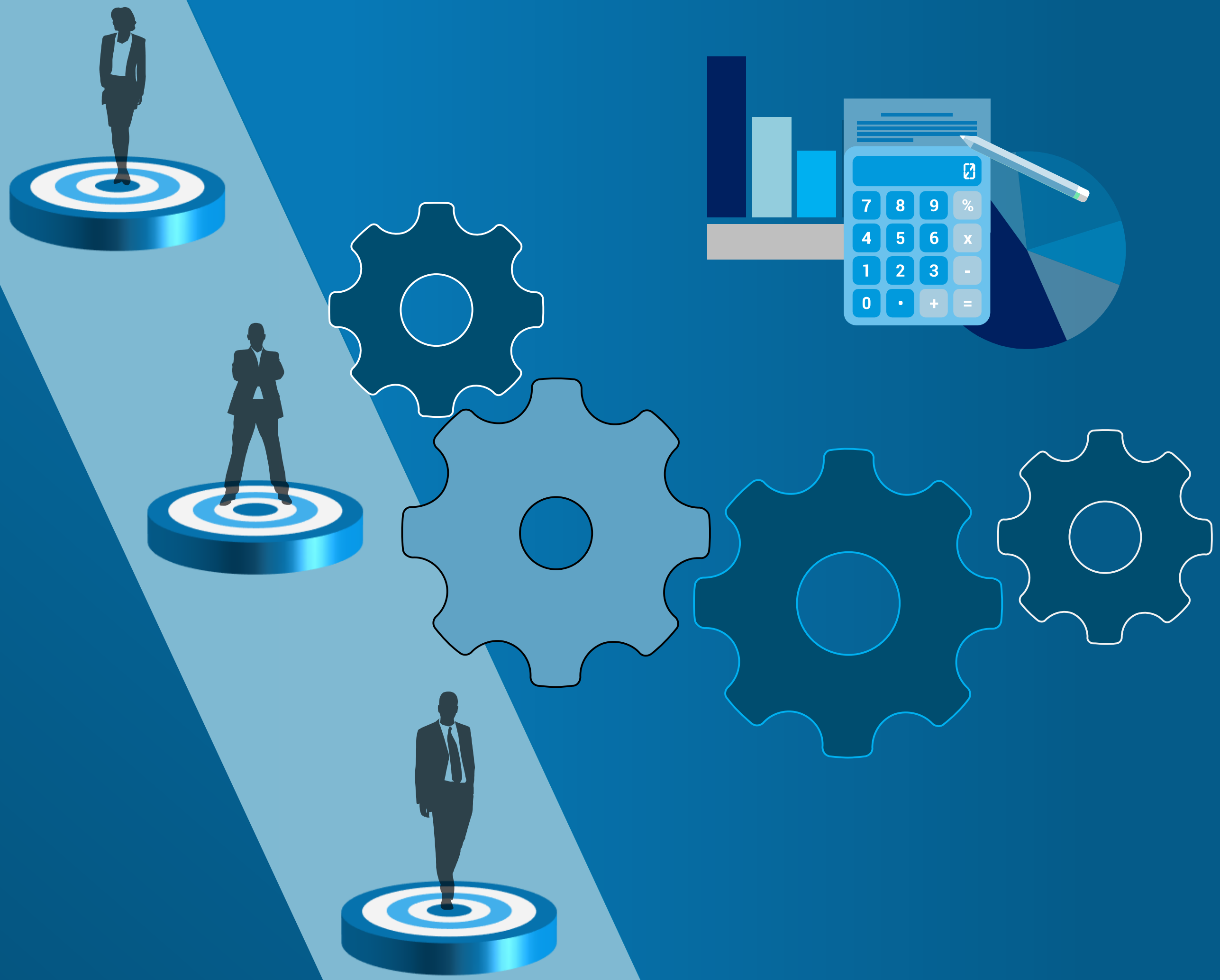
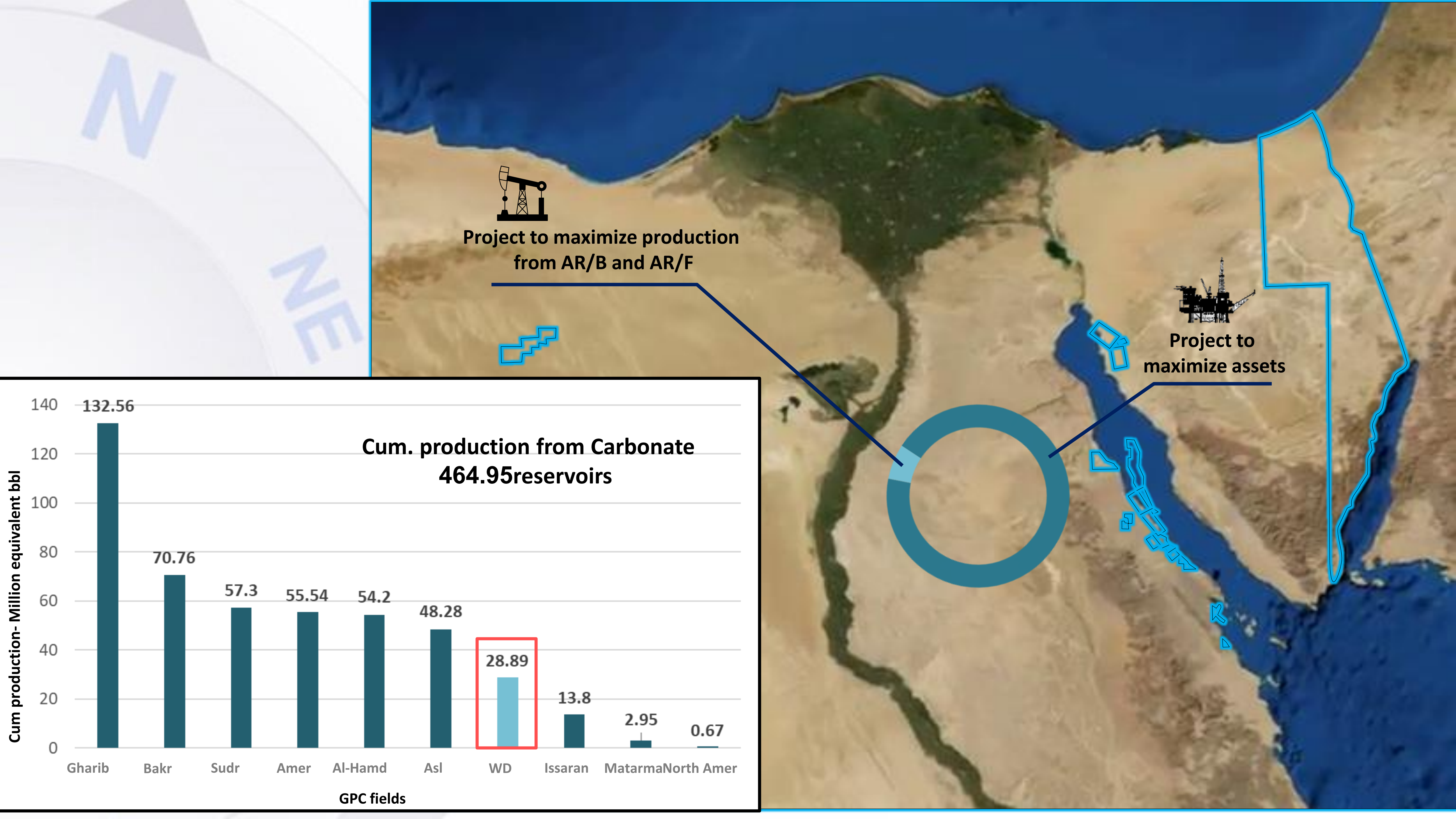
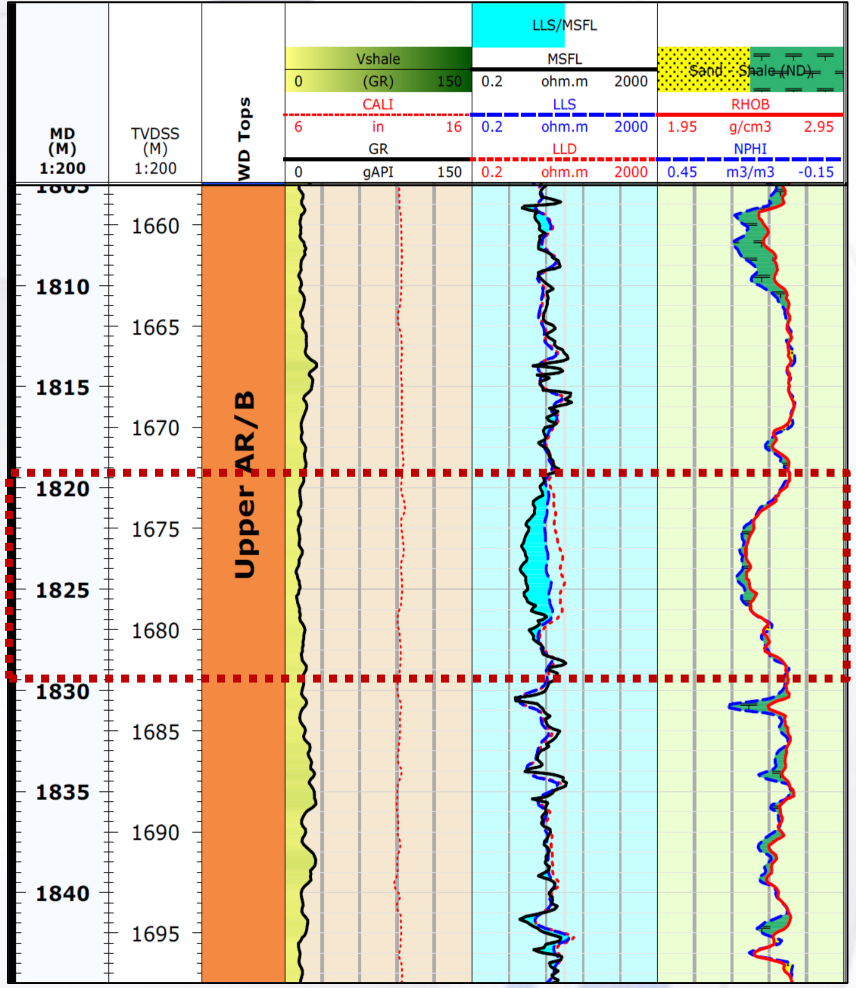
Lessons Learned of the First Edition of Carbonate Reservoirs Workshop
(New Development Opportunities)

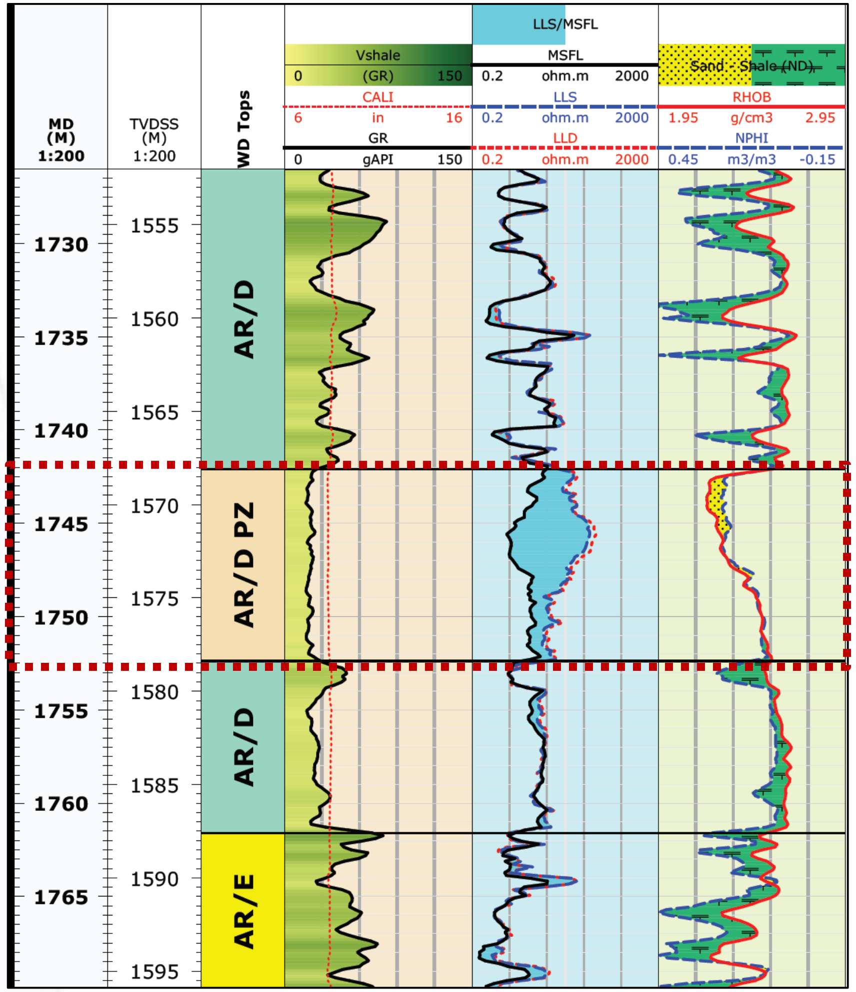




Project to maximize production from AR/B and AR/F
Project to maximize assets
Cum. production from Carbonate
464.95reservoirs
Cum production- Million equivalent bbl
140
120
100
80
60
40
20
0
132.56
70.76
57.3
55.54
54.2
48.28
28.89
13.8
2.95
0.67
Gharib
Bakr
Sudr
Amer
Al-Hamd
Asl
WD
Issaran
Matarma
North Amer
GPC fields



