B03 – Guided Interpretation #3

This chapter assumes that you have followed the first two guided sessions, or that you are familiar with Emeraude. The purpose of this third example is to illustrate the use of the 3-phase model and the Global regression.

The data for this example were created by modifying the second Guided Interpretation log data. The density and the apparent velocity channels were manually edited, and a water holdup was introduced. The data being partly synthetic, the objective of this chapter is solely to demonstrate software mechanics.

B03.1 • Opening B03

➢ Start Emeraude and Open the file B03.ke2 located in the Emeraude Examples directory.

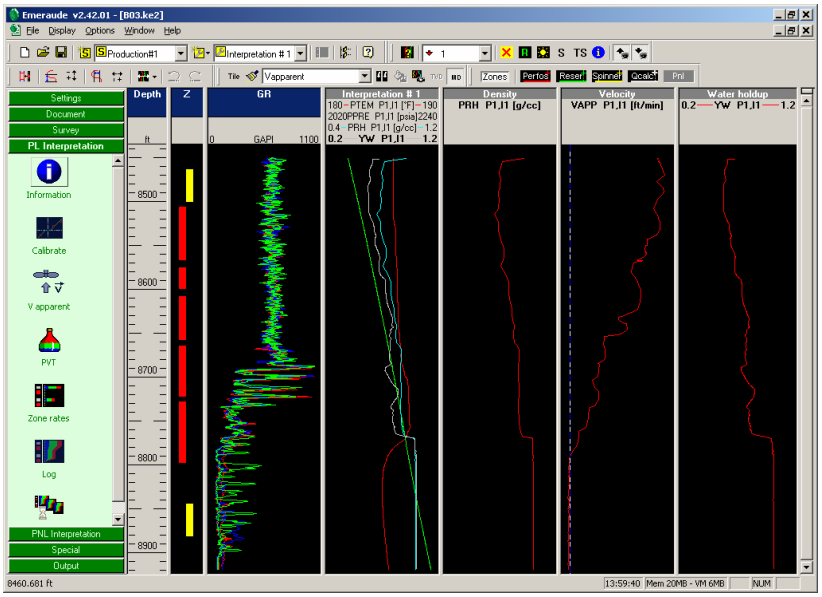


Fig. B03.1 • B03

In addition to the Z track, the screen shows a Gamma Ray track, the interpretation track with the reference channels (density, temperature, pressure and holdup), and the match tracks. In the browser the General Well data is complete with all relevant information entered. The document has one survey called Production #1. The log data has been removed except for the Gamma Ray channels, simply to minimize the file size. An interpretation was initialized and carried out, up to the creation of rate calculation zones. Interpretation reference channels are defined for Temperature, Pressure, Density (with associated Cable Speed), and Water holdup. You can click on the PVT option to check the selected PVT model. This model is 3-phase.

B03.2 • First interpretation

- Click on Zones rates and for the calculation zones, accept the default based on the top of perforated intervals

The Zone Rate Init screen is displayed and shows the default selection made by the software. We saw that the PVT has the potential for 3 phases. Since there are enough measurements (density and water holdup here) Emeraude suggests the "3-Phase L-G" model. This model combines a Liquid-Gas and Liquid-Liquid slippage correlation.

- Change the default Dukler L-G correlation to Petalas and Aziz

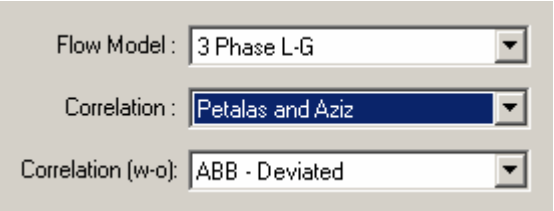


Fig. B03.3 • Zone Rate Init

With the selection above, the Petalas and Aziz correlation is used to calculate the slippage between the gas and mixed liquid phases. Within the liquid phase the ABB-Deviated correlation is used to compute the slippage velocity between the oil and the water phases. Accept the current selection and move to the Rate Calculation tab, Fig. B03.4.

