B04 – Guided Interpretation #4

This example illustrates the following options:

- Apparent Downflow
- SIP (selective inflow performance)
- Temperature
- Standing water column option
- Well sketch

B04.1• Example data

Open the file B04.ke2 located in the Examples directory, Fig. B04.1.

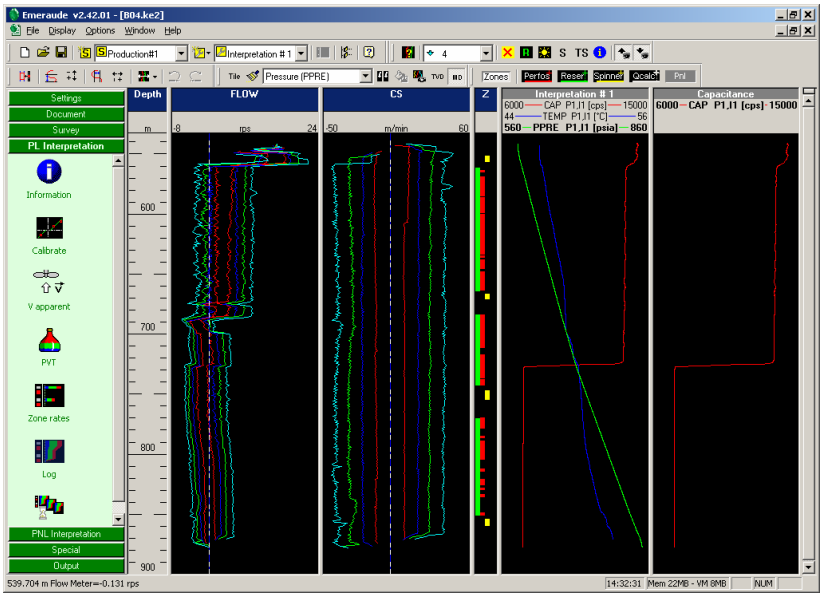


Fig. B04.1

This file contains 4 different surveys/interpretations. There are 1 shut-in and 3 productions. The tool string includes the following tools: Spinner, Gradio, and Capacitance. The gradio failed in the surveys: Shut-in #1, Production #1, Production #3. All surveys have been interpreted except for Production #1 which is considered in the sections below. The well is around 50° deviated. The tubing shoe is set at some 725 meters, after which there is 9 5/8 casing. There are 3 reservoirs, the uppermost producing through a sliding sleeve around 560 m. There is no water production at surface.

Production #2 illustrates the profile obtained in this well (you can activate this survey to see the interpretation). The combination of the well deviation, the large casing diameter, and the large water holdup at the bottom of the well creates favorable conditions for phase re-circulation inside the casing. It can be seen that the complete log, everywhere faithful to the data, exhibits only downflow of water inside the casing. The schematic however,

is showing upflow of oil in that zone. This result was obtained using the Apparent Downflow option of Emeraude, which is illustrated in the section below.

An alternative, described in section B04.4, is to use the temperature quantitatively. In any case, a proper interpretation of the data inside the casing can only be obtained by disregarding the spinner in that section.

B04.1.1 Production#1 Interpretation

Reference channels for pressure, temperature, and capacitance have already been produced. We will first create a pseudo-density channel from the pressure.
Open the data browser; then the nodes Production #1, Interpretation #1. Select the Pressure channel and then the icon **f'** (or derivative option in the popup menu).
Enter smoothing = 2m.
2 new tracks appear at the right: one titled DPDZ and the match track labeled "Density". Hide the DPDZ view. The density is also added to the Interpretation #1 user view.

