



General Petroleum Company



Hesham Mokhtar Ali (Reservoir Engineer)

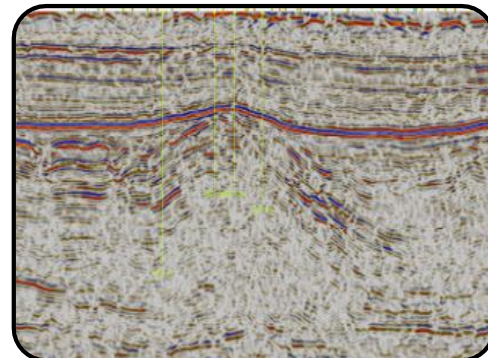
Omar Soliman (Geologist)





Workshop of Carbonate Reservoirs – GPC 2021

Abu-Sennan Sub-basin Inversion Opens Doors to Add Khoman Formation as a Promising Reservoir, GPT Field, Western Desert (Case Study)



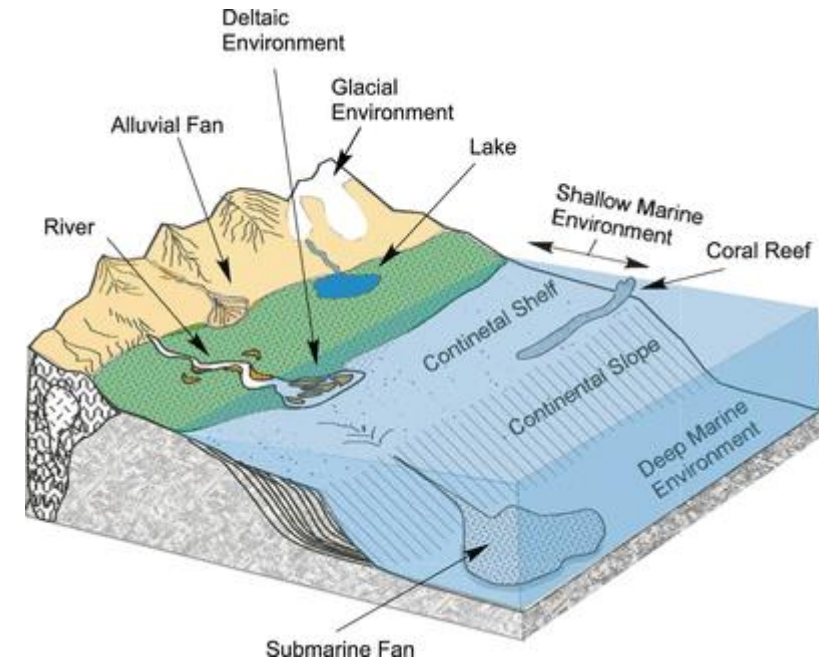


Agenda



- Introduction
- Structural overview for Abu Sennan ridge and GPT field
- Petrophysical analysis & stratigraphic facies for Khoman reservoir at GPT field
- Production and pressure performance
- Recovery efficiency
- Development plan for Khoman reservoir in GPT analogues
- Conclusions & recommendations

