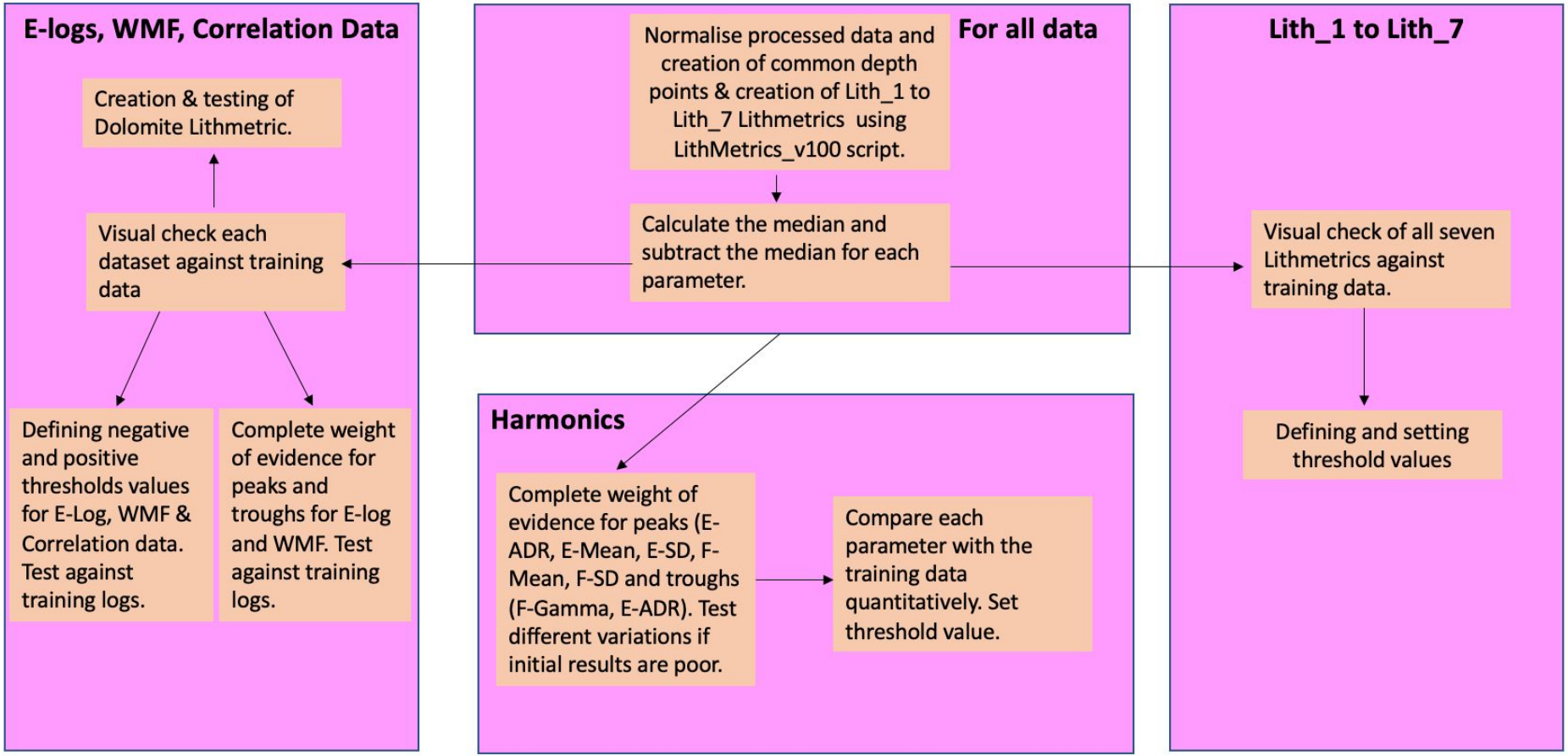
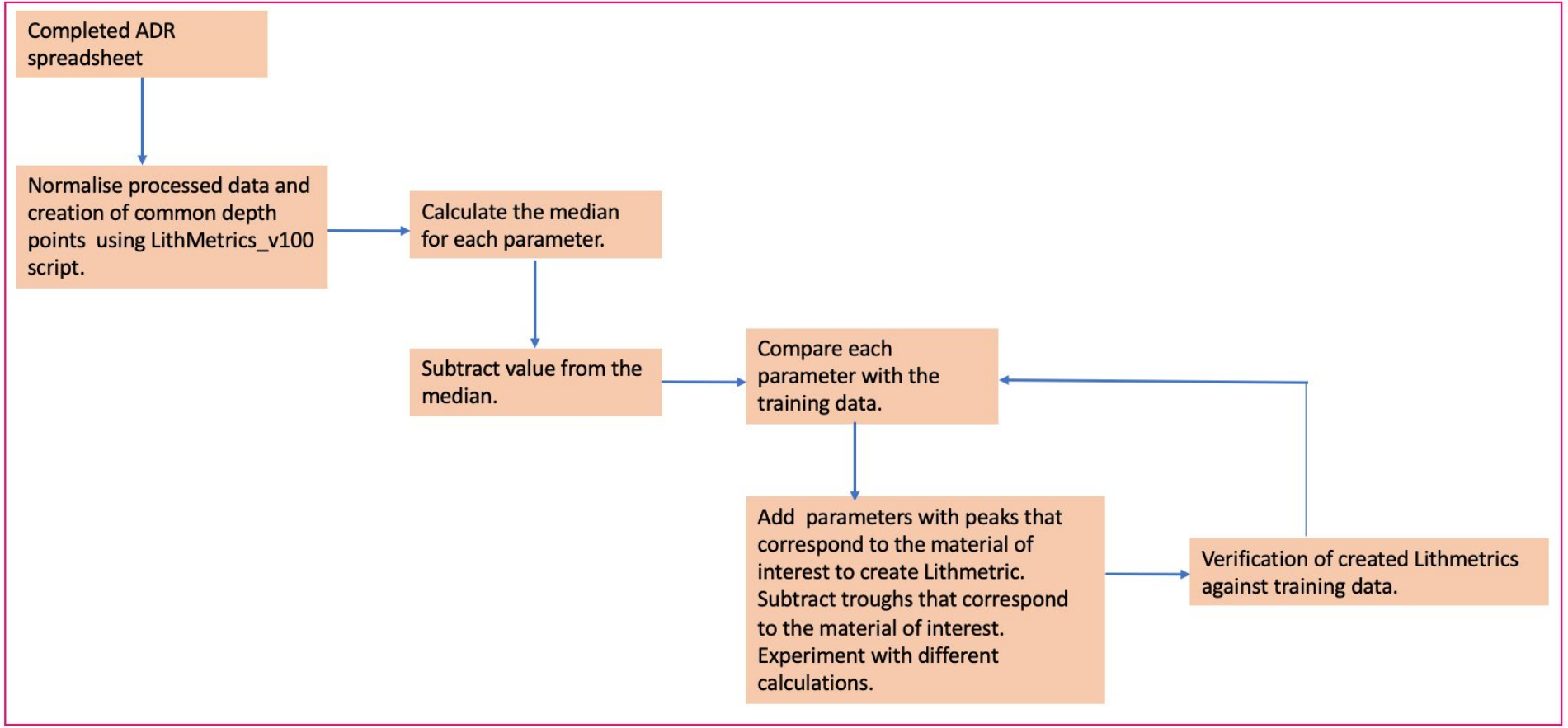
00232 Lithmetrics

- This report covers all aspects of Lithmetrics carried out on the 00232 dataset.
- This project provides an update on tests that showed promise on previous projects and is followed by some new tests that have been applied to this dataset.
- The aims were to see if Lithmetrics could be used to identify changes in lithology and then apply positive findings to the blind sites.
- Because much of the shallower units aren't seen due to the beam saturation, the main focus was firstly on identifying dolomites and breccias but secondly the base of the Waulsortian Limestone.

Overall methodology steps for this project



Difference from the Median Method



Difference from the median method

Depth (m)	Depth (ft)	E-Log MA3	Median	Difference to Median
150	492.126	0	0.3493	-0.349298
151	495.407	0.666667	0.3493	0.317369
152	498.688	0.8	0.3493	0.450702
153	501.969	0.842498	0.3493	0.4932
154	505.249	0.951795	0.3493	0.602497

Parameter (normalised to 0-1)

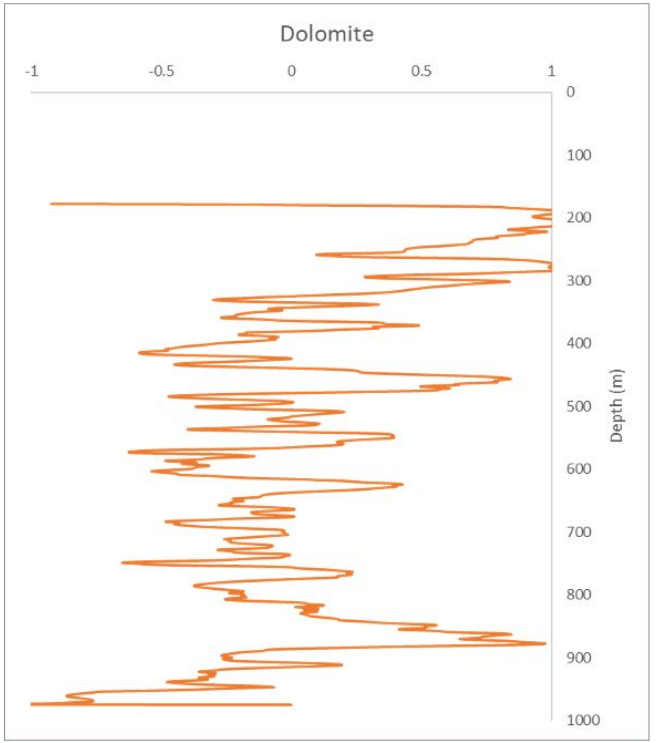
Median for full each parameter dataset

Median subtracted from parameter

- Top XXm cropped from the dataset because of beam saturation. This was different for each V-bore.
- Medians were calculated for each dataset.
- The differences from the median are then calculated.
- Lithmetrics were then created by adding peaks in parameters at identical depth and subtracting troughs in parameters at identical depths.
- Data range for parameters limited to -0.5 to + 0.5 to identify peaks in parameters with a smaller range.

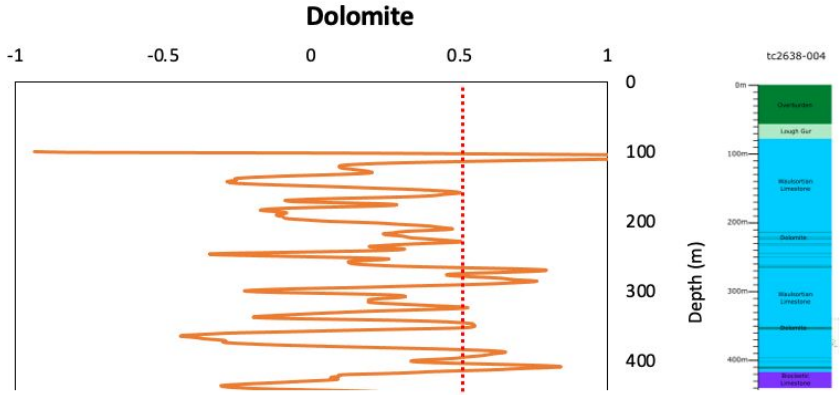
Dolomite (Difference from the Median)

- After comparing the difference from the median method graph for each parameter visually against the training logs a calculation was devised that could be tested against all the training sites.
- The WMF and the Correlation criteria were used for trying to identify dolomites.
- These parameters were tested and combined into a single metric because the harmonics have previously been used successfully for establishing relationships with sulphides.



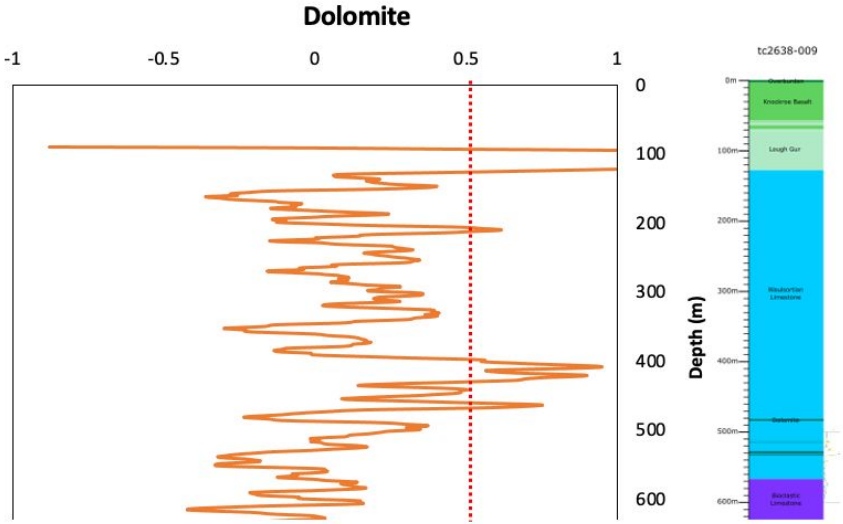
Equation used.
Corr 5-10MHz + Corr 1-5MHz + WMF

Difference from the Median: tc2638-004



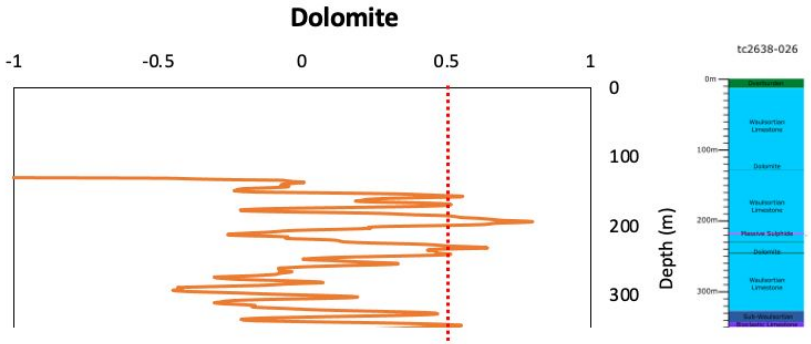
- Multiple thinner dolomites also present.
- Values above 0.5 show some good matches for dolomites in the larger sections shown in the figure, although some of the smaller examples above 150m are not seen.

