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Simple Guidelines for Screening Development Options for Oil-Rim Reservoirs

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Presentation Outline

Introduction

Problem Statement and Study Objectives

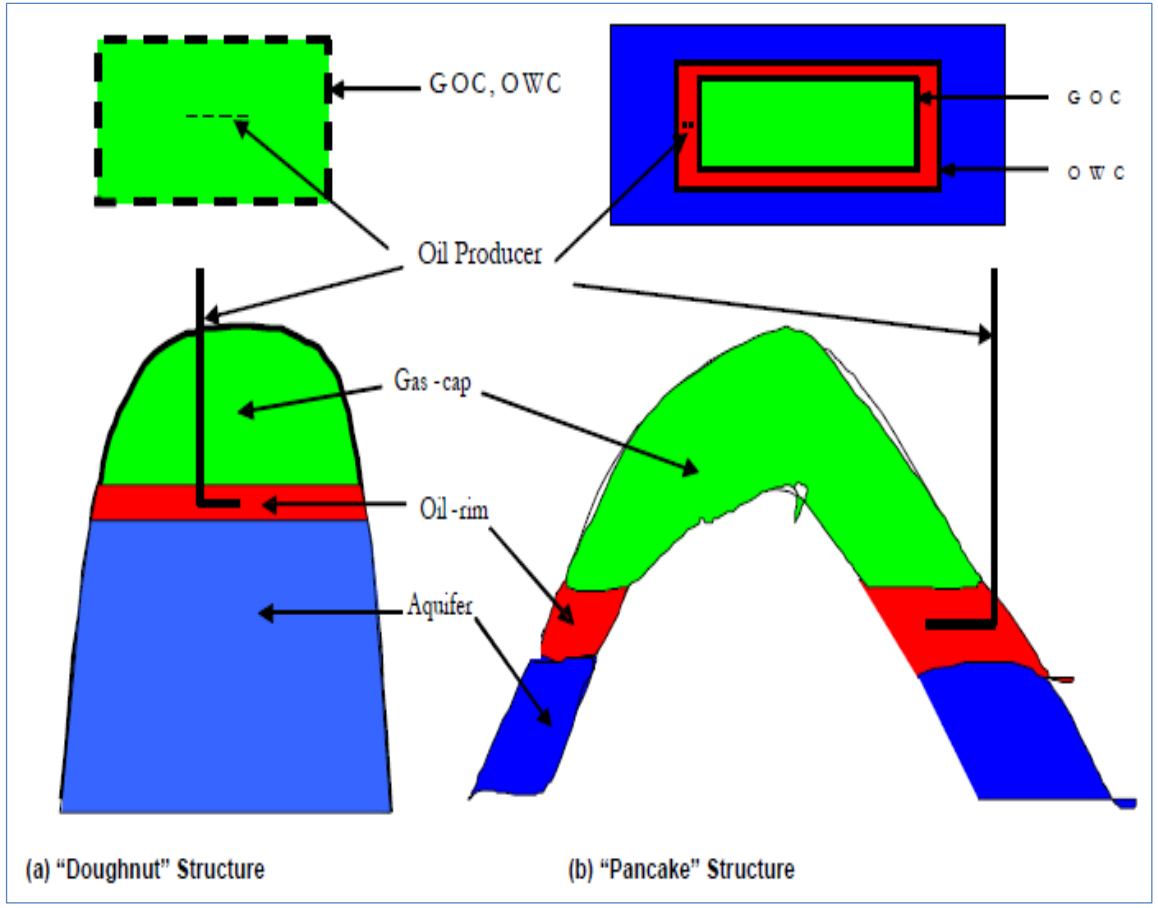
Study Method

Results and Analysis

Conclusion

Introduction

- Oil-rim is a saturated reservoir, with
  - a large, active gas cap,
  - a relatively thin oil column, and
  - a large, active aquifer
- Structurally:
  - Doughnut, or
  - Pancake
- Common in the Niger Delta
  - Challenging to screen and manage
    - ➢ Yet, high economic attraction
  - Optimality of development solution
    - ➢ **Exploit oil, gas, or both?**



Lawal et al. (2010)