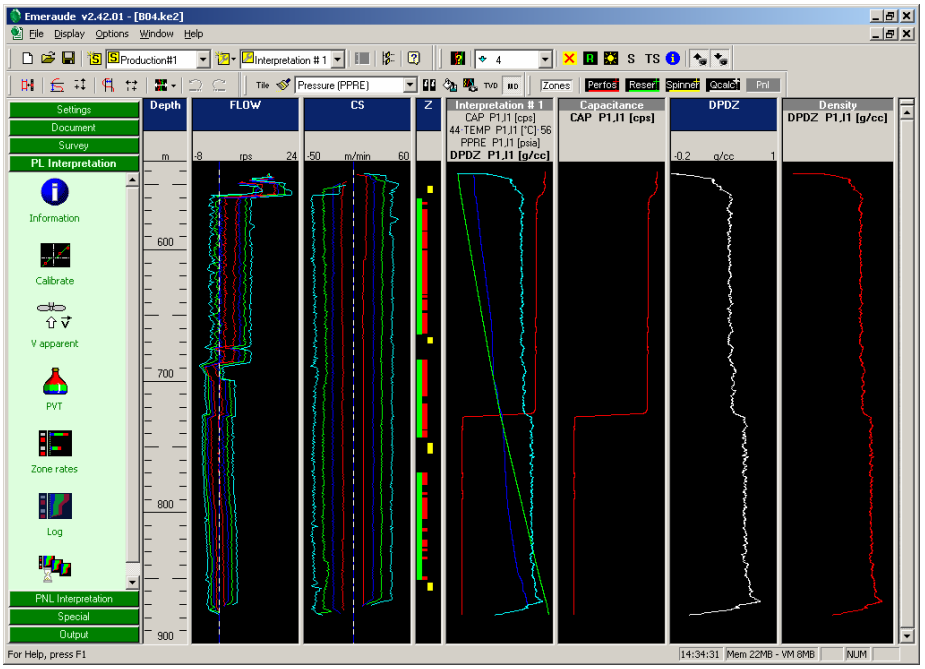


Fig B04.2

In shut-in #1, the DPDZ was checked against the PVT data. It was decided to offset the channel by –0.027 g/cc (this can be viewed inside the data browser). The same shift is applied here (y -> a.y + b inside the data browser).

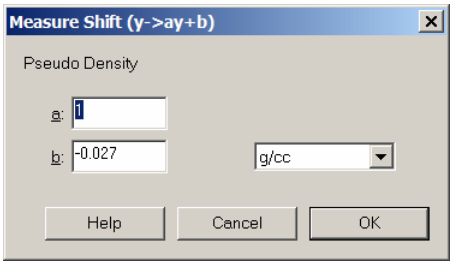


Fig B04.3 Shifting the density channel

Calibration / Vapparent

Spinner calibration zones were already defined. Click on the Calibrate icon to view the calibration. Accept all defaults and generate VAPP.

Below 686 meters the VAPP is negative. From 726 down this is the 9”5/8 casing. It can be seen on the density and capacitance that most of this section is occupied by water, and the spinner is telling us that this water is going down. We will assume that what is actually happening is only an apparent down flow and that water falls back only as a result of being dragged upward by an up flowing light phase, oil.

In this chapter we will run two interpretations to substantiate this fact: one using the specific Apparent Downflow option, the other using the Temperature.

Hide the cable speed and spinner views.

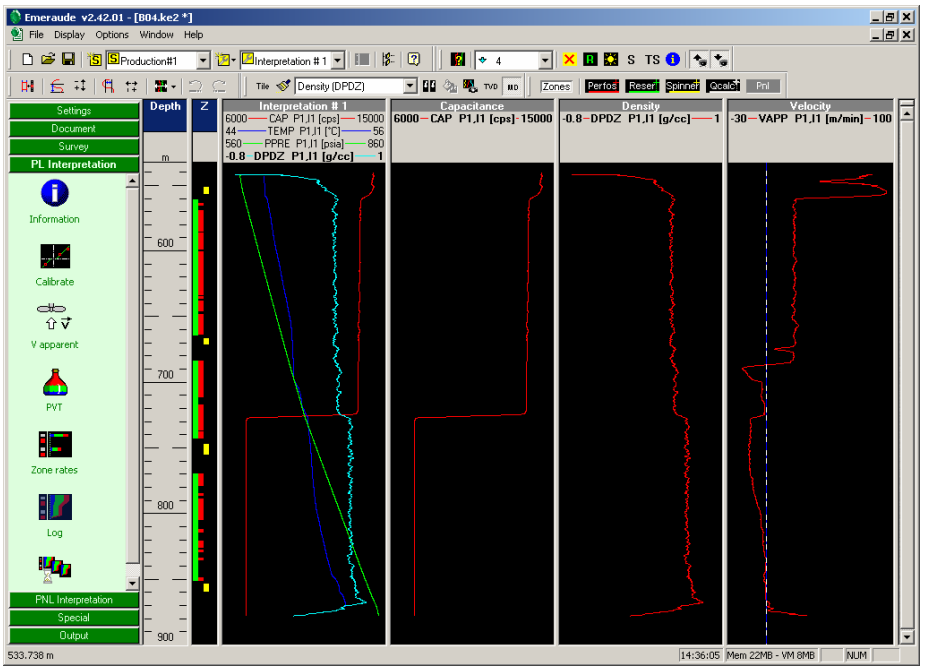


Fig B04.4

Click on the Calculation zones button and create zones “Same as Spinner” calibration zones.

