

Injection Analysis of the Wertz Tensleep Formation

Team Can-Am

DAN, INDY, JORDAN AND CAM



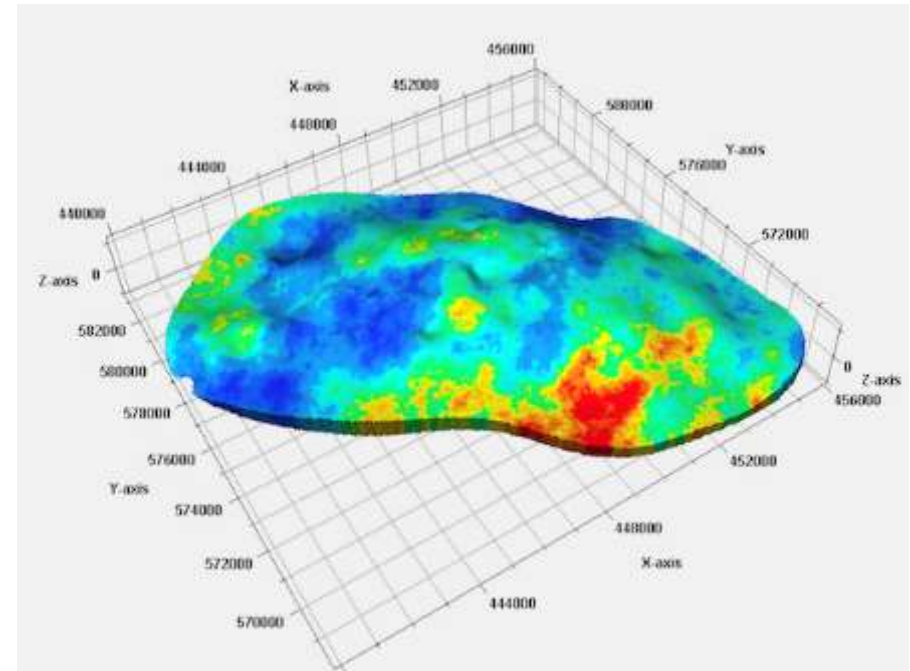
UNIVERSITY OF WYOMING

Outline

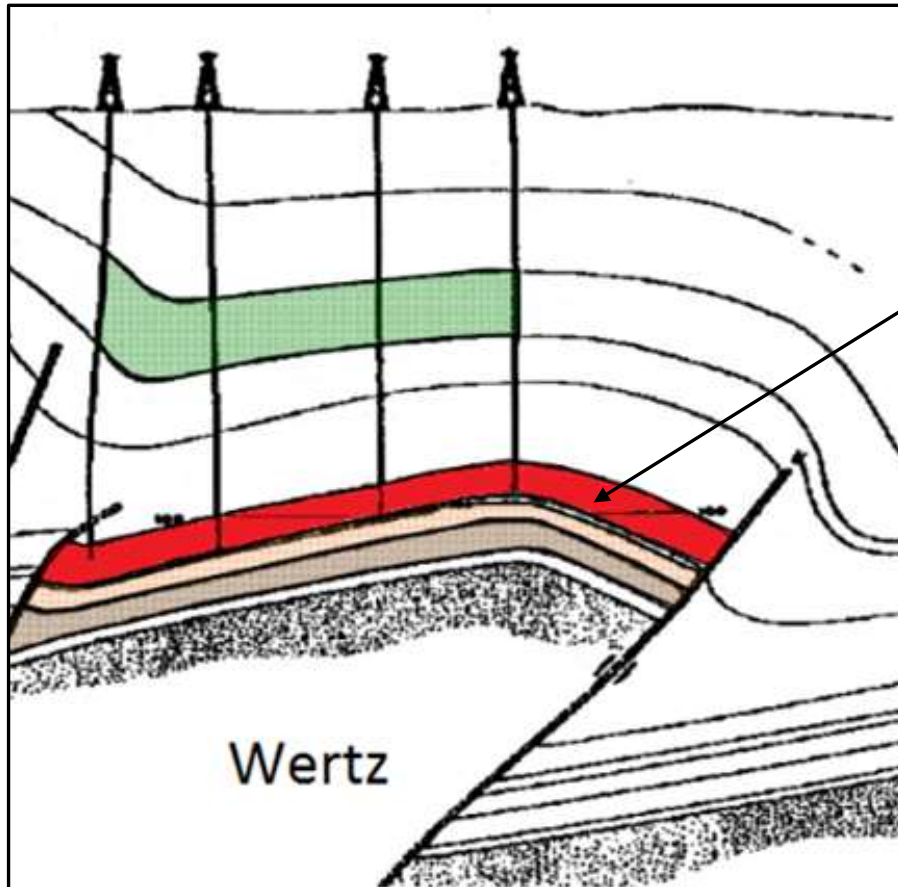
- Objectives
- Introduction of Formation
- Operational History
- Performed Work
 - No-Flow Boundaries
 - Dimensionless Analysis
 - Underperforming Patterns Focus
 - Permeability Map
- Proposed Solutions and Economics
 1. Gas Reallocation
 2. Workovers
 3. New Well
- Summary

Objectives

- Learn about the reservoir.
- Look at specific patterns.
- Determine the issues and propose solutions.
- Economic analysis.
- Determine the best options to increase production.



Field Introduction/Geology



Tensleep

History of Wertz Tensleep

1936: Field discovered by Sinclair.

1978: Pilot waterflood installed.

1980: Field wide five-spot pattern waterflood.

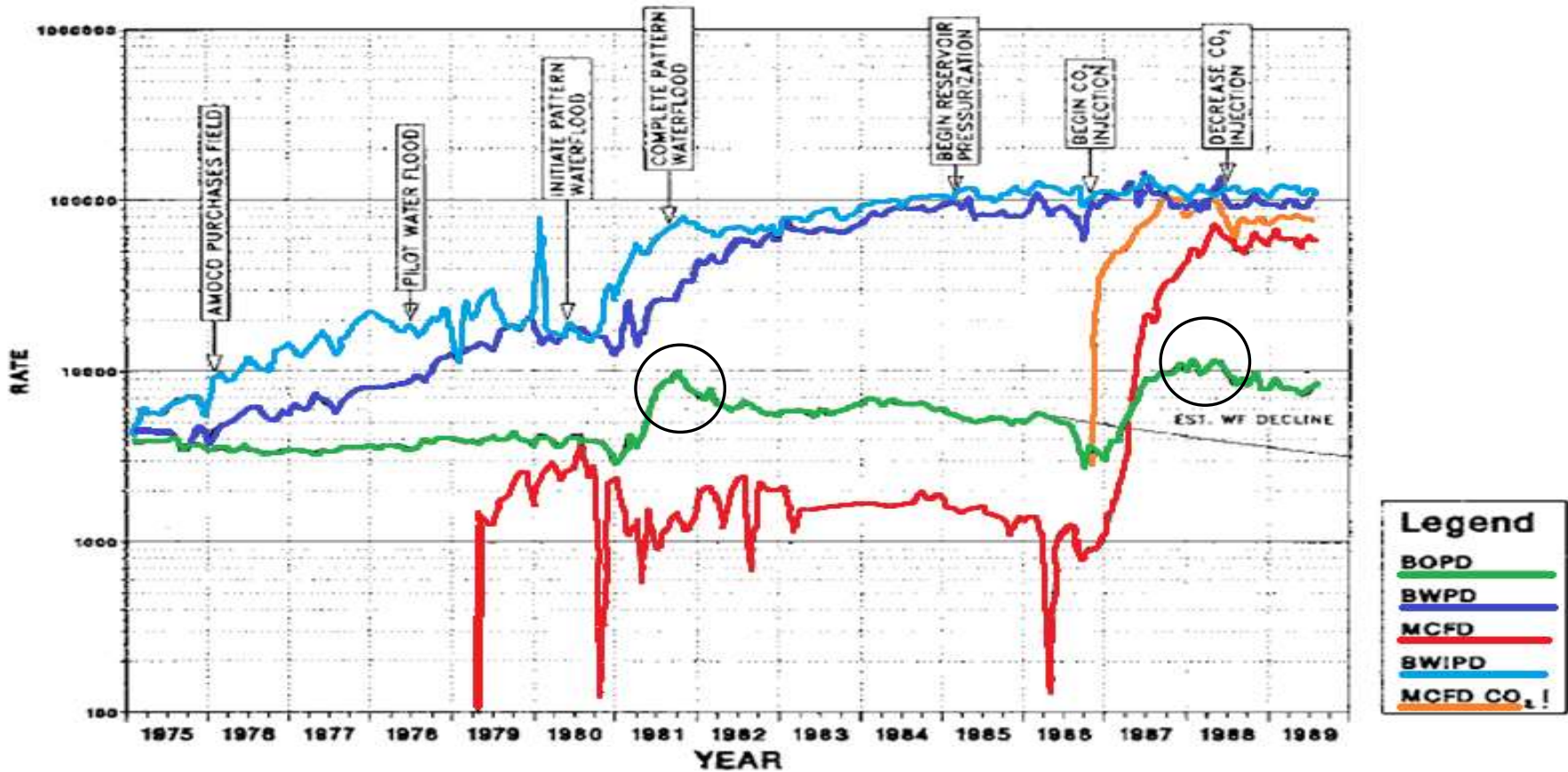
1985: Reservoir pressurization started.

1986: CO₂ Injection started.

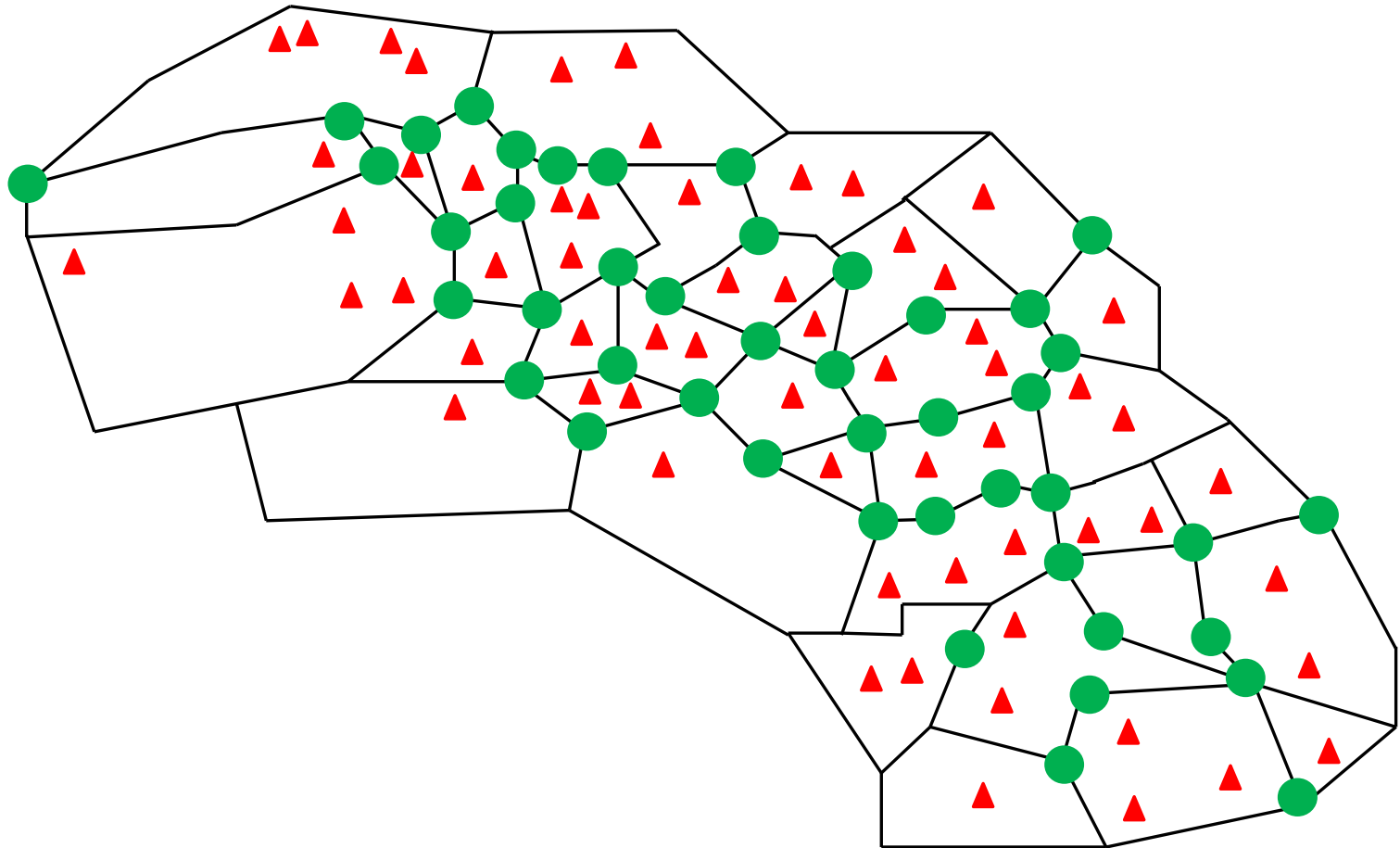
1988: Production peaked.



