



This example gives an overview of the Emeraude PNL module.

## B06.1 • Loading the data

### B06.1.1 • PNL data types

The table below summarizes the data types, as well as the default mnemonics for the PNL. Data are loaded as usual, either with the 'Load' option of the 'Survey' panel, or the 'Load Well Data' option of the 'Document' panel.

[-] Sigma borehole	[-] Total porosity	[-] Total water saturation
[-] SIBH	[-] PHIT	[-] SWT
[-] SIBF	[-] Neutron porosity	[-] Water saturation
[-] Sigma formation	[-] PHIN	[-] SW
[-] SIF	[-] Effective porosity	[-] Bound water saturation
[-] SIGM	[-] PHIE	[-] SWB
[-] Sigma hydrocarbon	[-] V dry clay	[-] Free water saturation
[-] SIHYD	[-] VK	[-] SWF
[-] Sigma matrix	[-] V shale	[-] Gas Saturation
[-] SIMA	[-] VSH	[-] SG
[-] Sigma shale	[-] Near to far gate counts	[-] Hydrocarbon saturation
[-] SISH	[-] RATIO	[-] SHYD
[-] Sigma water		
[-] SIW		
[-] Sigma water bound		
[-] SIBW		
[-] Sigma water free		
[-] SIWF		

Fig. B06.1 • PNL data types

### B06.1.2 • Loading

- Start Emeraude, create a new document, a new survey, and load the data from the file B06.las. This file contains the following curves: Gamma Ray, Formation  $\Sigma$ , Effective Porosity, and Vshale.

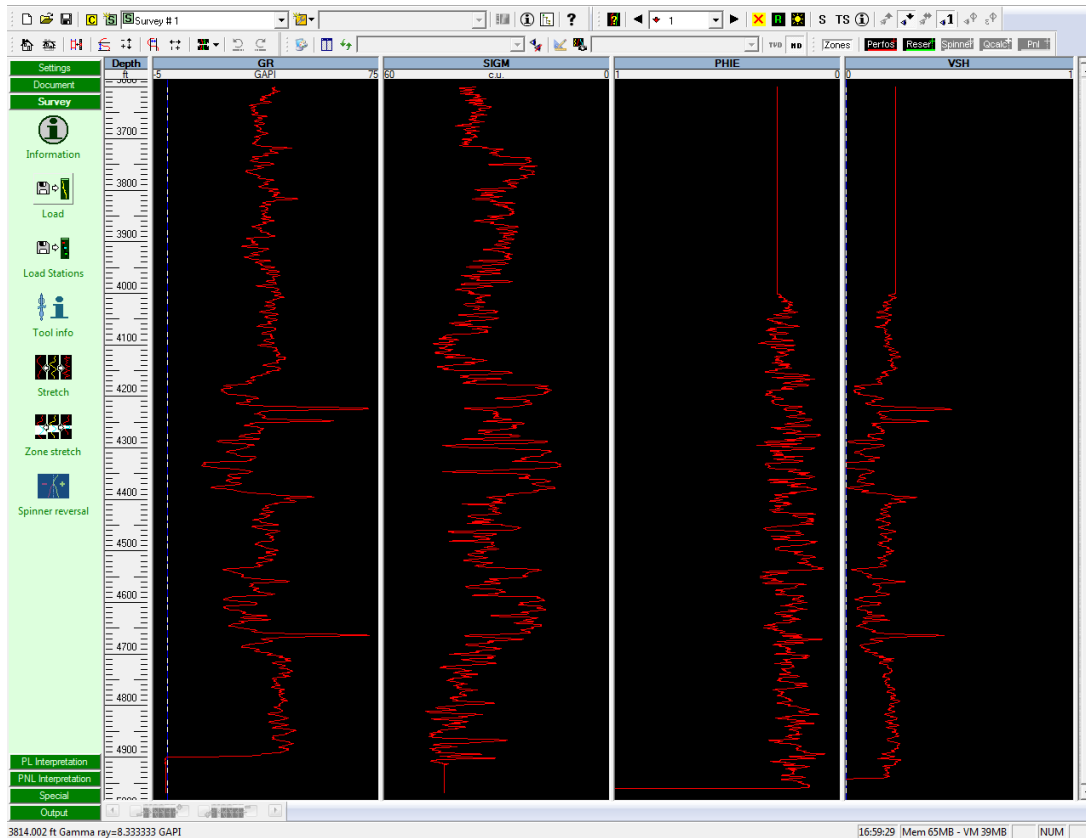


Fig. B06.2 • PNL data loaded

## B06.2 • Interpretation

### B06.2.1 • Initializing the interpretation

- Go to the 'PNL Interpretation' control panel and select the 'Information' option.
- Accept the default name/short name, the 'PNL Interpretation settings' screen is displayed, Fig. B06.3.

At the top of the dialog a switch is offered between Clean Formation (no shale), Shaly assuming a Single Water model, or Shaly assuming a Dual Water model.

Based on the selected model, the grid indicates the list of channels required to perform the interpretation, i.e. to calculate Sw. The last few rows, with a question mark icon, are for optional input.

