CROSSPLOTTING 2 ATTRIBUTES AGAINST A 2D COLORBAR – PROGRAM crossplot

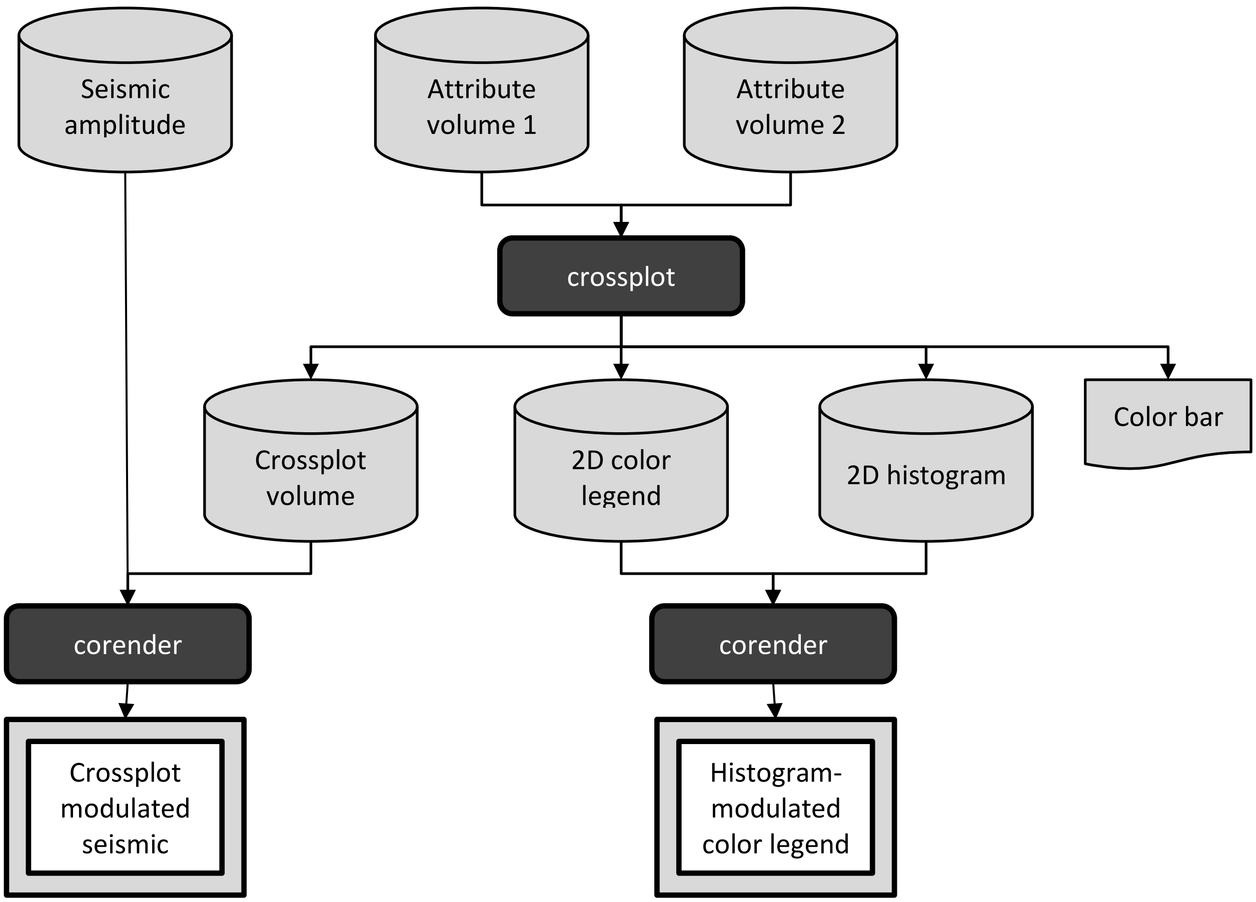
Contents

Overview

Whether using well logs or seismic attributes, crossplotting two data types (logs or volumes) against each other is one of the most important tools in quantitative data analysis. In many situations, the most important output is the output histogram, which is perhaps more accurately described as a probability density function. If such a display is the interpretation objective, one can plot a third data type against the color, resulting in say, a pdf of P-impedance vs. v_P/v_S ratio plotted against the x and y axes, and the porosity plotted against the color axis. AASPI provides some of these tools under the *Machine Learning Toolbox > Analyze Input > Attributes* tab. In this document, we show a different analysis workflow commonly used to crossplot input data volumes, where the 2D histogram is projected onto a 2D color legend, and that color legend use to encode a 3D output volume that has the same size as the two input attribute volumes. Program **crossplot** is closely related to multiattribute compositing and visualization programs **hlplot**, **hsplo**t, **hlsplot**, and **rgb_cmy_plot**, where two or three attributes are plotted against HLS, RGB, or CMY color axes.

Computation Flow Chart

Program **crossplot** reads in two attribute volumes or two projection or classification component data volumes and generates a 2D histogram, 2D color legend, and color-encoded crossplot data volume. The python script will also corender the 2D histogram and 2D color legend to represent the location of the more important colors in the crossplot volume. Outside the python script, the color-encoded data volume can be corendered with the original seismic amplitude data.



