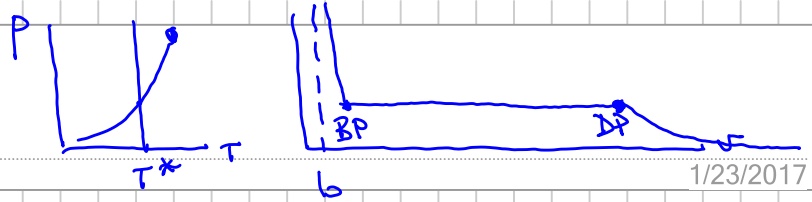
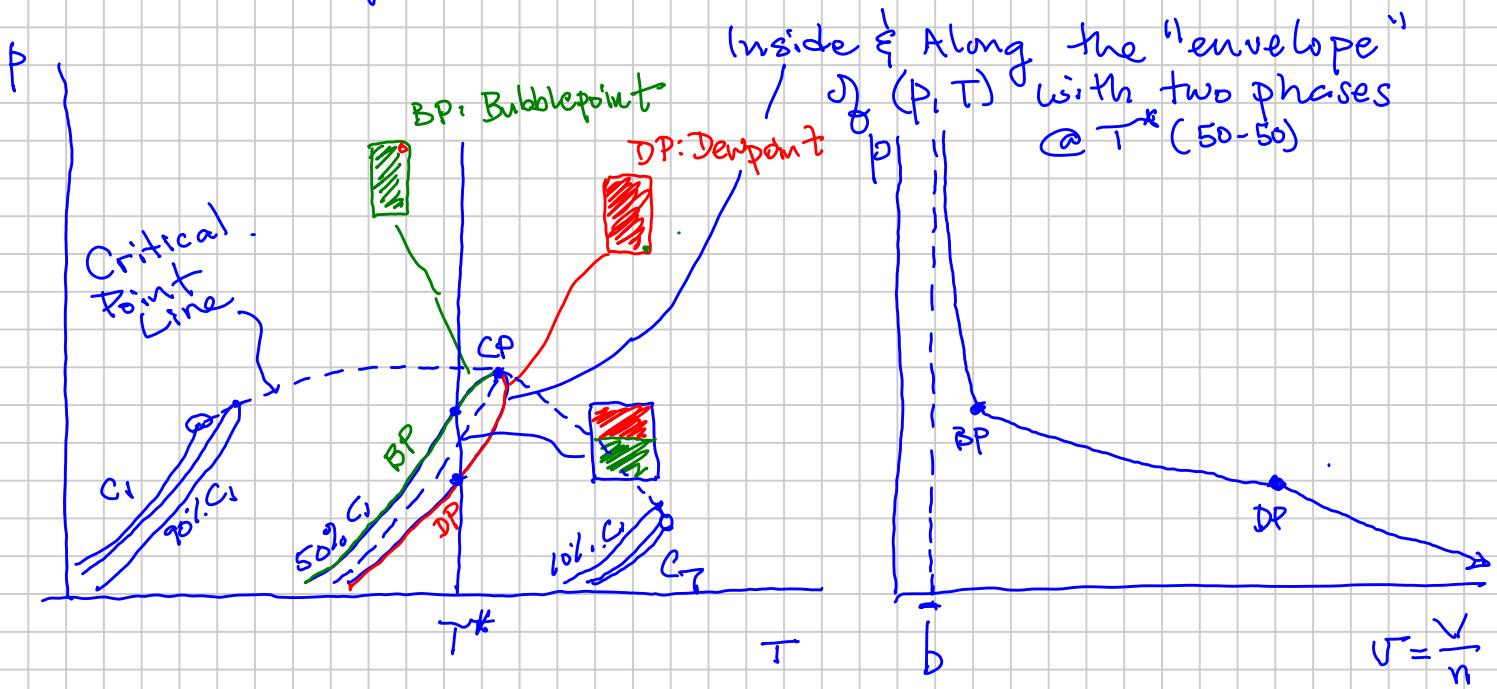


PHASE DIAGRAMS

- Binary Systems (e.g. $C_1 - C_n$)
- Multi-component Petroleum Reservoir Fluids

$$\left.\begin{array}{l} \frac{dp}{dv} \leq 0 \\ \frac{dv}{dp} \leq 0 \end{array}\right\} c = -\frac{1}{V}\frac{dV}{dp} > 0$$



CP: Critical Point.