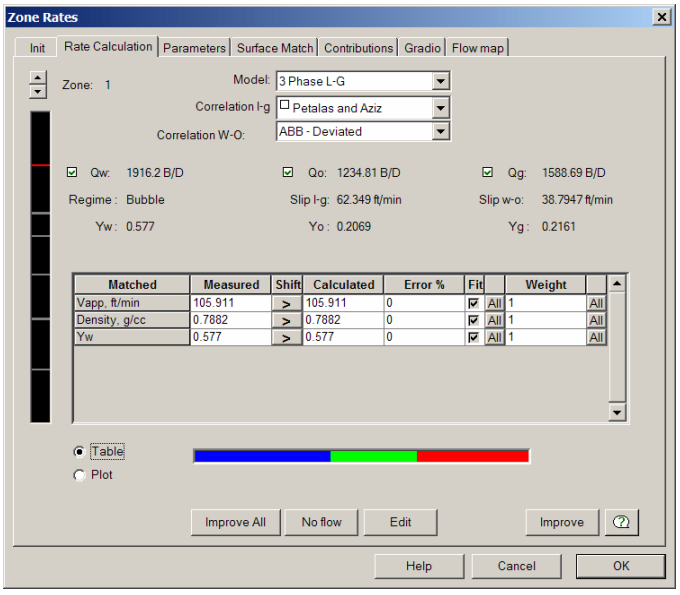


Fig. B03.4 • Zone Rate Calculation; top zone

The model and correlations are repeated at the top of the dialog and could be changed locally. All 3 rates have been calculated from the current input. The two slippage velocities for the particular solution can be seen.

It should be noted that the oil-water slippage is given relative to the liquid phase; hence the reported value is equal to:

$$\text{Slip O} - \text{W} = \left(\text{V}_\text{o} - \text{V}_\text{w}\right) \times \left(\text{Y}_\text{o} + \text{Y}_\text{w}\right)$$

- Move to the bottom zone, set it to NoFlow.
- Validate the Zone Rates results with OK
- Generate both schematic and complete logs, using a depth increment of 2 ft.