Output file naming convention

Program **crossplot** will always generate the following output files:

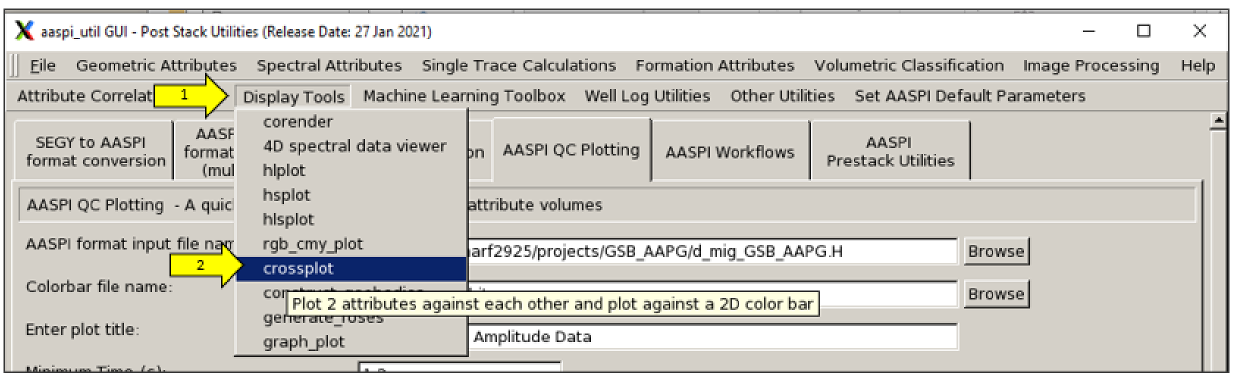
Output file description	File name syntax
crossplotted volume	crossplot_*unique_project_name*_*suffix*.H

2D color legend	color_legend_*unique_project_name_suffix*.H
2D histogram	histogram_*unique_project_name_suffix*.H
program log information	crossplot_*unique_project_name_suffix*.log
program error/completion information	crossplot_*unique_project_name_suffix*.err

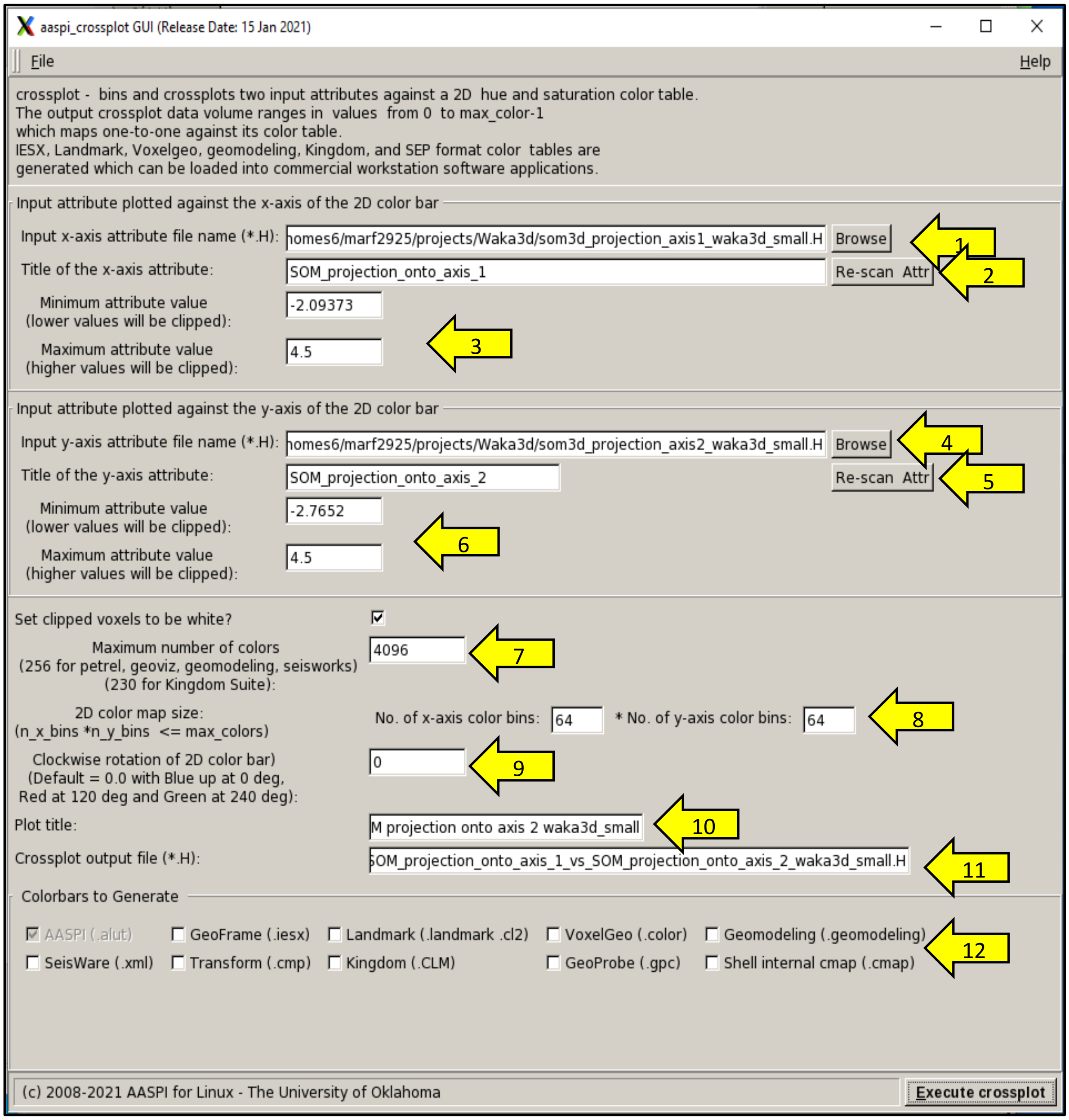
where the values in red are defined by the program GUI. The errors we anticipated will be written to the **.err* file and be displayed in a pop-up window upon program termination. These errors, much of the input information, a description of intermediate variables, and any software trace-back errors will be contained in the **.log* file.

