B05 – Guided Interpretation #5

This example treats a deviated producer (74deg) logged with Multiple Probe Tools, two DEFT, and stationary water velocity measurements. The well is producing from 4 sets of perfs, through isolated, internal gravel pack screens. The PLT data does not cover the deepest set of perfs. The following facilities are illustrated in this example:

- Handling X-Y caliper data.
- Image views.
- Well views.
- Working with Multiple Probe Tools.
- Loading / processing of stationary measurements.
- By-passing slippage correlation when enough information is provided.

The data for B05 is contained in several files:

- B05_gwd.las: “General well data”; contains an open-hole gamma-ray and a deviation survey,
- B05d1.las, B05d2.las, B05u1.las, B05u2.las: flowing survey log data (except stations),
- B05_sta_8071.las, B05_sta_8325.las, B05_sta_8578.las: stations with water velocity (name indicates depth in ft),
- B05.epv: PVT file.

B05.1 • Create B05 and load the general well data

Start Emeraude and create a new document with oilfield units. In the Document panel, select “Load Well Data” and load the channels present in the file B05_gwd.las: open-hole gamma ray and deviation survey. Only the gamma-ray is plotted by default. *The creation of a well view will be illustrated later.*

In Document – Well Details, Define the Perforations and Reservoir zones as given below (note that reservoir zones can be associated a name):

Perforations (ft)		Reservoir zones (ft)		
8248	8314	8232	8317	A
8461	8530	8447	8535	B
8615	8734	8581	8737	C
9009	9068	8995	9074	D

B05.2 • Create the survey and load the log data

In the survey panel, select the “Create a new Survey” icon in font of the survey drop list of the main toolbar. Call it Production#1, short name P1. Select “Load” and “Add” the files: B05d1.las, B05d2.las, B05u1.las, B05u2.las.

The depth is always increasing in these LAS files. However the depth direction in the logging file is used by Emeraude as a starting point to determine whether a LAS file is an Up or a Down pass. Consequently, you will need to change the pass type/direction (and index) manually in the load dialog, Fig. B05.1.

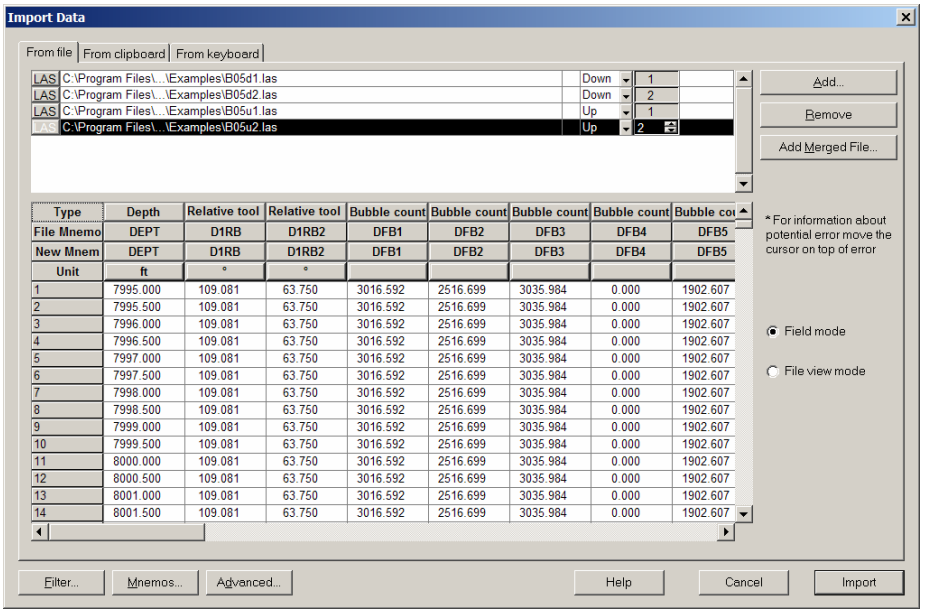


Fig. B05.1 • Loading the log data

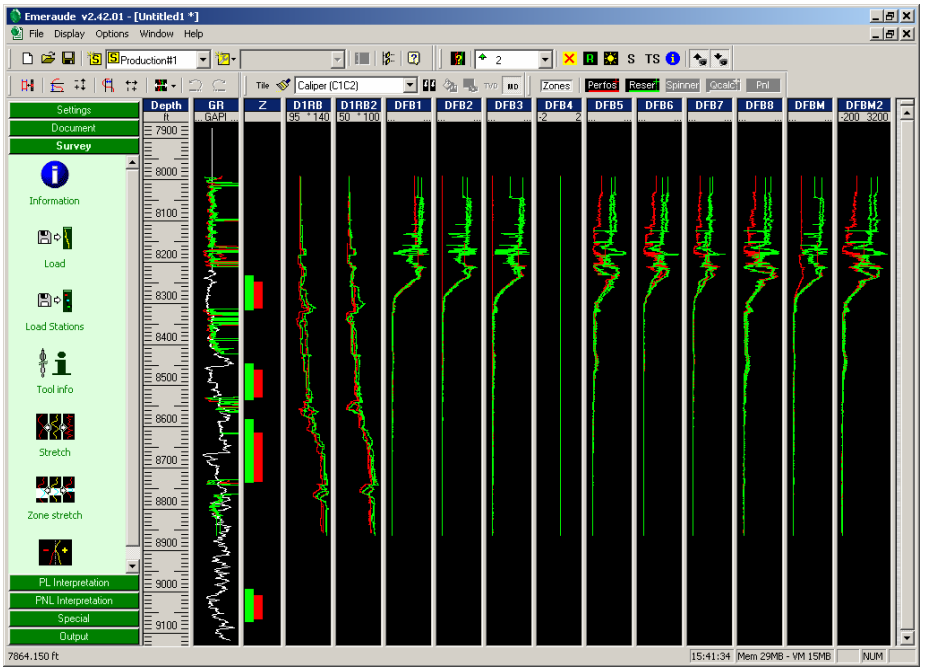


Fig. B05.2 • Log data loaded

Remove all channels from the screen by double clicking on any plot title bar, and dragging the maximized plot off the screen. Click on the option next to the hidden plot list to access the dialog opposite, Fig. B05.3. Using the "Ctrl" key for multiple selection, you can highlight on the left part: GR, SCVL, SPIN, WPRE, WTEP, C1C2. Move the selected views to the right with ">", and validate with OK.

Tile the plots. The screen is re-organized as on Fig B05.4.

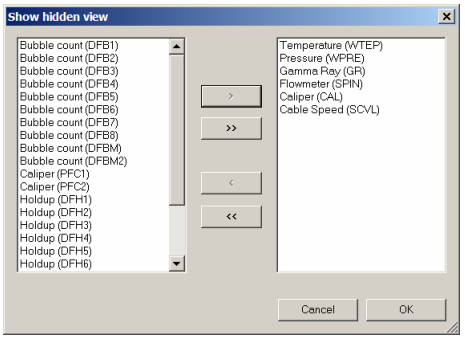


Fig B05.3

The C1C2 channels are constructed automatically from the PFC1 and PFC2 channels. Their values are calculated as $\mathrm{CaliperC1C2} = \sqrt{\mathrm{CaliperC1} \times \mathrm{CaliperC2}}$.

Note: See "How to use caliper data" in the online help for more detailed explanation of X-Y caliper data.

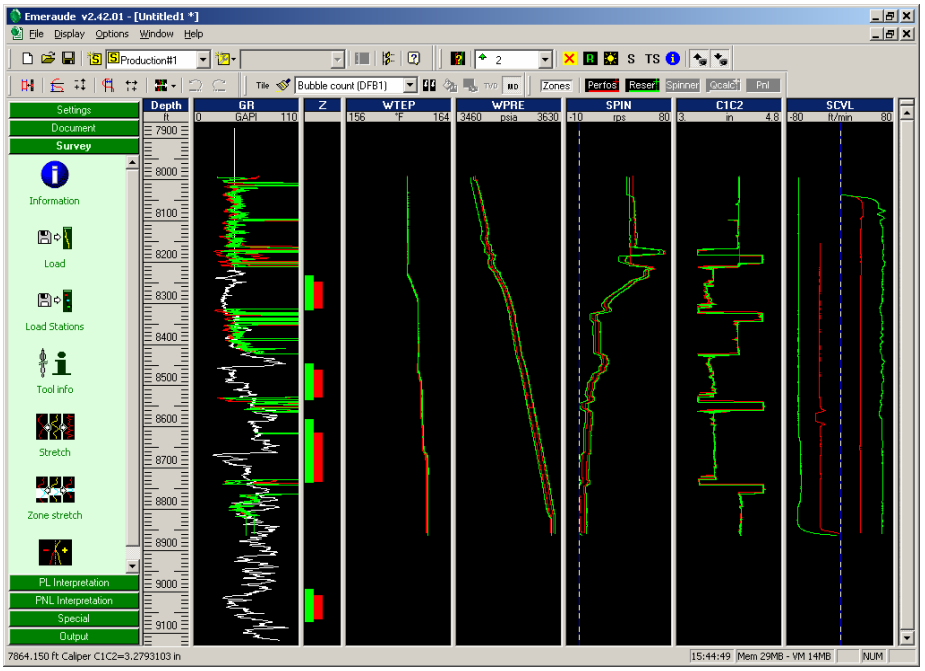


Fig. B05.4 • Screen re-organized

Go to the Survey page and select "Load Stations". Use the "Add" button to select the three files: B05_sta_XXXX.las. A depth channel is present in those files. Otherwise, at the time of loading, Emeraude would prompt you for the depth of each station. *It is a recommended practice to name the stations after the depth.*

When the stations are loaded, an additional track appears with the mnemo VW. This track displays 3 (sets of) discrete values, one for each station. Inside the data browser you can check the contents of the Log Data, Fig. B05.5. If you did not set the pass type/index right for the last two passes you can still change them inside the browser: select the pass, then right click + "Properties".