Difference from the Median: tc2638-009



- Multiple thinner dolomites also present. However even the thinner examples within the Waulsortian are not identified by the Lithmetric.
- Values above 0.5 show some good matches for dolomites.

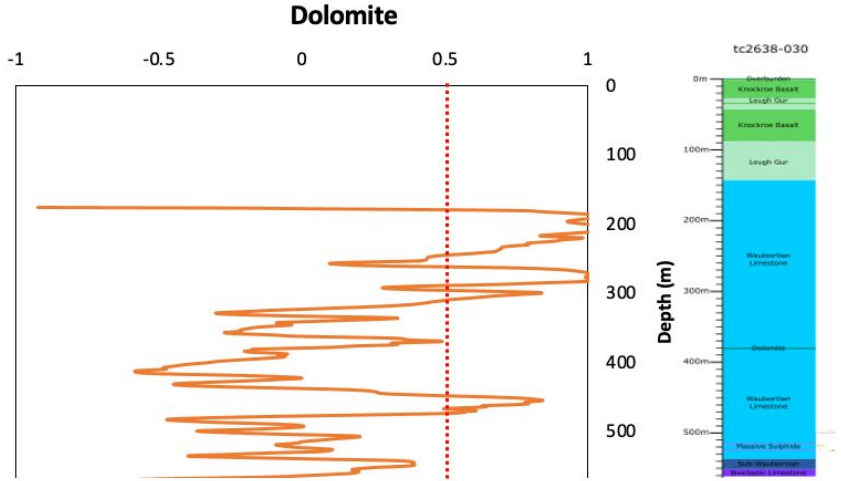
Difference from the Median: tc2638-026



- Multiple thinner dolomites also present. However even the thinner examples within the Waulsortian are not identified by the lithmetric at 120-140m.

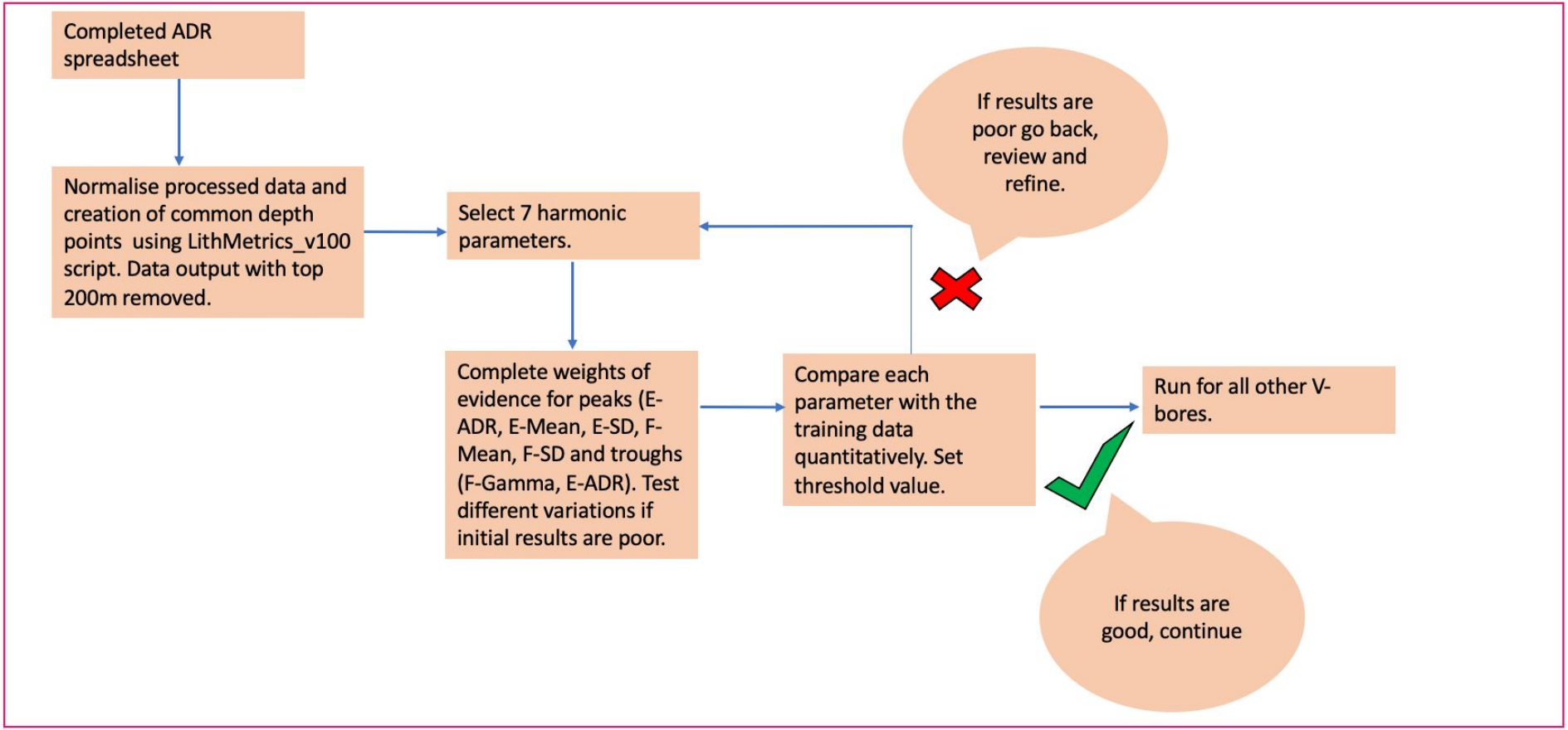
- Values above 0.5 show some good matches for dolomites at 250m and there seems to be an inverse relationship between the dolomite lithmetric and the massive sulphide.

Difference from the Median: tc2638-030



- No obvious relationship between the dolomite lithmetric and the dolomite present in the drill log.
- Because the results are inconsistent in the four training sites, this method will not be used for the blind holes.

Flow diagram Weights of Evidence

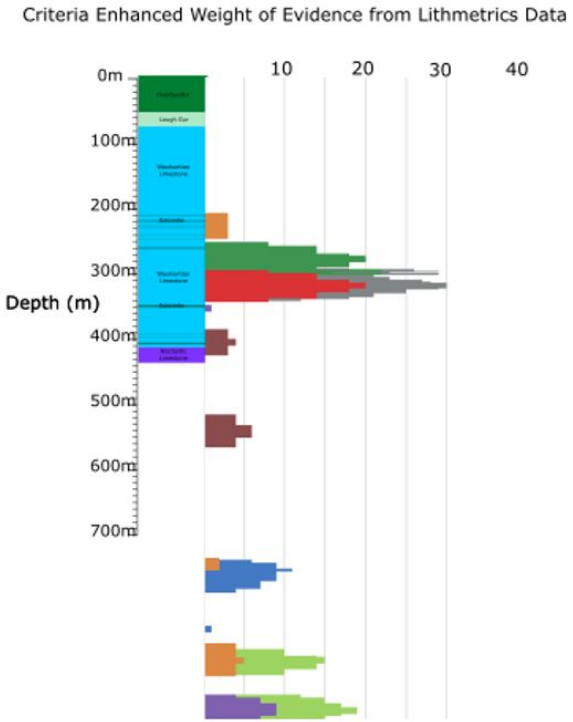


Weights of Evidence Method

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)

- This uses the same normalised data used for the difference from the median method.
- 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 (see *).
- *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.
- This gives a value more similar to the estimated percentage of sulphides from the training data and only adds 1-1.5 hours to the analytical process.

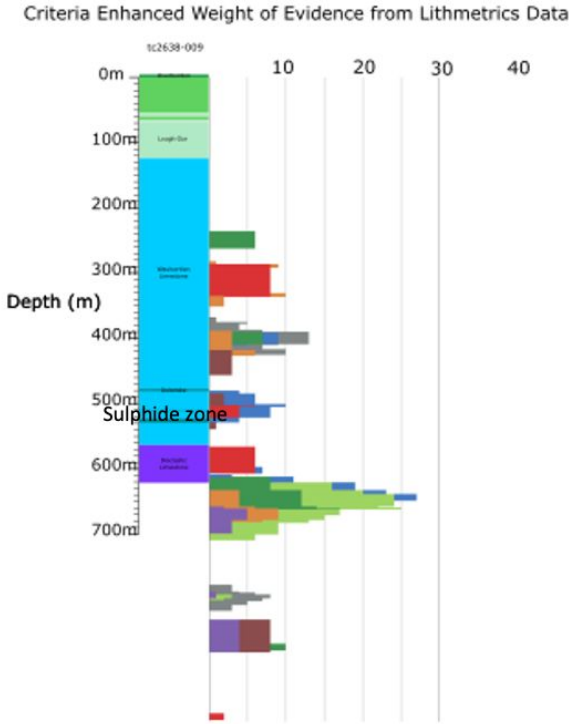
Lithmetrics Weights of Evidence: tc2638-004



- Metallic area is between 350-380m The weight of evidence method suggests the mineral zone is shallower between 280-380m. When the full training data is examined much of this area 280-350m is associated with breccia rather than Zn and Pb.

- There may also be further mineralisation below 500m with regular peaks as high as 19.

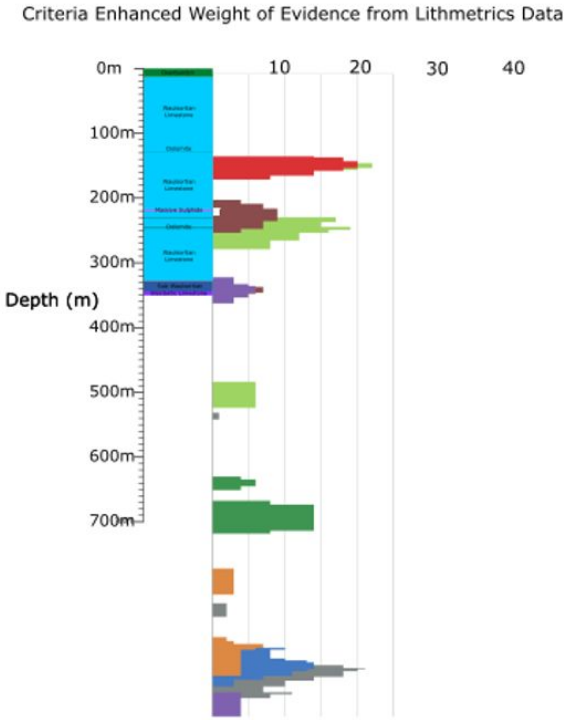
Lithmetrics Weights of Evidence: tc2638-009



- Metallic area is between 500-595m. This is identified using the weight of evidence method. However, there also appears to be multiple false positives at both 300m and 600m. When the full training data is examined, many of these are associated with breccias.

- There may also be further mineralisation below 600m with regular peaks as high as 28.

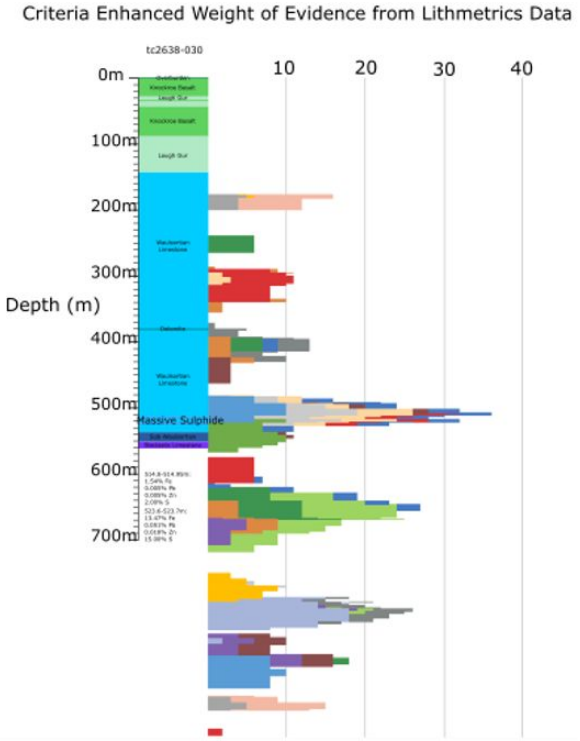
Lithmetrics Weights of Evidence: tc2638-026



- Metallic area is between 214-225m. This is identified using the weight of evidence method. However, there are also false positives at 130-150m and 320-340m. The latter marks the change of formation from the Waulsortian in the sub-Waulsortian and the bioclastic Limestone. When the full training data is examined, many of these false positives are associated with breccias.

- There may also be further mineralisation below 500m with regular peaks as high as 20.

