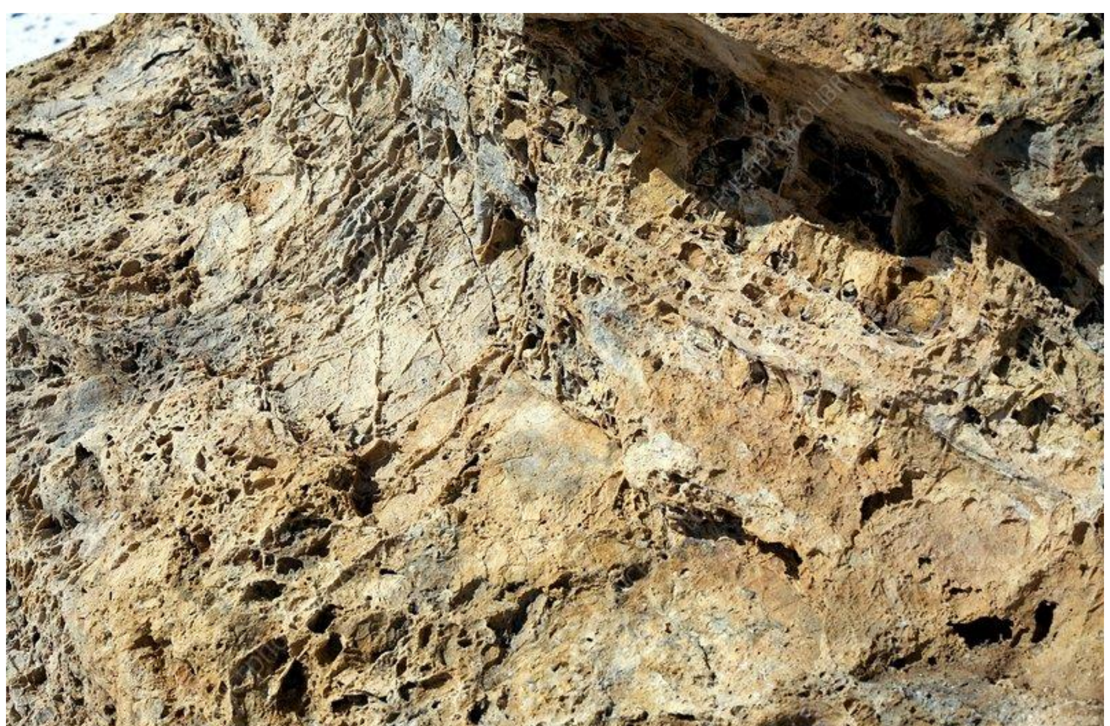
Miocene Carbonate reservoirs in Gulf of Suez

Distribution, Architecture and Reservoir Characterization

Geo./ Tamer Remaly

Eng./ Amr Hegazy

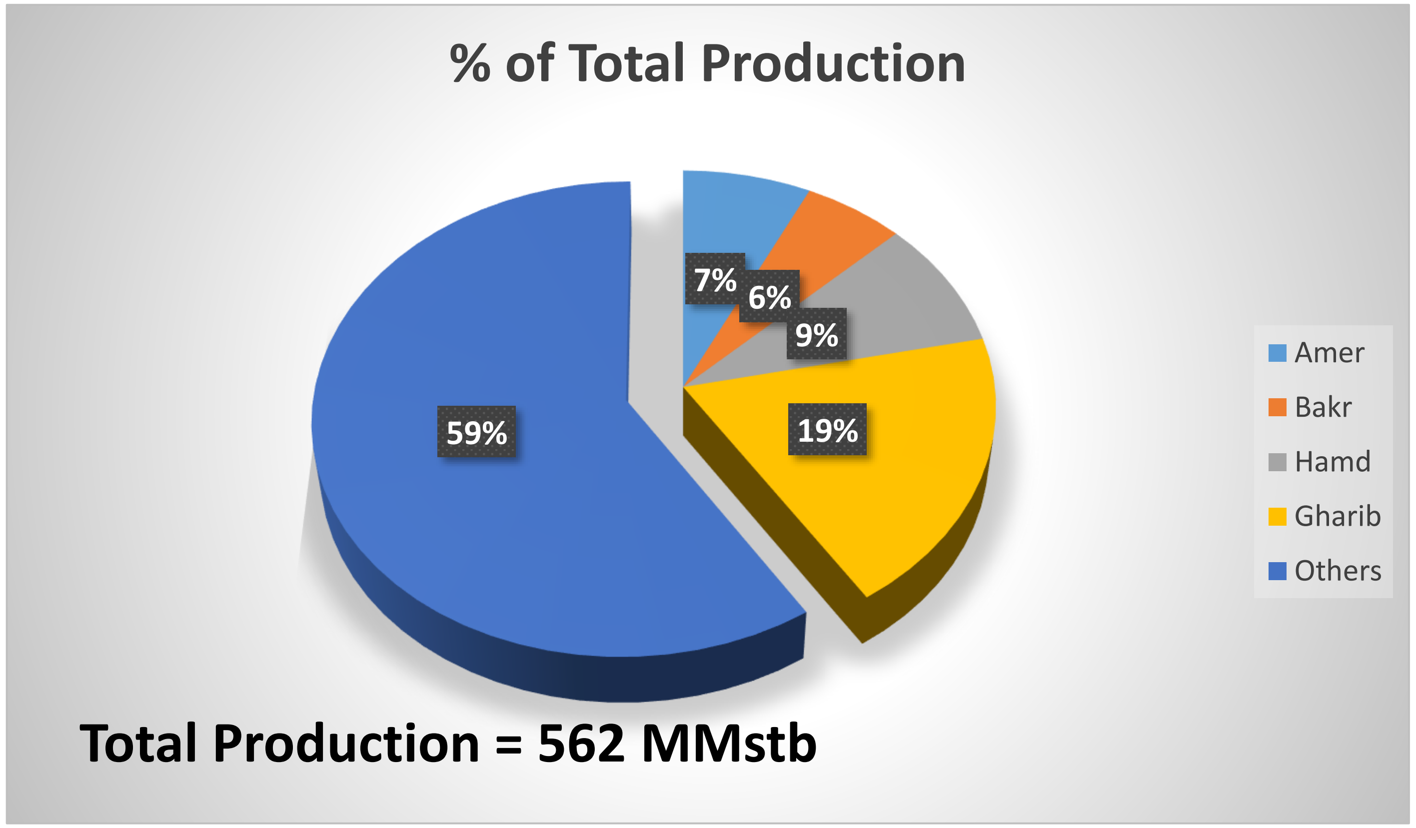


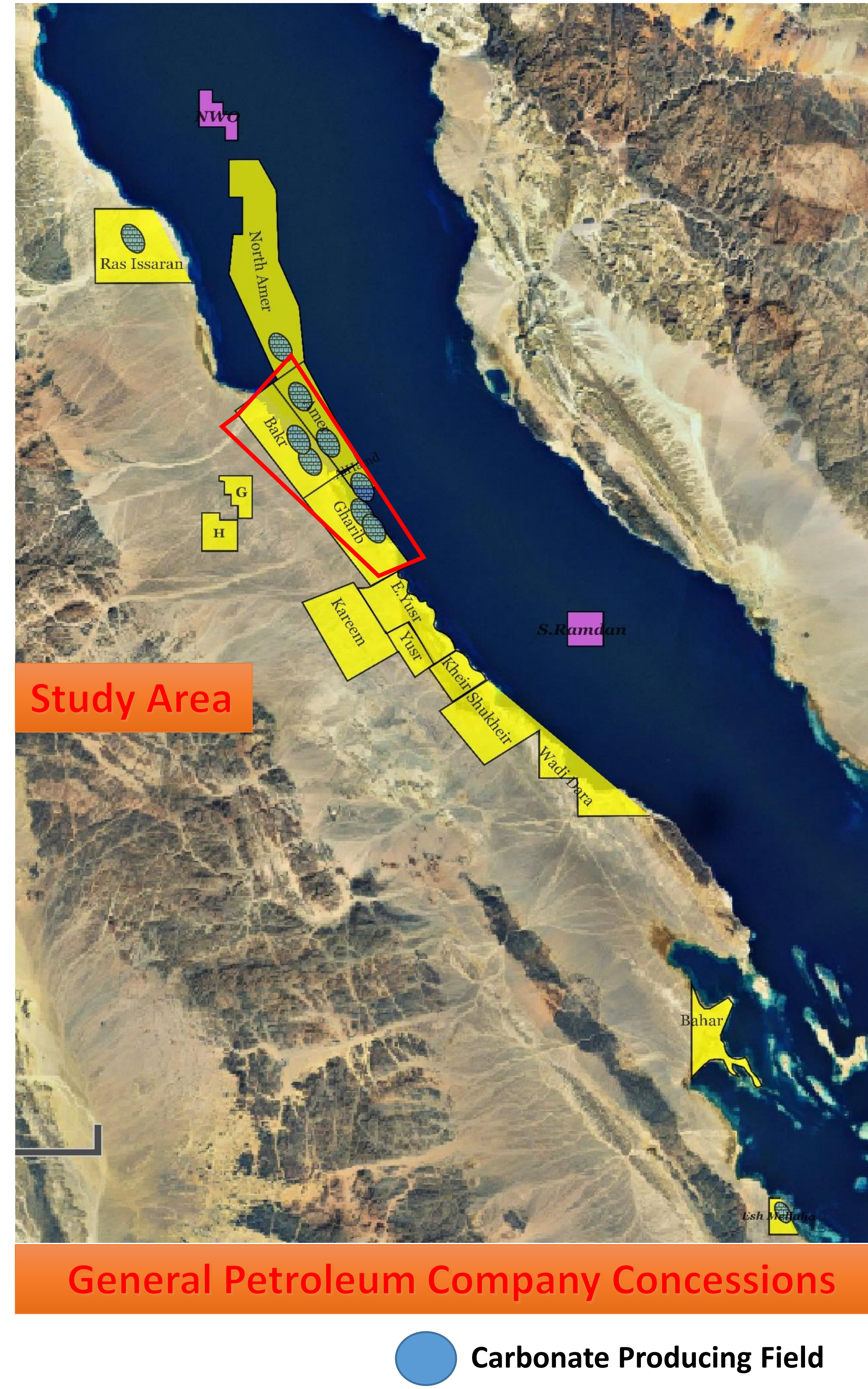
AGENDA

- Introduction
- Seismic & Structure Overview
- Stratigraphic Model
- Petrophysical Evaluation
- Diagenesis Impact
- Integrated Workflow for reservoir characterization
- Summary & Conclusion

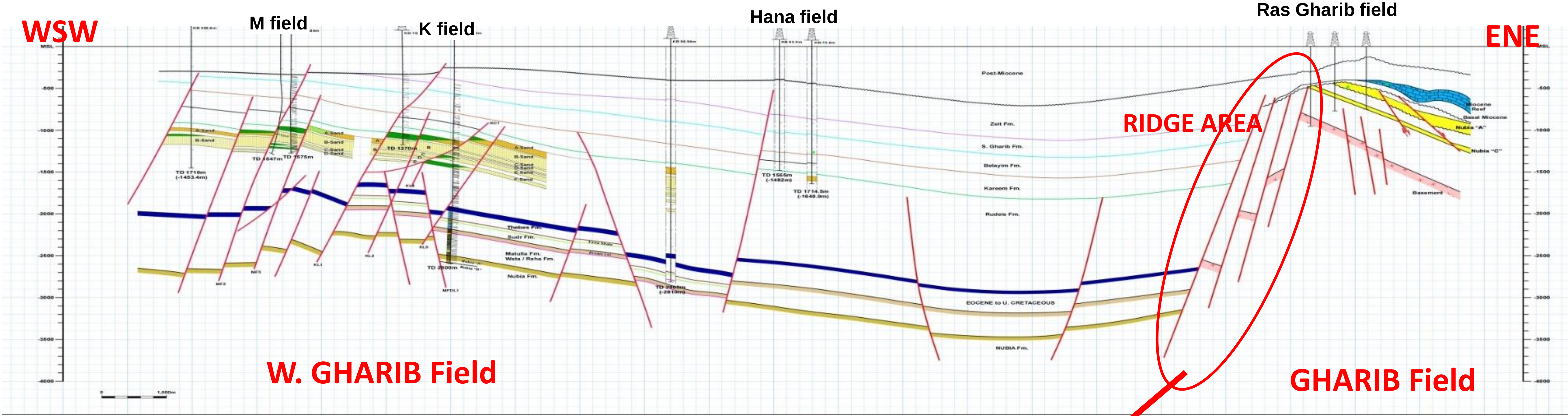
INTRODUCTION

- This case study represents **MIOCENE CARBONATE RESERVOIRS** in the central province of Gulf of Suez