Problem Statement and Study Objectives

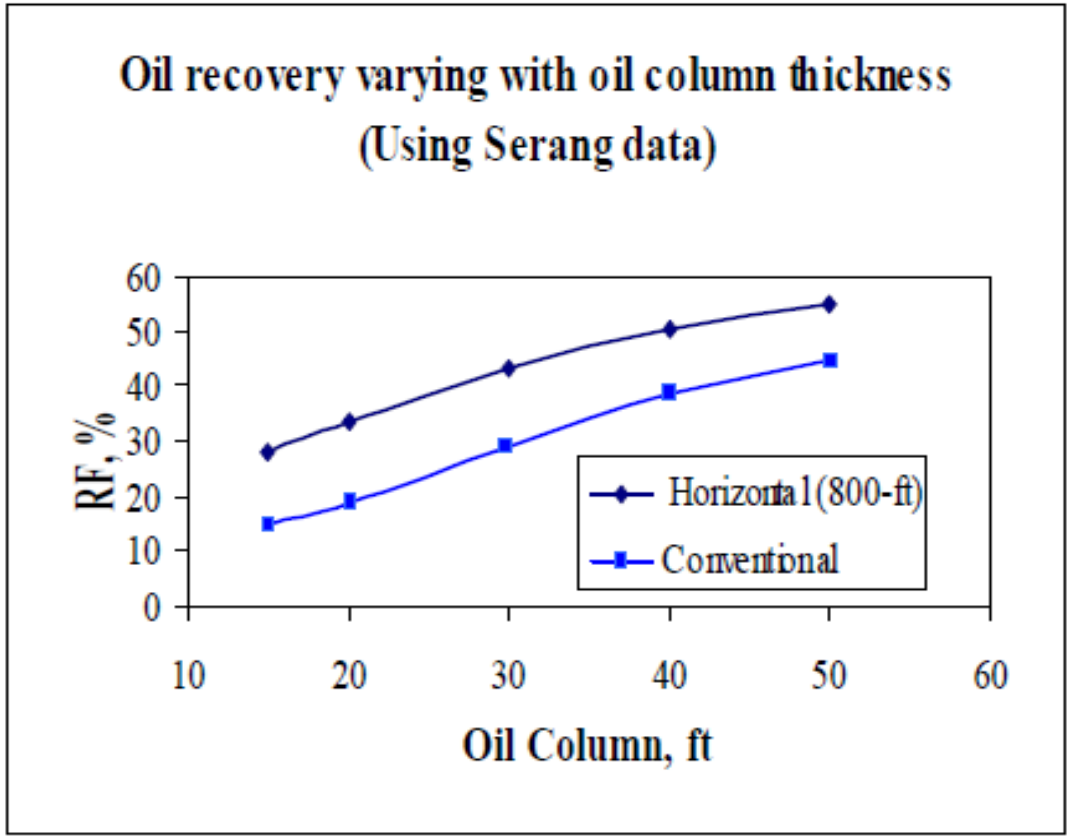
- Screening of possible development options is challenging
  - Considerable manpower
  - High computational costs
  - Delayed business decisions
- Develop simple guidelines to screen development options i.e.
  - Oil-then-gas development (OTG)
  - Concurrent oil and gas development (COG)
  - Gas-only development (GOD)

Existing Methods

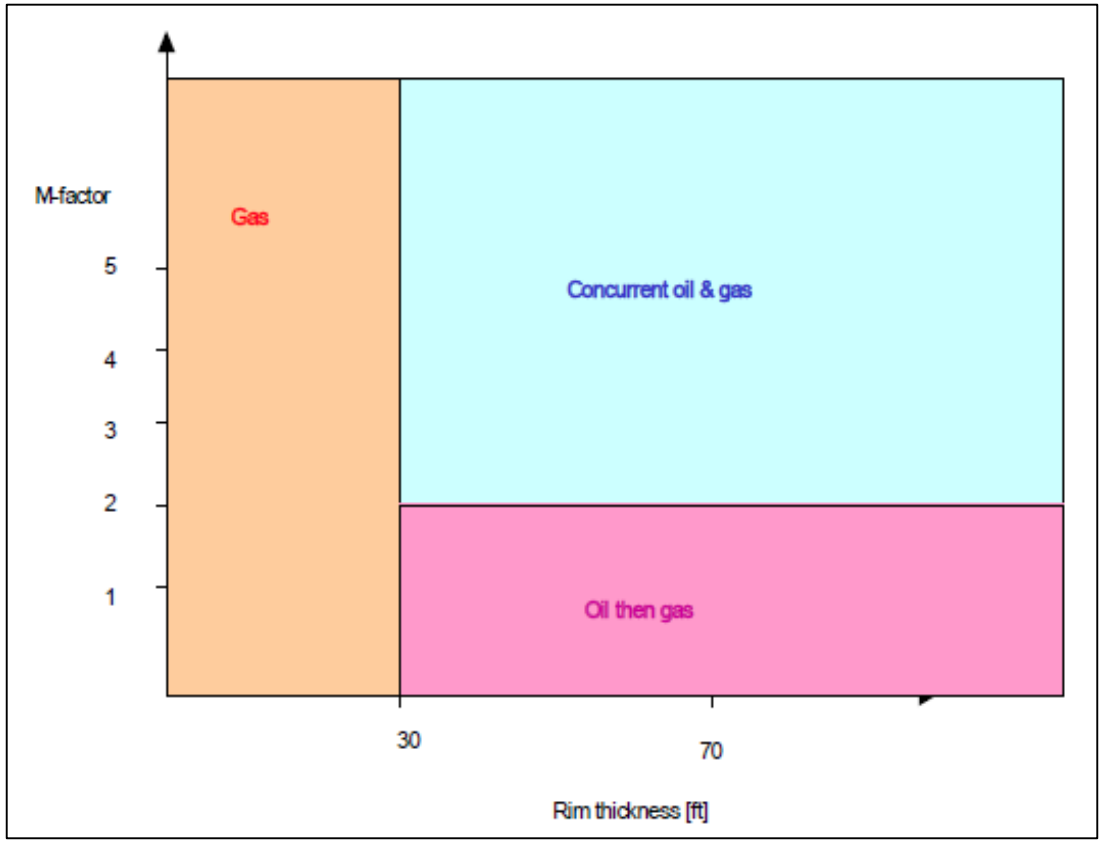
- **Analytic:** based on first principles, but relatively simplistic
  - Lawal et al. (2010)
- **Simulations:** based on extensive numerical simulation studies, but not generic
  - Uwaga and Lawal (2006)
  - Kabir et al. (2008)
- **Empirical correlations:** based on actual performance data, but field-specific
  - Vo et al. (2000)
  - Osoro et al. (2005)
- **Hybrid:** combination of above methods
  - Wyne et al. (2005)