- Where the BP & DP lines converge
- Phase (G & L) properties become identical
- Depends on the composition

Multicomponent (Petroleum Reservoir) Mixtures: COMPONENTS

100s - 1000s of Compounds

non-HCs: N_2 CO_2 H_2S (H_2O)

Light HCs: C_1 C_2 C_3 $i\text{-}C_4$ $n\text{-}C_4$ $i\text{-}C_5$ $n\text{-}C_5$ $C_{6(s)}$ (straight chain) — Alkanes

{ Heptanes-plus: C_7 C_8 C_9 C_{10} ... C_{20} ... C_{30} .. C_{N+} }

PNA

- Paraffins — Straight-chain HCs
- Naphthenes — Cyclic single-bonds
- Aromatics — Have 1 or more benzene rings) — Cyclic with Double Bonds

Component Amounts:

Fractional Compositions ($\sum_{i=1}^{N} = 1$)

Mass m_i m_i / m_t = w_i ("weight")

w_i w_{gi} w_{oi}

Moles n_i n_i / n_t = z_i Total, y_i Gas, x_i Oil

(Ideal Volumes) V_i

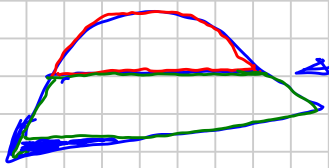
- Gas: $V_{\bar{g}} = \sum (V_i)_{\bar{g}}$ @ STC — Ideal Gas
- Oil: $V_{\bar{o}} \cong \sum (V_i)_{\bar{o}}$ @ STC (1 atm) — Ideal (Liquid) Mixing

(Ch. 7)

Oil @ STC subscript $\bar{o}$

Gas @ STC subscript $\bar{g}$

Fluid Types



At the Gas-Oil Contact Always Saturated @ GOC? (No)

GAS			OIL		
DRY GAS	WET GAS	GAS CONDENSATE	VOLATILE OIL	BLACK OIL	DEAD OIL

WET GAS: $T_R >$ Cricondentherm

Gas: $T_R > T_c(z_{Ri})$ ⇒ Dewpoint pressure @ T_R

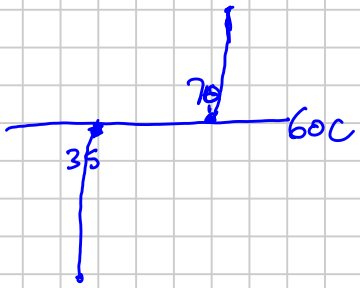
Oil: $T_R < T_c(z_{Ri})$ ⇒ Bubblepoint pressure @ T_R

Saturated Oil = Oil Phase Saturated with ~~a gas~~

a relevant specific gas

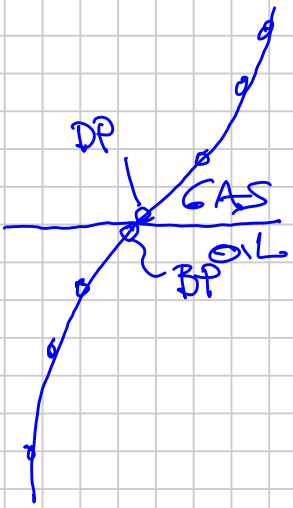
e.g. the equilibrium gas of the oil at its bubblepoint

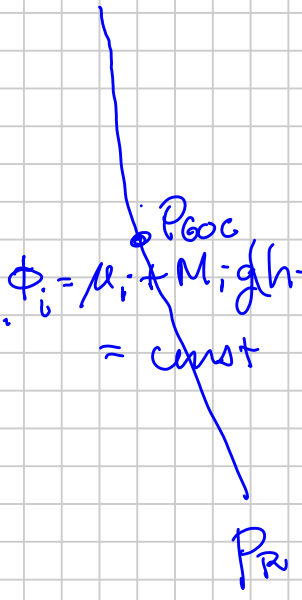
95/100 mol-% C_1 Gas on top of Oil in a reservoir,

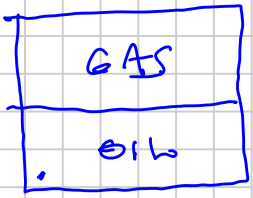


$p_{GOC} \approx p_b$ of GOC Oil $= p_d$ of GOC Gas

1/100 mol-% C_1 $p_{GOC} > p_b$ of GOC Oil $= p_d$ of GOC Gas Undersaturated GOC







SPE 28000

Compositional Gradients in Petroleum Reservoirs

by Curtis H. Whitson,* *U. Trondheim* and Paul Belery,* *Fina Exploration Norway*
*SPE Member

