

Multiattribute display of dip magnitude modulating dip azimuth – Programs hlplot and hsplot

In section 6, pages 12-13, we used transparency (in PowerPoint!) to blend the dip magnitude and dip azimuth volumes to generate a composite image. A much better composite image can be generated by modulating the dip azimuth by the dip magnitude rather than by blending the two images. To do so, return to the **aaspi_util** GUI and select (1) *Display tools* and then (2) *hlplot*:



Program **hlplot** plots one attribute against hue (H) and a second attribute against lightness (L). You should have a GUI that looks like this:

X AASPI - program hiplot (Release Date: January 29, 2014)	
∬ <u>F</u> ile <u>H</u> el	р
hlplot - bins two input attributes against a 2D hue and lightness color table. The output composite data volume ranges in values from 0 to {hue*lightness} which maps one-to-one against its color table. IESX, Landmark, Voxelgeo, geomodeling, Kingdom, and SEP format color tables are generated which can be loaded into commercial workstation software applications.	
Input Attribute Plotted Against the Hue Axis	
Input attribute file name (*.H): 1 dip_azimuth_lum_filt_boonsville_0.H Browse	
Title on Hue Axis: 2 Jazimuth 5 Re-scan Hue Attr	
Range of Hues:	
Attr. value to be plotted against min 4 -180	
Attr. value to be plotted against max_hue: 180	
Input Attribute Plotted Against the Lightness Axis	
Input attribute file name (*.H): Ile/dip_magnitude_lum_filt_boonsville_A Browse	
Title on Lightness Axis: dip	tr
Attr. value to be plotted against min_lightness: 0 8	
Attr. value to be plotted against max_lightness: 20	
Min lightness value (1.0 => white): 10	
Max lightness value (0.0 => black): 0.3	
Maximum number of colors (256 for petrel, geoviz, geomodeling, seisworks) (230 for Kingdom Suite):	
2D Color map size: (nH *nL <= max_colors) Hue: 17 * Lightness: 15	
Plot title: dip_vs_azimuth	
Composite Output File (*.H): dip_mag_vs_dip_azim_boonsville.H	
Execute	
(c) 2008-2014 AASPL. The University of Oklahoma	_
(c) 2000-2014 AASI * The Oniversity of Okarionia	

(1) In this L browse and select the file example *dip_azimuth_lum_filt_boonsville_0.H* as the file to be plotted against Hue. The current GUI is somewhat more clever than previous releases and will trigger off the substring "dip azimuth" in the file name such that (2) the string azimuth appears for the Title on Hue Axis, (3) the string cyclical (-180 +180) color bar will appear as appropriate color bar, and (4) the Attr value to be plotted against min_hue (in this case, -180.0 degrees) and the

Attr value to be plotted against max_hue (+180.0 degrees) are read from the values of min_amplitude and max_amplitude from the input file entered after arrow 1. All of these default values can be altered, though for azimuth attributes these values are almost always the optimum ones. If you mistype the range of minimum and maximum values, or if for some reason they are not in your *.H input file you can always (5) *Rescan Hue Attr* to recompute the largest possible range in the data.

The Lightness section is similar. The current GUI is again, somewhat more intelligent than our first releases, such that when (6) I click the Browse button, only files that most commonly couple with those after arrow 1 will appear. Since I have previously entered a file name beginning with "dip azimuth" the GUI will present a list of those beginning with "dip magnitude". In this case choose dip_magnitude_lum_filt_boonsville_0.H as the file to be plotted against Lightness. The (7) Title on Lightness Axis defaults to be "dip magnitude", the (8) Attr. value to be plotted against min Lightness defaults at "0" and the (9) Attr. Value to be plotted against max_ Lightness defaults to be "12" where the latter two values were stored as "min amplitude" and "max amplitude" in the input *. H file. However, our previous dip magnitude images showed a maximum dip magnitude of about 5 degrees, so (9) in the Attr. Value to be plotted against max Lightness box type in 5. The Minimum and Maximum Lightness Value (10) and (11) respectively, allow you to define the lightness value to plot the attribute against, with a minimum lightness of 1.0, representing white, and a maximum lightness of 0.0, representing black. Leave the (12) Maximum number of colors to be 256 since most workstation software will not allow you to import files with more than 256 colors. If this is the case, (13) keep the number of Hue and Lightness bins at 17 and 15. Finally, (15) type in a name for your output file dip mag vs dip azim boonsville.H and click Execute. The following four images will appear when the job completes:



The first image is a 2D color bar. On the right of the 2D color bar is the 1D color bar that you will load into your interpretation workstation. Note that it has been multiplexed (or wrapped) horizontally. White corresponds to low dip magnitude, and solid color to high dip magnitude, with pastel colors in between. Note that an azimuth of 0^{0} (North) appears as blue, while azimuths of both -180^{0} and $+180^{0}$ (South) appear as yellow. The GUI recognizes this to be a cyclic 2D color bar or color wheel and also provides the following image:



The color wheel is plotted using the **aaspi_plot** utility which is designed to display seismic amplitude and attribute data. I've annotated the image in PowerPoint to give a more explicit definition of the color wheel:



Flat (horizontal) events with a dip magnitude of 0^0 are plotted against white. Events with a dip magnitude of 50 and dip azimuth of 0^0 (North) appear as

blue, 60° as magenta, 120° as red, 180° (South) as yellow, 240° as green, 300° as cyan, and 360° as blue. Less strongly dipping events appear as pastel colors.





The third image is a 2D histogram:

The second image will be an animation of time slices of the output data mapped to the 2D color bar. Strong dips are displayed as pure colors and weak dips as gray.



A list of the files generated by program hsplot gives the following:

-rw-rr	1	kmarfurt	aaspi	276	Sep	20	21:10	wheel_dip_mag_vs_dip_azim_hsplot_boonsville_0.H
-rw-rr	1	kmarfurt	aaspi	303	Sep	20	21:10	legend_dip_mag_vs_dip_azim_hsplot_boonsville_0.H
-rw-rr	1	kmarfurt	aaspi	8275	Sep	20	21:10	hsplot_18_14_h360voxelgeo
-rw-rr	1	kmarfurt	aaspi	7680	Sep	20	21:10	hsplot_18_14_h360sep
-rw-rr	1	kmarfurt	aaspi	9917	Sep	20	21:10	hsplot_18_14_h360landmark
-rw-rr	1	kmarfurt	aaspi	7756	Sep	20	21:10	hsplot_18_14_h360iesx
-rw-rr	1	kmarfurt	aaspi	22562	Sep	20	21:10	hsplot_18_14_h360gpc
-rw-rr	1	kmarfurt	aaspi	5033	Sep	20	21:10	hsplot_18_14_h360geomodeling
-rw-rr	1	kmarfurt	aaspi	62	Sep	20	21:10	hsplot_18_14_h360CLM
-rw-rr	1	kmarfurt	aaspi	5632	Sep	20	21:10	hsplot_18_14_h360alut
-rw-rr	1	kmarfurt	aaspi	7168	Sep	20	21:10	hsplot_18_14_h360,,aaspicolor
-rw-rr	1	kmarfurt	aaspi	1789	Sep	20	21:10	dip_mag_vs_dip_azim_hsplot_boonsville_0.H00
-rw-rr	1	kmarfurt	aaspi	3459	Sep	20	21:10	dip_mag_vs_dip_azim_hsplot_boonsville_0.H
-rw-rr	1	kmarfurt	aaspi	26842	Sep	20	21:10	hsplot_18_14_h360out
[kmarfurt@o	pa.	l boonsvi)	lle]\$					

The files wheel_dip_mag_vs_dip_azim_hsplot_boonsville_1.H and legend_dip_mag_vs_dip_azim_hsplot_boonsville_1.H correspond to the 2D color wheel and 2D rectangular legend plotted above. The file dip_mag_vs_dip_azim_hsplot_boonsville_1.H corresponds to the seismic attribute displayed above. If you typeAttr <dip_mag_vs_dip_azim_hsplot_boonsville_1.H you obtain :

where you will note the 'seismic data' range between 0 and 255. Although each sample is stored as a floating point number, they are actually integers that correspond to color lookup tables. The file *hsplot_18_14_h360.alut* is one of these color lookup tables that is in Petrel format. The AASPI software outputs color tables in many of the commonly used formats. The limitation is that the commercial software needs to have a well-defined format (e.g. with documentation, or else a simple ascii file) and the ability to import a color table from a file.

Loading and displaying multiattribute plots in Petrel

Schlumberger has been gracious enough to provide OU with licenses for education and research, hence the example on how to load a composite attribute volume into Petrel. Loading such volumes in Voxelgeo, Kingdom Suite, Landmark, Geoprobe, IESX, and Geomodeling are similar. Unfortunately, a few packages (e.g. Geographix) do not allow loading an ascii color bar from a file.

