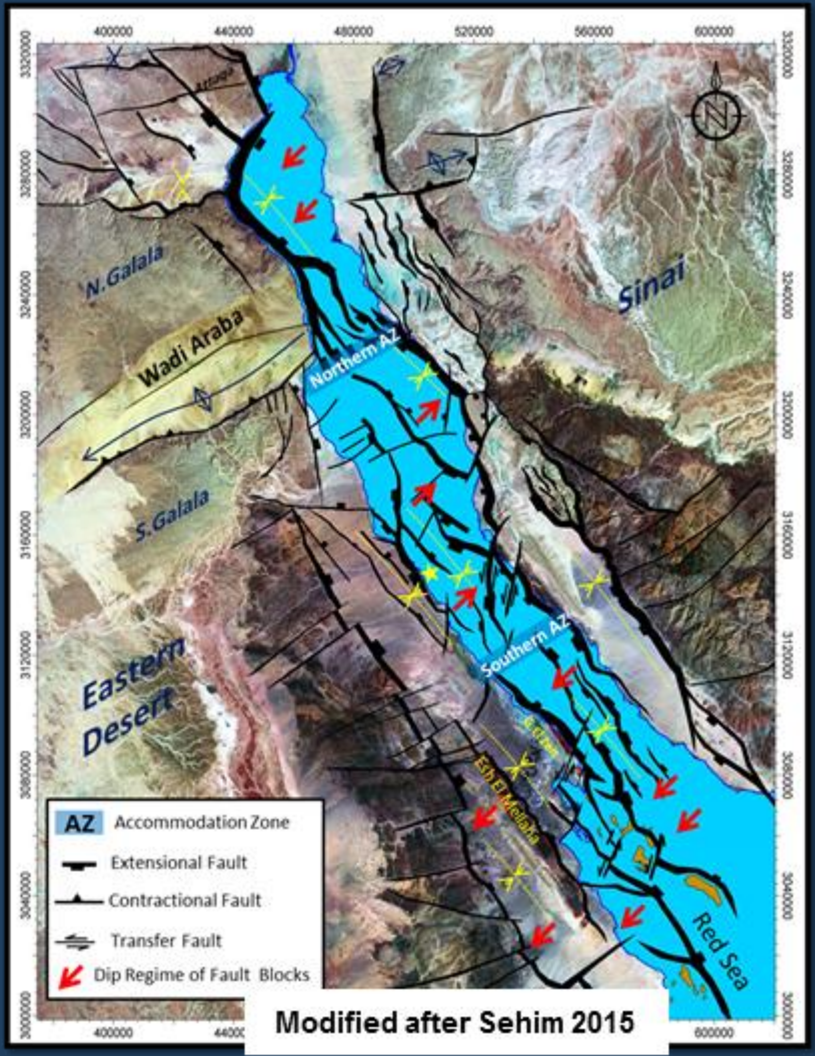
Heterogeneity, Reservoir Characterization and Integrated Simulation Modeling for Miocene Carbonate Reservoir - Ras Fanar Field – Gulf of Suez

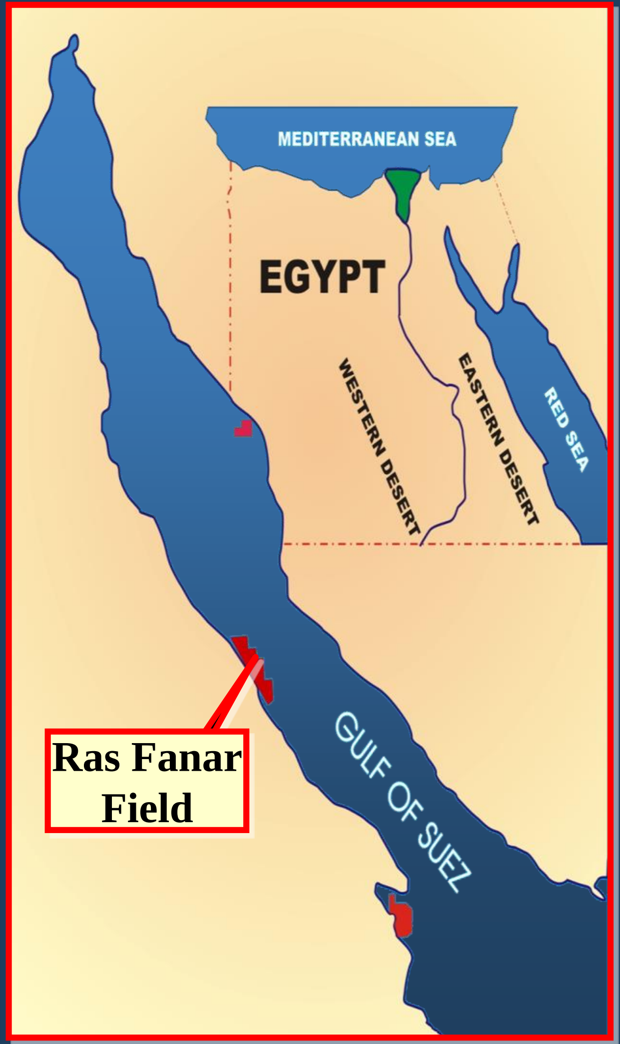
- SUCO/EGPC
- Nasser Atta (Geophysical Ass. General Mng.)
- Mohamed Samir (Reservoir Engineer)
- Under supervision: Geo. Wegdan A. Saleh

Asst. Chairman for Exploration & Board member

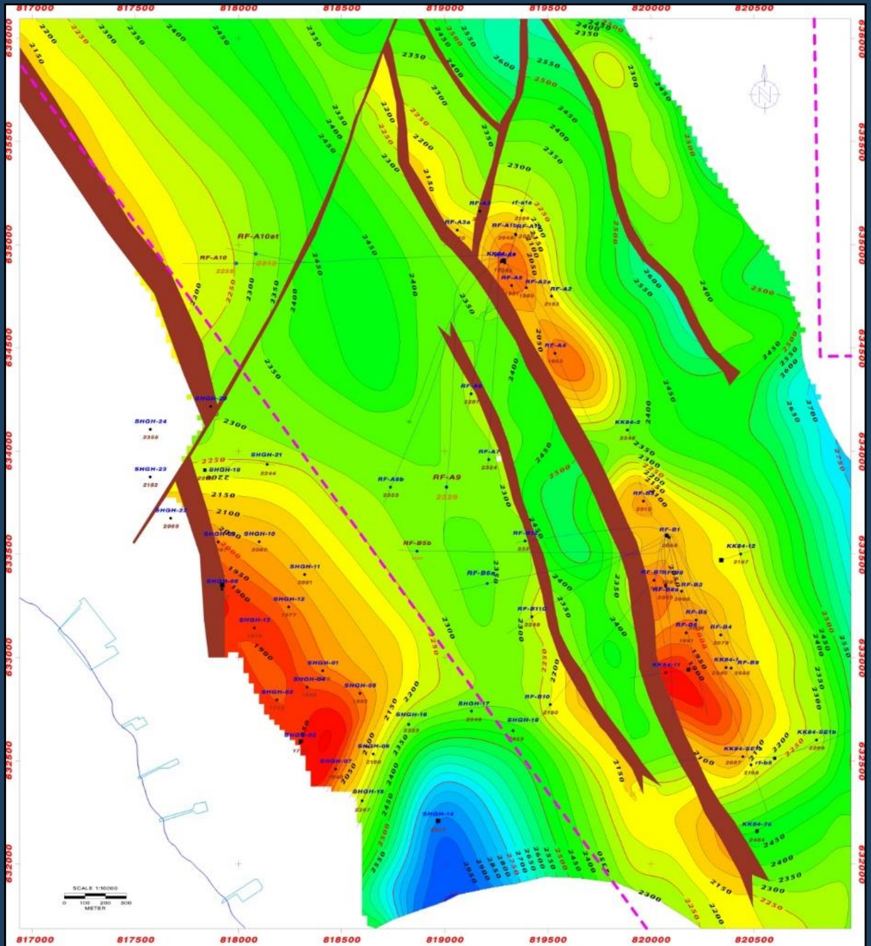
Ras Fanar Field Overview

- **Ras Fanar Oil Field Is Located Offshore Of The Western Side Of The G.O.S Some 3.5 Km. East Of Ras Gharib Shoreline In A Water Depth Of About 100 Ft.**
- **Ras Fanar Had Been Discovered In 1978 By The Exploratory Well Kk 84-1.**
- **The Well Penetrated 400 Ft Of Carbonate Oil Bearing Interval Of Bealyim "Nullipore" Formation.**
- **Production Has Been Started On January 1984.**

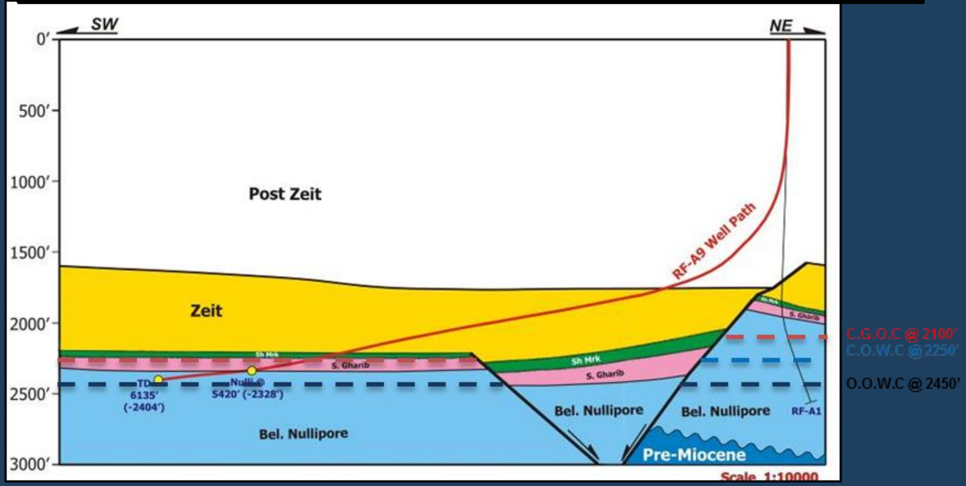


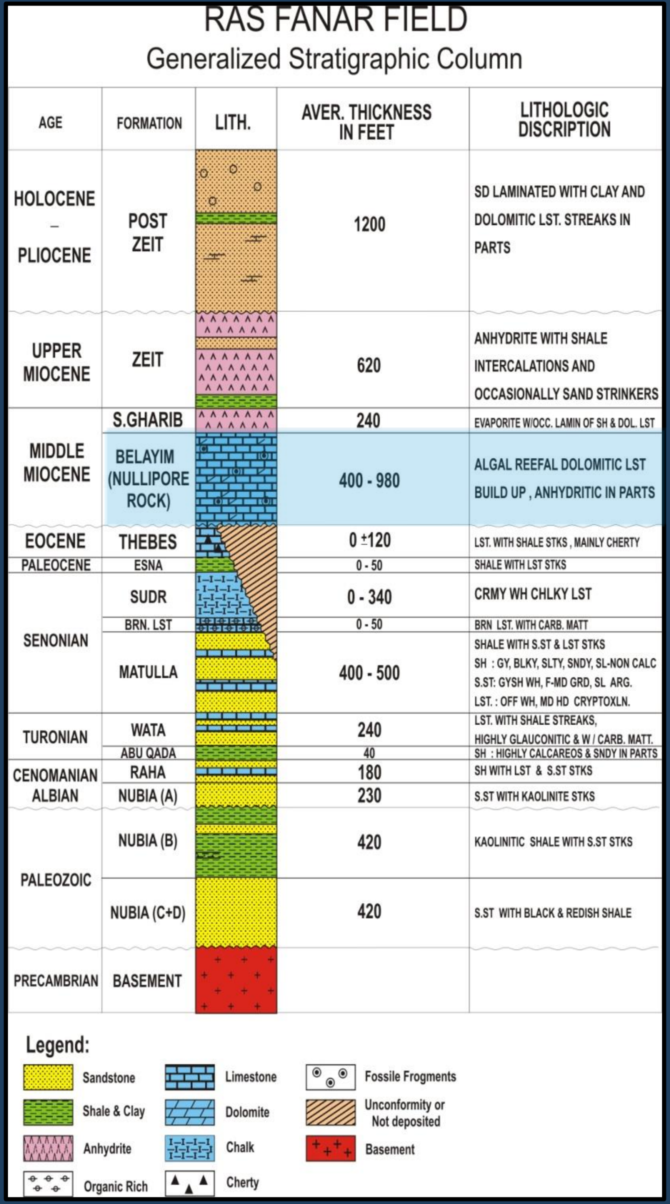


Ras Fanar Field Overview



Structure Contour Map on Top Belayim Nullipore Reservoir

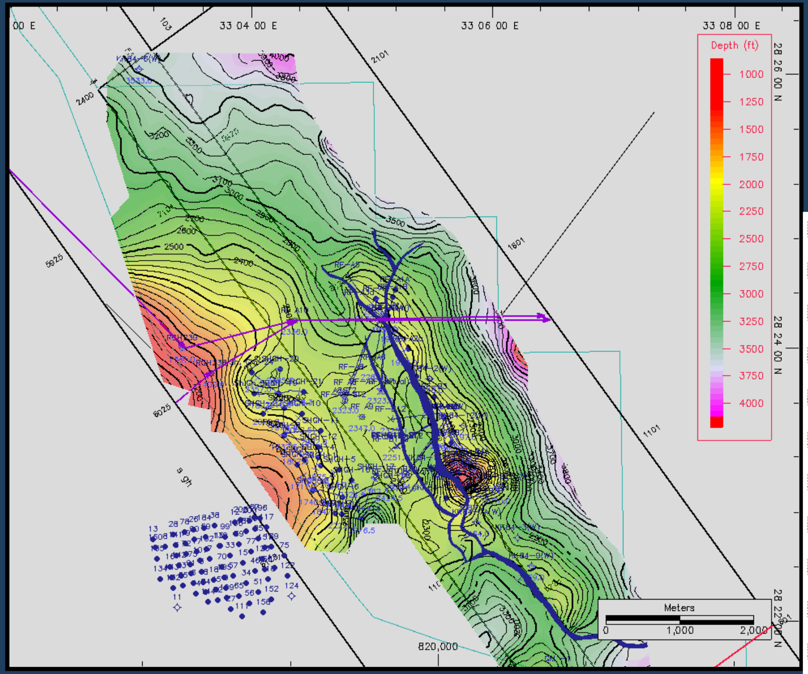




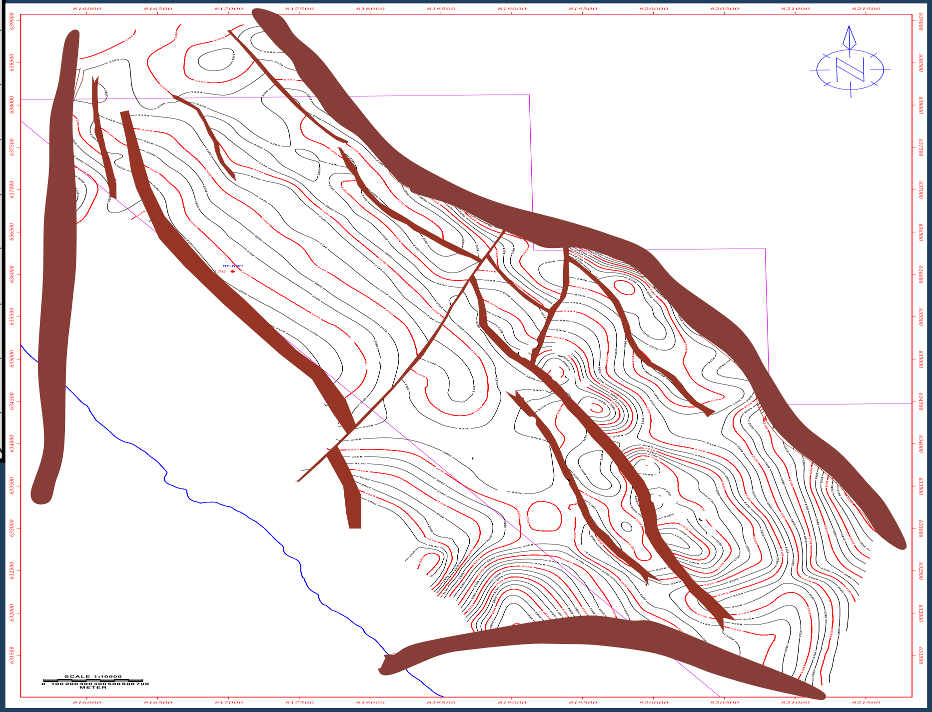
RAS FANAR FIELD
Generalized Stratigraphic Column

AGE	FORMATION	LITH.	AVER. THICKNESS IN FEET	LITHOLOGIC DISCRIPTION
HOLOCENE – PLIOCENE	POST ZEIT		1200	SD LAMINATED WITH CLAY AND DOLOMITIC LST. STREAKS IN PARTS
UPPER MIOCENE	ZEIT		620	ANHYDRITE WITH SHALE INTERCALATIONS AND OCCASIONALLY SAND STRINKERS
MIDDLE MIOCENE	S.GHARIB		240	EVAPORITE W/OCC. LAMIN OF SH & DOL. LST
	BELAYIM (NULLIPORE ROCK)		400 - 980	ALGAL REEFAL DOLOMITIC LST BUILD UP , ANHYDRITIC IN PARTS
EOCENE	THEBES		0 ±120	LST. WITH SHALE STKS , MAINLY CHERTY
PALEOCENE	ESNA		0 - 50	SHALE WITH LST STKS
SENONIAN	SUDR		0 - 340	CRMY WH CHLKY LST
	BRN. LST		0 - 50	BRN LST. WITH CARB. MATT
	MATULLA		400 - 500	SHALE WITH S.ST & LST STKS SH : GY, BLKY, SLTY, SNDY, SL-NON CALC S.ST: GYSH WH, F-MD GRD, SL ARG. LST. : OFF WH, MD HD CRYPTOXLN.
TURONIAN	WATA		240	LST. WITH SHALE STREAKS, HIGHLY GLAUCONITIC & W / CARB. MATT.
	ABU QADA		40	SH : HIGHLY CALCAREOS & SNDY IN PARTS
CENOMANIAN	RAHA		180	SH WITH LST & S.ST STKS
ALBIAN	NUBIA (A)		230	S.ST WITH KAOLINITE STKS
PALEOZOIC	NUBIA (B)		420	KAOLINITIC SHALE WITH S.ST STKS
	NUBIA (C+D)		420	S.ST WITH BLACK & REDISH SHALE
PRECAMBRIAN	BASEMENT			