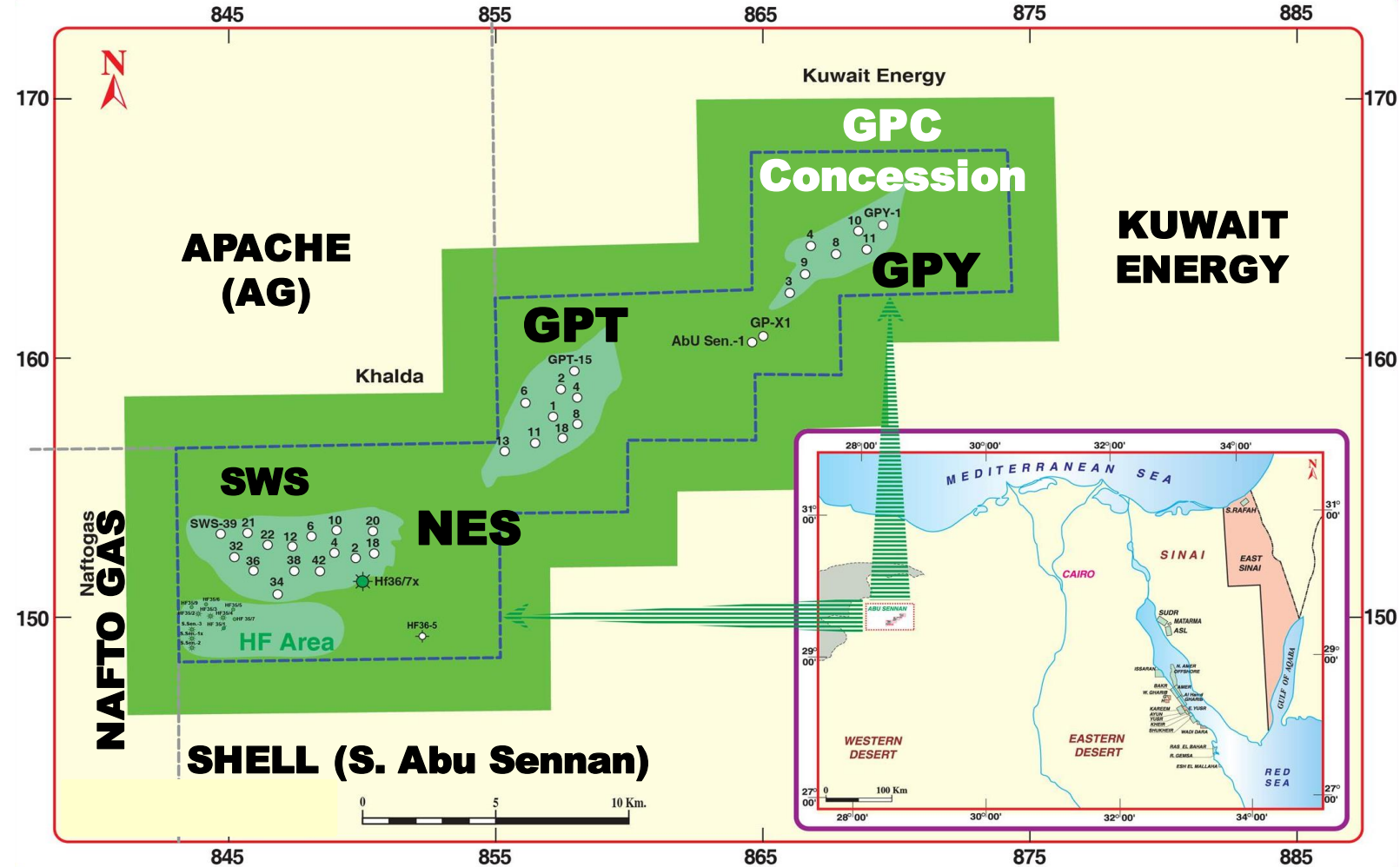
- GPT field is the first field discovered by GPC in Abu Sennan concession in 1981.
- It is located about 16 km to the southeast of Abu Al-Gharadig field.
- Khoman Formation (Santonian Maastrichtian) was deposited in deep marine to outer shelf conditions.
- Khoman Formation exhibits a marked change in facies showing two main lithologic units:
 - **Khoman (A)**
 - **Khoman (B)**
- Khoman gas reservoir was tested at commercial gas rates for first time in 1992 at GPT field, Abu Sennan Area.



Flügel E (ed) (1982) Microfacies analysis of limestones. Springer, New York, NY

Introduction

- Abu Sennan concession is located in the northern Western Desert of Egypt ($\approx 230 \text{ km}^2$), on the south of Khalda AG, East of NAFTA Gas Abu Sennan, and west of Kuwait Energy's concession.
- GPC fields produce hydrocarbons mainly from Bahariya and Abu Roash reservoirs (**SWS, GPT, NES**, etc.).

