Geo.\Mohamed Qenawy

Eng.\Eslam Elsayed

Factors Affecting On Eocene Carbonate Reservoir Productivity

(GPC Achievement Cases)

Agenda

- **Introduction:**
  - Eocene producing oil fields, Gulf of Suez.
  - Stratigraphic Setting.
  - Production History.

- **Production Heterogeneity Factors:**
  - Subaerial Exposure.
  - Structure Influence.
  - Diagenetic Features & Matrix porosity.
  - Eocene Subzonation.
  - Acid Stimulation.

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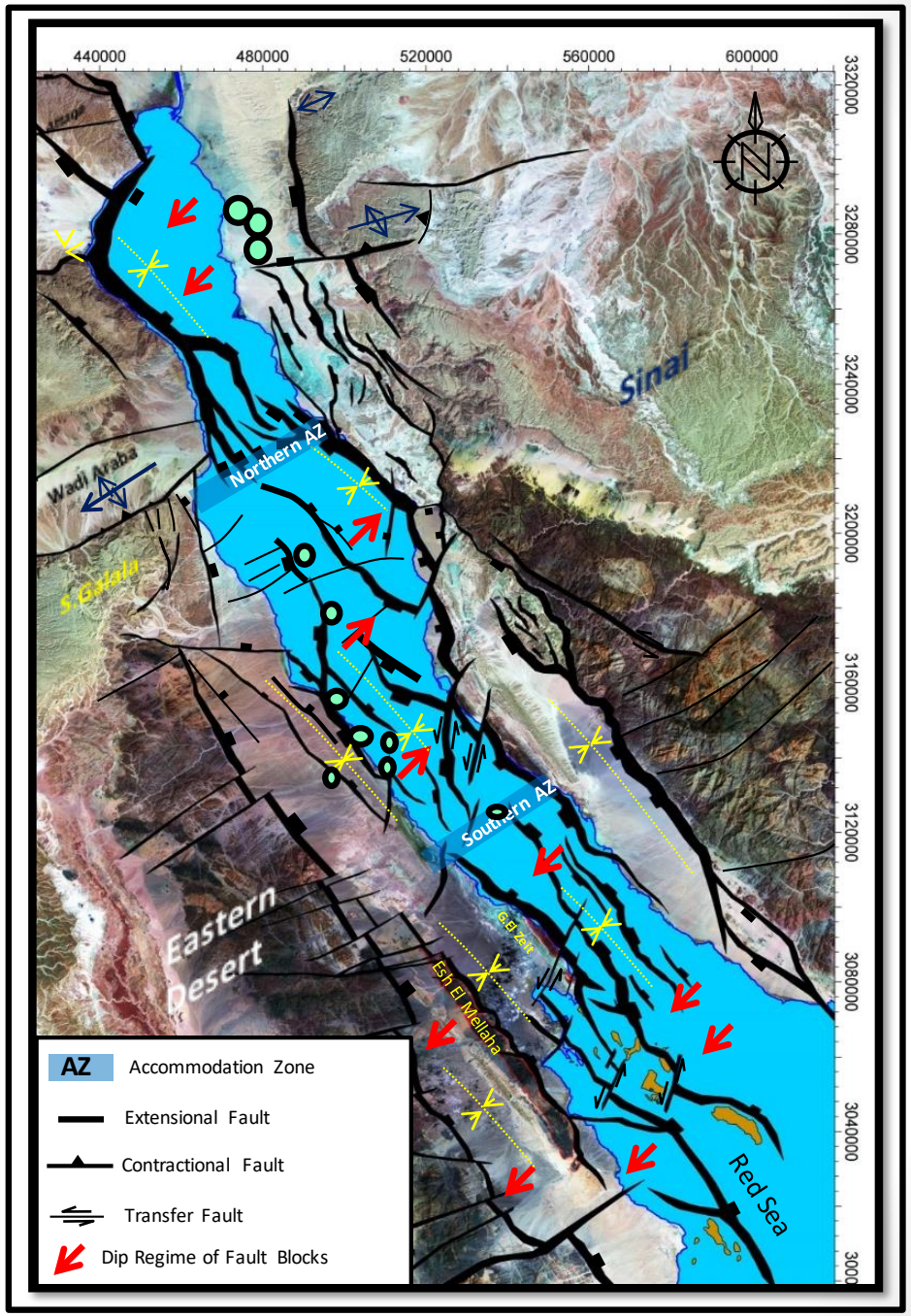
GPC Oil fields, Gulf of Suez



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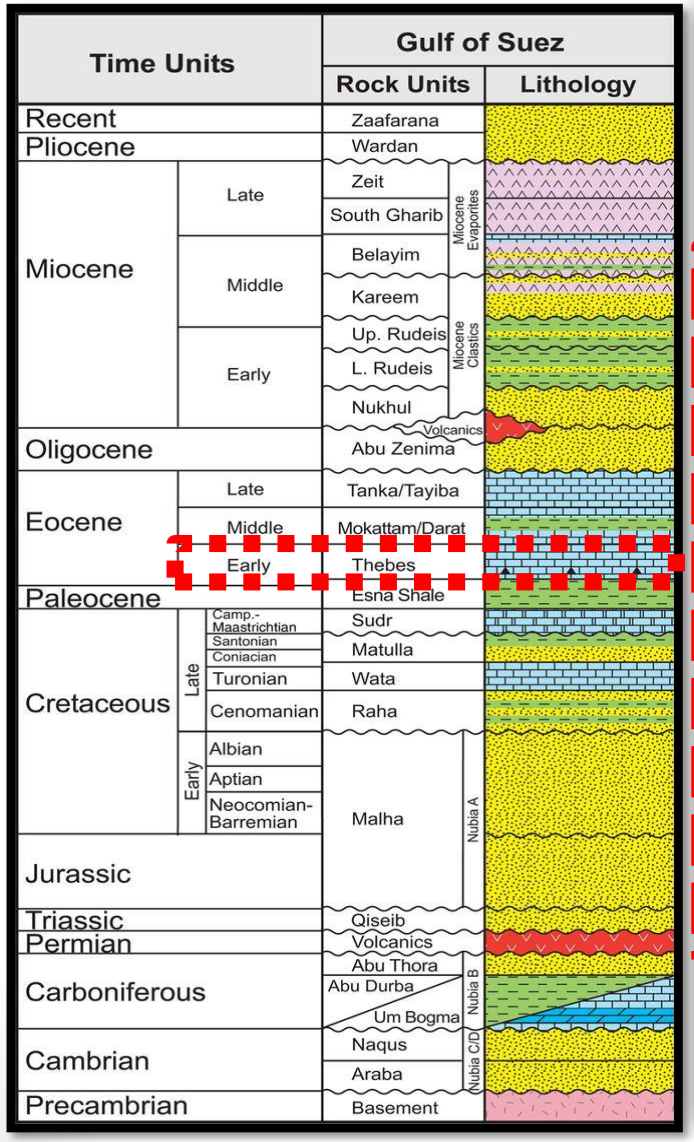
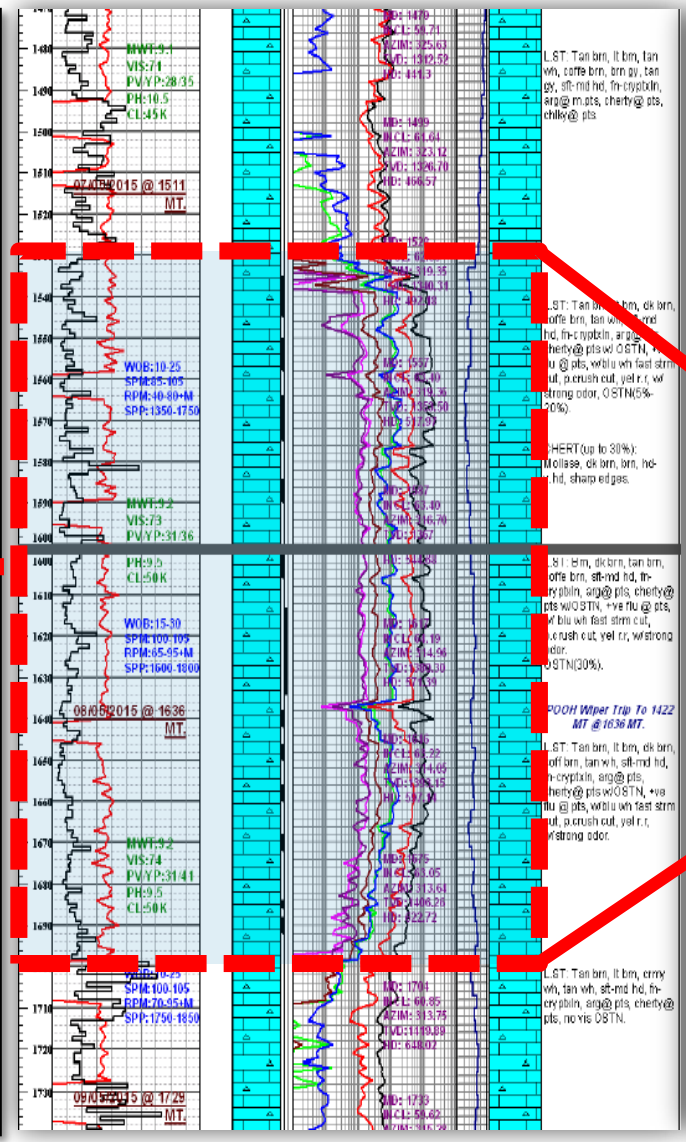
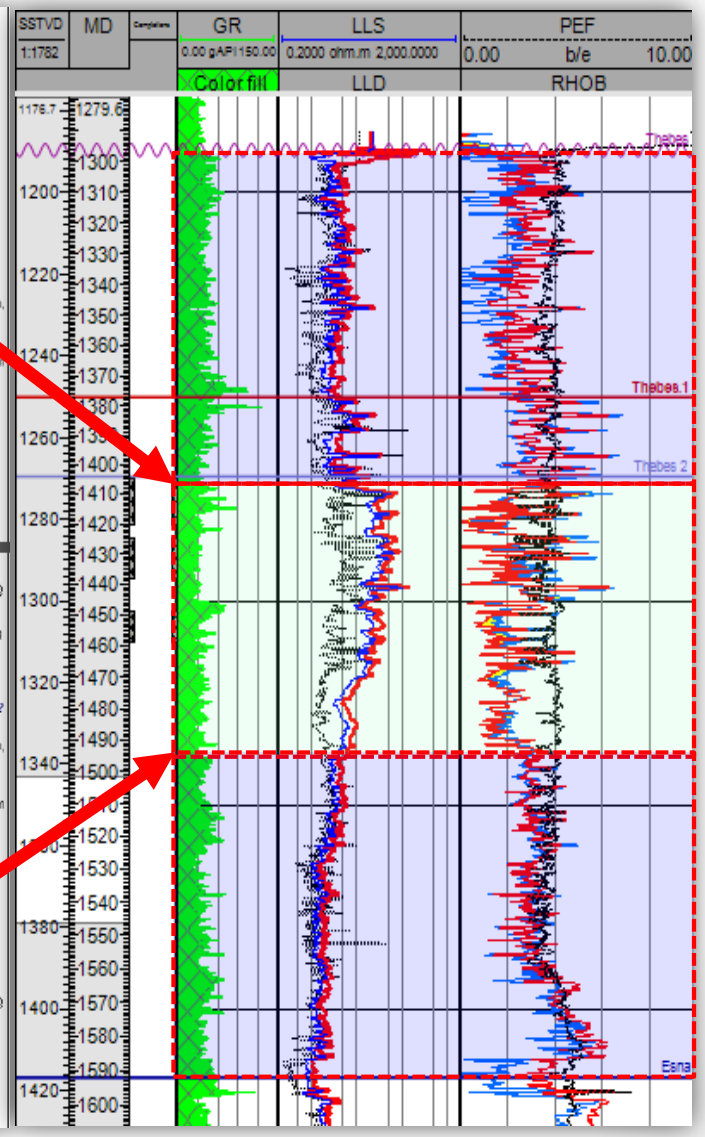
Stratigraphic Setting







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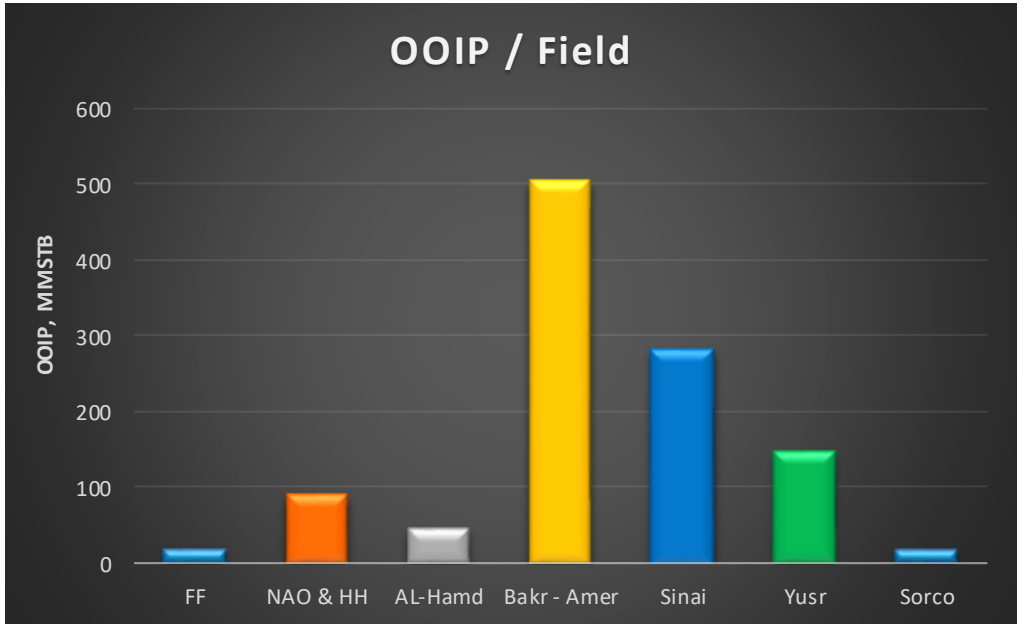
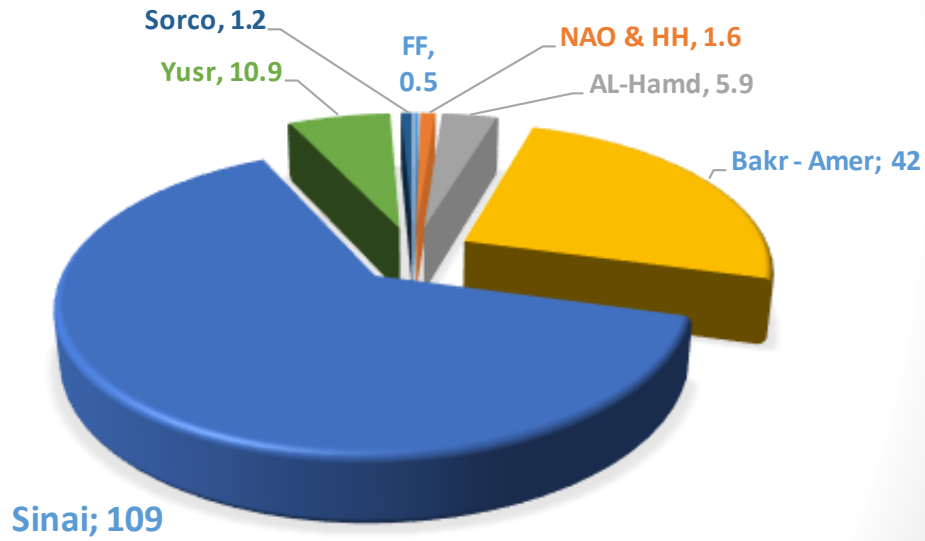
GPC Fields Production Contribution from Eocene