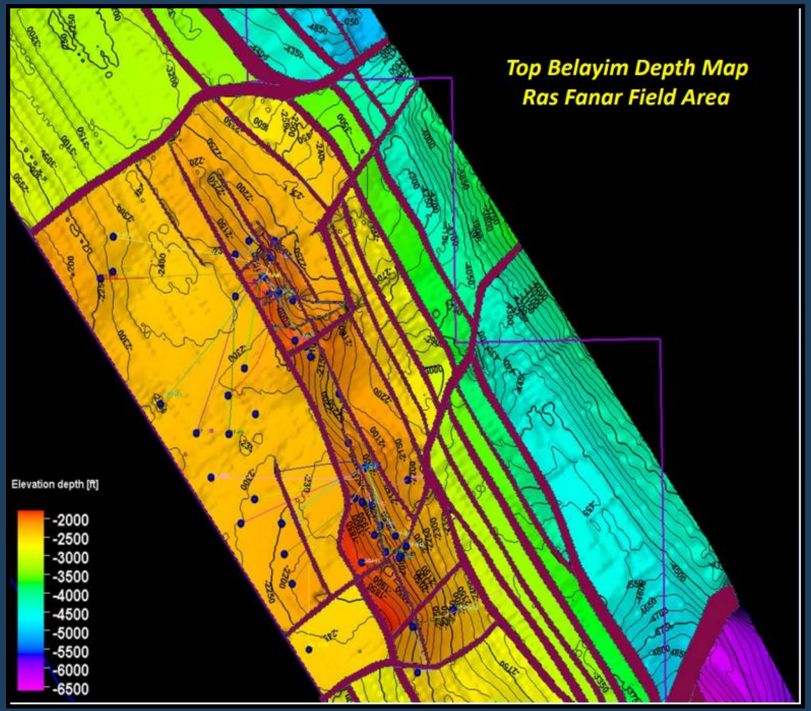
Structure Contour Map On Top Belayim Nullipore



Ras Fanar Map (Top Nullipore Formation) 2003



Ras Fanar Map (Top Nullipore Formation) 2007



Ras Fanar Map (Top Nullipore Formation) 2014

Ras Fanar Reserves Updating

1986 BP

- STOIIP 220 & Ultimate oil 86 MMstb from 6 wells (3 in each platform)

1990 Shell

- Ultimate oil 120 MMstb and develop the main area by additional 8 wells (4 in each platform)

1996 ESP

- Ultimate oil 145 MMstb, but the wells showed rapid increase in water cut. So, reduced again to 120 MMstb

2002 DEA

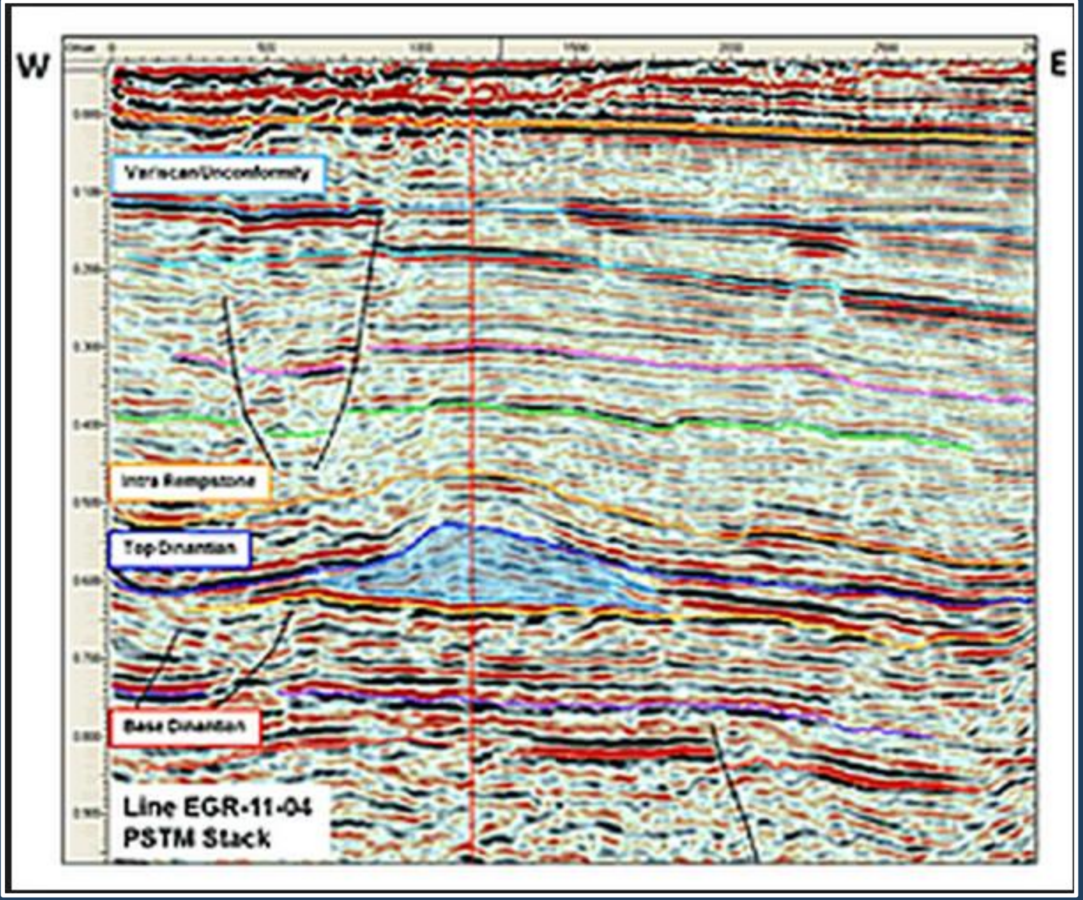
- Ultimate oil 108 MMstb and develop the main area by additional 3 wells + add 5 MMstb for the west area from 6 wells)

2007 Roxar

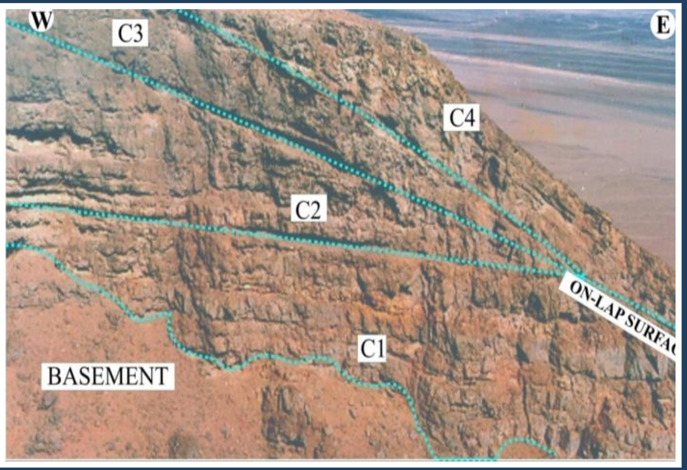
- Ultimate oil form main area kept 108 MMstb and increase the ultimate for west area to be 25 MMstb and add additional 9 wells

Patch Reef

- Is small and circular in shape, it may provide shelter of a lagoon on its lee ward side.



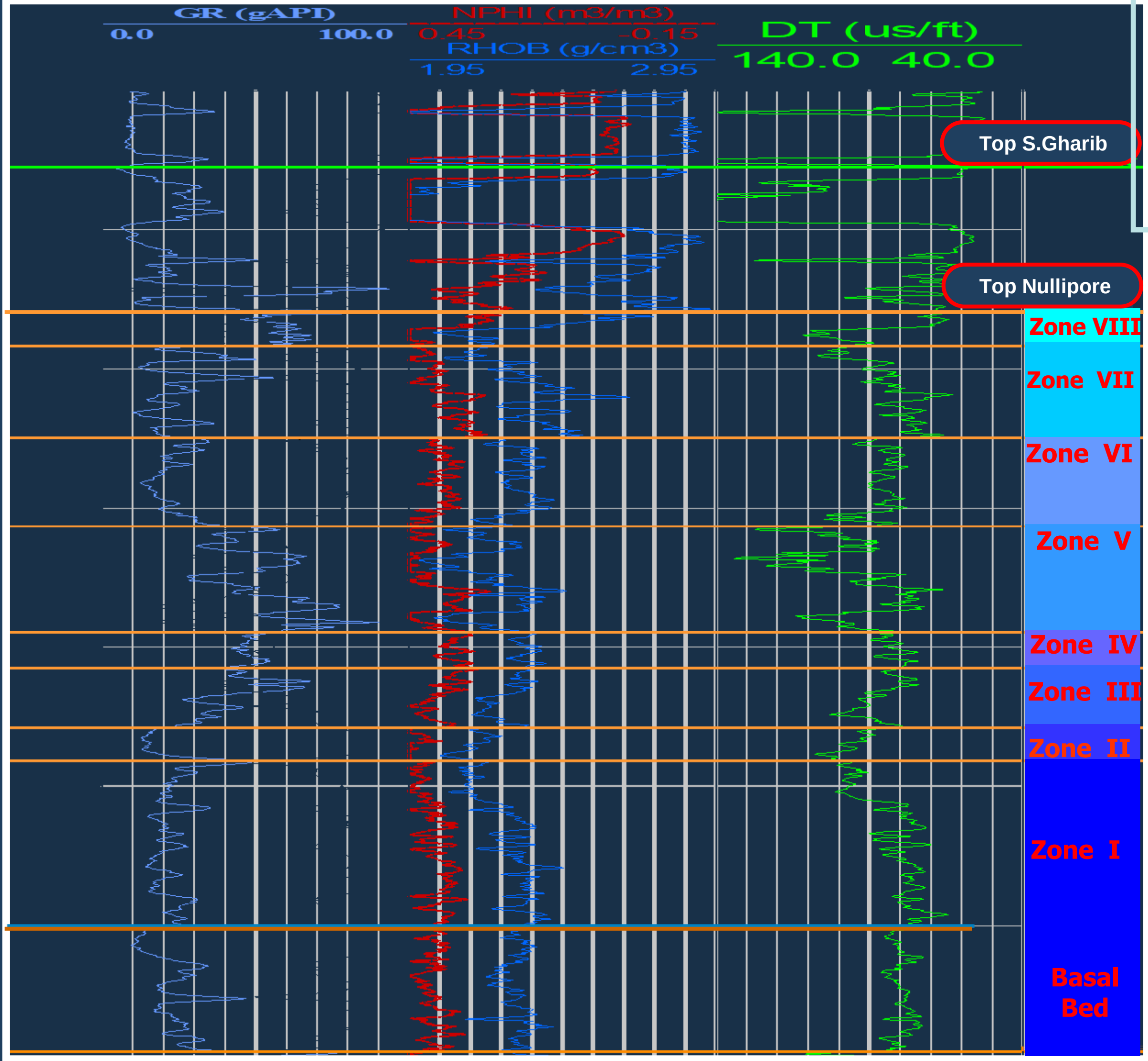
Type Section Of “Nullipore”



- **Type Section Of “Nullipore” (About 130 M Thickness) Is Represented In Wadi Gharandal Area.**
- **Type Section Reflects The Shallow Marine Warm Water Conditions That Favourable For Reefal Development.**
- **This Carbonate Reveal A Multi-scale Heterogenity System**
- **To Understanding How To Deal With Our Reservoir It Must Be Investigate The Surface Outcrop.**
- **It Is Proved That The Structure Setting , Some Facies And Coralline Algae Are Similar To Those Present In Esh El Malaha, Gulf Of Suez.**

“Nullipore” Zonation

- **The Petrographical And Sedimentological Evaluations Through The Description Of 60core Samples Representing 1600 Ft, Reveal That The “Nullipore” Can Be Subdivided Into 8 Lithofacies Zones Underlain By Basal Bed .**



Sandy mudstone to wackestone (biomicrite)

Molluscan Dolomitic packstone (molluscan biomicrite)

Fossiliferous packstone to boundstone (algal biomicrite)

Deeply-weathered dolomitic wackestone to packstone (biomicrite)

Fossiliferous dolomitic wackestone to packstone (biomicrite)

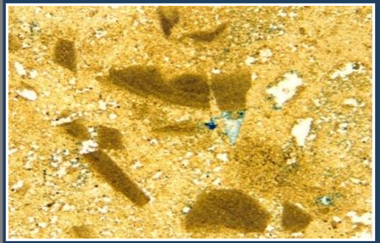
Anhydritic fossiliferous packstone to boundstone (algal biomicrite)

Anhydritic dolomitic wackestone to packstone (algalbomicrite)

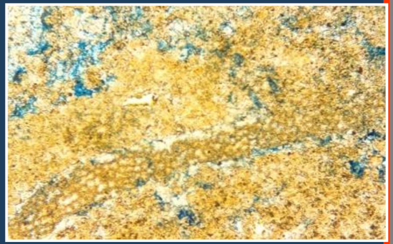
Anhydritic fossiliferous packstone (biomicrite)

“Nullipore” Petrographical And Sedimentological Evaluations

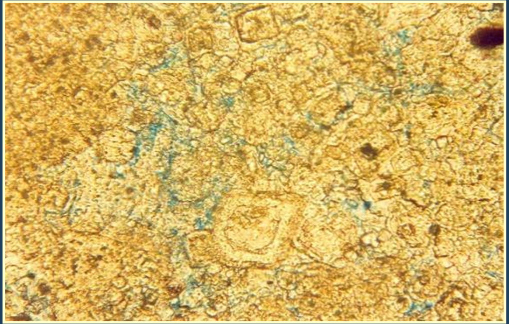
ZONE VIII



Algal mudstone (P.P.L.)



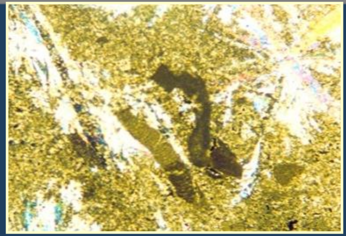
Bryzoan fragment, open intercrystalline pores (P.P.L.)

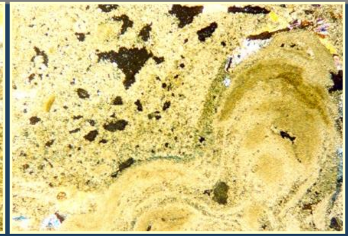


Intrcrystalline and intracrystalline pore space within Fine crystalline dolorhobs (P.P.L.)

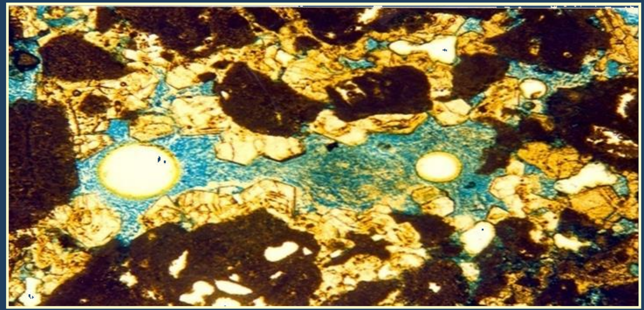
ANHYDRITIC FOSSILIFEROUS PACKSTONE (BIOMICRITE)

ZONE VII





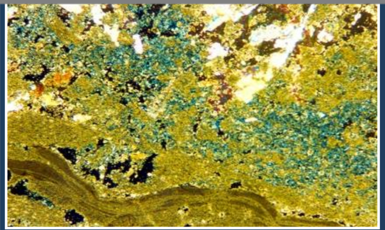
Algal oncoid and fragment (Lithophyllym sp.) with anhydrite rosettes grow within the dolomitic lime matrix (Crossed Nicoles)



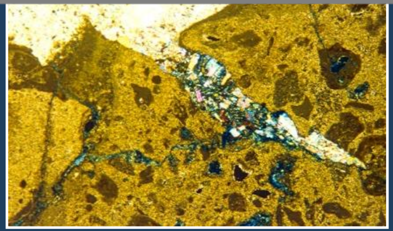
Intergranular pores and vuggs partially filled with fine to medium celestite crystal (p.p.l.)

ANHYDRITIC DOLOMITIC WACKESTONE TO PACKSTONE (ALGAL BOMICRITE)

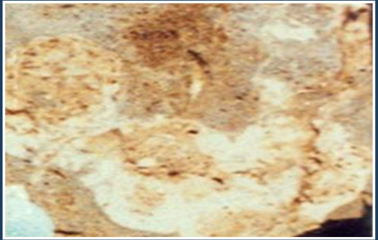
ZONE VI



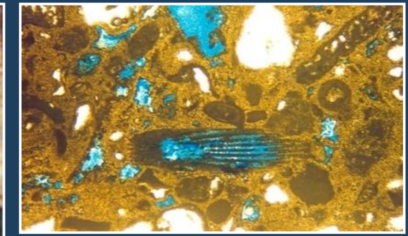
Algal fragment with anhydrite partially filled vuggs (Crossed Nicoles)



Anhydrite filing microfracture



Large algal oncoide in LST with open pores and microvugs

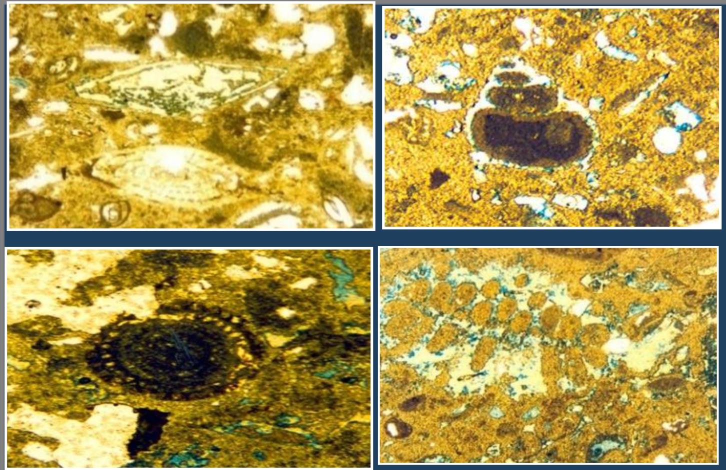


Partially leaching litho- and bioclast result in open moldic and vuggs (P.P.L.)

ANHYDRITIC ALGAL PACKSTONE TO BOUNDSTONE (ALGAL BIOMICRITE)

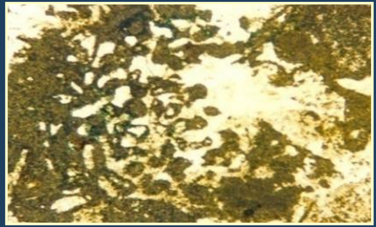
"Nullipore" Petrographical And Sedimentological Evaluations

ZONE V



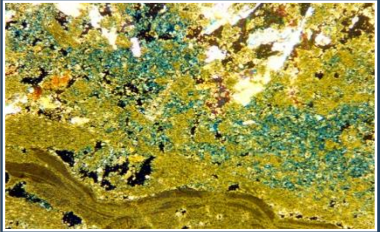
Partially leaching of Bryzoa, Borelis melo, smale gastropodes and Amphistigina sp. embeded in adolomitic matrix

Collapsed Brescia

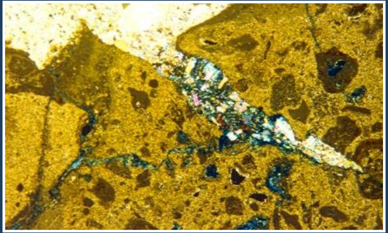


Completely leaching of coralline fragment with anhydrite fillings (P.P.L.)

