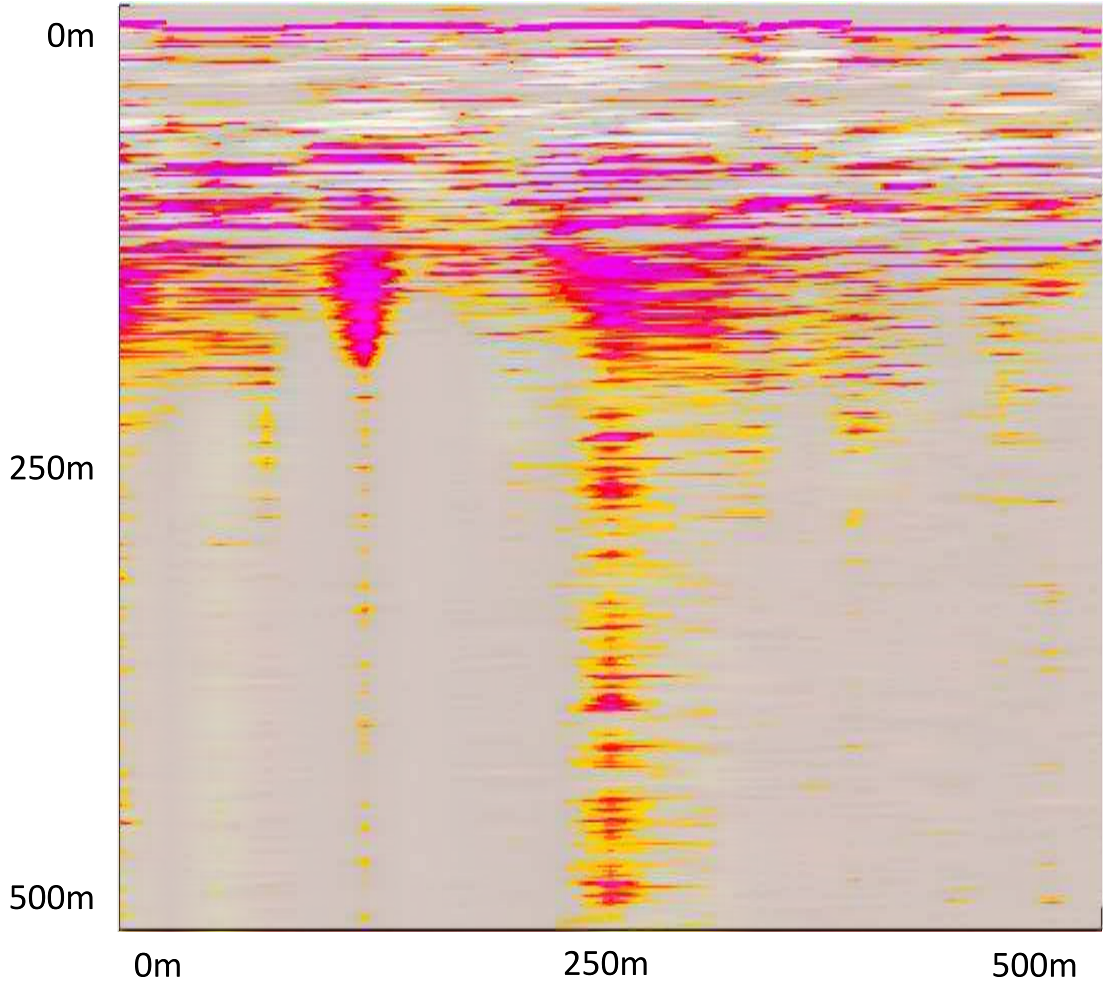
P-Scan Transect – Validation with Seismic

