

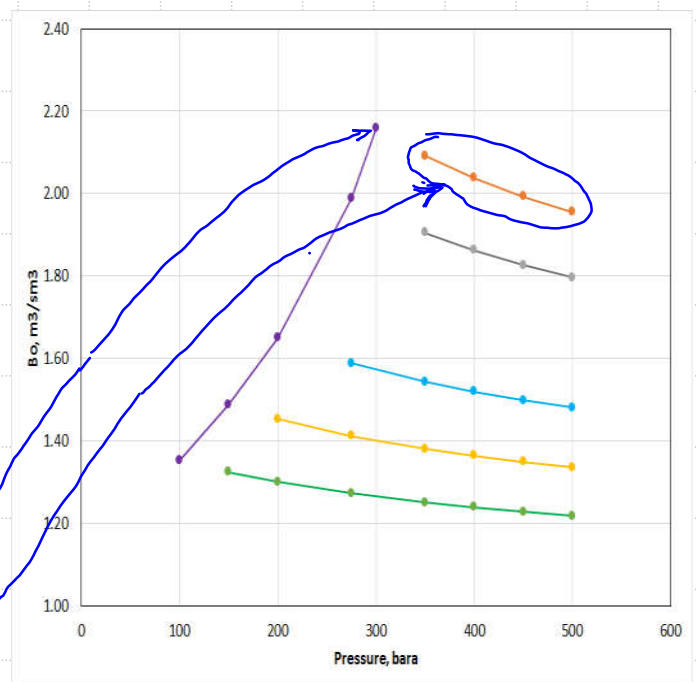
# HOME WORK 04 - ECLIPSE BLACK OIL PVT TABLE

## OIL TABLE:

Rs	po	Bo	1/Bo	uo	Oil Density
Sm3/Sm3	bara	m3/Sm3	Sm3/m3	cp	Kg/m3
66.713	100	1.353	0.7390	0.1846	
	150	1.324	0.7554	0.2099	
	200	1.301	0.7689	0.2348	
	275	1.273	0.7857	0.2714	
	350	1.251	0.7994	0.3074	
	400	1.239	0.8073	0.3310	
	450	1.228	0.8144	0.3543	
	500	1.218	0.8208	0.3772	
107.763	150	1.489	0.6717	0.1498	
	200	1.453	0.6883	0.1697	
	275	1.412	0.7082	0.1992	
	350	1.381	0.7241	0.2284	
	400	1.364	0.7331	0.2478	
	450	1.349	0.7412	0.2670	
	500	1.336	0.7485	0.2861	
157.637	200	1.650	0.6062	0.1236	
	275	1.588	0.6296	0.1468	
	350	1.543	0.6479	0.1700	
	400	1.519	0.6581	0.1854	
	450	1.499	0.6672	0.2009	
	500	1.481	0.6753	0.2163	
262.88	275	1.988	0.5030	0.0934	
	350	1.905	0.5250	0.1089	
	400	1.862	0.5370	0.1193	
	450	1.826	0.5475	0.1298	
	500	1.796	0.5568	0.1403	
314.708	300	2.158	0.4633	0.0843	
	350	2.091	0.4781	0.0932	
	400	2.038	0.4908	0.1021	
	450	1.993	0.5017	0.1111	
	500	1.956	0.5113	0.1201	

→ Saturated properties for oil compos with  $R_s = 66.173$

→ under saturated properties for same oil composition.



$$\rho_o = \frac{62.4\gamma_{wo} + 0.0136\gamma_{go}R_s}{B_o}$$

$$\text{and } \rho_g = \frac{0.0764\gamma_{gg} + 350\gamma_{og}r_s}{B_{gd}}, \dots\dots\dots (7.8)$$

} equations in field units. Be careful!

$\gamma_{go} = \gamma_{gg}$   
&  $\gamma_{oo} = \gamma_{og}$  } assumption

→ oil composition is defined by 'Rs'

→ it is not necessary to define undersaturated properties for every oil composition. At least one oil compos should have the undersaturated table. in Eclipse.