Most of these methods do <u>not</u> consider both static and dynamic reservoir properties!

Some Screening Methods

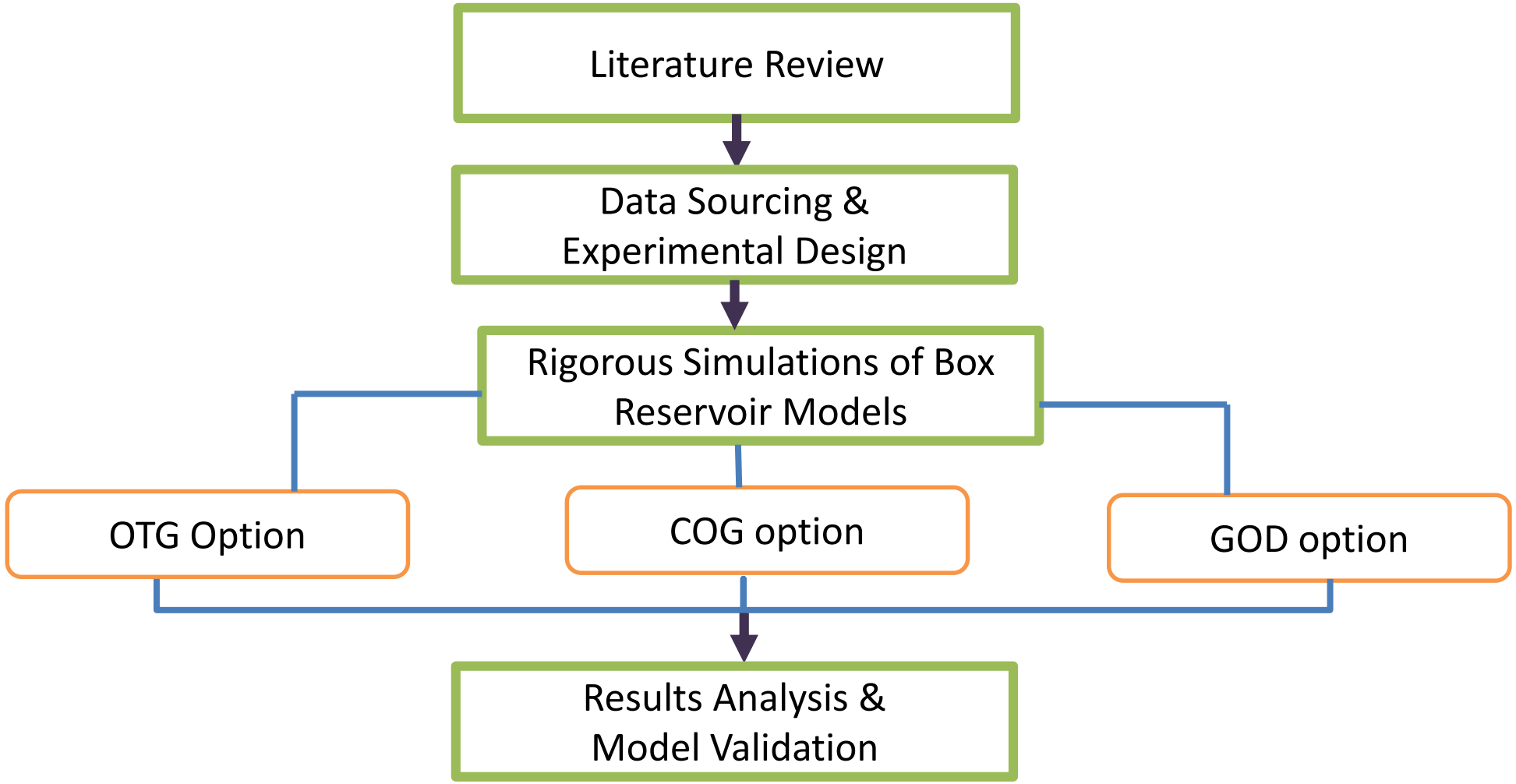


Vo et al. (2000)

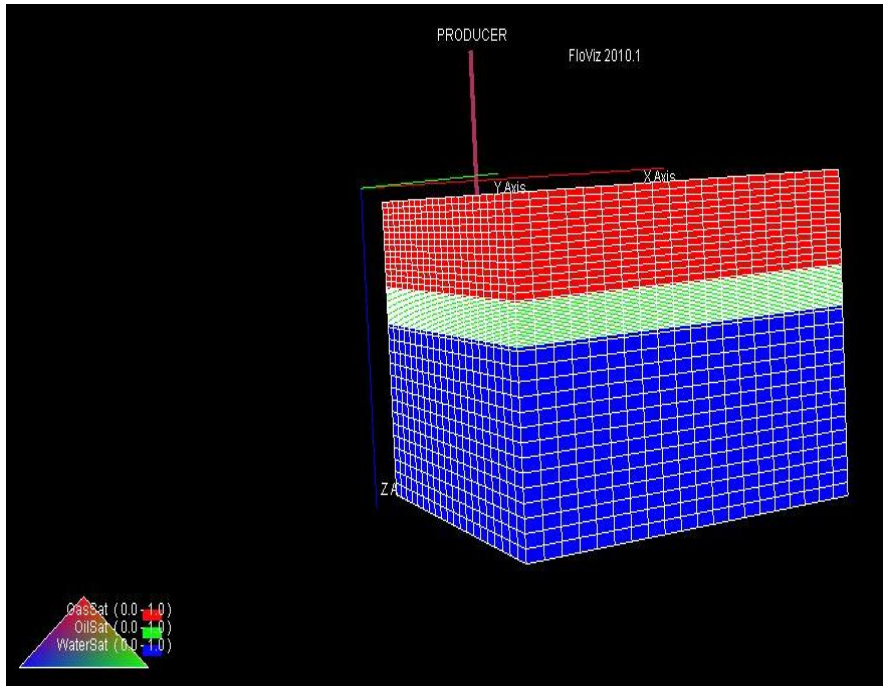


Wyne et al. (2005)

Study Method



Model and Parameterisation



Parameter	Low	Medium	High	Type
Oil rim thickness (ft)	20	40	60	Static
Oil API	24	32	40	Dynamic
Kv/Kh	0.01	0.1	0.5	Static
Krg	0.7	0.85	1	Dynamic
Krw	0.3	0.5	0.7	Dynamic
Kro	0.5	0.7	0.9	Dynamic
HGOC (ft) i.e. well stand-off from GOC	(i.e. 50% of oil rim)			Static
	10	20	30	
Kh (mD)	500			Static
HWL (ft)	2000			Static
Qliquid (%STOIIP per annum)	5			Constraint
Qgas (% FGIIP) per annum	5			Constraint

Some Cases and Results

Run	Ho (ft)	Oil API	Kv/Kh	Krg	Krw	Kro	Ql (STB/d)	Qg (MSCF/d)	OTG Oil RF (%)	COG Oil RF (%)	GOD Gas RF (%)
