Navigating in TSG8 - Functional Overview

Spectral Analysis Software for Geoscientists since 1995

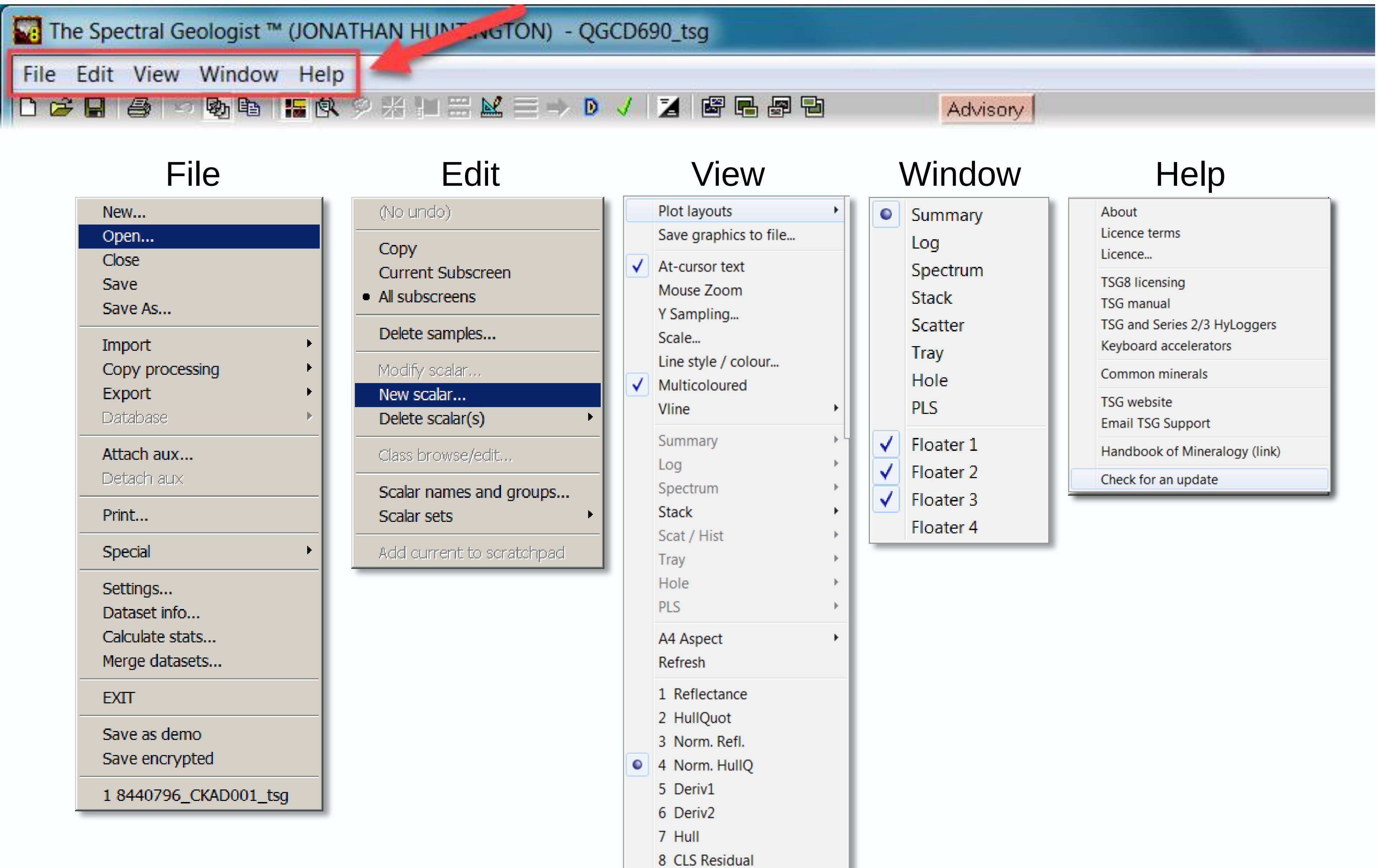
What does TSG provide? - 1

- Imports reflectance spectra and images from multiple instruments
  - *Reflectance spectra from 380-15,000 nm (0.3 – 15 micrometres) (VNIR, SWIR, MIR, TIR)*
  - *ASD, Spectral Evolution, Agilent, HyLoggers, Corescan, ENVI SpecLibs, ASCII*
- Various levels of automated mineral interpretation with unmixing
  - *Built-in spectral reference libraries & spectral modelling tools*
  - *Tools for editing & providing context & domains to those interpretations*
- Tools for creating your own spectral indices (called Scalars in TSG)
- Multiple & vibrant visualization tools with mineralogical filters
- Handles field-sample or core images & GPS data, where they exist.

What does TSG provide? - 2

- Imports external numerical or textual data (e.g. assays & logs)
- Exports data and images to other packages
- Downsamples to different intervals
- Advanced statistics: PCA and Cluster analysis
- Quantification tools for calibrating spectra to known analyses
  - *(PLS modelling & prediction)*
- Exports and imports between MS SQL and Oracle databases
  - *(e.g. NVCL servers)*
- Product generation, reporting, workflow management & housekeeping.

Navigating in TSG8 – Top Left - Management



TSG Data Files

Spectra from hand-held devices will normally be in a single package of files.

Spectra and images from 3rd generation HyLoggers (HyLogger-3) will be in two groups of files with the VNIR/SWIR in one package and the TIR in another.

The two dataset packages know about each other and depending on which is active are referred to as the primary and associated datasets respectively.

A typical complete dual HyLogger-3 package is shown at the right.

- 20610_0164.jpg
- 20610_0165.jpg
- 20610_PRL21_SAR8_tsg.bip
- 20610_PRL21_SAR8_tsg.ini
- 20610_PRL21_SAR8_tsg.tsg

ASD

- 20610_PRL21_SAR8_tsg_1.ini
- 20610_PRL21_SAR8_tsg_2.ini
- 20610_PRL21_SAR8_tsg_3.ini
- 20610_PRL21_SAR8_tsg_4.ini
- 20610_PRL21_SAR8_tsg_5.ini
- 20610_PRL21_SAR8_tsg_6.ini
- 20610_PRL21_SAR8_tsg_7.ini
- 20610_PRL21_SAR8_tsg_cras.bip
- 20610_PRL21_SAR8_tsg_hires.dat
- 20610_PRL21_SAR8_tsg_holeimg.jpg
- 20610_PRL21_SAR8_tsg_tir.bip
- 20610_PRL21_SAR8_tsg_tir.ini
- 20610_PRL21_SAR8_tsg_tir.tsg
- 20610_PRL21_SAR8_tsg_tir_1.ini
- 20610_PRL21_SAR8_tsg_tir_2.ini

Opening Datasets

Core tray images

VNIR / SWIR Package – Open 1st

Layout files

Linescan image of core

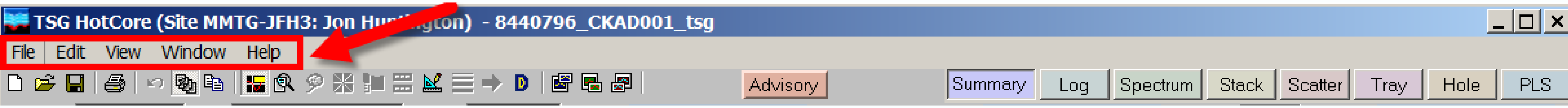
Profilometer data file

Hole Mosaic image

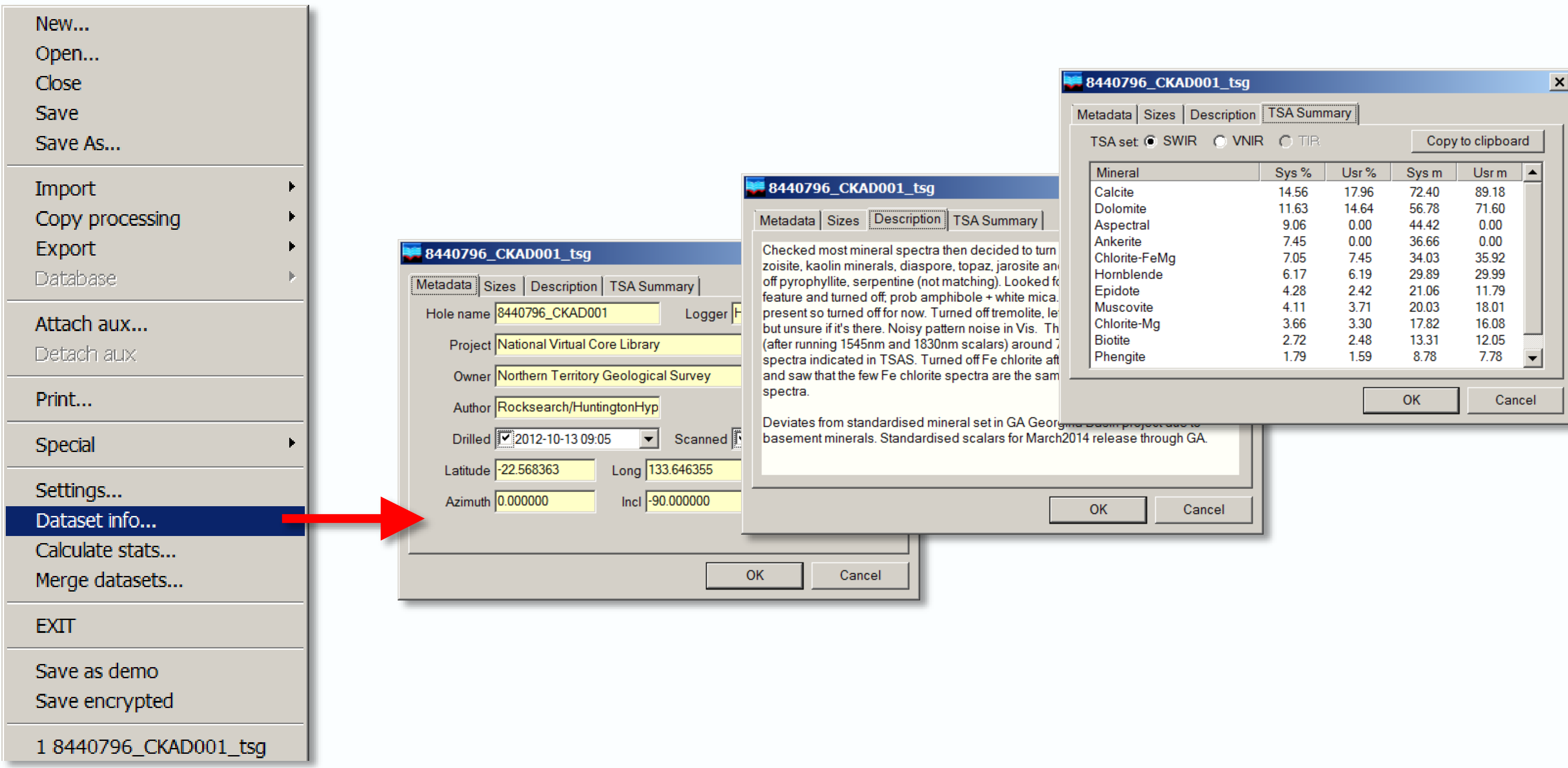
TIR Package - Open later

- 20610_0164.jpg
- 20610_0165.jpg
- 20610_PRL21_SAR8_tsg.bip
- 20610_PRL21_SAR8_tsg.ini
- 20610_PRL21_SAR8_tsg.tsg
- 20610_PRL21_SAR8_tsg_1.ini
- 20610_PRL21_SAR8_tsg_2.ini
- 20610_PRL21_SAR8_tsg_3.ini
- 20610_PRL21_SAR8_tsg_4.ini
- 20610_PRL21_SAR8_tsg_5.ini
- 20610_PRL21_SAR8_tsg_6.ini
- 20610_PRL21_SAR8_tsg_7.ini
- 20610_PRL21_SAR8_tsg_cras.bip
- 20610_PRL21_SAR8_tsg_hires.dat
- 20610_PRL21_SAR8_tsg_holeimg.jpg
- 20610_PRL21_SAR8_tsg_tir.bip
- 20610_PRL21_SAR8_tsg_tir.ini
- 20610_PRL21_SAR8_tsg_tir.tsg
- 20610_PRL21_SAR8_tsg_tir_1.ini
- 20610_PRL21_SAR8_tsg_tir_2.ini

Navigating in TSG8 – Dataset Info

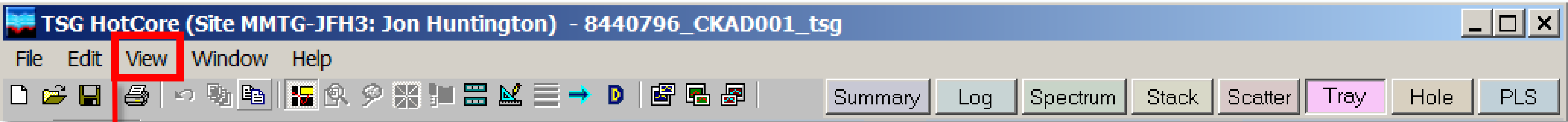


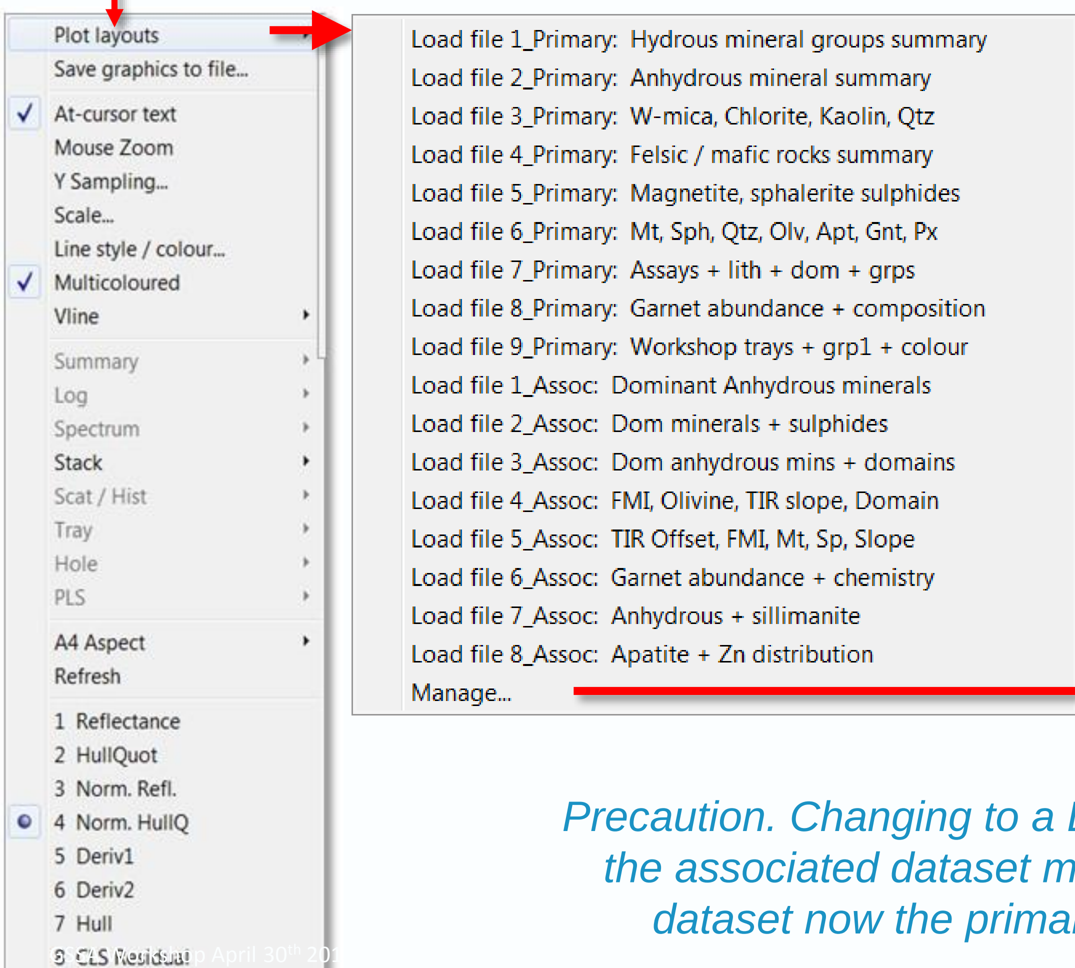
File … Dataset Info …….. Metadata ………. Description ………. TSA Summary



Navigating in TSG8 – Layout Manager

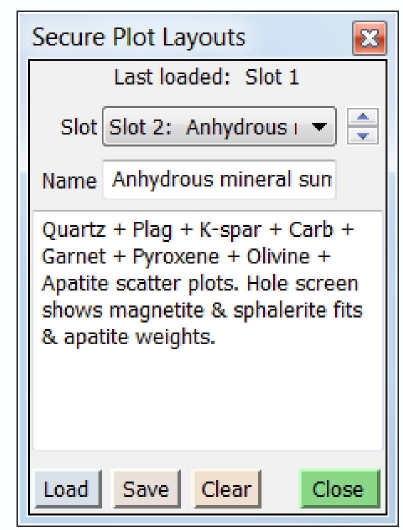
Explore previously saved screen content, if present.





....Click on any item to go to a saved set of screens showing specific information

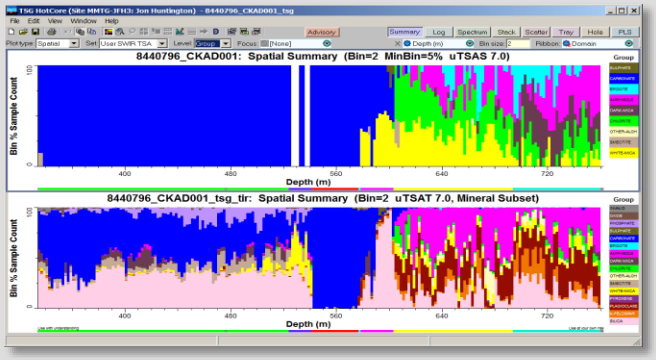
Use "Manage" to enter, edit or view detailed content



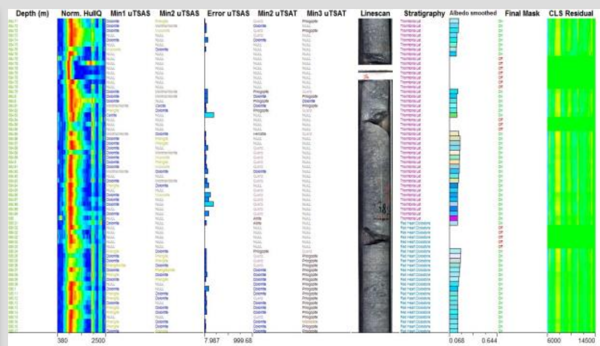
Precaution. Changing to a Layout from the associated dataset makes that dataset now the primary one.

Navigating in TSG8 – Top Right Content Menus

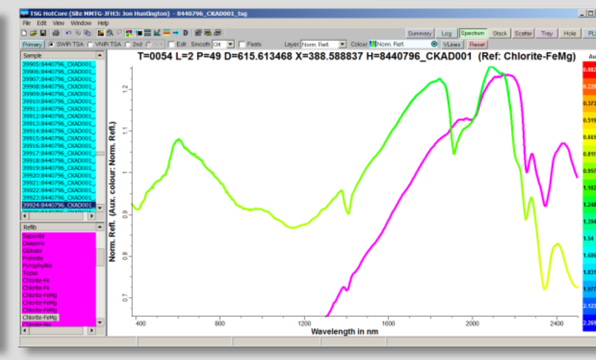
Summary



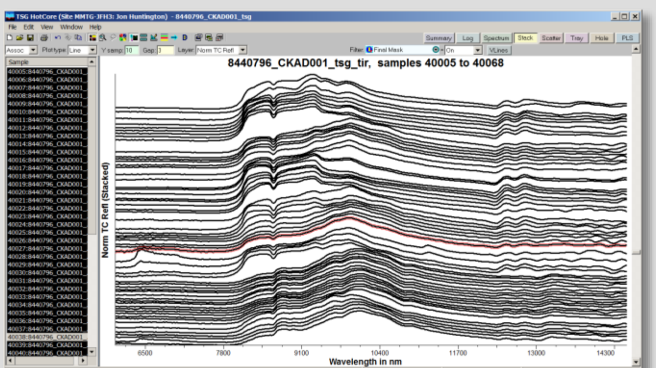
Log



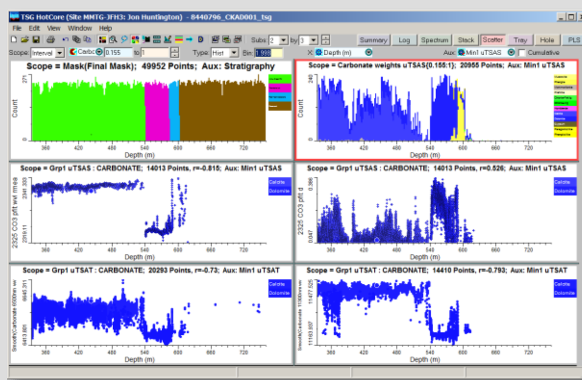
Spectrum



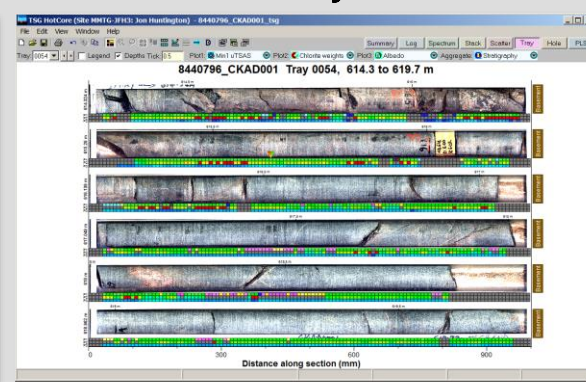
Stack



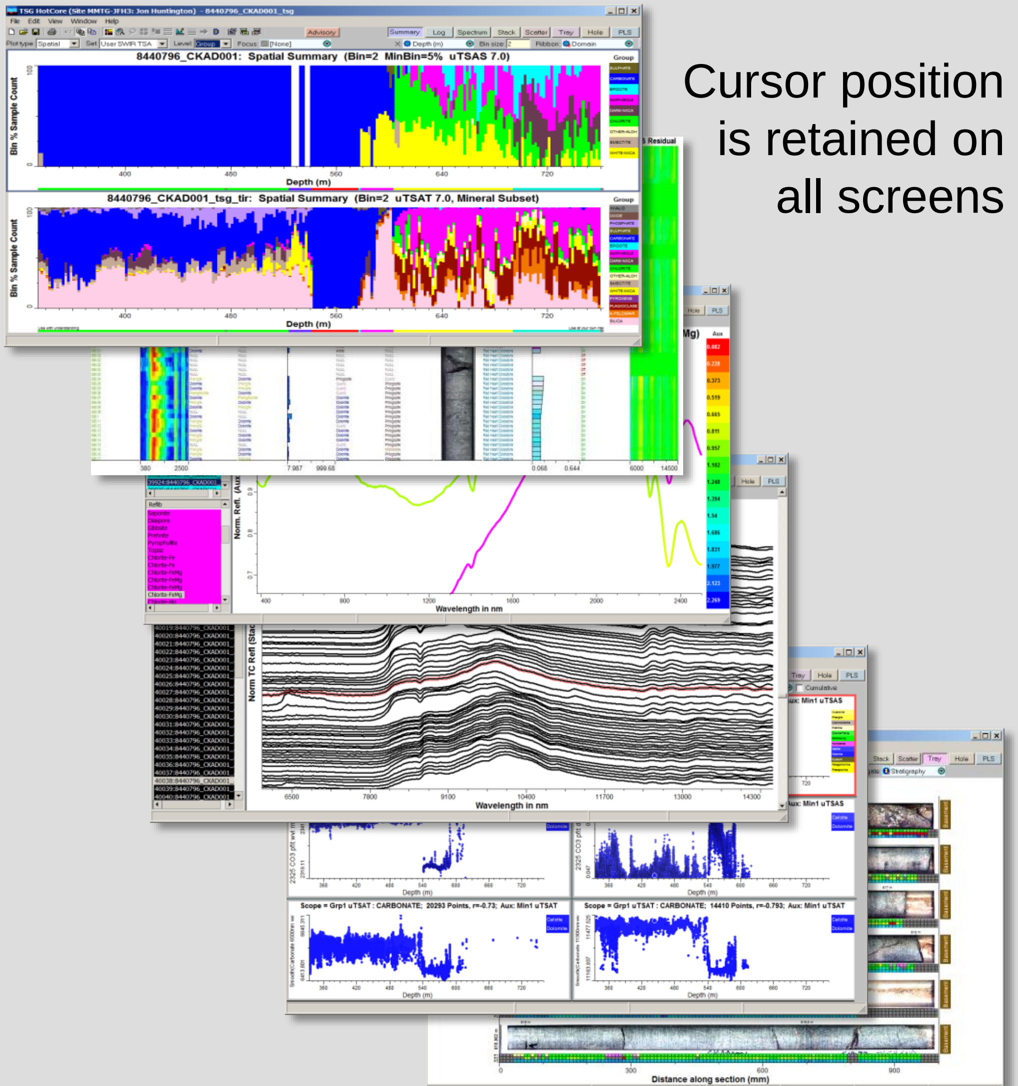
Scatter



Tray

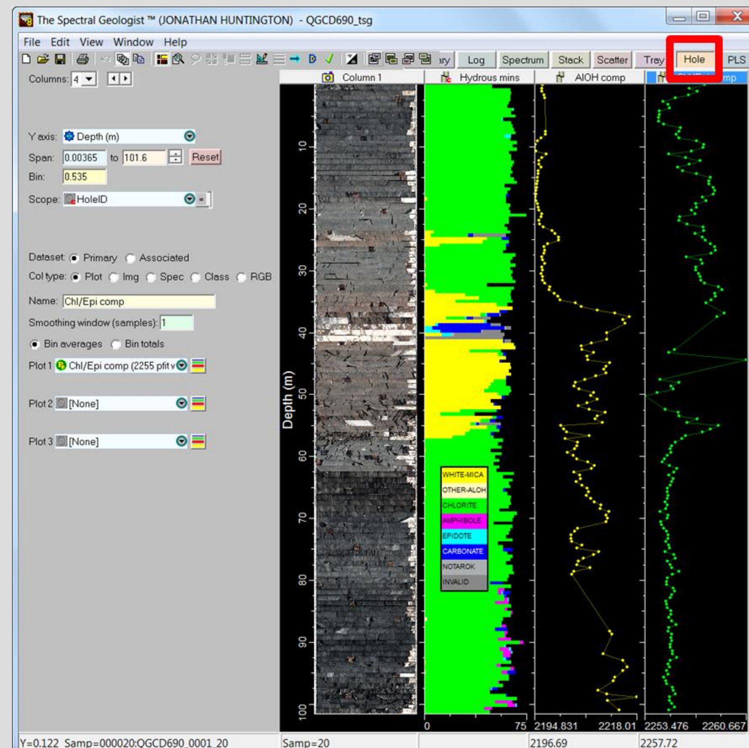


Navigating in TSG8 – Top Right Content Menus



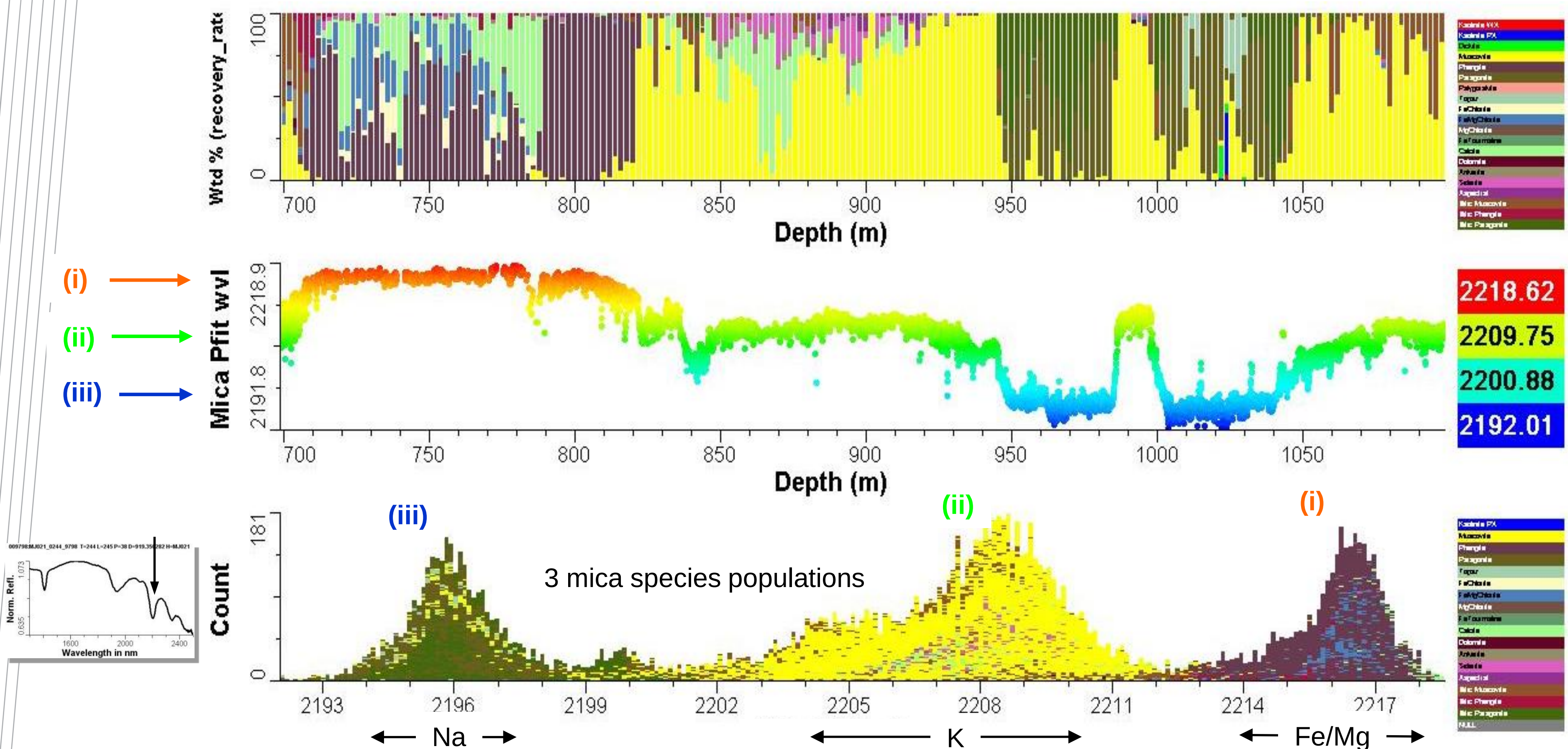
Cursor position is retained on all screens

Hole

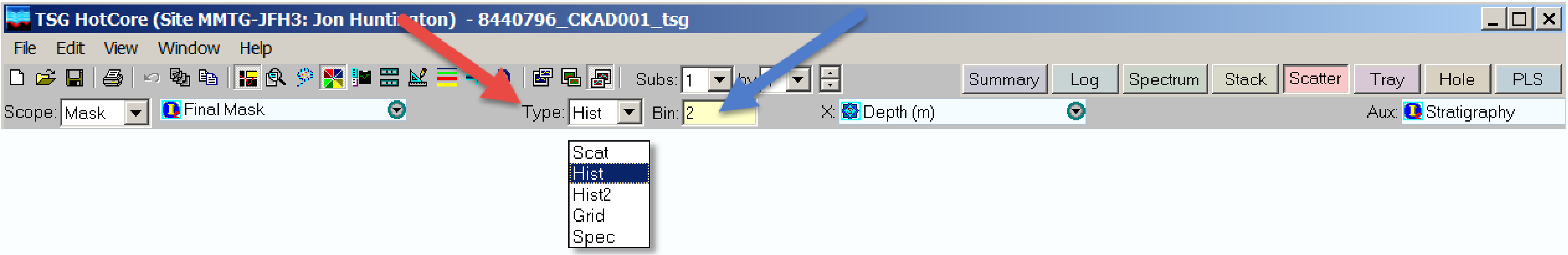


Types of TSG Plots

A. Histograms of classification results vs. depth (top) – Drill hole summaries
B. Per sample (dot) plots (centre) - To map mineral chemistry details
C. Histograms of other quantities (bottom) – e.g. wavelengths, assays, etc.



Types of Scatter Screen Plots



Choose the type of plot from the “Type” drop-down menu (red arrow).