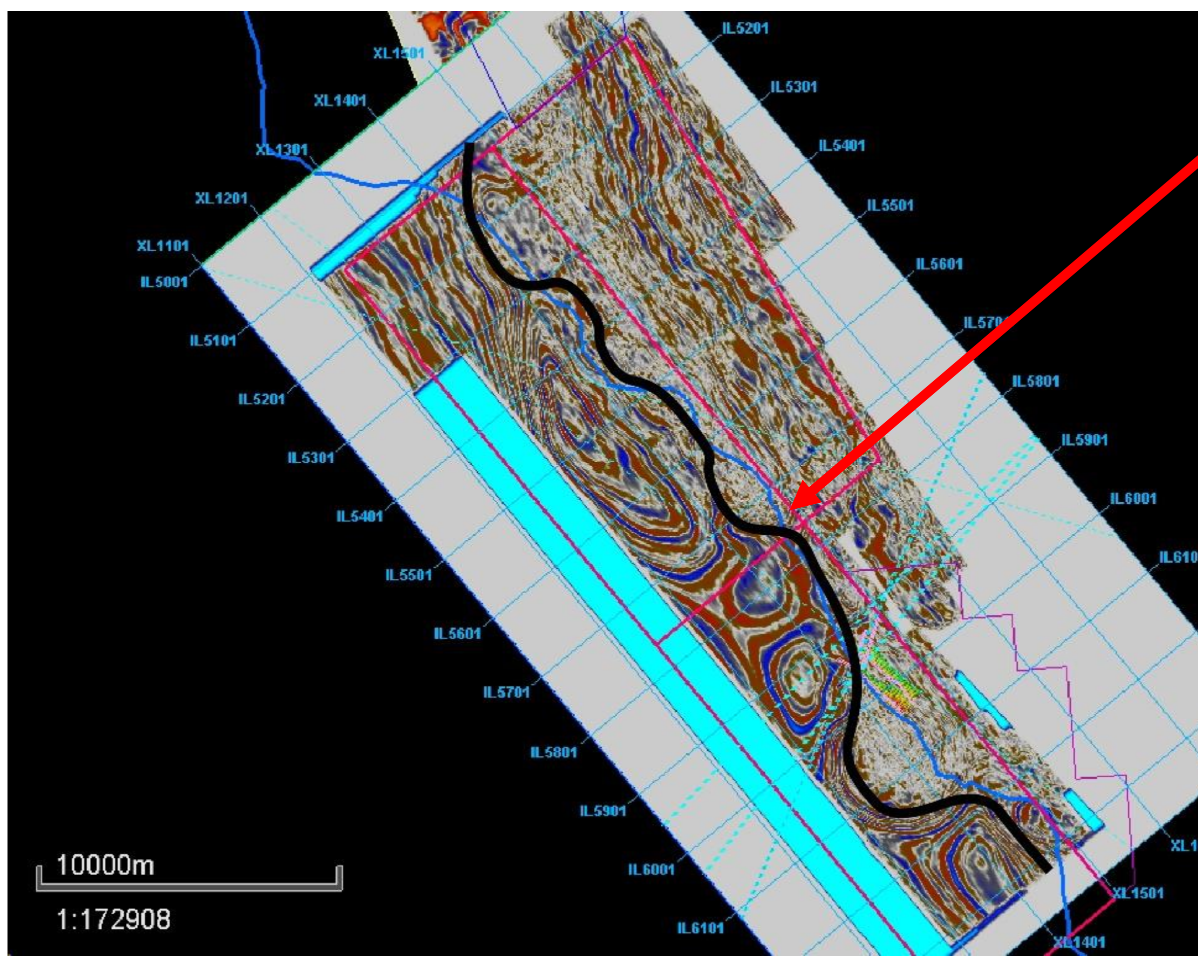


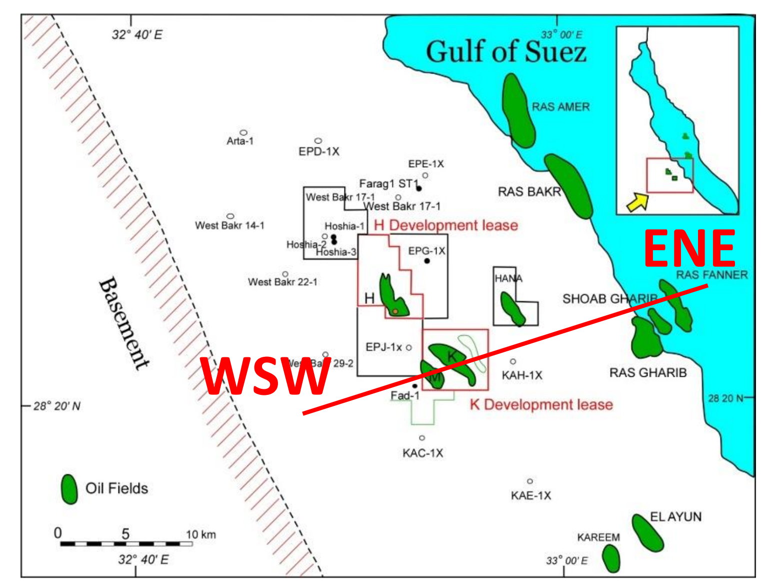
Seismic & Structure Overview

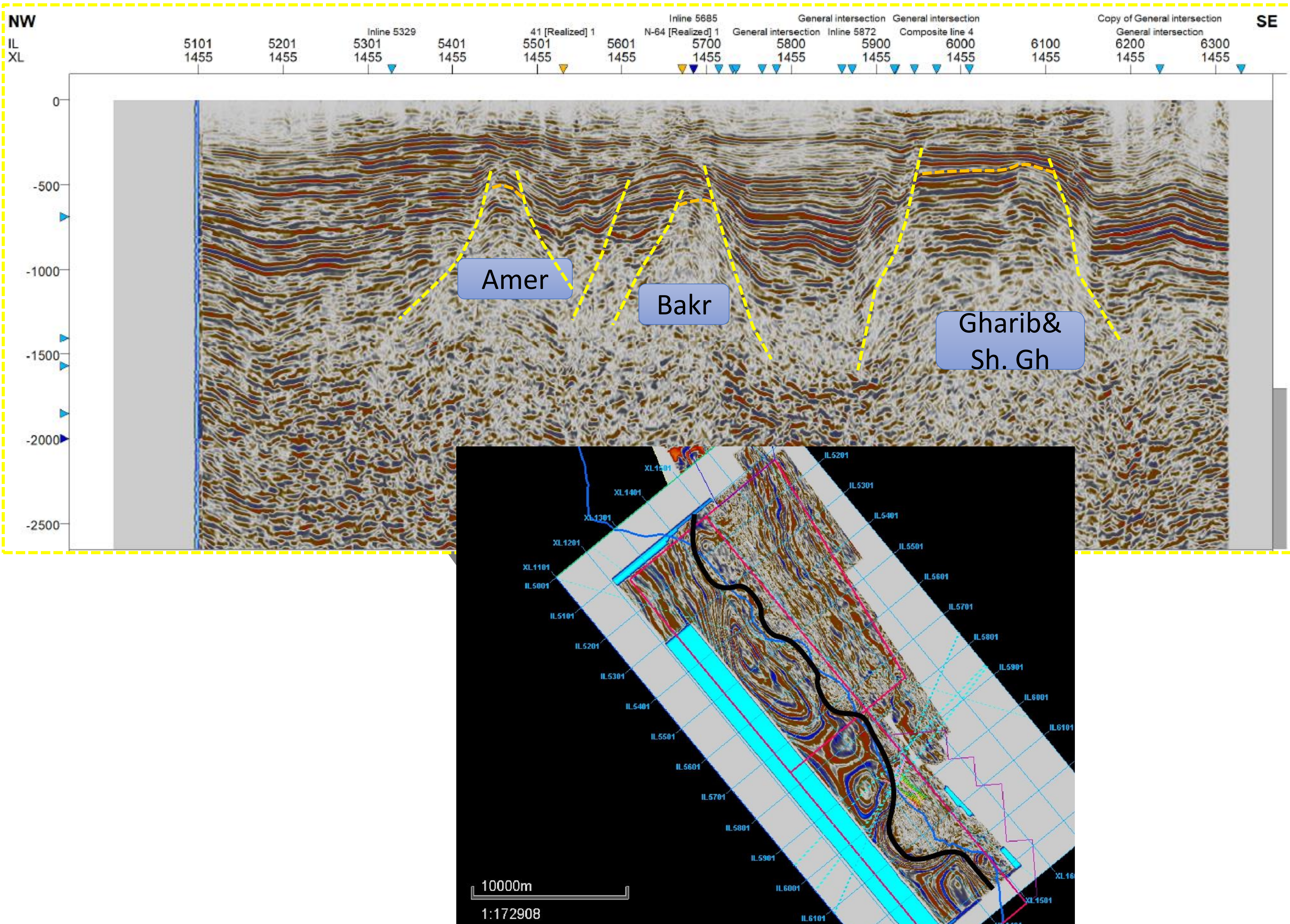


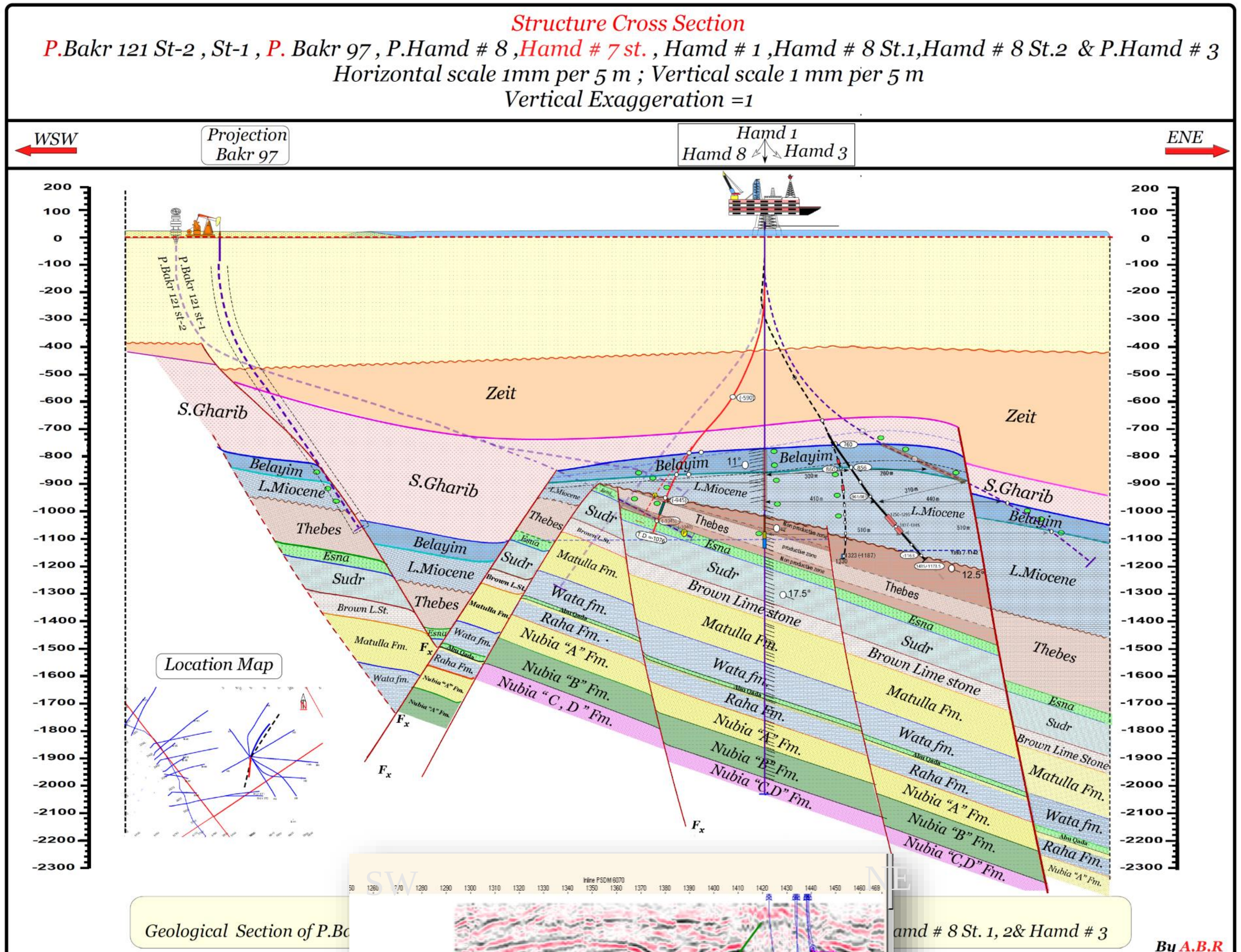
Main Fault

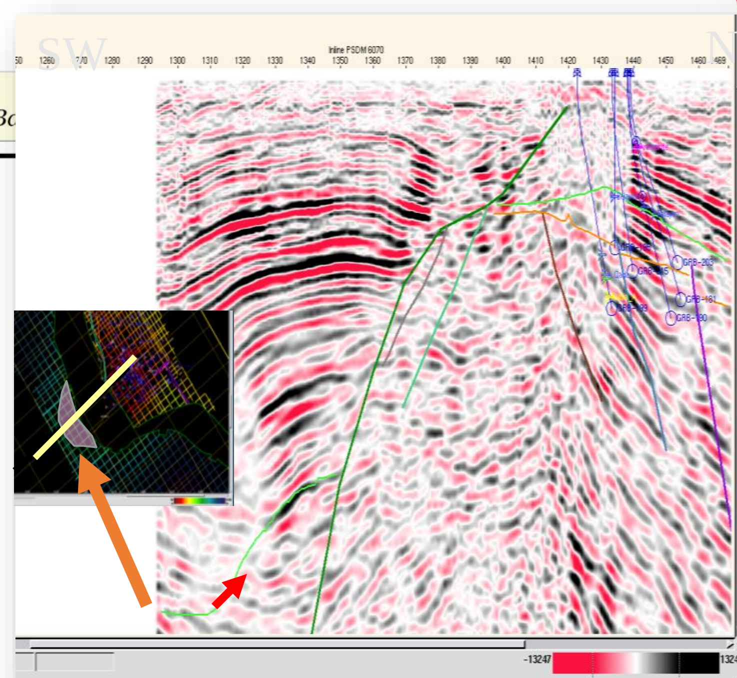
SW NE

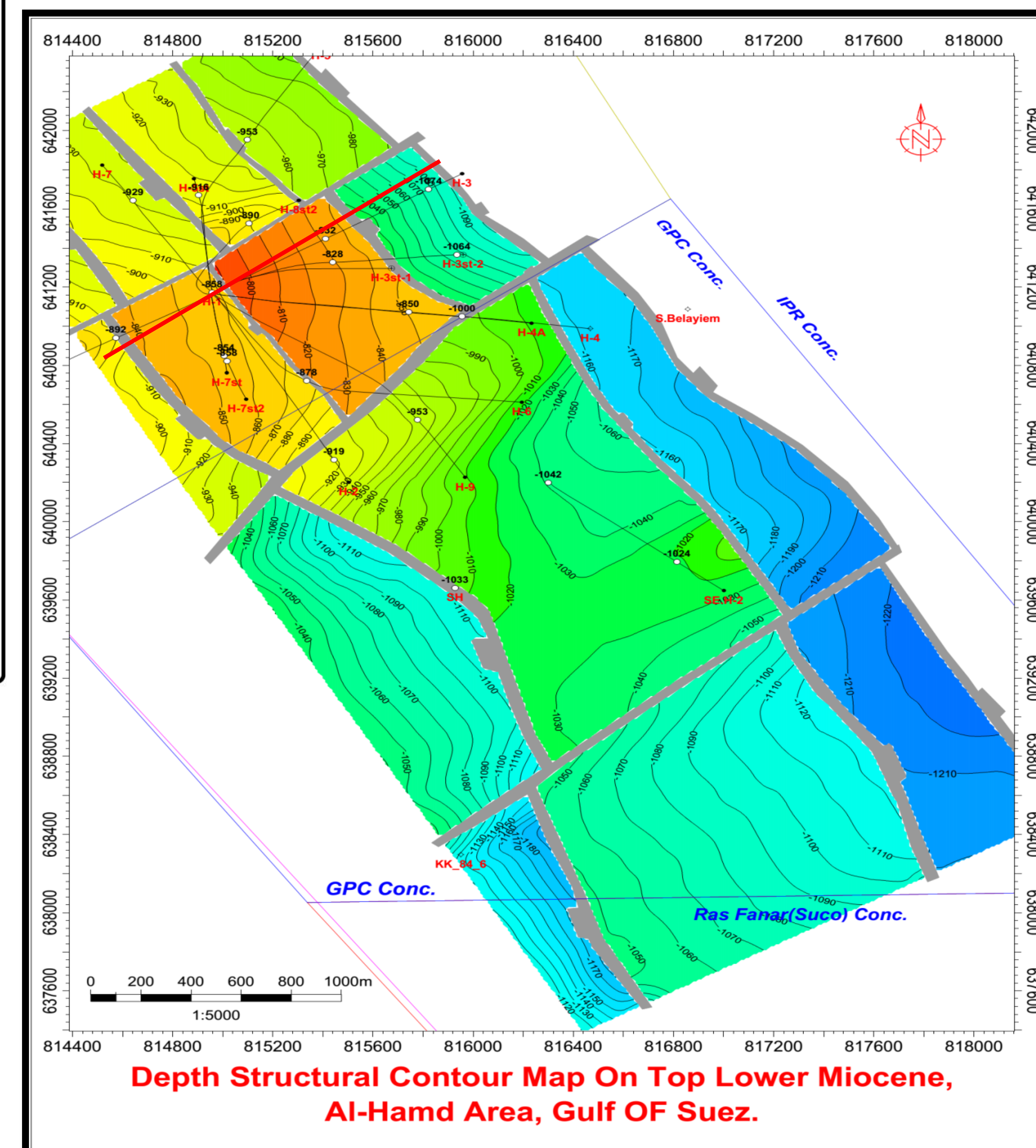





NW
SE
IL
XL
Inline 5329
41 [Realized] 1
Inline 5685
N-64 [Realized] 1
General intersection
General intersection
General intersection
Inline 5872
Composite line 4
Copy of General intersection
General intersection
5101 1455
5201 1455
5301 1455
5401 1455
5501 1455
5601 1455
5700 1455
5800 1455
5900 1455
6000 1455
6100 1455
6200 1455
6300 1455
0
-500
-1000
-1500
-2000
-2500
Amer
Bakr
Gharib&
Sh. Gh
10000m
1:172908


Structure Cross Section
P.Bakr 121 St-2 , St-1 , P. Bakr 97 , P.Hamd # 8 ,Hamd # 7 st. , Hamd # 1 ,Hamd # 8 St.1,Hamd # 8 St.2 & P.Hamd # 3
Horizontal scale 1mm per 5 m ; Vertical scale 1 mm per 5 m
Vertical Exaggeration =1
WSW
Projection Bakr 97
Hamd 1
Hamd 8
Hamd 3
ENE
P.Bakr 121 st-1
P.Bakr 121 st-2
Zeit
S.Gharib
Belayim
L.Miocene
Thebes
Esna
Sudr
Brown L.St.
Matulla Fm.
Wata fm.
Raha Fm.
Nubia "A" Fm.
Nubia "B" Fm.
Nubia "C, D" Fm.
Brown Lime stone
Location Map
Fx
Geological Section of P.Ba
amd # 8 St. 1, 2& Hamd # 3
By A.B.R


SW
NE


814400
814800
815200
815600
816000
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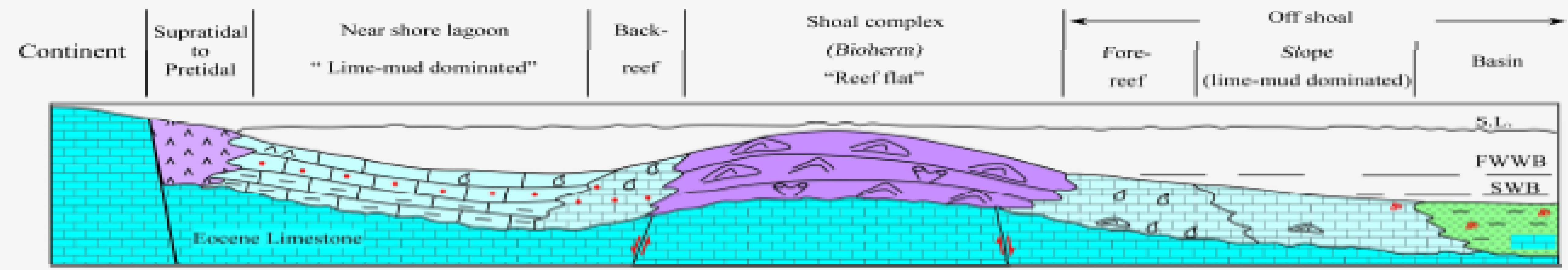
816800
817200
817600
818000
642000
641600
641200
640800
640400
640000
639600
639200
638800
638400
638000
637600
H-7
H-8st2
H-3
H-3st-2
H-3st-1
H-4A
H-4
H-7st
H-7st2
H-9
S.Belayiem
GPC Conc.
IPR Conc.
Ras Fanar(Suco) Conc.
KK_84_6
0 200 400 600 800 1000m
1:5000
Depth Structural Contour Map On Top Lower Miocene,
Al-Hamd Area, Gulf OF Suez.

