TPG 4150 RESERVOIR RECOVERY (METHODS)

Note Title 8/20/2018

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RESERVOIR RECOVERY METHODS

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① RESERVOIR - What is it?

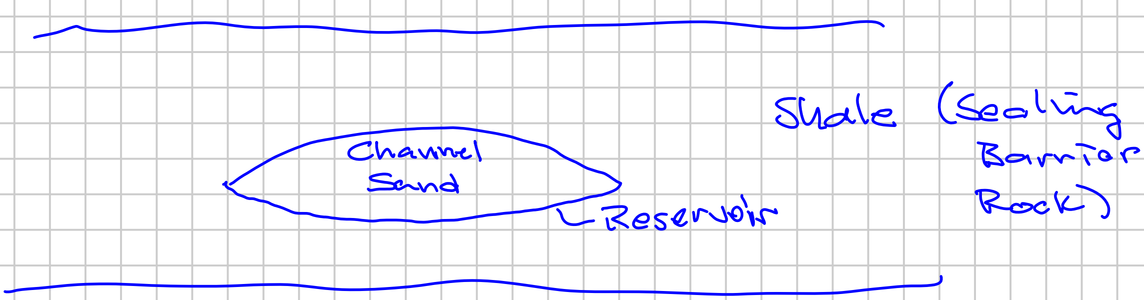
A porous and permeable rock containing fluid (e.g. hydrocarbons, HC) resources that can be accessed (and usually produced) by wells drilled from, connected and controlled at the surface by equipment and facilities such as pumps, compressors, separators, pipelines, and storage tanks.

(a) Geologic (and Petrophysical)

$\phi, k, P_c \ldots$

↓

- Stratigraphic Container



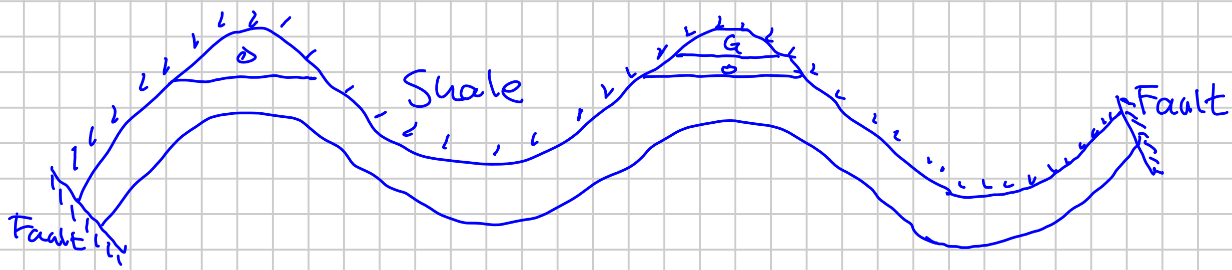
Side View

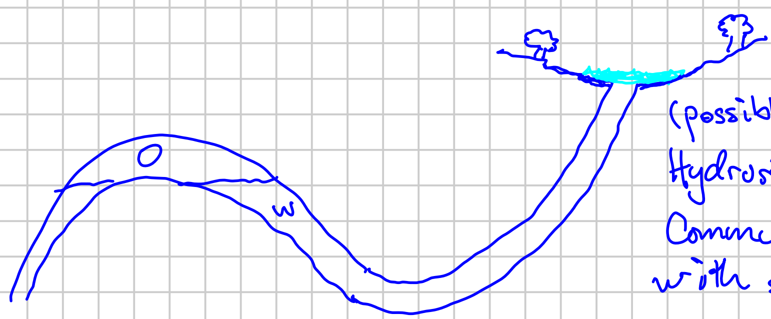
" HCs (and associated waters e.g. Aquifer AQ) are sealed in all directions by ultra-low ($k \to 0$) permeability rock/effective barriers. Sealing barrier rocks are usually "neighbor" strata to the HC-bearing reservoir, most often "shale". The sealing rock, if organic rich, may be the source of HCs." CHW

– Structural Container

Laid down ~ horizontally or flat at an angle

⇓ Transformed via folding, salt dome intrusion, faulting ...