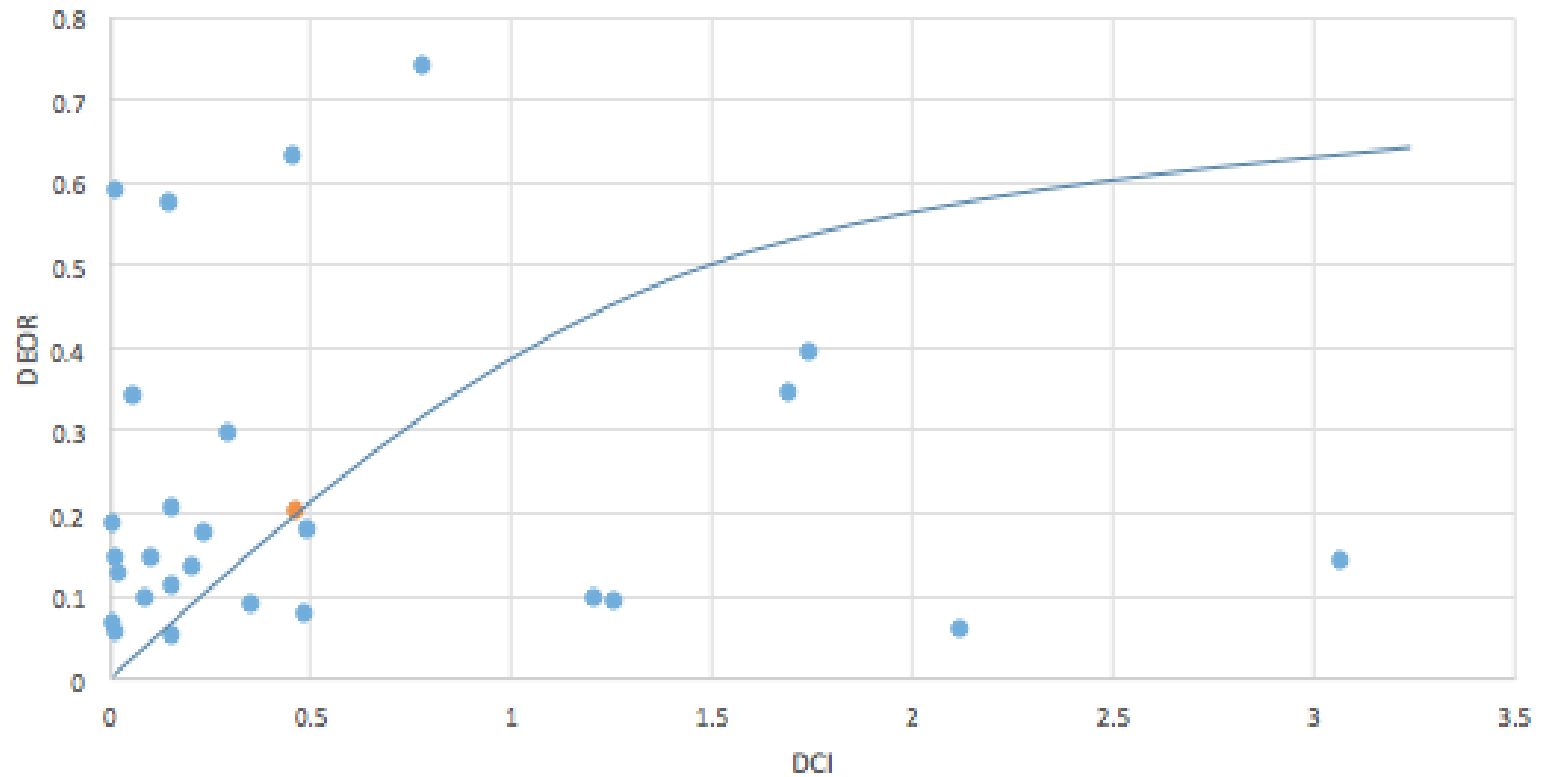
History of Wertz Tensleep



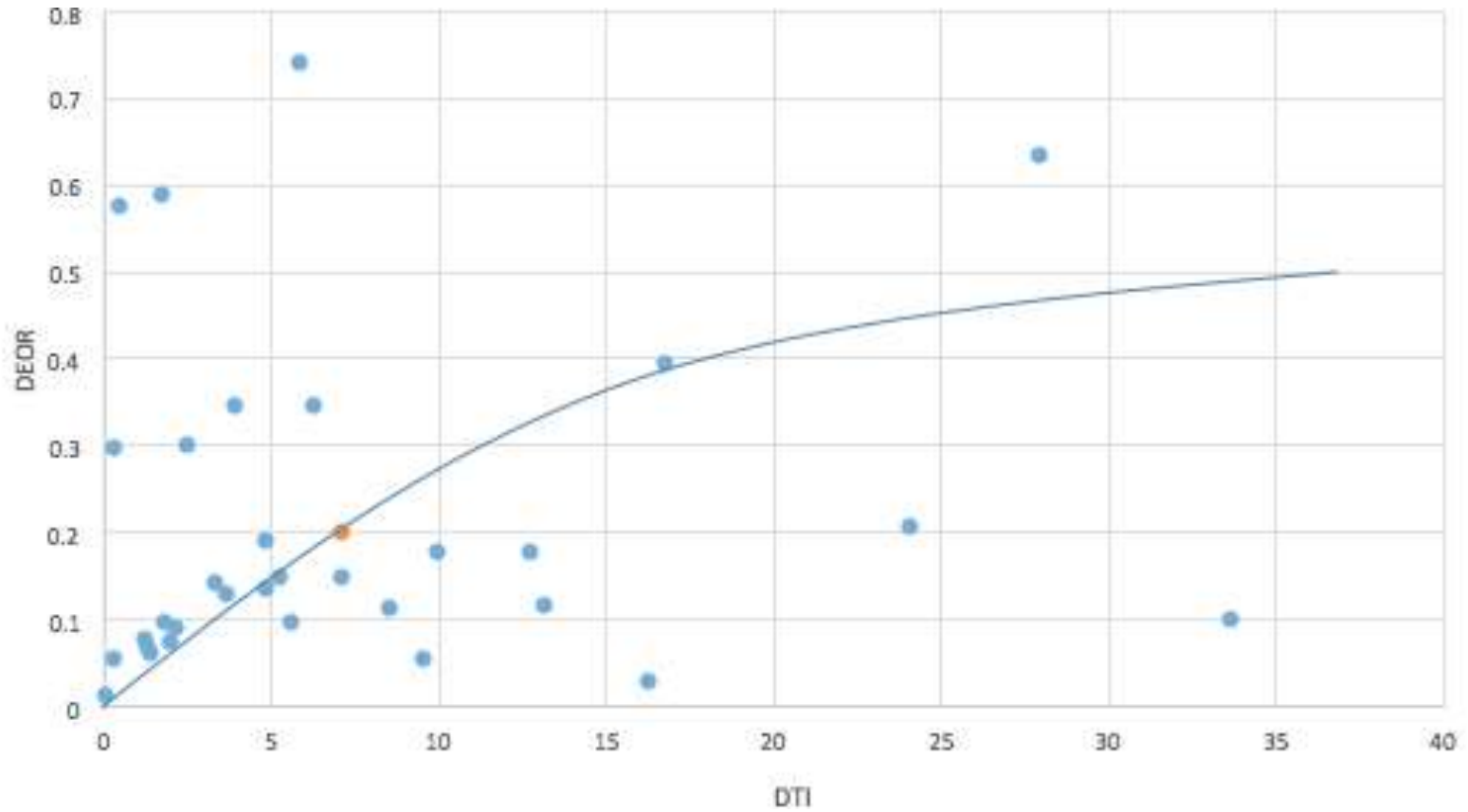
No Flow Boundaries

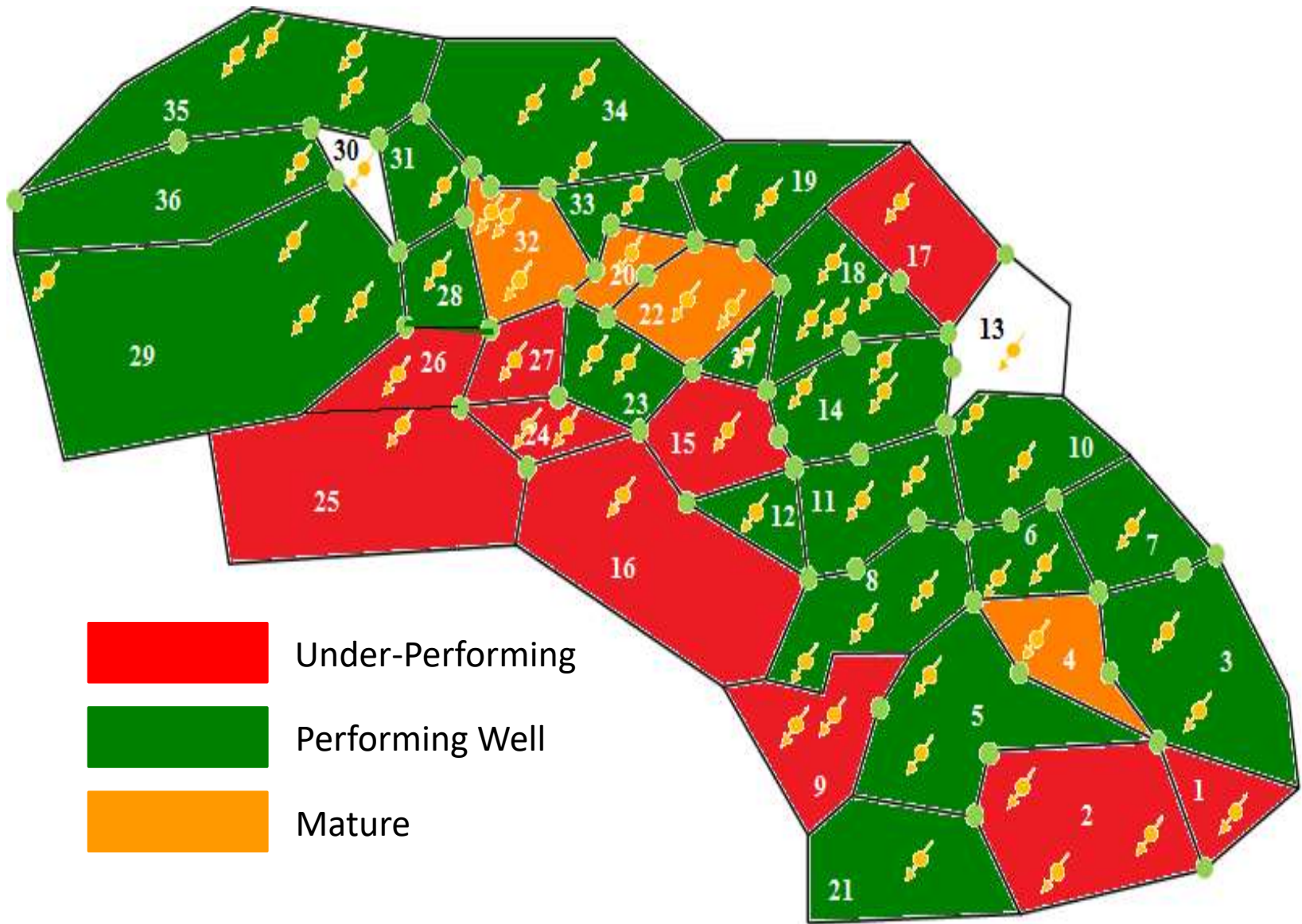


DCI vs DEOR

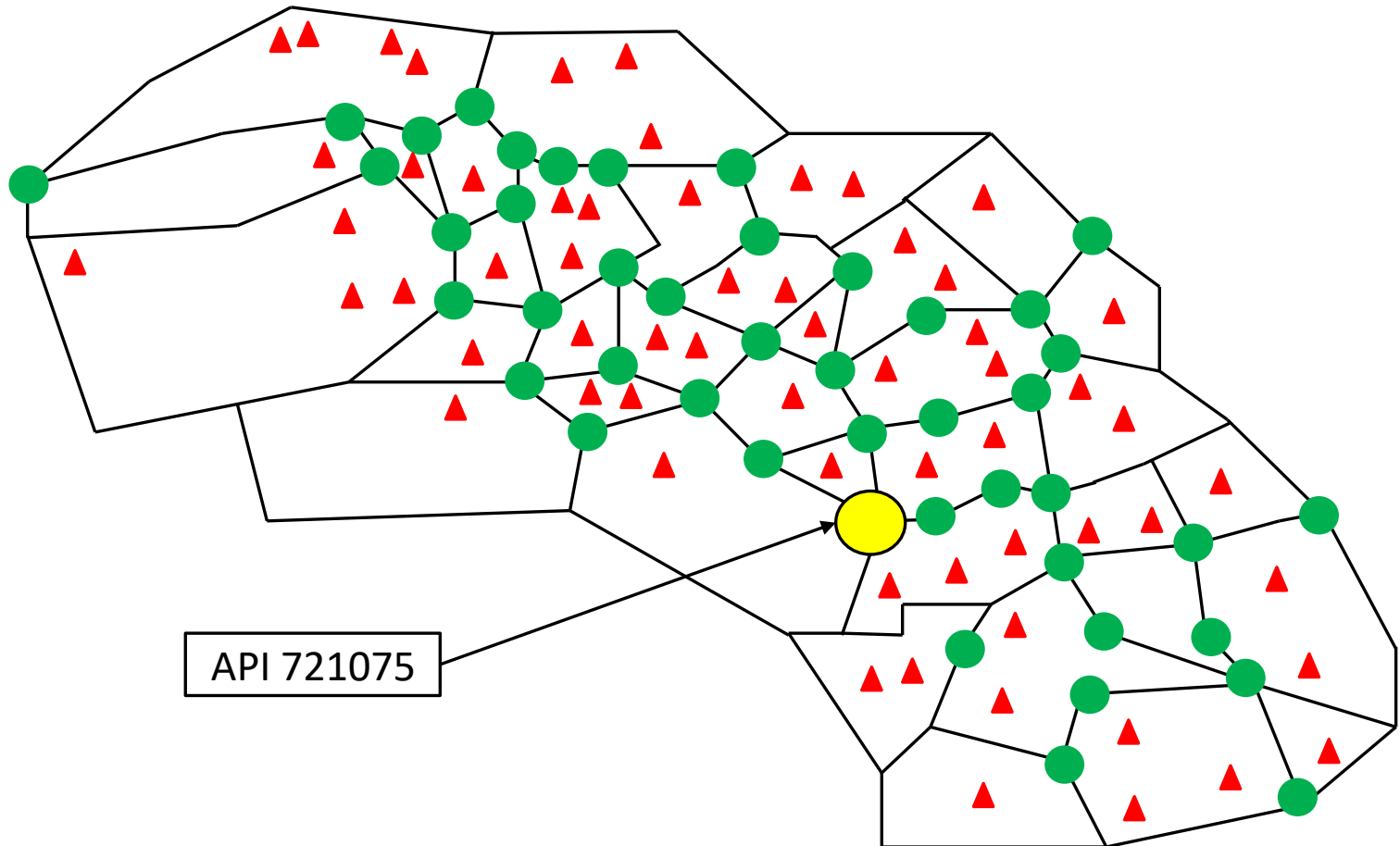


DTI vs DEOR





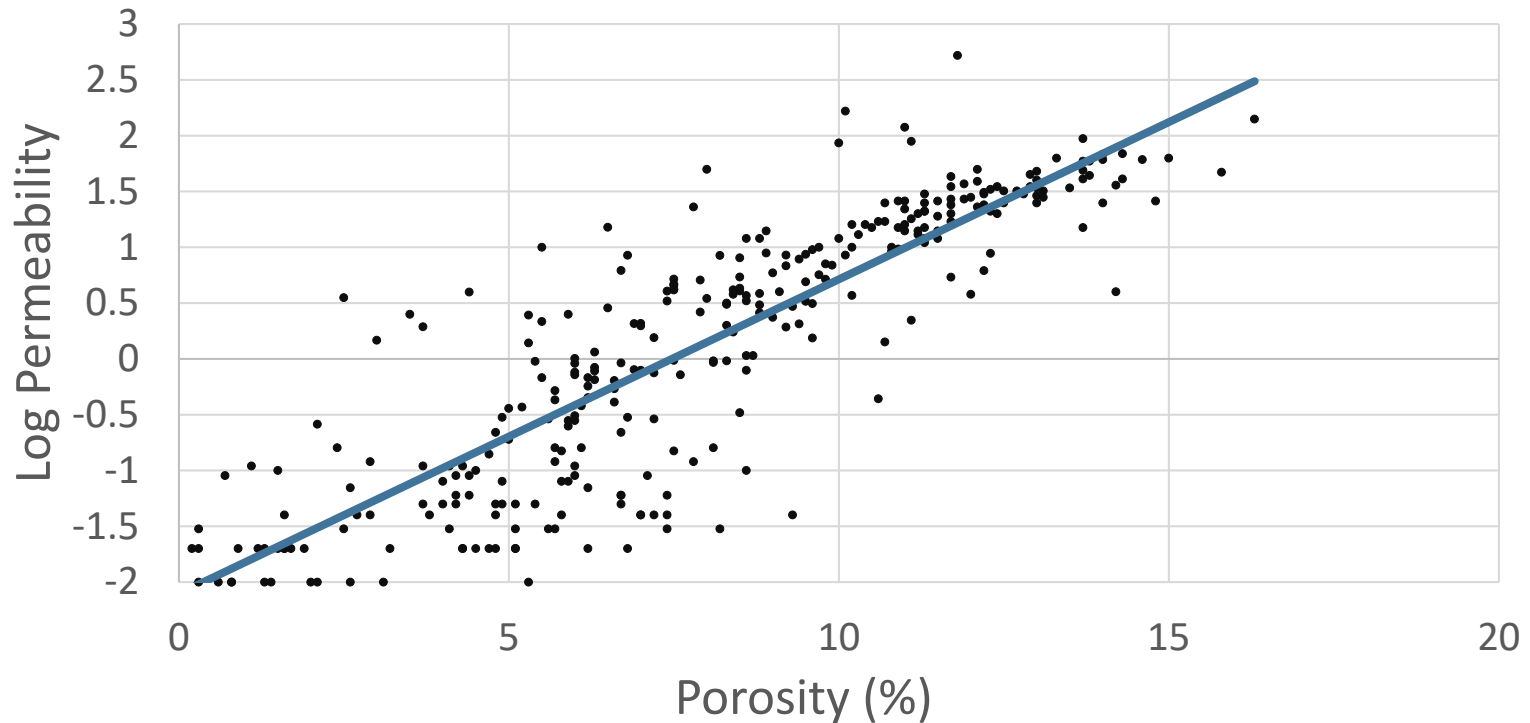
Core Data



Core Data

Core Data #	Depth (ft)	Permeability (md)	Porosity (%)	So	Sw
1	6660	10	10.8	33.2	26.1
2	6661	11	11.3	29.4	24.8
3	6662	15	11.3	25.8	23.5
4	6663	2.63	7.9	38.4	12