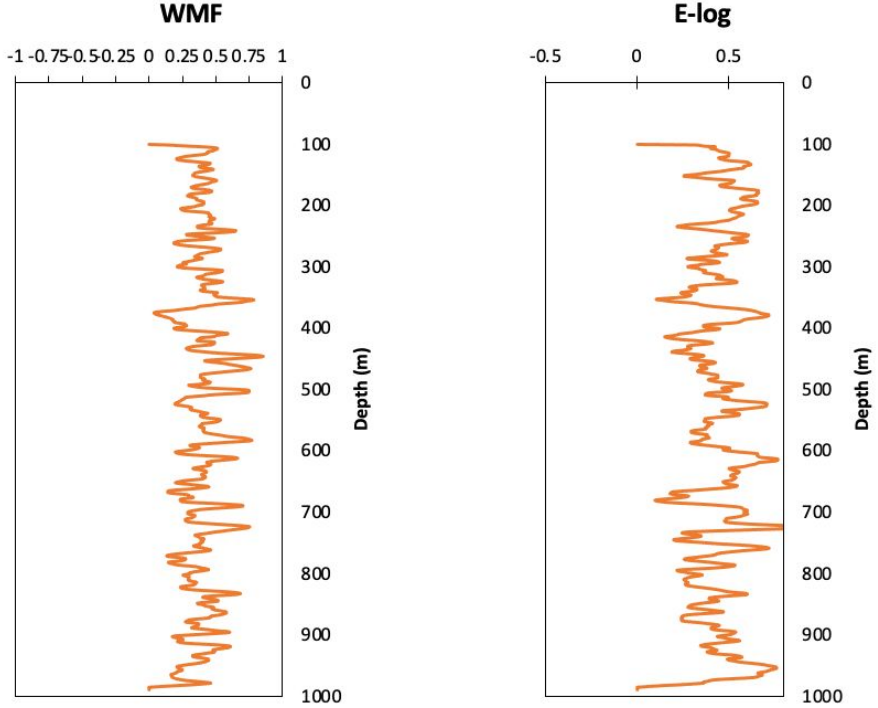
Lithmetrics Weights of Evidence: tc2638-030

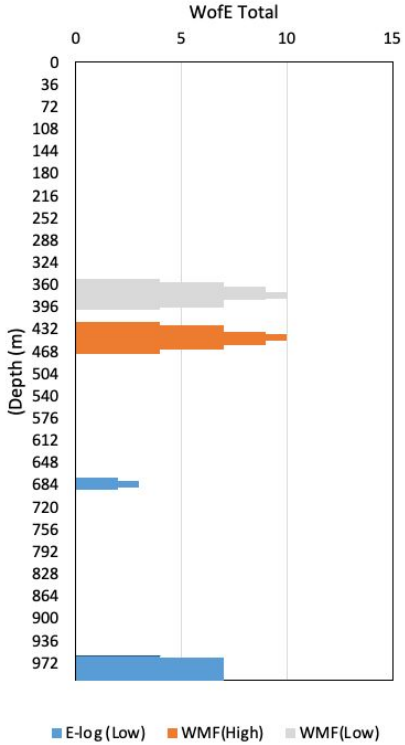


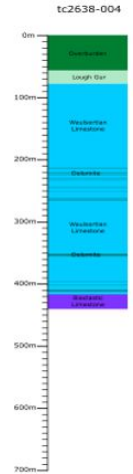
- Metallic area is between 516-527m. This is identified using the weight of evidence method. However, there are also false positives between 190-480m. The latter marks the change of formation from the Waulsortian in the sub-Waulsortian and the bioclastic Limestone. When the full training data is examined, many of these are associated with breccias.
- There may also be further mineralisation below 500m with regular peaks as high as 30.
- This method does offer promise as a tool for sulphides but there are multiple false promises many of which correspond with the breccias.

Weights of evidence using WMF and E-log

EWMF WofE: tc2638-004

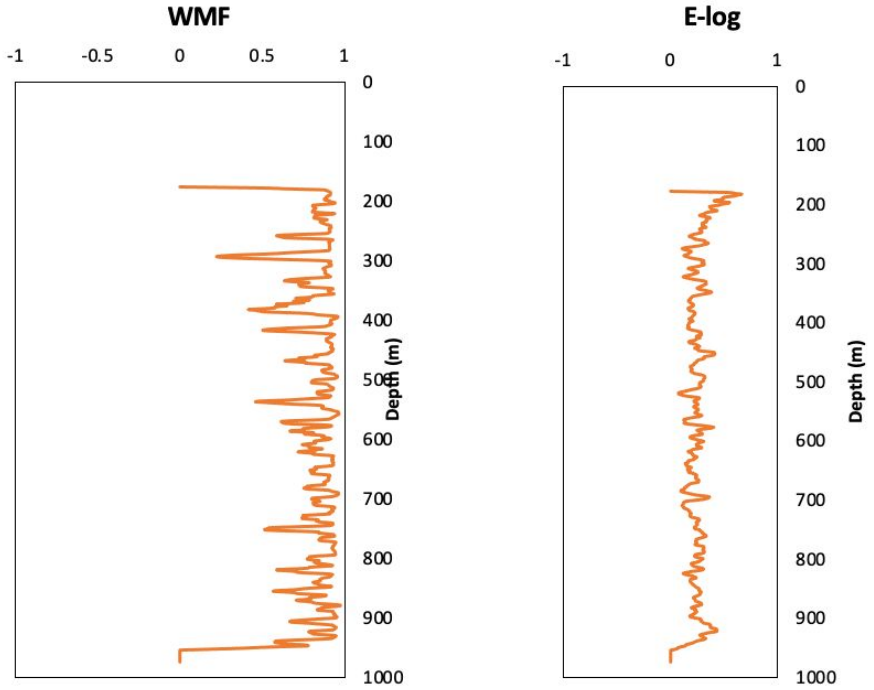


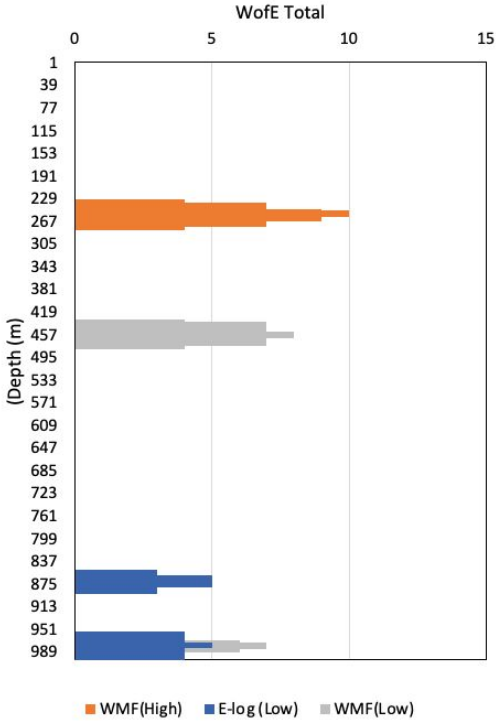


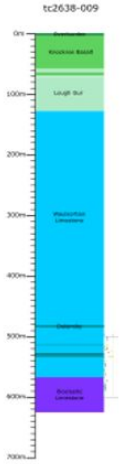


- No E-log lows correlate with the training data.
- Low WMF picks out the second deepest dolomite but no correlations with dolomite are seen.
- The High WMF identifies the Bioclastic Limestone.

EWMF WofE: tc2638-009

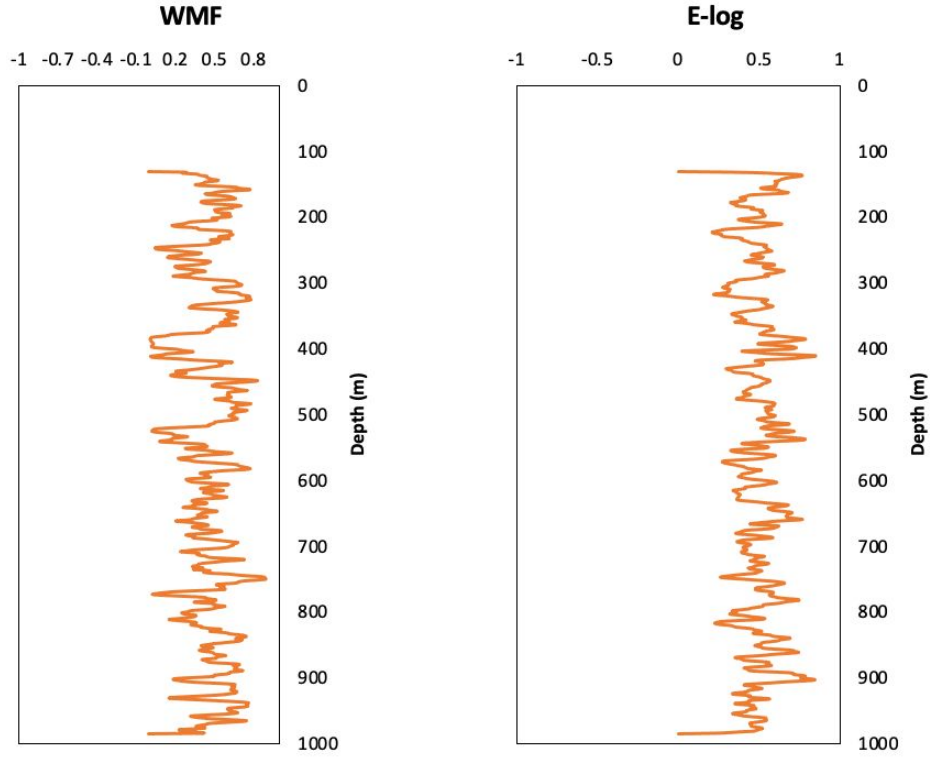


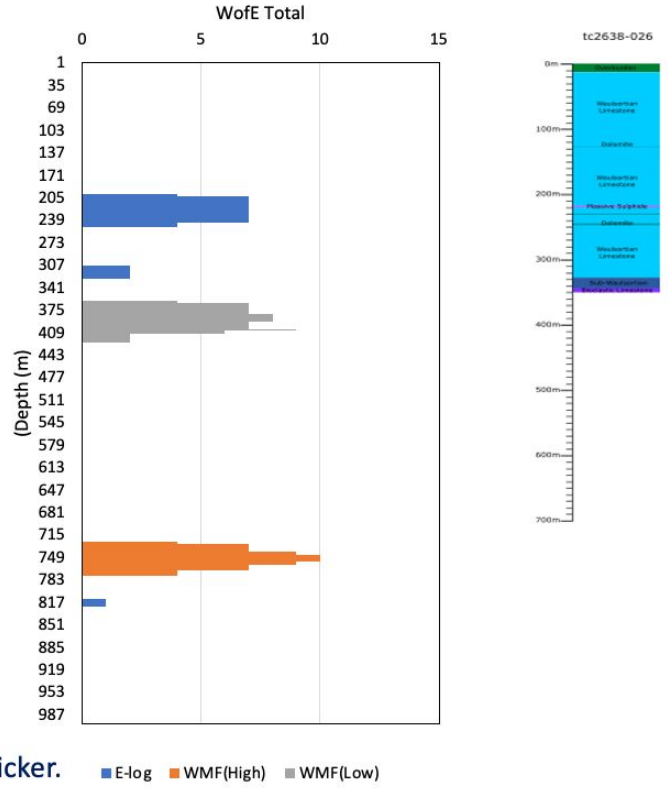




- The E-logs do not correspond to any known training data.
- The low WMF picks out the one of the dolomites but not the thicker section below 530m.
- The high WMF does not pick out any obvious change in lithology although there are highs in WMF corresponding to the Bioclastic Limestone.

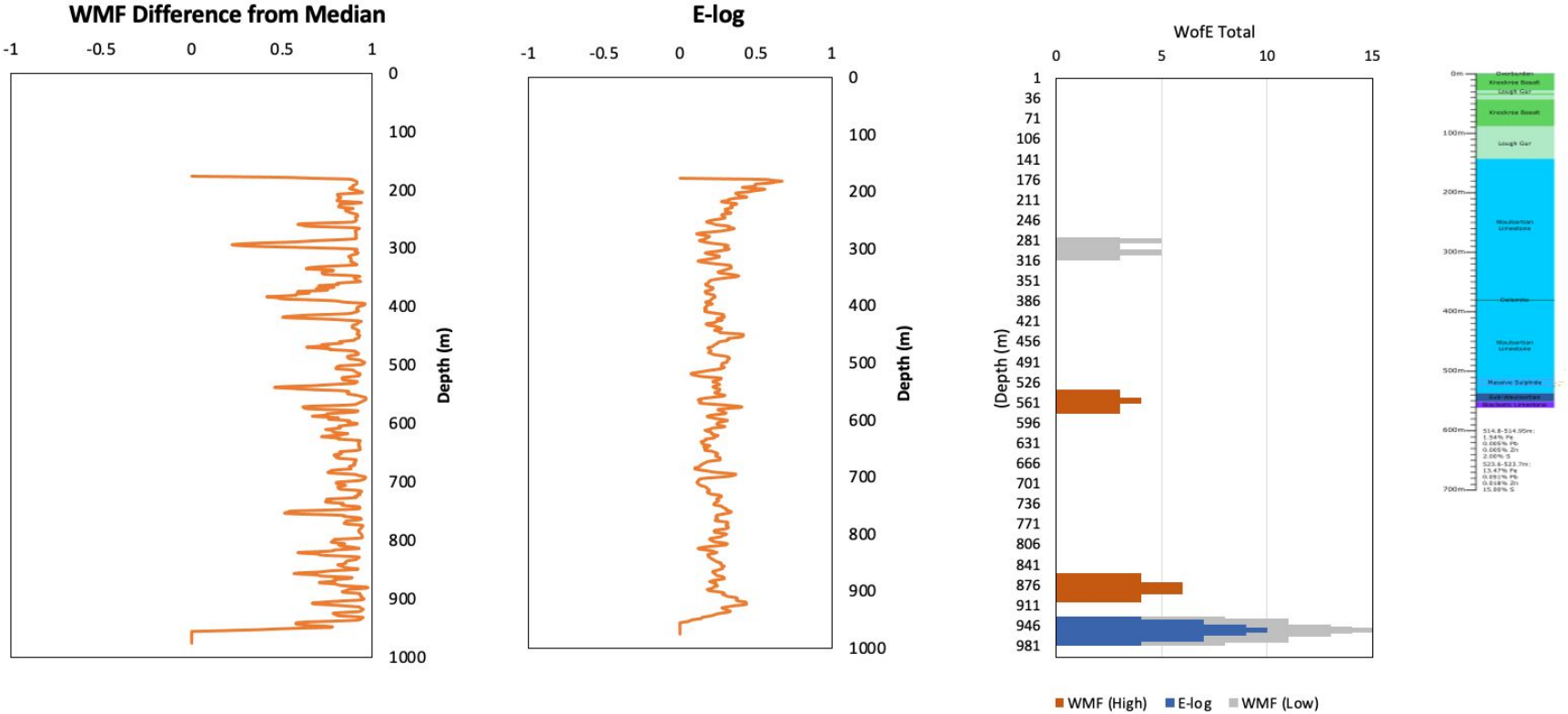
EWMF WofE: tc2638-026





- E-log lows are corresponding to the massive sulphides but the WSCC values are much thicker.
- The low WMF does not pick out any known lithological change.
- The highest WMF does not pick out of any known lithological change. However, peaks in WMF are seen corresponding the Sub-Waulsortian and Bioclastic Limestone.

