B06 Guided Interpretation #6: PNL

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.

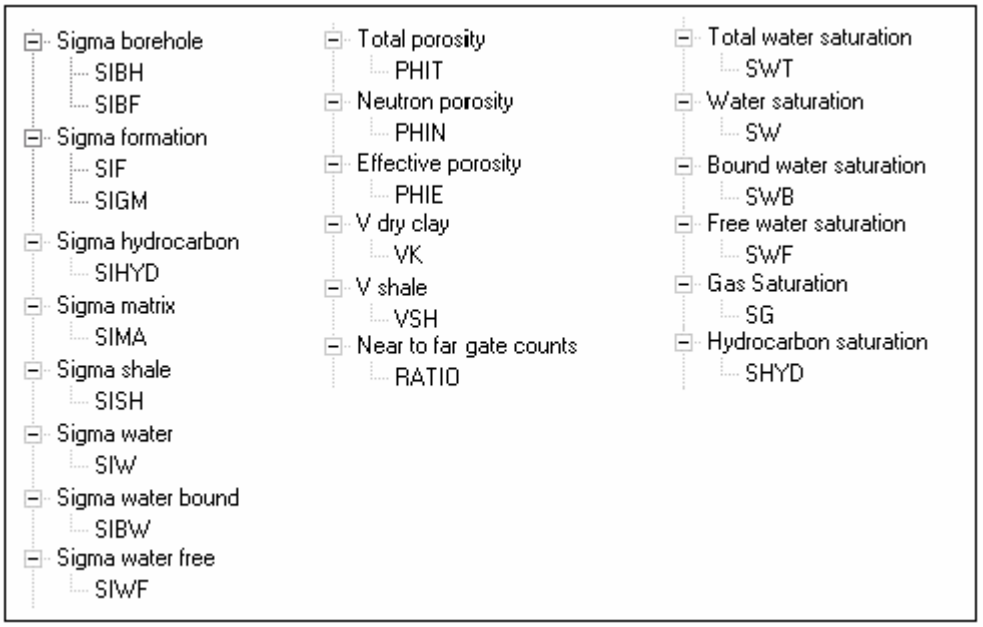


Fig B06.1

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 Σ, Effective Porosity, and Vshale.

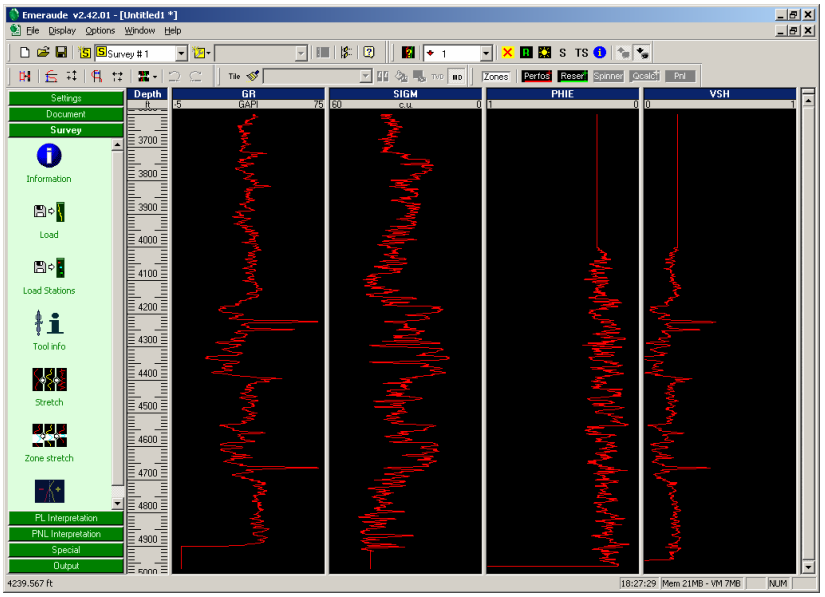


Fig B06.2 PNL data loaded

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.