Structure Model

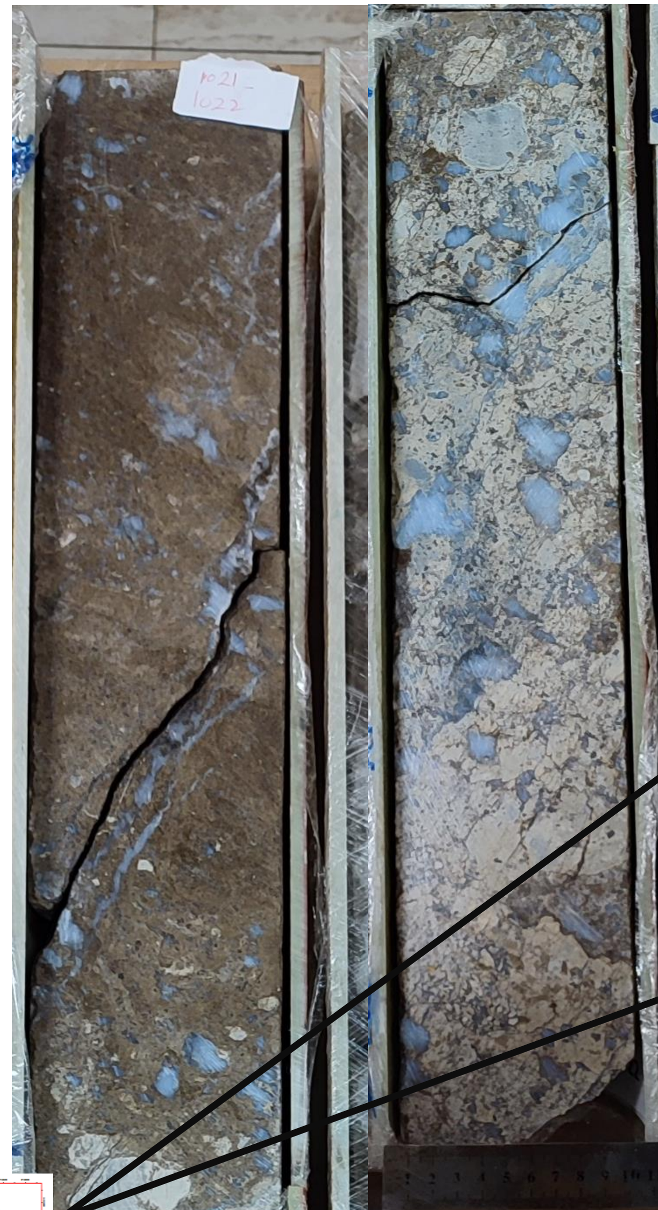
Stratigraphic model ???

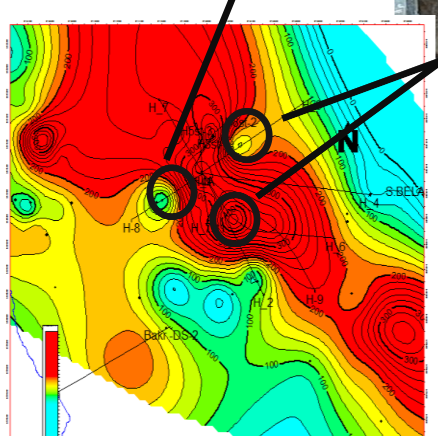


Microfacies type	Evaporites (nodular anhydrite)	Lime-mudstone to wackestone	wackestone to grainstone	Algal boundstone	Rudstone to grainstone	wackestone to floatstone	Basinal shale to lime-mudstone
Salinity	Hypersaline	Slightly saline		Normal salinity			
Water energy	Medium to low	Low	High	Very high	High	Medium	Very low
Faunal content	Rare	Bivalve / benthics	Algae/ benthics	Algae / coral	Algae/ benthics	Plankties	
Reservoir potential	Very low	Low	High	High	Moderate to high	Low	Very low
Reservoir quality	Very poor	Poor	Good	Very good	Good	Poor	Poor

STRATIGRAPHIC MODEL

Back reef

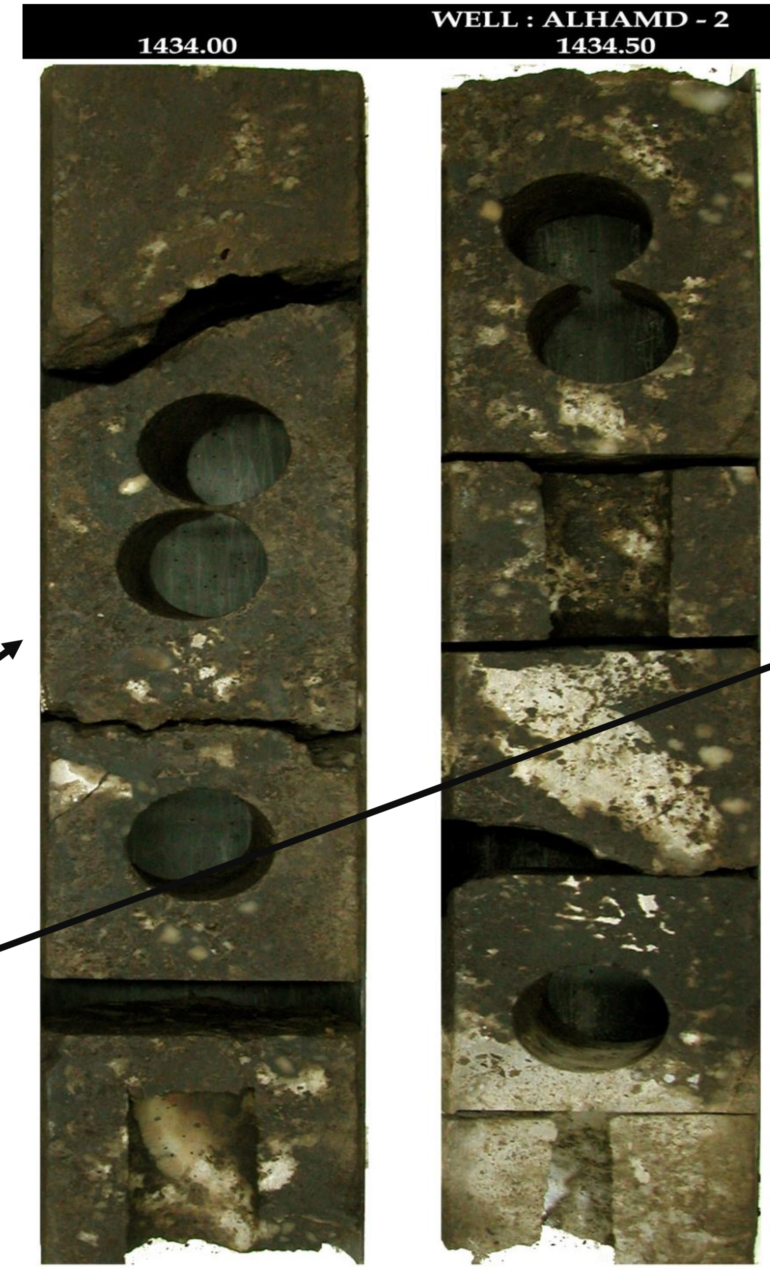




Core-photographs of Representative Lithofacies Types from Core, Miocene, AL HAMD-8 well:
1020-1021 m

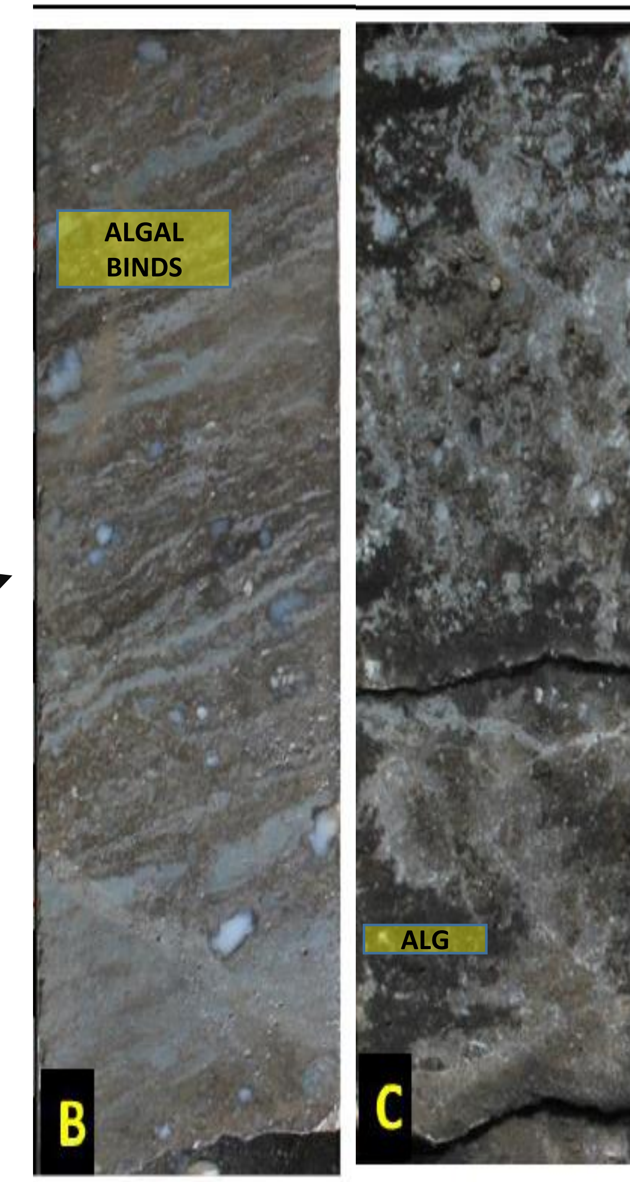
CRYSTALLINE DOLOSTONE-AN DOLOSTONE

Back to core reef



Core-photographs of Representative Lithofacies Types from Core, Miocene, AL HAMD-2 well:
L)1501-1501.5 m-**Dolostone**
R) 1503.5m-1504m, Dolobafflestone (D/Bf)

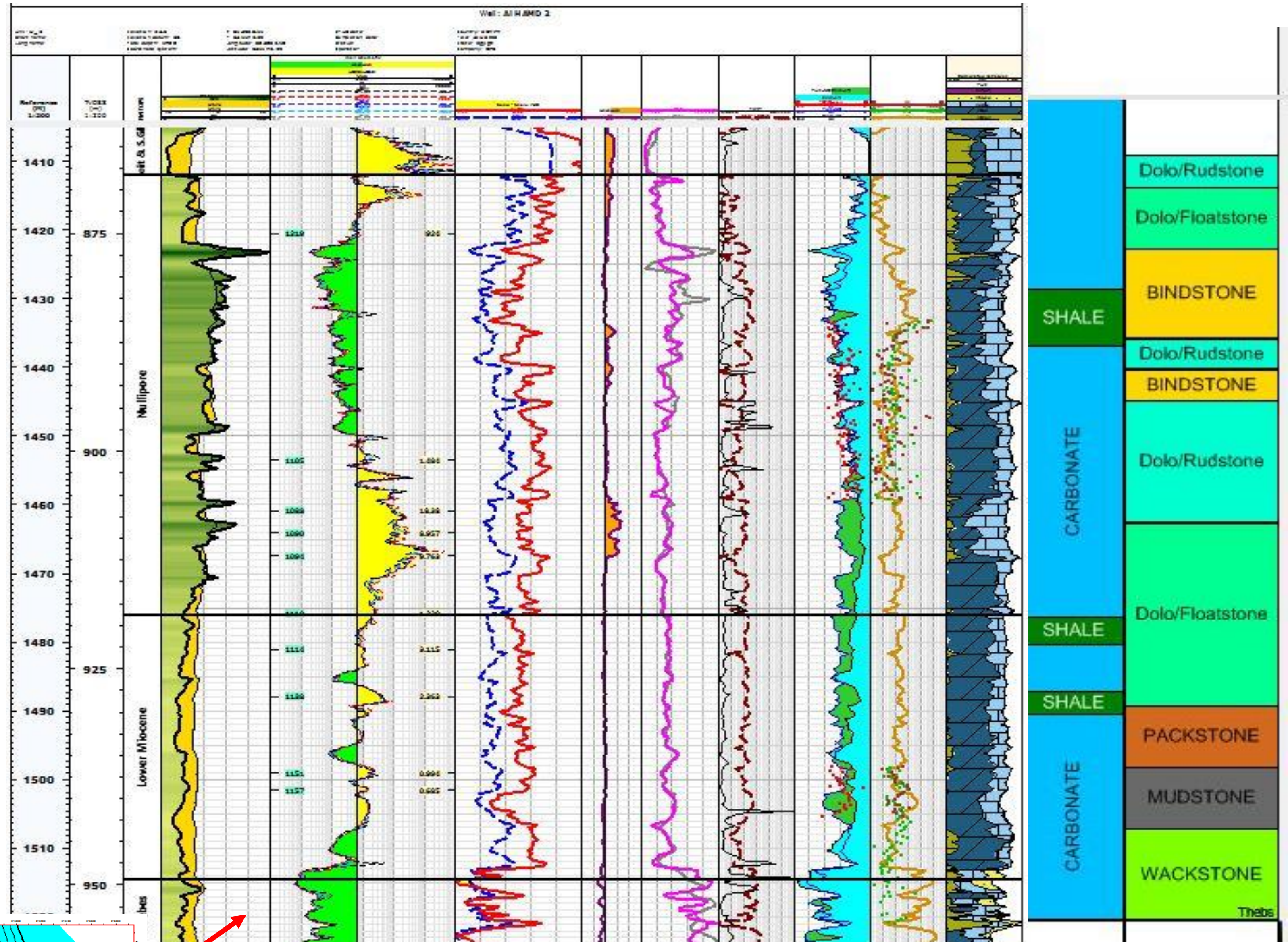
core to fore reef

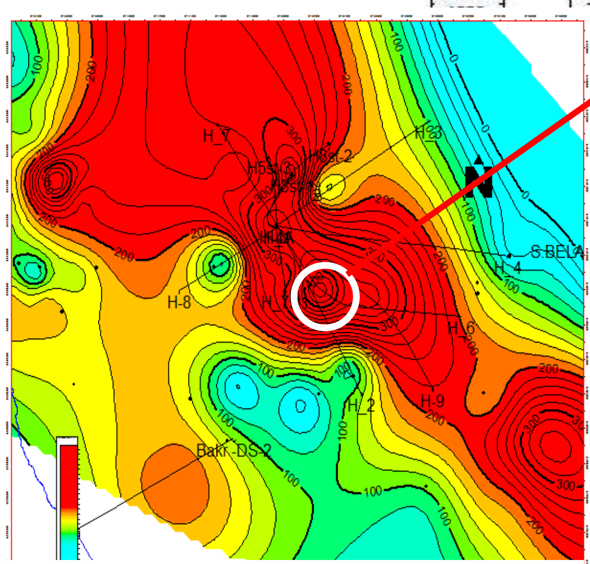


Core-photographs of Representative Lithofacies Types from Core, Miocene, AL HAMD-8 ST-1 well:
B)1063.24m-1063.50m,
Dolobindstone(D/Bin)
C) 1073m-1073.28m, Dolobafflestone (D/Bf)