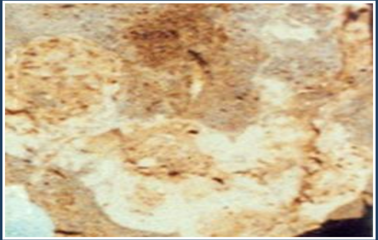
ZONE VI



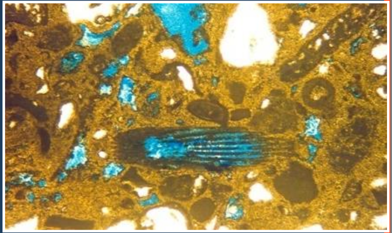
Algal fragment with anhydrite partially filled vuggs (Crossed Nicoles)



Anhydrite filing microfracture

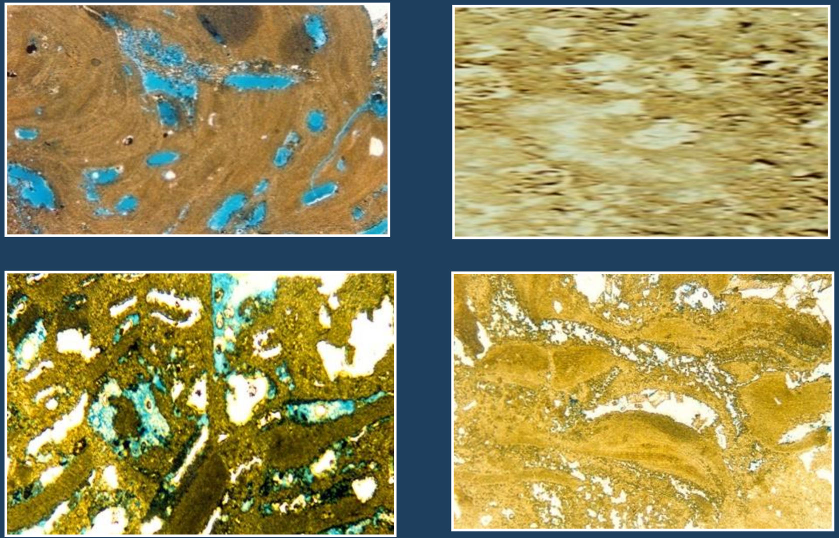


Large algal oncoide in LST with open pores and microvugs

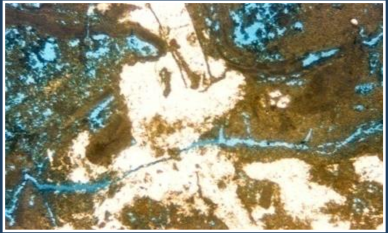


Partially leaching litho- and bioclast result in open moldic and vuggs (P.P.L.)

ZONE III



Algal oncoide with open internal pores, vuggs & microfracture (*Lithothamnium.* Sp.) (P.P.L.)



Secondary anhydrite fillings transicted by an open fracture

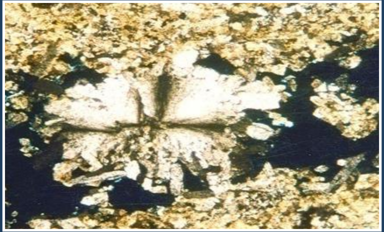
FOSSILIFEROUS DOLOMITIC WACKESTONE TO PACKSTONE (BIOMICRITE)

ANHYDRITIC ALGAL PACKSTONE TO BOUNDSTONE (ALGAL BIOMICRITE)

FOSSILIFEROUS PACKSTONE TO BOUNDSTONE (ALGAL BIOMICRITE)

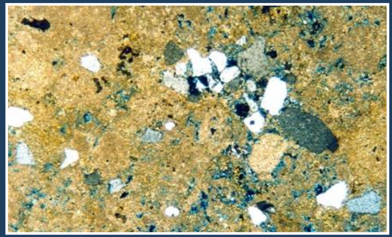
“Nullipore” Petrographical And Sedimentological Evaluations

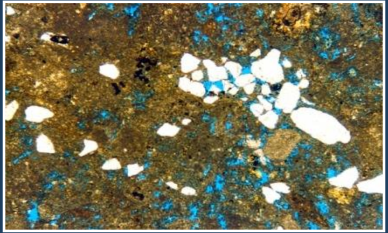
ZONE I



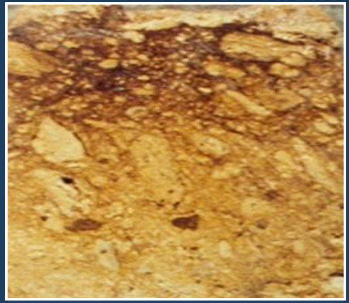
A vug partially filled with celectite

Completely leaching Molluscan fragments





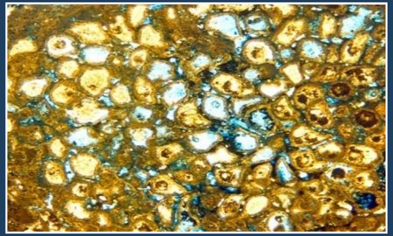
Photomicrograph showing cluster of Subangular to subrounded decrial quartz grains within the dolomicrite matrix

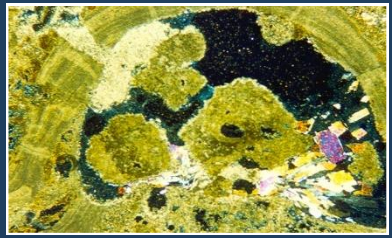


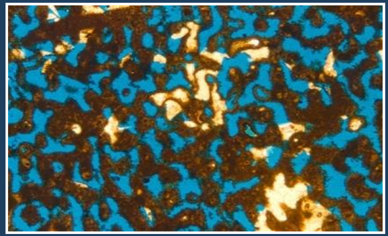
Bands of polymectic conglomerate

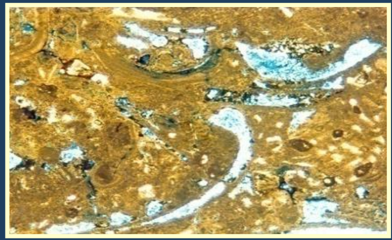
SANDY ANHYDERITIC MUDSTONE TO WACKESTONE (BIOMICRITE)

ZONE II









Completely leaching of Bryzoan and coral fragments (partially filled with anhydrite) and Molluscan remains resulting in open moldic cavity and vuggs (P.P.L.)

Anhydrite nodular

MOLLUSCAN DOLOMITIC PACKSTONE (MOLLUSCAN BIOMICRITE)

“Nullipore” Digenetic Processes and effect on Porosity

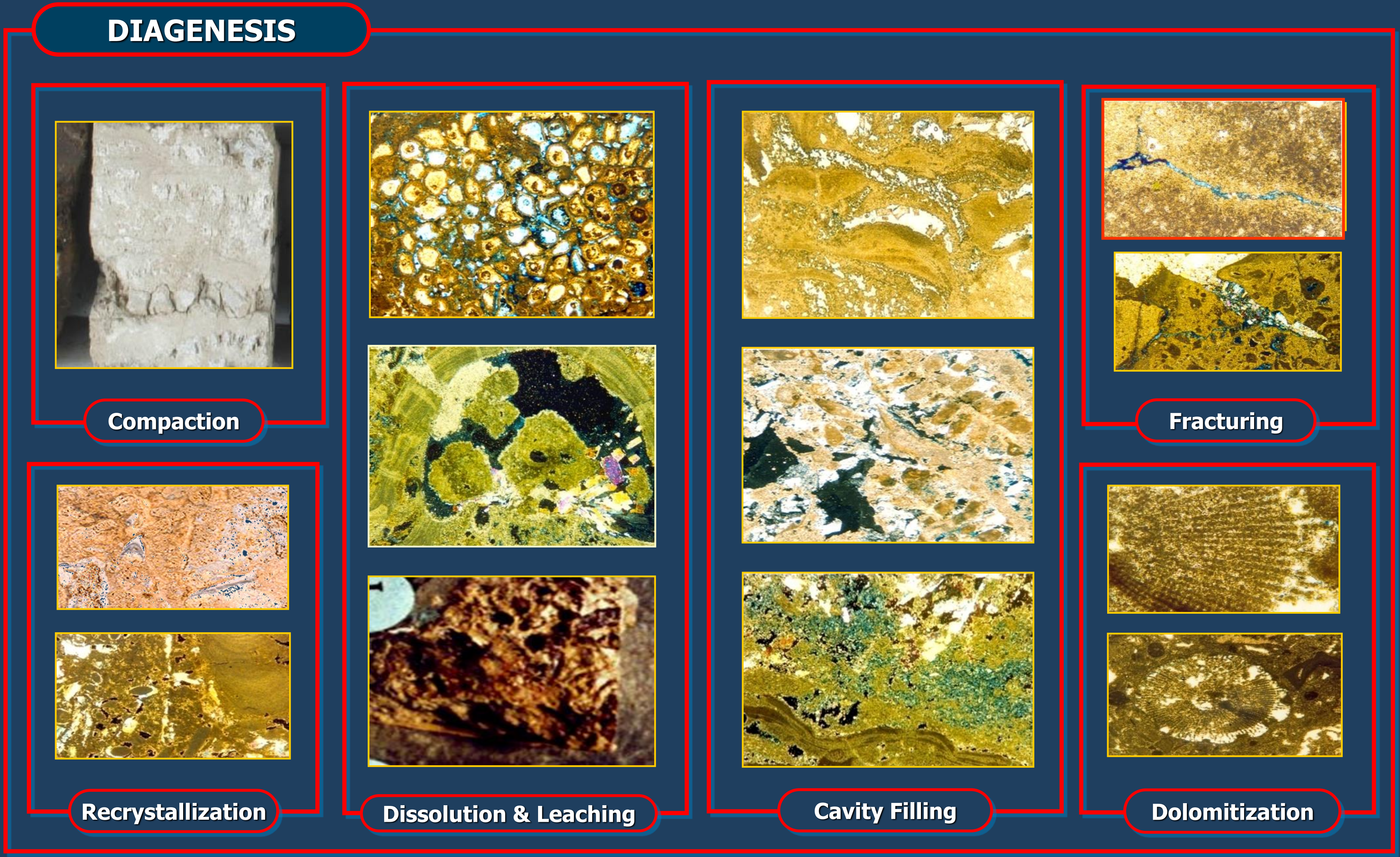
- **Post-depositional History Of The “Nullipore” Reservoir Is Very Complex.**
- **It Comprises Several Digenetic Processes (Pre-uplift) And (Post-uplift) That Largely Affected The Reservoir Properties.**

Those Digenetic Processes Led To:-

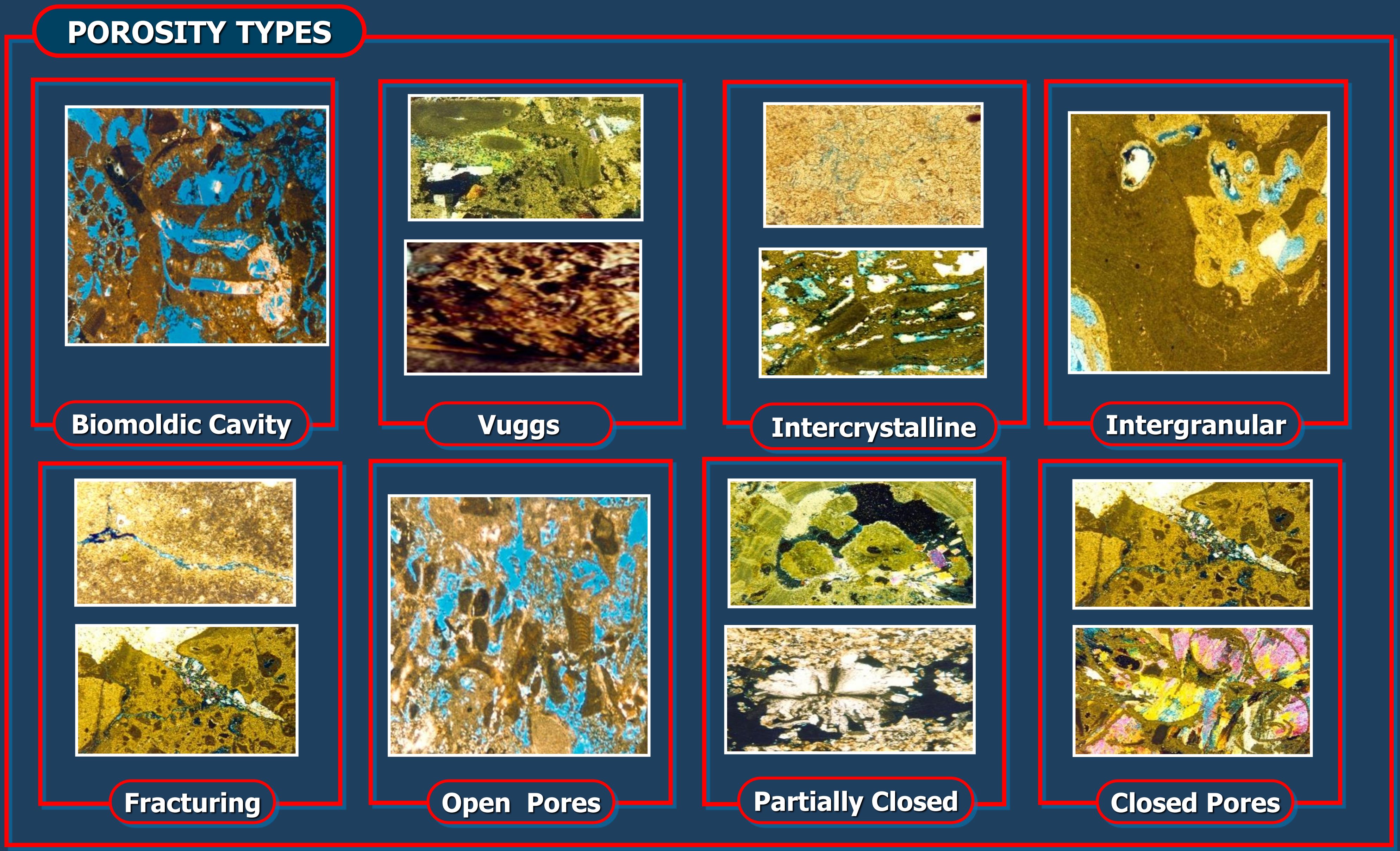
- **Either Porosity-destructive.**
- **Or Porosity-constructive.**

They Has Resulted In An Extremely Heterogeneous Reservoir Rock.

“Nullipore” Digenetic Processes

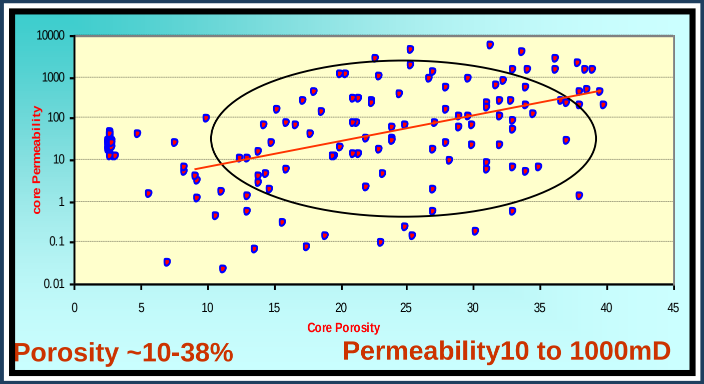


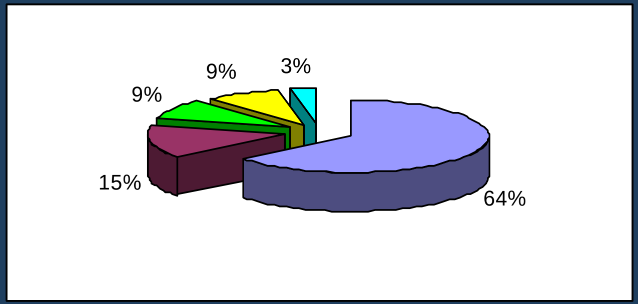
“Nullipore” Porosity



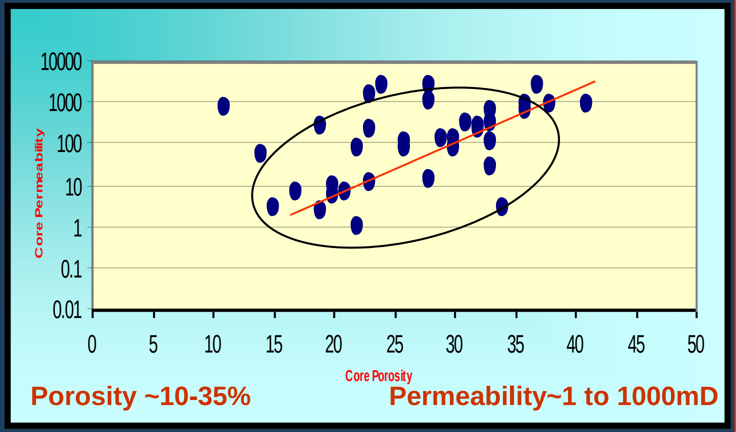
“Nullipore” Zonation and associated Porosity