Total Oil in Place exceeds
1.2 Billion STB



Total Oil Produced
+/-172 MMSTB



HOW DOES IT WORK

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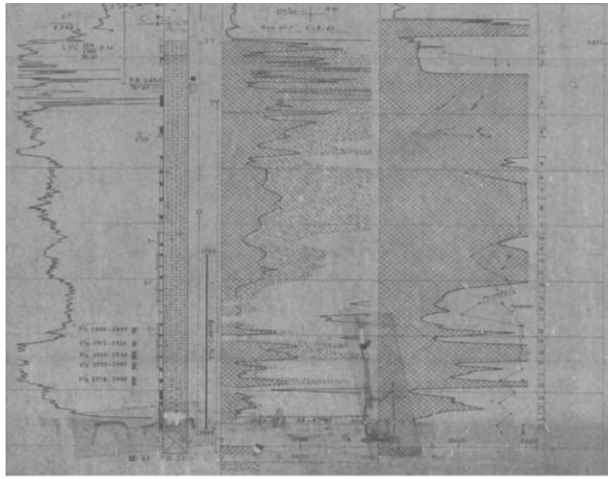
Karst

Surface Outcrop @Benisweif, Egypt

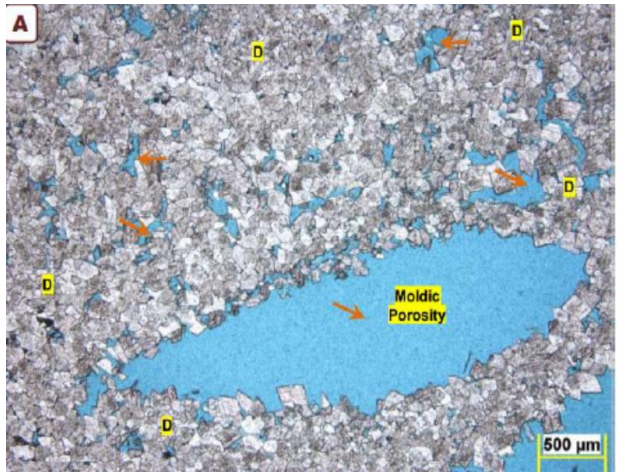
Subaerial Exposure

Sudr-35 Facies

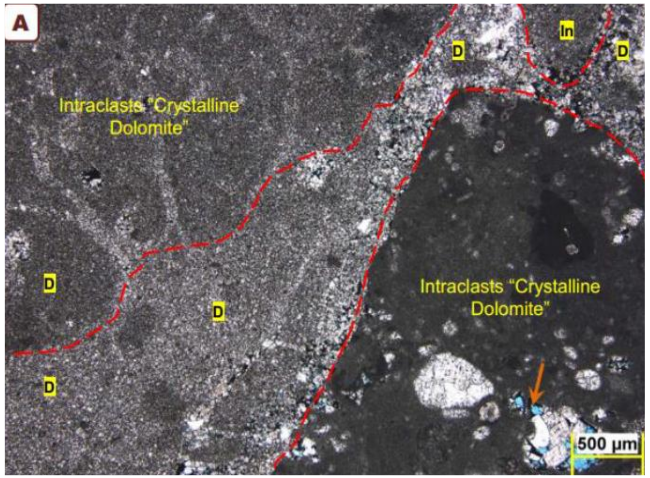


Drilled 1961

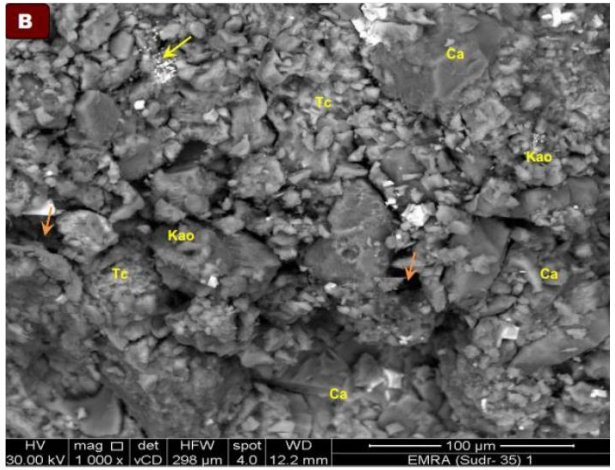
Cum. 15.9 MMBBL



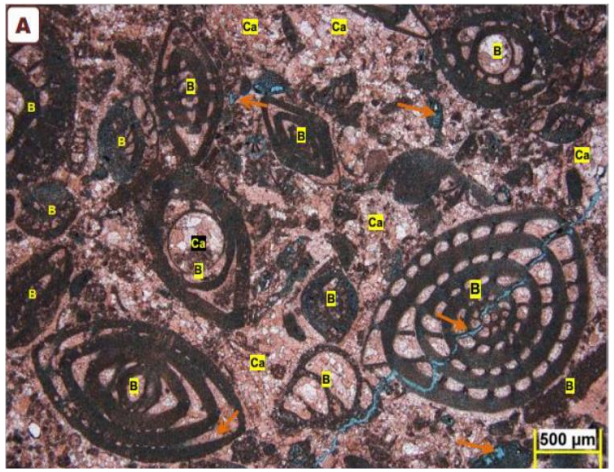
Crystalline Dolomite
@Middle Eocene



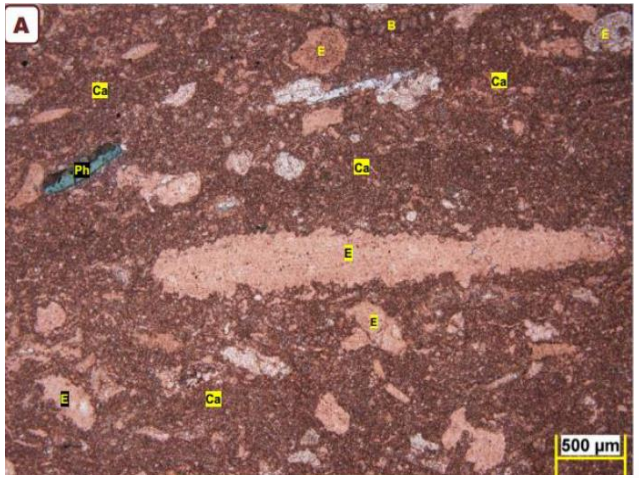
Intraclast Crystalline Dolomite
@Lower Eocene