Scat = per sample (dot) scatter plots

Hist = simple histograms

Hist2 = weighted histograms (as defined by ‘y’ axis scalar)

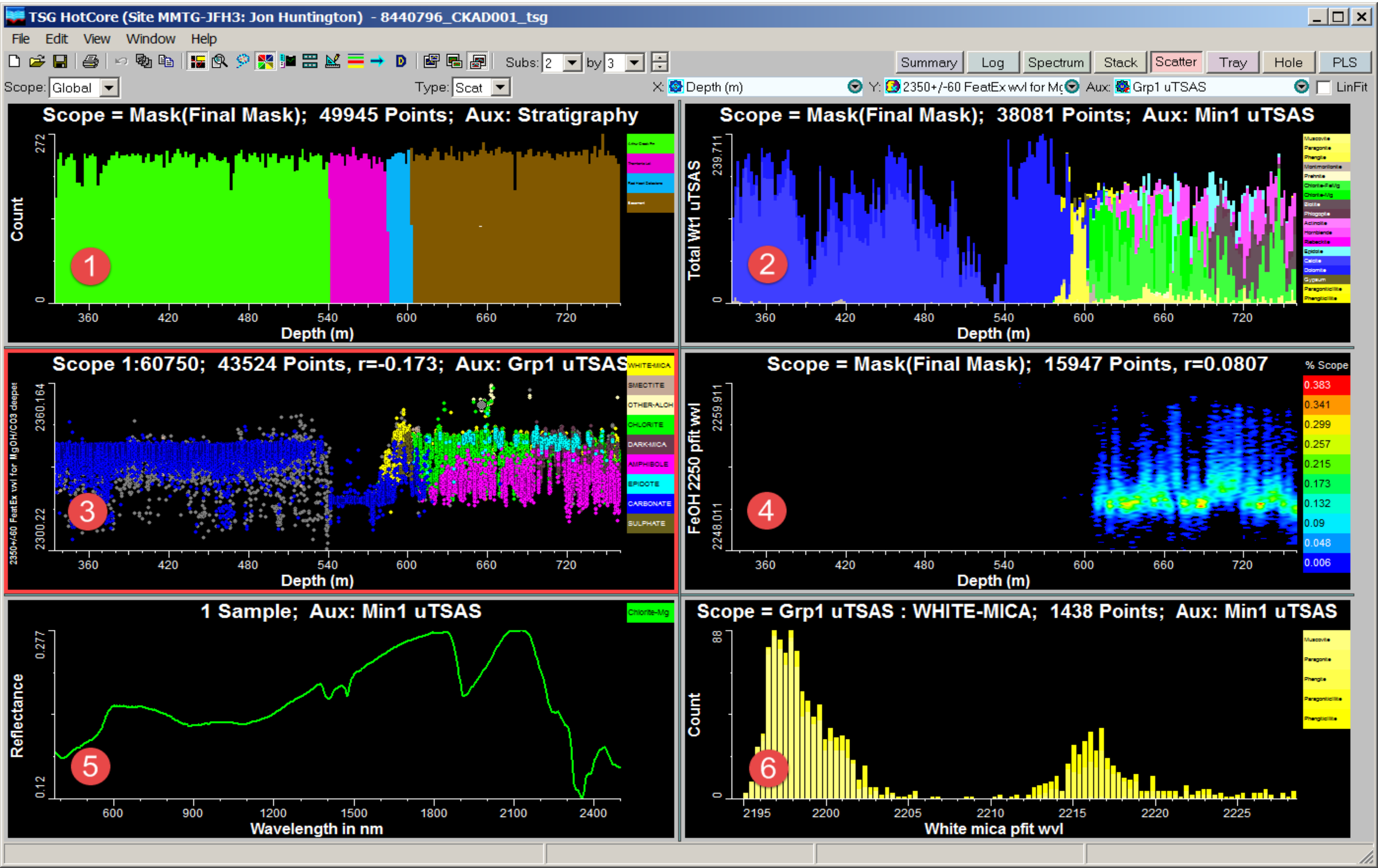
Grid = point density plots

Spec = current sample spectrum

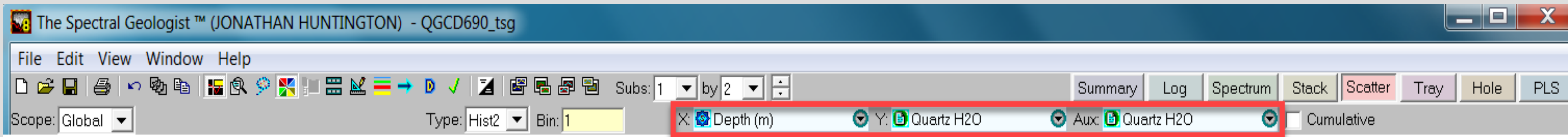
Histogram bin size or interval is set at the blue arrow location

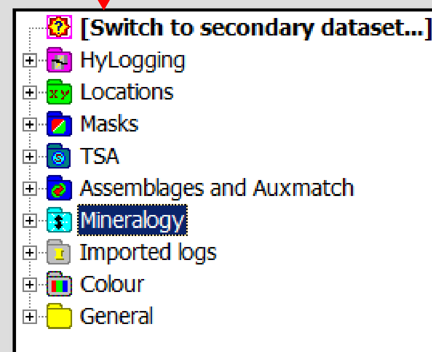
Plot Type Examples

1=Hist, 2=Hist2, 3=Scat, 4=Grid, 5=Spec, 6=Scoped Hist



Scatter Screen Axes





Almost any variable can be plotted on TSG's 3 scatter screen axes:

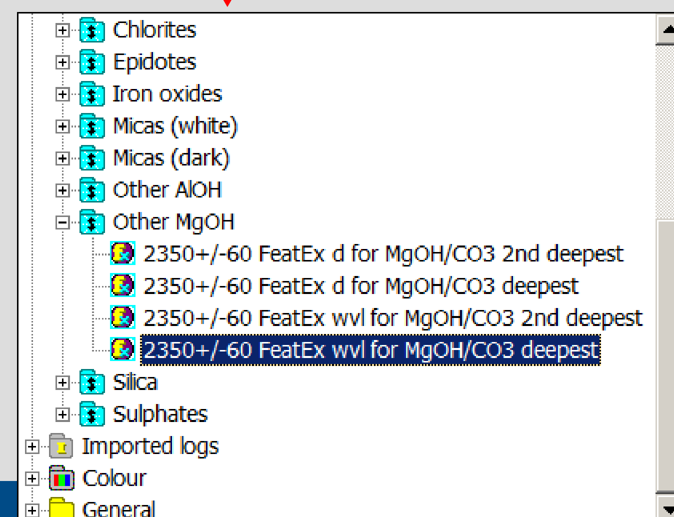
'X' (commonly depth, but not necessarily)

'Y' any other scalar

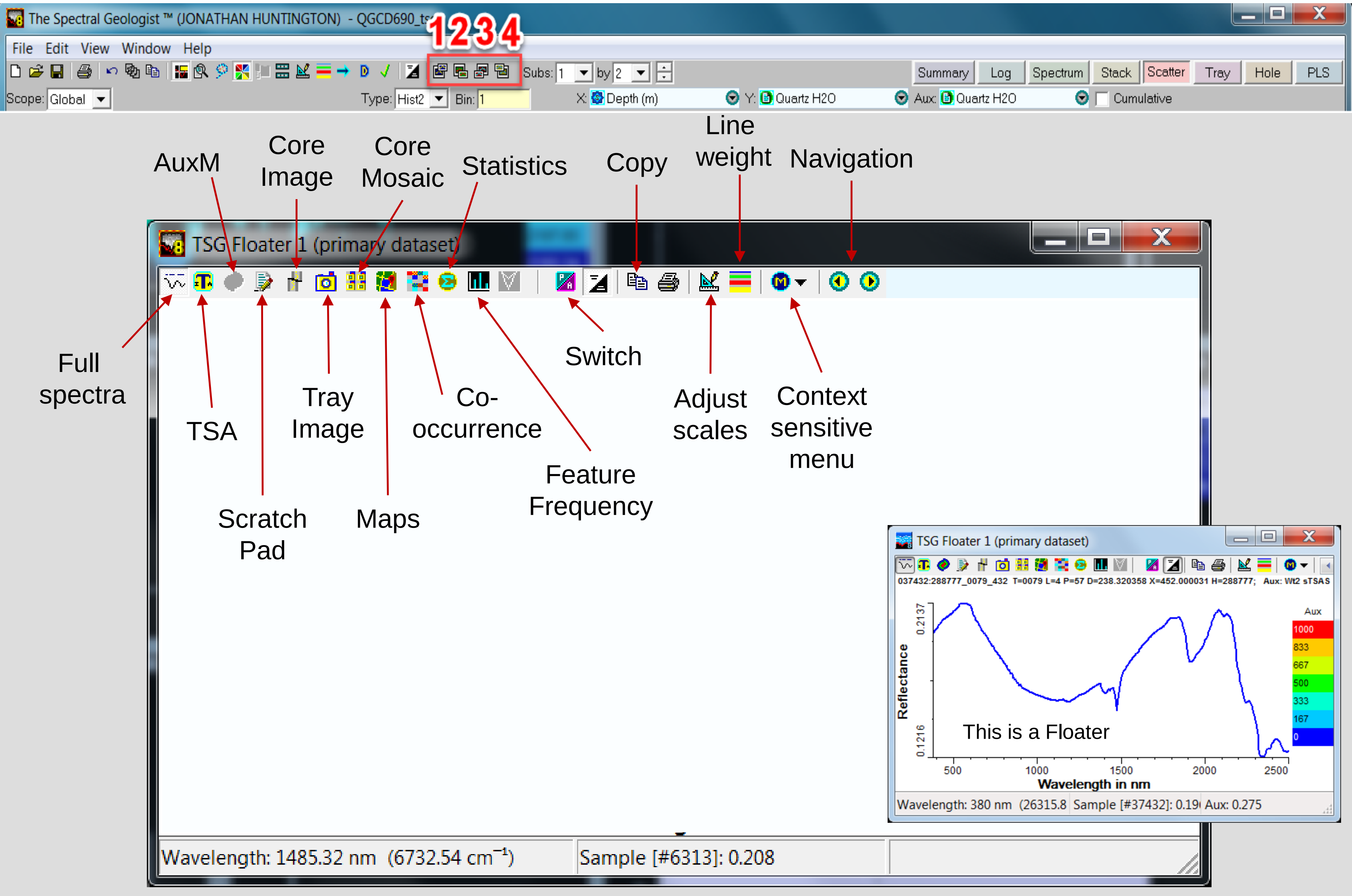
"Aux' the colouring variable

Pick variables from the respective axis drop-down lists. These show all scalars in TSG, arranged in Folders.

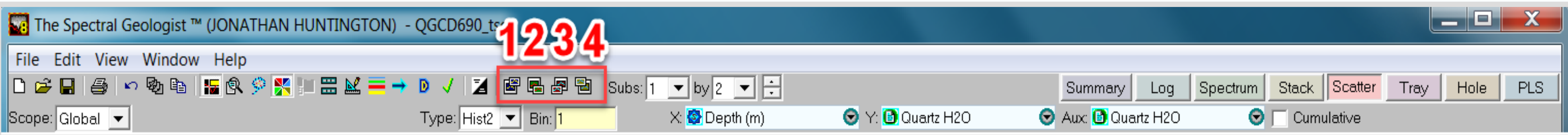
Try exploring these



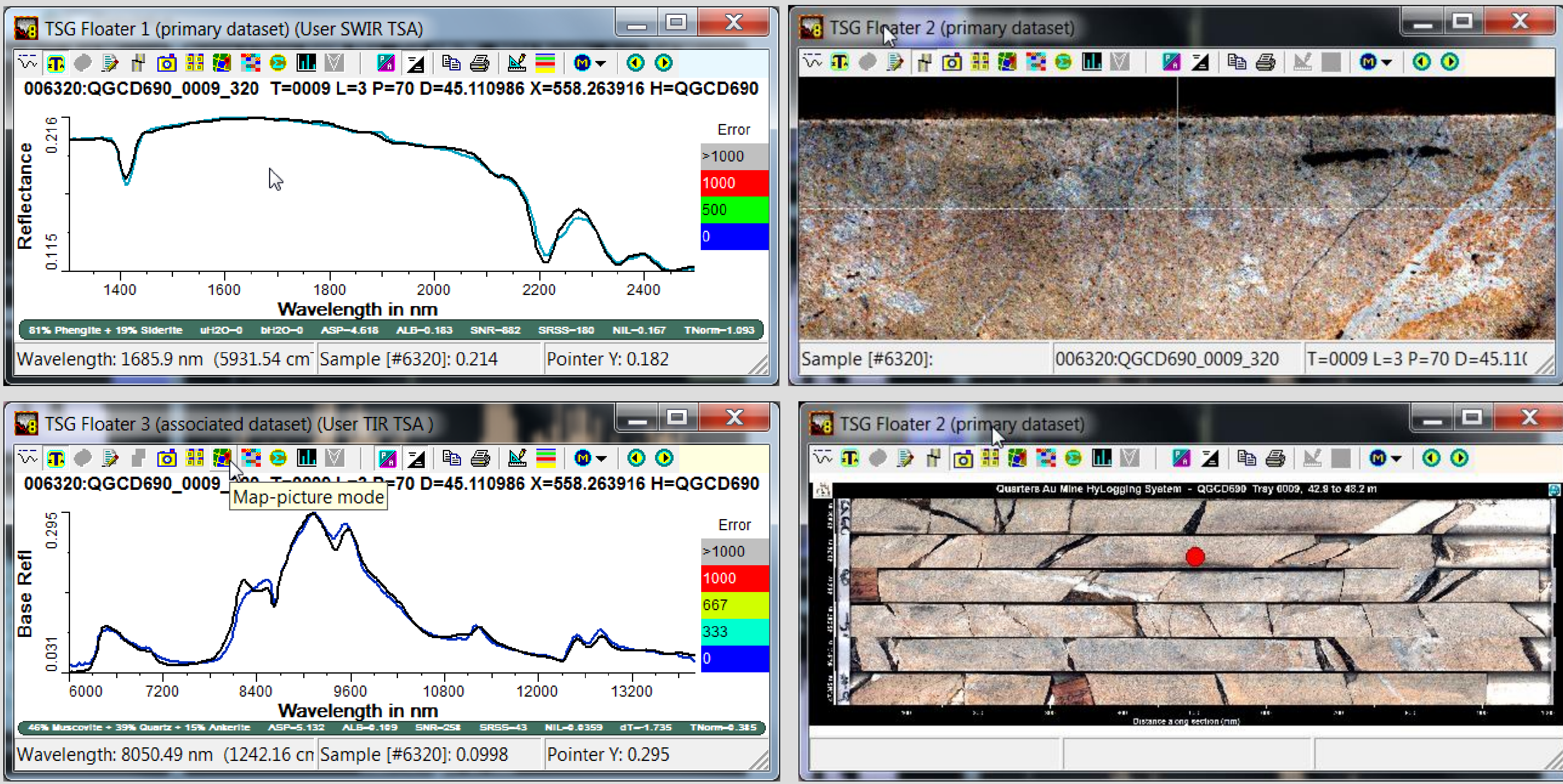
TSG Floater Functionality – 1 to 4 Floaters



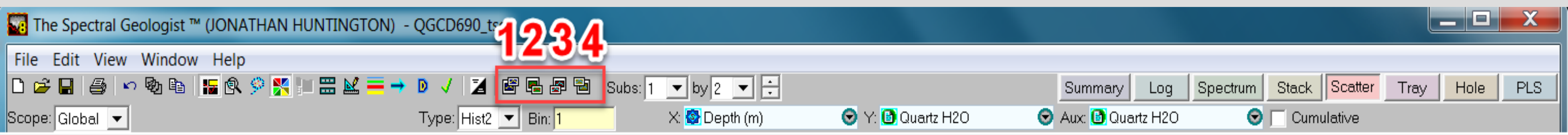
TSG Floaters – Explore spectra, fits, images & more



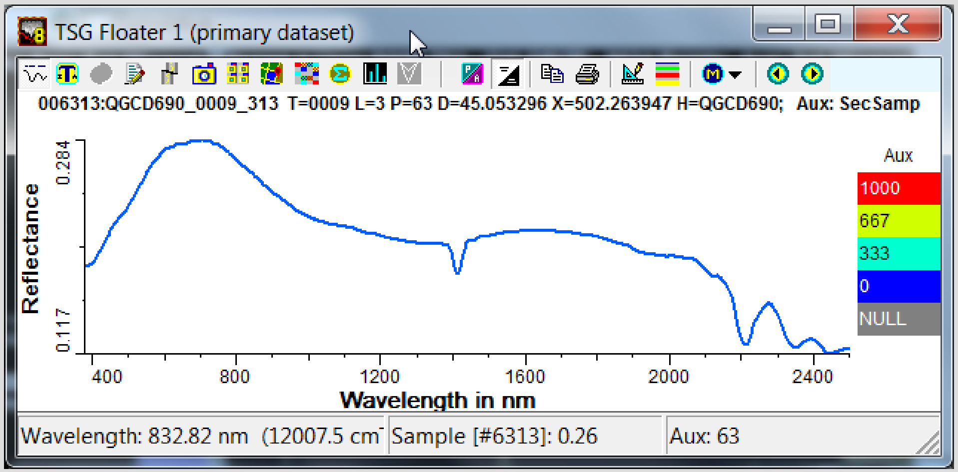
All floaters share common functions: spectra from different wvl regions, images, models & more.

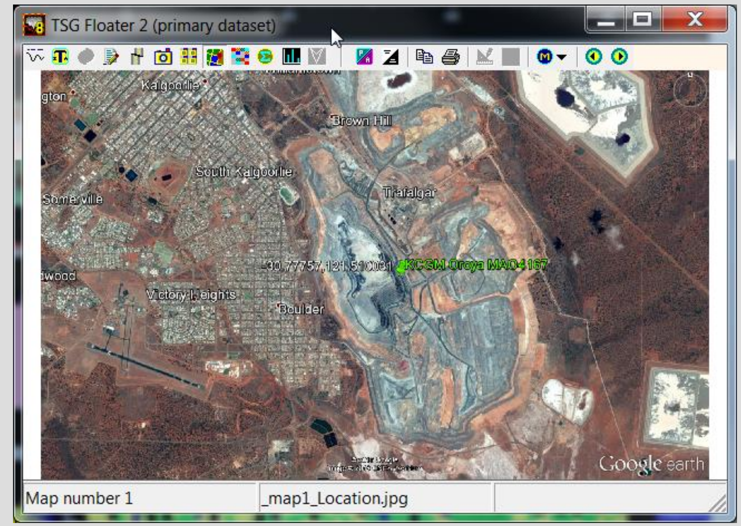


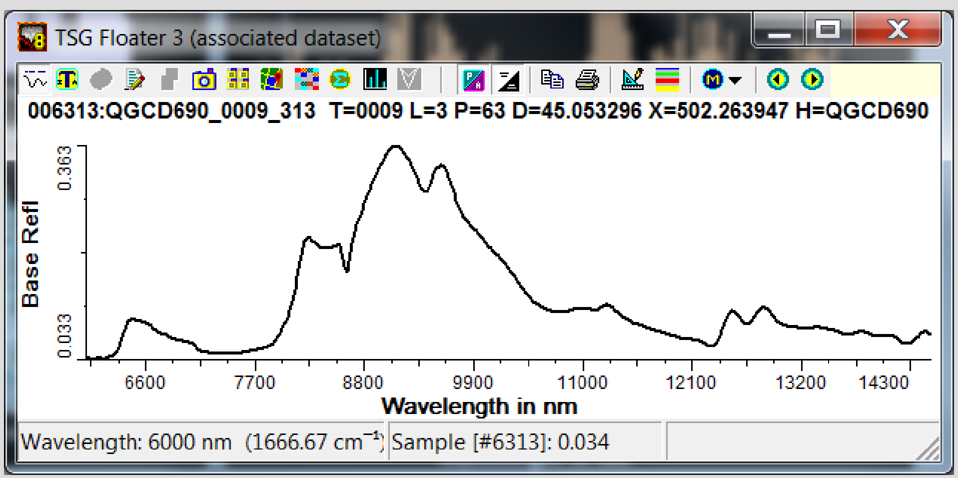
TSG Floaters – Explore spectra, fits, images & maps

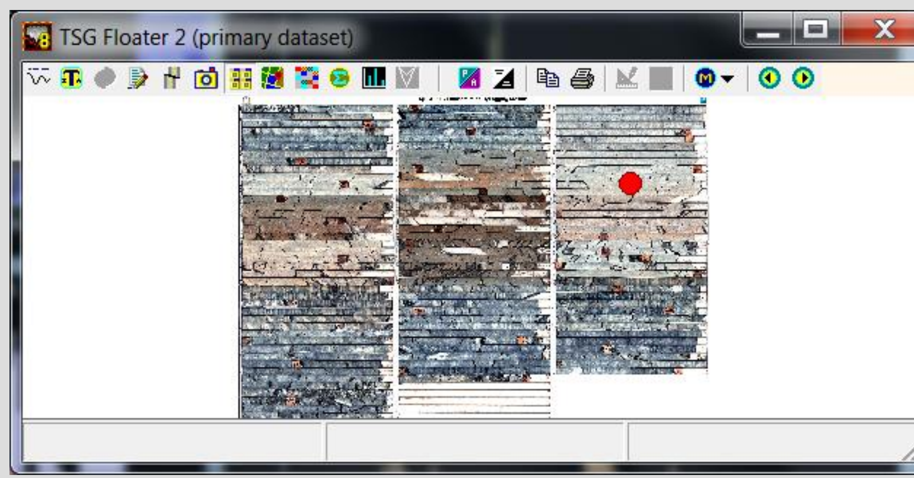


All floaters share common functions

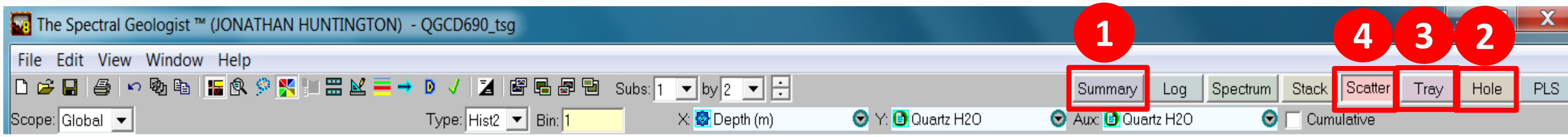








Exploring Content - Top Right Menu Items



Finding content will depend on how your service provider has set things up for you.

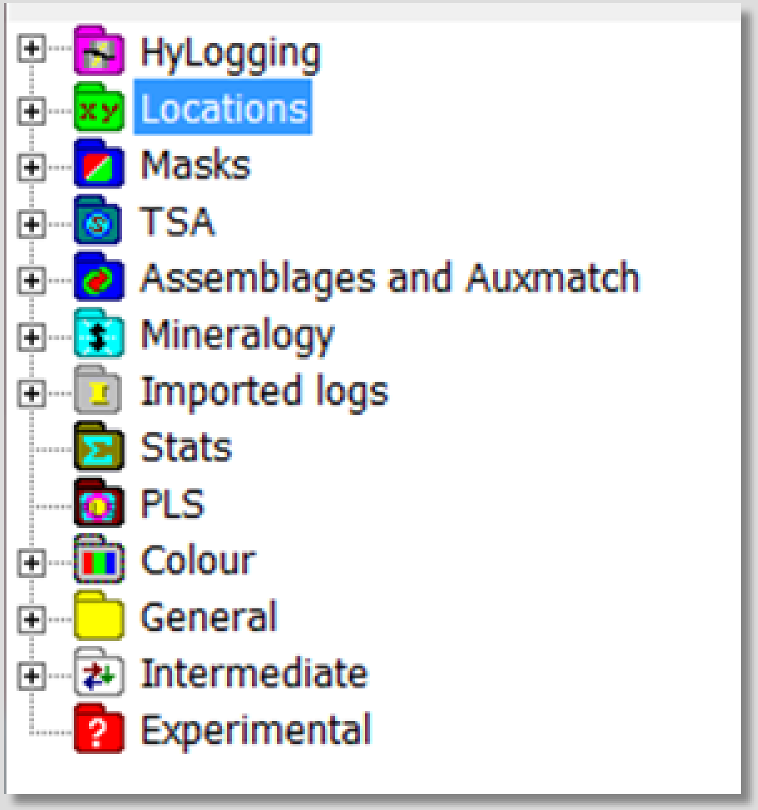
The most important screens will be those highlighted at top right:

1. The **Summary Screen** for an initial whole-of-dataset overview of minerals
2. The **Hole Screen** for a further, top-down, whole drillhole strip log like view.
3. **Tray Screen** for exploring the detail on individual core trays
4. The **Scatter Screen** for detailed views of individual minerals, groups, assays, etc.

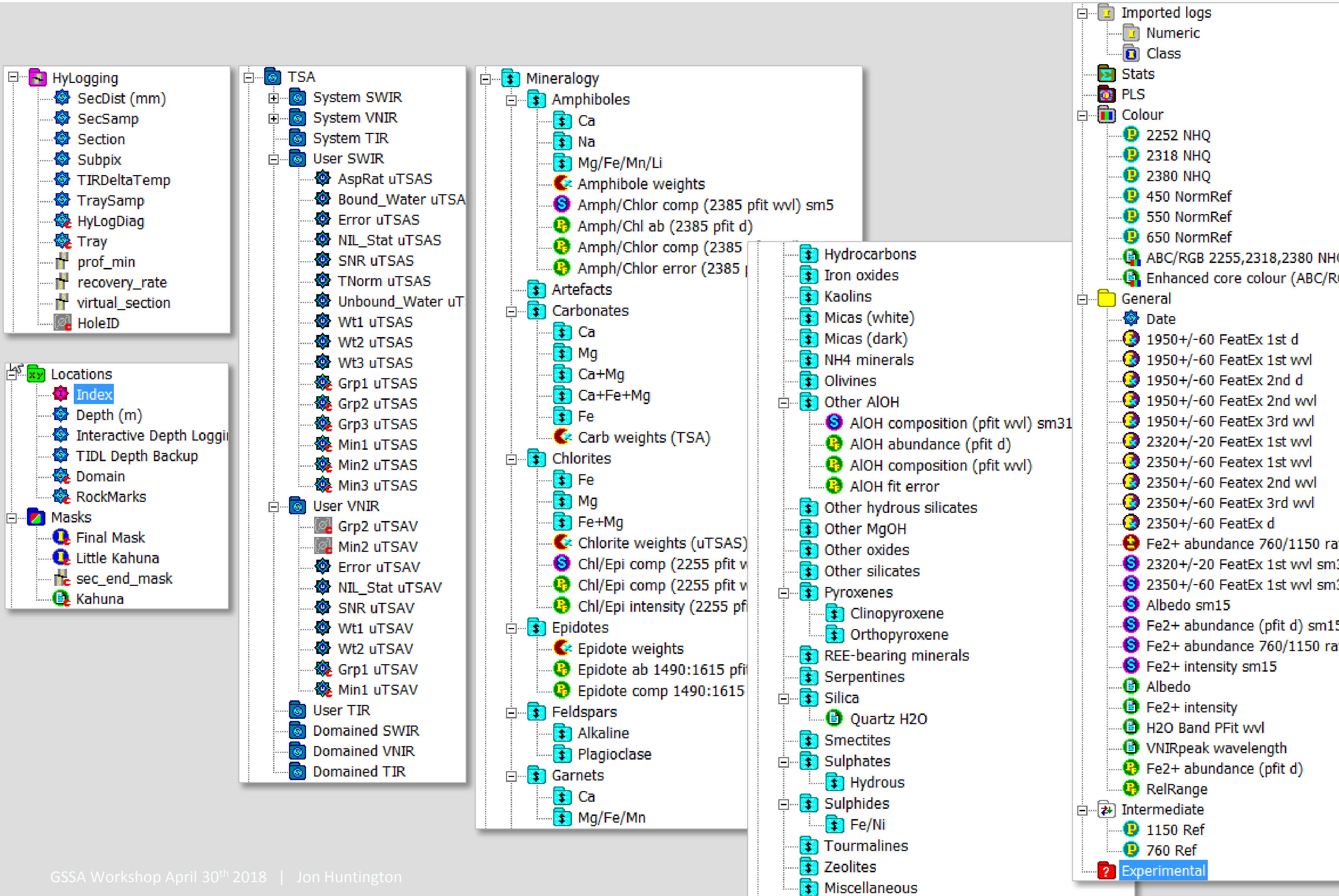
Exploring and Organising Content - Folders

What data might be available?

All information derived from a spectrometer (e.g. a HyLogger), including images and information extracted from spectra, mineral interpretations, indices (what we call scalars), imported logs, assays, GPS locations, masks,etc., are stored in folders and sub-folders (right).

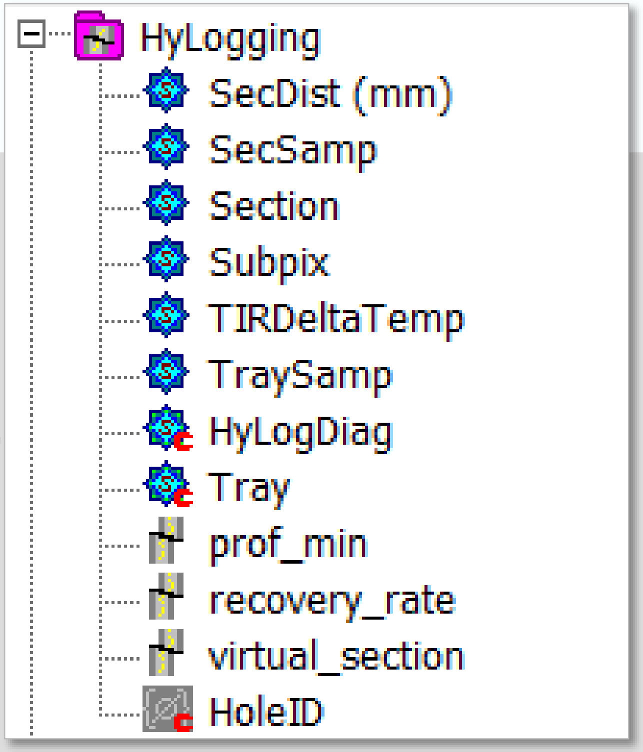


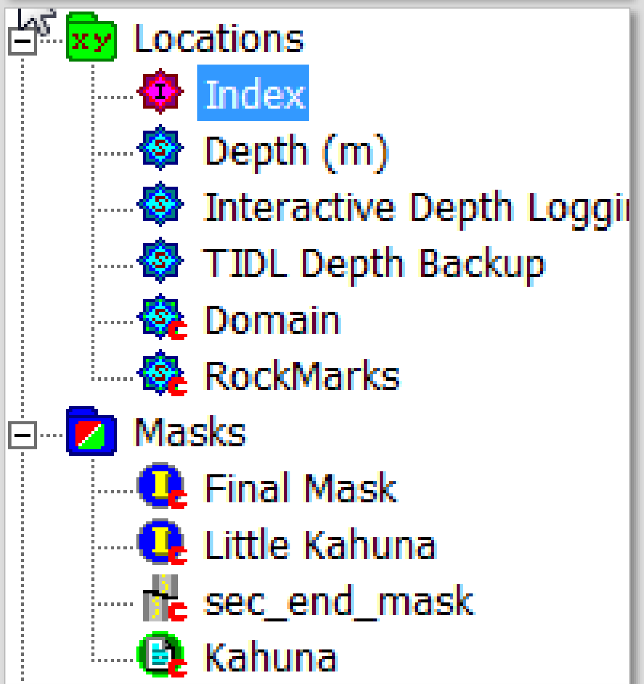
Typical Drill Hole Folder Structure & Content



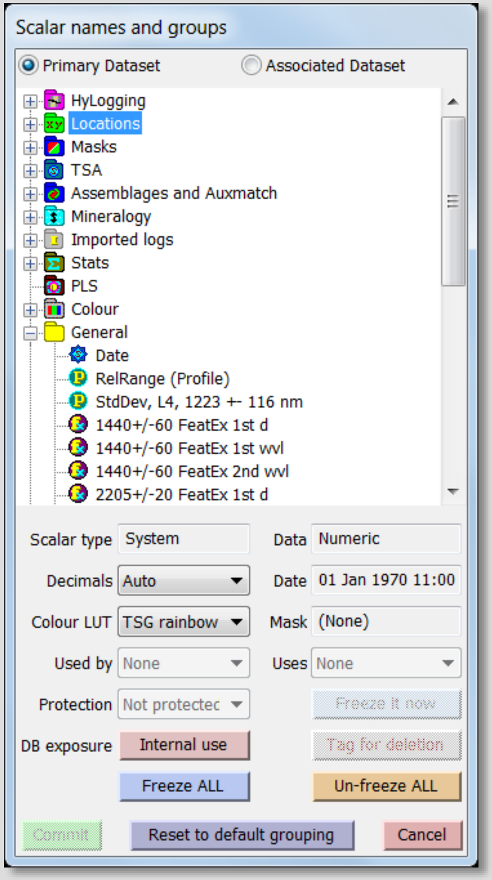
Special HyLogging Folders

HyLogging datasets have particular scalars that record tray and sample geometry, etc., ……………………………





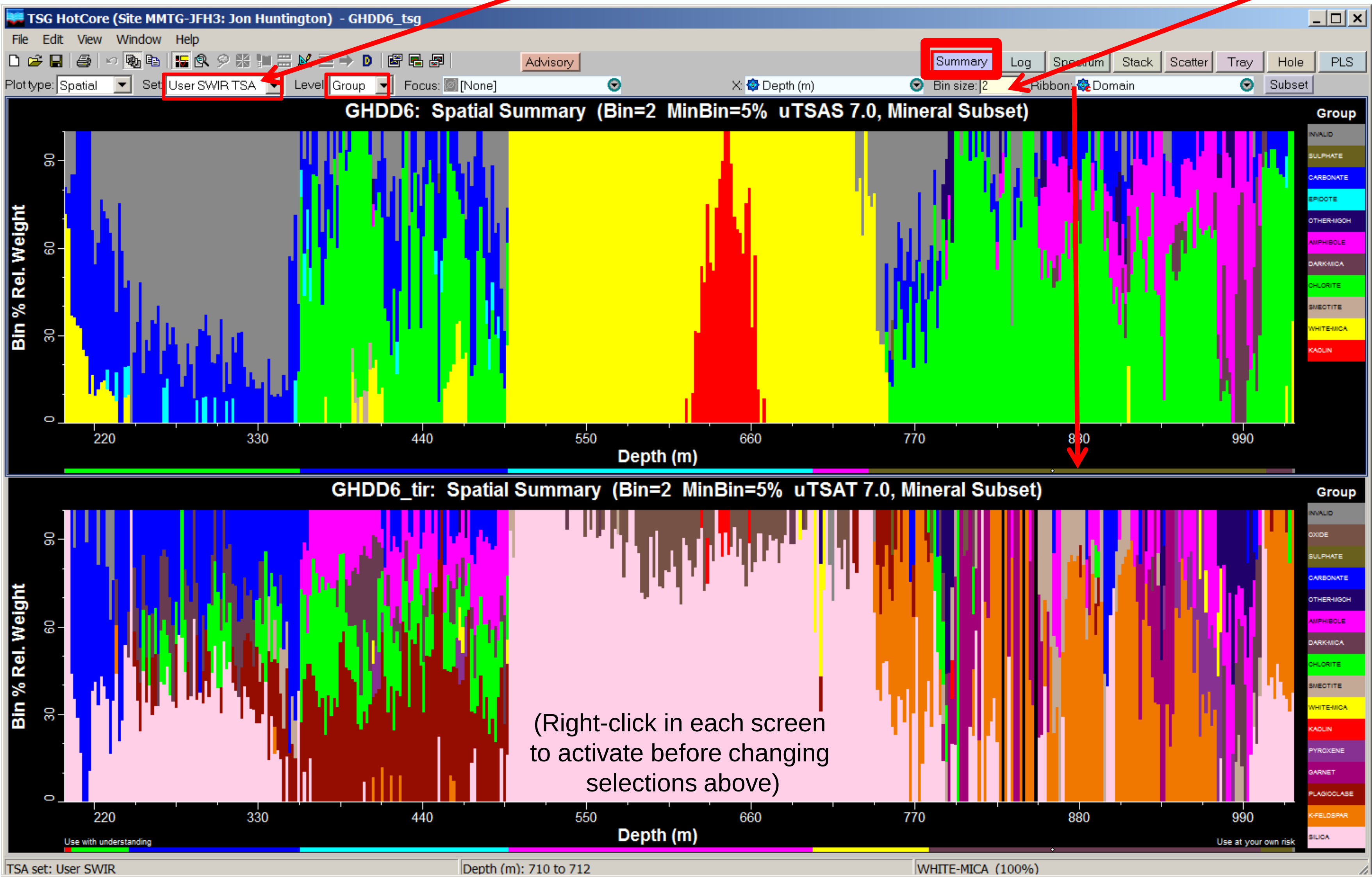
Scalars can be edited & moved between folders in the Edit > Scalar names & Groups with right-click Cut & Paste functions …….



