Note Title 11/20/2018

GAS INJECTION EOR
(Pore-Level Recovery)

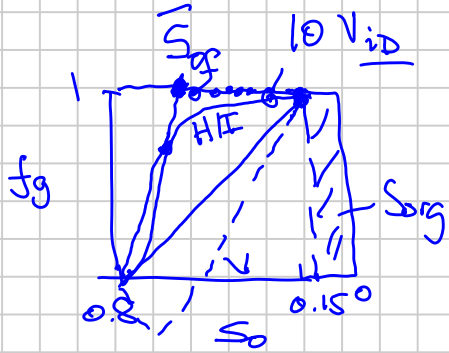
① Purely Immiscible

② Vaporization-Dominated

③ Swelling-Viscosity Reduction

④ Multi-Contact Miscible

⑤ Unconventional
- Naturally Fractured
- Shale "Ultra-Tight"
- Steam



① Purely Immiscible

* No component exchange between reservoir phases

- 1D BL displacement ($k_r, \mu \Rightarrow \lambda$) $S_{oi} \rightarrow S_{org}$
  slow
  80% 55% 15%
  @1PVI

- 2D BL (Vertical Flow, Gravity)
  high k

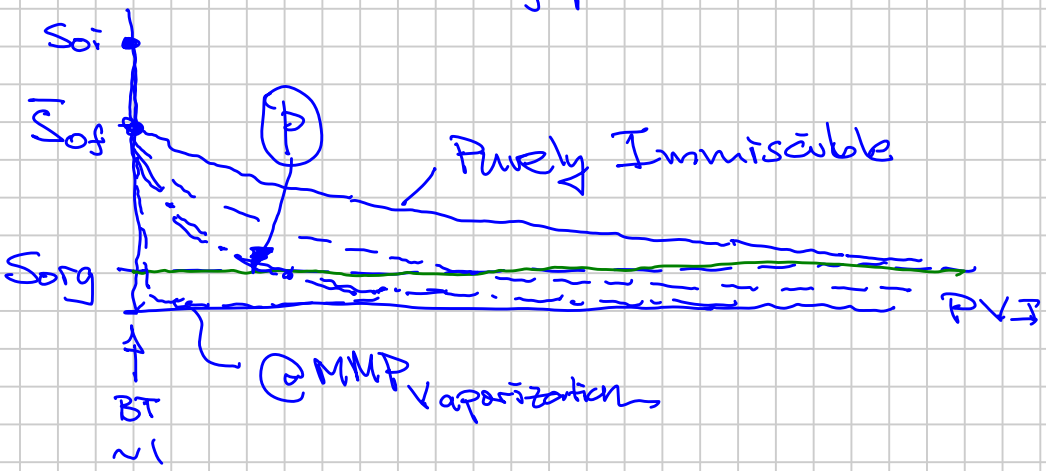
  $S_{oi} \rightarrow S_{org}$
  Fast
  @1PVI

$\Rightarrow$ Leaky Piston

② Vaporization-Dominated

- Light Oil (>35°API) / Condensate (>45-50°) $C_{7-15(20)}$ Light Heavies
- High Pressure
- Net component transfer from RO phase to RG(IG) phase $K_i \equiv \frac{y_i}{x_i}$ ↑ higher K_i RG ↑ RO

- BL ⇒ $S_{oi} \Rightarrow \underline{\underline{S_{of}}} \Rightarrow$ ○ (low value) $= f(p)$



③ Swelling-Viscosity Reduction

- Heavier Oil (22-32°API) $\mu_o \sim 5-50 \Rightarrow 1-10$
- Lower p_R < 3500 psia $V_{oi} \rightarrow V_{os} \sim 1.2 \rightarrow 2^+$
- Undersaturated Oils
- Injection Gas: HCs "C_1" C_2-C_4 also

CO_2

- Can be / often used together with water injection (WAG) and alternating

Note Title 11/21/2018

MISCIBLE GAS INJECTION

(Pore Level Recovery) $S_{oi} \to 0$ where swept

- First Contact Miscible (FCM)

- Multi-contact / Developed Miscibility

Location of Front

Downstream — • VGD (Vaporizing Gas Drive)