The first step is to convert the SEP-format file dip_mag_vs_dip_azim.H to a SEGY-format file dip_mag_vs_dip_azim.segy using the *Sep2Segy (single)* tab in **aaspi_util**. Then, depending on how your disk drives are mounted and shared, you will need to copy this data from your Linux system to your PC where you run PetreOnce the data have been converted and copied, launch Petrel, open your Boonsville project, and add the new SEGY file into the project by highlighting the survey name and clicking the *Import File (on selection)* icon:



The following window should pop up:

Import file							? 🗙
Look in:	🚞 segy		*	G	ø e	• 📰 -	
A 2 Documents Desktop My Documents	d_mig_boonsvill dip_azim_coh_b dip_mag_vs_dip energy_ratio_si hlplot_18_14_h hlsplot3d_16_4 shape_vs_curv.	le.segy boonsville.segy b_azim_boonsville.segy milarity_boonsville_0.segy 4.alut _4_h3.alut .alut edness_boonsville.segy edness_pastel_boonsville.seg	Y				
My Computer 1 My Network File example/descr	File name: Files of type: iption:	SEG-Y Import with preset par	ameter	s (*.*)	•	•	Open Cancel
This SEG-Y import The SEG-Y trace I	allows loading parar header positions can	meters to be set before the files a be set and the file can be sca	s are lo inned.	aded.			

First, choose to load (1) *SEG-Y import with present parameters (*.*)*, since the header values for the AASPI volumes may be different from your default settings. (The Petrel loading utilityis fairly clever, but let's just do this for clarity). Then (2) select *dip_mag_vs_dip_azim_boonsville.segy* as the file to be loaded.

Click Open and the following panel pops up:

	S Y Import							
	Vintage Set default vintage 💌 New							
	○ 2D							
	☐ Ignore SEGY coordinates							
	Byte Header format							
	X coordinate 🔨 73 💌 4 byte (32-bit) integer 💌 Scan 👔							
	Y coordinate 77 🔽 4 byte (32-bit) integer 🔽 Start trace							
	V Import V Import Vintage Set default vintage New 2D 3D Ignore SEGY coordinates Byte Header format X coordinate 73 4 byte (32-bit) integer Scan X coordinate 73 4 byte (32-bit) integer Start trace 1 Traces to scan 100 Traces to scan 100 Coordinate 17 4 byte (32-bit) integer COP number 17 4 byte (32-bit) integer COP number 17 4 byte (32-bit) integer COP number 17 4 byte (32-bit) integer Shotpoint number 17 4 byte (32-bit) integer Coordinate scale Samples per trace 800 Sample interval Step headers from first file C18 Trace header locations: 19 11 10 C22 Shot × coord 10 10 C0 C0 10 10 10 C0 C0 10 10 10 10 10 10 10 10 10 10 10 10 10							
	Inline number 13 V 4 byte (32-bit) integer V 100							
	Crossline numb							
	CDP number 21 V 4 byte (32-bit) integer V							
	Shotpoint number 17 💽 4 byte (32-bit) integer 🕑							
Y Import ? Vintage Set default vintage New 2D 3D Ignore traces with null (0,0) coordinates Byte Byte Header format X coordinate 73 4 byte (32-bit) integer Scan ? Y coordinate 77 4 byte (32-bit) integer Statt trace 1 Unine detection method Trace header fields ? Traces to scan 100 Cordinate 121 4 byte (32-bit) integer 100 100 Corossline number 17 4 byte (32-bit) integer 100 100 Corossline number 17 4 byte (32-bit) integer 100 100 CDP number 21 4 byte (32-bit) integer 100 100 Sample format 18M floating point 2 2 100 100 Sample format 18M floating point 2 1 100 100 100 Sample format 18M floating point 2 2 1 100 100 100 Sample format 18M floating point 2 1 100 100 100 <t< th=""></t<>								
	Samples per trace 800 Sample interval 2							
	Time/depth first sample 0 Coordinate scale 1							
	Sample format IBM floating point Samples per trace 800 Time/depth first sample Sample interval Use trace weighting factors Skip header sanity checks							
	SEGY headers from first file							
3	C18 Trace header locations: C19 line number in bytes 13-16 C20 xline (cdp) number in bytes 21-24 C21 coord scale factor in bytes 71-72 copied from input data C22 shot x coord in bytes 73-76 copied from input x-coordinat C23 shot y coord in bytes 77-80 copied from input y-coordinat C24 group x coord in bytes 81-84 copied from input data C25 group y coord in bytes 85-88 copied from input data							
	V Import V Import Vintage Set default vintage New 2D 3D Ignore SEGY coordinates Byte Peader format X coordinate 73 4 byte (32-bit) integer Scan Coordinate 73 4 byte (32-bit) integer Scan Scan Scan Scan Coordinate 1 Trace header fields Scan Scan							
	V OK X Cancel							

First, select (1) *3D* since you will wish to load a 3D seismic volume. Then (2) select *Trace header fields* as the *Line detection method*. Next, scroll down under *SEGY headers from first file* and note that the (3) *Inline number* is in bytes 13-16 and the *Crossline number* in bytes 21-24. The value of 21 is the 1977 SEG-Y standard for CDP number and is usually set as the default crossline number for interpretation systems. However, most interpretation systems were started before the 2003 SEG-Y standard for 3D seismic data was adopted, such that finding the inline number takes some detective work. For all the AASPI volumes, the inline number will be in bytes 13-16. Enter (4) the value of 13 for the *Inline number* byte location.

