Note Title 2/11/2016

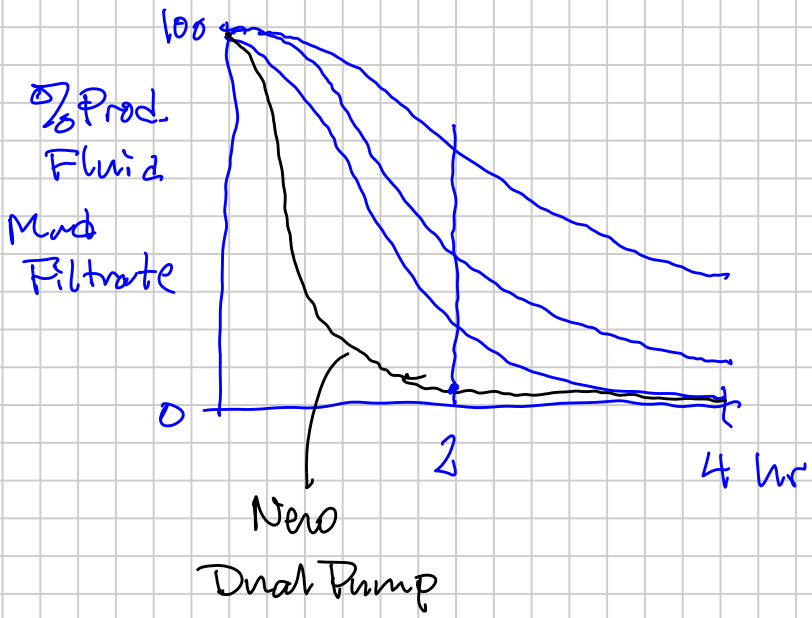
Laboratory PVT Experiments (Ch. 6)

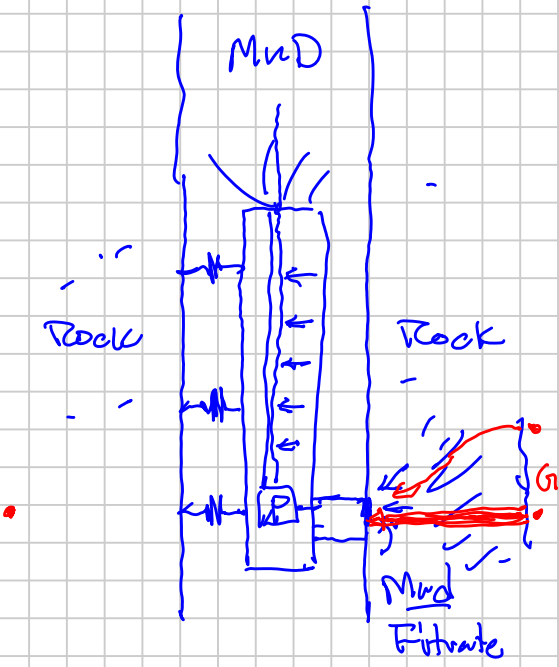
① Sample reservoir fluids < In-Situ Initially In Place
Produced Reservoir Fluids
• (not contaminated)
• (Core — or —)

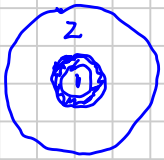
Types of Sampling Methods

(a) Openhole Formation Tester
- RFT (~1980)
- MDT (>1990) | RCI |

Sample BEFORE setting pipe







Local @ Depth (±1 m) Production Test
⇒ Reservoir Fluid + Mud Filtrate

• Water-Based Mud ⇒ Reservoir Fluid Sample ≡ In-Situ @ Depth

• Oil-Based Mud ⇒ Reservoir Fluid Sample =
In-Situ Fluid + Oil Mud
(0.x% – 20+%)

- Don't usually use these samples for Lab PVT measurements unless
  - % OBM very low < 1%
  - No samples that are not contaminated