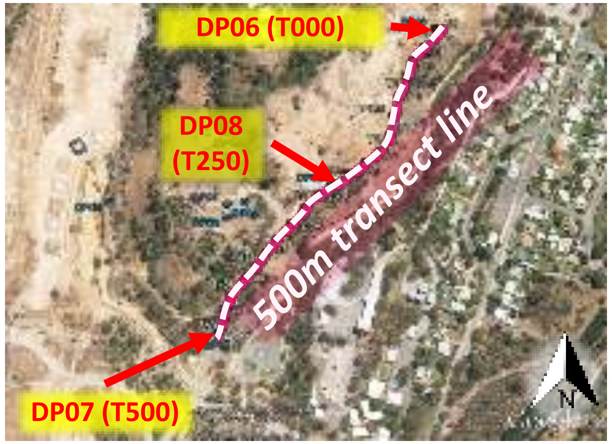


Approximated chainage coincidence 0-500m

- Overlay of the seismic profile onto the E-Mean transect.
- Now, the similarities and the good stuff:
  - The most striking similarity is that many of the major faults are detected with very similar trends and positions.
  - The second marker horizon coincides with the major impedance increase of the section.
  - The major dips and thickness variations of the units correspond between the interpretation of the Seismic and the E-Mean dataset.
  - The area marked in yellow, marks the area with strong mineralisation, for which both the seismic and the E-Mean detect as being bound by faults.
  - Finally, it's important to point out how the E-Mean transect is much better than the seismic at imaging the features of the first 100m.

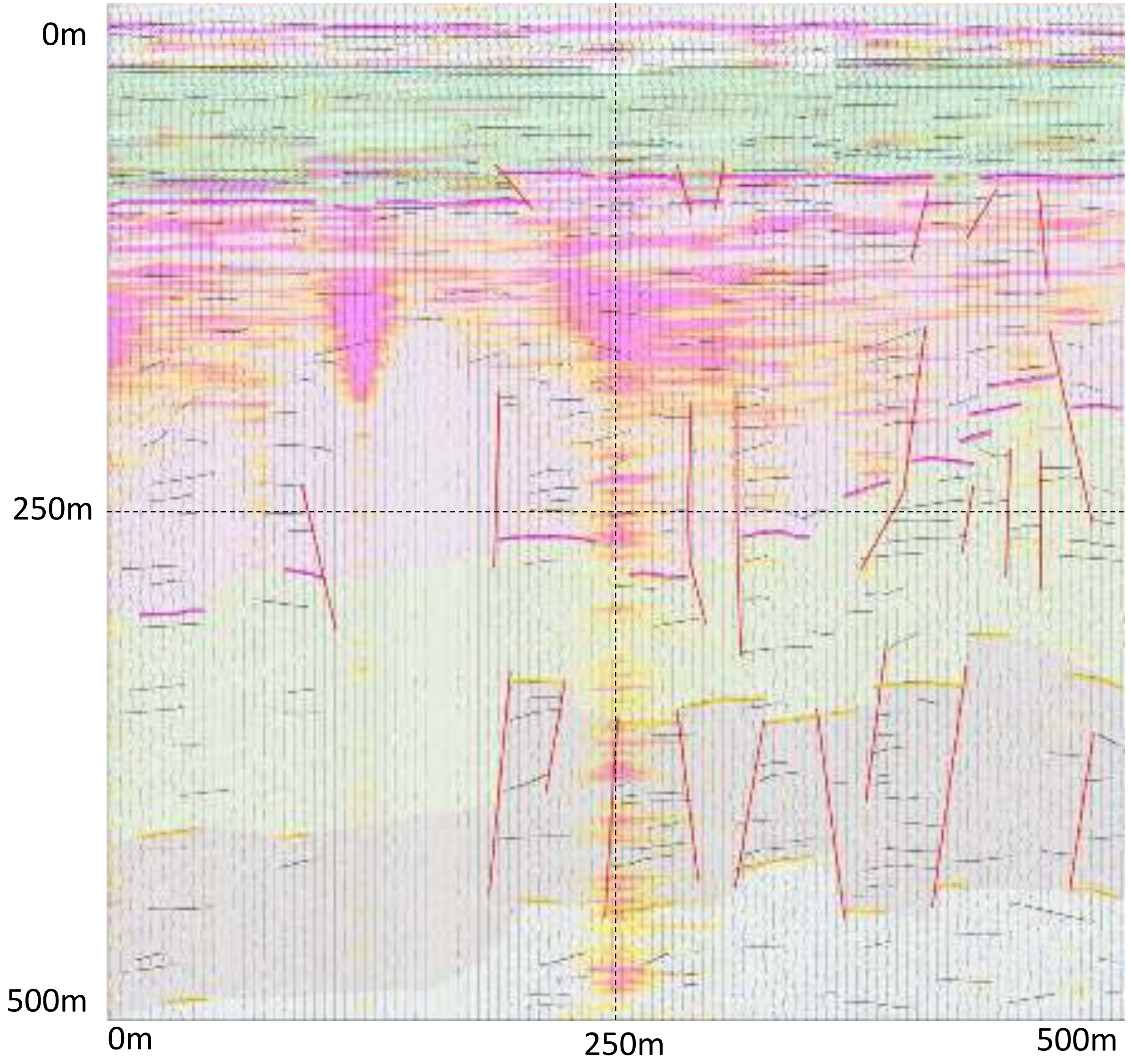
Stare Transect – Repeatability of 00136 VS 00231