If you open one of the station nodes, and select the VW channel, the “Plot vs. Time” tab displays a graph of VW versus time, Fig. B05.5 >

In this particular case the station contains only 3 identical values. Raw station data will usually exhibit a distinct behavior with significant variations.

Note that the delete part options works versus time for station channels and can be executed directly from the “Plot vs time”

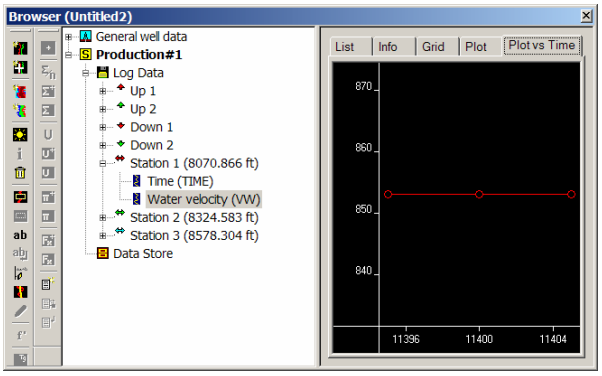


Fig. B05.5

Before proceeding with the next section, we will create an empty interpretation, simply to enable the screen capture button . Go to the main toolbar, select the “Create a new Interpretation” icon in front of the Interpretation drop list. Validate the two subsequent dialogs with OK, and use the  button to “Add” the current screen layout as “Original” for instance.

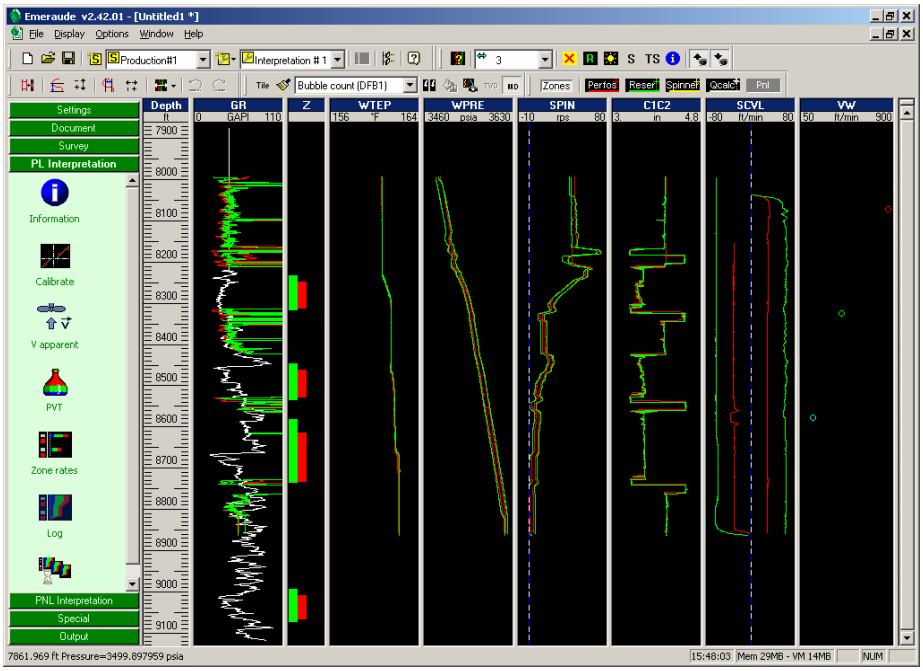


Fig. B05.6 • Original layout

B05.3 • Settings - Multiple Probe Tools

There are two DEFT tools in the string, to which we will refer as DEFT1 and DEFT2. DEFT1 corresponds to the mnemonics:

- DFB1, DFB2, DFB3, DFB4, DFBM, DFH1, DFH2, DFH3, DFH4, DFHM, D1RB

And DEFT2 to:

- DFB5, DFB6, DFB7, DFB8, DFBM2 DFH5, DFH6, DFH7, DFH8, DFHM2, D1RB2

In order to later present images, a required step is to check whether the current list of tool definition includes the above. Go to “Settings” – “Multiple Probe Tools”, Fig. B05.7.

Emeraude 2.42 contains one default definition for the DEFT bubble counts, the DEFT holdups, the GHOST bubble counts and holdups, the CAT, and the FSI. The default DEFT probe / mnemo assignment is the same as for DEFT1 above. On the other hand, no definition matches the naming used for DEFT 2, so we will create one.

Select the DEFT (DFHx) tool and “Copy”. Name the Copy “DEFT (DFH5-8)”. Change the holdup mnemonics to DFH5, …, DFH8. Change the tool bearing mnemonic to D1RB2, Fig. B05.8. Do the same for the bubble counts: select the DEFT (DFBx) tool and “Copy”. Name the Copy “DEFT (DFB5-8)”. Change the holdup mnemonics to DFB5, …, DFB8. Change the tool bearing mnemonic to D1RB2.

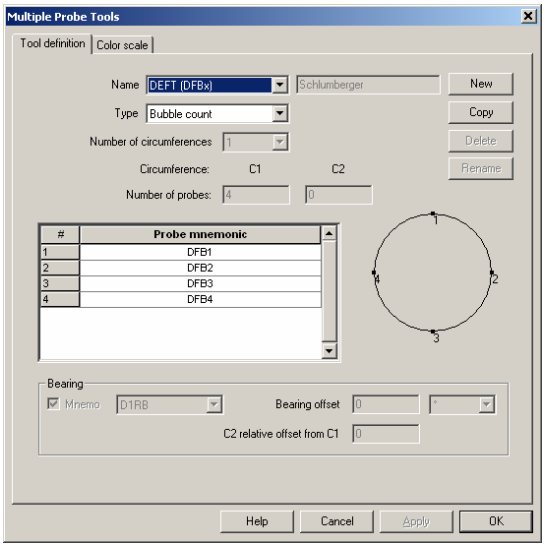


Fig. B05.7 • Settings – MPT

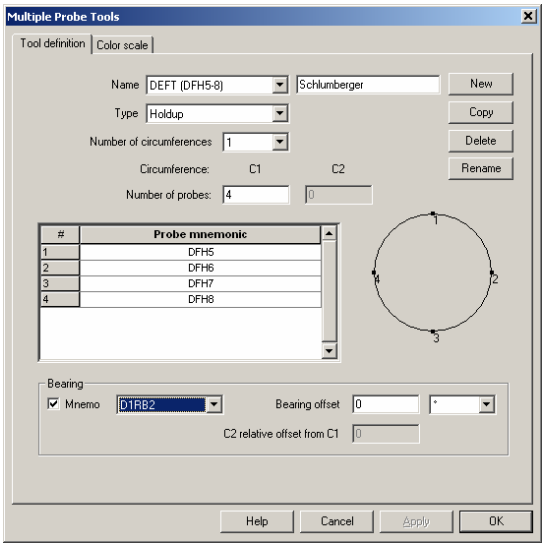


Fig. B05.8 • DEFT (DFH5-8) created

The new definitions are added to the Windows Registry and will be available for future sessions of Emeraude.

B05.4 • Survey – Tool info

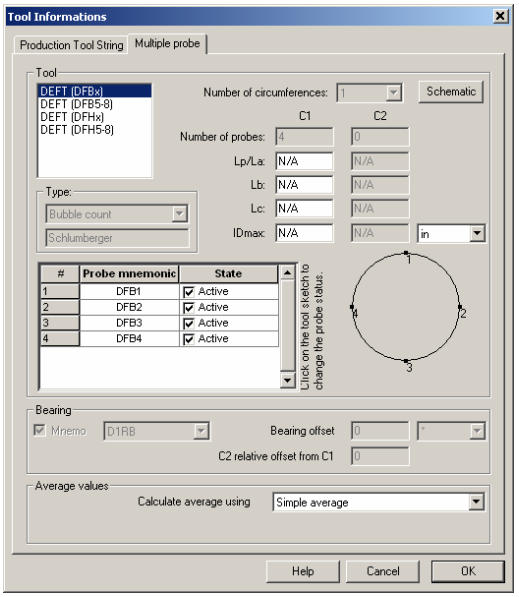


Fig. B05.9

Go to “Survey” – “Tool info”, the second tab gives the list of Multiple Probe Tools found in the current survey. The list shows here as expected DEFT (DFBx), DEFT (DFB5-8), DEFT (DFHx), and DEFT (DFH5-8).

Probe status

For each particular tool the probe status can be assigned in the grid as either Active, Disable, or Ignore. The status influences the bubble/holdup images and also the reference channel processing.