→ For other oil composition, it takes the scale copy of undersat table defined for one oil composition.

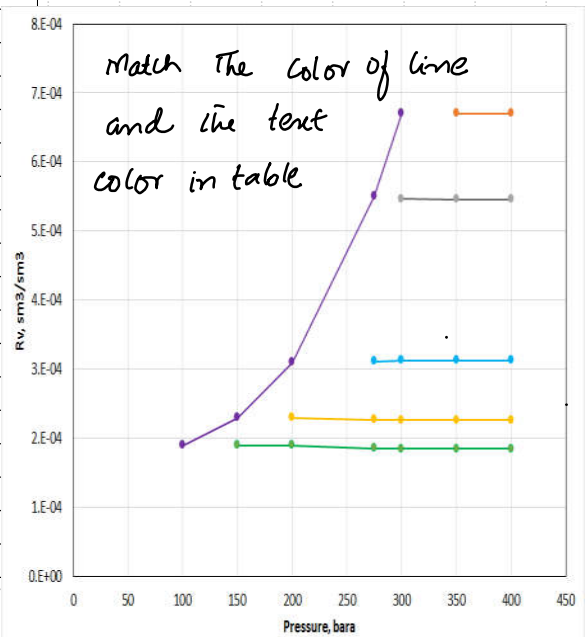
pg bara	Rv Sm <sup>3</sup> /Sm <sup>3</sup>	Bgd m <sup>3</sup> /Sm <sup>3</sup>	1/Bgd Sm <sup>3</sup> /m <sup>3</sup>	ug cp	Gas Density Kg/m <sup>3</sup>
100	0.00019	0.01334	74.946	0.0159	
	0.00000	0.01334	74.946	0.0159	
150	0.00023	0.00883	113.199	0.0184	
	0.00019	0.00879	113.804	0.0184	
	0.00000	0.00879	113.804	0.0184	
200	0.00031	0.00675	148.148	0.0221	
	0.00023	0.00674	148.368	0.0215	
	0.00019	0.00670	149.231	0.0215	
	0.00000	0.00670	149.231	0.0215	
275	0.00055	0.00530	188.679	0.0304	
	0.00031	0.00523	191.058	0.0273	
	0.00023	0.00520	192.271	0.0264	
	0.00019	0.00517	193.573	0.0263	
	0.00000	0.00517	193.573	0.0263	
300	0.00067	0.00506	197.550	0.0342	
	0.00055	0.00501	199.521	0.0323	
	0.00031	0.00492	203.087	0.0290	
	0.00023	0.00489	204.708	0.0280	
	0.00019	0.00485	206.101	0.0279	
	0.00000	0.00485	206.101	0.0279	
350	0.00067	0.00465	215.100	0.0379	
	0.00055	0.00458	218.341	0.0357	
	0.00031	0.00446	224.366	0.0321	
	0.00023	0.00441	226.809	0.0310	
	0.00019	0.00438	228.415	0.0309	
	0.00000	0.00438	228.415	0.0309	
400	0.00067	0.00435	229.779	0.0413	
	0.00055	0.00427	234.247	0.0389	
	0.00031	0.00412	242.483	0.0349	
	0.00023	0.00407	245.761	0.0338	
	0.00019	0.00404	247.586	0.0336	
	0.00000	0.00404	247.586	0.0336	

→ saturated value for  $R_v = 0.00019$   
 $P_d = 100$  bara for gas  $R_v = 0.00019$

→ undersat value for  $R_v = 0.00019$   
 &  $P = 150$  bar

→ undersat value for  $R_v = 0.00019$   
 &  $P = 200$  bar

→ undersat values at  $R_v = 0.00019$   
 &  $P = 275$  bar



- Gas Composition defined by  $R_v$
- PVT tables at 300 bara & 400 bara have exactly same  $R_v$  values bcz there is no gas with  $P_d$  of 350 and 400 bara and max  $R_v$  we have is 0.00067 whose  $P_d = 300$  bara
- The entire table at 350 & 400 bara gives undersat properties of all gases.