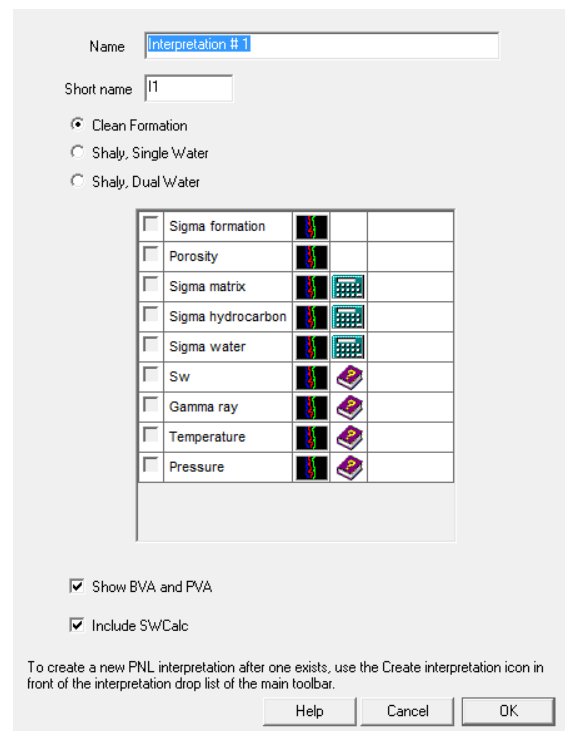


Fig. B06.3 • Interpretation settings



**Define**

Equivalent to the 'Define' option used in the 'PL Interpretation settings' dialog. This option invokes the average dialog where channels are sought within the Survey Up/Down passes as well as General Well Data.



**Compute**

The 'Compute' option can be used within this dialog to initialize the various channels for instance using correlations. Details are given below.

**Checkbox**

At the beginning of each line, a checkbox indicates whether a channel of the considered type has been defined within the interpretation.

**Mnemonic**


The last cell on each line gives the mnemonic of the current channel (when the definition has been done).



**Optional Channels**

For optional channels the Help file can be consulted (with the question mark button) to see a brief explanation of what the channel may be used for.

- Select the 'Shaly, Single Water' model. The list of required channels is shown in Fig B06.4.

The first three channels are available from the input and can be initialized using the 'Define' option .

- Select this option in turn and in the subsequent dialog, choose the curve present in Down1 and click OK.

This creates a copy of the channel inside the 'Interpretation' node.

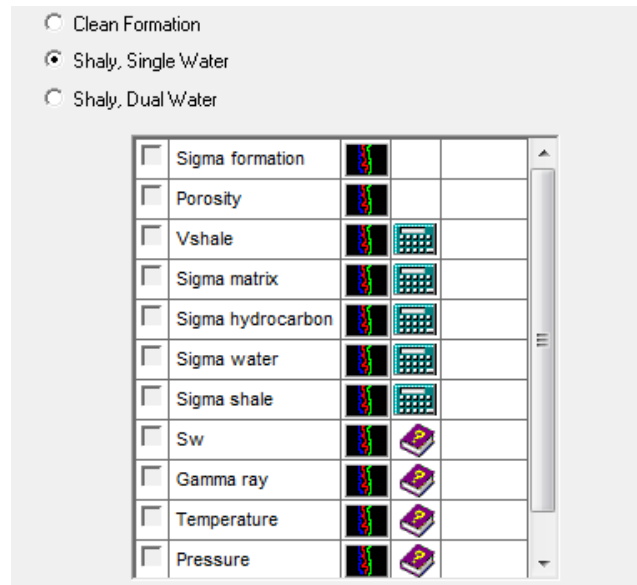



Fig. B06.4 • Interpretation settings dialog

*If a neutron porosity had been defined (mnemo PHIN), an additional control would appear in the PNL Interpretation Settings to let the user enter a value for 'PHIN sh' used to correct the neutron porosity for shale.*

### B06.2.2 • Selection of Parameters

#### Σ matrix

- There is no input curve so we will use the  button.

The table on the right in the dialog is there only to indicate possible values. In this particular example:

- Keep the default value of 10 c.u. that can be re-defined later in the interpretation process.

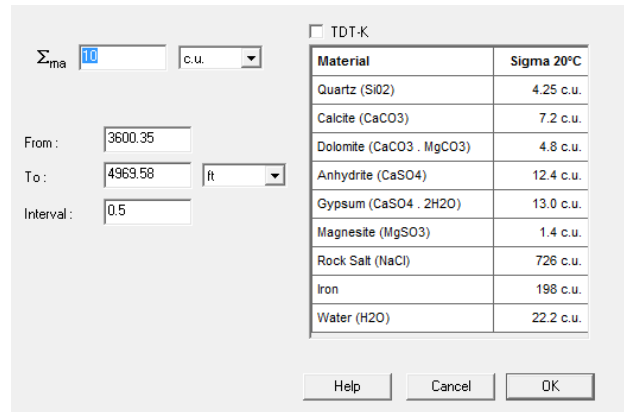



Fig. B06.5 • Sigma matrix screen

#### Σ hydrocarbon

- Select the 'Calculate' button .