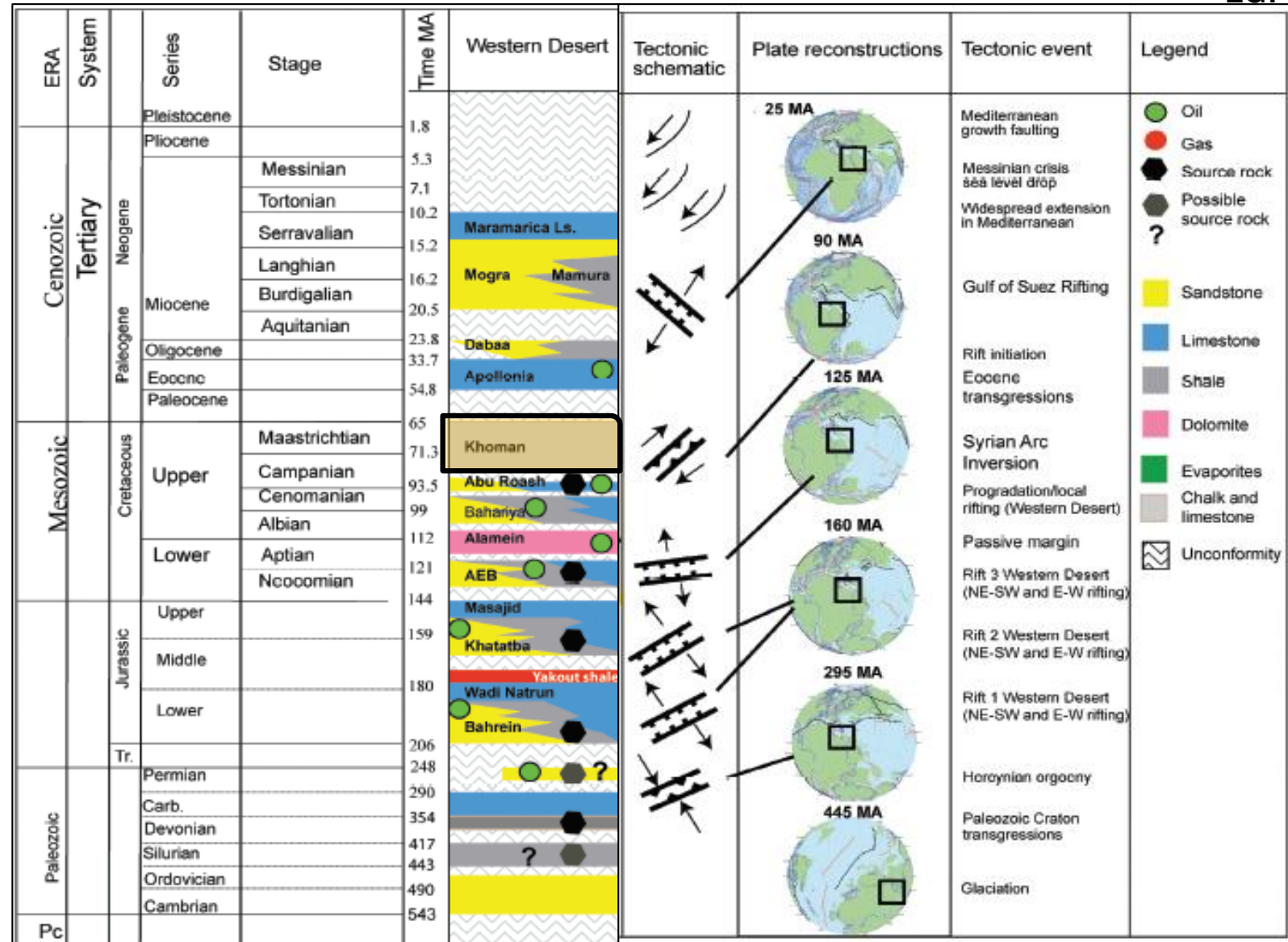
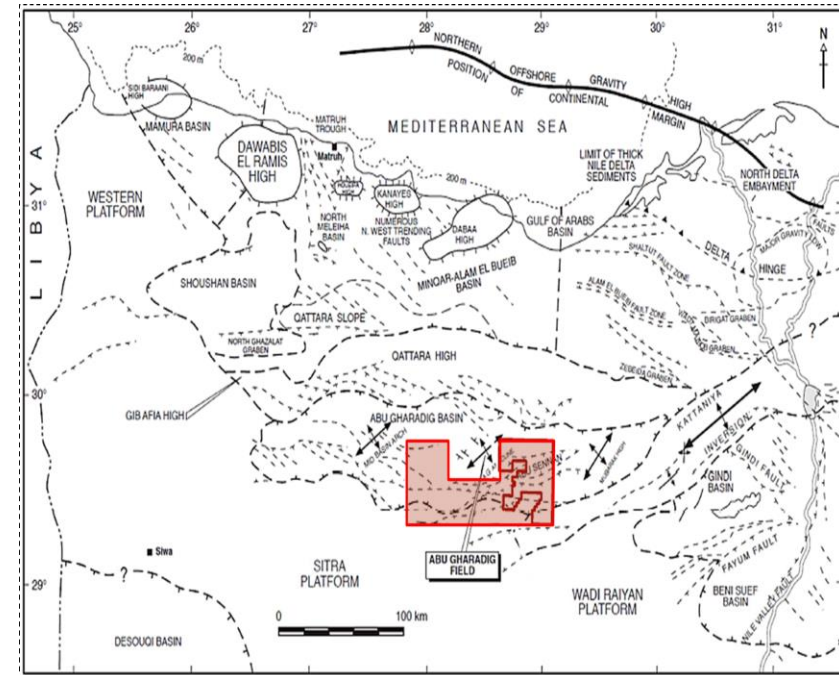