1	20	40	0.50	0.70	0.3	0.9	442	6014	17.09	15.16	76.72
2	60	24	0.50	0.70	0.7	0.5	1654	6681	12.17	12.24	76.42
3	60	40	0.01	1.00	0.3	0.5	1328	7139	23.92	19.88	75.43
4	20	24	0.50	1.00	0.3	0.5	551	5861	8.35	7.86	77.17
5	20	24	0.01	1.00	0.7	0.9	551	5861	16.53	13.49	77.11
6	20	40	0.01	0.70	0.7	0.5	442	6013	21.15	17.65	76.74
7	60	24	0.01	0.70	0.3	0.9	1654	6681	20.62	17.71	76.42
8	20	24	0.01	0.70	0.3	0.5	551	5861	13.12	10.79	77.10
9	40	32	0.10	0.85	0.5	0.7	1007	6435	16.74	14.10	76.47
10	60	40	0.50	1.00	0.7	0.9	1328	7139	18.05	16.04	75.40
11	60	24	0.50	0.70	0.3	0.9	1654	6681	16.76	13.87	76.42
12	60	24	0.01	0.70	0.7	0.5	1654	6681	15.61	13.50	76.42
13	20	24	0.50	0.70	0.7	0.9	551	5861	11.11	10.91	77.17
14	20	24	0.50	1.00	0.7	0.5	551	5861	8.08	7.36	77.10
15	60	24	0.01	1.00	0.7	0.9	1654	6681	18.89	16.78	67.97