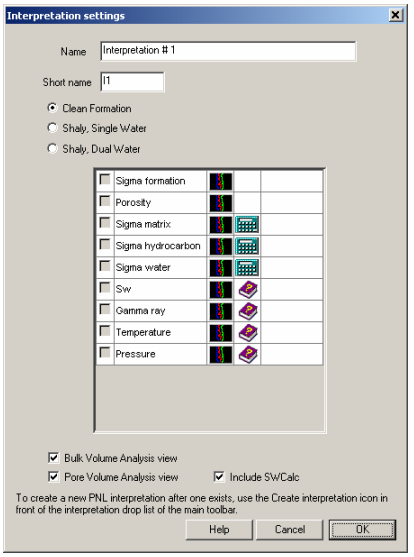


Fig B06.3

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

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.

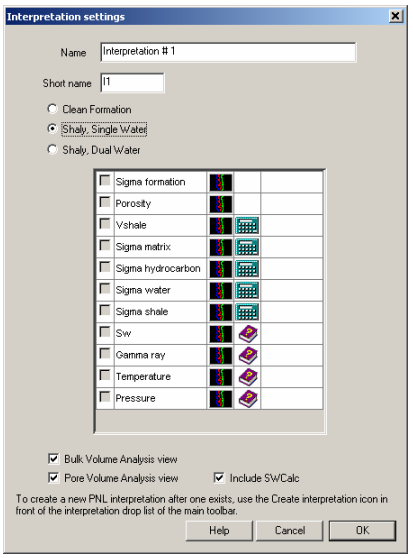


Fig B06.4

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.

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

B06.2.2 • Selection of Parameters

S **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 we will keep the default value of 10 c.u. (capture units) that can be re-defined later in the interpretation process.

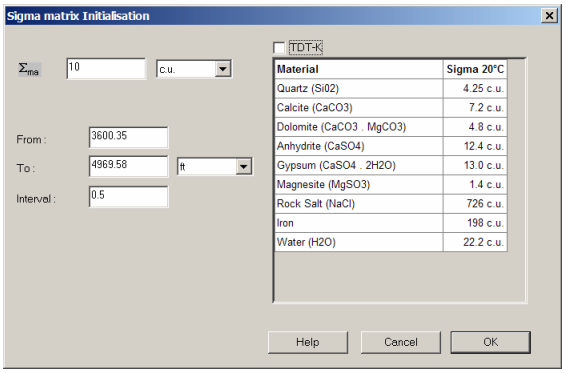


Fig. B06.5

S **hydrocarbon**

Select the 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 of 21 c.u. Validate with OK.

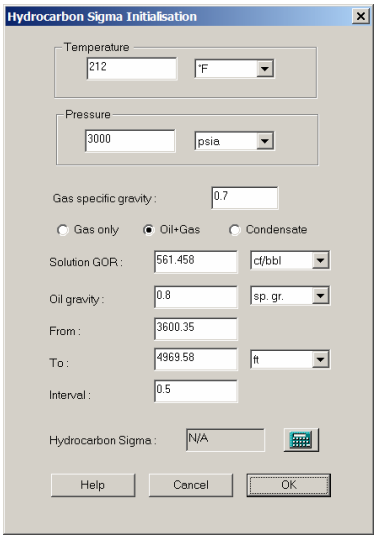


Fig. B06.6

S **water**

Select the 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 56 c.u.

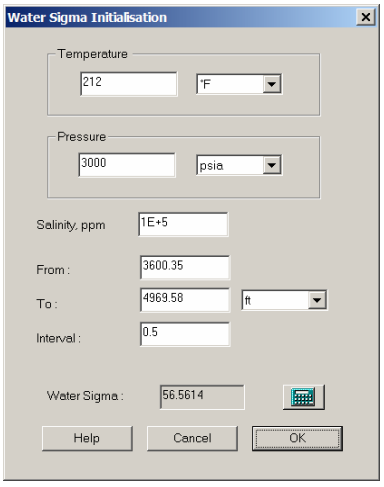


Fig. B06.7

S **shale**

Select the  button.