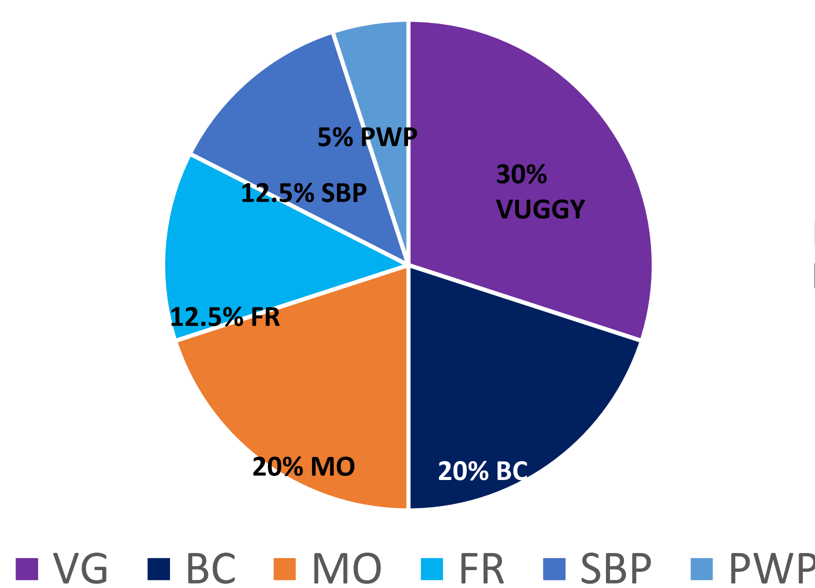
H-2 WELL BACK TO CORE REEF

VSH	Sw (%)	Øe (%)
15	20	18

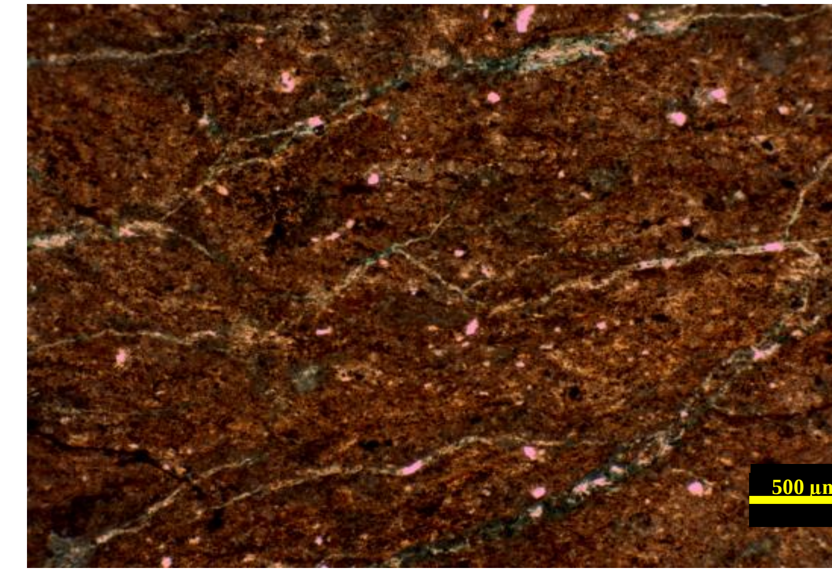


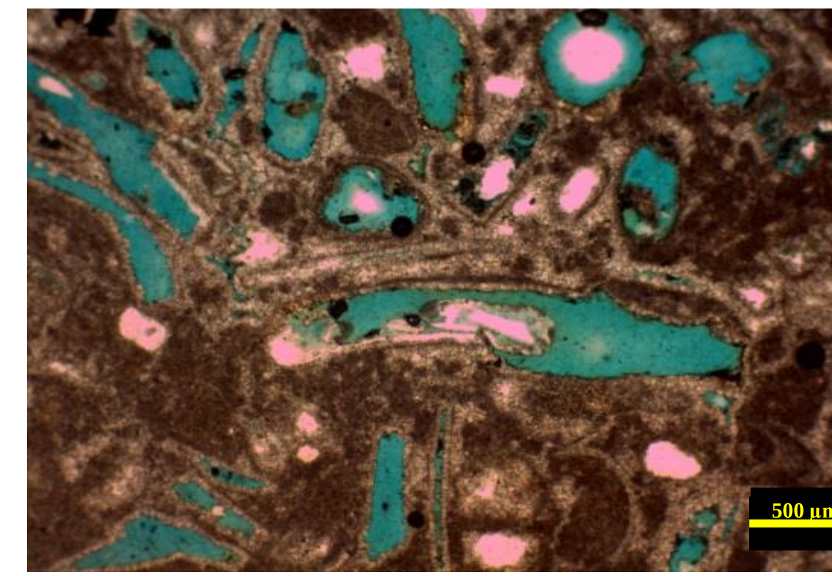


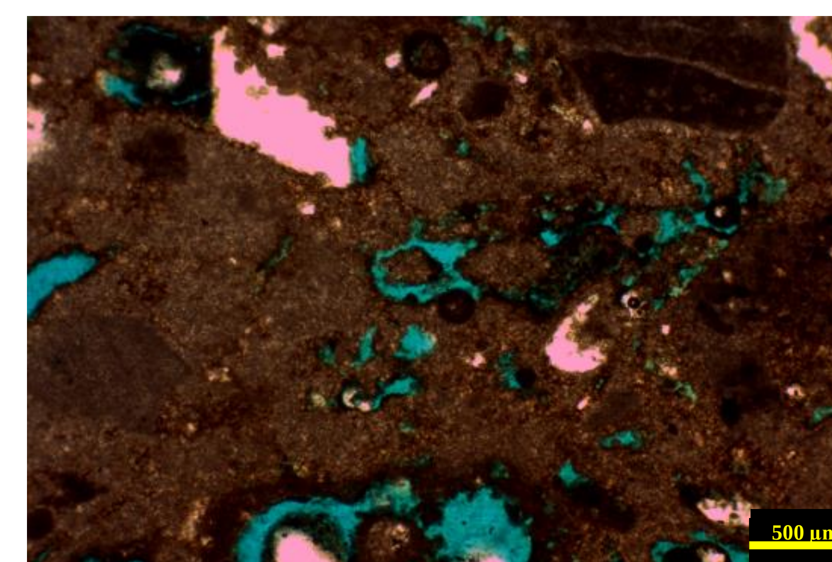
Thickness map of reefal Miocene reservoir

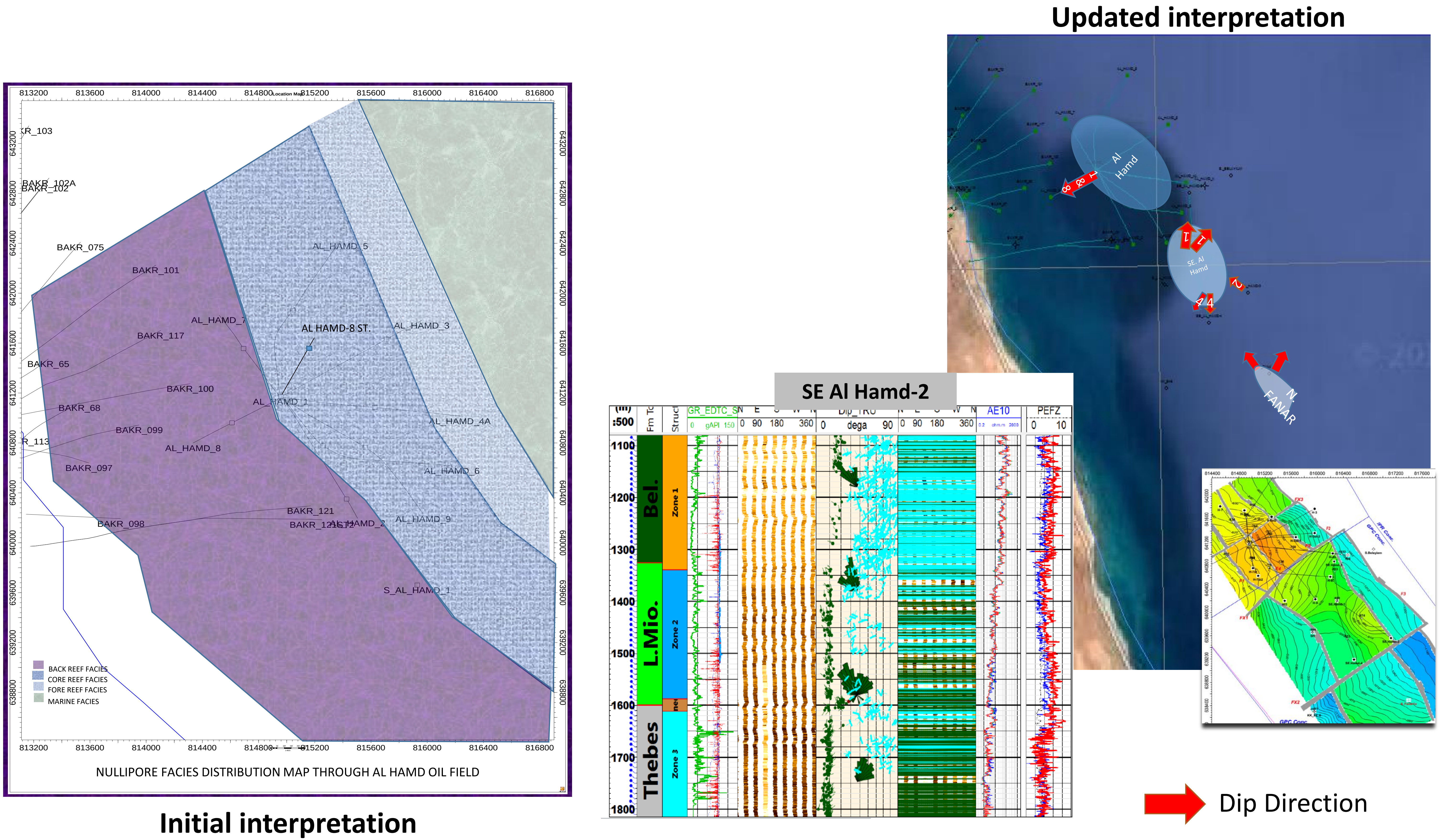


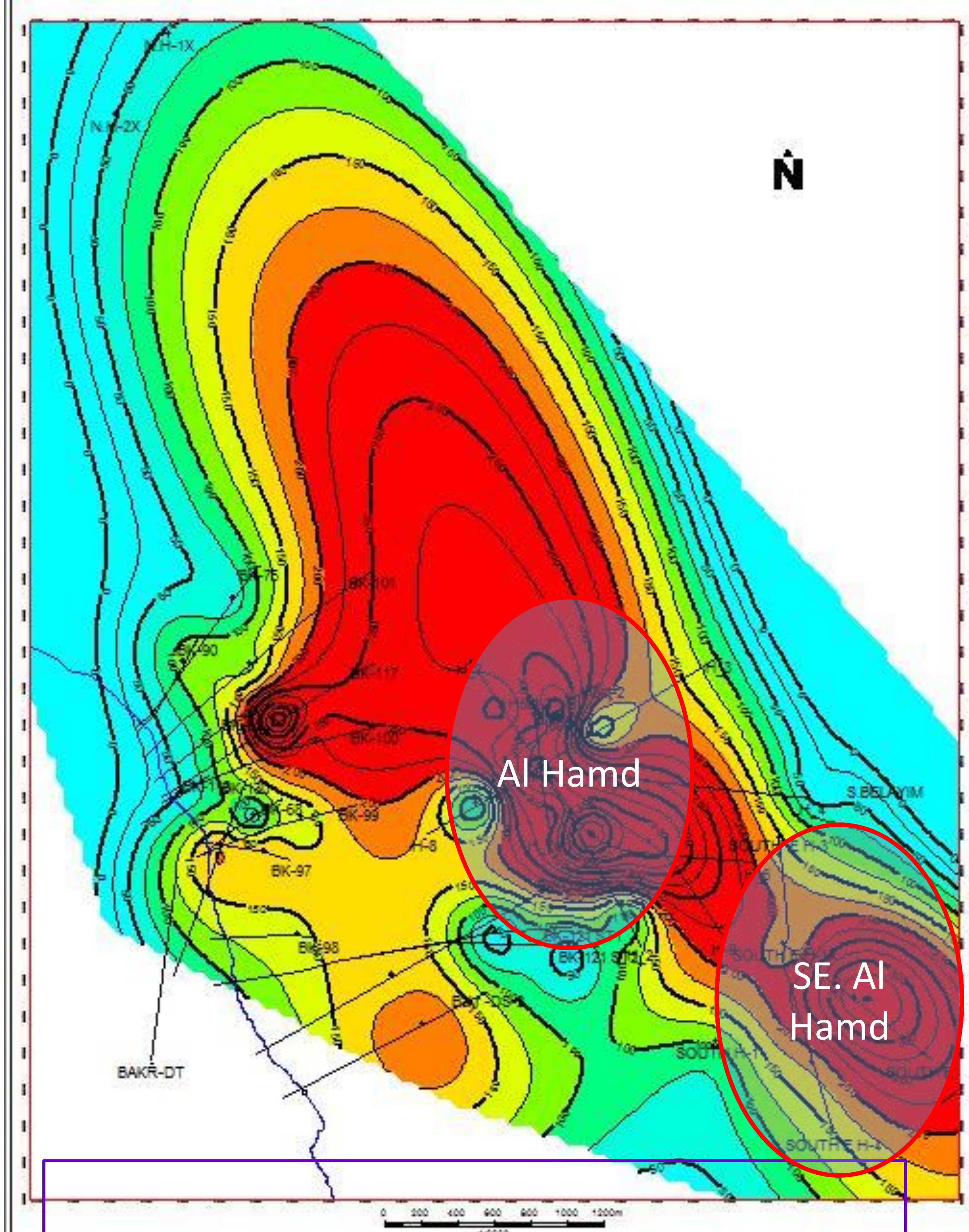
Major porosity types in % by volume
Al Hamd Field



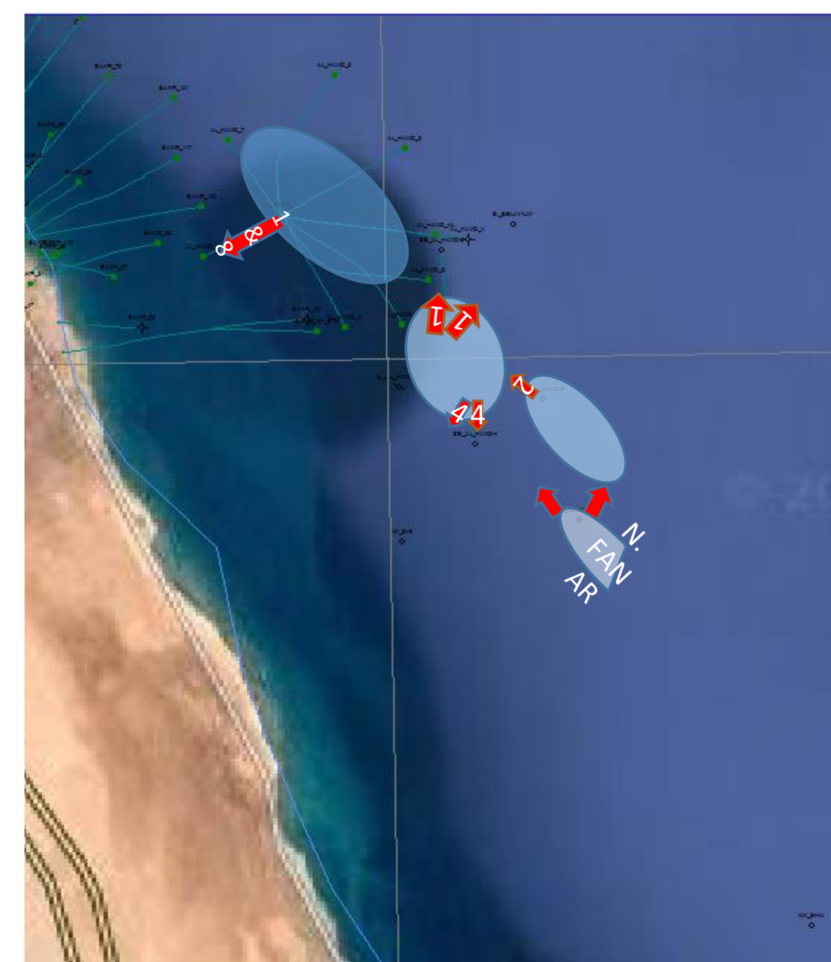





Updated interpretation
Al Hamd
SE. Al Hamd
N. FANAR
SE Al Hamd-2
Fm Tc
Struc
GR_EDTC_S
Dip_TRU
AE10
PEFZ
Bel.
L.Mio.
Thebes
Zone 1
Zone 2
Zone 3
Dip Direction
BACK REEF FACIES
CORE REEF FACIES
FORE REEF FACIES
MARINE FACIES
AL HAMD-8 ST.
NULLIPORE FACIES DISTRIBUTION MAP THROUGH AL HAMD OIL FIELD
Initial interpretation