Click OK and the data begins to load. The file will then be under your *Input* tab:



Double click the last file in the list *dip_mag_vs_dip_azim_boonsville* to open the *Settings* pop-up window:

Settings for 'dip_mag_vs_dip_azim_boonsville'
📝 Style 📵 Info 🚹 Statistics 📮 Colors
Operations SEG-Y settings Geometry Opacity
Realize Amplitude
Source amplitude range: ~0.0000 to ~255.0000
Set from source as shown above
3 Zero centric Min: 0.0000 Max: 255.0000
× 500 A 1500 200 5 3000 3500 4000
8
6
4
2-
Lower clipping: 0.0000% Upper clipping: 0.0000%
Filter Bins: 4096 Original quality: Floating point 32 bit
6 Realization quality: Integer 8 bit 🔽 Show
Output file <project folder="" pdb=""> Output file <project folder="" pdb=""> Output file </project></project>
Vintage
Realized volume size: Max 23.0 MB

Under the *Operations* tab, you will note that (1) the histogram is neither Gaussian (like seismic amplitude) nor log-normal (like RMS amplitude and envelope). Rather, what you see is the histogram of the dual attribute data multiplexed into a single composite attribute histogram. Next, select (2) *User defined* and unselect (3) *Zero centric*. The composite attributes will range from 0 to 255. In order to map accurately against the 2D color bar,

explicitly set (4) *Min* to be 0.0 and (5) *Max* to be 255.0. Since the data range between 0 and 255, choose the (6) *Realization quality* to be *Integer 8 bit*. Finally, click Realize and close the window when to exit when done.

🗄 🛄 Input 🛄 🔲 Z=-1099 😑 🆚 📃 shape_vs_curvedness_pastel_boonsville 🔄 📃 Inline 153 🔄 📃 XLine 140 😑 🌍 🔲 shape_vs_curvedness_pastel_boonsville 🔄 📃 Inline 153 🔄 📃 XLine 140 🝋 📃 Z=-1100 😑 🐗 🔲 energy_ratio_similarity_boonsville_0 🔄 📃 Inline 153 🔄 🔲 XLine 140 🖻 🏟 🔲 shape_vs_curvedness_boonsville 🗋 📃 Inline 153 🔄 📃 XLine 140 🖃 🏶 🔲 dip_mag_vs_dip_azim_boonsville 🗋 📃 Inline 153 🝋 📃 XLine 140 🖃 🌍 🗹 dip_mag_vs_dip_azim_boonsville | 🔄 📃 Inline 153 🔄 📃 XLine 140 🔄 🗹 Z=-1100

Your Input tab should have the Realized data under it:

Choosing the plot the time slice at t=-1100 ms (for those of you not familiar with Petrel, it has the time and depth axes as positive UP) you should get the following display:



Petrel assigns the default Seismic color bar. You will need to import the 2D color bar generated by program **hlplot**. To do so, first copy the file *hsplot_18_14_360.alut* down from your Linux workstation. Rename it to be something that makes sense, such as *dip_azim_2D.alut*. Then highlight your *Templates* tab and click the import icon:



The following window opens:

Import file							? 🛛	
Look in:	🚞 segy		*	G 🖻	1 🖻	•		
And the second s	 dip_azim_2D.alu hlplot_18_14_h hlsplot3d_16_4 shape_vs_curv 	ut 4.alut _4_h3.alut .alut						
Desktop								
My Documents								
My Lomputer	File name:				*		Open	
	Files of type:	Color tables (alut file) (*.alut)			~		Cancel	
My Network		Open as read-only						
File example/desc	ription:							
140 255 000,000,000,255 001,001,001,255 002,002,002,255 003,003,003,255							 	
<							>	

First, (1) select *Files of type* to be *Color tables (alut file) (*.alut)*. Then (2) select the file *dip_azim_2D.alut* and click *Open*.

The following pop-up window appears:

😌 Color table trimming options 🛛 🛛 🔀
Trim color control points Trim opacity control points
🗸 OK 🔀 🔀 Cancel

Petrel will want to Trim your color and opacity control points. It is extremely important that you unselect this default option or your color mapping will not work! Once unselected, click OK.

