

**Thebes Appraisal Study:
Integrated Approach
GUPCO**



❑ Regional Understating for Eocene in GoS

- Regional Facies
- Regional Isopach
- Outcrop Analogue
- Eocene Source rock & Temp. Maps

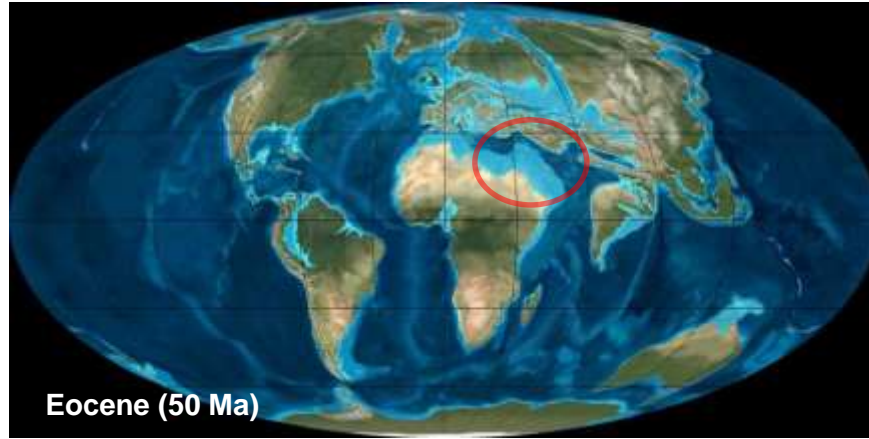
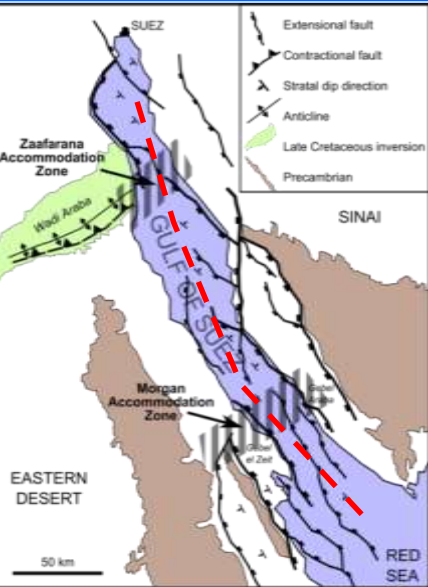
❑ GUPCO's Appraisal Cases

- Thebes FM. Zonation
- Conventional & Side-Wall Core
- Petrophysical Characterization (ex. October Field)
- Two Dimensional Fluid Characterization T2-Diffusion
- Sidki Field Case

❑ Reservoir Engineering

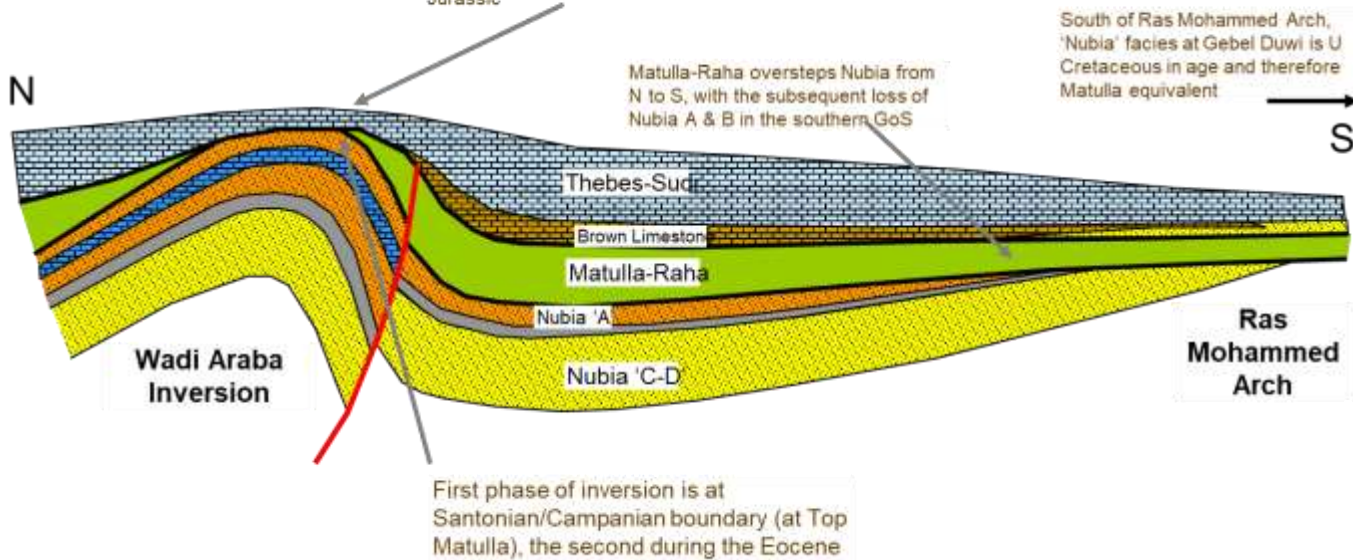
- Perforation & Acid Stimulation
- Well Performance
- Pressure Build-Up (PBU) Test
- Conclusion – Successful Appraisal & Findings

Eocene Sequence in Gulf of Suez



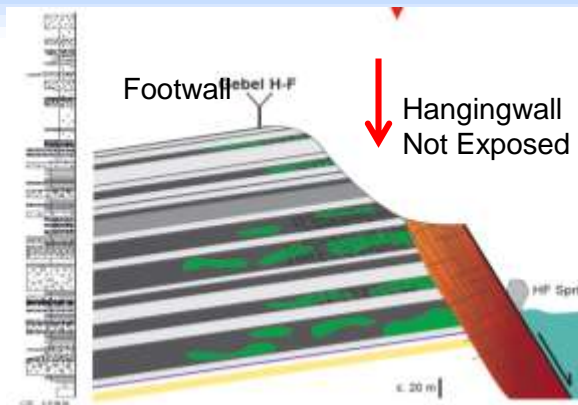
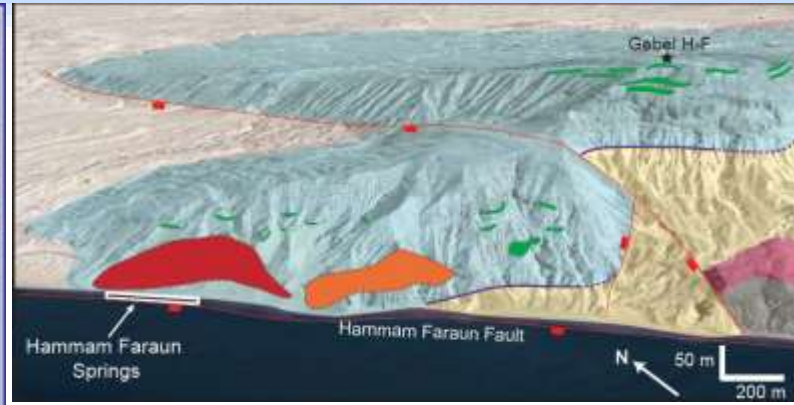
Eocene (50 Ma)

N from Wadi Araba, Nubia 'A' stratigraphy is that of N Egypt/Western Desert (Masajid, Khatatba etc.) & marks the southern edge of marine Jurassic

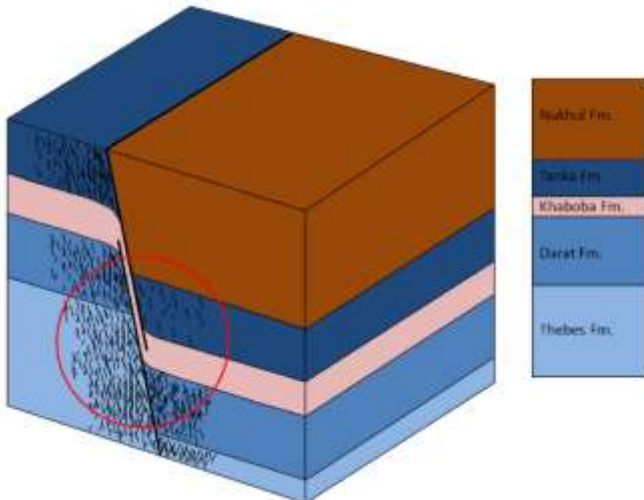
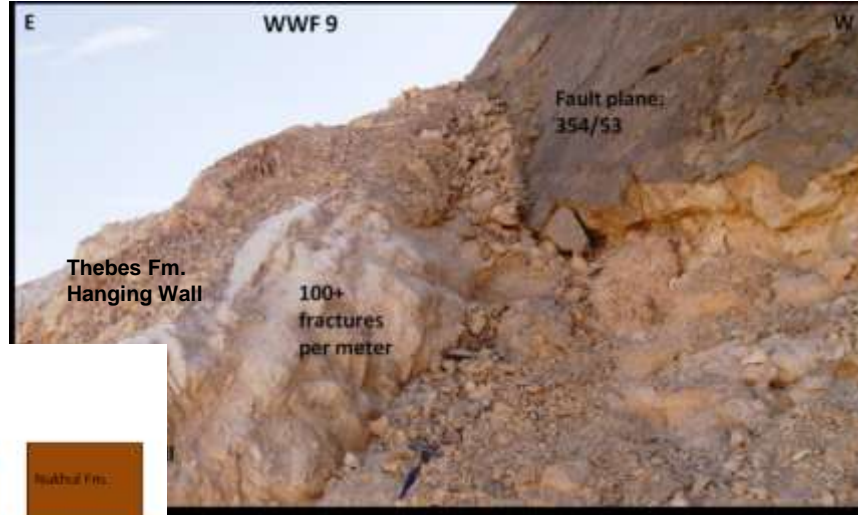