"HCs trapped by overlying impermeable barriers (e.g. shale layers or faults), often with significant deformation of the ~ flat strata laid down originally – e.g. by uplift (salt domes), folding, etc.

NEXT LECTURE:

- Barriers (No Flow)
  - Types
  - Importance (Flow Communication | Well Placement | Gravity)
- Mapping
  - Structure
  - Isopach
  - ϕ, k, S_w, "Net" (N&G), P_c
  - Initial Pressures & Temperatures (& Fluids)

http://www.ipt.ntnu.no/~curtis/courses/Reservoir-Recovery/2018-TPG4150/

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RESERVOIR RECOVERY METHODS

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HCPV $\xrightarrow[\text{"PVT"}]{\text{TPG4145}}$ Surface Products

PV

V_b

- Surface Oil
  Stock Tank Oil $\}\ \bar{o}$

$q_{\bar{o}}$

- Surface Gas $\bar{g}$

Energy:

6 Mscf ~ 1 STB

2.5 \$/Mscf \$70/STB

\$15/BOE

- Volumetric Material Balance
- Darcy Flow Eq.

- Barriers (No Flow)
  - Types
  - Importance (Flow Communication | Well Placement | Gravity)

- Mapping
  - Structure
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  - ϕ, k, S_w, "Net" (N/G/R), P_c
  - Initial Pressures & Temperatures (& Fluids)

Fault Block
Layer

RESERVOIR FLOW UNITS (RFU)

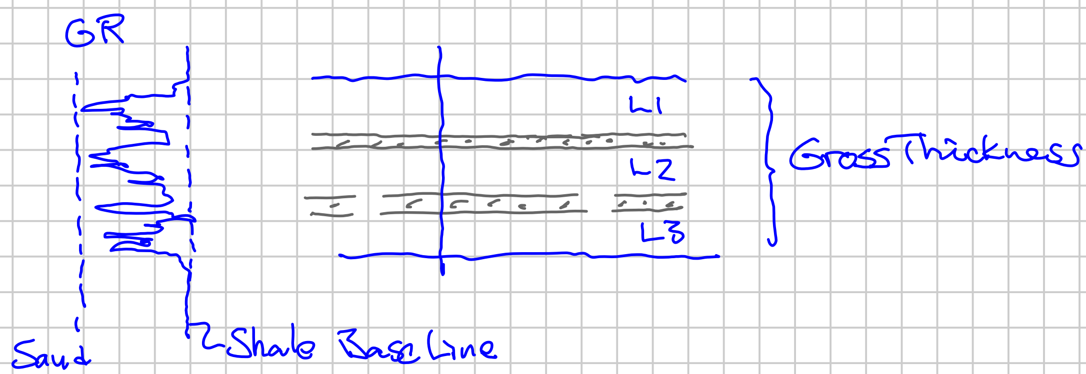
Reservoir volumes that are not connected or do not have flow between themselves, caused by two types of flow barriers:

(1) Fault : (a) sealing fault $k_F = 0$
(b) Leaky fault $k_F > 0$
Always consider both cases

(2) Very-low k rock, normally shale

important in defining "non-net pay"

Define "very low"