The Temperature and Pressure values are given only when there is no Pressure/Temperature channel defined in the interpretation. Otherwise, the value will be read directly from those channels. At the bottom the calculated Σ value is displayed when the 'Calculate' button is clicked.

- Keep the default values; you can check that they give a hydrocarbon sigma around 21 c.u. Validate with OK.

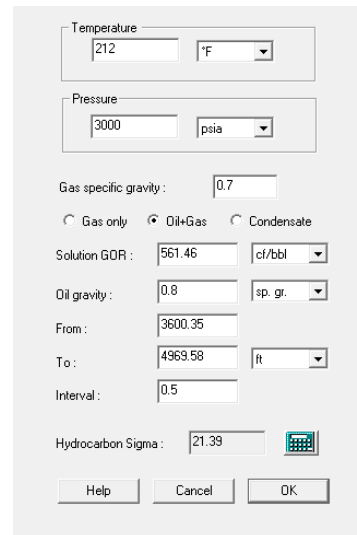


Fig. B06.6 • Hydrocarbon Sigma initialisation

#### Σ water

- Select the 'Calculate' button .

For temperature and pressure the same principle as for the hydrocarbon Σ applies: if there are such channels inside the interpretation, they will be used directly.

- Change the salinity to **100000 ppm**, you can check that the water capture cross section is changed to about 56 c.u.

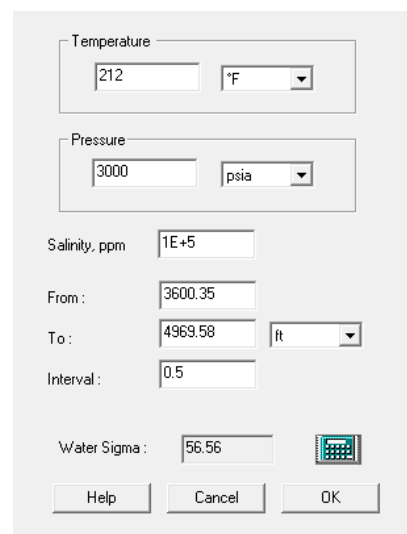



Fig. B06.7 • Water Sigma screen

**Σ shale**

- Select the 'Calculate' button .
- The default value is initialized as the maximum-recorded formation Σ.

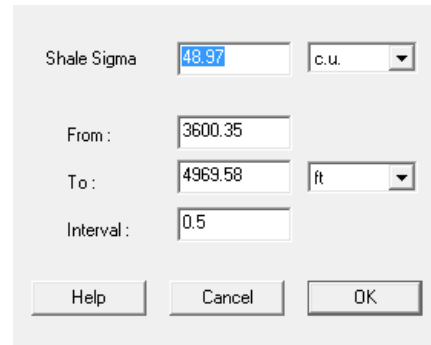


Fig. B06.8 • Shale Sigma screen

**B06.2.3 • Automatic Views and Input Channels**

The boxes for the interpretation views; 'Bulk Volume Analysis' (BVA) and 'Pore Volume Analysis' (PVA) are checked by default. Click OK. One interpretation view is created for BVA. The PVA will be created upon the computation of the water saturation SWCalc. Hide all the views except for the Gamma Ray and the BVA view.

- Open the browser to check the content. All channels created appear under the 'Input' interpretation node, see opposite.

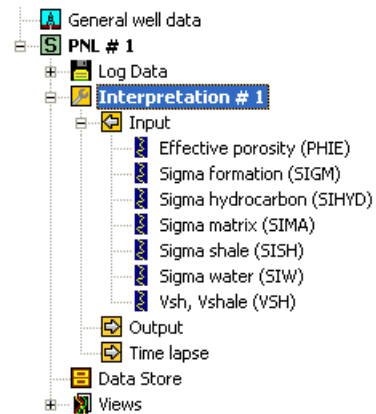


Fig. B06.9 • Input interpretation mode

- Hide the undesired channel and tile.

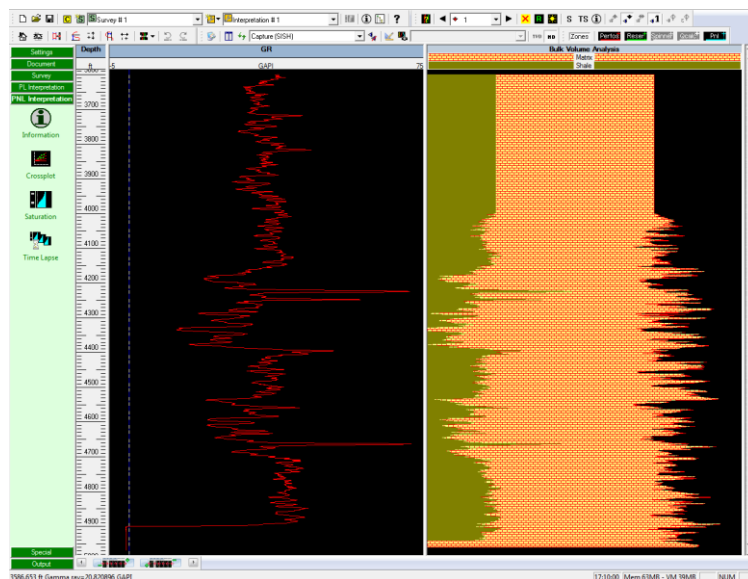





Fig. B06.10 • Gamma Ray and BVA view

## B06.3 • Cross-plots

### B06.3.1 • Basic cross-plot functions

- Zoom the depth  from 4,000 to 4,900 ft. Hit 'Total range' to apply the changes.
- Press OK.
- Define two PNL zones from 4,360 to 4,417 ft and from 4,597 to 4,647 ft.