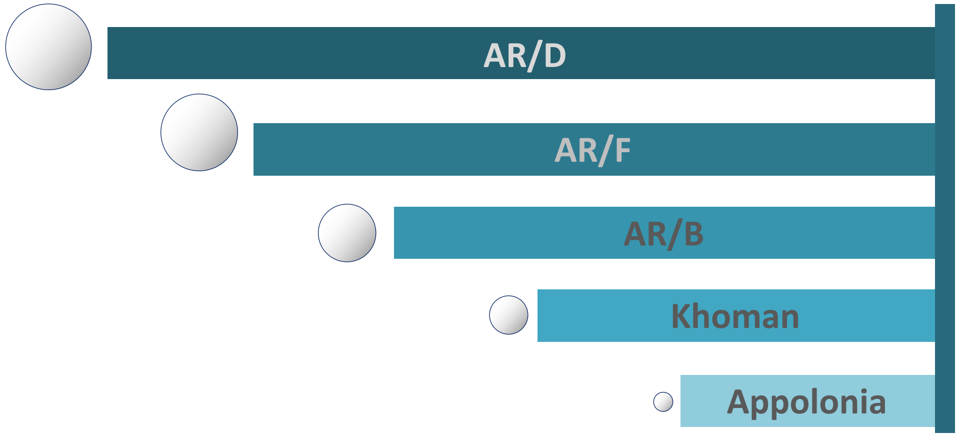
Porosity: 15%

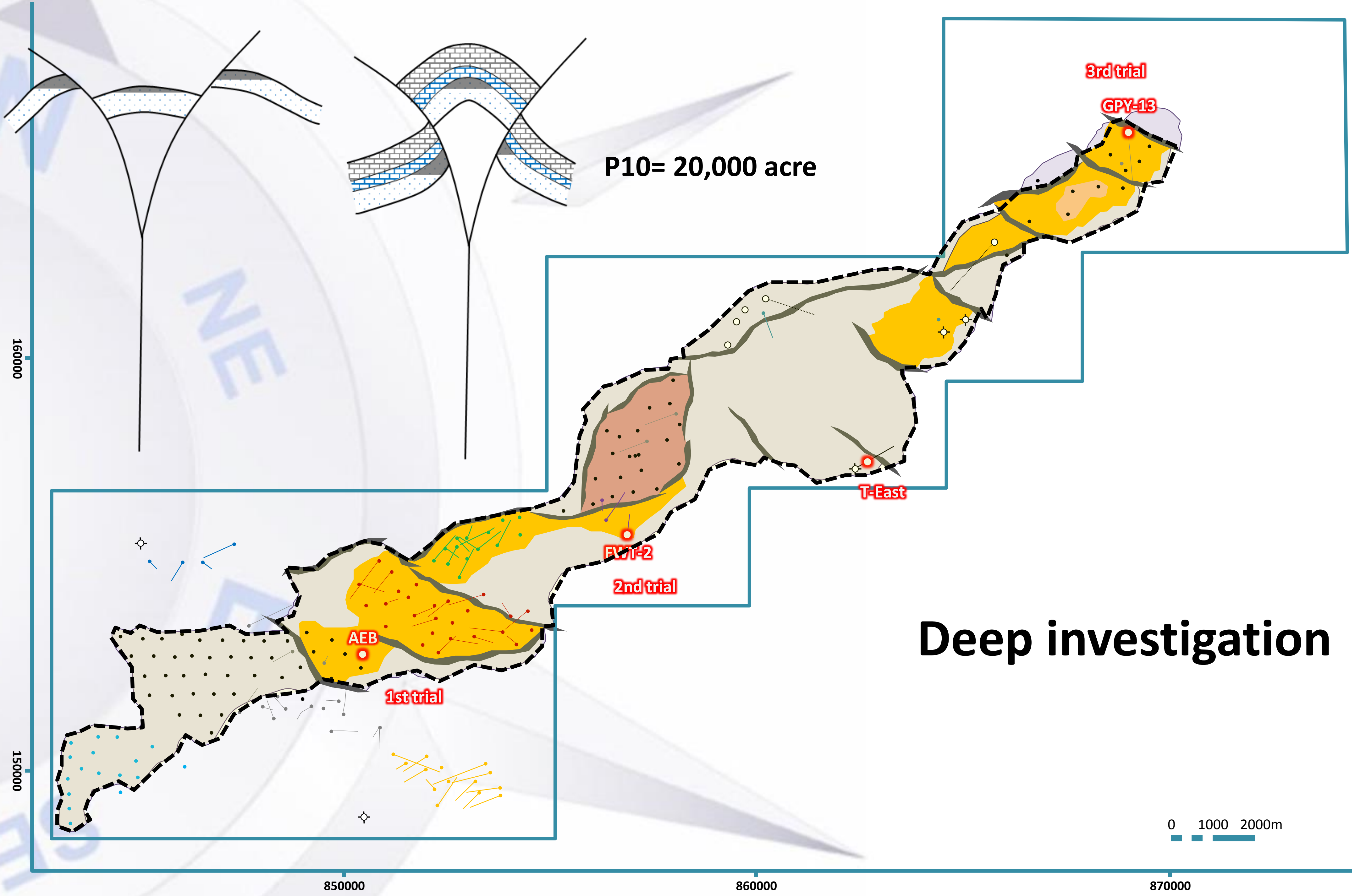


Porosity: 20%

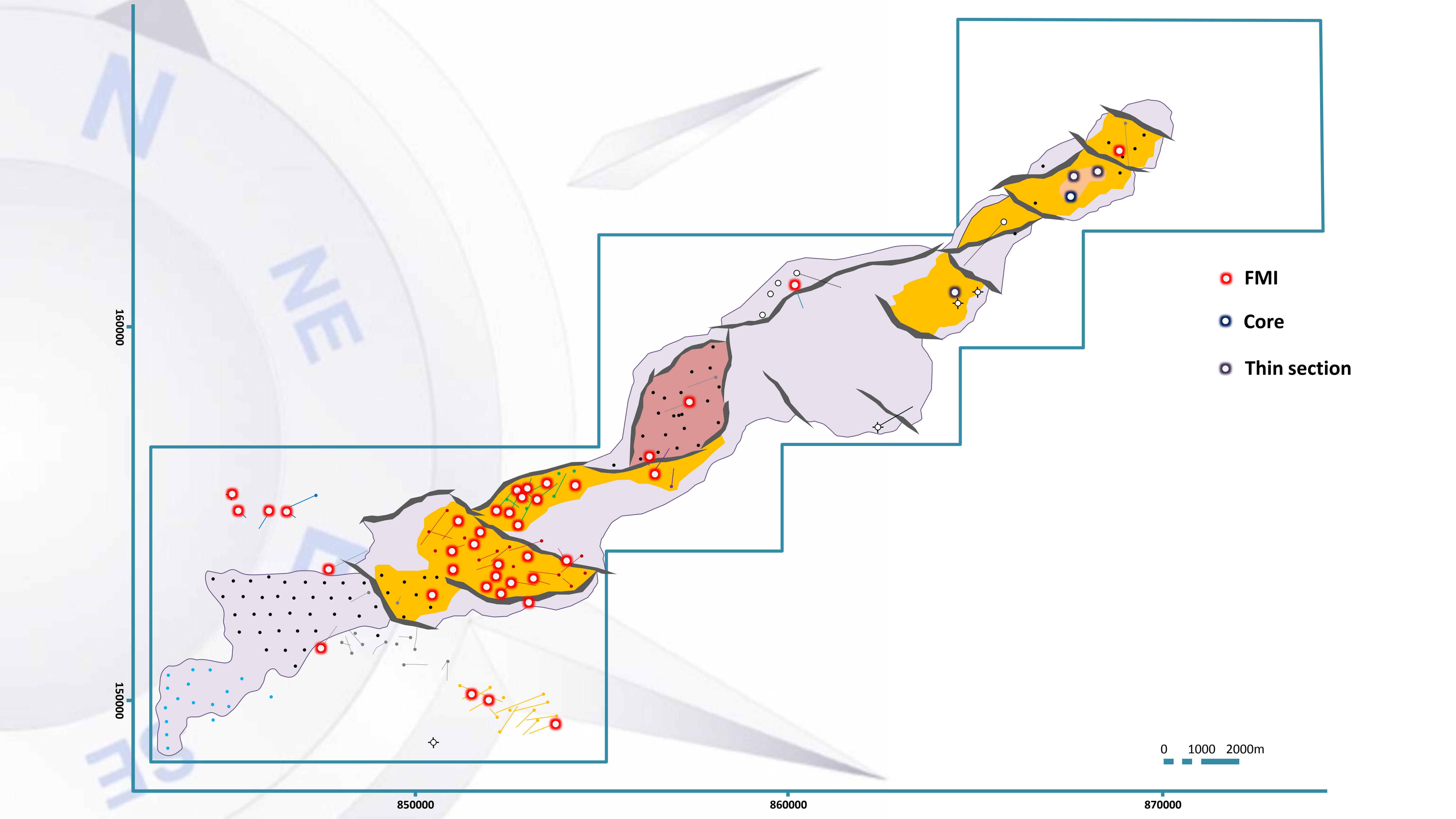
From 50 bbl/d to 300 bbl/d stabilized

From 200 bbl/d to 1600 bbl/d initial



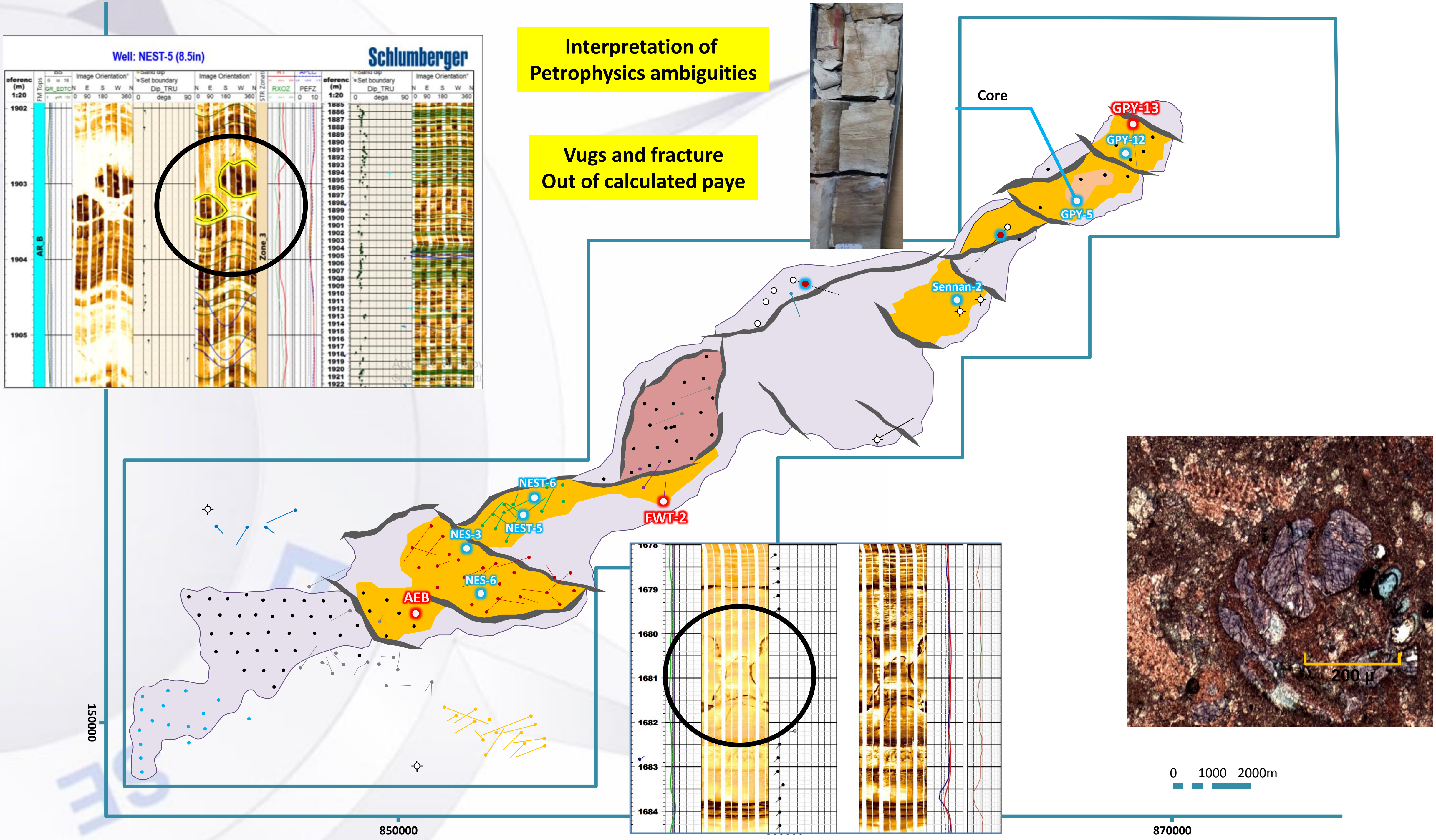


Deep investigation

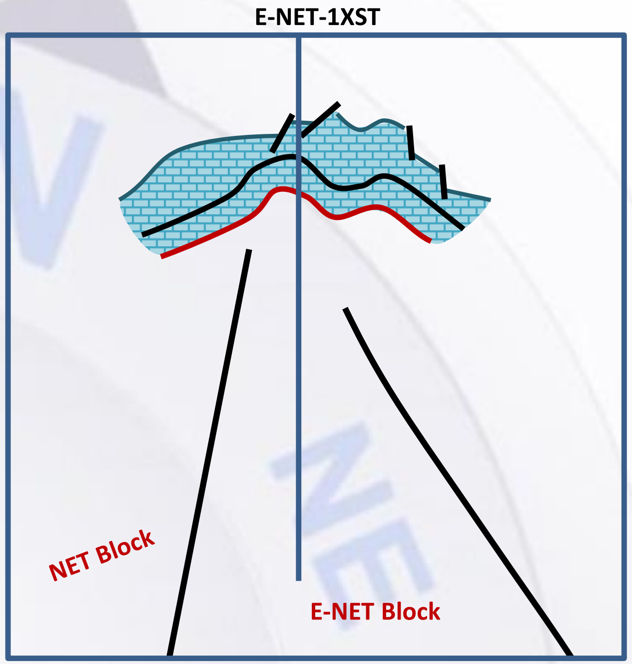

FMI
Core
Thin section
0 1000 2000m
160000
150000
850000
860000
870000

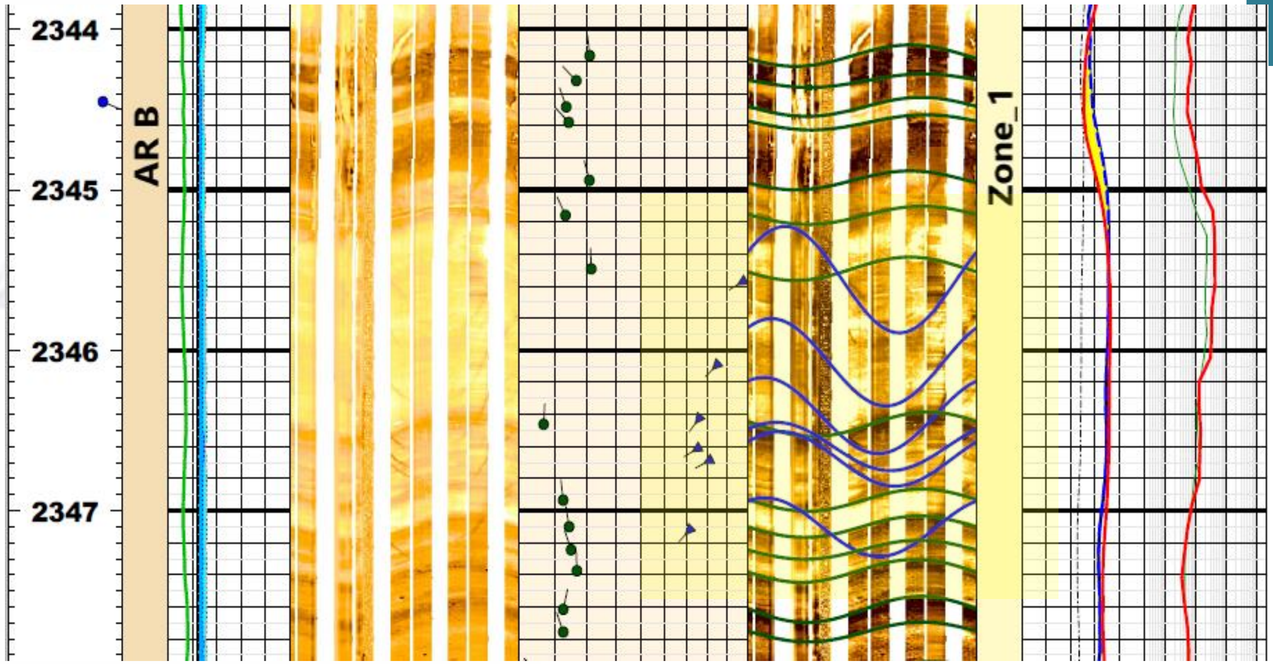
Interpretation of
Petrophysics ambiguities

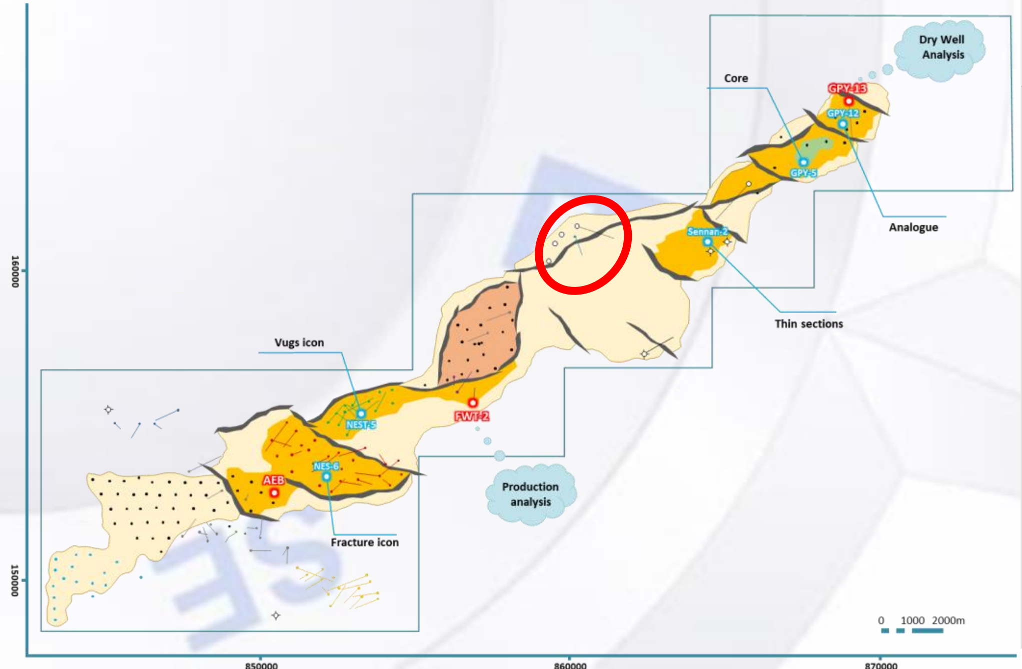
Vugs and fracture
Out of calculated paye

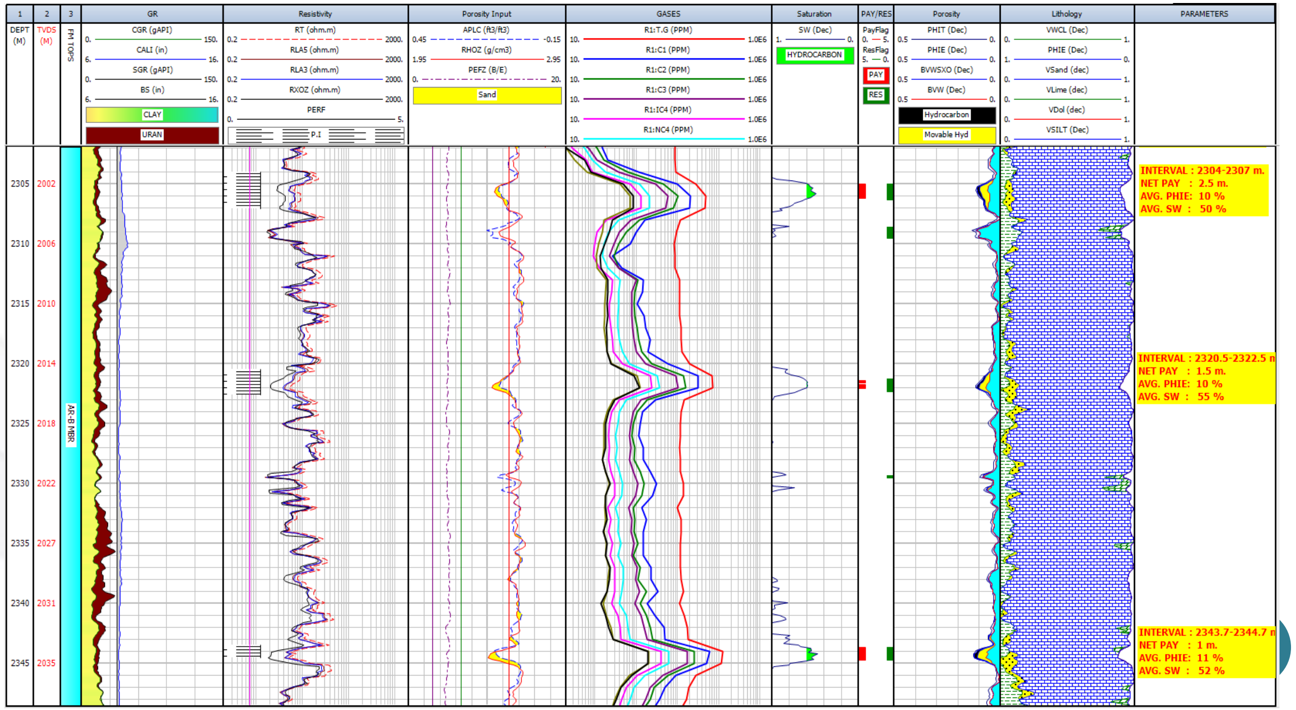


E-NET-1XST


E-NET-1XST
NET Block
E-NET Block


2344
2345
2346
2347
AR B
Zone_1

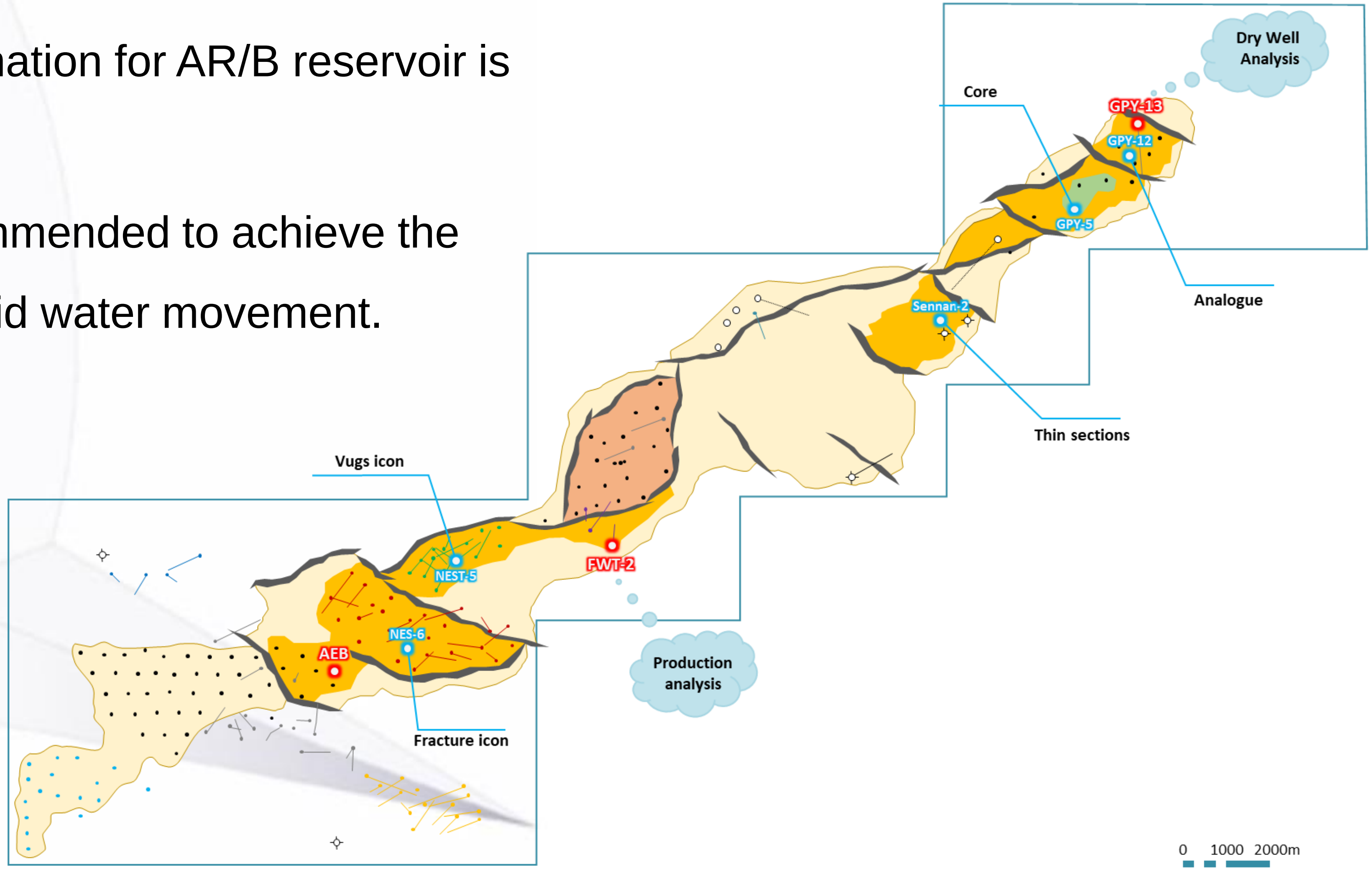

Dry Well Analysis
Core
Analogue
Thin sections
Vugs icon
Production analysis
Fracture icon
GPY-13
GPY-12
GPY-5
Sennan-2
FWT-2
NEST-5
NES-6
AEB
0 1000 2000m
850000
860000
870000
160000
150000


GR
Resistivity
Porosity Input
GASES
Saturation
PAY/RES
Porosity
Lithology
PARAMETERS
INTERVAL : 2304-2307 m.
NET PAY : 2.5 m.
AVG. PHIE: 10 %
AVG. SW : 50 %
INTERVAL : 2320.5-2322.5 m
NET PAY : 1.5 m.
AVG. PHIE: 10 %
AVG. SW : 55 %
INTERVAL : 2343.7-2344.7 m
NET PAY : 1 m.
AVG. PHIE: 11 %
AVG. SW : 52 %

AR/B Carbonate

- Changing the characterization approach for AR/B carbonate helped to improve production with sustainable rates.
- Specifically, proper stratigraphic zonation for AR/B reservoir is important to select the sweet spots.
- Selective perforation is highly recommended to achieve the best performance and eliminate rapid water movement.

GPC concession border



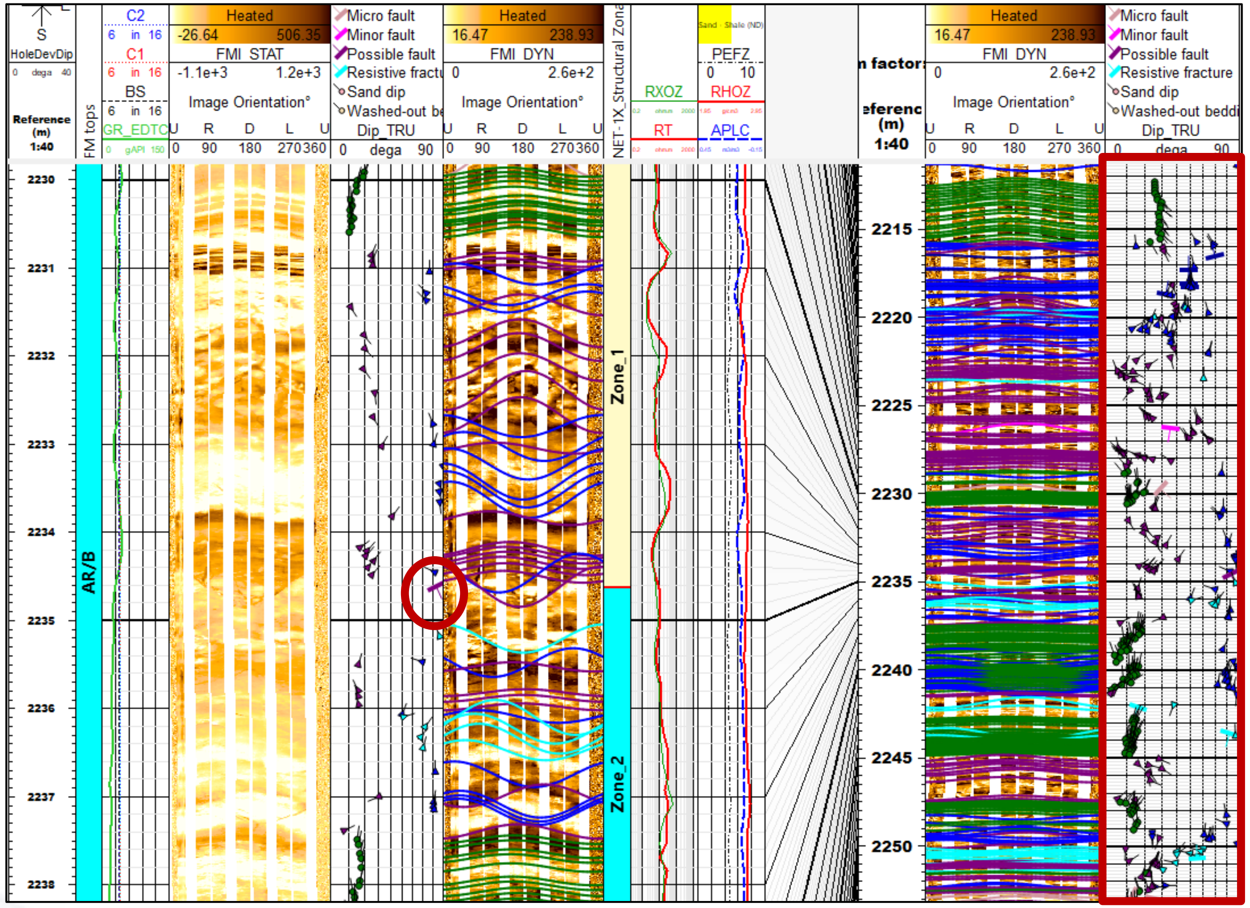
E-NET-1X: AR/B Reservoir

- AR/B member shows bed boundary dips (green tadpole) and deformed dips (purple triangle).
- A possible fault @2234.6m, developed with strike orientation towards NE-SW.