B04.2• Interpretation with Apparent Downflow

Select Zone Rates and choose:

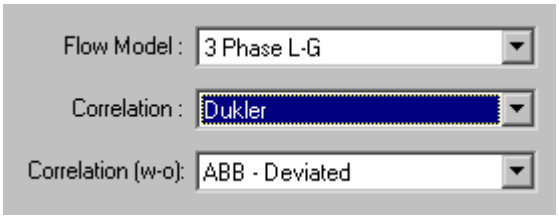


Fig B04.5

Click on the Rate Calculation tab.; select the “Plot” display:

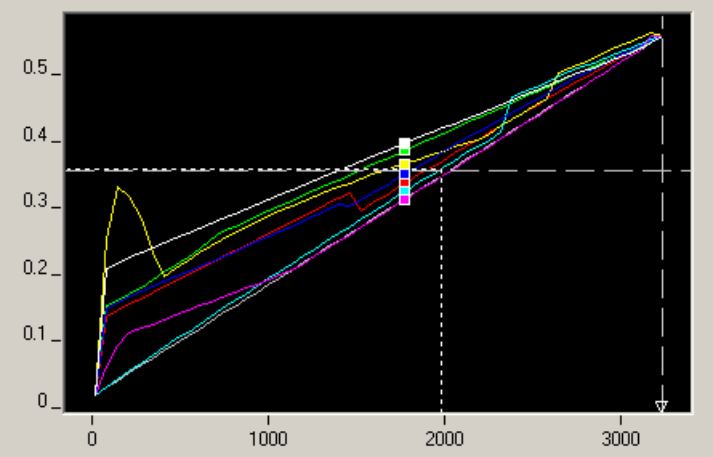


Fig B04.6

It can be seen that there is fairly good agreement between the surface rates, the model, and the measurements.

Move to Zone 3 (Rate Calculation Tab).

The rates are all negative. Checking the pressure/PVT, we know that we are above bubble point so we toggle the model to Water-Hydrocarbon(L). The “Apparent Downflow” option is now enabled. Check it.

“Apparent Downflow” can occur in deviated wells with a high heavy phase holdup. In a deviated well with a high water holdup, the water may be dragged upwards by the oil flowing up on the high side of the pipe, and fall back on the low side of the pipe. This circulation of water may be “seen” by the spinner as only downward flow when it is in fact due to upwards oil flow. Deciding that the flow is up when the spinners says it is down, can be done if additional information is available (zone pressure, temperature, etc).

An “Apparent downflow” option in the Zone Rate dialog can be used for quantitative interpretation. The option is available in both Liquid-Liquid and Liquid-Gas cases and is offered regardless of the sign of the Vapp . In this option, the rate of the light phase Qlight (Qhc in our case) is assumed to be a function of the slip velocity, Vs

and the holdup of the heavy phase: $Q_{light} = C_{ADF} \times (Vs+V_{ADF}) \times (1 - Y_{heavy}) \times A_{pipe}$where C_{ADF} and V_{ADF} are editable parameters (accessed in the “Edit” dialog, both set to 1 by default).

The spinner measurement is disregarded and the superficial velocity of the heavy phase is set to 0. The match is preferentially on water holdup. Yet because of the larger water holdup the density is certainly more reliable here. Select the “Table, “Unfit “ the capacitance (Zone 3 only), return to the Rate Calculation and click Improve:

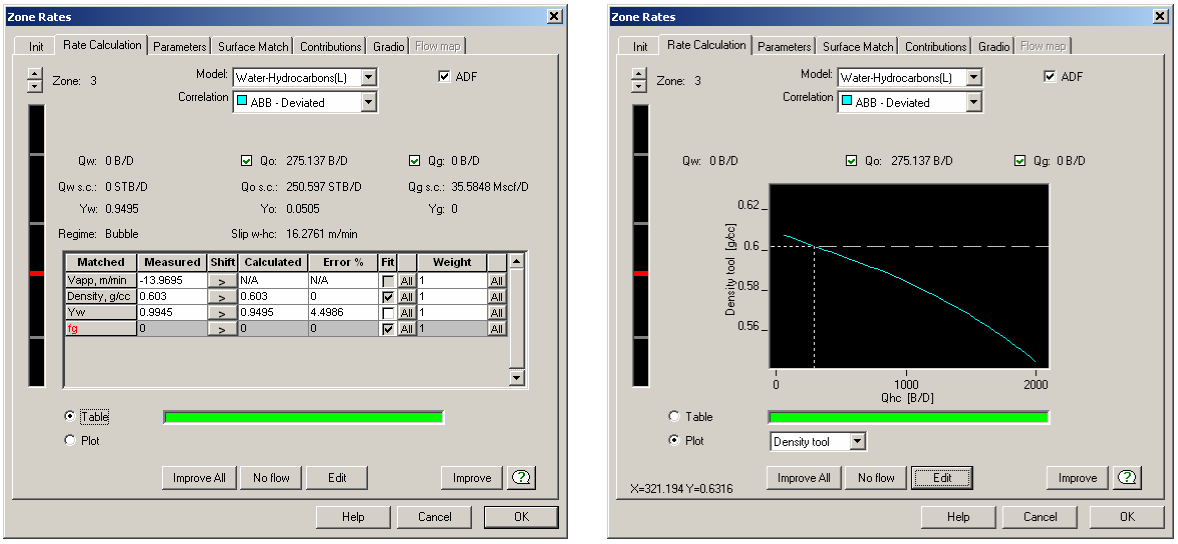


Fig B04.7

Select the bottom zone and set it to No Flow.
Generate the schematic logs.

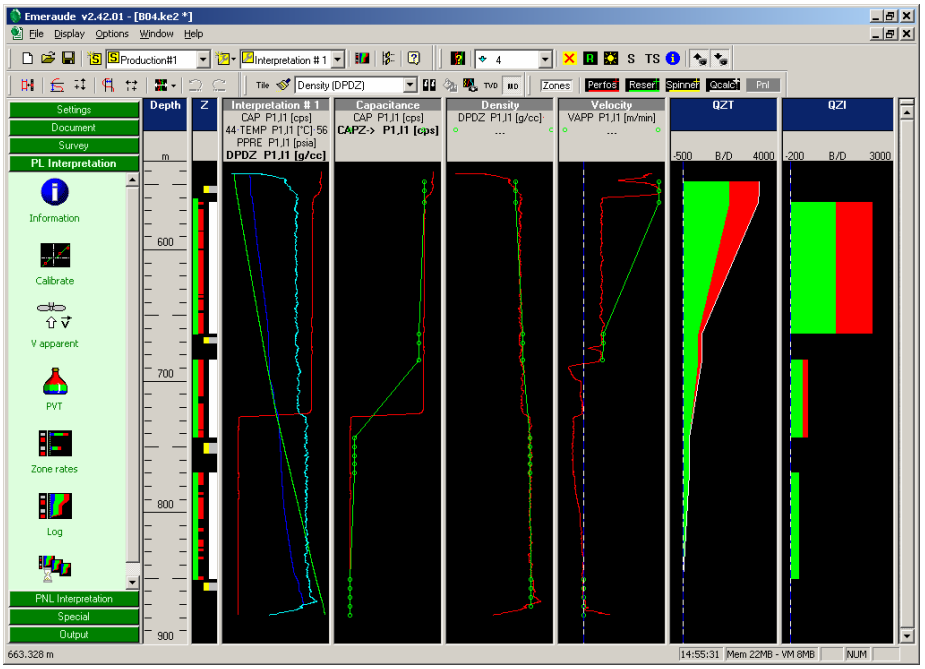


Fig B04.8

The simulated channels change value linearly across the inflow zones. The simulated VAPP has no data wherever Apparent Downflow applies. This is because the VAPP model disregards VAPP completely and uses holdup/density measurements only.

Also, for the top reservoir, the contribution shown on the schematic is assigned linearly to the corresponding inflow zone. This of course, is different from what the spinner “sees” since the top reservoir contribution is entering only at the level of the sliding sleeve.

Also, note that all other interpretations inside this document have been carried out in the exact same manner:

1. Set/Reset All Zones with 3-Phase L-G (Dukler + ABB-Deviated)
2. Zone 3, change to Water-Hydrocarbon, Check ADF, Disallow Yw, Improve
3. Zone 4, Set Vm = 0

B04.3• S.I.P.