Regional Structure Overview



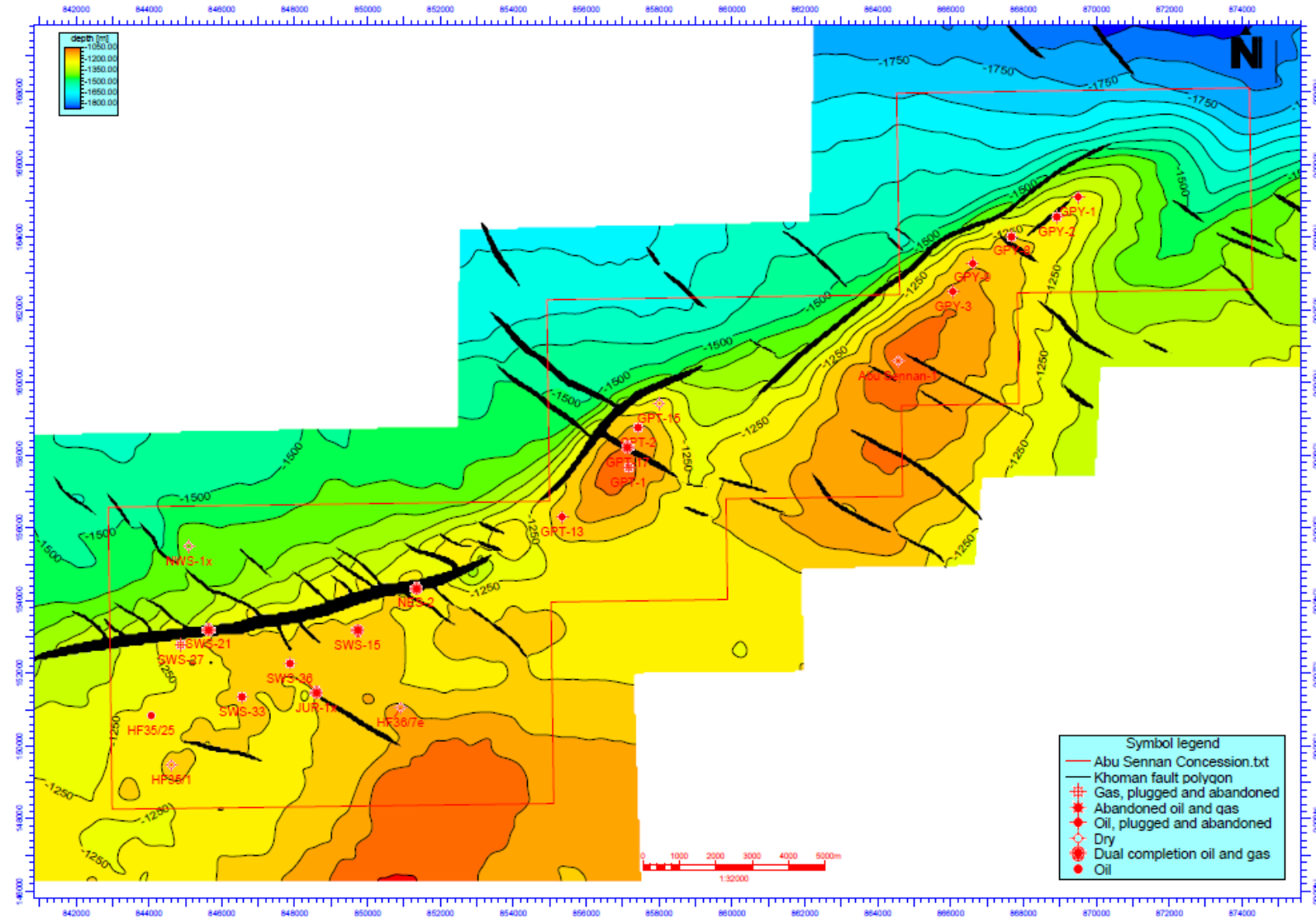
EGPC



The petroleum geology of Egypt and history of exploration, John Dolson.