Exploring Content - Summary Screen

Results of automated unmixed mineral group classification / interval.

Try changing the interval / bin size.



Automated Mineral Interpretation

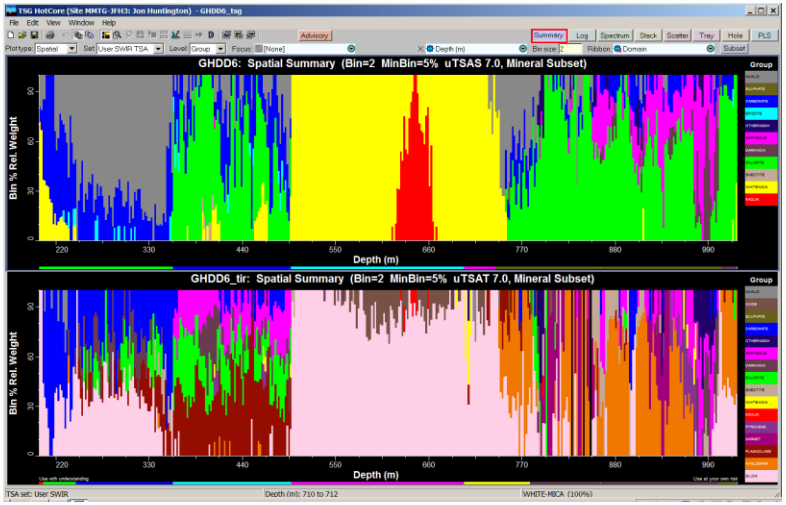
With tens to hundreds of thousands of spectra in a drill hole (125 per metre) automation is essential.

TSG uniquely provides automated tools for unscrambling mineral mixtures almost always evident in spectra and modelling their likely mineral composition. Methods available include:

- TSA - **T**he **S**pectra **A**ssistant unmixing and labeling algorithm
- CLS - **C**onstrained **L**east **S**quares unmixing

Both provide complementary facilities with different upsides and downsides.

Both draw on reference libraries of notionally pure minerals to model components using statistical fitting methods.



None can be guaranteed to be 100% correct 100% of the time.

Geological context and caution are <u>always</u> <u>essential</u>.

Digression - Acronyms

1. **TSG** & **TSG8** – The Spectral Geologist software package
2. **TSA** – The Spectral Assistant – Interpretation Algorithm
   - **s**TSAS, sTSAV, sTSAT (system level TSA) (S=SWIR, V=VNIR, T=TIR)
   - **u**TSAS, uTSAV, uTSAT (user edited level TSA)
   - **d**TSAS, dTSAV, dTSAT (domained TSA with restricted mineral sets [RMS])
3. **CLS** – Constrained Least Squares – unmixing algorithm
   - CLST,
4. **jCLST** – Joint CLS algorithm using SWIR knowledge for thermal infrared unmixing
5. **Scalars** – Indices showing the depth or wavelength of an absorption feature, or a classification of minerals. Numeric or textural.
6. **Obsolete names** - ~~TSG-Pro, TSG-Core, TSG-HotCore~~

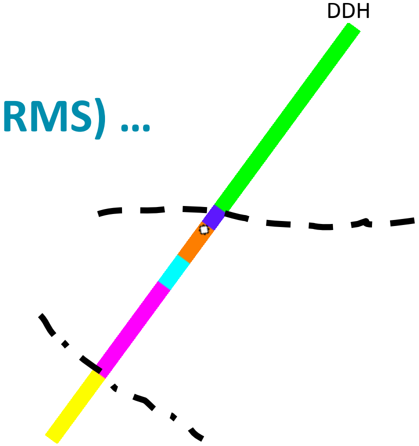
Mineral Interpretation Context - TSG's Hierarchical Approach

1. A System-provided Global View - A Global Mineral Set (GMS)……………

- Provides an initial guide rather than a blank sheet of paper.
- But doesn't know where you are!
- Doesn't know anything about your project's geological context
- Produces **sTSAS, sTSAV, sTSAT/sjCLST** results

2. A User-constrained local or drill hole view – A District Mineral Set (DMS)…..

- Edited on the basis of broad-scale understanding of geological context,
- Produces **uTSAS, uTSAV, uTSAT/ujCLST** results
- See TSA's Active Mineral Lists (**AML**) under TSG Settings > TSA

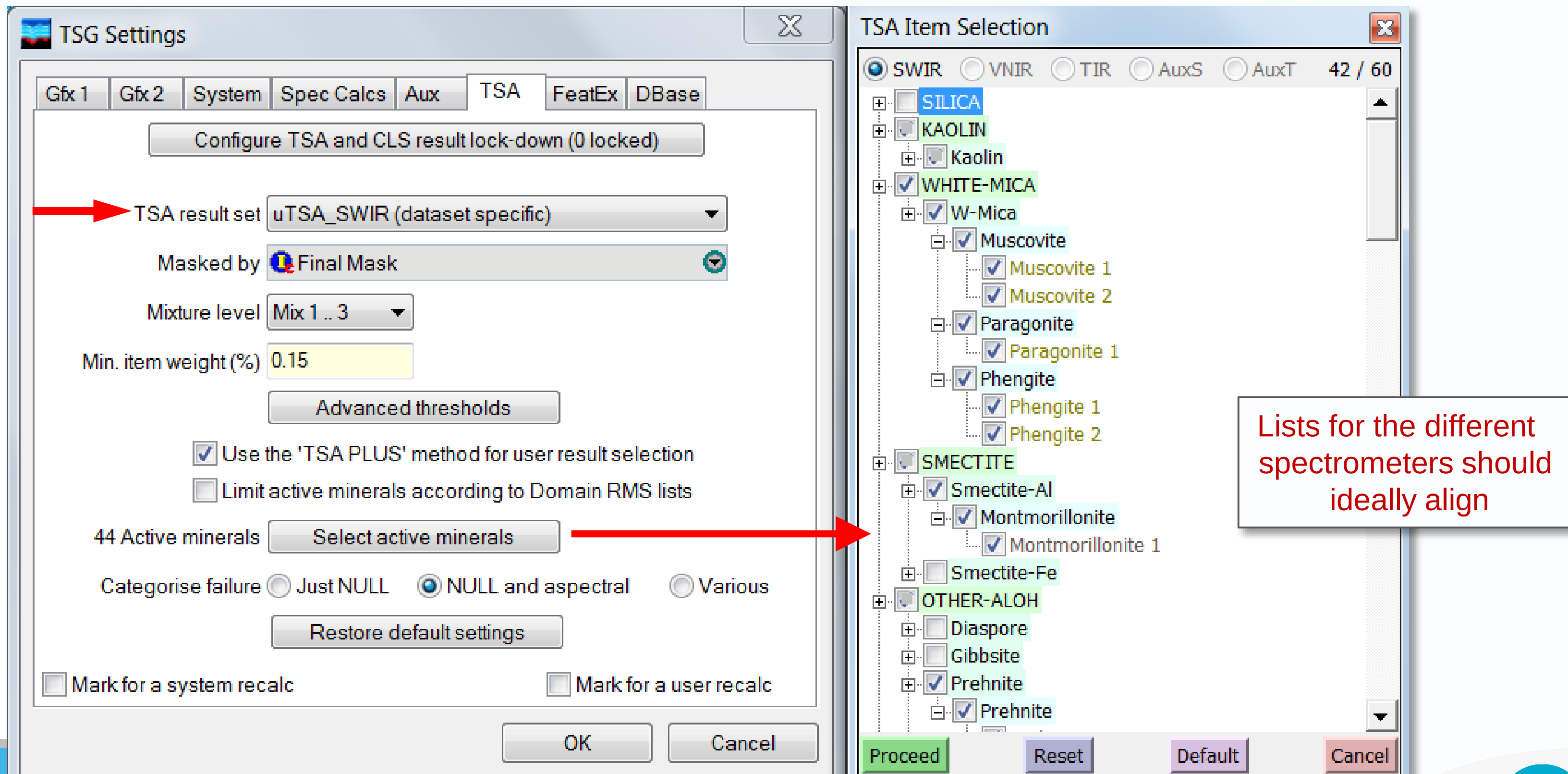


3. An edited, within drill-hole Domain view – Restricted Mineral Set (RMS) …

- Uses the Domain Editor. Produces a set of Domain RMS results, e.g. **dTSAS**
- Based on modelling the "best" and simplest fits
- Brushed up with a summary of everything the HyLogger's told you
- **CLS** results are always Domained (mostly CLST) by definition.

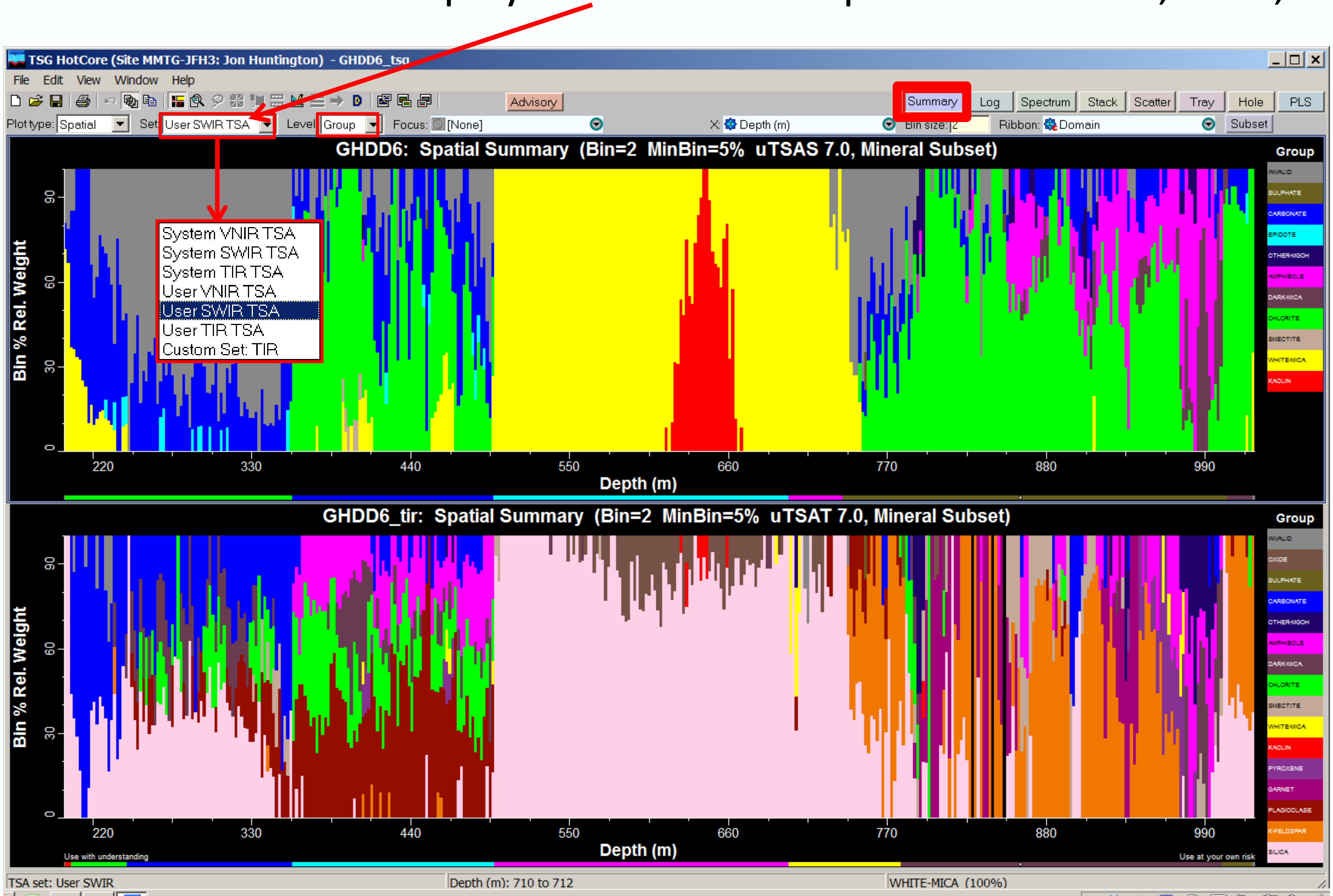
Editing Drill Hole Active Mineral Lists (AML)

Every dataset & each spectrometer needs a set of Active Minerals that must be edited to upgrade an unsupervised System-level result to a supervised User set. Otherwise tears will results!

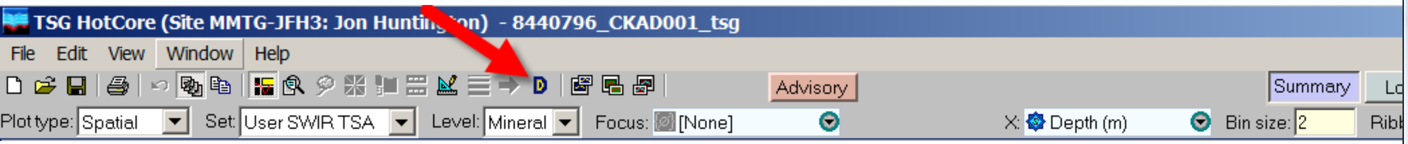


Exploring Content - Summary Screen

Each sub-screen can display a different interpretation - VNIR,SWIR,TIR

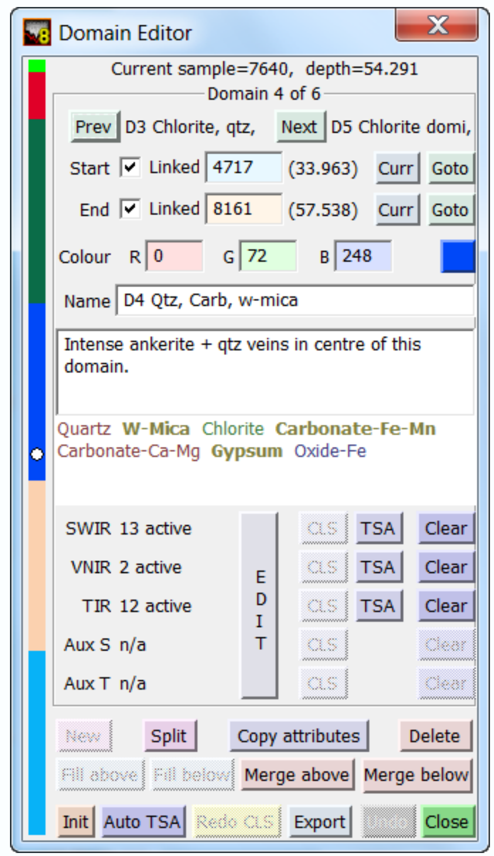


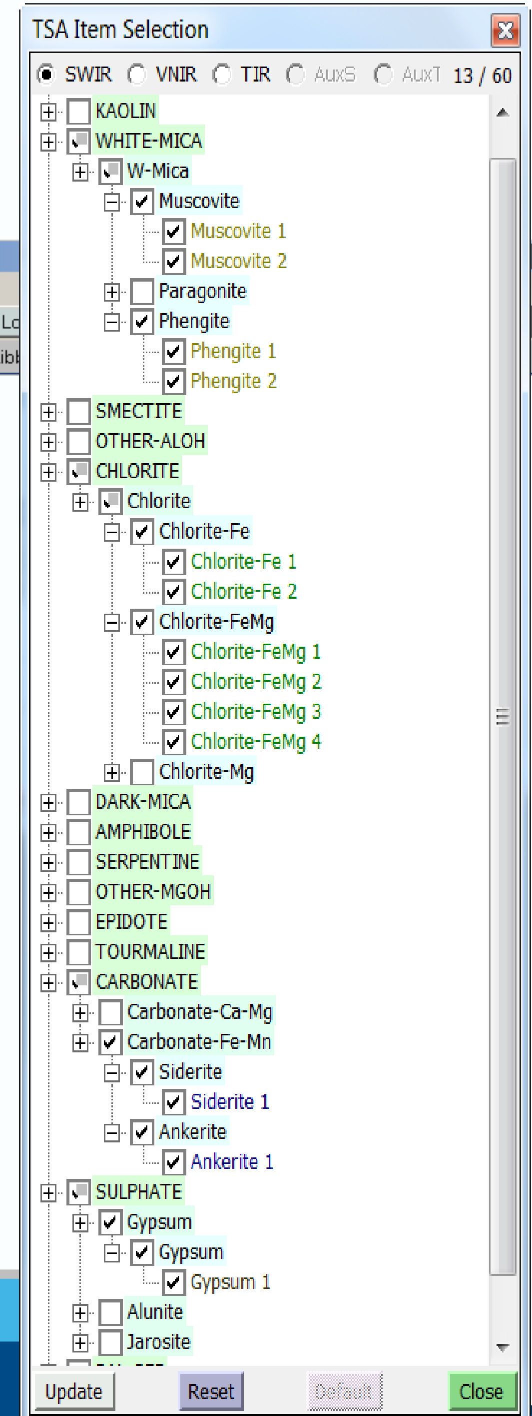
Domains and the Domain Editor



The domain editor allows the user to:

- create spectroscopic and mineral domains,
- assign different mineral assemblages to those domains
- test the fits and
- create summary notes about the domains composition

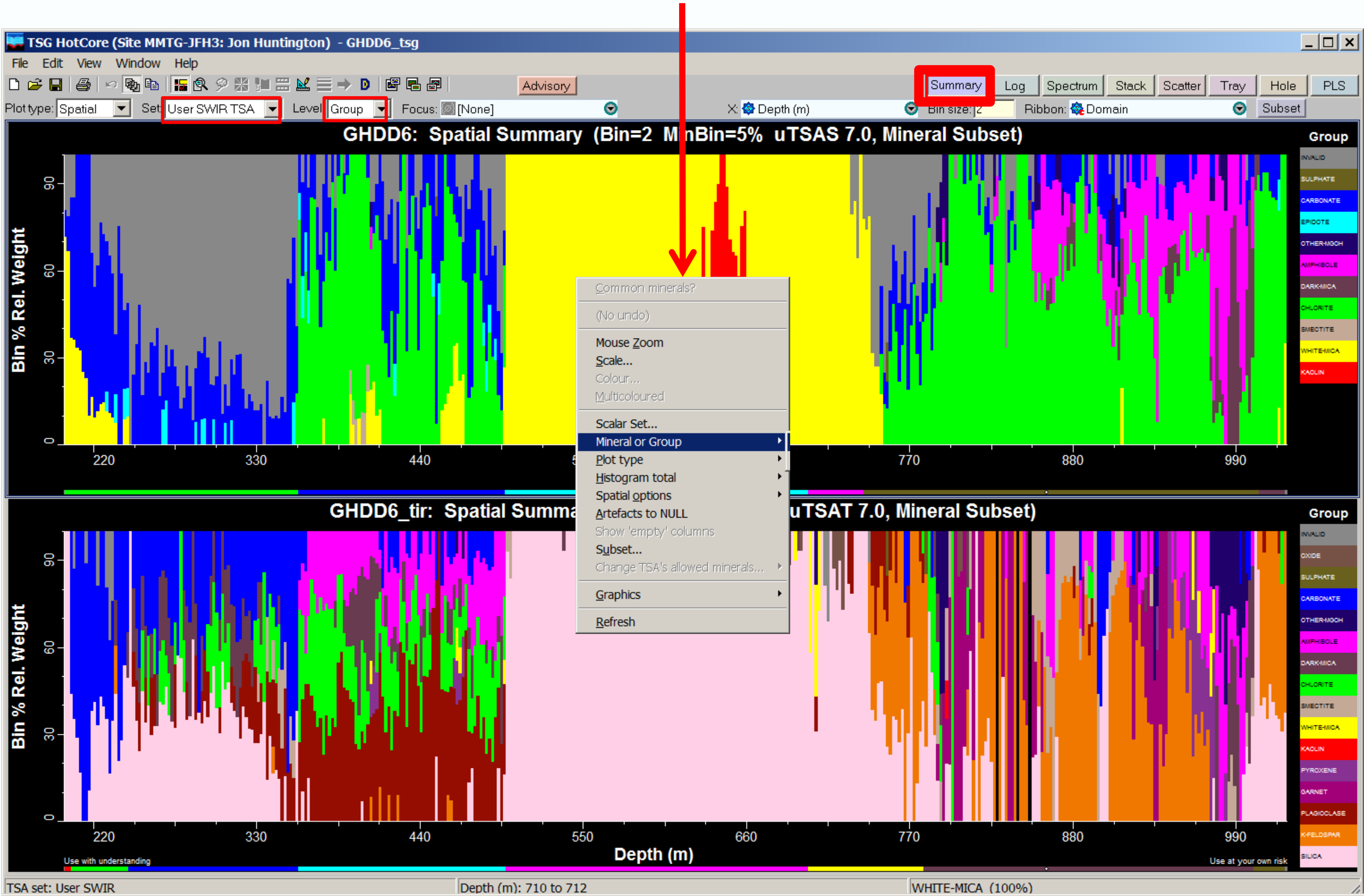




Exploring Content - Summary Screen

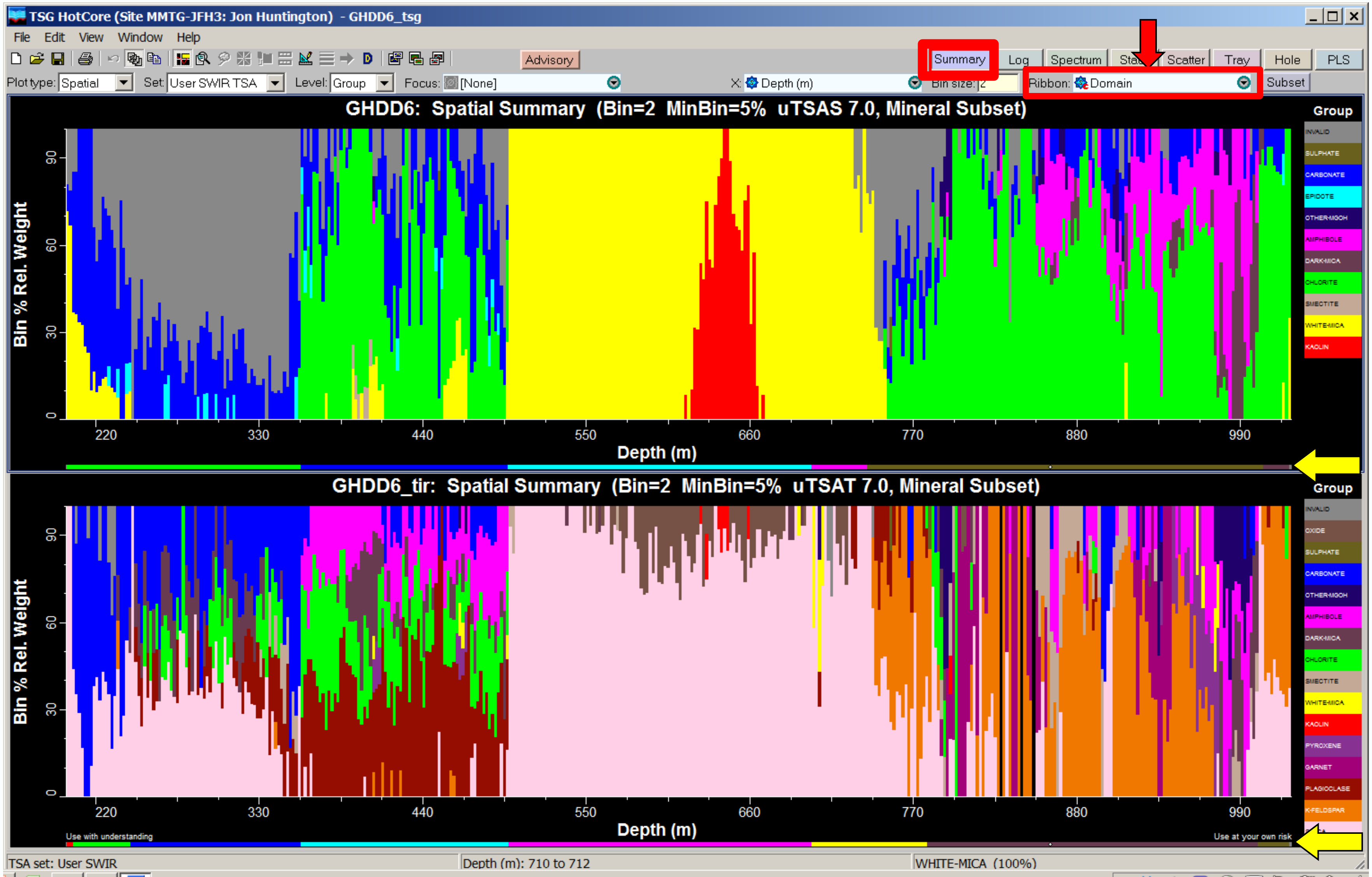
Results of automated unmixed mineral group classification / interval.

Use right-click menu for local changes applicable to each sub-screen. Click in a sub-screen and then try making some changes.



Exploring Content - Summary Screen

Domains, if they have been created, can be plotted by selecting the Ribbon Scalar (red arrow) which will appear at the yellow locations.



Exploring Content - Summary Screen

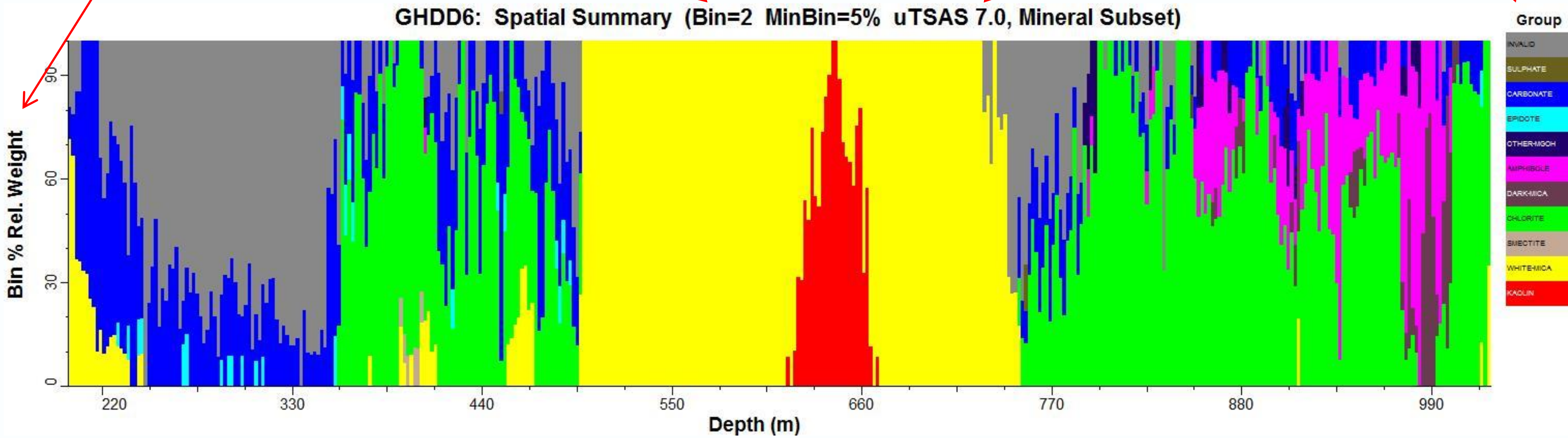
The Summary Screen displays normalised mineral or mineral group counts or weights/proportions.

Drill hole name

Sampling interval / bin size typically metres

Minimum content per interval changeable from right-click menu

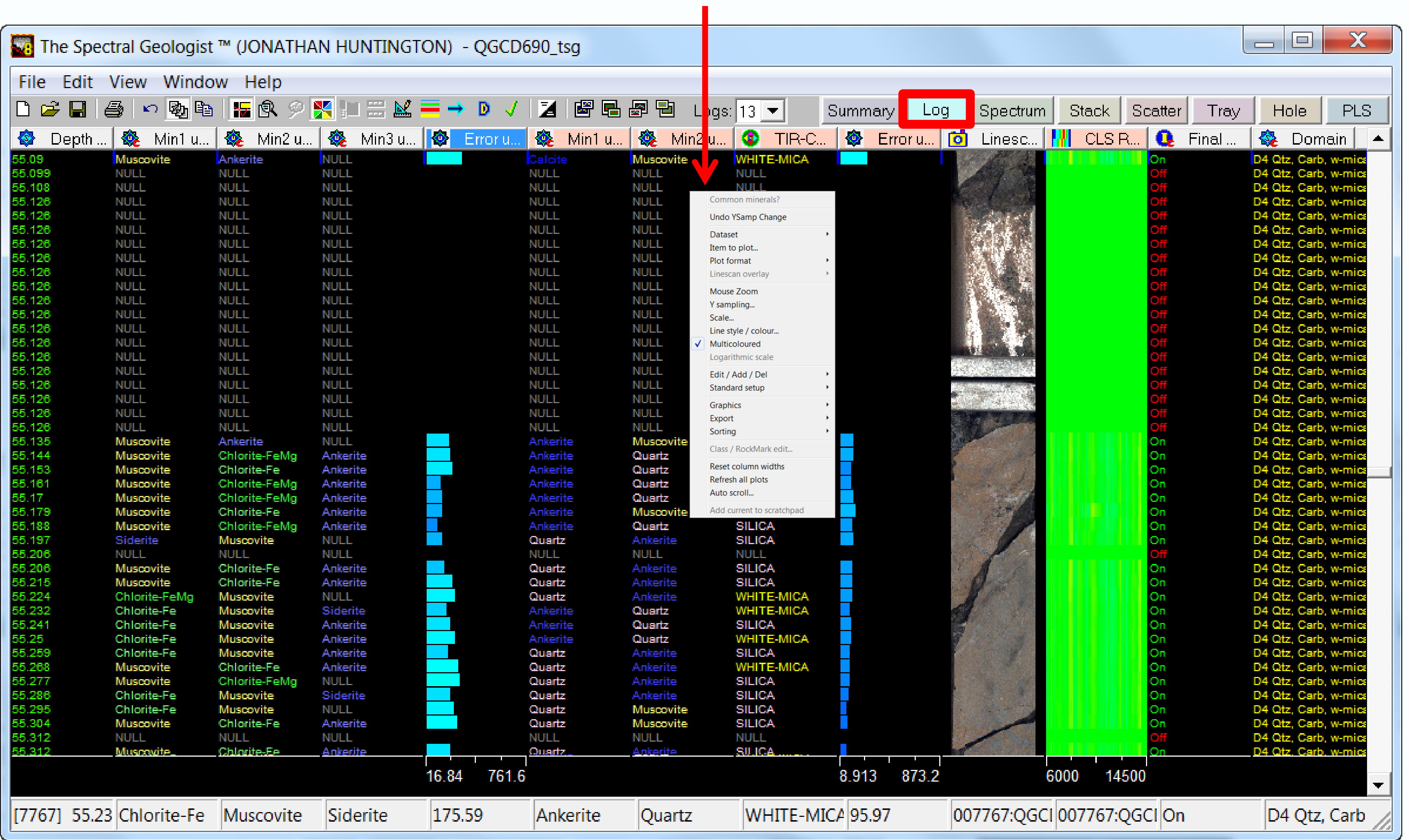
Algorithm Version



Exploring Content – Log Screen

Conventional per-sample logs of numerical or class results or images.

Use right-click menu for local changes applicable to each sub-screen. Click in a log column to experiment with changes.