Invoking the crossplot GUI

To initiate **crossplot** return to the **aaspi_util** window click (1) *Display tools* then scroll down to (2) *crossplot*:



The **crossplot** window shown below will appear:



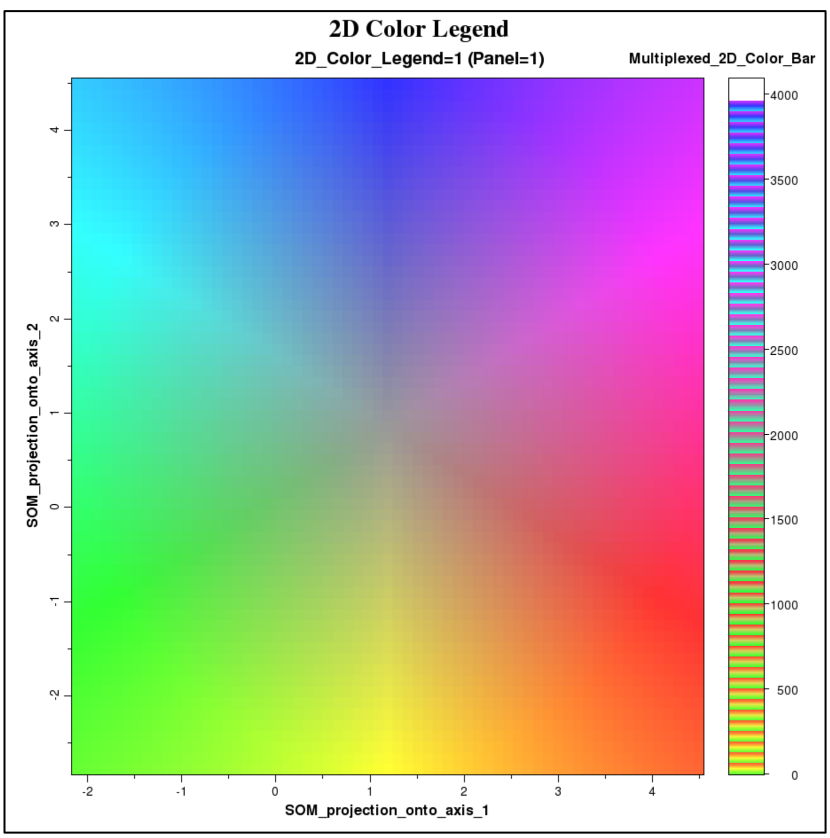
In this example we display the two projection axes of a self-organized map classification previously generated by program **som3d**. Similar projection axes are produced for generative topographic map classification program **gtm3d,** whereas program **pca3d** and **ica3d** provide multiple projections (called principal components for **pca3d** and independent components for **ica3d**) any two of which can be crossplotted.

First, (1) select the first attribute or component volume to be plotted against the horizontal or *x* crossplot axis. The (2) axis title and (3) range of the first attribute will be read from this history (*.H) AASPI-format file and can be edited. For many attribute pairs, a reasonable choice for the

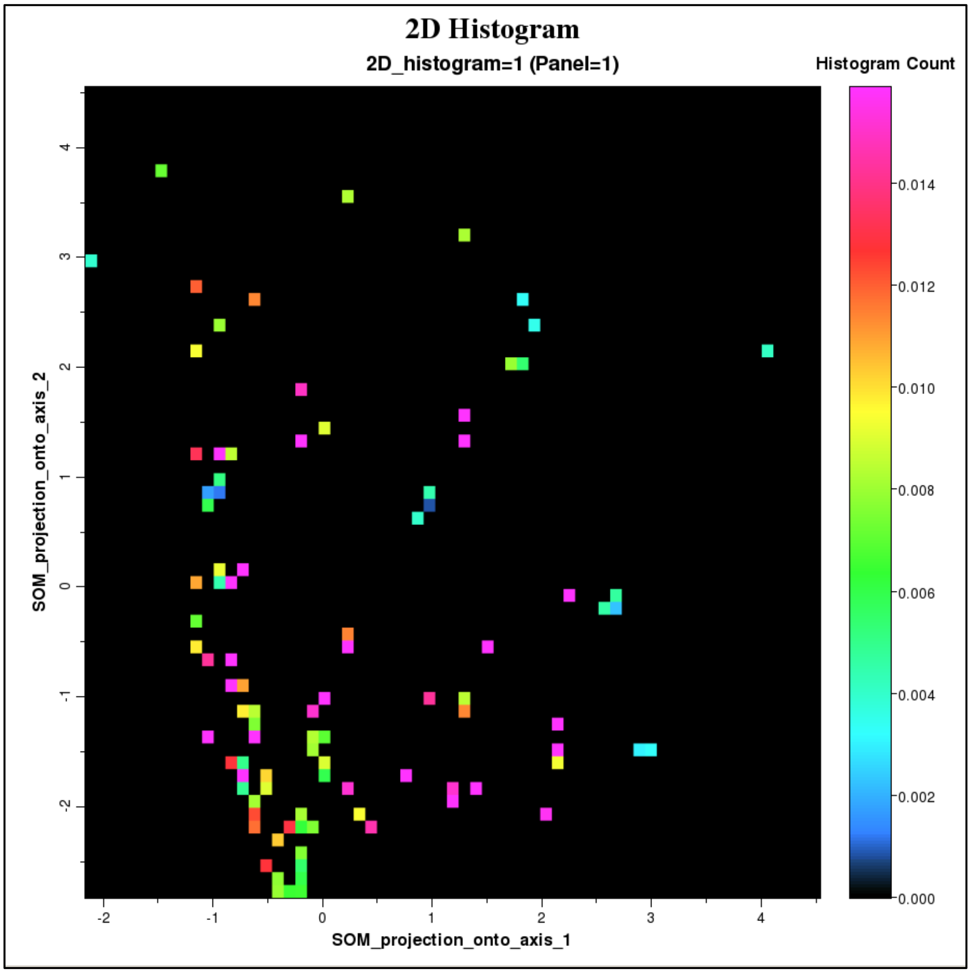
(4) second attribute or component volume to be plotted against the vertical, or *y* axis, will automatically appear. If your workstation software does not have good crossplotting capabilities, you will want to limit the (7) *Maximum number of colors* to be the limit on your workstation (e.g., 240 for Kingdom Suite, and 256 for most other packages) so that you can import the resulting volume and colorbar. Be aware that even though software like Petrel allows only 256 colors, its crossplot tool results in a 256*256 color display providing significantly improved color depth. If your goal is to use this tool only is the AASPI software, we suggest you change the default maximum number of colors to be a larger number (at least 4096) and the (8) *No. x-axis color bins* and *No. y-axis color bins* to be 64. You can set these values to be your default parameters in the future by invoking the *aaspi_util/Set AASPI Default Parameters tab*.