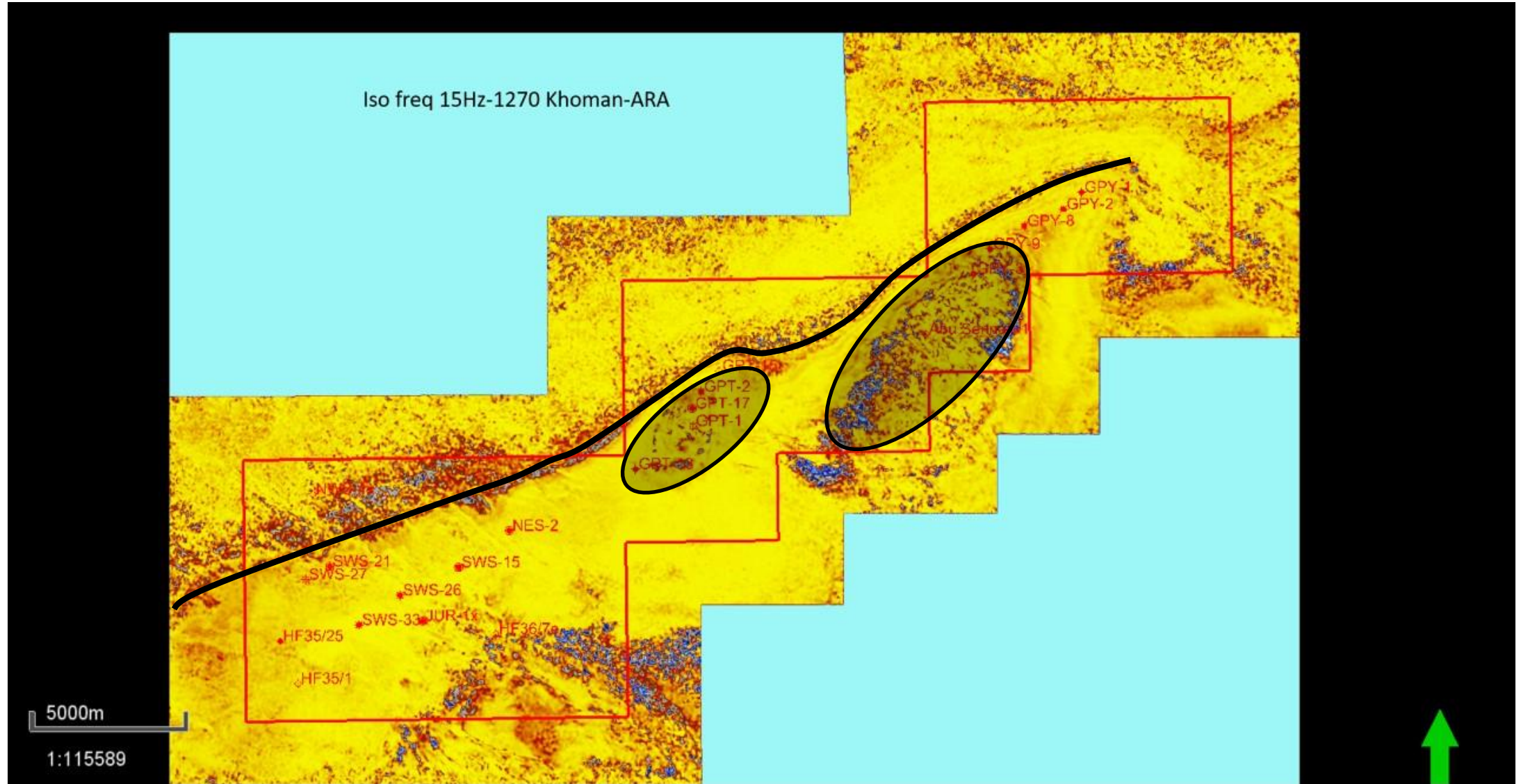
Khoman Structure



Structural depth map near top surface level of Khoman Formation



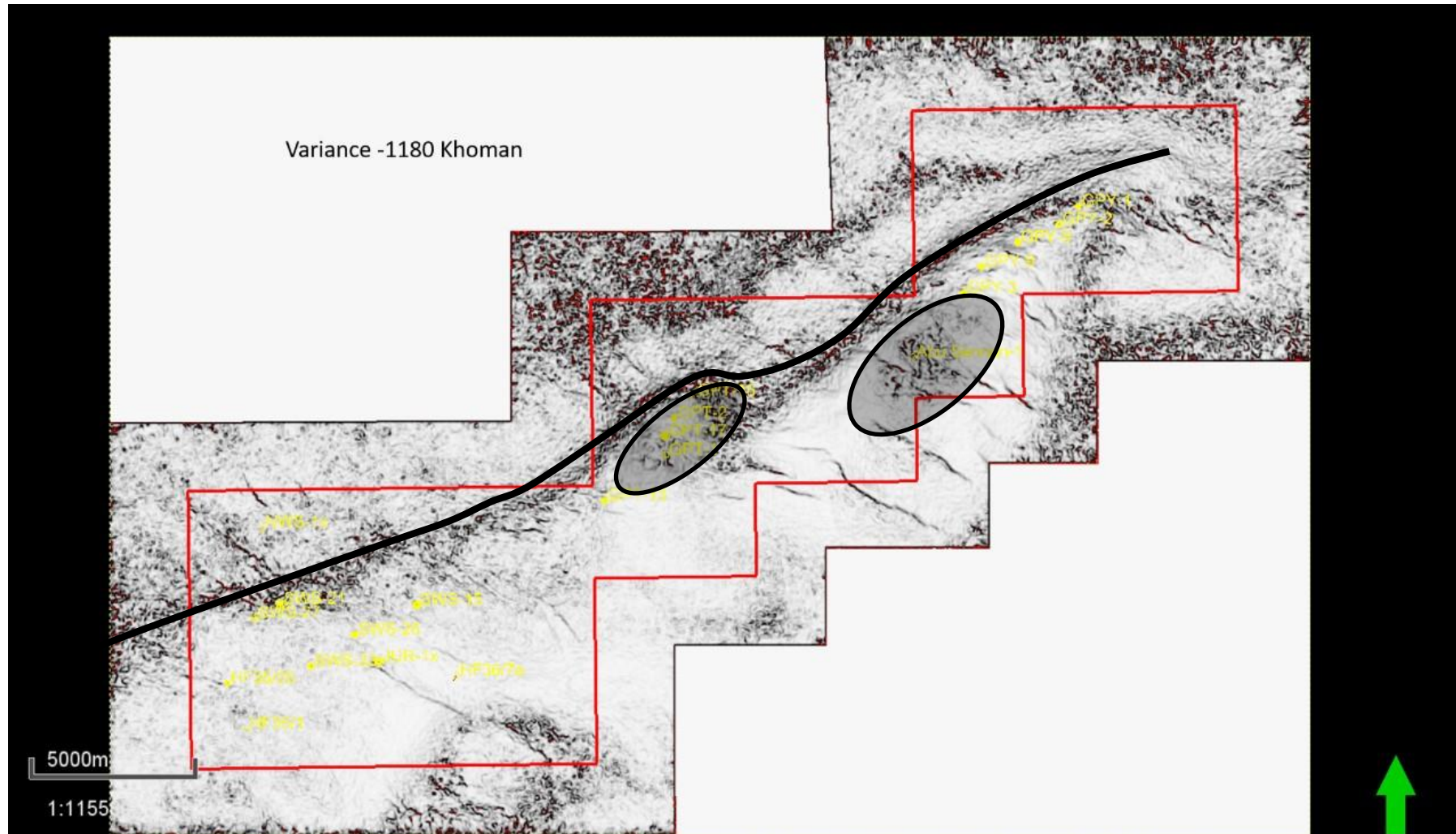
Khoman Structure