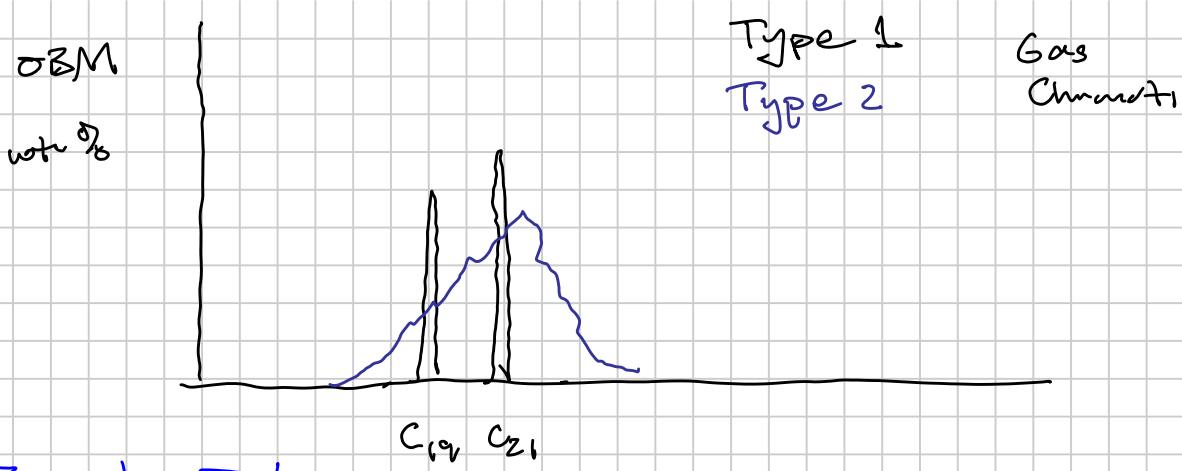
on a weight basis

- Always make a mathematical DECONTAMINATION to get an (very accurate) estimate of the in-situ reservoir fluid composition $\hat{z}_{Ri}$

$$z_{Si} = f_{obm} \cdot x_{obmi} + (1 - f_{obm})\, z_{Ri}$$

- z_{Si}: MDT RCI
- f_{obm}: wt% OBM
- x_{obmi}
- z_{Ri}: In-Situ RF

Back-calculate z_{Ri} by assuming f_{obm}



Formation Tester

✓ (a) Open Hole ✓ Bottom hole Samples (MDT | RCI | ...)

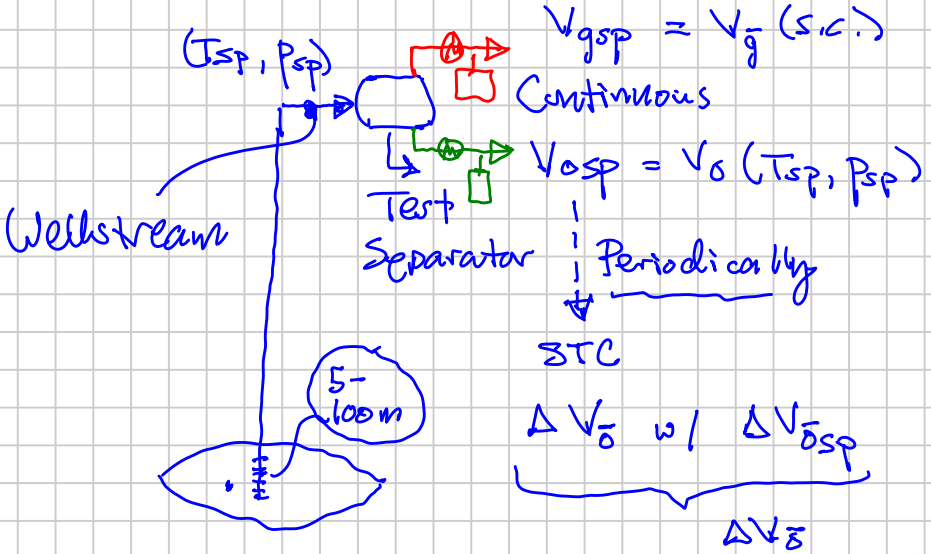
(b) Surface Separator Samples (SEP)

(c) Cased-Hole Bottomhole Samples (BHS)