The default value is initialized as the maximum-recorded formation Σ.

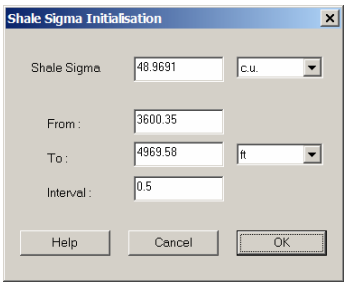
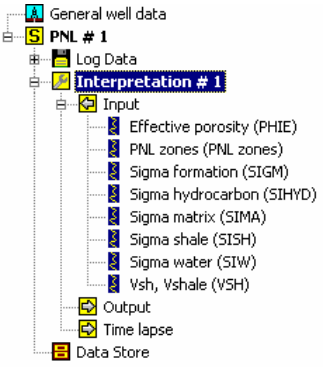


Fig. B06.8

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.



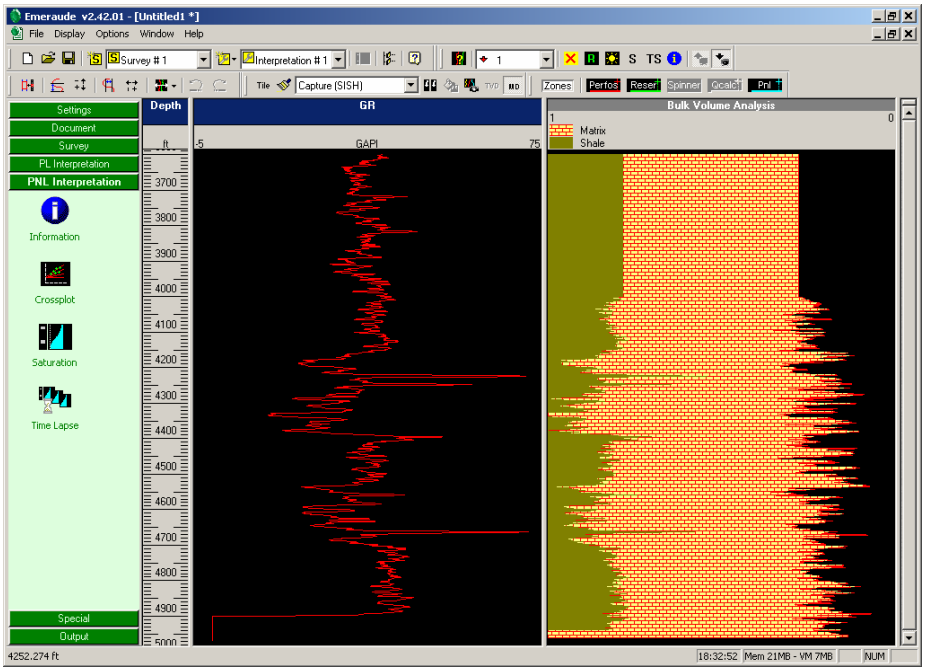


Fig B06.9

B06.3 • Crossplots

B06.3.1 • Basic crossplot functions

Zoom the depth from 4,000 to 4,900 ft.

Define two PNL zones from 4,360 to 4,417 ft and from 4,597 to 4,647 ft. You can use the Pnl button in the zone toolbar, or else the Zones button to type in the exact depths.

Click the Crossplot button. The crossplot options depend on the interpretation model chosen as follows:

Single Water model: Σ–ϕ, Σ_{eq} - ϕ_{eq}, Σ_{ma} – V_{ma}
Dual Water model: Σ_{wa} – S_{wb}

With the Single Water model, crossplots can be built with or without the shale correction.