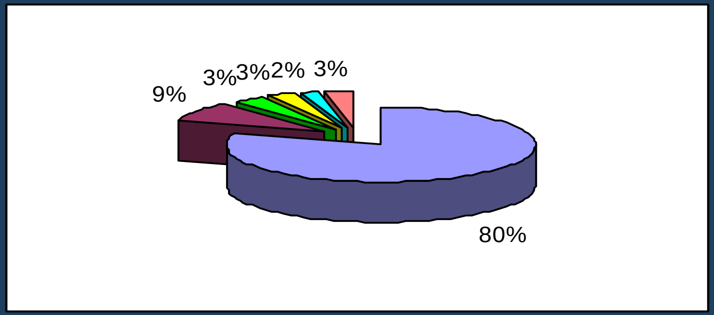
ZONE VI



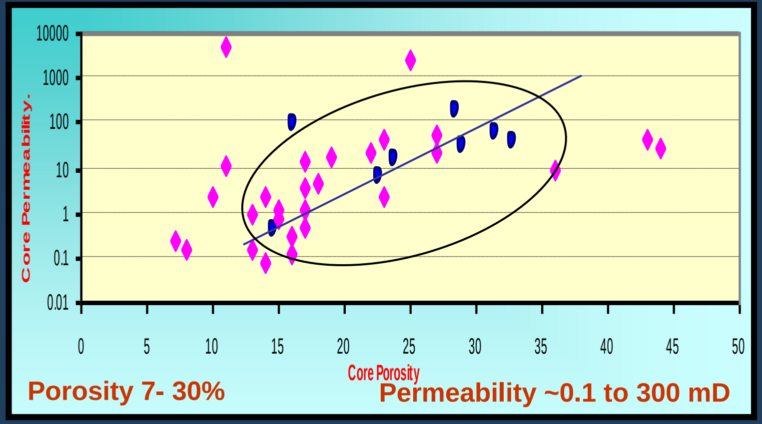


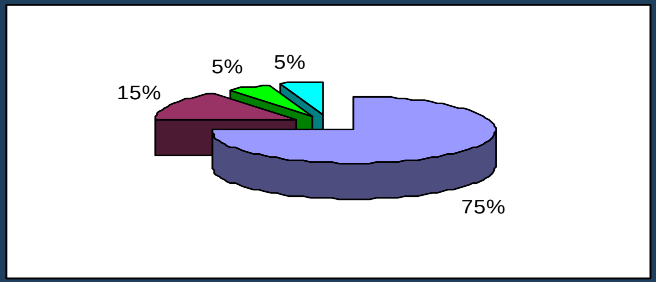
ZONE VII





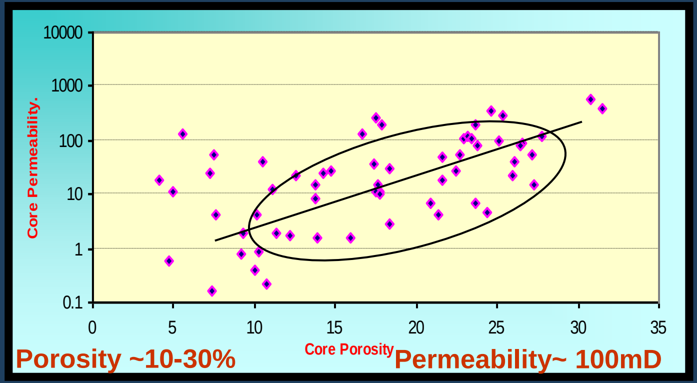
ZONE VIII

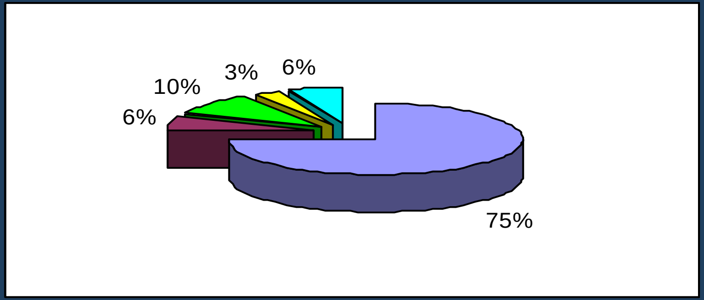




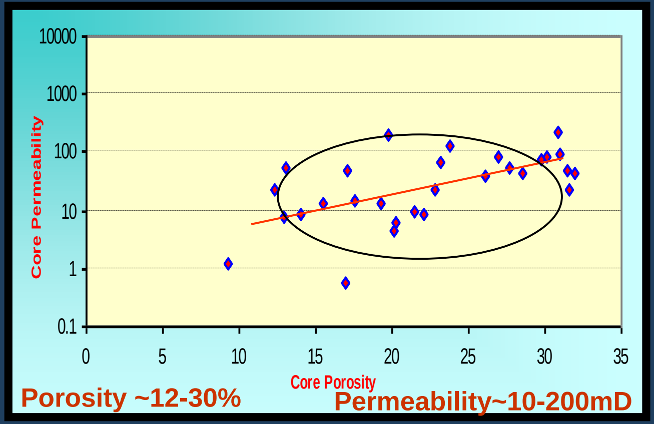
“Nullipore” Zonation and associated Porosity

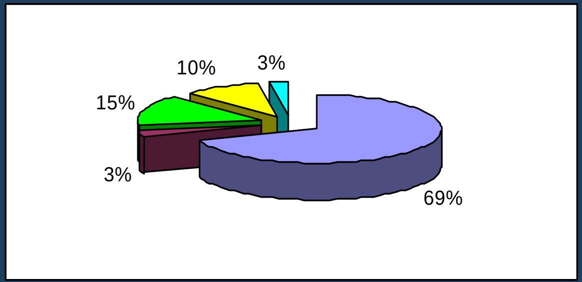
ZONE III



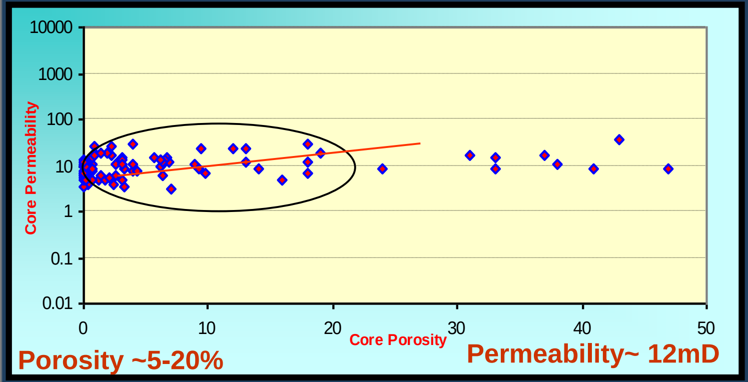


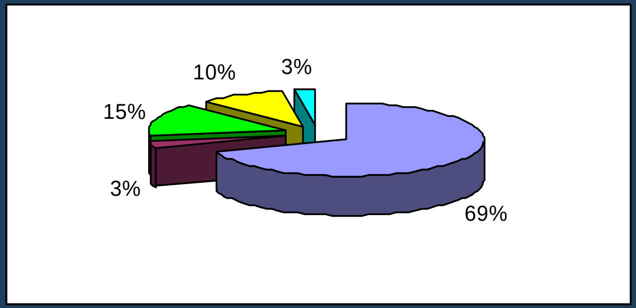
ZONE IV





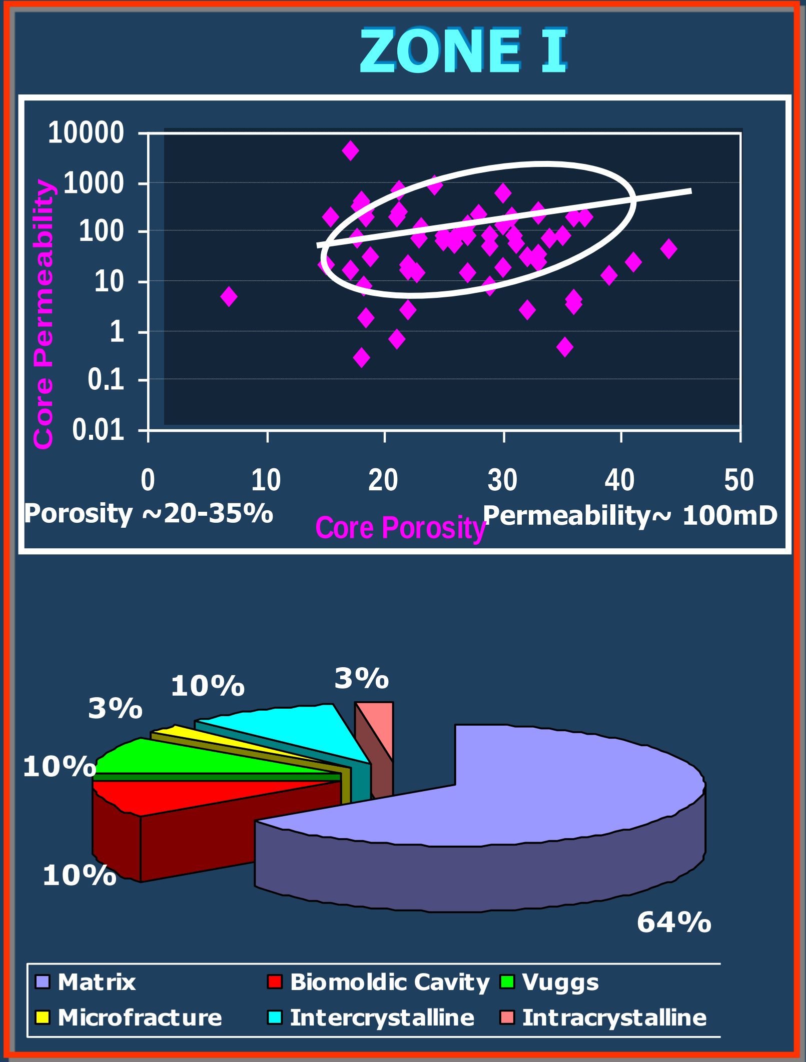
ZONE V

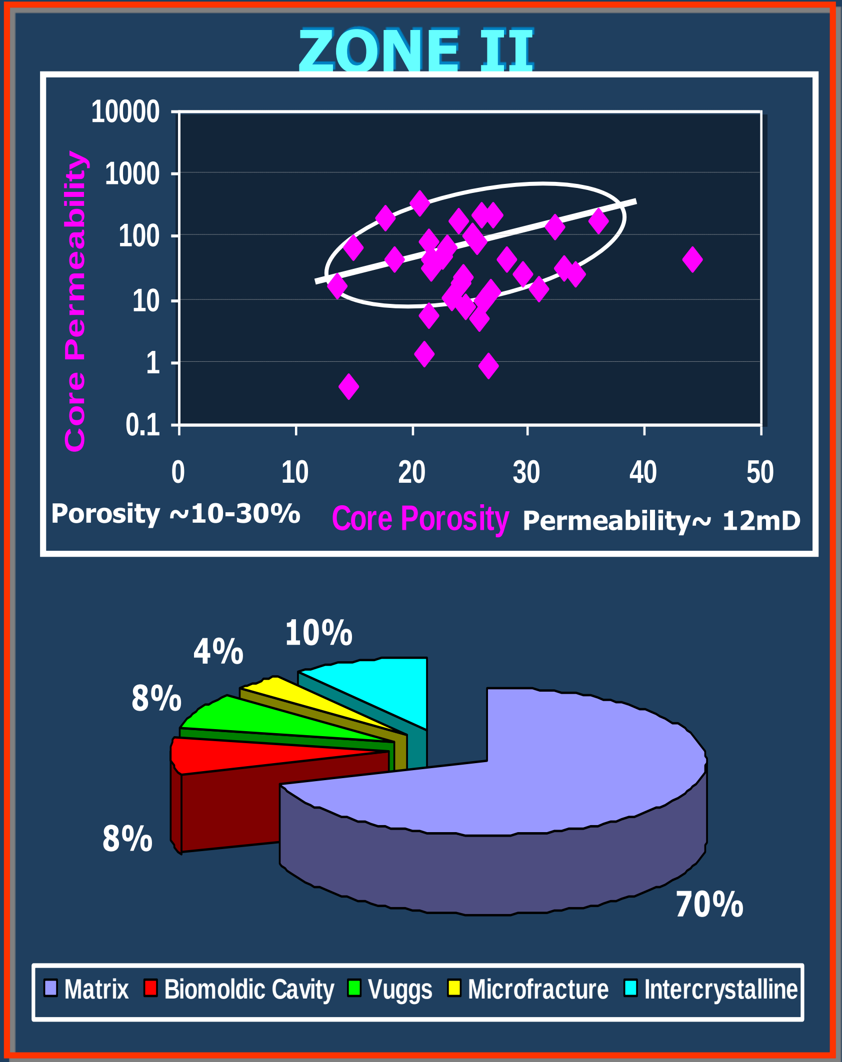




Matrix | Biomoldic Cavity | Vuggs
Microfracture | Intercrystalline | Intracrystalline

“Nullipore” Zonation and associated Porosity





“Nullipore” Sequences classification

The distribution of coralline algae together with the fancies characters get a good information about the paleopathymetry of that carbonate.

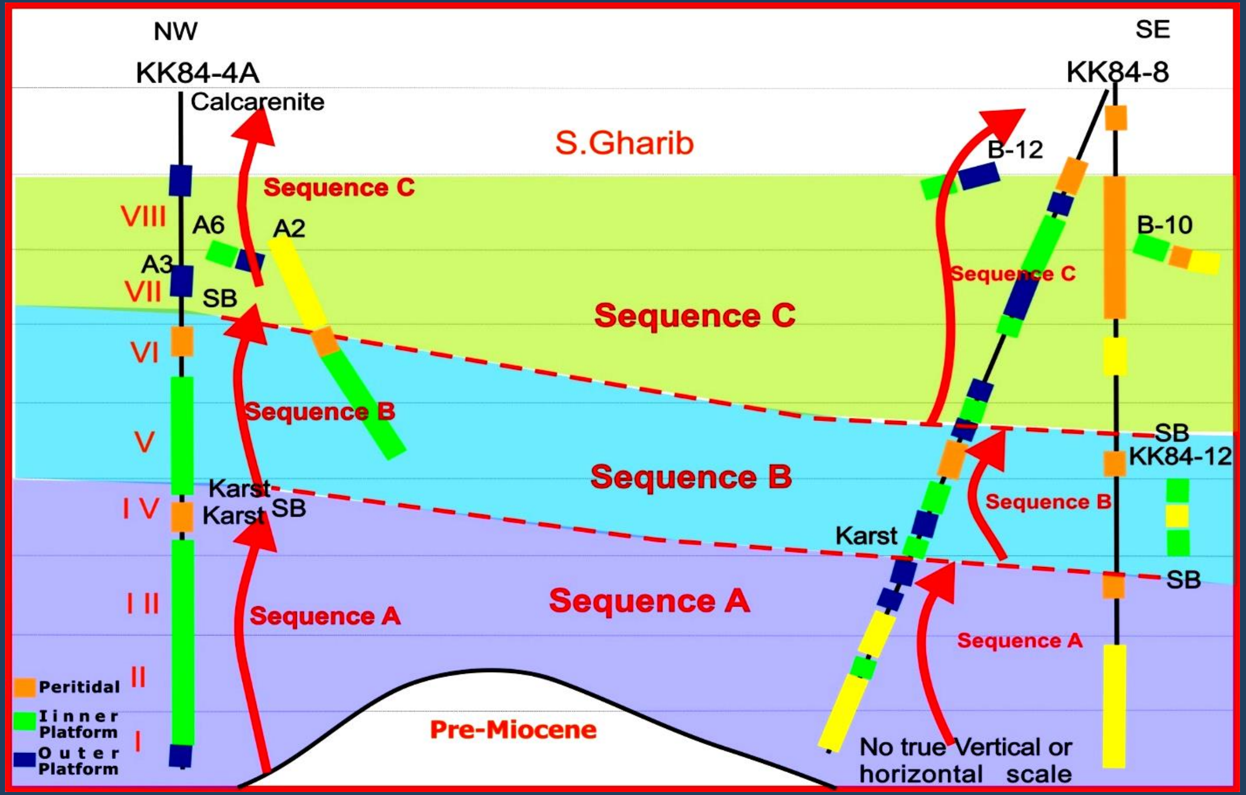
The “Nullipore” Can Be Divided (From Bottom To Top) Into 3 Regressive Sequences (A, B And C Respectively) WITH RESPECT TO RESERVOIR ZONEATIONS.

“Nullipore” Sequences classification

- **Sequence A (Zones Basal Bed, VIII and VII) starts with inner-ramp packstones and passes upwards into a restricted inner ramps.**

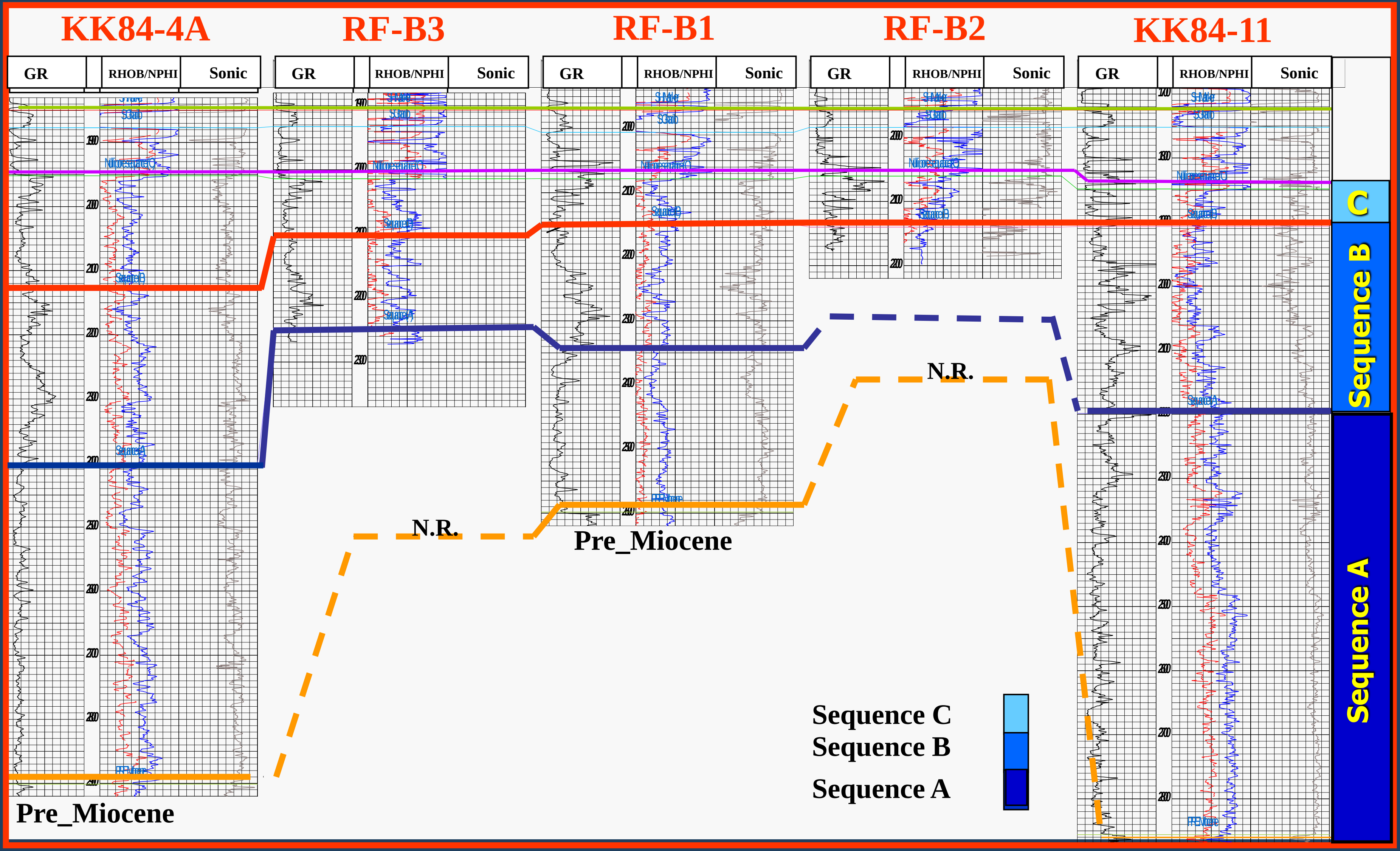
- **Sequence B (Zones VI and V) indicates mainly open marine (inner neritic) environment having a water depth less than 30m.**
Some wells show a complete regressive sequence of inner – to mid - ramp.

- **Sequence C (Zones IV, III, II and I) suggests deposition**
in a predominantly inner - ramp environment.