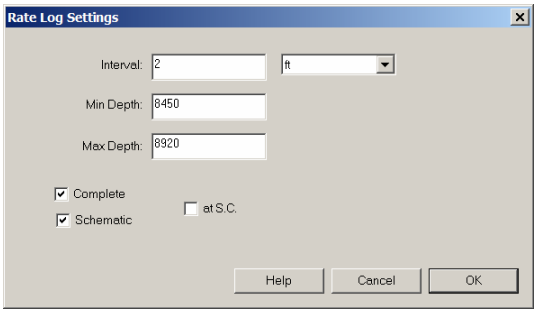


Fig. B03.5 • Rate log settings with 2 ft increment

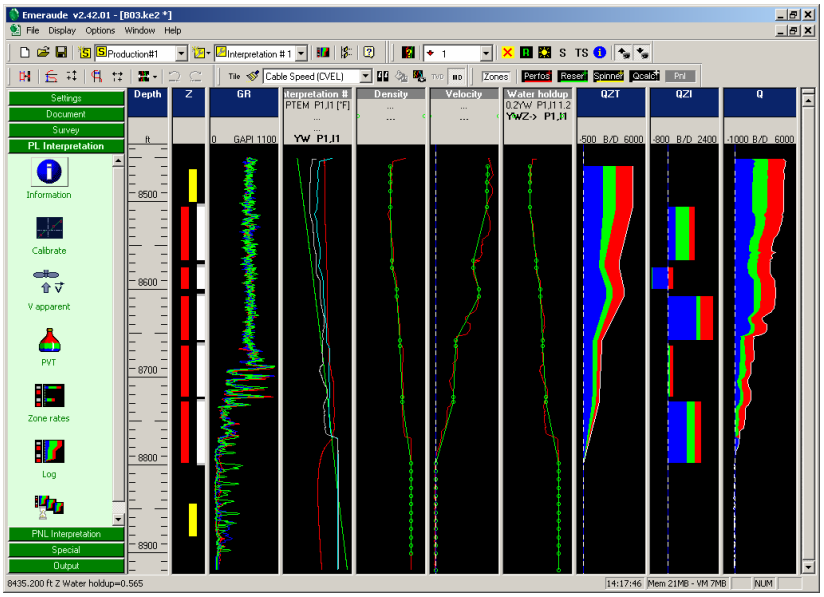


Fig. B03.7 • Rate logs generated

The QZI logs show that the second contributing interval is producing gas, yet taking water and oil at the same time. This is certainly not physical. In Zone Rates, Emeraude calculates for each zone the cumulative rate values to best reproduce the input measurements, using the selected model/correlations. Each zone is treated individually and the objective is only to match the input measurements locally. The Global regression can be used to resolve inconsistencies when they arise, by imposing additional constraints to the solution. This is illustrated in the following sections.

- Hide the Gamma Ray, Q and the Reference channel track. Tile.

B03.3 • Global Regression

Before running the Global regression we will setup a user view in order to assess how the match will deviate from the automatic solution.

- Open the data browser and drag the following three channels from the “Output – Schematic” into the Data Store: “Z Density (PRHZ)”, “Z Water holdup (YWZ)”, “Z Vapparent (VAPPZ)”.

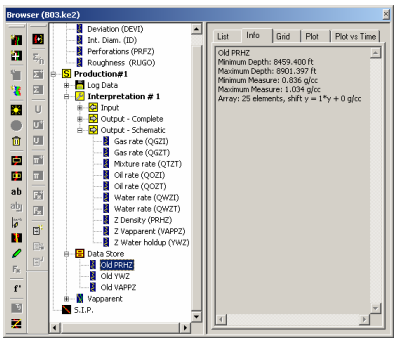


Fig. B03.9 • PRHZ, YWZ, and VAPPZ copied to Data Store; names edited

This operation creates a copy of the original channels. Any new zone rates calculations will overwrite the initial results. The names can be changed as illustrated above in the same manner as for changing a file name under the Windows Explorer. Note, that only Data Store channels have an editable name.

- Create a user view in the browser and drag and drop the renamed channels from the Data store as well as the original channels from Output schematic.

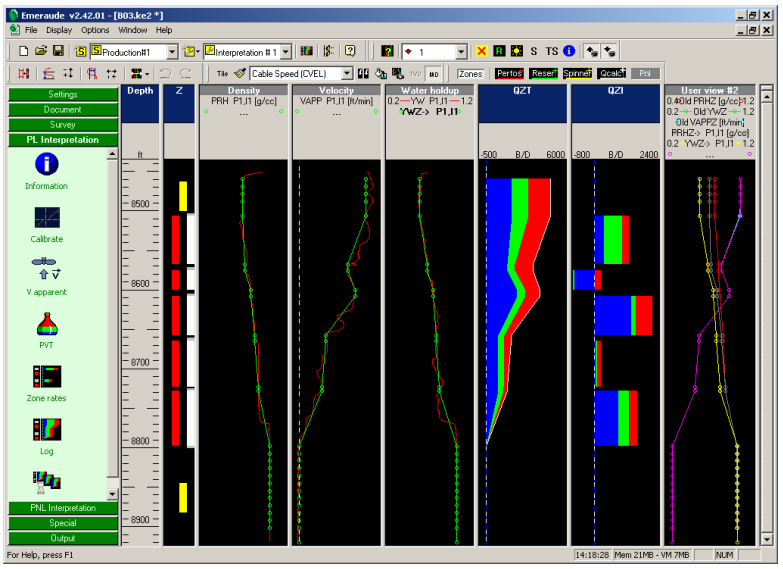


Fig. B03.10 • Copies of PRHZ, YWZ, and VAPPZ added on the user views

For the time being the original version of the simulated channels and their copies overlap, but this will change once the zone rate calculation is modified: the output data will be re-calculated while the data contained in the data store will not be updated.