net thickness (rock) ⇒ yields recovery of HCs

Well Types

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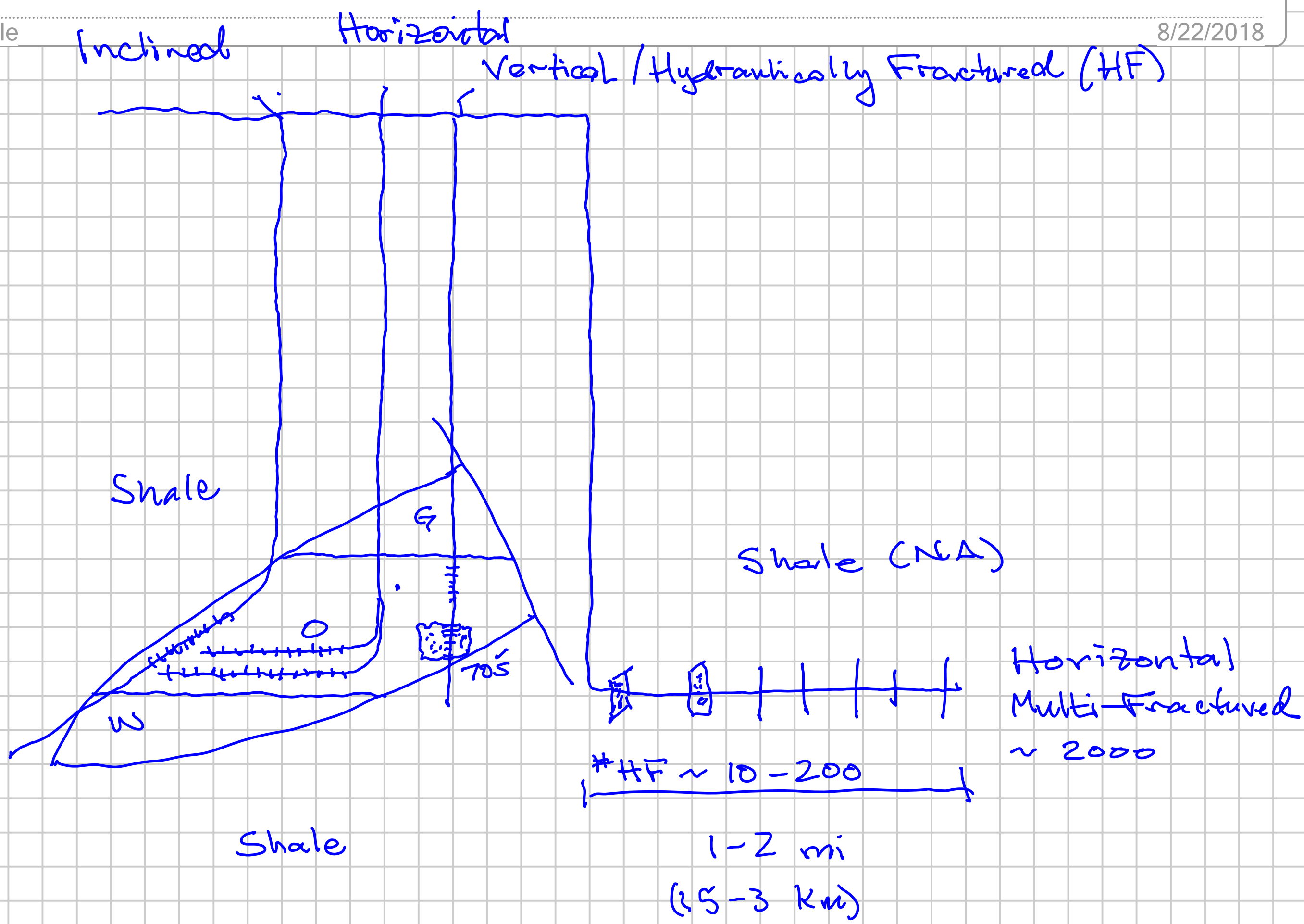


RECOVERY

- Recovery of Surface Products

STO SO $\bar{o}$

SG $\bar{g}$

Categories of Recovery Processes

SO (RO)

{ EOR (2)
{ IOR

EOR: Enhanced Oil Recovery

- Inject a Fluid into the Reservoir (1)

W+G { • Water (Saline)
{ • Gas (HC | CO_2 | N_2 : Flue Gas)

• Chemicals added to the above

Natural "Depletion"
- No Injection

IOR: Improved Oil Recovery

- EOR
- Well Type & Well Completion (Depletion and/or EOR)