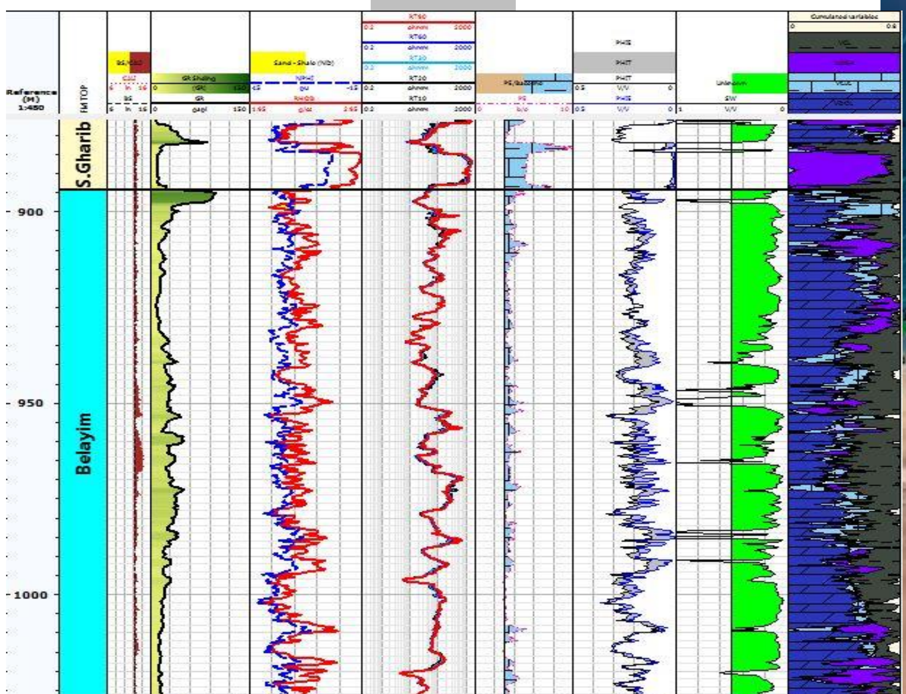


Miocene CarbonateThickness map of Al Hamd, SE Al Hamd & Bakr

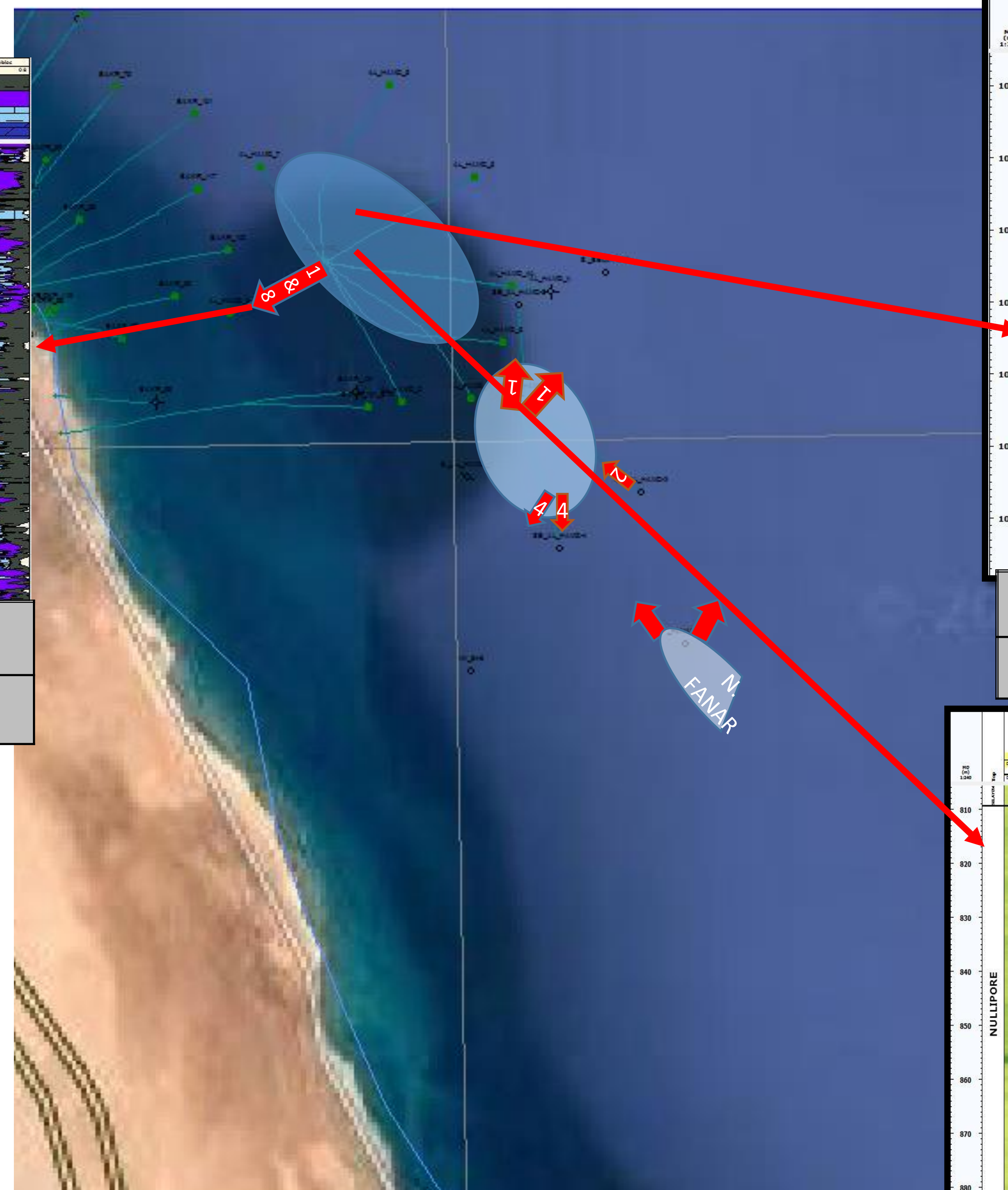


Petrophysical Evaluation

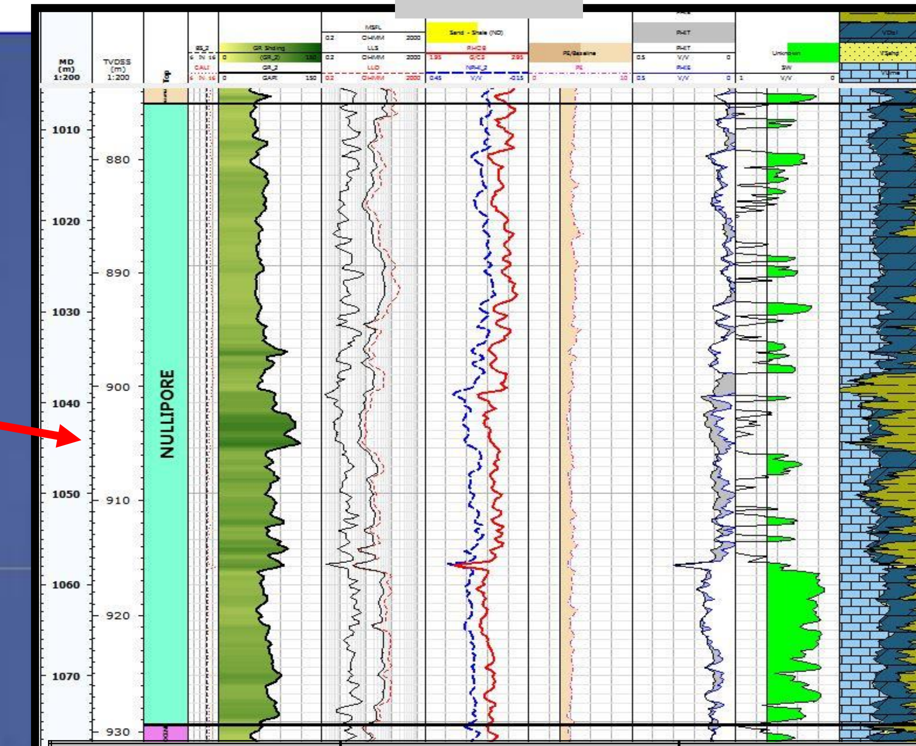
H-8



VSH	Sw (%)	Øe (%)
10	27	12

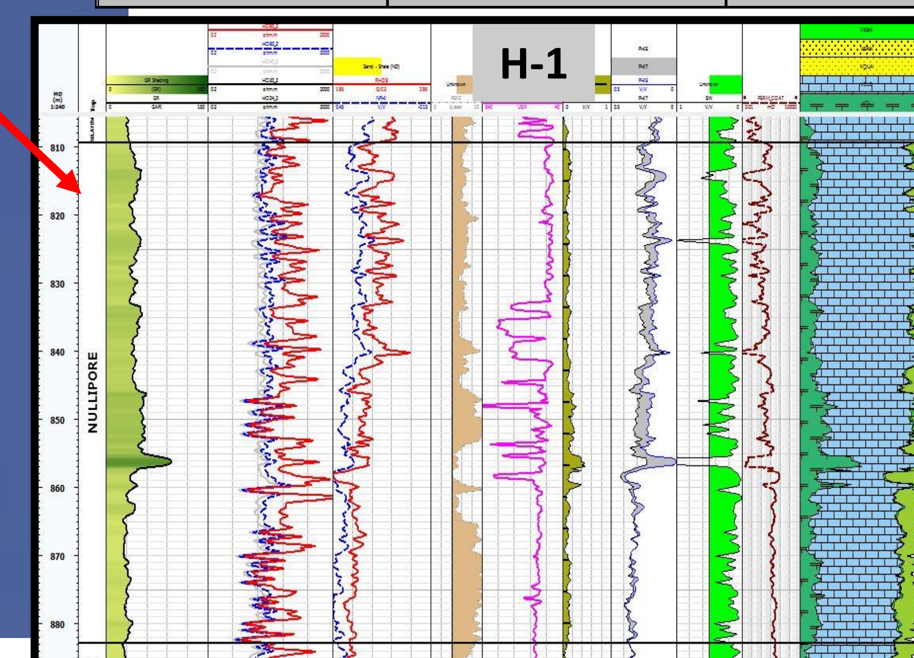


H-8 ST



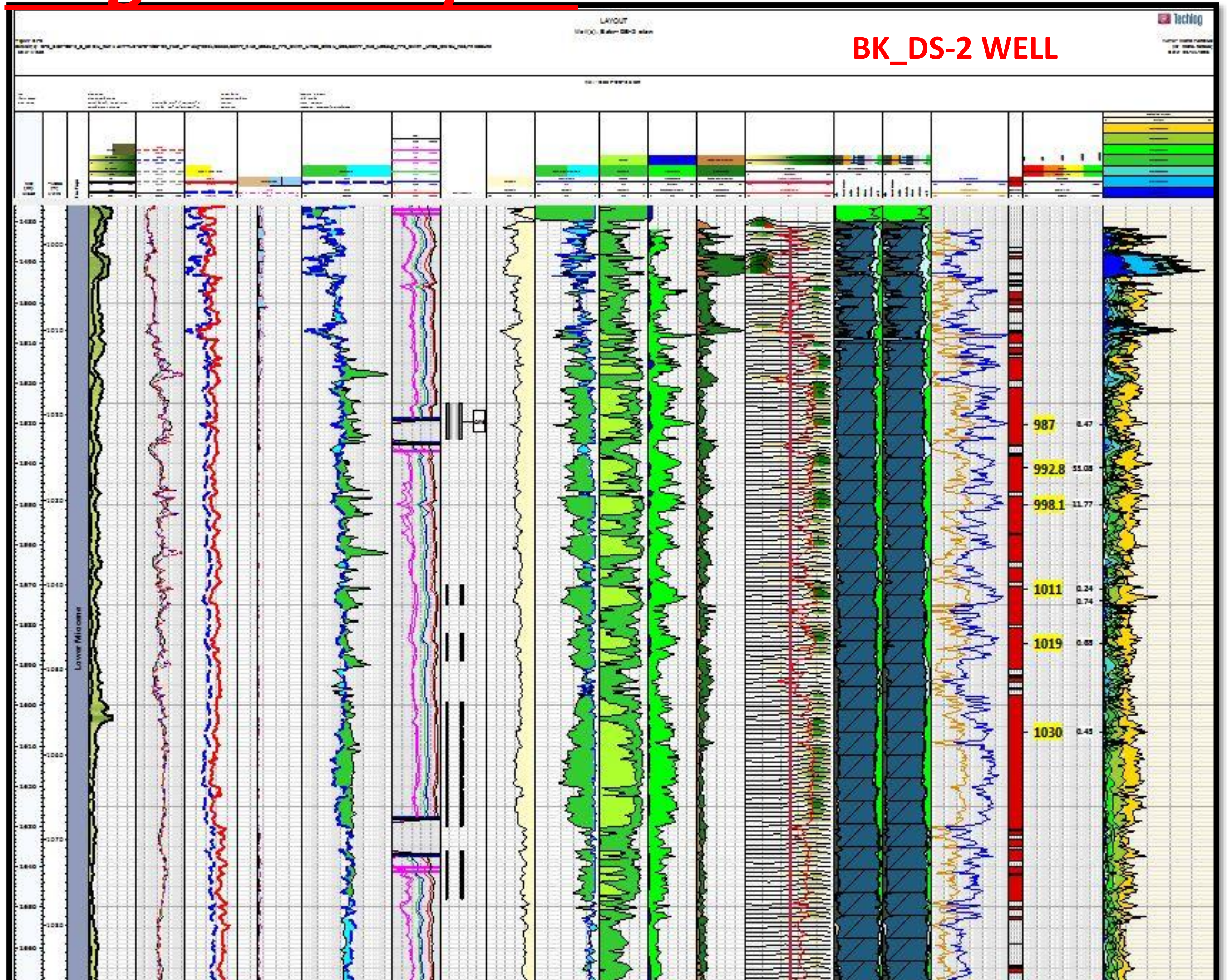
VSH	Sw (%)	Øe (%)
14	18	18

H-1

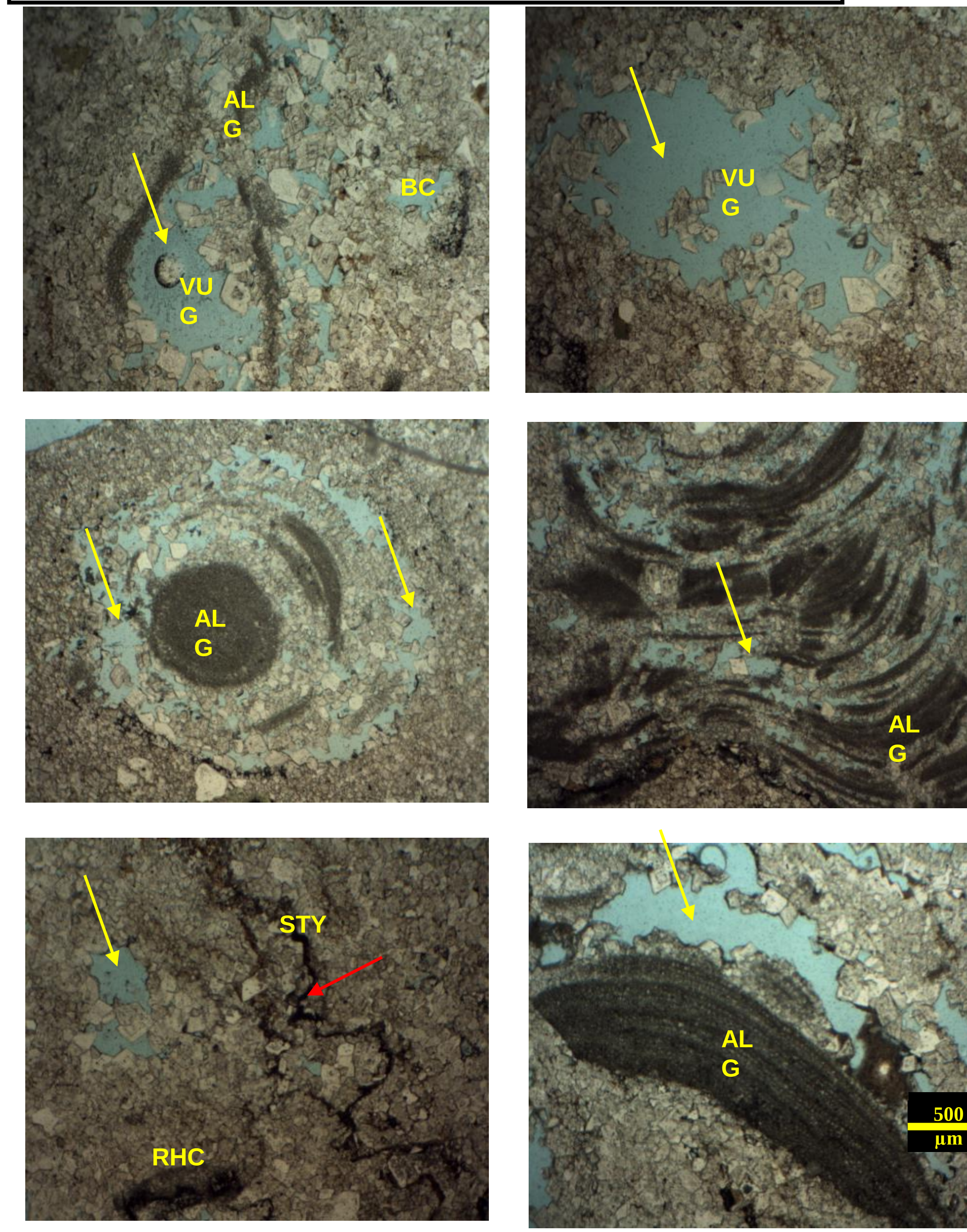


VSH	Sw (%)	Øe (%)
8	19	22

Diagenesis Impact



Rock Name: Crystalline Dolowackstone.



