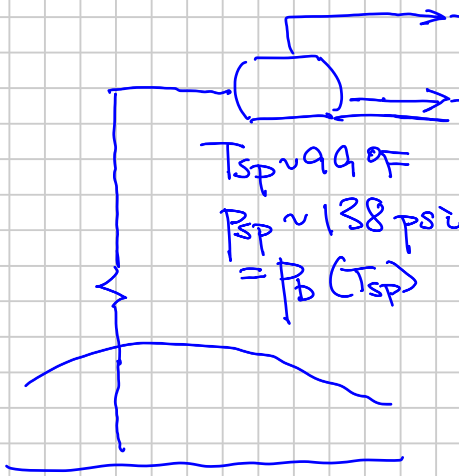
Note Title 10/6/2016

Compositions Summary
Sampling
Fluid Initialization

} $z_i \Leftrightarrow$ GOR, OGR — Product Ratios

(Bilal) Dynamite Gas Condensate (Sep. Sample)



5324 scf → Lab GC

Sep Gas (20 L)

1 sep bbl

Sep. Oil (< 1 L)

↓

Lab

Flash-to-STC (1 atm, T_a)

GOR_F

$\bar{g} \rightarrow GC \quad m_{\bar{g}i} \quad y_{Fi}$

$\bar{o} \rightarrow GC \quad m_{\bar{o}i} \quad w_{\bar{o}i} \quad x_{Fi}$

↳ $M_{\bar{o}}$

$\rho_{\bar{o}}$

Lab

175 ±

Calc

$$M_{\bar{o}} = \frac{\left(\sum^{30+} w_{\bar{o}i}\right) = 1}{\sum^{30+} \frac{w_{\bar{o}i} \pm}{M_i \pm}}$$

± 165

$$m_{\bar{o}30+} = m_{\bar{o}} - \sum_{i=1}^{29} m_{\bar{o}i}^{GC}$$

- Base-line Shift ±
- Internal Standard

$$A_i^{GC} \sim m_i^{GC}$$

$$GOR_{sp} = R_{sp} = \frac{scf}{sep.\ bbl} = 5324\ scf/sep\text{-}bbl$$

$\Rightarrow f_{gsp}$

$$z_{wi} = f_{gsp}\, y_{spi} + (1 - f_{gsp})\, x_{spi}$$

e.g. C_1 67.227 75.480 3.099

Back-Calc. $$f_{gsp} = \frac{z_{wi} - x_{spi}}{y_{spi} - x_{spi}}$$

$$f_{gsp} = \frac{n_{gsp}}{n_{gsp} + n_{osp}}$$

$$= GOR_{sp}, \ldots$$

✓ $$GOR_{sp} = \frac{V_{gsp}}{V_{osp}}$$

$\frac{V_{\bar{g}}}{n} = 379$

$p_{sc} V = n R T_{sc}$

$$n_{gsp} = V_{gsp} \cdot \left(\frac{R T_{sc}}{p_{sc}}\right)^{-1}$$

Convert scf to lb-mole

$$\frac{1}{379} \quad \frac{\text{lb-mole}}{\text{scf}}$$

$$n_{osp} = \underbrace{V_{osp} \cdot \left(\frac{\rho_{osp}}{M_{osp}} \right)}_{\equiv \nu_{osp}}$$

Basis of $\underline{V_{osp} = 1 \text{ sep. bbl}}$ (arbitrary) $\Rightarrow \underline{V_{gsp} = 6 R_{sp}}$

$$f_{gsp} = \frac{(1)\, R_{sp} / 379}{(1)\, R_{sp} / 379 + \left(1 \text{ bbl} \cdot 5.615 \text{ ft}^3/\text{bbl}\right) \dfrac{\rho_{osp}\, [\text{lb/ft}^3]}{M_{osp} \left[\frac{\text{lb}}{\text{lbmole}}\right]}}$$