Era	Period	Epoch	Group	Formation	Lithology	Tectono-stratigraphy
Cenozoic	Recent/Pliocene		EITor	Zafarana	[Lithology]	Post-rift
				Wardan		
	Miocene	Upper	Ras Malaab	Zeit	[Lithology]	Syn-rift
				South Gharib		
		Middle		Belayim	[Lithology]	
				Kareem	[Lithology]	
	Lower	Gharandal	Rudeis	[Lithology]		
			Nukhul/Abu Zenima	[Lithology]		
	Oligocene			Tayiba	[Lithology]	Pre-rift
				Mokattam	[Lithology]	
Eocene	Upper	El Egma	Thebes/Waseilyt	[Lithology]	Pre-rift	
			Esna	[Lithology]		
Paleocene			Sud Duwi/Thehmet	[Lithology]	Pre-rift	
			Matulla	[Lithology]		
Mesozoic	Cretaceous	Upper	Nazazzat	Wata	[Lithology]	Pre-rift
				Raha		
				Malha		
	Lower	El Tih	Qiseib	[Lithology]		
			Volcanics	[Lithology]		
			Abu Darag/Ahmeir/Rod el Hamal	[Lithology]		
Jurassic			Abu Thora	[Lithology]	Pre-rift	
			Abu Durba/Um Bogma	[Lithology]		
Triassic			Naqus	[Lithology]	Pre-rift	
			Araba	[Lithology]		
Permian			Arabian-Nubian Shield	[Lithology]	Pre-rift	
				[Lithology]		
Carboniferous	Upper	Ataqa		[Lithology]	Pre-rift	
				[Lithology]		
Cambrian	Lower	Qebliat		[Lithology]	Pre-rift	
				[Lithology]		

Hamam Faruan Block Outcrop of Eocene

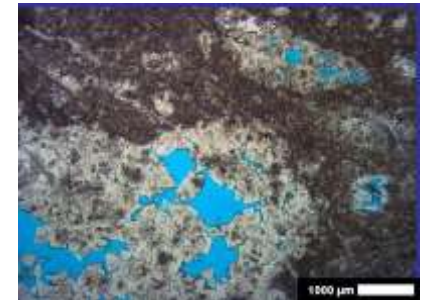


J. Hirani, et al 2012



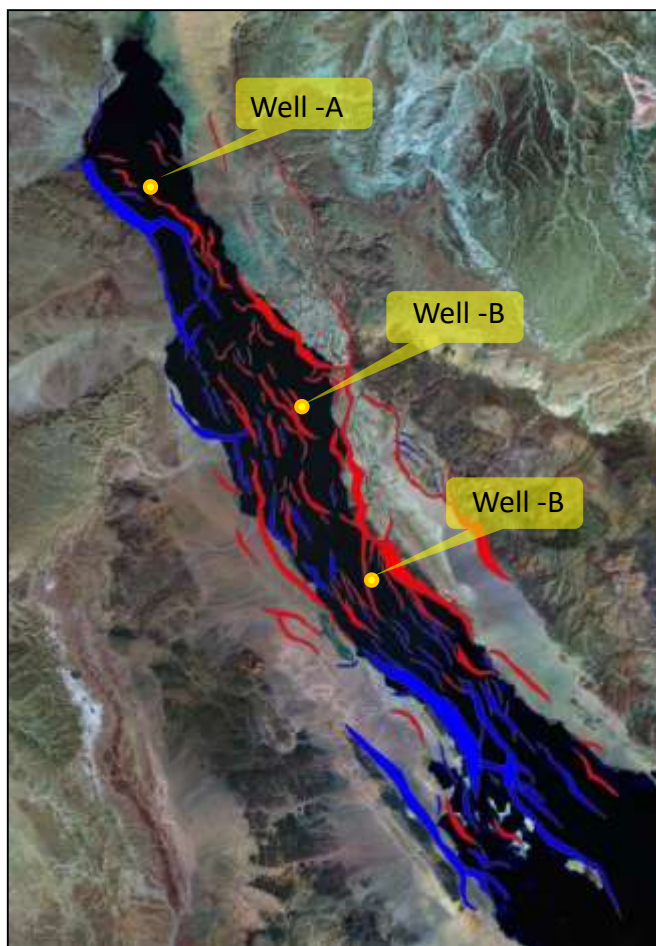
The fault plane (relatively discrete slip surface) and the highly fractured Thebes Fm. hanging wall. Note the hammer for scale.

- Fracture Pattern near faults
- Dolomitization

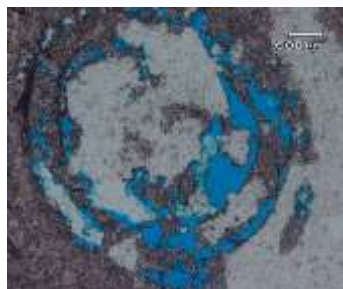


Dolomite in Thin Section

Eocene Cored Wells in GUPCO



Well -A, 15503.3, 100 X, PPL



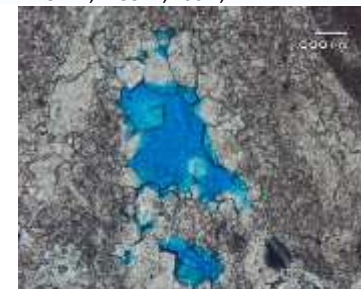
Moldic porosity, Dolomitization within the mold

Well -A, 15506.5, 40X, PPL



Fracture filled with Sparry calcite

Well -A, 15512, 200 X, PPL



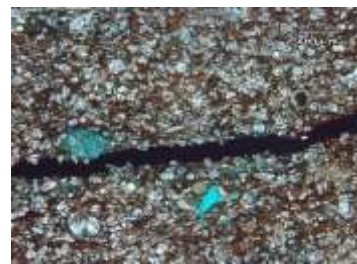
Intercrystalline porosity due to calcite recrystallization

Well -C, 11614, 40X, PPL



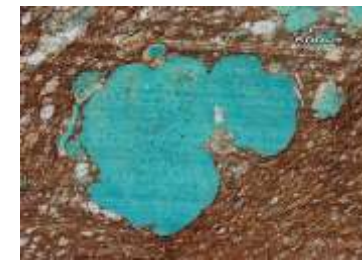
Micritic packstone with pyrite replacement of organic matter

Well -B ,SWC 12447, 40X, PPL



Fractured filled with Asphaltene

Well -B,SWC, 12486, 100X, PPL

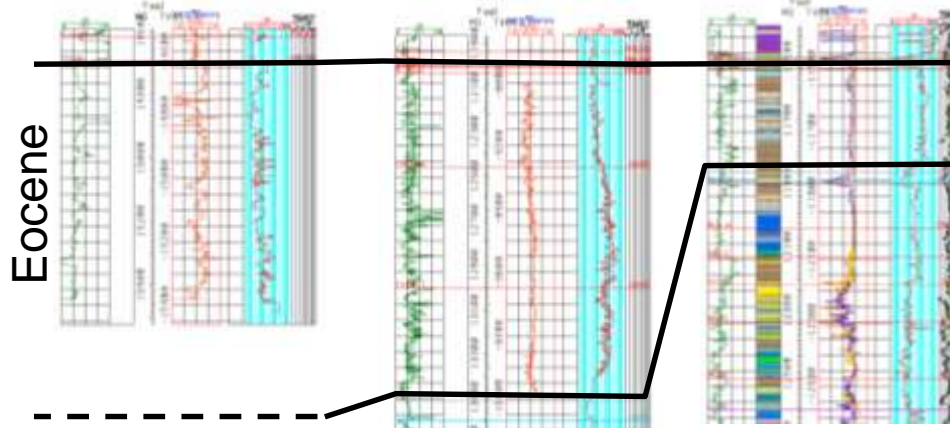


Wackstone with vuggy porosity of about 7%.