Reference channel processing

The processing will be accessed from the Interpretation Infos/New dialog. For the DEFT, only a simple average is implemented. When a probe is not active, its values are simply ignored in the average.

Tool Geometry :

Geometric parameters are entered at this level: Lp/La and IDmax; they are defined in the “Schematic” dialog opposite.

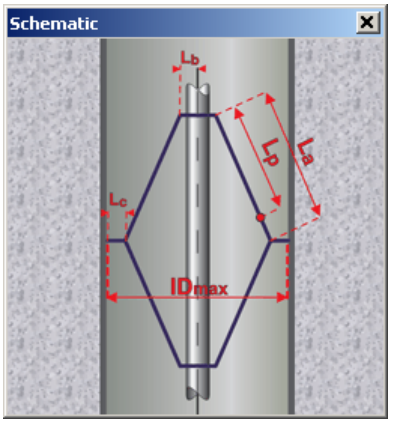


Fig. B05.9 bis

Select the tool “DEFT (DFHx)”, and then enter Lp/La = 0.75, Lb = 0, Lc = 0, and IDmax = 11 in.

The tool geometry is not required for:

- the creation of image views
- the calculation of holdups using a simple (or arithmetic) average or the CAT specific processing.

The geometry must be defined:

- To access the “stratified average” holdup calculation
- To visualize cross-sections of the wellbore.

B05.5 • Image views

In order to first look at DEFT1, re-arrange the screen as on Fig. B05.10 and show the following channels: GR, Z, D1RB, DFH1, DFH2, DFH3, DFH4. Based on this layout it is decided to make an image for pass Down2, bearing in mind that DFH4 may have to be ignored.

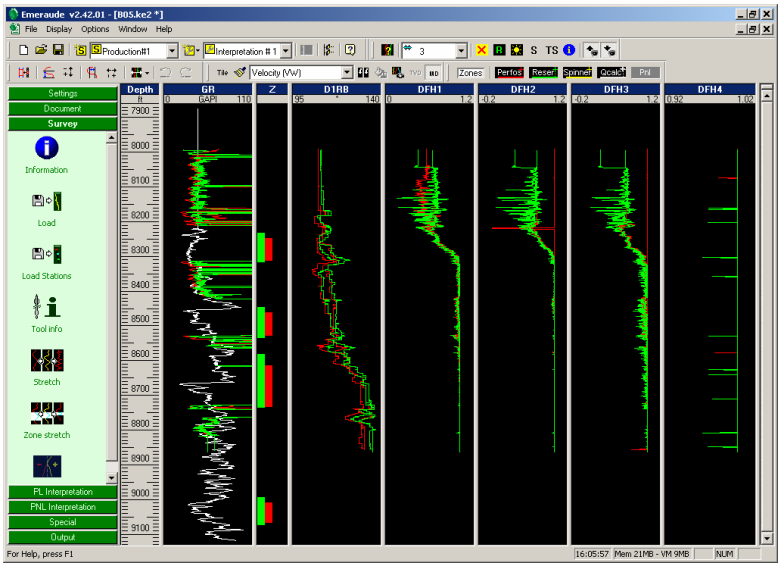


Fig. B05.10 • Layout for DEFT1

Open the data browser and select “Create image view”, either in the browser popup menu or using the  icon of the browser toolbar.

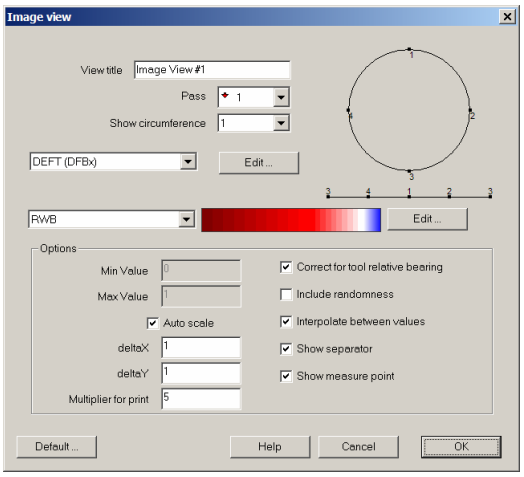


Fig. B05.11 • Image view creation

The “Image View” dialog allows the definition of:

- a specific title.
- the tool to be used from the list defined in the “Survey” - “Tool Info” dialog.
- the particular pass to display in the image.
- the image view color scale.

At this stage, you can recall the “Tool info” and/or the “Color scale” dialogs (via the “Edit” buttons) in order to view/edit the current options. Other controls specific to the image view are:

- “Min” and Max” define the scale range - if “Auto Scale” is checked, taken as the channel bounds.
- “delta X” & “deltaY” define the horizontal & vertical resolution in pixels. A multiplier is used for print.

- "Correct for tool relative bearing" corrects the image for the tool rotation using the relative tool bearing: the center of the view represents the top of the well.
- Include randomness: when the image is drawn using interpolation between two neighbor probes, this option adds random variations around the linear trend.
- "Interpolate between values": create a linear interpolation between two consecutive probe measurements.
- "Show separator": show vertical lines splitting the track in as many intervals as there are probes.
- "Show measure point": shows the probe position (undulating white line on the view in the middle of each track).

Select DEFT (DFHx) for the tool, and Pass Down 2, and validate. The image view is created, Fig B05.12:

An image corrected for relative tool bearing shows the top of the pipe at the center of the view. The view above indicates water at the top only because we included DFH4 in the image and this channel is erroneous. Note that you can also create a bubble count image in the same manner.

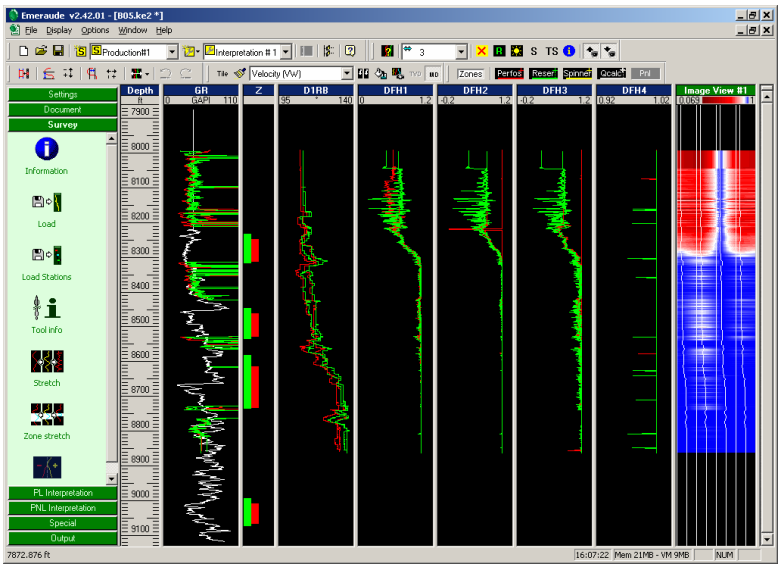


Fig. B05.12 • First image view created

B05.5.1 • Changing the probe status

Bring up the view properties by a right click on the image view + "Properties". Next to the tool name "DEFT (DFHx)" is an "Edit" button that takes you directly to the "Tool Info" dialog, "Multiple probe Tool" tab. In this dialog you can change the status of DFH4. When you click the status is changed in turn to Disable, then Ignore, and back to Active. Set the status of DFH4 to Disable. Validate the change and on the Image view "Properties" dialog, select "Apply" to see the change. When the status is set to Disable, no section is drawn that would use the disabled probe readings, Fig. B05.13 next page.

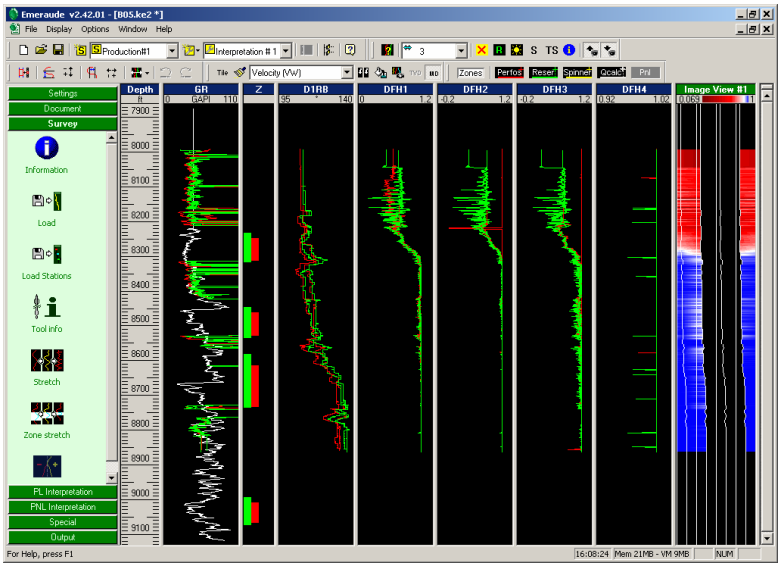


Fig. B05.13 • DFH4 status set to Disable

When the status is set to Ignore, interpolation occurs between the two neighbor probes Fig. B05.14.