Interval (MD)	Net (MD)	Net (TVDSS)	Sw (%)	Øe (%)
2304-2307	2.5	1.9	50	10
2320.5-2322.5	1.5	1	55	10
2343.7-2344.7	1	0.8	52	11

MD (m)	TVD (m)	T [°F]	Formation Pressure [PSIA]	Drawdown Mobility [md/cp]
2306	2156.27	189.53	3603.55	0.17
2322	2169.64	189.6	3518.07	0.04

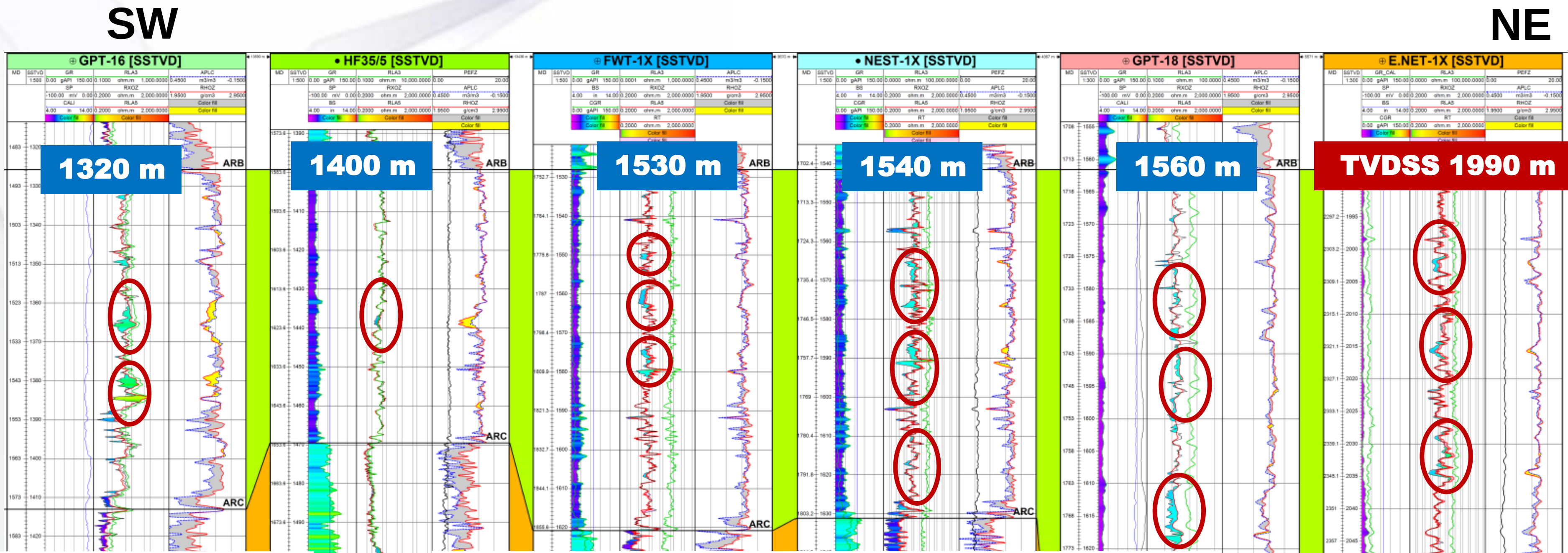
Borehole Image (NET-1X)

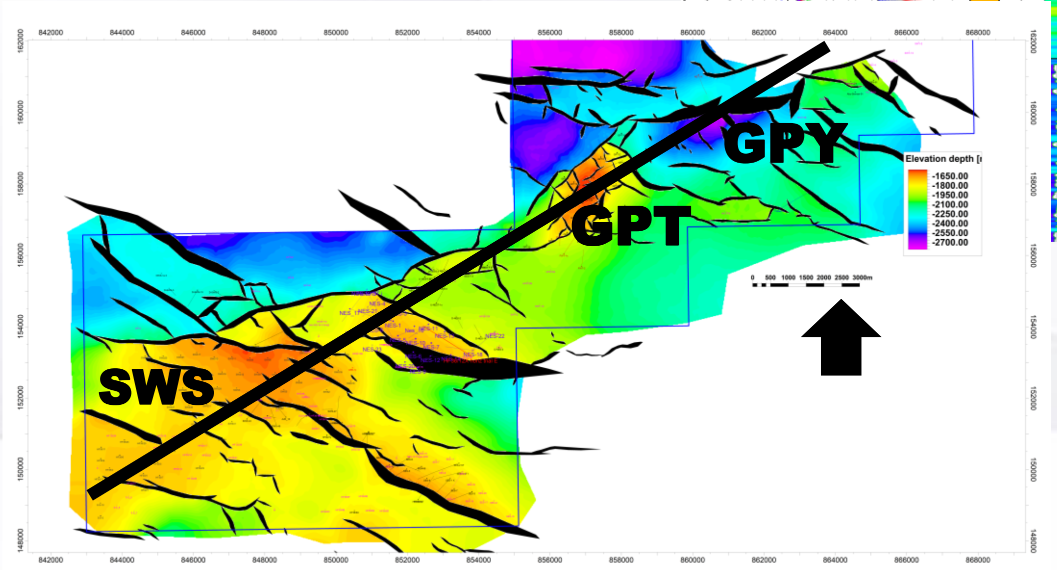


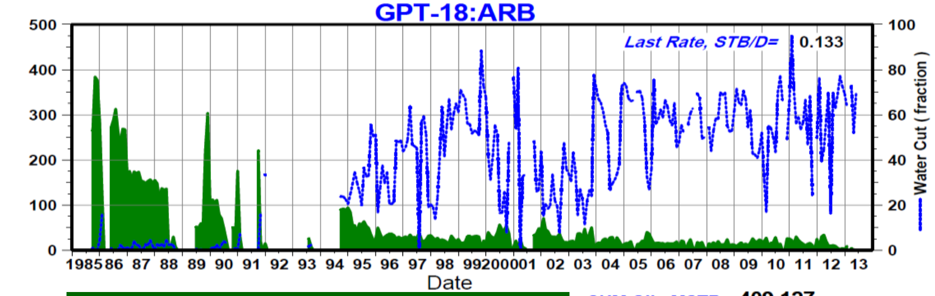
Average Sw: 52%
Average Poro: 10%

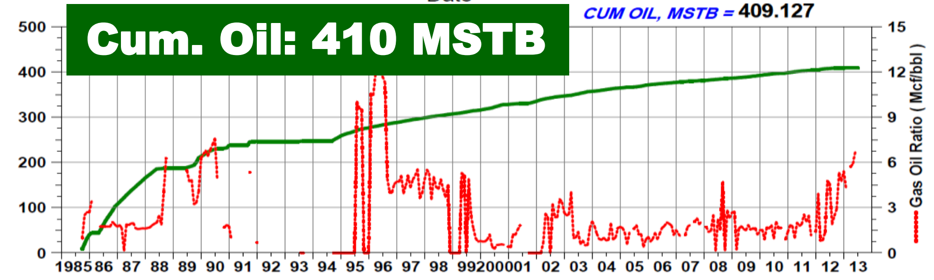
AR/B Regional Correlation

- Regional AR/B correlation shows changing the reservoir level with separate GOCs for different blocks.



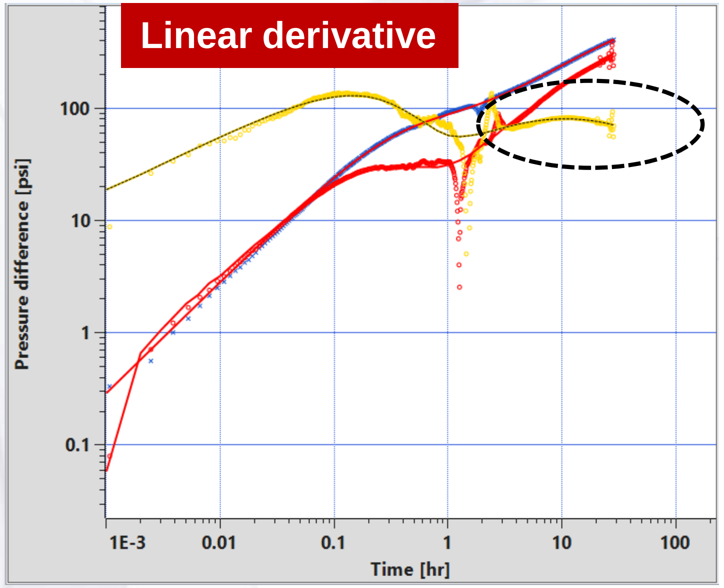


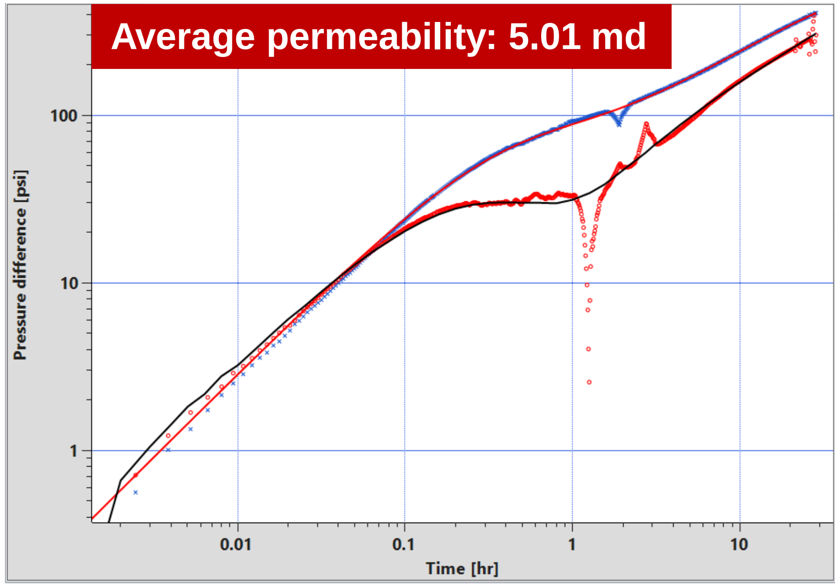


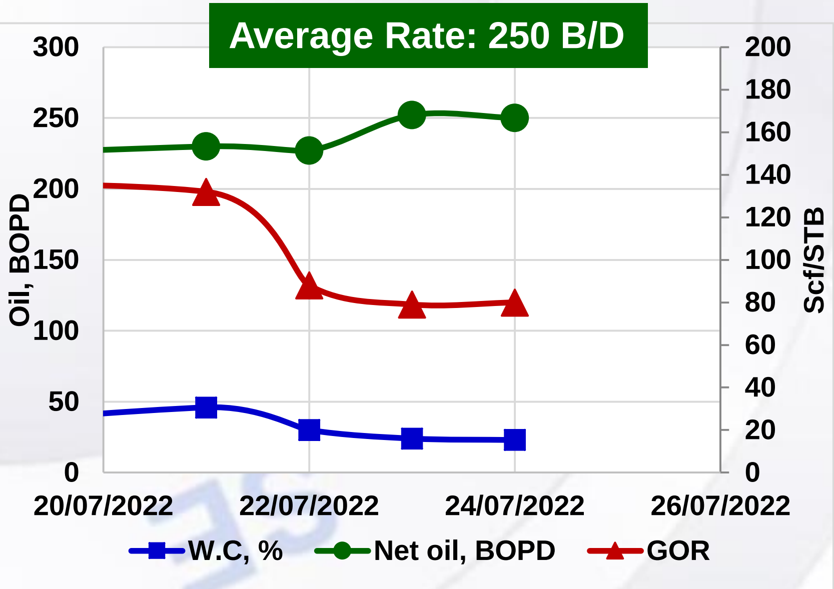


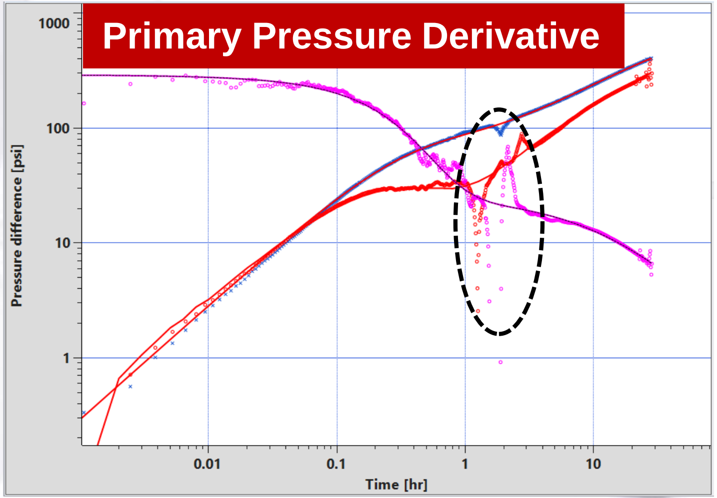
E-NET-1X Well Testing Interpretation

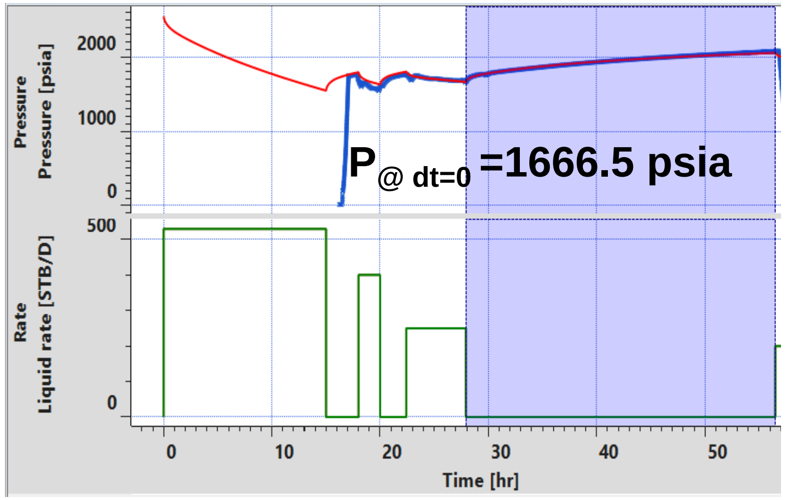
- **Reservoir model:**
  - Permeability:5.01 md
  - Skin: -6.70
  - Initial pressure: 2547.1 psia
  - **PI: 0.6 [B/D]/psia**
  - South: 417.51 ft
  - North: 693.12 ft
  - Reservoir: Homogeneous
  - Boundary: Parallel faults

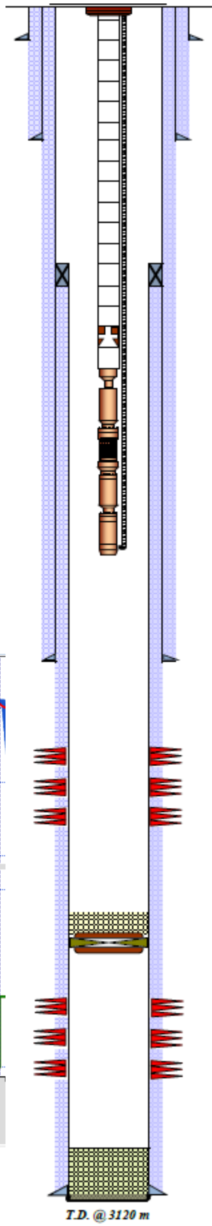








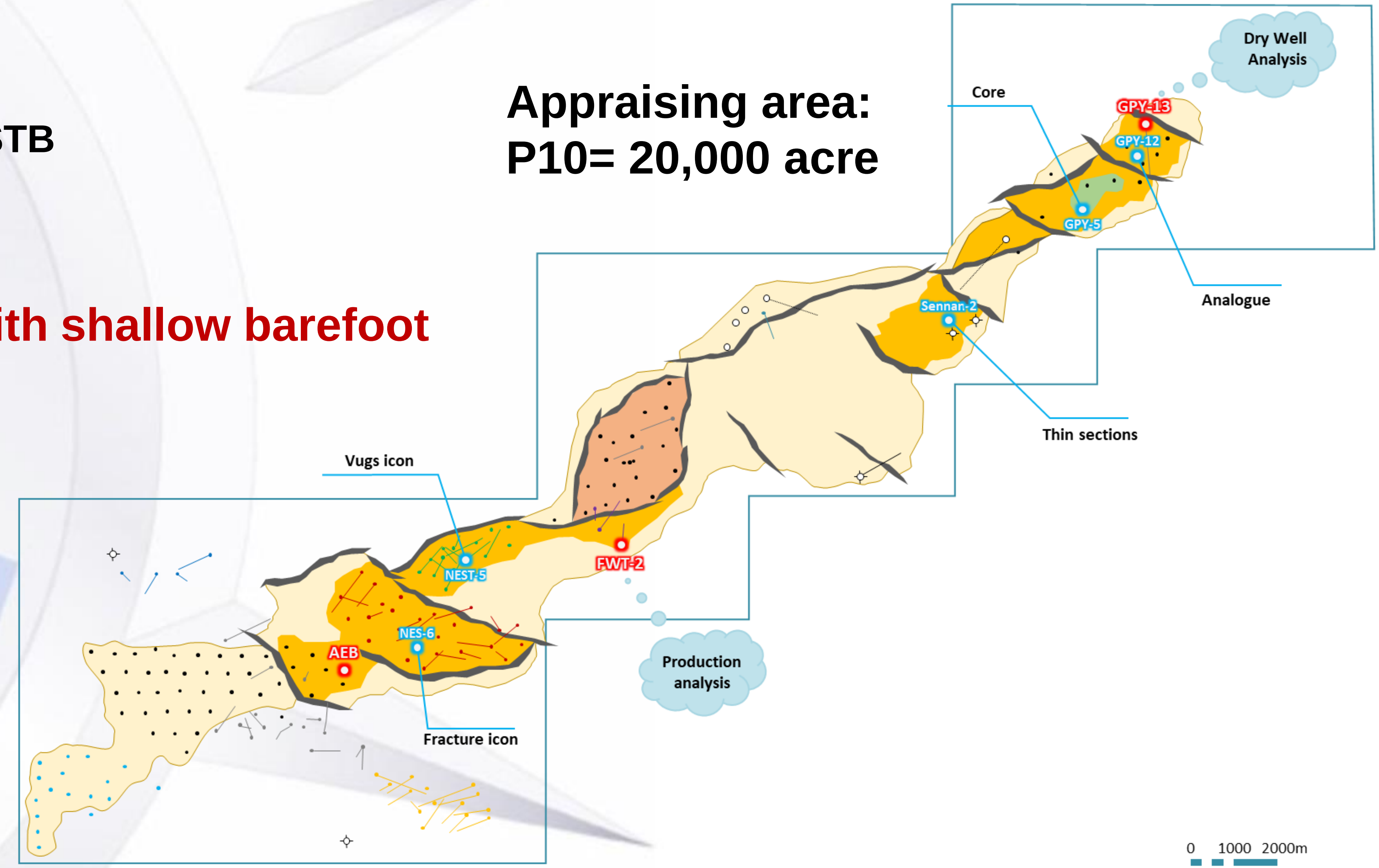




AR/B Way Forward

- **Added reserve:**
  - **STOIIP (2P): 2.5 MMSTB**
  - **Reserve: 0.5 MMSTB**
- **Develop the area with shallow barefoot completion wells.**

Appraising area:
P10= 20,000 acre



G.P.C

EGPC

Brown Fields Rejuvenation

"Maximizing Production & Recovery"

