Bo and Rs in black oil models

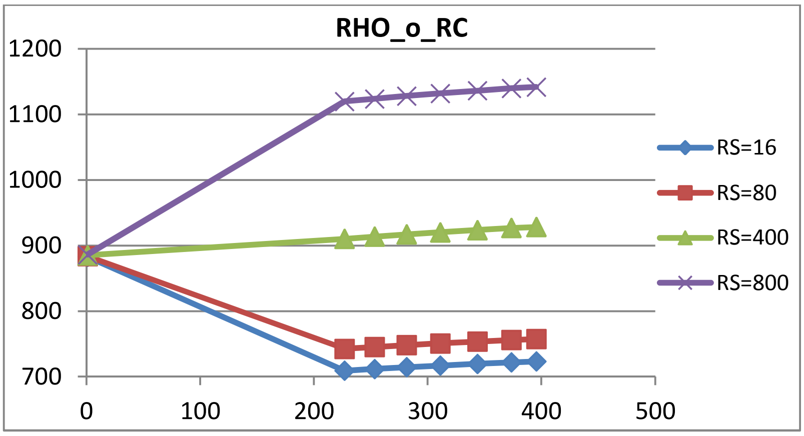
In the IMEX model, $q_o^{ST} = 36\ m^3/D$, and $q_o^{RC} = 45\ m^3/D$.
Reflecting on this, with Rs = 80, a relatively small amount of surface gas is produced, signifying that the reservoir oil volume is actually larger than the surface volume, and the liquid oil must have been compressed during its flow from reservoir to surface – now *that's* simply ridiculous! So first conclusion is that for a given Bo-table, Rs cannot be chosen freely, but is restricted in some way (the obvious is so obvious in hindsight…)

To examine this a little more thorough, I did some simple calculations of RC density. Solving the standard Bo-definition for RC density gives:

$$\rho_o^{RC} = \frac{\rho_o^{ST} + R_s \rho_g^{ST}}{B_o}$$

Using the same $B_o(p)$ as above, the reservoir oil density was computed for *Rs*-values of 16, 80, 400, and 800.

The results are shown in the figure below



This is density for the current oil phase, i.e. including condensed gas. A unit volume of liquid oil at ST has some mass. Condensing gas means this oil mass + some gas mass occupies the same unit volume, hence the total mass in the volume increases. I.e. oil phase density must increase with pressure. All the curves in the figure have the same density increase with pressure (slope of curve) for pressures above bubble point (that's a consequence of using the same Bo-table for all the *Rs*-values). The big difference is when going from ST to bubble point RC. The case *Rs* = 400 is almost linear in the whole range (coincidence…), and as such should be the expected curve for compression of pure liquid oil, i.e. without any gas condensation. In the two lower curves the oil/gas mixture has lower density than the liquid oil (so the liquid oil must have expanded during the pressure increase (???)), which is clearly unphysical.

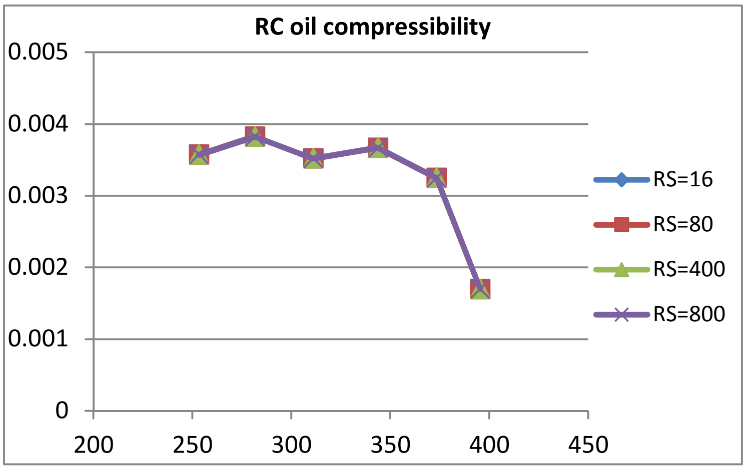
The case *Rs* = 400 can be regarded as a "limit" case – any permitted curves must clearly be above this one, and even *Rs* = 400 is not consistent with no condensation, so the minimum permitted Rs for this Bo-table must lie somewhat above. *How* far can probably be calculated from gas properties.

Conclusion: For a given Bo-table (especially Bo at bubble point), *Rs* cannot be chosen freely, but must lie in some restricted interval to be physical consistent with the Bo variation. From gas properties this value of *Rs* can probably be calculated (estimated) fairly accurately. (So in some sense, *Rs* should be a function of the Bo-variation, and not a parameter that can be "freely" defined by the user – ECLIPSE and IMEX are a little too sloppy here!)

Also calculated oil (phase) compressibility for this case. The compressibility from surface to RC bubble point was of course strongly dependent on *Rs*, with the following values:

R_s = 16: C_o = -0.245
R_s = 80: C_o = -0.19
R_s = 400: C_o = 0.028
R_s = 800: C_o = 0.209

Above bubble point the $C_o(p)$-curve was identical for the four cases (expected, since the same Bo was used), as shown in the figure below.



Note that the compressibility is about 0.003, which is much larger than liquid oil compressibility, and is a clear indication that the oil contains large amounts of condensed gas (recall this is a function of the Bo alone, irrespective of *Rs*-value).

Hence another factor which shows that the amount of condensed gas is determined by the Bo-curve, and only secondary by the *Rs*-value.

Note also the "strange" values ST → RC.