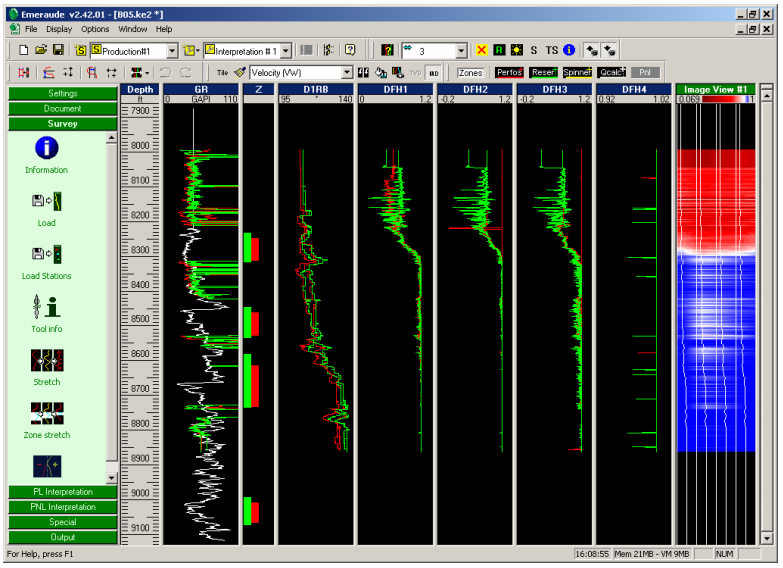


Fig. B05.14 • DFH4 status set to Ignore

B05.5.2 • Changing the color scale

From the Image view “Properties” dialog you can click on the “Edit” button next to the Color Scale to access the dialog next page.

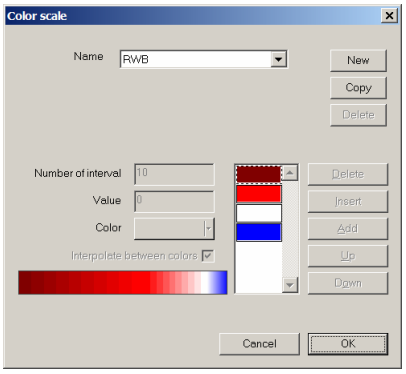


Fig. B05.15 • Color scale edition

Several color scales are predefined on a normalized range. These scales can be duplicated and the copy modified; new scales can also be created.

RWB	
Blue	
Rainbow	
CAT Air-Water	
CAT Water-Air	

For a given scale, one can add as many colors as desired, each color is associated with a given value, and the number of intervals between values is entered (used to interpolate between two successive colors/values). Non-linear color scales can thus be created where little changes near the bounds are highlighted. User-defined scales are saved in the registry and become accessible for any future session of Emeraude.

Save the screen layout using the capture button . Add the new layout as DEFT1.

B05.5.3 • Image view for the second DEFT

In a manner analogous to what was done for DEFT1, images can be constructed for the second DEFT tool as well. Re-organize the screen to show the DEFT2 holdup and relative bearing channels: DFH5, DFH6, DFH7, DFH8, D1RB2, Fig B05.16. As for DEFT1, open the data browser to create an image view for the tool DFH5-8, pass Down2.

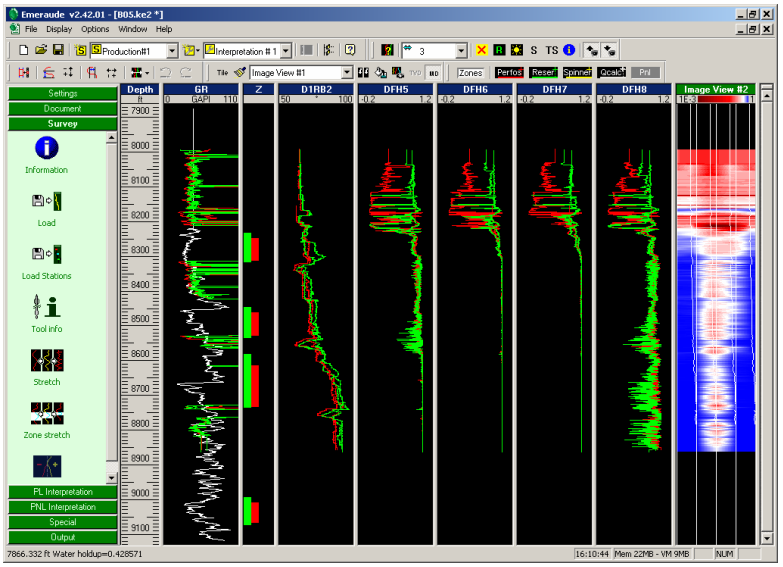


Fig. B05.16 • DEFT2

This new screen layout can be captured under the name DEFT2 for instance.

B05.5.4 • Combining both tool readings

A look at the values of relative tool bearing D1RB and D1RB2 in the data browser indicates that D1RB2 is equal to D1RB – 45. The dual tool configuration is thus as shown opposite. If the first probe of the dual tool is taken as DFH1, the tool bearing for that tool is D1RB.

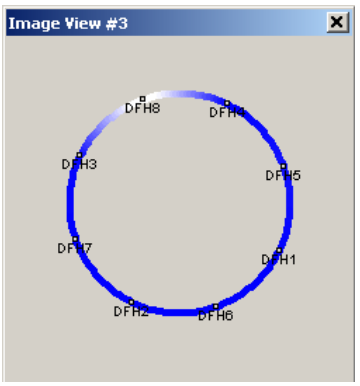


Fig. B05.17

In “Settings” – “Multiple Probe Tools” a new tool can be defined to match this configuration. For the tool type select “Holdup”, then click on “New” and call the new tool “Dual DEFT”. The number of probes should be set to 8, the relation between probe index and mnemos should follow the picture on the right, starting with DFH1, and the relative tool bearing channel should be set to D1RB, Fig. B05.18.

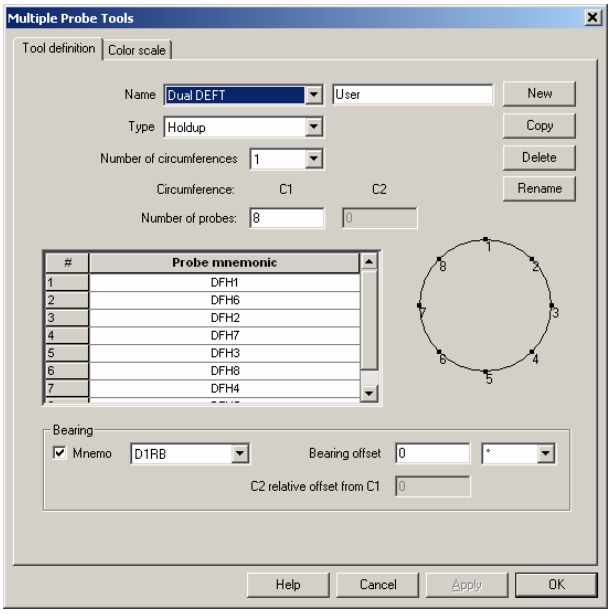


Fig. B05.18 • Dual DEFT definition

In “Survey” – “Tool Info” you will find the newly defined tool. The status for probe 7, i.e. DFH4, should be set to Ignore. When this is done, a composite image can be created for pass Down 2 using the new tool definition, Fig B05.19. On this figure the former image views for DEFT1 and DEFT2 alone have been added. Those image views can be renamed by a right click on the view and “Log title”. The name can also be changed in the data browser.

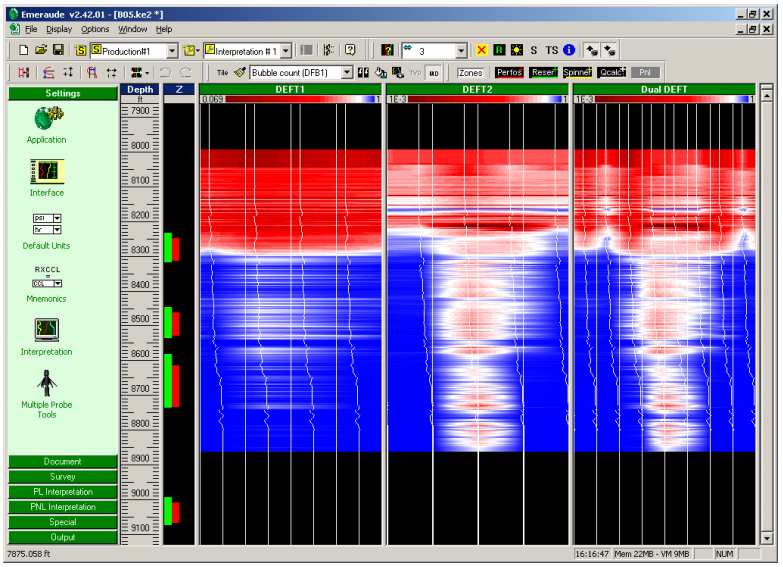
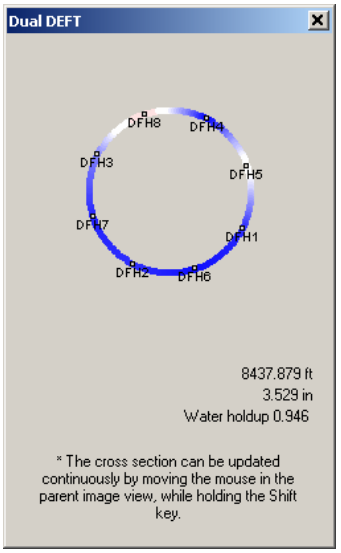


Fig. B05.19 • Image views for pass down2: DEFT1, DEFT2, and Dual DEFT

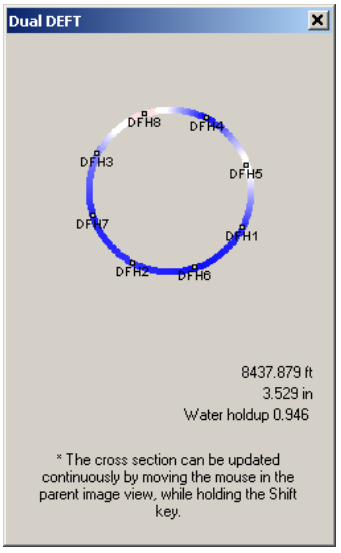
The dual image shows some discontinuities going from the reading of one tool to the other, which is expected when looking at the images for DEFT1 and DEFT2 next to each other.