- By superimposing the two images, we can see the same important features, with the newest processing bringing more impactful changes and better resolution.

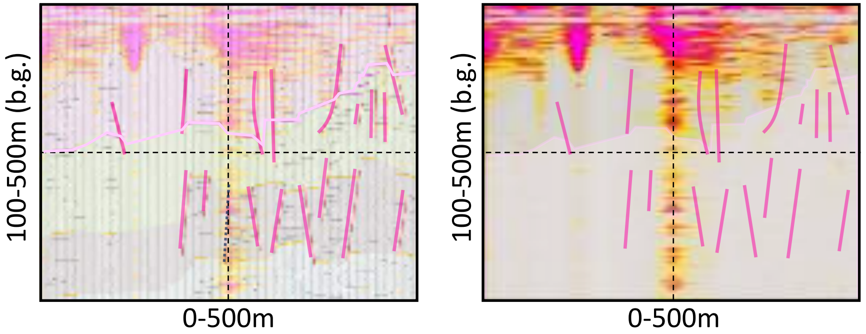
Repeatability of features between Transects

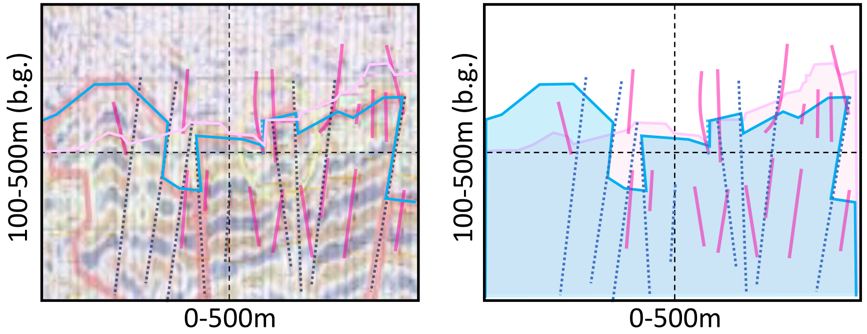


- Overlay of the Stare Transect onto the P-Scan Transect.
  - The Stare Transect offers much better vertical contrast, even, although is not as proficient at marking the laterally continual features.
  - Most of the features shown in the Stare Transect can also be imaged from the P-Scan transect, both images offer a useful complement to one another.
  - The Stare transect excels at showing areas with significantly higher or lower energy.
  - The P-Scan transect excels at mapping structures.
- Ultimately, the two datasets, collected with different scan modes over the same line, offer a great amount of coherence and repeatability in imaging the subsurface features that respond to the E-mean harmonics.

Conclusions on Transects for Sulphide Identification

- The work completed in the Stare and P-Scan transect datasets assess whether Harmonic Energy Mean is a satisfying 2D tool with which to image the structures and sulphides of the subsurface.
- We have proved the repeatability of the features between Stare and P-Scan datasets, ensuring that both are able to pick the same heterogeneities and features in the subsurface.
- We have proved the validity of the E-Mean interpretation by comparing it to the coincidental Seismic profile, ensuring that we are able to track major marker horizons as well as the most relevant faults and structures.





- I conclude that the Profile Scan Harmonic Energy Mean (128px) wiggle plots are a useful tool to image structures of the subsurface, and recommend that we use it more commonly.
- However, it’s important to note that it has not been successful at directly imaging the sulphides, so the use of v-bores is still of importance.
- This method coupled with sulphide identification methods such as the WofE will be able to produce very good deposit-scale level models of mineralisation and structure.