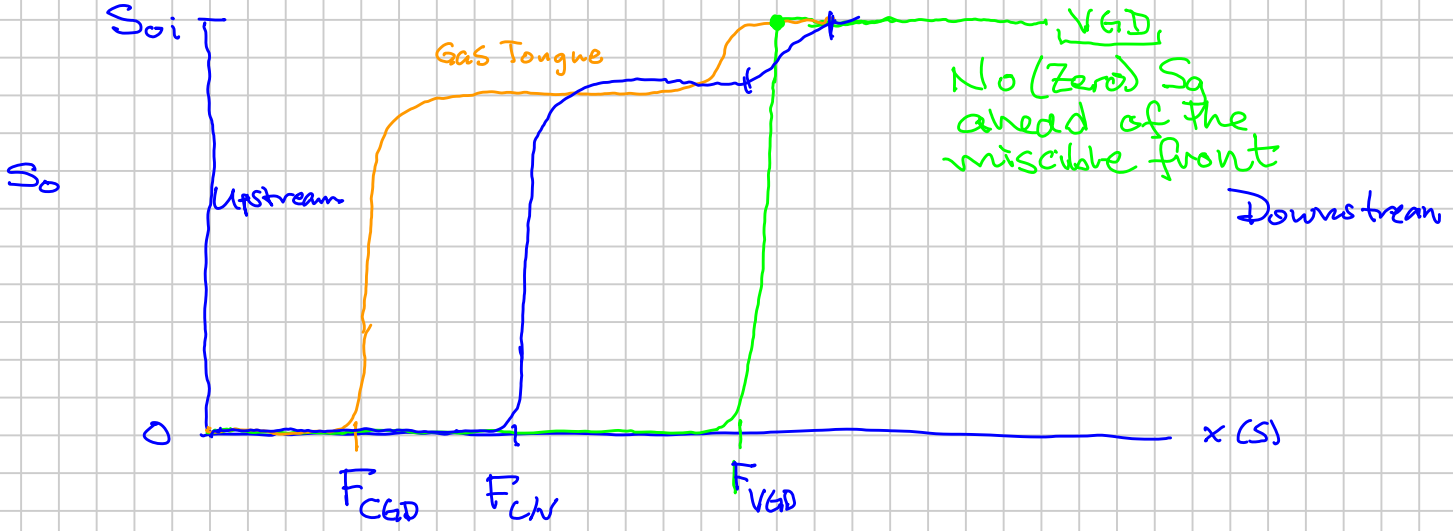
Upstream — • CGD (Condensing —"—)
"non-existant"