You can use the  button in the zone toolbar, or else the  button to type in the exact depths.

- Click the 'Crossplot' button. The cross-plot options depend on the interpretation model chosen as follows:

Single Water model:  $\Sigma - \phi$ ,  $\Sigma_{eq} - \phi_{eq}$ ,  $\Sigma_{ma} - V_{ma}$

Dual Water model:  $\Sigma_{wa} - S_{wb}$

With the Single Water model, cross-plots can be built with or without the shale correction.

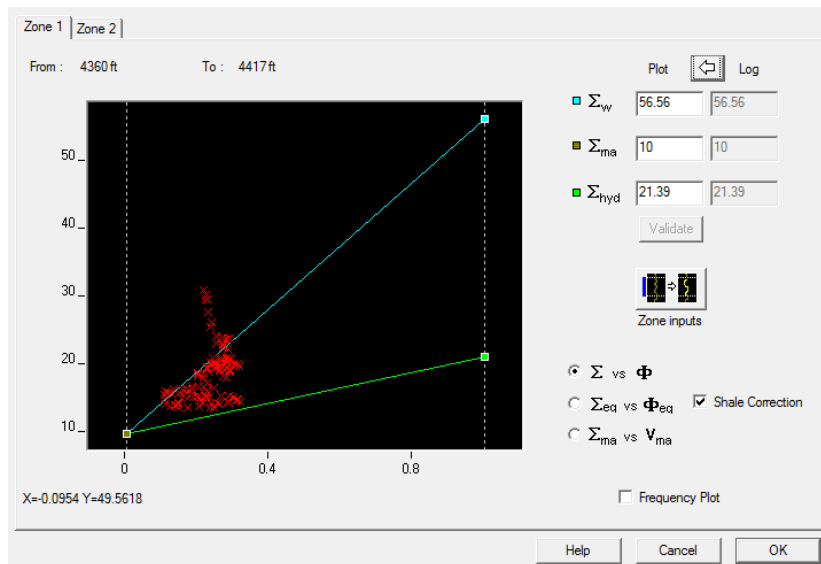




Fig. B06.11 • Cross-plots

At the top right of the plot are displayed the log values and the cross-plot values. When entering the dialog those values are the same. In our example the  $\Sigma - \phi$  cross-plot seems to warrant a higher  $\Sigma_w$ , perhaps a higher  $\Sigma_{ma}$ . The local value of those parameters can be modified either by direct edition in the field, and , by dragging the lines on the screen or moving the line end-points.


#### Manual edition

- You can experiment by changing manually the value of  $\Sigma_{ma}$  to 13 and click . The plot is updated.
- You can change the  $\Sigma$  values on the plot by clicking and dragging the end-points: the new values are updated in the boxes.

### Dragging

By clicking the left mouse button inside the cross-plot you can drag a line. When you move the mouse up/down only the line intercept changes. When you move the mouse left/right the line rotates. As you drag the line, Local  $\Sigma$  values are updated in the 'Plot' column at the top right. Drag the line between  $\Sigma_w$  and  $\Sigma_{ma}$ . Note that when you do so,  $\Sigma_{ma}$  will be changed as well. You can also move onto an end-point and drag this point alone. When dragging the line or editing values manually, only local parameters are modified. To actually change the log values requires the user to call the 'Modify logs' option.



This option is accessed by pressing on  that displays the dialog:

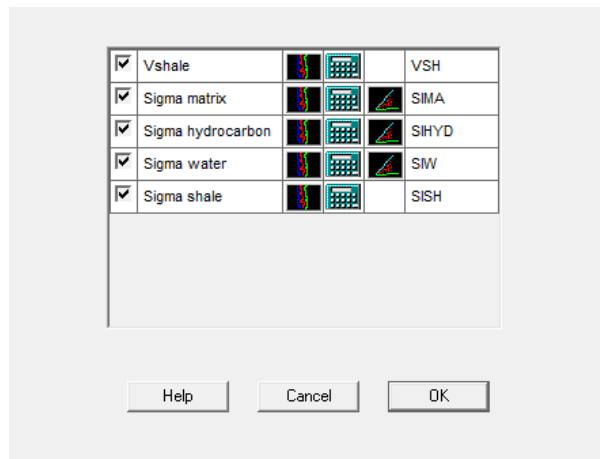



Fig. B06.12 • 'Zoned actions' dialog

Then, pressing on  displays the dialog:

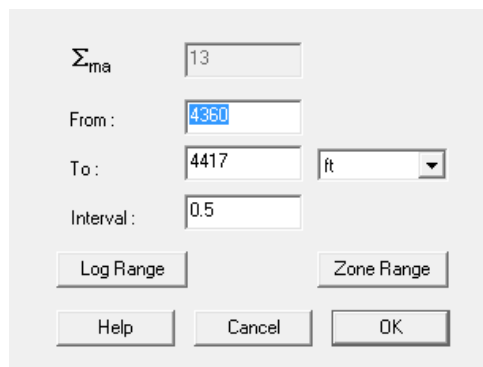



Fig. B06.13 • Cross-plot parameters

Where the user can specify the log range to be modified according to the new cross-plot parameters.