Results Analysis: OTG

$$R_f = 17.21 + 3.38B - 3.19C + 1.99F + 1.93G - 1.18BC$$

Where:

$B = -7.5287 + 0.170651\ (API)$

$C = 1.975141\left(\frac{k_V}{k_h}\right)$

$F = 5.00794\ K_{ro}$

$G = 0.001658 Q_l$

$BC = 0.511525\left[(API)\left(\frac{k_V}{k_h}\right)\right]$

$\frac{K_v}{K_h}$: $Vertical\ anisotropy\ or\ ratio\ of\ vertical\ to\ horizontal\ permeability\ (fraction)$

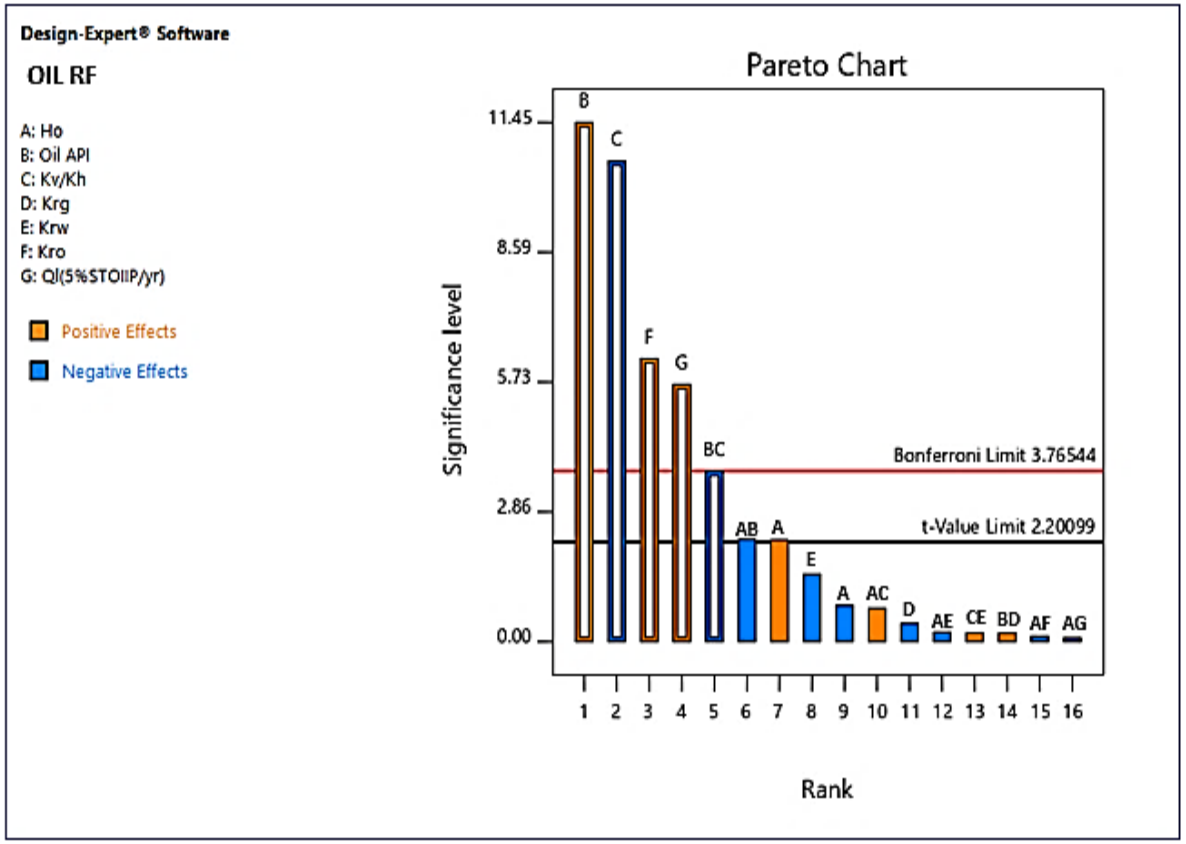
K_{rw}: $Relative\ permeability\ to\ water\ at\ s_{orw}\ (fraction)$