EWMF WofE: tc2638-030



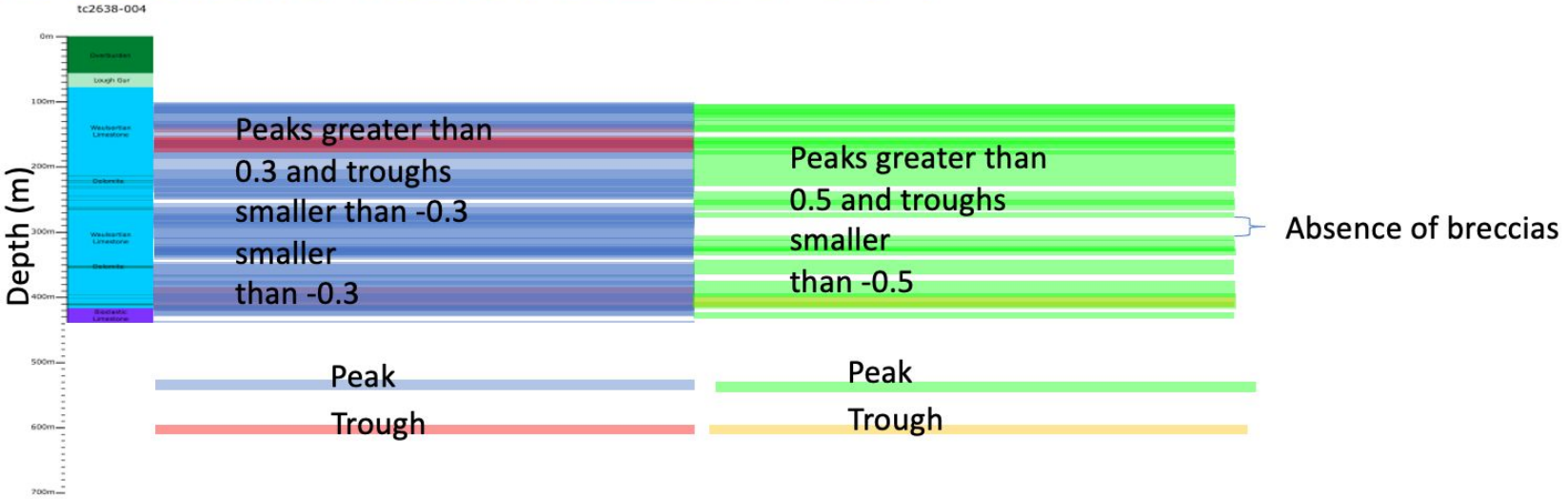
- E-log lows do correspond to the massive sulphides but the lowest values do not.
- Low WMF do not pick out any known lithological change, though the dolomite is picked out by a low value in WMF.
- Peaks in WMF are seen corresponding to boundary between Waulsortian and the Sub-Waulsortian.

Thresholds for Correlation, E-log, WMF

- A threshold value of +0.5 and -0.5 is applied to the difference from the median data for the following six parameters, E-log, WMF, Corr 1-5, SD 1-5, Corr 5-10 and SD 5-10.

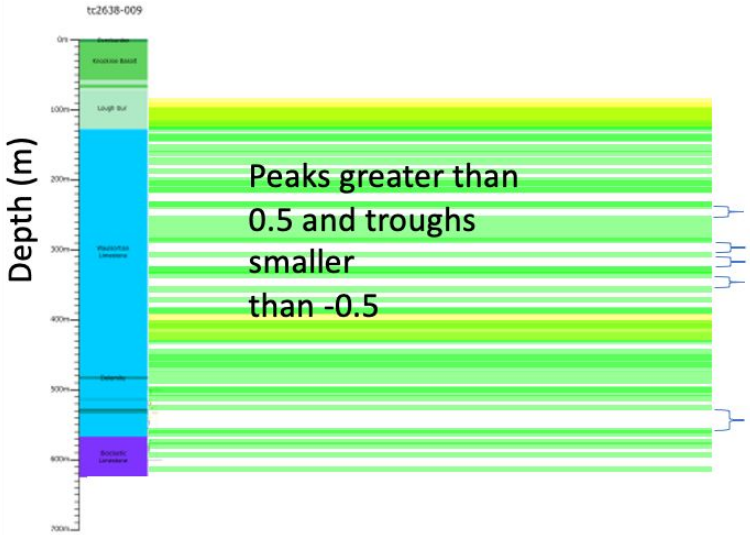
- Initially threshold values of -0.3 and +0.3 will also applied. However, these were seen too regularly throughout the test site, so after TC2638-04, only a threshold of +0.5 and -0.5 was used.

Threshold Tests: tc2638-004



- Troughs are only seen at 150m and 400m with a threshold of -0.5.
- Peaks are seen regularly once the beam saturation is taken into account.
- Large gaps are seen at 300m which might correspond to an absence in breccias but the remaining smaller gaps do not.

Threshold Tests: tc2638-009

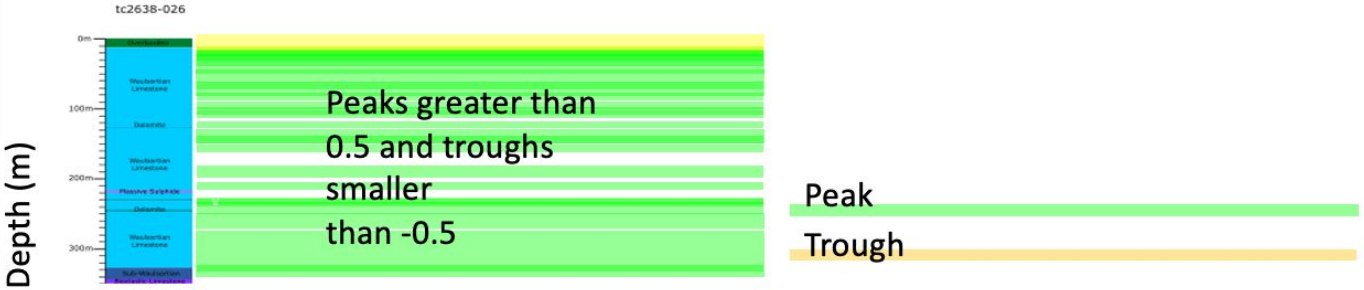


Peak

Trough

- Troughs are only seen at 100m and 400m and do not appear to correspond to any lithological change.
- Peaks are seen regularly once the beam saturation is taken into account though there are fewer close to dolomites.
- There is no association with gaps and lithology change.

Threshold Tests: tc2638-026



- Troughs are only seen at 100m and 400m and do not appear to correspond to any lithological change.
- Peaks are seen regularly once the beam saturation is taken into account some of these are associated with dolomites such as at 250m but others are not.
- There is no association with gaps and lithology change.

Threshold Tests: tc2638-030

Peak

Trough

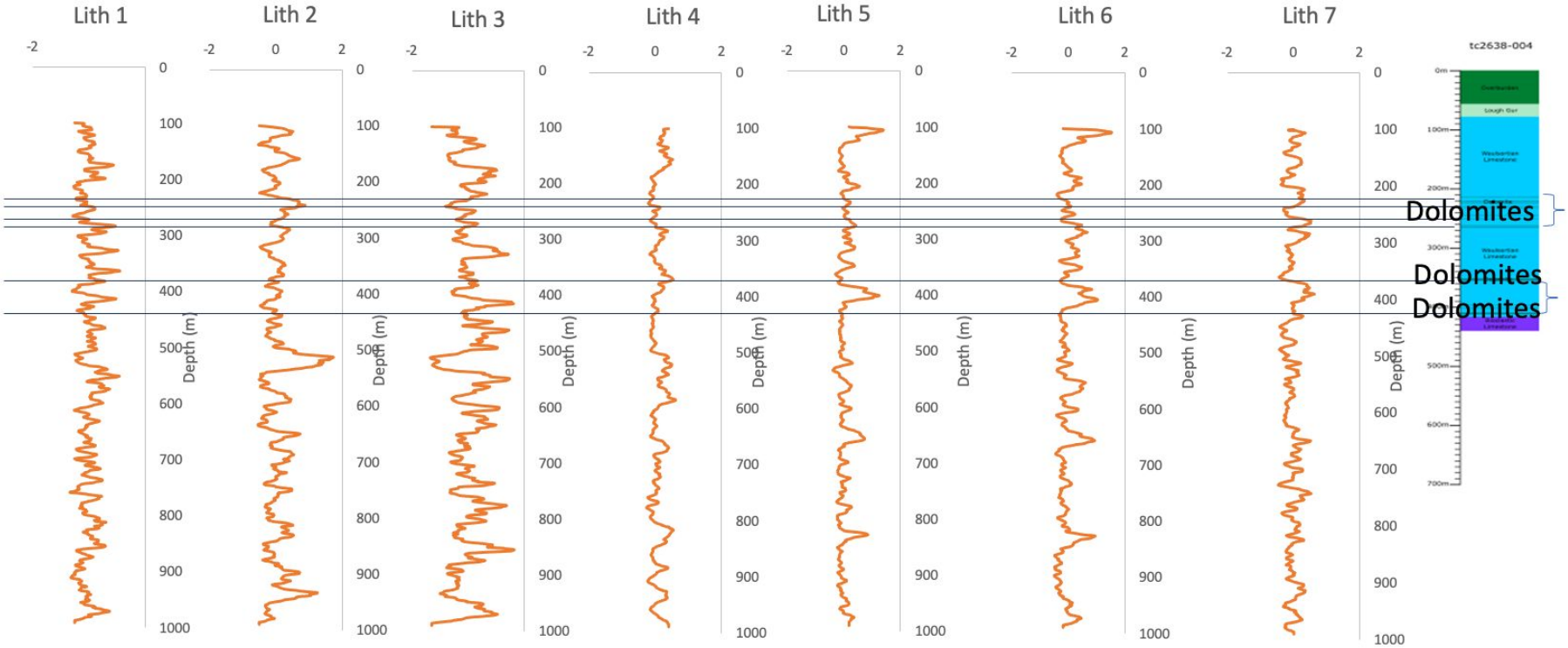
- Troughs are seen throughout the V-bore.
- Peaks are seen regularly once the beam saturation is taken into account some of these are associated with dolomites.
- There is no association with gaps and lithology change.
- There is no consistent relationship between lithology and the threshold data. This will be discontinued for the blind sites.

Seven Lithmetrics outputted from the script

Name	Formula
Lith_1	FADR*Fmean*EADR/Fgamma*FSD
Lith_2	Fgamma*Fmean*FSD/Emean*ESD
Lith_3	FADR*Egamma*Emean*ESD/Fgamma*FSD
Lith_4	FADR*EADR/Fmean*Emean*ESD
Lith_5	F-gamma*Egamma*Corr1-5/FSD*EADR*CorrSD1-5
Lith_6	FADR*Egamma*Corr1-5/Fgamma*CorrSD1-5
Lith_7	Fgamma*EADR*Corr5-10/FADR*Egamma*WMF

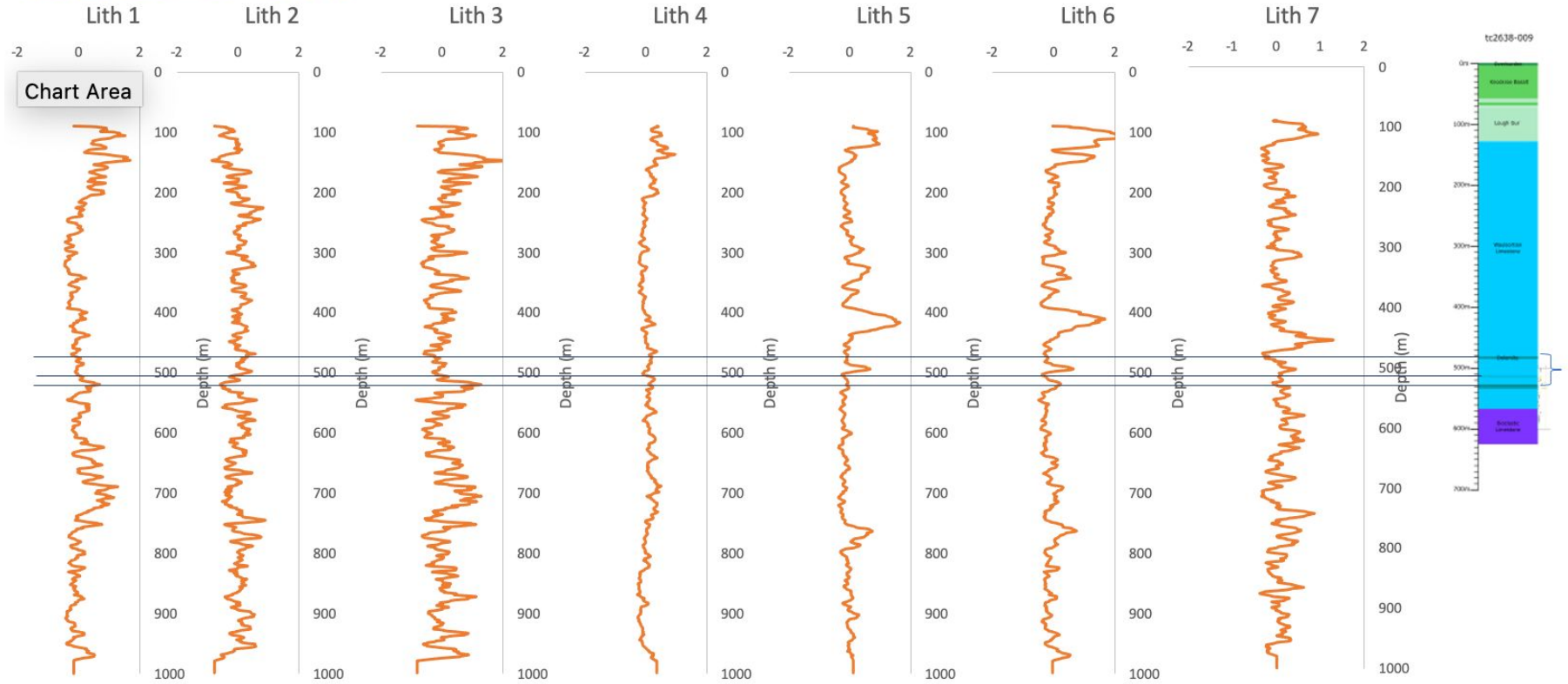
- All seven Lithmetrics output by the Lithmetrics script were compared with the training data to see if any parameters show any links with the training data.
- The majority of these use the harmonics dataset. However, Lith_5, Lith_6 & Lith_7 use either the correlation data or the weighted mean frequency data.