$$\boxed{f_{gsp} = \left\{ 1 + \underbrace{379(5.615)}\left(\frac{\rho_{osp}}{M_{osp}}\right) \frac{1}{R_{sp}} \right\}^{-1}}$$

$$\rho_{osp} = 0.768 \text{ g/cc} = 47.9 \text{ lb/ft}^3$$

$$\times 62.4 \frac{\text{lb/ft}^3}{\text{g/cc}}$$

$\underline{M_{osp} = 153.45}$ (calc'd I)

$$f_{gsp} = \left\{ 1 + 379(5.615)\left(\frac{47.9}{153}\right)\left(\frac{1}{5324}\right) \right\}^{-1}$$

$$= \underline{0.889} \quad \text{vs} \quad \underline{0.886}$$

vs. (using z_{wC_1}, y_{spC_1}, x_{spC_1})

e.g. C_1 **67.227** 75.480 ✓ 3.099 ✓

$$\text{Back-Calc. } f_{gsp} = \frac{z_{wi} - x_{spi}}{y_{spi} - x_{spi}}$$

z_{wC_1} if $M_{osp} = 163 \Rightarrow f_{gsp}$ ↓ z_{wi}

Uncertainty in mol-% C_1 due to uncertainty in M_{osp} (i.e. $M_{\bar{o}F}$) = **0.42 mol%**

M_{osp}	f_{gsp}	z_{wC_1}
153	0.8891	67.453
163	0.8949	67.872

vs Lab Reported $z_{wC_1} = 67.227$

Generally the lab-reported molar compositions are $\pm$ 0.25 - 2^+ mol-% for C_1 * and C_{7+} *

for various reasons:

GC * w_i $\pm$ BLS (Internal Standard)

* M_i (M_{N+})

* $M_{\bar{o}}$ M_{osp}

* Flash - GC - Recomb : GOR_F $\pm$ 5%

* Sep. (Physical) Recomb : $(GOR_{sp})_{lab} \pm 5\%$

$$\left(\frac{P}{T}\right)_{sp} \simeq \left(\frac{P}{T}\right)_{\text{Lab Opening}}$$

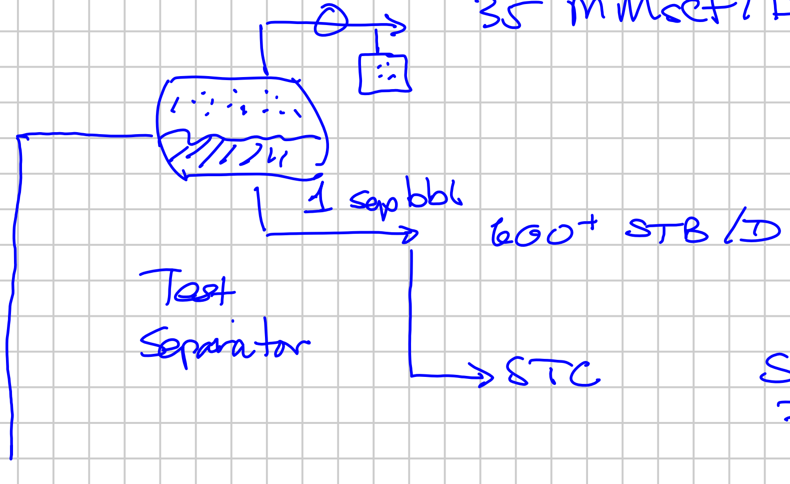
$$\frac{138}{(99+460)} = \frac{P_{open}}{(140+460)} \Rightarrow P_{open} \simeq 138 \cdot \frac{140+460}{99+460}$$

$$= 148 \text{ psia}$$

vs 155 psia

Why would gas bottle to $T > T_{sp}$ be a not-good thing?

