



NORTHERN
TERRITORY
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NORTHERN TERRITORY GEOLOGICAL SURVEY

HyLogger Data Package 0083

HyLogger drillhole report for WWD001,
West Warrego, Warramunga Province, Northern Territory.

Belinda Smith



206.319 m 205.426 m 204.533 m 203.64 m 202.747 m 201.854 m

HyLogging Systems - 8308312_WWD001 Tray 25, 201.9 to 207.2 m



0

200

400

600

800

1000

Distance along section (mm)

DEPARTMENT OF PRIMARY INDUSTRY AND RESOURCES
MINISTER: Hon Paul Kirby MLA
CHIEF EXECUTIVE: Alister Trier

NORTHERN TERRITORY GEOLOGICAL SURVEY
EXECUTIVE DIRECTOR: Ian Scrimgeour

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The Spectral Geologist Advisory

The results in this report were obtained using The Spectral Geologist (TSG) software. The software uses The Spectral Assistant (TSA) as a default to identify minerals and their abundances for the Short Wave Infrared (SWIR) and Thermal Infrared (TIR) spectrum. TSA is a general unmixing algorithm and is trained on a relatively small subset of commonly-occurring minerals. It does not make the right identifications all of the time. The unmixing is an interpretation result of 'best fit'. TSA abundances are relative abundances, only the two (or three) most spectrally active minerals identified in the Short Wave Infrared (SWIR) and the three (sometimes four) most spectrally active minerals in the Thermal Infrared (TIR) wavelengths are reported. If there are more than two or three minerals actually present in the sample in the SWIR (or three to four minerals in the TIR) then this is not reflected AT ALL in the reported abundances. Minerals are reported as a fraction of the overall spectral fit rather than actual quantifiable concentrations (total minerals present add up to 1). The SWIR wavelength only identifies hydrous silicates and carbonates. It does not reflect the TOTAL mineralogy of the sample. Northern Territory Geological Survey (NTGS) processed datasets exclude some minerals in the TSA library if the mineral is a poor spectral fit or unlikely in that geological environment, introducing a further element of interpretation.

Since April 2014, the TIR spectral responses have also been matched to minerals using Constrained Least Squares (CLS), which is an alternative unmixing classifier. CLS uses a Restricted Mineral Set (RMS) to minimise non-unique mineral modelling in the TIR spectrum. The RMS is determined by the processor who interprets 'domains' (hole intervals interpreted to have similar mineralogy) and then limits the set of possible mineral matches based on the geological understanding and spectral characteristics of that domain.

Since April 2017, the TIR spectral responses may also be matched to minerals using joint Constrained Least Squares (jCLST), which is an unmixing classifier that replaces the earlier system TSA (sTSAT) used in TSG versions 7 or earlier. In TSG8, jCLST is the default system unmixing algorithm, which interprets the TIR data using the results from the SWIR spectra, and using scalars focussing on selected features in the Visible Near Infrared (VNIR) and TIR wavelengths. TSG8 datasets may have TIR mineral results reported as domained TSA (dTSAT), user TSA (uTSAT) or domained CLS (TIR-CLS1).

Any results from the TIR should be used with caution as algorithms and TSA libraries are in a constant state of revision. More information about the samples in the TIR reference library can be found in Schodlok *et al* (2016a).

These results were published using TSG Version 8.0.5.12 dated November 2019.

Please note: the results in this report are an interpretation from the spectral response.

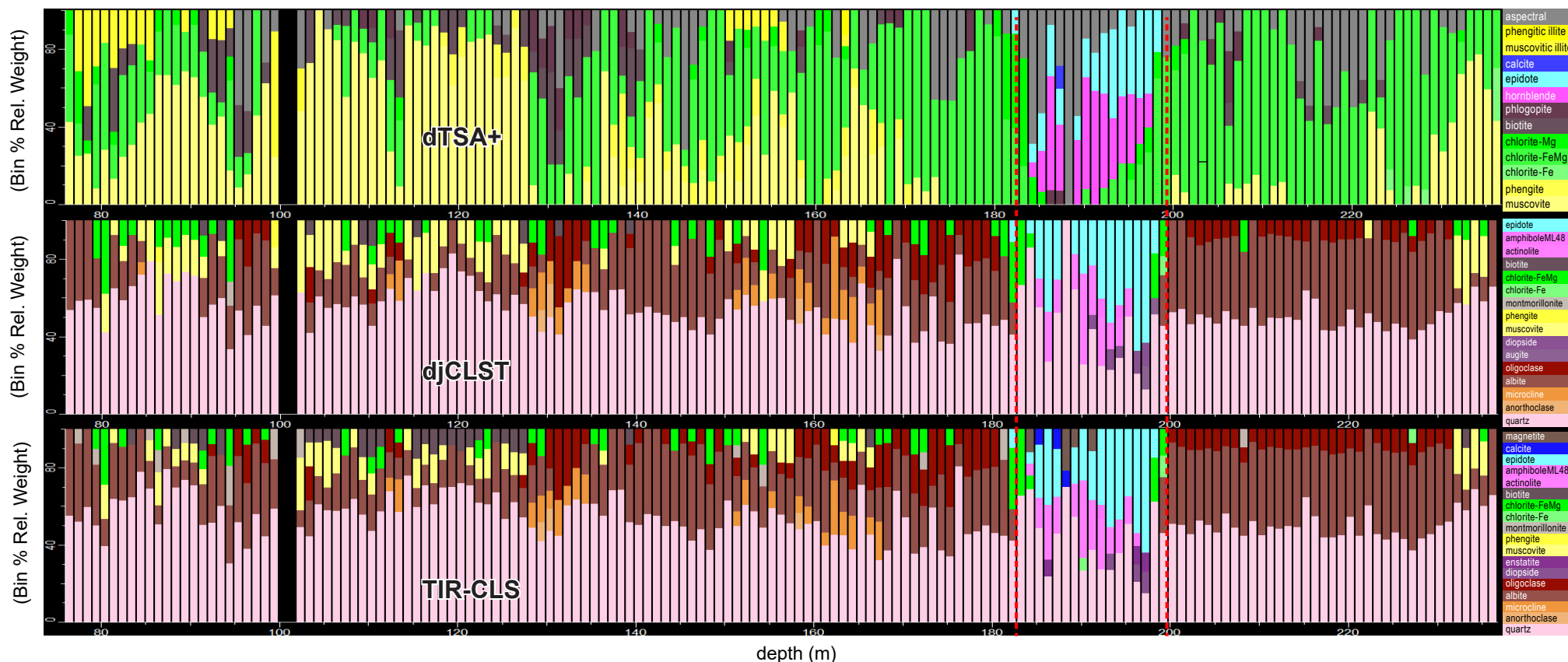
WWD001: Introduction

Hole ID	WWD001	Unique identifier	8308312
Geological terrane	Warramunga Province	Total depth	236.8 m
Latitude GDA94	-19.43313262°	Longitude GDA94	133.6589332°
Easting MGA94	359212 (Zone 53)	Northing MGA94	7850698 (Zone 53)
Dip	-50°	Azimuth	160° (magnetic)
Logged by	C. Brauhart, Sipa Exploration NL	Logged report ref	Neumayr 2019 (CR2009-1078)
Start core depth	76 m	End core depth	236.8 m
Date HyLogged	May 2012	HyLogged by	Darren Bowbridge
Date of HyLogger report	January 2020	HyLogger report author	Belinda Smith
TSG version and build	8.0.5.12 (November 2019)	TSG product level	3 (Huntington 2010)

Summary of information from from Neumayr (2019):

- Drilled under the NTGS Geophysics and Drilling Collaborations program (Round 1: 2009).
- Drilled to test for Tennant Creek style ironstone-hosted Au-Cu-Bi mineralisation in the Warramunga Formation. Drilling consisted of 4 drillholes (WWD001–004). This HDP focuses on one drillhole (WWD001).
- Drilling targeted a series of magnetic anomalies. While drill sumps were discovered during field reconnaissance, Sipa did not find any drilling information at the time of drilling in 2009. However, follow-up work by Emmerson Resources in 2012 (Osborne 2012) identified that some of these magnetic anomalies were drilled by Geopeko. WWD001 focused on Geopeko's Explorer 18 target and may be the only drillhole at this location.
- Drilling intersected metasedimentary rocks, interpreted to be part of the Warramunga Formation, along with felsic porphyry intrusions and ironstones.
- Sipa interpreted a quartz-chalcopyrite vein at 199 m in WWD001 as evidence of mineralising fluids. This interval returned a maximum value of 0.5 m at 4640 ppm Cu, 22.7 ppm Bi, 4 ppb Au and 4740 ppm S from 199 m downhole depth.
- Osborne (2012) relogged portions of WWD001 (imported into the WWD001 TSG dataset) with the objective of comparing the ironstone with 'classical Tennant Creek ironstones'. The report concluded that the Warrego West ironstones are more siliceous, with chlorite and quartz dominating over magnetite-hematite. The ironstones were interpreted to have been subjected to an intense epidote-quartz (+/- magnetite) alteration event that resulted in metasomatic skarn-like textures. Osborne (2012) interprets this alteration event to have resulted from the intrusion of the Warrego Granite.

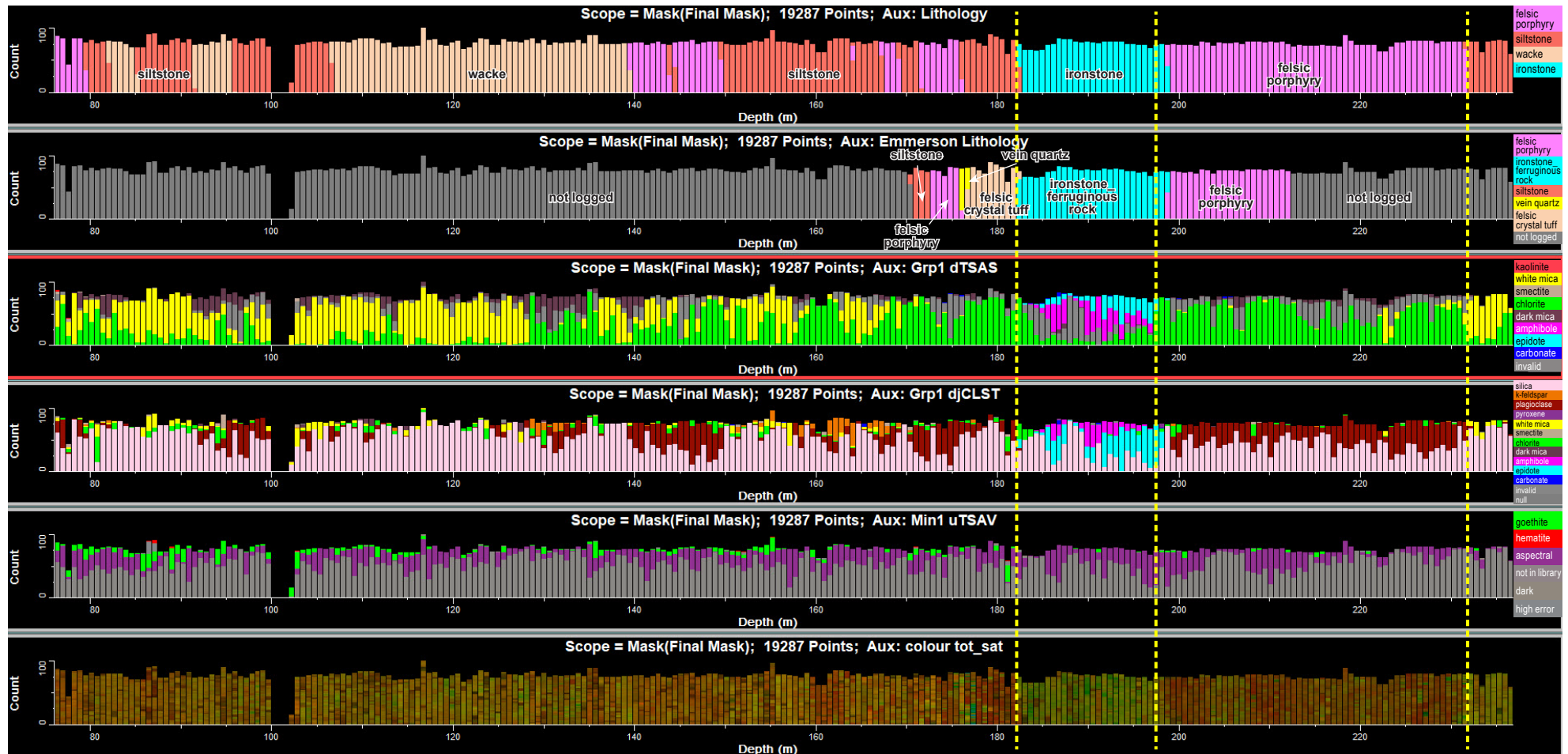
WWD001: Mineral summary – all minerals, TSA and CLS



From Summary Screen: Row 1 are the domained SWIR results using TSA+. Row 2 are the TIR results derived using the domained jCLST algorithm (see Guide to Scalars for a description of algorithms). In this dataset, djCLST is used in preference over TIR-CLS1 and dTSAT (which was used in HDP0081). The rationale for using the djCLST results for this dataset, rather than the dTSAT results, are discussed on page 18. TIR modelled results for djCLST and domained CLS are shown here for comparison as the TIR spectra have non-unique results. The main differences between the TIR summary results are some mineral proportions: TIR-CLS has higher magnetite, calcite and pyroxene results within the dotted zone. The djCLST results have more matches to white mica around 100-130 m, which correspond with the SWIR results. The difference summary can also be viewed on page 19. In summary, WWD001 has variable proportions of quartz, plagioclase (mainly albite?), chlorite, white mica, biotite, and sporadic K-feldspar to ~183 m depth. There is a notable mineralogy change 182–198 m characterized by an epidote-amphibole-quartz zone, with lesser chlorite, magnetite, calcite, and pyroxene. Below 199 m, the mineralogy is quite consistently quartz-plagioclase-chlorite with minor biotite and white mica.