Terrigenous clays support
exposure surface @Top Eocene

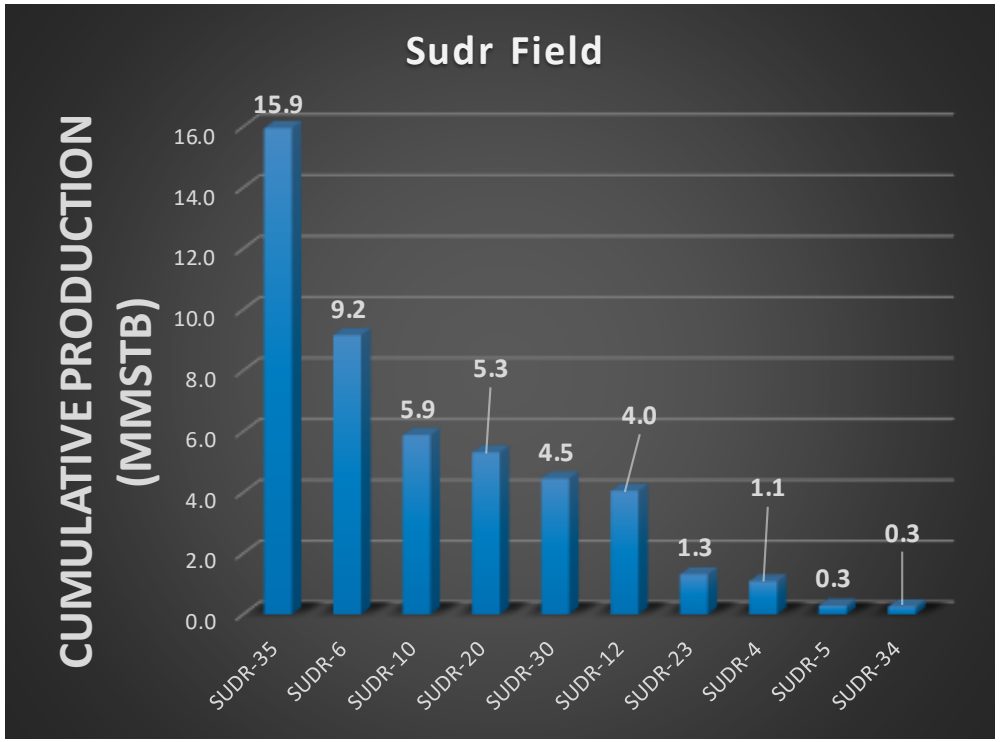


Benthic Forams Grain Stone
@Middle Eocene

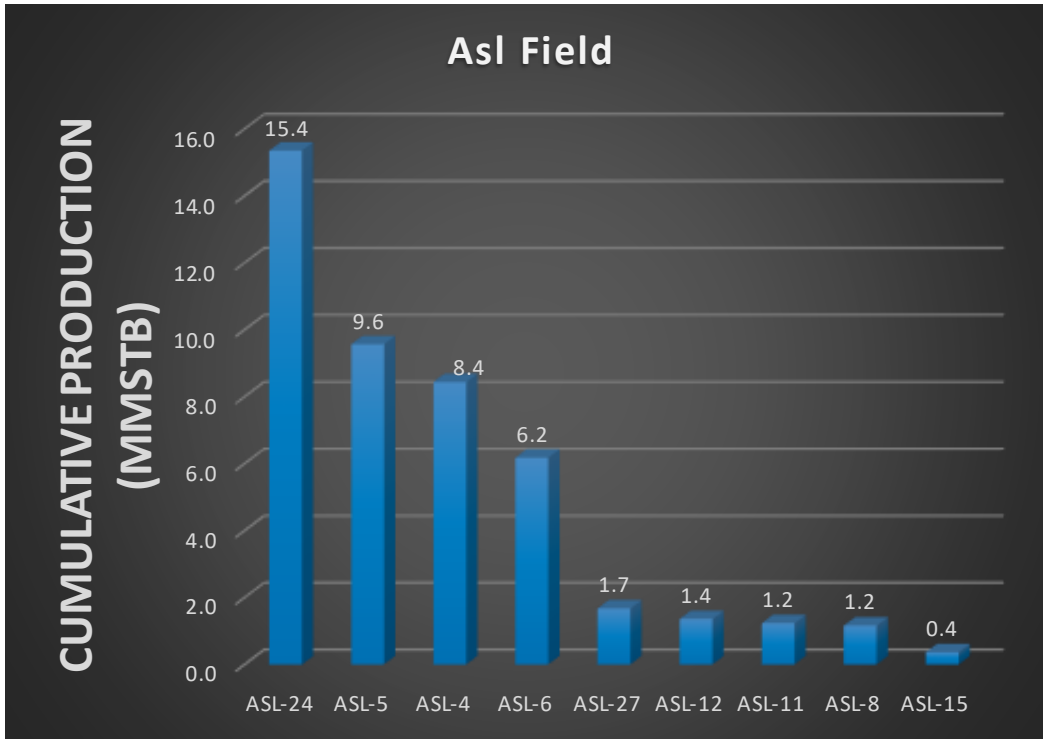


Echinoderms Grainstone
@Lower Eocene

Karst Production History



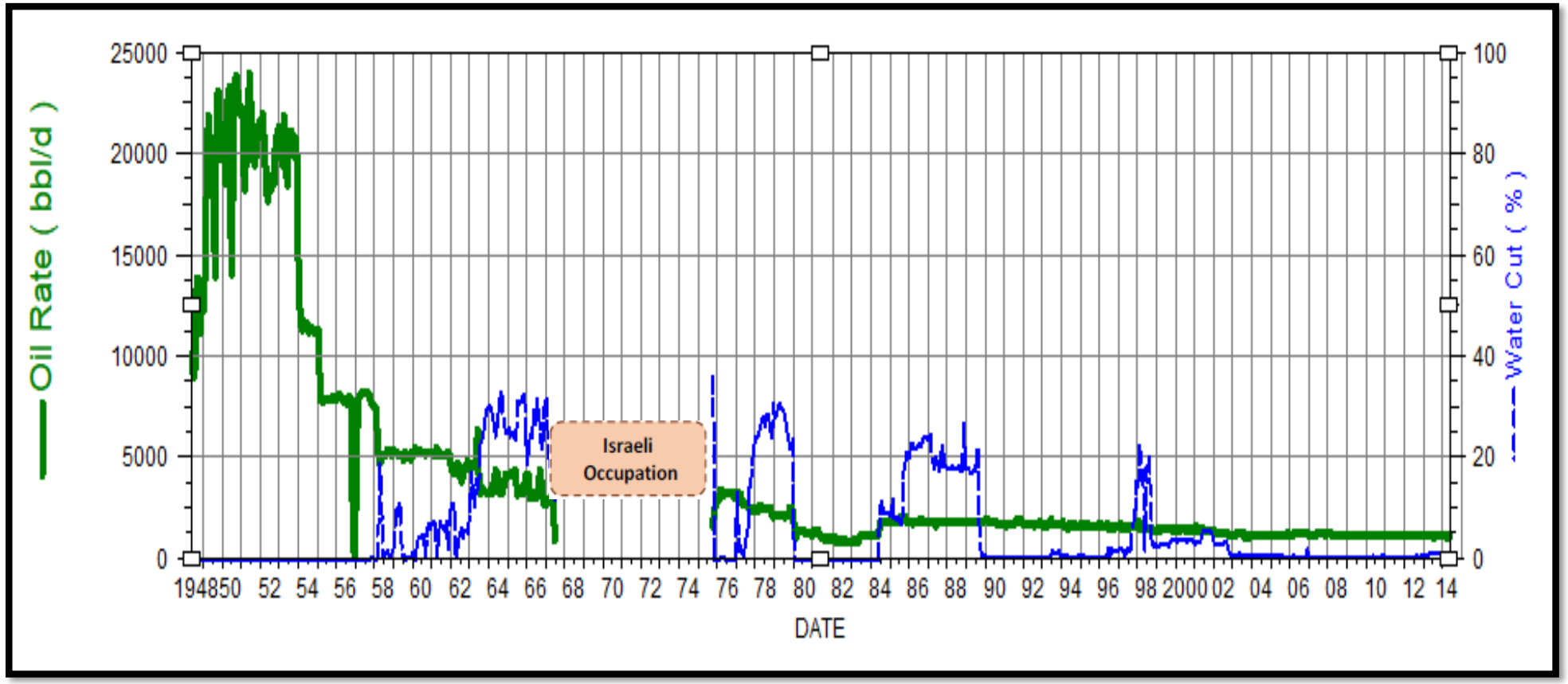
Cum. Prod.> 50 MMBBL



Cum. Prod.> 40 MMBBL

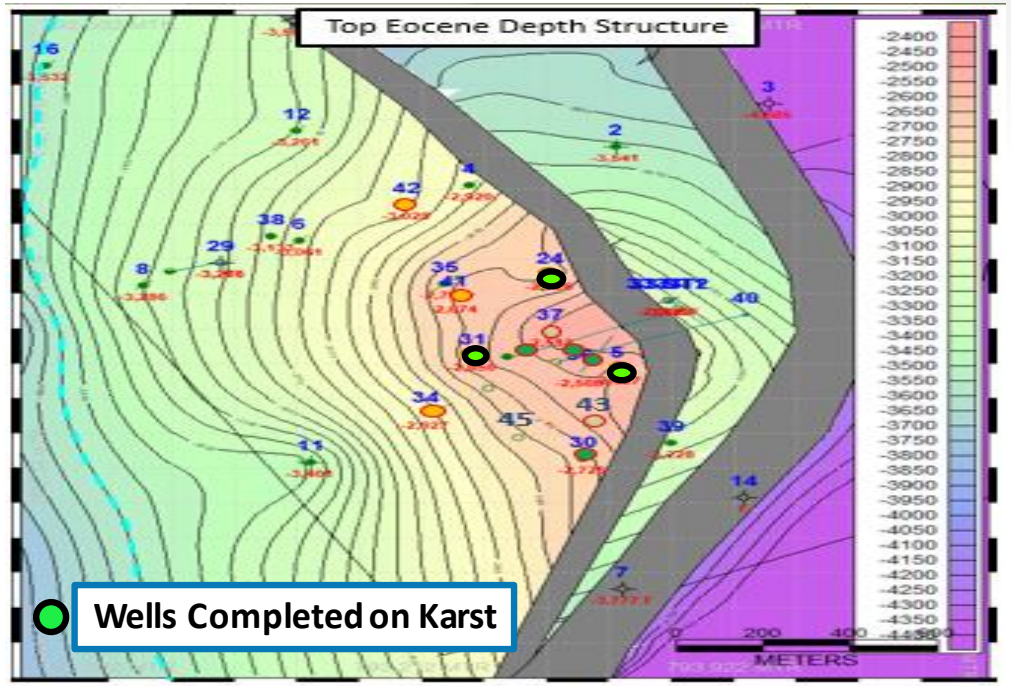
Karst Production Behavior

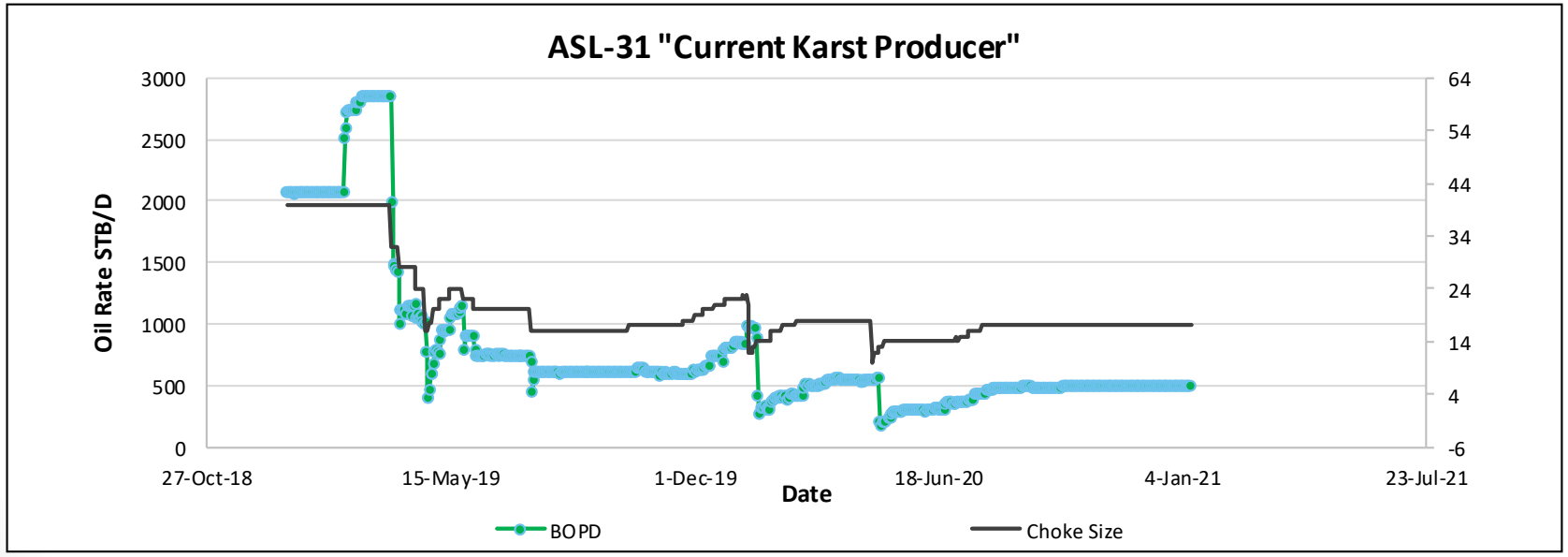
- High Initial production reached 25 MSTB and massive Cum.Prod exceeds 100 MMTB
- Plateau production for 50 year +/- 1100 STB.



Practical Experience During Karst Production

- ✓ Well Interference & direct hydraulic communication between Karst wells.
- ✓ Critical Drawdown (Choke size) Vs Water Break-through & well flowing.





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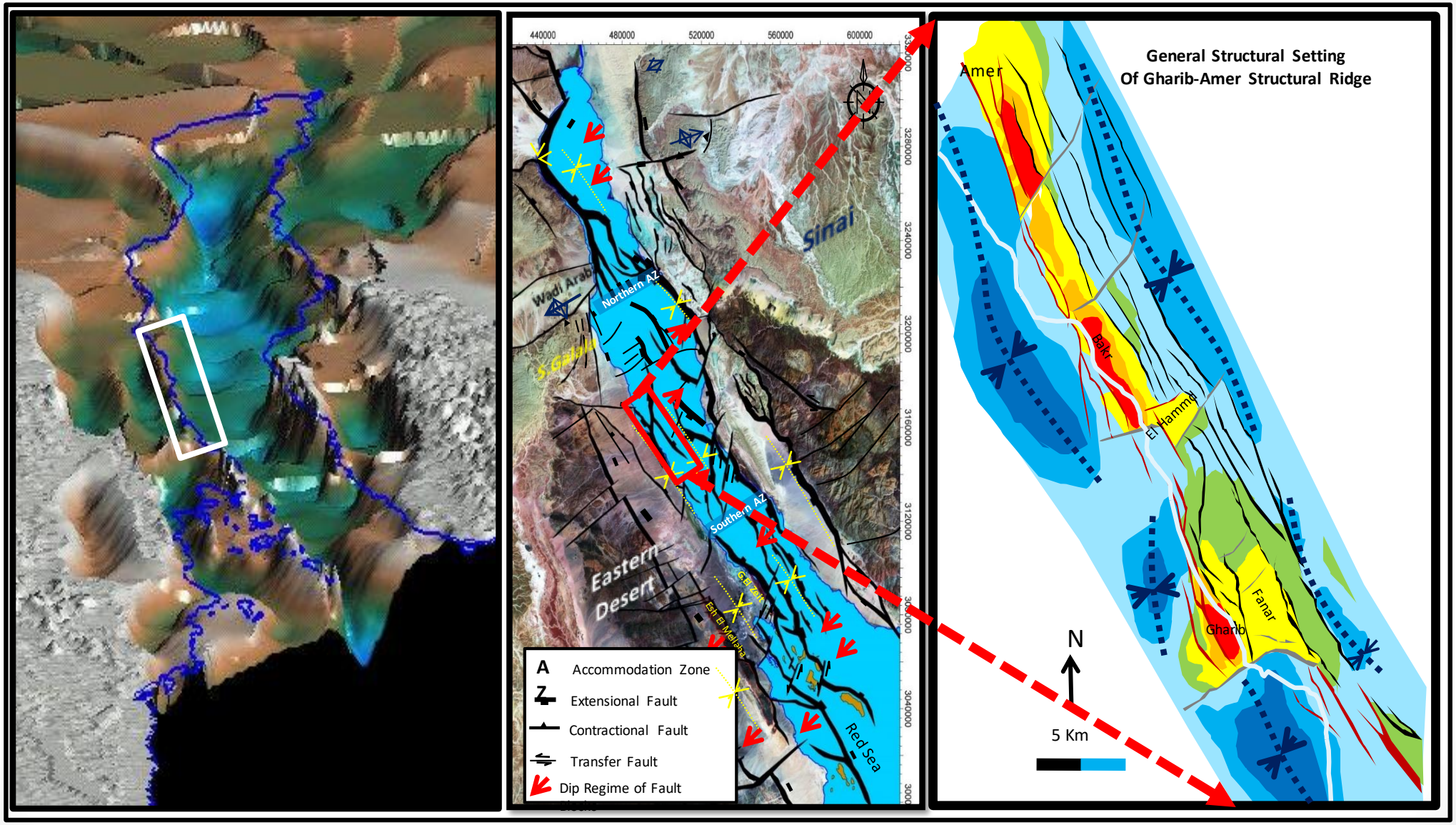
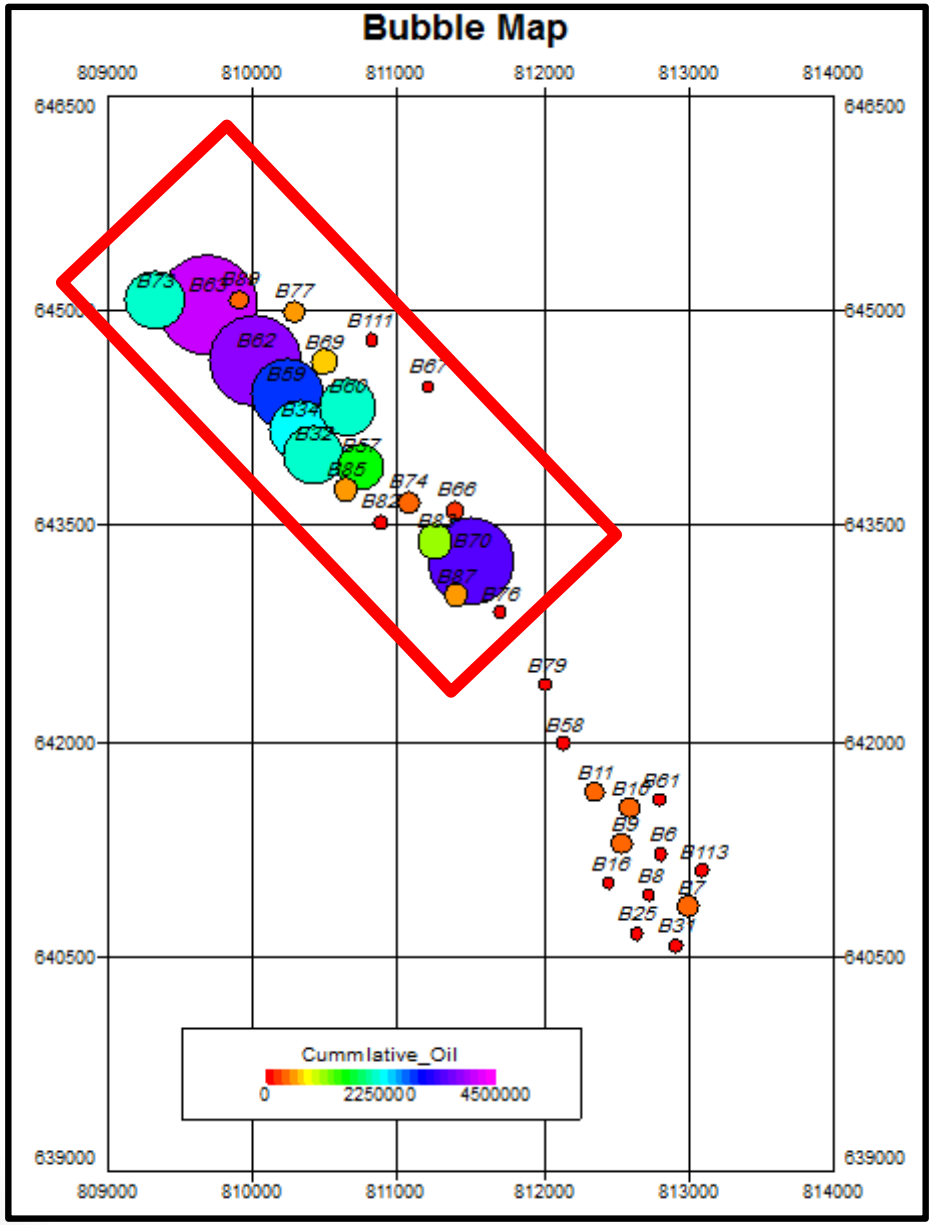
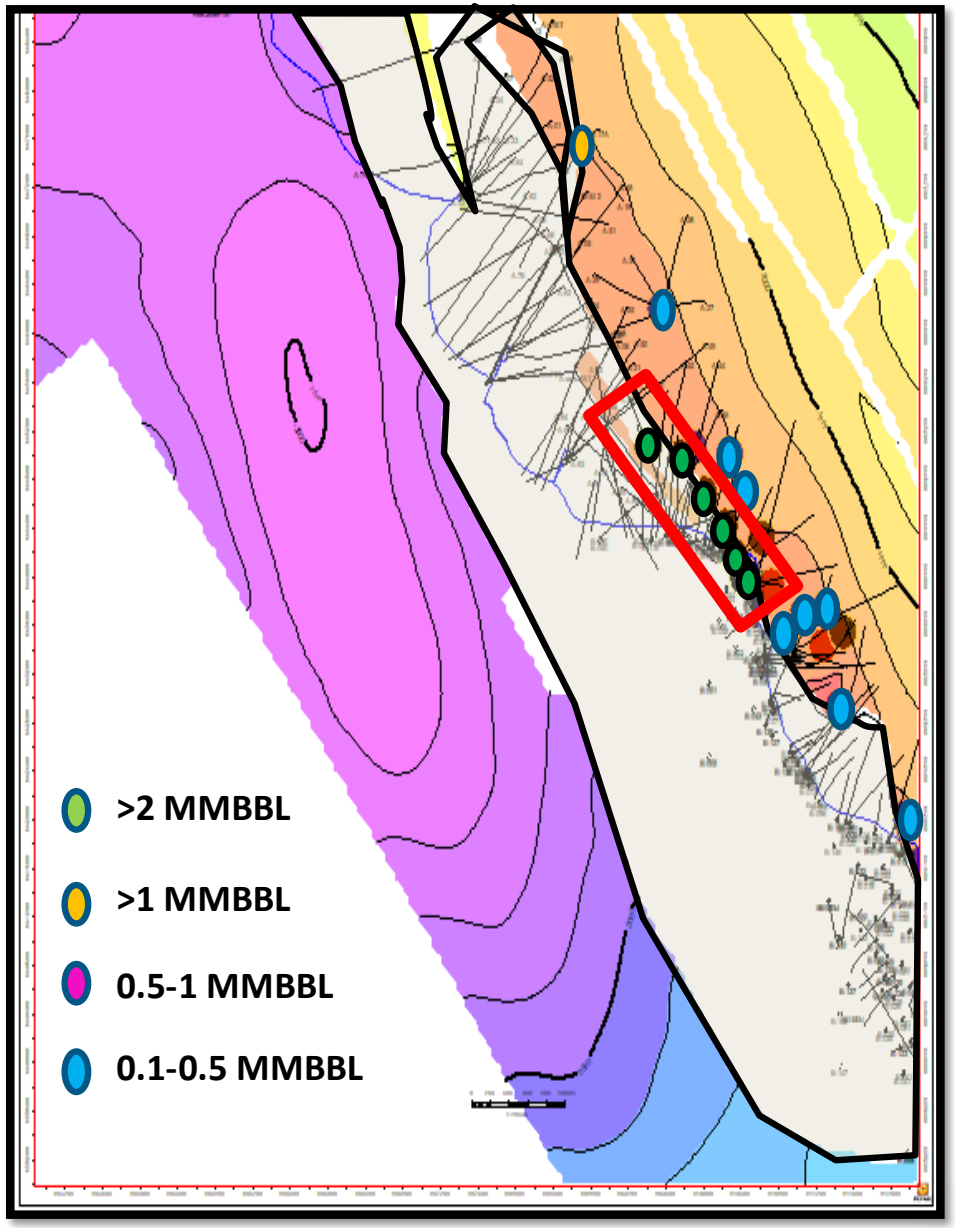
Structure Influence