The default orientation of the 2D color bar has blue at 0°, magenta at 60°, red at 120°, yellow at 180°, green at 240°, and cyan at 320°. This orientation can be changed under the (10) Clockwise rotation of the 2D color bar option. The default (11) *Plot title* is constructed from the previously entered crossplot axes titles and can be modified. The default (12) *Crossplot output file name* is constructed from the names of the two input files and can also be modified. Finally, if you wish to load the crossplotted volume into your commercial workstation software, select the appropriate (11) colorbar formats under *Colorbars to generate*.

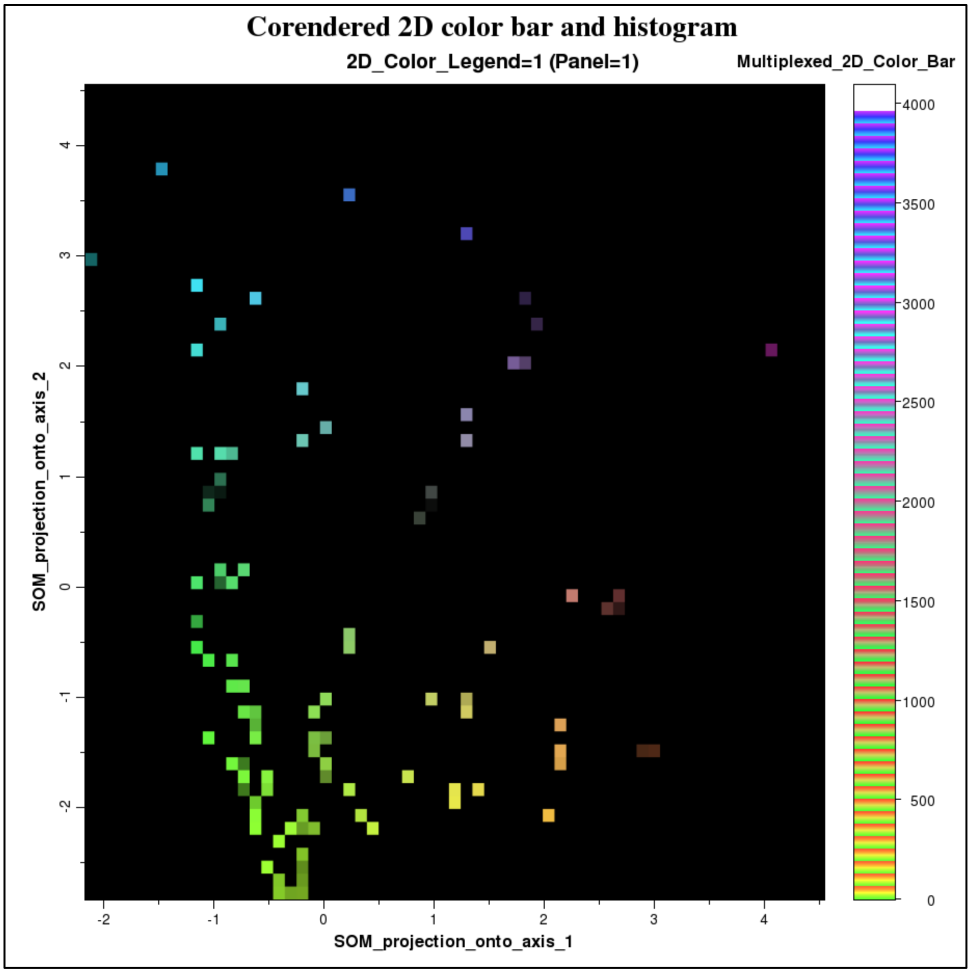
Clicking the *Execute crossplot* button will then generate four plots. The first plot will show the 2D color legend:



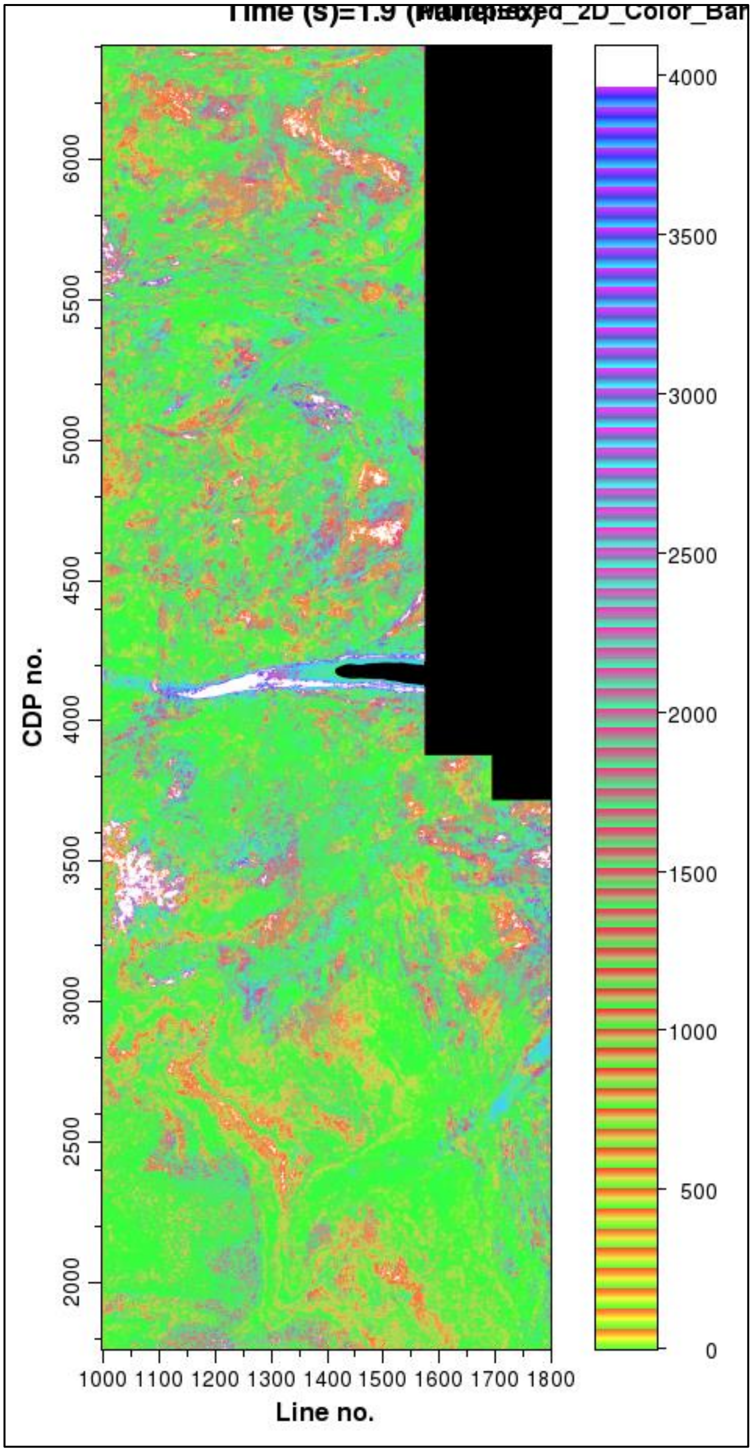
The second plot will show the 2D histogram, or probability density function:



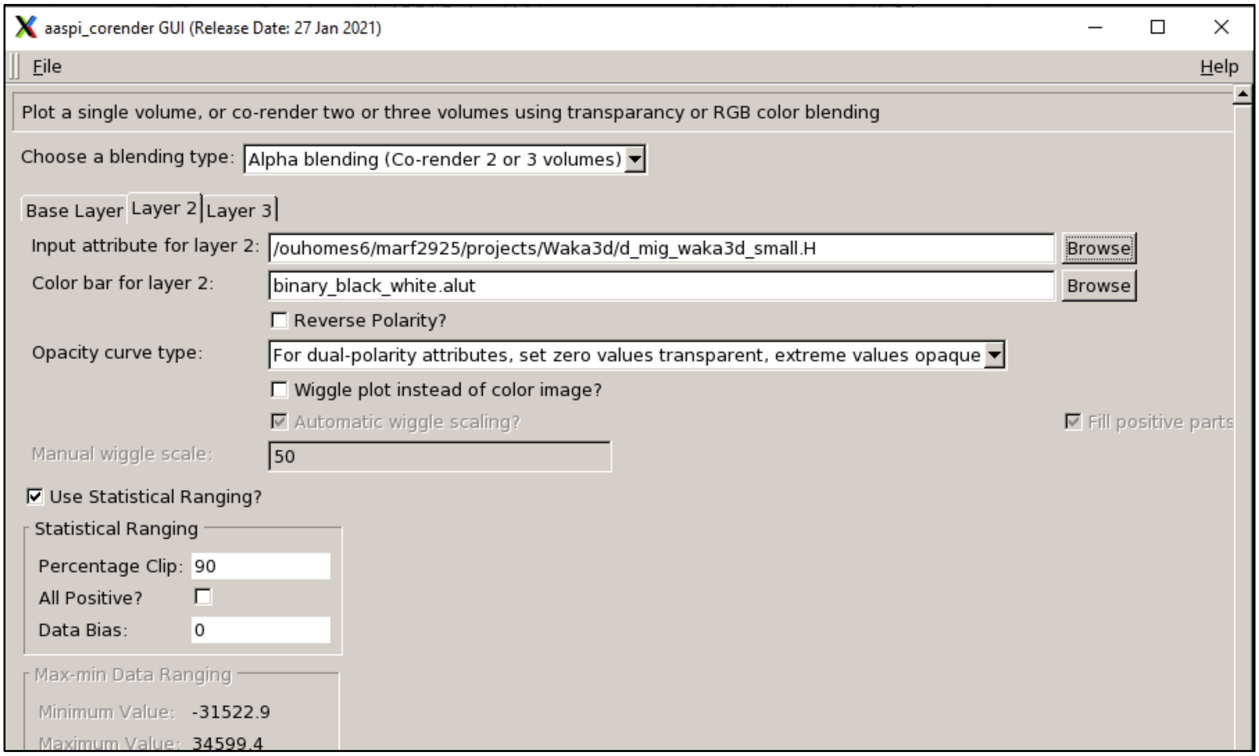
In this image, the histogram count corresponds to the number of voxels that fall within one of the 256 prototype vectors used in the SOM classification and is plotted against a rainbow color bar. To better visualize the colors that represent each prototype vector, the **crossplot** python script invokes AASPI program **corender** as shown in the previously displayed flow chart:



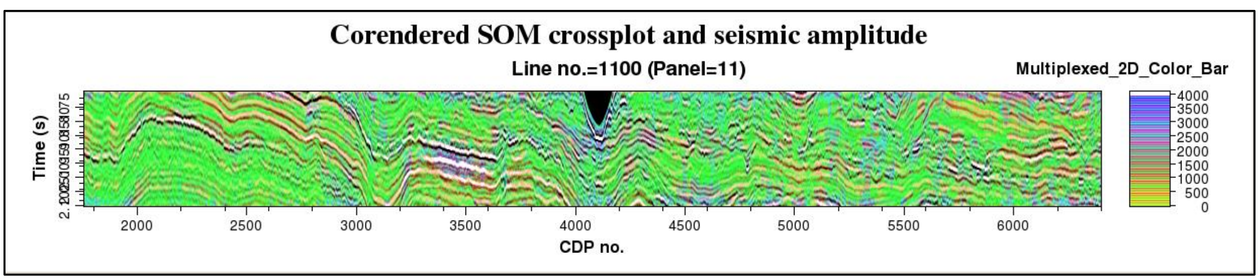
Where the stronger part of the histogram components appear as bright colors and the weaker parts become progressively darker. The last image to be generated will be a suite of time slices through the crossplotted volume:



Areas that appear white are values that fall outside the limits of the crossplot defined by options (3) and (6) in the GUI. If we wish to visually correlate the crossplotted values (in this case, the SOM "clustered" data), we can use program corender (as shown in the lower left of the computation flow chart displayed previously). Program corender is under the *aaspi_util > Display Tools > corender* tab. In this application, set the *Base Layer* to be your crossplotted data volume:

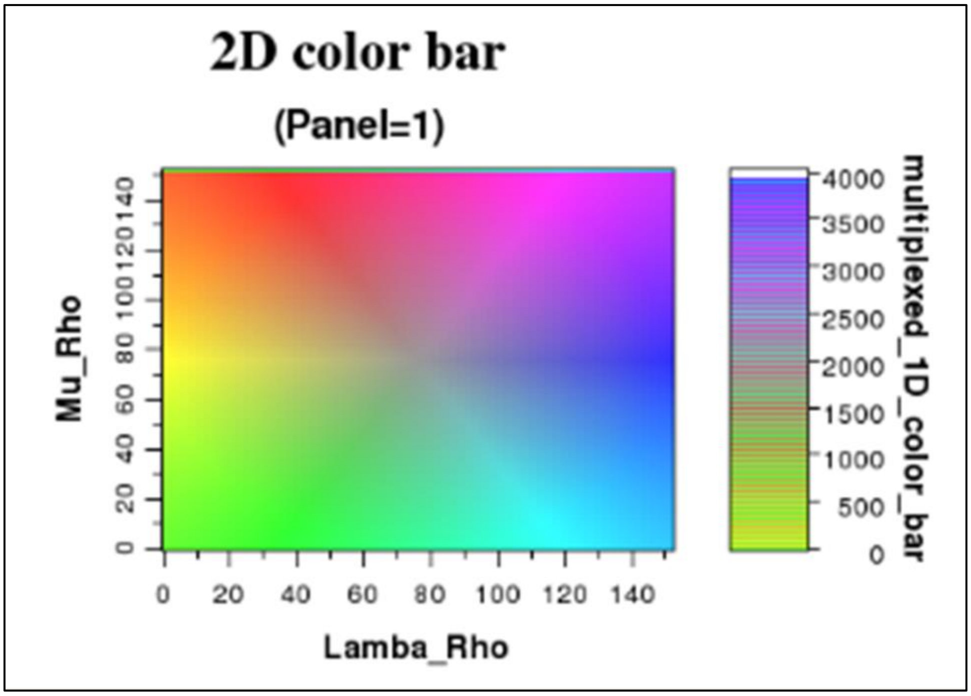


Note that the appropriate color bar and range of the data (from 0 to ncolors-1) appear. Then on Layer 2, Browse to find the original seismic amplitude volume. The software assumes that this second layer will a dual polarity seismic amplitude volume which be plotted against a binary black-white color bar with low values near zero being transparent and those near the maximum positive and negative values opaque. Clicking *Execute corende*r gives the following image:

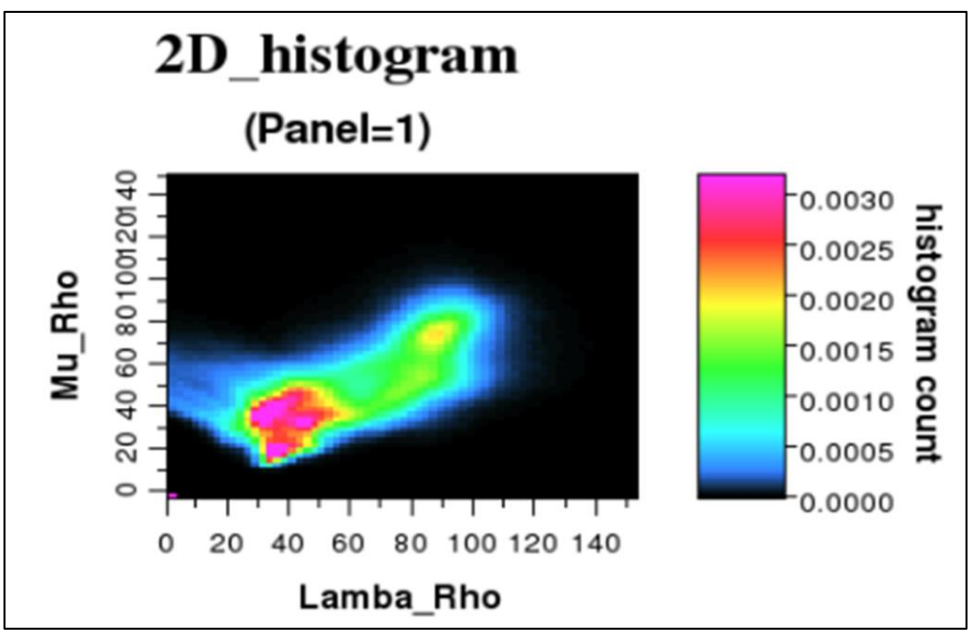


Crossplotting seismic attributes

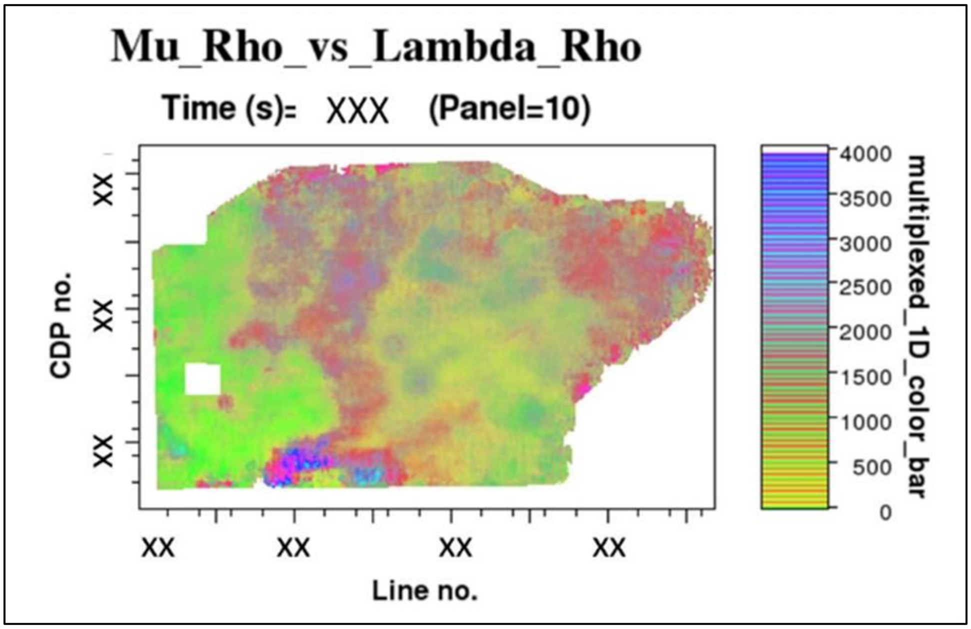
We originally developed program corender to crossplot two prestack inversion volumes, $\lambda\rho$, and $\mu\rho$ for a Barnett Shale data volume. We no longer have access to those data, and at the time, did not have the current corendering capabilities. In order to have red correlate to quartz rich facies, green to clay-rich facies, and magenta and blue to carbonate-rich facies, Perez-Altamar and Marfurt (2015) rotated the color bar using option 9 in the previous description of the GUI to obtain:



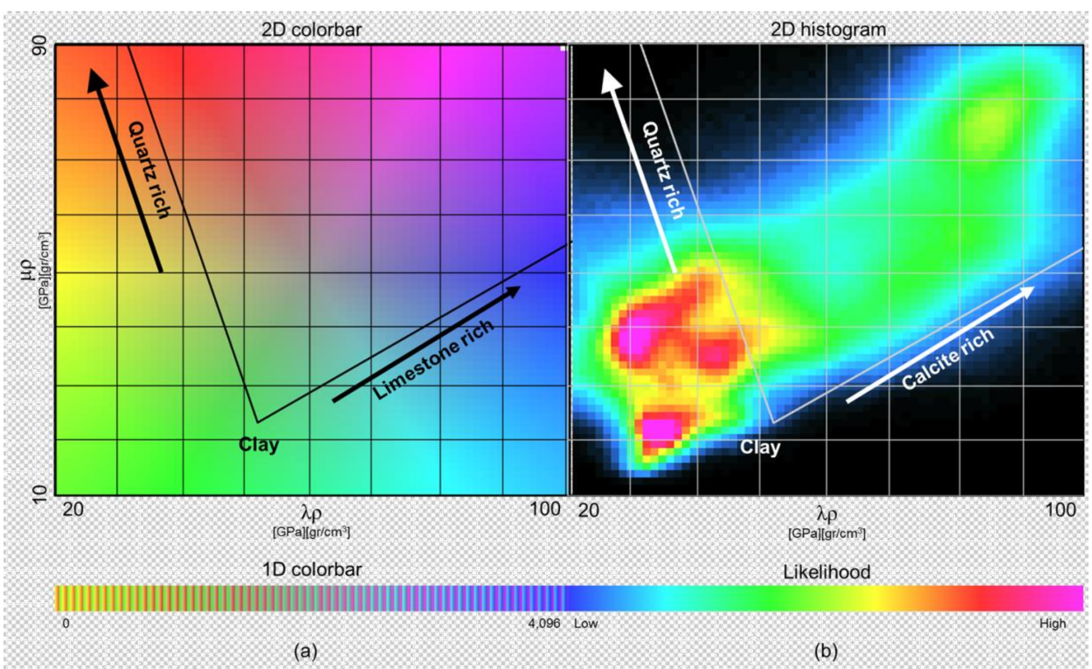
Unlike the previous example using crossplot to display the results of SOM classification, the corresponding *λρ-μρ* 2D histogram is continuous:



A time slice through the crossplotted data volumes looks like this:



By changing the range of the 2D histogram, we can enhance different features of interest. In the example below from Perez (2013), the quartz -rich facies is located towards the upper left, the clay-rich towards the lower left, and the calcite-rich facies towards the upper right. Figure 4 shows the same data as shown in Figures 2 and Figure 3 after modifying the ranges to more accurately represent the data. Quartz-rich facies appear as yellow and red, clay-rich as green, and calcite-rich as magenta, blue, and purple, providing an estimate of the lithological and geomechanical behavior.



Key horizons were picked on the original seismic amplitude data using well logs as control. The resulting figure shows the Marble Falls upper frac barrier as magenta, the Viola Limestone lower frac barrier as purple, and an intermediate Forestburg limestone as magenta-purple. The Upper Barnett maps to green, corresponding to clay-rich, and is not a target in this survey. In contrast, the Lower Barnett has a strong red (quartz-rich) component overlying a somewhat deeper green (clay-rich) unit, and serves as the landing zone for the 200+ horizontal wells drilled in this survey. More details on this particular work can be found in Perez-Altamar and Marfurt (2014, 2015).

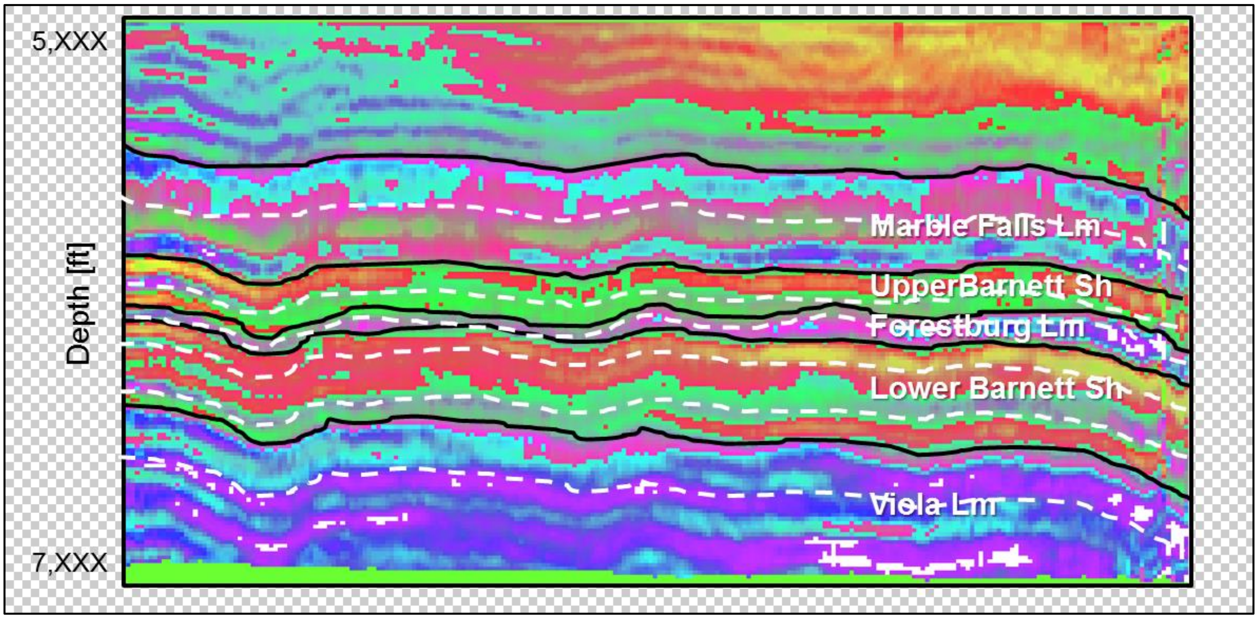


Figure 5.

References

Perez-Altamar, R., and K. Marfurt, 2014, Mineralogy-based brittleness prediction from surface seismic data: Application to the Barnett Shale: Interpretation, **2**, T255–T271, doi: 10.1190/INT-2013-0161.1

Perez-Altamar, R., and K. J. Marfurt, 2015, Identification of brittle/ductile areas in unconventional reservoirs using seismic and microseismic data: Applications to the Barnett Shale: Interpretation, **3**, T233-T243.