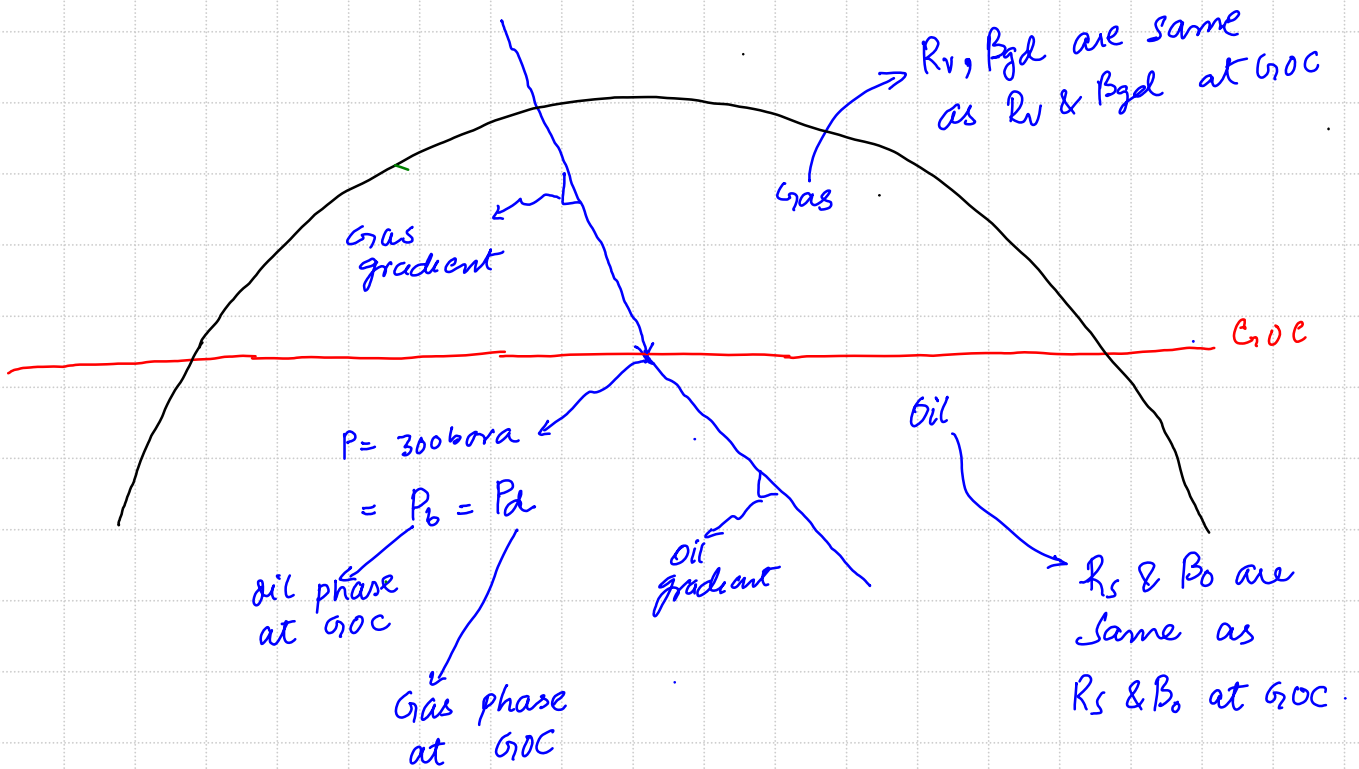
### How TO USE GAS PVT TABLE:

- 1- For a given gas composition  $R_v$  (e.g.  $R_v = 0.00055$ ), look for the lowest pressure where  $R_v = 0.00055$  is just next to any pressure value (275 bara)
- 2- This pressure is  $P_d$  for given gas and all properties at this pressure are saturated properties for given gas.