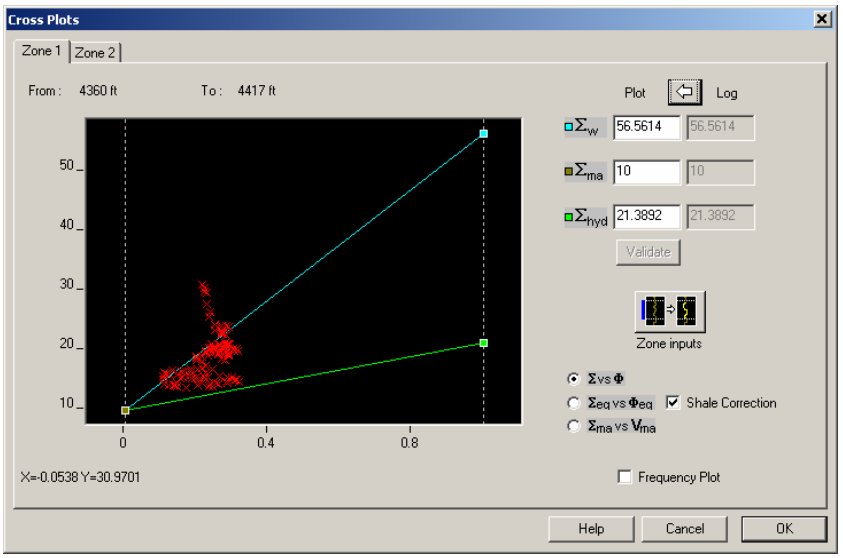


Fig B06.10

At the top right of the plot are displayed the log values and the crossplot values. When entering the dialog those values are the same.In our example the Σ–ϕ cross plot seems to warrant a higher Σ_w, perhaps a higher Σ_{ma}. The local value of those parameters can be modified either by direct edition in the field, and Validate, or by dragging the lines on the screen.

Manual edition

You can experiment by changing manually the value of Σ_{ma} to 13 and click validate. The plot is updated.

Dragging a line

By clicking the left mouse button inside the crossplot 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 Σ values are updated in the "Plot" column at the top right. Drag the line between Σ_w and Σ_{ma}. Note that when you do so, Σ_{ma} will be changed as well. Try to move in such a way as to keep a constant value for that parameter. 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.

Do not make any log modification at this stage.

B06.3.2 • Additional crossplots

In order to help refine the input parameters, two other crossplots (in addition to Σ–ϕ) can be built when an initial value of the water saturation is available, as often happens with the Open Hole logs. These additional crossplots are: Σ_{eq} - ϕ_{eq} and Σ_{ma} – V_{ma}.

Return to Survey, open the file B06_tl.las. Load only the first curve (mnemo SW80). This will be defined as pass Down 2. Skip the other columns.

Go to the Infos/New option of the PNL panel, click on the  option for the input SW, and select the channel from pass Down2. Return to the crossplot option.

Select Crossplot option S_{eq} - f_{eq}:

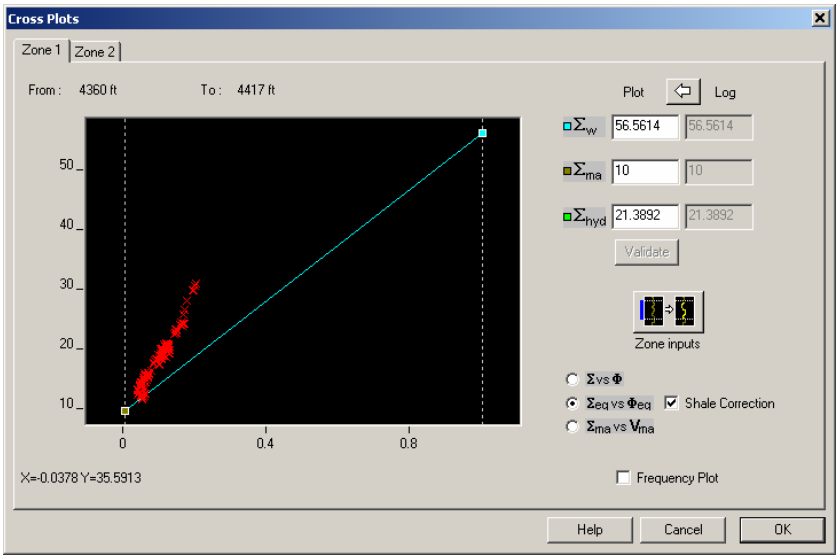


Fig B06.11

This plot removes the influence of hydrocarbon on the data. Hence on the crossplot the data points should lie on a line joining Σma, and Σwater – provided of course Sw 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 Σma will change). Set Σwater to 88, and validate.