tc2638-004



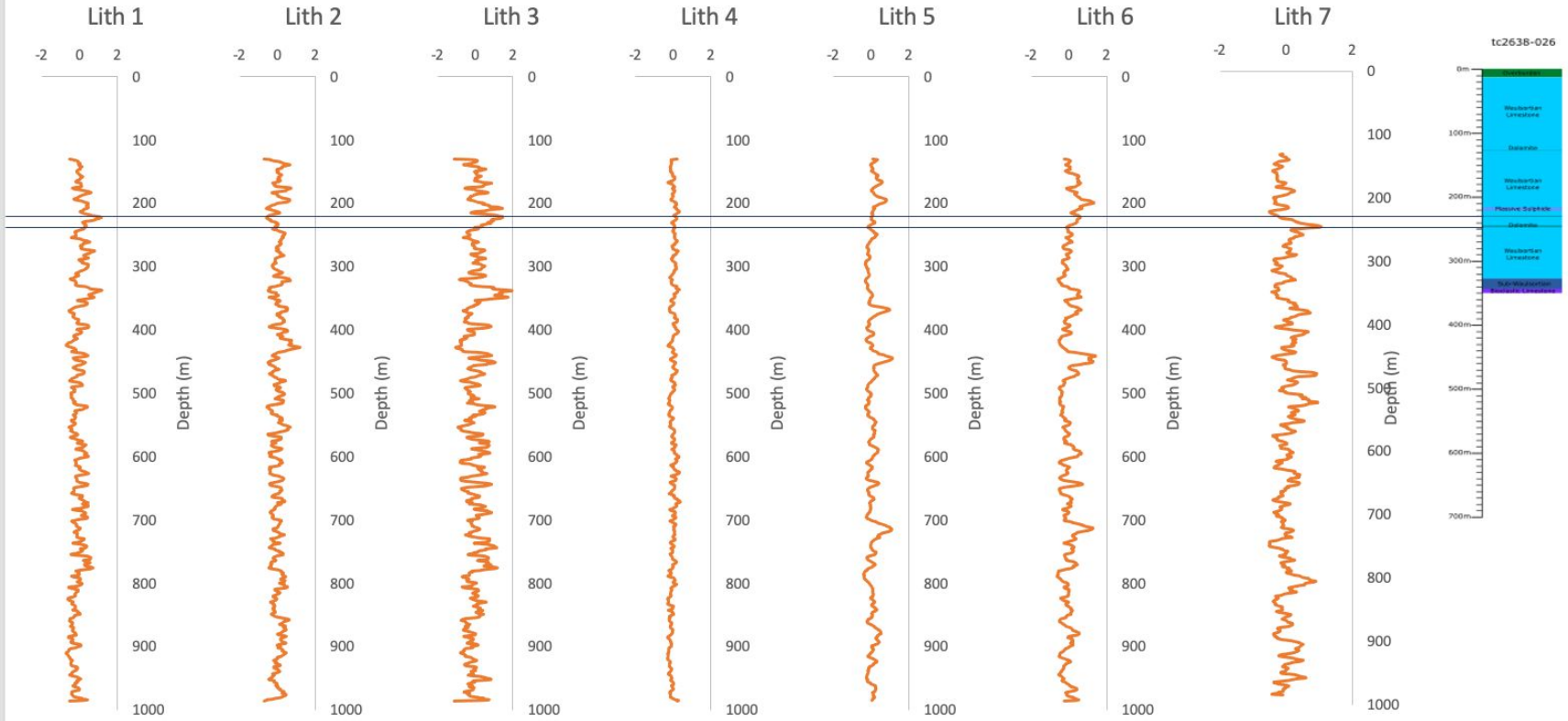
- In general peaks in Lith_7 are seen where dolomites are seen in the training log noted by the clustering at 200-280m and the relative absence of peaks between 280-360m.
- Lith_7 is the only one to show any kind of consistent relationship with the dolomites.

tc2638-009



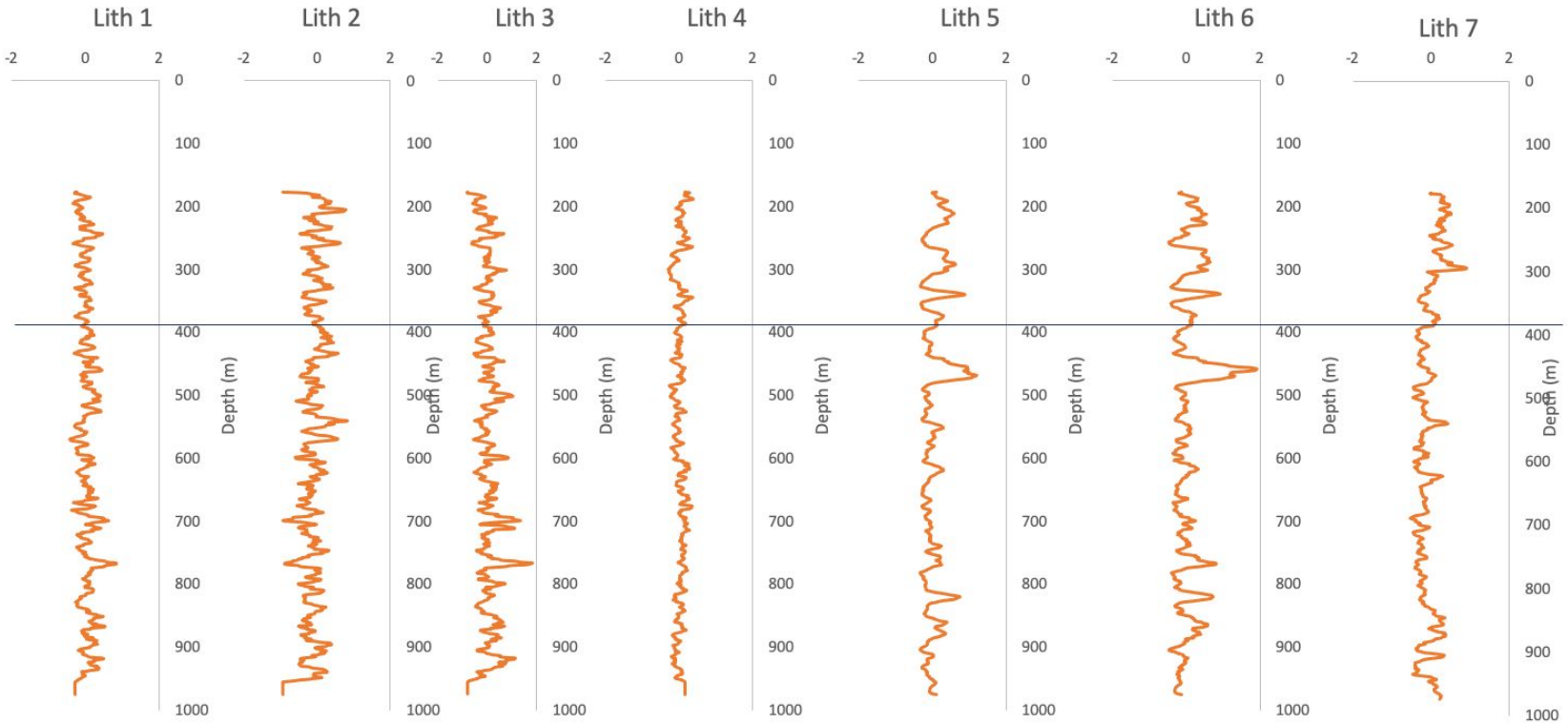
- The main area of dolomite is seen between 490-520m. This is matched by peaks in Lith_5 and Lith_6.
- According to the training data, cemented dolomite is seen at 440m. This closely matches the largest peak in Lith_7.

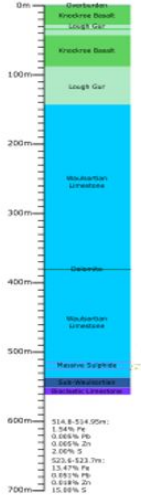
tc2638-026



- The main area of dolomite is seen between 240-260m. This is matched by a peak in Lith_7.
- This is also seen in Lith_3. However in Lith_3 a larger peak is seen in 320-330m which is not seen in Lith_7.

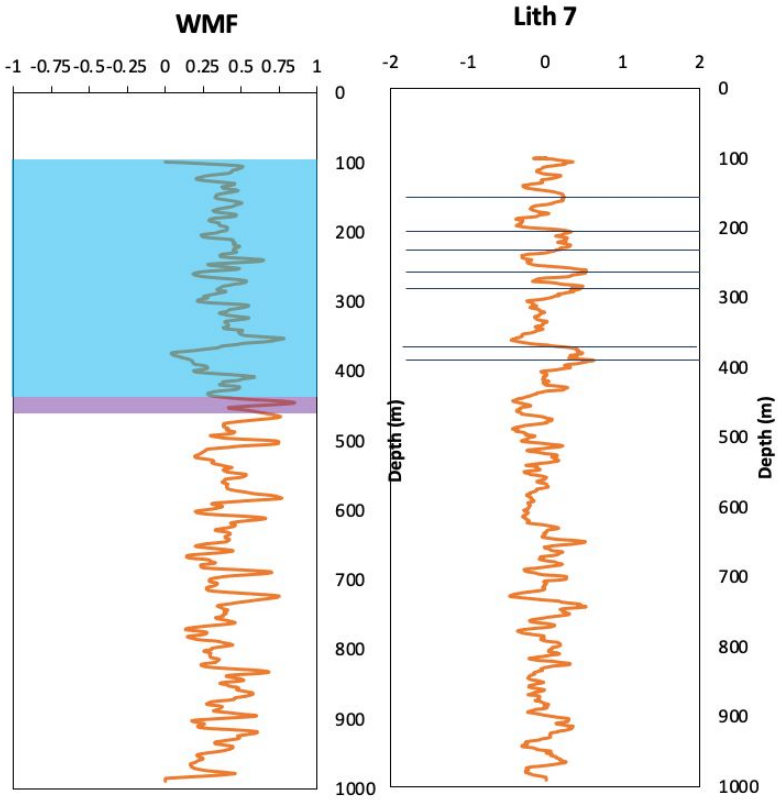
tc2638-030



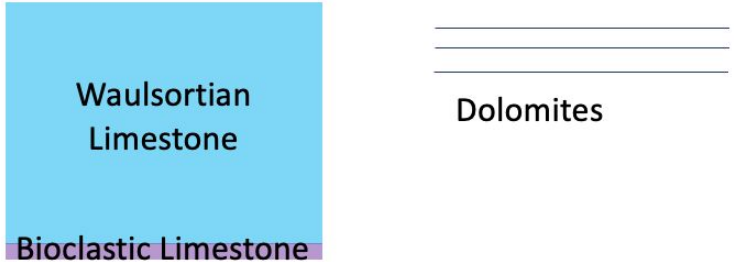


- The main area of dolomite is seen at 380m. This is matched by a peak in Lith_7 and according to the training data there is also dolomite at 300-310m again picked out by dolomite.
- Larger peaks are seen in Lith_5, Lith_6 at 450m but this is not associated with dolomite.

Lith_1-7 Summary



- Consistent matches between Lith_7 and dolomite are shown and so this will be used going forward. The remaining 6 calculated Lithmetrics will be discontinued.
- Sometimes low values for WMF correspond to dolomite.
- Based on the four training sites peaks in WMF above 0.25 sometimes correspond to base of the Waulsortian providing values drop to 0 immediately below the peak.
- A threshold value can be used for defining dolomite. For this project, a threshold of -0.25 is used for WMF and +0.25.



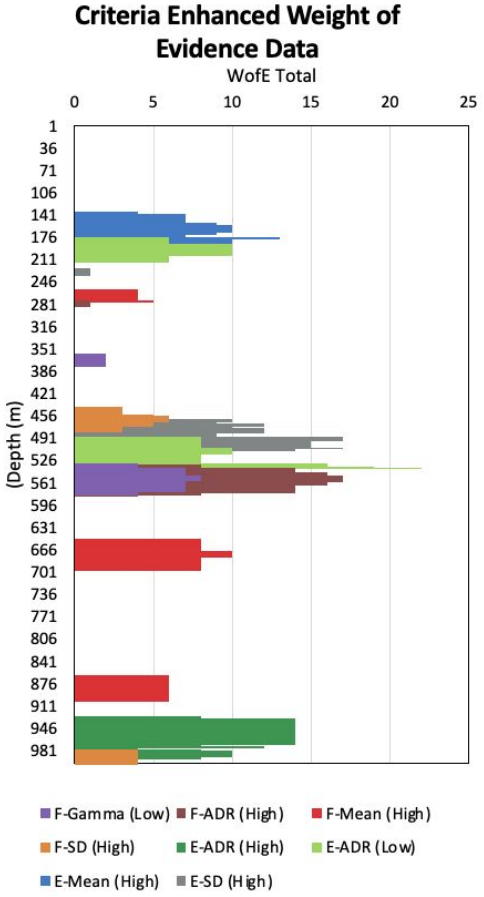
Interpretation Methodology

- Using findings from the training data results, the following criteria was used for identifying sulphides and dolomites in the blind holes.
- A criteria for identifying the base of the Waulsortian is also applied to the blind holes.

Weighted Sulphide Criteria	WMF criteria for base Waulsortian	WMF threshold for Dolomite	Lith_7 threshold for Dolomite
Multiple parameters congregating at over 50m interval. Values greater than 20 are considered sulphides.	Depth between 350-450m area where peak above 0.25 followed by a trough below 0.	Values smaller than -0.25 considered dolomites	Values greater than 0.25 considered dolomites.