Exploring Content – Log Screen

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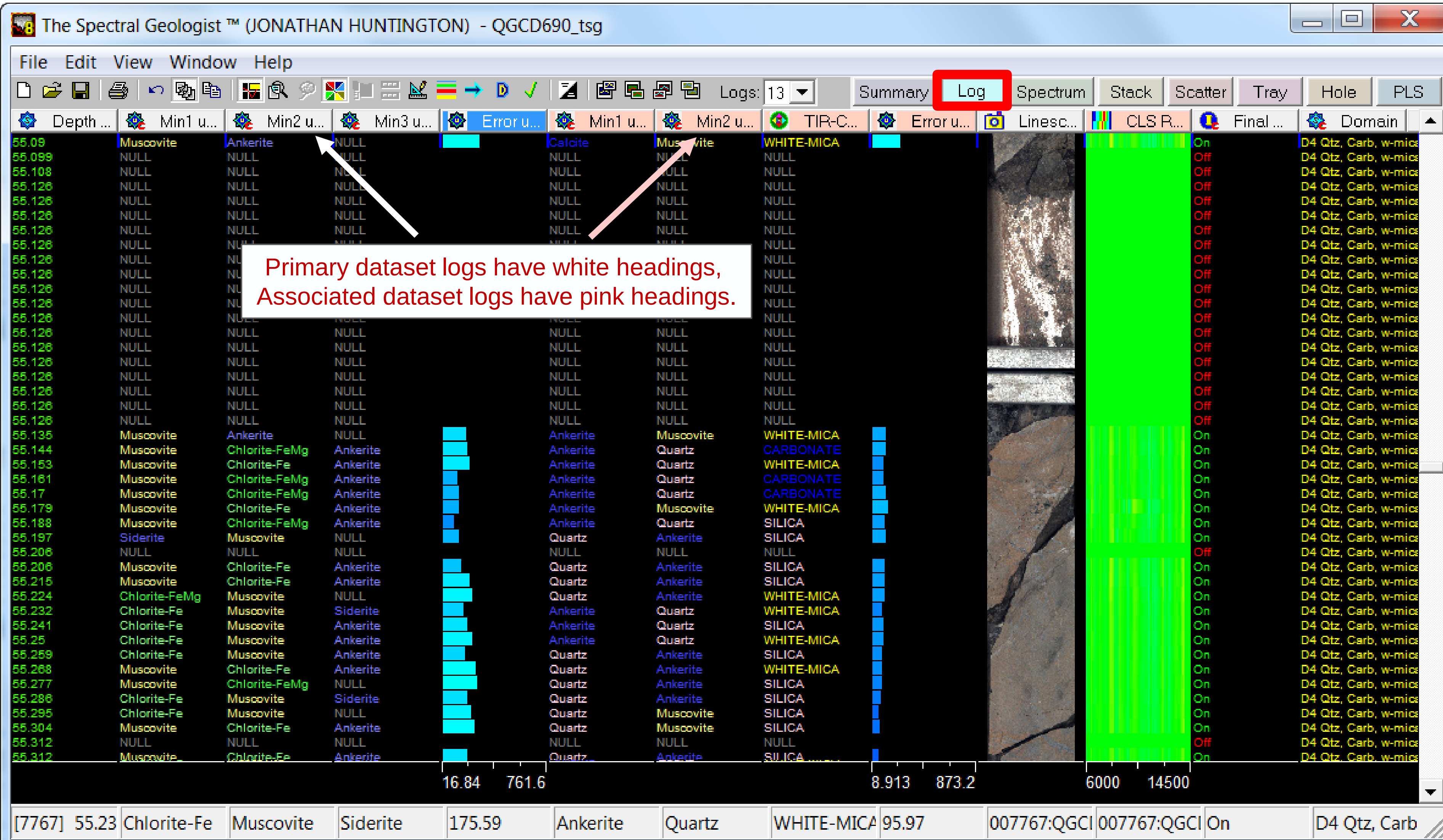
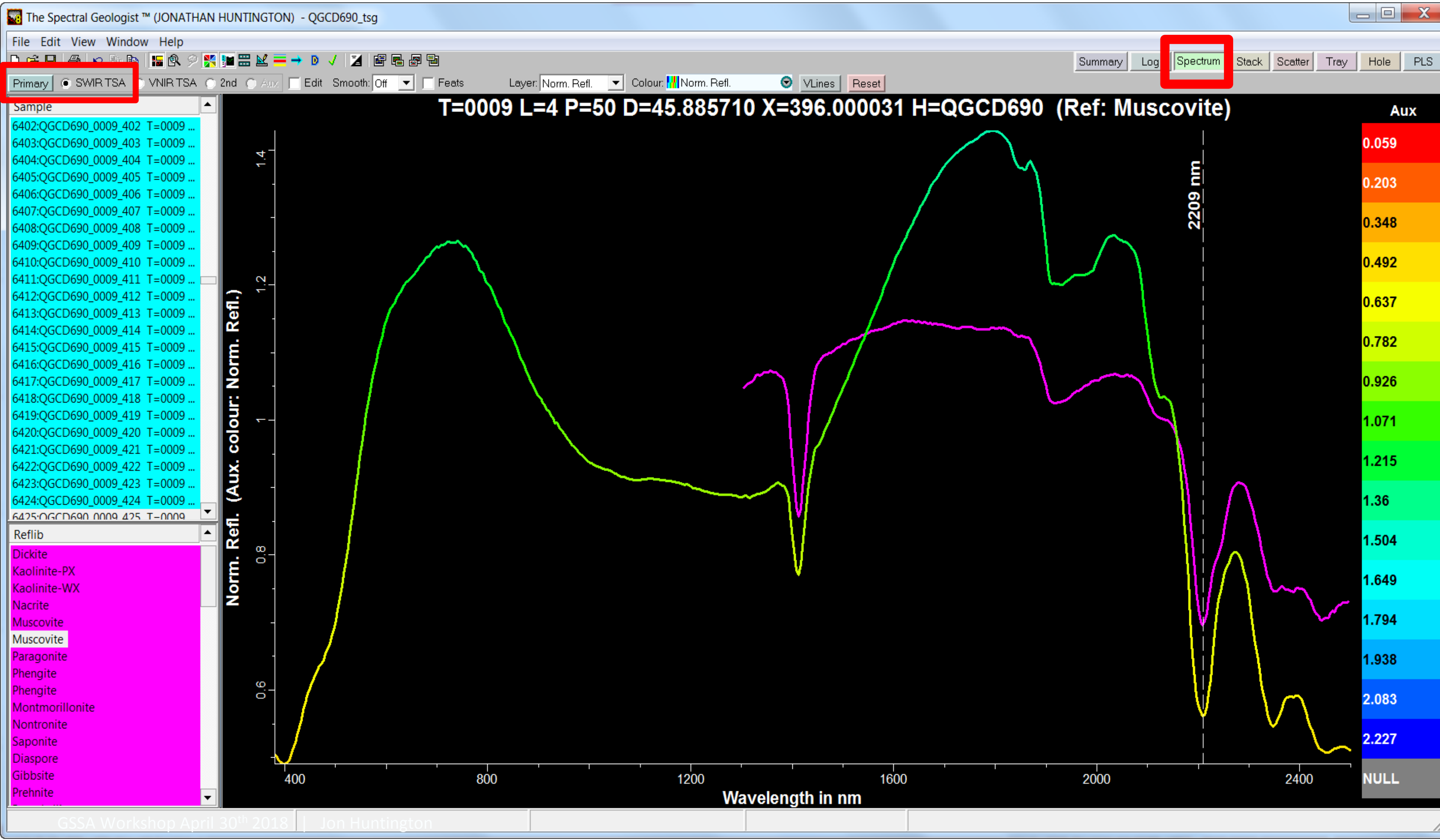
Use right-click menu for local changes applicable to each sub-screen. Click in a log column to experiment with changes.



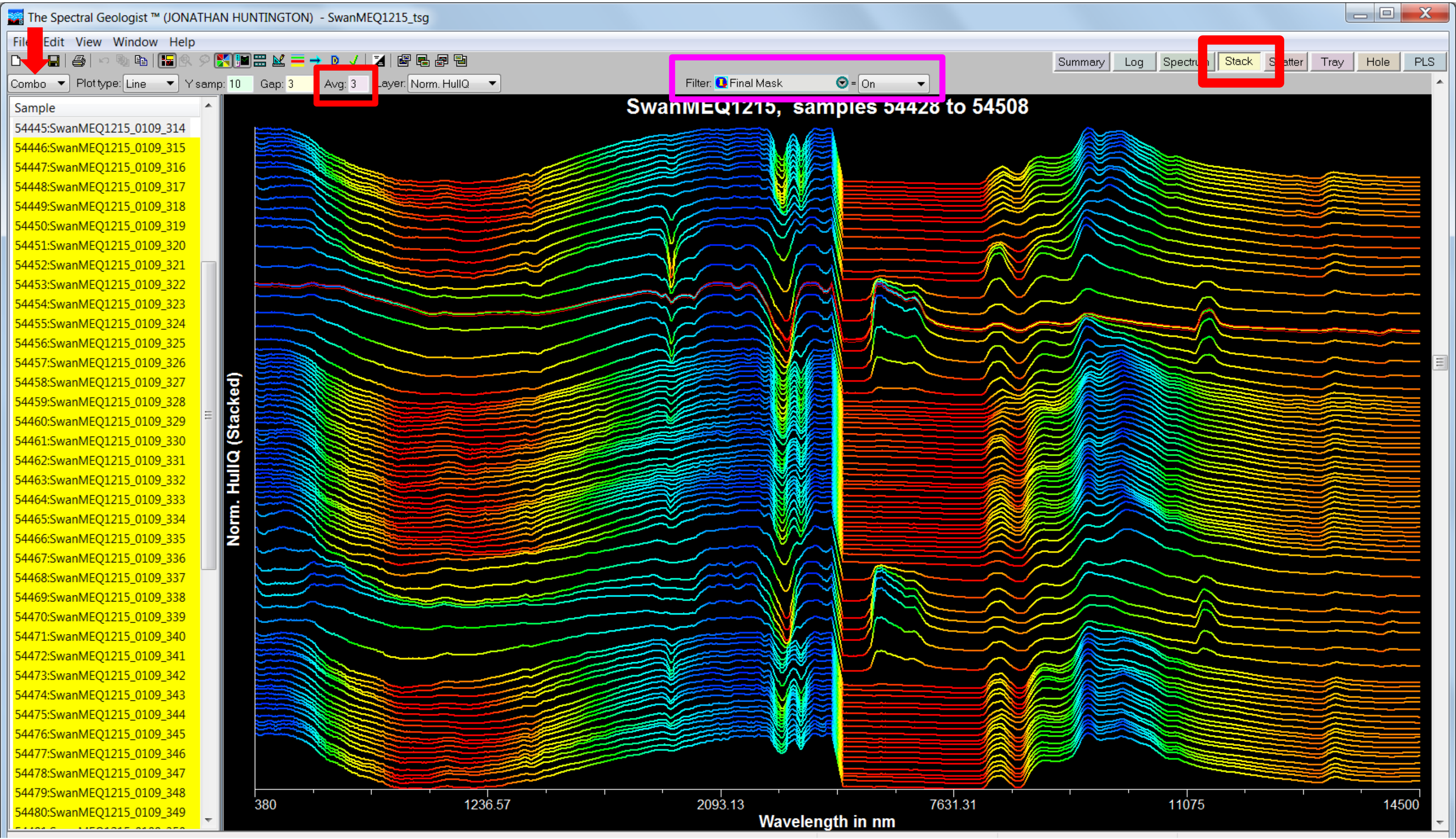
Exploring Content – Spectrum Screen

Individual +/- various reference library spectra (pink). Can help interpretations. V-lines provide movable guides. View external Aux libraries after Attaching.



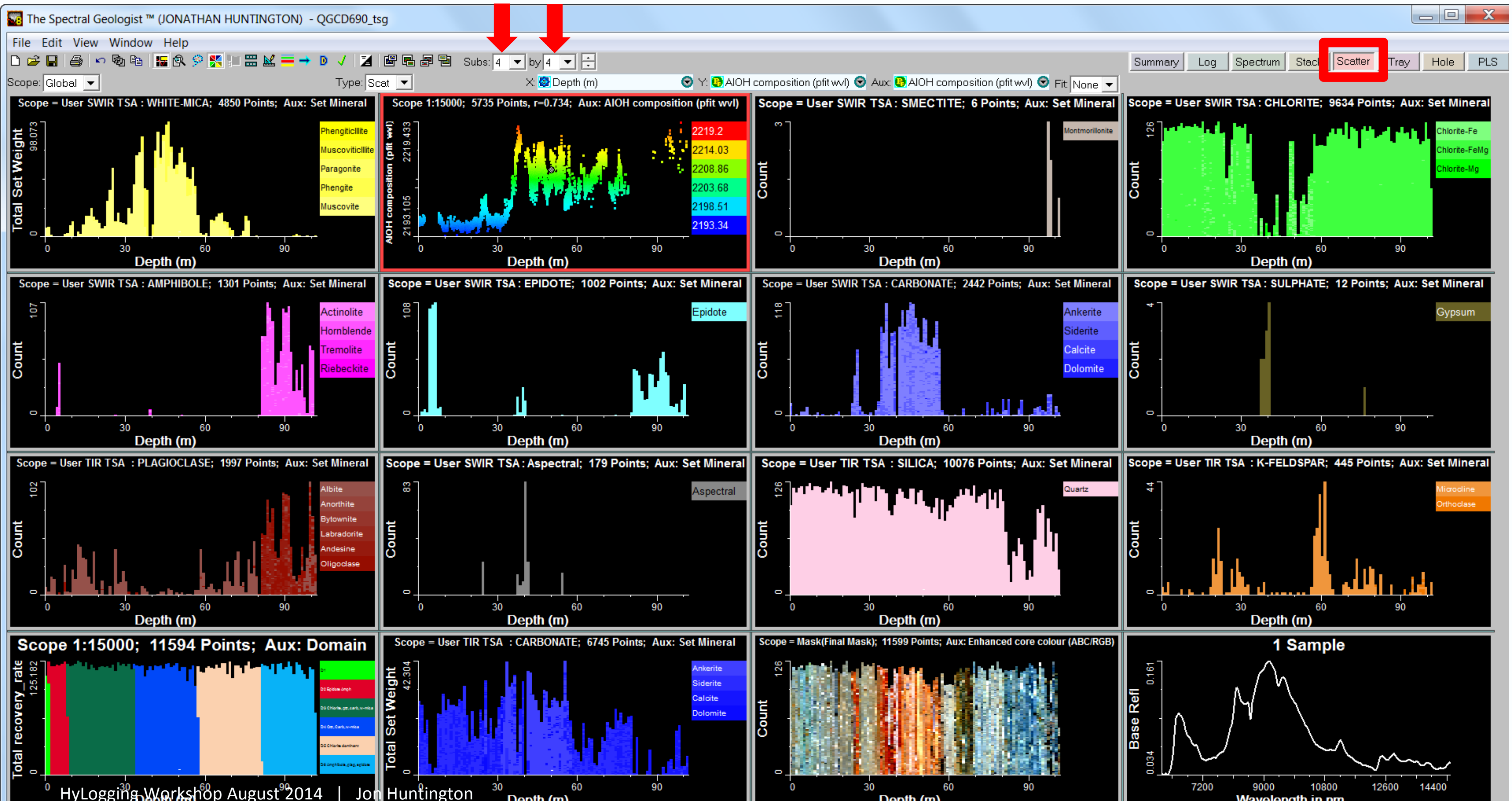
Exploring Content – Stack Screen

For examining groups of spectra to appreciate similarities or changes across boundaries. Use Final Mask filter to only see rock spectra. Multiple wvl options.



Exploring Content – Scatter Screen

From 1 to 25 sub-screens controlled by X & Y “Subs” (arrowed) showing histograms, scatter plots, mineral classes, lithologies, assays, core colour, spectra and more.



Exploring Content – Scatter Screen Plot Types

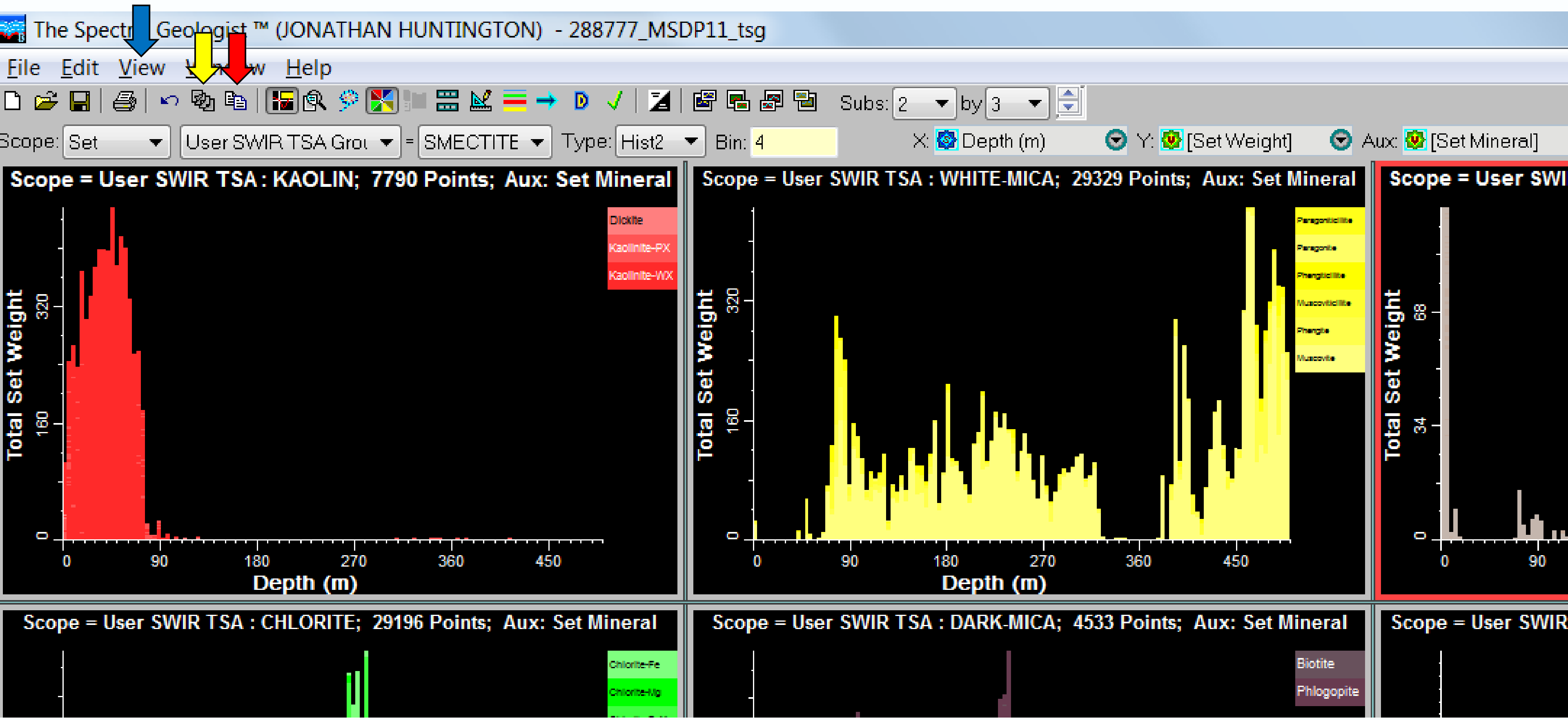
Plot types (histograms, scatter plots, spectra, grids) are selected with the Type drop-down (yellow arrow). The current sub-screen is outlined in red (red arrow)

Exploring Content – Expanding Sub-screens

Double click outside the plot axes to expand current sub-screen to fill the whole screen. Ditto to return to the previous view. Current cursor position is preserved.

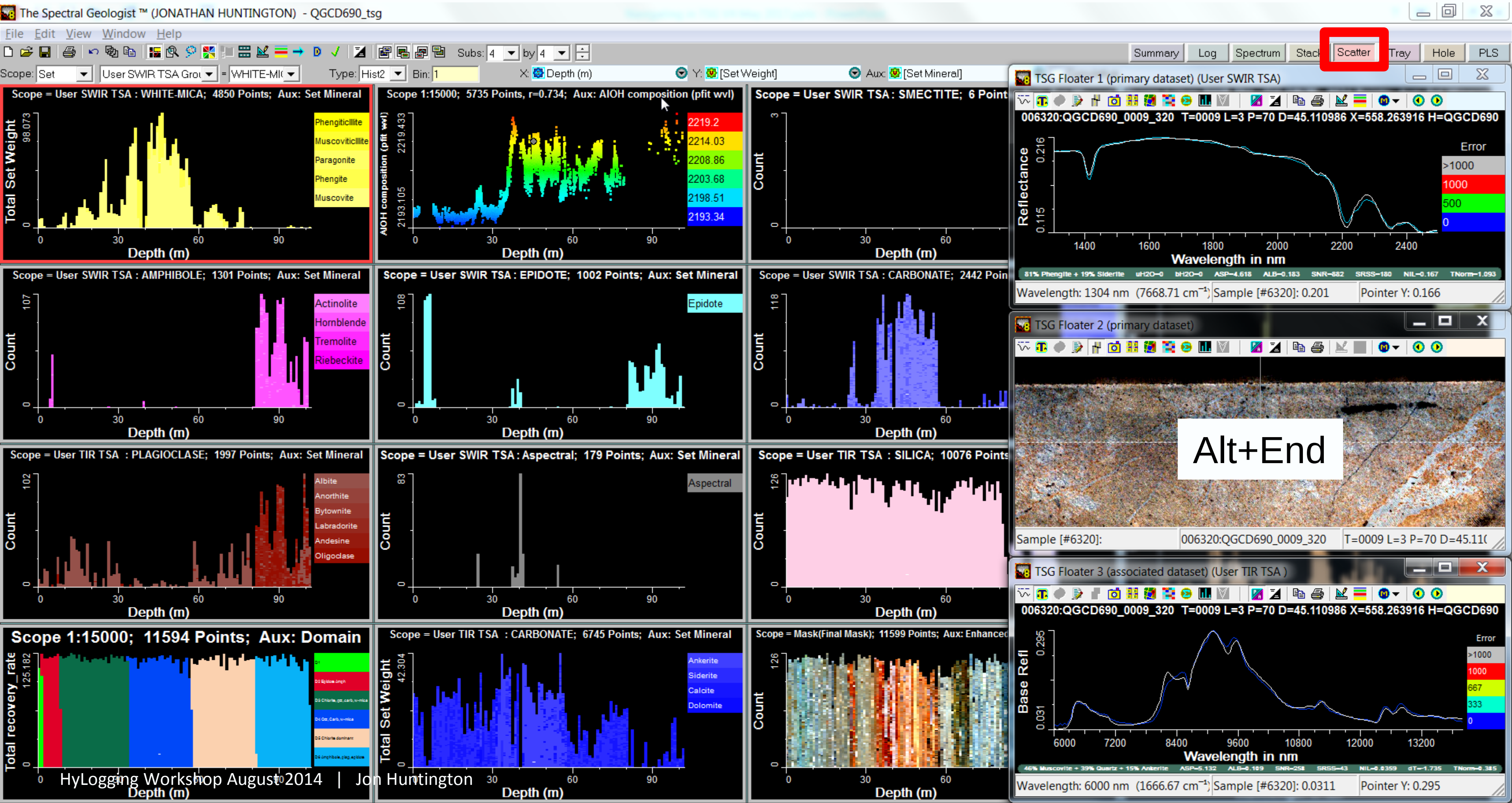
Scatter Screen Export

Select all sub-screens or only one at yellow arrow then copy to clipboard at red arrow to place in another application. Use View > Save to save graphics to a file (blue arrow). Right-click any sub-screen to export content to a .csv file.



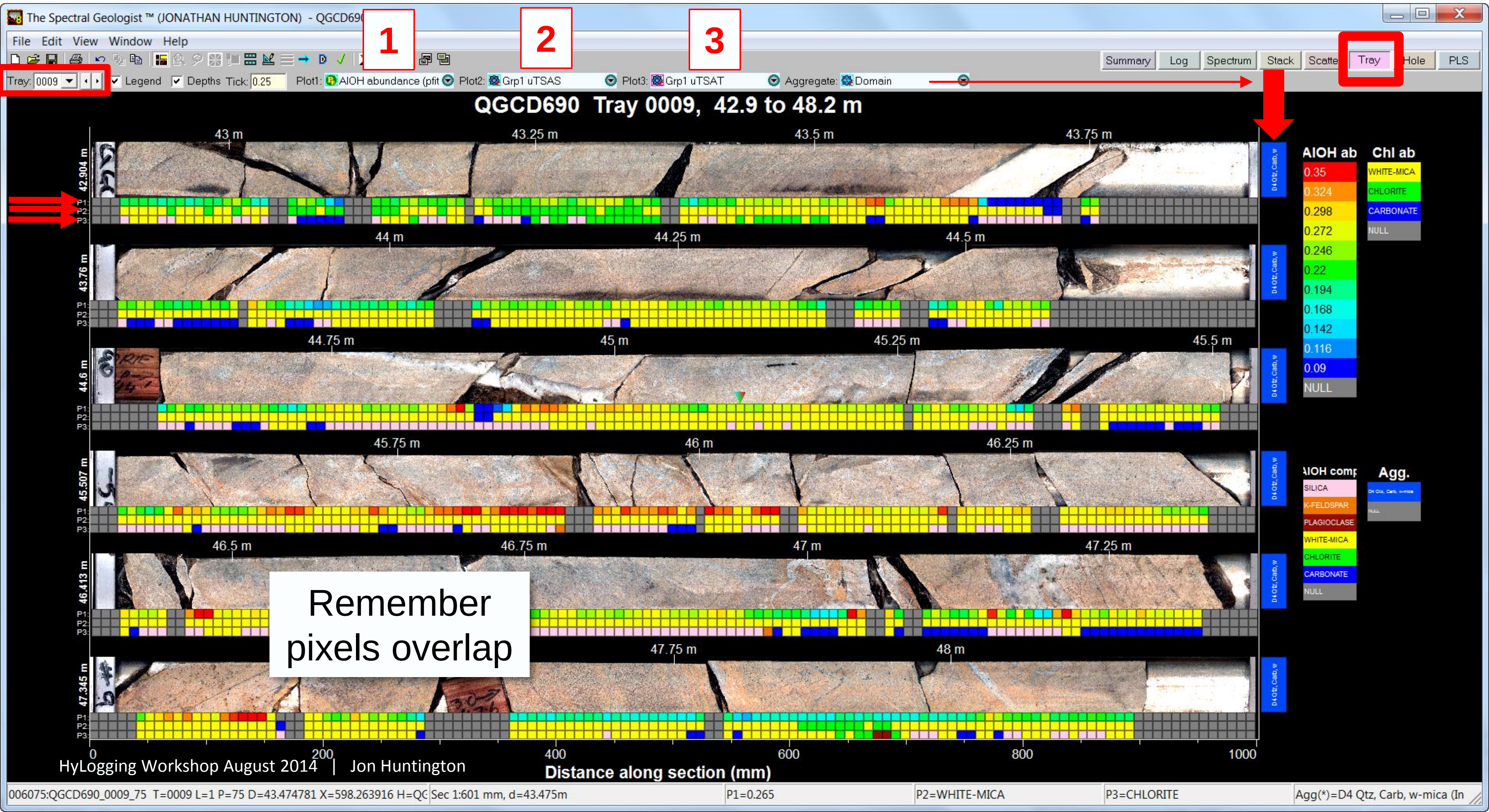
Manage screen space with Floater short-cut keys

Place or hide Floaters in any screen with <Alt+Home> or <Alt+End> to display left or right or toggle <CNTRL+Del to hide/restore. <CNTRL+Home> or CNTRL+End to display top or bottom.



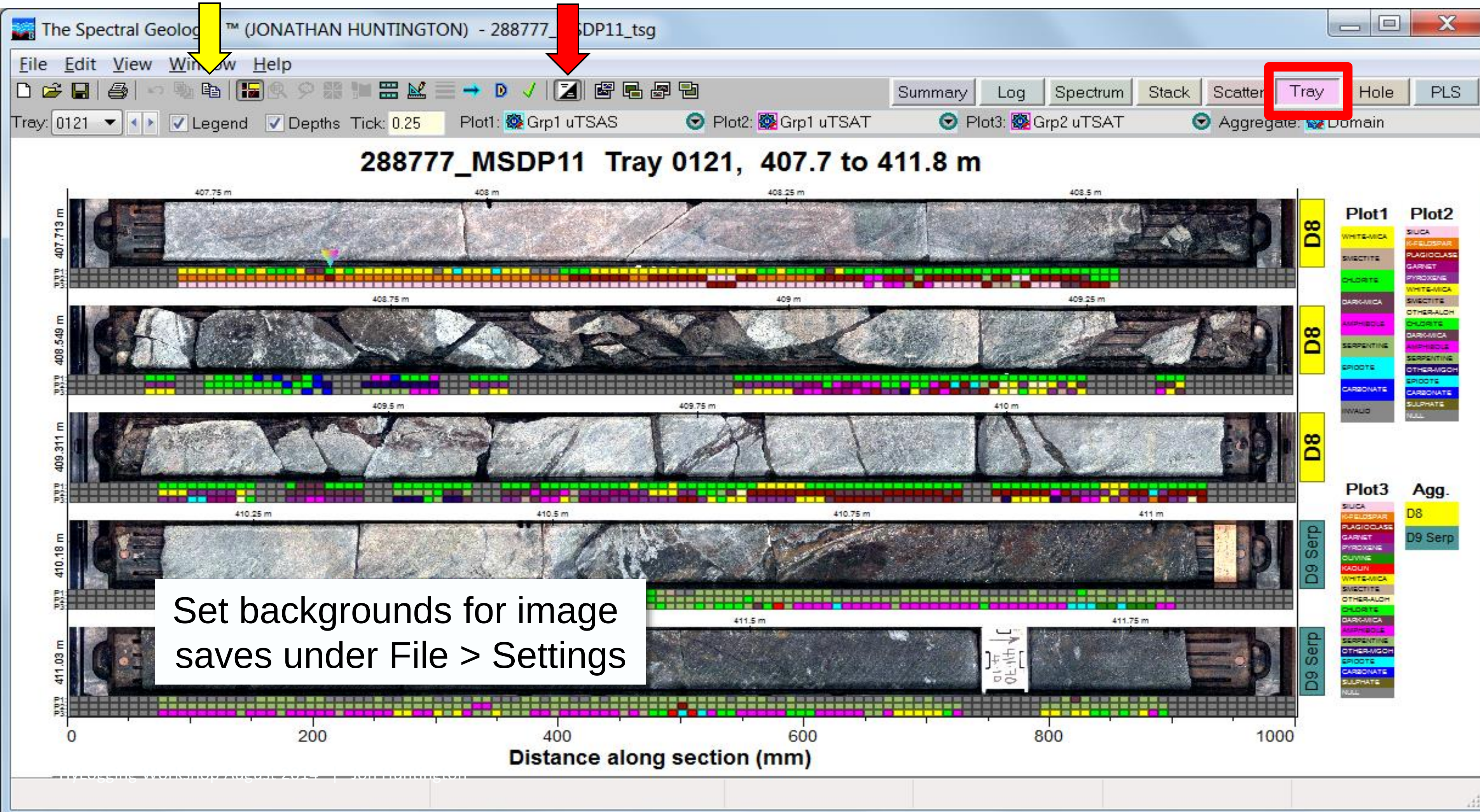
Exploring Content – Tray Screen

Reproduces and annotates the original core tray sample by sample. Can show classes, indices, assays, lith codes, etc. This is also where depth logging is done. Content can be exported, plain or annotated.



Exploring Content – Tray Screen

Toggle screen backgrounds between black or white on any TSG screen at red arrow. Copy current screen to clipboard to place in another application at yellow arrow.

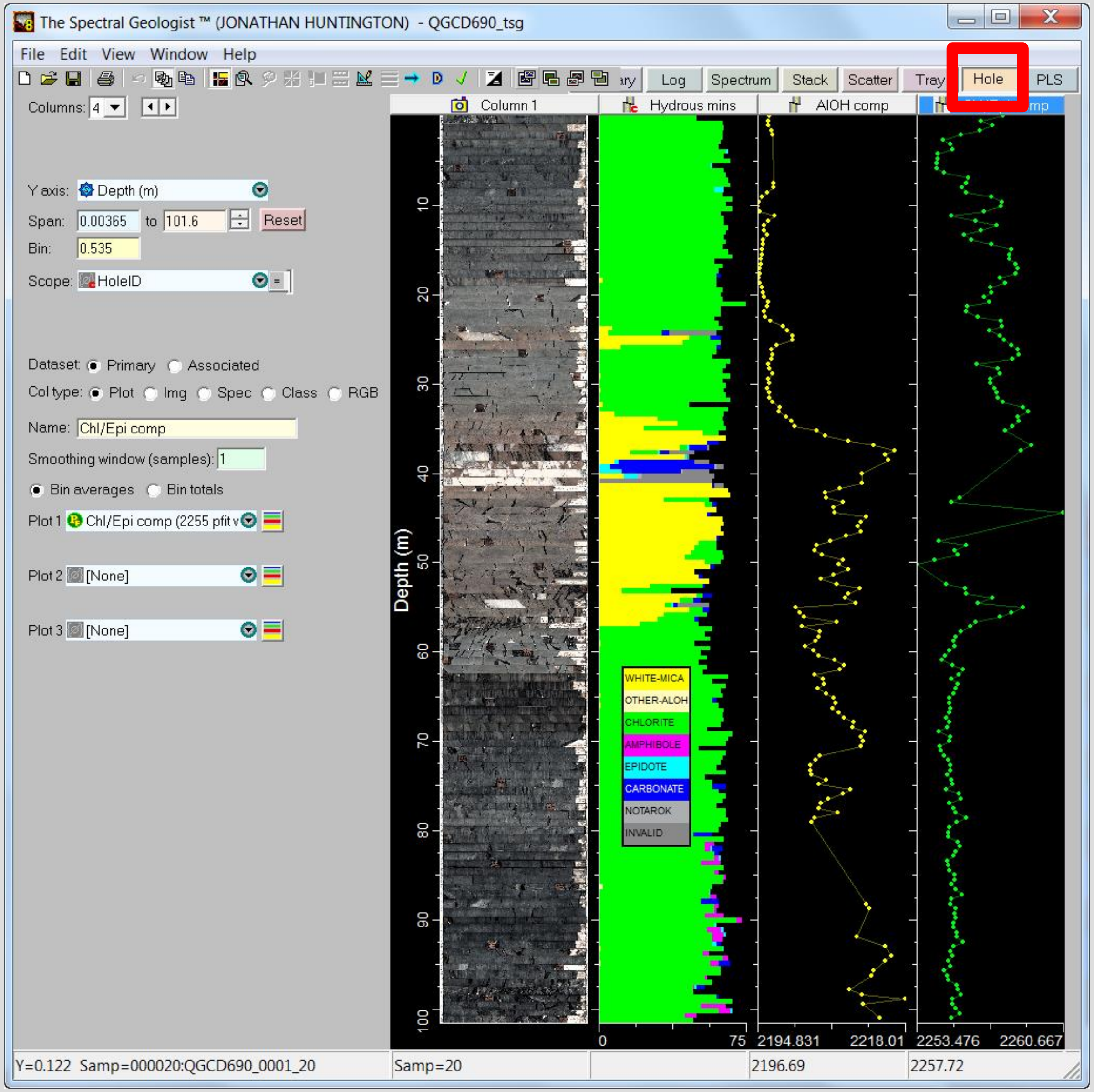


Exploring Content - Hole Screen

See an entire drill hole in one A4 aspect plot.