WWD001: Mineral summary

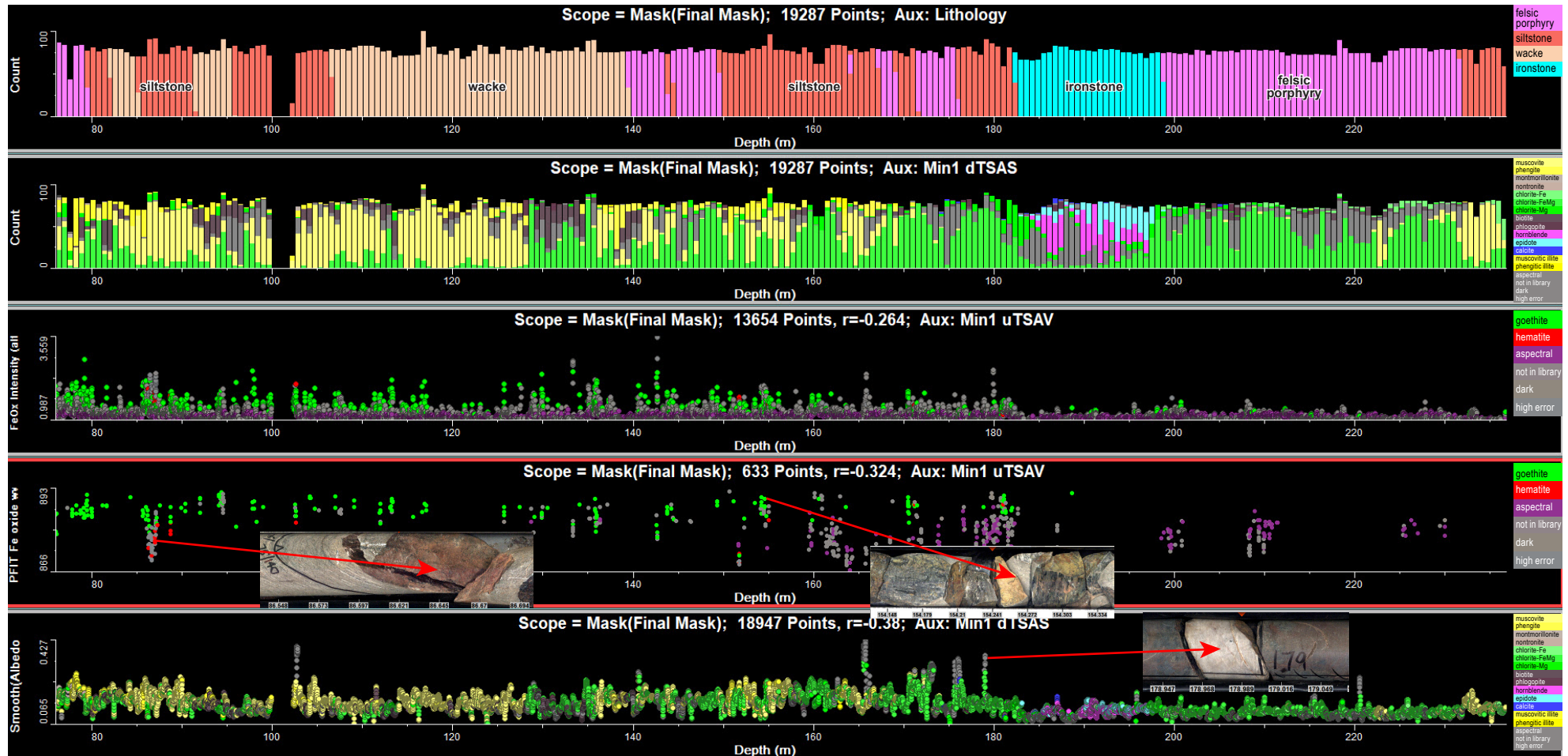
(View | Plot Layouts Load file
1_VNIRSWIR: Mineral Summary)



Row 1 plots the logged lithology from Neumayr (2009). Row 2 plots the incomplete lithology log by Osborne (2012). Row 3 plots the dominant mineral group for spectral matches in the SWIR. Row 4 plots the dominant mineral group for matches in the TIR (using the jCLST results for the remainder of the HDP). Row 5 plots the VNIR matches, which are limited to Fe oxides (hematite and goethite, but not magnetite). Row 6 plots the core colour. Dotted lines show mineralogy changes. The dominant mineralogy change is within the logged ironstone / ferruginous rock (182–198 m), which is characterised by presence of epidote-quartz-amphibole and absence of white mica, plagioclase, and K-feldspar minerals. The logged siltstone unit near the base of the drillhole (from 231 m to EOH; row 1) has an increase in white mica and quartz compared with the overlying logged felsic porphyry. The logged felsic porphyry units have notable plagioclase and quartz in the TIR and dominantly chlorite in the SWIR.

WWD001: SWIR and VNIR mineral summary

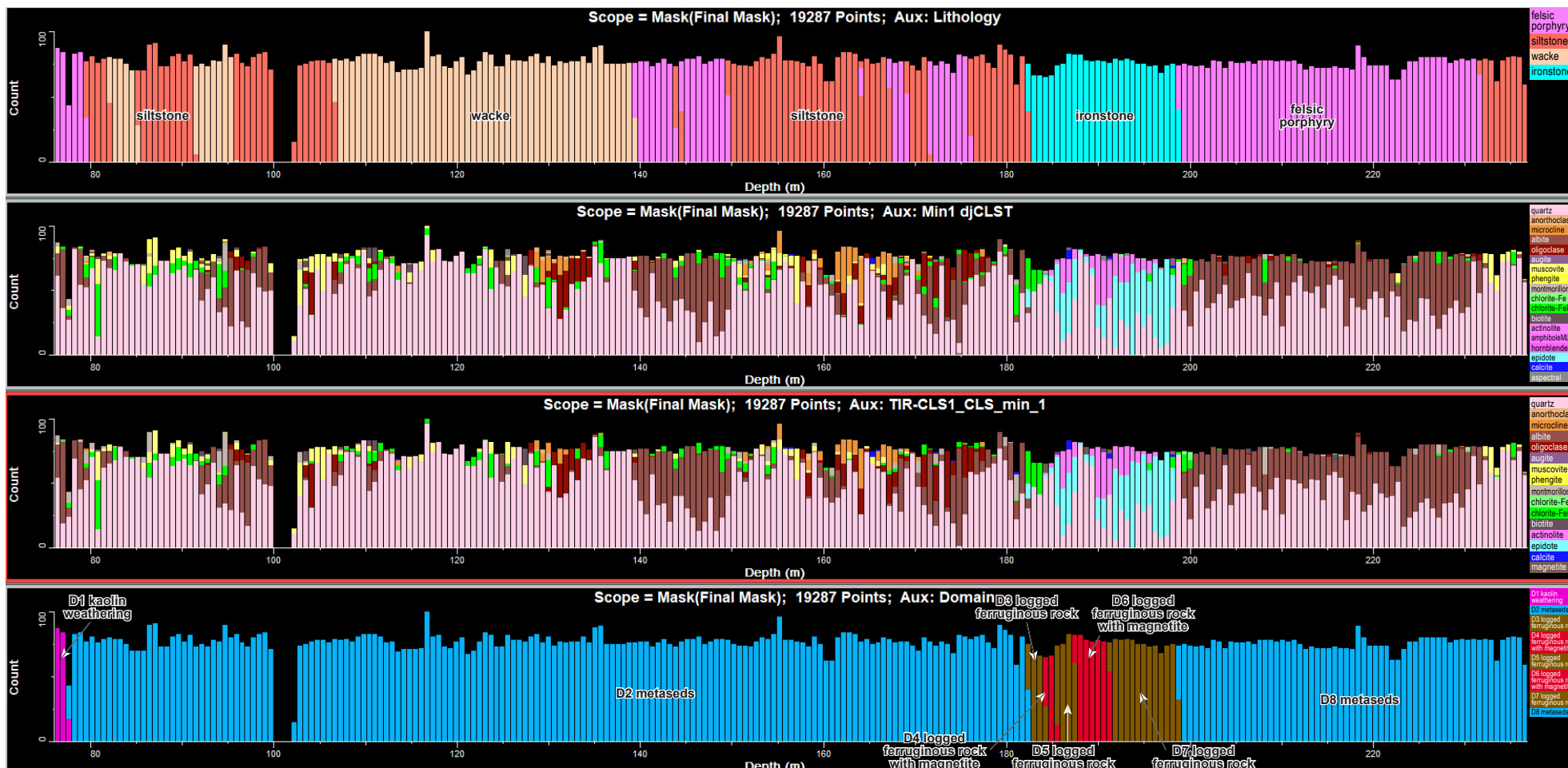
(View | Plot Layouts Load file 2_VNIRSWIR: SWIR VNIR Summary)



Row 1 plots the logged lithology from Neumayr (2009). Row 2 is the SWIR spectra coloured by the dominant mineral (may be in a mineral mixture). Row 3 is the VNIR spectra plotted against FeOx intensity batch scalar and coloured by the match to VNIR minerals. Row 4 plots the wavelength of the Fe oxide feature of the VNIR Fe oxides, coloured by the mineral match. Hematite has a shorter wavelength feature compared with goethite. There is some shorter wavelength hematite matches around 86 m (see inset left) that corresponds with hematite on open fractures. Patchy goethite from top of hole to ~180 m also corresponds with fracture linings (see inset middle). Row 5 plots the smoothed albedo, with sharp peaks (grey, spectral) highlighting quartz veins (see inset right). In summary, the Fe oxides (hematite and goethite) in WWD001 are in short discontinuous intervals on fractures. Magnetite is not easily characterised and is discussed further on page 14.

WWD001: TIR mineral summary - overview

(View | Plot Layouts Load file
1_TIR: TIR Summary)



Row 1 plots the logged lithology from Neumayr (2009). Rows 2 and 3 plot the dominant TIR mineral (from a mineral mix) using a domained restricted mineral set (RMS). Row 2 uses the djCLST algorithm and row 3 is the CLS algorithm. Both algorithms use an RMS interpreted for each domain, allowing up to 3 mineral results per spectrum in the dTSAT results and up to 6 mineral results in the TIR-CLS1 results. However, these plots show only the dominant mineral. At the dominant TIR mineral level, there is little difference between the djCLST and CLS results. The main mineral is quartz, with narrow zones of variable minerals such as albite, epidote and amphibole. The logged ironstone is notable for the epidote and amphibole content. The TIR-CLS also shows some minor matches to calcite and magnetite. See pages 14, 18 and 19 for more discussion regarding the magnetite content; and pages 12, 18 and 19 for the carbonate content. For more information on domains in the TSG dataset, open the 'D' tool on the toolbar within the TSG software. There are few domains in this drillhole as the mineralogy is relatively uniform for most of the core. The variation is within the logged ironstone, which has alternating intervals characterised by magnetite presence.