3- For under saturated properties of same gas look for same  $R_v$  at  $P > P_d$  i.e. all values in gray color. All properties in gray color are under saturated properties for  $R_v = 0.00055$  b/c they belong to  $P > P_d$  for given gas.

4-  $R_v = 0$  is defined in each table which is lower limit of  $R_v$  (i.e. dry gas). and subsequent properties at  $R_v = 0$  for any pressure will be dry gas properties at that pressure

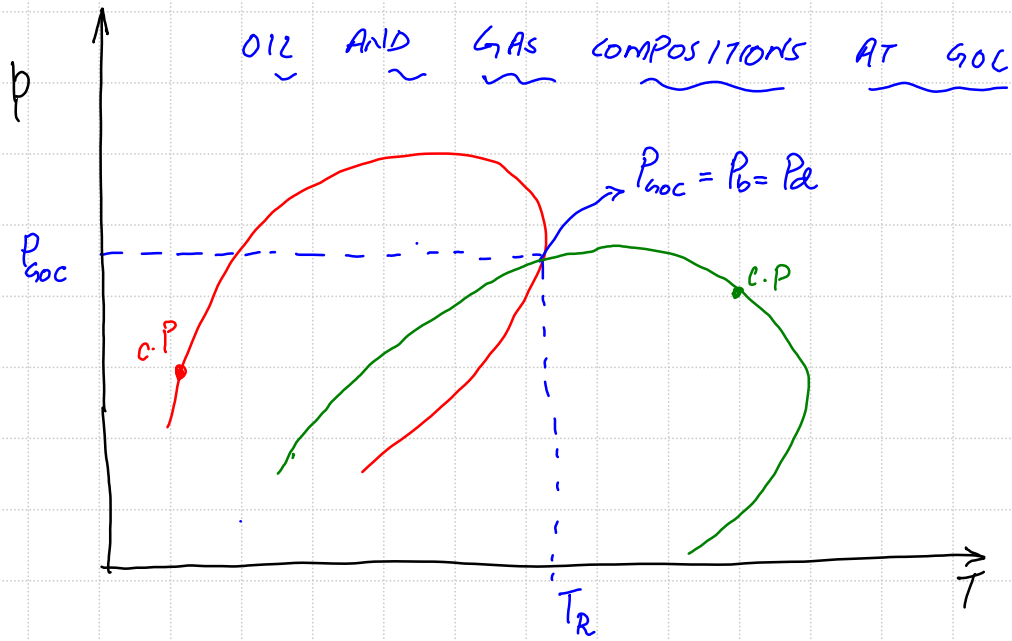
### INITIAL CONDITION FOR INPLACE CALCULATION:



$$\begin{aligned} N_T &= N_o + N_g = N_o + G_g R_v \\ G_T &= G_g + G_o = G_g + N_o R_s \end{aligned}$$