Iso-frequency map near top of Khoman



Khoman Structure



Variance seismic attributes map near top of Khoman



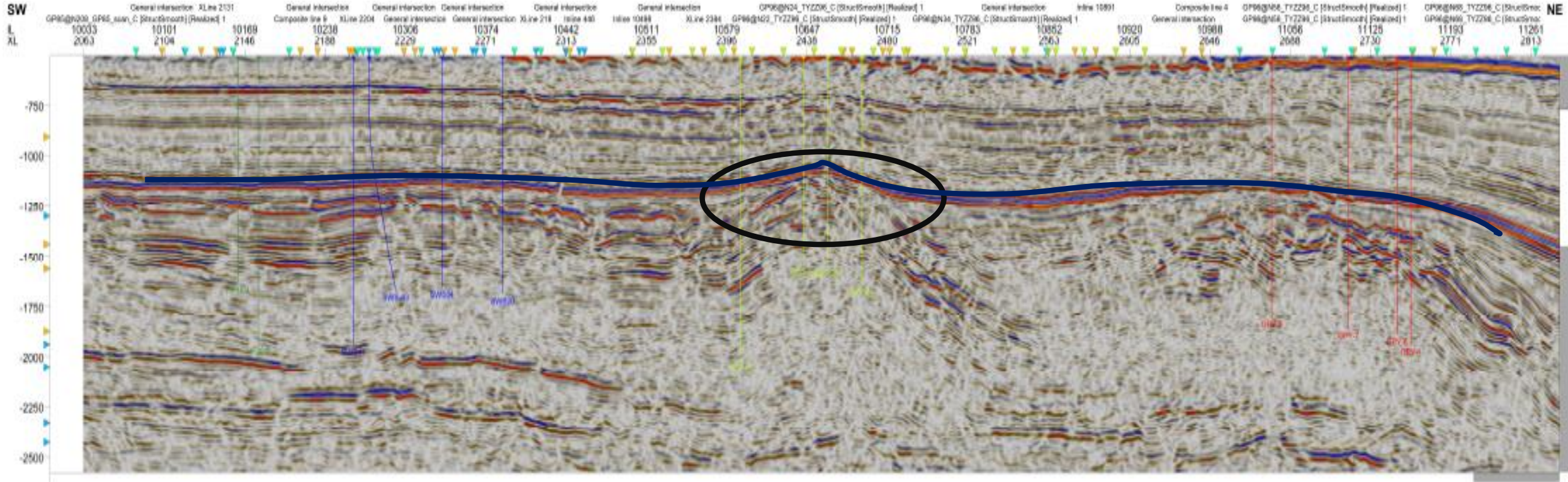
Seismic Amplitude Across Abu Sennan