Do not make any log modification at this stage.

### B06.3.2 • Additional cross-plots

In order to help refine the input parameters, two other cross-plots (in addition to  $\Sigma - \phi$ ) can be built when an initial value of the water saturation is available, as often happens with the Open Hole logs. These additional cross-plots are:  $\Sigma_{eq} - \phi_{eq}$  and  $\Sigma_{ma} - V_{ma}$ .

- Return to 'Survey', open the file B06\_tl.las. Accept to define mnemos that are unknown.
- Define SW80 as a Water saturation
- Use the filter to skip the other columns.
- Select 'Import'. The new curve is loaded in Pass Down 2
  
- Go to the 'Information' option of the PNL panel.
- Click on the  option for the input SW.
- Select the channel from pass Down2.
- Return to the 'Crossplot' option.
  
- Select the Crossplot option  $\Sigma_{eq} - \phi_{eq}$ :

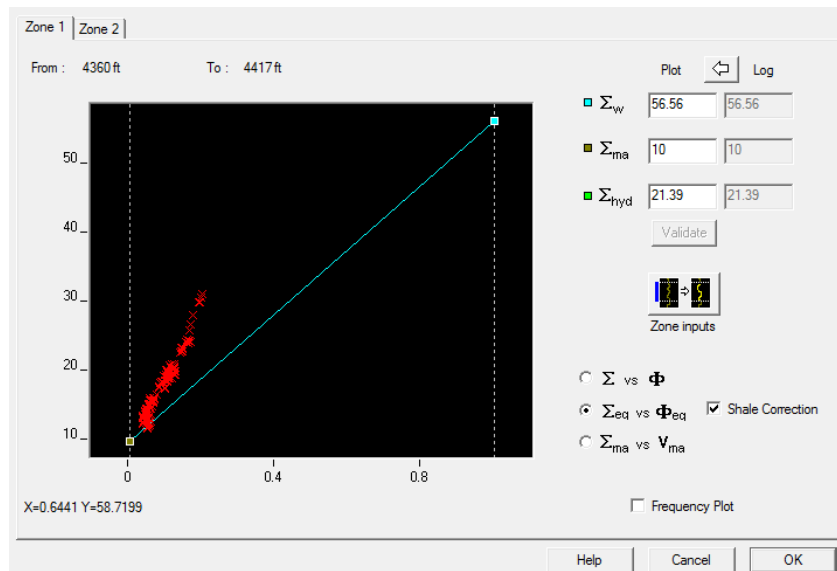



Fig. B06.14 • Cross plots

This plot removes the influence of hydrocarbon on the data. Hence on the cross-plot the data points should lie on a line joining  $\Sigma_{ma}$ , and  $\Sigma_{water}$  – provided of course  $\Sigma_w$  has not changed since the first measurement (open hole logs in our case), which is not true in this example. In fact it is rarely true in most wells in which pulsed neutron logs are run but we are here only trying to validate our choice of parameters.

- Drag the line to fit the data points (of course  $\Sigma_{ma}$  will change). Set  $\Sigma_w$  to 88,
- .

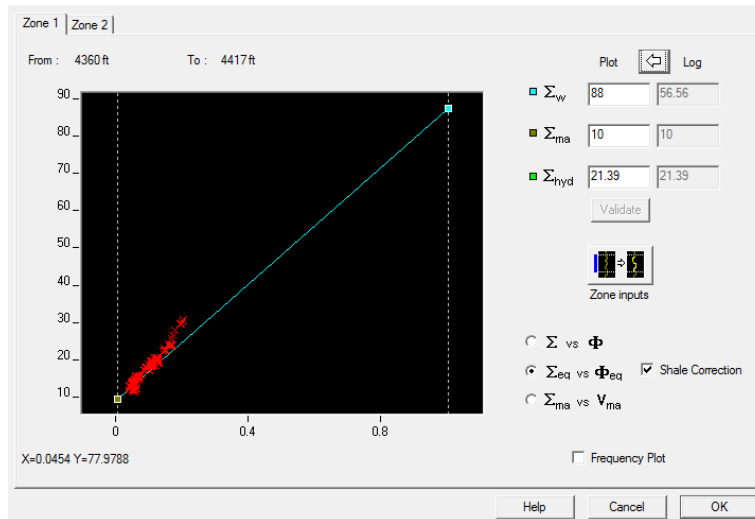


Fig. B06.15 • Cross-plots dialog

Note that you can also at this stage gauge the effect of the shale correction on this cross-plot by toggling between the two options on the 'Shale Correction' checkbox.