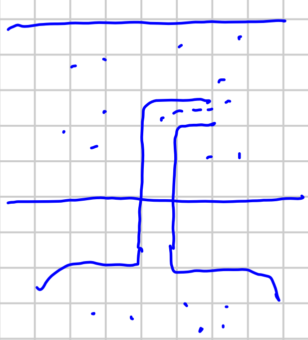
Liquid carryover into the gas sample bottle



$$\text{Shrinkage Factor} = \frac{V_{\bar{o}}}{V_{osp}}$$

$$= \frac{1}{B_{osp}}$$

Separator Oil Volume Factor



Gas Liquids:

y_{spi} 1 Mscf $\Rightarrow$ gallons of i from 1 Mscf

L_i GPM

~~lb/lb-mole~~

$$L_i = y_i \cdot \frac{1000 \text{ scf/Mscf}}{379 \text{ scf/lb-mole}} \cdot \left(\frac{M_i}{\rho_{iL}}\right) \cdot \frac{7.48 \text{ gal}}{ft^3}$$

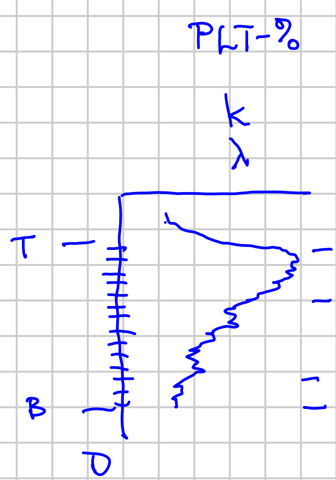
~~lb/ft³~~

$$\frac{\text{gallons}}{\text{Mscf}} = \underline{\quad\quad} \; y_i \left(\frac{M_i}{\rho_{Li}}\right)$$

\$ Condensate 3rd Product

\$\$ NGL C_{3+} C_{4+} } Liquids extracted from surface gases

\$\$\$ LPG C_3 C_4



$$\bar{z}_{Ri} = \frac{\int_B^T \lambda(D)\, z_{Ri}(D)\, dD}{\int_B^T \lambda(D)\, dD}$$

SAMPLING

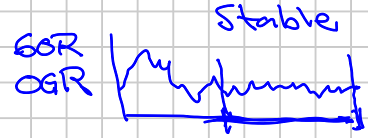
① ⓶a

* Types of Sample Methods

① ⓶a

① Surface Separator Samples

Want: GOR (t) ~ stable



z_{Ri}

② Bottomhole Samples

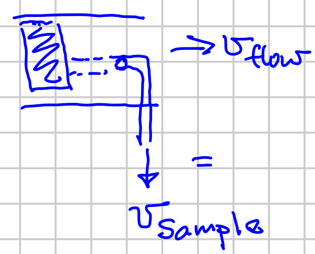
(a) Traditional Cased-Hole (wireline) : OILS

(b) Openhole Formation Tester (MDT, RCI, ...) : z_{Ri} (D)

③ "Exotic" Samples

(a) Isokinetic Separator Samples ⇒
SPE 28829

(b) Isokinetic Wellhead Samples



* Special Sampling Issues :

BHS { – Waxy fluids ("high" content n-alkanes C_{20+}) = f (T)

– Asphaltenic fluids $p \to p_s (p_b)$ max tendency to deposit asphaltene

Excess of these wax-forming compounds in surface samples

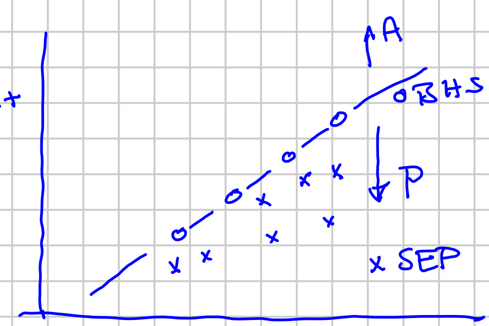
– Water
• Salinity | HC/CO_2 Solubilities (Ch. 9)

– Oil-Based Mud issues

• Only Openhole Formation Samples

– Decontamination of $\gamma_{\bar{o}}$ γ_{7+}

(OHF) MDT-type samples.



$$\text{OHF} \quad z_{S_i} = z_{Ri}(D) \cdot (1 - f_{obm}) + x_{obmi} \cdot f_{obm}$$

✓ ? ✓ ?