GPC 2022 Workshop

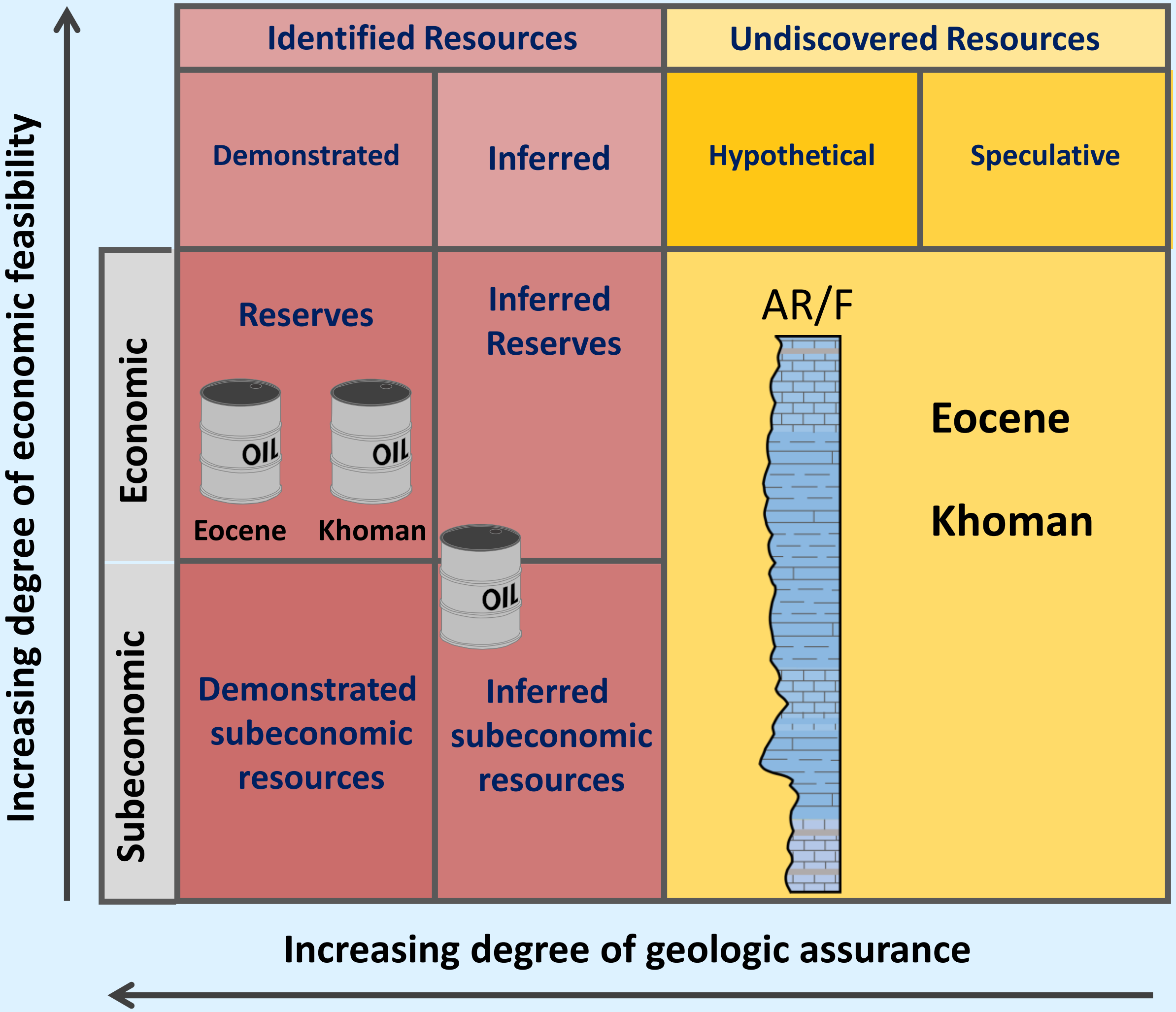
AR/F Reservoir

Life of production

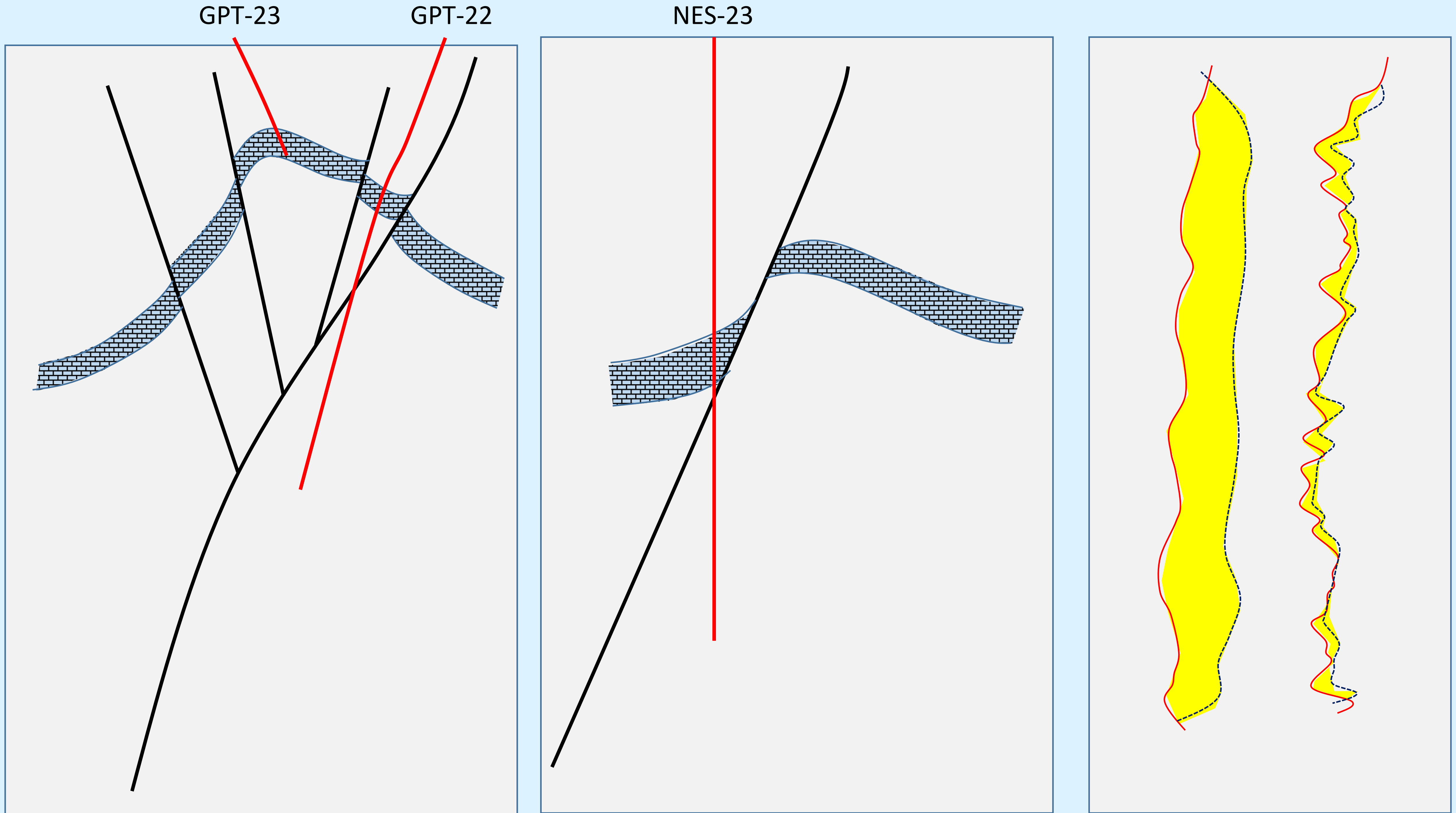
Barefoot vs cased hole

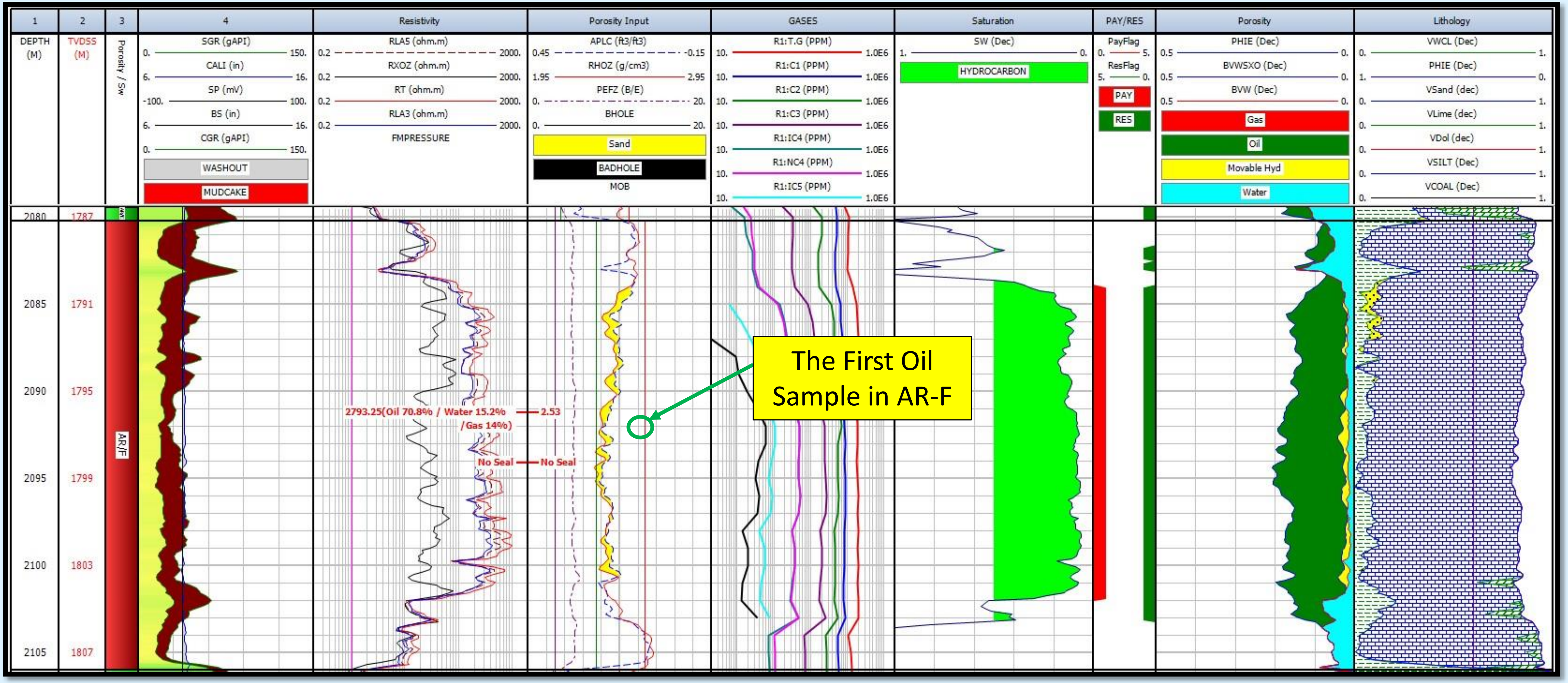
Compression vs tension

Fluid type (there is gas, where is oil)



The Mckelvey diagram (after Mckelvey, 1972)

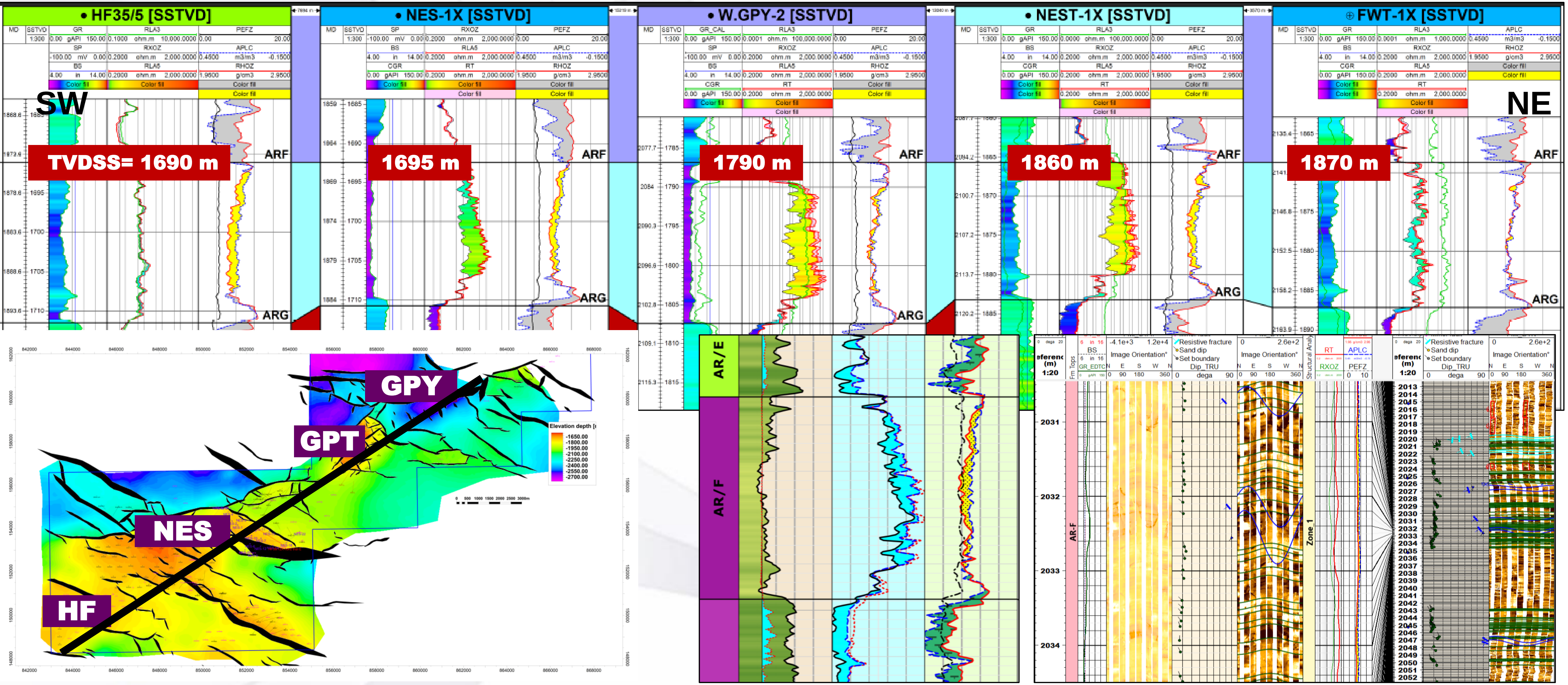

GPT-23
GPT-22
NES-23



Fm Name	INTERVAL (MD)	INTERVAL (VSS)	Net (MD)	Net (TVDSS)	Sw (%)	Øe (%)
AR-F MBR	2084-2102	1790-1804.3	-	-	11	16

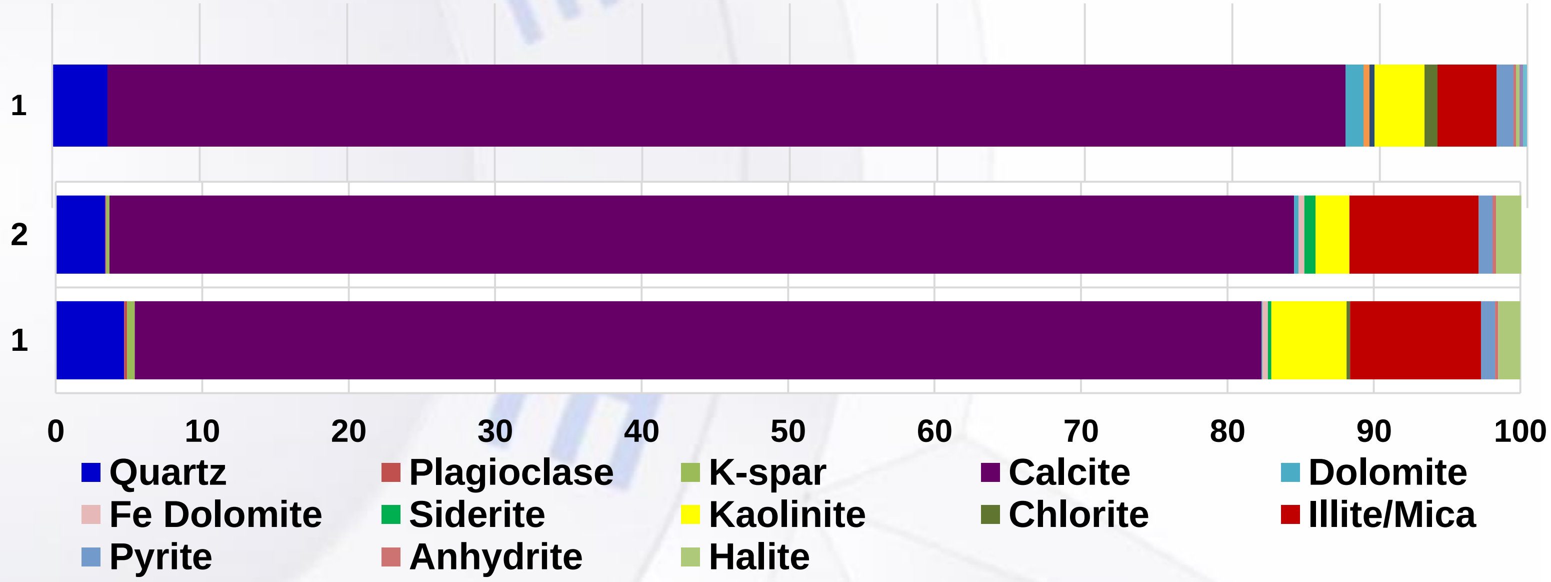
Regional AR/F Structural Settings

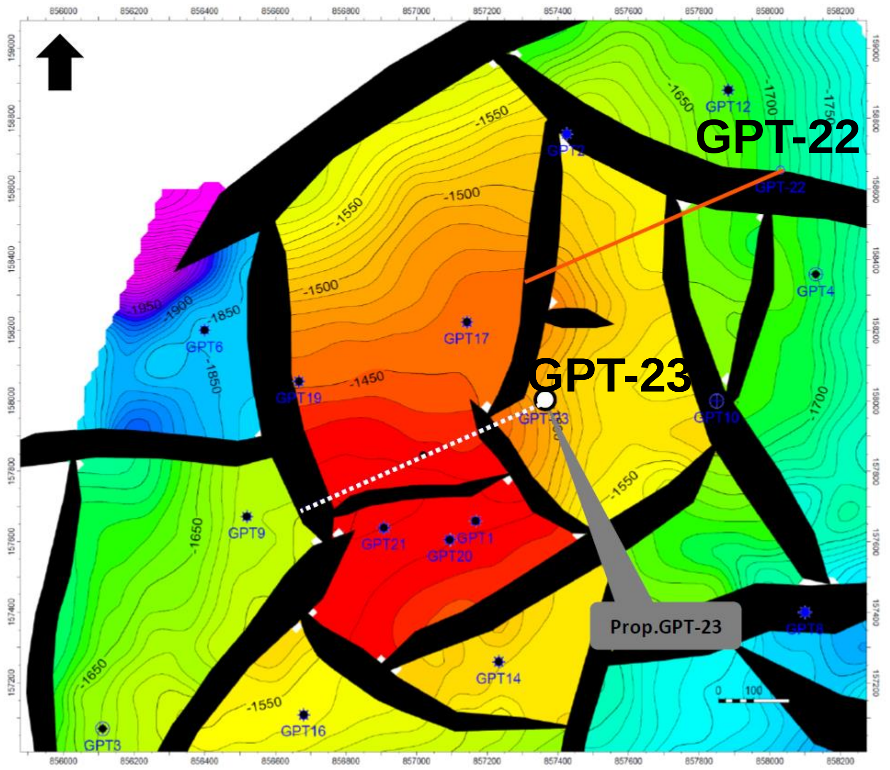
- AR/F reservoir is tested throughout several wells with very short drawdown periods and severe reduction in BHFP.
- Integrating engineering and geological data is a vital rule to rejuvenate such very tight reservoir.



GPT-22 Stimulation Overview & Results

- Two wells were drilled one up structure and down structure and tested barefoot after acid stimulation
- **With a fit-for-purpose stimulation treatment, AR/F showed a sustainable production with barefoot completion approach.**
- AR/F is initially tested as barefoot completion.





Solubility testing

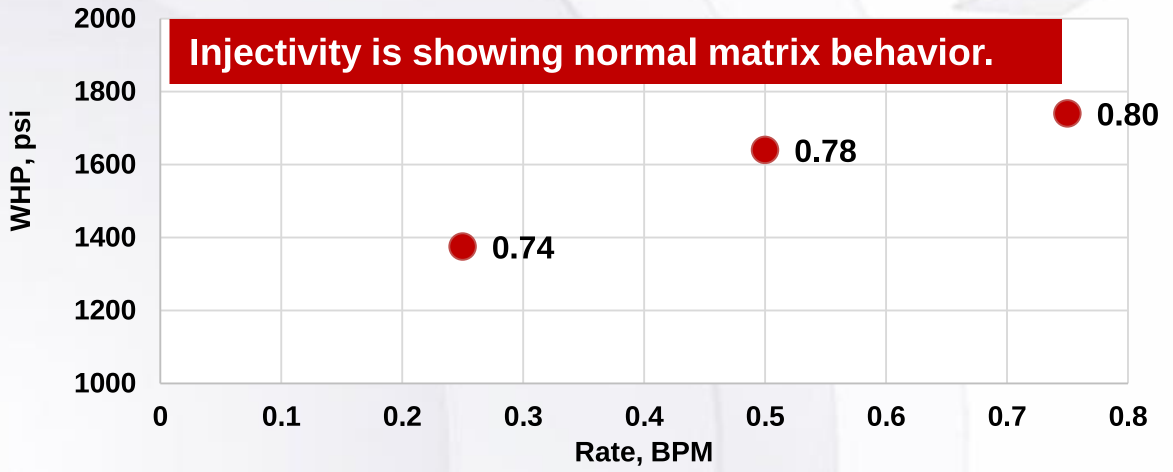
15% HCl	20% HCl
77.88	78.78
83.8	85.26
84.31	89.71
82.52	89.58

Mineralogy grouping:

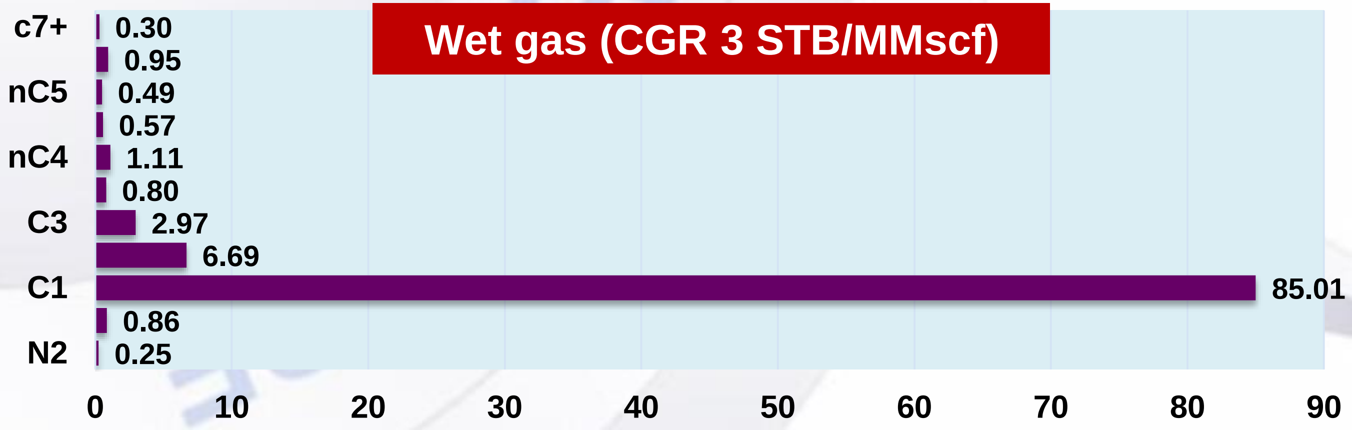
ID	Tectosilicates	Carbonates	Phyllosilicates	Other
1	5.38	77.61	14.32	2.69
2	3.67	82.34	11.14	2.90

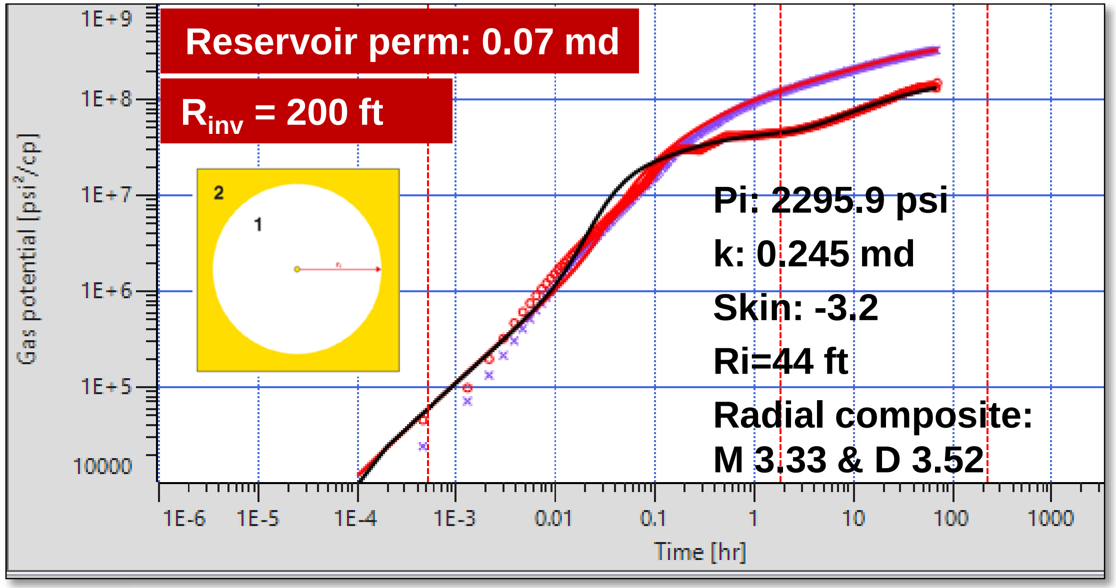
GPT-22 Stimulation Overview & Results

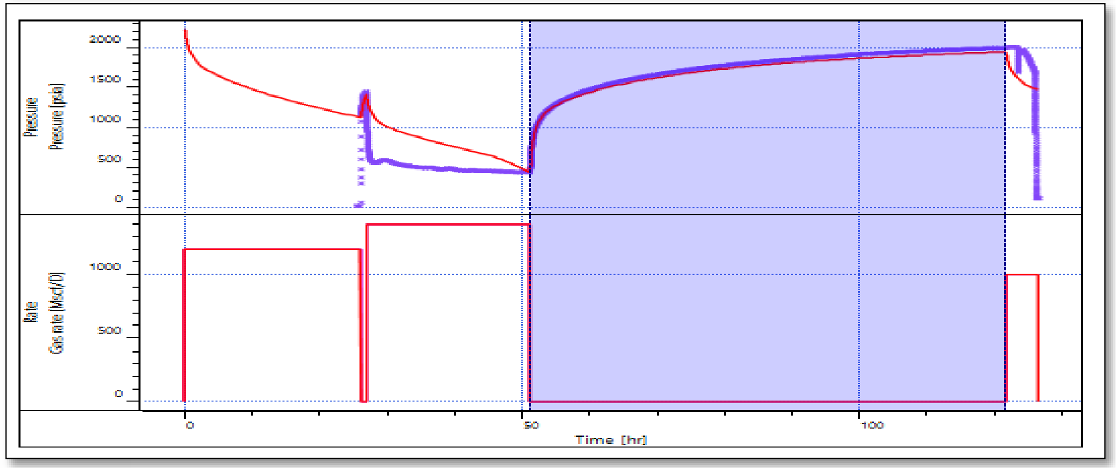
- Conventional acid stimulation was performed
- WHP decreased from 1700 to 985 psi at the end of job.