The new color bar will appear at the bottom of your *Seismic color tables* in the *Templates* tab:



Return to the Input tab and double-click the realized data volume dip_mag_vs_dip_azim_boonsville (Realized) to open the Setting tab:

Se Se	ttings for 'dip	_mag_vs_dip_a	zim_boonsville	[Reali 📡
			Geometry	Upacity
V	Style		III 5	
	🗾 Name:	dip_mag_vs_dip_	azim_boonsville [R	ealized] 📝
	Color:			-
	Туре:	3D seismic		
	🕤 Template:	📑 🚺 dip_azim	_2D	
	Domain:	$t \downarrow$ Elevation tir	ne	*
	Vintage:	🔿 👩 Seismi	ic Time 16	?
	Date:	11/ 3/2009		~
	Comments 🎯 H	listory		
				~

Under the *Info* tab, (1) select your new color bar, *dip_azim_2D*. Click Apply and your seismic attribute time slice may look like the following:



The problem here is that Petrel is interpolating colors. Go back to the *Settings* tab and under the *Style* tab, click (1) *None* as the *Interpolation Method*. You will encounter this problem when using any discontinuous color bar. In addition to multiattribute images, these may occur with discrete classifications (e.g. if you import classes from Stratimagic) or discrete color tables from facies inversion (e.g. green for shale, yellow for sandstone, blue for limestone).

Settings for 'dip_mag_vs_dip_azim_boonsville [Reali X
Colors 🔯 Operations Geometry Opacity
Style 🚺 Info 📊 Statistics
🐲 'Base map' annotation
Settings are inherited from parent folder.
Volume visualization
Method 💿 None 🔘 Bilinear 🔘 Smooth
 Interpolate using tile edge blending Enhance intersection resolution: Vertical: 3 Vertical: 3 Vertical:
Visualization Enable zone and segment filters for intersections Enable bump mapping Enable transparency for intersections
Max resolution 💿 Full 🔘 Medium 🔘 Low
Performance Enable compressed textures Fast scene movement
Decimation while dragging: 2 🔽
Time to wait for data 500 ms 0 5000

The new image looks like this:



Later, using program **similarity3d**, you will generate various coherence images. You will wish to set your transparency for energy-ratio similarity to be transparent for coherent regions, and black for incoherent regions:



Co-rendering the energy ratio similarity image with the composite dip magnitude vs. dip azimuth image results in the following:



Careful examination indicates that the color-encoded dip magnitude vs. dip azimuth images shows the reflectors dipping into the circular karst collapse features.

Plotting dip vs. azimuth vs. coherence – Program hlsplot

Earlier, we showed how we can plot dip magnitude against saturation and dip azimuth against hue to obtain a multiattribute image whereby one attribute modulated another. We can carry this construct one step further and plot coherence against lightness. To do so, return to the **aaspi_util** GUI and select *Display Tools* and select *hlsplot* as shown below:

🗙 AASPI program aaspi_util - Post Stack Utilities (Rele	ase Date: January 29, 2014)	
Eile Volumetric Attributes Formation attri	butes Display Tools Other Utilities Set	AASPI Default Parameters <u>H</u> elp
SEGY to AASPI format conversion (multiple files)	SPI to : <u>h</u> lplot lat con <u>h</u> splot Isingle h <u>l</u> splot	Workflows AASPI Prestack Utilities
SEGY to AASPI - Convert Poststack seismic vo	olumes rgb plot crossplot	
SEGY Header Utility :	plot_4d_spectral_components	
2D SEG-Y Line rather than 3D Survey ?	graph plot	
SEGY format input file name (*.segy,*.sgy,*.s	EGY,*.SGY):	Browse View EBCDIC Header
AASPI binary file datapath: Absolute file name followed by a '/'	/raid5/mcahoj/sep_data/	
Unique Project Name:		
AASPI Output File Name (*.H):		
Verbose:	2	
VBlock:	0000	
Byte loc. of X-Coord:	81 4 byte int 💌	
Byte loc. of Y-Coord:	85 4 byte int 💌	
Byte loc. of line (inline) no.:	89 4 byte int 💌	
Byte loc. of cdp (xline) no.:	.93 4 byte int 💌	
Override scalco) - use value in header 💌	
Override the time of the first sample (ms) :		
Vertical Unit:	ns 💌	
Horizontal Unit: f	t 📕	
Amplitude Threshold:	E+10	-
Max. no. spikes/trace:	2	
Read text header as ASCII:	l	
Execute		
(c) 2008-2014 AASPI - The University of Oklah	oma	

The following GUI will appear:

	ŀ
Bin three input attributes against a 3D hue, lightness, and saturation color table. The output composite data volume ranges in values from 0 to {hue*lightness*saturat maps one-to-one against its color table. IESX, Landmark, Voxelgeo, geomodeling, Kingd format color tables are generated which can be loaded into commercial applications.	ion} which om, and SEP
Hue	
Attribute Against the Hue Axis (*.H)	Browse
Title on Hue Axis:	Be-scan Hue
Range of Hues: 2 [vclical [-180 +180]	
Attr. value to be plotted against min hue:	
Attr. value to be plotted against max_hue:	
Lightness	
Attribute Against the Lightness Axis	Browse
Title on Lightness Axis:	Re-scan Lightne
Attr. value to be plotted against min_lightness: 0.5	
Attr. value to be plotted against max_lightness:	
Min lightness value (0.0 => black):	
Max lightness value (1.0 => white):	
Saturation	
Attribute Against the Saturation Axis 6 dip_magnitude_filt_boonsville_0.H	Browse
Title on Saturation Axis: dip_magnitude	Re-scan Saturat
Attr. value to be plotted against min_saturation:	
Attr. value to be plotted against max_saturation: 5	
Min saturation value (0.0 => shades of gray):	
Max saturation value (1.0 => pure colors):	
Maximum number of colors 256	
(256 for petrel, geoviz, geomodeling, seisworks) (230 for Kingdom Suite):	
(256 for petrel, geoviz, geomodeling, seisworks) (230 for Kingdom Suite): Color map size: (H*L*S <= 256) H: 4 * L: 4 * S: 15	
(256 for petrel, geoviz, geomodeling, seisworks) (230 for Kingdom Suite): Color map size: (H*L*S <= 256) Plot title:	
(256 for petrel, geoviz, geomodeling, seisworks) (230 for Kingdom Suite): Color map size: (H*L*S <= 256)	
(256 for petrel, geoviz, geomodeling, seisworks) (230 for Kingdom Suite): Color map size: (H*L*S <= 256) Plot title: Composite Output File (*.H): Execute	

The appearance of the **hisplot** GUI is similar to that for program **hsplot**, except that now you will need to define three rather than two files. (1) For *The Attribute Against Hue (*.H)* select dip_azimuth_median_filt_boonsville_0.H. The dip azimuth should be plotted against a cyclical color bar. We want yellow to map against 180°

and blue to map against 0° and so (2) choose cyclical (-180 +180) for *Range of Hue*. The dip azimuth ranges from -180° to $+180^{\circ}$, so (3) enter - 180 and +180 under the *Attr. value to be plotted against min_hue and max_hue* boxes.

Enter (4) *energy_ratio_similarity_boonsville_0.H* (coherence) as the *Attribute Against Lightness (*.H)*. The range of this attribute varies from 0.0 to 1.0, but very few values fall below 0.5. Let's clip the range to be displayed and (5) type 0.5 and 1.0 in the *Attr. value to be plotted against min_lightness and max_lightness* boxes.

Enter (6) dip_magnitude_filt_boonsville_0.H as the *Attribute Against Saturation (*.H).* The range of this attribute varies from 0.0 to 15, but as with our hsplot earlier, (7) type 0.0 and 5.0 in the *Attr. value to be plotted against min_saturation and max_saturation* boxes.

As of September 2009, most interpretation workstations only allow importation of 256 colors (several allow more internally). Therefore under *Color map size:* ($H^*L^*S <=256$) leave the defaults (8) of 4, 4, and 15. The last parameter to enter is (9) the *Composite Output File* (*.*H*) where you will enter *dip_azim_coh_boonsville.H*. With all the parameters selected, (10) click *Execute*.



As with program **hsplot**, a color legend appears. The one above has been also annotated in PowerPoint. Although we specified four levels of coherence, the program cheats a little bit, and steals one of the darker unsaturated colors from the first level and makes it black (annotated as *Coh level 1*). For the coherence ranges we specified, this color corresponds to values of coherence <0.5 . The next four levels correspond to coherence values that range between 0.500- 0.625, 0.625-0.750, 0.750-0.875, and 0.875-1.000. The lightnesses of these five levels are *L*= 0.00, 0.15, 0.30, 0.45, and 0.50. Blocks of constant saturation (dip magnitude for this example) progress horizontally. Within each block the hue (dip azimuth for this example) progresses horizontally as well. A color wheel should also appear:

The four lightness levels are shown below. Each color wheel corresponds to a range of dip from 0^0 to 5^0 , at increasing levels of coherence. The black level of coherence (c < 0.5) is not displayed.





The resulting image is overall less pastel than the image generated using program **hsplot**. The less-coherent areas become darker, with the least coherent areas being black. Several collapse features can easily be identified. The areas marked 'joints' are less clear. However, subsequent curvature calculations will sharpen these areas where there is a lateral change in dip magnitude and dip azimuth.