Midstream — • C/V GD (Condensing/Vaporizing)
90% Zick 1986/87

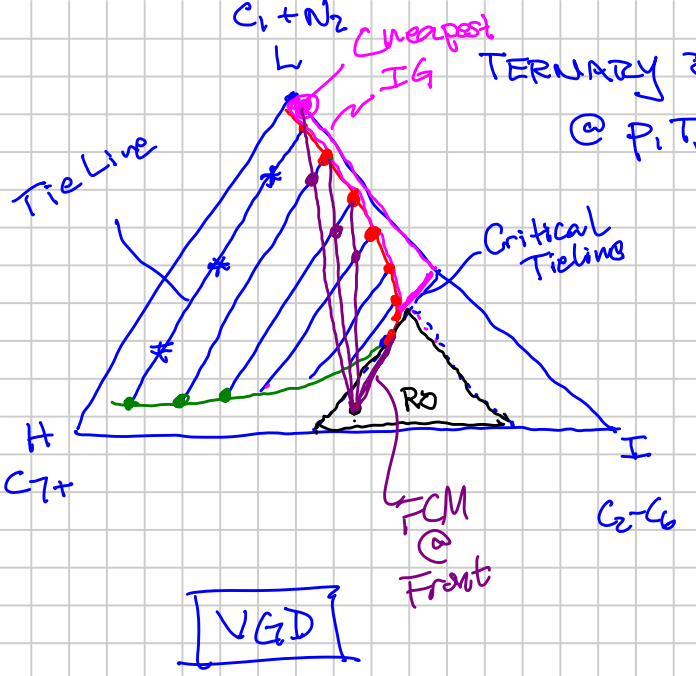
K-values! $K_i(p, T, z_i)$ *

Altered
Frontal Gas
Frontal Oil

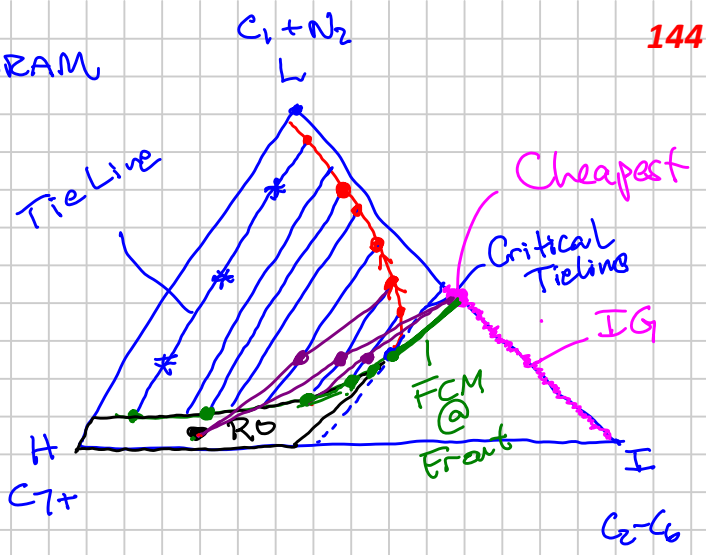
Frontal Gas & Frontal Oil



* Development of an altered "frontal" gas and/or "frontal" oil ⇒ frontal phases become FCM



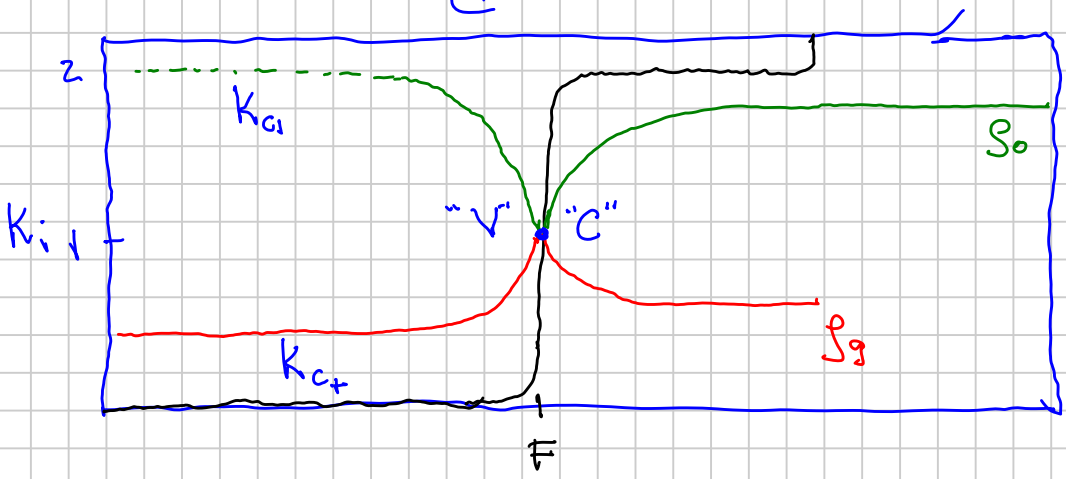
VGD



CGD

C/V Gas Drive "Signatures"