Hours	B.S, inch	WHP, psig	BS&W, %	Gas, MMscf/D
15	1/2	371	0	0.86
24	3/4	269	0	1.28



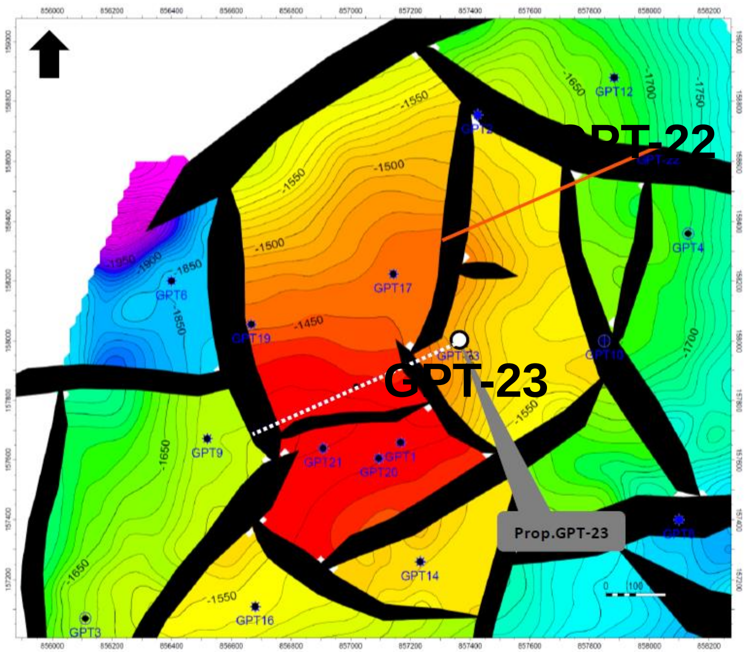




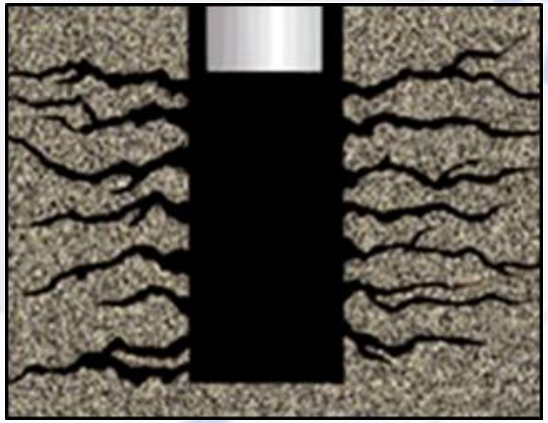
- **Gas gravity: 0.7**
- **Condensate gravity: 65 °API**

GPT-23 Stimulation Overview & Results

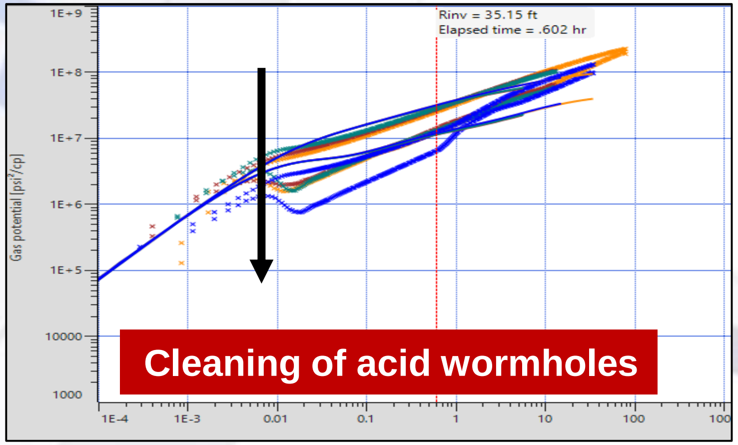
- **Injectivity is showing presence of some natural fractures**
- **VDA, MSR & Emulsified Acid (SXE)** were used to improve acid stimulation performance
- **SXE acid treatment showed** better production performance by achieving acid deeper wormhole penetration thereby blocking high-perm zones and diverting the treatment towards tight zones.
- **Pressure dropped from 1350 psi T/ 350 psi then to zero.**

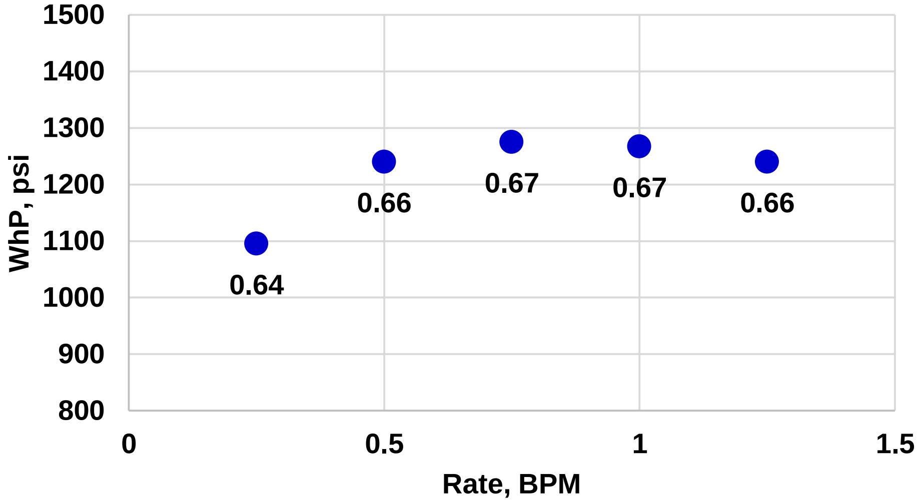


SXE retarded HCl Acid



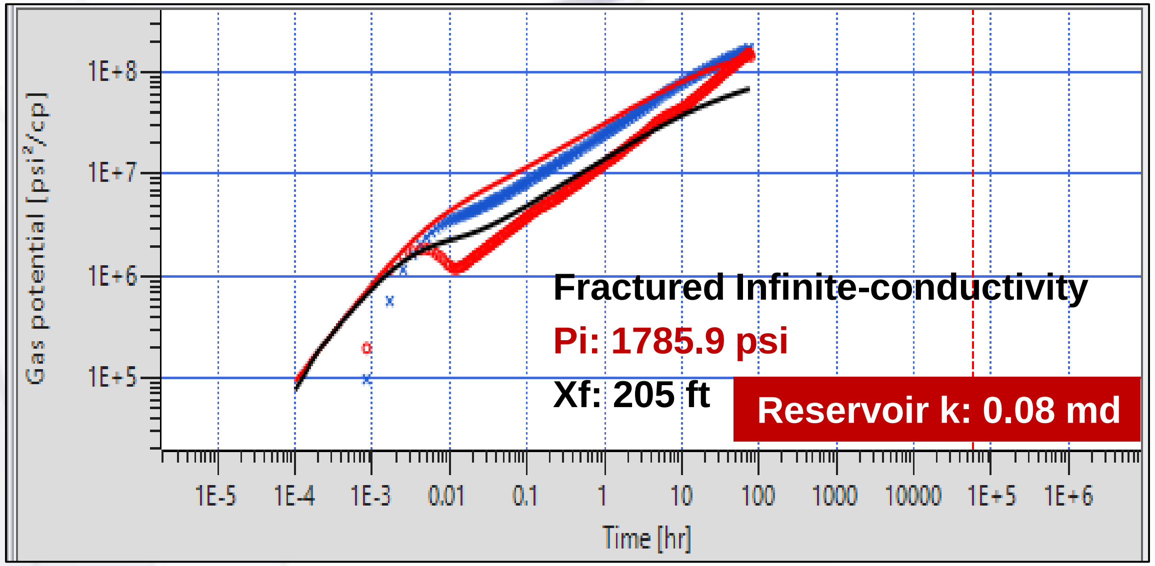
Pressure derivative shows a successive reduction in skin after SXE treatment



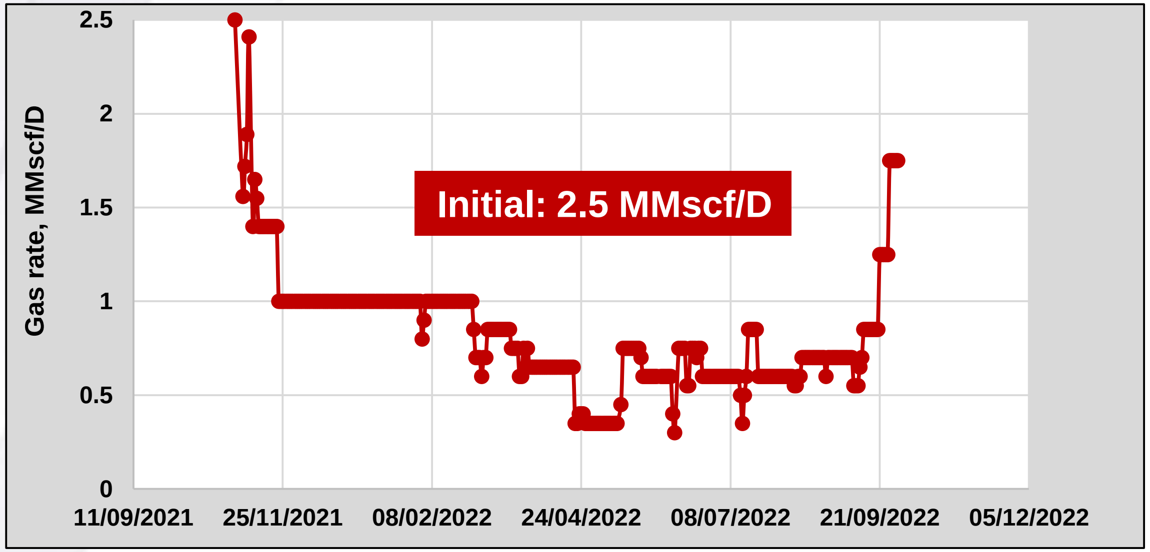


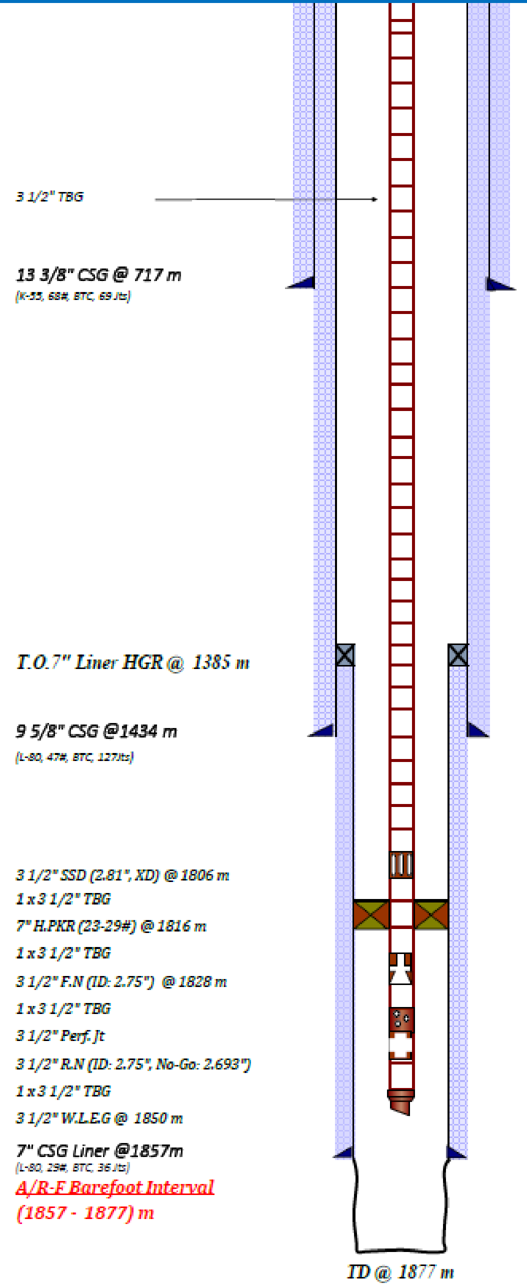
GPT-23 Testing Results

- Standard HCl acid reacts very quickly in carbonate formations.
- **The SXE acid retards the acid reaction rate, enabling deep, live-acid penetration.**
- This oil-external emulsion is formed with a 70:30 HCl-to-oil ratio, stabilized with an emulsifier.



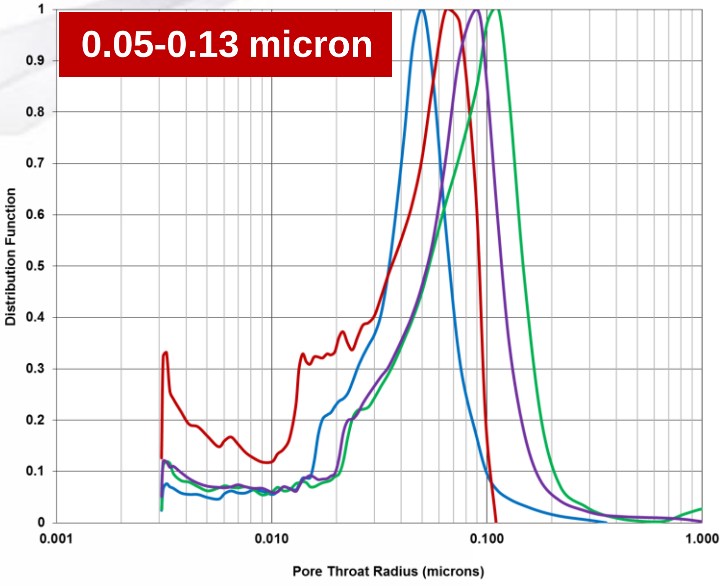
Cum gas production 230 MMscf

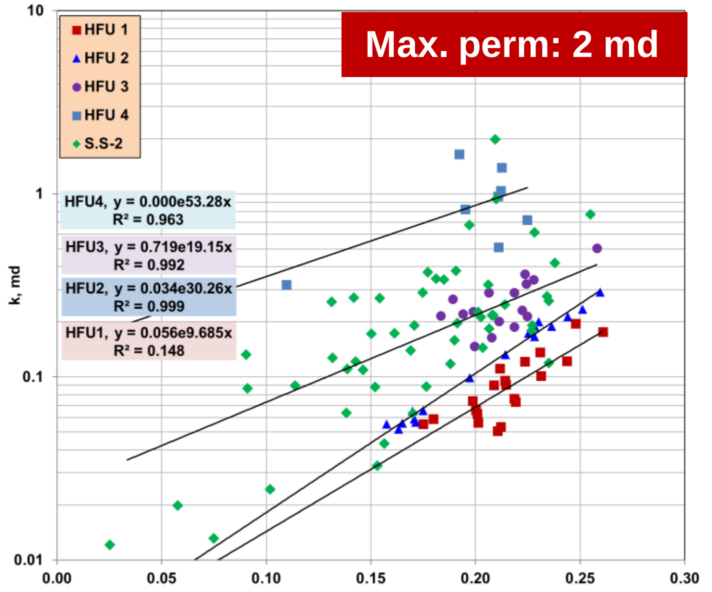


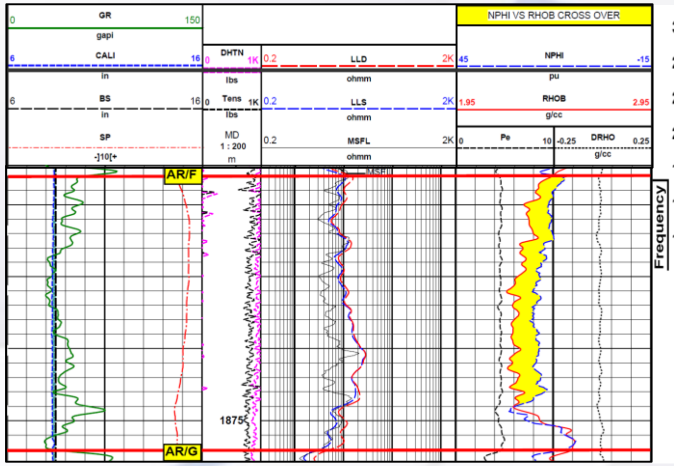


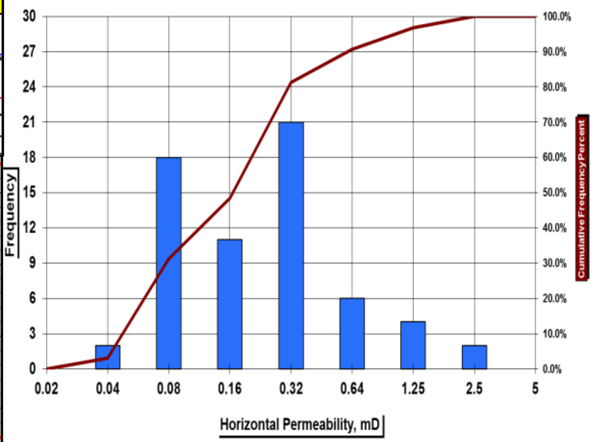
AR/F Core Data Overview

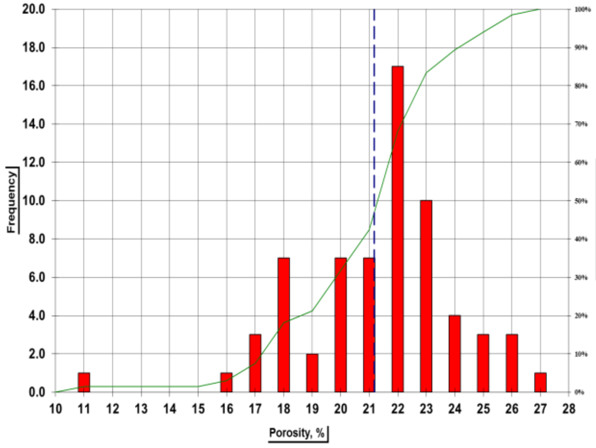
- Laminated, abundant bioclasts and calcite filled vugs, locally hairline fractures and stylolites.
- **Porosity:**
  - Range: 0.03-0.15
  - Arithmetic mean: 0.12
- **Permeability:**
  - Range: 0.01-1.8 md
  - Geometric Mean = 0.16 md
- **MICP data:**
  - Most probably uni-model with a pore throat radius ranging 0.05-0.13 micron