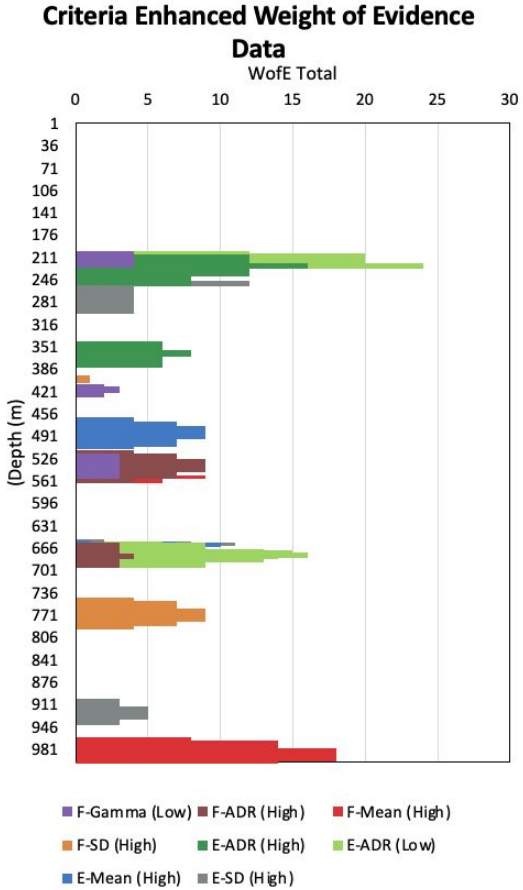
Blind Holes WofE

Blind WofE: L004



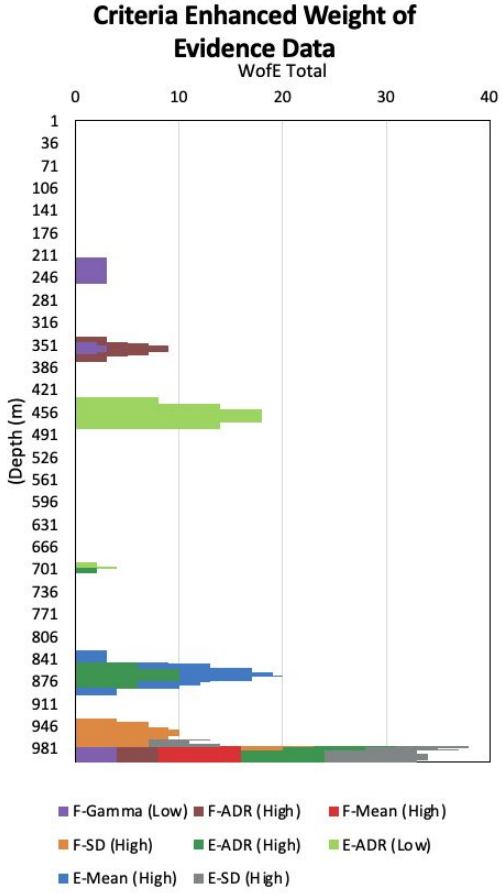
- Using the Criteria Enhanced Weight of Evidence Data, there is a concentration of peaks between 140-220m, 430-570m and 930-1000m.
- The weights for two of the three key parameters E-ADR high, and F-Mean high are only associated with the 930-1000m peak concentration.
- E-ADR low concentrates principally around 491-525m and corresponds the most with other harmonic parameters.
- This suggests the most concentrated occurrence of breccias or sulphides is between 430-570m.

Blind WofE: L009



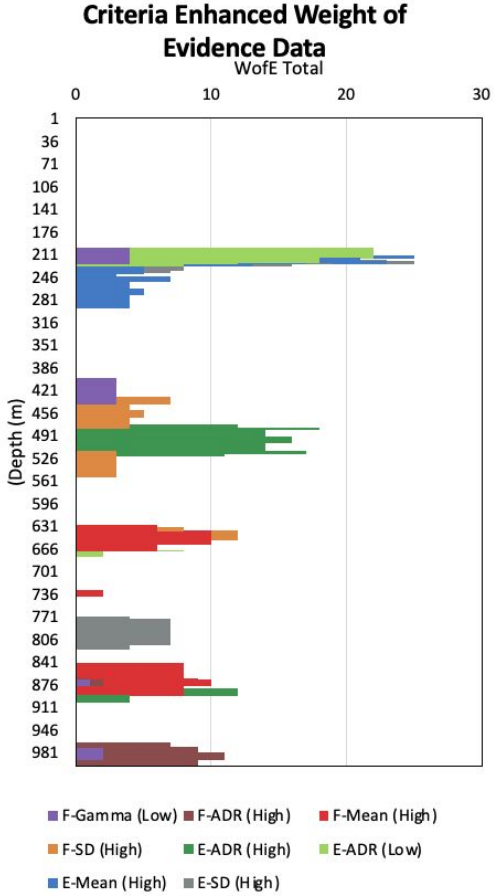
- Using the Criteria Enhanced Weight of Evidence Data, there appears to be a concentration of peaks between 210-290m, 460-560m and 640-700m.
- The weights for two of the three key parameters E-ADR high, and E-ADR low are associated with the 210-290m though some of the E-ADR low is associated with the 640-700m peak.
- The F-Mean high is seen between 530-560m and below 970-1000m.
- The results suggests regular occurrences of either sulphides or breccias but only at 210-250m are values above 20.

Blind WofE: L030



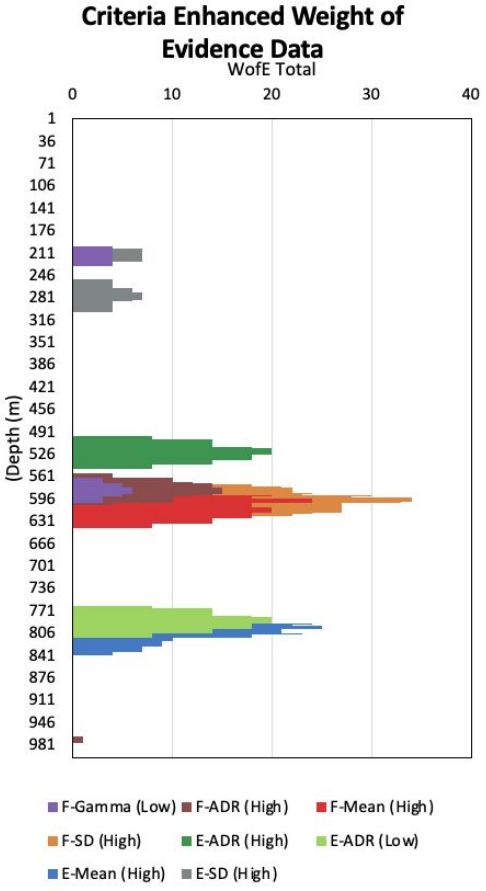
- Using the Criteria Enhanced Weight of Evidence Data, there are peaks below 940-1000m.
- Of the three key criteria only E-ADR low is seen above 700m, with values above 10 seen between 430-480m.
- All the rest of the key parameters are seen below 700m.
- The results suggests the majority of breccias or sulphides occur below 840-1000m with sulphides possible between 430-480m.

Blind WofE: P1



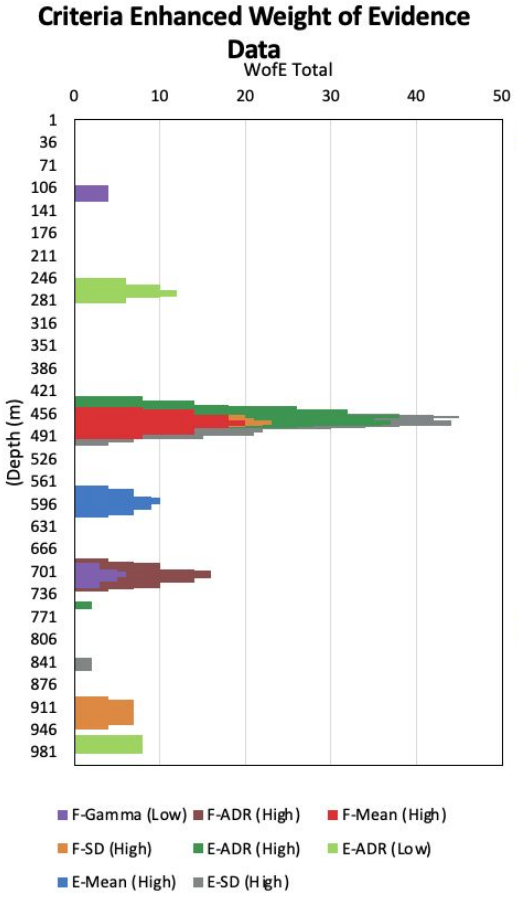
- Using the Criteria Enhanced Weight of Evidence Data, there are peaks between 200-300m, 390-550m, 630-670m, 771-810m, 841-900m and 970-1000m.
- Of the three key criteria E-ADR low is seen at 200m, while E-ADR high mostly concentrates 480-530m, while F-Mean concentrates 630-660m and 850-900m.
- The results suggests regular occurrences of breccia but there is no clear presence of sulphides. The most likely occurrence of sulphides between 210-230m.

Blind WofE: P2



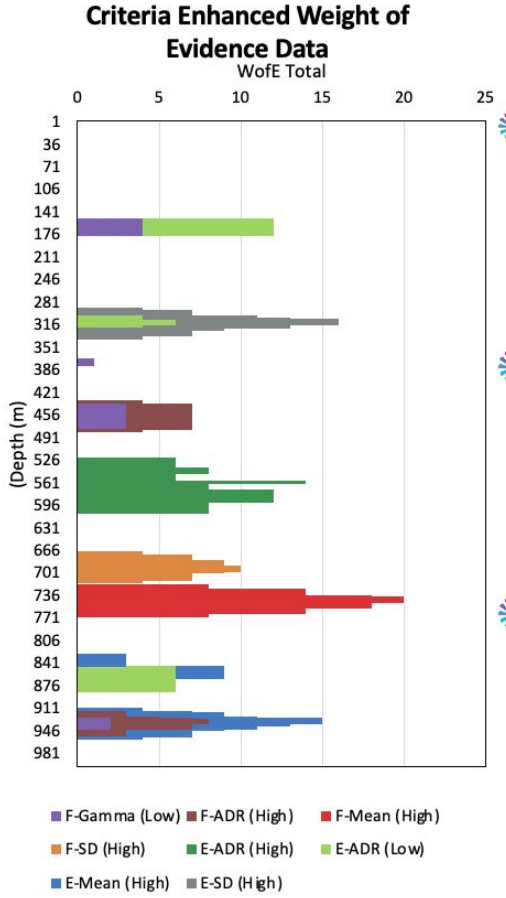
- Using the Criteria Enhanced Weight of Evidence Data, there are peaks at 500-630m and 770-840m.
- Of the three key criteria, E-ADR(high) is seen at 500-540m, F-Mean(high) is seen at 600-635m, while E-ADR(low) is seen at 770-800m.
- The results suggests a concentration sulphides most probably at 500-635m, while breccias occur between 210-300m.

Blind WofE: tc2638-036



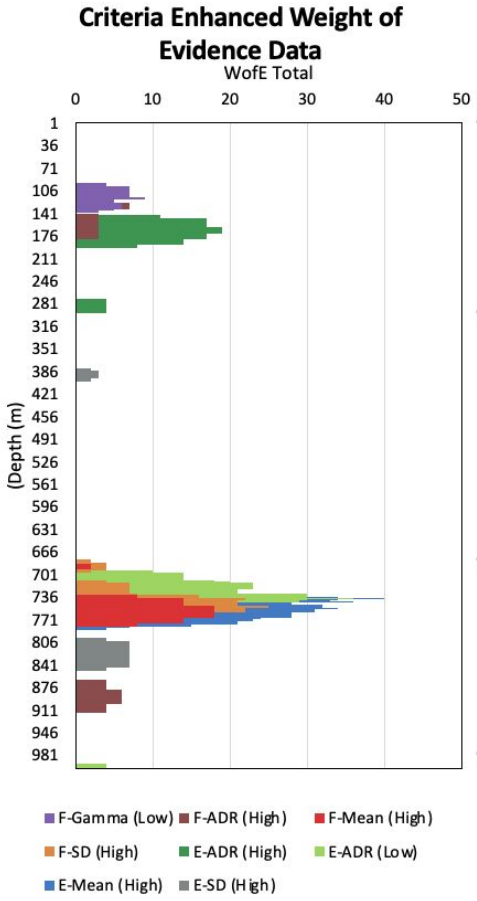
- Using the Criteria Enhanced Weight of Evidence Data, there are peaks at 250-280m, 425-500m, 565-610m, 675-720m, 900-940m and 950-980m.
- Of the three key criteria, E-ADR(high) is seen at 425-480m, F-Mean(high) is seen at 450-500m, while E-ADR(low) is seen at both 240-280m and 950-975m.
- The results suggests a concentration sulphides most probably at 425-500m with other peaks associated with breccias.

Blind WofE: tc2638-070



- Using the Criteria Enhanced Weight of Evidence Data, there are peaks at 150-170m, 290-330m, 425-480m, 525-600m, 670-770m, 825-880m, 910-950m.
- Of the three key criteria, E-ADR(high) is seen at 525-600m, F-Mean(high) is seen at 730-770m, while E-ADR(low) is seen at 150-160m, 300-320m, 850-880m.
- The results suggests the most likely mineralisation is at 730-770m, though it is also likely to occur at 525-600m. The remaining peaks are likely to be breccias.