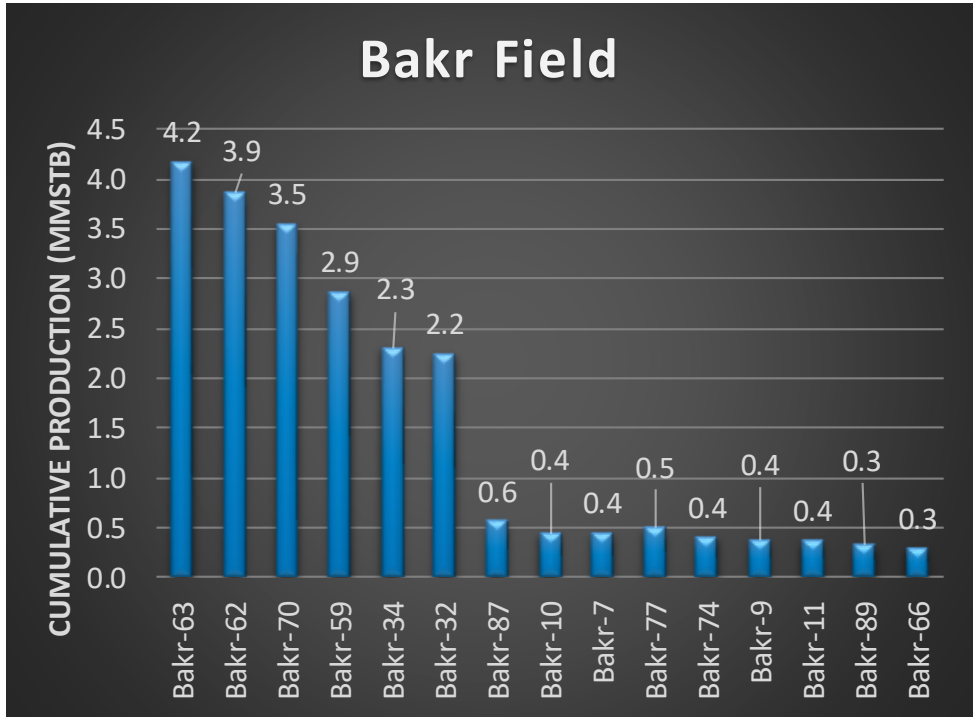
Basement Relief Map *Generalized Structure Map, GOS* *Bakr-Amer Structure Map*

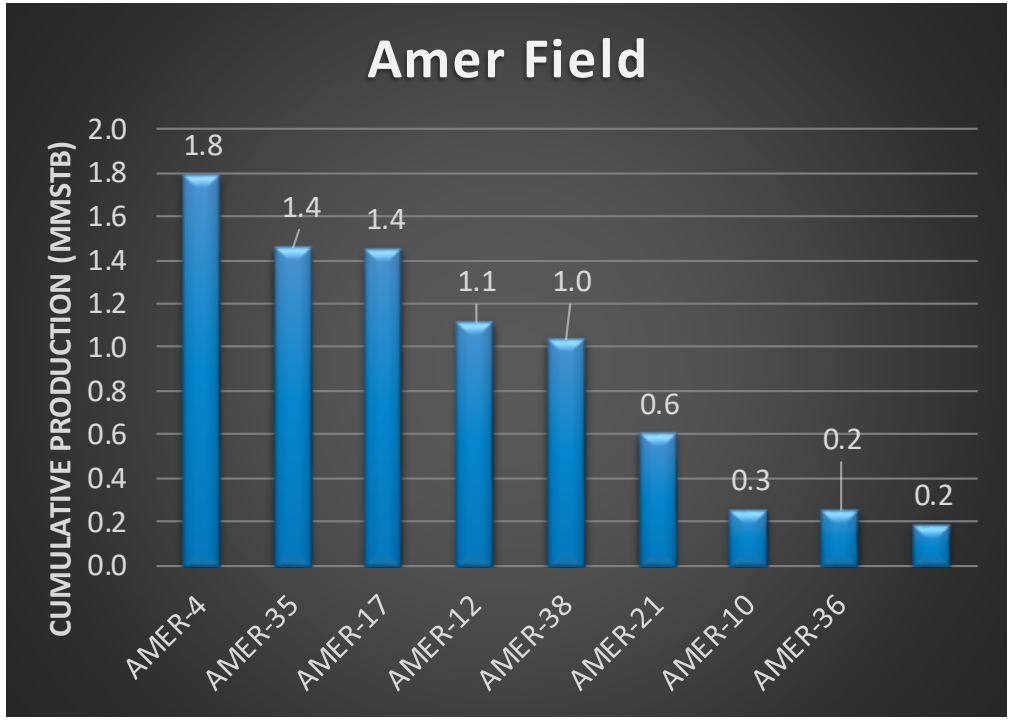
Structure Influence(Case.1-N.Bakr)





Production History



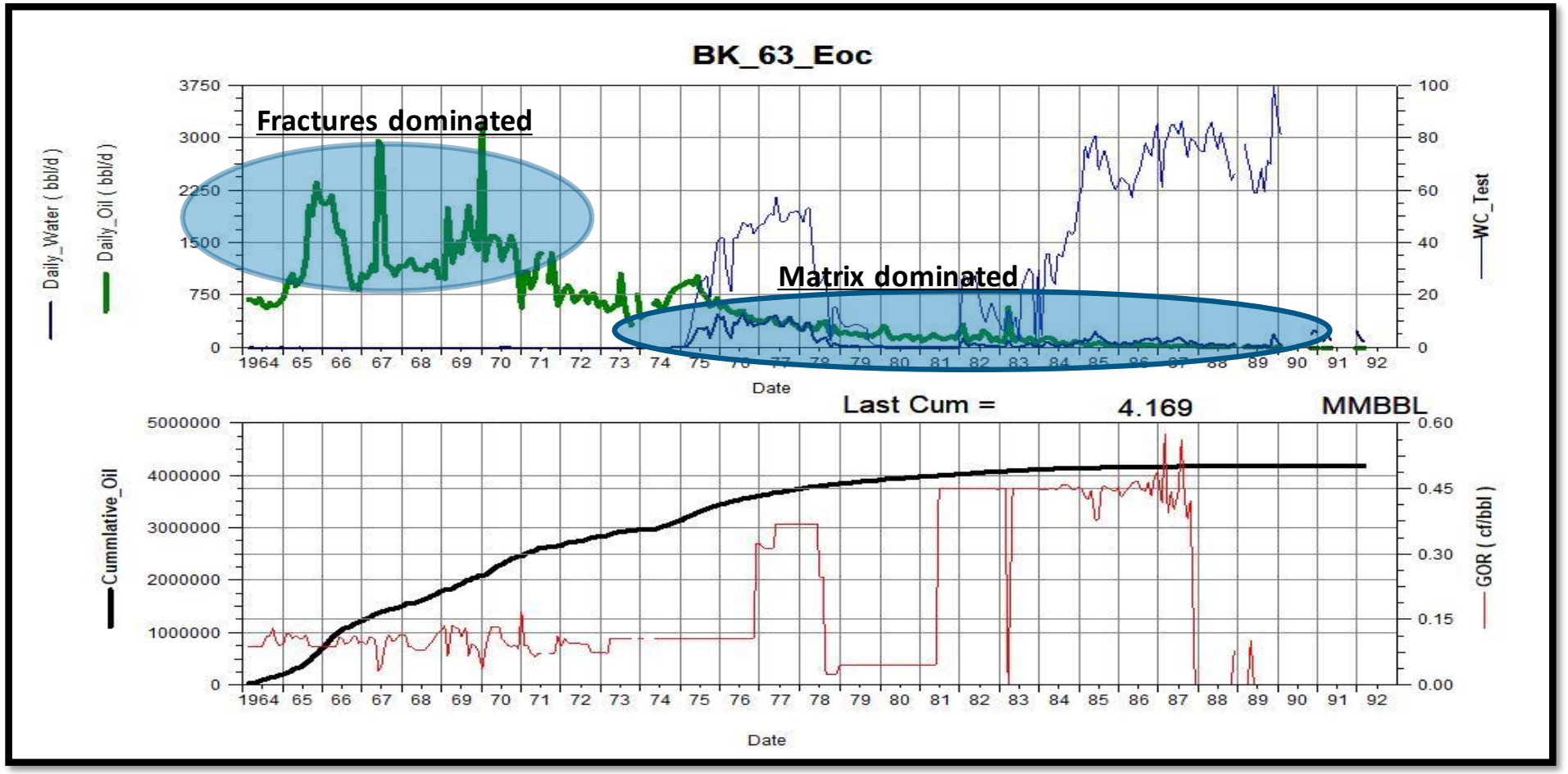


Cum. Prod.= 32 MMBBL
34 wells

Cum. Prod.= 11 MMBBL
22 wells

Structure Influence(Case.1-N.Bakr)

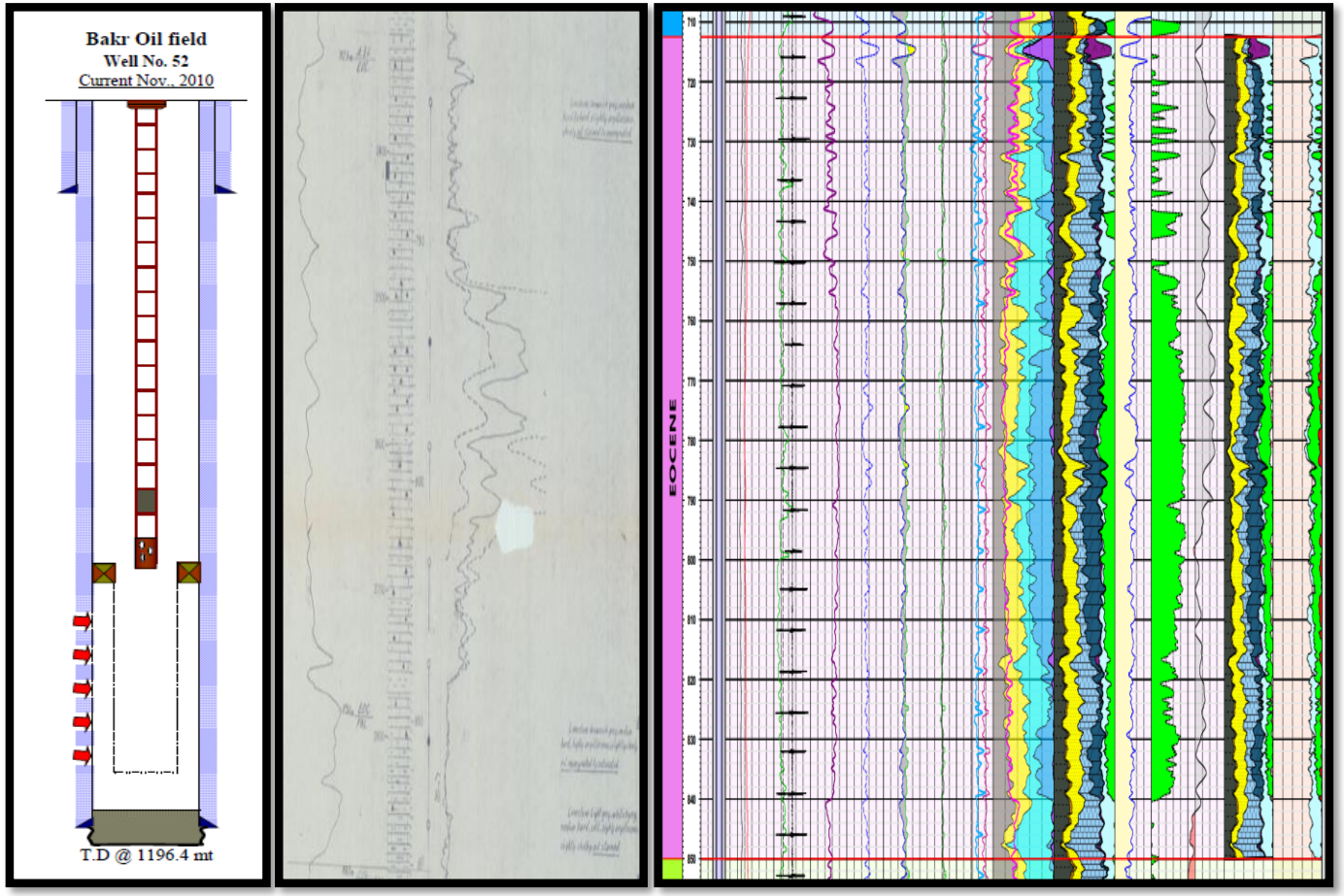
N.Fractured Well Production Behavior



Structure Influence(Case.1-N.Bakr)