In 1980 significant compositional gradients were reported in the Brent field, North Sea.[5-7] In the Brent formation of the Brent field a significant gradient in composition was observed, with the transition from gas to oil occurring at a *saturated GOC*. These papers also describe the unusual transition from gas to oil in the absence of a saturated gas-oil contact. The transition occurs instead at a depth where the reservoir fluid is a critical mixture, with a critical temperature equal to the reservoir temperature and a critical pressure less than the reservoir pressure (i.e. at an *undersaturated GOC*). Apparently the Statfjord formation in the Brent field is an example of a reservoir with an undersaturated GOC.

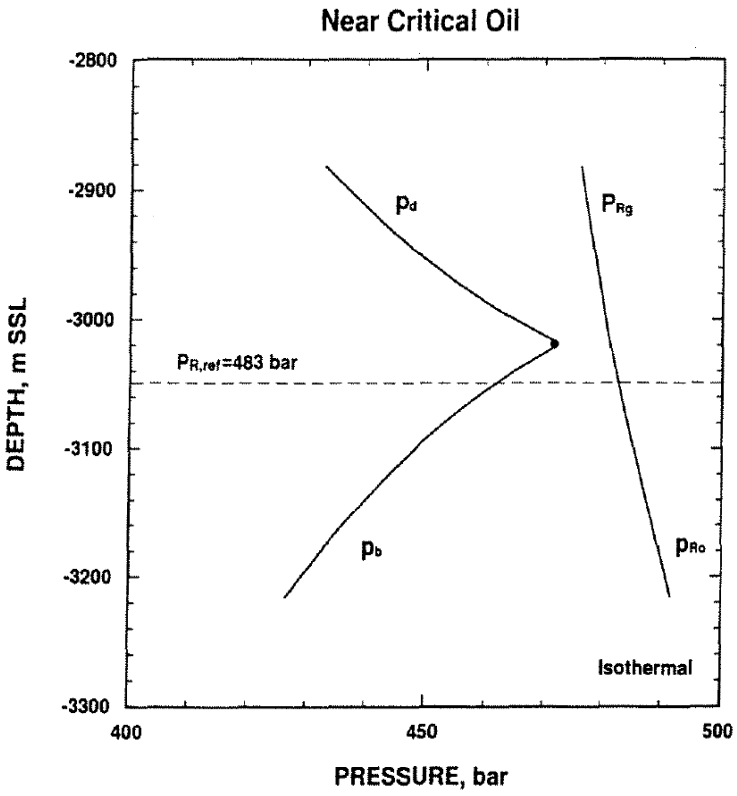


Fig. 17 Saturation pressure variation for Near Critical Oil system using isothermal GCE; slightly undersaturated GOC.

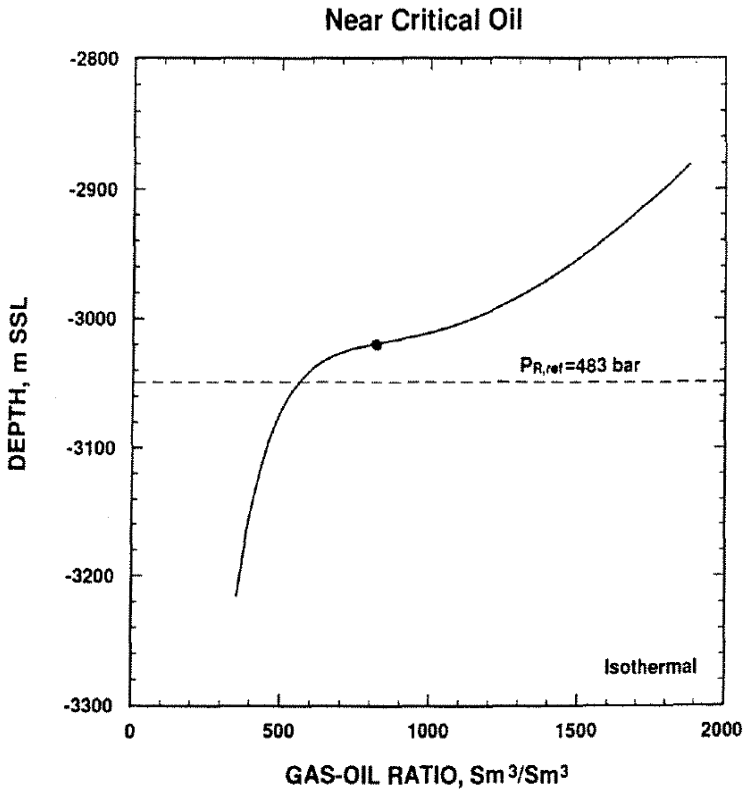


Fig. 18 Gas-oil ratio variation for Near Critical Oil system using isothermal GCE; slightly undersaturated GOC.