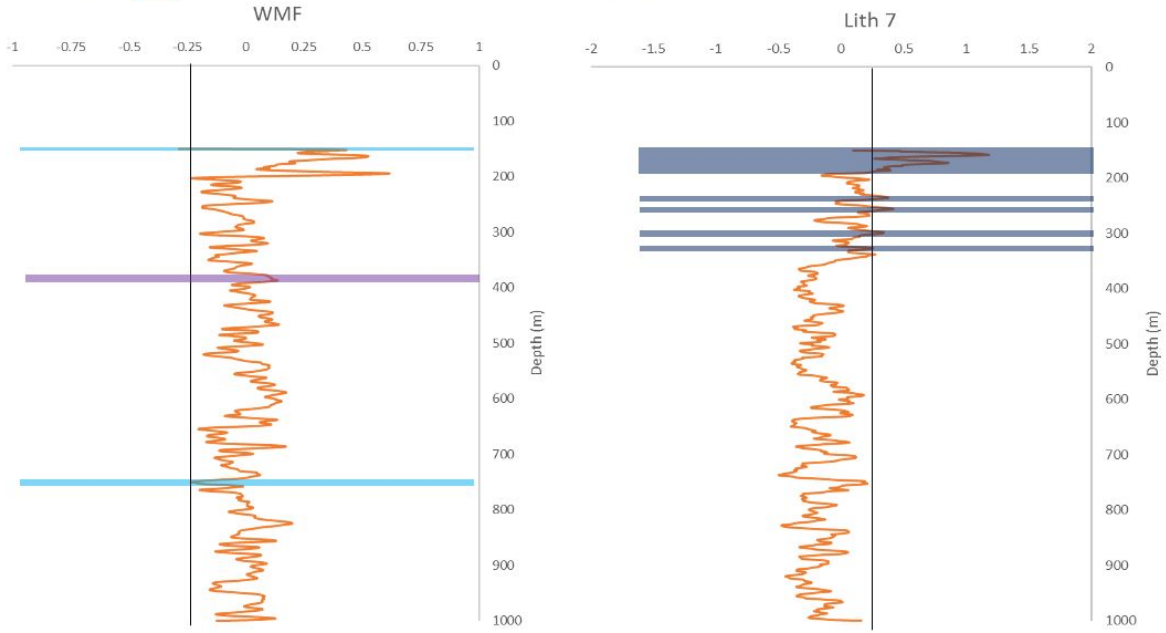
Blind WofE: tc2638-P01

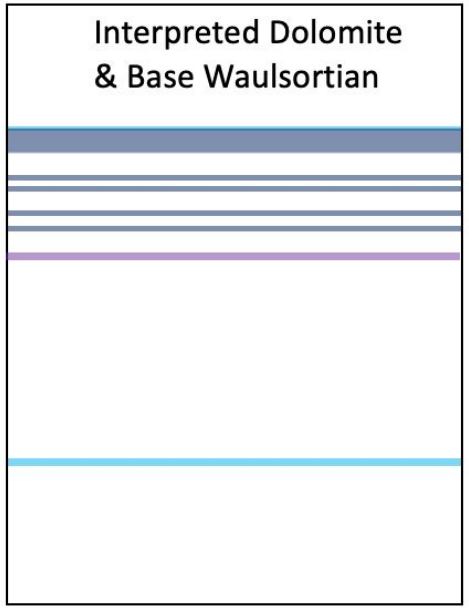


- Using the Criteria Enhanced Weight of Evidence Data, there are peaks at 100-190m, 670-775m and 800-900m.
- Of the three key criteria, E-ADR(high) is seen at 150-200m, F-Mean(high) is seen at 730-770m, while E-ADR(low) is seen at 700-735m.
- The results suggests the most likely mineralisation is at 700-775m, with the other peaks likely to be breccias.
- Overall the results are inconclusive because different parameters appear at very different depths at each site.

Blind Holes Lith_7 & WMF

Lith_7 & WMF: L004

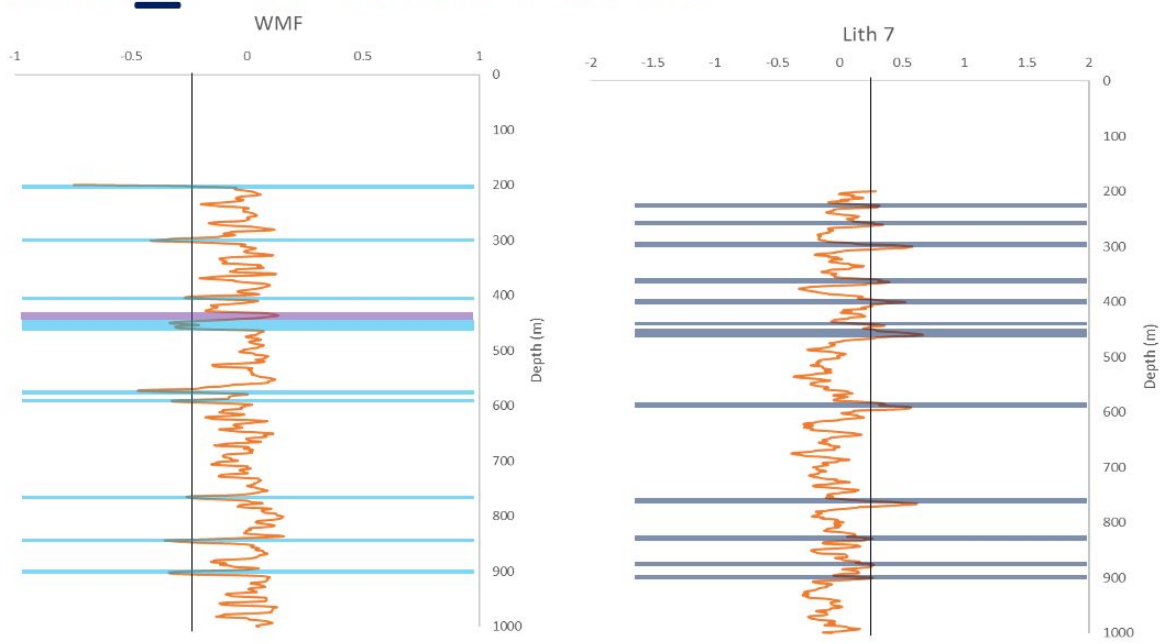


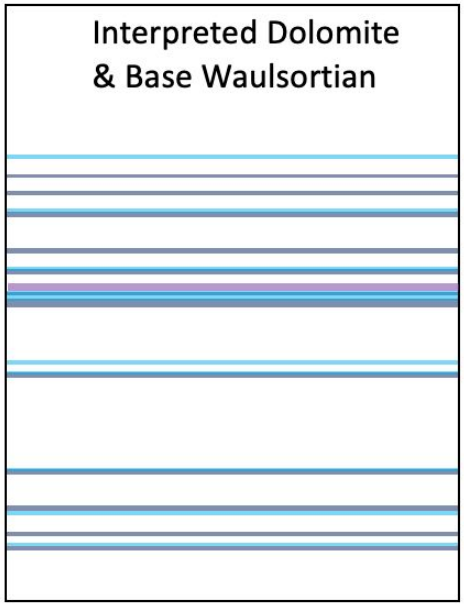


- When a threshold value of -0.25 for WMF and +0.25 for Lith_7 is applied, dolomite is identified regularly between 150-200m and further occurrences between 230-250m and 300-325m.
- The Base Waulsortian is identified by a broad peak at 390m.

Dolomite from WMF
Dolomite from Lith_7
Base Waulsortian

Lith_7 & WMF: L009

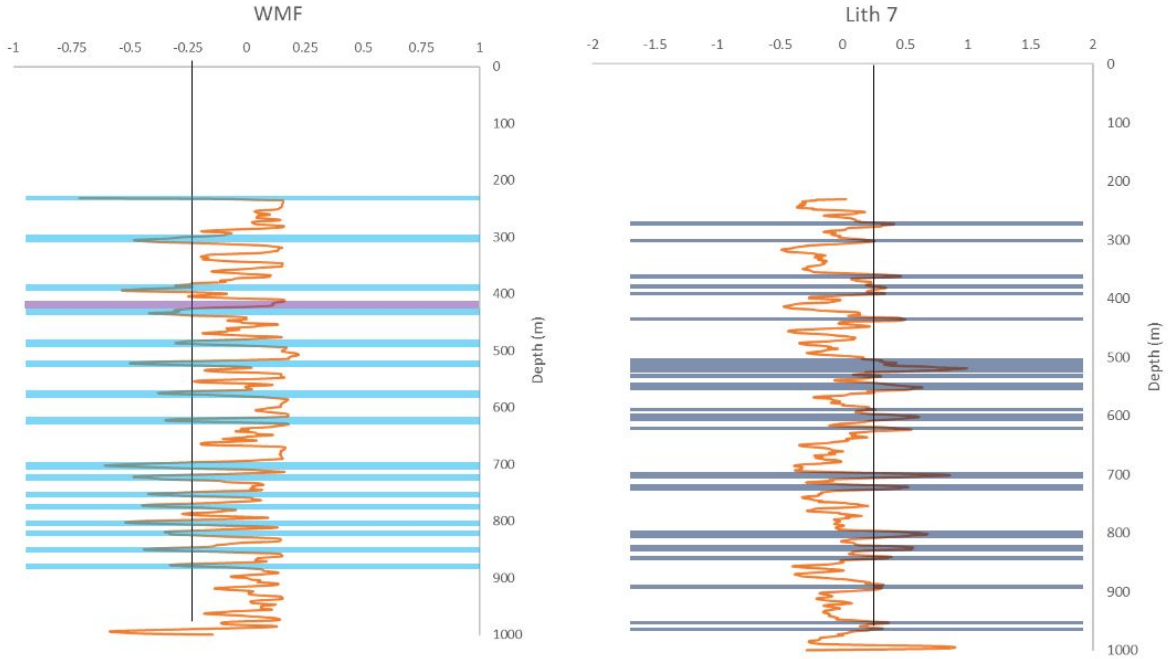


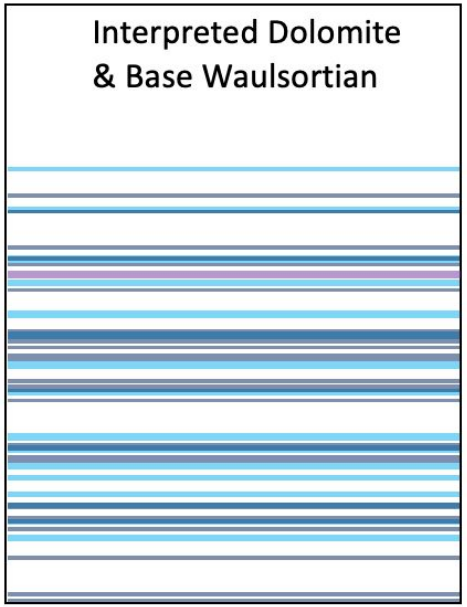


- When a threshold value of -0.25 for WMF and +0.25 for Lith_7 is applied, dolomite is seen regularly at 200-300m, 370-430m, 580-600m, 770-900m.
- The Base Waulsortian is located at approximately 420m.

Dolomite from WMF
Dolomite from Lith_7
Base Waulsortian

Lith_7 & WMF: L030

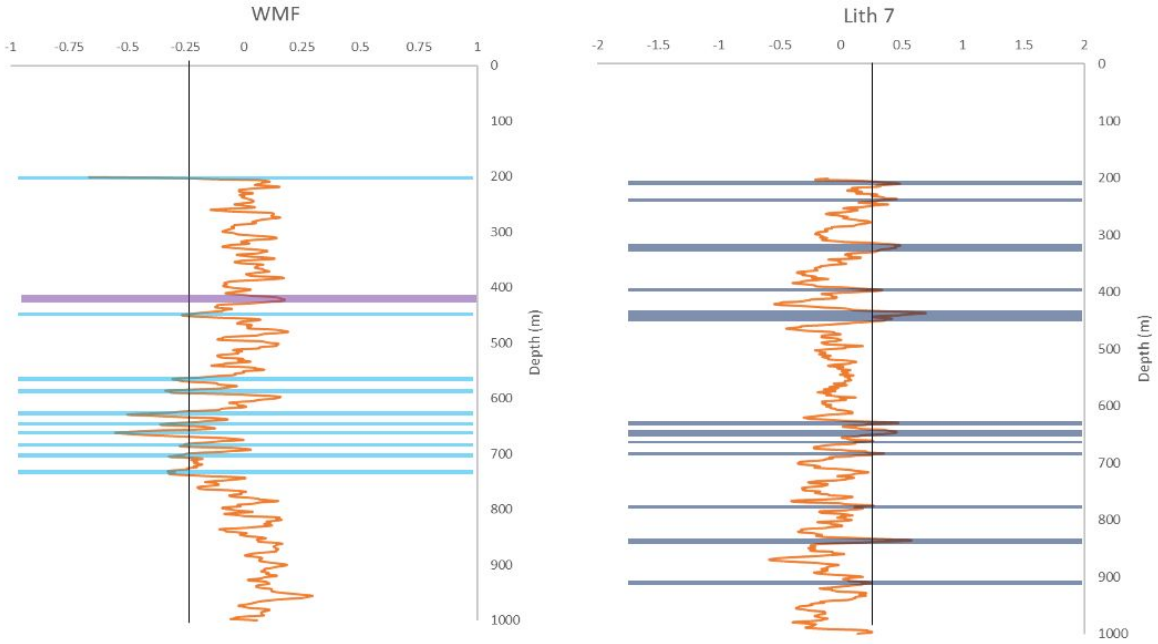


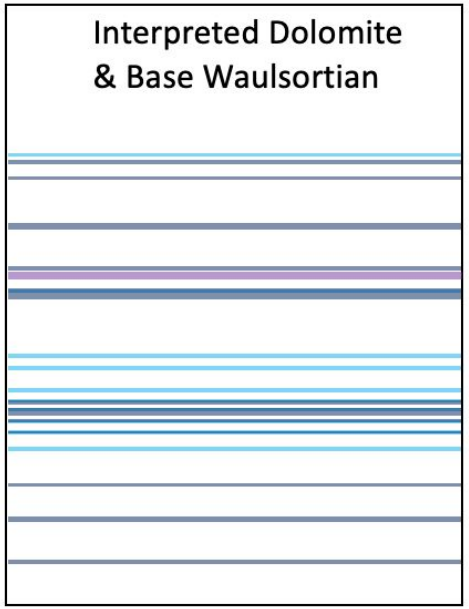


- When a threshold value of -0.25 for WMF and +0.25 for Lith_7 is applied, dolomite is seen regularly. Dolomite is mostly commonly seen at 200-300m, 370-450m, 500-600m, 700-880m.
- The Base Waulsortian is located at approximately 410m.