Remaining Potential

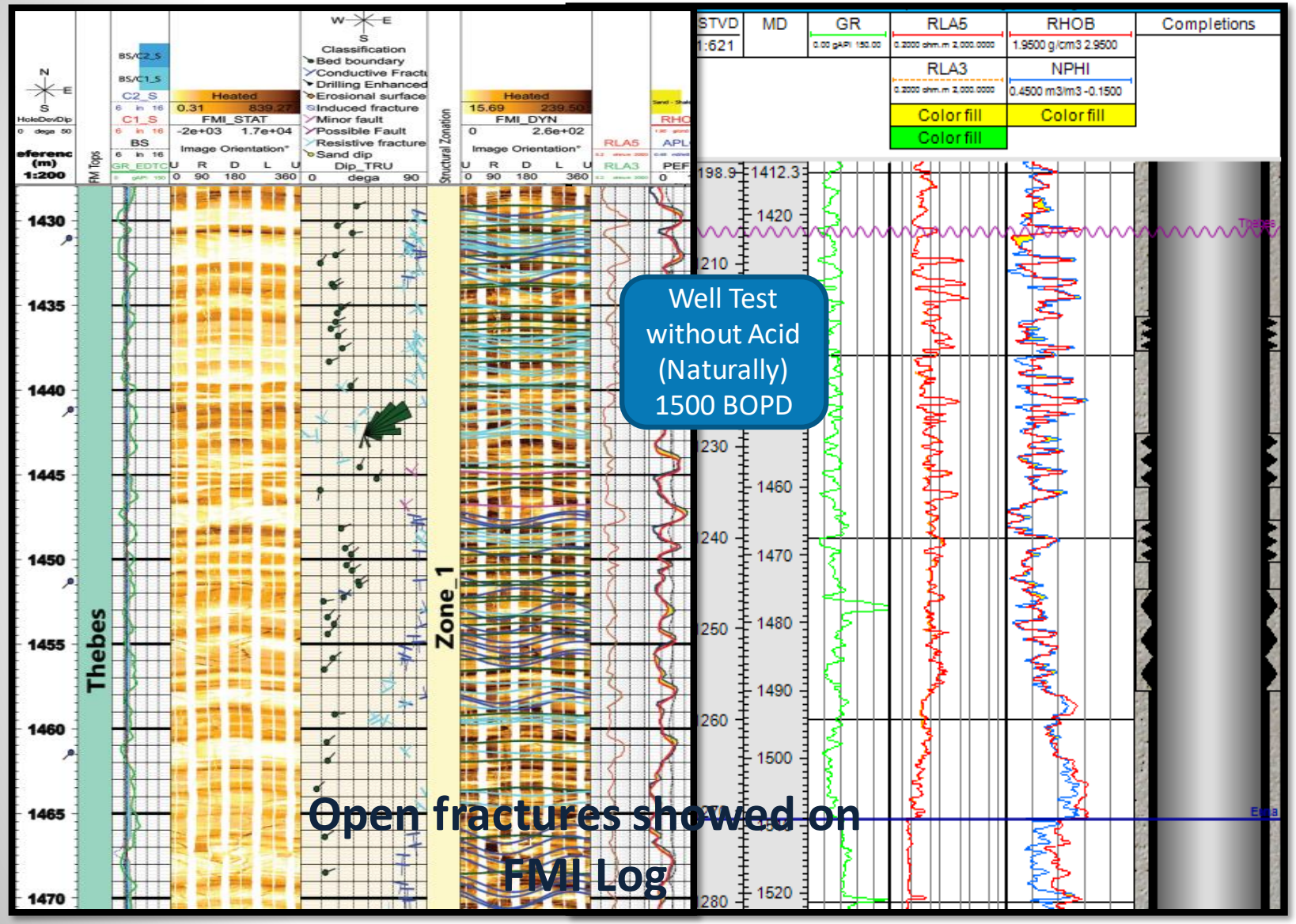
- To evaluate the Remaining Potential in Eocene at N.Bakr Area Bakr -52 was selected to Run PNX and results was very Encouraging . Logs shows minor Gas and high Oil saturation all over the Pay zone , But Masked by Fracture Water Production
- Main Challenge is to Isolate Fractures and stimulate Matrix.



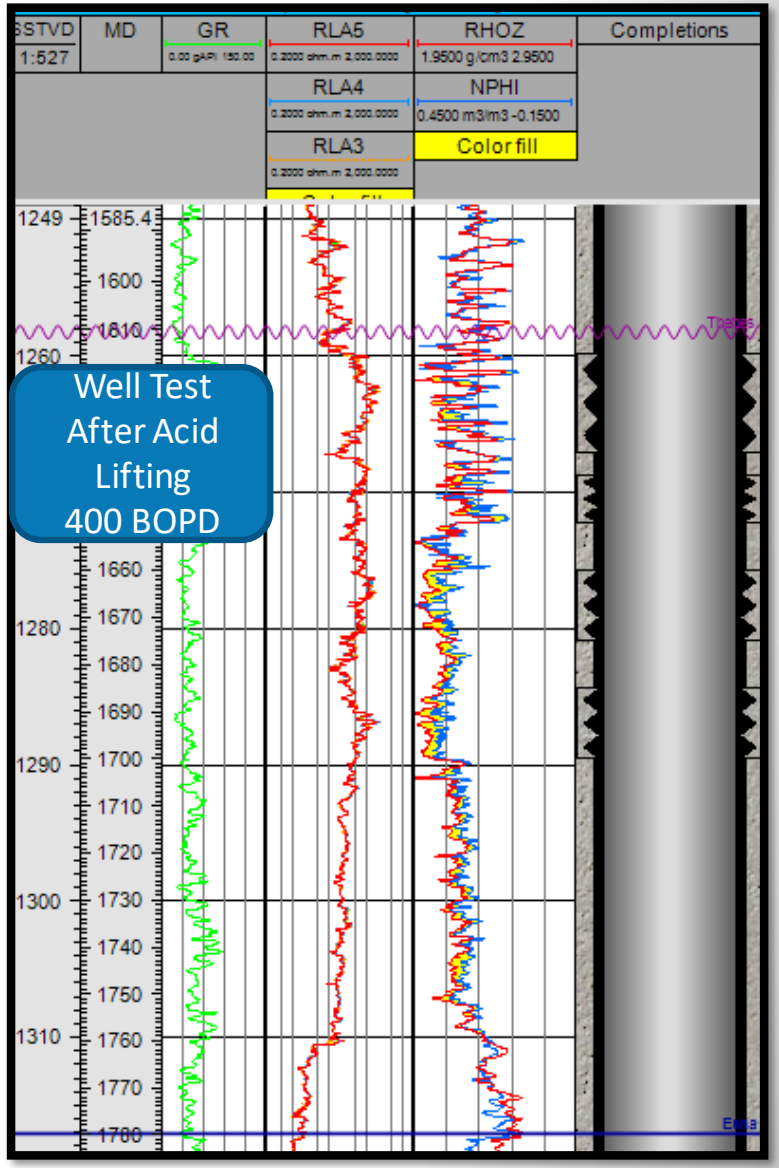
Log for Well Bakr -52

Structure Influence(Case.2-HH Field)

HH-B



HH-C

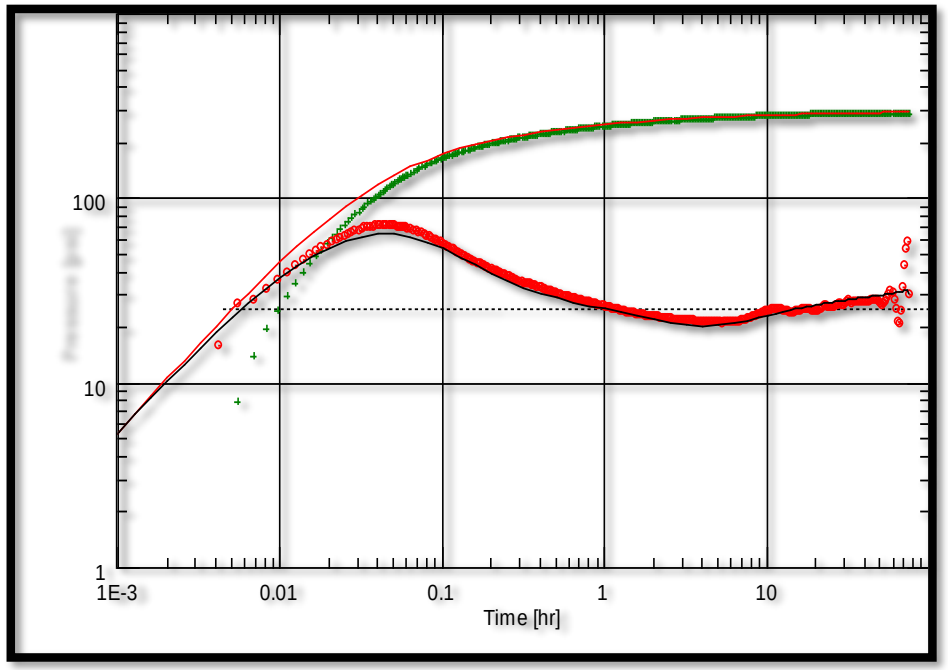


Well test analysis

- well HH 2-B test interpretation confirmed Dual porosity Model.

Reservoir = Two porosity PSS
Boundary = Intersecting faults - Pi/N

Pi = 1832.62 psia
k.h = 14000 md.ft
k = 85.5 md
Omega = 0.742
Lambda = 1.72E-6



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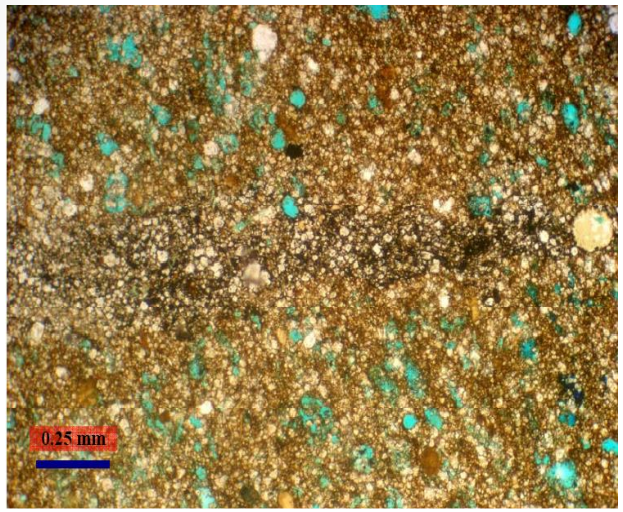
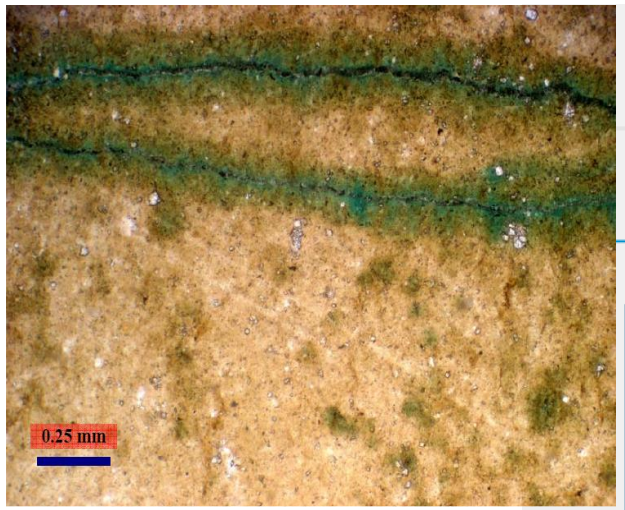
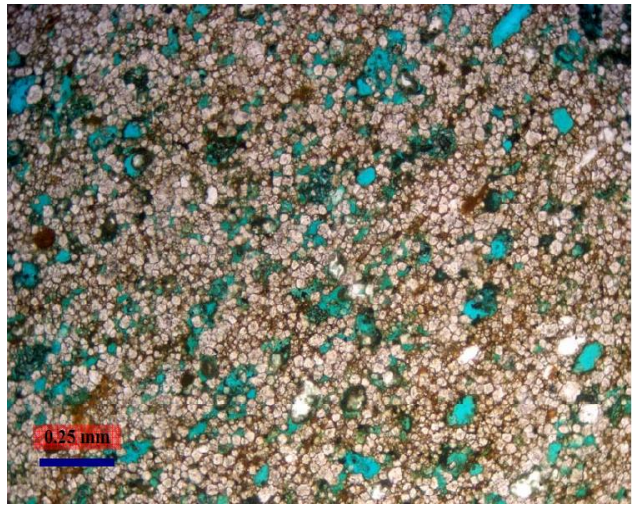
Diagenetic Features & Matrix Porosity (Constructive Diagenesis)