WWD001: TIR mineral summary 2

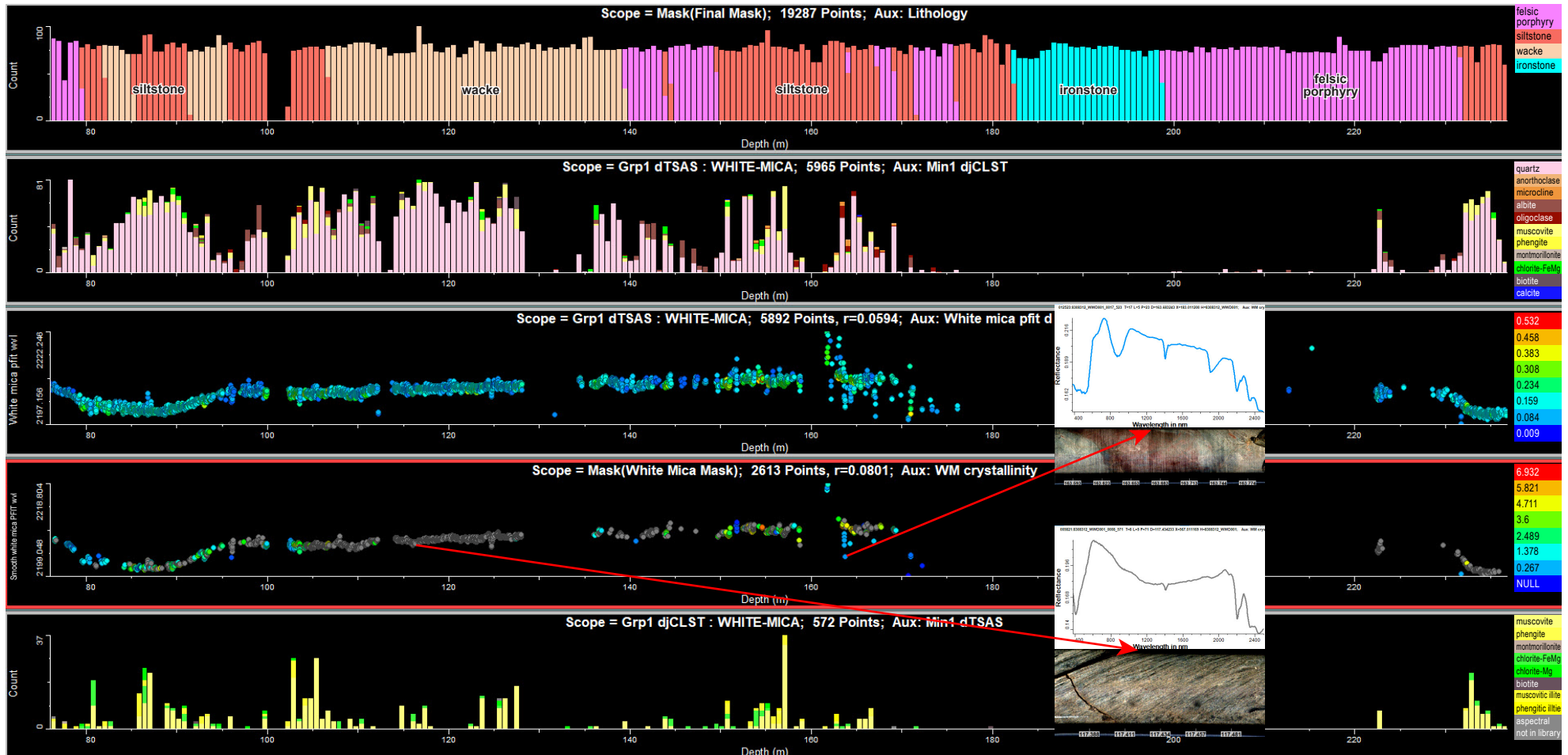
(View | Plot Layouts Load file
2_TIR: TIR Mineral Summary 2)



Row 1 plots the logged lithology from Neumayr (2009). Row 2 is the dominant TIR mineral from the domained joint CLS algorithm. Row 3 show the TIR spectra that match dominantly to quartz, plotted by the depth of the quartz 8625 nm feature (analogous to abundance) and coloured by the strength of a longer wavelength quartz feature at ~12500 nm. The zone from ~172–183 m has increased quartz, defined by the zone between the dotted lines at 172–180 m. The peaks are from quartz veins (see inset image). Rows 4–6 plot the TIR spectra that contain a match to K-feldspar, plagioclase and pyroxene respectively. Note that the logged ironstone has no plagioclase or K-feldspar minerals. The pyroxene is limited to the logged ironstone. Row 7 plots the TIR spectra that match dominantly to epidote, coloured by the dominant SWIR mineral (light blue is epidote). This gives greater confidence to the epidote matches in the logged ironstone, and indicates epidote is present but is subdominant in the mineral mix. Row 8 plots domains.

WWD001: White micas

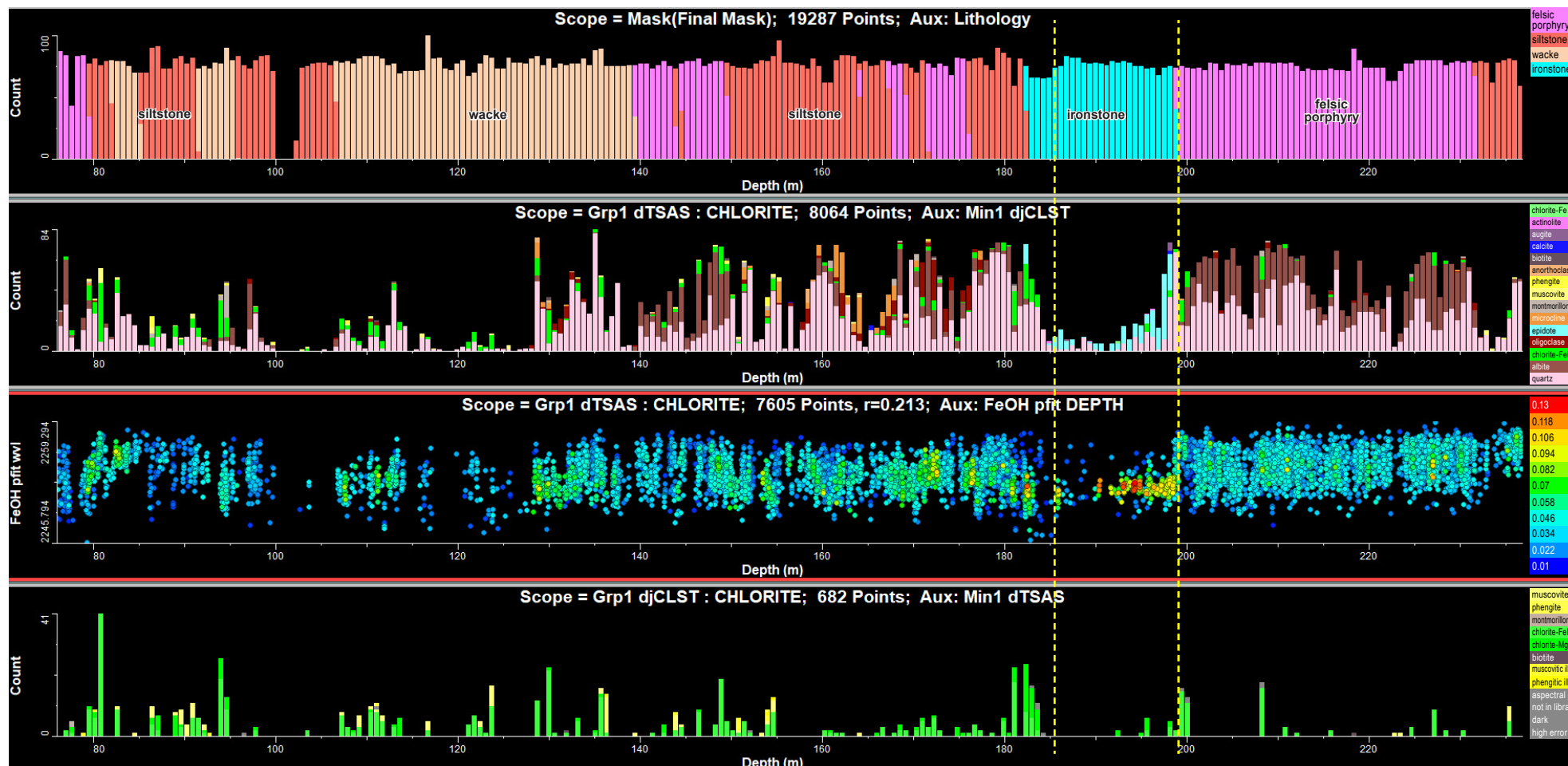
(View | Plot Layouts Load file
3_VNIRSWIR: White Micas)



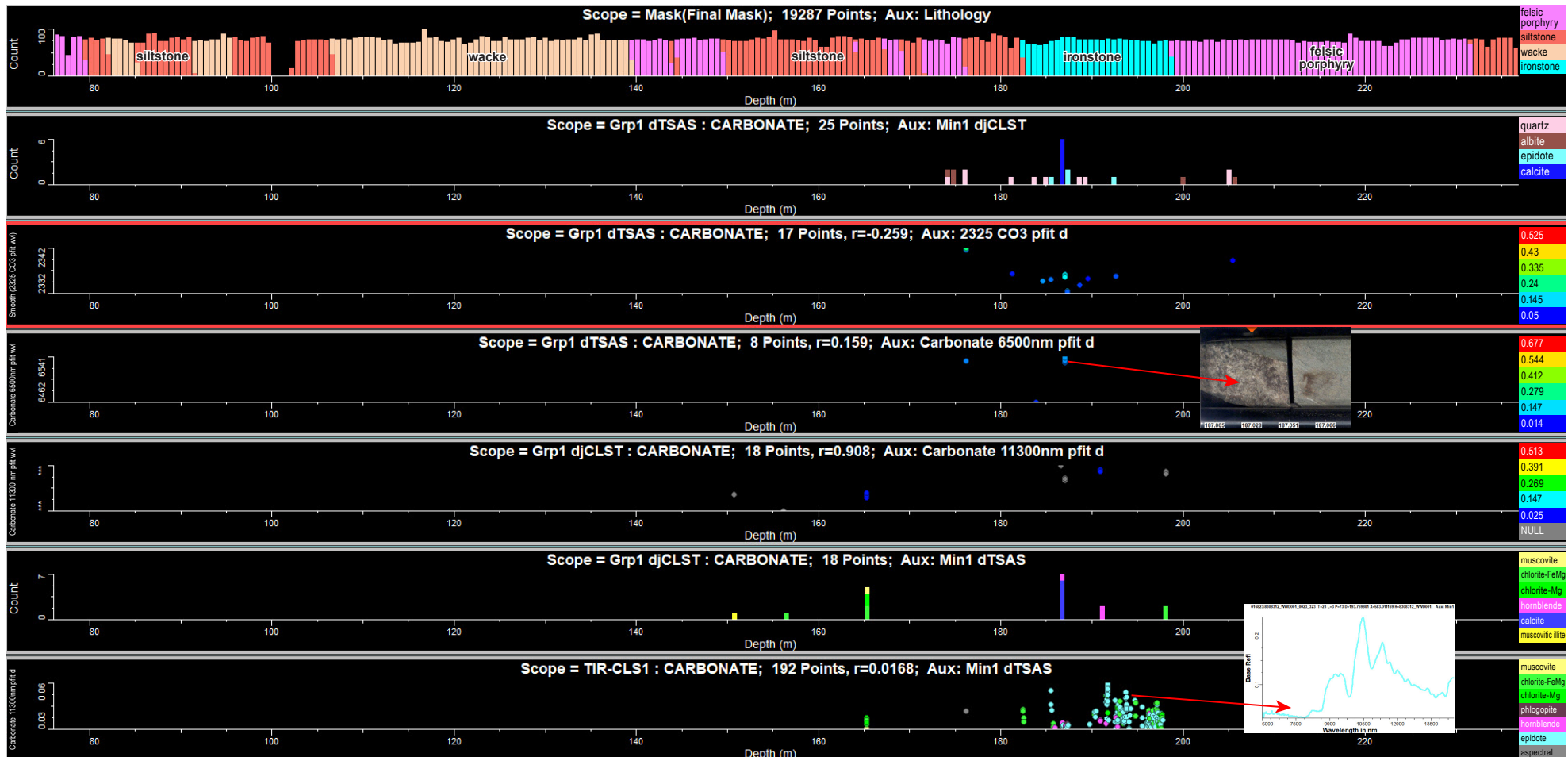
Row 1 plots the logged lithology from Neumayr (2009). Row 2 plots the SWIR spectra that match dominantly to white mica, coloured by the dominant TIR mineral. Most of the SWIR white mica are found with quartz. Row 3 are the SWIR white micas plotted by the wavelength of the white mica feature around 2200nm and coloured by the depth of that feature. Wavelength changes may show white mica composition changes. The depth of the white mica feature is a measure of the strength (abundance) of the white mica. Most of the white mica is muscovitic (2197–2211 nm white mica feature wavelength). There are gradational changes in the white mica composition to ~160 m depth. Between 160–175 m, the white mica is less common and has a greater variability in wavelength. Row 4 plots the SWIR spectra that match dominantly to white mica (masking out any spectra with <85% weighting of white mica using the TSA algorithm), plotted by the white mica wavelength and coloured by the white mica crystallinity. The uniform wavelength white mica for the interval 105–128 m is commonly 'null' crystallinity (grey colour). This is due to the absence of the 1900 nm feature (see lower inset images) and indicates the white mica present is muscovite with no illite or bound water within the white mica in the logged metasedimentary rocks. In comparison, there are white mica crystallinity changes (and changes in white mica wavelength) from ~155 m (see upper inset images). There is a well-developed 1900 nm feature in the lower crystallinity white micas: one interpretation is that these illitic white micas may develop in the presence of hydrothermal fluids? Row 5 plots the TIR spectra that match dominantly to white mica, coloured by the dominant SWIR mineral. There are less matches than the dominant mineral because quartz is the dominant mineral for most intervals in the TIR.