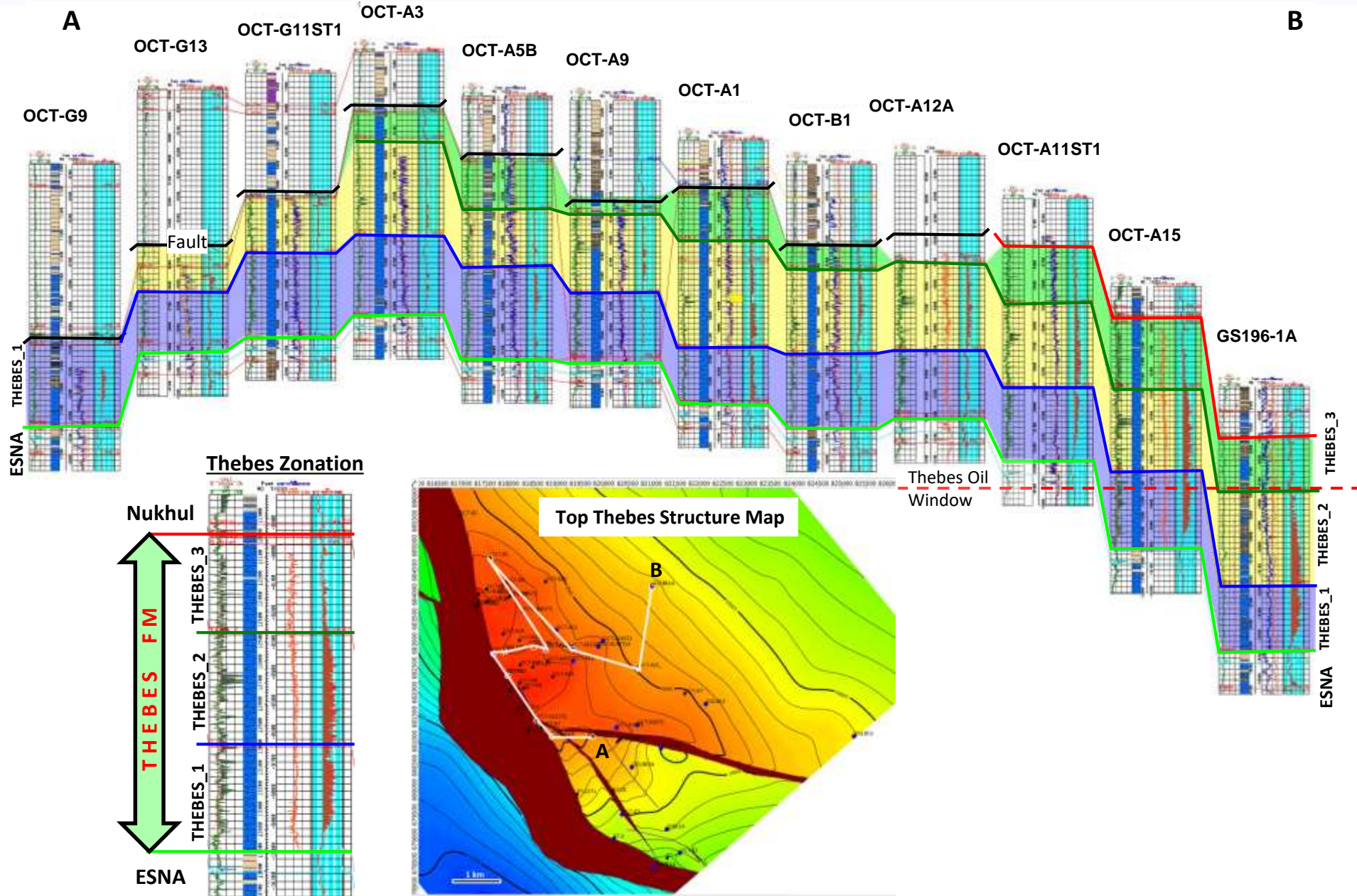
Well -A

Well -B

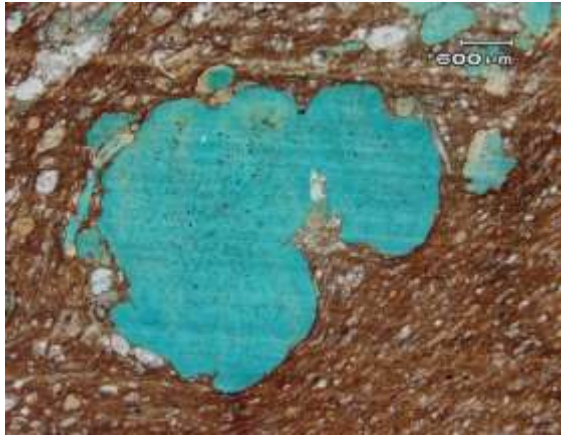
Well -C



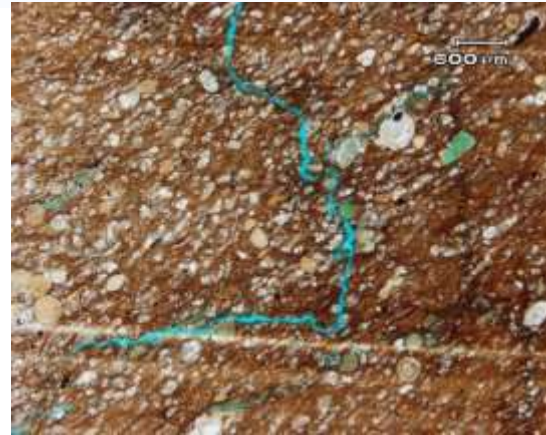
Thebes FM. Zonation in October Field



OCT-A15 Thin Sections (Side-Wall Core)



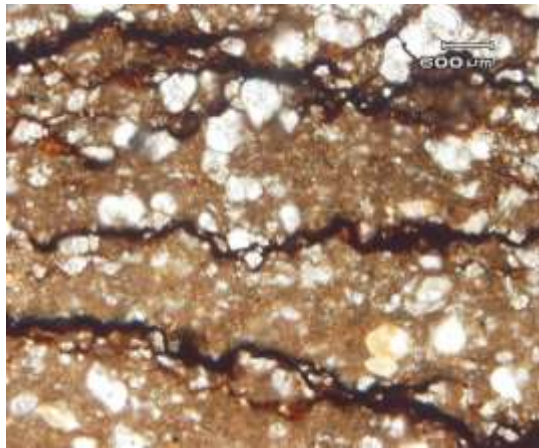
Vuggy porosity represent about 7% of the rock within wackstone.



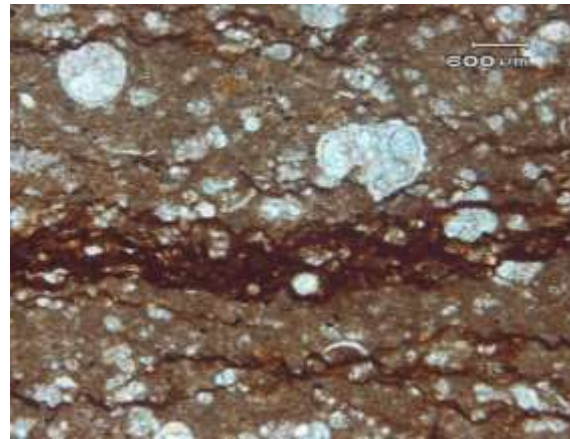
Micro-Fractured porosity with siderite and reworked Glauconite.



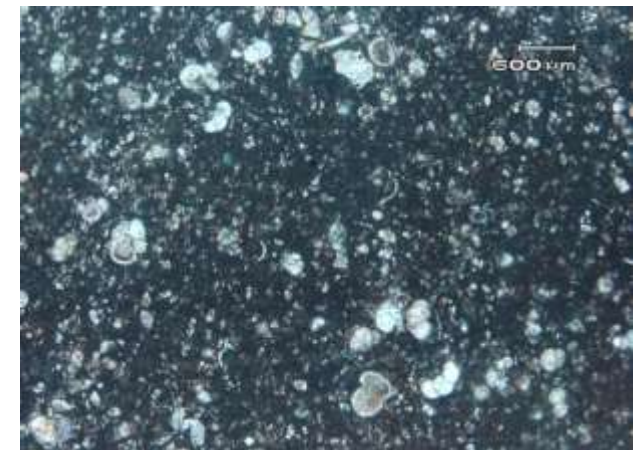
Fracture filled with sparry calcite due to Mesodiagenesis events.



Pathway moved in oriented direction around fossils and also cut the fossils itself

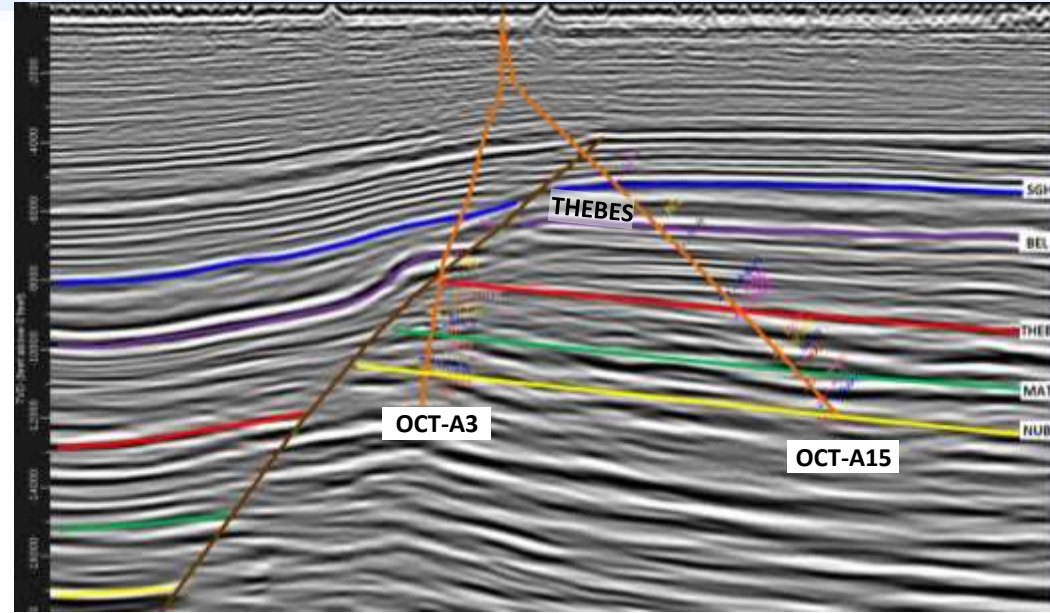
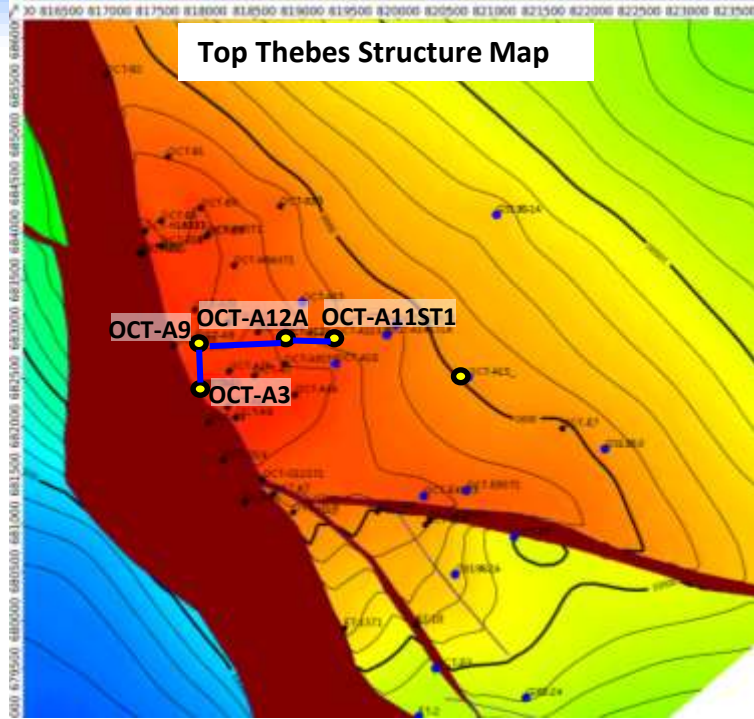


Bitumen filled Paleo fracture pathway with Spary calcite filling the cast of the Globogerinoides.