} Production Testing @ Surface

(b) Surface Separator Samples

1 atm | 60°F (20°C, ?)



$$GOR_{sp} \quad R_{sp} = \frac{V_{gsp}}{V_{osp}}$$

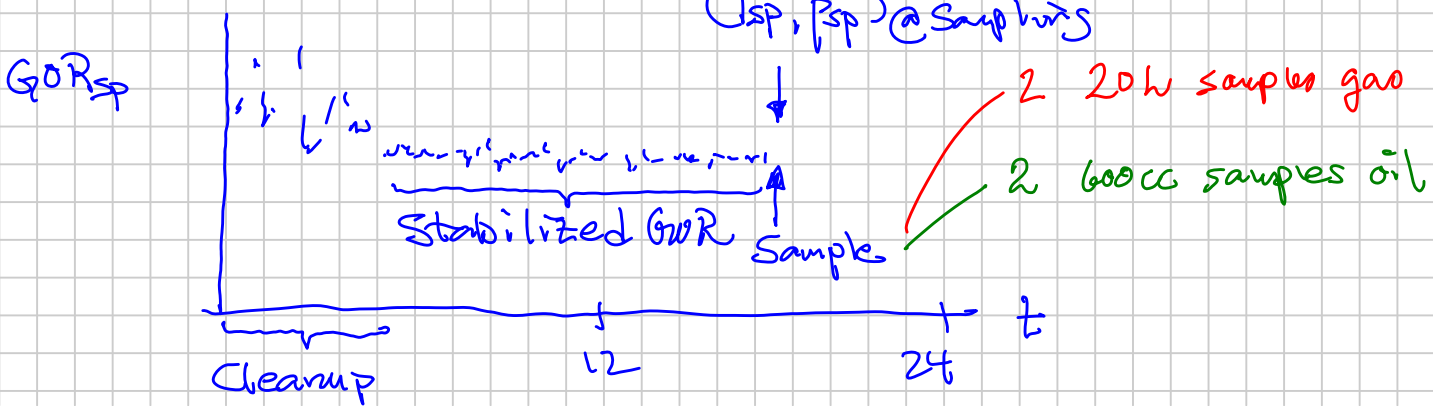
$\left[\frac{scf}{stb\text{-}bbl}\right]$

$\left[\frac{Sm^3}{Sep\ m^3}\right]$

ΔV_o w/ ΔV_{osp}

$$SF_{osp} = \frac{\Delta V_o}{\Delta V_{osp}} < 1$$

Shrinkage Factor 0.7 – 0.98



Lab Needs to recombine physically Sep Gas + Sep Oil:

(1) GOR_{sp} $\frac{scf}{(sep\text{-}bbl)}$ NOT be given $\frac{scf}{STB}$ ← q_o

(2) T_{sp}, P_{sp}

If STB are reported by the testing company.

(q_{osp}) t $\boxed{q_o}$ ... Comment

$q_o(t) = q_{osp}(t) \cdot (SF)$

SF = 0.826 — " — — " — SF = 0.712

Most recently measured

SF = 0.86

Sep. Test Samples ⇒ Get larger sample amounts @ rel. low cost

- Oils ✓
- Gas / Gas Cond. ✓

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Possible Problems:

- Oil with solids precipitation (wax, asphaltene)
  - Low-Temperature Driven @ Surface Sp. Oil is wrong
  - $P \to P_b$ Pressure Driven

- $p_{wf} < (p_s)_{in\,situ}$ ⇒ 2 phases go to flowing in the near well region

$(z_{w'_o}) \sim z_{R_i}$ ↑ In Situ

- Bit too little 'gas' ↪ $GOR_p \leq GOR_i = R_{si}$ Oils
- Too Little 'Liquid' ↪ $GOR_p > GOR_i = \frac{1}{r_{si}}$ G.C.