WWD001: Chlorite

(View | Plot Layouts Load file
4_VNIRSWIR: Chlorite)



Row 1 plots the logged lithology from Neumayr (2009). Row 2 plots the SWIR spectra that match dominantly to chlorite, coloured by the dominant TIR mineral. Row 3 plots the SWIR chlorite spectra by the SWIR spectral feature around 2255 nm (FeOH pfit wvl) coloured by the depth of that feature. The wavelength changes indicate chlorite composition changes; the depth of that feature is analogous to chlorite abundance. There is a wavelength range between 2249–2257 nm (Mg chlorite to FeMg chlorite composition) for most of WWD001 (particularly below 128 m), and chlorite is the most common SWIR mineral. The dotted lines indicate a change in chlorite distribution and wavelength: the chlorite is more magnesian and possibly found with epidote. Row 4 plots the TIR spectra that match dominantly to chlorite, coloured by the dominant SWIR mineral. As with white micas, quartz is the dominant TIR mineral so there are fewer spectra that have chlorite as the dominant mineral in a mineral mix.



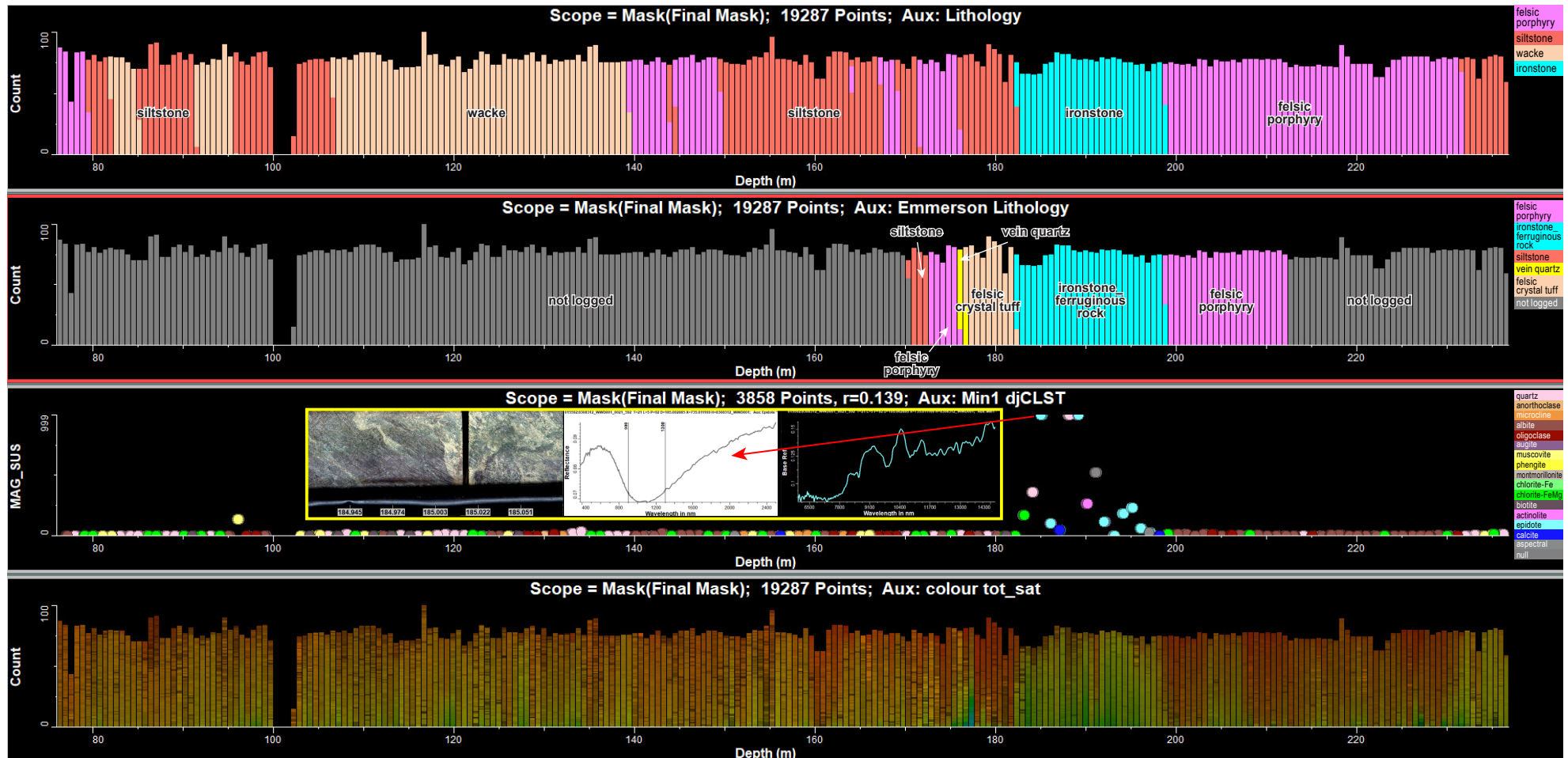
Row 1 plots the logged lithology from Neumayr (2009). Row 2 plots the SWIR spectra that match dominantly to carbonate, coloured by the dominant TIR mineral. Row 3 are the SWIR carbonate spectra plotted by the wavelength of the characteristic carbonate reflectance feature around 2325 nm and coloured by the depth of that feature. Changes in wavelength are analogous to carbonate abundance. Rows 4 and 5 plot TIR (djCLST) spectra that match dominantly to carbonate, plotted by the wavelengths of characteristic carbonate features in the TIR around 6500 nm and 11300 nm. The results are coloured by the strength (height) of that feature. Row 6 plots the TIR spectra that match dominantly to carbonate, coloured by the dominant SWIR mineral. Carbonate matches are sporadic in WWD001 due to the distribution of carbonate being limited to veins (see upper inset image) and mostly within the logged ironstone and intervals above the ironstone. Row 7 plots the TIR spectra (from the TIR-CLS algorithm results) that match dominantly to carbonate, plotted by the depth (abundance) of the characteristic carbonate feature at 11300 nm. The TIR-CLS results reported more carbonate matches than the djCLST results (see pages 5 and 19) but the spectra (see lower inset image) indicate that some of the matches are from modelling a spectral feature that is also common in TIR epidote (false positive carbonate match). In summary, carbonate is very minor in WWD001 and occurs in veins / fractures. The TIR-CLS1 algorithm overstates the carbonate matches.



Row 1 plots the logged lithology from Neumayr (2009). Row 2 is all SWIR spectra with a match to biotite plotted against the SWIR wavelength of biotite (2255 nm) and coloured by the dominant mineral. Note that biotite is present in small abundances and is more common in the metasedimentary rocks in the upper part of the drillhole. Row 3 plots all SWIR spectra with a match to amphibole, plotted by the depth of the MgOH 2390 nm feature and coloured by the dominant SWIR mineral. The dark mineral (upper inset image) is amphibole, surrounded by epidote (pale apple green). Row 4 shows all SWIR spectra that have a match to epidote, plotted by the 1555 nm epidote feature. The logged ironstone has many SWIR epidote matches, and is pale green (lower inset image). Row 5 plots kaolin group minerals by the depth of the kaolin doublet at 2160 nm. Kaolinite is within fractures near the top of the cored interval. There are a few smectites plotting in row 6, mainly along fracture surfaces.

WWD001: Rock properties and petrophysics

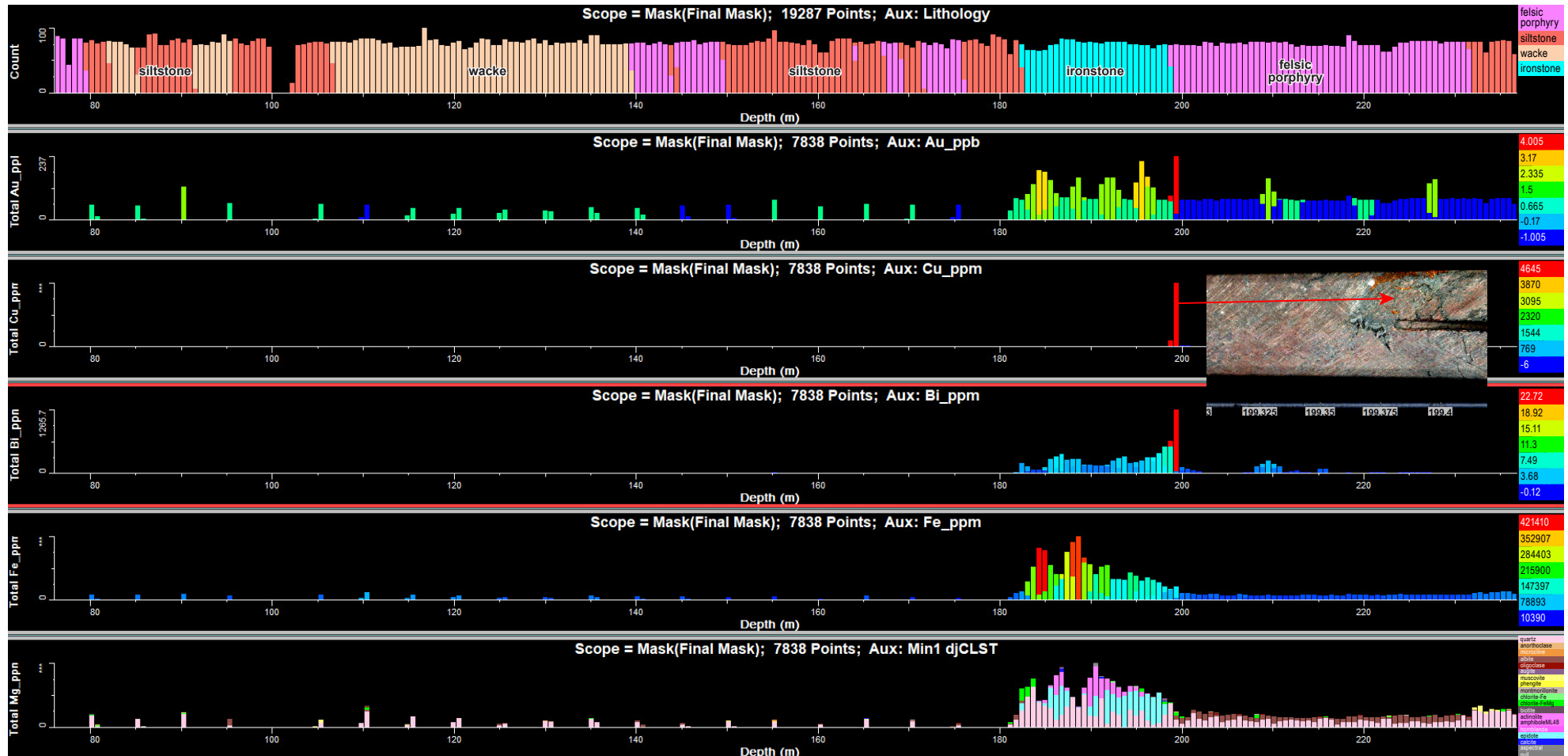
(View | Plot Layouts Load file
7_VNIRSWIR: Rock properties and petrophysics)



Row 1 plots the logged lithology from Neumayr (2009). Row 2 plots the incomplete lithology log by Osborne (2012). Row 3 plots the magnetic susceptibility ($\times 10^{-3}$ SI) collected by Sipa Exploration (Neumayr 2009). Row 4 is core colour. Most of the magnetic susceptibility measurements are very low, with the logged ironstone / ferruginous rock showing locally strong magnetic susceptibility measurements. The core image and spectra from a high magnetic susceptibility measurement is shown in the inset image. The SWIR spectra (central portion) shows a broad open reflectance minima between ~ 900 – 1300 nm and no features in the SWIR. The corresponding TIR spectra shows an upward trending slope (right portion of inset image) with spectral features that match to epidote. Both the SWIR and TIR spectra have features that have been noted in magnetite-bearing ironstones (Smith *et al* in prep). This indicates that magnetite is present within the logged ironstone / ferruginous rock but this interval has common epidote (see image on left portion of inset image).