$$N_o = \frac{V_o \times \phi \times S_o}{B_o} = \frac{V_p \times (1)}{B_o}$$

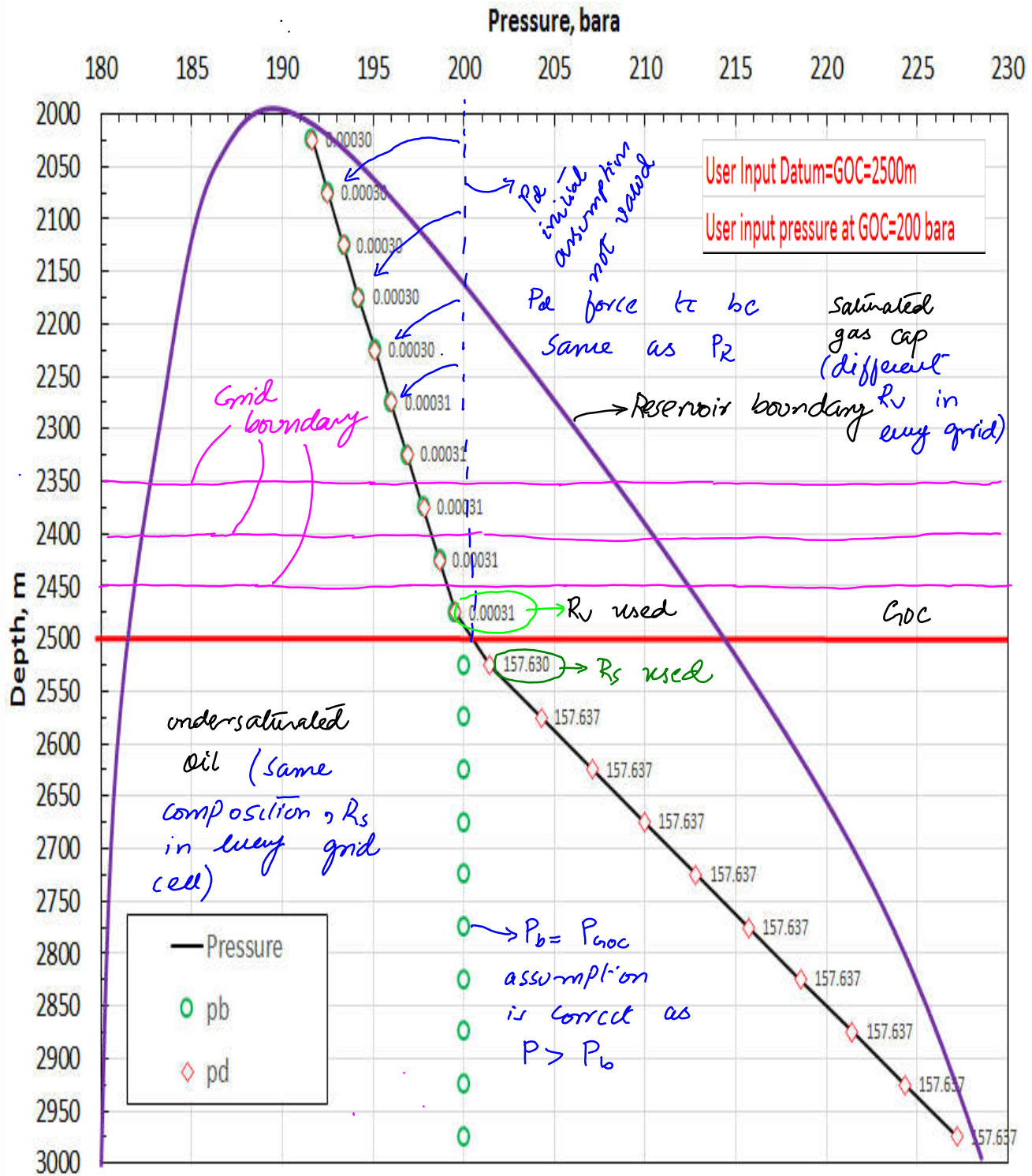
$$G_g = \frac{V_o \times \phi \times S_g}{B_{gd}} = \frac{V_p \times (1)}{B_{gd}}$$



At GOC,  $P_b = P_d$  at  $T_R$  does not mean that the gas and oil at GOC are at their critical points! Because they have different compositions whose  $P_{sat}$  at  $T_R$  are same as shown in diagram.

# ECLIPSE MODEL INITIALIZATION WITH BO TABLE

## WITH 1D MODEL





user input for the model:

- Grid framework (size of grid)
- Datum depth ( $GOC = 2500$  m)
- Pressure at datum (200 bara)
- BO Properties as given in exercise
- Surface densities:

Surface Density (Kg/m <sup>3</sup> )		
Oil	Water	Gas
800	1022	0.9907

} not same as exercise

ECLIPSE solution: (For initial condition)