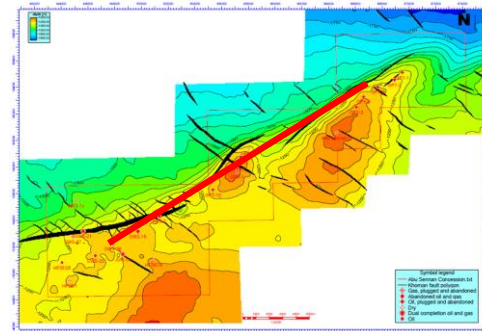
SWS

GPT

GPY

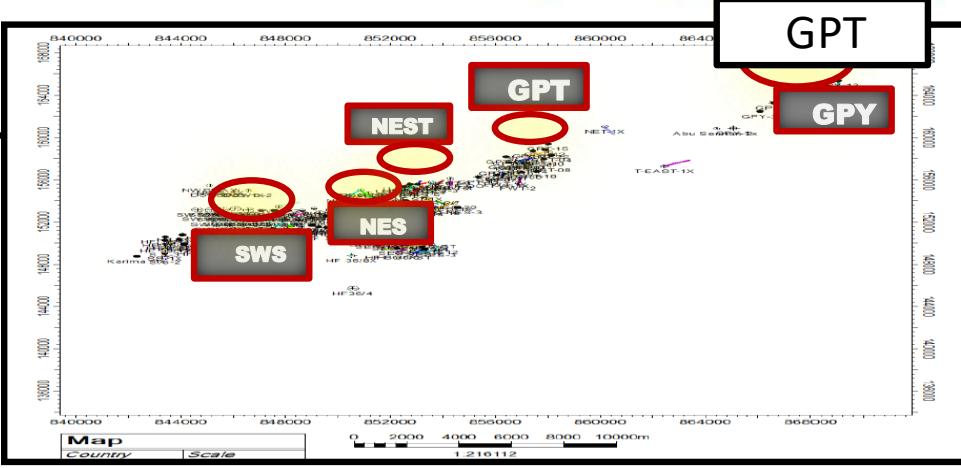
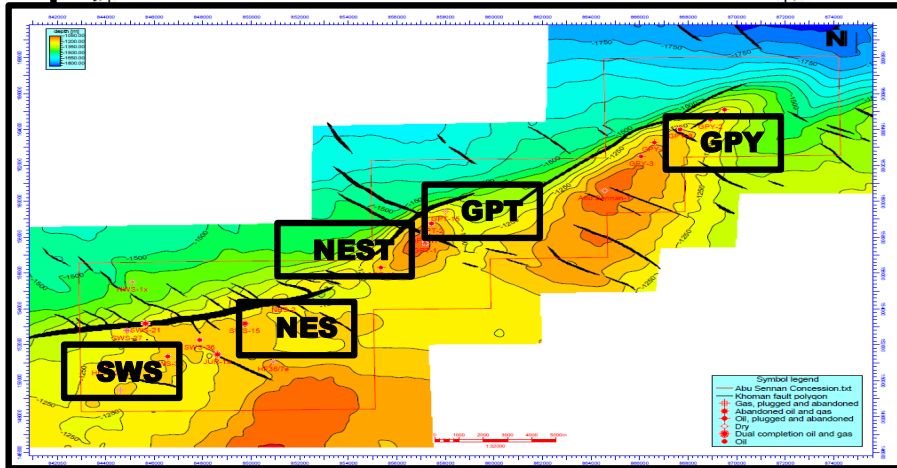
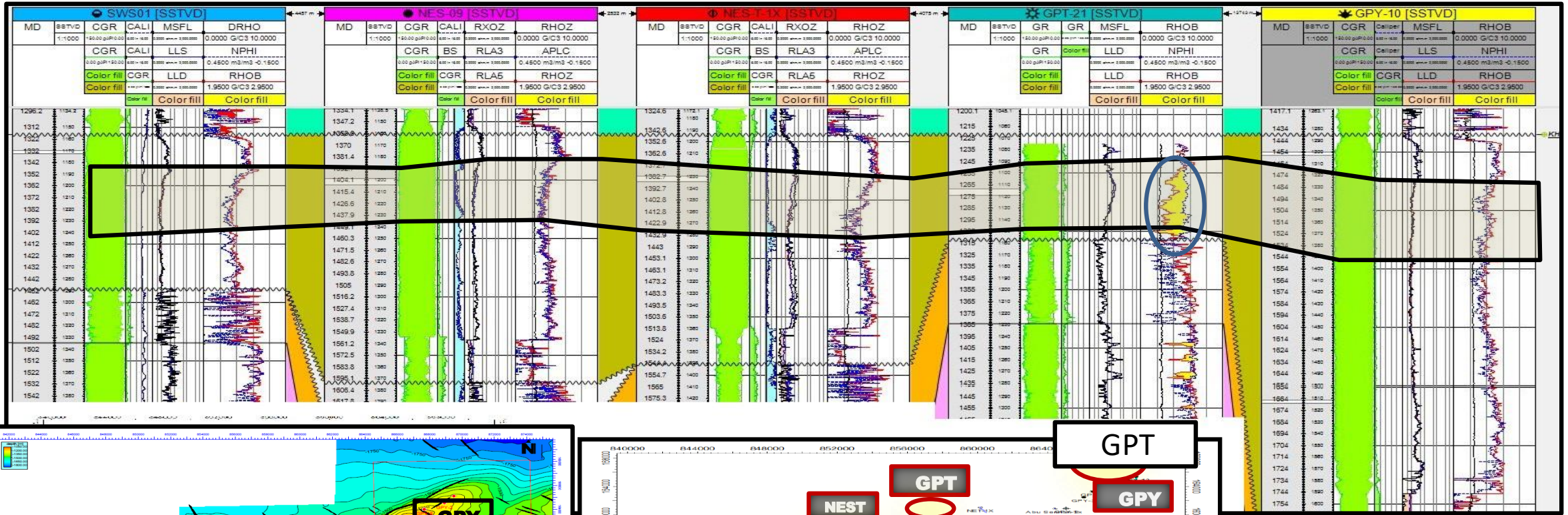