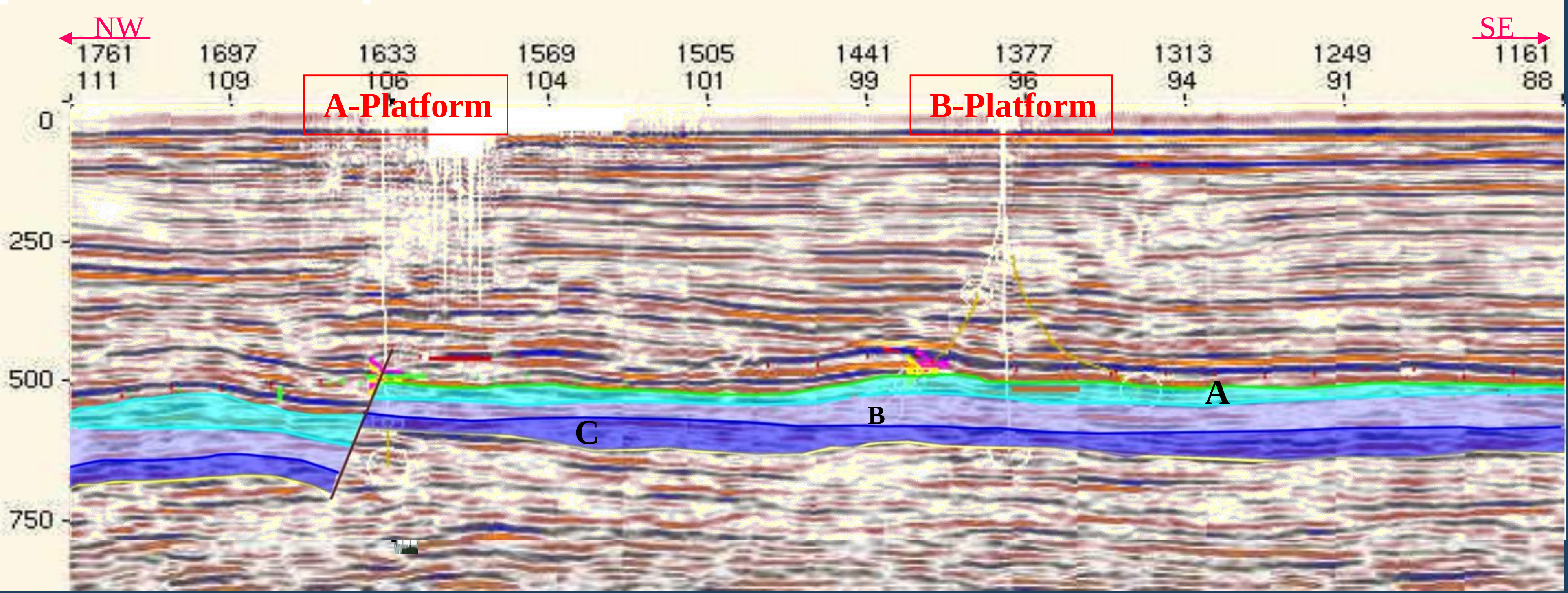
NW-SE SKETCH SECTION TO ILLUSTRATE APPROXIMATE LOCATION OF CORED SECTIONS, FACIES ASSOCIATIONS AND DEPOSITIONAL SEQUENCES A, B AND C WITH RESPECT TO RESERVOIR ZONEATIONS.

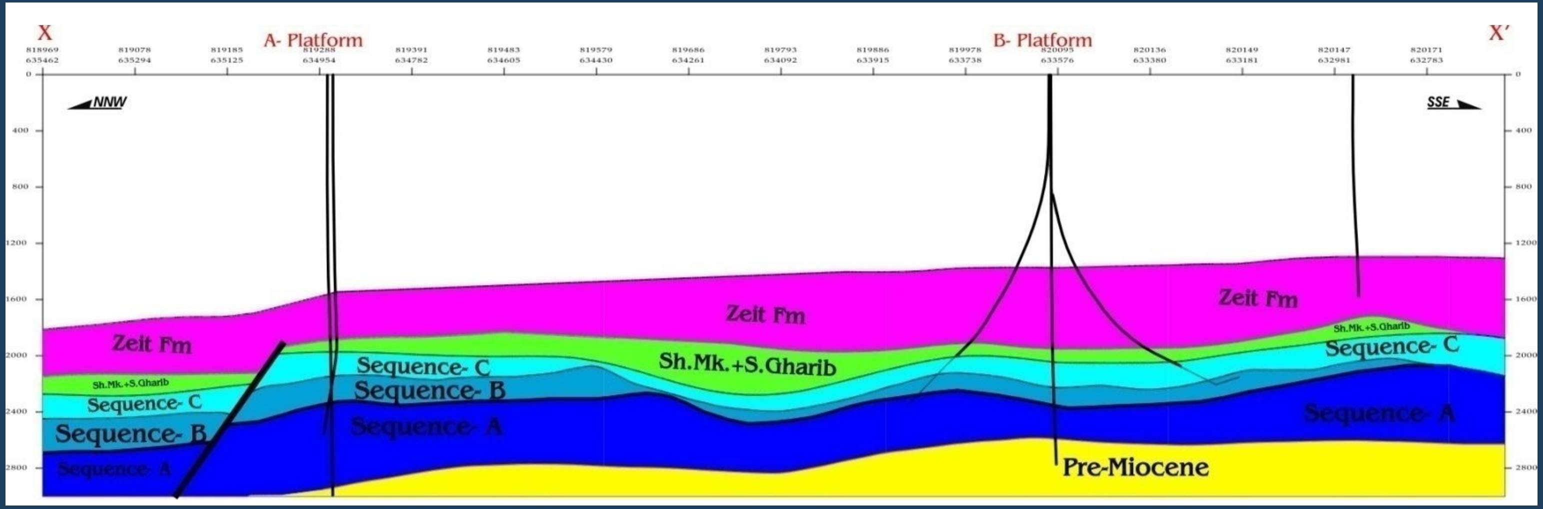
“Nullipore” Sequences classification

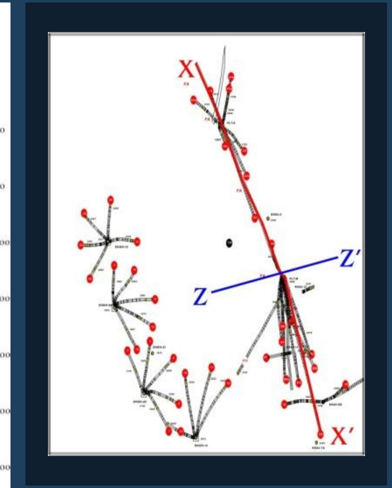


CORRELATION CHART FOR “NULLIPORE” USING E- LOGS

"Nullipore" Sequences classification

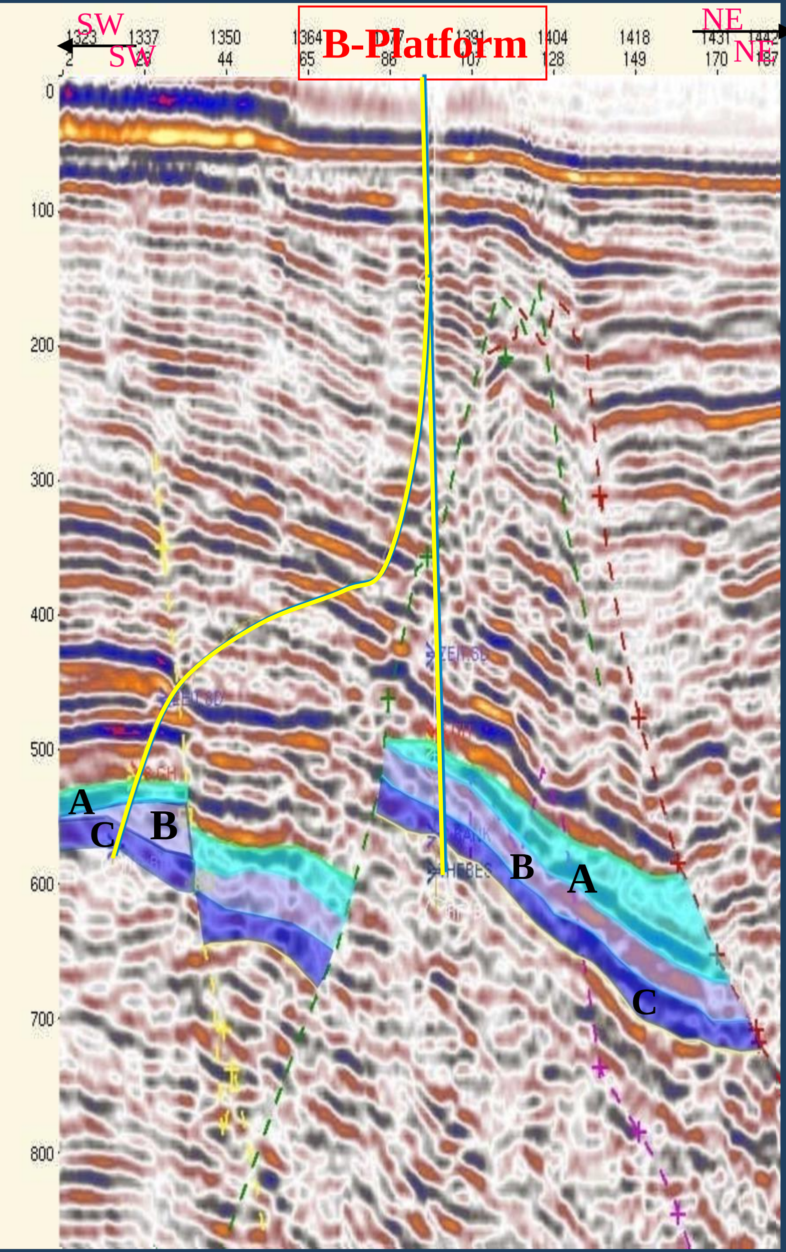




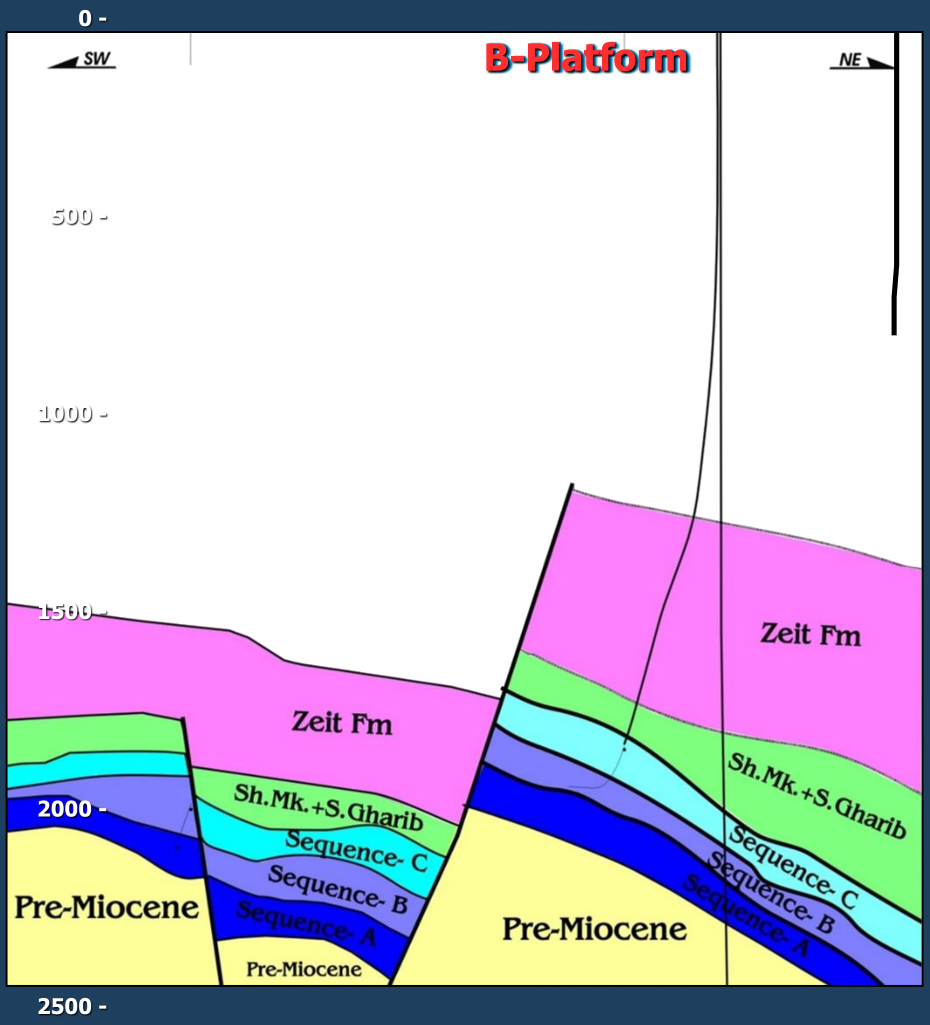


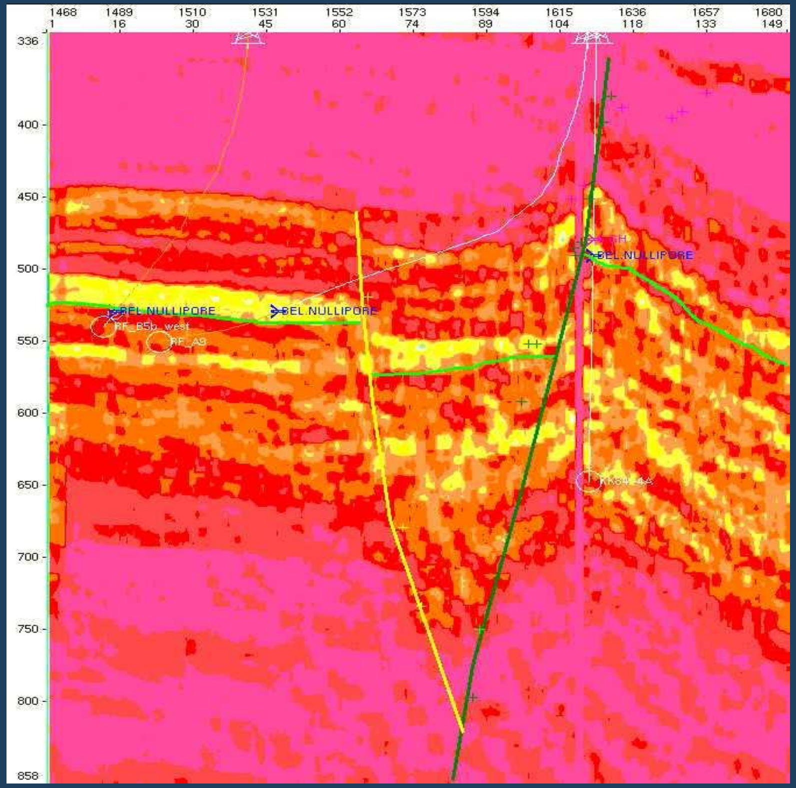
Seismic and Geological cross section passing through NNW to SSE