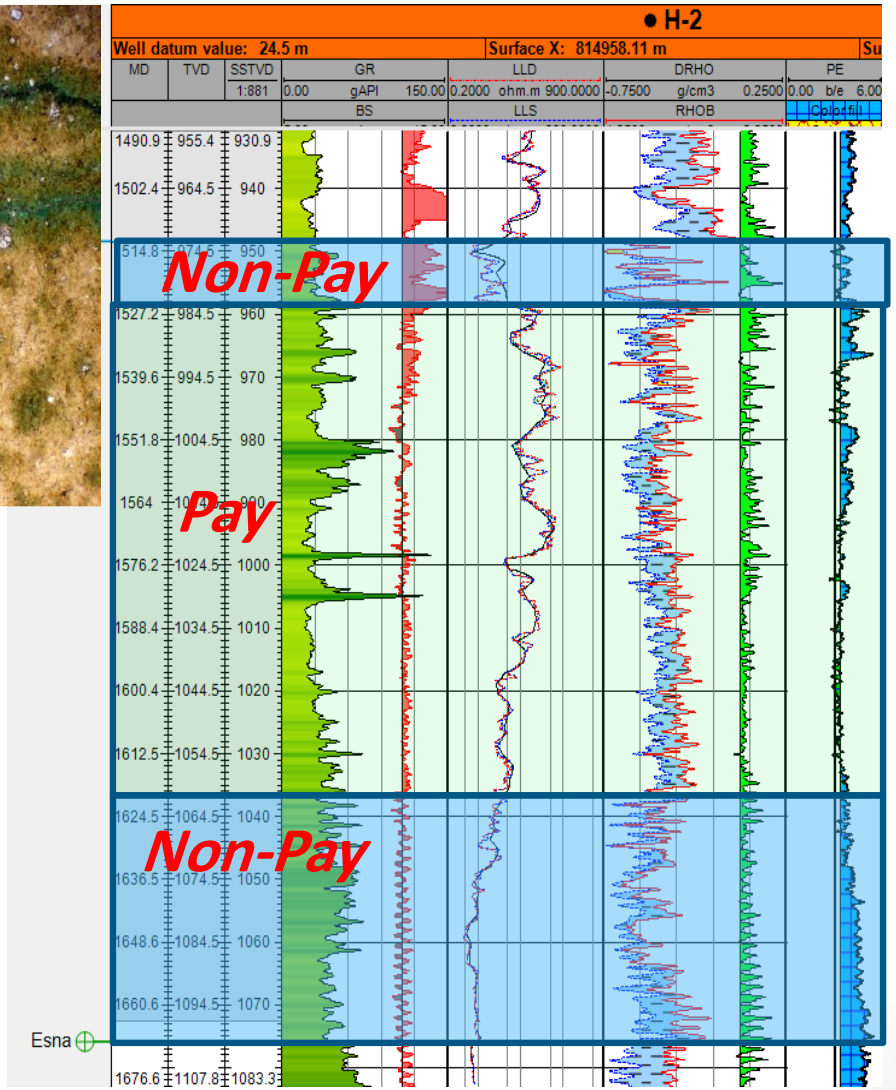
Dolosparite



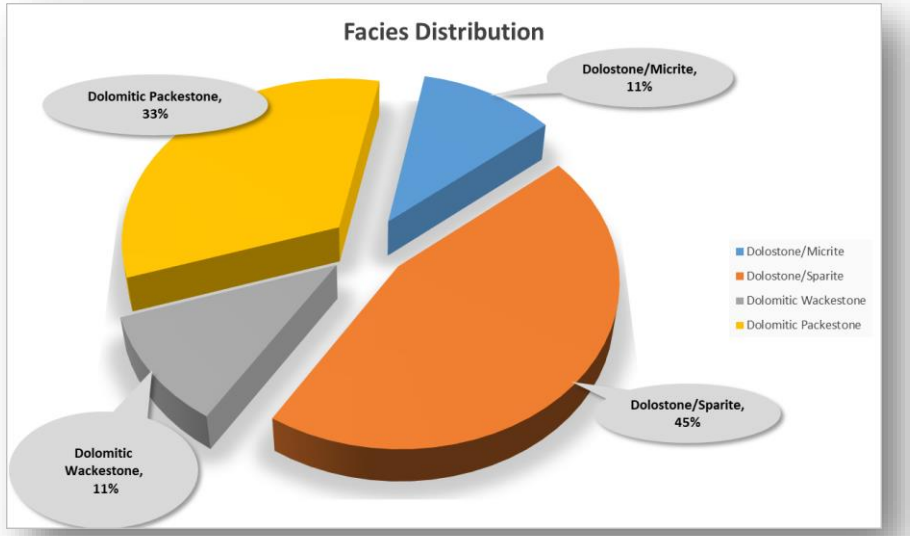
Mudstone

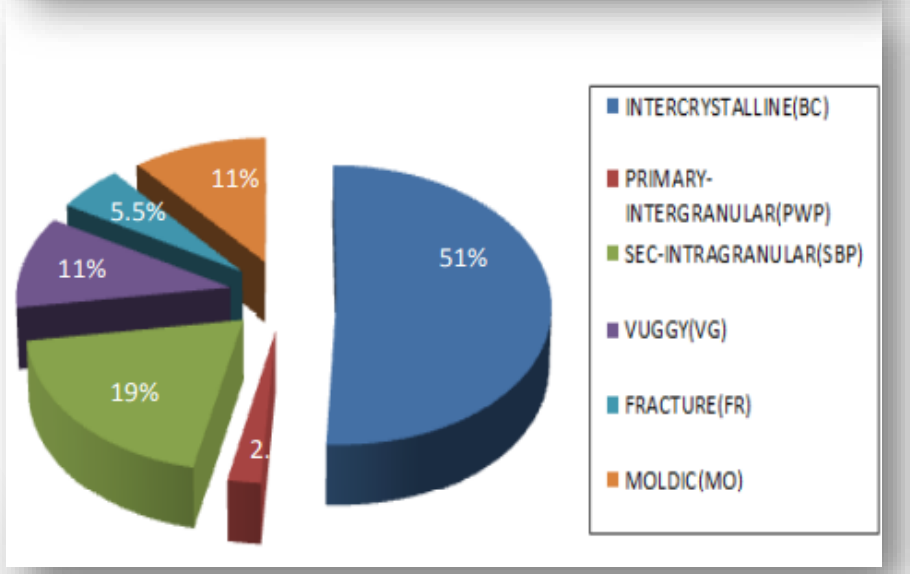


Dolosparite
(Vuggy&Intercrystalline)



Diagenetic Features & Matrix Porosity (Constructive Diagenesis)

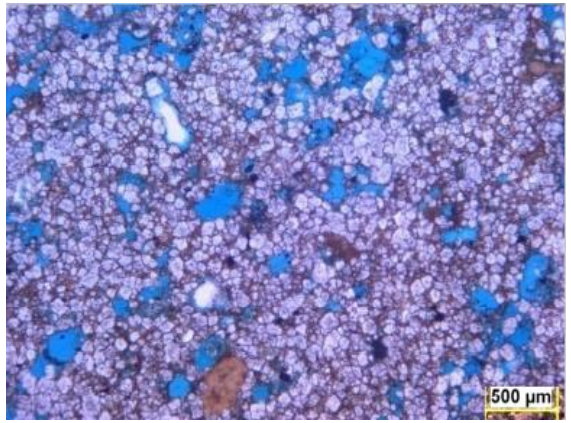




AlHamd-2

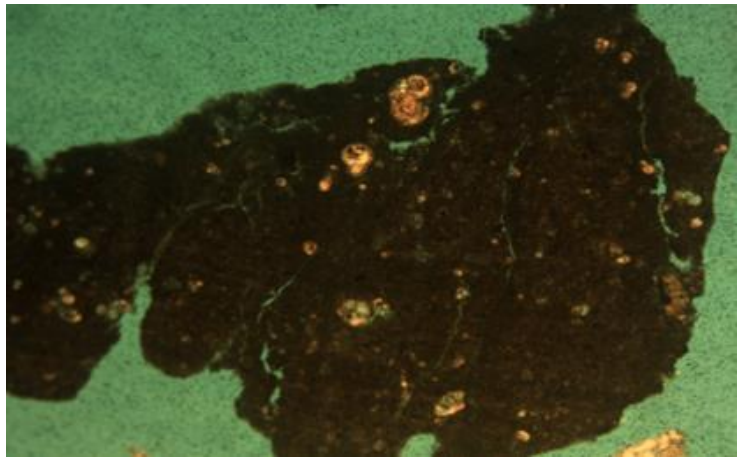
Facies Distribution &Quality

The Well Cum Prod. Over 5 MMSTB

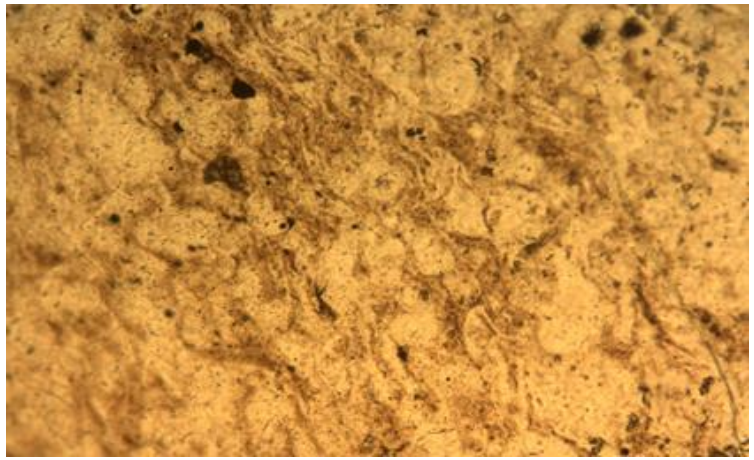


Intercrystalline Porosity=51% of total pores

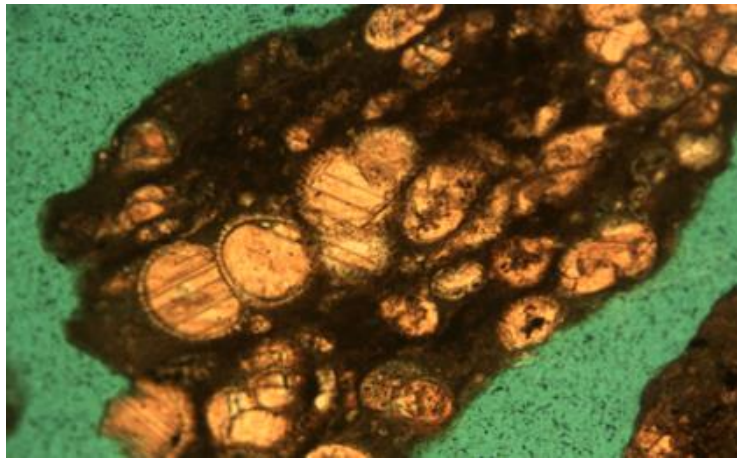
Bakr- N.Amer Facies(Destructive Diagenesis)