- Select the Cross-plot option:  $\Sigma_{ma} - V_{ma}$ .
- Select 'Frequency plot'.

A grid is drawn on the plot, and a summation is made for each small square of the grid, giving the total number of points inside the corresponding square on the plot.

On the  $\Sigma_{ma} - V_{ma}$  cross-plot  $\Sigma_{ma}$  is calculated by solving the  $\Sigma_{log}$  equation in reverse, assuming again that the saturations have not changed since initial times. The volume of matrix,  $V_{ma}$ , is  $V_{ma} = 1 - P_{hie} - V_{sh}$ . Hence on the plot the data points should funnel towards the proper value of  $\Sigma_{ma}$  for  $V_{ma} = 1$ .

- By moving the mouse cursor on the plot check that this is around a value of 11 c.u.
- Modify the local value of  $\Sigma_{ma}$  and

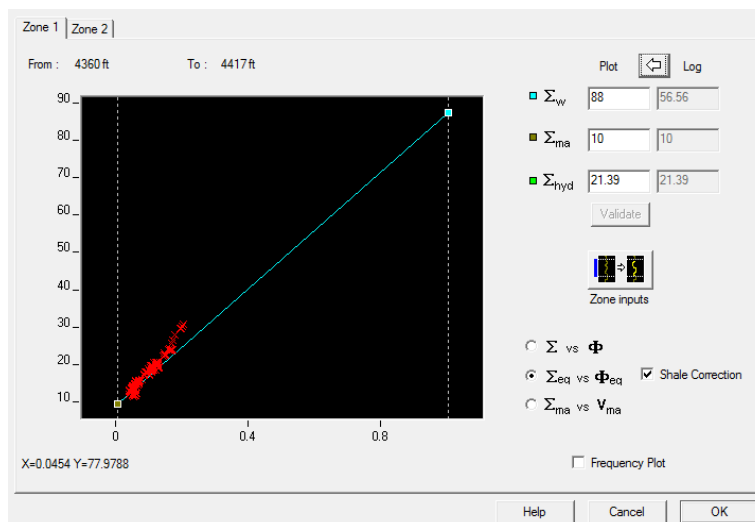
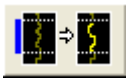


Fig. B06.16 • Cross-plots dialog

- Make sure to use (and Validate) the following values:  
 $\Sigma_w = 88$  c.u.  
 $\Sigma_{ma} = 11$  c.u.

### B06.3.3 • Log and input data modification

- Select the 'Zone inputs' option .

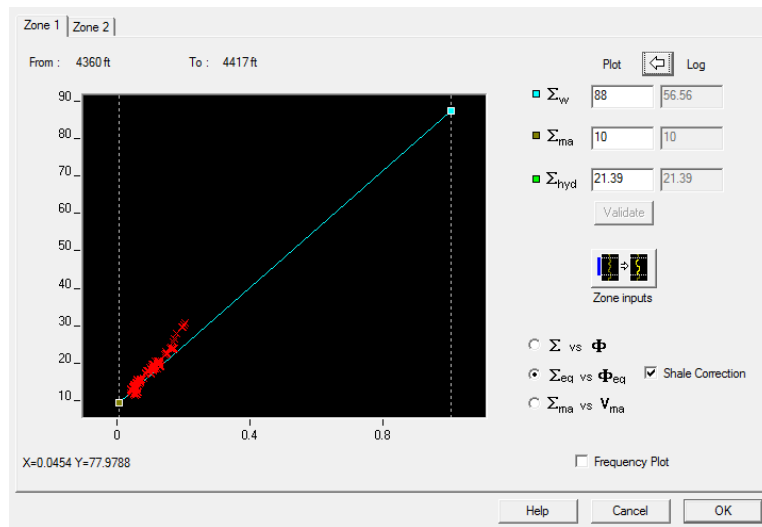






Fig. B06.17 • 'Zoned actions' dialog

Options in this dialog can be used in two ways:

- To define whole or part of a missing channel.
- To re-define whole or part of an existing channel.

There are 3 possible ways to define/re-define channel values:

-  Using a lateral average of some curves located inside the survey Up/Down passes or General Well Data.
-  Using the Compute options described earlier.
-  Using the cross-plot values when applicable. This option is offered only for those parameters that are used in building the cross-plots.

For all three  $\Sigma$ matrix,  $\Sigma$ hydrocarbon and  $\Sigma$ water, select the  option and click OK. You can check after leaving the 'Zone inputs' dialog that the 'Log values' in the top right corner, match the Local values (again check that you have  $\Sigma$ ma = 11,  $\Sigma$ water = 88;  $\Sigma$ hyd should be unaltered around 21 c.u.).

- Modify the logs over the 'Log Range' by pressing on **Log Range** in the dialog.
- Hit OK.
- Click OK to leave the cross-plot dialog.