“Nullipore” Sequences classification

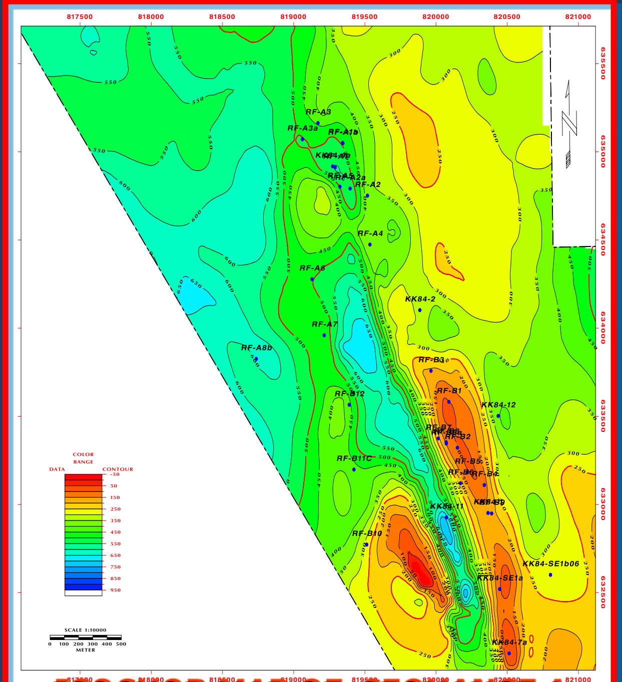


Seismic and Geological cross section passing through SW to NE

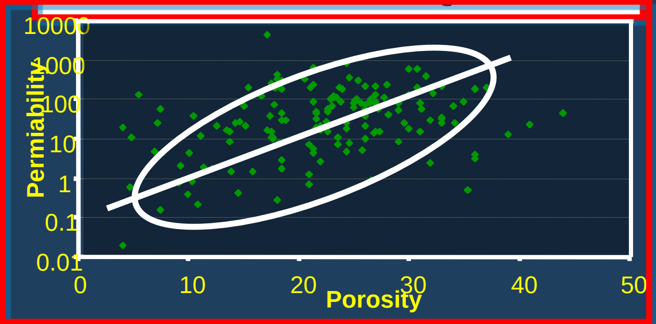




“Nullipore” Sequences classification

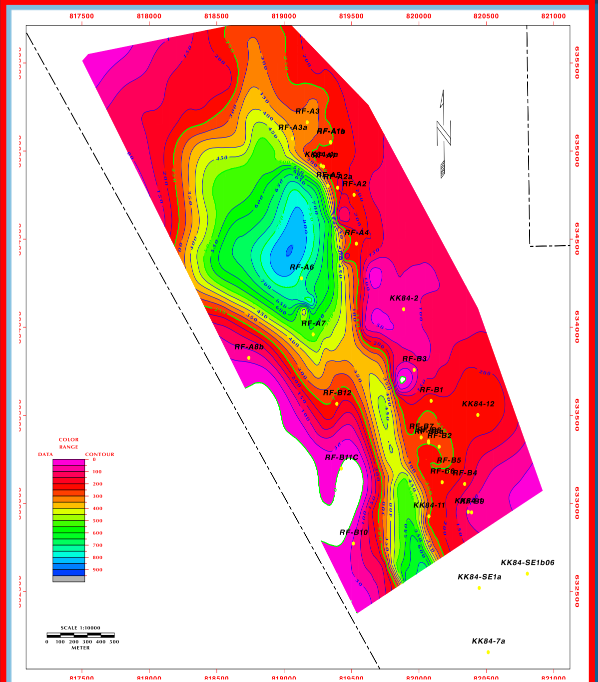


ISOCHOR MAP OF SEQUANCE A

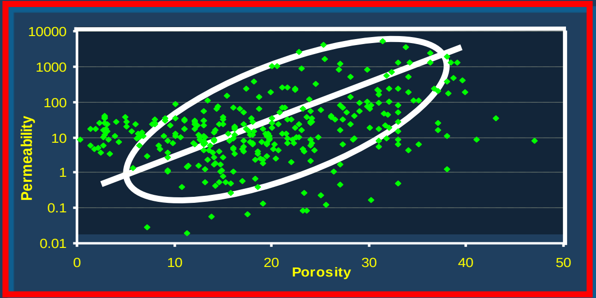


CORE POROSITY/PERMEABILITY CROSS-PLOT

Porosity ~20-30
Permiabity ~ 250

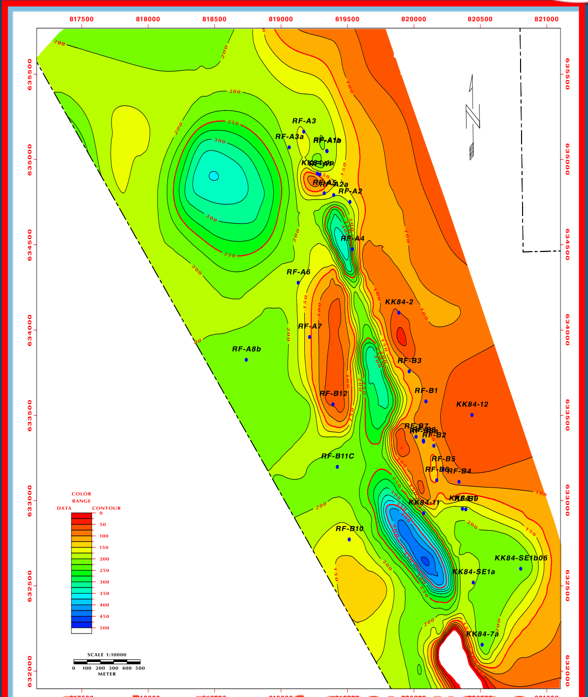


ISOCHOR MAP OF SEQUANCE B

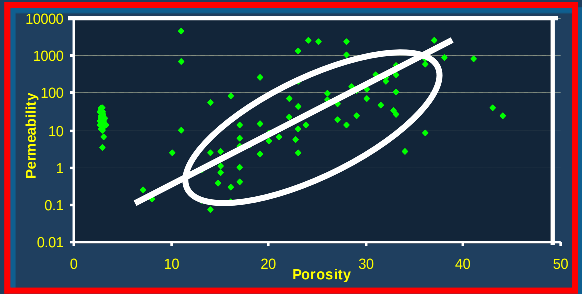


CORE POROSITY/PERMEABILITY CROSS-PLOT

Porosity ~20-35
Permiabity ~ 1000

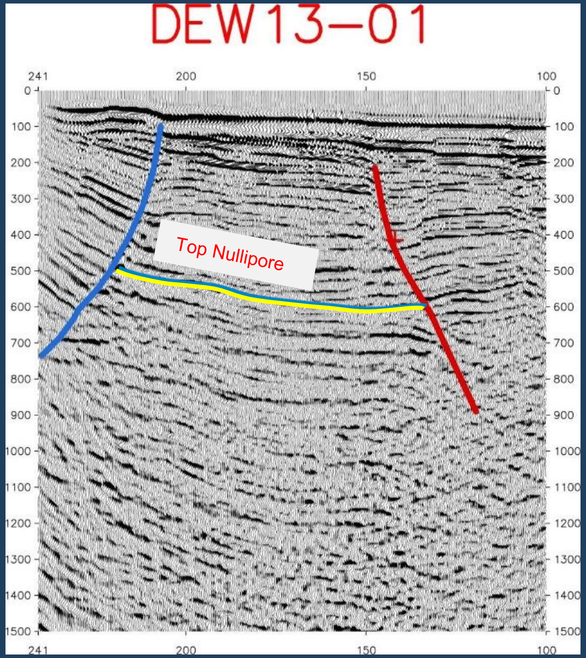


Isochor Map of SEQUANCE C

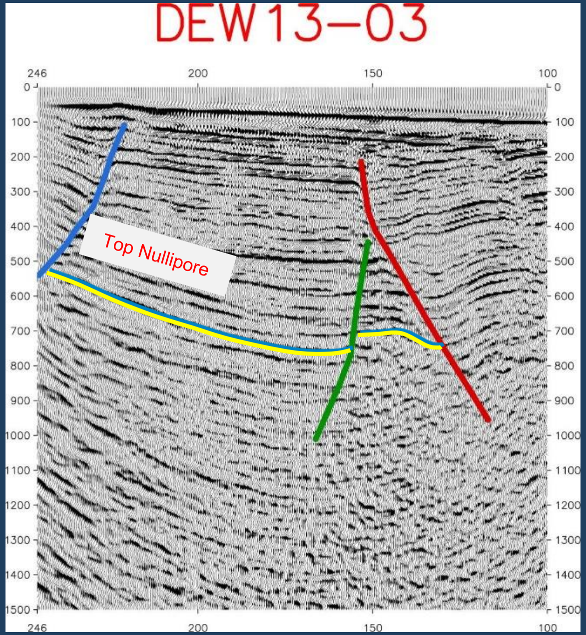


Core Porosity/Permeability Cross-plot

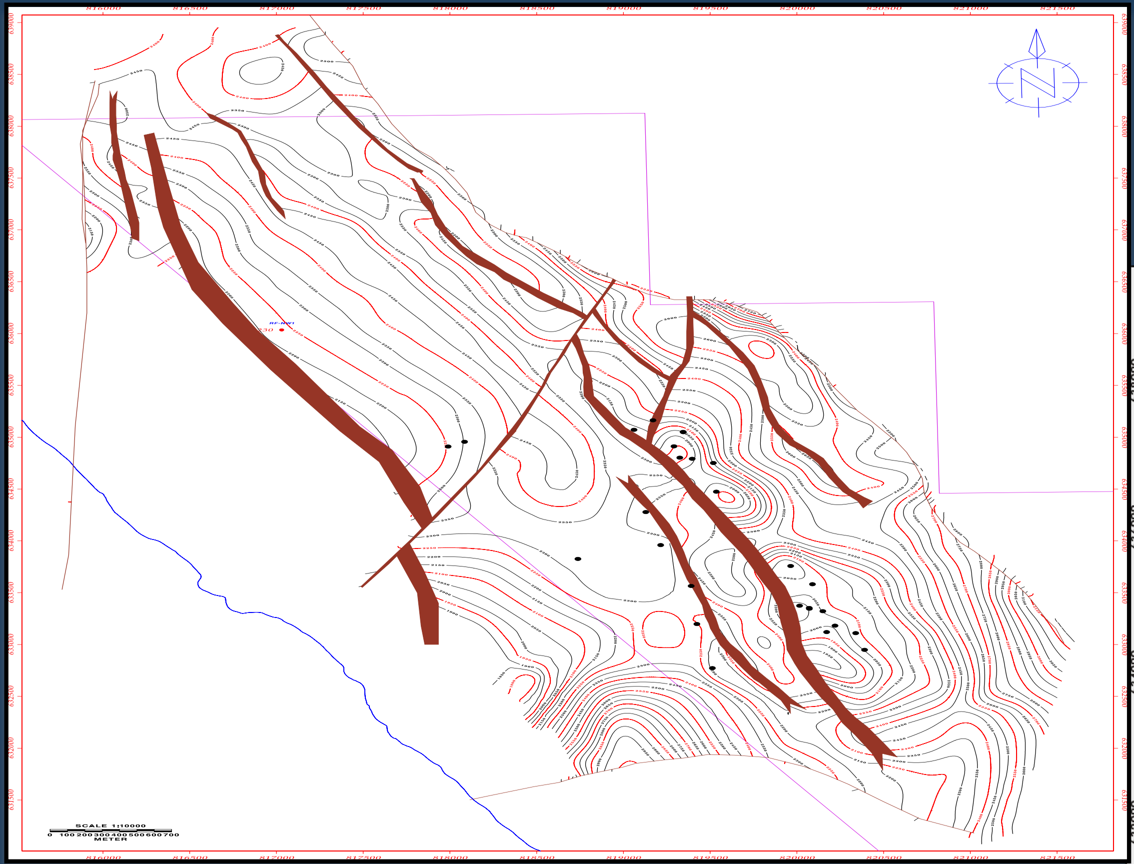
Porosity ~20-30
Permiabity ~ 300

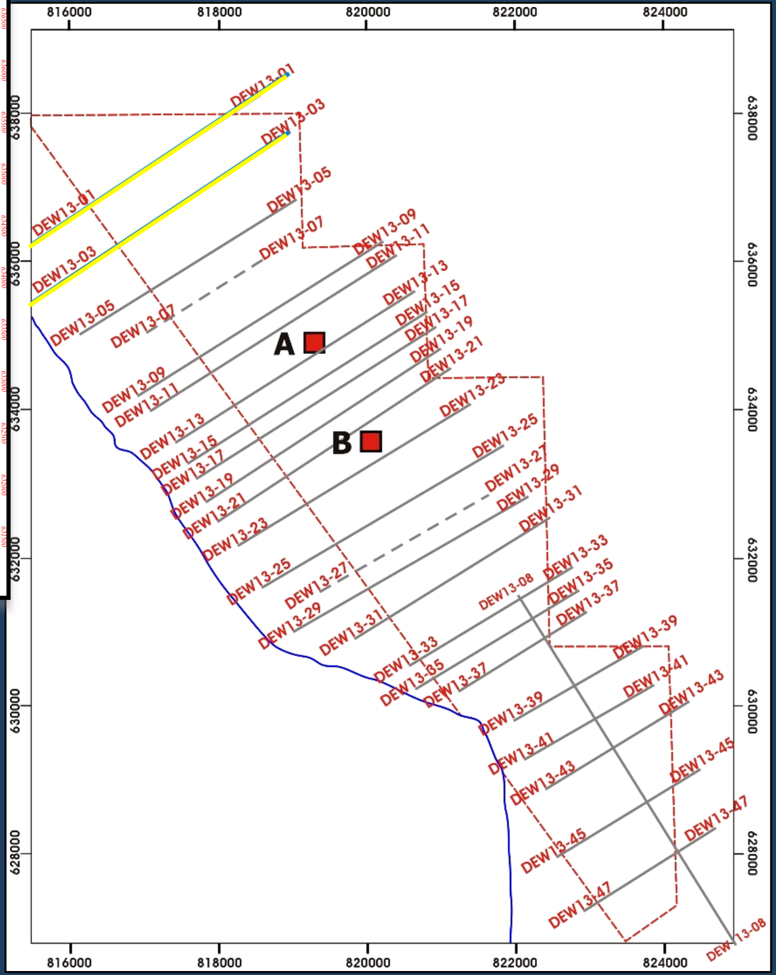


DEW13-01
Top Nullipore

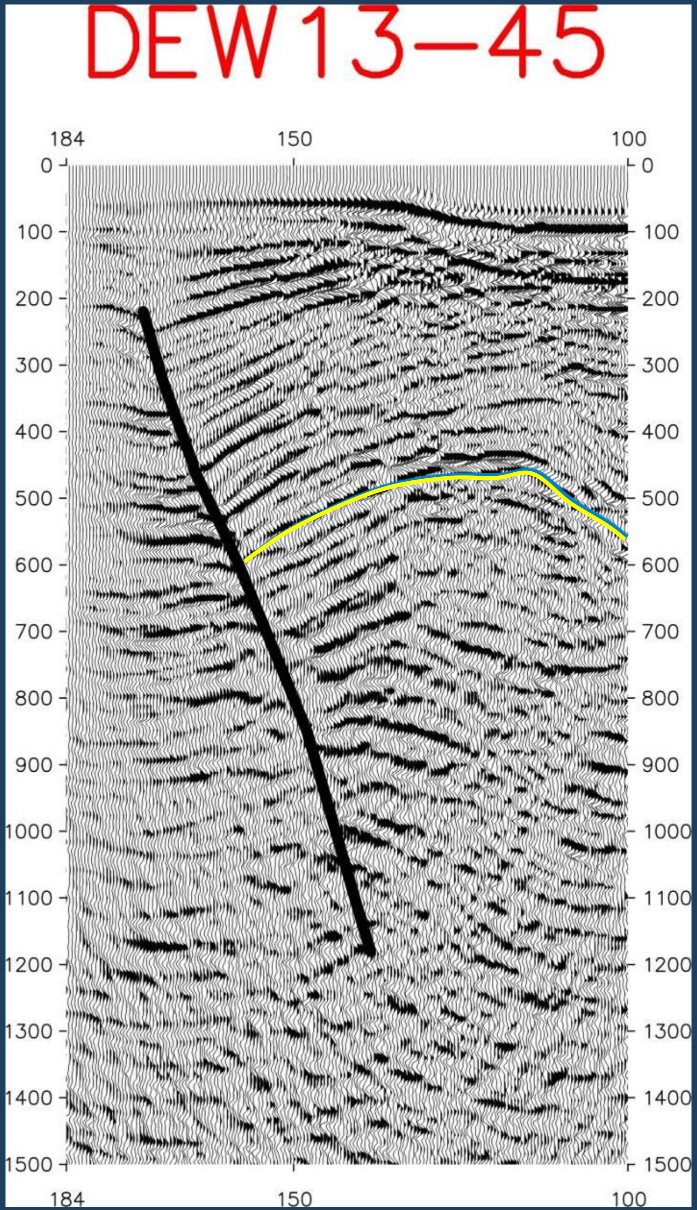


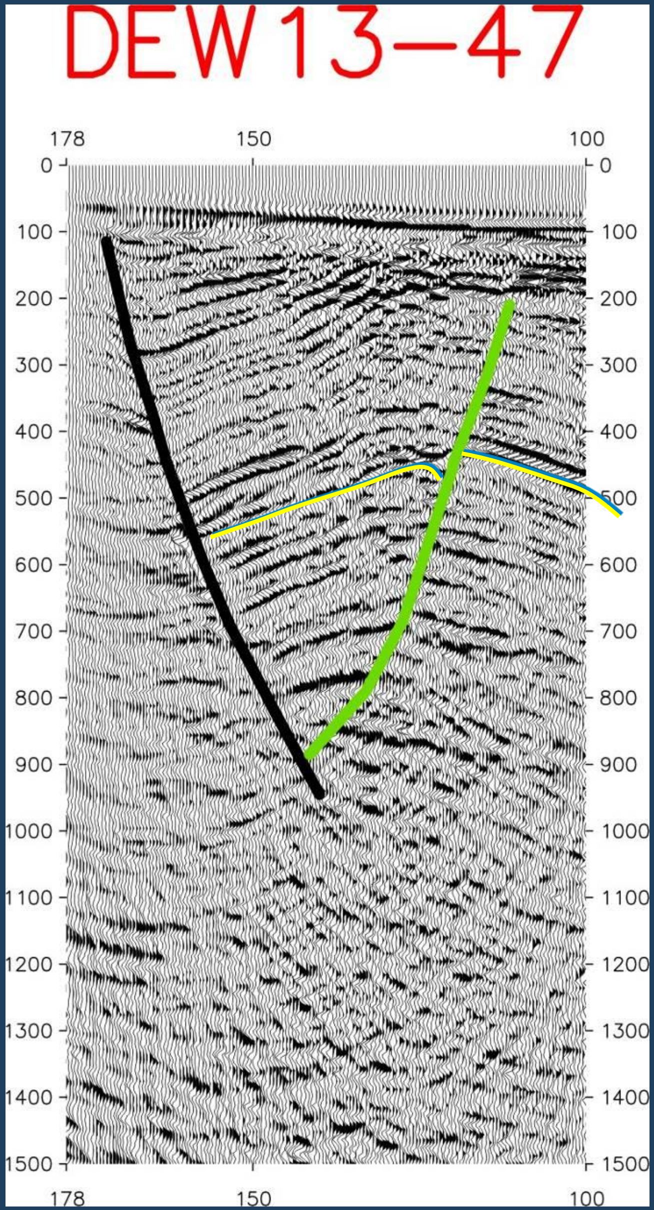
DEW13-03
Top Nullipore

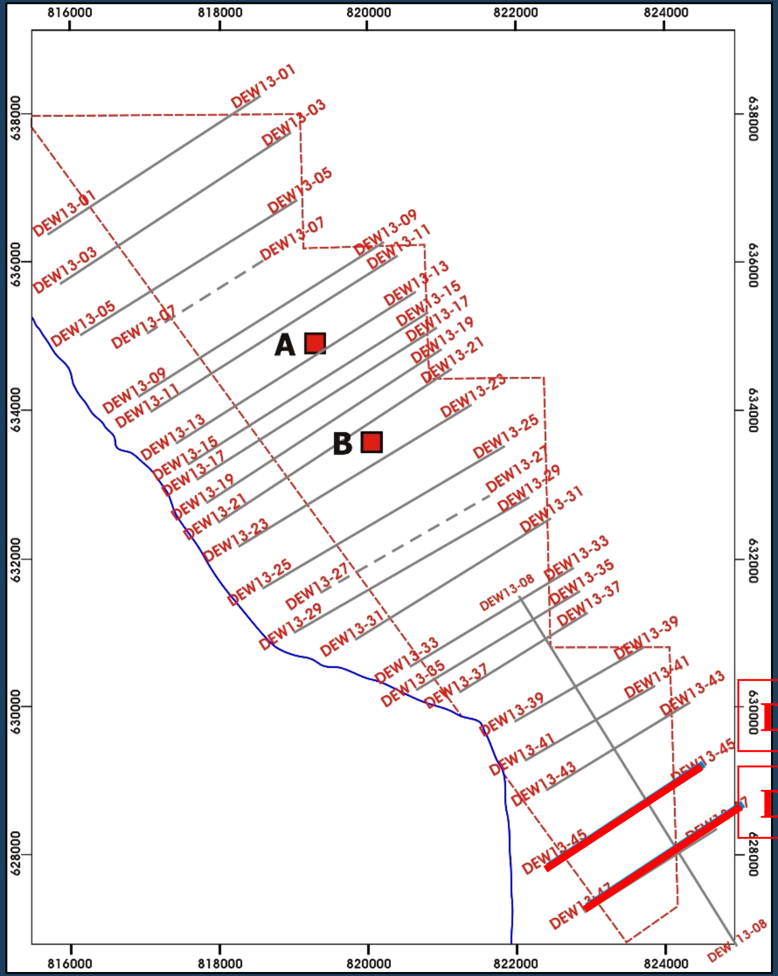




A
B
DEW13-01
DEW13-03
DEW13-05
DEW13-07
DEW13-08
816000
818000
820000
822000
824000







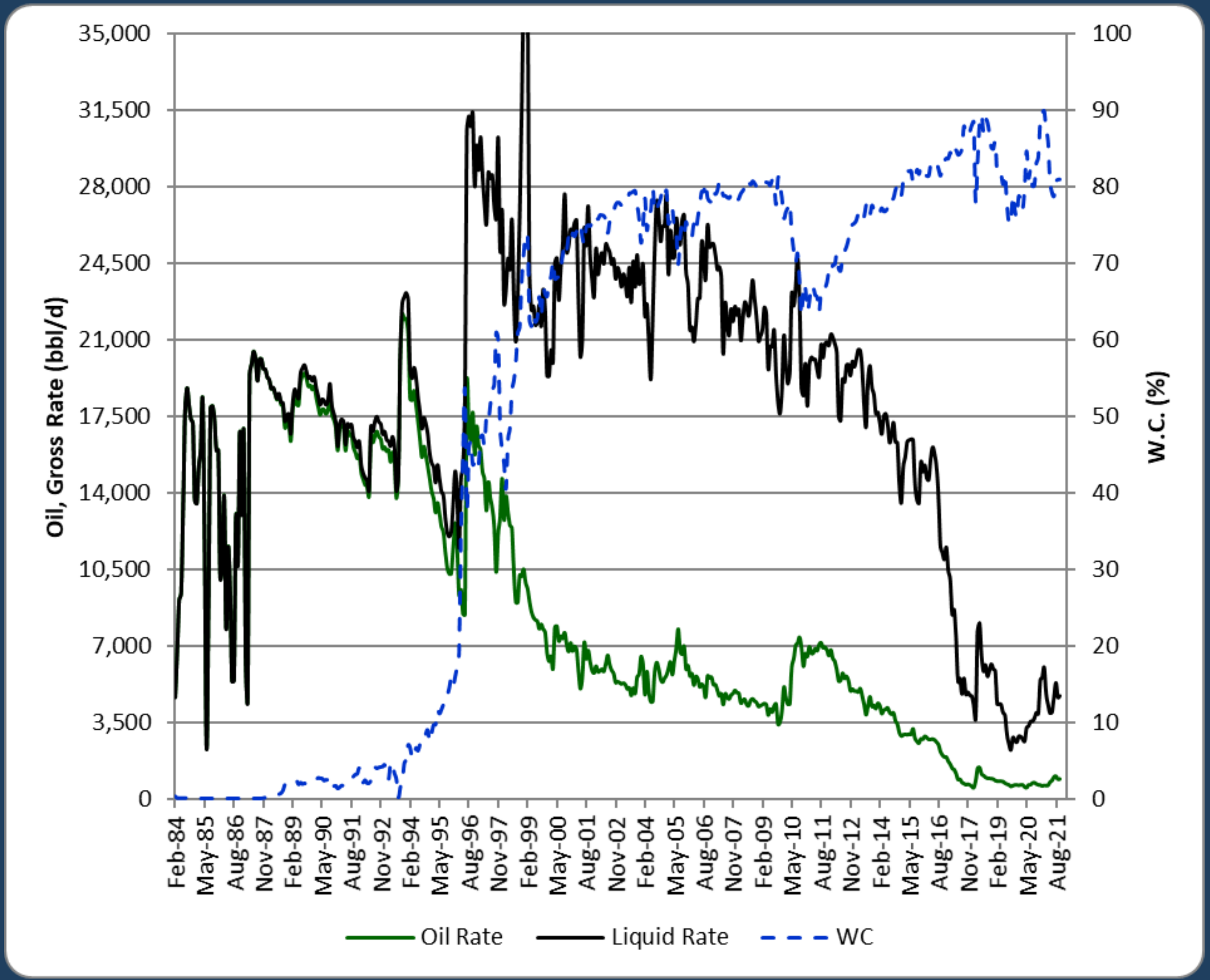