Can show images, classes, indices, assays, lith codes, etc. in a variety of styles.

Zoom-in on specific depth intervals for more detail.



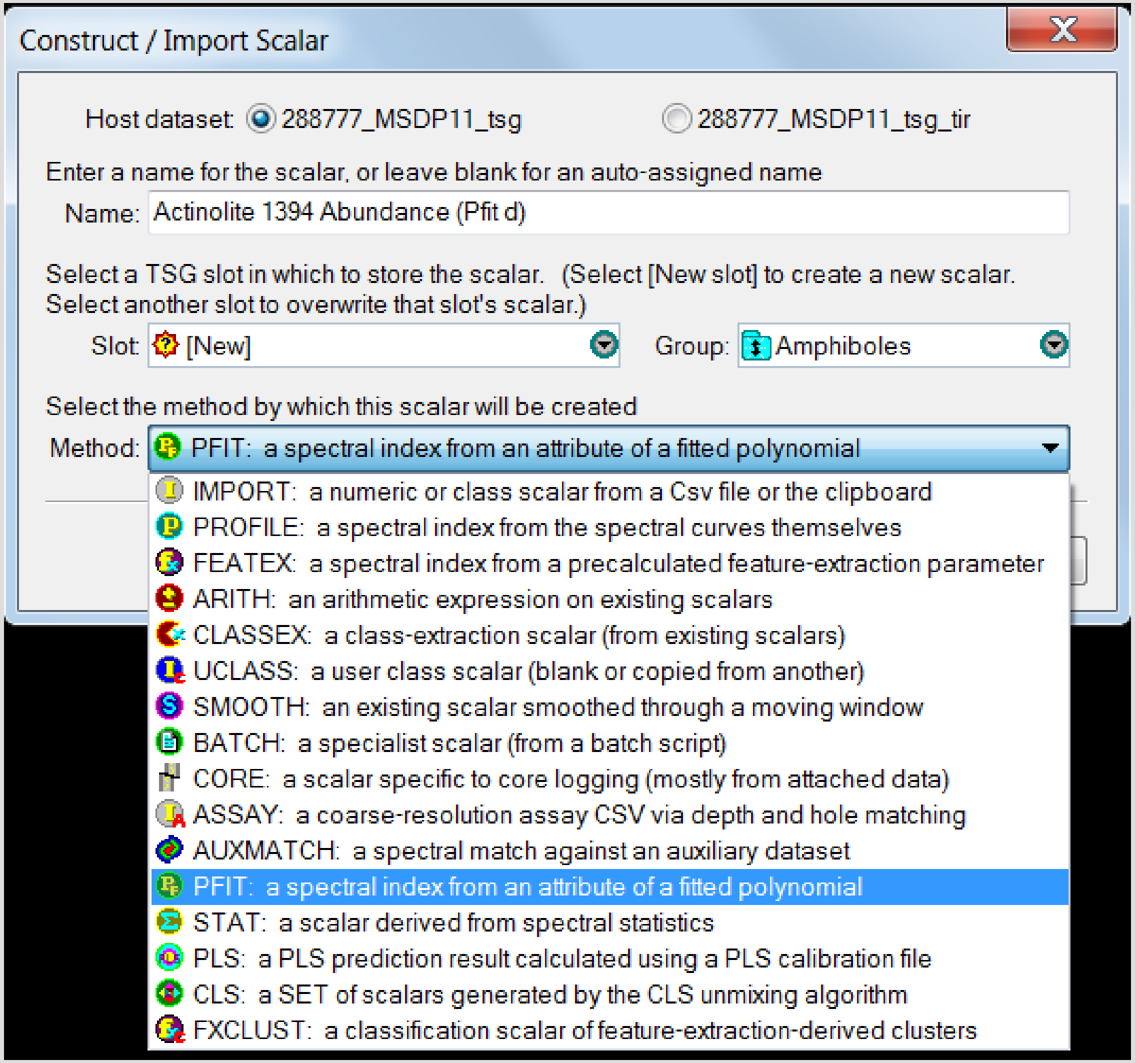
Creating Content – Scalar Creation Methods

New scalars are created from any screen under Edit > New Scalar from the main top left menu, or in the Log Screen, by right-clicking then > Edit, Add, Del.

TSG offers a large number of tools for creating or importing new scalars and content. At right each is briefly described.

Two of the commonest are the Profile method and the Pfit method.

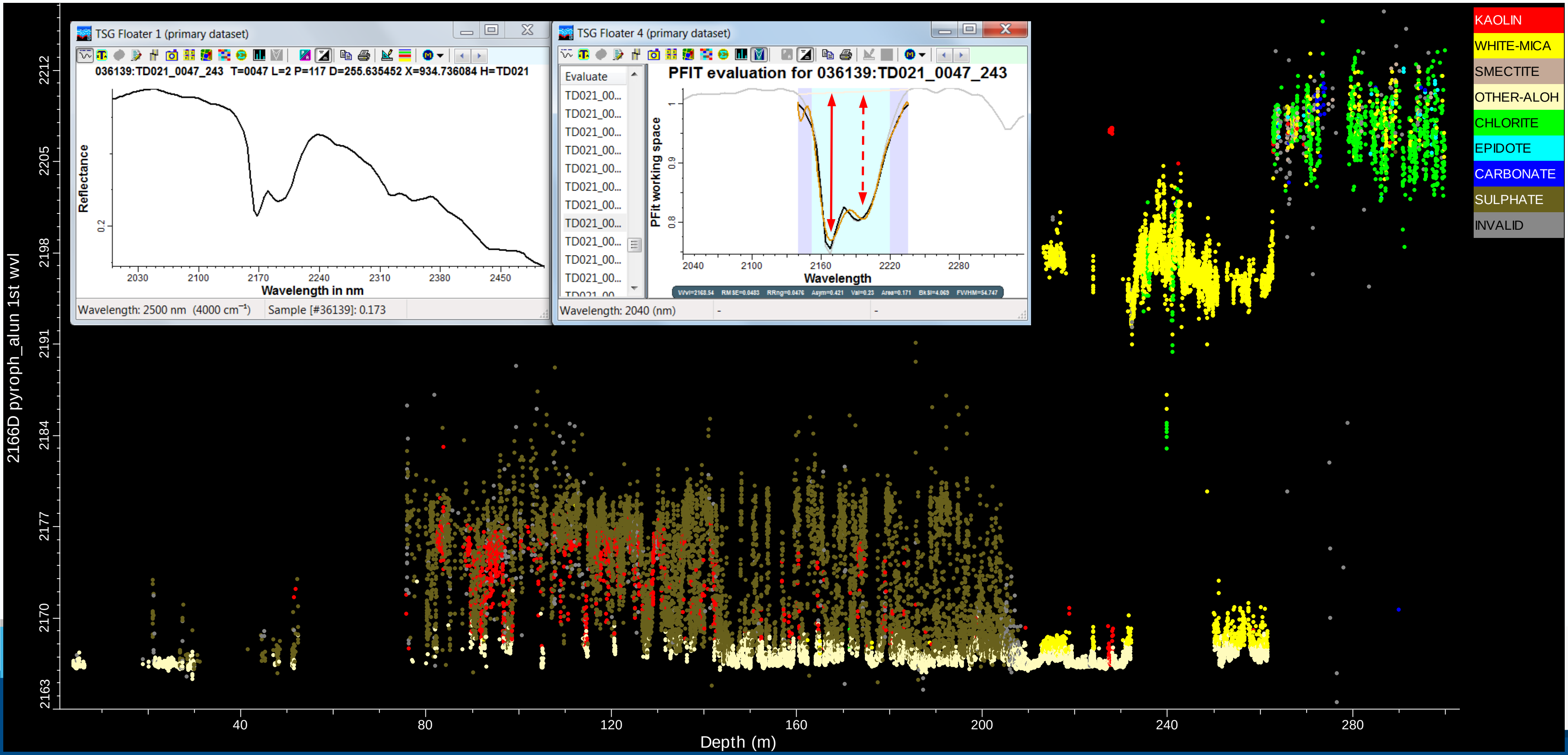
Each of these can be discussed and explored.



Modelling Absorption Feature Parameters

Depth & Wavelength ≡ Abundance & Composition

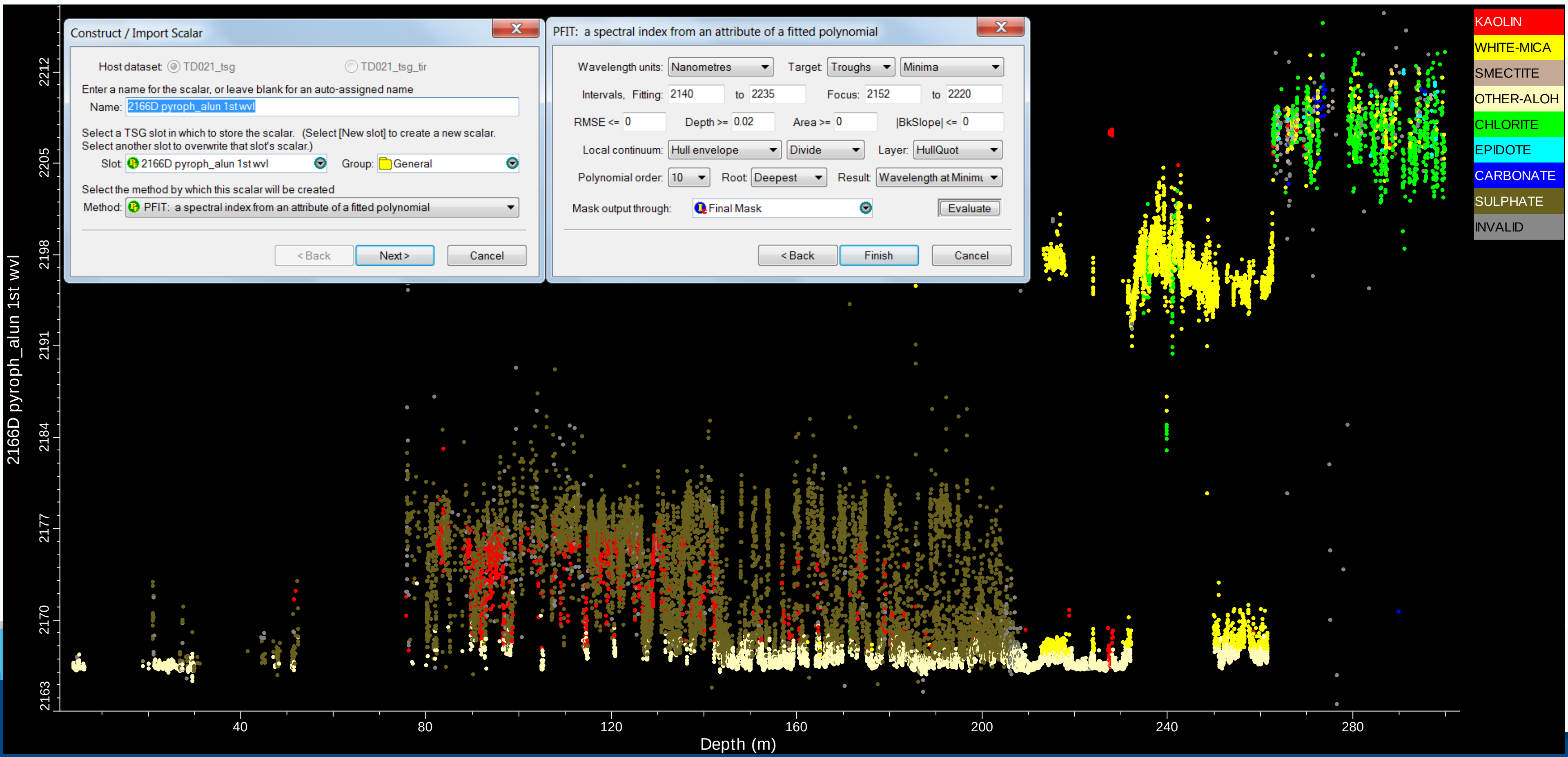
Using the Pfit tool to extract the depths (relative abundance) & wavelengths (composition) of absorption features for an entire drill hole.



Modelling Absorption Feature Parameters

Depth & Wavelength ≡ Abundance & Composition

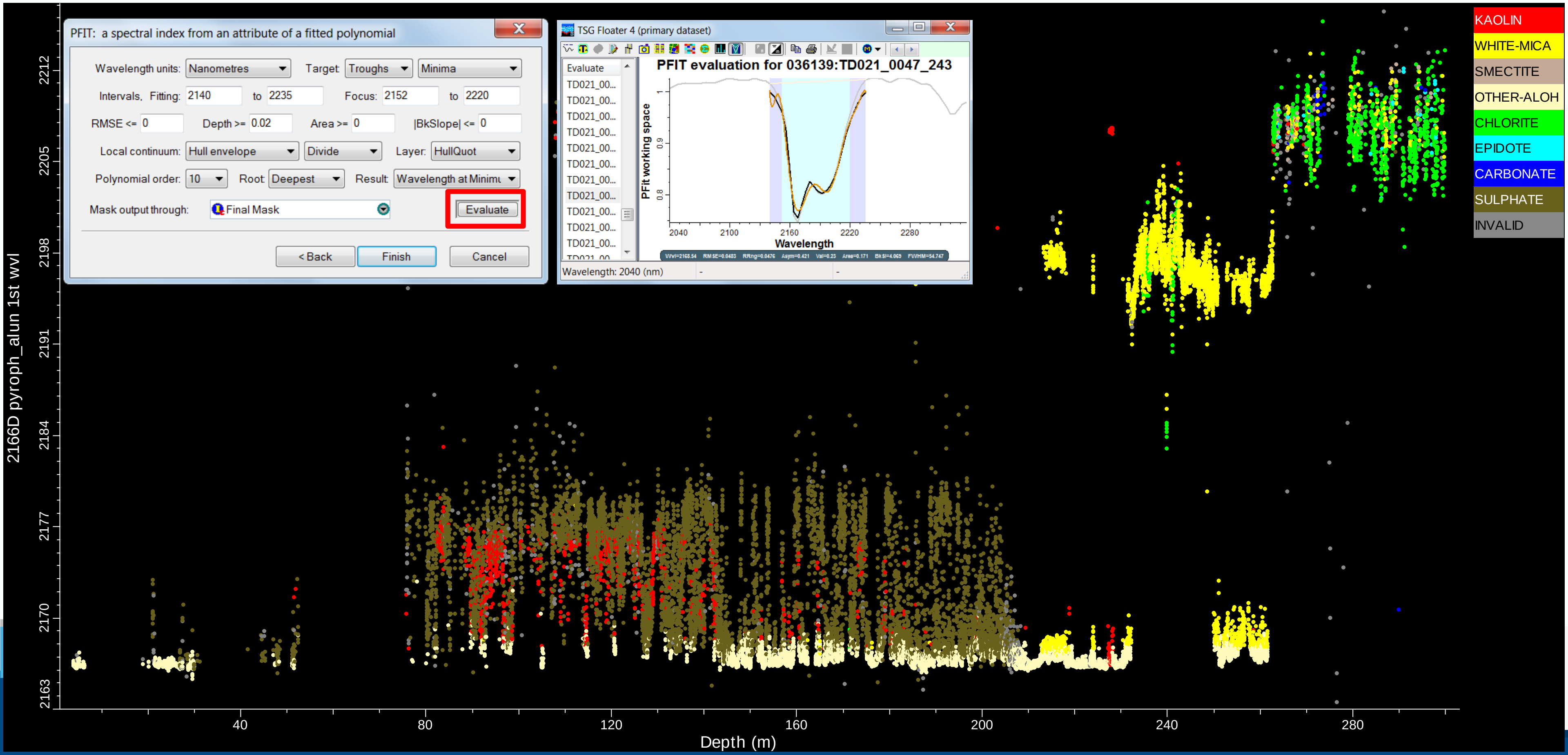
Using the Pfit tool to extract the depths (relative abundance) and wavelengths (composition) of absorption features.



Modelling Absorption Feature Parameters

Reviewing rules and evaluating fits

Right-click, select the ‘Y-axis scalar’ and ‘Modify’ to see to the Pfit dialogue. Review or edit rules or hit “Evaluate’ to see the fit. Select other samples to review their fits.



Importing and Exporting Data

Importing

The following are easily imported from spreadsheets or CSV or LAS files direct or via the clipboard. See main File menu.

- Alphanumeric text data (e.g. manual logs, log codes, stratigraphy, lithology, XRD results etc.)
- Numeric data (e.g. GPS coordinates, assays, mag' susc', wireline logs, etc.)
- Reflectance spectra from field instruments or spectral libraries as ENVI-SpecLib files or ASCII 2 column files.
- Maps as .jpg files into the Floater maps option.
- Sample images as .jpg files from Smart phones with synchronisation tools.
- TSG can handle geochemical data without any spectral data.
- All data once imported can be plotted.
- Imports are synchronized to depth or sample #. TSG depths ∴ need to be as good as possible. Depth logging (assignment) handled in Tray Screen.

Handling GPS coordinated spatially data

Importing coordinates:

- directly from instrument
- via .csv file import
- from Smart phone

User Scatter Screen as a map making tool, e.g.

- Eastings vs. northings coloured by mineralogy, or any other TSG variable.

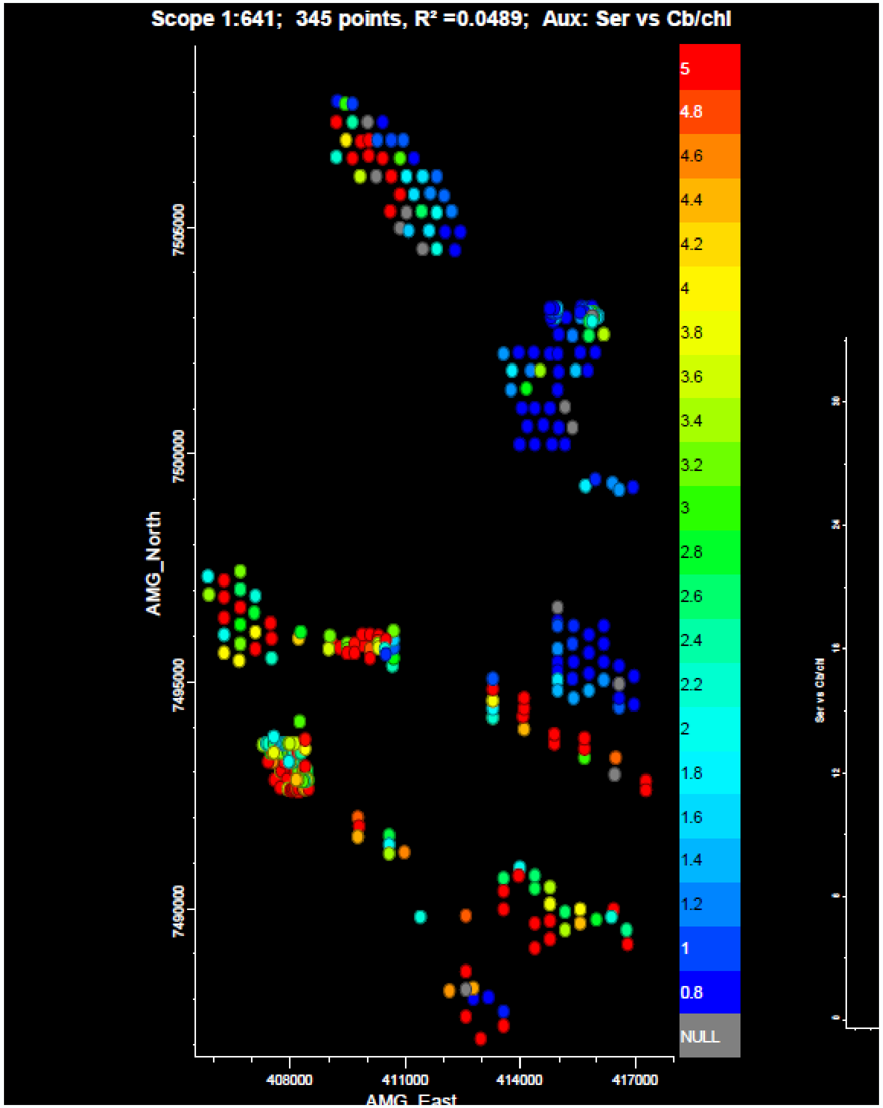


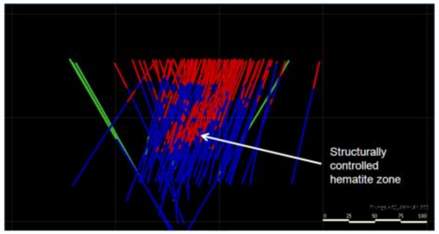
Image courtesy of Sasha Pontual

Importing and Exporting Data

Exporting

All data (interpretations, scalars, anything) can be exported to .csv files for import into other packages.

e.g. ioGas, Leapfrog, GOCAD, etc.



Exports can be at native spatial resolution or “downsampled” to some other interval (e.g. 1 m or to a user specified set of intervals)

- Class exports can be done “intelligently” and concatenated
- Numeric exports can be totals or averages

All images can be exported as .jpg or .png files

Spectra can be exported to ASCII, ENVI-SpecLib or TSG files.

Specialist tools not discussed today

- **Copy Processing** – Use another dataset to copy process its scalar methods into a new dataset. Saves time and builds consistency.
- **Writing Scripts and Script Libraries** – Write and build libraries of batch scripts for undertaking routine & repetitive calculations.
- **Headless TSG** – Run TSG unsupervised without any windows in the background taking instructions from a script.
- Computing dataset **statistics** (correlation and covariance structure), principal components and class classification (clustering).
- **Partial Least Squares** (PLS) for modelling relationships between spectra & say, XRD results or geochemistry. Quantification of TSG's relative results.
- **NVCL uploading**. TSG can upload its data files into Oracle or MS SQLServer databases for storage and then using server download tools retrieve them back into TSG.
- Importing and using **external** spectral reference **libraries**.

CSIRO

Acronyms

1. **TSG** & **TSG8** – The Spectral Geologist software package
2. **TSA** – The Spectral Assistant – Interpretation Algorithm
   - **s**TSAS, sTSAV, sTSAT (system level TSA)
   - **u**TSAS, uTSAV, uTSAT (user edited level TSA)
   - **d**TSAS, dTSAV, dTSAT (domained TSA with restricted mineral sets [RMS])
3. **CLS** – Constrained Least Squares – unmixing algorithm
   - CLST,
4. **jCLST** – Joint CLS algorithm using SWIR knowledge to guide thermal infrared unmixing. *Evolving*
5. **Scalars** – Indices showing the depth or wavelength of an absorption feature, or a classification of minerals. Numeric or textual.
6. **Obsolete names** - ~~TSG-Pro, TSG-Core, TSG-HotCore~~

Short-cut Keys

See under <HELP>

General:

	F1	Main help
<SHFT>	F1	About TSG
<CTRL>	F1	Supplementary HyLogger help
<ALT>	F1	You're looking at it now
	F2	Summary screen
	F3	Log screen
	F4	Spectrum screen
	F5	Stack screen
	F6	Scatter screen
	F7	Tray screen (HyLogging dataset)
	F8	Hole screen
	F9	PLS screen (if licensed)
	F10	First floater (toggle)
	F11	Second floater (toggle)
	F12	Third floater (toggle)
<CTRL>	F10	Third floater (toggle)
<CTRL>	F11	Fourth floater (toggle)
<ALT>	<HOME>	Set up 3 floaters on the left
<ALT>	<END>	Set up 3 floaters on the right
<CTRL>	F4	Hide / restore modeless tool windows
<CTRL>	<DEL>	Hide / restore modeless tool windows
	<PgUp>	Page up (action depends on window)
	<PgDn>	Page down (action depends on window)
<ALT>	<RET>	Settings
<ALT>	P	Current sample to scratchpad
<CTRL>	1	Load layout 1 (if present)
<CTRL>	2	Load layout 2 (if present)
<CTRL>	3	Load layout 3 (if present)
<CTRL>	4	Load layout 4 (if present)
<CTRL>	5	Load layout 5 (if present)
<CTRL>	6	Load layout 6 (if present)
<CTRL>	7	Load layout 7 (if present)
<CTRL>	8	Load layout 8 (if present)
<CTRL>	9	Load layout 9 (if present)
<CTRL>	0	Layout manager

Main TSG windows:

<ALT>	F4	Exit TSG
<CTRL>	N	Create a new dataset
<CTRL>	O	Open a dataset
<CTRL>	Q	Close the current dataset
<CTRL>	S	Save the current dataset
<CTRL>	A	Save the current dataset using a new filename
<CTRL>	P	Print
<CTRL>	I	Assay import
<CTRL>	D	Downsample
<CTRL>	Z	Settings
<CTRL>	E	Domain editor (toggle)
<CTRL>	K	Class / Rockmarks editor (if viable)

Floater windows:

<ALT>	F4	Close floater
<CTRL>	S	Spectrum mode
<CTRL>	A	Aux-match mode
<CTRL>	T	TSA mode
<CTRL>	I	Picture mode
<CTRL>	L	Linescan mode
<CTRL>	M	Mosaic-pic mode
<CTRL>	P	Scratchpad mode
<CTRL>	O	Co-occurrence mode
<CTRL>	Z	Stats mode
<CTRL>	F	Feature frequency mode

Depth logging:

<Left arrow>		Previous sample
<Right arrow>		Next sample
<Up arrow>		Previous core section
<Down arrow>		Next core section
<Page up>		Previous core tray
<Page down>		Next core tray
<Spacebar>		Equivalent to LMB click, in an LMB-lock mode
	F1	LMB lock = 'None'
	F2	LMB lock = 'Space'
	F3	LMB lock = 'Sec Start'
	F4	LMB lock = 'Sec End'
	F5	Toggle 'Depth'
	F6	Calc
	F7	Toggle final-mask status for current sample

Follow-on Resources - 1

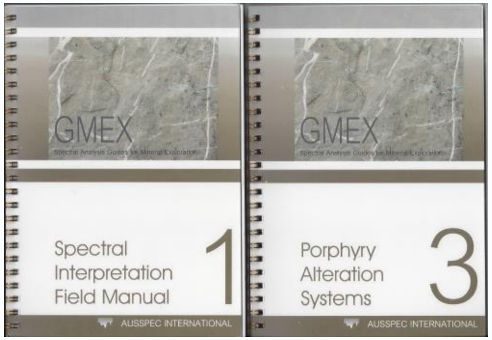
1. **TSG8-Viewer** – Free TSG-Base version for read-only viewing of previously processed TSG or NVCL datasets. Available from the TSG website.

2. TSG website for info - www.thespectralgeologist.com

3. South Australia's SARIG site - https://sarig.pir.sa.gov.au/Map

4. Link for TSG purchase - http://bit.ly/TSG-V8

5. GMEX Minerals Guides from Ausspec International
   e: sasha.pontual@ausspec.com
   t: 1300 85 44 65
   w: ausspec.com



Follow-on Resources - 2

1. AuScope Website: http://www.auscope.org.au/
2. AuScope Portal: http://portal.auscope.org/portal/gmap.html
3. NVCL web page: http://www.auscope.org.au/site/nvcl.php
4. CSIRO HyLogging website: http://www.csiro.au/Organisation-Structure/Flagships/Minerals-Down-Under-Flagship/Exploration/hylogging-systems.aspx
5. GS SA HyLogging web site:

   https://sarig.pir.sa.gov.au/
6. Corstruth – Access to over 2,300 drill hole plots & Google Map interface

   http://www.corstruth.com.au
7. AUSGIN from GA

   http://portal.geoscience.gov.au/gmap.html

Acknowledgements

I acknowledge the many people who have contributed to the development of the TSG package.

Primarily Peter Mason, code developer and maintenance engineer “extraordinaire”.

Mark Berman and Andy Green have contributed to the development of the TSA, CLS and jCLS unmixing algorithms and many other ideas.

Sasha Pontual and Nick Merry contributed to aspects of the initial interface design in the 1990s.

Over the years many CSIRO colleagues and external users, nationally and internationally, including especially Australia’s Geological Surveys, who have all helped and made valuable suggestions.

Thank you

Feedback & questions to:

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Web: hhgeoscience.com.au
Phone: +61 (02) 9490-8839   Mobile: +61 408-221-934

2018 HyLogging with TSG Workshop

Geological Survey of South Australia's Tonsley Core Library

Monday 30th April 2018

Workshop Goals

1. Learn how to objectively create valuable mineralogical and geological logs of drill-core from hyperspectrally-scanned and imaged cores and chips using the TSG8 software package on HyLogging data.

2. Learn how to import external data to analyse alongside the HyLogged mineralogy and imagery and export into other packages.

3. Learn how to access publically available drill core data and understand what has been done to it and how it can be used independently.

4. Take away records in MS Word or PowerPoint of your own logs created using TSG8.

Task 1 – Core Familiarisation

1. In the Layout lab, familarise yourselves with drillhole geology, in particular, primary versus alteration mineralogy.
2. Address a series of questions relevant if logging this drillhole, e.g.
    a. *where is the base of weathering?*
    b. *what is the mineralogy of the skarn?*
    c. *what are the alteration minerals in the igneous units?*
3. These questions should be investigated further when working with the spectral data throughout the day.
4. Record your observations by core tray number and depth. Take photos if it helps to jog your memory later
5. Make use of your hand-lens, scribe, magnet and acid bottle (provided in the lab).

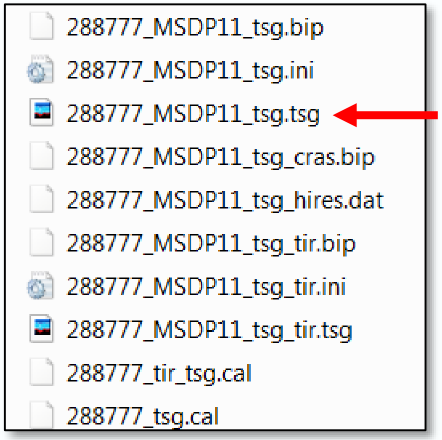
Task 2 – Basic TSG Navigation

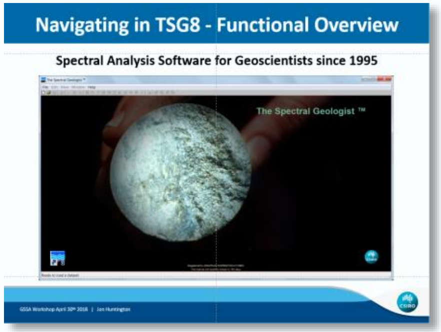
1. Open the provided TSG dataset MSDP11.tsg (not MSDP11_tir.tsg)

2. Follow-along with guided tour from the speaker

3. This task is primarily about navigating TSG's options not geology

4. Use provided, more detailed, PDF presentation as a reference guide where necessary.





Task 3 – Refining Initial Mineral Interps

1. In *Summary Screen* & then, more importantly, the *Scatter Screen* examine sTSA results & note what might be correct / incorrect
2. Using histograms of abundance (use right-click > *Standard Setup* in *Scatter screen > System TSA*) examine & note down low abundance or unlikely minerals. Maximise all 'Y' scales with right-click > *Scaling Extras > Auto Scale all > Y on*.
   - *Use Floaters to check for, a) believable fits or, b) core images to check on edges.*
3. Edit Active Minerals Lists (*File > Settings > TSA*) to exclude noted errors of commission & stupid (incompatible) results for VNIR, SWIR & TIR). Check "*Mark for re-calc"* at each stage. Wait for TSA to re-run
4. Once re-run visit *Summary Screen*, *Log Screen* and *Scatter Screen* and assign all displays of interps to uTSAS & uTSAT respectively. Optionally do the same to the *Tray Screen* using the right-click *Standard Layout* options.
5. Understand Aspectral distribution & compute ≡ RelRange scalar.

Task 4 - Build Domains

1. In *Summary Screen* (make Bin=2m) recognise homogenous mineralogical assemblages & using *Domain Editor* (D) [1] at right create new Domains [2] for entire hole from top to bottom.

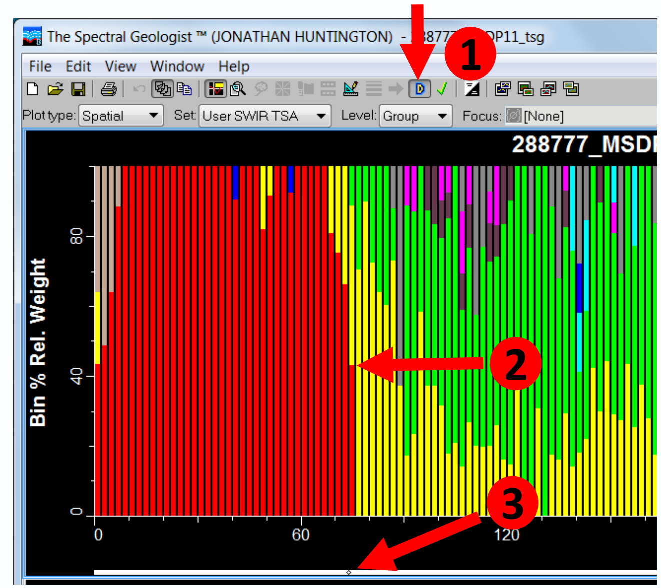
2. For each Domain place cursor where you want a boundary. Consider both SWIR & TIR plots. Hit "New" in Domain Editor then "Proceed". Domain will appear in Ribbon [3]. Repeat throughout hole.

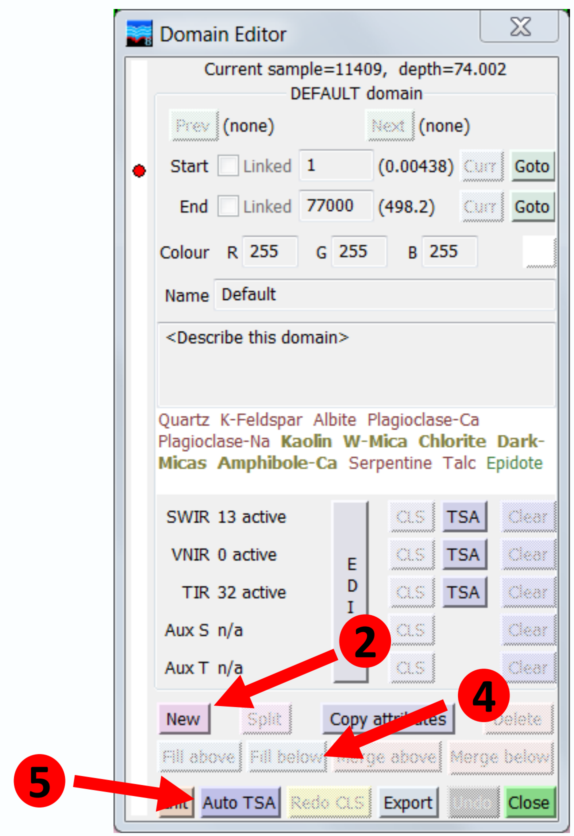
3. For last domain partially fill then choose > Fill below [4].