The 3D volume has integer values ranging from 0-255 stored as floating point numbers. When loaded into commercial workstation software, these data should be loaded with a user-defined range between 0 and 255. The corresponding color table (ending in *.alut, *.iesx, *.geoprobe, etc.) should be loaded and mapped one-to-one against the data volume. Stretching and squeezing the color bar will destroy the one-to-one mapping and should not be used.

Plotting attributes against red, green, and blue – program rgbplot

Program **rgbplot** quite simply plots one attribute against red, a second against green, and a third against blue. At present, the SEP programs Grey and Stube only allow 256 colors, which provide an insufficient number of bins (only 6) along each axis. Our future C++ graphics utilities will have 32-bit vs. 8-bit color. If you have greater than 8-bit color, the output of this program should work just fine.

To invoke program **rgbplot**, click Displays, then **rgbplot** on the **aaspi_util** GUI:

Eile Volumetric Attributes Formation	attributes	<u>D</u> isplay Tools	<u>O</u> ther Utilities	Set <u>A</u> ASPI Defau	ılt Parameters	<u>H</u> e
SEGY to AASPI AASPI to SEGY	AASPI to !	hlplot				1
ormat conversion format conversion (multiple files)	format con (single	<u>n</u> spiot bisplot		Workflows	Prestack Utilities	
	. ,	rab plot			1	<u> </u>
SEGY to AASPI - Convert Poststack seism	ic volumes	c <u>r</u> ossplot				
SEGY Header Utility :		<u>p</u> lot_4d_spe	ctral_componen	ts		
2D SEG-Y Line rather than 3D Survey 2		generate ro	ses			
SEGY format input file name (* segv * sg	/ * SEGY *	graph plot				
	,,,				srowse view EBCDIC	. Hea
AASPI binary file datapath: Absolute file name followed by a '/'		/raid5/mc	ahoj/sep_data/			
Joigue Project Name				-		
ASDI Output File Name (* LI)						
(ASFI Output File Name (*.n):		1				
/erbose:						
/Block:	10000					
3yte loc. of X-Coord:	181		4 byte int 💌			
Byte loc. of Y-Coord:	185		4 byte int 🔻	ĺ		
3yte loc. of line (inline) no.:	189		4 byte int 🔻	ſ		
3vte loc. of cdp (xline) no.:	193		4 byte int 🔻			
Override scalco	0 - 1150	value in header				
Override the time of the first sample (ms)			-			
(anticed the time of the mat sample (ms)						
	s					
lorizontal Unit:	ft	<u> </u>				
Amplitude Threshold:	1E+10					
Max. no. spikes/trace:	2					
Read text header as ASCII:						
Execute						
<u>Lacence</u>						

The following GUI appears:

🗙 AASPI - program rgbplot (Release Date: January 29, 2014)					
]] <u>F</u> ile	Help				
PURPOSE: generate a composite image by plotting each of three attributes of the same time against red, green, and blue color bars.					
INPUT FILES: three input files of the same time three input files of the same time (e.g. 3 spectral magnitude components, 3 offset amplitude volumes, three euler curvature components, etc.).					
OUTPUT FILES: A color lookup file and a composite SEP header/data set					
RED					
Attr. Against red (*.H): id5//For_RGB/Boilermaker_ma	g_14hz.H Browse				
Title on red Axis: Red					
GREEN					
Attr. Against green (*.H): id5//For_RGB/Boilermaker	mag_34hz.H Browse				
Title on green Axis: Green					
BLUE					
Attr. Against blue (*.H): id5]/For_RGB/Boilermaker_m	ag_54hz.H Browse				
Title on blue Axis: Blue					
COLOR PARAMETERS					
Minimum magnitude :	0				
Maximum magnitude :	1				
Maximum number of colors (256 for petrel, geoviz, geomodeling, seisworks) (230 for Kingdom Suite):	256				
Number of colors along each axis:	6				
Color intensity to plot against minimum data values: (black = 0.0, white=1.0)	0				
Color intensity to plot against minimum data values: (black = 0.0, white=1.0)	1				
Bias (needed for Voxelgeo):	0				
Composite Output File (*.H):	rgb_14_34_54_rgbplot.H				
(c) 2008-2014 AASPI - The University of Oklahoma	Execute				

I choose the three input attributes which are the 14, 34, and 54 Hz spectral components generated by program **spec_cmp** for the Boilermaker data volume. Because of the 8-bit color limitation, the following image is less than satisfactory, although we can see some channels tuned in at lower frequencies that appear as orange.



Crossplotting two attributes against a 2D color bar – program crossplot

This is a new utility included in AASPI as of late 2012 to address issues in mapping lambda -rho vs. mu–rho for pre-stack inversion volumes. To initiate **crossplot** return to the **aaspi_util** window click 1) *Display tools* then scroll down to 2) *crossplot*.