B03.3.1 • Imposing all positive contributions

➢ Go to Zone Rate, and activate the Contributions tab, Fig. B03.11.

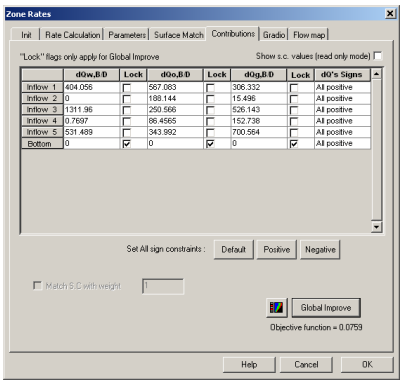


Fig. B03.11 • Contributions

The dialog displays the list of the inflow zones, and the contribution for each phase. All values in the dialog are editable; if a value is changed the cumulative rates are recalculated. If you change a value before running Improve, the value can be fixed by checking the fix checkbox.

➢ Contributions from the well bottom are zero and they do not need to be taken as variables. Check the "Lock" box for all three of them.

➢ Click on the Positive button, then on Global Improve. The global regression starts. Values inside the grid are updated after each iteration. This time, all zones are treated simultaneously in order, not only to match the input measurements, but also to satisfy the selected constraints. When the regression is over, a message next to the Improve button indicates the value of the objective function, an indication of the match quality.

➢ Exit with OK. All schematic outputs, including PRHZ, YWZ, and VAPPZ are updated and the plots display the new solution, Fig. B03.12.

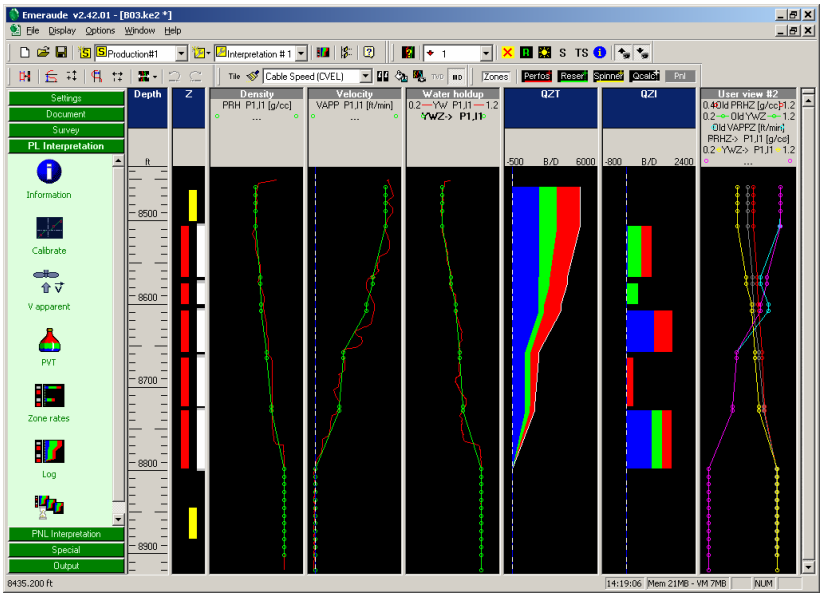


Fig. B03.12 • All phase contributions with the same sign on each interval

With very little difference in the match (see the user views) the global regression has resolved the inconsistency.

B03.3.2 • Imposing contributions to be negative

In this section, we assume that nothing validates the production of the zone at 8575-8600ft, and the only reason why we see this happening is the instability of the apparent velocity channel. We will return to the Global regression, but this time, change the constraint to impose a negative contribution for the zone.