DEW 13-45

DEW 13-47

Ras Fanar Field Highlight

Main Points:

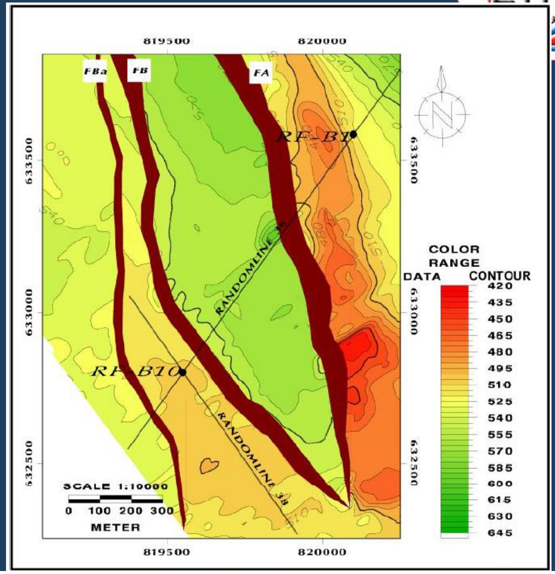
- Main Area from 84 to 96
- ESP Project in 96
- West Discovery in 2004
- Second Phase Development in 2010
- Arresting field Decline in 2017

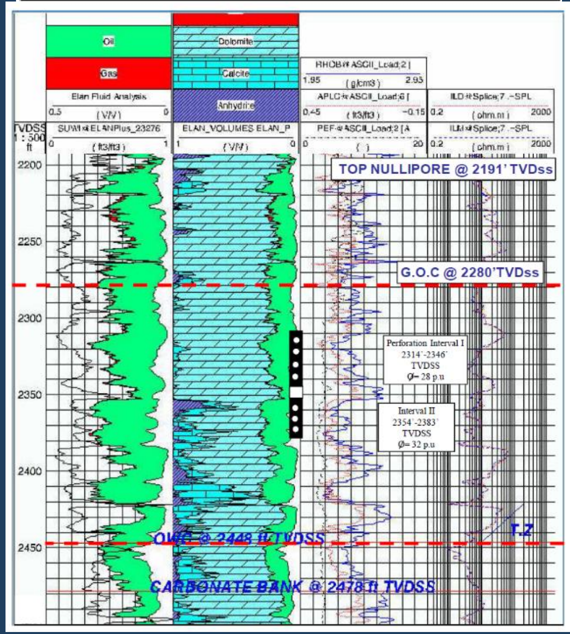


Cumulative Production 119 MMstb

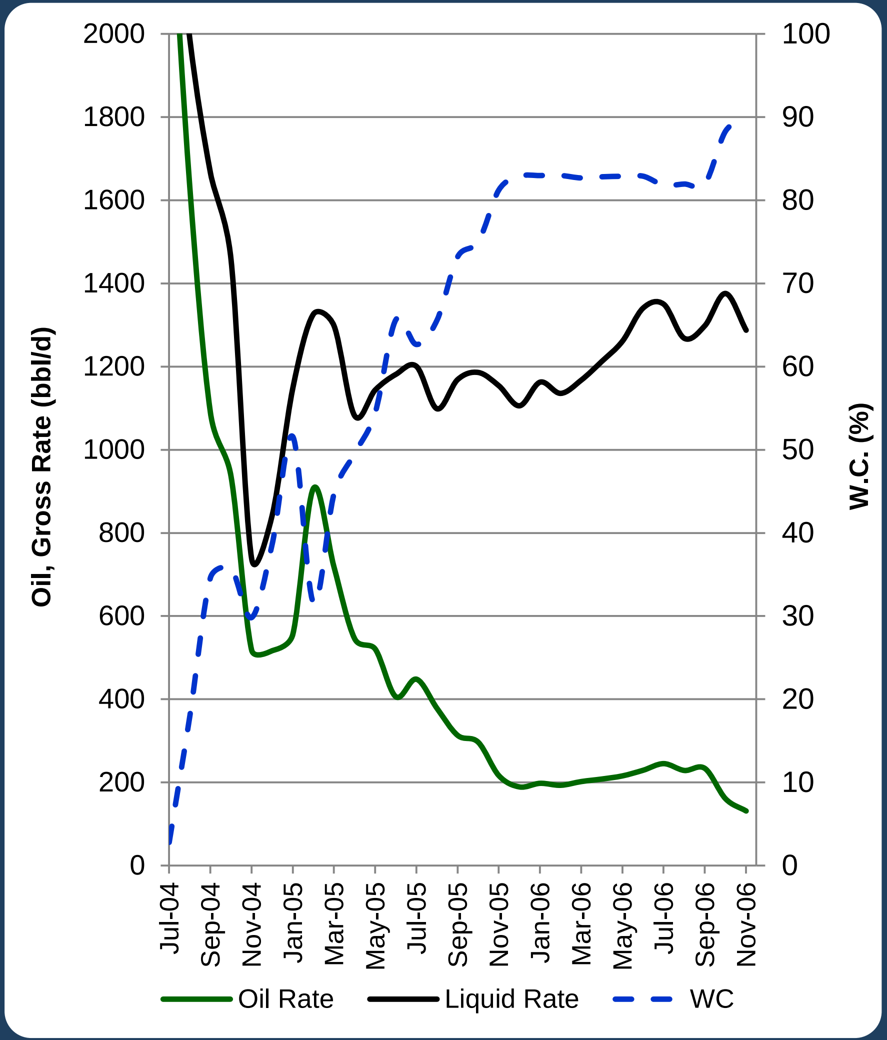
West Area Discovery

- SUCO decided to drill an exploratory well on 2004, in the western part of the lease area to appraise the Nullipore reservoir extension in the highly faulted block which was interpreted from 3D seismic interpretation.
- This discovery open a new major window to the west of the lease with the calculated oil reserve of 16 MMSTB.
- The development of this part of the lease was started from this time till now to approved this oil potentiality and the Nullipore reservoir extension.

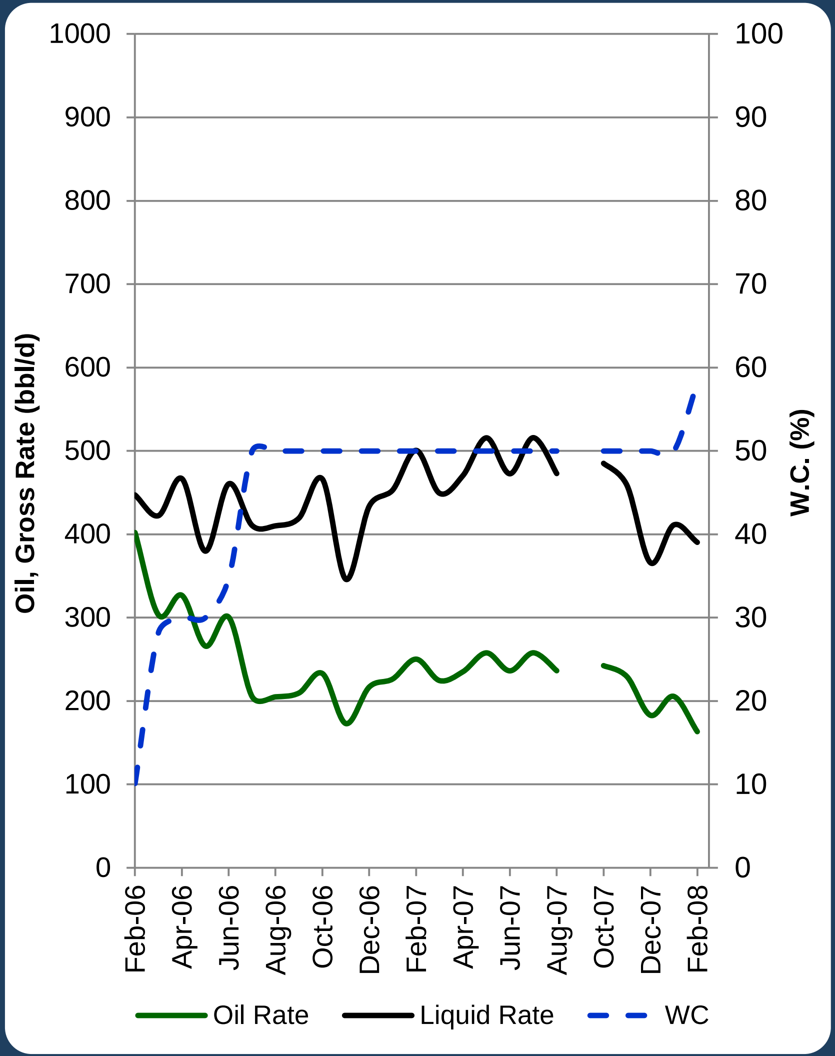




Challenges of First Phase Development

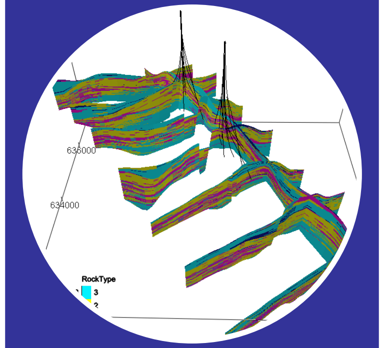


RF-B10 Performance

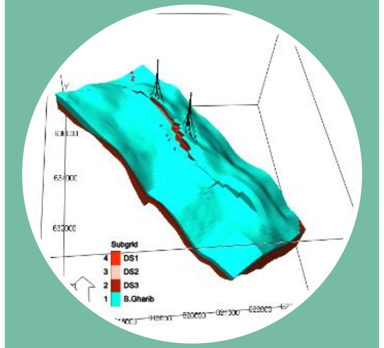


RF-A8b Performance

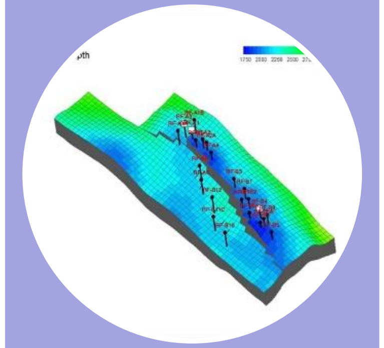
How to Proceed with the Development?