DIAGENTIC HISTORY	EOGENSIS			MESOGENSIS						
MICRITIZATION										
NEOMORPHISM										
DOLOMITE	■									
DISSULUTION OF GRAINS		■								
MECHANICAL COMPACTION AND FRACTURING				■						
ANHYDRITE					■					
PARTIAL DISSOLUTION OF DOLOMITE						■				
PARTIAL DISSOLUTION OF CARBONATE CEMENT										
TERRIGINEOUS CLAYS								■		
OIL EMPLACEMENT									■	
PYRITE										■

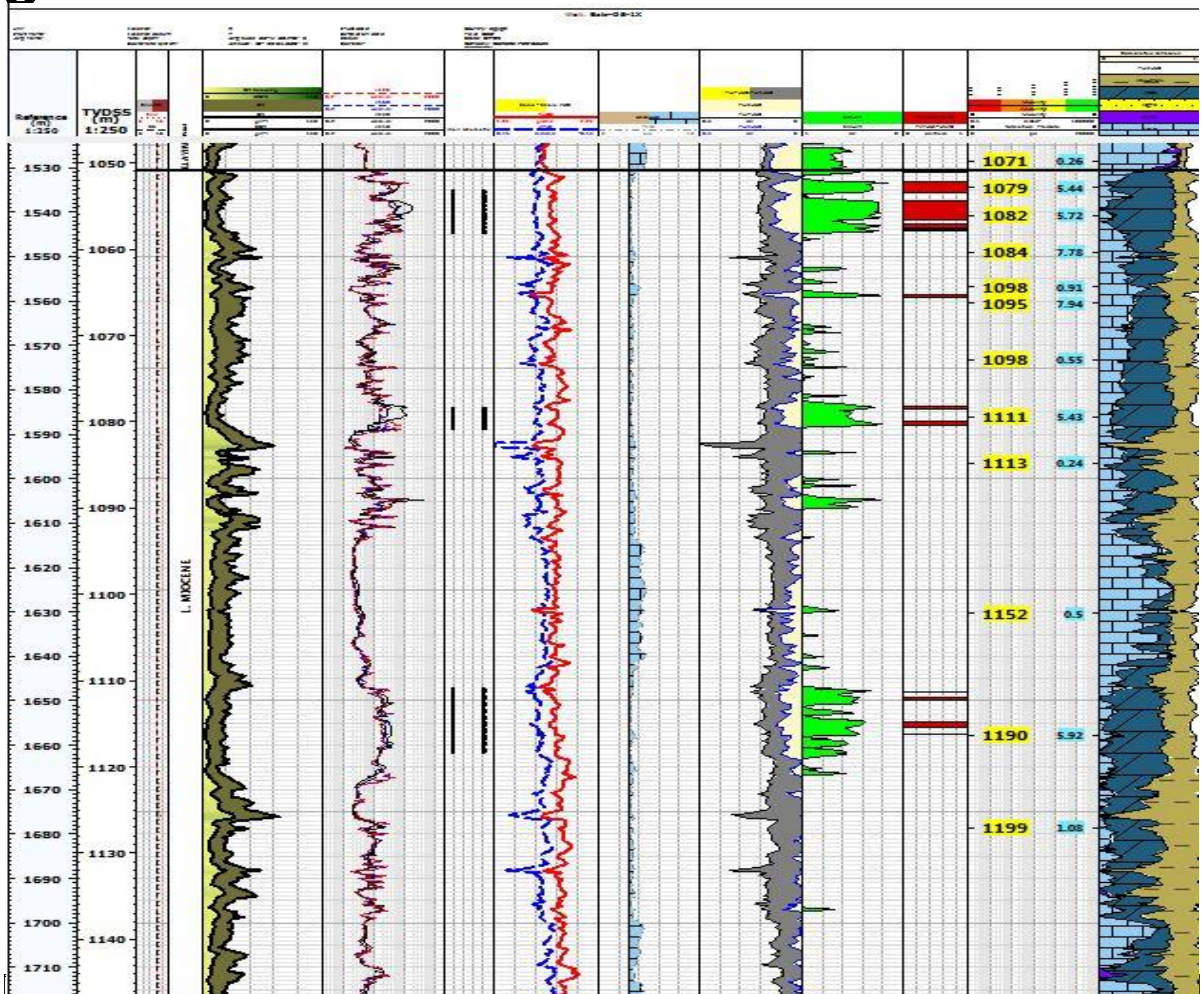
FACTORS ENHANCING POROSITY

1-DISSOLUTION OF BIOCLAST

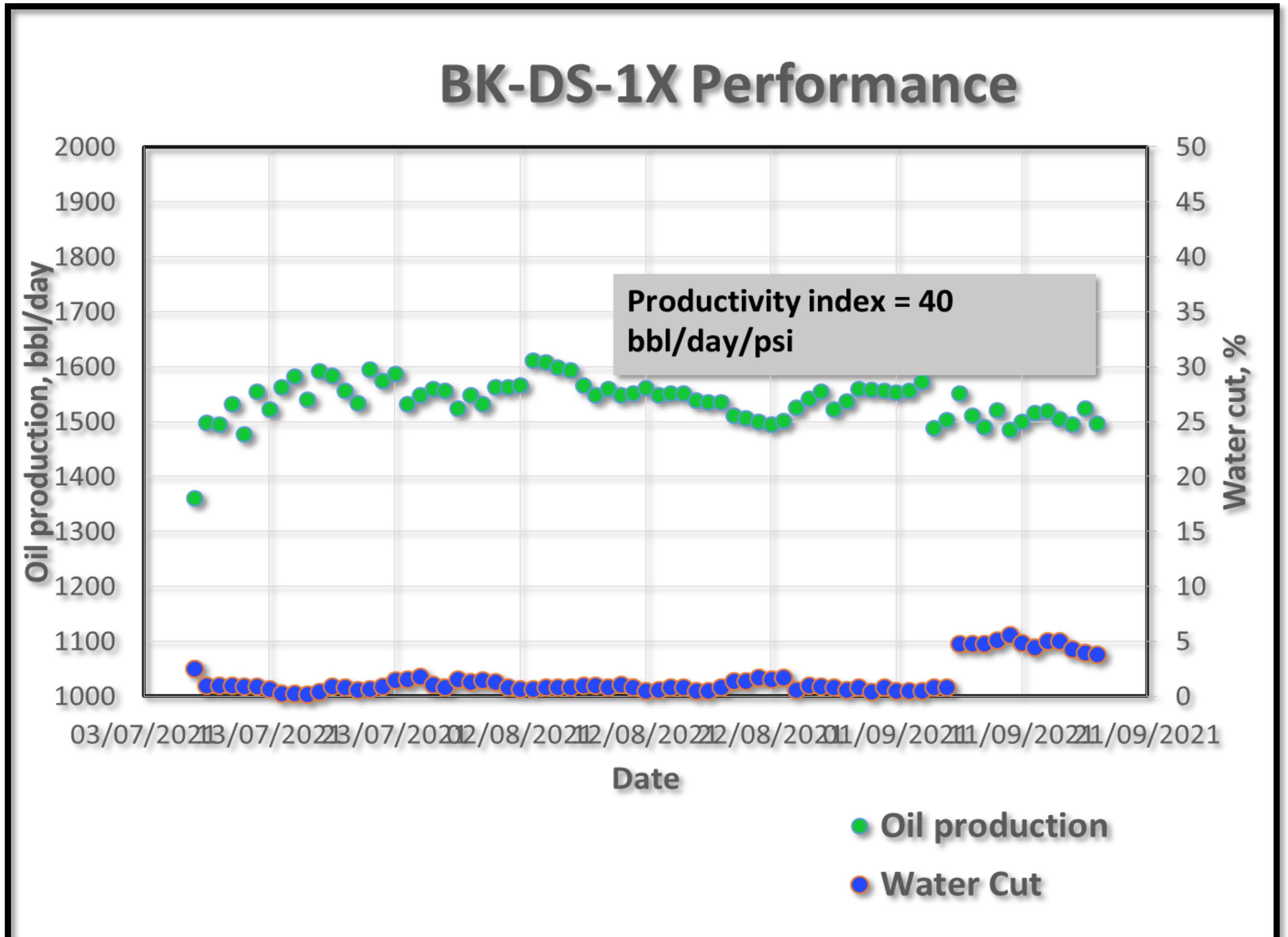
2-DOLOMITIZATION

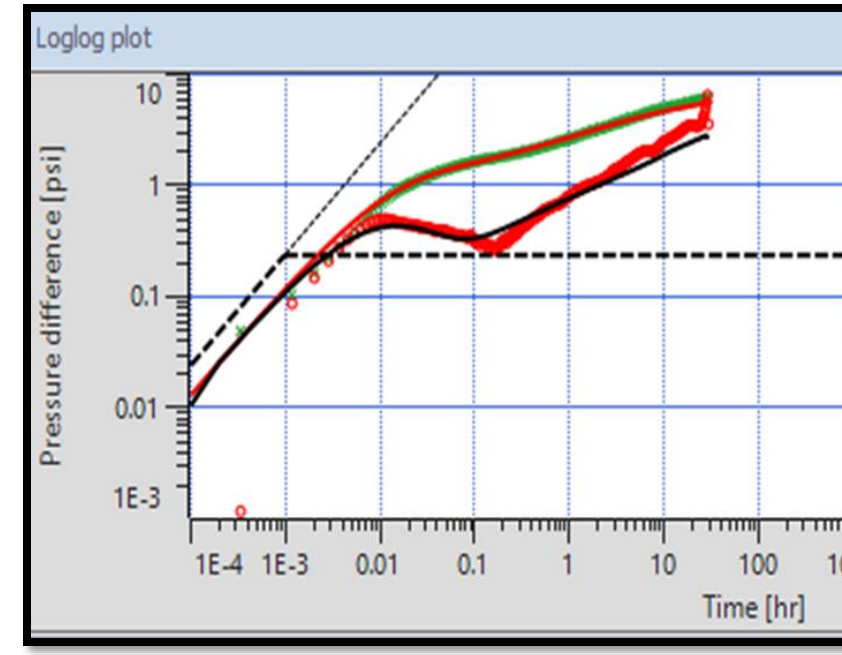
3-MINOR FRACTURING

Integrated Workflow for Reservoir Characterization



Fm Name	(MD)	(VSS)	(MD)	(TVDSS)	Sw (%)	Øe (%)
L. MIOCENE	1491.5-1504.5	1030.7-1037.5	4	2.5	35	14
	1513.5-1520	1042-1045.5	7	3	37	19
	1533-1544.5	1052-1058	7.5	3.5	32	15
	1558-1559	1065-1065.5	1	0.5	44	17
	1583-1588	1078-1080	2	1	36	11
CUM.	1491.5 – 1588	1030.7 – 1037.5	21.5	10.5	37	15





Analytical

Wellbore = Constant
Well = Slanted
Reservoir = Dual porosity transient (sphere)
Boundary = Parallel faults

Pi = 1063.22 psia
kh = 2.36177E+5 md.ft
k = 2825.55 md
C = 0.242819 bbl/psi
Skin = -3.80000
Omega = 0.05
Lambda = 17.7795
S = 507.399 ft
N = 453.257 ft

Integrated Workflow for Reservoir Characterization

Multi-domain Integration:

G & G

THE GENERAL PETROLEUM Co.

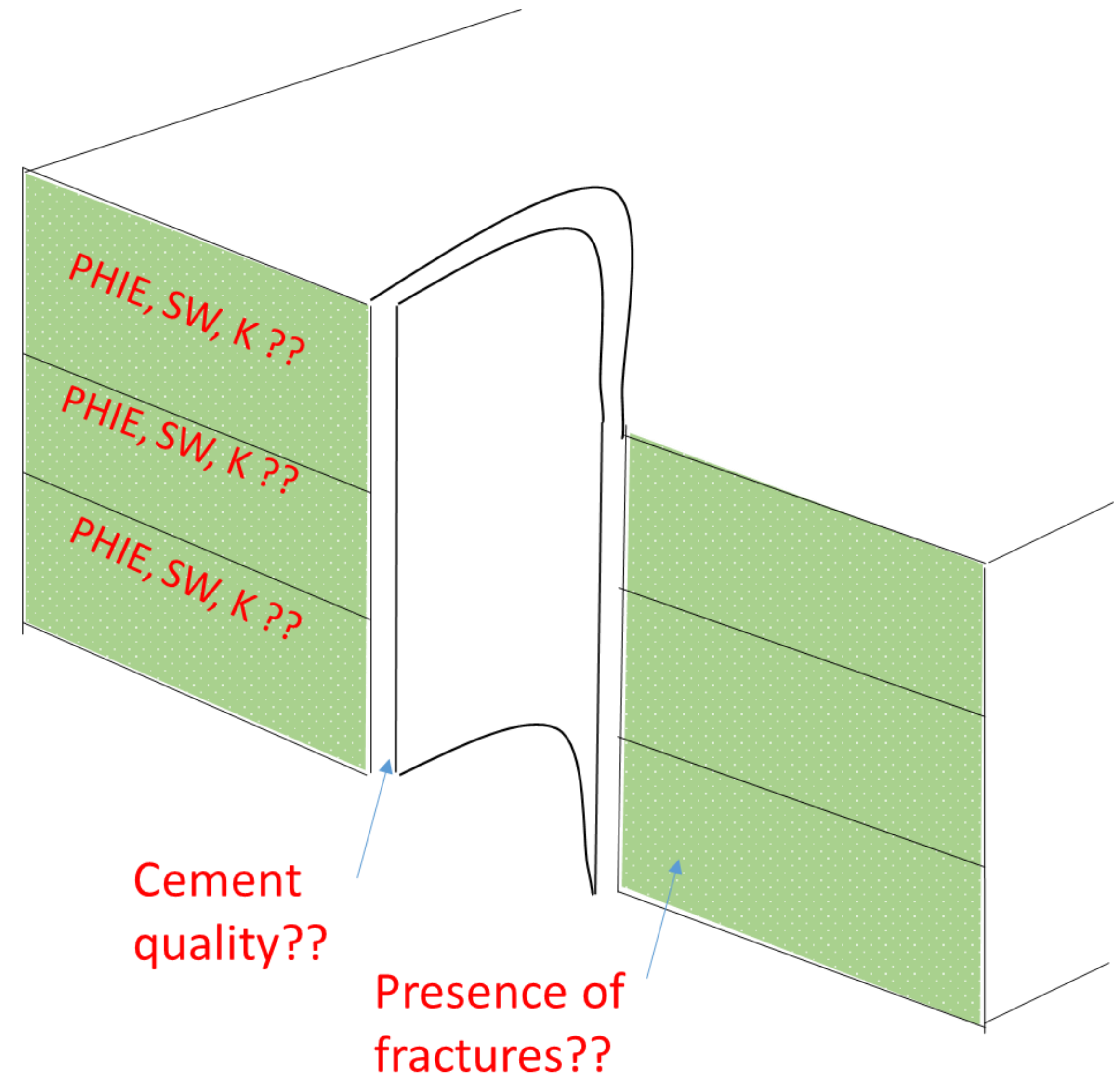
Schlumberger

Engineering

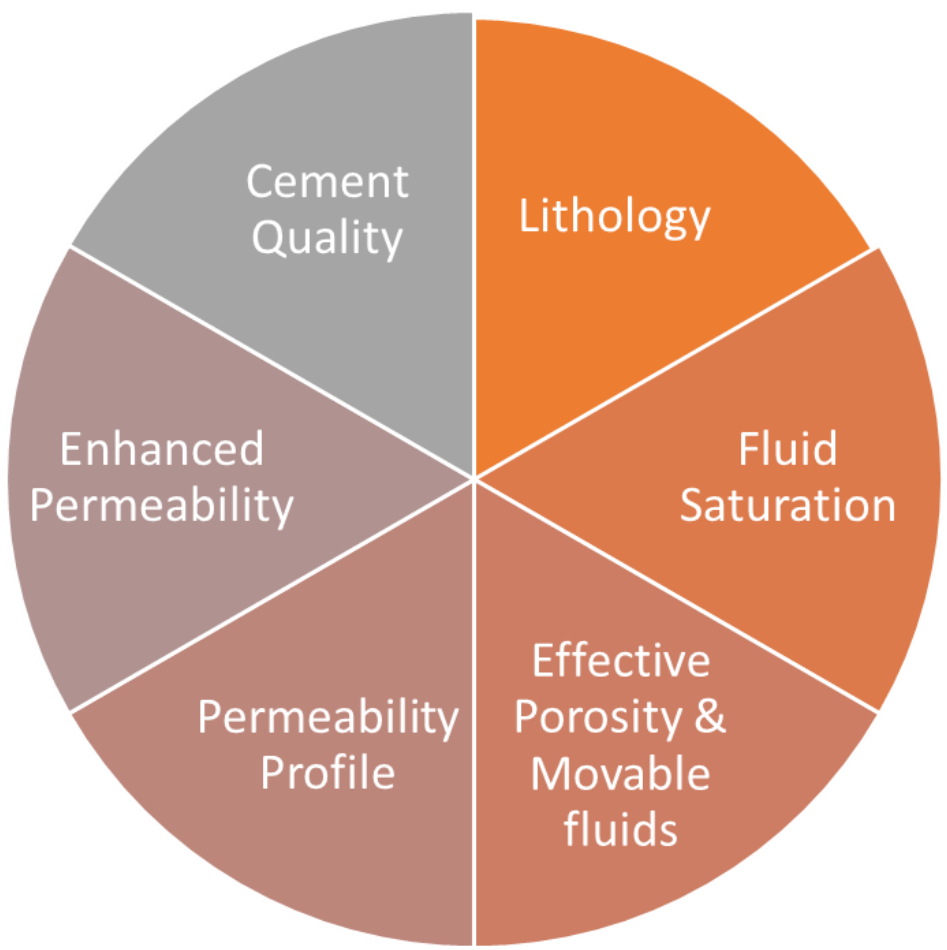
Main Challenges:

Carbonates can not be producing without acidizing

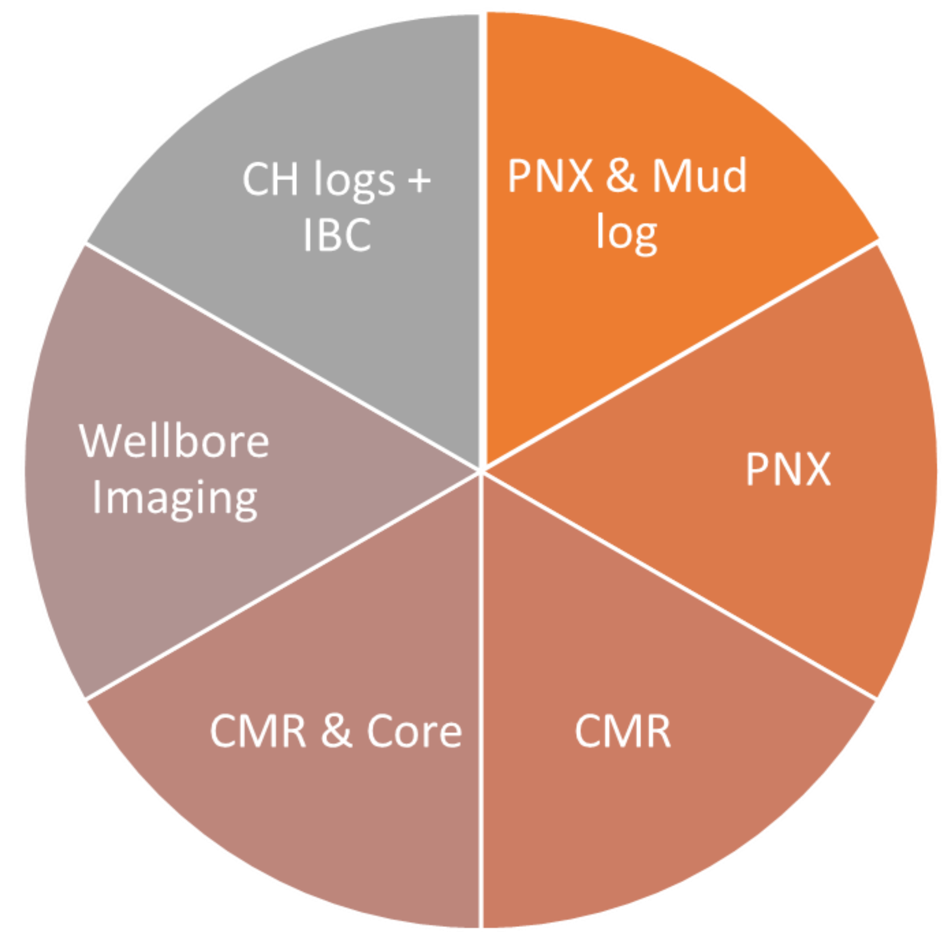
- Carbonate type
- Fluid Saturation
- Effective Porosity
- Permeability Profile
- Enhanced Permeability features
- Cement Quality



Problem Solving Workflow

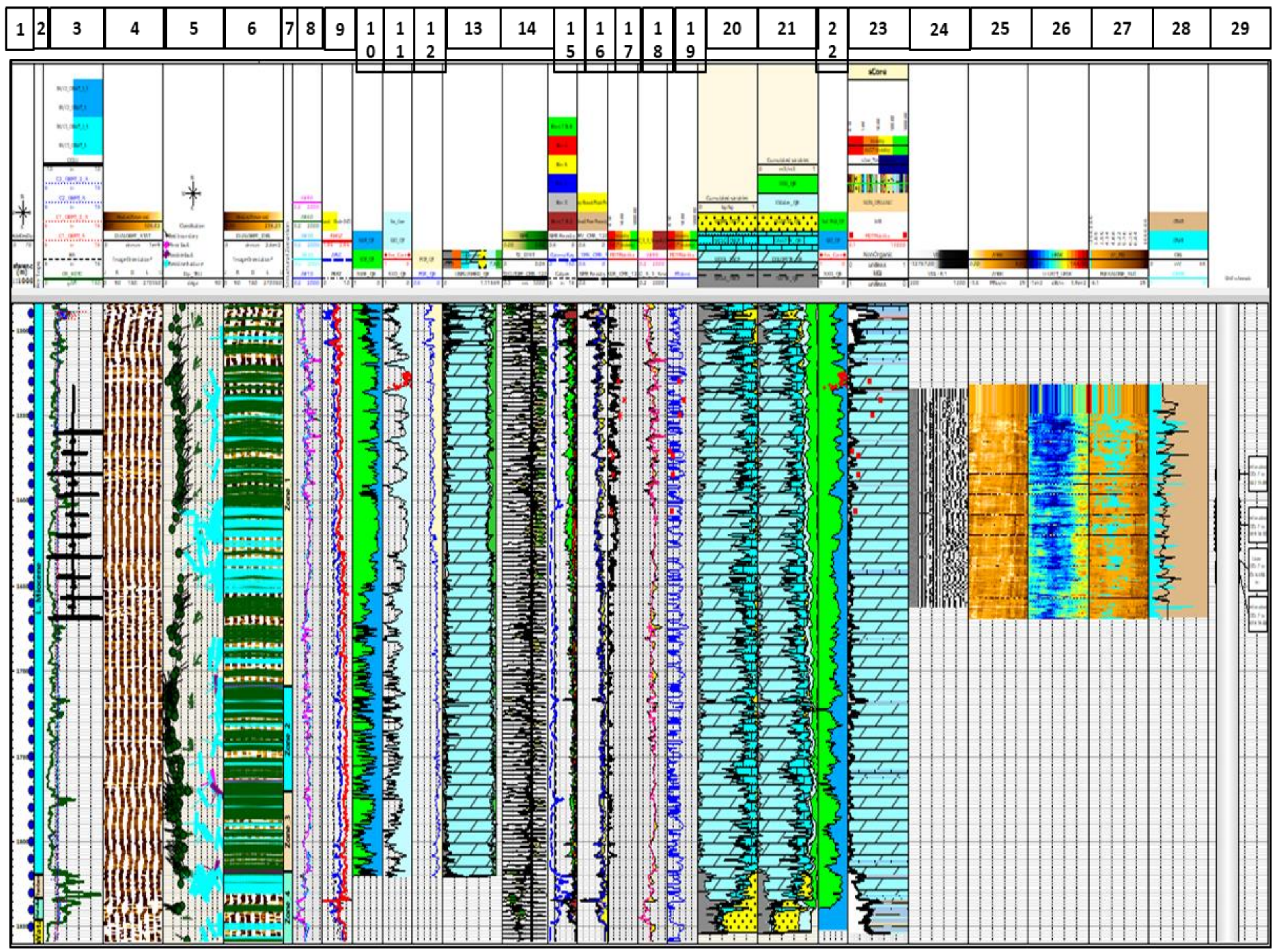


Problem



Solution

1st Worldwide Interface



- *Track 1: MD (m) and hole trajectory.*
- *Track 2: Formation Tops.*
- *Track 3: GR and DOBMI calipers.*
- *Track 4: DOBMI static image.*
- *Track 5: Picked classified dips.*
- *Track 6: DOBMI dynamic image.*
- *Track 7: DOBMI structural zonation.*
- *Track 8: TCOMBO resistivity curves.*
- *Track 9: TCOMBO neutron, density and PEF curves.*
- *Track 10: Elan water and oil saturations (Provided by GPC).*
- *Track 11: Elan water and core water saturations (Provided by GPC).*
- *Track 12: Elan porosity (Provided by GPC).*
- *Track 13: Elan volume fractions (Provided by GPC).*
- *Track 14: NMR T2 distribution. and NMR T2 cutoff_120.*
- *Track 15: NMR porosity, TCOMBO caliper and GR.*
- *Track 16: NMR porosity and NMR fluid volume fraction.*
- *Track 17: NMR permeability and MDT mobility.*
- *Track 18: OBMI Image resistivity and TCOMBO A90 resistivity.*
- *Track 19: OBMI mobility index and MDT mobility.*
- *Track 20: PNX weight fractions.*
- *Track 21: PNX volume fractions.*
- *Track 22: PNX water and oil saturations.*
- *Track 23: iCore high resolution lithofacies and MDT mobility.*
- *Track 24: Variable density log (Well integrity)*
- *Track 25: Acoustic impedance (Well integrity).*
- *Track 26: Acoustic attenuation rate (Well integrity).*
- *Track 27: Annulus image (Well integrity).*
- *Track 28: Cement bond amplitude and ration of cement Well integrity).*
- *Track 29: Well schematic (perforation intervals).*

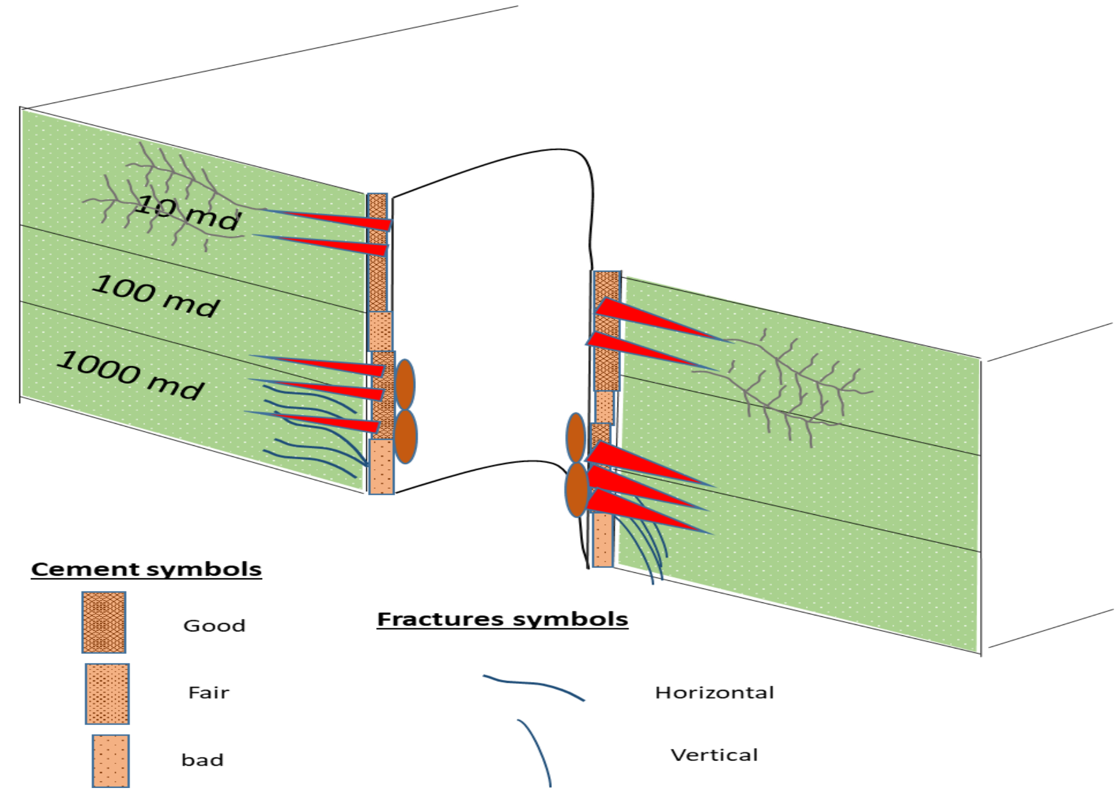
Added Value Output

Selective Perforation

Acid Diversion

Acid Retardation

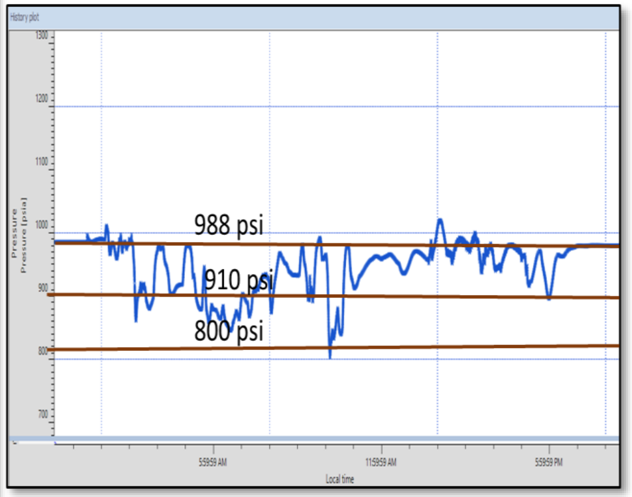
Treatment Placement



GPC Fit-for-purpose acid treatment (1st worldwide application)

Thief zone diversion	ClearPILL**
In-situ diversion	Oil SEEKER**
Acid Retardation	15% HCl + 1.5% Formic acid

Well Response before Acidizing

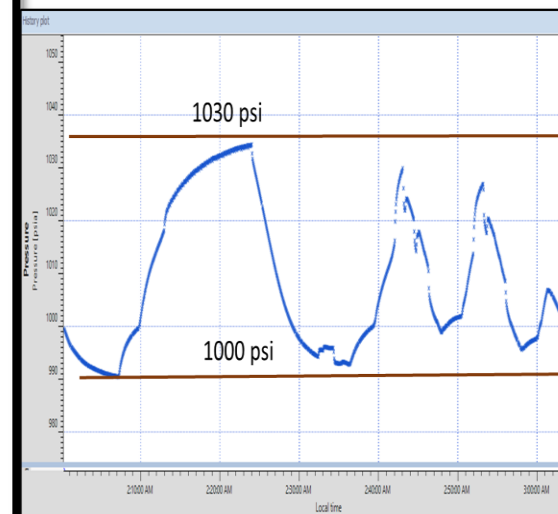


Lifting before acid

TIME :	UP/DN PSI	SEP PRESSURE PSI	GROSS BBL	W.C %	C.L PPM
4:30	100/90	80	134	93	21000
5:00	120/110	100	400	93	21000
5:30	140/130	125	530	92	21000
6:00	140/130	125	572	94	30000
8:00	90/85	80	169	75	30000
10:00	90/80	70	225	77	30000
12:00	90/80	70	152	75	30000
13:30	65/60	50	125	66	48000
16:00	75/65	50	184	43	61000
		Avg	277		

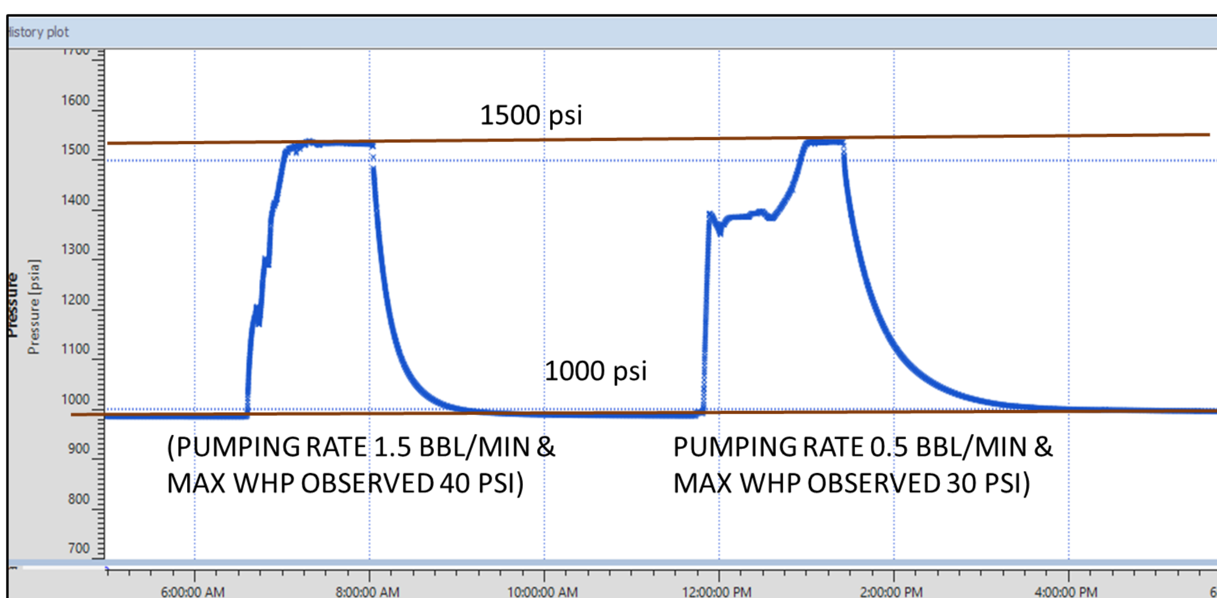
Productivity index= 1.4 - 3.5 Bbl/day/ psi