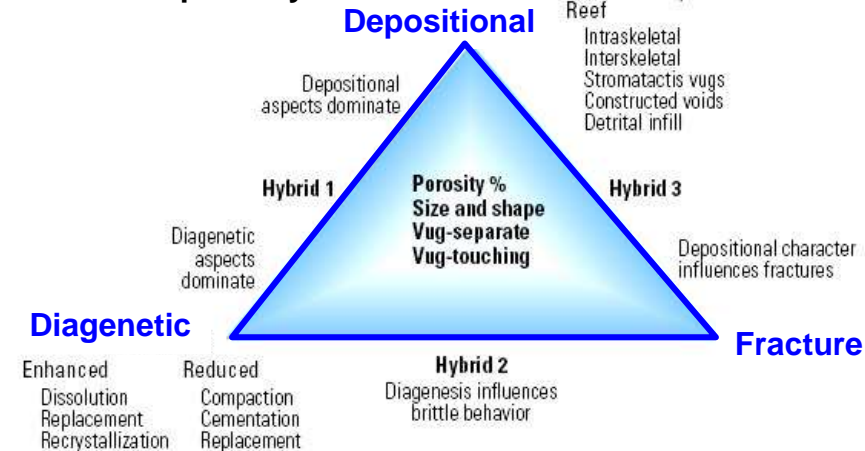


Micritic Wackstone with sparry calcite filled all Globogerinoides cast.

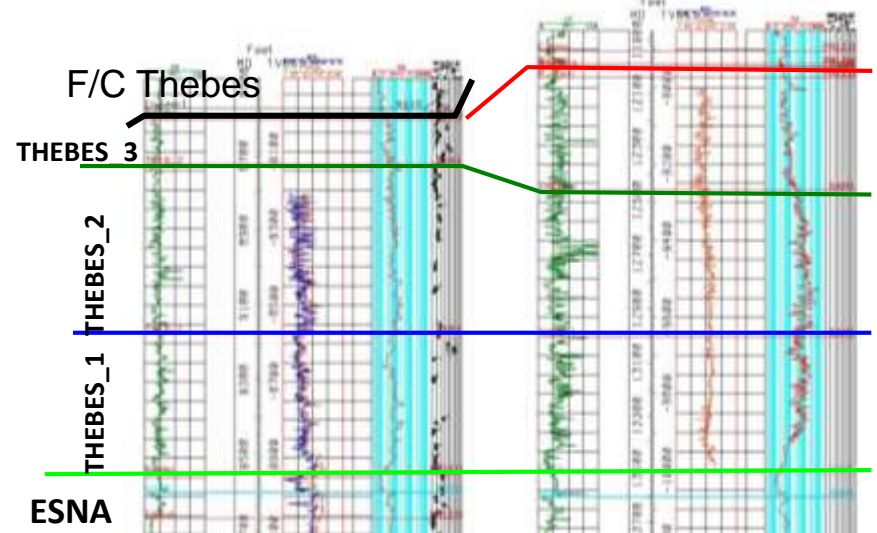
October (A) Platform Selected Wells for Study



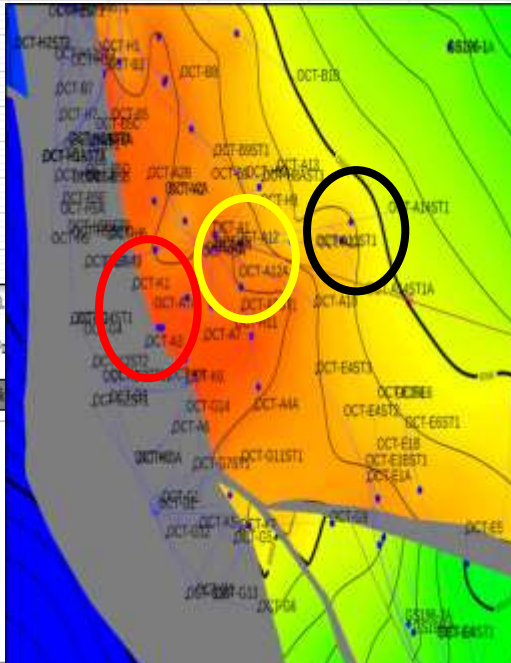
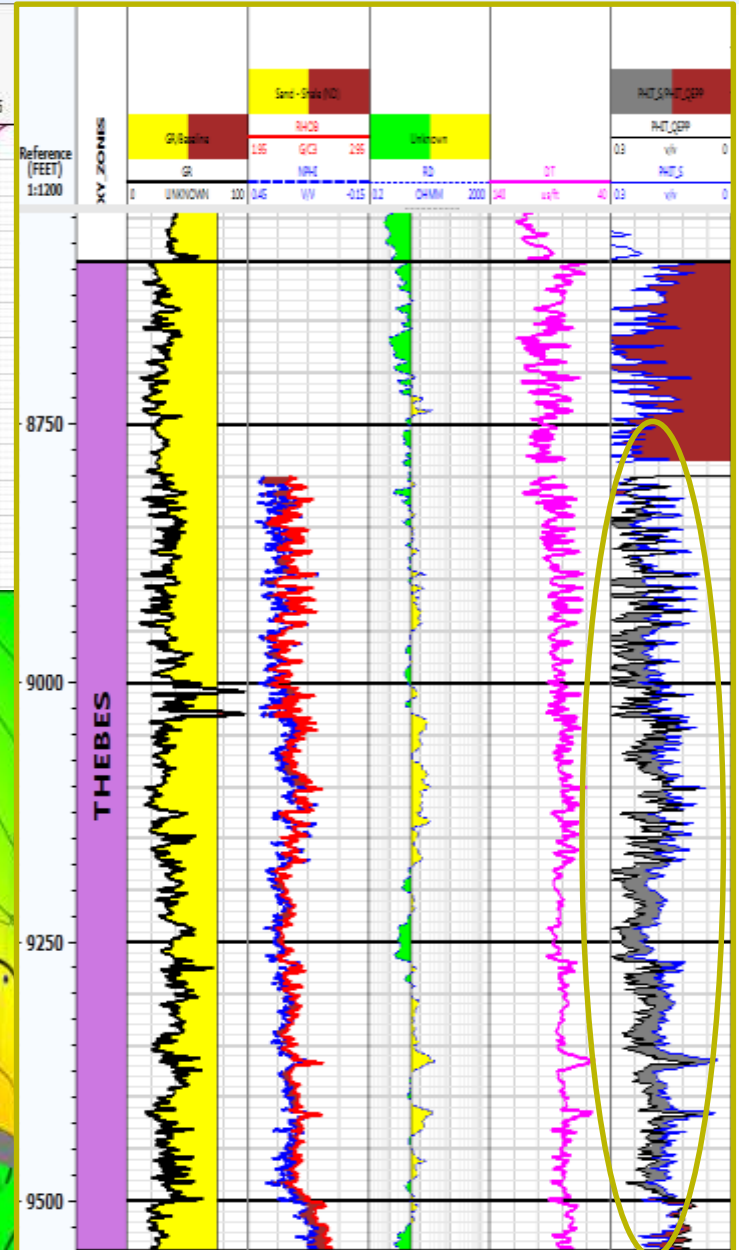
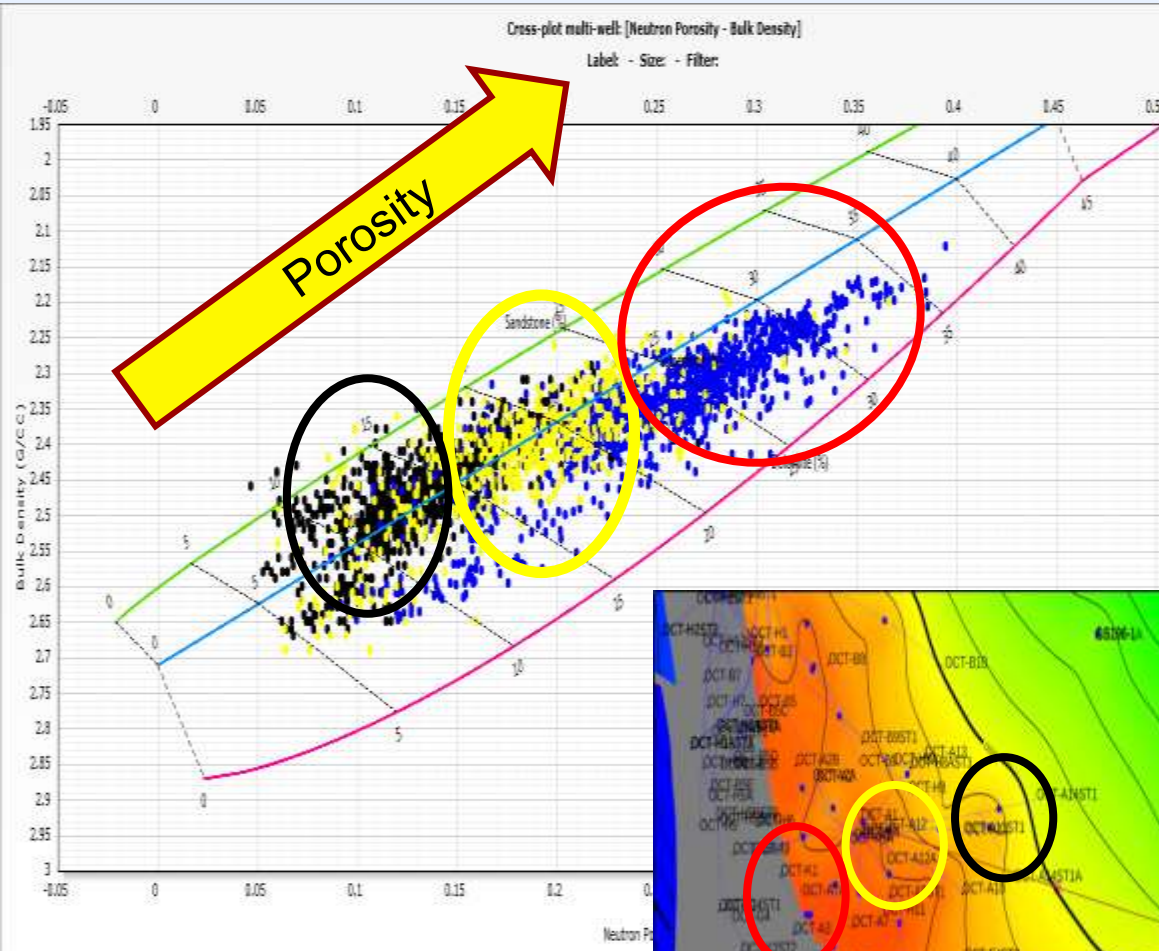
Genetically classification of Carbonate porosity