- Return to Zone Rates, Init tab. Click Set/Reset all zones.
- On the Rate calculation page, set “No flow” for the bottom zone.
- Click on the Contribution tab and set Inflow zone 2 to negative contribution only. Fig B03.13.
- As before, select the Lock checkbox for all bottom contributions.
- Run Global Improve.

Fig B03.14 shows the results after setting the zone to negative contribution. Now the zone takes water only, but produces nothing.

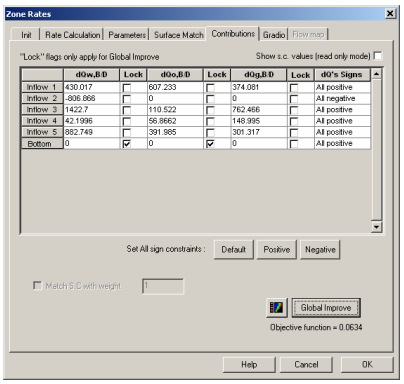


Fig B03.13

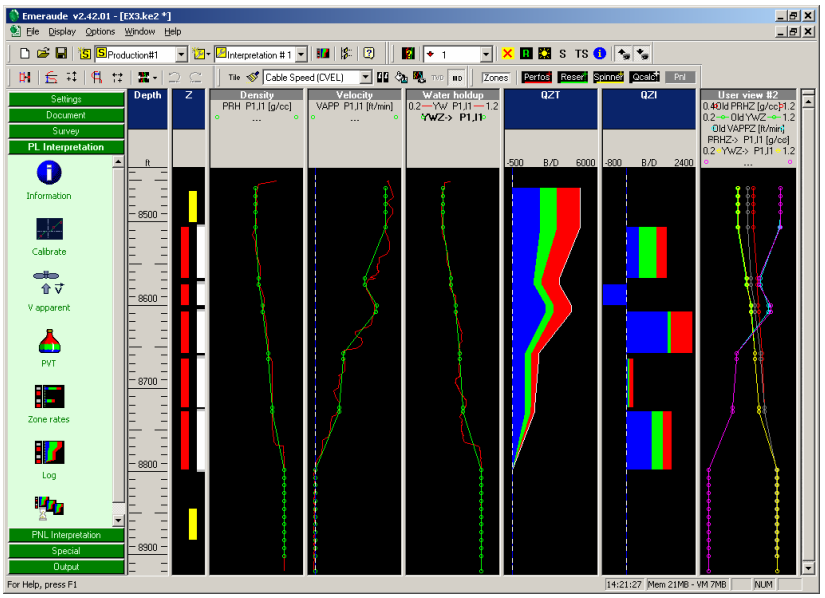


Fig. B03.14 • Negative contribution

B03.3.3 • Imposing no contribution for a zone

For the sake of demonstrating other possible constraints, we will run a last Global regression, assuming that there is no contribution from the fourth inflow zone.

- Return to Zone Rate, Contribution tab and set the rate in the fourth inflow zone to zero, check the three "Lock" check boxes.
- Run Global Improve.