Impact of Barriers to Vertical Flow on

1. Depletion
2. EOR

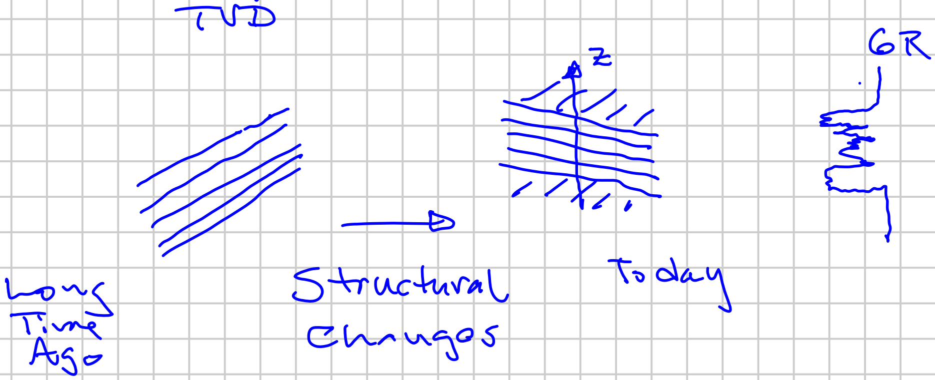
} & IOR (Well Type)

Reservoir rock is made up of sequential, stacked "history".

k_z $\quad$ $k_v(z)$ ← TVdepth TVD

Wellbore

k_{xy} : controlling flow R → WB



k_v : Defining "Effective" RFUs

- Depletion
- EOR (Injecting Fluid G &/or W)

$$\frac{k_z}{k_{xy}} \sim 1 \rightarrow \underbrace{0.1 \rightarrow <0.01}$$

① Depletion :

$\rightarrow k_{xy}$ $\qquad\qquad\qquad\qquad$ k_z

~ 10

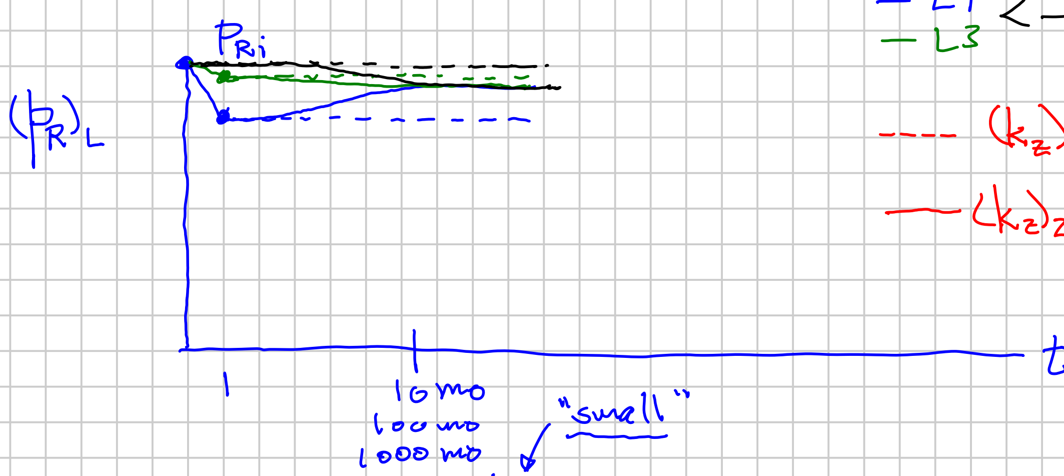
~ 1

$$(k_z)_2 \sim 10^{-x} \text{ md}$$

Typical Shale
$10 \sim 10{,}000$ nd
$10^{-5} - 10^{-2}$ md

Time 0 :

$$q_L \propto (k_{xy})_L$$



— L1 < — L2
— L3
---- $(k_z)_2 \cong 0$
— $(k_z)_2$ "sufficient"

"small"

$$q_z = \frac{k_z}{\mu L} \Delta p \cdot A_{\perp}$$

thickness of shale $\qquad$ huge

$$k_z \sim 10^{-3} - 10^{-4} \text{ md}$$

② EOR

$p_R \sim$ constant

Driving force of IW/IG $\quad \underbrace{\Delta \rho_{ow} \cdot g}_{\Delta \phi} \quad \underbrace{\Delta \rho_{og} \cdot g}_{\Delta \phi}$

$$q_z = \frac{k_z A_\perp}{\mu L} \Delta \phi_r$$

"small"

$\cancel{q_z}$

$\circ$ $q^W \sim 0$ small even for $(k_z)_{LZ}$ "large" md

more "RFU_{EOR}" than "RFU_D"