4. On completion select Auto TSA [5] in Domain Editor to assign initial Restricted Mineral Sets (RMS) for each Domain.

5. Note main minerals are added to each Domain description. Add Domain names for reference.

6. We will discuss how to edit Domains.



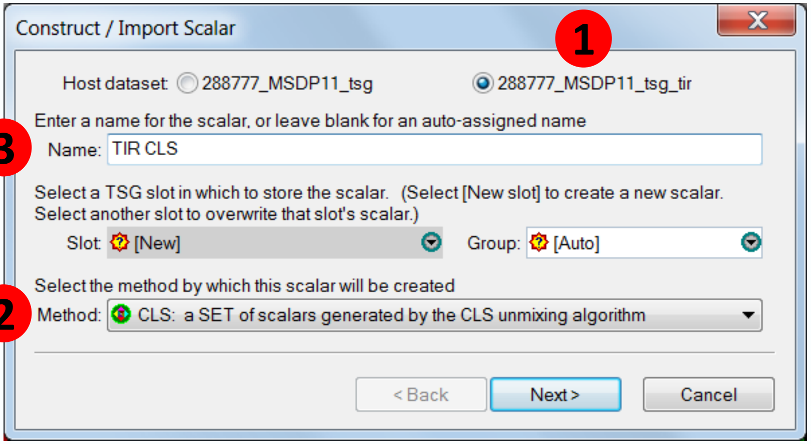


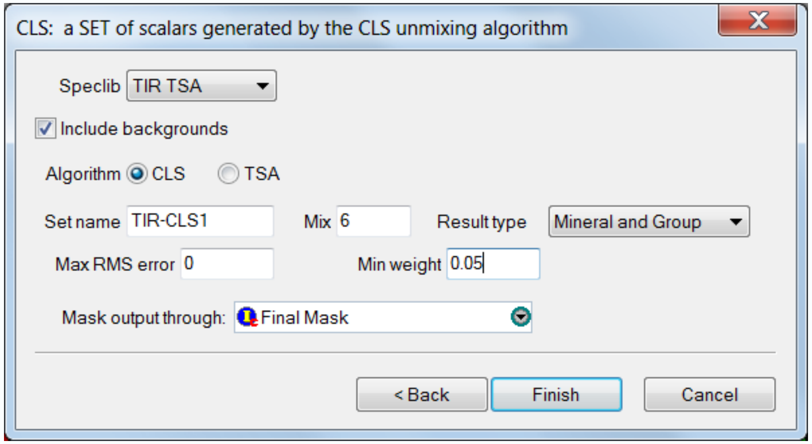
Task 5 – TIR Constrained Least Squares (CLS)

uTSAT has only done mineral mix=3, partly because of speed. We will need to go deeper

Calculate CLS scalar set with mix=6

1. Go *“Edit” > “New Scalar”*
2. Pick the TIR file [1] as we are unmixing the TIR data
3. Choose method = CLS [2]
4. Provide a name for scalar [3] and hit “Next”
5. Fill out as opposite considering the various options, then “Finish”

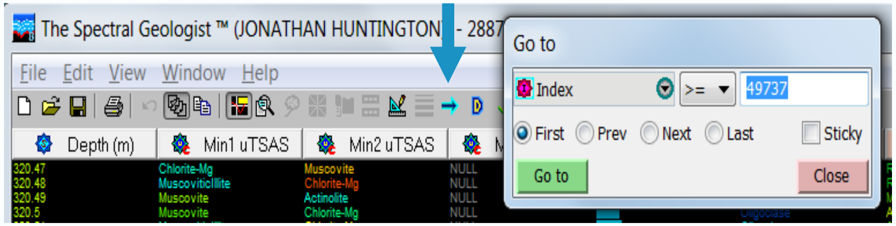




Task 6a - CLS Residuals

We can check if the correct restricted mineral sets (RMS) have been selected for each Domain by looking at the Residuals to the fits.

1. On the *Log Screen* use the blue "*Go to*" button to move to Sample/Index #49737.

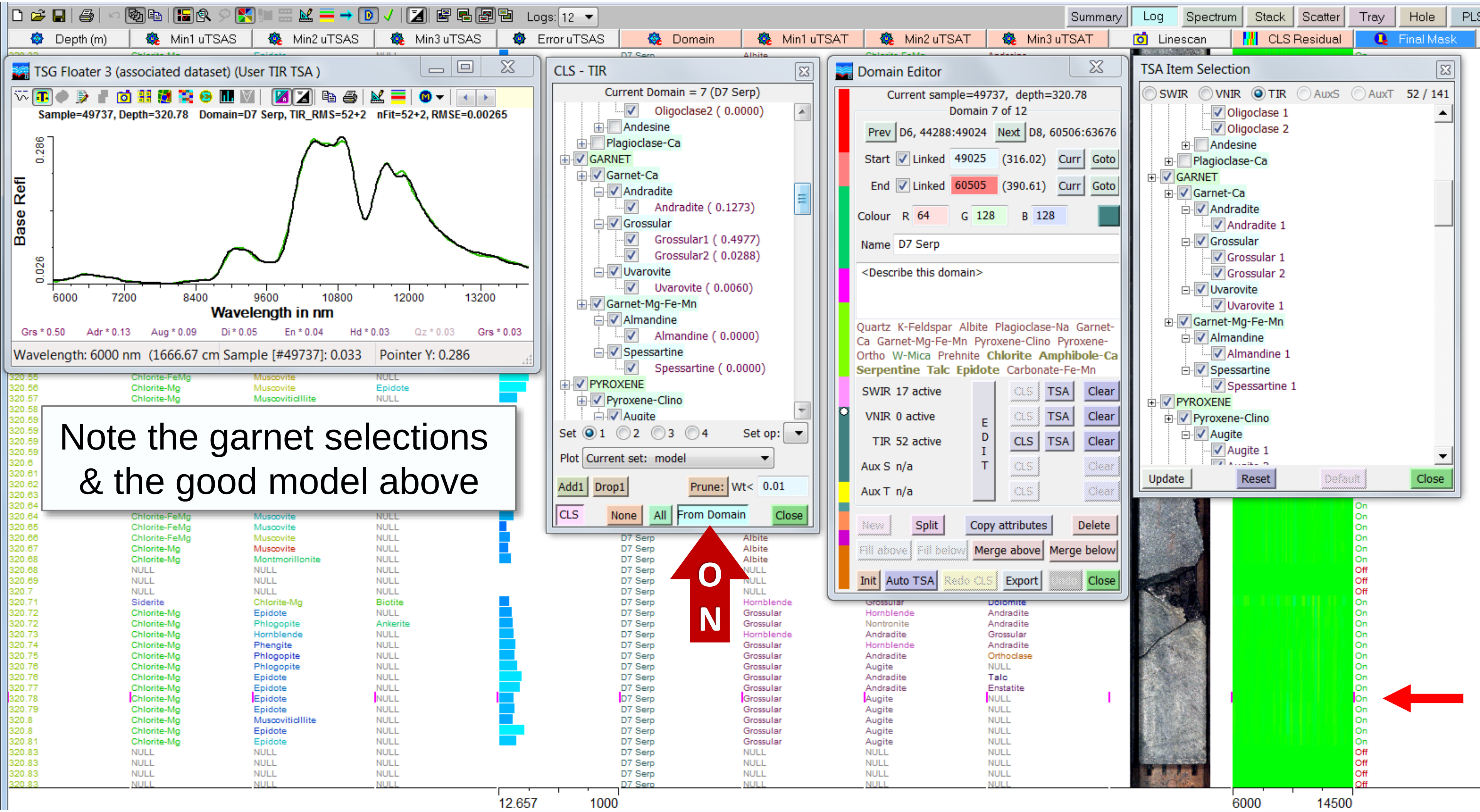


- Did you see the garnets in the core this morning?

2. Select a *Floater* with TIR spectra in TSA mode
   - Note its good fit to garnet
   - Choose Constrained Least Squares from the right-click *Floater* menu and turn on "From Domain"

3. Select the *Domain Editor* and then *Edit* then *TIR*
   - Your screen should look like the next page ......

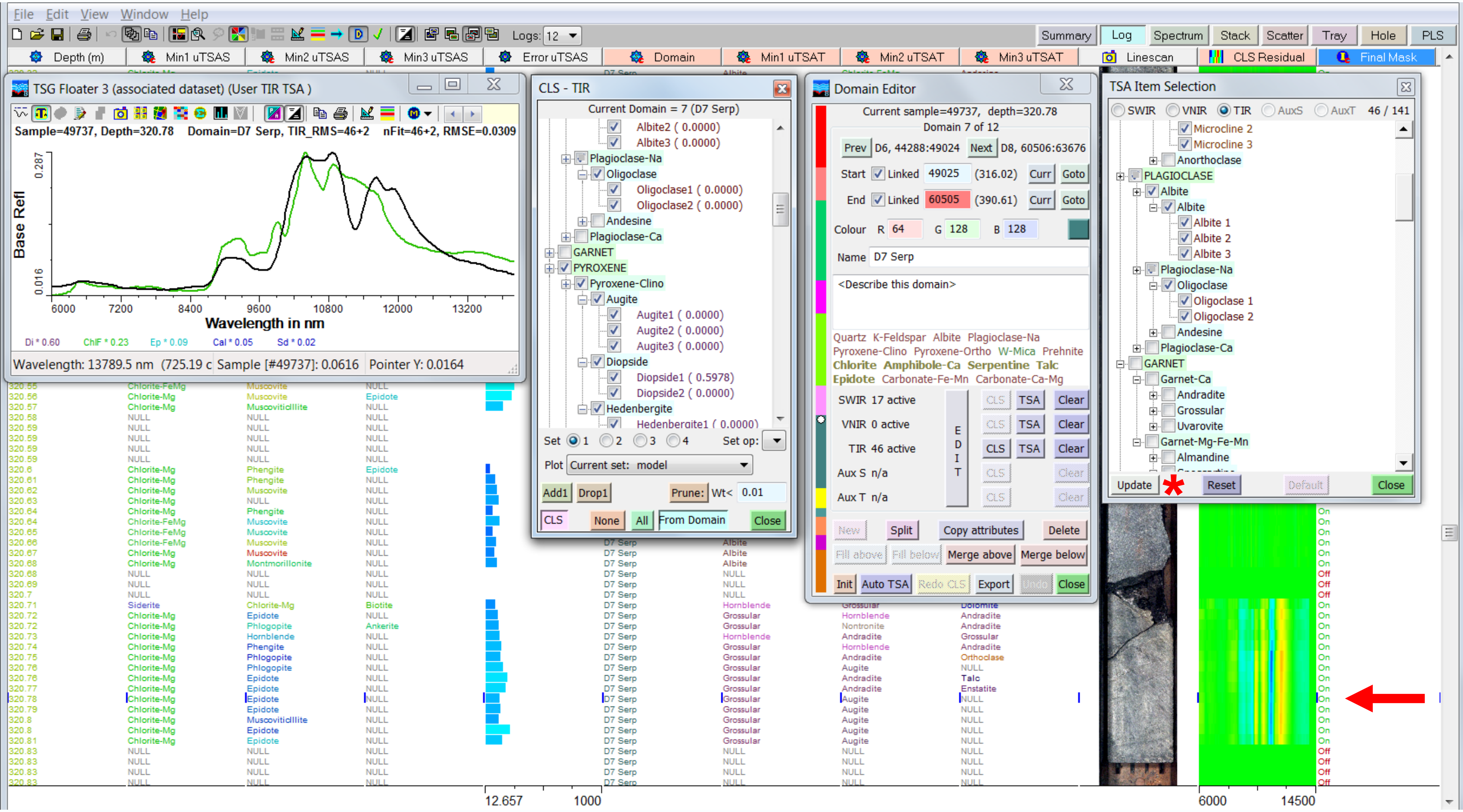
Task 6b - CLS Residuals



Note the garnet selections & the good model above

Next turn off the garnet in the right-hand RMS selection list then hit Update

Task 6c - CLS Residuals



So the idea is to check for & explain these high residual patterns

Before leaving turn the garnet on again then hit "Update" (starred).

Task 6d - CLS Residuals

So the CLS residual tool allows us to check each Domain for mineral spectra we may have missed.

High residuals occur due to:

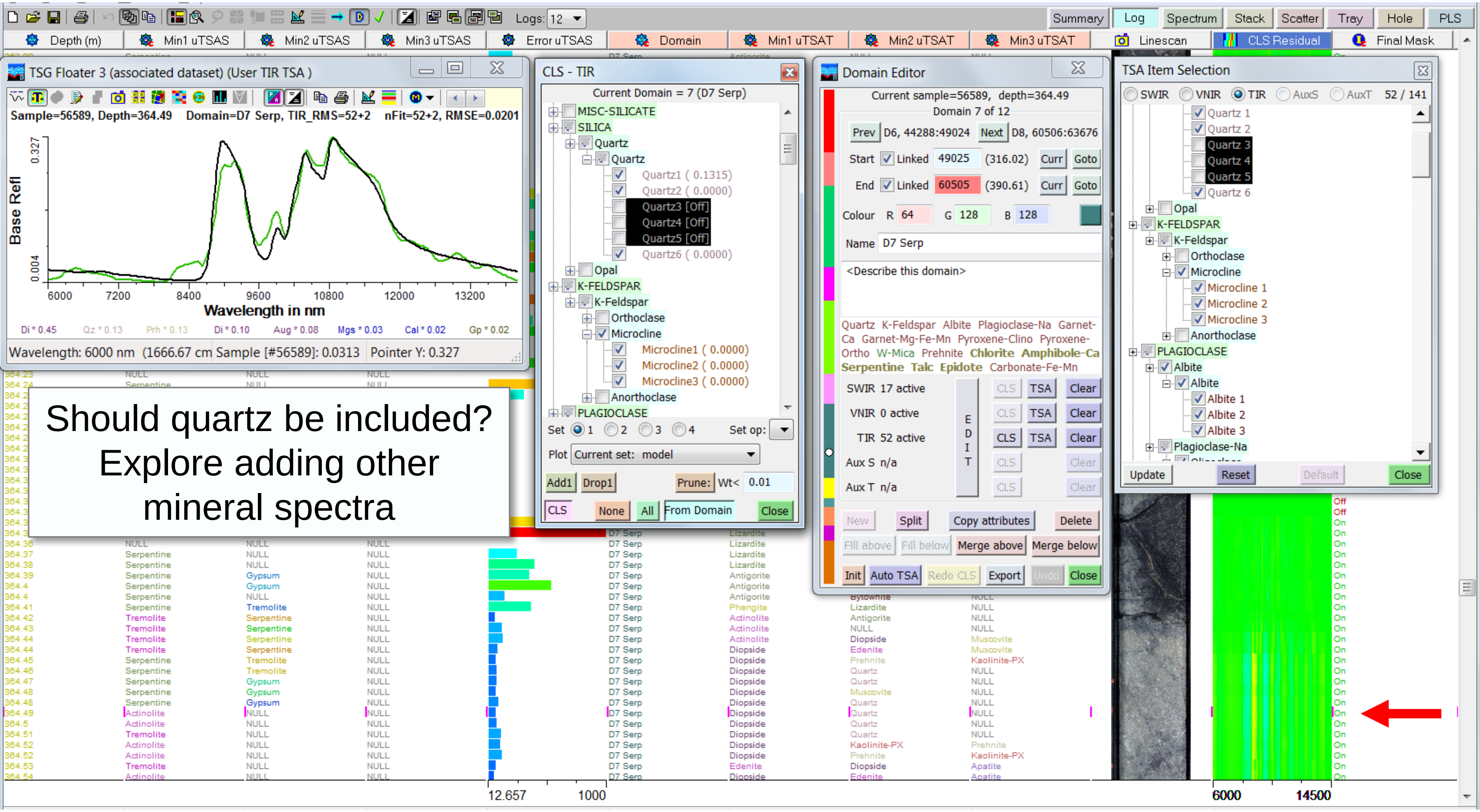
a. missed mineral spectra not allocated to a Domain
b. minerals not in the reference library
c. volume scattering effects, cracks and edges

Another way to view residuals is to plot the CLS Error scalar in a Scatter plot vs. depth & interrogate high values.

Use the “Go to” button and choose Index sample #56589

Using the *TIR Floater* in CLS mode & explain the high residuals there. The screen may look like the next page ….

Task 6e - CLS Residuals



Should quartz be included? Explore adding other mineral spectra

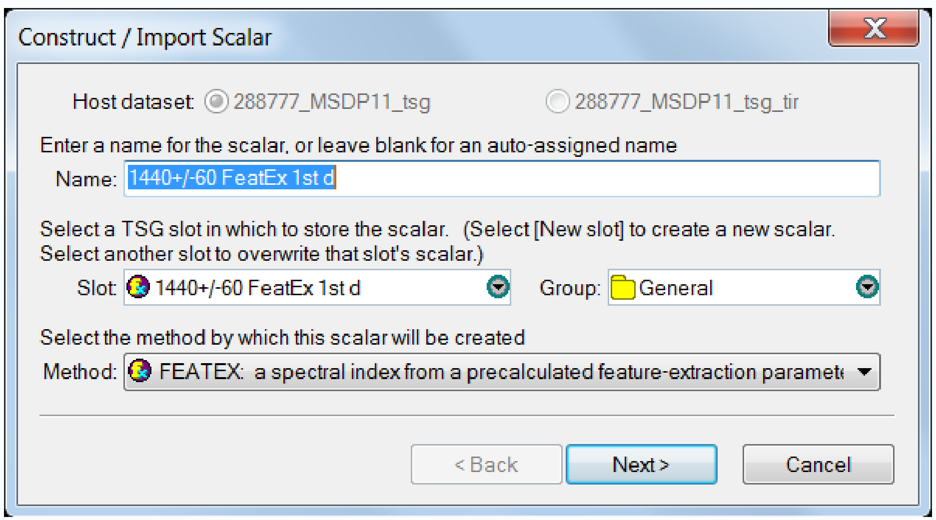
Discuss how to deal with this poorly fitting interval

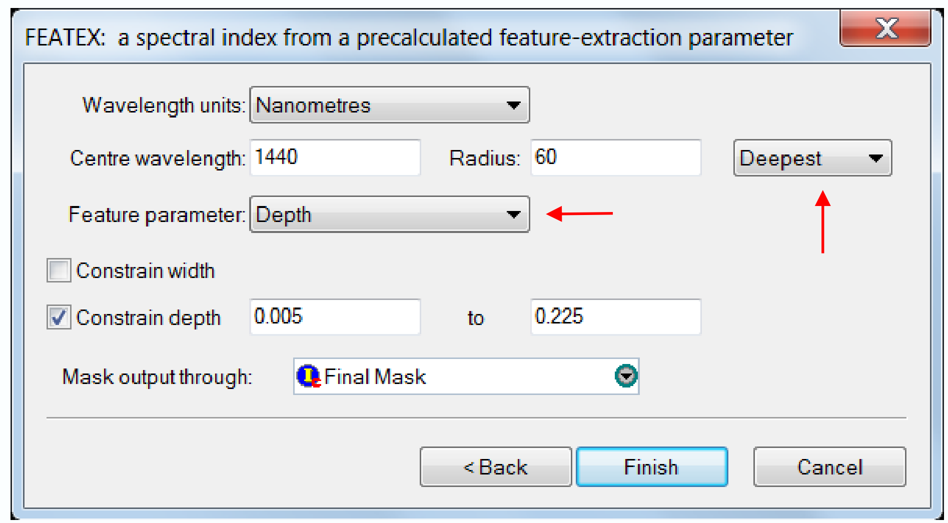
Task 7a – Building Simple Scalars

Indices of the depth & wavelength of absorption features provide a powerful characterisation of the data and can be used as proxies for abundance & composition respectively. They also help Domaining. TSG provides many ways of making scalars. FeatEx is one.

TSG keeps tables of all absorption Feature wavelengths in each spectrum. The FeatEx method allows us to extract & plot them.

1. Go ***Edit*** > *New scalar* > and copy these dialogues

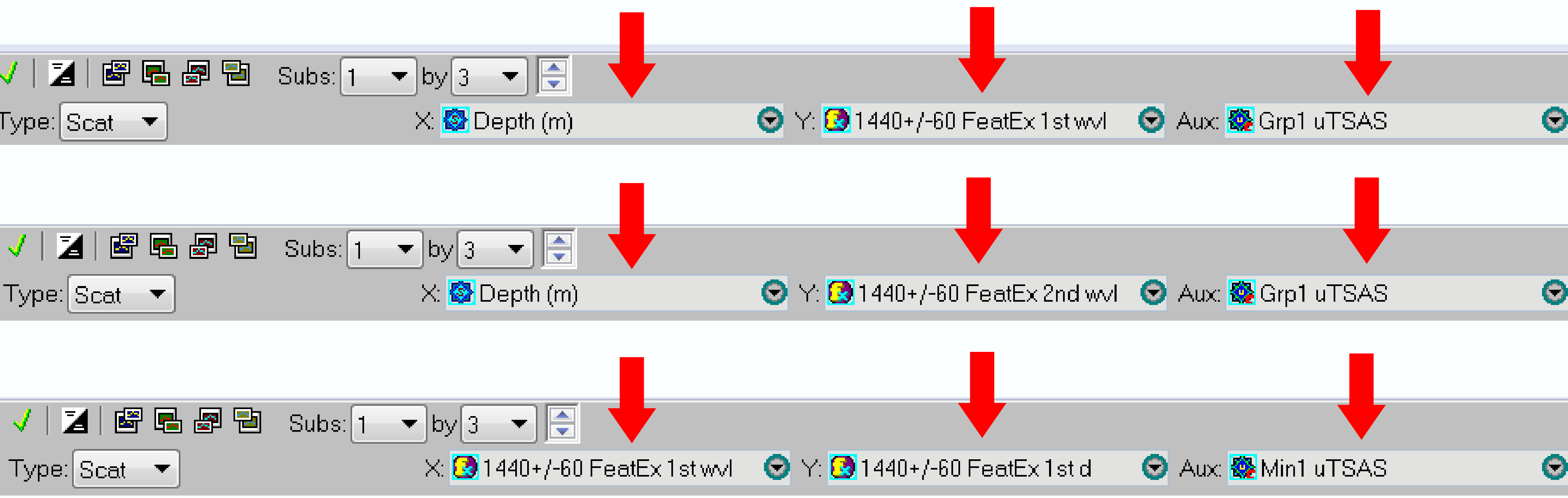




2. Repeat but calculate the Wavelength (wvl) as the Name, the Slot = New & Wavelength as the Feature parameter. Keep other parameters the same.
3. Duplicate 1st wvl, change Name & Slot & Second deepest in the 2nd dialogue box.

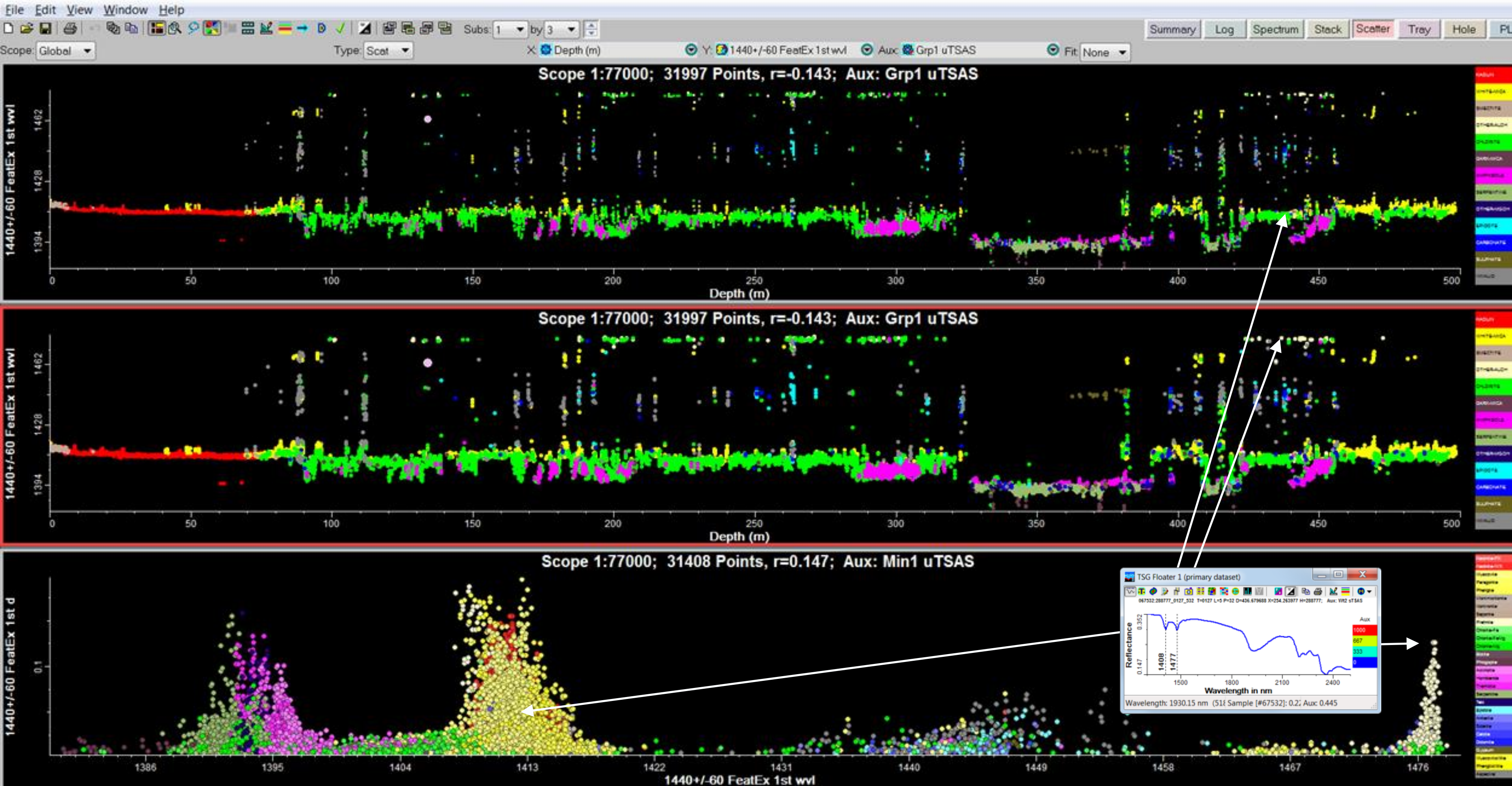
Task 7b – 1400 nm Feature Scalars

In the **Scatter** Screen now plot these three FeatEx scalars, as follows so as to produce three plots like the next page. .



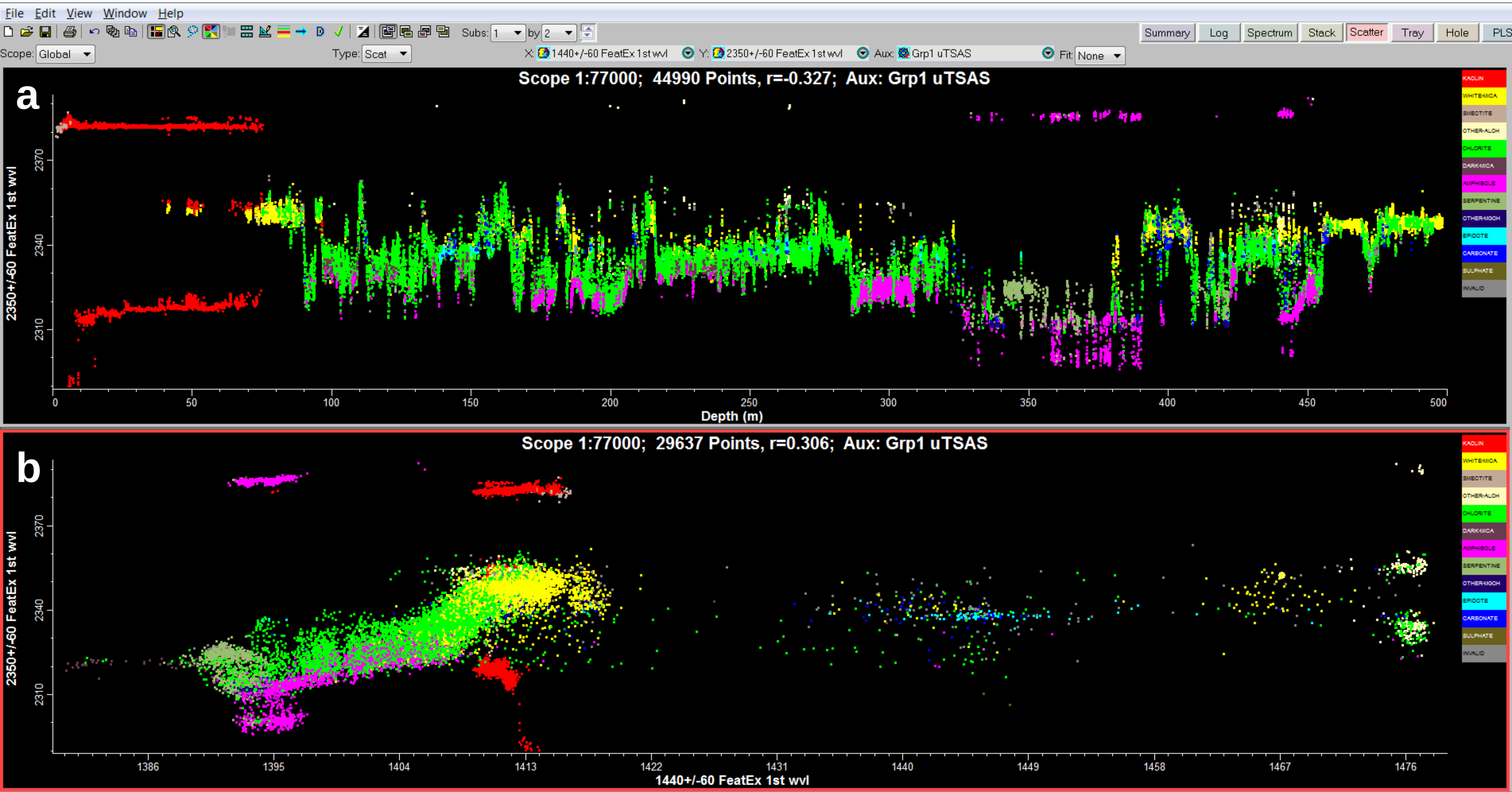
Task 7c – 1400 nm Feature Scalars

Note the patterns vs. depth & how different minerals & mineral <u>mixtures</u> appear at different wavelengths & depths in the hole. Use Floaters to check spectra & features. Do implied Domains match earlier ones?



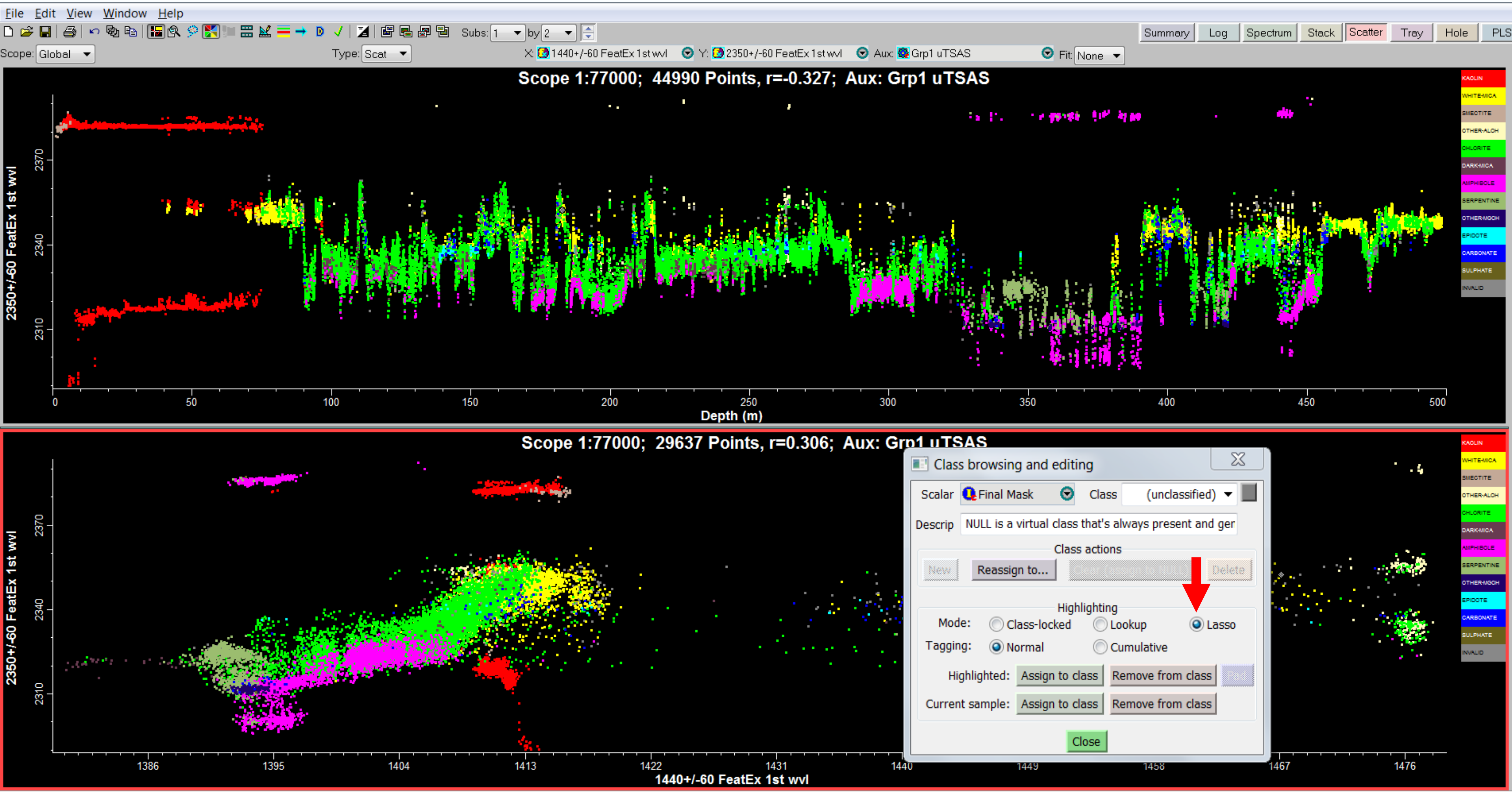
Task 7d – 2350 nm Feature Scalars

This idea can be repeated for the 2350nm region where mixtures make tracking overlapping wvls difficult. Make a 2350+/-60 FeatEx wvl scalar then plot a) vs. depth and b) vs. the earlier 1440+/-60 scalar.