@ 0.5 PVI



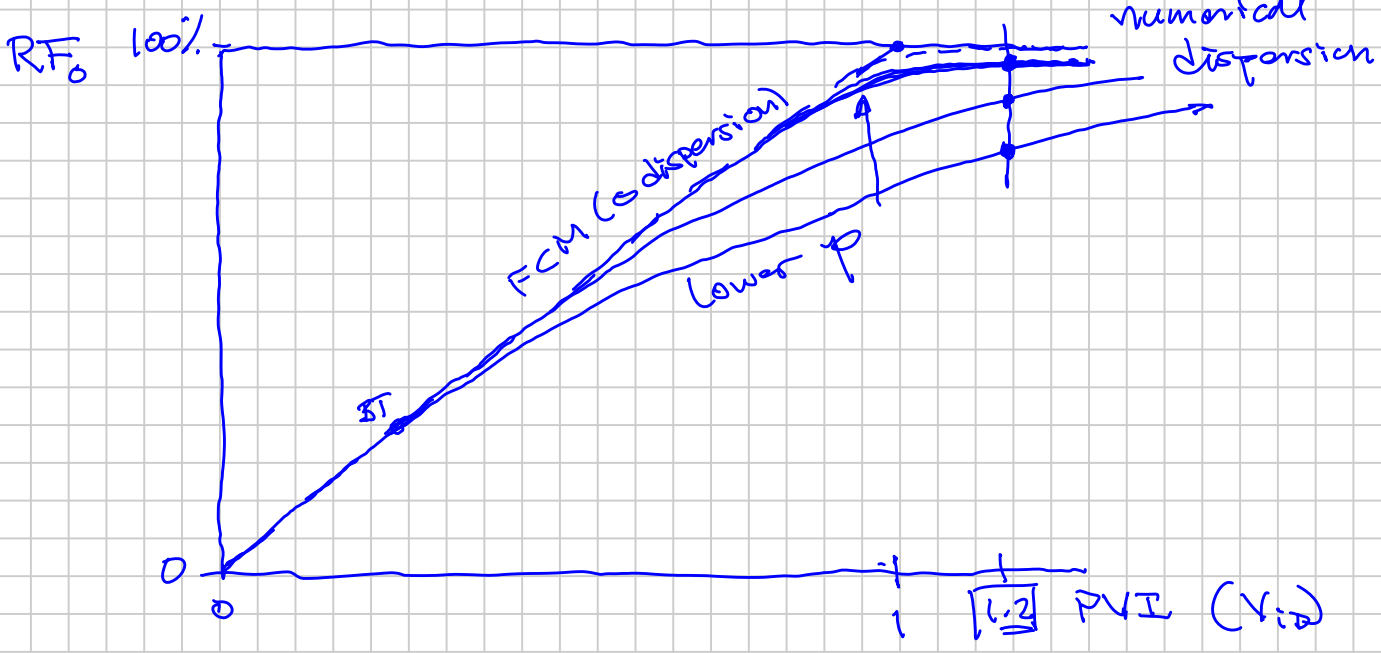
Hour-Glass Signature S_g / S_o K_{C_1} / $K_{C_{7+}}$

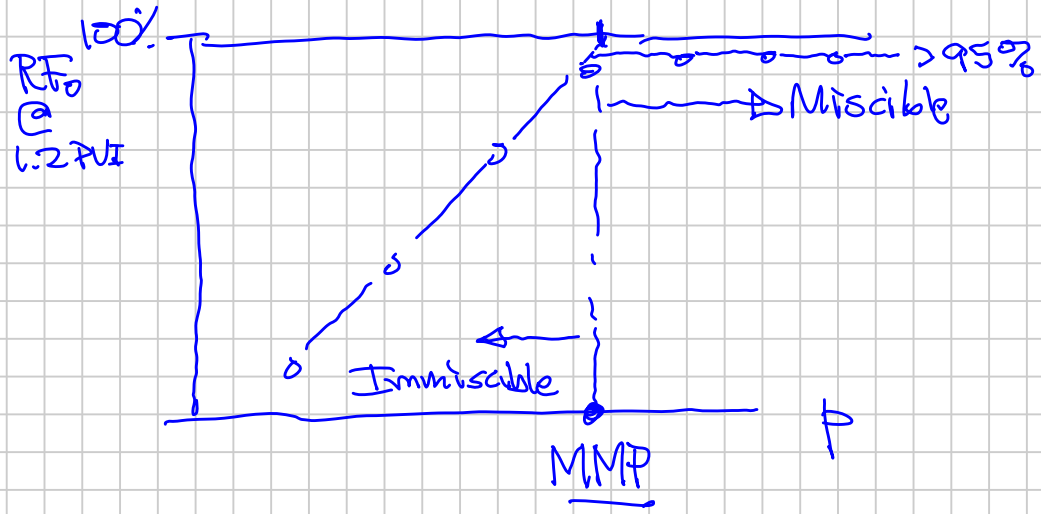
Min. 4-components ⇒ C/V Miscibility

Method of Characteristics

IG + RO ⇒ Develops Miscibility, or not

- Experimentally (Slim tube : 1D packed tube)
  ⇒ min physical disp
- Computationally (1D horizontal : many many cells ⇒ min numerical dispersion





EOS-based 1D Simulations ⇒ MMP

- EOS model needs to be "good"

  complex phase behavior
  PVT lab measurements
  near critical points

- IMPES formulation
  CFL ~ 1

- Sufficient grid cells to eliminate / minimize numerical dispersion

not real mixing of frontal gas and frontal oil