Move to the Special page and select SIP. The following IPR options are given:

- Straight line, C&n, LIT relations
- Surface/reservoir conditions
- P or m(p) for gas production
- Composite IPR (sum of all zones)

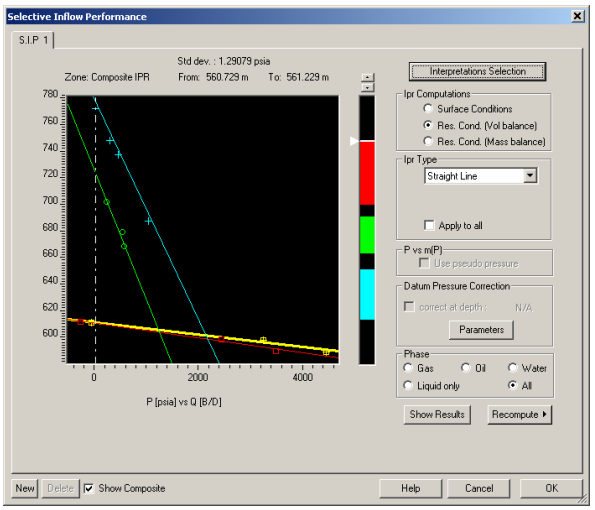


Fig B04.9

Click on Parameters and define the reference depth at 560 m.

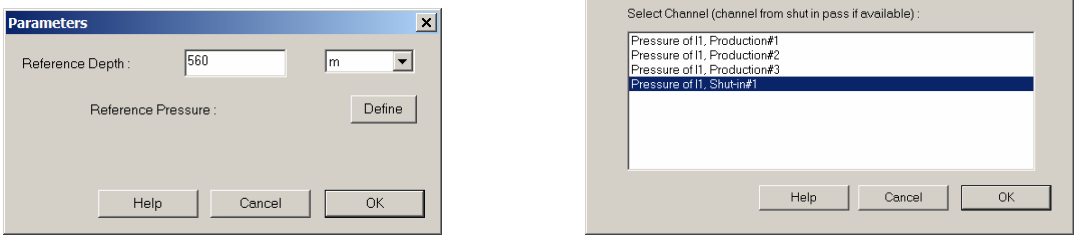


Fig B04.10a&b

Click the Define button in the dialog to select Shut-In #1 for the reference pressure.

After validating your inputs, click the box “correct at depth:”… When all pressures are corrected to a common datum, all the inflow curves (here the lines) should cross the Y axis at the same location. A discrepancy is representative of cross-flow. The Shut-in #1 survey the spinner is certainly not stable causing the difference.

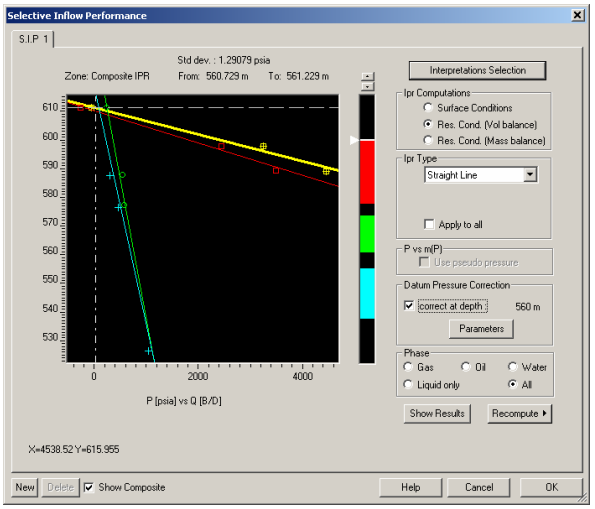


Fig B04.11

B04.4 • Temperature

On Production #1, we will redo the interpretation but instead of using the Apparent Downflow model inside the casing we will use the temperature.

Select PL Interpretation - Infos/New, Temperature tab.

Click on “Simulate Temperature” and “Match temperature”.

The geothermal profile could be defined by a point and a gradient, but this will be done interactively instead.

Enter delta P (Joule Thomson)= 50 psia.

Validate with OK. A warning indicates that the geothermal profile is undefined. We are going to define it now.