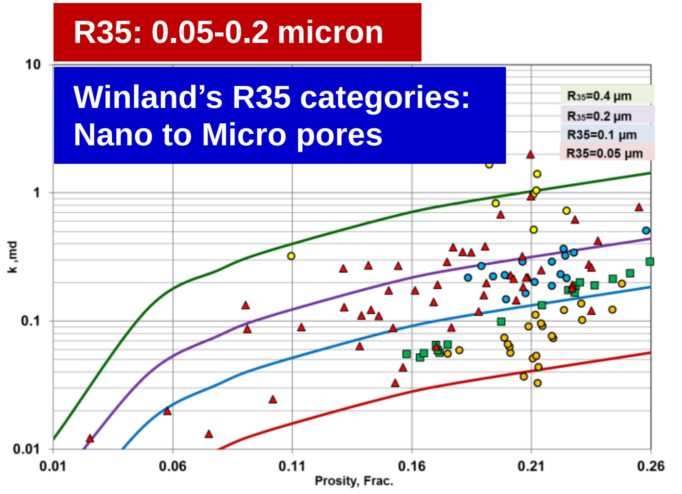






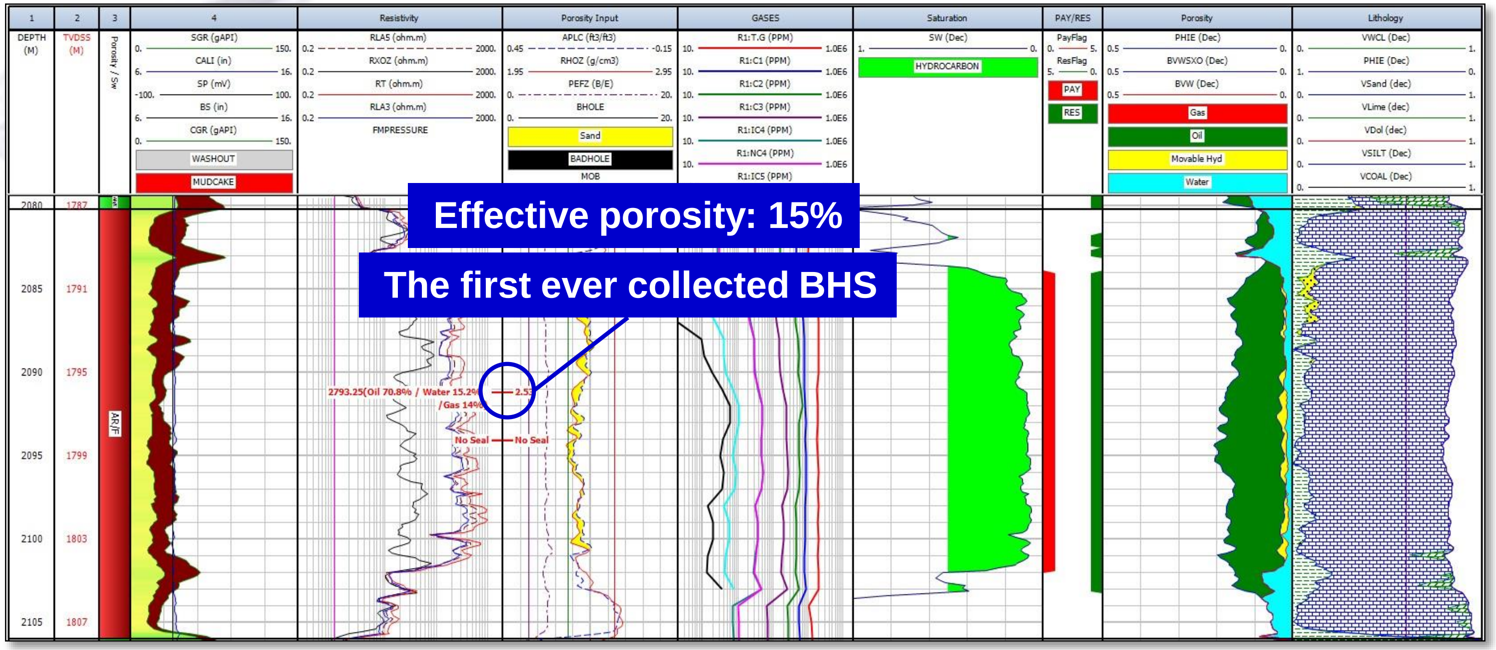


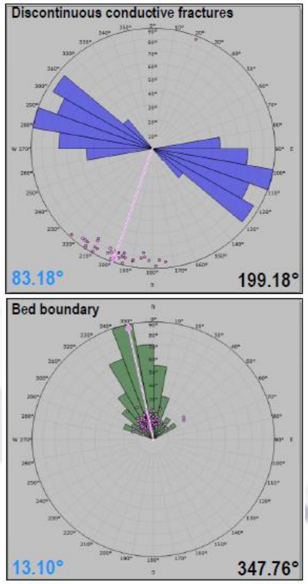


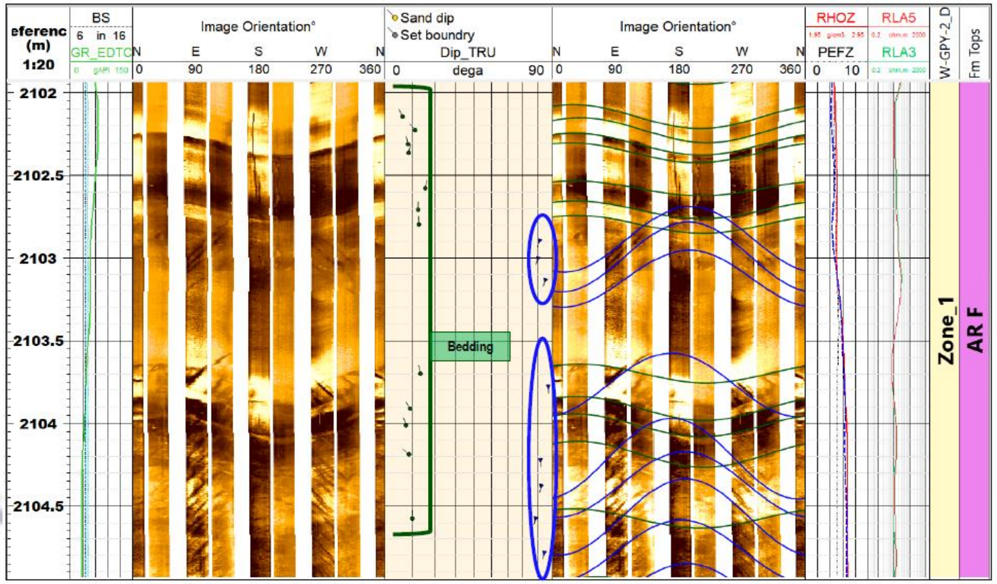


W-GPY-2 AR/F Reservoir

- The mean dip azimuth in dominant NW-SE strike orientation for the discontinuous conductive fractures.
- Discontinuous conductive fractures cutting through the beddings within AR/F member.





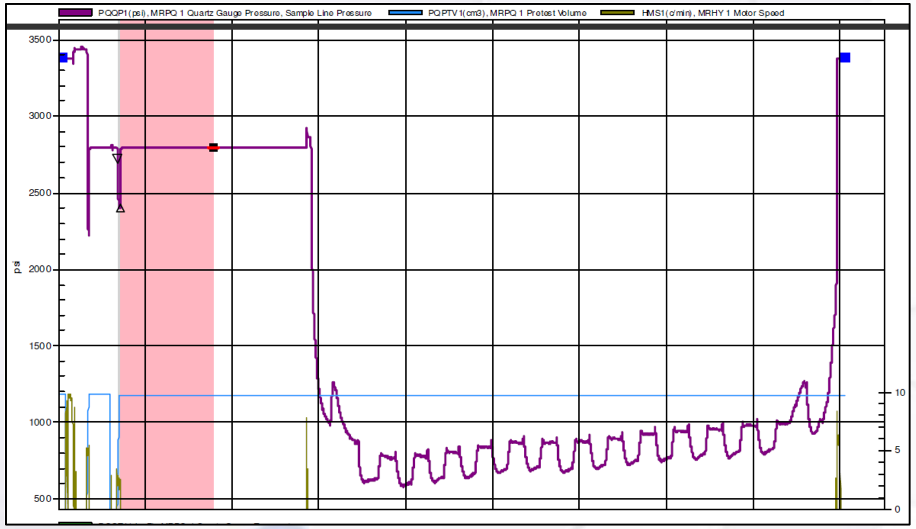


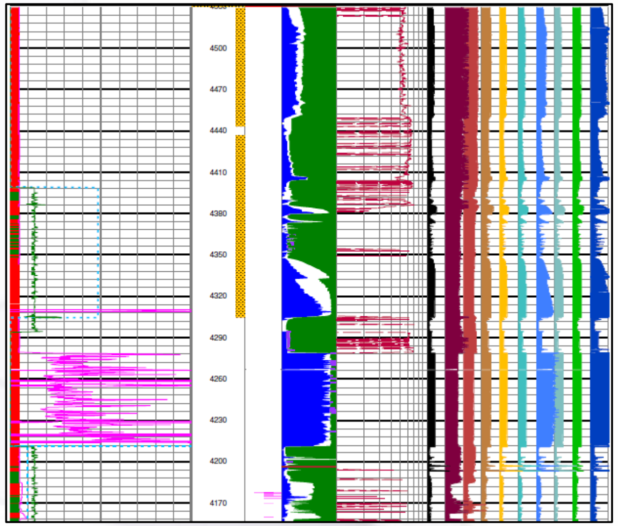
AR/F Fluid Sampling

- **NMR parameters:**
  - Free fluid porosity range: 4-10%
  - Permeability range: 0.2-3 md
  - Pore throat system: most common uni-modal system

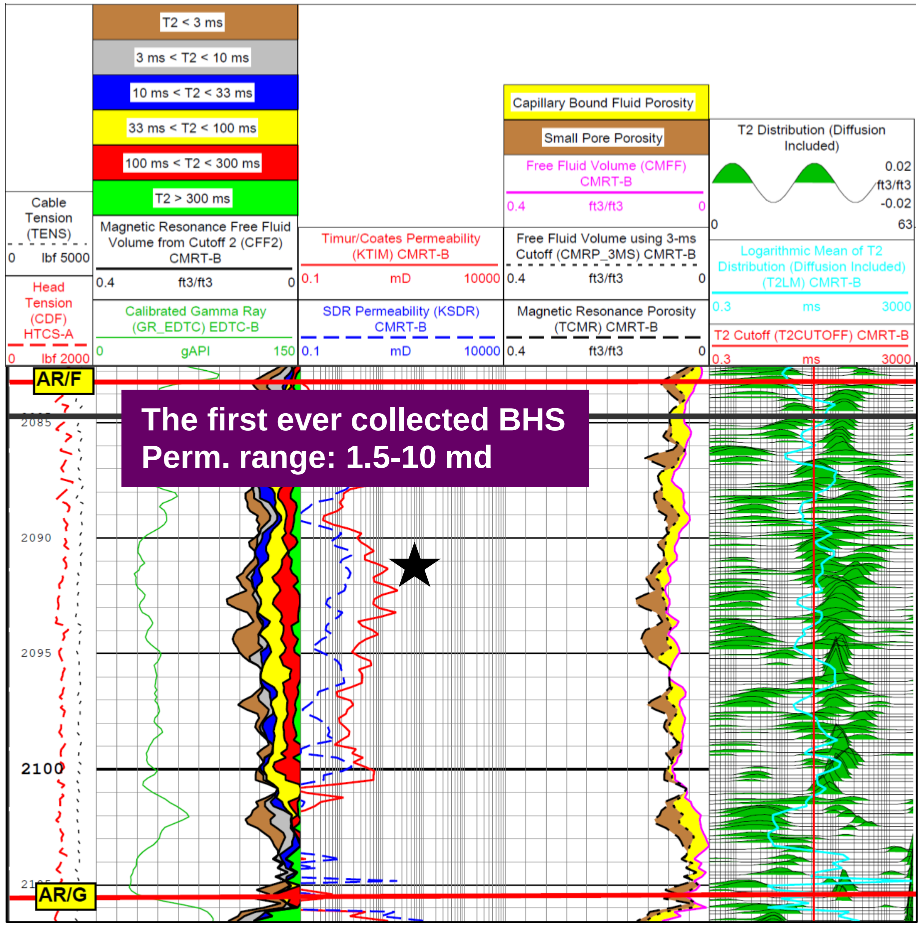
Sampling data:

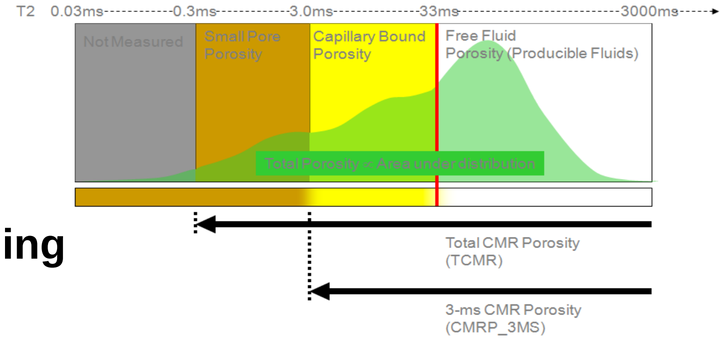
Depth (MD)	Formation Pressure	Mobility	LFA Analysis	Pumping Time	Pumping Volume
m	PSIA	mD/cP		Mins	Liters
2091.2	2778	2.53	Oil 70.8% Water 15.2% Gas 14%	45	13





Pre-testing and down-hole fluid analysis (Extra Large Diameter Probe)

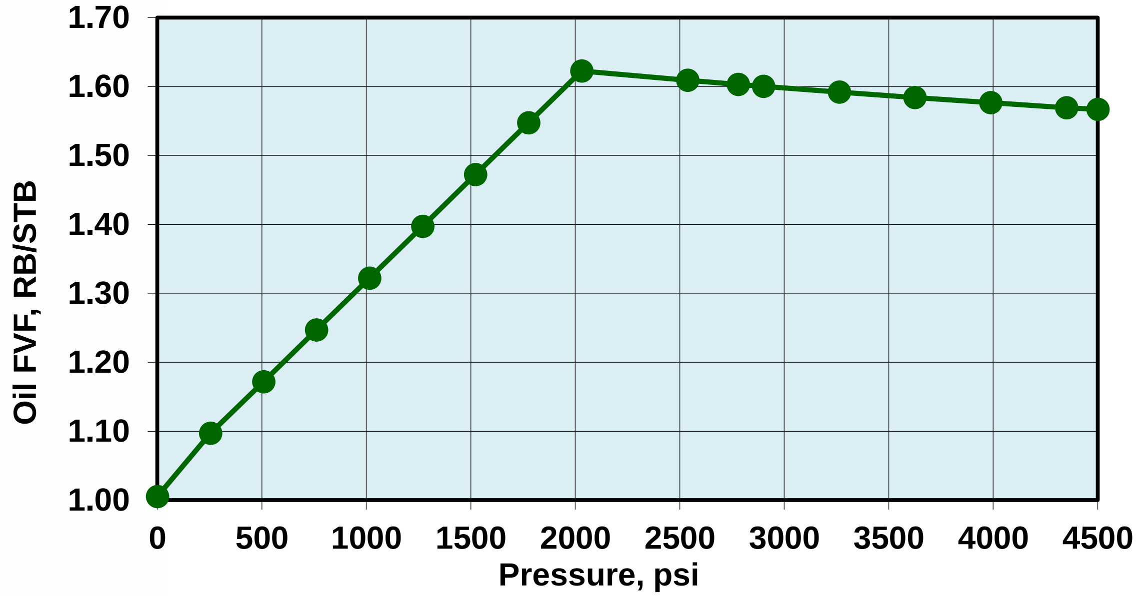


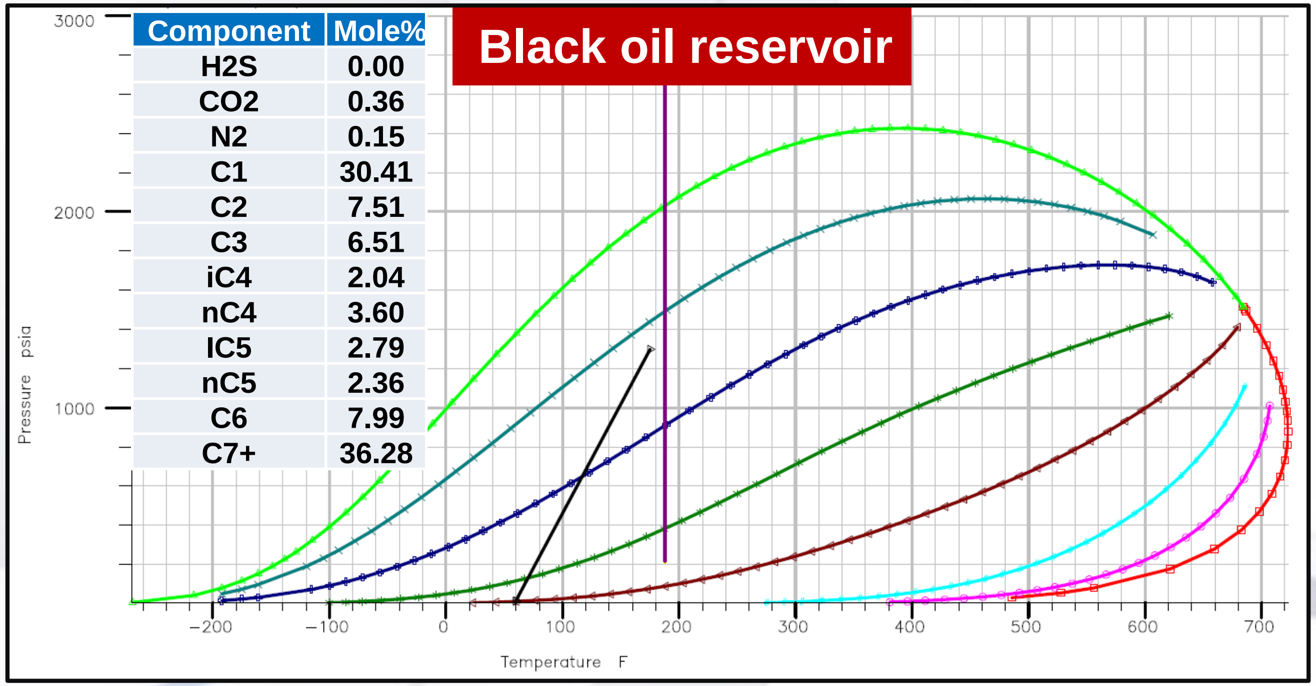


Porosity Partionning by NMR

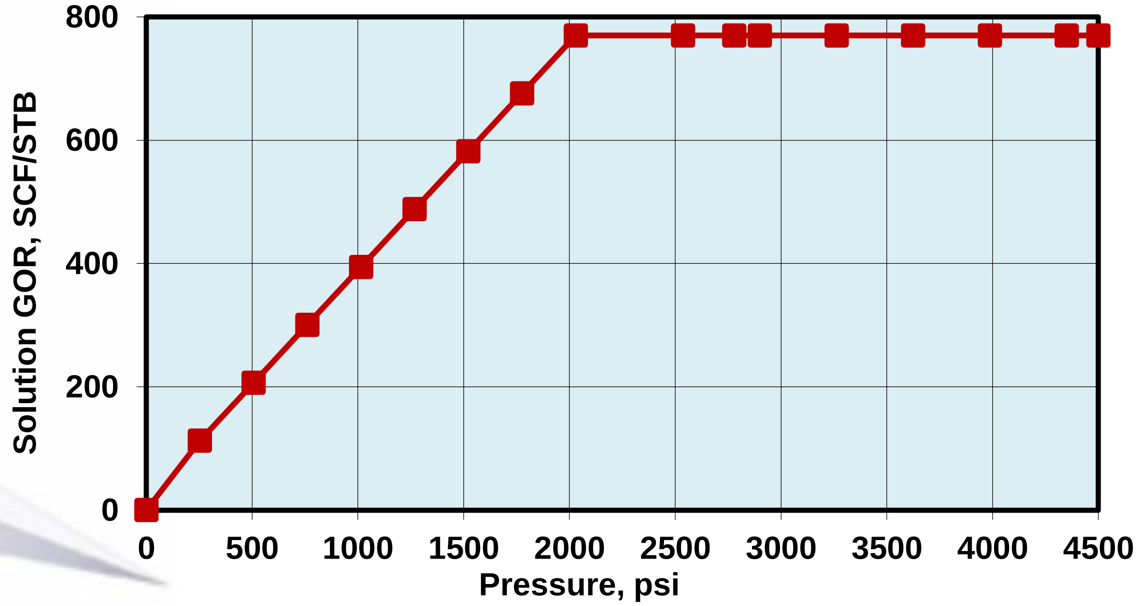
AR/F PVT

- **PVT parameters:**
  - Reservoir Pressure: **2778 psi**
  - Bubble Point Pressure: **2030 psi**
  - Reservoir Temperature: **188 °F**
  - Oil gravity: **40 °API**
  - Solution GOR: **770 scf/STB**
  - Initial oil FVF: **1.6 RB/STB**



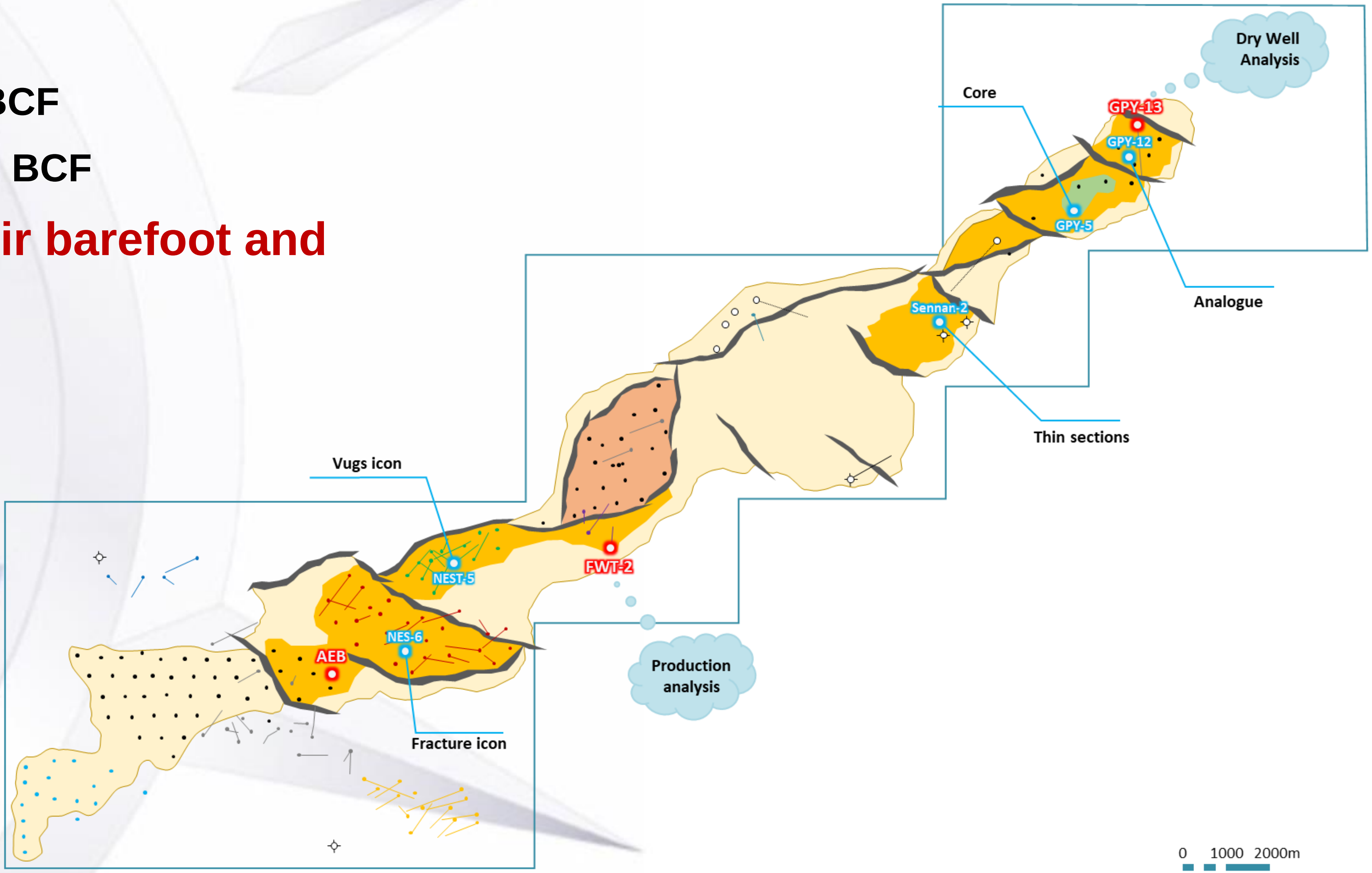


Component	Mole%
H2S	0.00
CO2	0.36
N2	0.15
C1	30.41
C2	7.51
C3	6.51
iC4	2.04
nC4	3.60
IC5	2.79
nC5	2.36
C6	7.99
C7+	36.28