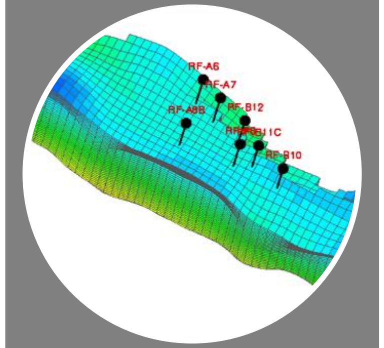
Structure Model



Static Model

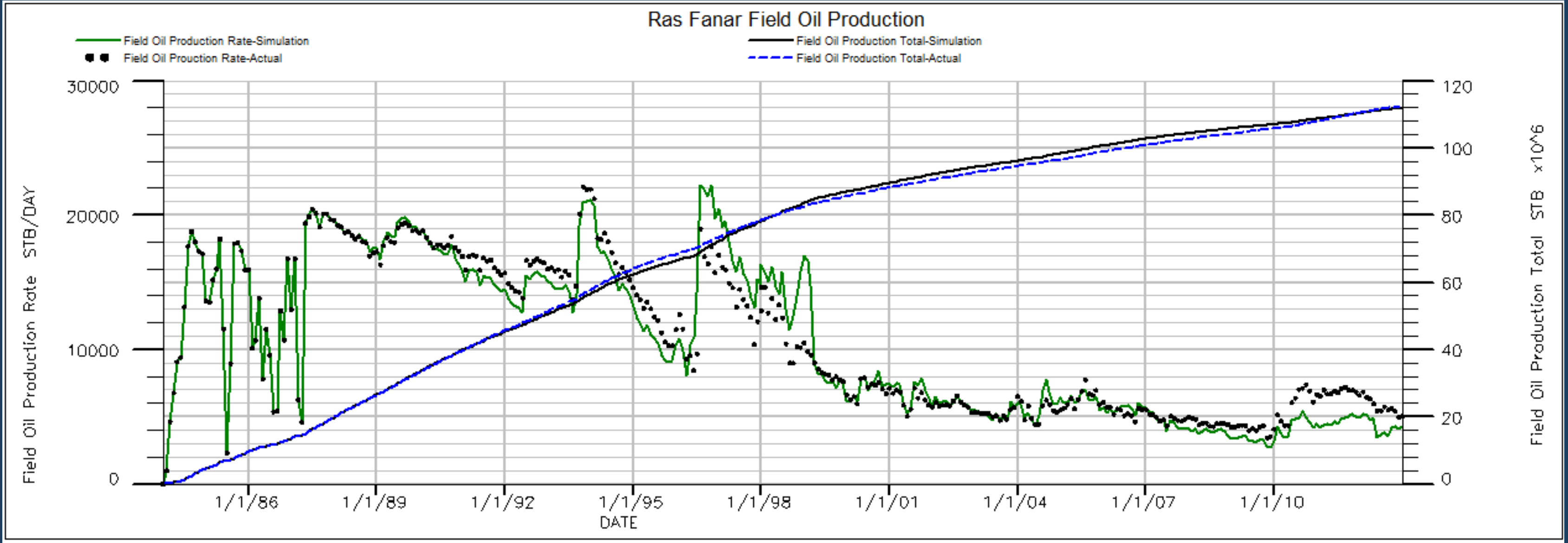


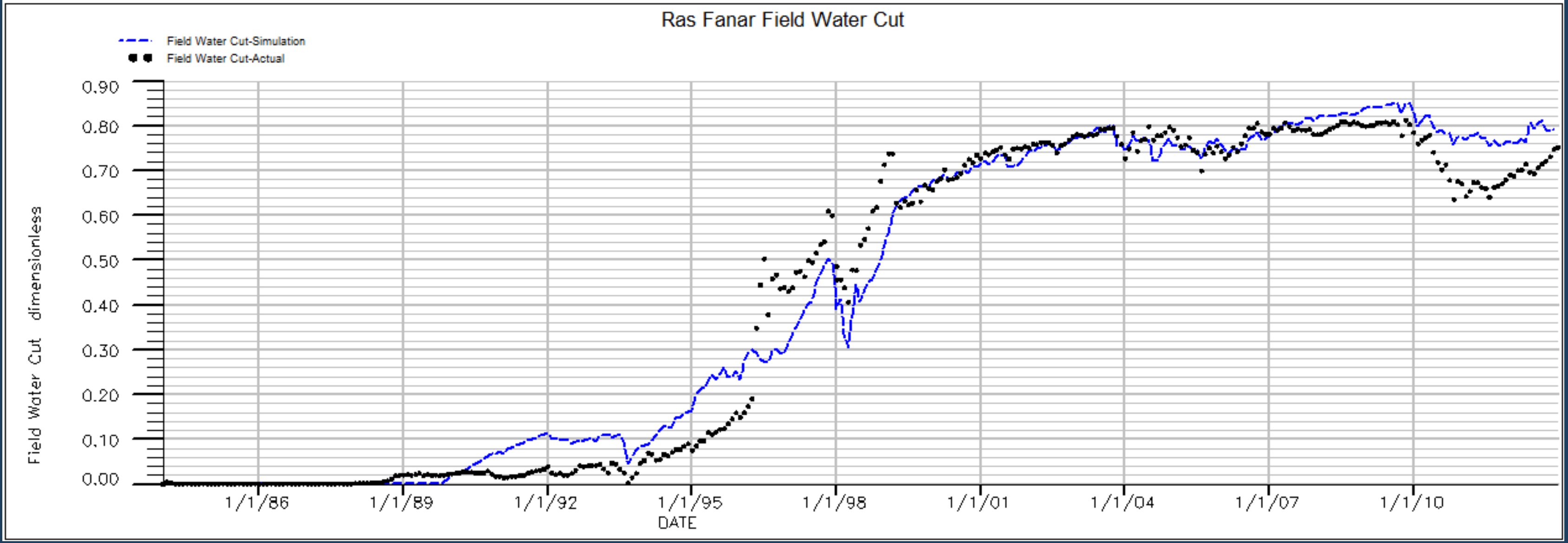
Dynamic Model



Prediction Scenarios

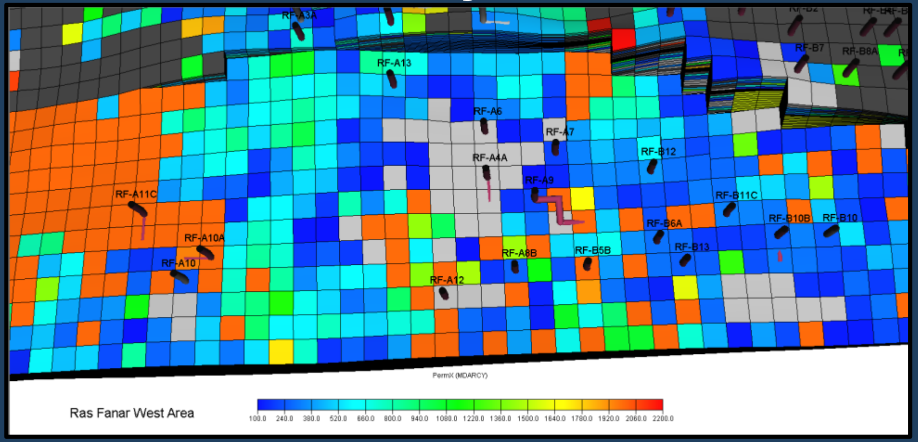
Integrated Reservoir Study



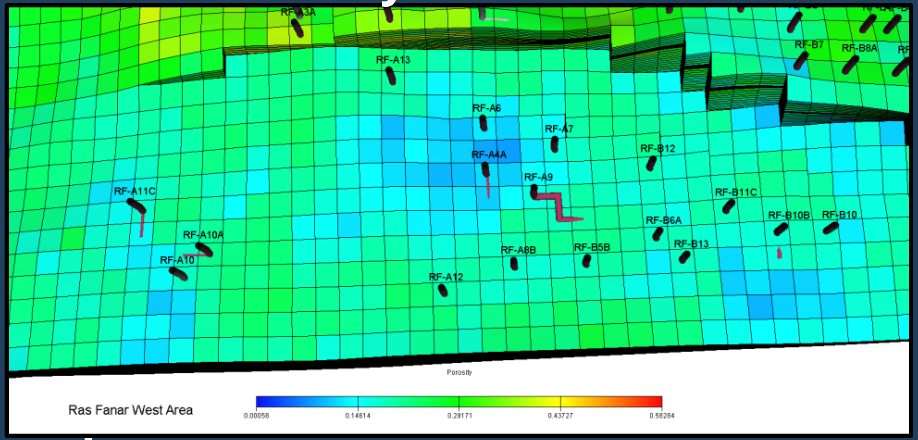


Property Distribution

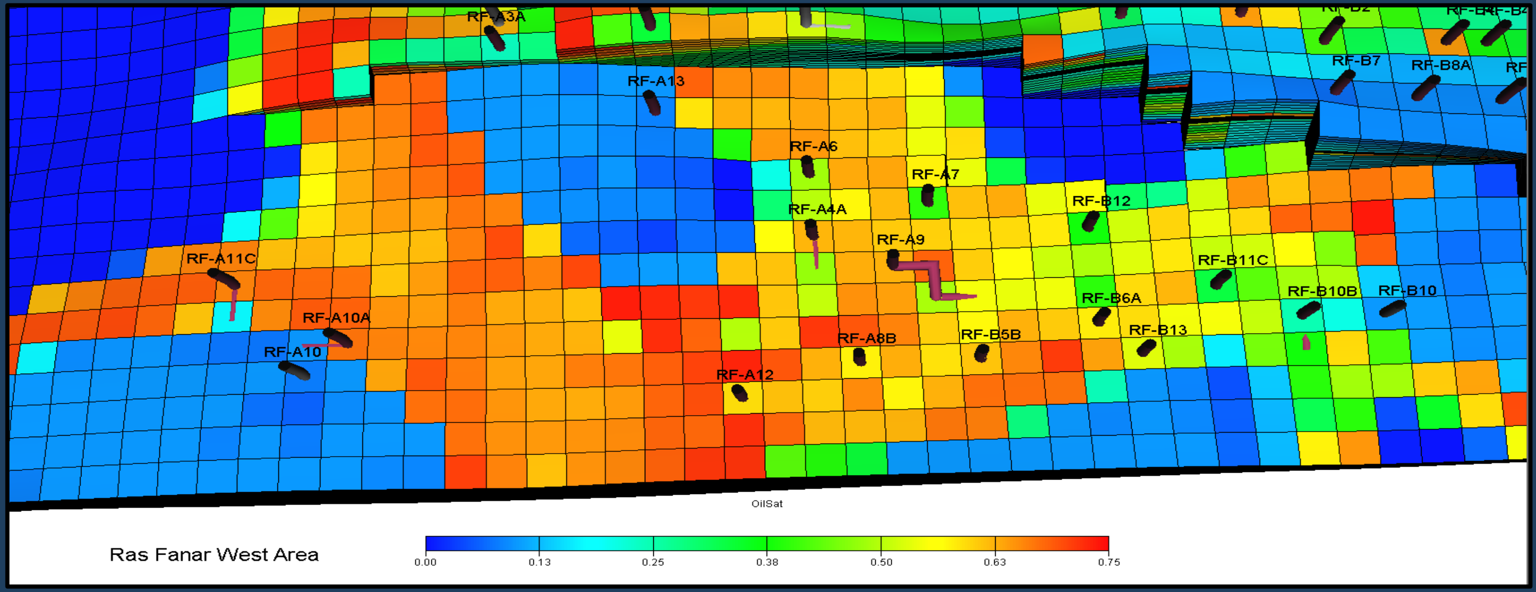
Permeability Distribution



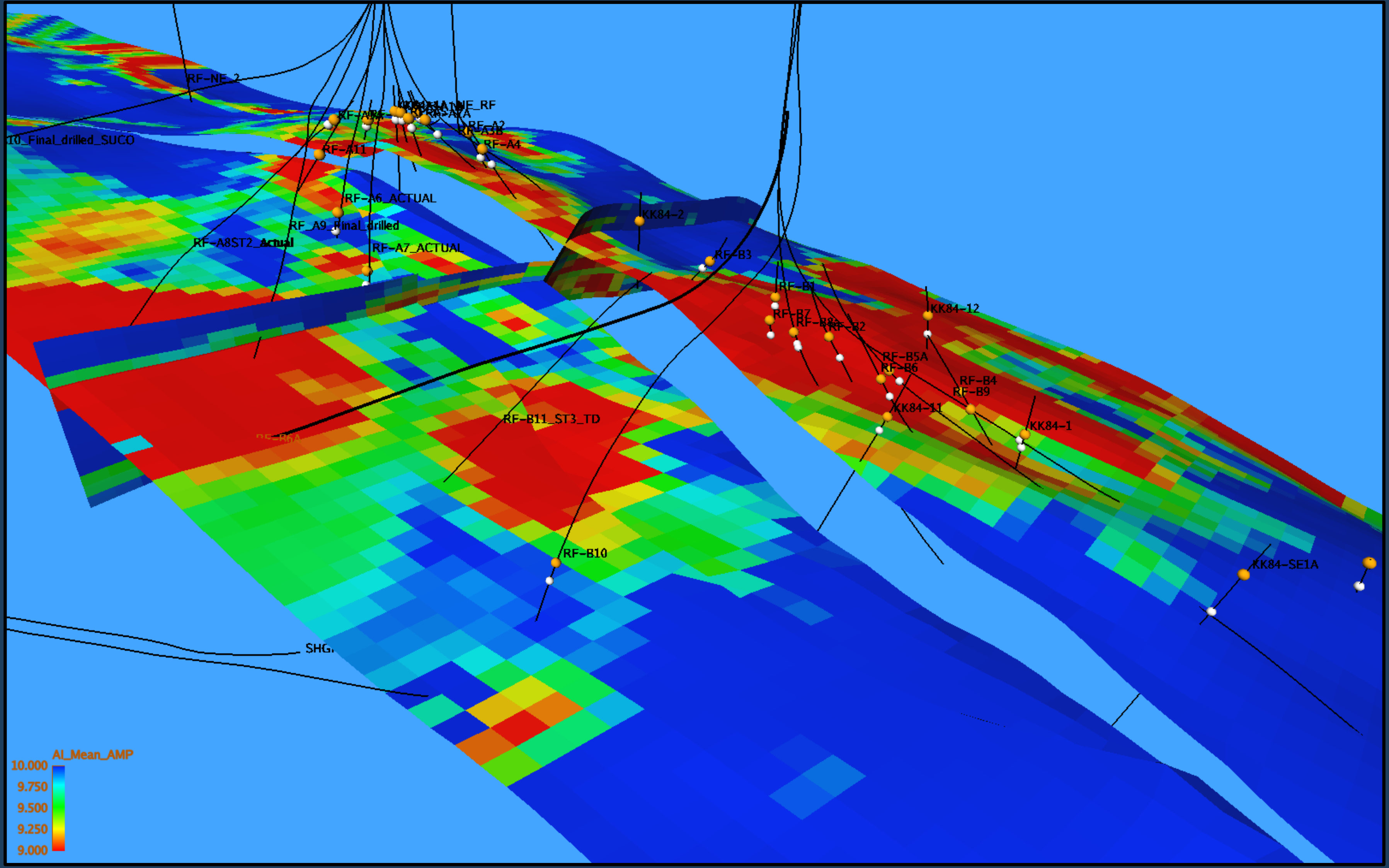
Porosity Distribution



Average Oil Saturation



Ras Fanar Acoustic Impedance Distribution



Second Phase Development Plan

Challenge: The Reservoir Heterogeneity

Action:

- Using Seismic Data
- Using Reservoir Simulation Model
- Long Well Path Through Payzone

Second Phase Development Plan

Challenge: Limited payzone thickness.

Action: Drilling of Horizontal Wells is the Best Suitable Well Design.

Challenge: Limited Well Slots on Platform.

Action: Sidetrack the Almost Watered Out Wells.

Second Phase Development Plan

Challenge: The Sharp Increase of Water Cut Experienced in the Phase I.

Action: Production Optimization for the Artificial Lift of New Wells

- General Challenges: Water Coning, Asphaltene, Paraffin's and Waxes Production.

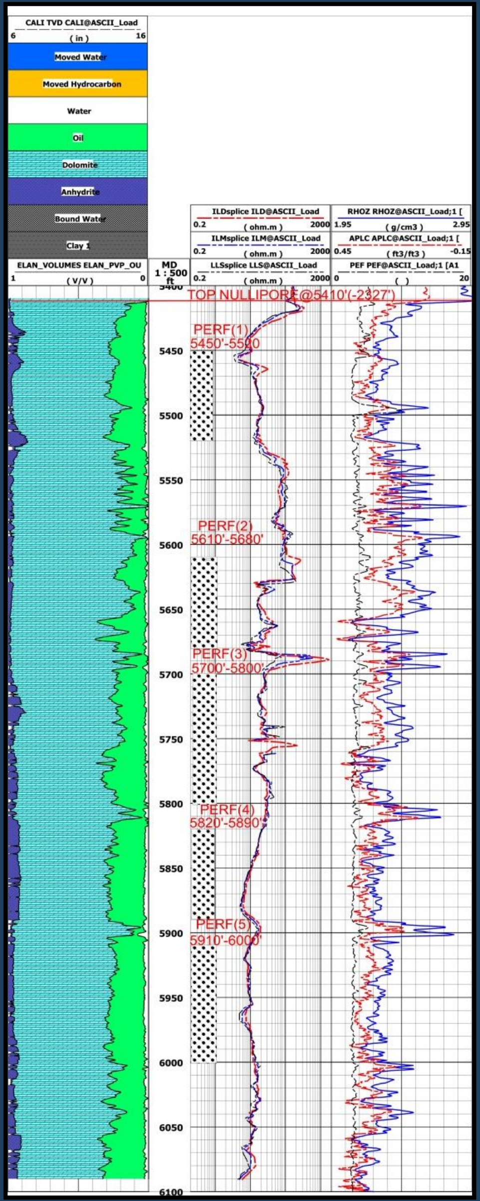
Infill Wells Selected Based on

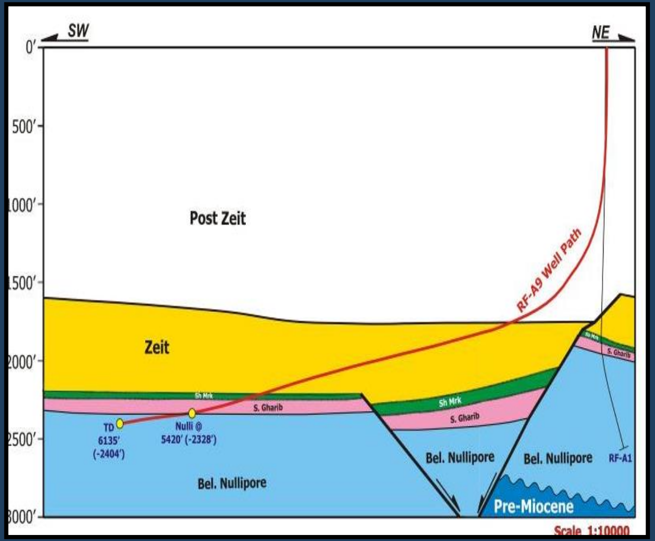
- Drainage Area Based on top Reservoir and top Perforation.
- Highest Area in Reservoir.
- Cut More Distance in Oil and Gas Zones.
- Better Locations Near Faults .

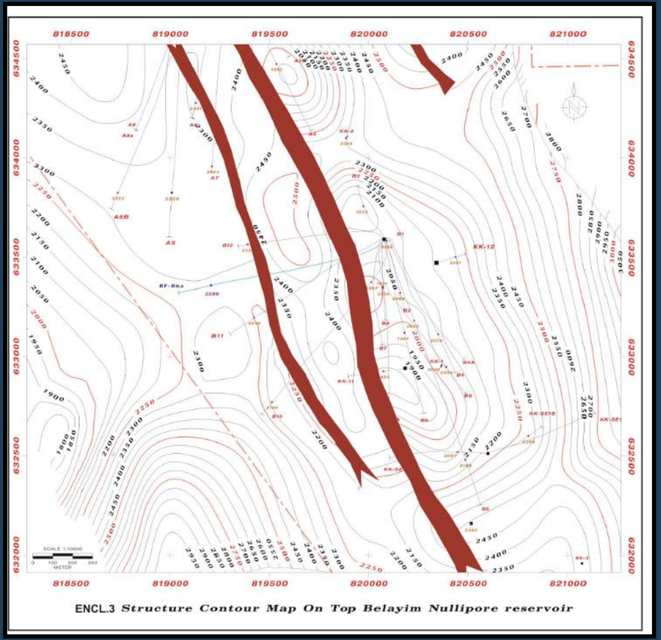
Well Planning

- Select Location
- Available Surface Locations
- Best Well Path
- Select Desirable Rate

Example: RF-B6a

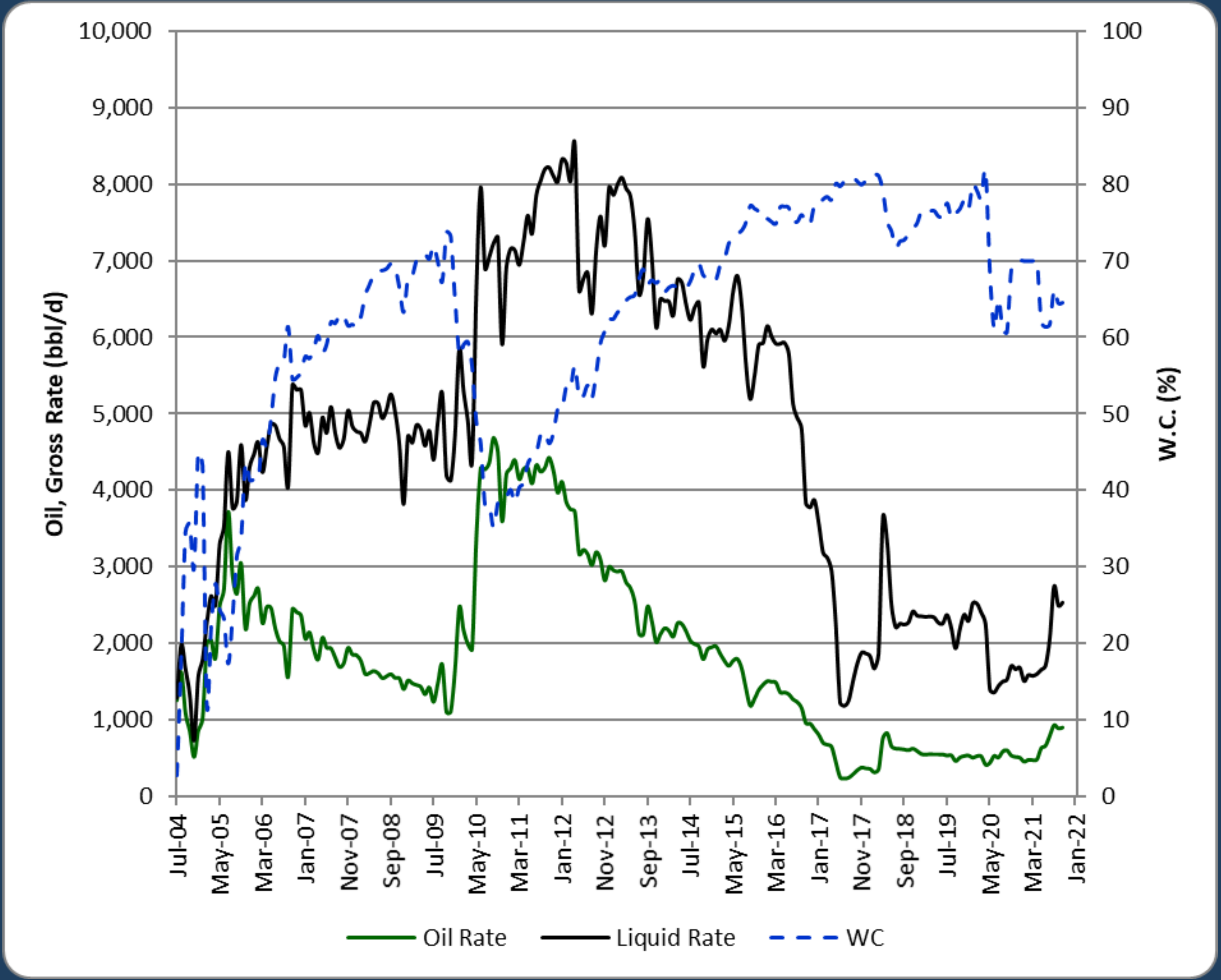






Initial Oil Rate (BOPD)	1800
Perforated Intervals (Ft-MD)	300
Perforated Intervals (Ft-TVD)	62
Cumulative Oil Production (MMSTB)	2.2

West Area Performance



Cumulative Production from West Area reached 11.5 MMstb