🗙 AASPI program aaspi_util - Post Stack Utilities (Pelease Date: February 18, 2014)						
]] <u>F</u> ile <u>V</u> olumetric Attributes Fo	tes	<u>D</u> isplay Tools	<u>O</u> ther Utilities	Set <u>A</u> ASPI Defau	t Parameters	<u>H</u> elp
SEGY to AASPI format conversion (multiple files)	ASPI to format con (single	<u>h</u> lplot <u>h</u> splot h <u>l</u> splot		Workflows	AASPI Prestack Utiliti	es
AASPI to SEGY format conversio	Single	r <u>g</u> b plot		ormat		
AASPI input file name (.H):		plot_4d_spe	ctral_componer	Browse	2	
SEGY format output file name (*.segy)	:	graph plot	363			
Vblock:	10000					
Verbose:	V					
Output dead and padded traces?:	\checkmark					
Byte loc. of X-Coord: 181		4 byte int	-			
Byte loc. of Y-Coord: 185		4 byte int	•			
Byte loc. of line (inline) no.: 189		4 byte int	•			
Byte loc. of cdp (xline) no.: 193		4 byte int	-			
Execute						
(c) 2008-2014 AASPI - The University of Oklahoma						

The **crossplot** window shown below will appear. In this example we input (1) the file *Lambda_Rho.H* in the *x-axis attribute* and (5) the file *Mu_Rho.H* in the *y-axis attribute*. If the range of values does not automatically appear click (2) and (5) *Re-scan Attr* to rescan the range of values in the two data volumes. Often you will wish to hand type these values (3) and (6) to clip the range of the data displayed. The maximum number of colors chosen depends on your interpretation software package. Most are limited to 256 colors. In this case (7), we have used 4096 colors. (8) *2D Color Map Size* allows you to adjust the number of color bins denoted to the x and y- axis. Finally, add a (9) *plot title* and a *composite output file* name (10).

🗙 AASPI - program crossplot (Release Date:	January 29, 2014)	
∬ <u>F</u> ile		<u>H</u> elp
crossplot - bins and crossplots two in The output crossplot data volume ran which maps one-to-one against its co IESX, Landmark, Voxelgeo, geomodel generated which can be loaded into c	put attributes against a 2D hue and saturation color table. ges in values from 0 to max_color-1 lor table. ing, Kingdom, and SEP format color tables are ommercial workstation software applications.	
Input Attribute Plotted Against the X-A	xis of the 2D Color Bar	
Input x-axis attribute file name (*.H):	/projects/Lambda_Rho.H Browse	
Title of the x-axis attribute:	Lambda_Rho Re-scan Attr	
Minimum attribute value (lower values will be clipped): Maximum attribute value (higher values will be clipped):		
Input Attribute Plotted Against the Y-A	xis of the 2D Color Bar	
Input variate ribute file name (* H):	/projecte/Mu Bha H	
Title of the v-axis attribute:		
Minimum attribute value (lower values will be clipped):		
(higher values will be clipped):		
Maximum number of colors (256 for petrel, geoviz, geomodeling, (230 for Kingdom Suite):	seisworks) 4096 7	
2D Color Map Size: (n_x_bins *n_y_bins <= max_colors)	8 No. of x-axis color bins: 65 * No. of y-axis color bins: 63	_
Clockwise rotation of 2D color bar) (Default = 0.0 with Blue up at 0 deg Red at 120 deg and Green at 240 de	, g):	
Plot title:	9 Mu_Rho_vs_Lambda_Rho	
Composite Output File (*.H):		
(c) 2008-2014 AASPI - The University	of Oklahoma	Execute

After clicking the execute button three plots will appear. The first one shows the 2D color bar, with Lambda_Rho on x-axis and Mu_Rho on the y-axis. The second plot shows the 2D histogram, which plots the probability density Lambda_Rho vs.Mu_Rho against the x-and y-axis. The third plot shows time slices through the 3D crossplotted volume. This can be converted into SEGY and then be loaded into your interpretation software.







Figure 2. A 2D histogram using the default scaling parameters.



Figure 3. A stratal slice of the Lower Barnett shown as a crossplotted volume of Lambda -Rho vs. Mu-Rho.

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 are 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 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 lithology and geomechanical behavior.



Figure 4. The same data as shown in Figures 2 and 3, but now adjusted to provide better dynamic range of the data.



Figure 5. A vertical slice through the crossplotted volume. Quartz-rich facies appear as red and orange, clay -rich as green, and calcite-rich as cyan, blue, and purple. (After Perez, 2013).

References

Perez, R., 2013, Brittleness estimation from seismic measurements in unconventional reservoirs: Application to the Barnett, Ph.D. dissertation, The University of Oklahoma.