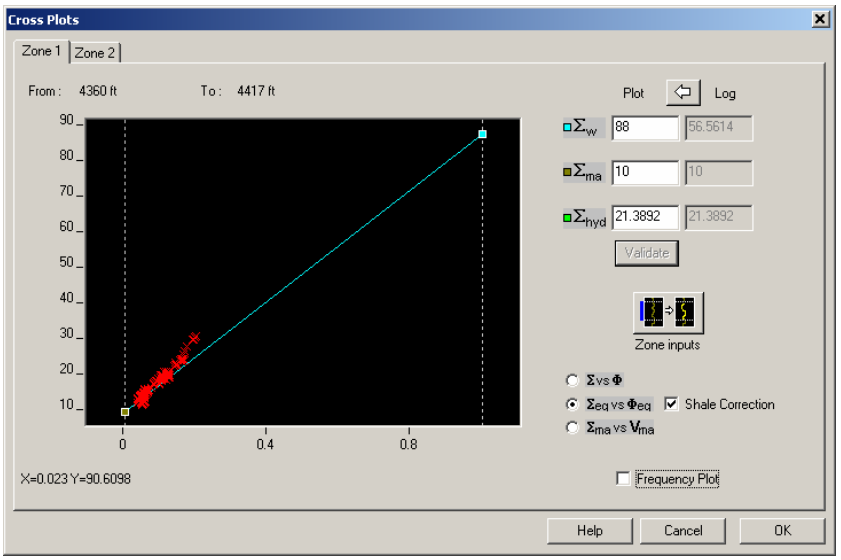


Fig B06.12

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

Select Crossplot option: S_{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 S_{ma} **– V_{ma}** crossplot Σma is calculated by solving the Σlog equation in reverse, assuming again that the saturations have not changed since initial times. The volume of matrix, Vma, is Vma = 1 – Phie – Vsh. Hence on the plot the data points should funnel towards the proper value of Σma for Vma = 1. By moving the mouse cursor on the plot you can check that this is probably around a value of 11 c.u.

Modify the local value of Σ_{ma} and validate.

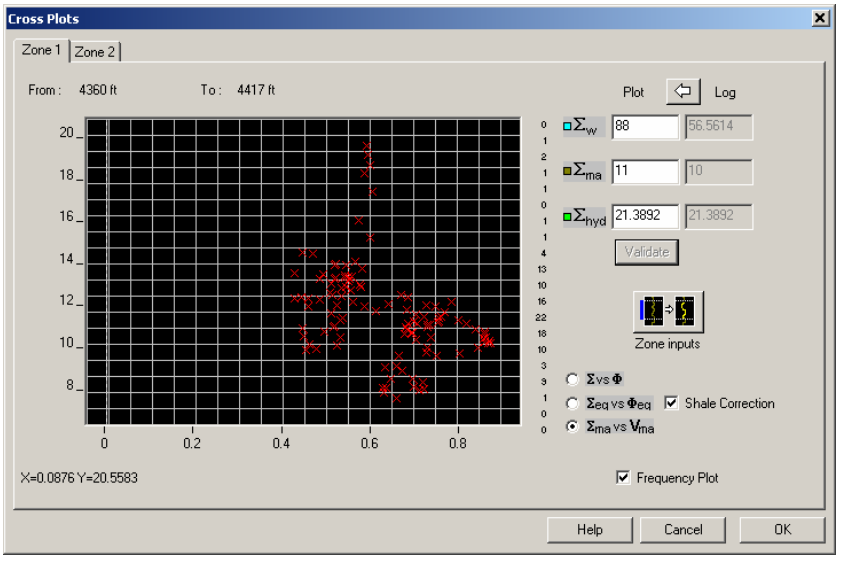


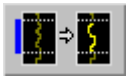
Fig B06.13

Use and validate the following values:

Σwa = 88 c.u.