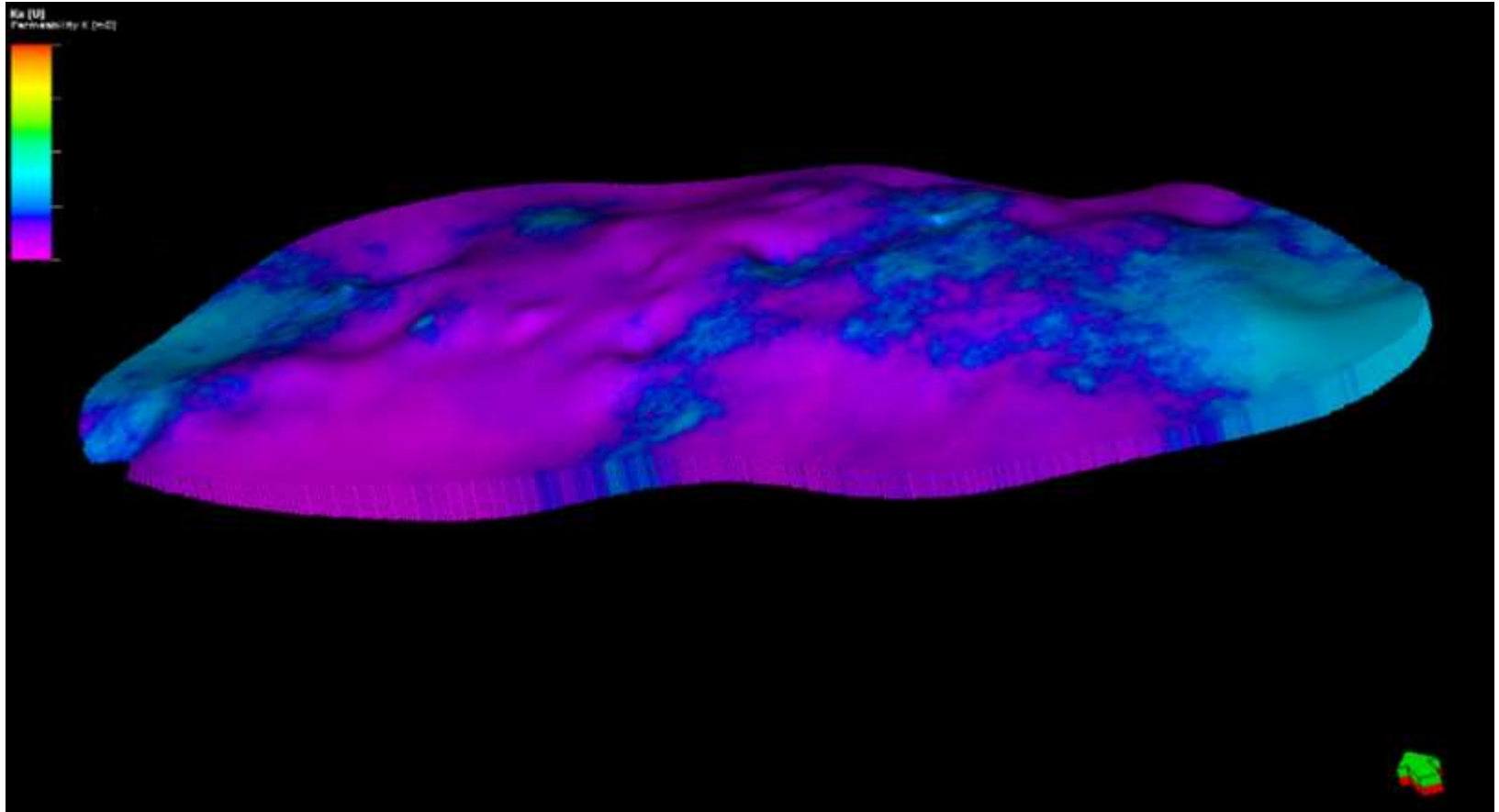
Porosity-Permeability



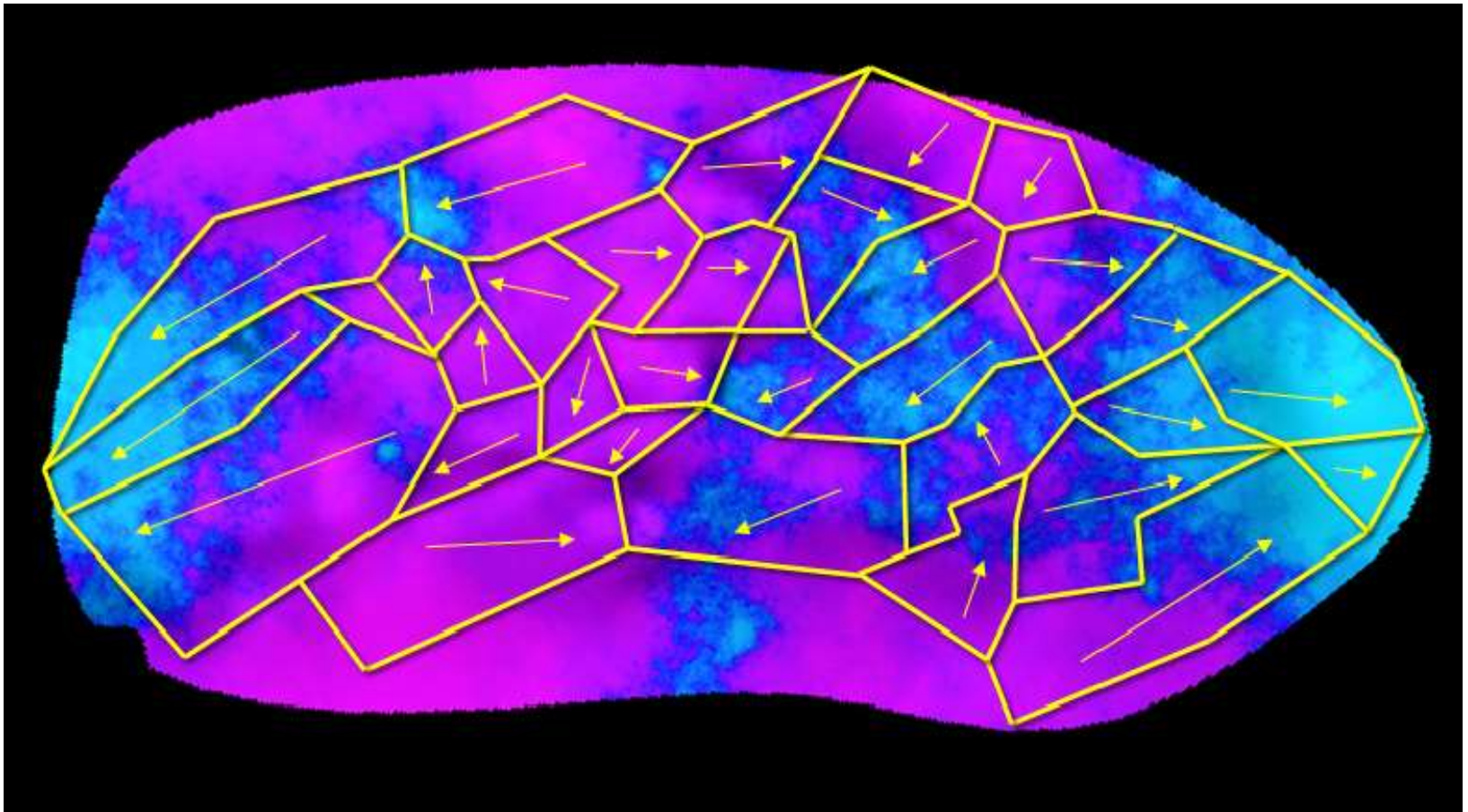
$$k = 0.2818 * \phi - 1.1049$$



Permeability Map



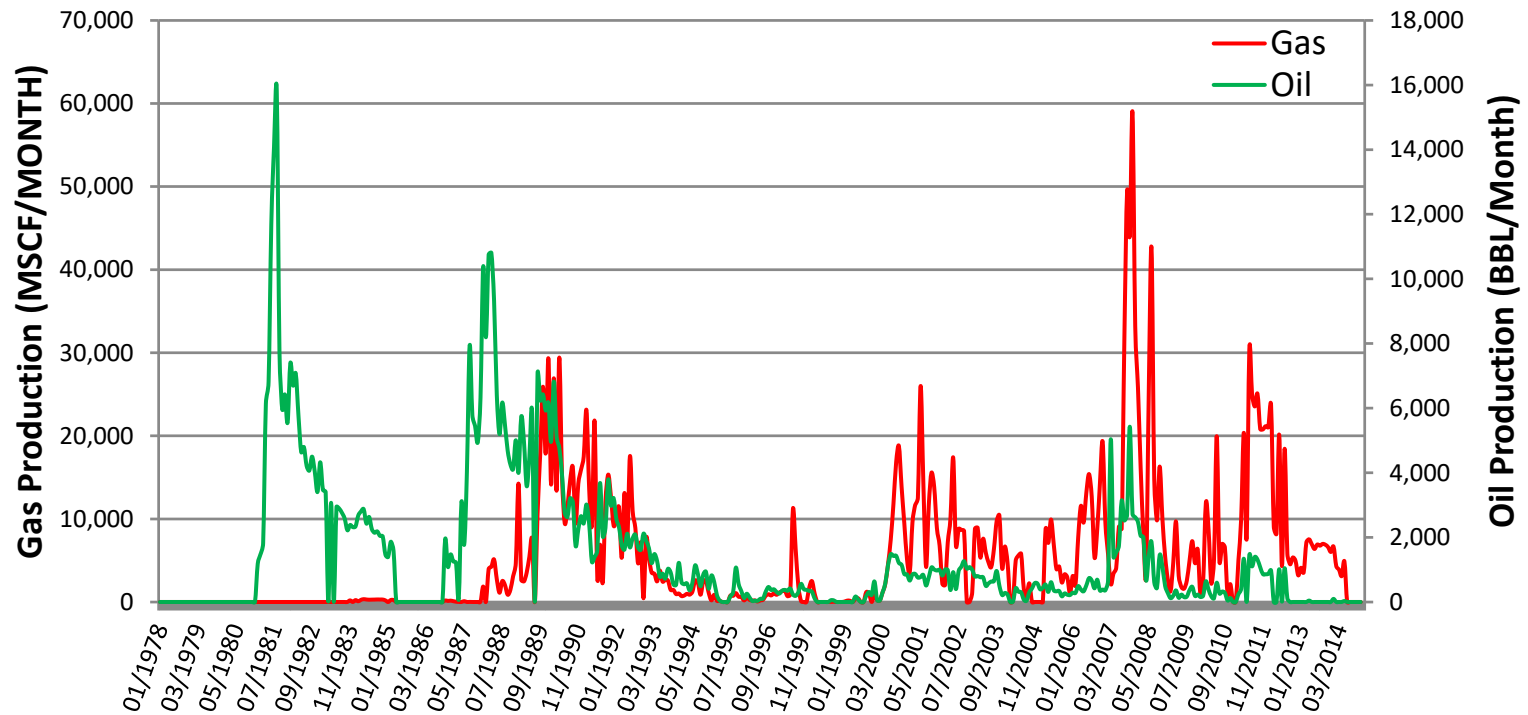
Permeability Direction



Gas Re-allocation

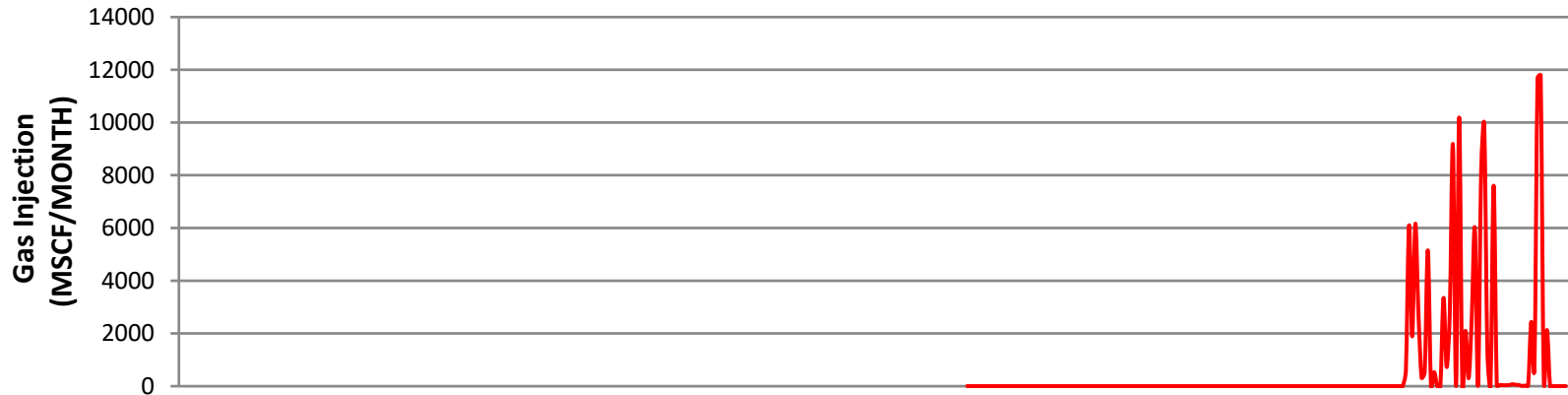
Pattern 26 – Gas Cycling

Total Oil and Gas Production Over Time

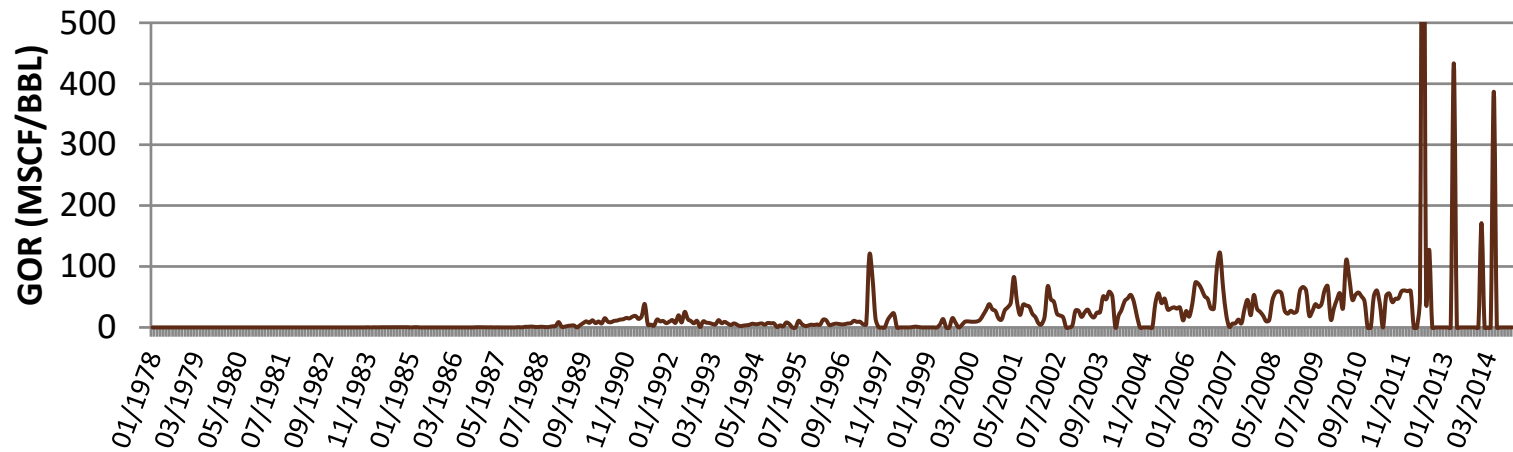


Pattern 26 – Gas Cycling

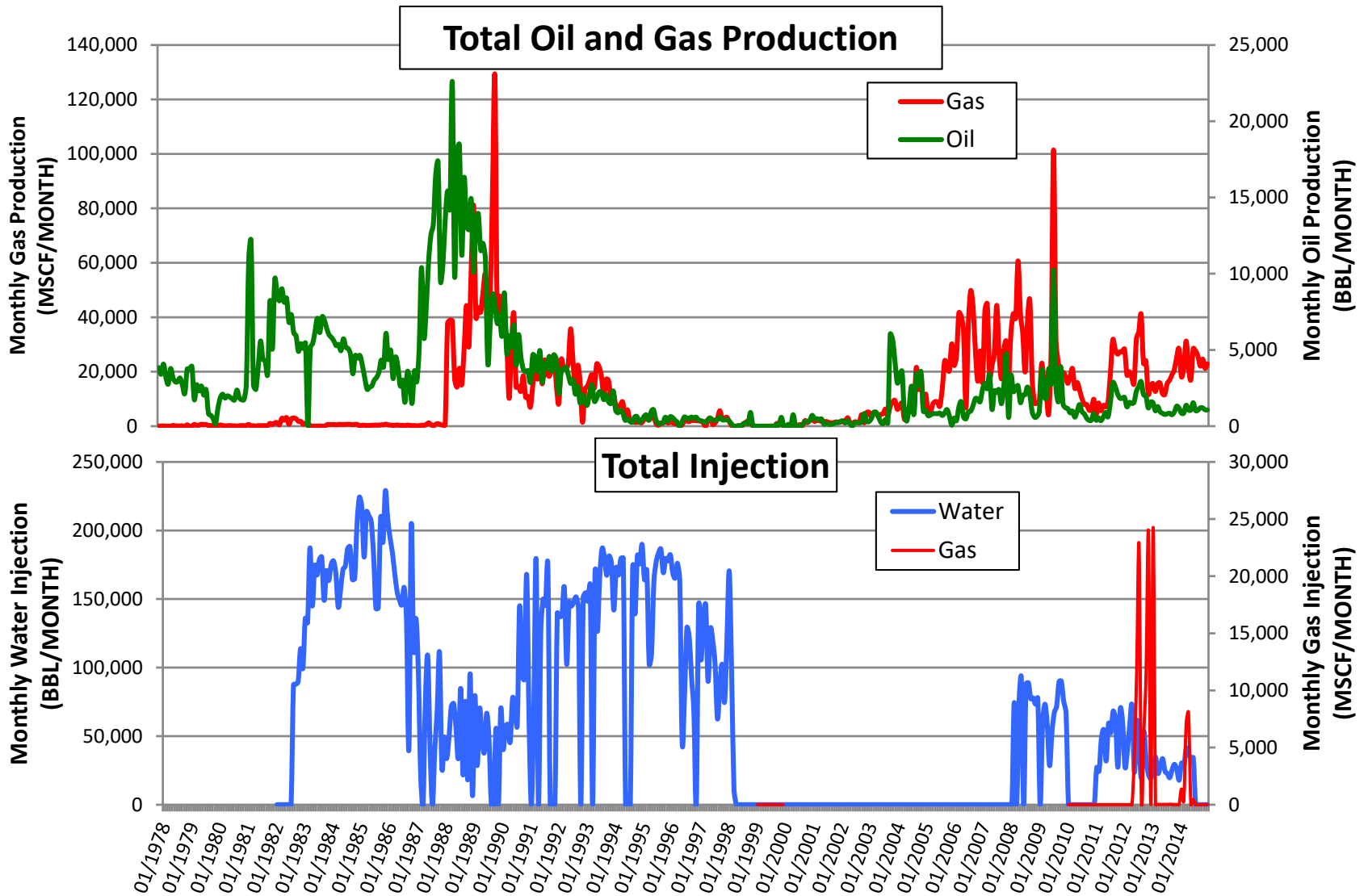
Gas Injection



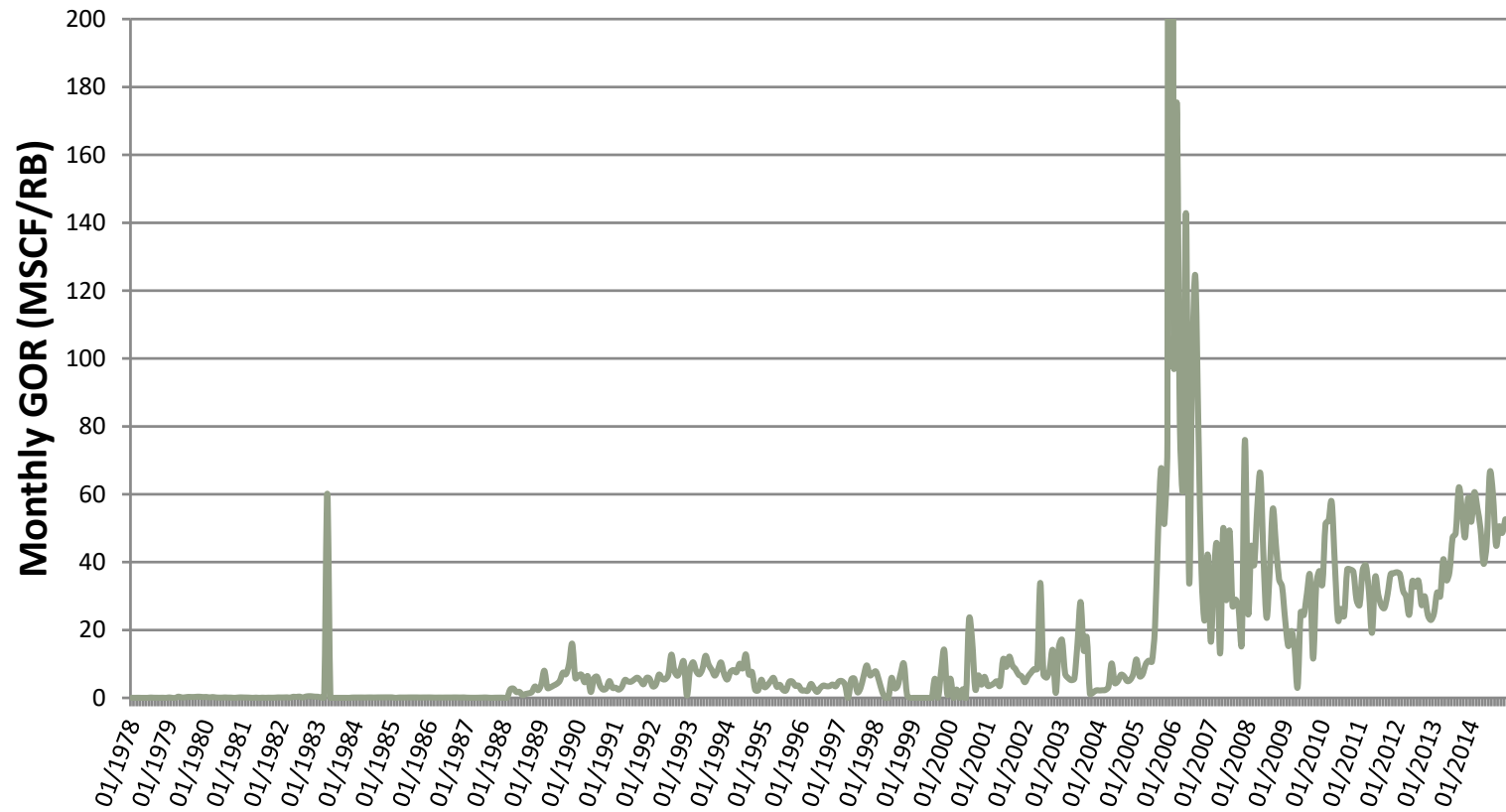