Dolomite from WMF
Dolomite from Lith_7
Base Waulsortian

Lith_7 & WMF: P1

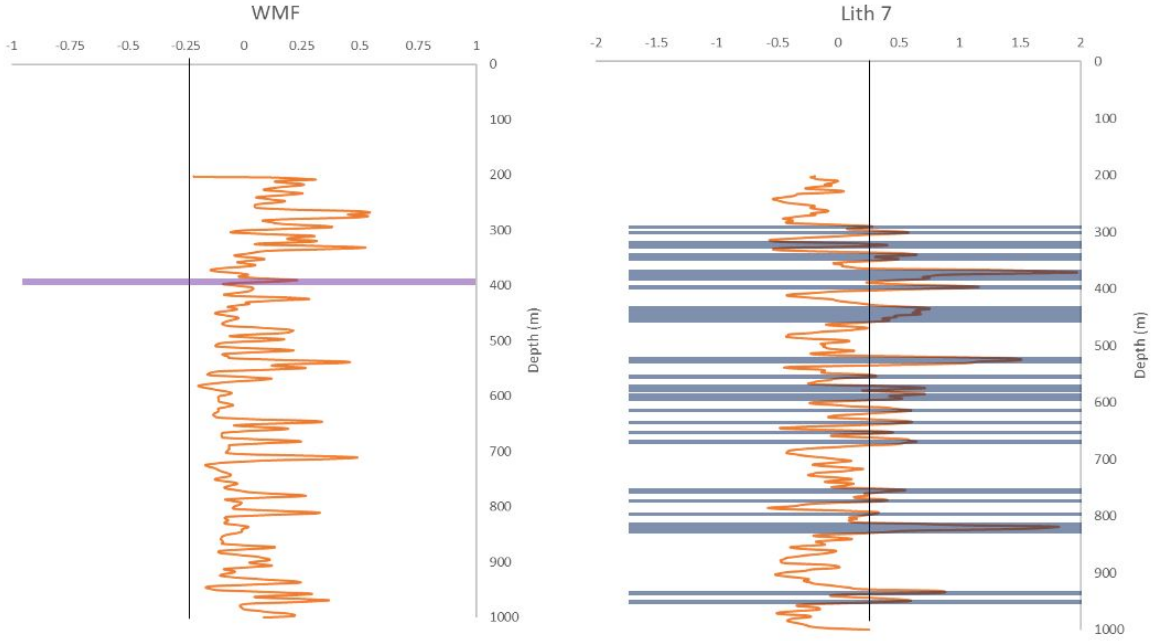


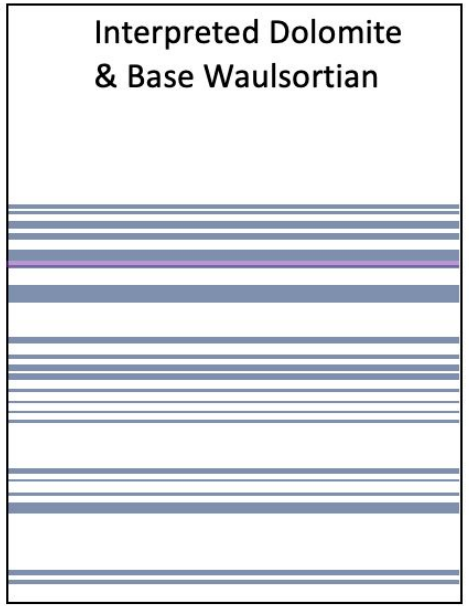


- When a threshold value of -0.25 for WMF and +0.25 for Lith_7 is applied, dolomite is seen regularly. Dolomite is mostly commonly seen at 200-230m, 310-430m, 550-700m.
- The Base Waulsortian is located at approximately 410m.

Dolomite from WMF
Dolomite from Lith_7
Base Waulsortian

Lith_7 & WMF: P2

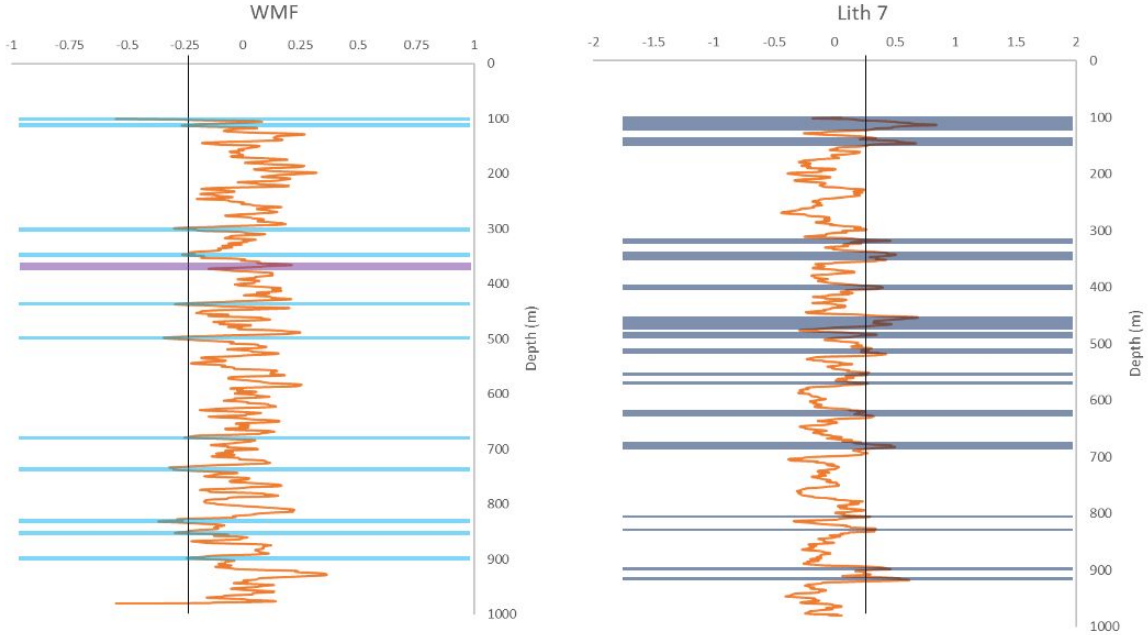


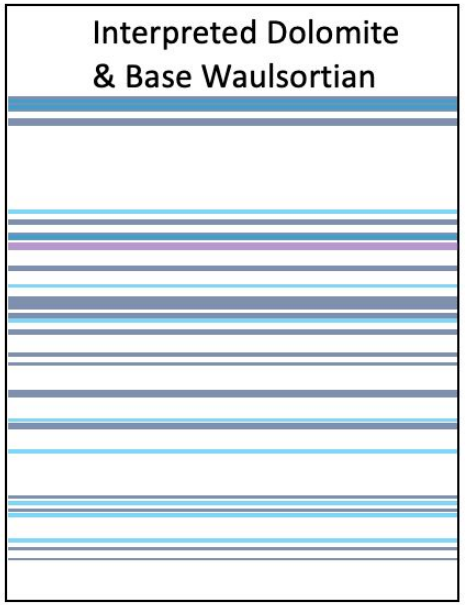


- When a threshold value of -0.25 for WMF and +0.25 for Lith_7 is applied, dolomite is seen regularly. Dolomite is mostly commonly seen at 290-400m, 510-650m and 750-810m.
- No values below -0.25 for WMF are seen.
- The Base Waulsortian is located at approximately 390m.

Dolomite from WMF
Dolomite from Lith_7
Base Waulsortian

Lith_7 & WMF: tc2638-036

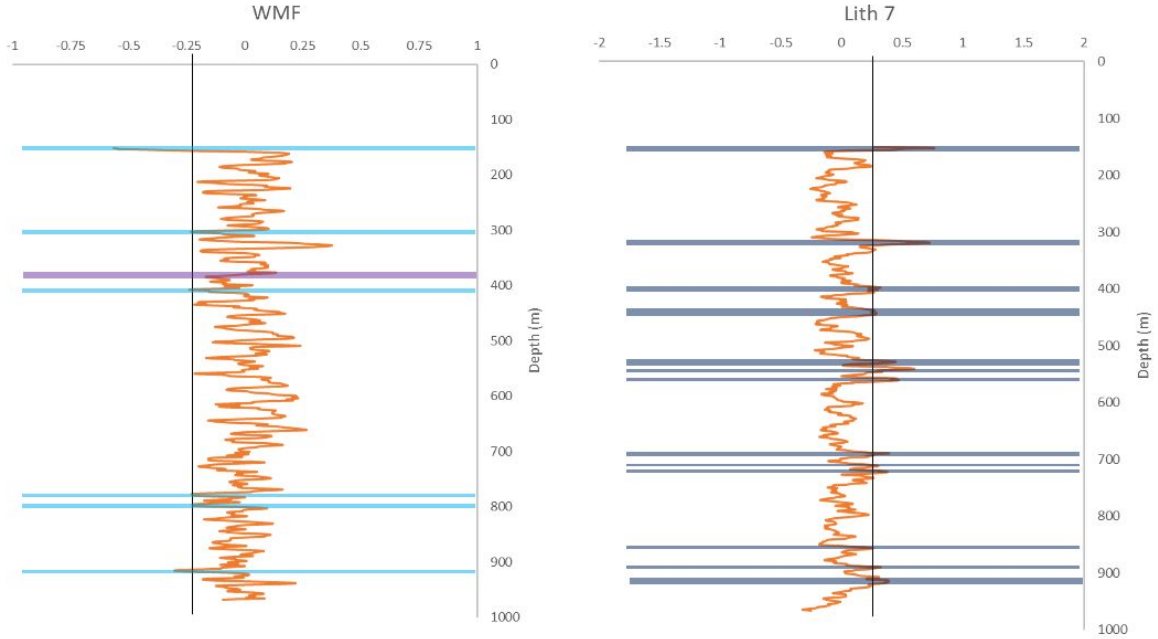


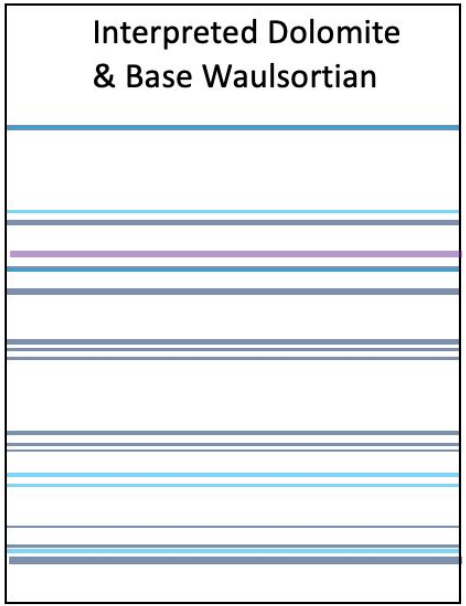


- When a threshold value of -0.25 for WMF and +0.25 for Lith_7 is applied, dolomite is seen regularly. Dolomite is mostly commonly seen at 100-130m, 300-340m, 400-550m, 600-680m,800-830m and 900-920m.
- The Base Waulsortian is located at approximately 350m.

Dolomite from WMF
Dolomite from Lith_7
Base Waulsortian

Lith_7 & WMF: tc2638-070

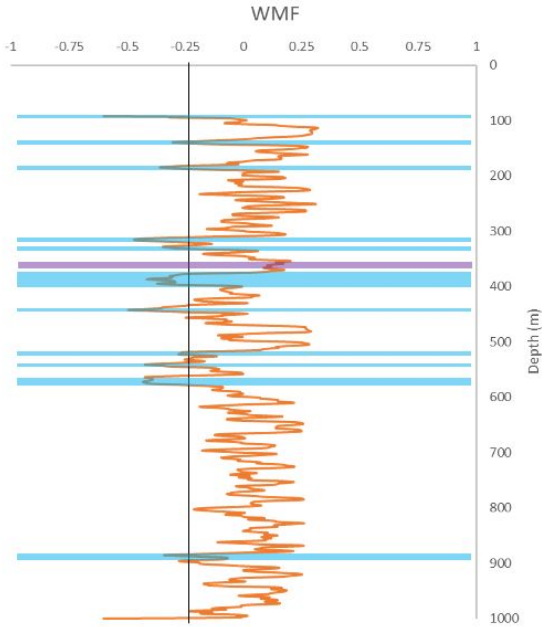


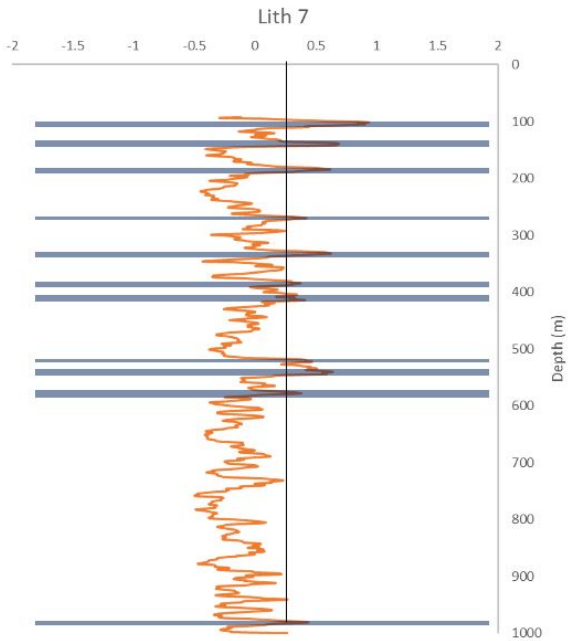


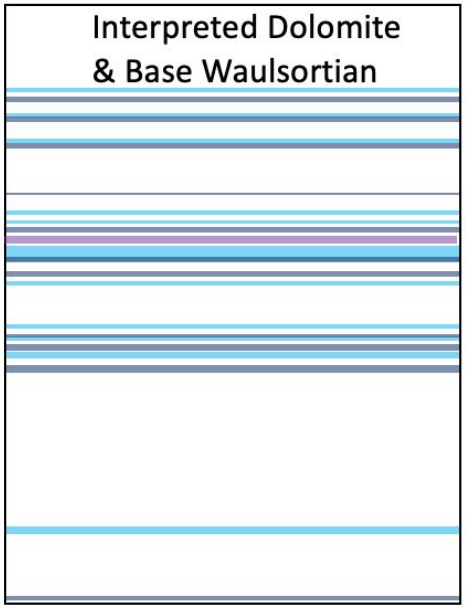
- When a threshold value of -0.25 for WMF and +0.25 for Lith_7 is applied, dolomite is seen regularly. Dolomite is mostly commonly seen at 140m, 300-320m, 400-430m, 510-540m, 690-740m and 850-910m.
- The Base Waulsortian is located at approximately at 320m.

Dolomite from WMF
Dolomite from Lith_7
Base Waulsortian

Lith_7 & WMF: tc2638-P01







- When a threshold value of -0.25 for WMF and +0.25 for Lith_7 is applied, dolomite is seen regularly. Dolomite is mostly commonly seen at 100-200m, 270-410m, 500-580m.
- The Base Waulsortian is located at approximately 350m.
- In order to verify the data, the results are compared with the cross sections included in the Geoscience Analyst model.
- Because no full dolomite data is included in the Geoscience model, the focus will be on the base of the Waulsortian and on the relationship with breccias.

Dolomite from WMF
Dolomite from Lith_7
Base Waulsortian