AR/F Way Forward

- Added reserve:
  - GIIP Reserve (2P): 3 BCF
  - GIIP Reserve (1P): 0.8 BCF
- Develop the reservoir barefoot and horizontal wells



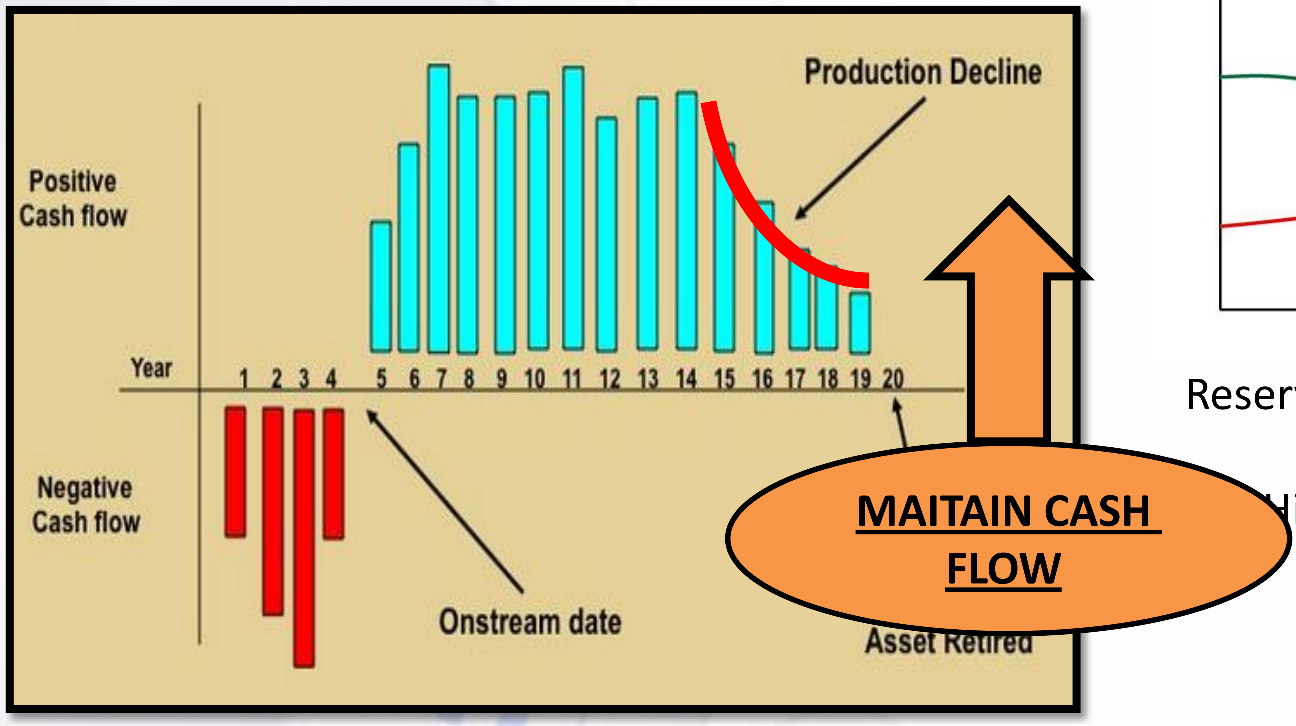
Brown Fields Rejuvenation

“Maximizing Production & Recovery”

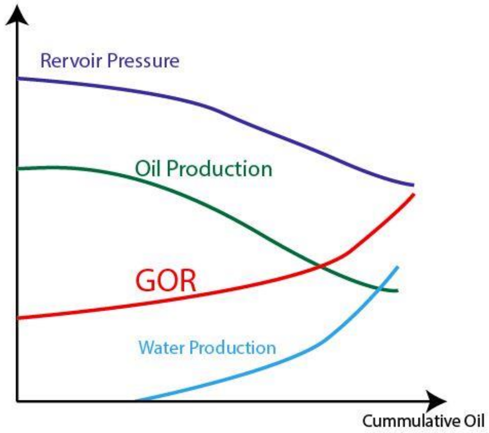
GPC 2022 Workshop

Offshore Brown and Green Marginal Fields

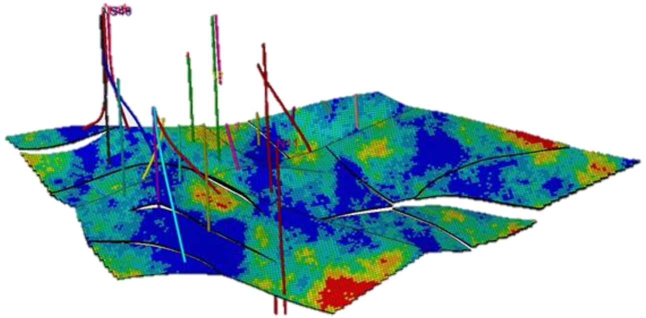
Offshore Brown Fields Challenges



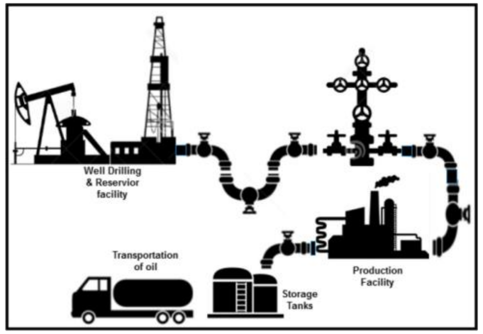
Typical Cash Flow for An Oil Field



Reservoir Pressure Depletio
High WC %
High Associated GOR



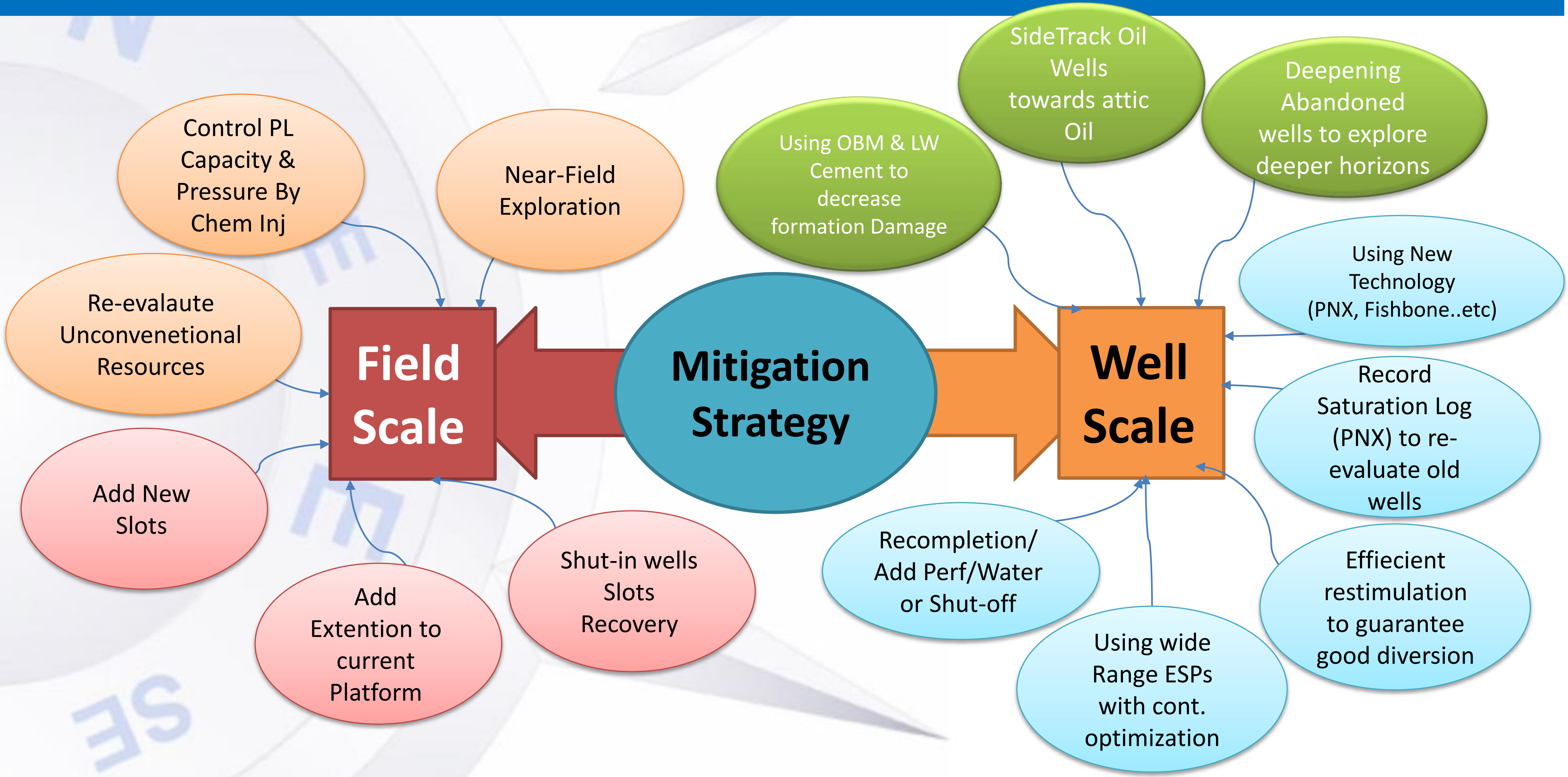
Unswept Oil Spots & Bypassed Reserves due to water breakthrough



Production Facilities & Flow Assurance Problems (Slots, Prod line Capacity)

The Brown field is an producing area with long history of production, high recovery factor relatively and Declining Cash flow.

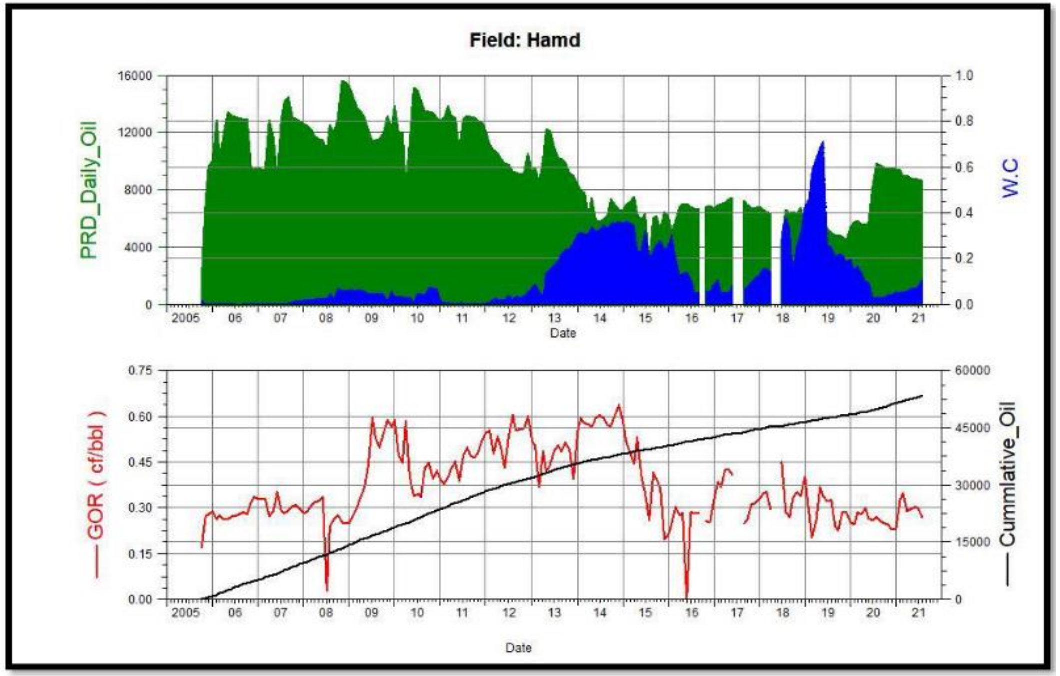
Mitigation Strategy



Case Study: Al Hamd Platform

- Al Hamd Field is a mature field at the end phase of production that usually associated with high gas/water production.
- Al Hamd field has several challenges:
  - – Reservoir Pressure Depletion
  - – Lateral water movement
  - – Secondry gas cap
  - – No Available Slots

Cum. Oil Prod : 57 Million STB



OOIP, MMSTB	Reserve, MMSTB	Cum Production, MMSTB	Remaining Reserve, MMSTB
485	63.05	56.78	6.2

Case Study: Al Hamd Platform

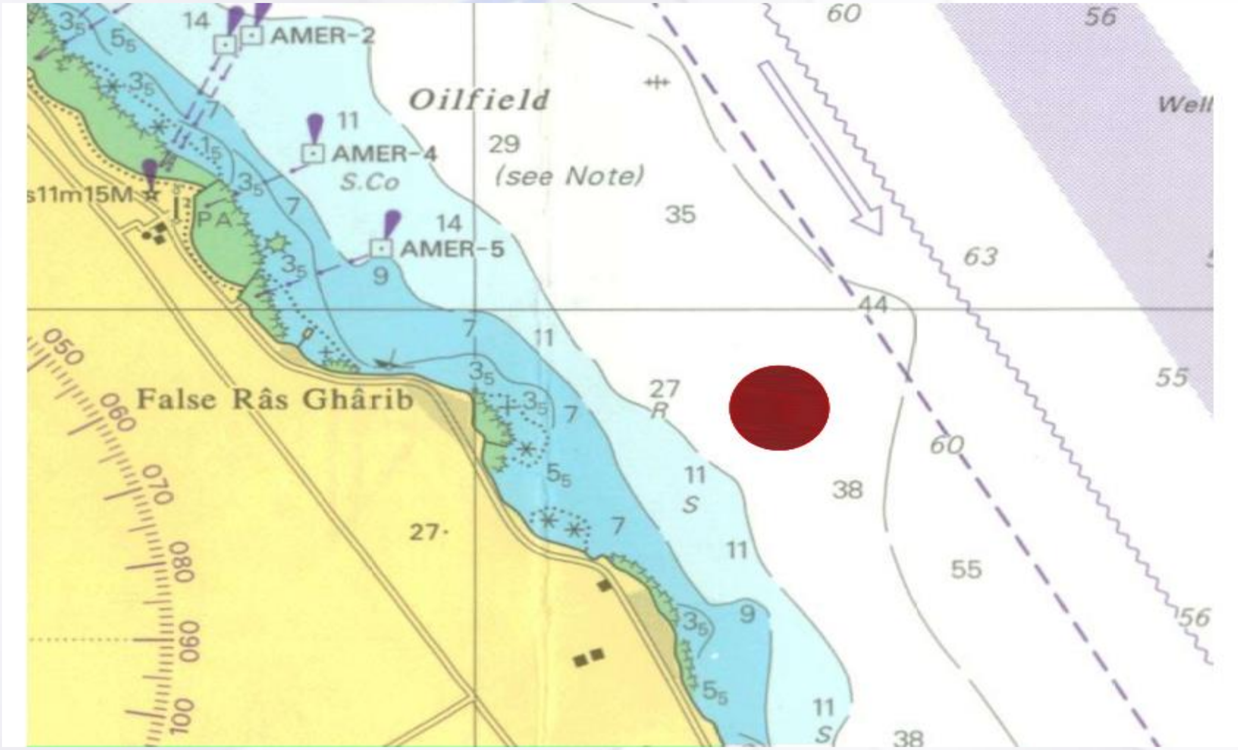
Several Actions Was Taken To Maintain Platform Production

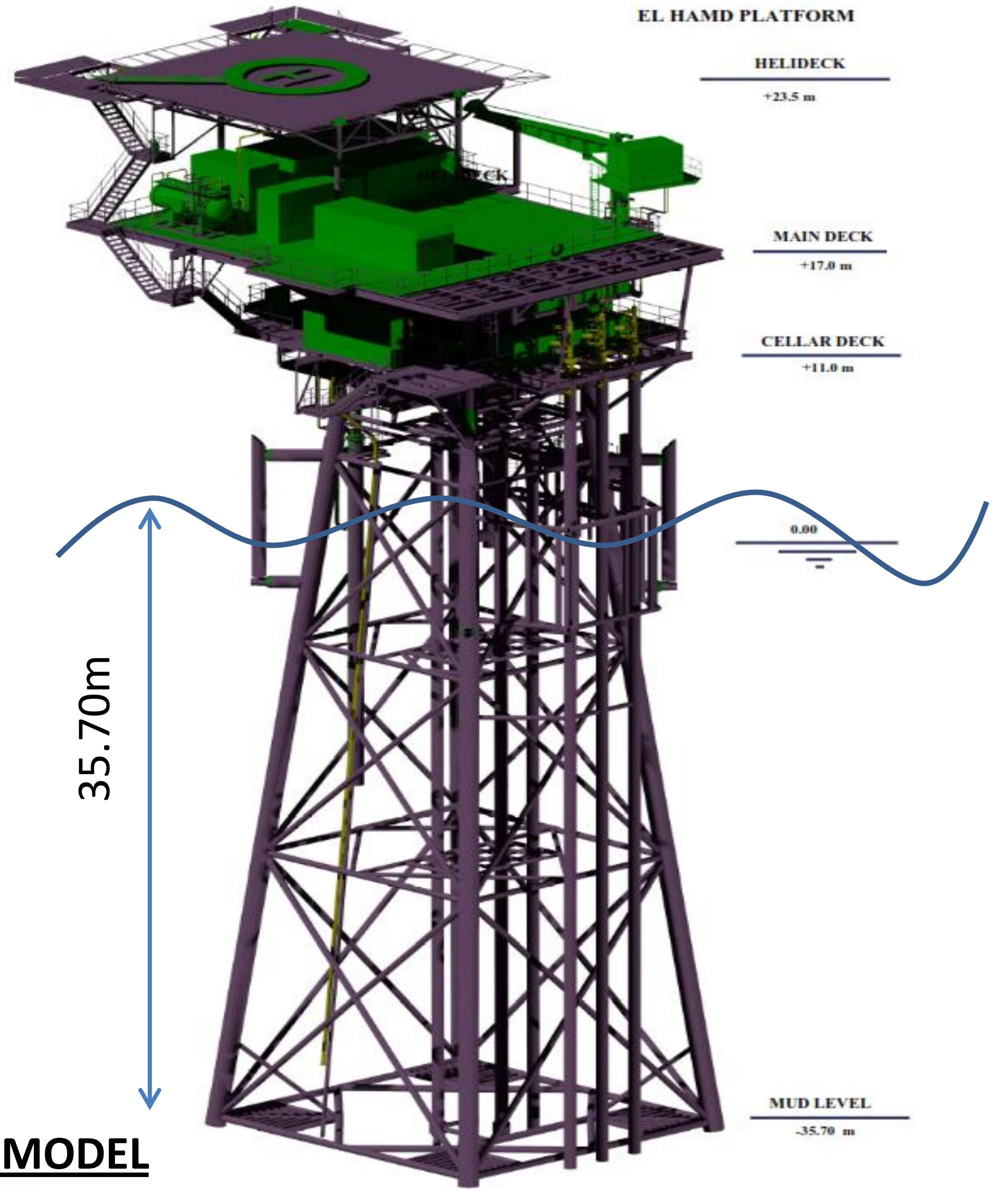
1. **Record Saturation Log (PNX) To Re-evaluate Old Wells**
   Al Hamd-6 & 4: R/C Wells To Gain +/- 3500 BOPD
2. **Near-Field Exploration / Add New Slots**
   W.AL Hamd-1X: +/- 1500 BOPD
3. **Add Extention to current Platform**
   More Wells Will be drilled to explore / Develpe North Direction
4. **Effiecient restimulation to guarantee good diversion**
   Al Hamd-8 st2: +/- 500 BOPD

5

Case Study: Al Hamd Platform

- Al Hamd Platform Is Well Head Platform Located In South East Bakr About 3km Offshore .