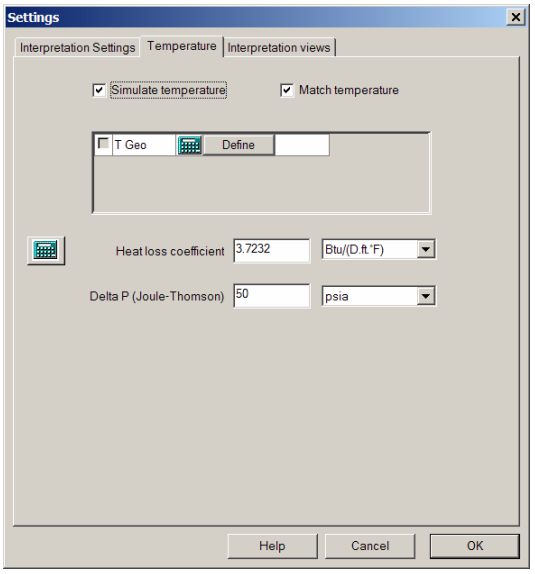


Fig. B04.12

Definition of the geothermal profile

After the previous step, Emeraude added a Temperature match view on the screen. Maximize this view, with a double-click on its title bar. Open the data browser; select the interpretation temperature in Interpretation#1. Click on the geothermal profile definition button  (or right click and select this option in the browser popup menu). Click the mouse around 800 and drag to about 847 m. While dragging, the defined geothermal profile appears alongside the temperature channel, Fig B04.13.

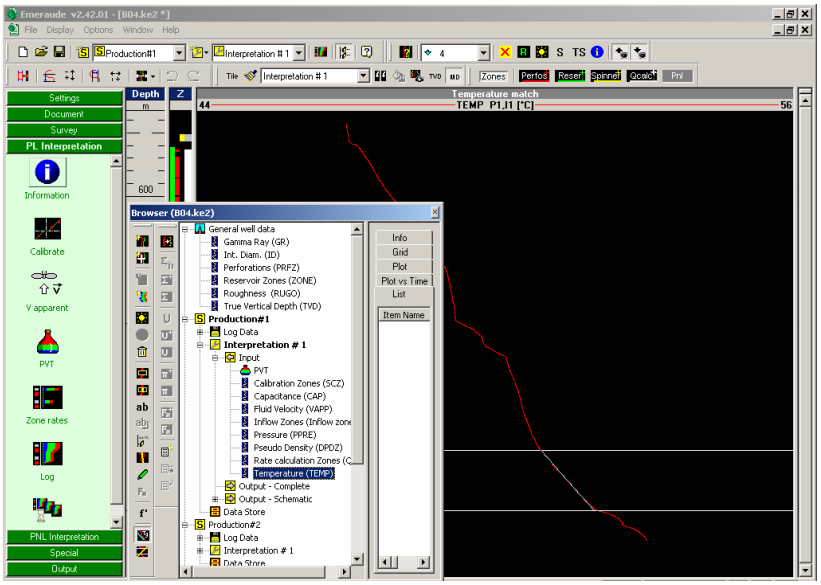


Fig B04.13

Observe that a new channel, “T. Geothermal”, is created inside the Interpretation node in the browser. This channel will only be plotted on the temperature match view. Restore the match view position and the previous screen layout. Also, as a quick way of erasing the previous analysis, re-generate V apparent (with defaults).

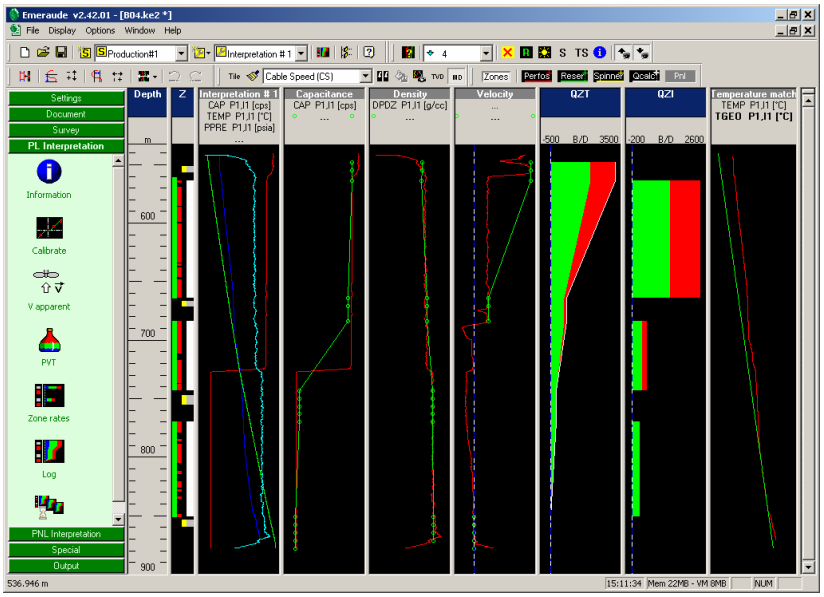


Fig. B04.14

Refining the inflow zones

By maximizing the Temperature match views, you can pinpoint the fluid entries and it is clear that the default inflow zones (in white in the Z-track) need to be resized. This can be done interactively, on the basis of the temperature profile alone. Note that you could also generate and use a temperature derivative channel as an additional guide.