Nevertheless, we will accept this difference as we will eventually average all the probe readings (except DFH4). We will see later in the interpretation if this assumption was valid.

Looking at the image alone it may be difficult to know the location of the various probes. This can be seen by a right click on the image view, and selecting the “Cross-section” option. This option brings up the dialog shown on Fig. B05.17. With the dialog on the screen, if you press the Shift key and move the mouse inside the image view, you will see a continuous update of the probe position and the interpolated holdup circumference. Access to the cross sections requires the definition of the geometric parameters, for the particular tool; this is entered in Survey – Tool info. The cross section will be drawn differently depending on the selected average holdup calculation type:



Arithmetic average holdup



Simple stratified average holdup

B05.6 • Interpretation

The interpretation will be based on the following:

- Vapp as calculated from the spinner.
- VW stations.
- Water holdup, calculated using the two DEFT measurements.
- dPdZ, pressure derivative.

When the reference channels are built, Emeraude will add reference and match views automatically. In order to make some room for those views, you can hide all tracks except the depth and Z tracks. For the purpose of spinner calibration, bring the SPIN and SCVL tracks on the screen, as well as the caliper C1C2 track.

The dPdZ channels need to be built. This can be done in one go for all passes: inside the browser, click on the pressure channel for one pass, and select the Derivative option (right click or f' button). Enter a smoothing of say 12ft and check the box at the bottom of the dialog to apply the same processing to all passes.

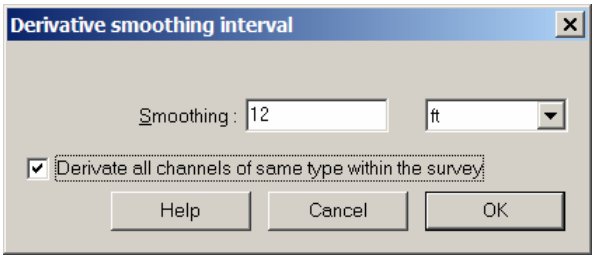


Fig. B05.20 • Pressure derivative for all passes

B05.6.1 • Reference channel construction

Go to the “PL Interpretation panel”.

Vapp

In our interpretation we defined 4 “Calibration zones”: 8110- 8130; 8359- 8394; 8566-8579; 8796- 8821.
You may either enter the above values in the grid directly (Use the “Zones” button of the zone toolbar), or double-click in the Z track to access the same dialog. You can also select the “Interactive” definition. In this case, you will need to call the option in turn for each zone. After the first one, you are always in interactive definition mode. Fig. B05.21. illustrates the choice of calibration zones. The top calibration zone lies in a section not covered by pass Up1. One could move this zone closer to the perforation where Up1 is still valid, but it would then encounter short caliper changes, which would render the calibration on that zone difficult.

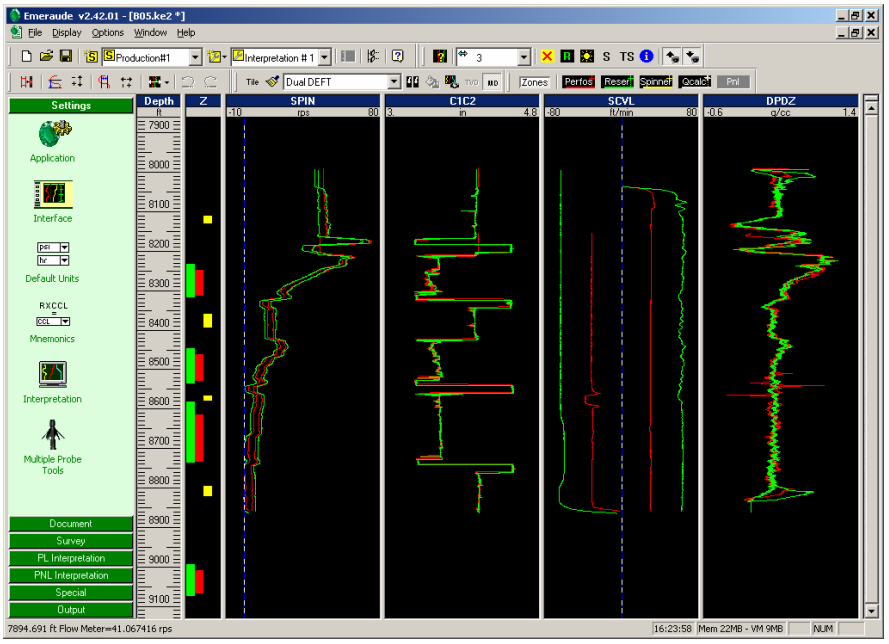


Fig. B05.21 • Spinner calibration zones defined.

Select “Calibrate” and accept the automatic calibration, Fig. B05.22. Select “Vapp”, leave all the weights to their defaults, and validate to generate the Vapp channel.

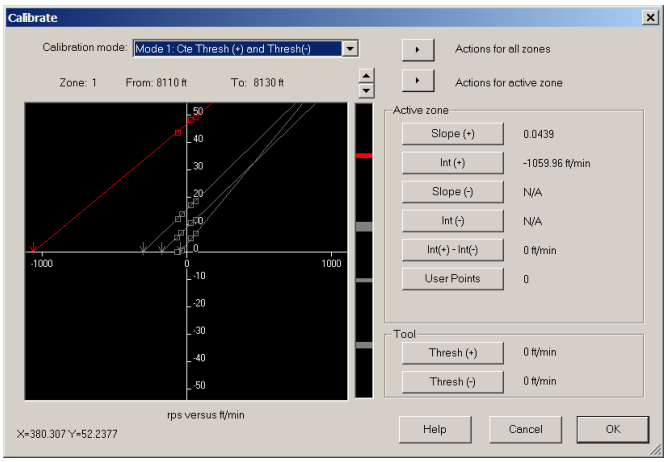


Fig. B05.22 • Spinner calibration

Go to “PL Interpretation” – “Infos/New” option:

Temperature/Pressure
Select “Define” and use the channel of pass Down 1 for both.

Water holdup
Select the “Define” button for Water holdup.
If you leave the mode to “Average”, you may then only average a group of existing holdup channels bearing a given mnemonic (e.g. DFHM). If, instead, you select the “Multiple probe processing”, the “Type” drop-list is filled with the name of the available tools inside the survey. Select Dual DEFT.

Select passes Down2 and Up2 in the list. For each pass, the processing is the one defined in the “Tool-Info” dialog, in this case, a “simple average”. For each selected pass, an average holdup is obtained by an arithmetic average of the local values. The final value is calculated by averaging the result on all the selected passes. Probes set to “Ignore” or “Disable” are not taken into account in the averaging.

The resulting channel is named YW.

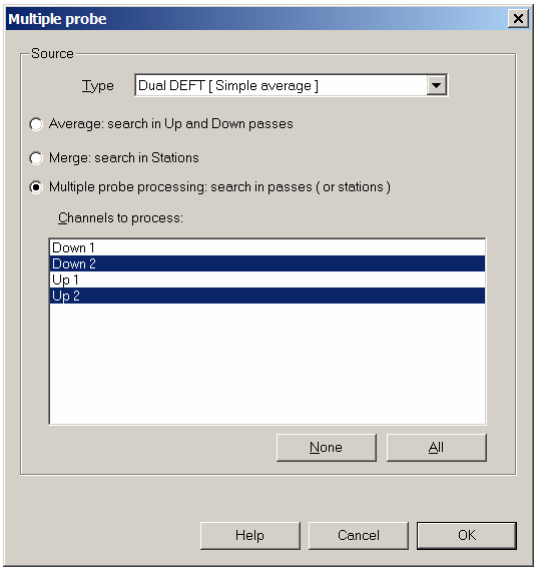


Fig. B05.23

With segregated flow, this process may lead to error as the geometry of the flow is totally disregarded. In practical situations, you may have been supplied a corrected average holdup as part of the log data. This corrected channel should be used directly when available. In the above dialog used to define the water holdup, you would leave the mode to “Average” and select the corrected channel (e.g. DFHCM).

Density
“Define” the density channel as the one of pass Down 2 for instance.

VW
Click on the “Define” button for water velocity. Set the mode to “Merge” and the list of available stations is displayed in the list below. Select “All” available stations, Fig. B05.24.