Depth	Pressure	pb	pd	Rs	Rv	Oil Density	Gas Density	1/Bo	1/Bgd
m	bara	bara	bara	Sm <sup>3</sup> /Sm <sup>3</sup>	Sm <sup>3</sup> /Sm <sup>3</sup>	Kg/m <sup>3</sup>	Kg/m <sup>3</sup>	Sm <sup>3</sup> /m <sup>3</sup>	Sm <sup>3</sup> /m <sup>3</sup>
2025	191.6	191.6	191.6	149.299	0.00030	585.01	174.98	0.6172	142.305
2075	192.5	192.5	192.5	150.158	0.00030	584.46	175.89	0.6160	142.906
2125	193.4	193.4	193.4	151.020	0.00030	583.91	176.81	0.6149	143.511
2175	194.2	194.2	194.2	151.888	0.00030	583.36	177.73	0.6138	144.119
2225	195.1	195.1	195.1	152.760	0.00030	582.80	178.66	0.6126	144.73
2275	196.0	196.0	196.0	153.636	0.00031	582.23	179.59	0.6115	145.344
2325	196.9	196.9	196.9	154.517	0.00031	581.67	180.53	0.6103	145.961
2375	197.8	197.8	197.8	155.403	0.00031	581.09	181.48	0.6091	146.582
2425	198.7	198.7	198.7	156.293	0.00031	580.51	182.44	0.6080	147.206
2475	199.6	199.5	199.5	157.188	0.00031	579.93	183.39	0.6068	147.833
2525	201.4	200.0	201.4	157.630	0.00032	580.06	185.36	0.6067	148.916
2575	204.3	200.0	204.3	157.637	0.00033	580.91	188.34	0.6075	150.455
2625	207.1	200.0	207.1	157.637	0.00034	581.76	191.35	0.6084	151.996
2675	210.0	200.0	210.0	157.637	0.00034	582.61	194.38	0.6093	153.539
2725	212.8	200.0	212.8	157.637	0.00035	583.47	197.44	0.6102	155.084
2775	215.7	200.0	215.7	157.637	0.00036	584.32	200.53	0.6111	156.632
2825	218.6	200.0	218.6	157.637	0.00037	585.18	203.64	0.6120	158.182
2875	221.4	200.0	221.4	157.637	0.00038	586.04	206.78	0.6129	159.735
2925	224.3	200.0	224.3	157.637	0.00039	586.90	209.95	0.6138	161.289
2975	227.2	200.0	227.2	157.637	0.00040	587.76	213.14	0.6147	162.846

→ values look same but are not sufficient decimal places  
GOC

grid cell which is the  $P_R^1$  and use the saturated  $P_o$  at  $P_R^1 = P_o$  from PVT table (newbs) i.e. values in purple text color

(g) The iteration continues until  $P_R^n \approx P_R^{n-1}$  and hence assign the final oil properties ( $P_o, B_o, R_s, \mu_o$ ) in the grid cell.

(h) For next grid,  $P_o$  calculated for previous grid can be used as initial value and rest of the procedure is same.

(i) In our case  $P_R > P_o$  in each grid.

• For pressure in gas phase:

→ Same procedure as of oil

→ In our case, every grid has  $P_R < P_d$  that is why Eclipse forced  $P_d = P_R$  and always use saturated table values (values in purple)

→ That is why values of  $R_v$  in table are different and look same just because of insufficient decimal places reported by Eclipse.

When the simulation will run, ECLIPSE uses three phase equations with three unknowns (saturated case)  $P_o, S_g, S_w$ . In every iteration when it calculates ' $P_o$ ' it will check whether  $P_o > P_b$

assumed initially, if yes then use undersat table of  $R_s$  defined initially. If  $P_o < P_b$  in a grid cell then  $P_o = P_b$  and  $P_b$  will change in the cell and Eclipse will always use saturated table at whatever  $P_o = P_b$  calculated for the grid cell.

Simulator always use saturated three phase equations and not undersaturated equation even for oil bcz it knows the  $P_b$  to compare with  $P_R$  at every iteration and once  $P_R < P_b$  it knows the new  $P_b$  is same  $P_R$  calculated.