Task 7e – 2350 nm Feature Scalars

Now right-click in bottom screen & use the "Class Browse Edit" tool with Lasso option active to highlight different clusters & note where they plot spatially. Are all the amphiboles (pink) the same? Note Domains. Do you need to add new ones?



Task 7f – Building Complex Scalars

Sometimes you need to map the characteristics of quite specific features in a spectrum and search for those throughout a whole drill hole. TSG provides the **Profile** and **Pfit** methods for this.

Here we use the **Pfit** method to map the relative abundance and composition from all spectra in the drill hole. We use a carefully constrained and thresholded polynomial fit to all spectra to very accurately extract depth and wavelength information.

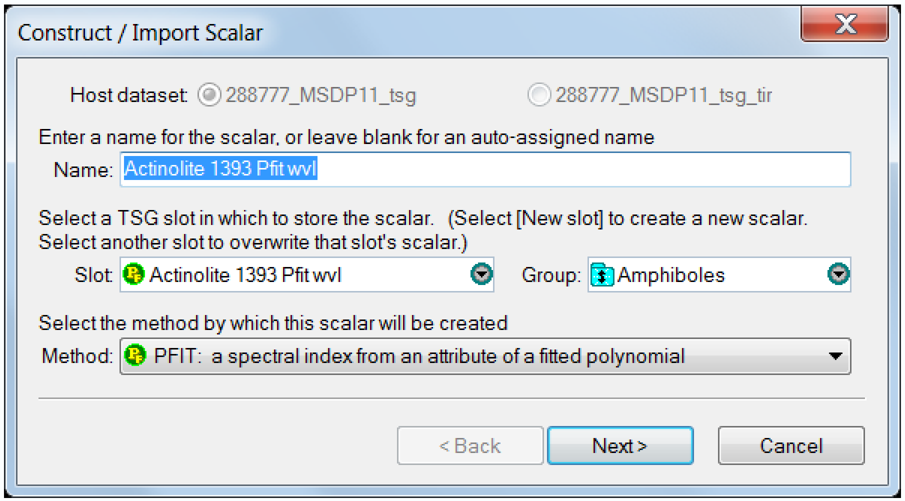
- The thresholds (blue arrow overleaf) are critical to this process and are ≡ to detection limits & thresholds in geochemistry.

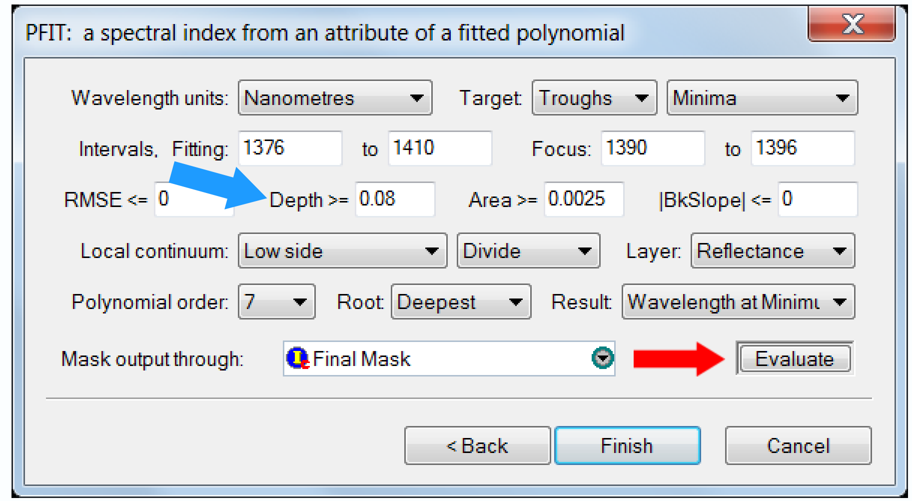
On the previous page we found variation in the Amphiboles. This example attacks the 1393nm absorption feature's characteristics by creating two related depth and wavelength scalars.

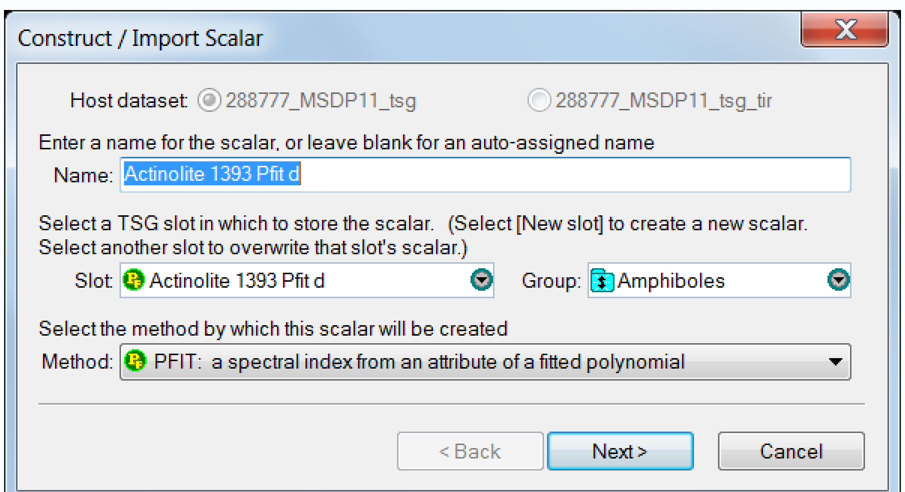
1. Go *Edit > New scalar > Method = Pfit*.
2. Give your scalars names and a folder location as per the following page.

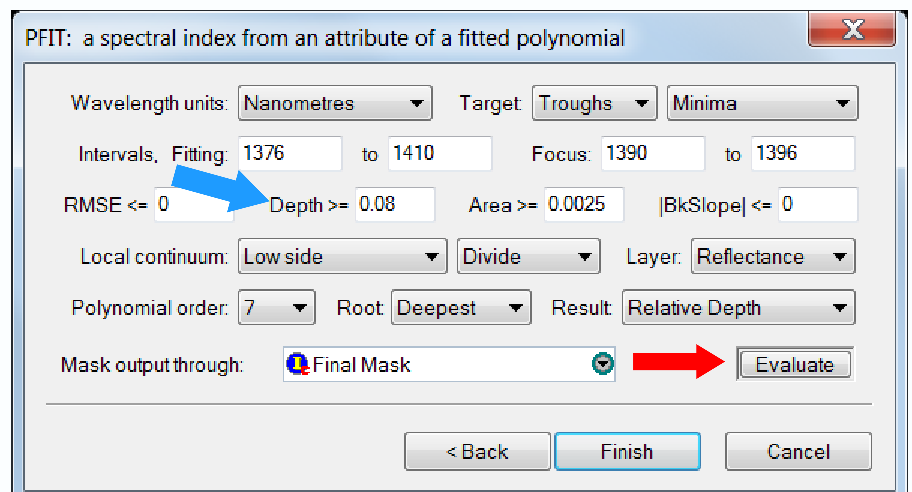
Task 7g – Polynomial Fitted Scalars

Create these scalars and then we can discuss the meaning of the various parameters and explore the evaluate button (arrowed).



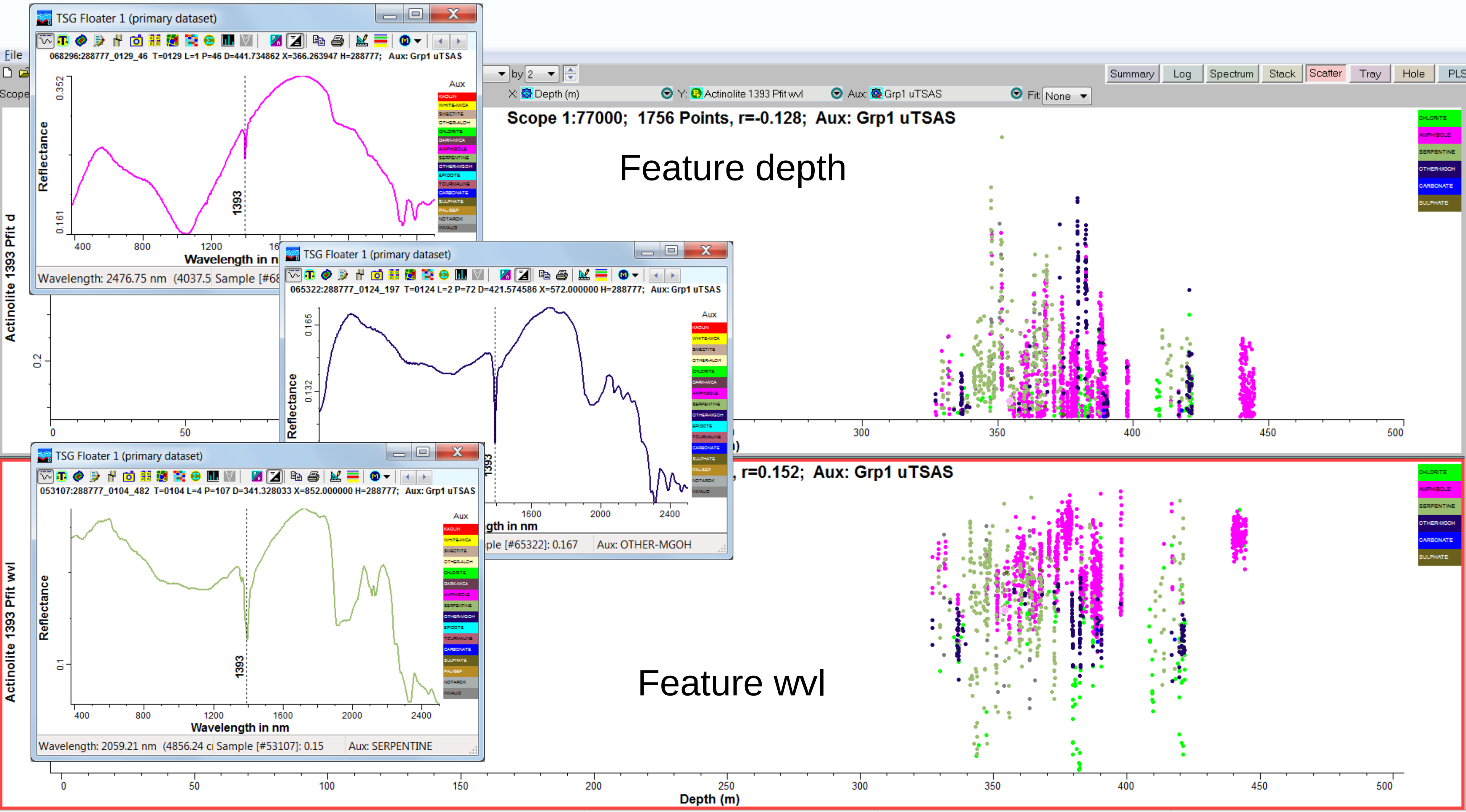






Task 7h – Polynomial Fitted Scalars

Your results should look like this in the *Scatter Screen*. From this you'll see that 3 minerals (actinolite, talc, serpentine) with very sharp 1393 features have been mapped, but with slightly different characteristics, occurring within the 1 Domain.

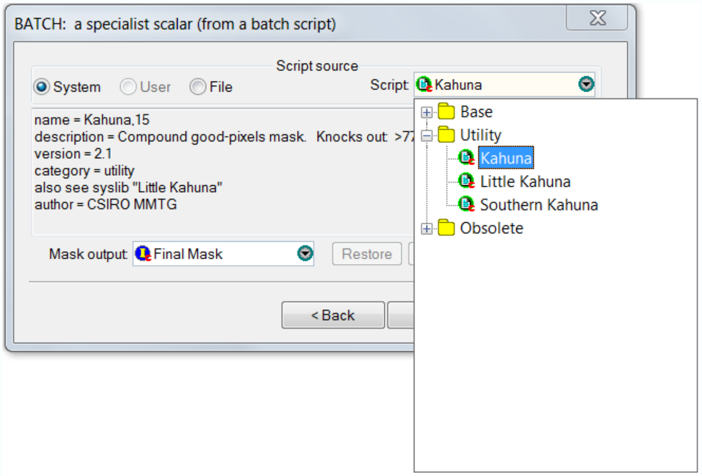


TSG's Built-in Scalar Scripts - 1

TSG provides several suites of built-in and attachable scalar-creation scripts.

- *Go Edit > New > Method = Batch.*

From here you can select the top right-hand drop-down of options of System provided scripts …



…. or load scripts from an external file source. TSG provides several with each installation. We will handout some thermal IR examples.

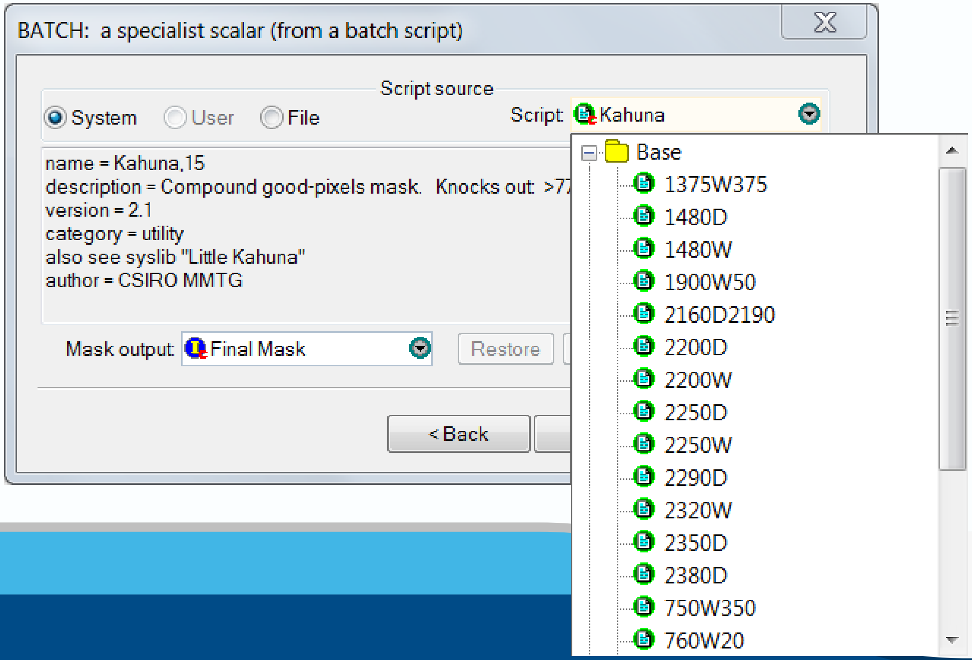
TSG's Built-in Scalar Scripts - 2

Built-in scripts in TSG8 have changed since earlier versions.

So called "Base" script names (below) are brief with names that use a convention of D for feature depth (often a proxy for abundance) and W for wavelength (often a proxy for composition) preceded by a wavelength in nanometres.

Once selected an info' box links to a table of use explanations while selecting the *Edit* button brings up the Script's text which can be viewed or edited.

Note most of these scripts have no thresholds set & may thus include garbage. This can be changed if the minval = 0 is present.



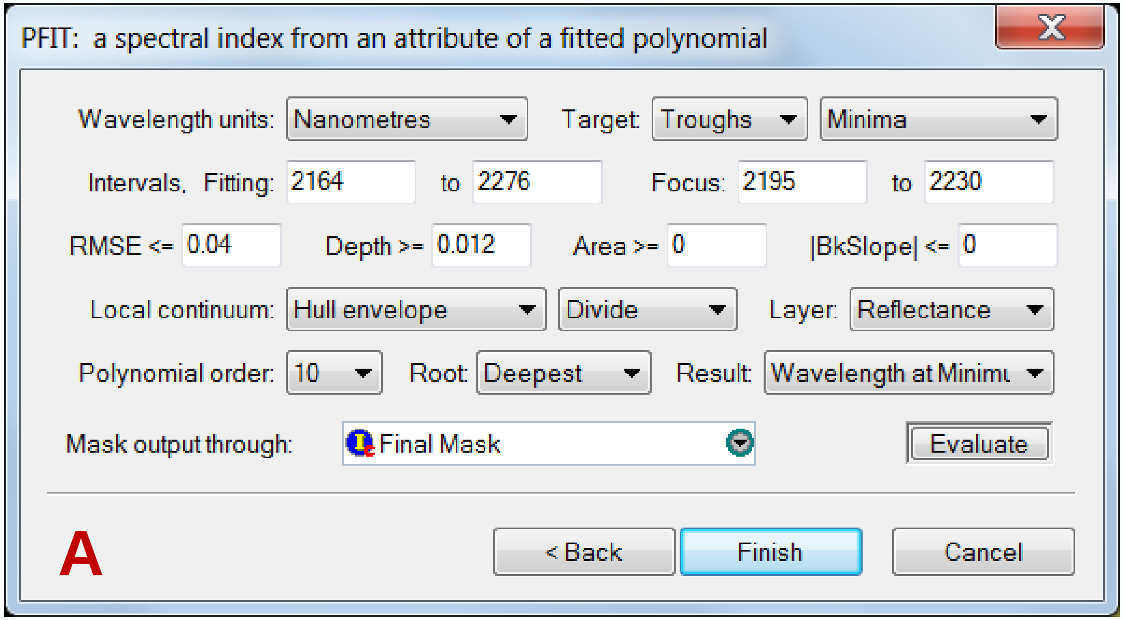
Task 7i – W-Mica + Chl/Epi/Biot Scalars

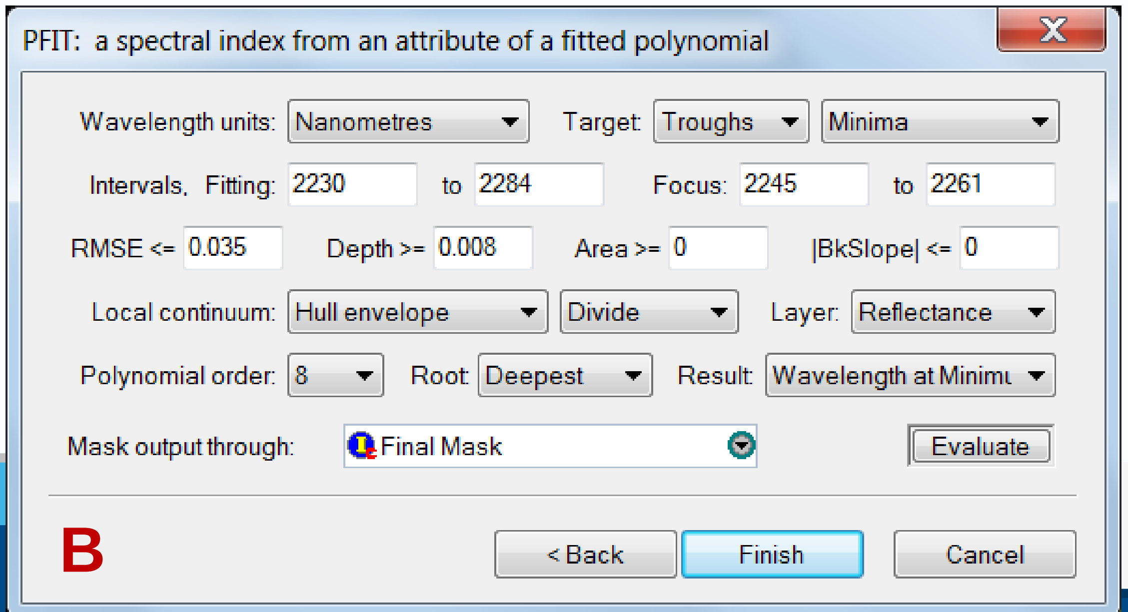
Some of the most frequently valuable scalars are those to track the abundance and composition of any white micas or chlorite / epidote / biotite minerals present.

Giving each new scalar an appropriate name try these,

A) for W-mica/Smectite

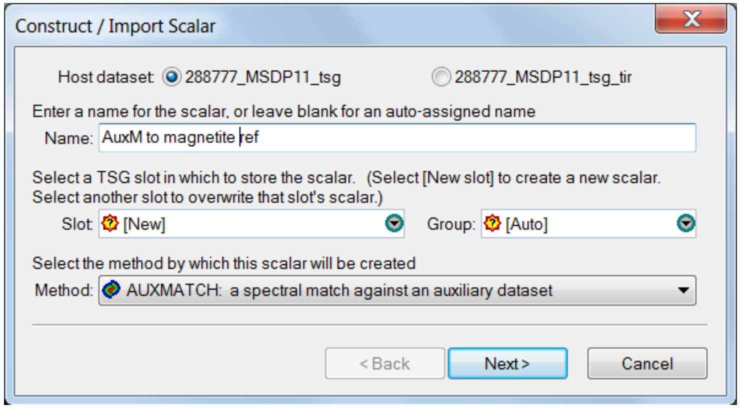
B) for Chl/Epi/Biot

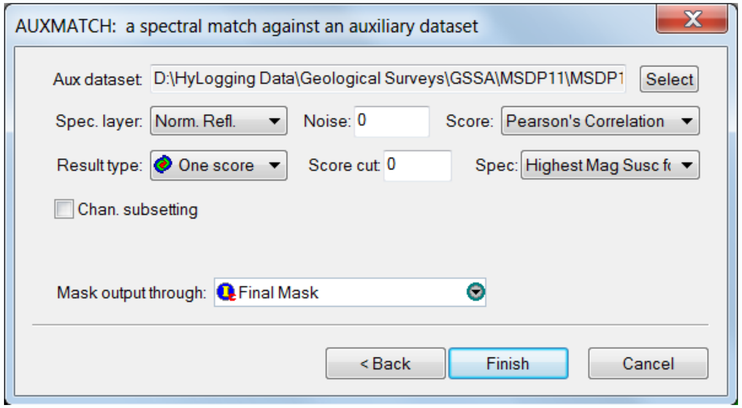




Task 7j – Using AuxMatch

1. Does magnetite have a spectral signature at any wavelength in our datasets?
2. Use the provided AuxM reference spectrum to search for magnetite, just in case
3. Compute a fit to this reference with the AuxM scalar method using the dialogues opposed
4. Plot the scalar in a *Scatter Screen* sub-screen using the Scat mode & colour it by the same scalar. AuXM scalars will be found in the "*Assemblages & AuxMatch*" folder
5. The initial AuxM scalar has a score cut-off = 0. Modify this scalar to place a cut-off at a more valuable threshold such as ?
6. Discuss options & results.

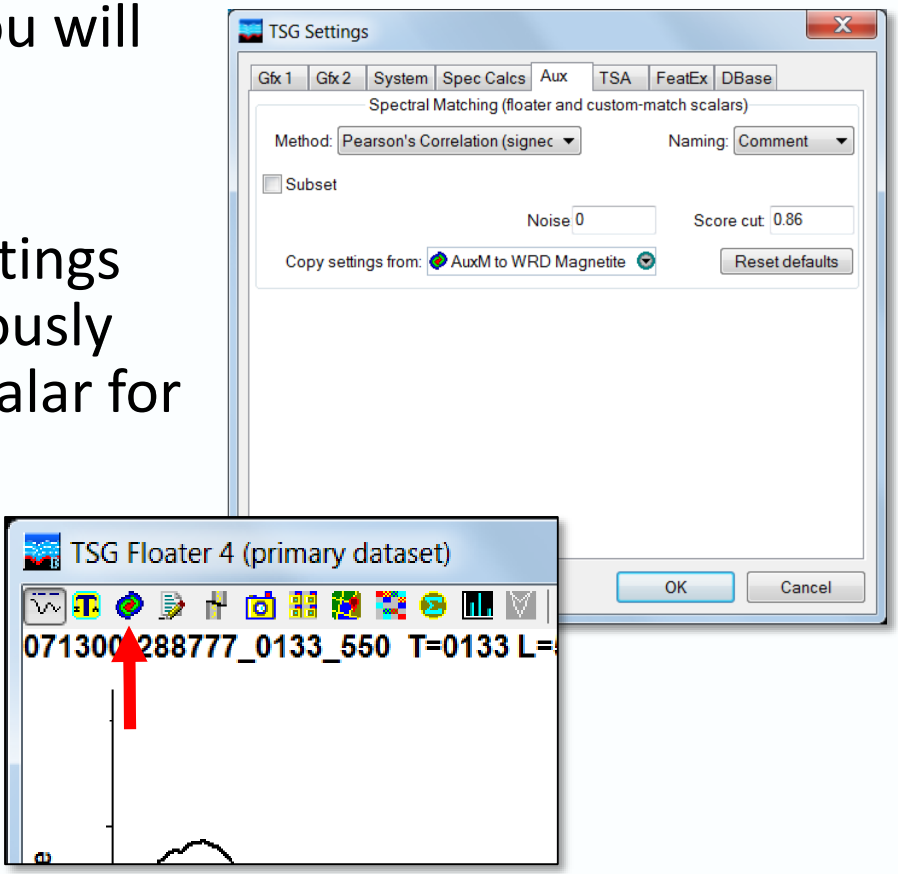




Task 7k – Attaching Aux Files

We can attach Aux spectra of any TSG compatible files for reference & visualization purposes. Here's how …..

1. On the ***Spectrum Screen*** go *File > Attach Aux* and then, for example, select the "Highest Mag Susc …" file from your disk.
2. Then go File > Settings > Aux. You will be presented with the dialogue opposite. We'll discuss this.
3. Note it is important that the settings in here match those used previously or subsequently in any AuxM scalar for consistent results. We'll discuss
4. AuxM results can be viewed in *Floaters* or the *Spectrum Screen* by selecting Aux or the Aux symbol (red arrow).



Task 8a – Thermal Infrared Scalars

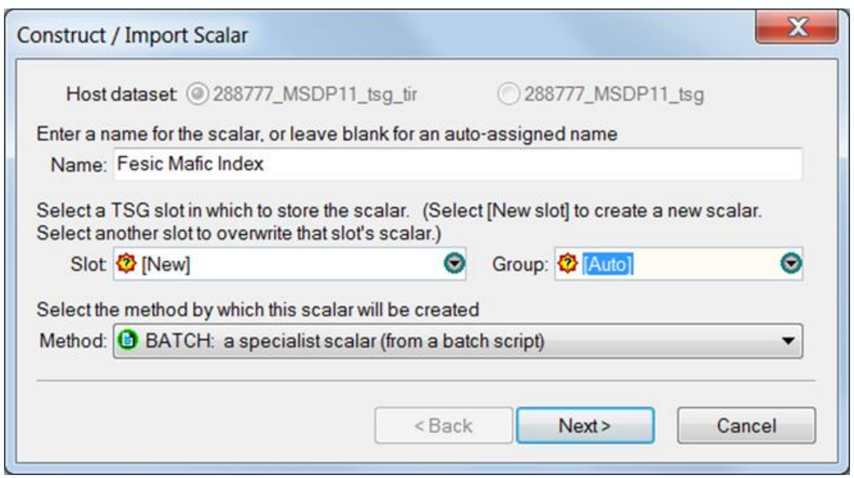
Because the TIR involves many more minerals and mixtures it is less easy to devise scalars to parameterise individual absorptions. However a few generic scalars will be found to be very valuable. Your tasks are:

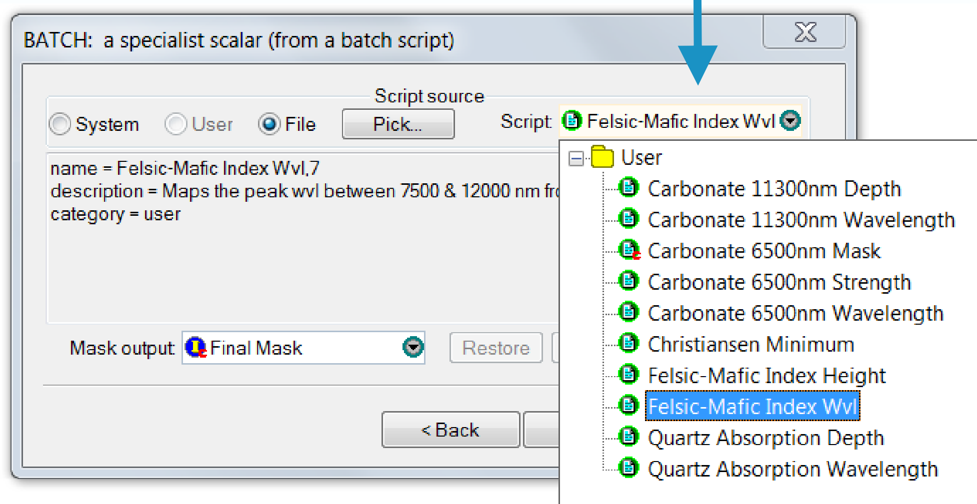
1. Find the built-in TIR batch scripts.
2. Calculate TIR Felsic-Mafic Index (FMI) & review purpose & value.
3. Display TIROffset & with imagery explain what it maps.
4. Calculate the four carbonate scalars and the two silica Scripts provided in the Batch Scripts. Results will be placed in their respective mineral folders.

Task 8b – Thermal Infrared Scalars

A suite of thermal infrared scalars were developed by Martin Schodlok and Jon Huntington in ~2011. Updated these are now provided as built-in User Batch Scripts for routine use in TSG8. See memory sticks

1. Open the MSDP11 TIR dataset
2. Go Edit > New Scalar > Batch > Next > File > Pick > *Sub-Directory*
3. Then pick the "FMI" or other script from the drop-down list.