The Merge algorithm constructs a single channel containing a lateral average of the values present at each station. This resulting channel has absent values between every valid point and it will be displayed as a set of discrete points on the views. No interpolation is ever done between the values, so in particular, this channel cannot be used as part of a complete log calculation.

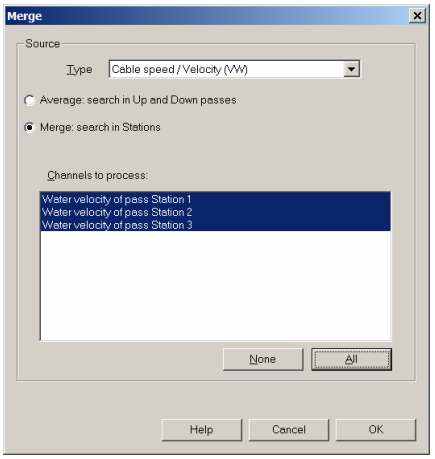


Fig. B05.24

Leave the Interpretation “Infos/New “ dialog with OK.

Caliper

The caliper channels are present in the log passes only. It is necessary to add a caliper channel inside the Interpretation. This can be done in several ways, for instance by drag and drop or using the “Lateral average – Compute from list” option. Open the data browser. Select the node “Interpretation#1”. Activate the “List” tab on the right, where you will see the content of the Interpretation (Input, Output – Schematic, Output – Complete). In the data tree, move up and open the Down2 node. You can then drag the C1C2 channel and drop it on the right, Fig. B05.25. *Note that using the “List tab you do not need to keep the Interpretation node visible on the left.*

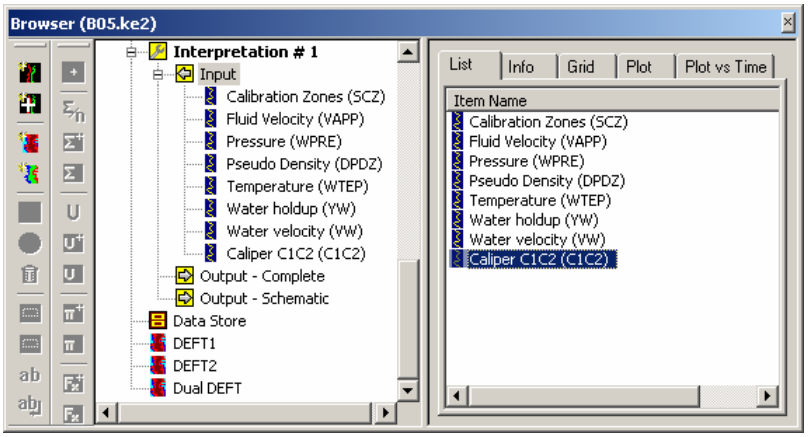


Fig. B05.25

As reference channels are built, the corresponding match views are created. There is also an ancillary view for YW. You can setup the screen as in Fig. B05.26.

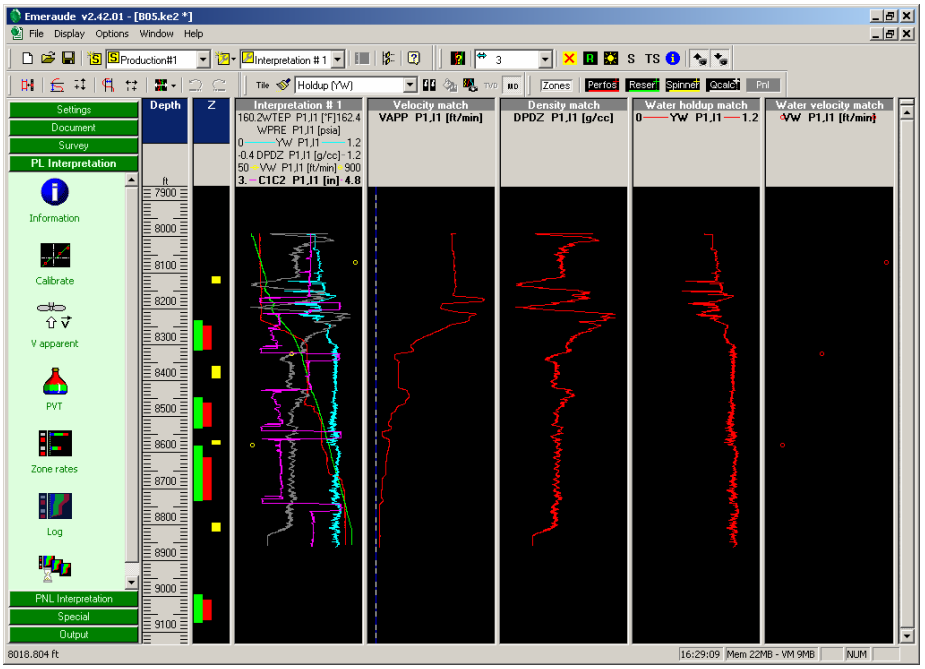


Fig. B05.26 • Reference channels and match views.

B05.6.2 • PVT

The PVT is available in the B05.epv file. Click the "PVT" icon of the Interpretation panel, and select to load this file. Scan through the properties of the various phases in order. You will see that most parameters have been matched to measured values:

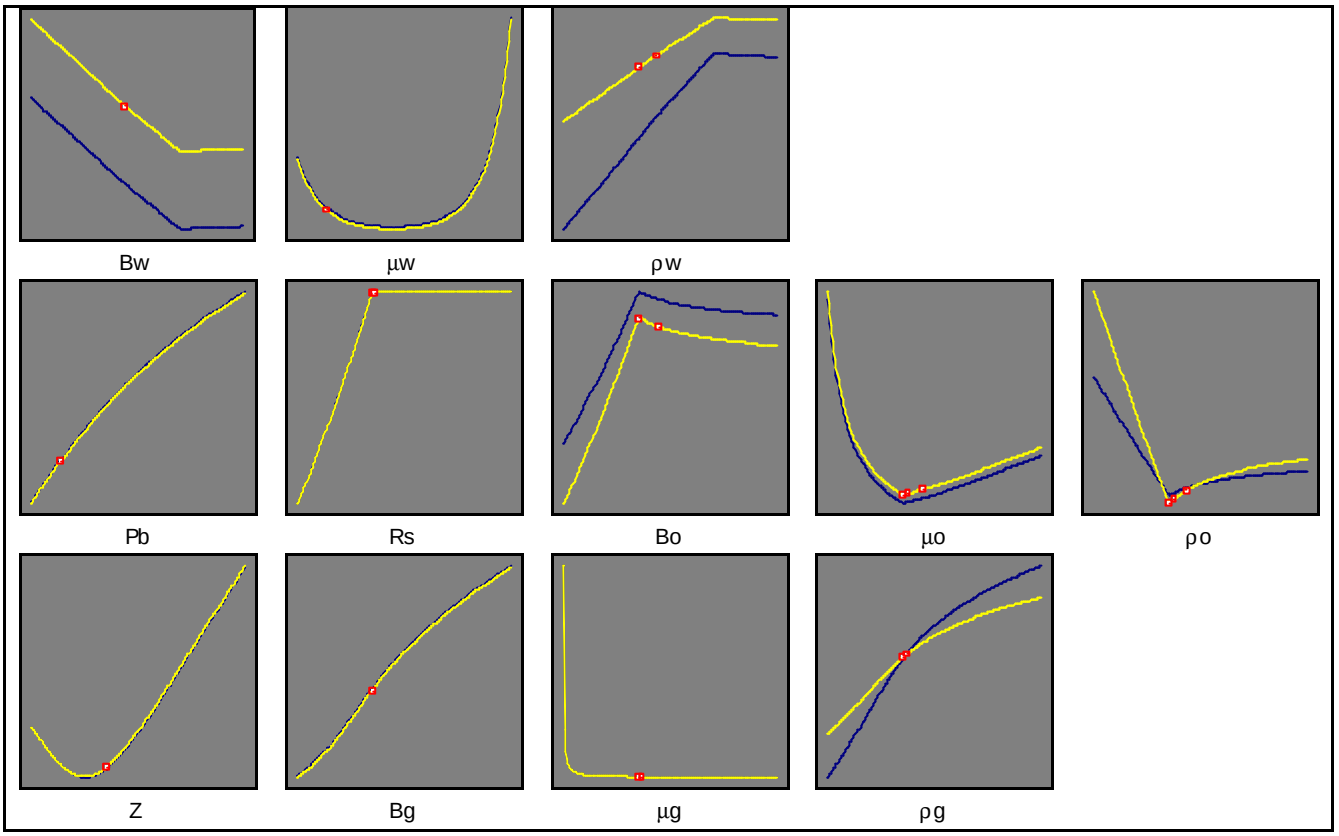


Fig. B05.27 • PVT constraints

B05.6.3 • Zone Rates

In order to use the VW information it is necessary that the stations be included inside calculation zones. Select the "Calculation zones" options, and "Interactive zone definition". Create a first calculation zone to include the top station. Then select the "Calculation zones" option in turn to create zones 2 and 3 for stations 2 and 3, zone 4 below the third set of perforations, and a final zone below the fourth perforation, Fig. B05.28.