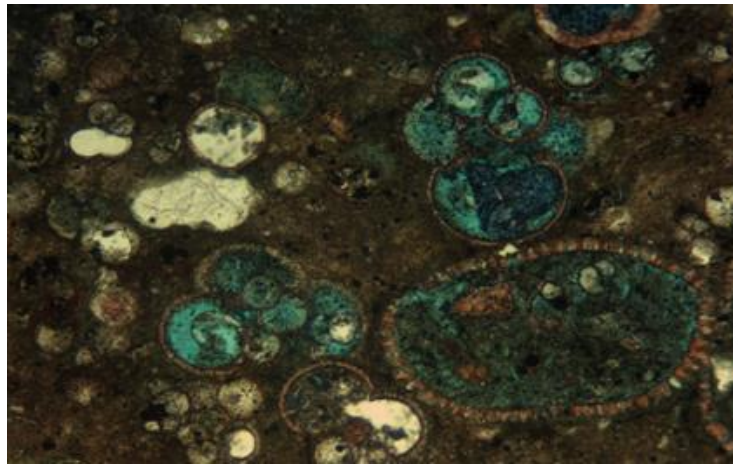
MUDSTONE



CHERTY



PACKSTONE



PACKSTONE

Wackestone-
Packstone Facies

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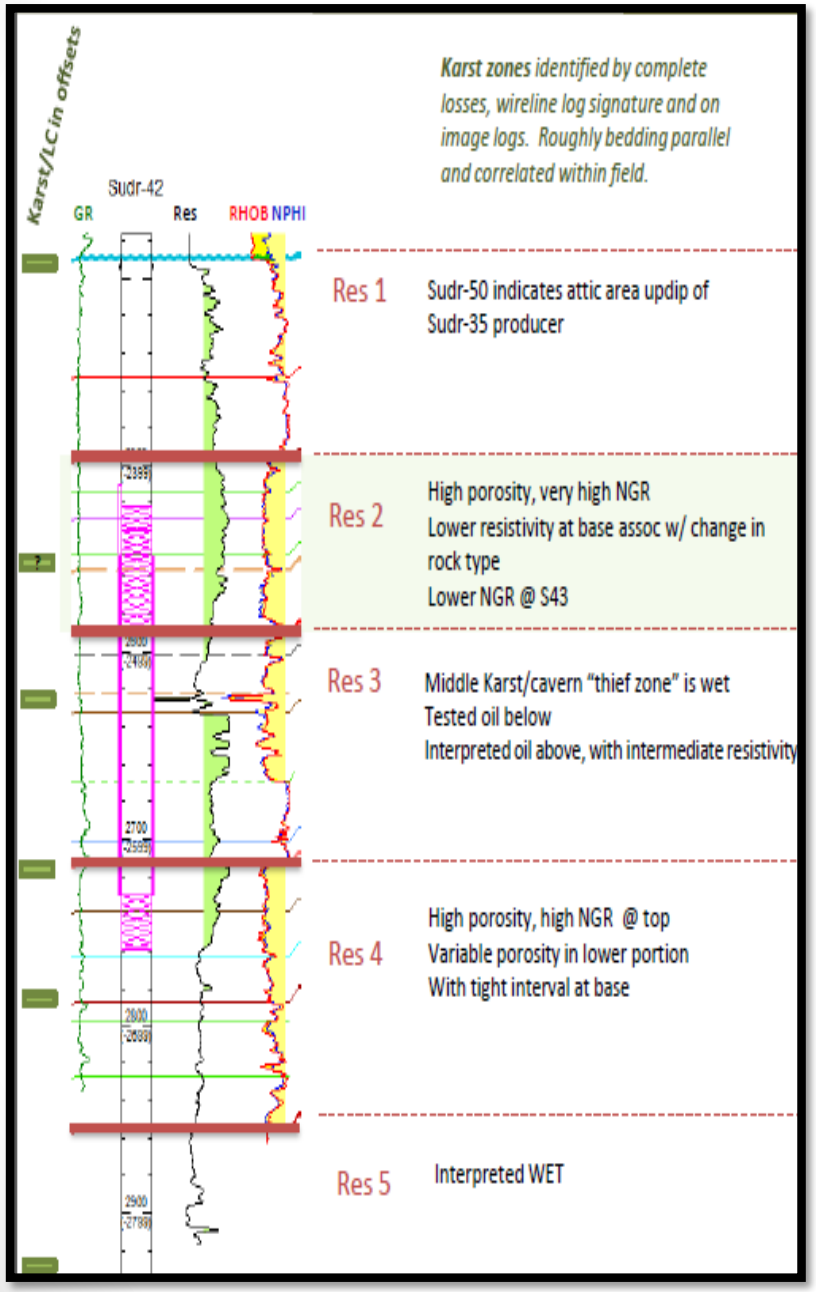
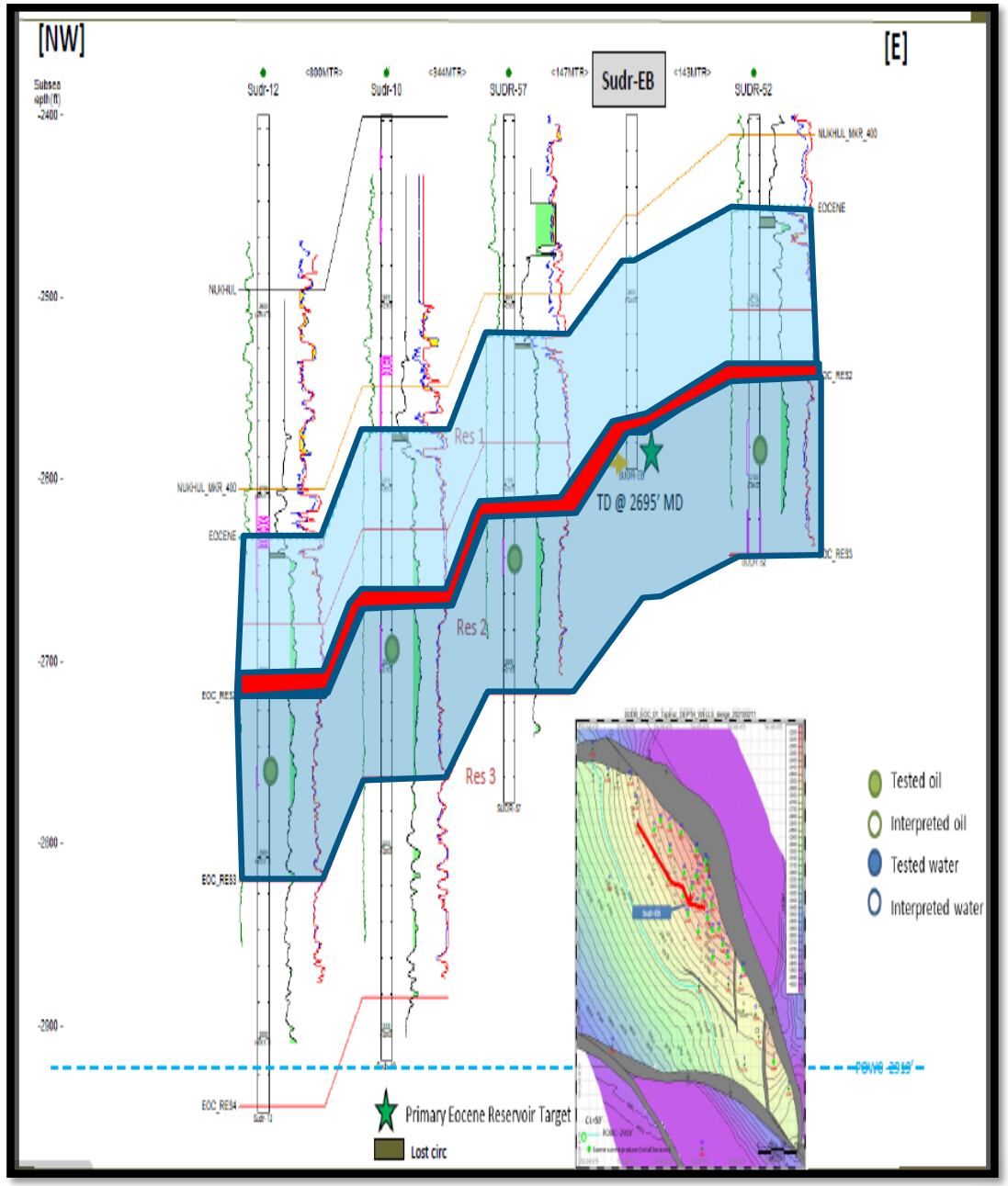
Eocene Subzonation(case.1)

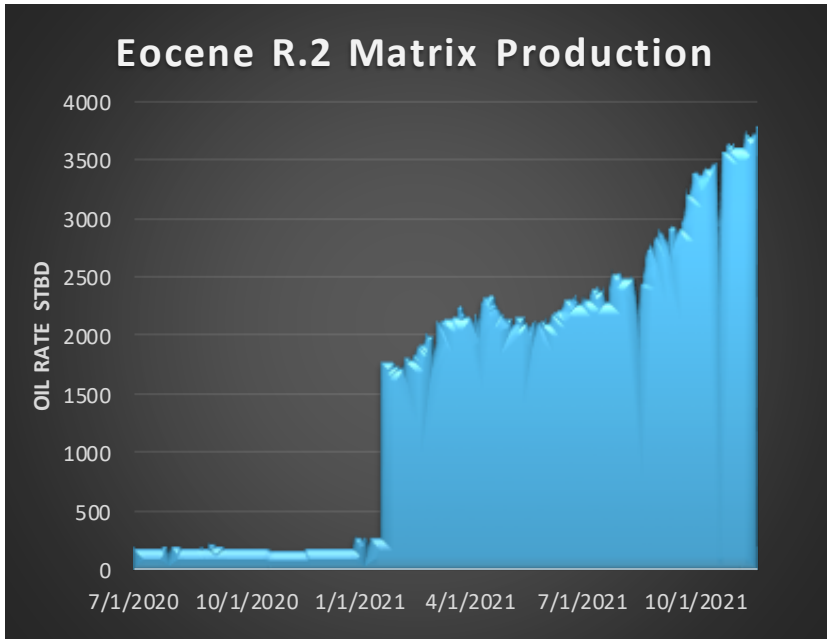


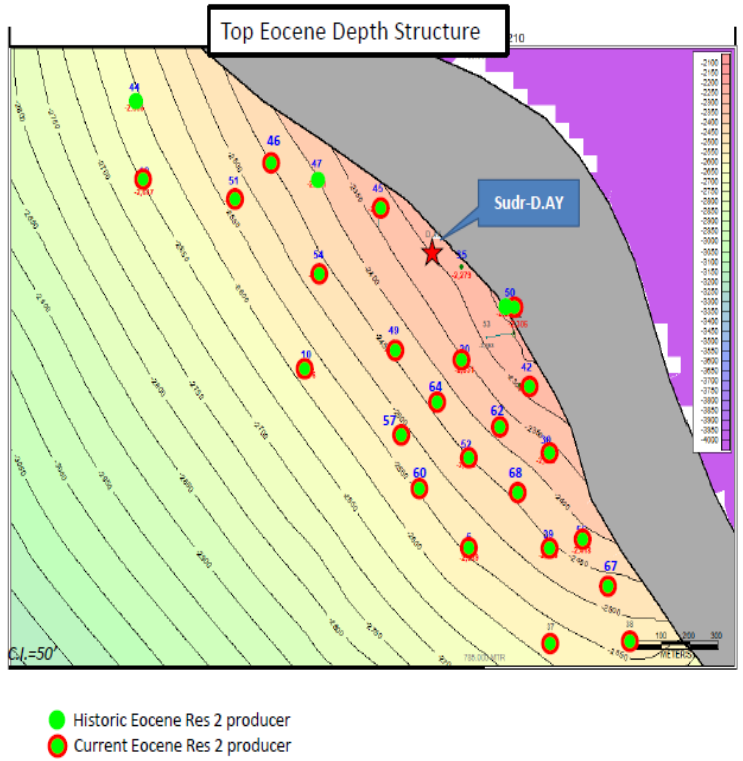


Eocene Subzonation(case.1)

Eocene Zonation Unlocked Potential

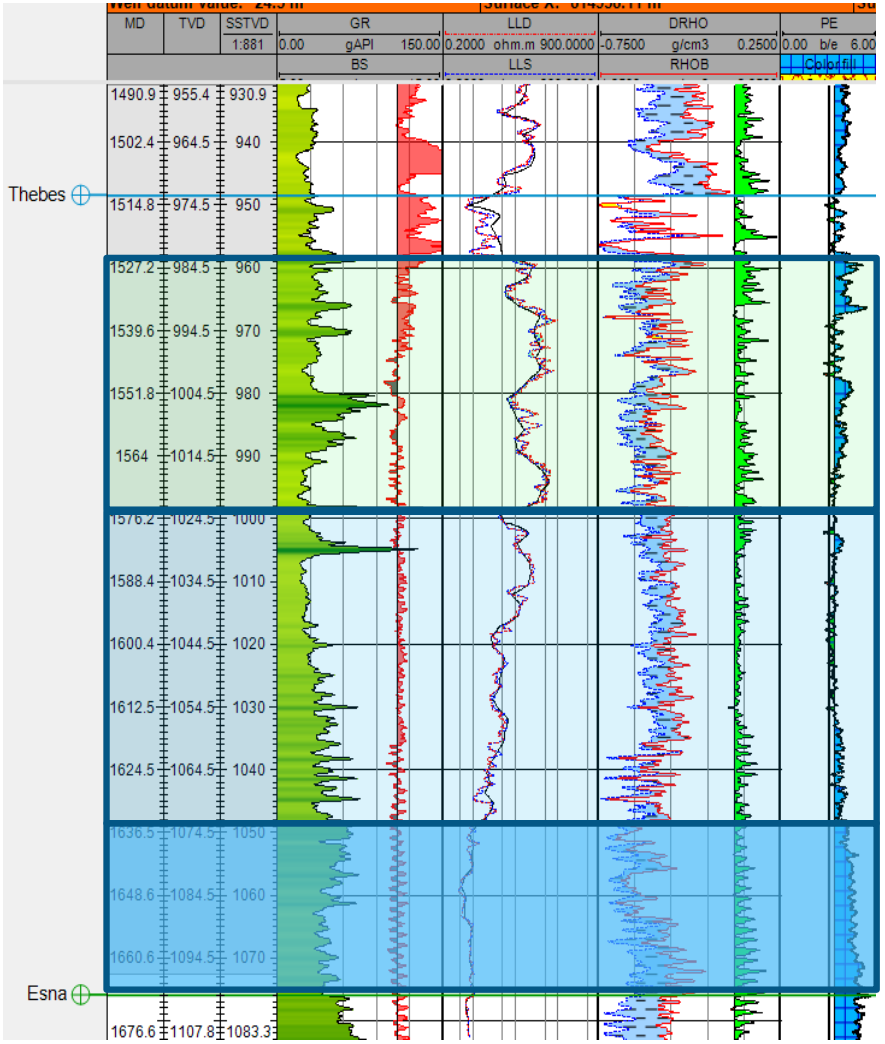
- New logs helped in Eocene Sub-Zonation which was reflected on producing the by-passed potential of lower zones below upper Karst that helped in rapidly increase on Field oil rate from 200 STB/D to around 4000 STB/D just from R.2 Zone.





Eocene Subzonation(case.2)

Old interpretation



Oil Zone

Transition Zone

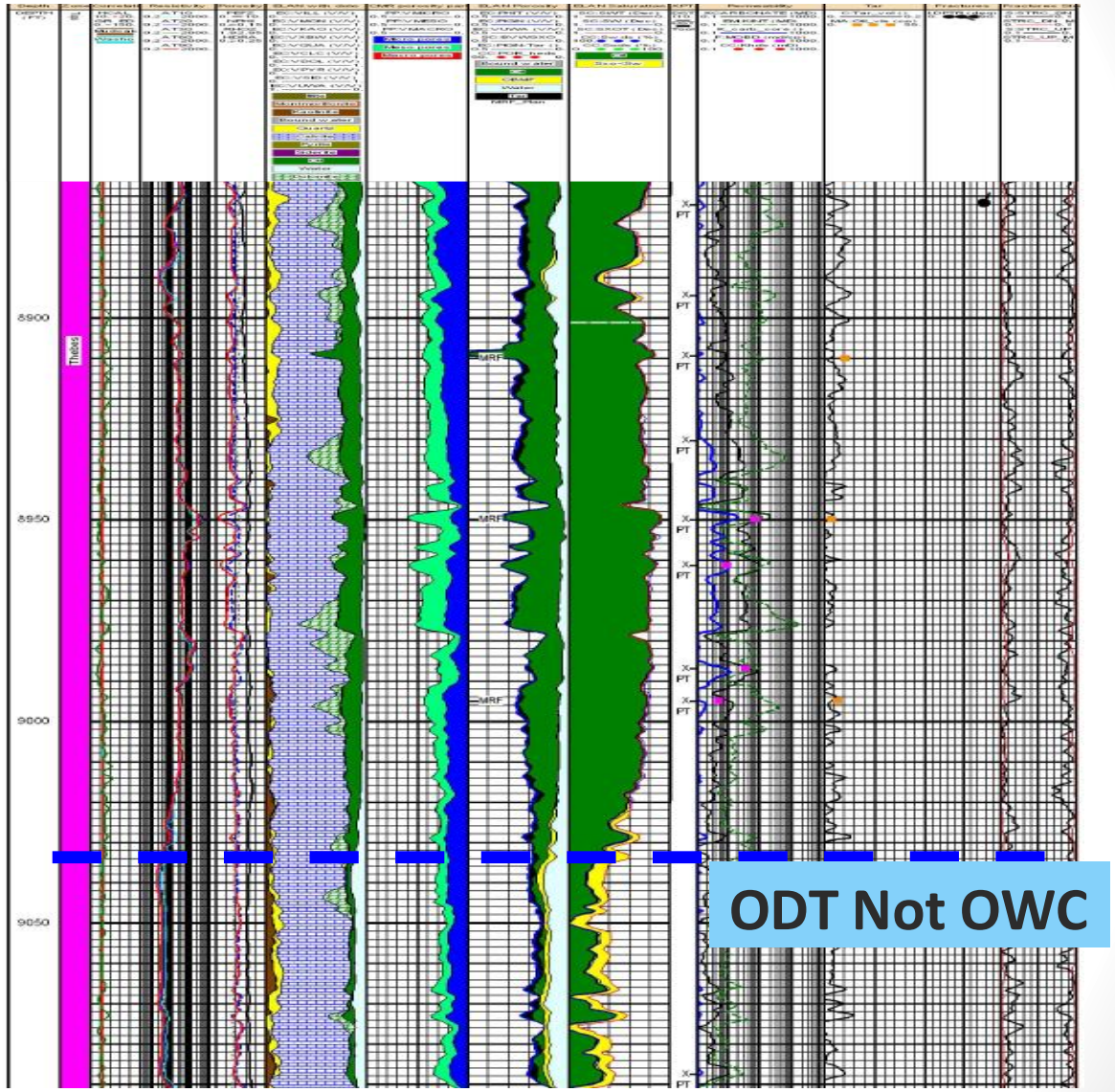
Water Zone

Eocene Subzonation(case.2)
(Affecting OWC)

- Due to heterogeneity & different rock types encountered in Eocene , We **can`t** relay on **resistivity log** to detect OWC level However **NMR** will differentiate between interstitial water and free water.