GOR



Pattern 15 Analysis

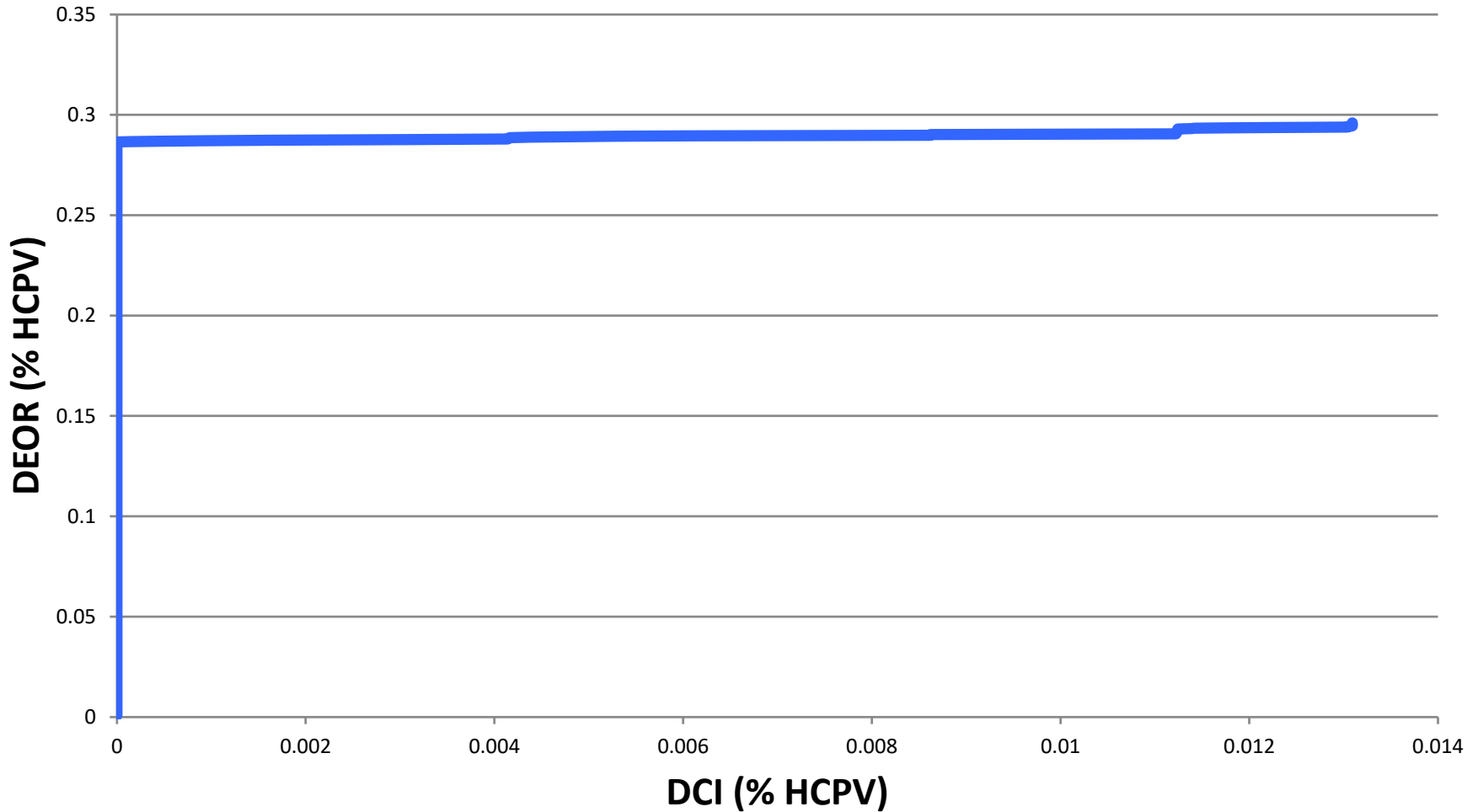


Pattern 15: GOR



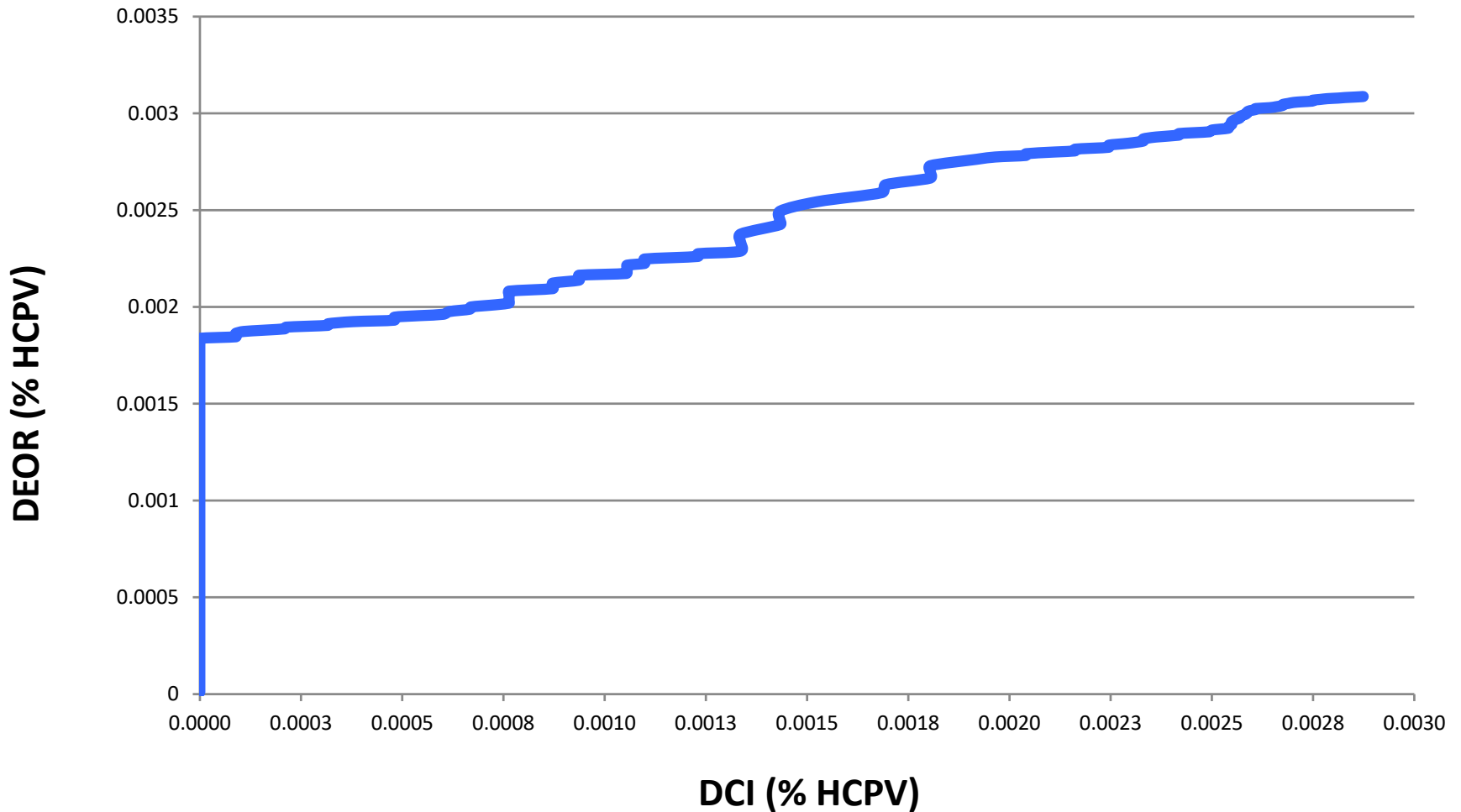
Pattern 15: Dimensionless Analysis

Dimensionless Enhanced Oil Recovery VS Dimensionless CO₂ Produced



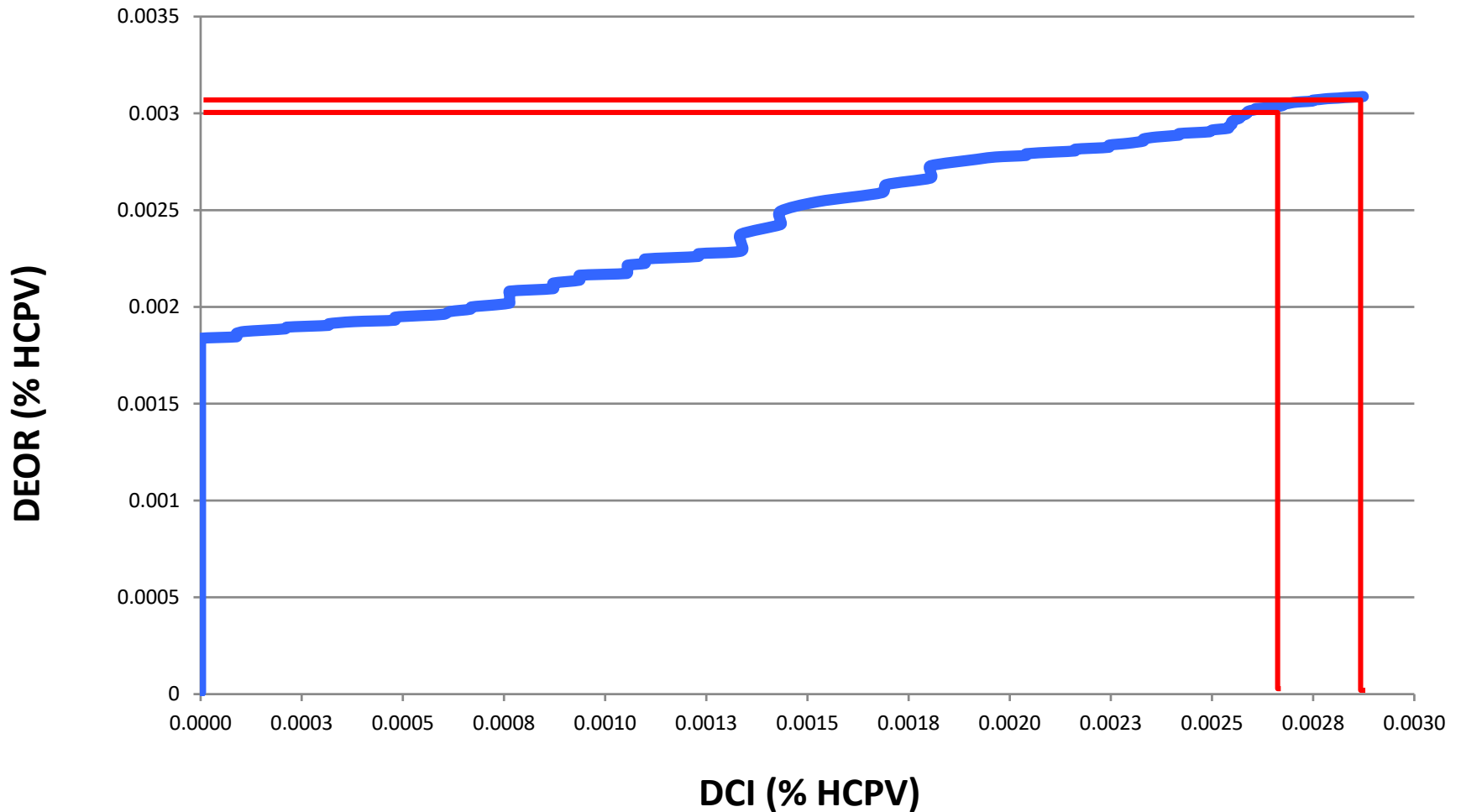
Predicted Production: Pattern 24

Dimensionless Enhanced Oil Recovery VS Dimensionless CO₂ Produced



Predicted Production: Pattern 24

Dimensionless Enhanced Oil Recovery VS Dimensionless CO₂ Produced



Gas Reallocation Summary

Pattern	HCPV (RB)	Gas Taken (MCF/MONTH)	Gas Given (MCF/MONTH)	Dimensionless Gas Change (DCI)	Delta DEOR	Delta Qo (RB/MONTH)
2	556,000	1,524.00		2.74E-03	-1.25E-04	-69.38
4	7,900,000	3,371.00		4.27E-04	-4.06E-05	-320.41
9	1,093,000	2,133.00		1.95E-03	-2.19E-04	-238.84
15	4,400,000	4,695.00		1.07E-03	-8.81E-06	-38.75
24	229,000,000		3,907.67	8.05E-06	1.42E-05	3,248.30
25	509,000,000		3,907.67	3.62E-06	7.60E-06	3,866.88
27	243,000,000		3,907.67	7.59E-06	9.62E-06	2,337.30