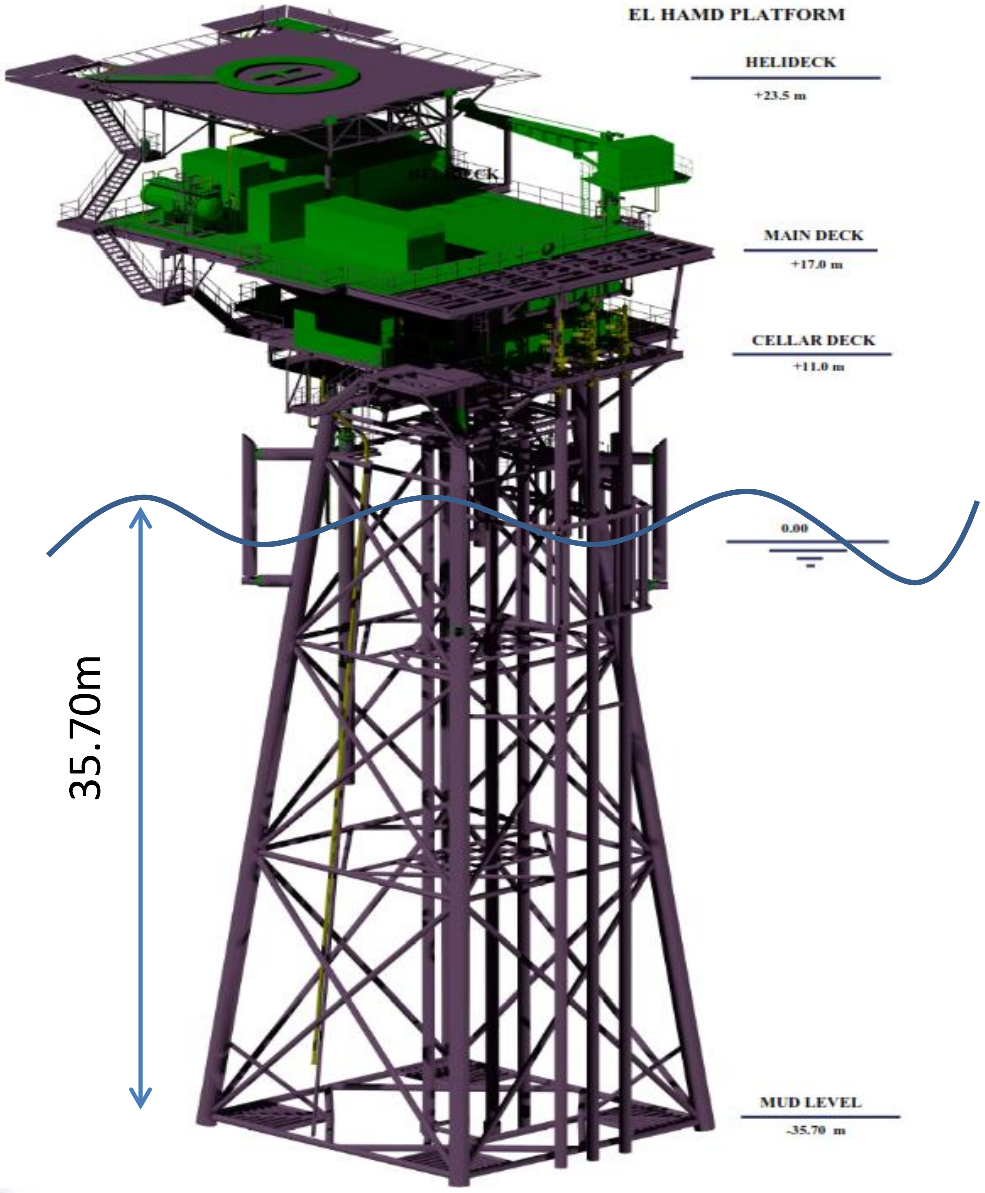




ELHAMD PLATFORM 3D-MODEL

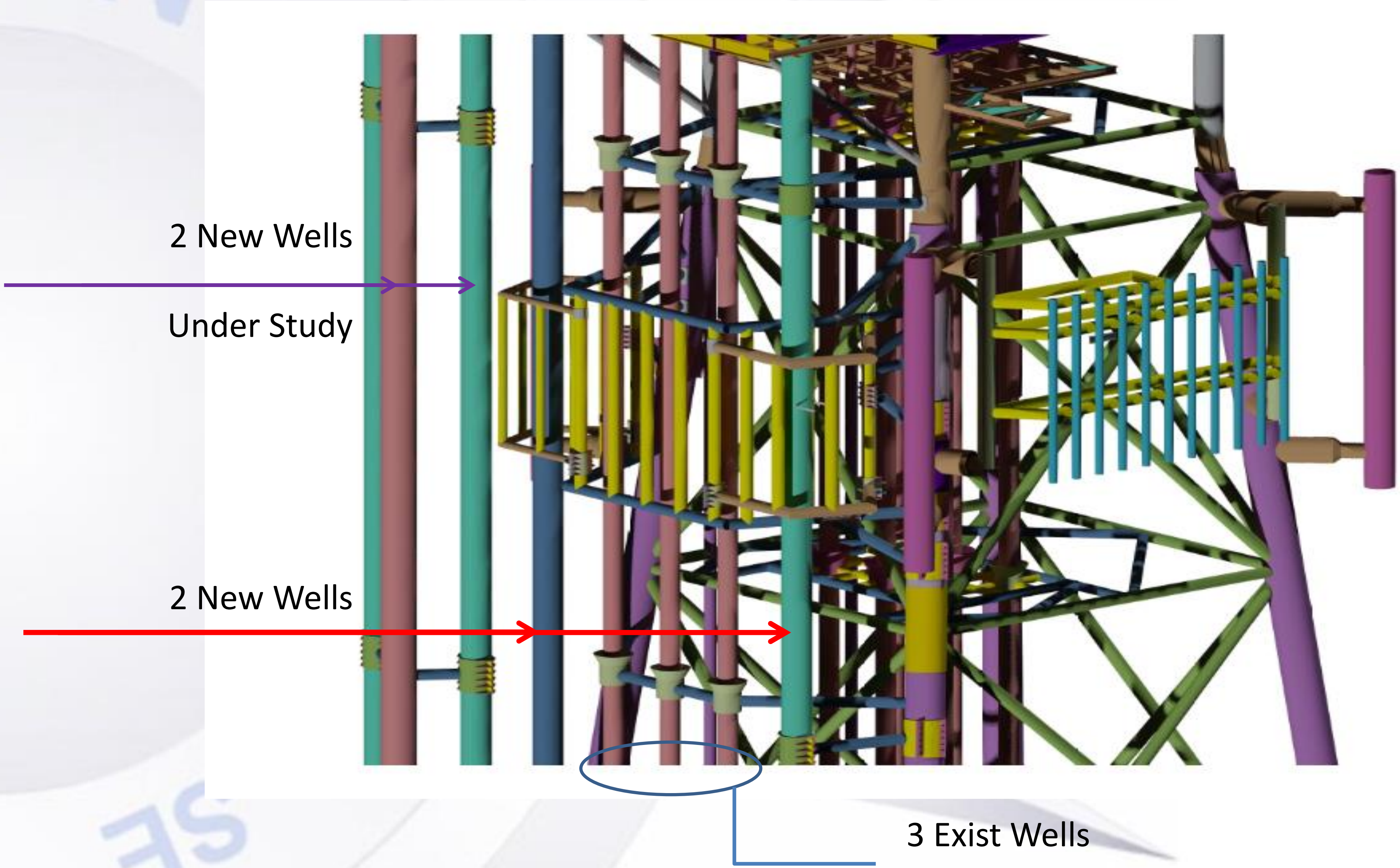
Case Study: Al Hamd Platform

- Requirements:
  - – Adding 2 Slots To Occupy 2*30 inch cond.
  - – Study To Add 2 Other Slots
- Components:
  - – 6 Wells Inside the platform jacket.(Main design)
  - – 3 Wells Outside the platform jacket.(Ext 2009)
  - – 3 Decks (Cellar, Main And Helideck).
- Challenges :
  - – The Difficulty Of Finding A Empty Space to suit slots .
  - – Minimize The Piping Needed.
  - – Minimize Under-water Activities.

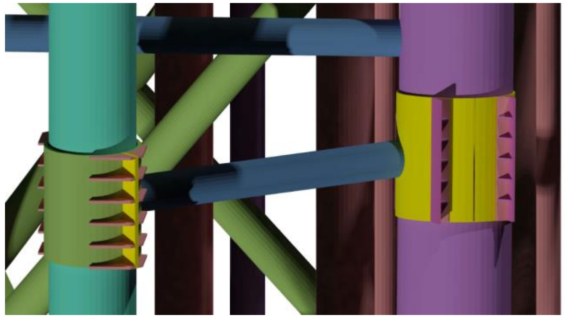


ELHAMD PLATFORM 3D-MODEL

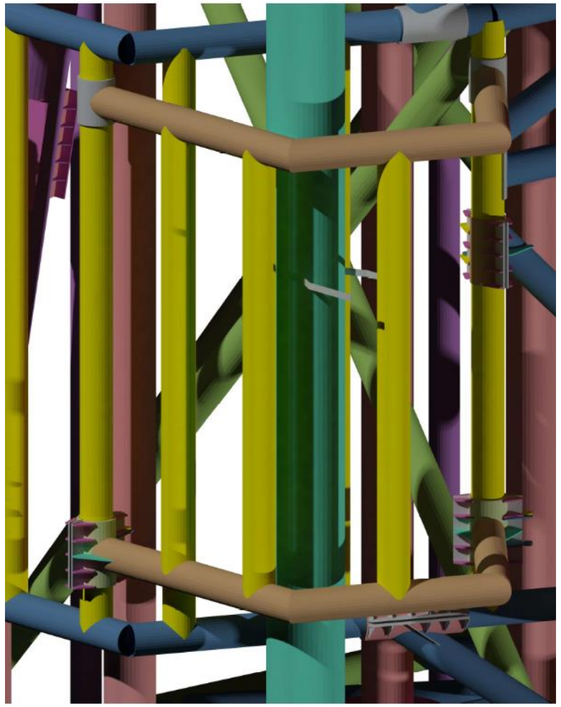
Case Study: Al Hamd Platform



Part Of El Hamd Platform For Clarify



Clamp Detail



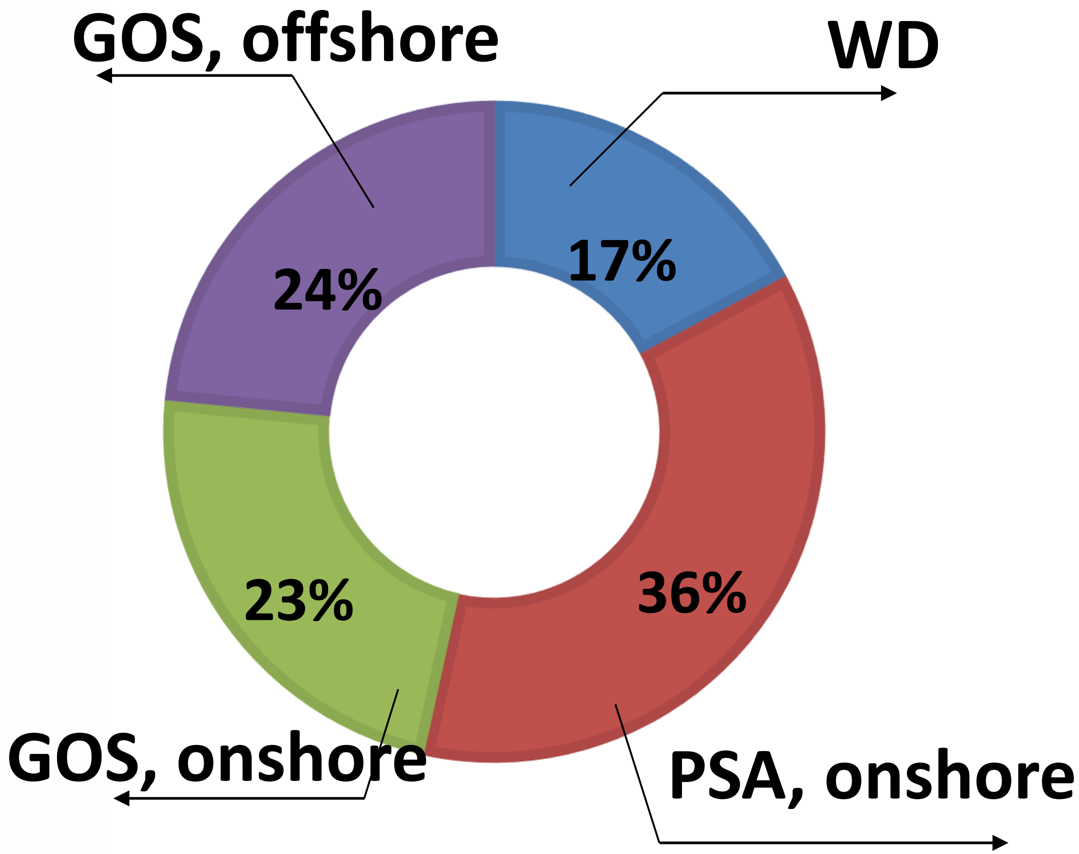
Guard Detail

Green Marginal Fields: Why it's marginal?

- Some of new green fields are classified as marginally economic due to:
  1. Its low expected reserve for its low original hydrocarbon in place
  2. Difficulty in developing the discovery
  3. Depletion encountered from nearby production pools
  4. Ucertainty in production and the need for prototyping.
- As "Easy Oil" Fields availability diminishing, Companies are driven to invest in Marginal Fields.

Marginal Fields Cash Flow Startegy

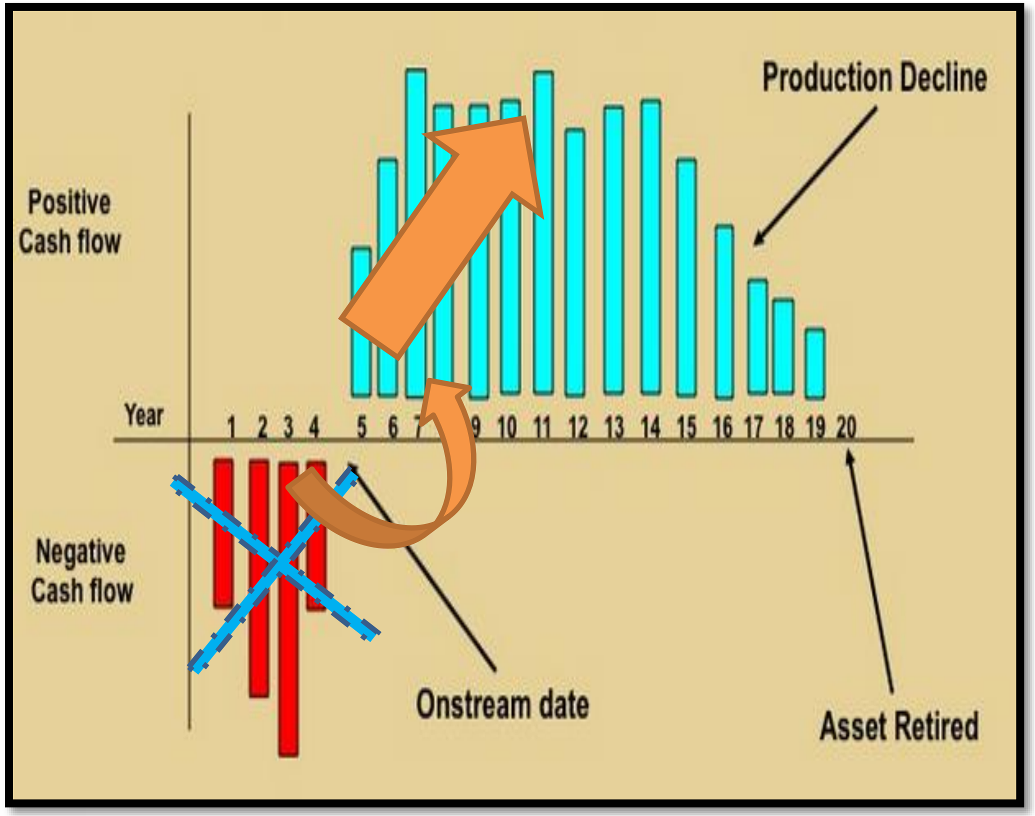
- In recent years, GPC explored some Green Marginal Fields that required to have unconventional thinking for development and production facilities installation.
- About 24% of GPC concession area is located into Gulf of Suez, so EPF option will give a great chance for exploration efforts to be extended.
- The Successful Discoveries will be put on production in no time by the concept of EPF to allow:
    1. More evaluation time
    2. Accelerate production
- The existing platforms will be used as tie-in points for using the existing production facilities.



GPC Concessions Area Distribution

Marginal Fields Cash Flow Startegy

- Unlike Conventional projects, Marginal fields startegy will focus on Maximizing the **TIME VALUE** for money by:
  - Eliminating any required initial **CAPEX** by converting it to **OPEX**
  - Accelerating **CASH IN**.
  - Exploiting the available **CASH MONEY** in several projects at same time rather than focusing on just one project.

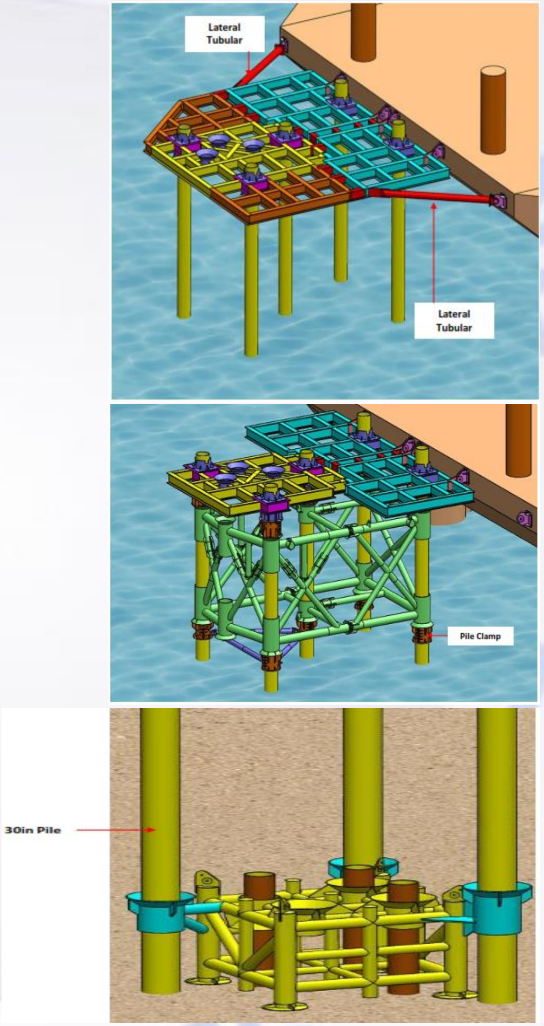


Typical Cash Flow for An Oil Field

Green Marginal Asset Model

Location	HH 83-2 –FIELD	SE-EL HAMD FIELD	GG83/2 FIELD
OVERVIEW	- Light structure supported by Rig.	- Light structure supported by Rig	6 x 36" piles to support the platform Mid-brace structure (MSB) Subsea template structure (SST) 2-level topside deck facilities platform plus small sump deck 2 Offloading Risers
Water Depth	23 Meters	51 Meters	64 Meters
Structures	Template , mid brace & deck floor	Subsea str , mid brace & deck floor	Subsea str , mid brace & 2 deck floor
TOPSIDE	TOPSIDE FACILITIES AND RISER (Fire fighting eq,WHCP,2 manifolds,,,,etc)	TOPSIDE FACILITIES AND RISER (Fire fighting eq,WHCP,2 manifolds,,,,etc)	TOPSIDE FACILITIES AND RISER (Fire fighting eq,WHCP,2 manifolds,,,,etc)

Green Marginal Asset Model

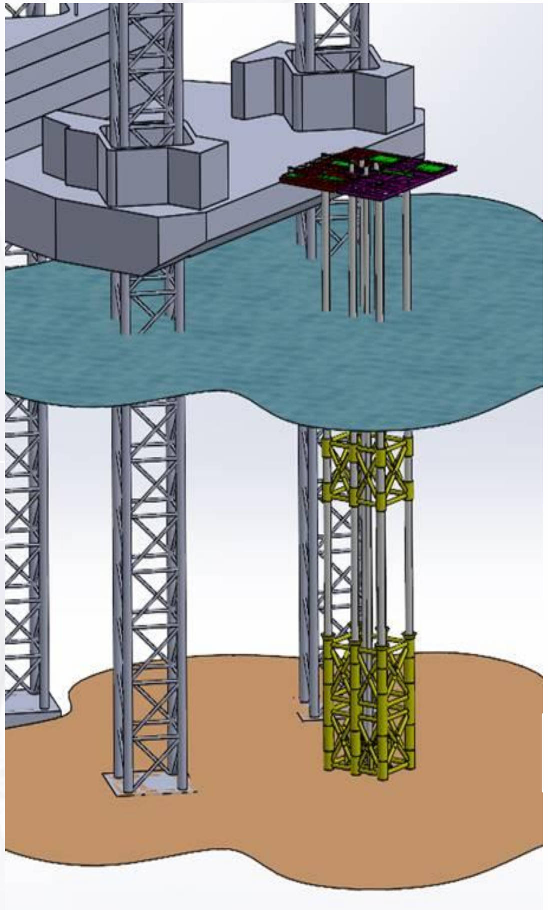


TOP FLOOR

MID BRACE

TEMPLATE

HH 83-2

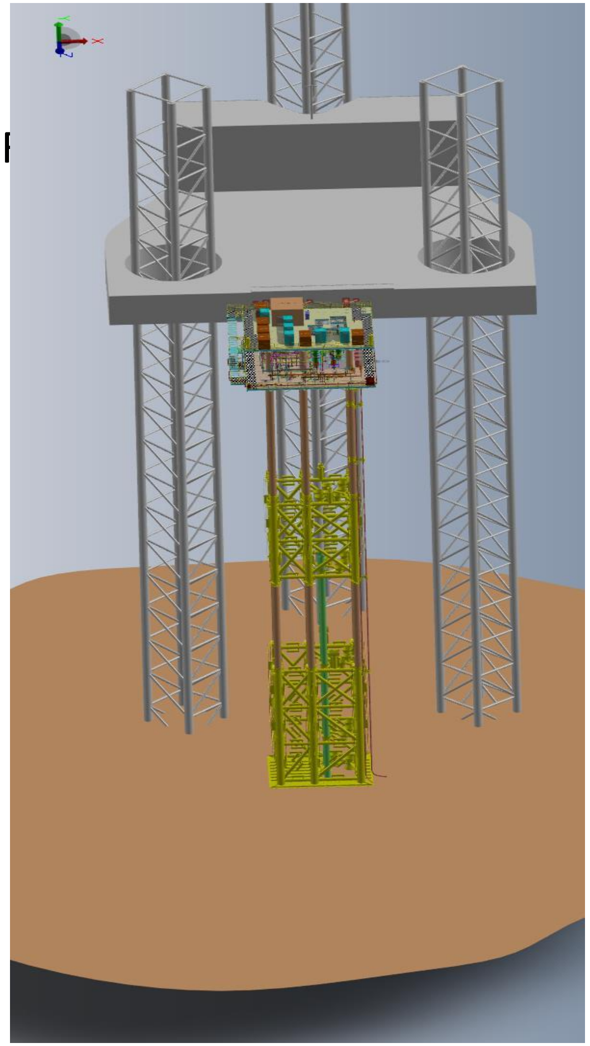


TOP FLOOR

MID BRACE

S.SEA.STR

SE-EL HAMD



TOP FLOOR

MID BRACE

S.SEA.STR

GG83/2

Conclusions

- **Marginal unconventional resources** are representing new development opportunities for recently high energy demands.
- In carbonates, integrated petrophysical evaluation (**TC, Image Logs, Core Data, NMR, Pulsed Neutron, Sonic Scanner, etc.**) are required for proper characterization.
- The proper **reservoir pore-system identification and classification** is critical success factor for reservoir development plan.
- **Barefoot completion** associated with fit-for-purpose HCl acid treatment (**Nitrified, Emulsified**, etc.) may improve the production performance.
- **Economic feasibility study** is essential for determining the type of production facilities for offshore assets.

Thank You
&
Questions