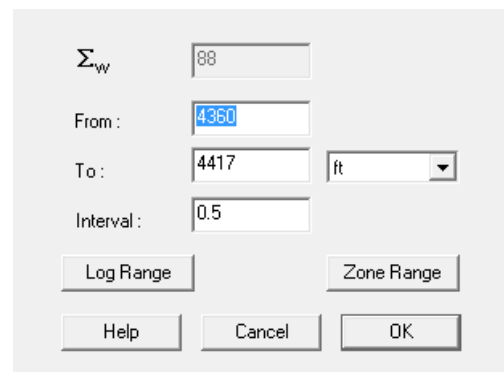


Fig. B06.18 • Cross-plot parameters

### B06.4 • Sw calculation

- Click on the 'Saturation' button in the Control Panel and OK.

The water saturation is calculated and a new view appears: 'Wcalc'. The BVA view now shows the water and hydrocarbons filling the pore space, in proportions corresponding to the calculated saturation. The PVA (Pore Volume Analysis) view is now created and as the SWCalc option in the 'Interpretation settings' dialog was checked, the calculated water volume will appear automatically on the PVA view.

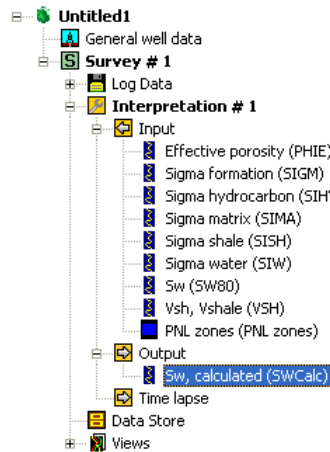


Fig. B06.19 • Data browser showing the Interpretation contents

- Hide the SW80 channel and reset the 'Current depth window' horizontal scale for SWcalc.

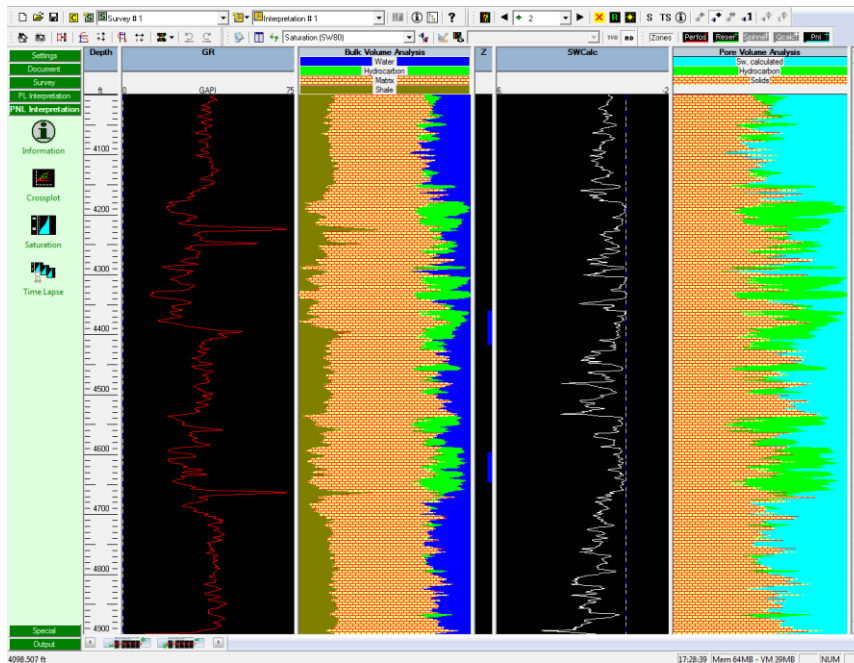


Fig. B06.20 • After calculation of the water saturation

The BVA and PVA automatic views display the Bulk Volume of Water:  $BVW = Phie * Sw$ . Whereas the display of the PVA View is governed by the contents of the 'Time-Lapse' node, the BVA View only displays the BVW curve corresponding to the saturation that has just been calculated.

## B06.5 • Time lapse presentation

The 'Time-Lapse' option allows presenting together any number of successive saturation curves, in order to visualize the variations of the saturation with time as new pulsed neutron surveys are performed. In our example, the TDT survey that we just interpreted was performed in 1982, and we want to compare the saturation with the original saturation computed from open hole logs run in 1980.

In the browser:

- Drop the original saturation from the 'Down2' onto the 'Time-Lapse' node.
- Rename it 'SW80'.
- Click on the 'Time-Lapse' icon in the Control Panel.

This opens up a dialog box in which the applicable Sw curves are selected for the time-lapse presentation. Of course it is essential that the earlier Sw profiles be selected first in order to respect the timing sequence for the presentation. Failure to do this would result in an incorrect shading sequence for the time-lapse presentation, yielding an incorrect visual representation of the replacement of hydrocarbons by water.

The 'Include SWCalc' box in the 'Interpretation settings' was previously checked and although SWCalc does not appear in the time lapse dialog nor in the time lapse node, it will automatically show in the PVA view and will be considered as the most recent saturation.

Once the dialog box is closed, the PVA view will display BVW curves corresponding to the two saturation profiles, SW80 and SW, Calculated. The deep-blue coding represents the original water, and the light blue represents the produced hydrocarbons that have been replaced by water. Green represents the hydrocarbons remaining after the 1982 TDT survey.