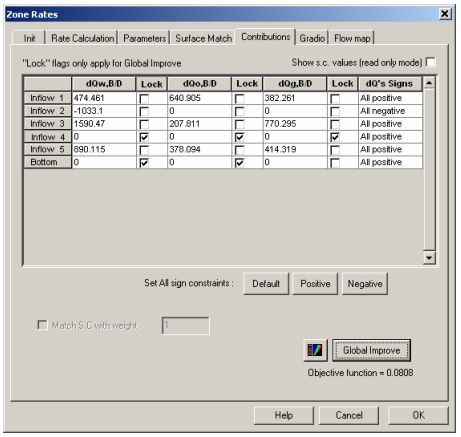


Fig. B03.15 • Contributions

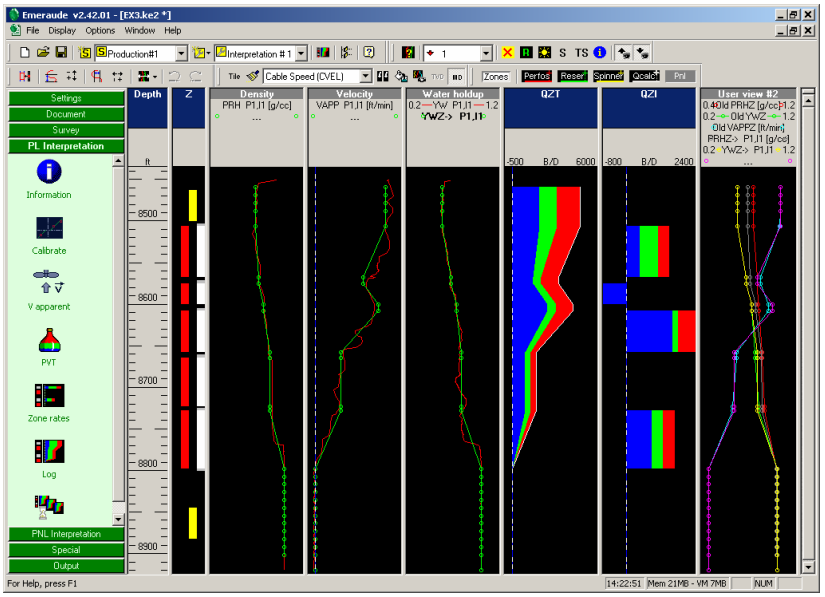


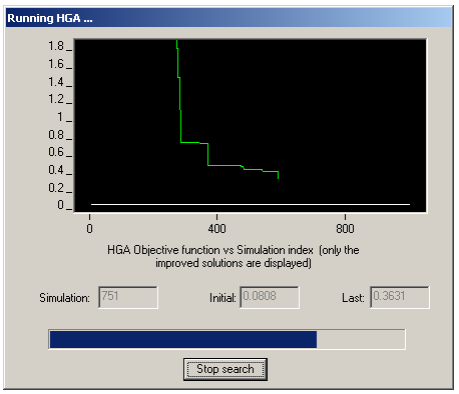
Fig. B03.16 • No contribution from the 4th perforation

B03.3.4 • Hybrid Genetic Algorithm (HGA)

It is possible to couple the Global Regression with a pre-processing called HGA, for “Hybrid Genetic Algorithm”. This pre-processing is particularly suited at avoiding local traps or finding a better starting point for the regression. Access to HGA is enabled in the “Interpretation” option of the “Settings” panel. When enabled, the Global regression (“Contributions”) dialog shows 2 additional controls:

- A check box to use HGA in the next run (off by default)
- A button to view/edit the HGA parameters. *This should normally not be changed*.

When running a global regression with the HGA option checked, a dialog appears to show the HGA progress.



In this dialog, the following information is plotted/displayed:
- In white, the value of the objective function corresponding to the solution before the call (base case)
- In green, the value of the objective function for the consecutive improvements in HGA

Typical behavior

HGA is not “biased” by the starting point and it will usually start with solutions having a much higher (worse) objective functions than the base case. Also, a Genetic Algorithm improves the solution iteratively, but unlike a classical optimization, it does not provide a systematic improvement at each iteration. This will be translated in the plot where new points are drawn only when there is an improvement. So the plot may seem to be halted for some time and then start again. An automatic scaling is executed every 5 new points.

If HGA finds a solution with an objective function smaller than the base case, then after completion/or termination, this solution will be used as the new starting point of the global regression. If HGA stops without such a better solution, the global regression starts from the base case. *Note that you can stop HGA at any point, in particular if you see that it successfully reduced the objective function.*

You can experiment with HGA on the current example.

This concludes the third Guided Interpretation. Again, it must be stressed that the input data for this example is partly synthetic. The objective of the chapter was only to demonstrate software options that can be applied to resolve inconsistencies in rate profiles.