Additional \approx **8,785 RB** of Oil Production

Gas Reallocation Economics

Pattern	Revenue Generated/Lost (\$40)	Revenue Generated/Lost (\$50)	Revenue Generated/Lost (\$60)
2	-2,775.07	-3,468.83	-4,162.60
4	-12,816.31	-16,020.39	-19,224.47
9	-9,553.62	-11,942.02	-14,330.43
15	-1,550.06	-1,937.58	-2,325.09
24	129,931.98	162,414.98	194,897.98
25	154,675.08	193,343.85	232,012.62
27	93,492.07	116,865.09	140,238.11

Price Of Oil	Cumulative Profit (\$)
\$40	351,404.08
\$50	439,255.10
\$60	527,106.12



Work Over Program

Pattern 17

■ Justification for New Well Proposal

		Averages
Utilization	1.41	5.621
Np	0.048	0.189
DOR	0.228	0.388
DEOR	0.179	0.202
DCP	1.514	4.018
OR-Np	0.227	0.958

Well Name: WERTZ ABC 62

API number: 49-007-20627

Surface location:

Bottom hole location:

Date: May 18/2015

AFE#: TBA

Well Authorization: WYCO29520B

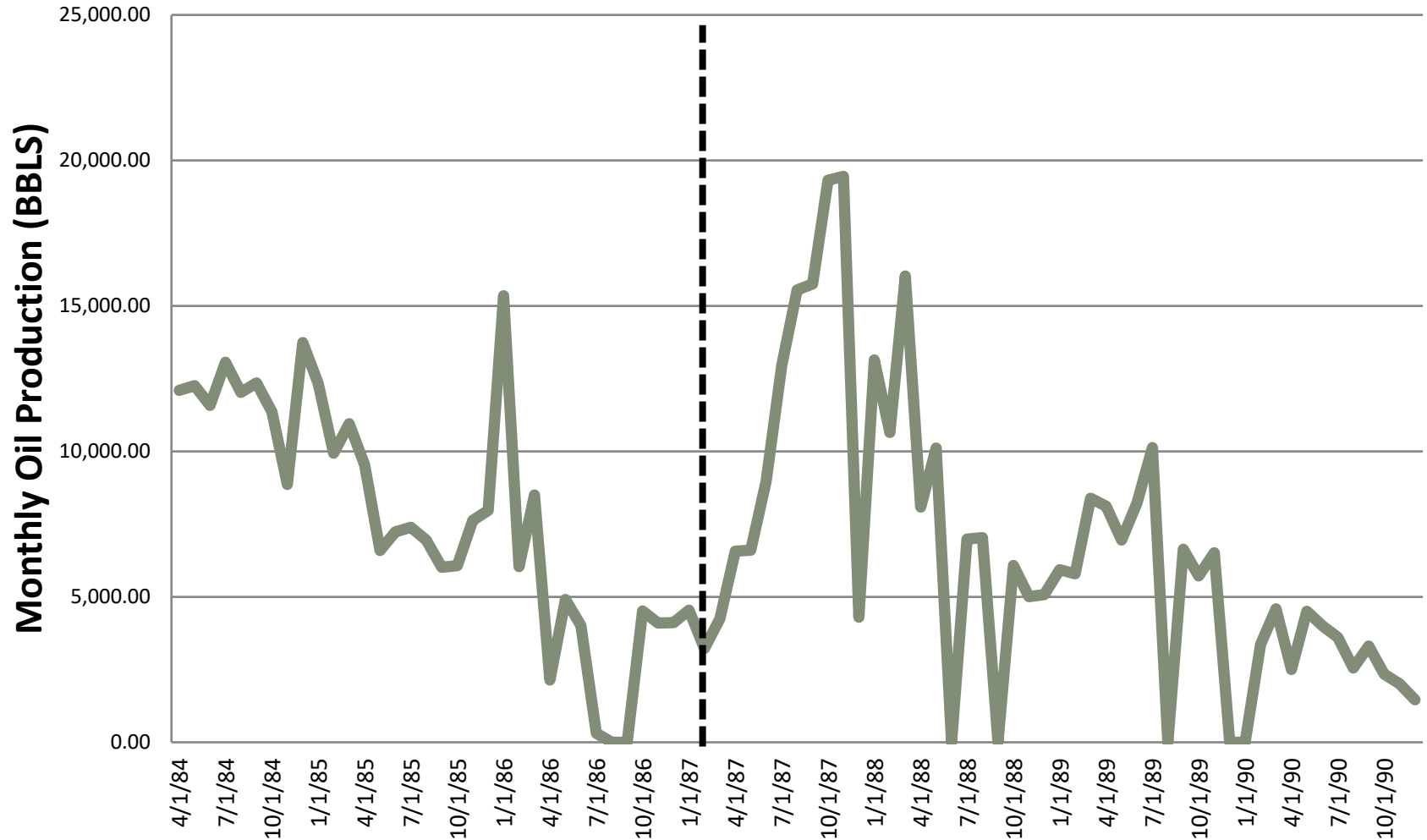
1. Install and check wellhead conditions and verify correct wellhead equipment from page 1.
2. Conduct 10 min bubble test
3. Move in and rig up service rig
4. Change wellhead to BOP
5. Pull out of hole tubing string
6. Lay down service rig
7. Move in wire line
8. Rig in Pressure truck
9. Pressure test wire line casing and wire line BOP
10. Set packer at 6600 m
11. Pressure test packer
12. ~~Prepare perforation gun on wire line~~
13. Run in hole to perforation interval 6207-6400 ft.
14. Perforate, POOH
15. Release packer, pull out of hole
16. RIH and set production log, rig out wire line
17. Rig in service rig and begin flow back test, check rig tank cuttings
18. Run in hole tubing string to ___ft.
19. Change BOP to original wellhead

**Tensleep
6207-6500 ft.**



Predicted Performance

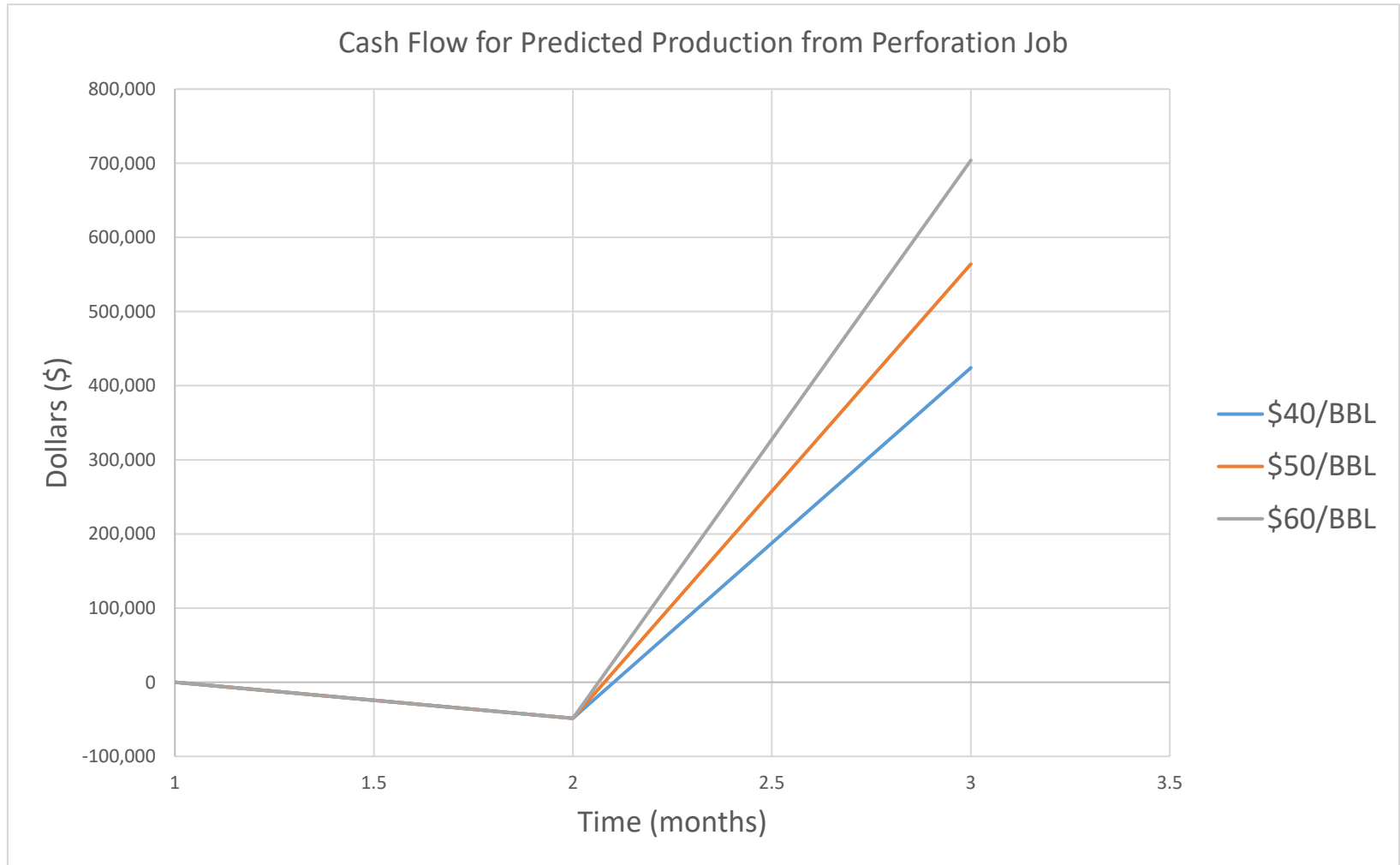
Pattern 14: Production



Work Over Costs

Workover Cost Analysis			
Service	Cost/day	Total Number of Days	Total Cost per Job
Service rig	\$ 7,000.00	3	\$ 21,000.00
Wireline truck	\$ 20,000.00	1	\$ 20,000.00
Wellsite consultant	\$ 1,000.00	3	\$ 3,000.00
Production log		1	\$ 25,000.00
Job total			\$ 69,000.00

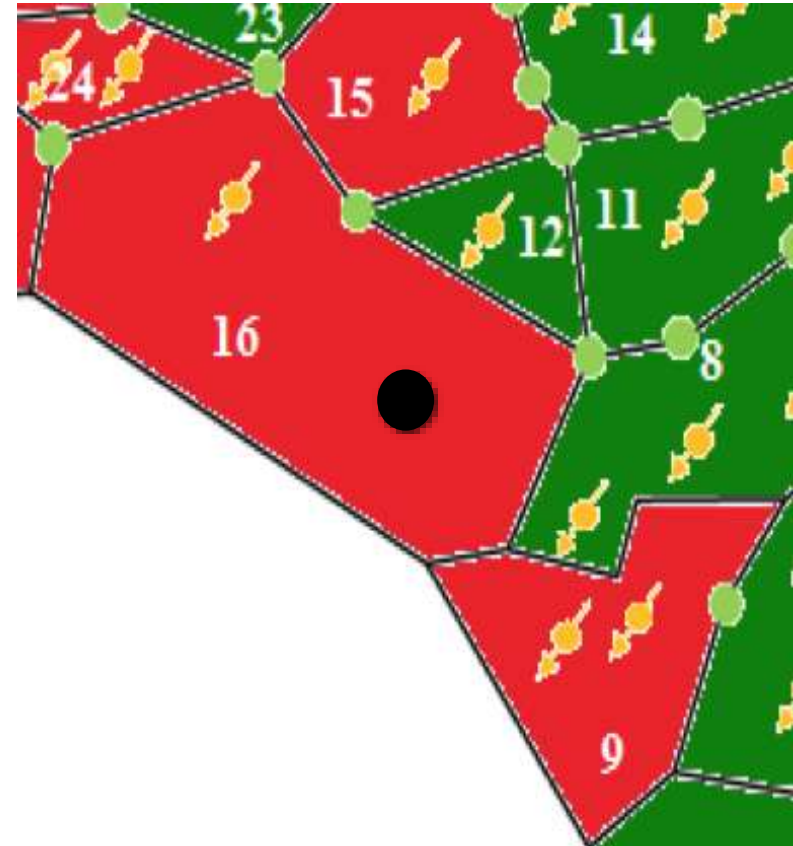
Cash Flow for Pattern 17



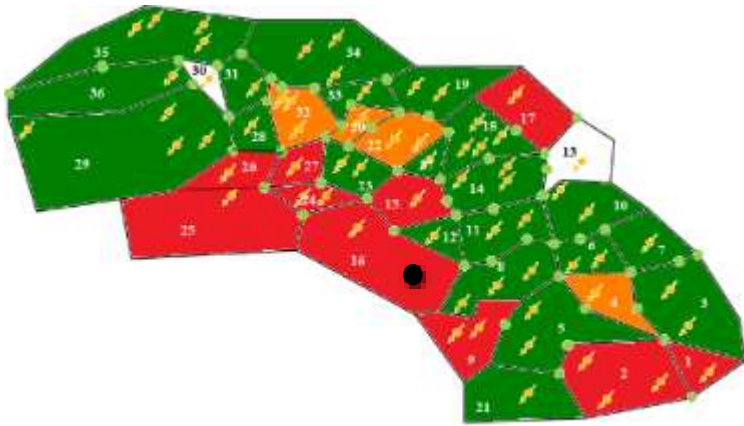
New Well Proposal

New Well In Pattern 16

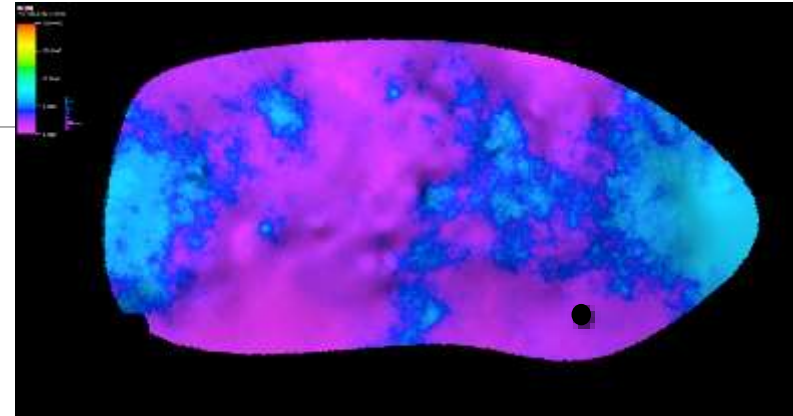
- Largest HCPV
- Continues Line Drive
- High Oil Saturation
- Porosity Acceptable
- Will Need To Be Fractured