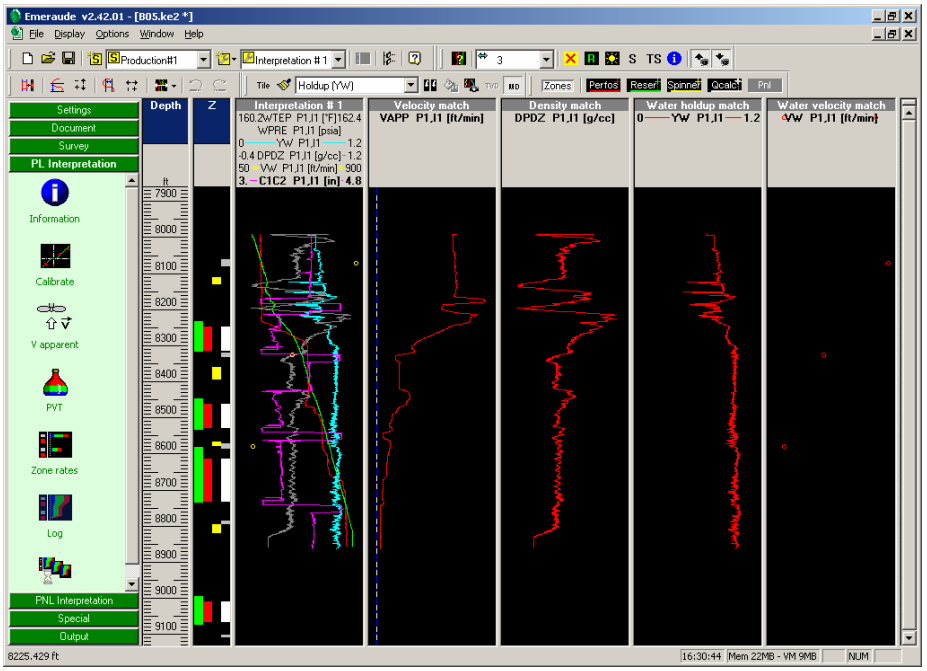


Fig. B05.28 • Calculation zones created

Select “Zone Rates”. The default model is 3-Phase L-G. Select Petalas & Aziz for the Liquid-Gas slippage, and ABB-Deviated for Water-Oil. In the Results tab, on the first 3 zones, you can check that the regression is using Vapp, Density, YW, and VW, Fig. B05.29. VW is not available on the bottom 2 zones. On the lowermost zone, no measurement is available but Vm can be set to 0 manually, which will permit that the schematic does not stop at the last data point, and will thus allow Emeraude to calculate contributions for all perforations.

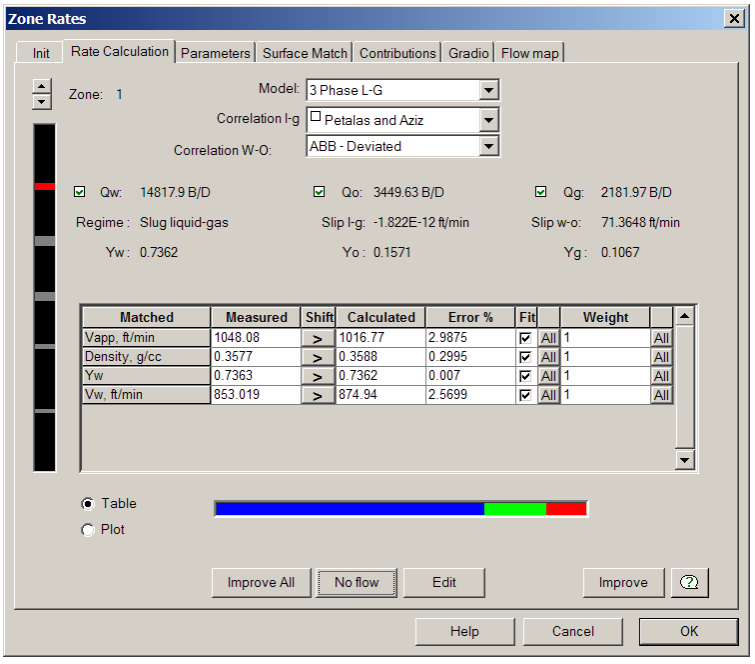


Fig. B05.29 • Zone Rate

Validate the Zone Rates results and generate the schematic logs down to 9100 ft, Fig B05.30.

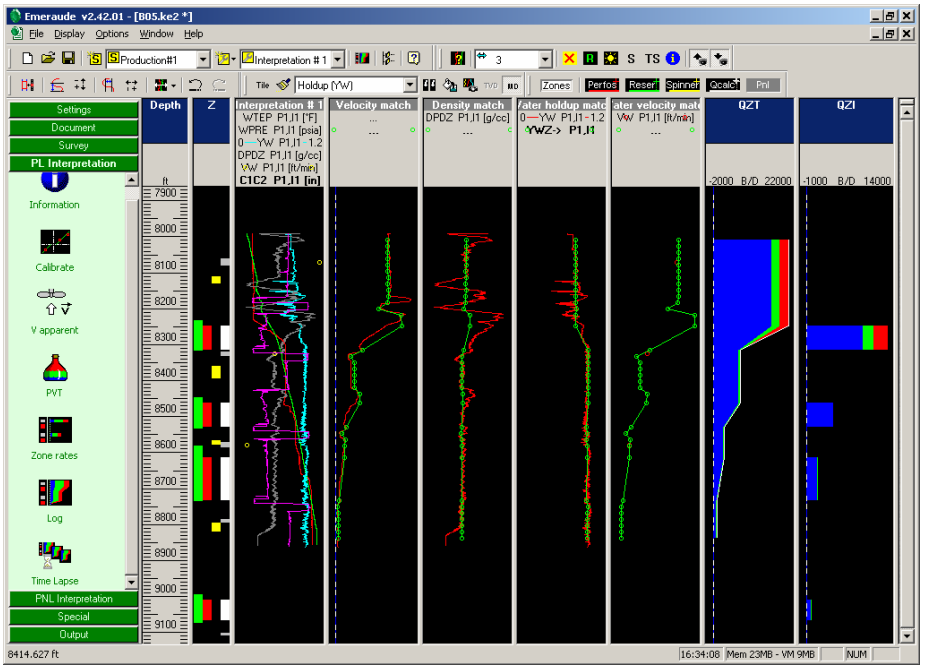


Fig. B05.30 • Schematic generated

Overall, there is a good agreement between measured and simulated data, even though the problem is over-specified and the slippage velocities are estimated using correlations. We could in fact let Emeraude infer slippage velocities from the measurements.

On the top zone, there are 3 unknowns, and 4 measurements including a direct velocity, so we can relax the Liquid-Gas slippage. One the middle 3 zones, we can switch to a Water-Hydrocarbon model and relax the Water-Oil slippage. This can be achieved in the following manner:

Go to Zone Rates:

- For the top zone set the L-G slippage to “Cte slippage”.
- For the next three zones, set the Model to Water-Hydrocarbons (L) and the correlation to “Cte slippage”.
- Run Improve All.

On zones where the slippage is inferred from measurements you will see a checked box in front of the “Slip” button. On zones using the Water-Hydrocarbons model, the value of fg is displayed in the results table in red. This is to indicate that this residual is based on the PVT, not on the measurements. Validate to update the schematic logs. A slightly better agreement can be seen, in particular at the top of the log, see B05.31.

B05.6.4 • Complete Rate

Generate the complete rate log with a 2 ft depth increment, Fig. B05.31

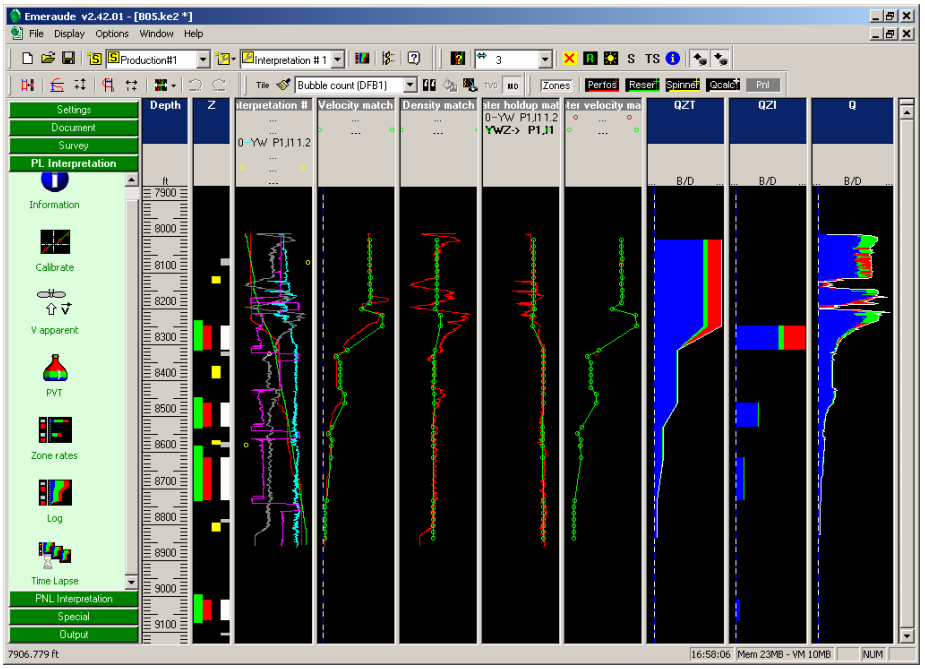


Fig. B05.31 • Complete generated

Unlike the schematic log, the complete log is not making use of VW. The complete log is based only on VAPP, YW, and DPDZ. The consequence is that for the top section of the log, the slippage velocity cannot be considered a variable during the regression. The value found on the top calculation zone is used.