For the sake of this session we will define the inflow zones by keyboard input. Select the Zones option (or double-click in the Z track) to access the grid where the inflow zone limits can be edited. Enter the values: 559 - 654; 699 - 727; 789 – 848 m.

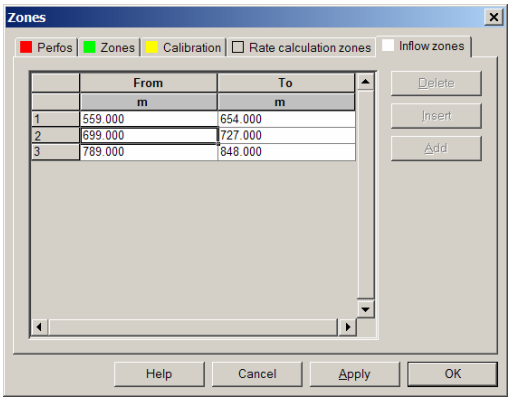


Fig. B04.15

Deleting the irrelevant section of the VAPP channel

We use the browser and the Delete parts option to remove the VAPP data in the region where re-circulation occurs. Delete the data approximately between 681 and 840 m. *In fact, it would be sufficient to delete VAPP in front of the third calculation zone.*

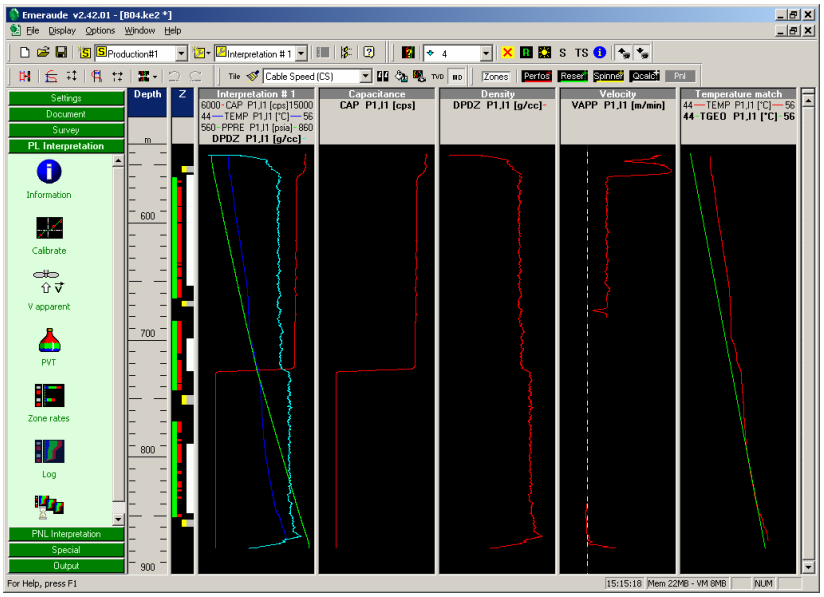


Fig B04.16: Vapp after the re-circulation part has been deleted

Zone Rates

Select Zone Rates. The default model is for 3-Phase L-G. Accept the defaults (with Dukler for the liquid-gas slippage and ABB-deviated for water-oil).

Set the bottom zone to No Flow.

You will notice in the Rate Calculation tab, that 2 residuals are added for the temperature for each calculation zone. One residual deals with the temperature at the top of the inflow zone below, the other with the temperature at the bottom of the inflow zone above. The former one is simulated from with an enthalpy balance on the inflow zone below and is essentially a function of the contribution of that zone. The latter one represents heat loss from that inflow zone to the zone above and is only a function of the cumulative rate. *You can check the Technical Reference (on-line) for details.* Unlike other measurements that can be simulated anywhere in the well bore based solely on the cumulative rate at that level, the temperature must be simulated globally, level by level. For this reason, a global regression should always be run whenever the temperature is matched.