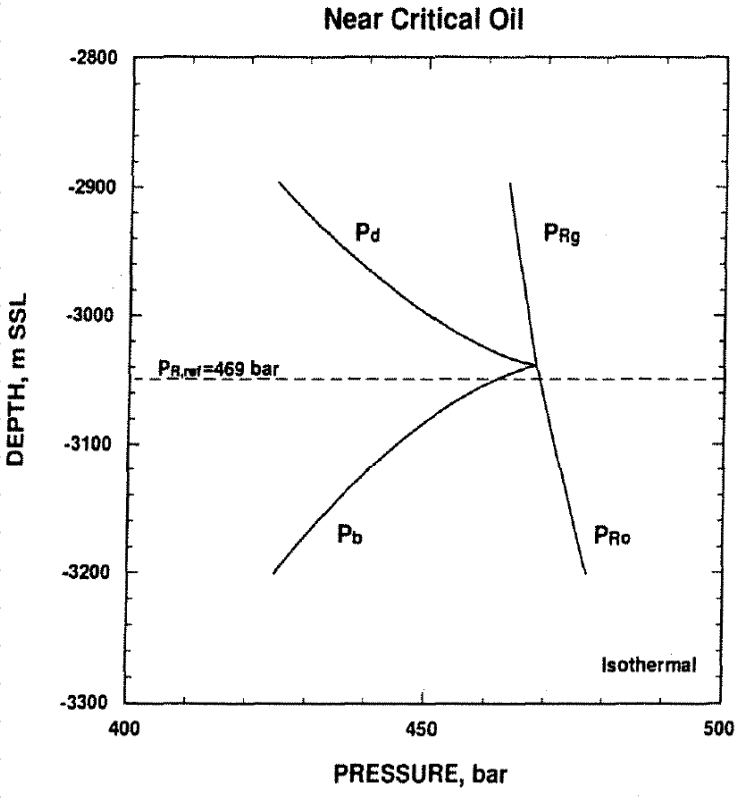


Fig. 19 Saturation pressure variation for Near Critical Oil system using isothermal GCE; saturated GOC.