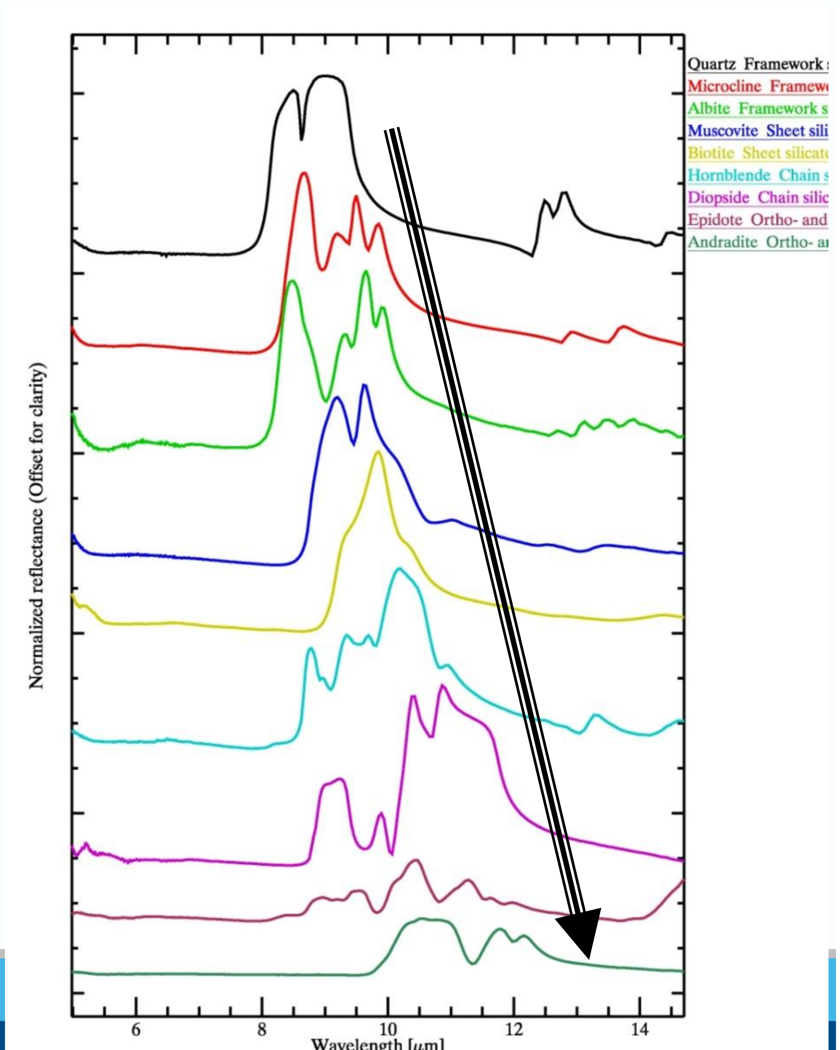




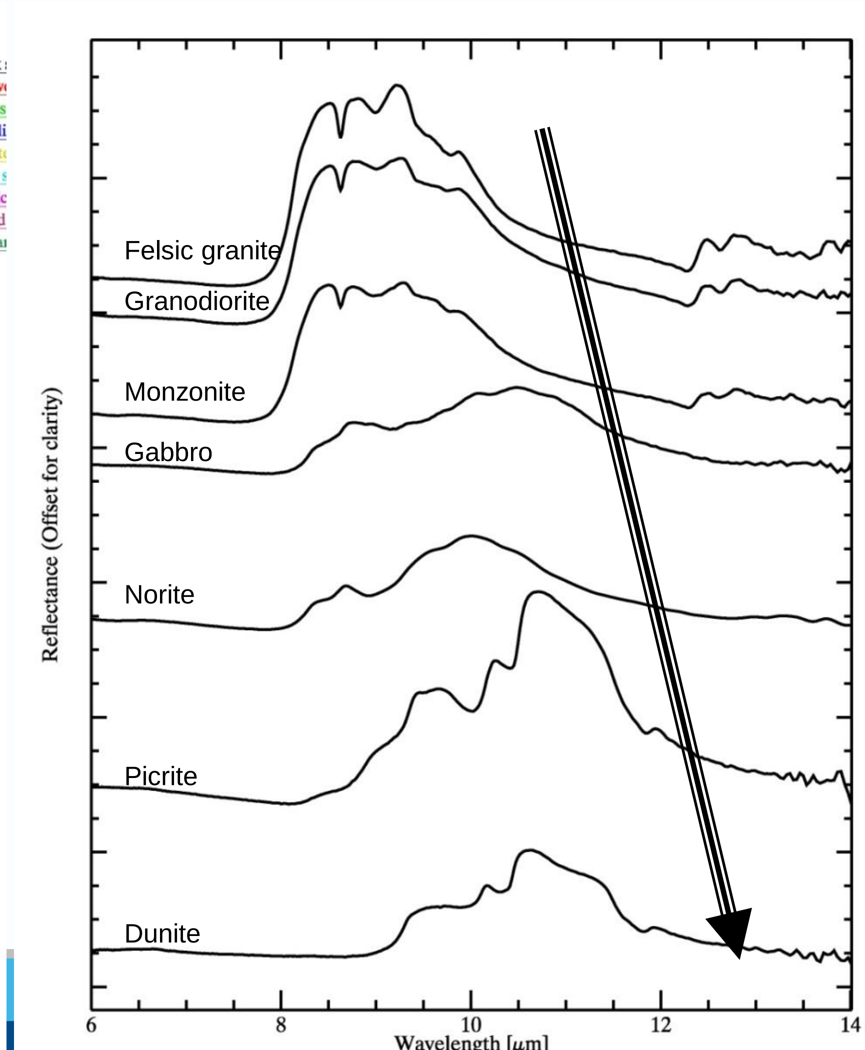
Task 8c - The FMI Rationale - Recap

(Traditionally only applied to igneous rocks but works well on many other rock types and minerals)

Minerals



Rocks

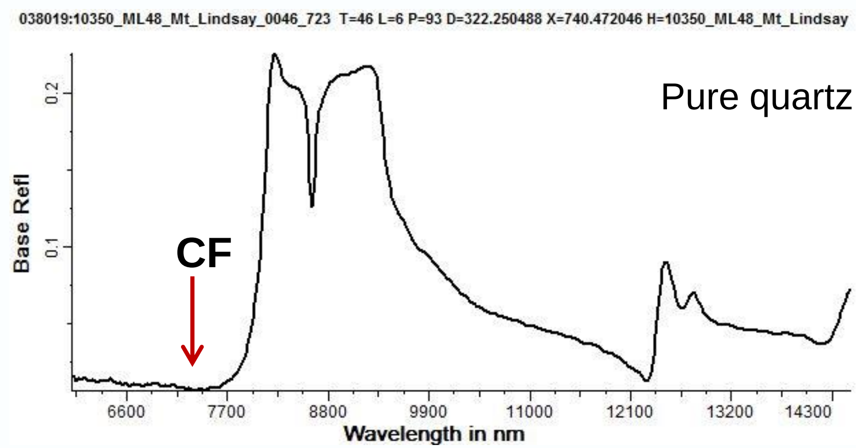


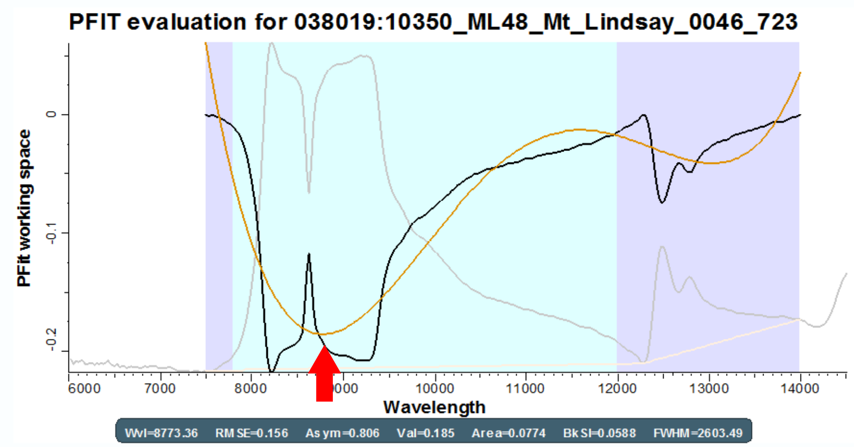
Task 8d - The Felsic Mafic Index (FMI) recap

The FMI (an empirical alternative to the published "Christiansen Frequency[1]") tracks not the CF minimum wvl but the wvl of the overall peak reflectance curve between 7,800 & 12,000 nm computed with a 4th order polynomial (bottom right). Such an Index is very useful for differentiating dominantly Felsic vs. Mafic vs. Ultramafic lithologies.

Additionally we mask out any carbonate bearing samples using their reflectance peak at 6500 nm as carbonates have less bearing on the felsic / mafic nature of a lithology and also distort the computation of the true felsic / mafic mineralogy.

[1] Logan, Hunt, Salisbury & Balsamo, JGR Vol.78, No.23, 1973, Compositional Implications of Christiansen Frequency Maximums for Infrared Remote Sensing Applications.

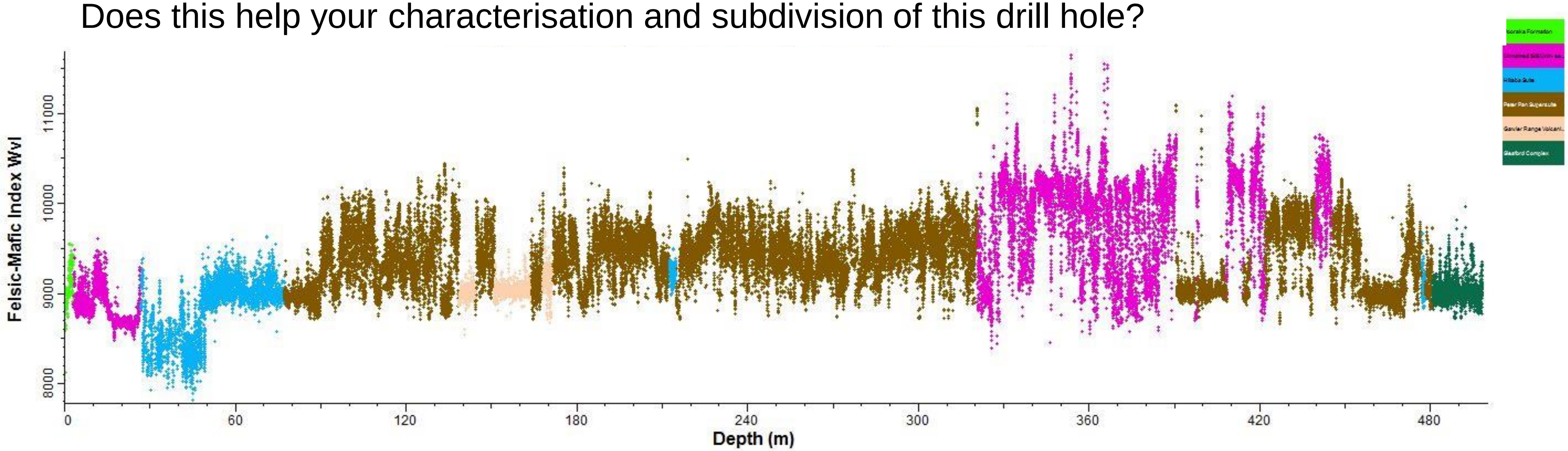


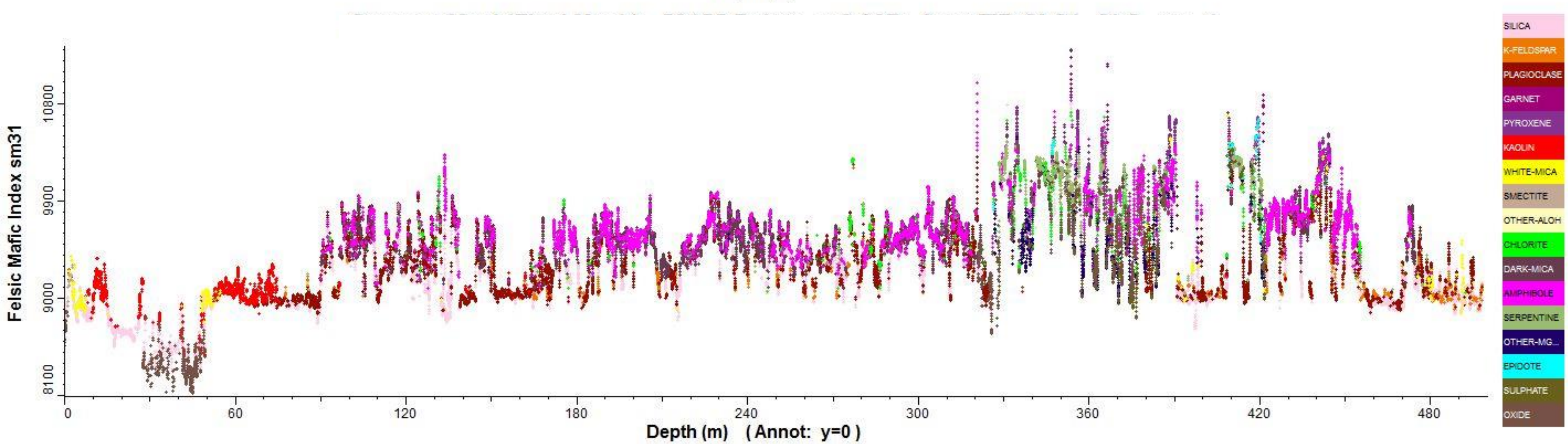


The modelling shown involves inverting the spectrum (black) and fitting the low order polynomial (orange) to determine the curve's inverted peak wvl. This wvl is then reported & plotted.

Task 8d - MSDP11 Felsic Mafic Index

Your FMI pattern should look like this below. The top plot is coloured by mapped "Strat_ Name") and the bottom smoothed version by the dominant CLS TIR mineralogy. Note all the correlations & possible disagreements where new units / Domains may be required. Does this help your characterisation and subdivision of this drill hole?

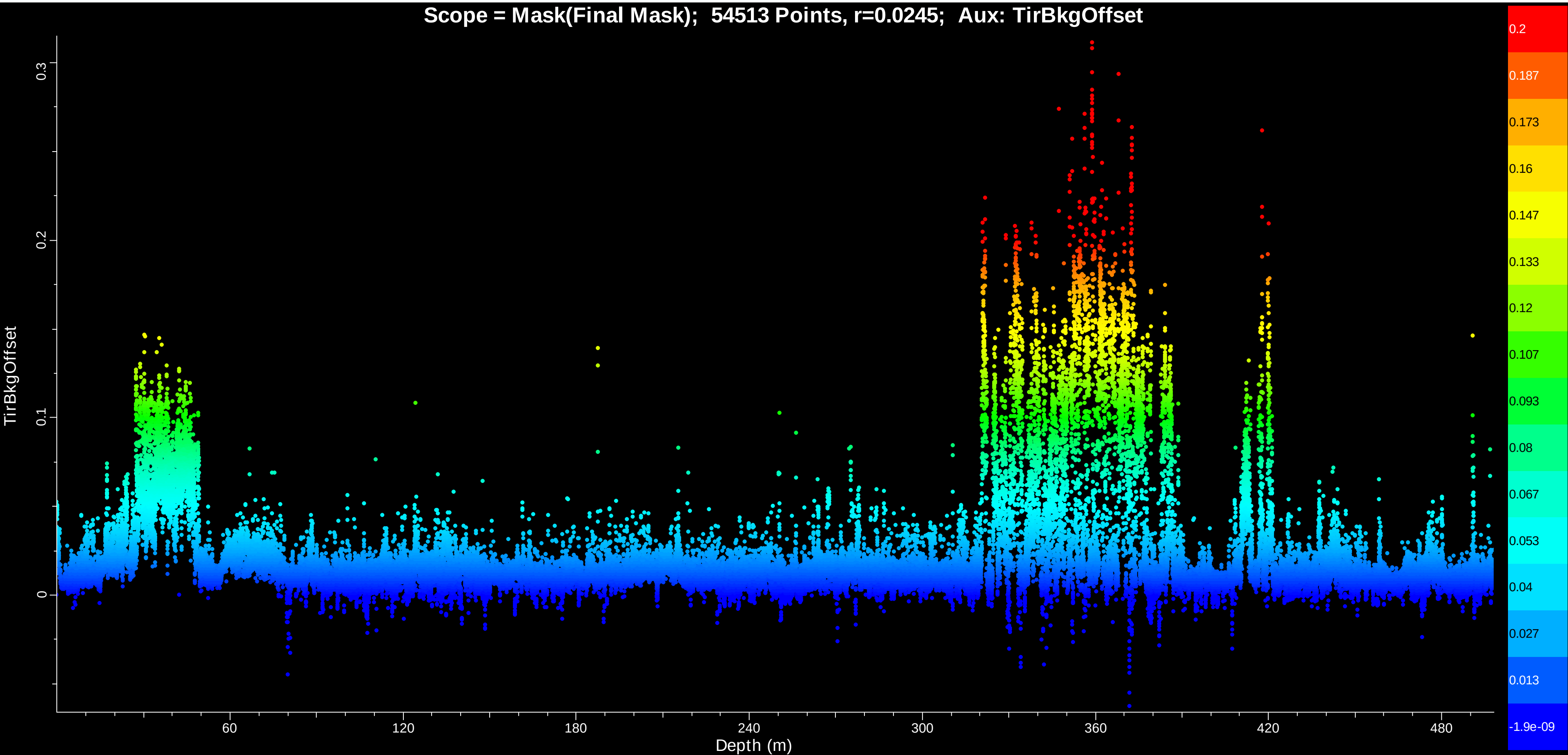




What does the TIRBkgOffset Scalar Tell You?

In the TIR dataset's HyLogging folder is a system scalar called TIRBkgOffset. It is one of several background terms used in the modelling of mineral spectra.

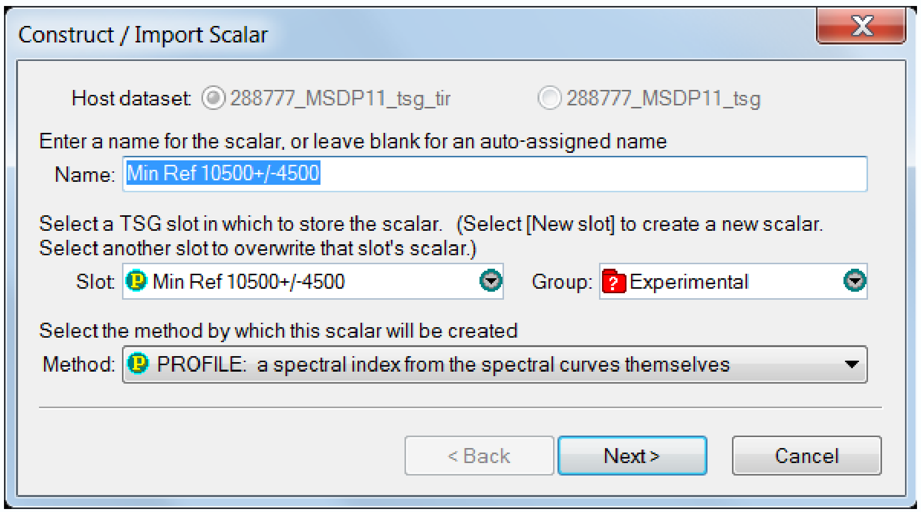
- Display it and with the imagery in a *Floater* examine what it is telling you and why? Use *Scope = Mask*. Let's discuss.

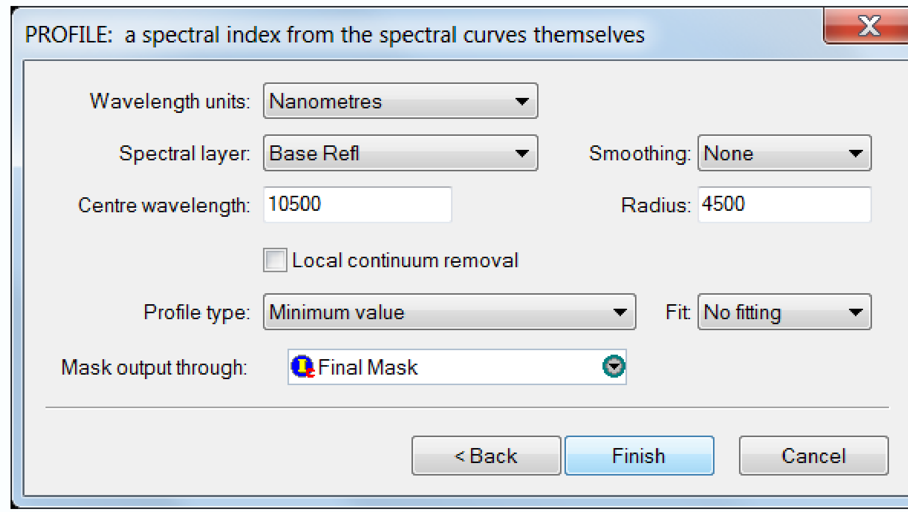


What does the TIRBkgOffset Scalar Tell You?

You can compute your own better equivalent of the TIRBkgOffset with this scalar below. Try it, display it and examine its value in the overall characterisation of the drill hole. Are there geological and non-geological things that influence this scalar?

- Go *Edit* > *New Scalar* > Choose TIR dataset > copy dialogues below



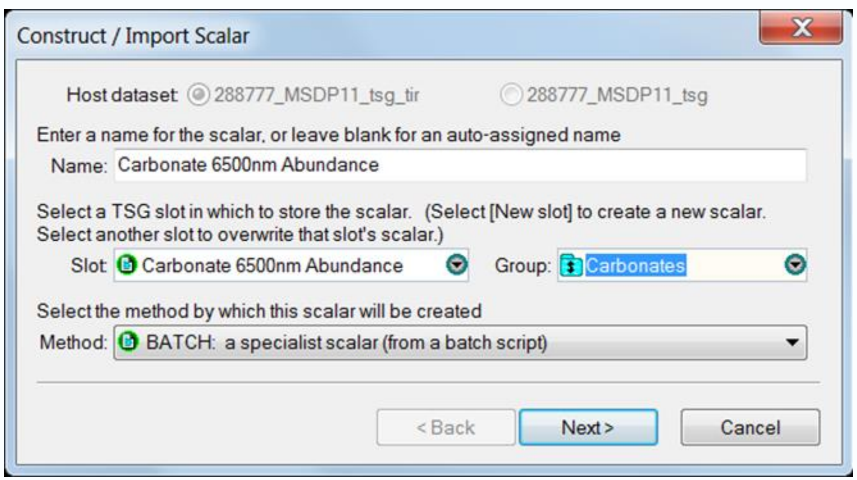


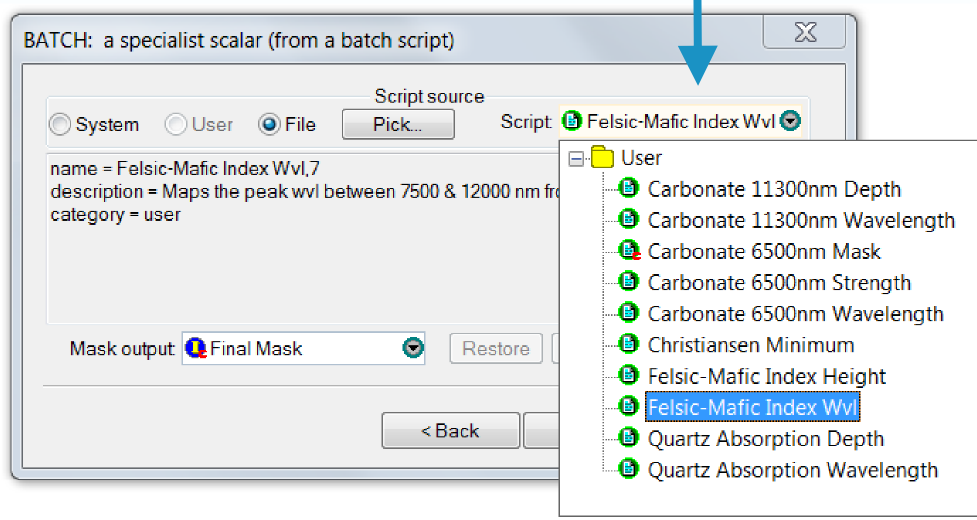
- Add to your drill hole report if you think it's useful and briefly explain why

Task 8e – TIR Carbonate Scalars

Generally the TIR is better at mapping Carbonates than the SWIR due to less overlap of features. Using the provided Batch Scripts on the memory sticks create the five Carbonate scalars (below) then display them in the Scatter Screen

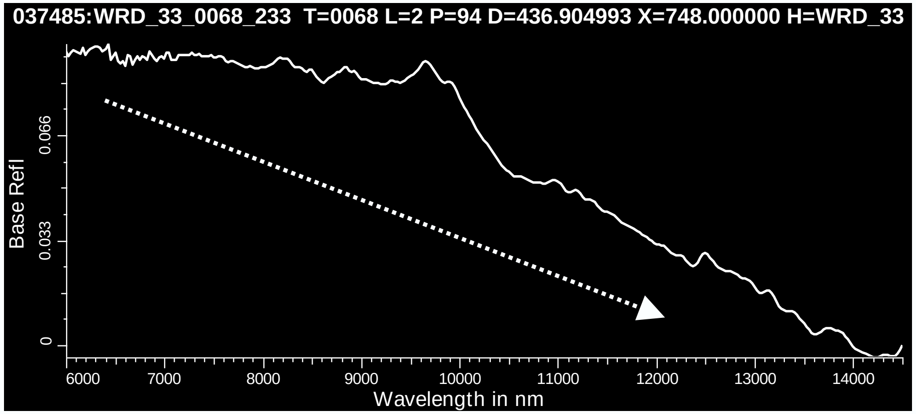
1. Open the MSDP11 TIR dataset
2. Go *Edit > New Scalar > Batch > Next > File > Pick > Sub-Directory*
3. Then pick each of the CO_3 scripts in turn and run them
4. Let's discuss the results.

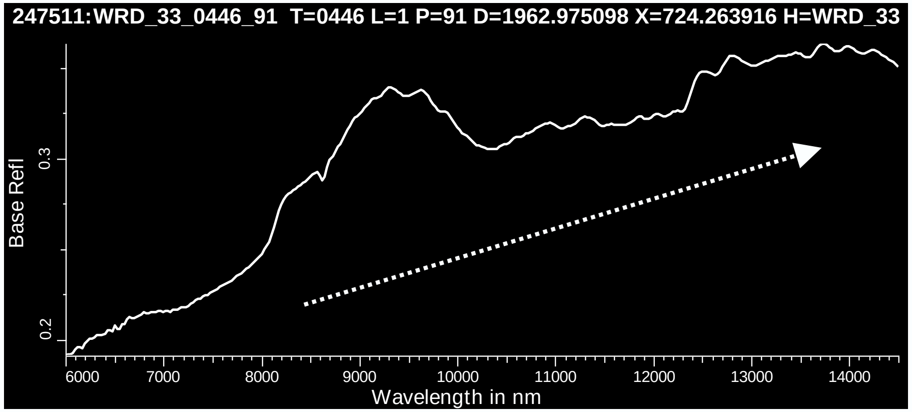




Task 8f – TIR Magnetite Scalar

TIR reference spectra of several oxides (e.g. hematite, limenite, magnetite) show very modest amplitude features, however they do exhibit consistence slopes: hematite a negative slope, magnetite a positive slope.





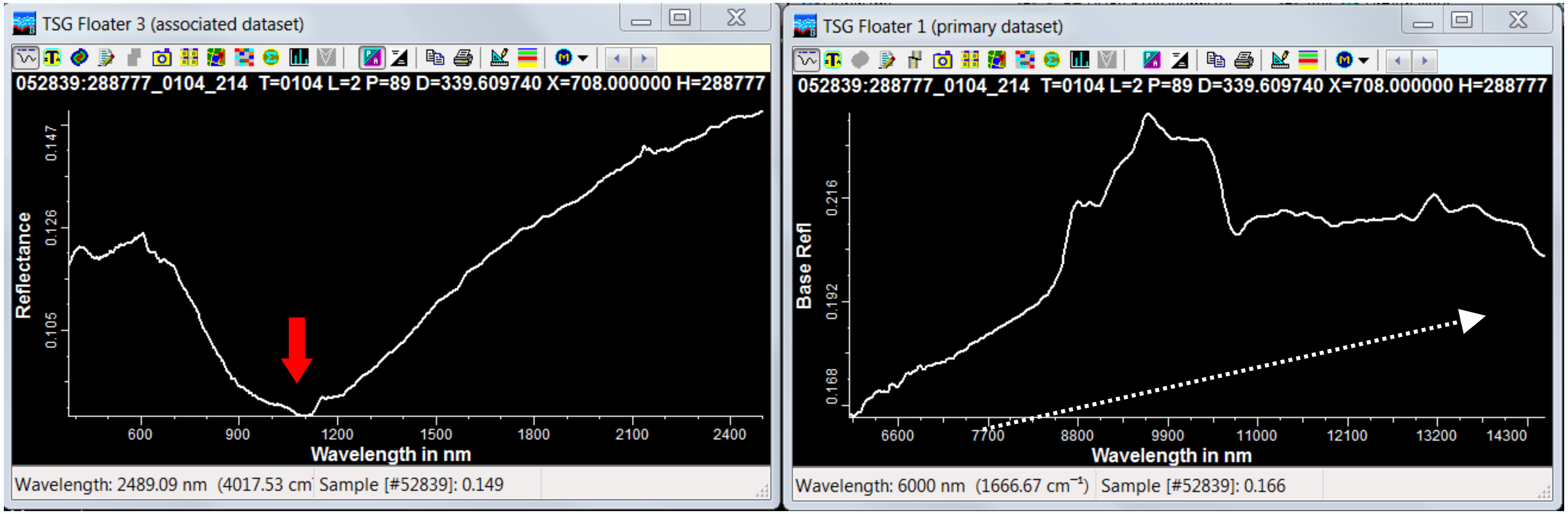
We can take advantage of this in TSG and compute a slope scalar that will illustrate this. See next page.

Caution: Non-ambient temperature effects can also impose slopes.

Task 8g – TIR Magnetite Scalar

- Using two input scalars and the arithmetic method compute 14250 NormRef minus 6100 NormRef. Interrogate the resulting plot with TIR & SWIR Floaters and an image. Is the magnetite obvious?

TIR magnetite spectra with the strong positive slopes commonly pair with the SWIR magnetite spectral shapes discussed previously (see below left). The scalar above when computed for MSDP11 or WRD33 will enhance many magnetite bearing samples / intervals.



Task 9 – Comparing uTSA, CLST and Scalars to help build your report

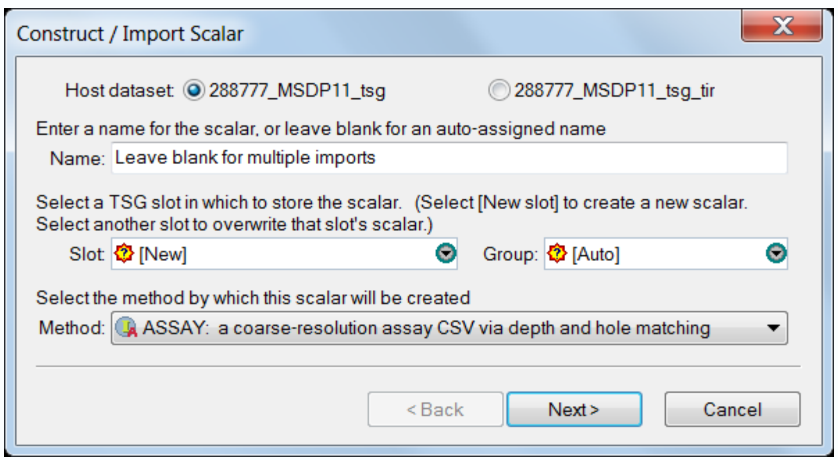
1. Set up the *Summary Screen* to show uTSAS and uTSAT results and compare.
2. Set up the *Summary Screen* to show uTSAT and CLST results and compare.
3. Can you build in series of *Scatter Screens* that best show the dominant SWIR and TIR minerals, the best scalars and the Domains as a summary of everything you've learnt.
4. Cut and Paste the best of these into your Word or PowerPoint Report.
5. Feel free to write a few words as to your conclusions.

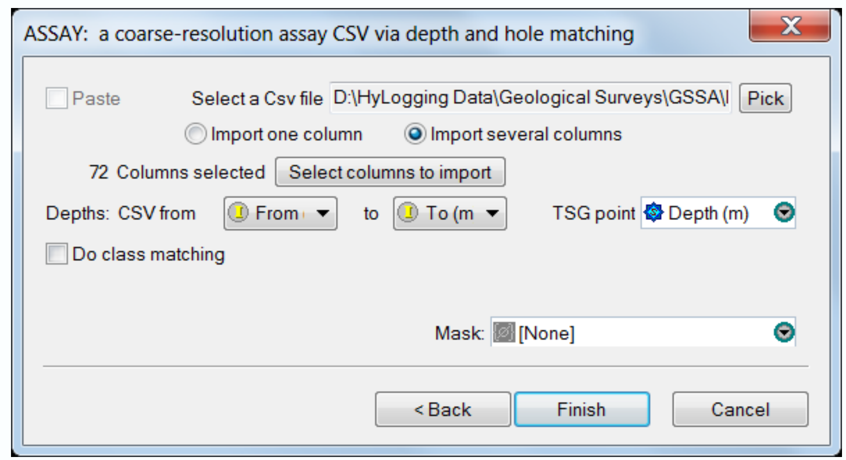
Task 10 – Importing External Data

Find the Geological Logs and Assays provided. It does not matter that the incoming data is on a different sampling interval to the HyLogging data. The incoming data will be resampled to match.

1. Go *Edit > New Scalar > Method = Assay*...... > Next
2. Import from a file source or from the clipboard.

Note this type of input requires a "From depth" and a "To depth"

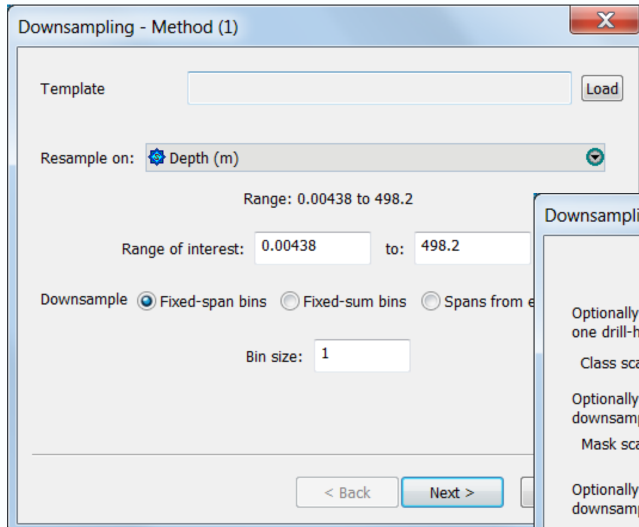


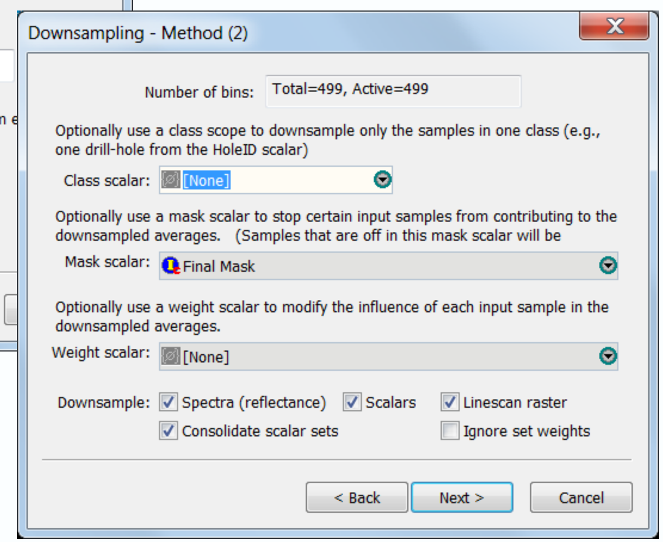


3. Consider how you will display some of this data in the *Scatter Screen* to match some spectral results, e.g. Depth vs. Assay in Scat or Hist mode along with some spectral results?

Task 11 – Exporting TSG Data

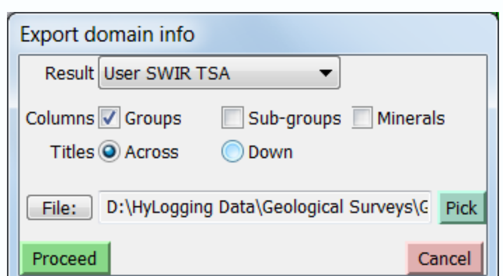
Your can export graphics from most screens. Your can also export data in csv format for many screens. The main place to export data for other packages is via the *File > Export* options. Results data can concatenated into larger intervals (Downsampled) to new intervals. Downsampling can be done in many ways including by sample number or depth.





1. Choose *File > Export > Downsample* and explore the options.

2. You should also export your Domain Summaries from the Domain Editor for import into Excel.



Task 12 – Create a Report of Your Logs in Word or PowerPoint

Task 13 – Accessing publically available datasets

GS SA HyLogging web site: https://sarig.pir.sa.gov.au/

AuScope Website: http://www.auscope.org.au/

AuScope Portal: http://portal.auscope.org/portal/gmap.html

Corstruth – Over 2,300 drill hole plots, Google Map interface + analytics

http://www.corstruth.com.au

NVCL web page: http://www.auscope.org.au/site/nvcl.php

AUSGIN from GA: http://portal.geoscience.gov.au/gmap.html

Corescan HyLogging : http://www.corescan.com.au/news/corescan-and-csiro-sign-a-technology-alliance-for-the-future-development-of-hylogger-and-tsg

Acknowledgements

I acknowledge the many people who have contributed to the development of the TSG package, particularly Peter Mason, Mark Berman and Andy Green.

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Feedback and questions to:

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