Go to the Contributions page:

- Click the Positive button to set this constraint on all inflow zones.
- Set (or leave) the Match S.C. option checked with a weight of 10.
- Check the “Heat loss coefficient as a variable” option
- Select Global Improve.

Exit Zone Rates and generate the schematic logs, Fig B04.18.

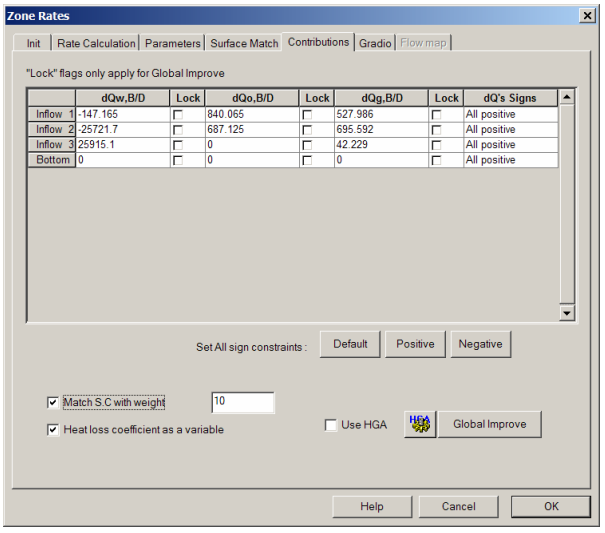


Fig B04.17

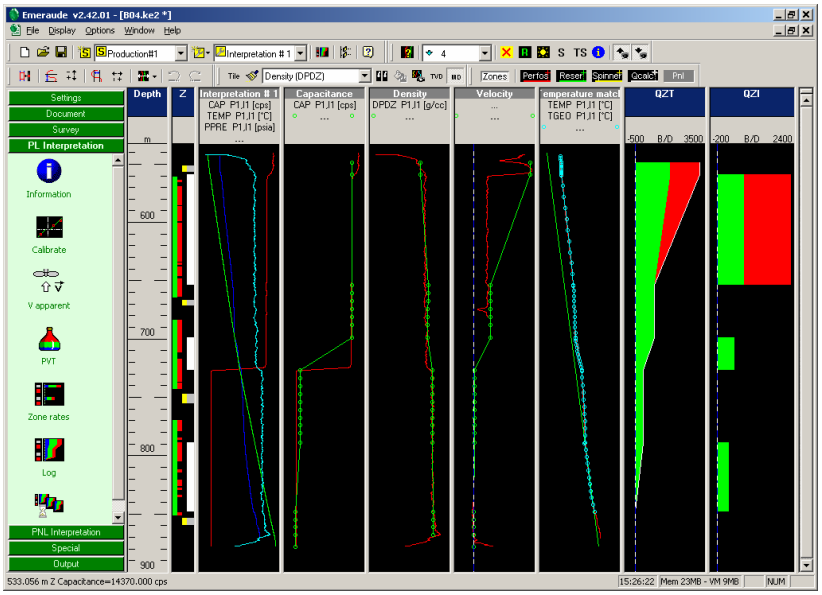


Fig B04.18

Compared with the solution obtained with ADF the overall profile is similar, and S.C. is matched. We see a slightly poorer match of the VAPP channel on the second calculation zone, perhaps also a poorer match on density and capacitance on that same zone. This could be modified by a change of weights and a new run of the Global Improve.

Enabling the Standing water option

We know that the water present inside the casing is not flowing to surface.

However, by default, Emeraude will only come up with a water holdup if this water is mobile. Which means that we will either have a water production at surface or else, end up with solution showing water production and a water thief zone. One way of dealing with such a situation is to use the “Standing water option”, which will allow a water holdup to be calculated yet no water flowing.

Select PL Interpretation - Infos/New. Check the “Flow through standing water up to” and enter 700 m.

You may then return the Zone Rates, Contributions tab, change all the dQw’s 0, and validate (there is no need to run Global Improve).

The schematic will be identical after exiting Zone Rates, even though no water is flowing.

A note on HGA

When working with temperature the Global Regression may very easily get trapped in local minima. This can be avoided using the Hybrid Genetic Algorithm (HGA) option, described at the end of the third guided session. Also one should bear in mind that HGA being a heuristic process, it is not guaranteed to succeed on the first call and you may have to re-run a Global Improve with HGA several times.

This concludes Guided Interpretation #4.