WWD001: Assays

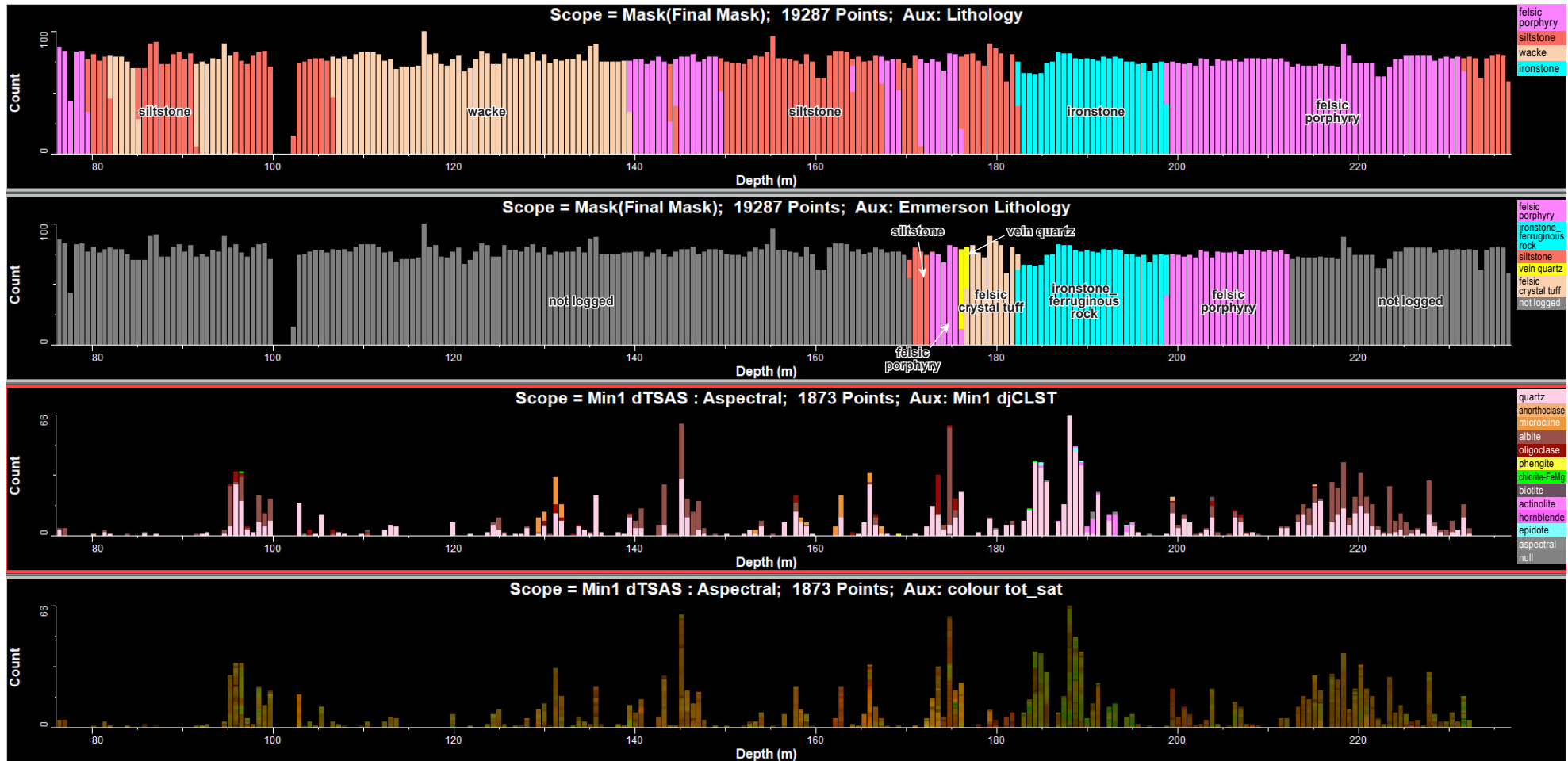
(View | Plot Layouts Load file
8_VNIRSWIR: Assays from Company)



Row 1 plots the logged lithology from Neumayr (2009). Rows 2–6 plot the assays from Neumayr (2009) and coloured by the assay values for rows 2–5. The assays are Au (ppb), Cu (ppm), Bi (ppm) and Fe (ppm) respectively. The highest values for Au, Cu and Bi are coincident at 199 m. The inset image shows chalcopyrite within felsic porphyry. The higher Fe_ppm values may coincide with increased intervals of magnetite (?). Row 6 plots Mg (in ppm) coloured by the dominant TIR mineral. The highest Mg values are within the logged ironstone, within zones that match to amphiboles and magnesian chlorites.

WWD001: Spectral response in SWIR

(View | Plot Layouts Load file
9_SWIR Spectral)



A SWIR spectral response is when the SWIR spectra cannot match to the library mineral spectra. This may be due to noisy spectra from measurements on dark core, or due to measurements from core containing minerals not in the TSA SWIR library. Some minerals do not have any diagnostic SWIR reflectance features, for example silicates such as quartz. Fine disseminations of sulphides or magnetite can affect the SWIR reflectance and result in a lack of features. Row 1 plots the logged lithology from Neumayr (2009) and row 2 plots the incomplete lithology log by Osborne (2012). Rows 3 and 4 plot the SWIR spectra that are classed as aspectral and coloured by the dominant TIR mineral (row 3) and the core colour (row 4). Most of the SWIR aspectral results match to a TIR result dominated by quartz or plagioclase. These minerals do not have any features in the SWIR. The magnetite in the ironstone may also be contributing to a SWIR aspectral response (for example, in inset image on page 14).

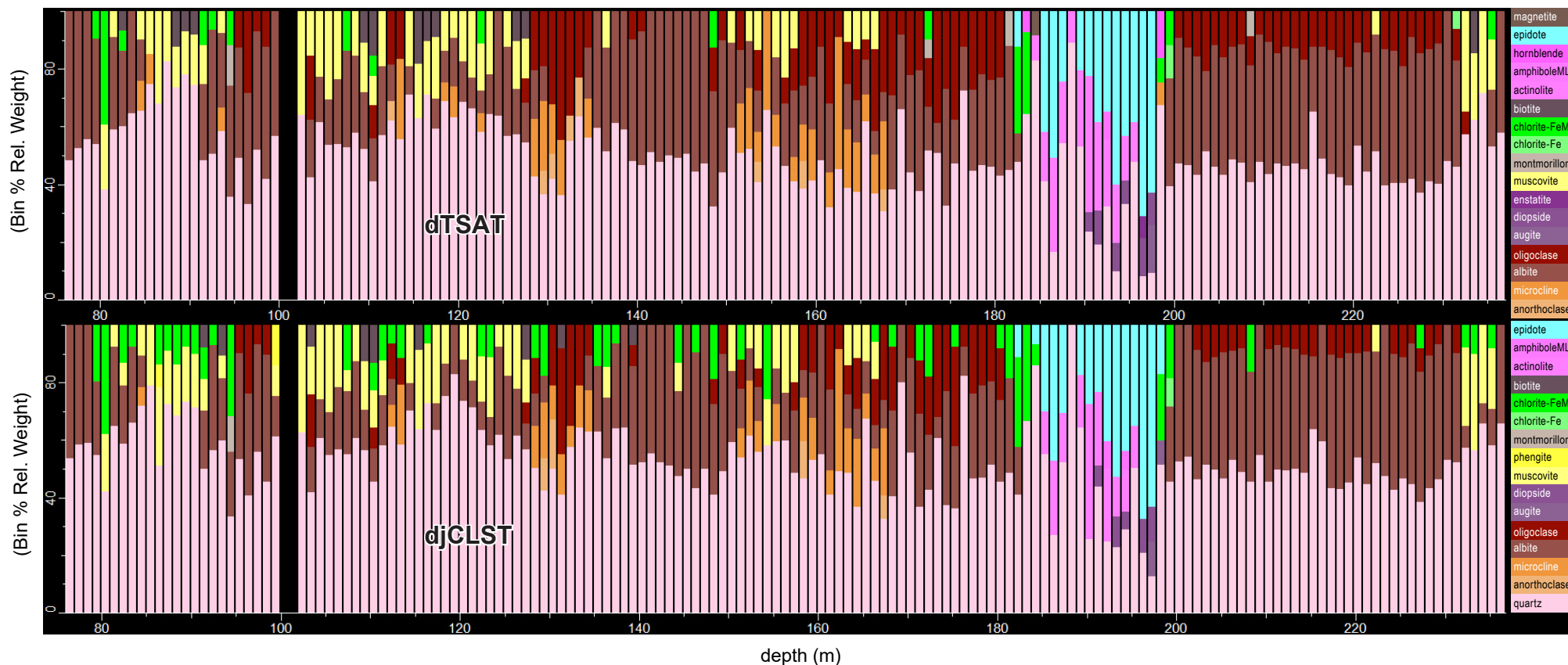
WWD001: Summary of HyLogger data interpretation

- WWD001 is one of four holes drilled to test geophysical anomalies for Tennant Creek-style ironstone mineralisation.
- Neumayr (2009) logged ironstone within WWD001. Relogging by Osborne (2012) interpreted that this ironstone is not a 'typical' Tennant Creek ironstone but the result of an epidote-quartz+/- magnetite alteration. The image below shows the texture and mineralogical variation in this logged ironstone.
- Quartz is the dominant TIR mineral and chlorite is the dominant SWIR mineral for most of the scanned interval. The logged ironstone (ferruginous rock) has less chlorite and is dominated by epidote with quartz, amphibole and localised magnetite.
- White mica, plagioclase and K-feldspar are absent within the logged ironstone but present (in varying proportions) through the rest of the hole. The logged felsic porphyry intervals have a higher proportion of plagioclase than the metasedimentary rocks.
- Carbonate is uncommon and limited to veins and fractures.
- In comparison with other Tennant Creek drillholes, WWD001 is notable for the high epidote-amphibole content within the ironstone. It is also notable that the textural and mineralogical features of this ironstone interval are different to other Tennant Creek ironstones, such as those described in Smith *et al* (in prep) and Smith (2019).



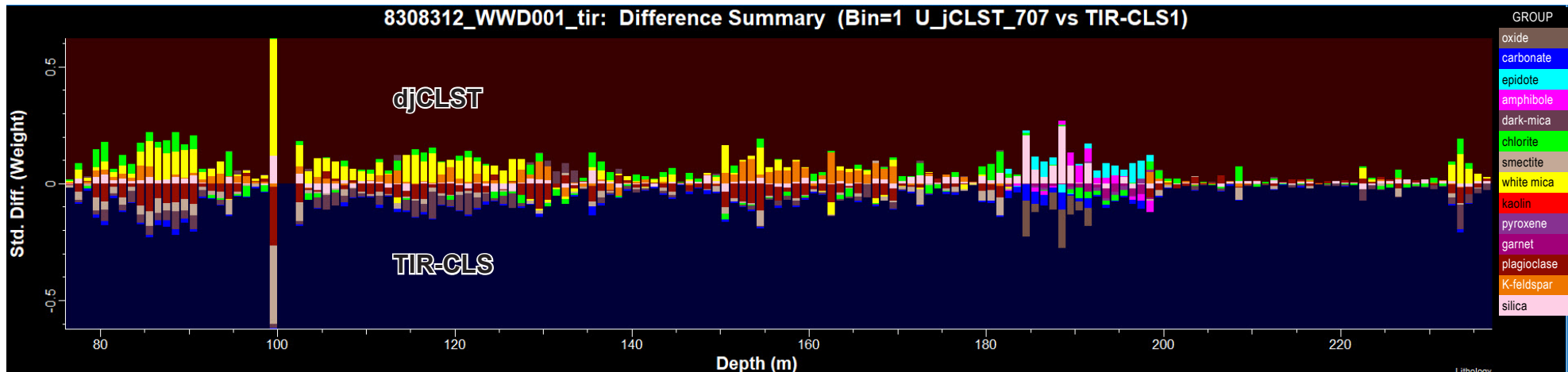
Variations within the logged ironstone zone. Darker zones are magnetite-rich; lighter green zones contain epidote +/- chlorite, quartz, amphibole. This image illustrates the mineralogy and textural changes that Osborne (2012) interprets as an epidote-quartz+/- magnetite alteration event related to the intrusion of the Warrego Granite, rather than a typical Tennant Creek-style ironstone.