Reservoir Molar OBM Contamination

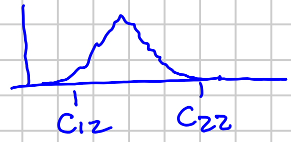
$$\text{"}f_{obm}\text{"} \equiv \frac{n_{obm}}{n_{obm} + n_R}$$

$M_{\bar{o}}$ M_{7+}

N+1 unknowns z_{Ri}, f_{obm}

⇒ Very good estimate of z_{Ri} & f_{obm} usually

OBM x_{obmi} x_{mi} <



Distribution OBM

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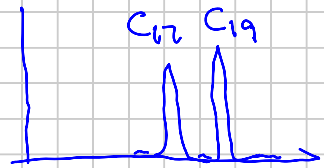
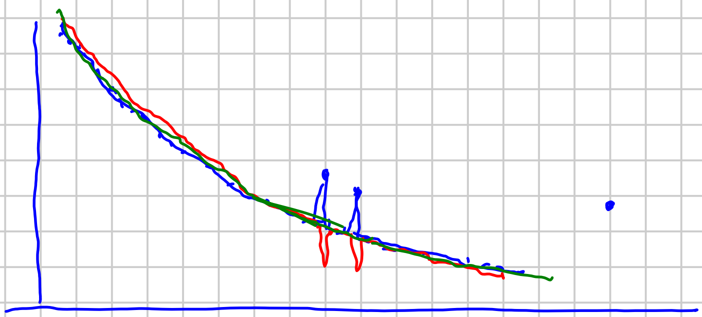


OHF z_{si} : C_{7+} components



f_{obm} ?

f_{obm} too large

f_{obm} ✓

f_{obm}

$$\hat{z}_{Ri} = (z_{si} - f_{obm}\, x_{mi}) / (1 - f_{obm})$$

C_{7+} of Flashed Oil or Reservoir Fluid

i	z_{si}	x_{mi}	$\hat{z}_{Ri}$
C_7			
C_8			
⋮			

C_{15} | C_{17}

OBM: $M_{obm} \sim 200$

16.14 ~ 224

Same basic procedure using Flashed Oil Mass fractions with OBM contamination

$$f_{Fobm} = \frac{m_{obm}}{m_{obm} + m_{\bar{o}F}}$$

GCOBM-report.pdf

$$w_{F\bar{o}i} = w_{\bar{o}i}(1 - f_{Fobm}) + w_{mi} \cdot f_{Fobm}$$

↑ Recombine w/ $w_{\bar{g}Fi}$ w/ $(GOR_F^*)_{corr}$

* WHY SAMPLE ?

II 1. Get an estimate of in-situ reservoir fluid

I 2. Build EOS model

II 3. Variation of in-situ fluids spatially

I 4. Studies on solid (wax | asphaltene) precipitation

I 5. Build PVT models for pipeflow (T variations)

II 6. Fluid definition (gas or oil)

II/I 7. Study fluid heterogeneity (II) | uncertainty analysis (I)

✓ (I) Build PVT Models — All ① - ④ Data

(II). Map In-Situ Fluid (z_i) Distribution — ①

What to do with the Samples, Once Collected ?

① Measure composition

②(a) Measure $p_s(T)$ | $\rho(p>p_s)$ } Minimum PVT test

②(b) Multi-stage separator test }

③ Viscosities

④ Two-phase behavior

- $V_o(p<p_s)$, $V_g(p<p_s)$ (a)
- ρ_o, ρ_g $p<p_s$ (b)
- $\{x_i, y_i\}$ $p<p_s$ (c)

✓ $\left\{ \begin{array}{l} \mu_o \\ \mu_g \end{array} \right.$ $p < p_s$ (d)

σ_{go} $p < p_s$ (e)

⑤ Fill little bottles that we give away

FLUID INITIALIZATION

$z_i\,(I, J, K)$

① Depth Variations (K)