Σma = 11 c.u.

B06.3.3 • Log and input data modification.

Select Modify Log option 

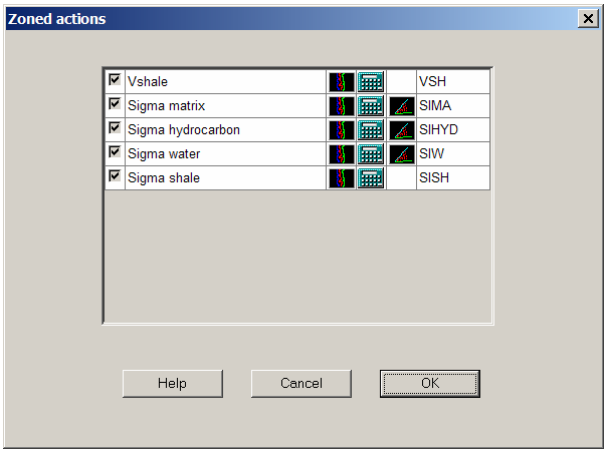


Fig B06.14

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 crossplots.

For all three Σmatrix and Σwater, select the  option and click OK. You can check after leaving the Modify Log dialog that the “Log values” in the top right corner, match the Local values (again check that you have Σma = 11, Σwater = 88; Σhyd should be unaltered around 21 c.u.).

Modify the logs over the “Log Range”. Click OK to leave the cross plot dialog.

B06.4 • Sw calculation

Click on the ‘Saturation’ button in the Control Panel. The water saturation is calculated and a new view appears: ‘SWCalc’. 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 Infos/New was checked, the calculated water volume will appear automatically on the PVA view. See section B06.5 Time-lapse for detailed information on this option.