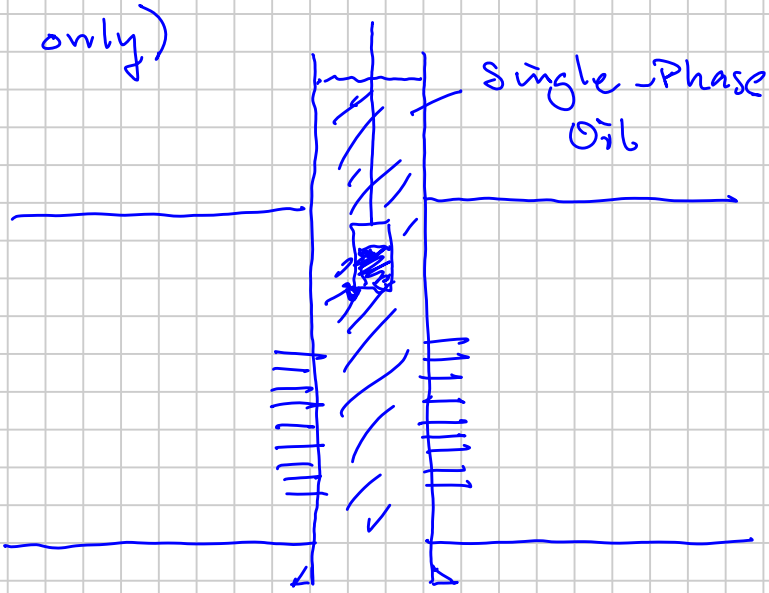
2%-15%

(c) Cased Hole BHS (Oils only)

- During a low flow rate p_{wf} as high as possible

OR

- During a shut-in after production testing



Some BHS samples maintain $p_{bottle} > p_{sampling}$ as the tool is removed.

- Try to keep the sample single phase oil

Why Collect Samples?

K ↑ J → I

① Get an estimate of what is initially in-situ z_{Ri} in the reservoir: Spatial variations in $z_{Ri}(i,j,k)$

Initial Fluids In Place

All you need is composition of samples OHFT (MDT) best source

② Build a **PVT Model** to describe gas and oil properties (ρ μ f_v or V_{ro} p_s (BP|DP) $y_i(p<p_s)$ $x_i(p<p_s)$ $K_i(p<p_s)$)

Use ALL samples with quality PVT data & N_2 (<1%) OBM contamination

f_v or V_{ro}: relative amounts of 2-phases

PVT Models:

(a) Empirical Correlation (Ch. 3) e.g. Standing

1948 1968

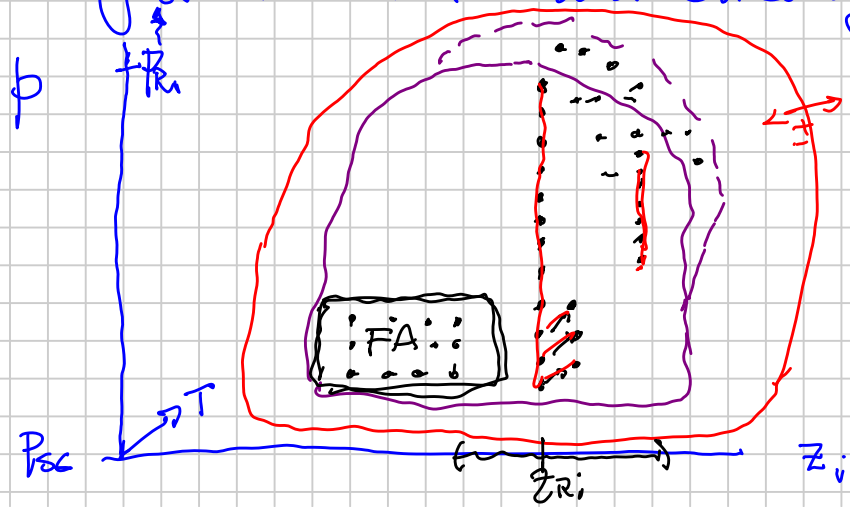
(b) Equation of State (gas & oil & critical) "Consistent"

*** 1990s

Cubic EOS

- van der Waals (1860s)
- SRK (Soave 1972 | Redlich Kwong 1949)
- PR (1977)

Why not use just lab PVT data directly?



- PVT Data
  - Need PVT Engineering
  - -- Gas Inj
  - PVT Mode