Two more surveys were performed over the interval 4520-4670, a TDT in 1990 and an RST in 1997.

- Reduce the depth interval to the above limits, and load the SW90 and SW97 channels from the B06\_tl file using the load option in the 'Time-Lapse' dialog.
- If necessary, declare the Mnemonics SW90 and Sw97 in 'Water saturation'.
- Skip the SW80 saturation already present in the 'Time-Lapse' node using the 'Filter' option.

The two saturations can be loaded simultaneously and will be displayed directly into the 'Time-Lapse' node. The name affected to the loaded saturations is the name originally found in the file (showing as the 'File Mnemo' in the loading dialog).

In order to respect the timing sequence of the surveys, SWCalc must show between the SW80 and SW90 saturations, which is not possible with the present choice of options.

- Go to the 'Interpretation settings' dialog and uncheck the 'Include SWCalc' box.
- Go back to the 'Time Lapse' dialog and click on the browser button.

That button accesses a 'selective' data browser showing only the relevant (already loaded or calculated) Sw curves that can be chosen for inclusion in the time lapse interpretation.

- Select the 'SWCalc' saturation and click OK.

- Rename it 'SW82' and re-order the sequence correctly using the 'Up' and 'Down' buttons (top saturation being the earliest).

On the PVA view, the display now shows the two additional saturation profiles, and incremental hydrocarbon depletion volumes are now represented by increasingly lighter shades of blue.

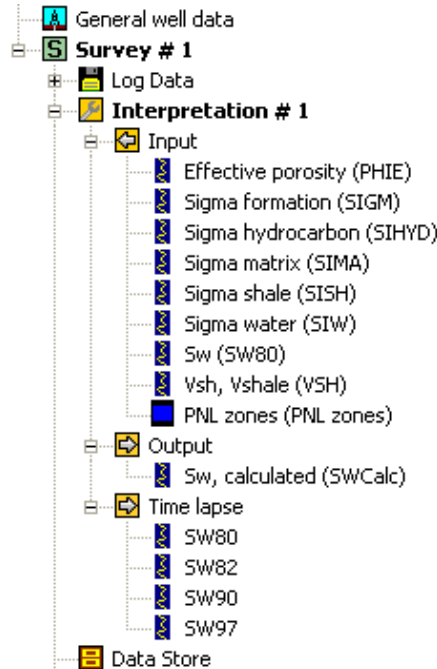


Fig. B06.21 • Data browser

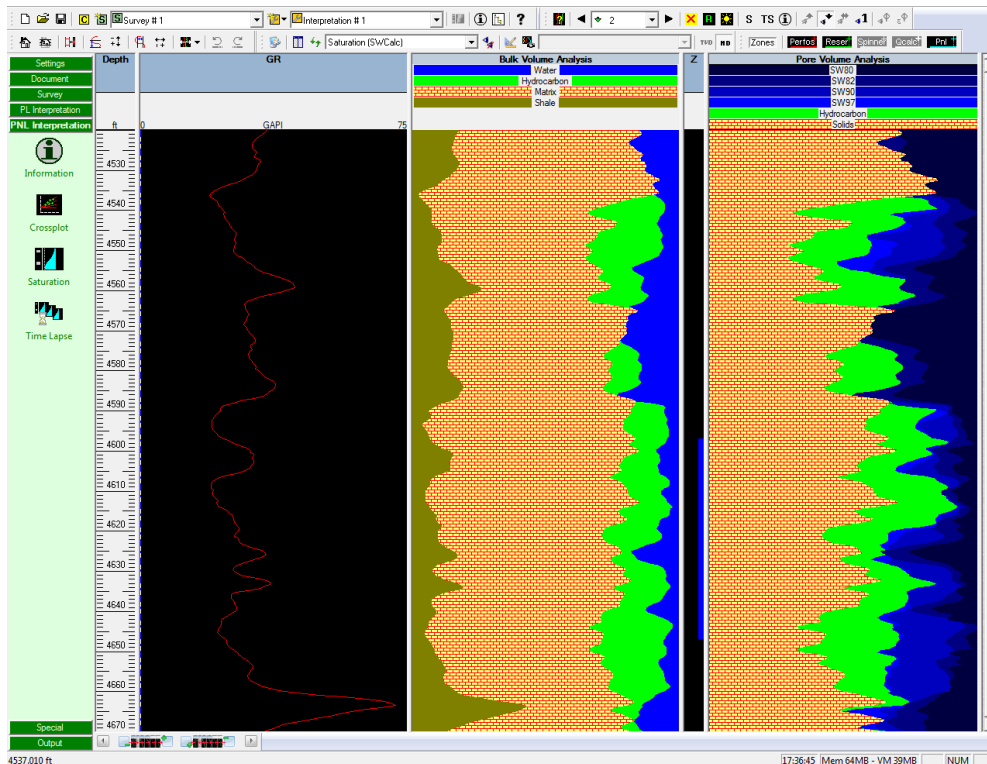


Fig. B06.22 • Time lapse interpretation

This concludes Guided Interpretation#6.