K_{ro}: res.

property$Relative\ permeability\ to\ oil\ at\ s_{wmin}\ (fraction)$

H_o: $Oil\ rim\ thickness\ (ft)$

Q_l: $Liquid\ flow\ rate, 5\%STOIIP/yr\ (stb/day)$



Results Analysis: COG

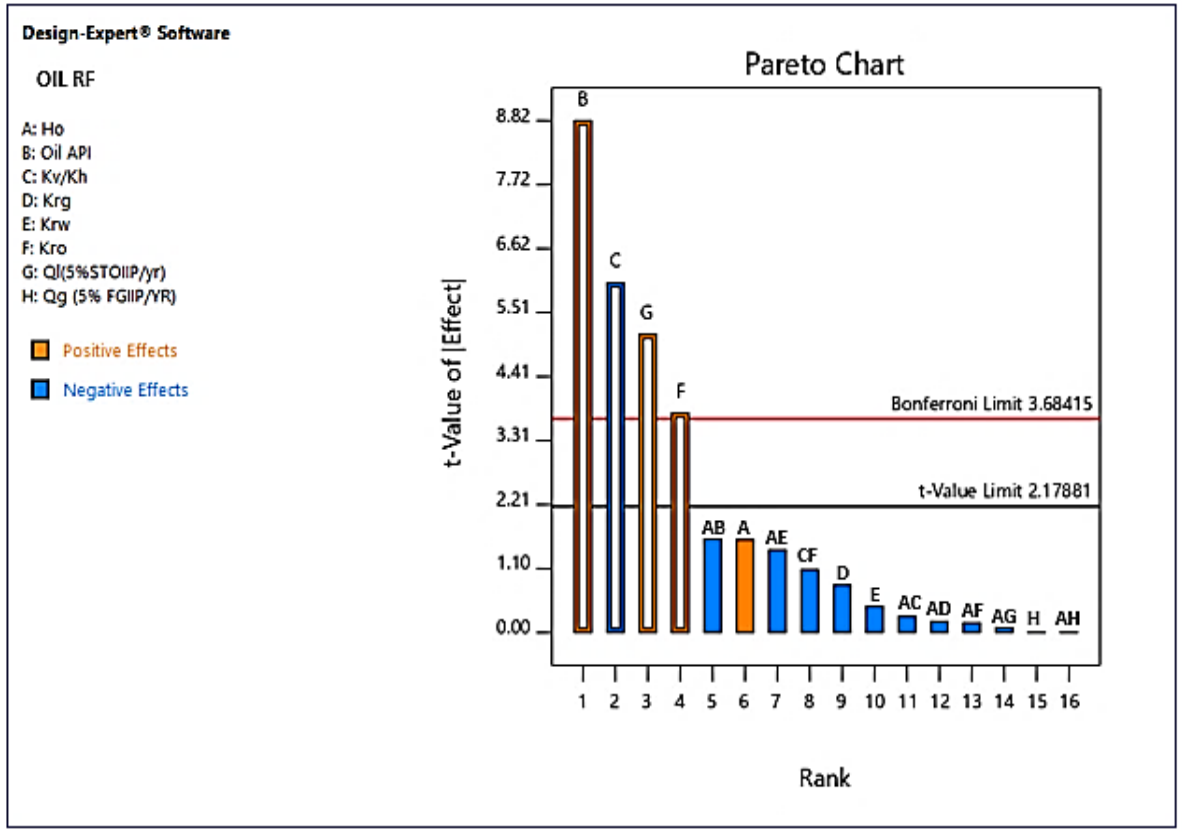
$$R_f = 15.00 + 2.28B - 1.85C + 1.18F + 1.89G$$

Where:

$B = -7.33465 + 0.154518(API)$
$C = 4.083676\left(\frac{K_V}{K_h}\right)$
$F = 4.982034\ K_{ro}$
$G = 0.00164\ Q_l$

API: $Oil\ API\ (degree)$

$\frac{K_v}{K_h}$: $Vertical\ anisotropy\ or\ ratio\ of\ vertical\ to\ horizontal\ permeability\ (fraction)$
K_{rw}: $Relative\ permeability\ to\ water\ at\ s_{orw}\ (fractio$
K_{ro}: $Relative\ permeability\ to\ oil\ at\ s_{wmin}\ (fraction)$
H_o: $Oil\ rim\ thickness\ (ft)$
Q_l: $Liquid\ flow\ rate, 5\%STOIIP/yr\ (stb/day)$