OCT-A3



October "A" Platform- Petrophysical Characterization

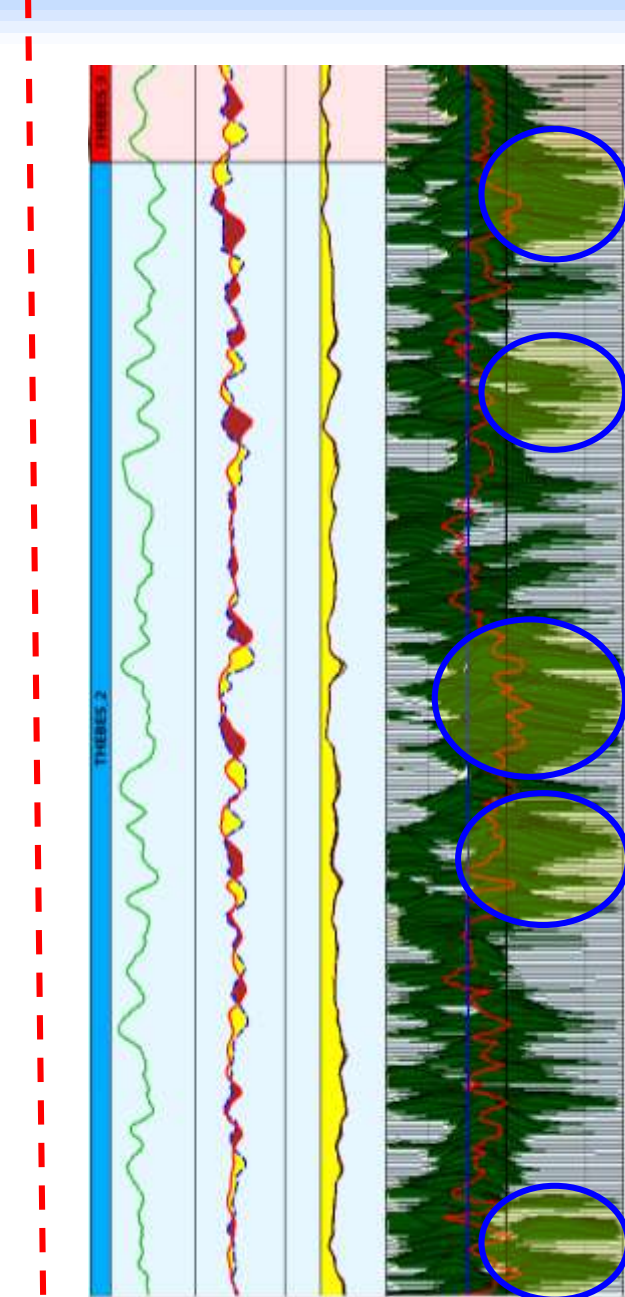
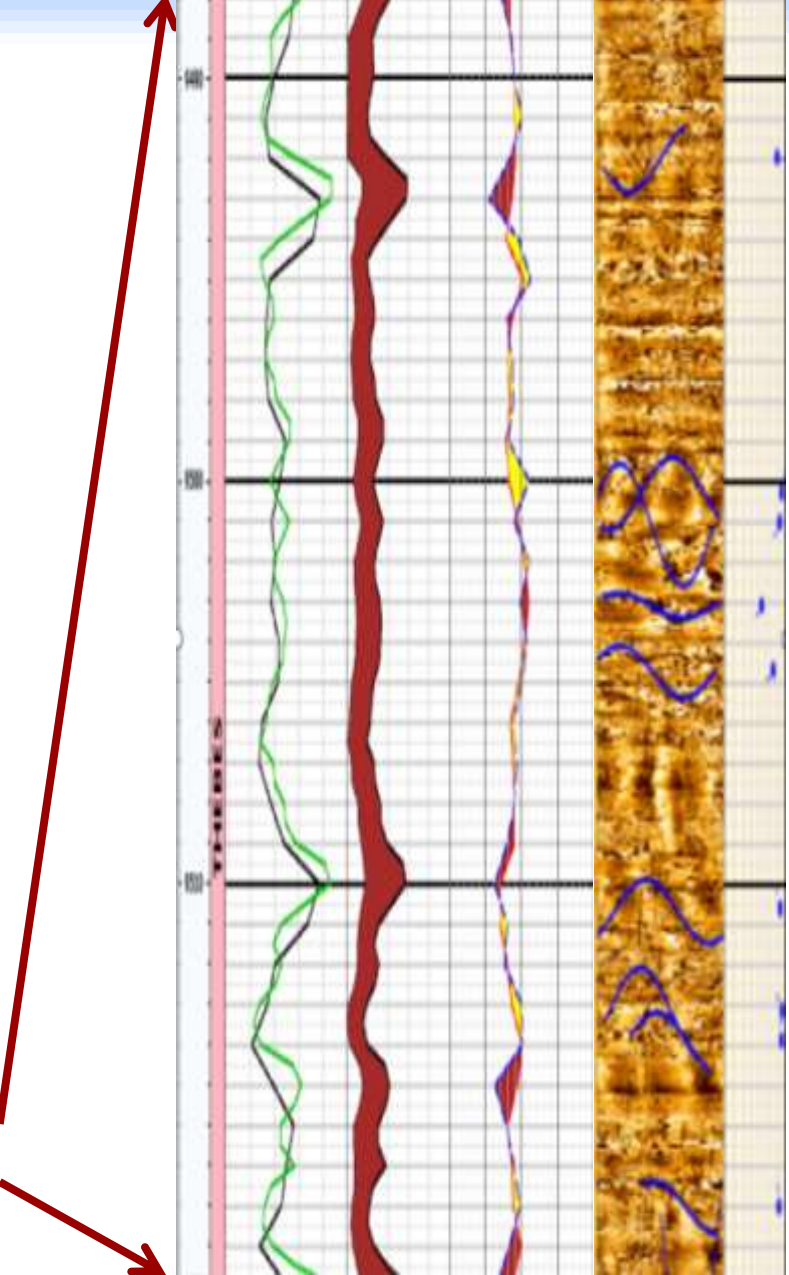
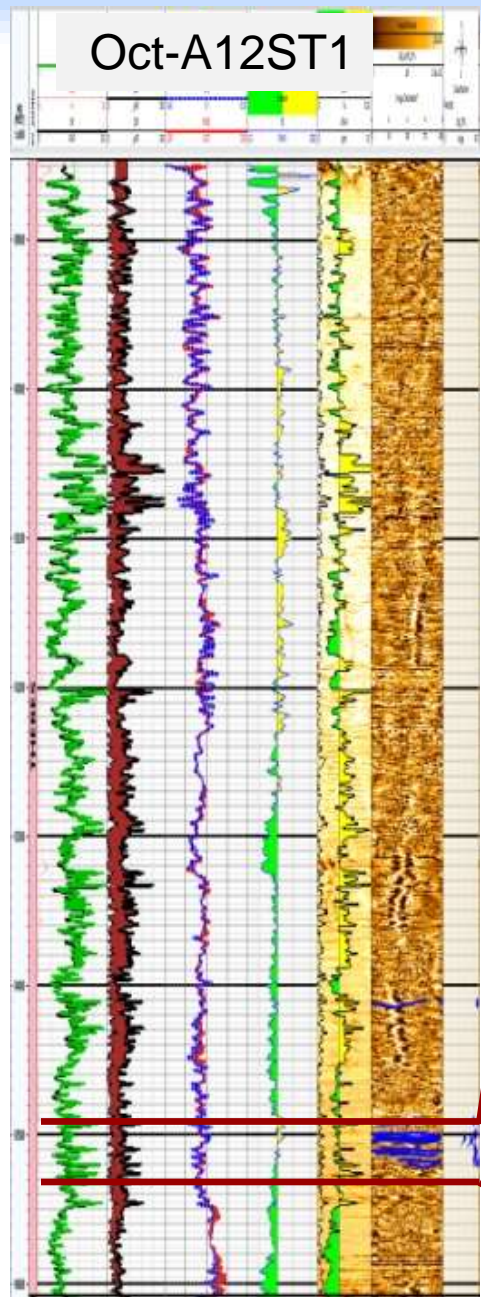


Charts:
Schlumberger, CP-1c & CP-1d, Neutron Porosity vs Bulk Density, NPH (rho = 1 g/cm³)