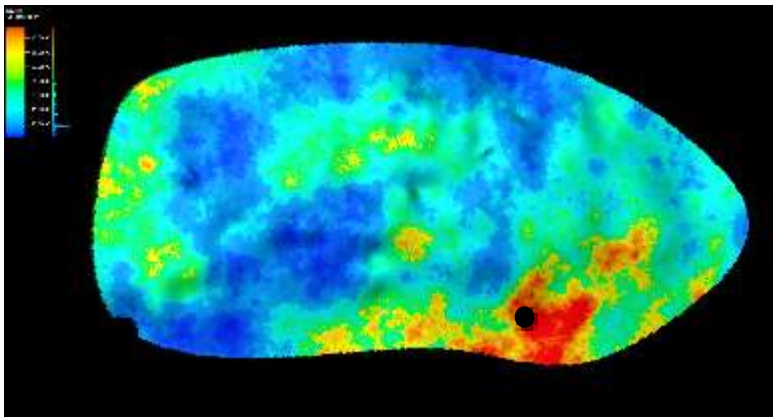
New Well In Pattern 16



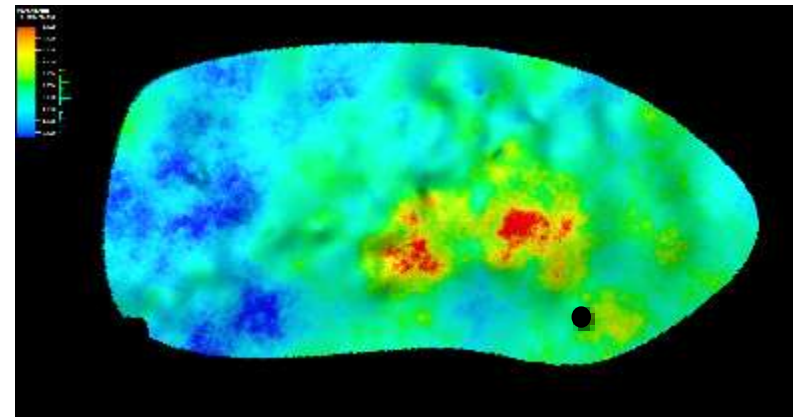
Location



Permeability



Oil Saturation



Porosity

BHA#1: 311 mm
BHA#2: 222 mm
BHA#3: 171mm

TD#1: 500 ft.
TD#2: 4000 ft.
TD#3: 6625 ft.

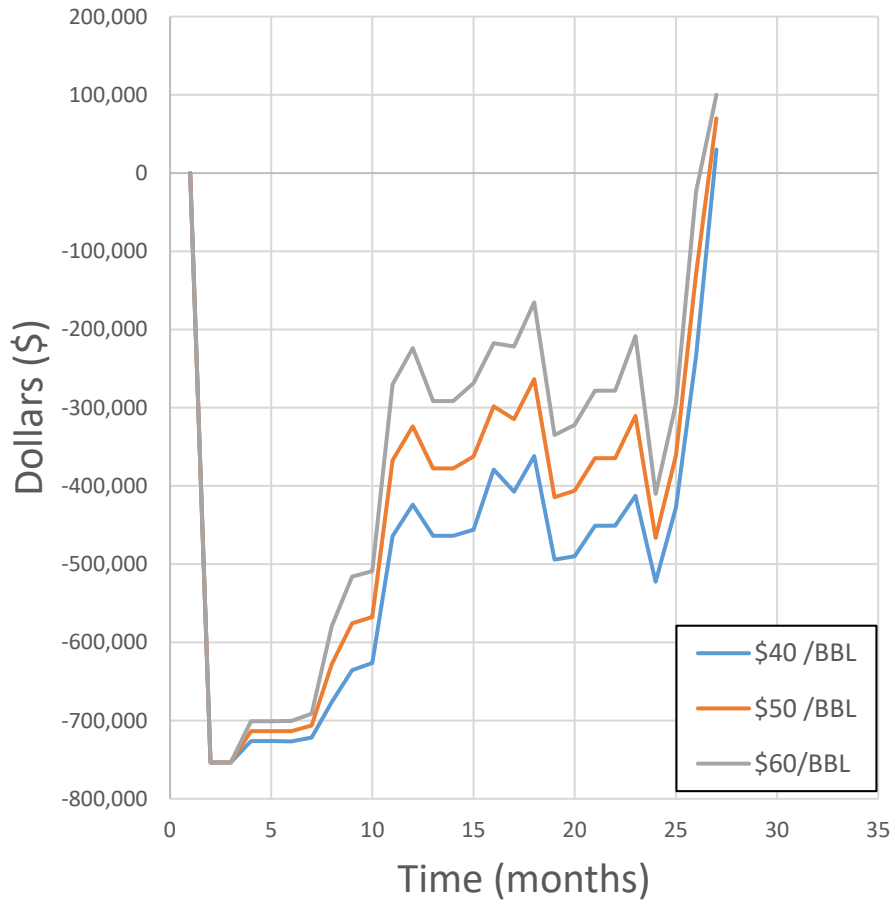
1. MIRU
2. Pre spud/ safety meeting
3. Prep conductor pipe, weld on flange
4. Nipple Up diverter
5. Make up BHA#1
6. Spud the well with BHA#1
7. Drill to TD#1
8. POOH, wiper trip
9. RIH surface casing and cement in place
10. Wait on cement, always 8 hrs.
11. Pressure test surface casing
12. Nipple down diverter, nipple up BOP, pressure test BOP
13. RIH BHA#2
14. Drill through shoe, pull up 1 meter
15. Preform LOT (Leak of Test) of FIT (Formation Integrity Test)
16. Drill to TD#2, POOH, wiper trip
17. RIH intermediate casing and cement plug
18. Cement, wait on cement
19. Pressure test intermediate casing
20. RIH BHA#3
21. Drill through shoe, pull up 1 meter
22. Preform LIT or FIT
23. Drill to TD#3
24. POOH, wiper trip
25. RIH production casing
26. Cement, wait on cement
27. Pressure test production casing
28. Displace mud with final completion fluid
29. ND BOP, NU wellhead
30. Release rig, move off location

6625 ft.
Tensleep
formation 325 ft.

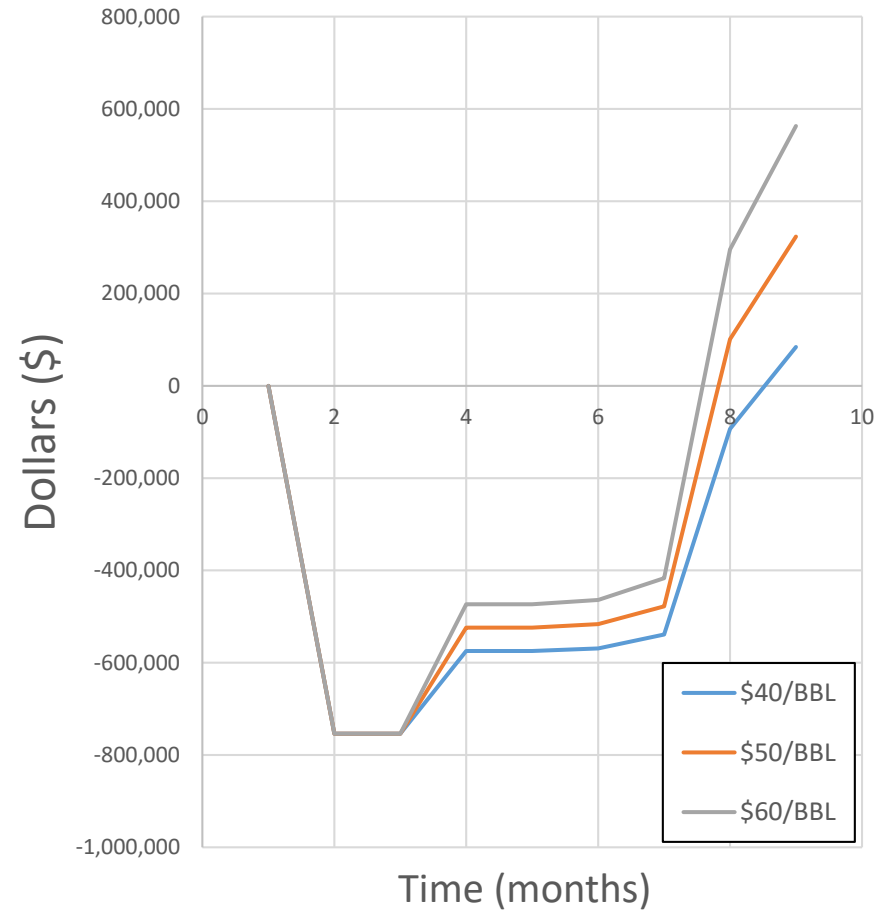


Pattern 16

Well Cash Flow



Pattern Cash Flow



Summary

- Taking CO2 Injection from Patterns: 2, 4, 9 and 15
- Giving CO2 Injection to Patterns: 24, 25, and 27
- Perforate Tensleep Formation in Pattern 17
- Drilling a New Well in Pattern 16
- Spending \$969,000
- Predicted increased revenue \$90,000/month
(Total Monthly Revenue of ≈\$966,000/month)



Economic Summary

- Re-allocate Injection

Cumulative Estimated Production Increase Of:

8,500bbl/month

- Perforation Job

Cost ≈\$69,000

Revenue ≈\$36,000/month

- Drill New Well

Cost ≈\$900,000

Revenue ≈\$34,615/month



Thank You!!!

Dr. Saman Aryana for his considerable help
throughout the semester



Questions



Current Producing Zones

Wyoming Oil and Gas Conservation Commission

Formation	Depth
MUDDY, FM	4062
LAKOTA, FM (INYAN KARA GP)	4150
SUNDANCE, FM	4426
NUGGET, SS	4588
ALCOVA, LS (CHUGWATER GP)	5221
DINWOODY, FM	5935
PHOSPHORIA, FM	5988
TENSLEEP, FM	6207
AMSDEN, FM	6690
DARWIN, SS MBR (AMSDEN FM)	6778
MADISON, FM	6856

Top Perfs	Bottom Perfs	Holes/Ft	Size
6780	6846		304
6950	6990		304

Economic Assumptions

- Royalty Burden – 10.0%
- Working Interest – 100%
- Price of Oil, $P_O = \$(40,50,60)/\text{bbl}$
- Price of Gas, $P_G = \$4.25/\text{Mscf}$
- Cost of Fluid Handling, $P_{FH} = \$4.00/\text{bbl}$
- Cost of Gas Handling, $P_{GH} = \$0.07/\text{Mscf}$

Economics

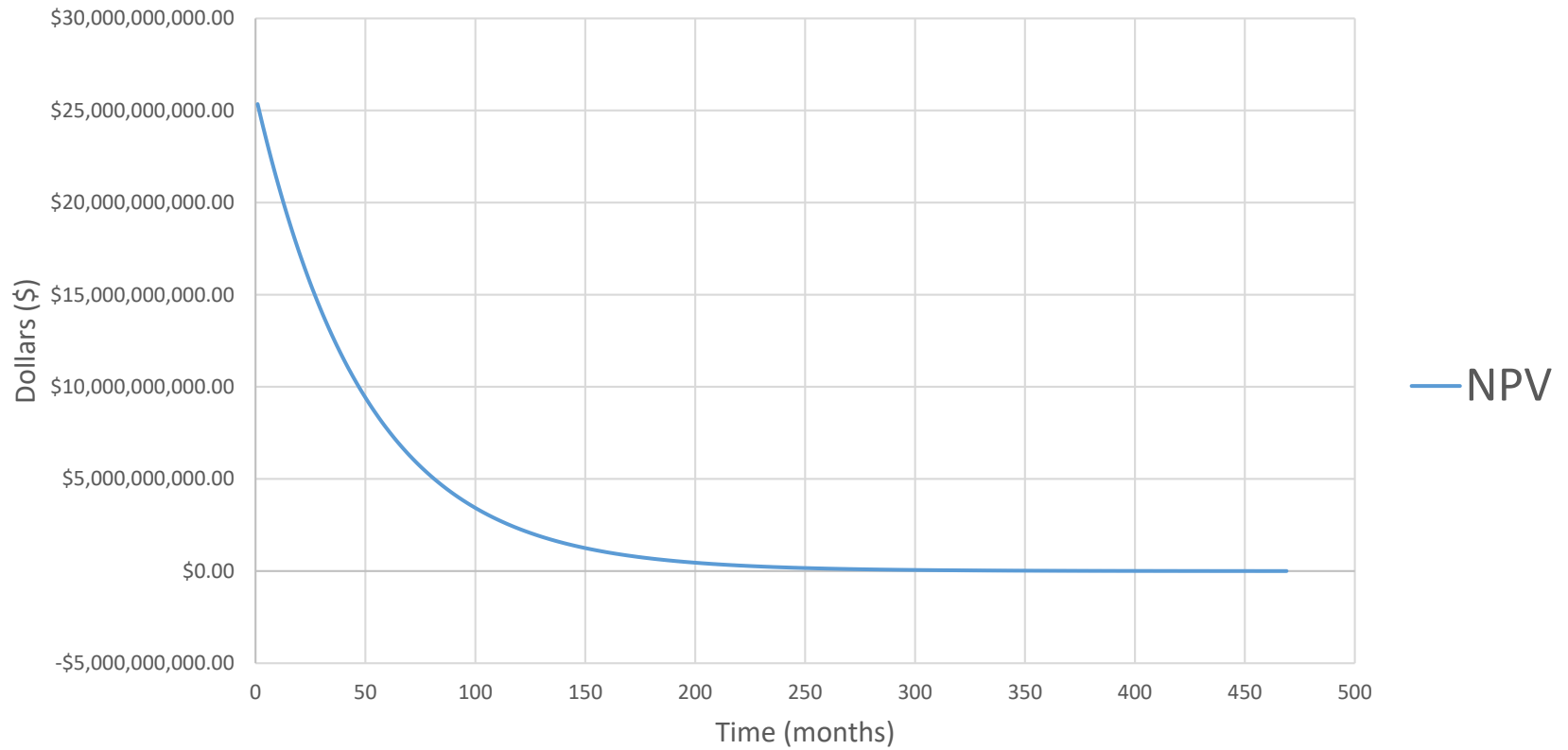
- Field acquisition cost \$935,000,000
- Labor ~\$1,680,000/year
- Production Log ~\$25,000
- Lift Mechanism – Beam Pump
 - \$250,000/unit
 - \$10,000 Salvage Value
- Location – Wyoming
 - 8% severance tax on oil and gas
- Federal Tax
 - 37% of income