Results Analysis: GOD

$$R_f = 75.66 + 0.4564A + 6.55D - 0.0113E + 0.0115F - 7.87G - 25.35AD - 5.93AG - 4.34BD - 0.0280DE + 36.24DG$$

Where:

$$A = -11.1267 + 0.800962H_O$$

$$D = -0.05091K_{rg}$$

$$E = -0.0156K_{rw}$$

$$F = 0.195651K_{ro}$$

$$G = 11796.29Q_g$$

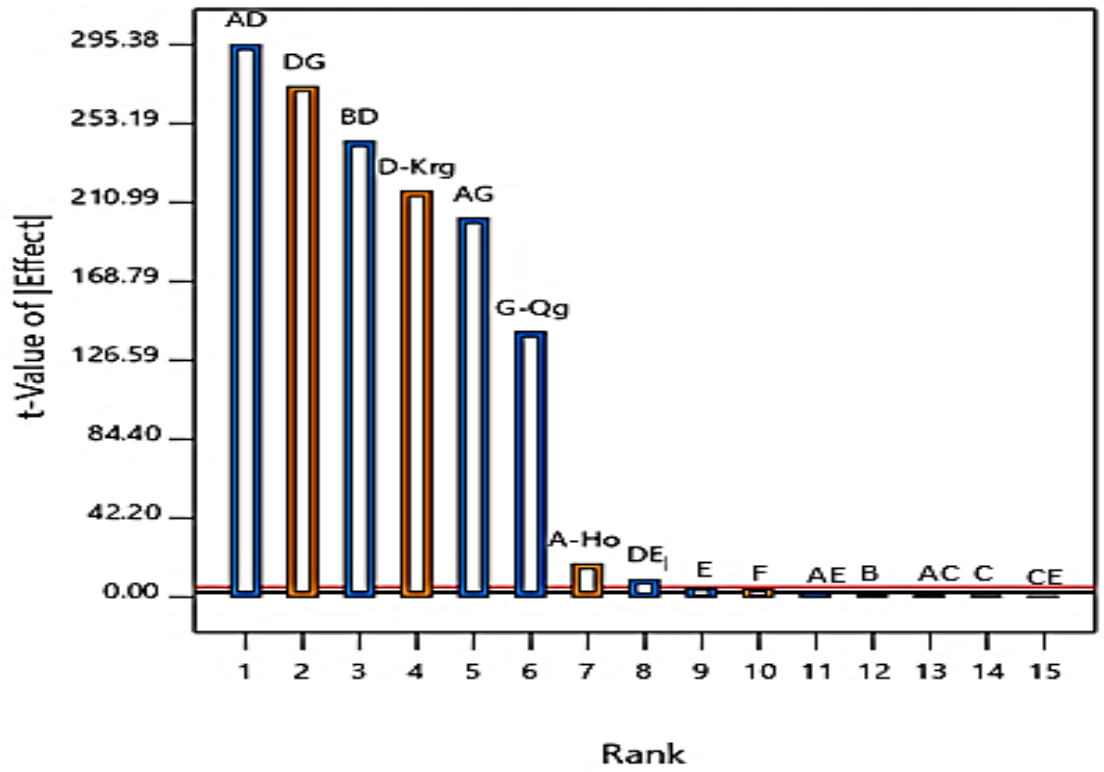
$$AD = 20.01527(H_o \times K_{rg})$$

$$AG = 513049(H_o \times Q_g)$$

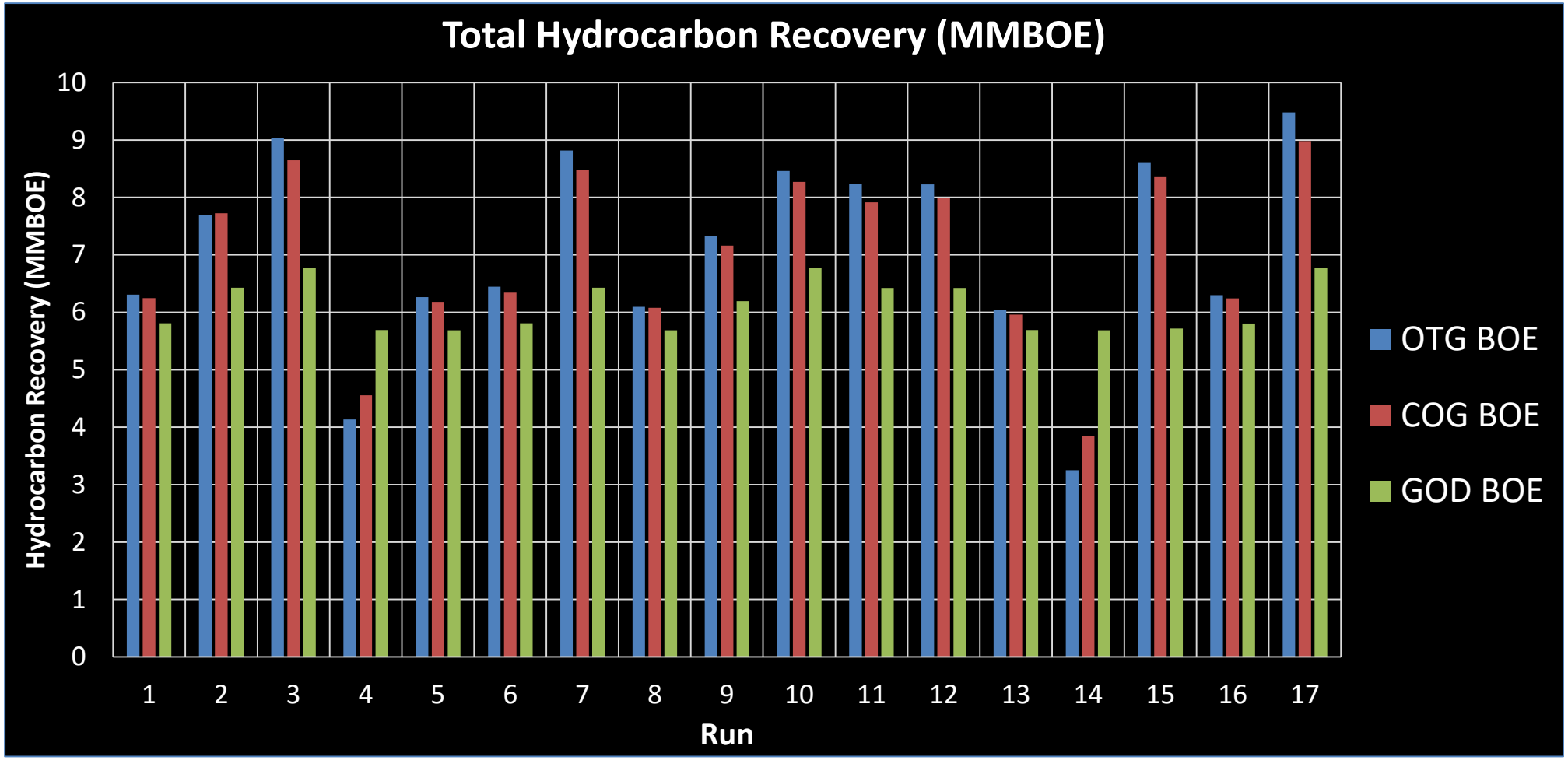
$$BD = 15.21879(API \times K_{rg})$$

$$DE = 0.030695(K_{rg} \times K_{rw})$$