Wells:
W129-USA_UND_CAD_MEMORY
OCT-A1_WIRE
OCT-A11ST1_WIRE
OCT-A9_WIRE

Zonation: XY_ZONES_2
THEBES_1

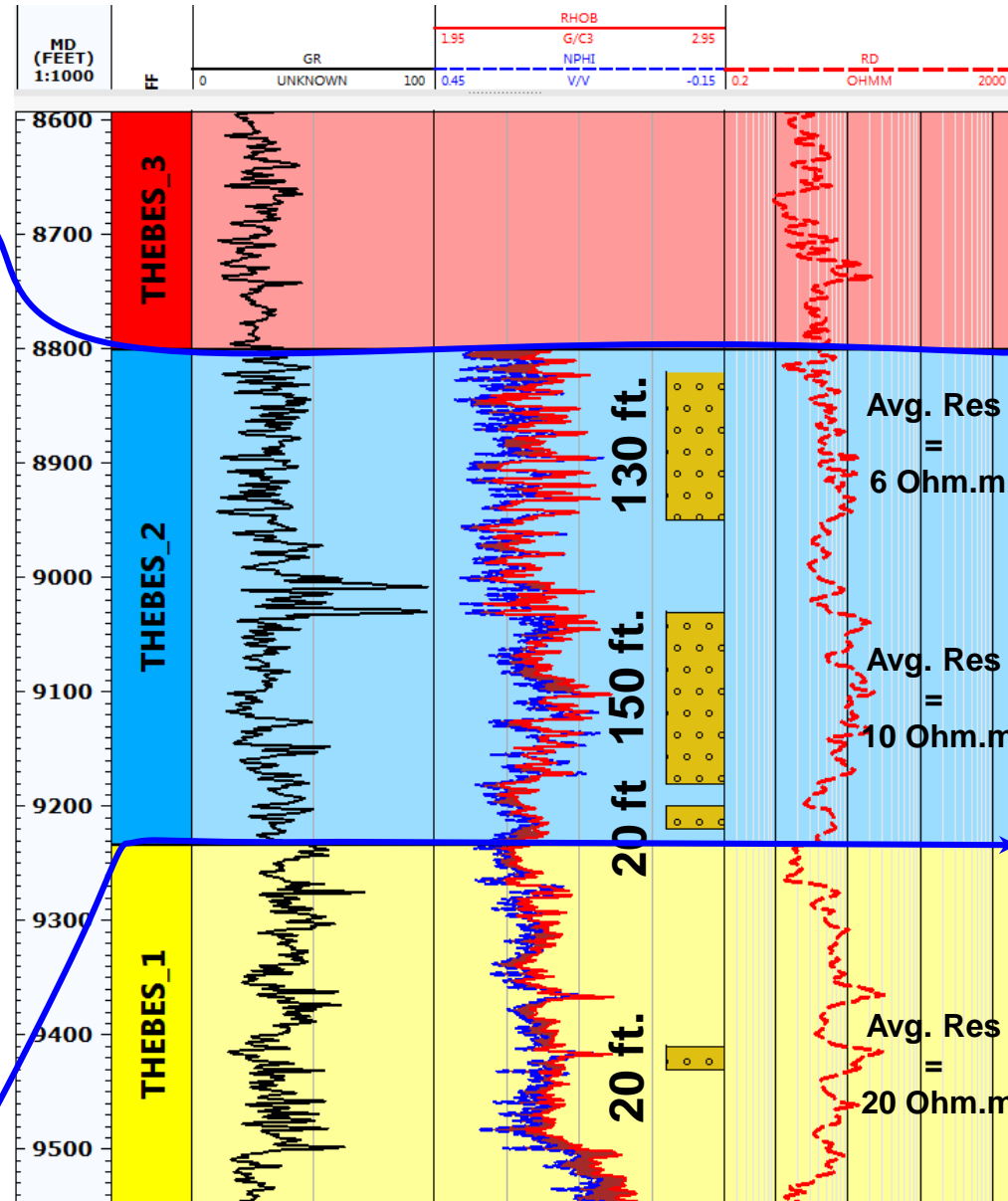
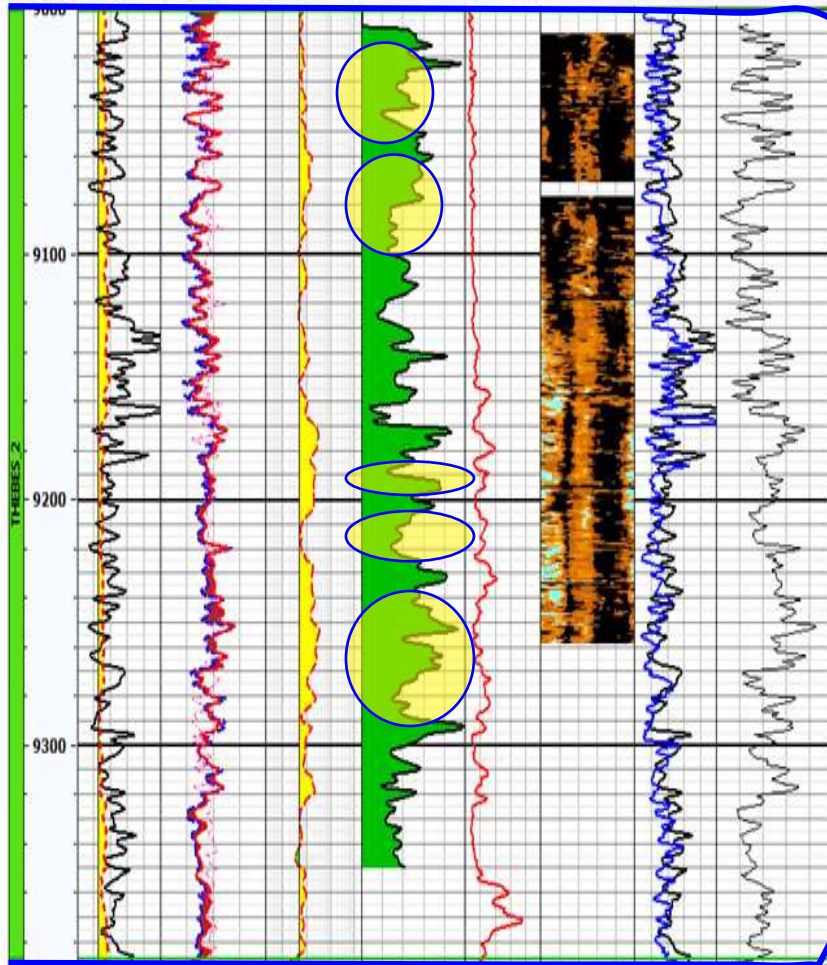
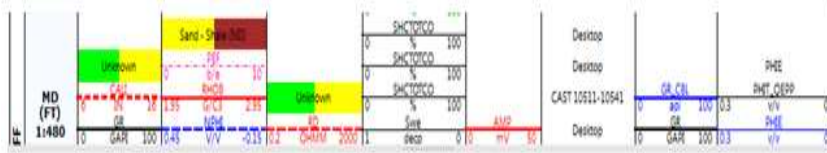
October "A" Platform- Petrophysical Characterization



OCT-A3 Perforation



Oct-A3 Perforation Intervals



- The average total porosity is around 20 PU, which may be considered an indication for facies enhancement.
- Deficit between sonic and density – neutron porosity support secondary porosity presence. Unfortunately we don't have any advanced tools to evaluate the secondary porosity in detail.

Challenges:

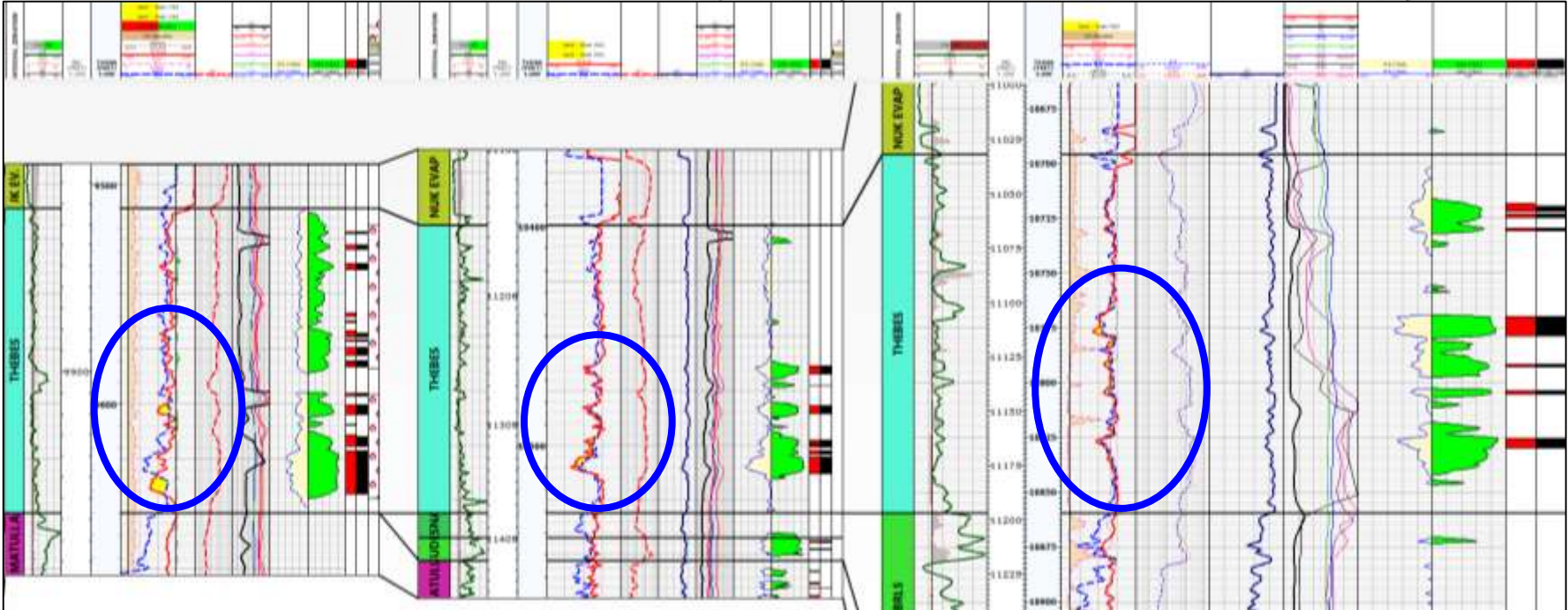
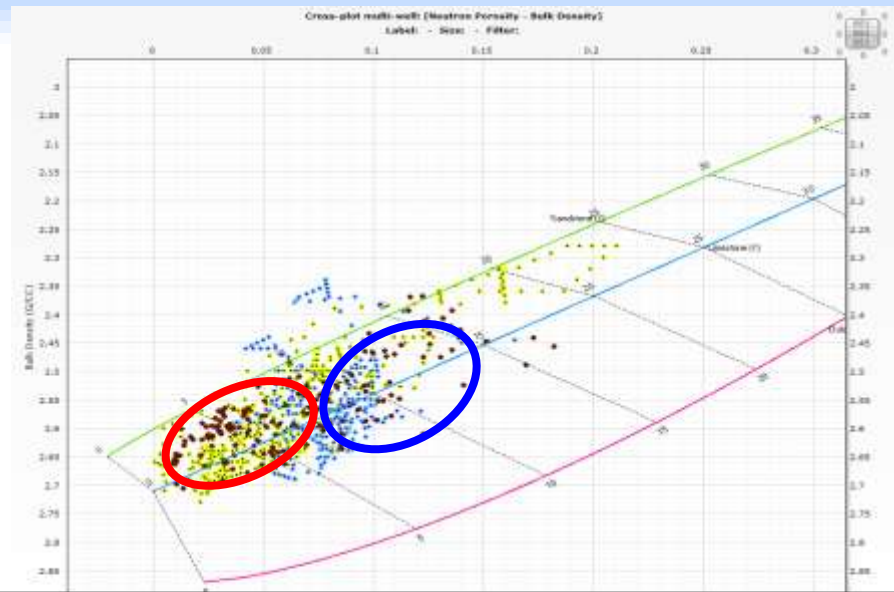
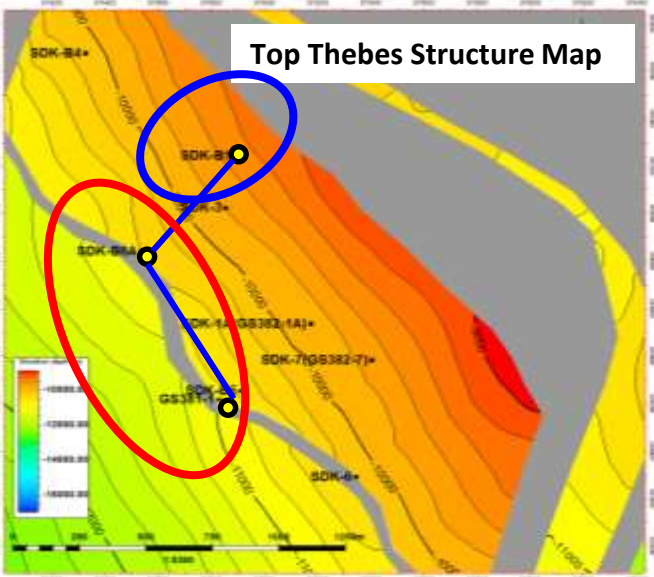
- Oil Saturation is a big concern, as we don't have enough information about
 - 1- the Water resistivity (R_w).
 - 2- cementation (m).
 - 3- saturation exponent (n).
- Residual oil saturation content