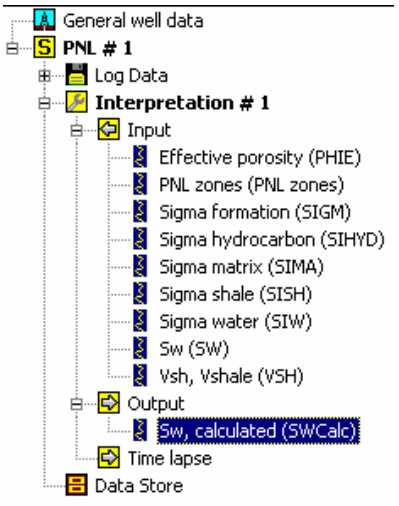


Fig. B06.15; Data browser showing the Interpretation contents

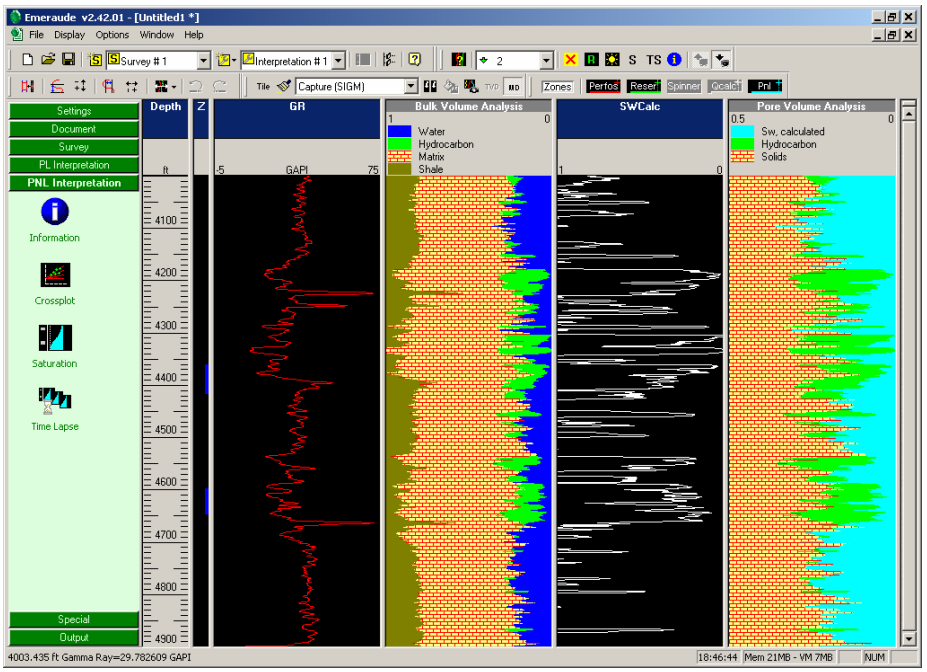


Fig B06.16 After calculation of the water saturation

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' load into the 'Time-Lapse' sub-level. 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.

"Include SWCalc" box in the Info/New 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 SWCalc. 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. Skip the SW80 saturation already present in the 'Time-Lapse' node. 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 Info/New dialog and unchecked 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.

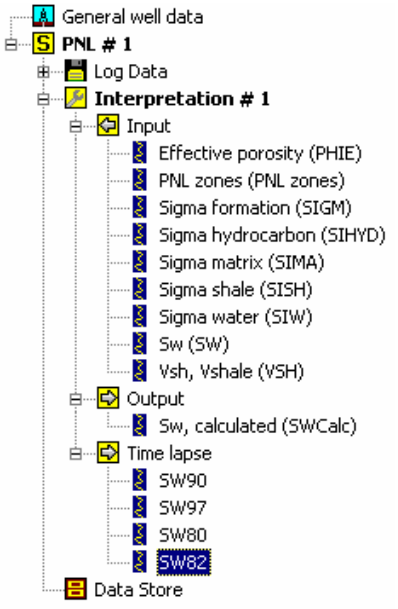


Fig. B06.17

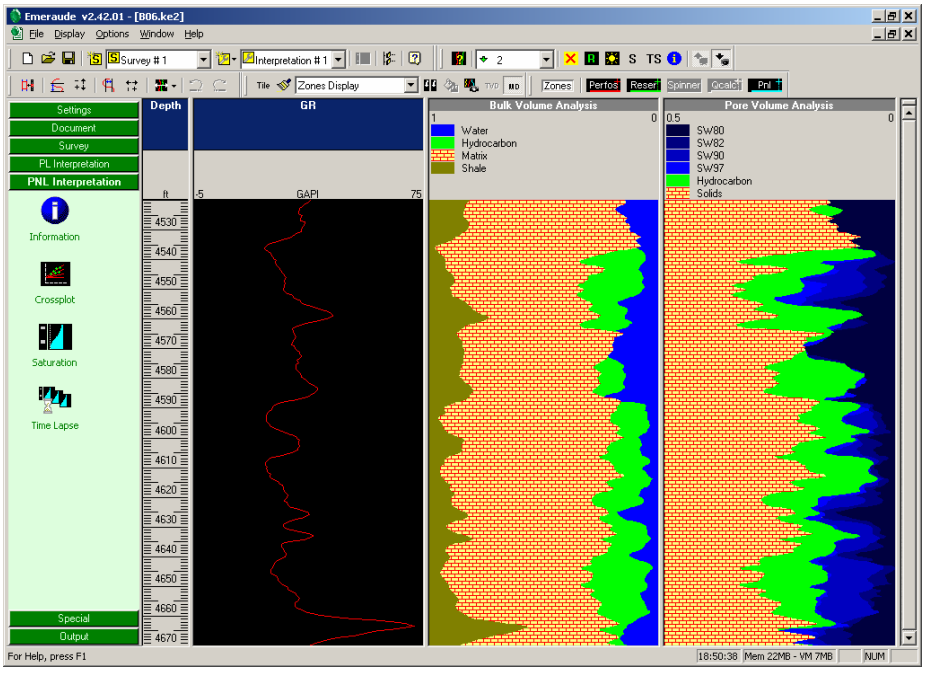


Fig B06.18

This concludes Guided Interpretation#6