WWD001: Comparison of TIR results using djCLST and TSAT



TIR spectra can have non-unique unmixing results, so different mineral assemblages could be modelled to fit the measured spectrum. As noted on page 3, TSG has a number of unmixing algorithms that can be used to produce a mineral result. During spectral interpretation and processing, the TIR spectra are assessed by spectral features, VNIRSWIR results, geological context, and available external data such as assays and petrophysics. Spectral data are domained (as previously described). A final step is producing the mineral summary using TIR-CLS (as outlined on page 5) and also comparing the domained joint CLS algorithm (djCLST) with the older TSA algorithm (dTSAT). In HDP 0068–0080, the djCLST algorithm is used. Above is a comparison of the domained TSAT results with the domained jCLST results in WWD001. The djCLST results for the upper part of the hole (to ~180 m depth) have more chlorite matches, whereas the dTSAT has more white mica and biotite matches for these intervals. The SWIR results indicate chlorite is more common than white mica or biotite, so the djCLST results are used in preference to the dTSAT results for WWD001. Magnetite is not well represented in either algorithm; it is best represented in TIR-CLS algorithm.

WWD001: Differences in TIR results using dTCLST and TIR-CLS



A feature introduced to the Summary Screen in TSG from TSG Build 8.0.4.2 is the 'Summary screen difference plot'. This is described in Mason (2019) and is designed to highlight the differences in unmixing results. The x-axis is the scanned depth, plotted with an arbitrary 1 m bin size. The y-axis shows the difference between the compared results; a line at 0 would indicate no difference between the unmixing results. The results above the 0 show minerals (in mineral groups, not individual minerals) that match with a higher proportion in the dTCLST result. The results below the 0 show mineral groups that match with a higher proportion in the TIR-CLS results. From this plot, the dark mica (dark brown; 104–126 m) in the TIR-CLS plot is more commonly unmixed to white mica (yellow) in djCLST plot. The white mica is supported by the SWIR results. The ironstone–ferruginous rock (182–198 m) matches to epidote+quartz+amphibole in the djCLST results, whereas the TIR-CLS has a higher proportion of magnetite and carbonate matches. Magnetite is considered likely, but the carbonate matches are less likely (see page 12) than the amphibole matches, which are supported with the SWIR results. Within the metasedimentary rocks, the TIR-CLS results commonly match to plagioclase (dark red) and this matches to white mica and K-feldspar in djCLST. Further work (XRD) is recommended to determine whether the plagioclase or K-feldspar+white mica response is more accurate.

WWD001: TSG metadata

File | Dataset Info

From HyLogger Checklist icon

8308312_WWD001_tsg

Metadata Sizes Description TSA Summary

Hole name: 8308312_WWD001 Logger: HyLogger 3-7

Project: National Virtual Core Library

Owner/Cust: Northern Territory Geological Survey

Author: Belinda Smith

Drilled: 2009-10-26 12: Scanned: 2012-05-15 09:

Latitude: -19.433133 Long: 133.658933 Datum: GDA94

Azimuth: 160.000000 Inc: -50.000000 RL: 0.000000

OK Cancel

8308312_WWD001_tsg

Metadata Sizes Description TSA Summary

8308312_WWD001_tsg 8308312_WWD001_tir_tsg

Tray 5, 6 suspect metres noted from IDL logging. Epidote tested using PFIT scalars and confirmed as present with diagnostic 1545 nm, 1830nm spectra. Epidote can occur in mixtures with hornblende, FeMg chlorite. Fe tourmaline is doubtful; missing 1440nm feature and the other 3 diagnostic features (2206nm/2244nm/2306nm) are present but not always right at those wavelengths. Quartz H2O scalar highlights quartz veining. Ankerite is also doubtful; missing 2153nm feature and 2330- 2340nm feature often unclear/noisy. Reprocessed with TIR in January 2020; added Emmerson lithology from CSR0375; added assays and mag susc data from CR2009-1078. Checked for prehnite, pyrophyllite against scalars and turned off. Checked for sulfates but matching to quartz veins so turned off. No scalar matches to tourmaline so turned off.

OK Cancel

8308312_WWD001_tsg

Metadata Sizes Description TSA Summary

TSA set: SWIR VNIR TIR Copy to clipboard

Mineral	Sys %	Usr %	Sys m	Usr m
Chlorite-FeMg	24.85	28.51	46.72	53.65
Muscovite	19.38	20.89	36.13	38.95
Aspectral	6.61	8.06	12.50	15.19
Phengite	4.01	2.66	7.47	4.95
Chlorite-Mg	3.57	3.25	6.90	6.25
Biotite	3.41	4.00	6.40	7.48
Epidote	2.88	1.88	5.51	3.63
Phlogopite	2.87	2.84	5.39	5.33
Tourmaline-Fe	2.66	0.00	4.93	0.00

OK Cancel

8308312_WWD001_tsg

Metadata Sizes Description TSA Summary

8308312_WWD001_tsg 8308312_WWD001_tir_tsg

Turned off barium after comparing Ba assays with Ba scalar (and also checking spectra). Turned off olivine, alunites, sulphates, phosphates after checking spectral shapes and against lithology and SWIR spectra. Turned off talc; no matches in SWIR and except for base of hole; talc spectra are singletons. Checked garnet wvl and turned off uvarovite and andradite. Further checking indicates garnet is a bit suspect. Checked vonsonite and turned off. Looked for anthophyllite, edenite and turned off (not supported). Nontronite in TIR does not match SWIR nontronite, so turned off. Turned off apatite. Some matches to andalusite/cordierite in logged ironstone but not geologically likely so turned off. Pyroxene broad 11000 nm not clear and mixed with epidote; left on but difficult to confirm.

OK Cancel

8308312_WWD001_tir_tsg

Metadata Sizes Description TSA Summary

Samples: 23250 total; 19287 (82.95%) after masking; sample=8mm

Wavelength: 6000 to 14500 by 25 nm, chans=341

Depth: 76.003 to 236.78 m, span=160.78 (160.04 after masking)

Scalars: System=34, core=13, user=49, total=96

Linescan: Lines per sample=124, width=1018, JPEG quality=80

Profilometer: Measurements per sample=128

Disk size (MB): Sp1:62, Sp2:96, img:292, prof:11, pic:79, tot:541.56

Size / m (MB): Sp1:0.39, Sp2:0.60, img:1.82, prof:0.07, pic:0.49, tot:3.1

OK Cancel

8308312_WWD001_tir_tsg

Metadata Sizes Description TSA Summary

TSA set: SWIR VNIR TIR Copy to clipboard

Mineral	Sys %	Usr %	Sys m	Usr m
Quartz	40.26	40.34	76.48	76.67
Albite	19.35	17.58	36.47	33.17
Muscovite	5.06	4.82	9.54	9.11
Chlorite-FeMg	3.70	4.47	6.91	8.35
Oligoclase	3.29	5.19	6.18	9.73
Microcline	2.42	2.27	4.49	4.18
Epidote	2.32	2.35	4.46	4.52
Actinolite	0.94	1.07	1.77	2.03
Rutile	0.88	1.25	1.64	2.32

OK Cancel

The Spectral Geologist (BELINDA SMITH) - 8308312_WWD001_tsg

File Edit View Window Help

From HyLogger Checklist icon

HyLogging Checklist for 8308312_WWD001_tsg

Summary Basic TSA Scalars Domains & Plots DBase Journal

This dialog provides customers with the author's summary of steps taken and processing levels reached prior to their accessing this data. In addition, the Journal automatically tracks most changes and is worth visiting.

Signed off

Final mask: Yes Depth logging: Yes
Imagery: Yes System script scalars: Yes
Analyst's scalars: Yes Imported scalars: Yes
User SWIR TSA: Yes User TIR TSA: Yes
User VNIR TSA: Yes Domains: Yes
Rockmarks: Yes Plots: Yes
Layouts: Yes Database: NO

Save report

Include: ☒ Checklist ☒ Event journal ☒ as filtered

Copy to clipboard Save to file

OK Cancel

HyLogging Checklist for 8308312_WWD001_tsg

Summary Basic TSA Scalars Domains & Plots DBase Journal

User SWIR TSA

☒ Created ☒ Active minerals edited
☒ Through Domain RMS ☒ Noted in 'Dataset Info'
☐ Active minerals list exported ☒ Signed off by analyst

User TIR TSA

☒ Created ☒ Active minerals edited
☒ Through Domain RMS ☒ Noted in 'Dataset Info'
☐ Active minerals list exported ☒ Signed off by analyst

User VNIR TSA

☒ Created ☐ Active minerals edited
☐ Through Domain RMS ☐ Noted in 'Dataset Info'
☐ Active minerals list exported ☒ Signed off by analyst

OK Cancel

HyLogging Checklist for 8308312_WWD001_tsg

Summary Basic TSA Scalars Domains & Plots DBase Journal

Imported Scalars

☒ Geology ☒ Assays
☒ Other ☒ Signed off by analyst

Rockmarks

Level of attention: ☒ Minor ☐ Moderate ☐ Significant
☐ Validation XRD imported ☒ Signed off by analyst

Standard Batch-script Scalars

Interp support: ☐ Minor ☒ Major ☐ Essential
☒ Through 'Final Mask' (or better) ☒ Assigned to appropriate groups
☐ Ineffective scalars deleted ☒ Signed off by analyst

Analyst's Scalars

Interp support: ☐ Minor ☒ Major ☐ Essential
☒ Through 'Final Mask' (or better) ☒ Assigned to appropriate groups
☐ Ineffective scalars deleted ☐ Some aux-match scalars included
☒ Signed off by analyst

OK Cancel

HyLogging Checklist for 8308312_WWD001_tsg

Summary Basic TSA Scalars Domains & Plots DBase Journal

Domains

☒ Created ☒ Descriptions filled in
☒ SWIR RMS lists hand-edited ☒ TIR RMS lists hand-edited
☒ SWIR/TIR RMS lists aligned ☒ TIR CLS scalars created
☒ TIR CLS residual optimised ☒ Signed off by analyst

Plots

☒ Reputable User / Domained TSA ☒ Optimised TIR CLS
☒ Significant imports ☒ Significant Batch / User scalars
☐ All screens optimised ☒ Signed off by analyst

Layouts

☒ Survey-standard layouts ☒ Dataset-specific layouts
☒ Each screen checked, all layouts ☐ Groundhog day for Viewer clients
☒ Layout notes in Dataset Info ☒ Signed off by analyst

OK Cancel

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HyLogger specifications

The TSG dataset originated from HyLogger™3–7. The HyLogger instrument rapidly measures reflectance spectra and also captures continuous high-resolution digital colour imagery of drill cores in their original trays.

HyLogger 3–7 was built by CSIRO (CSERE, North Ryde, NSW) and delivered to NTGS in February 2010 as part of the AuScope National Virtual Core Library (NVCL) project, which was a collaboration between Federal Government's Department of Innovation, Industry Science and Research, CSIRO and state and territory Geological Surveys.

The HyLogger has a continuous motion table that moves at 48 mm/second, three spectrometers (a silicon-detector grating spectrometer for the [380, 1072] nm VNIR interval, an InSB-detector FTIR (fourier transform infrared) spectrometer for the [1072, 2500] nm SWIR interval and a further FTIR spectrometer with a HgCdTe photoconductive detector for the [6000, 14500] nm TIR interval. The spectrometers measure 12 spectra per second, or one spectrum for each 4 mm at the standard table speed of 48 mm/second. The camera is a Basler piA1900-32gc camera, taking 12 frames per second (or one for every 4 mm).

Full details of the HyLogger specifications can be found in Schodlok *et al* (2016b).