Thebes is known as a source rock to have heavy oil (10-15 API) in addition to Kerogen volume which is a big concern.

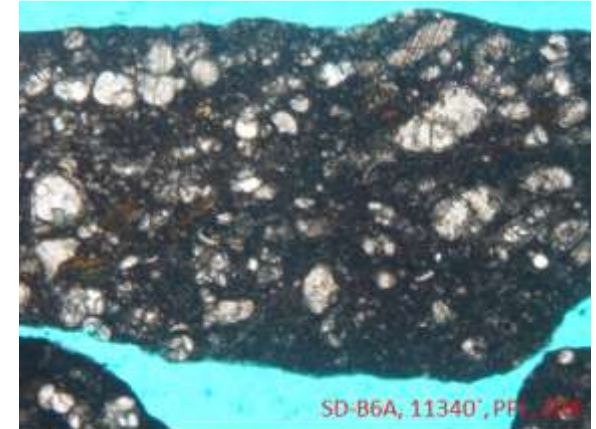
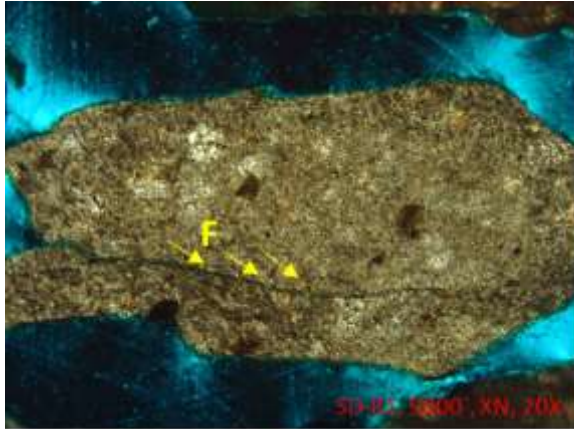
Sidki Selected Wells for Study



Top Thebes Structure Map



Sidki-Well#1 Thin Sections



Drilling cutting investigation for reservoir quality tracking indicated that :

1-The main limestone composition is the Wackstone to Grainstone with no obvious moldic or vuggy porosity.

2-Chert accumulated and created Partially open fractures which have been recorded in the cuttings of Chert nodules addressing the increase in permeability due to creation of fracture corridors.

Conclusion:

In Sidki Field, the chert brittleness increase the reservoir quality and form fractured reservoir.

Tracking the chert distribution and fracture propagation will increase reservoir potentiality.



Reservoir Engineering

October Field

OCT-A3: Perforation & Acid Stimulation



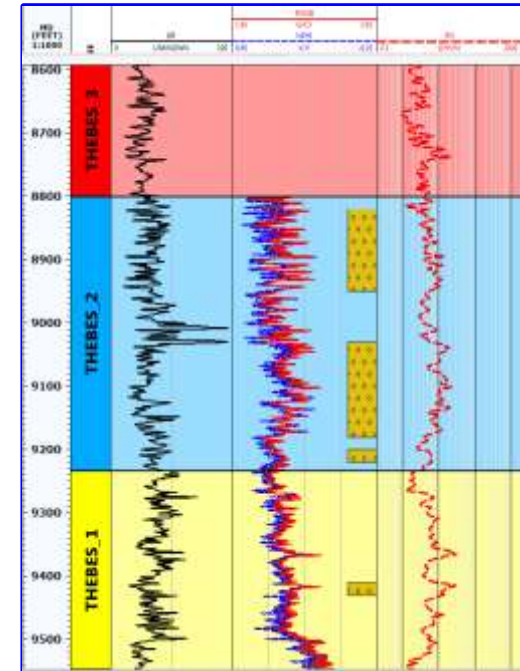
- **CBL-VDL** was run, then 4 5/8” **TCP Perforation (47” penetration)**
- **Coiled Tubing** was used to inject acid across perforation intervals
- **Stimulation Fluids** (at max rig capacity):
 - **Pre-flush:** Clay Fix to prevent formation clay reactions
 - **Main treatment:** consists of main two stages:
 - **1st stage:** 250 bbl of acid (15% HCl + 5% Acetic Acid)
 - **2nd Stage:** 500 bbl of Carbonate Stimulation Acid (CSA)
 - **Post Flush:** Clay Fix
- Acid Dose was ± 100 gallon / foot

Well Performance



- **After completing the well, and stimulating it:**
 - **First well rate was ± 1000 BFPD** (estimated)
 - **WC was measured above 90%**
 - After **two weeks, PLT** was run showing:

Intervals ft. ORKB	Length, ft.	Zone	Q_o , BOPD	Q_w , BWPD	Q_t , BFPD	WC	% Total	Remarks
8820 - 8950	130	Thebes	0	0	0	0%	0	Not Contributing
9030 - 9180	150	Thebes	3	167	170	98%	57%	
9200 - 9220	20	Thebes	3	127	130	98%	43%	
9410 - 9430	20	Thebes						
Total			6	295	300	98%	100%	



- The well was **flowing naturally**.

Note:

Estimated **PI** for **Thebes** is **0.006** BPD/psi/ft. compared to..

0.11 BPD/psi/ft. for **Nubia** formation

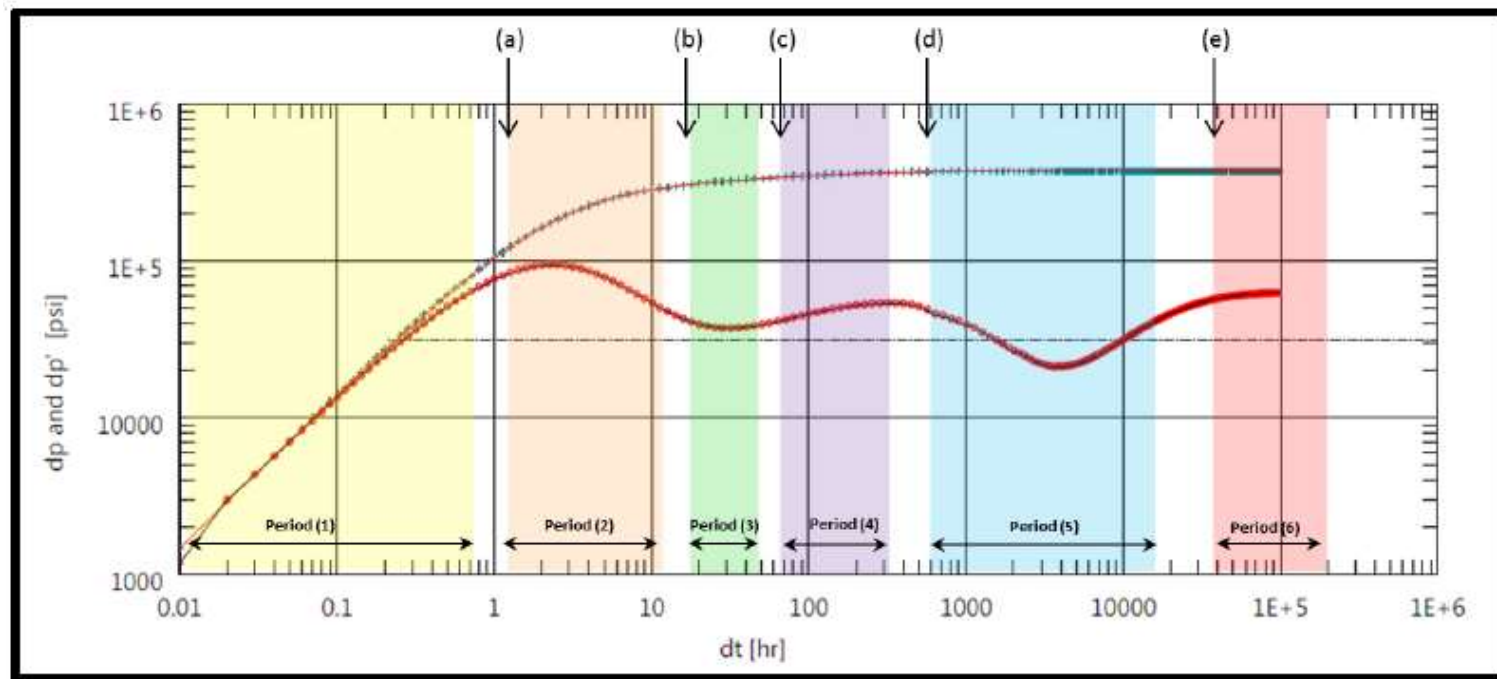
0.08 BPD/psi/ft. for **Nezzazat** formation