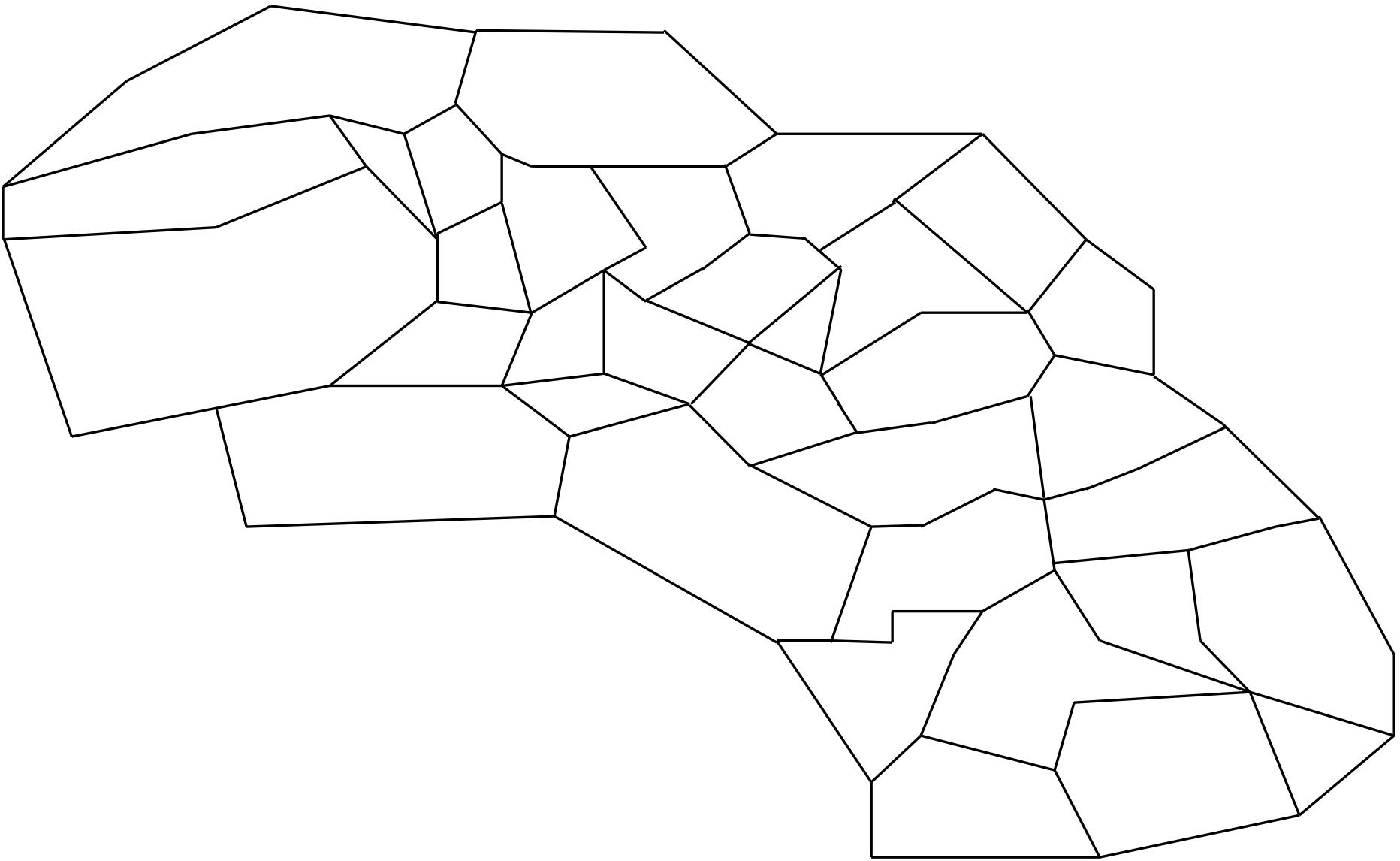
Economics

- Field OPEX = \$2,196,600/year
 - Well Cost = \$3,690.00/month/well
 - Economic Limit per pattern
49 STB/month, 42 STB/month, 37 STB/month
 - Unit Technical Cost
36.25 \$/bbl
- NPV ~\$25,349,730,823

NPV vs. Time

NPV over time





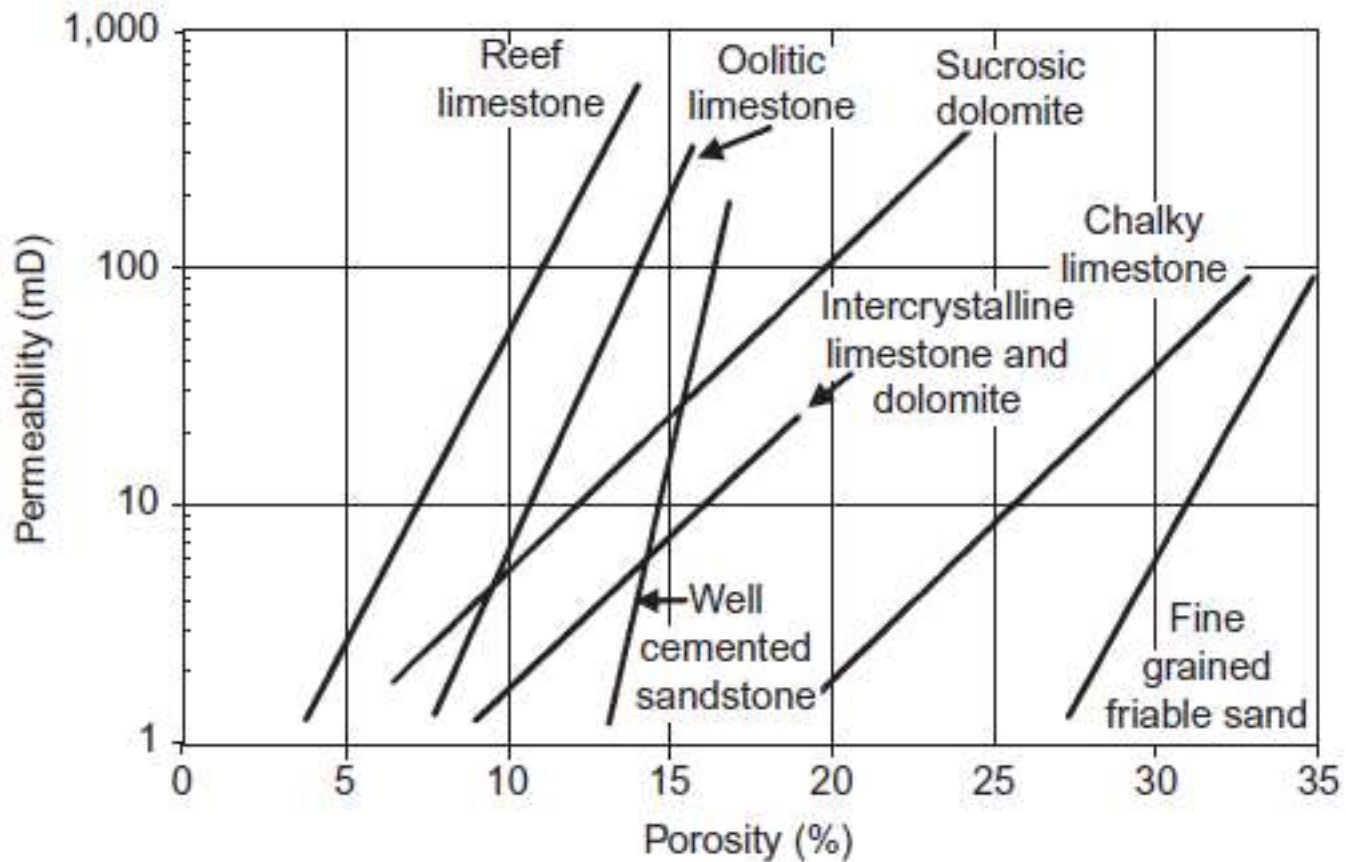


FIGURE 3.18 As typical permeability–porosity relationship for various rock types (courtesy of Core Laboratories).

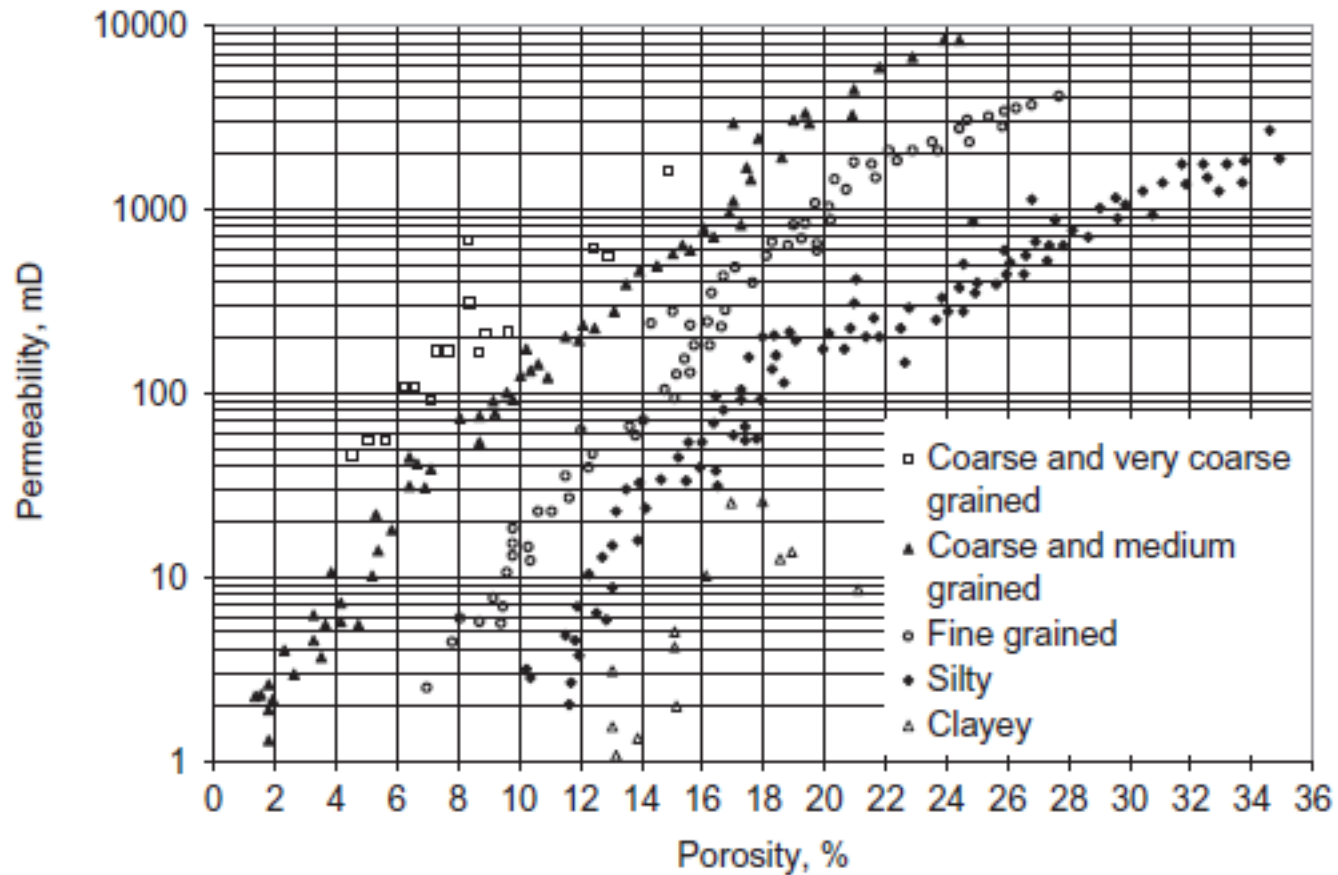


FIGURE 3.17 Influence of grain size on the relationship between permeability and porosity [16].

Permeability Direction