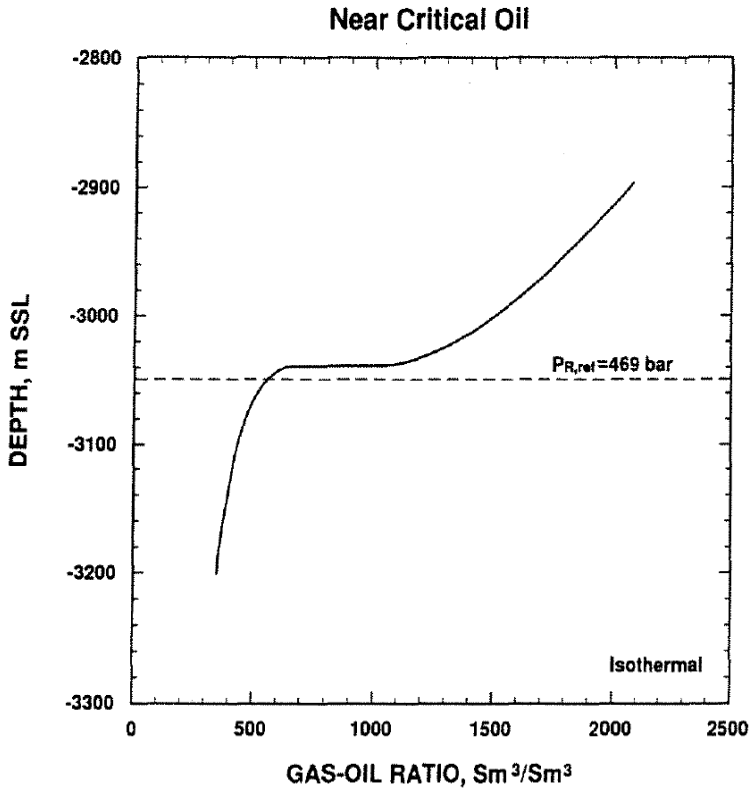
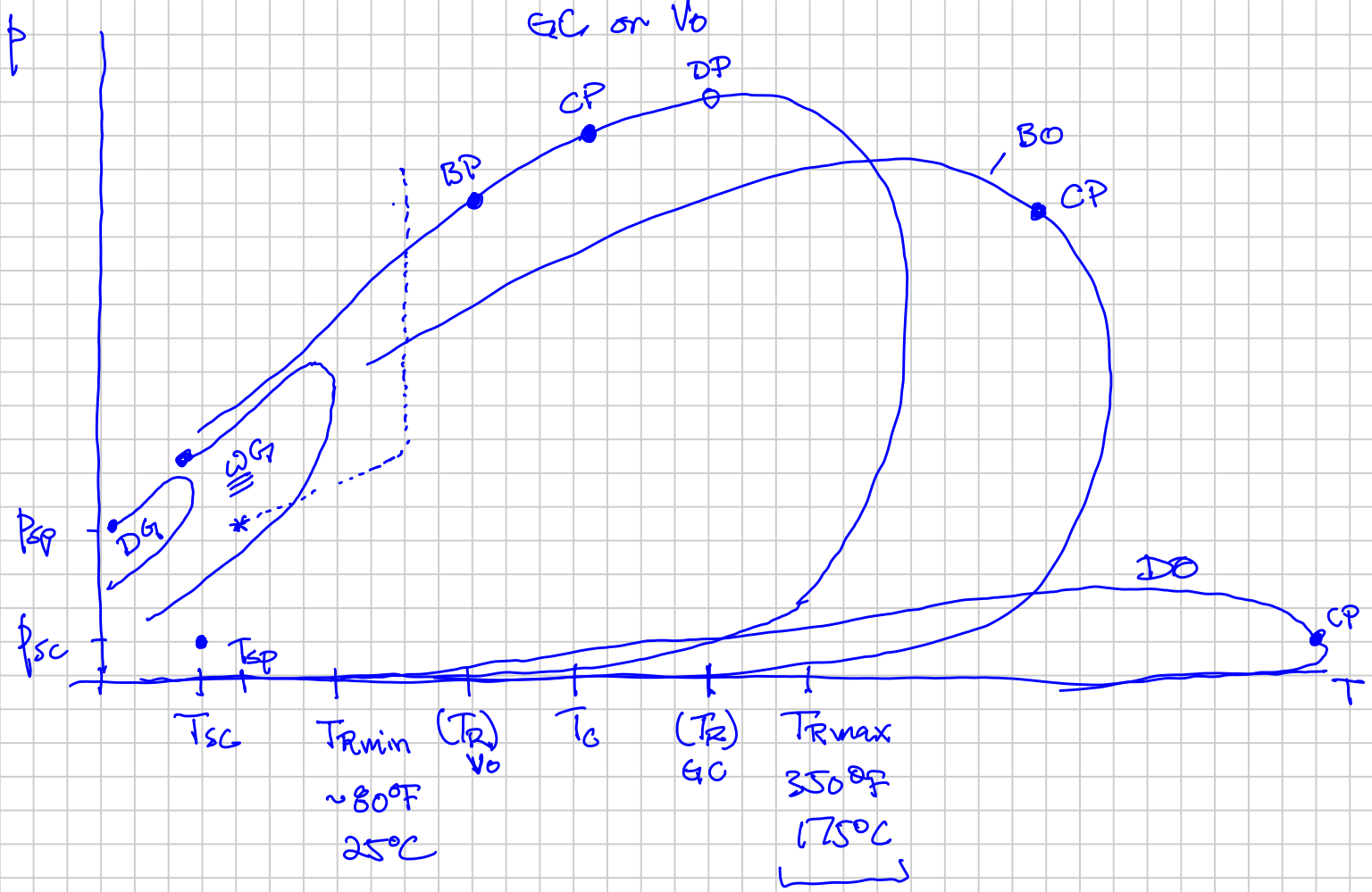


Fig. 20 Gas-oil ratio variation for Near Critical Oil system using isothermal GCE; saturated GOC.


P
GC or Vo
DP
CP
BO
BP
CP
WG
DG
Pep
DO
CP
Psc
Tep
T
Tsc
TRmin
~80°F
25°C
(TR) Vo
TG
(TR) GC
TRmax
350°F
175°C