Pressure Build-Up (PBU) test



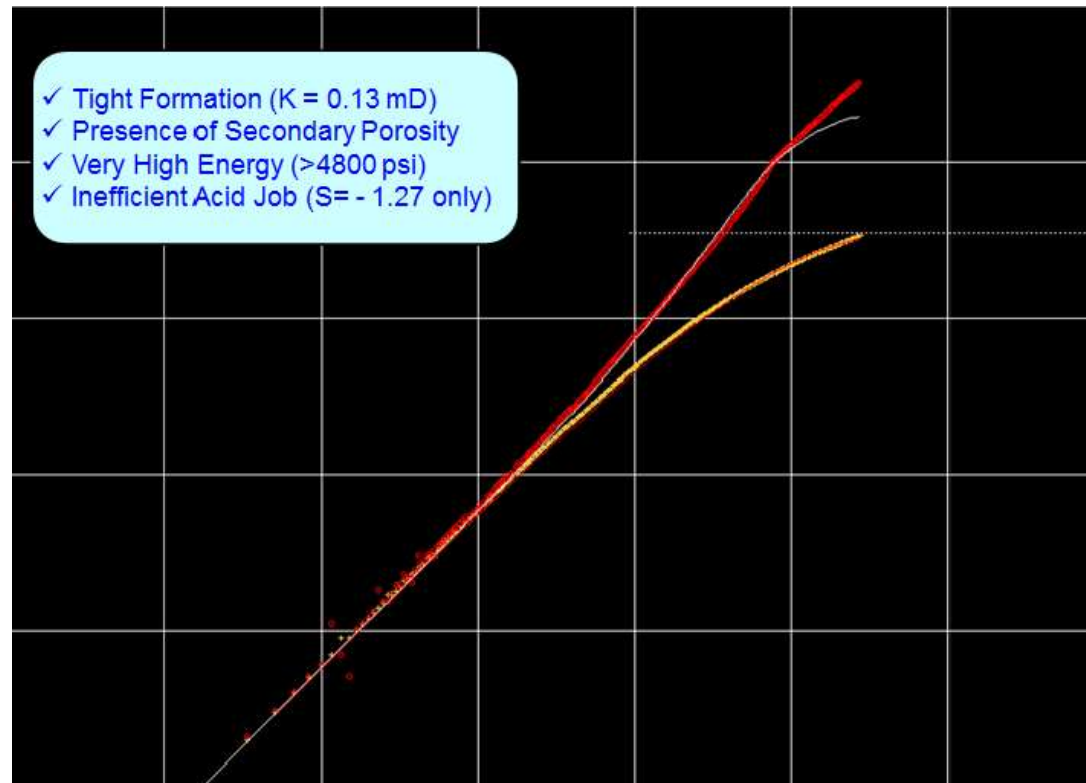
- **PBU objective was to estimate/confirm:**
 - Permeability
 - Near Wellbore Skin (S)
 - Initial Pressure
 - Presence of Secondary Porosity
- **PBU Design:**



Pressure Build-Up (PBU) Test



PBU Results



Conclusion:

- Thebes is **tight** formation with permeability equals **0.13 mD**
- Thebes rock is **dual-porosity** system (confirmed by Petrographic description).
- Thebes **energy** is very high (**$>4800 \text{ psi}$** @ 8600 TVDss) matching with Nubia and Nezzazat gradient which means they've the same pressure regime (virgin one).
- The **acid** stimulation job achieved $S = -1.27$

Oil Analysis:

- Oil has **14 deg. API**
- Couldn't collect enough oil sample for PVT

Water Analysis:

CATIONS :-

- Sodium	Na ⁺	15550	PPM
- Potassium	K ⁺	151	PPM
- Calcium	Ca ⁺⁺	538	PPM
- Magnesium	Mg ⁺⁺	106	PPM
- Iron	Fe ⁺⁺	2.8	PPM
- Manganese	Mn ⁺⁺	1.5	PPM
- Barium	Ba ⁺⁺	17	PPM
- Strontium	Sr ⁺⁺	85	PPM
- Zinc	Zn ⁺⁺	5.7	PPM
- Lead	Pb ⁺⁺	8.4	PPM

ANIONS :-

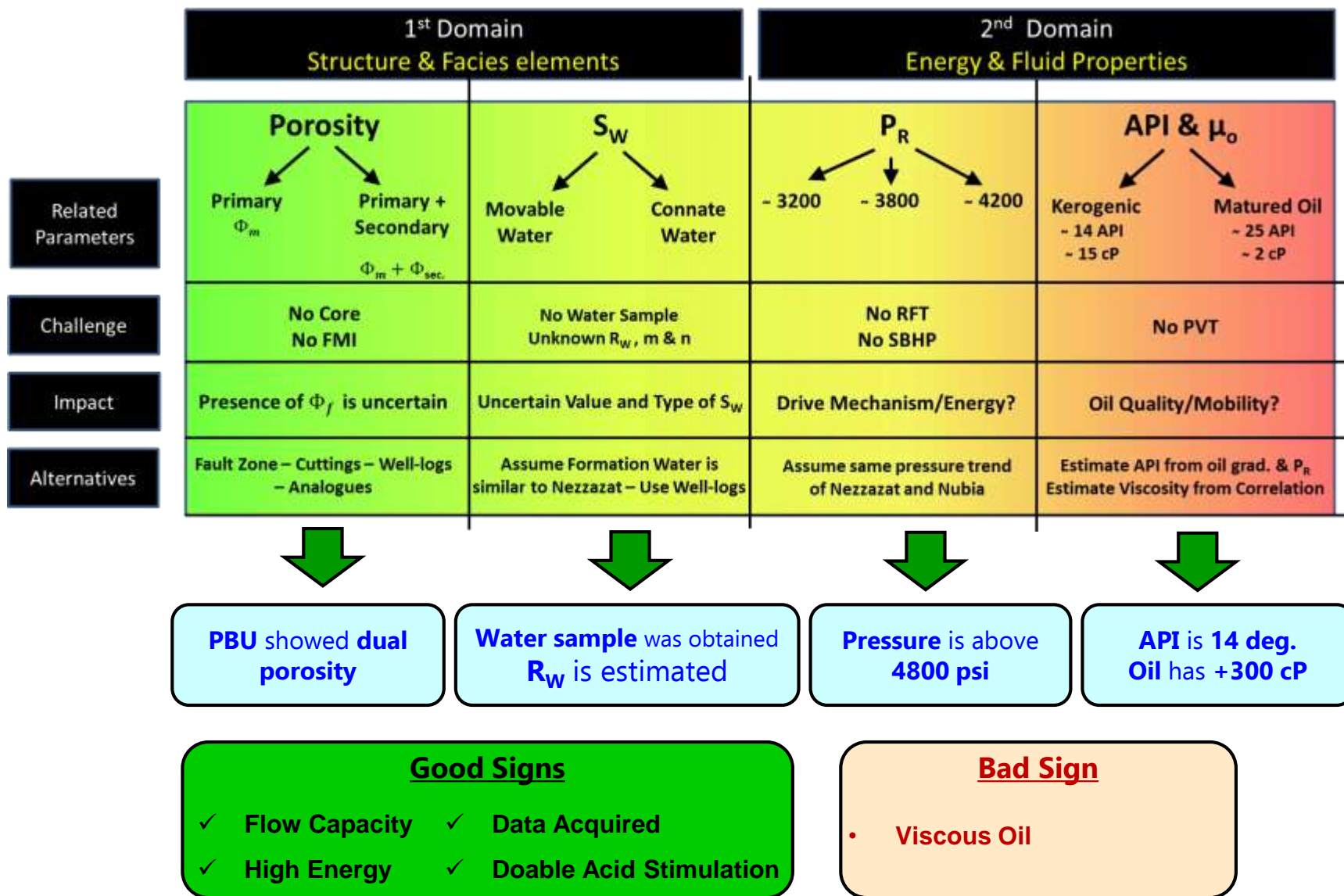
- Chloride	CL ⁻	24230	PPM
- Sulfate	SO ₄ ⁻	200	PPM
- Bicarbonate	HCO ₃ ⁻	2477	PPM
- Carbonate	CO ₃ ⁻	0	PPM

TOTAL DISSOLVED SOLIDS : 43372 PPM

Conclusion – Appraisal & Findings



GUPCO has **successfully appraised** Thebes.



Thank You