$$DG = 1317.555(K_{rg} \times Q_g)$$

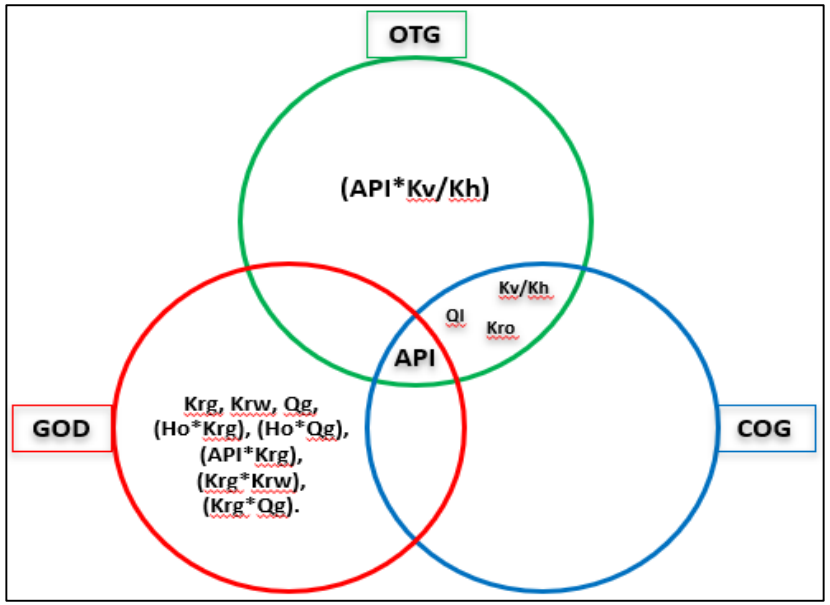


Performance Comparison



Conclusion

- Simple box models can give good insights for oil-rim development screening
- New guidelines developed for screening oil-rim development
  - Discriminate the development options
  - Account for both static and dynamic properties
  - For the cases examined, high-impact subsurface properties identified



Acknowledgements

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