Glossary

Glossary of acronyms and technical terms commonly used in HyLogging spectroscopy.

albedo	Normally applied to the mean broadband brightness of a spectrum over a specified wavelength range. A white or altered sample will commonly have a high albedo, whereas a graphitic rock will have a very low albedo.
aspectral	An aspectral response is a spectrum that does not match a TSA library spectrum within the SRSS error cut-off. An aspectral response may be due to many different factors including: dark/noisy spectrum; a mineral not in the TSA library; a silicate mineral without any absorptions in the SWIR (such as olivines, pyroxenes, feldspars, quartz without fluid inclusions).
AlOH	Aluminium hydroxide.
AusGIN	Australian Geoscience Information Network (Geoscience portal): http://portal.geoscience.gov.au/gmap.html is a web portal that hosts NVCL data.
AuScope	The national provider of integrated research infrastructure, of which the NVCL is an infrastructure programme. The AuScope portal (http://portal.auscope.org/portal/gmap.html) hosts NVCL data.
CLS	Constrained Least Squares – an alternative unmixing classifier that uses a RMS to minimise non-unique mineral modelling. Used mainly to model TIR spectra that can have several mixed mineral matches.
Corstruth	A webpage that plots the results (as a pdf summary) from an automated analysis of HyLogger data in the NVCL; www.corstruth.com.au
domain	A zone within a drillhole interpreted to contain a restricted set of minerals that are different to adjacent zones. Unmixing algorithms applied to domained datasets use a RMS that has been defined for each domain by the processing geologist.
EOH	'End of hole' – the end depth of the scanned (or drilled) core
FTIR	Fourier transform infrared spectrometer.
HgCdTe	Mercury cadmium telluride used in infrared detectors.
HQ	Hull quotient – a type of background corrected spectrum.
InSb	Indium antimonide – used in infrared detectors.
MCT	Mercury cadmium telluride used in infrared detectors.
MgOH	Magnesium hydroxide.
nm	Nanometre, being one billionth of a metre. A HyLogger 3 operates between 380 and 14 500 nm, with no measurements between 2500 to 6000 nm.
NVCL	National Virtual Core Library; the library of nationally available TSG datasets
scalar	Any set of imported or calculated values associated with spectral data loaded in TSG.
RMS	Restricted mineral set. The processor limits the set of possible mineral matches based on the geological understanding and spectral characteristics of the domain.
SEM	Scanning Electron Microscopy is a type of electron microscope that images the sample surface by scanning it with a high energy beam of electrons, giving information on sample composition and other properties. SEM results may be used to validate mineral identification by the HyLogger.
SNR	Signal-to-noise ratio.
SRSS	Standardised residual sum of squares (TSA's measure of mineral identification error). Low SRSS values are more reliable than high ones. The current 'bad' threshold is 1000.
SWIR	Shortwave infrared (light). In HyLogging applications it nominally covers the range 1000–2500 nm.
TSA	'The Spectral Assistant' – CSIRO trademarked algorithm that uses training libraries of pure spectra to match an unknown spectrum to a single mineral or to identify mixtures of two or more minerals. Part of the TSG software package.
TSG	'The Spectral Geologist' – CSIRO-developed specialist processing software, designed for analysis of field or laboratory spectrometer data. http://thespectralgeologist.com/
TIR	Thermal infrared (light). In HyLogging applications it nominally covers the range 6000–14000 nm.
VIS	Visible (light). The human eye is nominally sensitive between 390 and 750 nm.
VNIR	Visible near infrared (light). In HyLogging applications it nominally covers the range 380–1000 nm.
volume scattering	Radiation that is reflected after some absorption into the rock and changes the spectral shape and features. TIR spectral interpretation assumes that there is only surface scattering in a spectrum. Volume scattering leads to errors in TSA and CLS modelling.
wvl	Wavelength - used in TSG scalar names.
XRD	X-ray diffraction - an analytical technique that reveals information about the crystallographic structure, physical properties and chemical composition of a sample. It is based on observing the scattered intensity of an X-ray beam hitting a sample and measuring the scattered angle and wavelength or energy.

Guide to scalars in figures produced using TSG software

The terms used in the titles, x and y-axis for figures produced from TSG are described in the table below:

2200 wvl 2nd deepest	FEATEX scalar that measures the wavelength of the second deepest absorption feature from 2200nm +/- 50nm. Designed to measure the wavelength of the kandite doublet, which has a variable wavelength depending on whether it is kaolinite or dickite.
2325 CO3 PFIT wvl	PFIT scalar to measure the wavelength of a trough minima between 2285–2400 nm with a depth >0.05; polynomial order 8; hull envelope divided by reflectance reported as wavelength at minimum in nm. Used mainly to analyse carbonate composition changes by observing wavelength changes in the dominant absorption feature for carbonate in the SWIR. The 2325 CO3 pfit d measures the relative depth using the same parameters (above). The depth scalar is used to measure abundance (strength of feature).
2390 pfit d	Measuring the depth of a trough minima between 2365–2434 nm with a depth >0.02; polynomial order 10; hull envelope divided by reflectance reported as a relative depth. It is commonly used to confirm the presence of amphiboles, and other minerals with a 2390 nm feature. The 2390 pfit wvl uses the above parameters but reports the result as a wavelength at minimum (composition change).
Al smectite abundance	Developed by CSIRO in 2011 as multiple feature extraction method (MFEM) batch script, this (unvalidated) scalar maps montmorillonite and beidellite abundance by measuring the continuum removed depth of a fitted 4th order polynomial between 2120 and 2245 nm.
Apatite 9200 PFIT d	PFIT scalar created by J Huntington (of Huntington Hyperspectral) to confirm the TSA apatite response. Measures the wavelength of the minimum trough between 9192 nm and 9270 nm with a depth of >0.0006; polynomial order 6; hull envelope subtract base reflectance to give a relative depth.
Aux	Aux in a plot indicates the parameter that is colouring the points (bars in bar plot, points in scatter plot) in a figure. For example, Aux: stratigraphy indicates that the colours relate to stratigraphy. The key to the Aux colours are on the right side of each plot.
Aux match scalar	Aux matching involves simple curve matching between spectra in a main dataset and spectra in a Aux (Auxiliary or Custom) dataset. The Aux dataset is usually a custom library containing special hand-chosen spectra that have been interpreted in detail.
Biotite 2355nm PFIT depth	PFIT scalar to measure the depth of the MgOH trough minima between 2345–2370 nm with a depth >0.009; polynomial order 6; RMSE <=0.1; hull envelope divided by reflectance reported as wavelength at minimum in nm. Used in conjunction with the Biotite 2355nm PFIT wvl scalar and the TSAS results to characterise the presence of biotite, which may be difficult to distinguish from chlorite.
Biotite 2355nm PFIT wvl	PFIT scalar to measure the wavelength of the MgOH trough minima between 2345–2370 nm with a depth >0.009; polynomial order 6; RMSE <=0.1; hull envelope divided by reflectance reported as wavelength at minimum in nm. Used as a measure for the presence of biotite but has some overlap with chlorite.
Carbonate 6500nm pfit wvl	A PFIT scalar that replaces an earlier CSIRO batch scalar of a similar name. The PFIT scalar fits the feature between 6300–6800nm; focus 6400–6700nm, height >0.015; polynomial order 6; hull envelope subtract base reflectance for a wavelength at maximum result. Used to determine differences in the wavelength of the peak around 6500 nm, which shifts with different carbonate compositions. The carbonate 6500nm pfit d uses the same parameters but returns a result of relative height.
Carbonate 11300nm pfit wvl	PFIT scalar to measure the wavelength of the peak maxima between 11000–11580 nm with a height of >0.005; polynomial order 9; hull envelope subtract base reflectance to give wavelength at maximum. The Carbonate 11300nm pfit d scalar uses the same parameters to return a relative height result. Usually used in conjunction with the 6500nm feature. Recent work by Green and Schodlok (2016) suggests also analyzing features at 14 000nm.
Christiansen Minimum	Experimental batch scalar created by CSIRO that plots the Christiansen Minimum wavelength. The Christiansen Minimum occurs when the refractive index of the sample approaches the refractive index of the (medium) air surrounding the mineral grains, resulting in minimal scattering and minimal reflectance (Conel 1969). The Christiansen Minimum wavelength varies according to composition, so measuring the Christiansen Minimum wavelength can differentiate igneous rock compositions in the TIR.
Colour tot_sat	TSG standard scalar; it calculates the colour (separately per band) from the visible interval of the reflectance spectra and it is enhanced by a 'total saturation' (the S band is 'wired to 1'; no pastels). Refer to TSG Help Manual for more explanation.
Count	The feature frequency plots are bar plots with y-axis = count. The count is cumulative number of features within a bin. The bin size will vary according to the x-axis, which might be depth, wavelength in nanometres etc.
D1900	Measures the depth of the 'water feature' between 1860–1970 nm (focus 1880–1950 nm); depth >0.03; polynomial order 4; hull envelope divide reflectance reported as relative depth. This scalar is also an intermediate scalar in the 'WM crystallinity' scalar.
Epidote 473nm PFIT d	Measuring the depth of a trough minima between 440–490 nm with a depth >0.013; polynomial order 8; hull envelope divided by reflectance reported as a relative depth. Used as one of 3 scalars to confirm the presence of epidote. Other epidote scalars may include those searching for features at 1555 nm and/or 1830 nm

Guide to scalars in figures produced using TSG software (continued)

Epidote 1555 pfit d	PFIT scalar to measure the depth of a trough minima between 1500–1610 nm; polynomial order 10; hull envelope divided by reflectance reported as a relative depth. Measures the presence of epidote in a wavelength range which other minerals (such as chlorite) does not have features. Best used in conjunction with the Epidote 1830 nm pfit d and/or Epidote 473 nm PFIT d.
Epidote 1830 nm PFIT d	PFIT scalar to measure the depth of a trough minima between 1805–1850nm (focus 1824–1835 nm); polynomial order 8; hull envelope divided by reflectance reported as a relative depth. Measures the presence of epidote in a wavelength range which other minerals (such as chlorite) does not have features. Best used in conjunction with the Epidote 155nm pfit d and/or Epidote 473nm PFIT d.
FEATEX scalar	FEATEX scalars use a feature extraction algorithm in TSG to calculate the depth, width and/or wavelength position of a spectrum's absorption features. It uses pre-calculated feature extraction information from TSG's default algorithm.
Felsic-Mafic Index wvl	Experimental batch scalar created by CSIRO that maps the peak wavelength between 7500 and 12000 nm from a 4th order polynomial. Shorter wavelengths are more felsic than longer mafic ones. Most carbonate-bearing samples are excluded.
FeOH PFIT depth	PFIT scalar to measure the depth of a trough minima between 2240–2270 nm with a depth >0.04; polynomial order 10; hull envelope divided by reflectance reported as relative depth.
FeOH PFIT wvl	PFIT scalar to measure the wavelength of a trough minima between 2245–2260 nm with a depth >0.04; polynomial order 10; hull envelope divided by reflectance reported as wavelength at minimum in nm. Used mainly to analyse chlorite composition changes.
FeOx intensity (alt)	TSG standard scalar (batch scalar) that ratios the reflectance at 742 nm / reflectance at 500 nm to give the Fe slope.
Garnet 11400 comp wvl	PFIT scalar to measure the wavelength of the trough minima focussed between 10550 to 11600nm with a depth >0.2; polynomial order 6; hull envelope divided by base reflectance reported as wavelength at minimum in nm. Used to validate garnet species; almandine has shorter wvl; andradite has longer wvl.
Grp 1 Min	Group (coarse level) index of the primary mineral group component in a TSA result. Mineral groups include carbonates, white micas, pyroxenes etc. Grp2 Min would be the secondary/minor mineral group component in a mineral mix.
Hydrocarbon presence	A PFIT scalar designed to measure the presence of an absorption feature at 1730 nm, which is often found associated with oil bleeds. Another scalar designed to identify hydrocarbons is the 23140 nm PFIT scalar. Using both scalars together can identify oil bleeds when the spectral response is preserved (it can deteriorate over time).
Kaolin composition	A CSIRO-built batch scalar in TSG that measures the composition and crystallinity of kaolin group minerals ranging from well-ordered kaolinite to halloysite to dickite (and nacrite).
Kaolinite PFIT 2160 doublet d or D2160	A PFIT scalar measuring the relative depth of the kandite doublet absorption feature, as an analogue for crystallinity / abundance of kaolinite. Used to confirm that TSAS-assigned well-crystalline and poorly-crystalline kaolinite are present. PFIT used hull envelope divided by reflectance; focussed on 2155–2180 nm to determine the relative depth using a >0.01 cut-off, polynomial order 3, masked through Final Mask.
Mask (Final Mask)	Mask scalars are used to filter out unwanted spectra caused by scanning tray edges, core blocks etc. TSG uses the Final Mask as the default mask for both SWIR and TIR datasets and will synchronise the mask for both datasets. Many in-built TSG scalars are calculated after being filtered through the Final Mask.
Min 1	Mineral index of the primary mineral for a TSA singleton match or primary mixture component. Min 2 is the subordinate/minor mineral in a TSA mineral mix.
PFIT Fe oxide wvl	PFIT scalar to measure the VNIR feature fitting 750–950 nm (focus 830–910 nm); depth 0.026; polynomial order 3; hull envelope divided by reflectance to report wavelength at minimum. Used to test the wavelength of hematite and goethite matches, and perhaps identify hematite and goethite in zones that would return a uTSAV 'Not In Library' or 'aspectral' response. PFIT Fe oxide d has the same parameters but returns a relative depth of the absorption feature.
PFIT scalar	PFIT scalars take a section of the spectrum specified by the user, optionally does a local continuum removal, fits a polynomial and calculates a result directly from the polynomial's coefficients. PFIT scalars are used to define the wavelength of noted spectral features.
Pyrophyllite 2078nm D	PFIT scalar to measure the depth of a trough minima between 2060–2090 nm (focus 2070–2083 nm) with a depth >0.002; polynomial order 4; hull envelope divided by reflectance reported as a relative depth. Used to measure presence of pyrophyllite (along with Pyrophyllite 2319 nm D) which is useful in mineral mixtures which also contain overlapping features around 2200 nm (such as kaolins and white micas).
Pyrophyllite 2166nm D	PFIT scalar to measure the depth of a trough minima between 2156–2172 nm (focus 2160–2172 nm) with a depth >0.0507; polynomial order 4; hull envelope divided by reflectance reported as a relative depth. Used to measure presence of pyrophyllite but has limited use in mineral mixtures with kaolin group minerals (as there are overlapping features at this wavelength range).
Pyrophyllite 2319nm D	PFIT scalar to measure the depth of a trough minima between 2297–2335 nm (focus 2310–2323 nm) with a depth >0.024; polynomial order 6; hull envelope divided by reflectance reported as a relative depth. Used to measure presence of pyrophyllite (along with Pyrophyllite 2078 nm D) which is useful in mineral mixtures which also contain overlapping features around 2200 nm (such as kaolins and white micas).