On the above figure, one can see two well-defined intervals at the top where the solution produces a very small velocity and mostly gas. This corresponds to regions where the density is exhibiting two sharp peaks. This density is generated from the pressure derivative, in a well near horizontal. Furthermore, the significant diameter changes in this region may impact the pressure differential dramatically. Besides, the DEFT measurements do also exhibit erratic response in the same region. Overall, the density is the most affected and it is causing the erroneous complete log. One possible way of correcting the log would be to interactively edit the reference density. Another solution is simply to give it less weight in the solution, at least for the interval corresponding to the top 2 calculation zones.

In “Zone Rates”, “Rate calculation” tab, set the weight for the density to 0.1 on zones 1 & 2. Leave the Zone Rates solution unchanged and exit with OK. Re-generate the complete log, Fig. B05.32. A good agreement between schematic and complete logs is obtained.

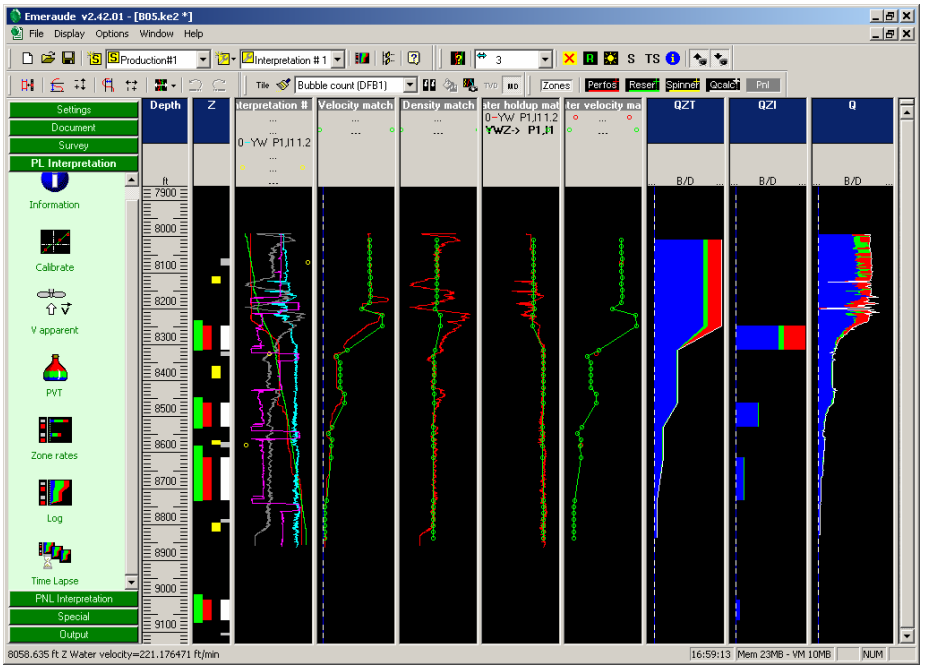


Fig. B05.32• Complete re-generated

B05.7 • Result presentation

In addition to the rate and image views, well views can be created to show the wellbore geometry together with the continuous holdup curves.

Inside the browser select “Create well view” or . The well view property dialog appears, Fig. B05.33:

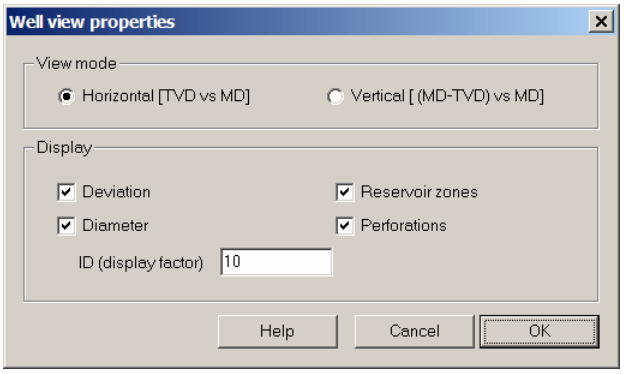


Fig. B05.33 • Well view creation

The well view can display the wellbore geometry from a deviation or a TVD channel. The wellbore schematic can also indicate the diameter changes. The view mode should be selected based on the well overall trajectory. If the well is near horizontal then the default “Horizontal” mode should be kept. For a near vertical well, select “Vertical instead”.

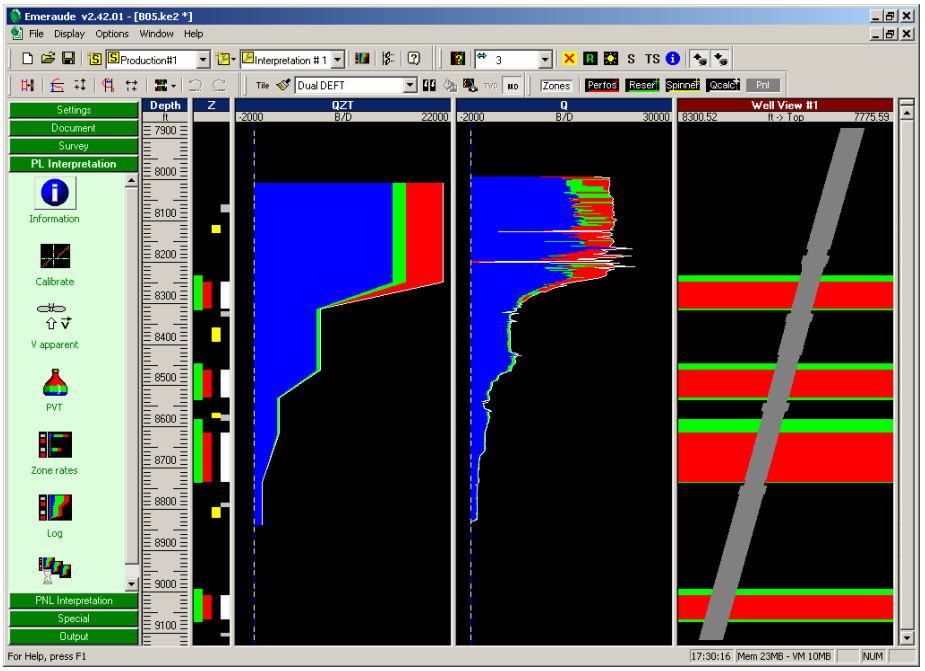


Fig. B05.32 • Well view with default settings

The following modifications can be brought to the well view:

Adding holdups

You can drop continuous holdup channels on the image view. For instance, drag and drop the YG, YO, and YW channels from the “Output – Complete” node of the Interpretation onto the view.

Changing aspects

With a right click on the well view you can return to the “Properties” dialog where a second tab, labeled “Fill area” is now present. You can use this dialog to redefine the aspect of the zones outside, inside the wellbore. You can also modify the color of reservoir/perfos. Note that the later change will apply to the Z track too.

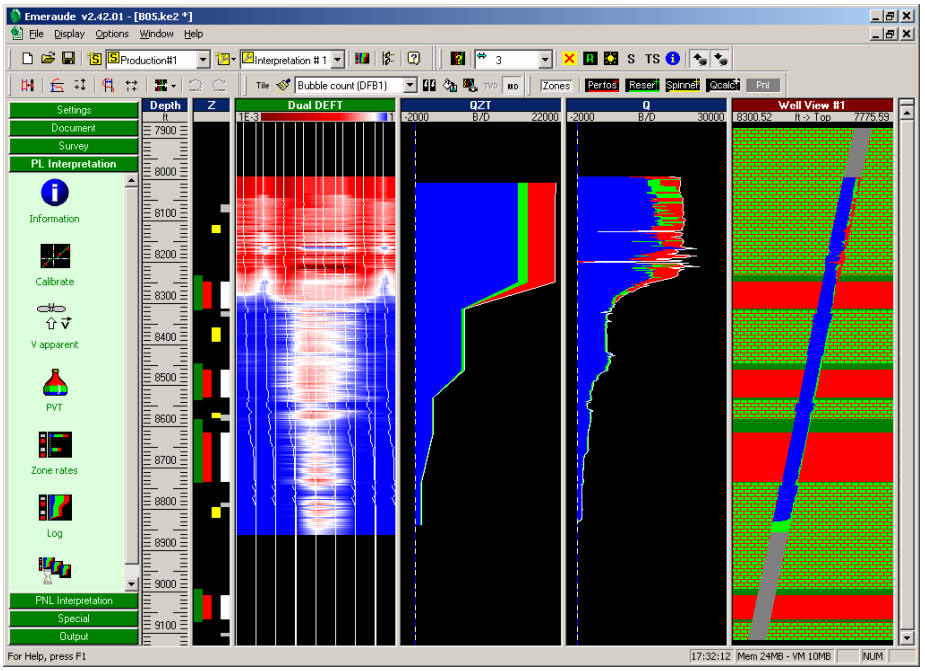


Fig. B05.33 • Final layout with modified well view

This concludes Guided Interpretation #5.