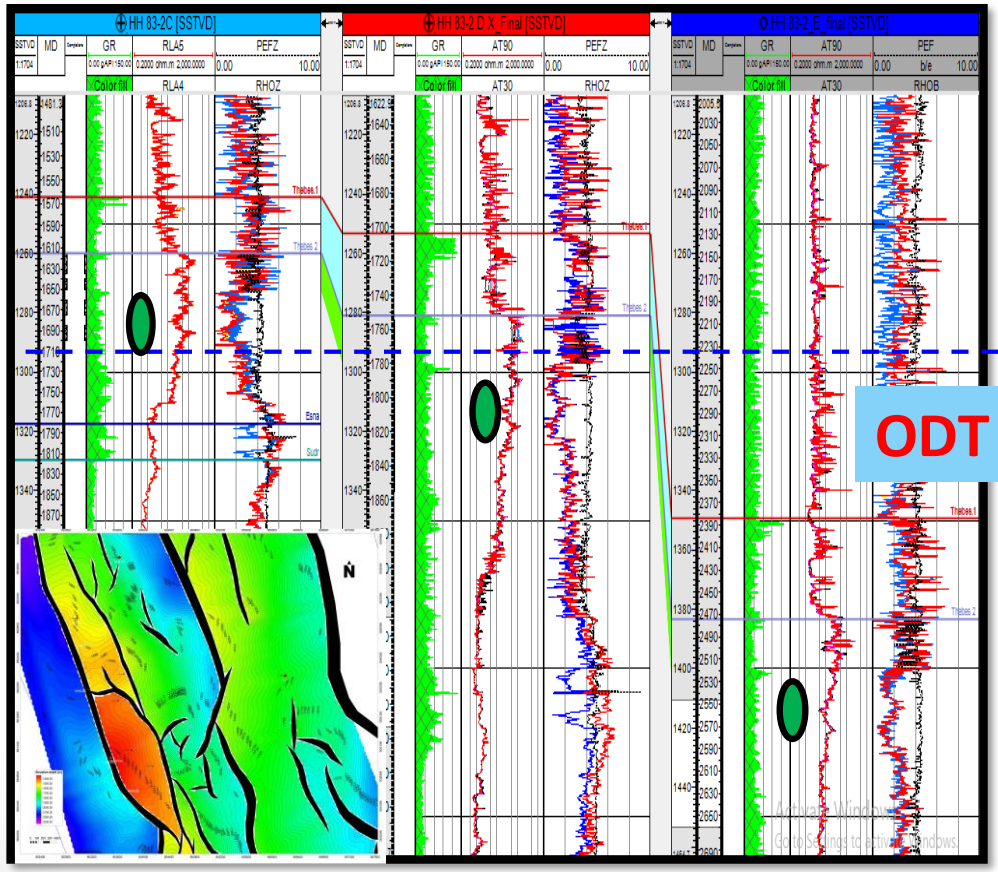
- NMR in NOW-2 well confirmed smaller pore size against low resistive zone.

- Deeper OWC had a great impact on OOIP calculation, drilling plan and economics.

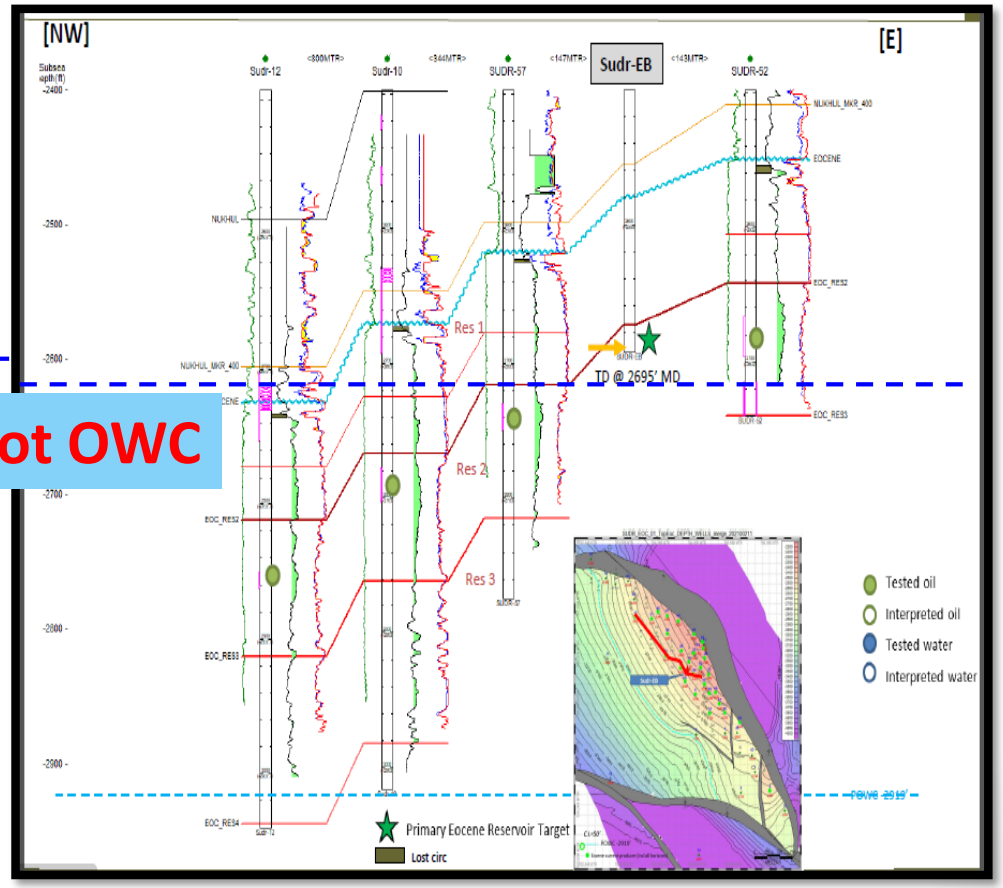


Eocene Subzonation(case.2)
(Affecting OWC)

- As We step down with dip or even Downthrown side, same log character which proves the Low- resistive zone is due to facies not Fluid effect that leads to deeper OWC & higher OOIP.



ODT Not OWC



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Well HH 2DX (case.1)

❖ Challenges

- Low solubility due to presence of Quartz in Eocene FM that leads to Low Solubility &shallower wormholes.
- Perform Stimulation Job across the Sweet Spots in the open hole interval, utilizing Self Positioning Tool (SPT)/ Pin Point technique in order to bypass damaged Zone.

Rate before SPT	After SPT
+/- 100 STB "intermittent"	400 STB

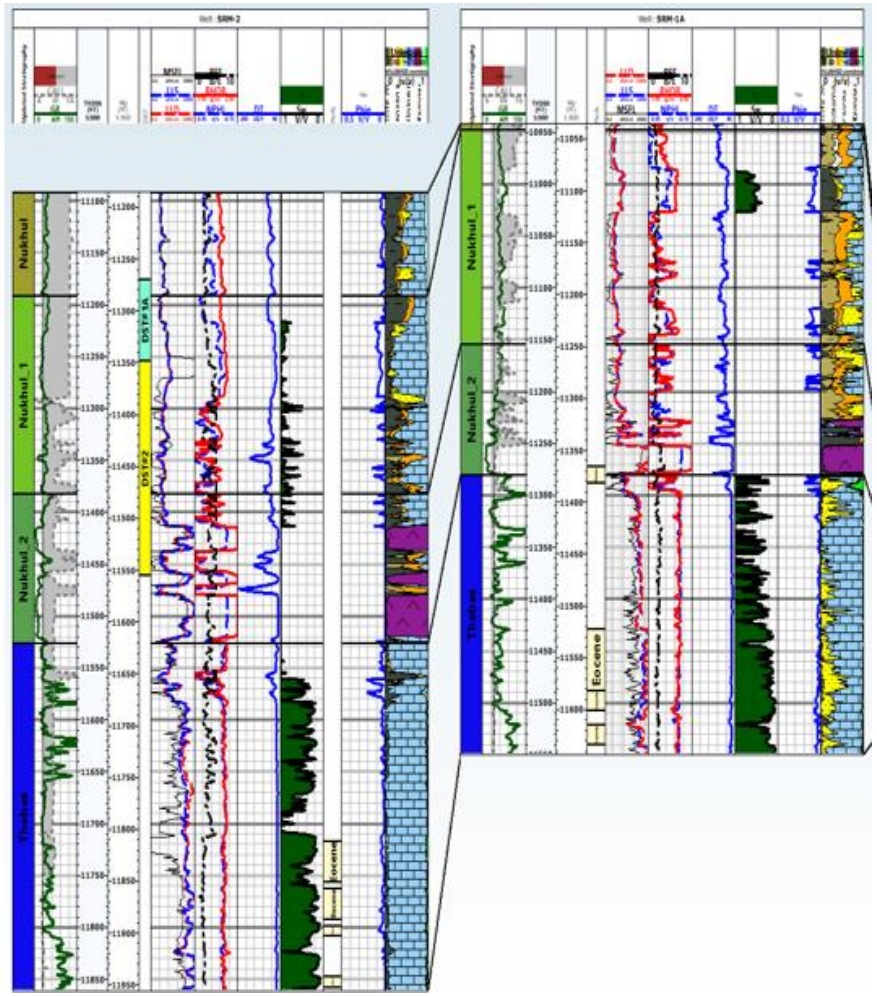
Solubility test results

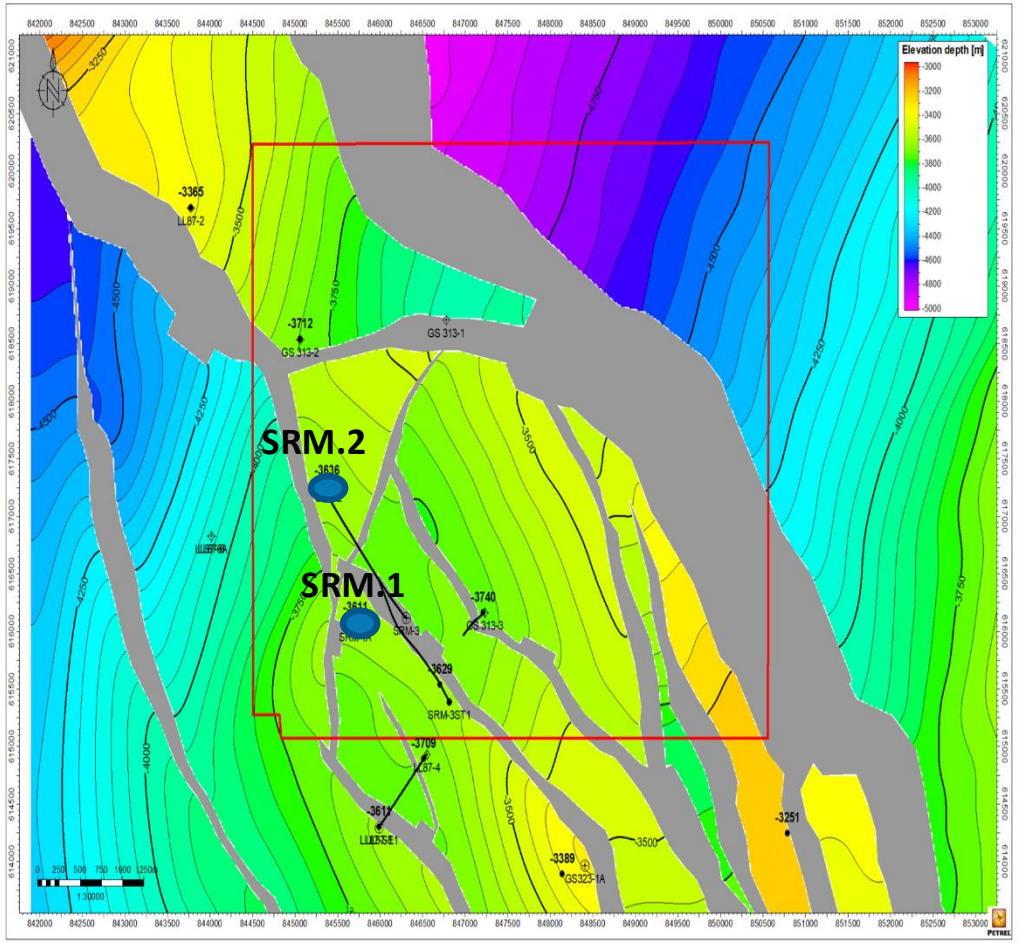
Sample	15% HCL	20% HCL
1	66.5	68
2	55	56.5
3	55.5	56.42
4	72	73

- ***XRD RESULTS FOR BULK ANALYSIS***

	Depth meter/feet		Framework Silicate			Total Clay	Carbonate				Other Minerals Grourps			Total
Well /Formation	Top Depth	Bottom Depth	Quartz %	Plagioclase %	K-feldspar %	Total Clay %	Calcite %	Dolomite %	Dolomite (Fe/Ca) %	Siderite %	Apatite %	Total Pyrite % (Mar+Pyr)	Barite %	Total %
HH83-2D/NA	1702.00 m	1750.00 m	32.6	0.0	0.0	2.5	59.0	2.7	0.2	0.7	1.0	0.7	0.6	100.00
HH83-2D/NA	1750.00 m	1775.00 m	51.6	0.0	0.0	3.0	39.2	3.6	0.3	0.4	0.7	0.7	0.5	100.00
HH83-2D/NA	1775.00 m	1825.00 m	55.8	0.0	0.0	2.6	36.3	2.8	0.3	0.3	0.6	0.7	0.6	100.00
HH83-2D/NA	1825.00 m	1852.00 m	37.7	0.0	0.0	4.1	51.7	4.2	0.4	0.3	0.3	0.8	0.6	100.00

South Ramadan (Case .2)





Structure Map on top PreMiocene

South Ramadan (Case .2)

- ***Tight Reservoir needed Acid break stage & WHP during Acid up to 2700 psi.***
- ***Deep well hence High Temp which affects Formation Solubility.***
- ***Perform a successful Stimulation Job across the intervals, utilizing SLB SXE Recipe in order to overcome High Temp. Zone and Create Deeper wormholes.***

❑ Results ***After Acid.***

Net BOPD	W.C.%	WHP, psi
1800	0.2	1200

Summary

- Many **diagenetic features** were detected in Eocene all over GPC fields like :-
  - ✓ **Subaerial Exposure** "Karst" in Sudr and Asl.
  - ✓ **Fractures** in Bakr, Amer and North Amer fields.
  - ✓ **Dolomitization** in Al Hamd oil field.

- Each feature has its own impact on production and optimum technique in **completion** and **stimulation**.

THANK YOU!