Guide to scalars in figures produced using TSG software (continued)

Prehnite 1475 nm PFIT	PFIT scalar to measure the wavelength of a trough minima between 1460–1485 nm with a depth >0.009; polynomial order 6; hull envelope divided by reflectance reported as a relative depth. Used to confirm prehnite, with the depth of the 1475 nm feature indicative of abundance.
Quartz 8625 PFIT d abundance	Experimental PFIT scalar to measure the 'abundance' of quartz in a sample by measuring the depth of reflectance minima at 8625 nm, which is characteristic of the presence of quartz. Scalar measure returns relative depth in nm, by subtracting the low side of the minima from normalised TC reflectance using a depth >0.02 between 8580–8700 nm.
Quartz 8625 PFIT d MAV	Smooths the 8625 PFIT d abundance scalar (above) by using the mean through a moving window. The output smooths out the effect of outliers to display gross changes in the quartz abundance in plots.
Quartz 12500nm peak d	Measuring a characteristic quartz peak between 12430–12600nm, polynomial order 3; hull envelope subtract base reflectance reported as a relative height. Used as a secondary feature for determining quartz presence. The quartz 12500 nm peak wvl uses the same parameters but returns a wavelength at maximum result.
Quartz 12800 nm peak d	an experimental PFIT scalar to identify a secondary quartz feature at around 12800 nm by fitting 12650–12950 nm; (focus 12700–12900 nm); polynomial order 4; hull envelope subtract normalised TC reflectance. This is an experimental scalar (so parameters may slightly change between datasets) and results can overlap with plagioclase and K-feldspar features. Use with care if these minerals are present.
Quartz absorption depth	Experimental batch scalar created by CSIRO to measure the depth of the characteristic quartz reflectance feature at 8625 nm. Similar to the Quartz 8625 PFIT d abundance scalar, but can be more effective in masking out spurious matches to some sulphates that formed from the core decomposition after drilling (refer Sever No.1 drillhole).
Quartz_H2O	An inbuilt batch scalar found in HotCore. Described as 'normalised ratio that maps samples with appreciable (1950 nm) water absorption in fluid inclusions, found mostly in quartz (and some carbonates)'.
Scope	The Scope option allows users to filter their data to visualise the behaviour of selected classes (eg; stratigraphy, mineral groups) and samples in different XY plots. The Scope indicates how many samples out of the total samples in the dataset are currently displayed in this plot window.
Smooth (Albedo)	TSG standard scalar (batch scalar) that first calculates the reflectance albedo over 450–2450 nm with basic channel outlier masking, then averages the numeric response (smooths) of the albedo. May also be called Albedo Rmean Smooth or Smoothed Albedo.
Smoothed scalar	Created by 'smooth an existing scalar using a moving window'. Generally uses averaging of the numeric response to create a smoothed scalar.
sTSAS, uTSAS, uTSA+, dTSA+	Mineral result from matching to the short wave infrared (SWIR) spectra against the TSA library. In TSG versions 7 and earlier; 'sTSAS' is the default system match. 'uTSAS' is the author-derived result from manually excluding some minerals and artefacts (eg; wooden core blocks, plastic chip tray spectra) during processing. In TSG versions 8 and later, TSA+ uses some information derived from selected features in both the SWIR and TIR to make a more informed choice about mineral mixtures. The 'd' indicates the results are 'domained'.
sTSAT, uTSAT, dTSAT	Mineral results from matching to the thermal infrared (TIR) spectra against the TSA library. 'sTSAT' is the default system match. 'uTSAT' is the author-derived result from manually excluding some minerals and artefacts during processing. 'dTSAT' indicates the results are 'domained'.
jCLST, ujCLST, djCLST	The jCLST algorithm has been developed by Andy Green (OTBC Pty Ltd; www.corstruth.com.au) as a replacement for sTSAT, which unmixes the TIR spectra on a sample by sample basis without reference to the results in the VNIR or SWIR (which can commonly return spurious mineral matches). In comparison, jCLST interprets TIR data using the results from a modified TSAT, TSA+ and from scalars using selected features in the VNIR and TIR. 'ujCLST' is the author-derived results from manually excluding some minerals during processing. 'djCLST' is author-derived results from manually domaining the drillhole into zones of similar mineralogy and restricting the minerals available for the jCLST algorithm in each domain.
sTSAV, uTSAV	Mineral result from matching to the visible near infrared (VNIR) spectra against the TSA library. 'sTSAV' is the default system match. 'uTSAV' is the author-derived result from manually excluding some minerals and artefacts (eg; galvanised tray spectral matches) during processing.
TIR-CLS1_CLS_min_1	CLS scalar showing the dominant modelled mineral (using the CLS unmixing algorithm) from the TIR wavelength range. For this scalar, the number of minerals allowed in the CLS mineral output is 3 (shows the 3 most dominant) although the scalar can allow for up to 6 minerals. The minerals available for modelling in the domain (RMS) is selected during the interpretation / processing stage.
TIRDeltaTemp	An inbuilt TSG scalar that measures the change in temperature between the instrument response measured from the rock and the background response. Plotting this scalar can highlight sulphides or artefacts (such as metal tray edges, metal depth marker tabs or instrument issues).
Tourmaline PFIT 2247nm d	PFIT scalar to measure the depth of a trough minima between 2230–2270 nm; polynomial order 4; hull envelope divided by reflectance reported as a relative depth. Used in conjunction with the 2366nm scalar to determine if tourmaline is present, especially if the SWIR TSA algorithm results need confirmation.
Tourmaline PFIT 2366 d	PFIT scalar to measure the depth of a trough minima between 2358–2385 nm; polynomial order 5; hull envelope divided by reflectance reported as a relative depth.

Guide to scalars in figures produced using TSG software (continued)

Tourmaline PFIT 2366nm	PFIT scalar to measure the wavelength of a trough minima between 2360–2375 nm with a depth >0.015; polynomial order 5; root mean square error (RMSE) ≤ 0.06; hull envelope divided by reflectance reported as a relative depth. Used to search for tourmaline in mixtures with chlorite and white micas (which may have overlapping features at around 2206 nm and 2244 nm).
U_SWIR_TSA705 Groups{item=WHITE-MICA}-> Set Weight	A Class Extraction scalar that extracts all the SWIR spectra that contain white mica and returns the weighting of the white mica within the uTSAS result (as a number between 0.15 and 1). Used as an intermediate scalar for the White Mica Mask. Created by New Scalar CLASSEX Search in: Domained SWIR TSA Groups and Match this item WHITE MICA and extract U_SWIR_TSA705 Weight (masked through Final Mask).
uTSA*	The result from TSA. The prefix 'u' is for 'user' and refers to the fact that TSA is trained on a reference library of minerals that have been limited by the author from the system set of minerals called sTSA* during the processing of the dataset. The minerals that are excluded from being matched to the TSA library are those that are considered to be unlikely in that geological environment and do not visually match the spectra well.
uTSAT invalid	A scalar created to mask out both Final Mask and 'aspectral', 'noisy' or 'null' for uTSAT Min 1 minerals. Plots that use uTSAT plot only spectra that were successfully matched in the TSA library, so noisy spectra (which may be noisy due to rubbly core, volume scattering etc) don't detract from displaying the dominant mineral or mineral group in the TIR. If a hole has a lot of 'invalid' spectra due to rubbly core, it may over-emphasise minor minerals in the TIR that are perhaps within unbroken core and may not reflect accurate mineral proportions.
White Mica Mask	A mask of the TSA results so that dTSAS (or uTSAS) results match only to white mica. Results from scalars such as WM crystallinity and White mica PFIT wvl (white mica composition) are affected by the presence of other minerals with an AIOH feature (such as smectites, kaolin group minerals, pyrophyllite). Using the White Mica Mask gives a better result for WM crystallinity. The White Mica Mask is developed from the U_SWIR_TSA705 Groups{item=WHITE-MICA}-> Set Weight by Edit New Scalar Method = UCLASS; Initialise as a mask from U_SWIR_TSA705 Groups{item=WHITE-MICA}-> Set Weight. Within the White Mica Mask then select Class/Rock Mark Edit and Select U_SWIR_TSA705 Groups{item=WHITE-MICA}-> Set Weight LE (less than or equal to) 0.85 and select IN for Class OFF.
White mica PFIT wvl	PFIT scalar to measure the wavelength of a trough minima between 2190–2229 nm with a depth >0.04; polynomial order 10; hull envelope divided by reflectance reported as wavelength at minimum in nm. Used mainly to analyse white mica composition changes by observing wavelength changes in the dominant absorption feature for white mica in the SWIR.
White mica PFIT d	PFIT scalar to measure the depth of a trough minima between 2190–2229 nm with a depth >0.12; polynomial order 4; hull envelope divided by reflectance reported as relative depth. Also referred to as 'D2200 white micas'.
WM crystallinity	Arithmetic scalar measuring D2200 white mica divided by D1900 masked by the Final Mask. White mica crystallinity measures the depth of the AIOH absorption feature relative to the depth of the water feature. A deeper water feature indicates lower crystallinity and may indicate an illitic white mica (which may also have some compositional substitution).

1.1 Basic HyLogging Product Levels

0. **Machine Data** package (QCed & archived by collecting team / agency: i.e. all repeats taken care of and data checked).
1. **TSG Data** package - TSG imported and formatted data (see note about TSG-QC outputs)
 - 1A. TSG imported imagery, spectra and supporting data (nothing else done). Raw system TSA run on import but no checking. Depths only based on tray starts & ends.
 - 1B. Final masked, basic depth-logged data, imagery enhanced, new tray imagery & mosaics created.. Further updates possible.
 - 1C. All standard "system" scalars (includes basic masked and reviewed TSA mineralogy) created & checked.
 - 1D. User TSA results included (i.e. retrained TSA) and all Scatter screens changed to uTSAS. Minimum database entry point.
 - 1E. Non-standard mineralogical (manually-generated) "user" scalars added, thresholded and checked. Might include an Aux match library or stats (PC) analysis.
 - 1F. All metadata tables updated. Optimum database loadable level. Further updates possible.
2. **Integrated Data** package - Imported numeric or class scalars added into TSG and depths adjusted if required to fit assay intervals.
3. **Published Data** package - Signed-off for public (NVCL) database publication. Default set of products (for web discovery) identified and tagged.
4. **Down-sampled Data** package - Optional down-sampled version of all of above.
5. **Project data** package. Abstracted data from many holes integrated in some way.

The HyLogger Product level refers to the level of processing of a dataset. This dataset is at 'Level 3' as it has imported stratigraphic information.