Injectivity before ClearPILL

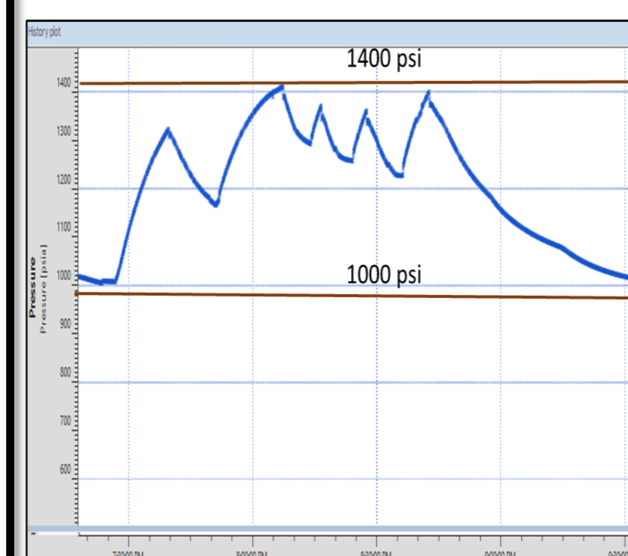


RATE BBL	MAX. CIRCULATION PRESSURE PSI	MAX. WHP PSI	BHP, psi	VOLUME BBL	TIME MIN	
0.50	360	0	1000	1.5	3	PI (1582-1587) MT.
1.25	2000	0	1030	3.75	3	
0.50	350	0	1000	1.5	3	PI (1599-1630) MT.
1.25	2100	0	1030	3.75	3	
0.50	350.00	0	1000	1.50	3	PI (1636-1648) MT
1.25	2300	0	1030	3.75	3	

1st & 2nd ClearPILLs

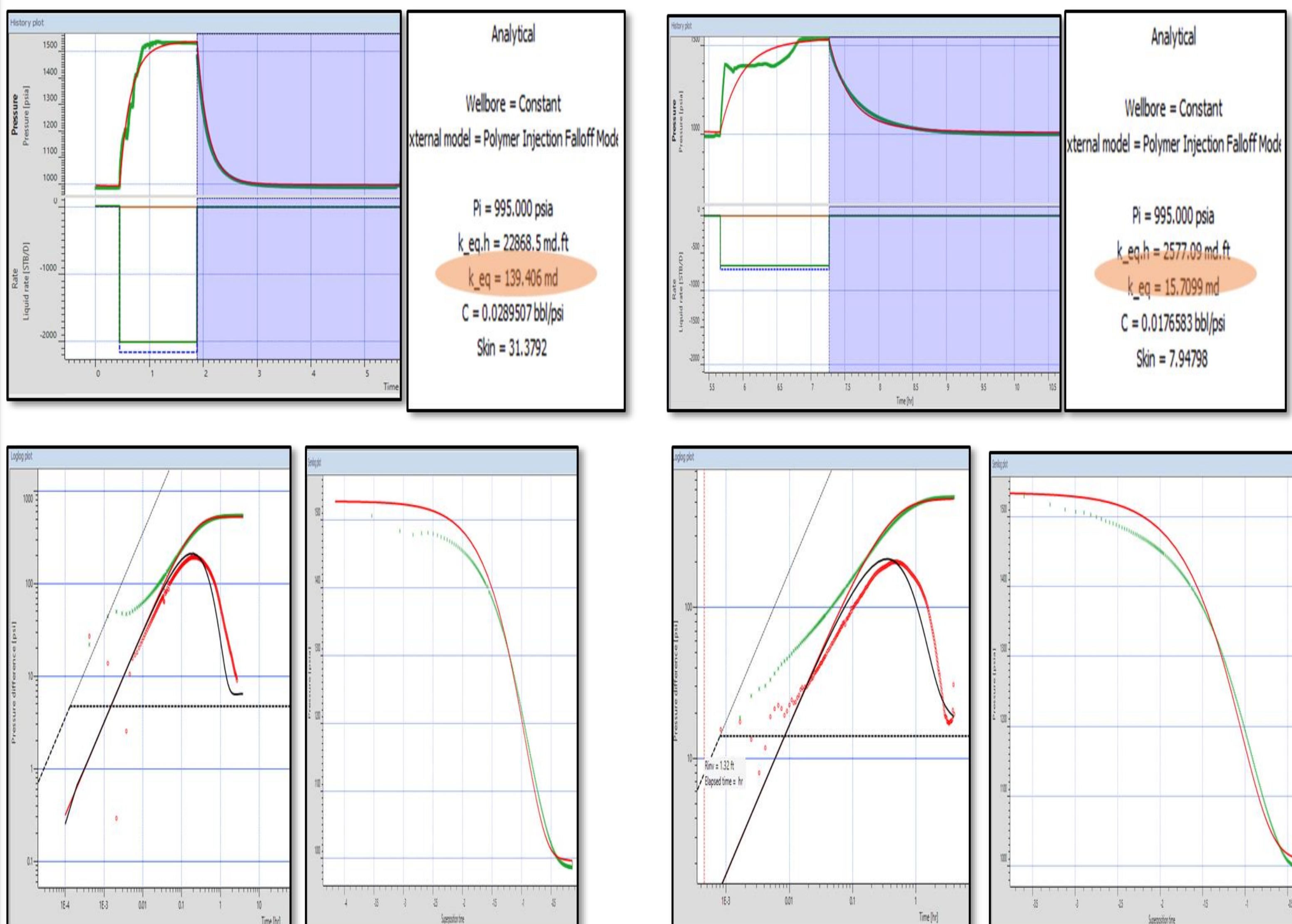


Injectivity after ClearPILL

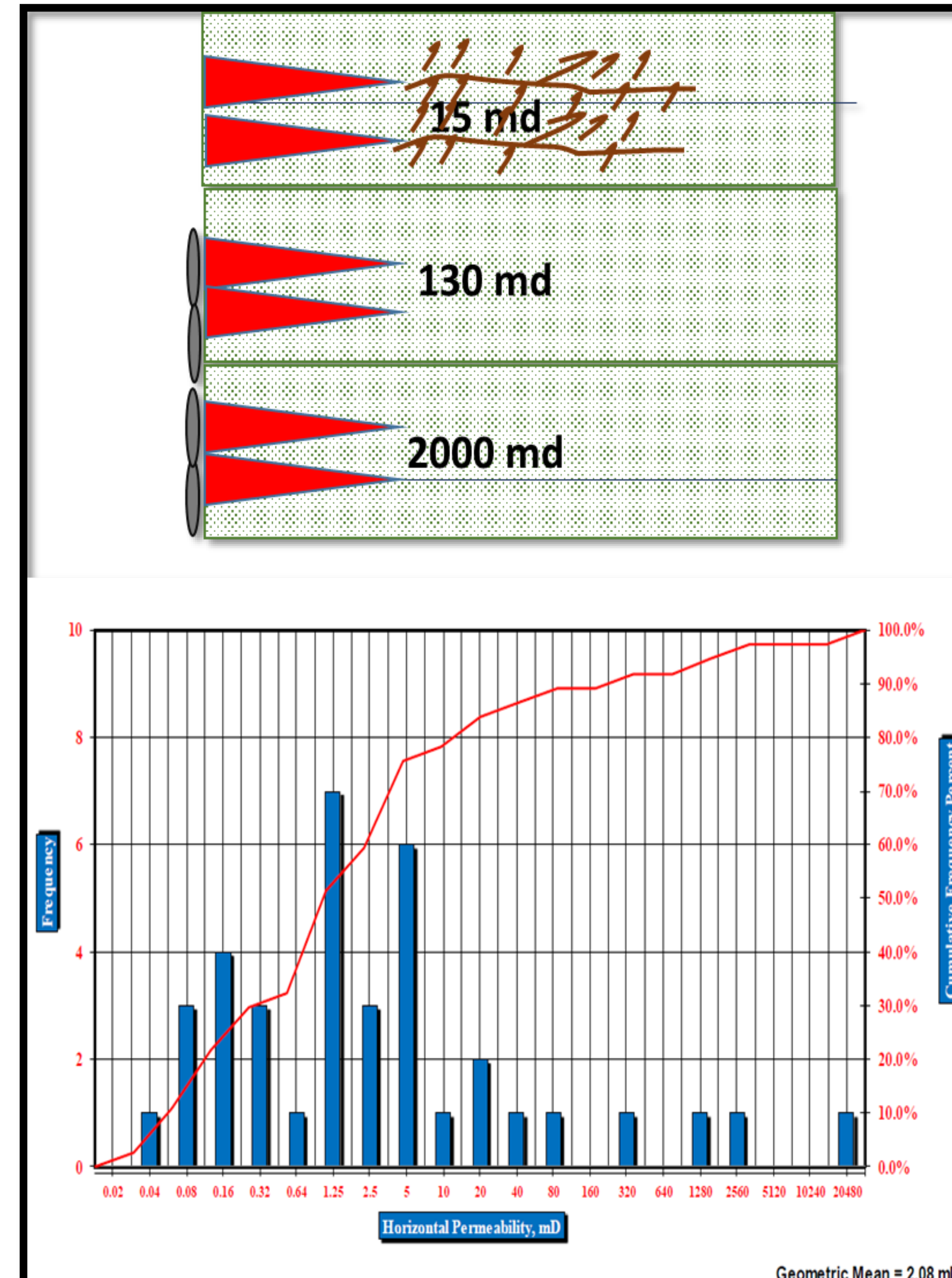


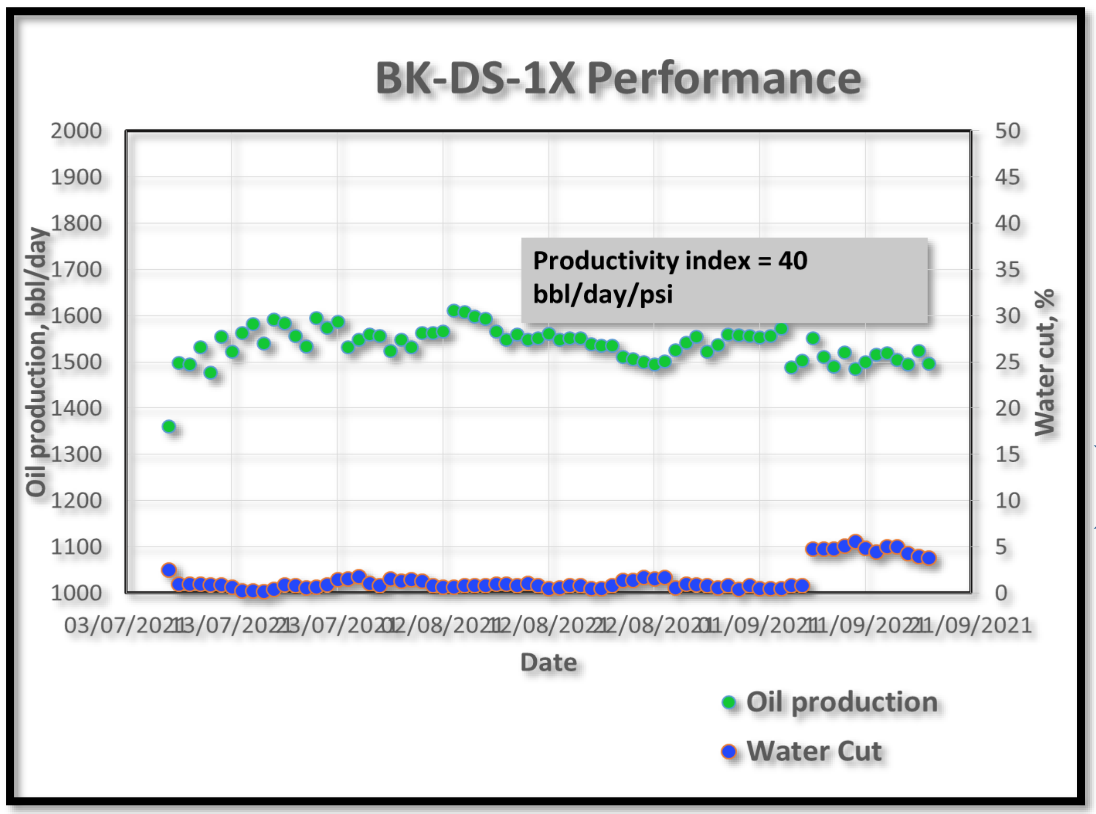
RATE BBL	MAX. CIRCULATION PRESSURE PSI	MAX. WHP PSI	VOLUME BBL	TIME MIN	
0.50	415	7	2	4	'PI (1636-1648) MT
1.25	3300	10	2	2	
0.50	400	5	3	7	PI (1599-1630) MT.
1.25	3500	9	4	3	
0.50	480	4	2	4	PI (1582-1587) MT.
1.25	3300	7	2	2	

Fall off analysis



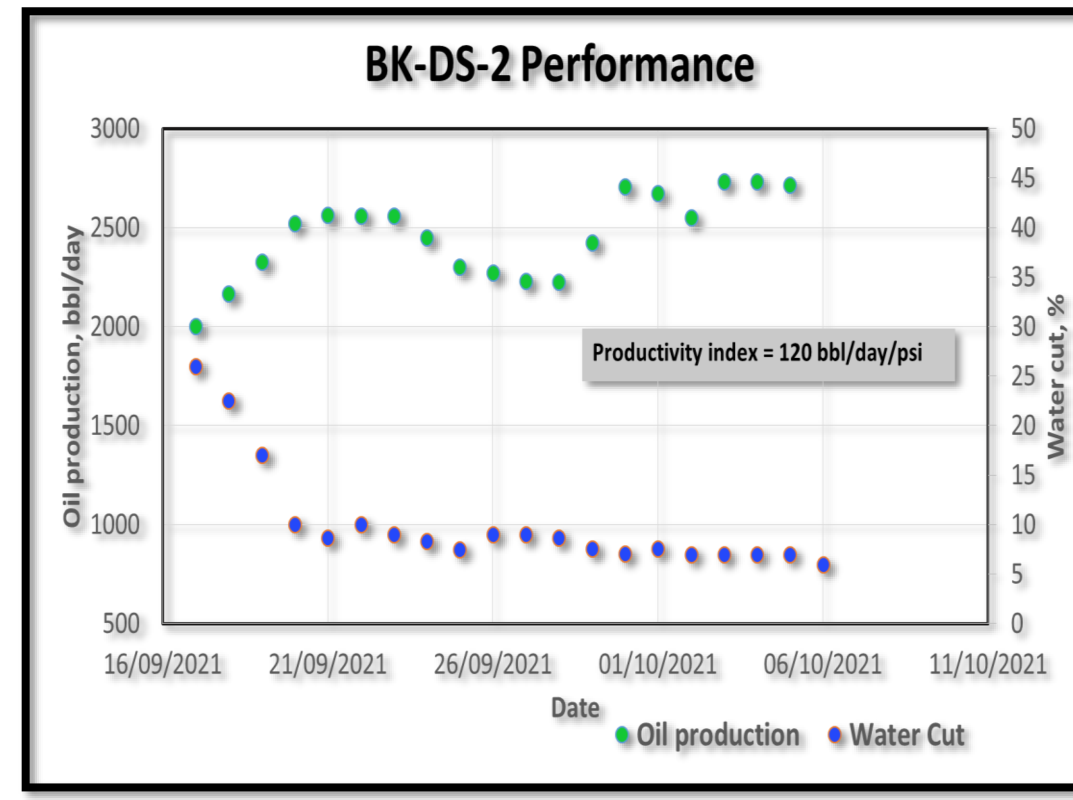
Conclusion





FOI (Qo)= 1.5

FOI (PI) = 3



Summary and Conclusion

- After comprehensive studies carried out on Miocene reefal Limestone and in participate with all geological and reservoir engineers teams new success achieved and high reserve added
- The main factor affecting controlling the reef geometry, reef thickness and reef facies type are Structure (Paleo high) and Depositional setting
- Diagenesis play an important role in reservoir quality.
- Continue for more discoveries based on the results of studies
- An integrated workflow between G&G and Engineering aid in better reservoir characterization.
- Proper Stimulation design can improve well productivity.

Thank You