SW-NE Seismic Line Across Abu Sennan Field



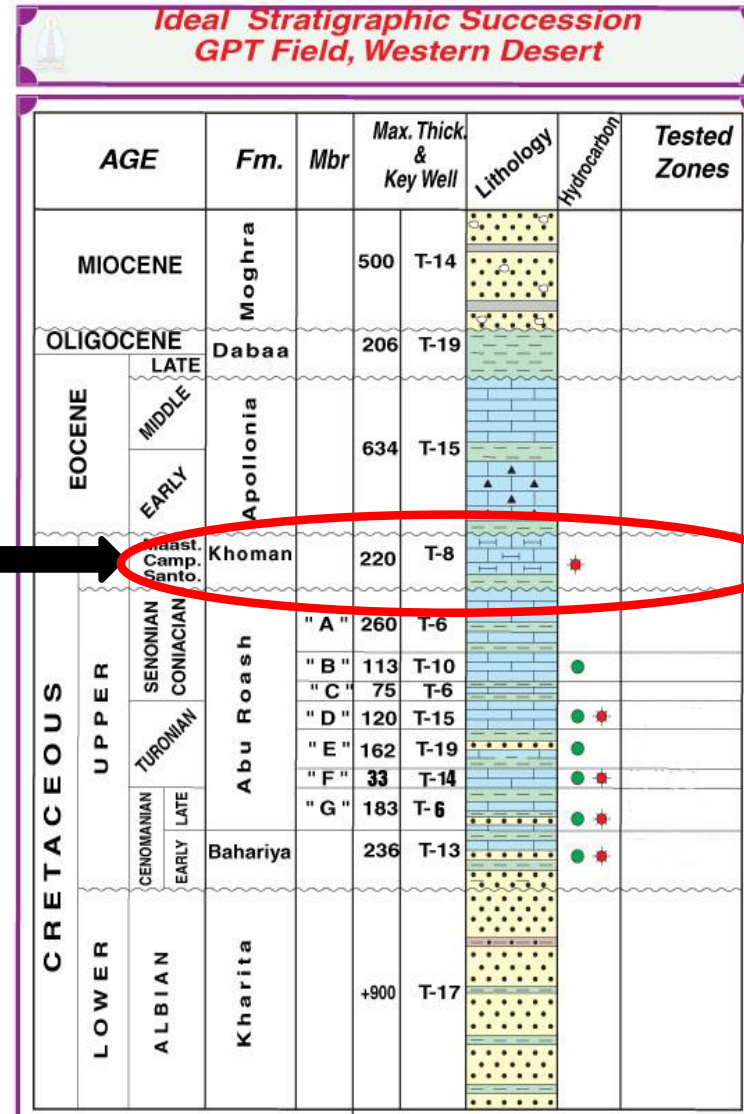


Regional Correlation line for Khoman Reservoir

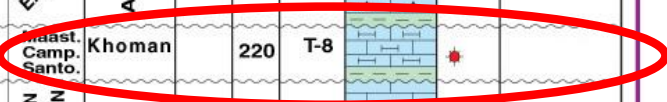




GPT Filed Stratigraphic Sequence



Khoman formation
 Upper Cretaceous
 Open Marine Environment



GPT-Field Reservoirs (Oil & Gas)

Khoman reservoir

AR/B Mbr reservoir

AR/D Mbr reservoir

AR/E Mbr reservoir

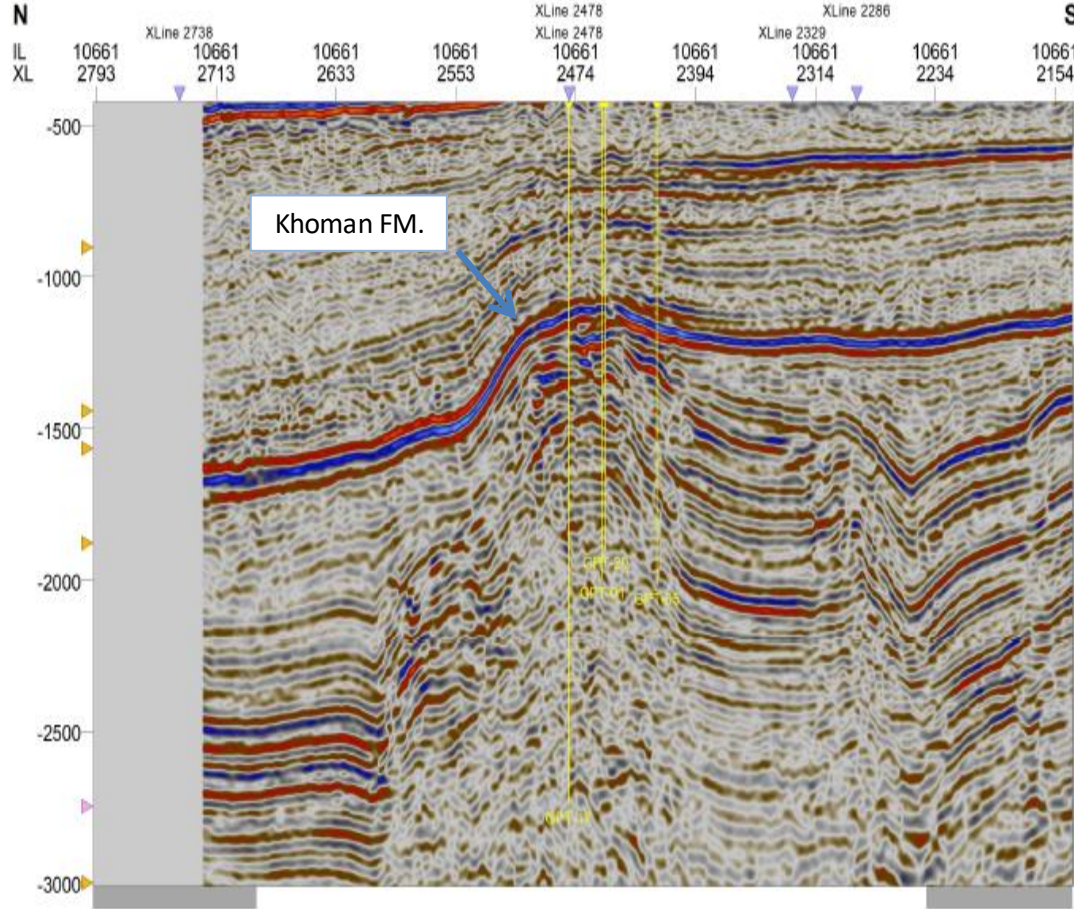
AR/F Mbr reservoir

AR/G Mbr reservoir

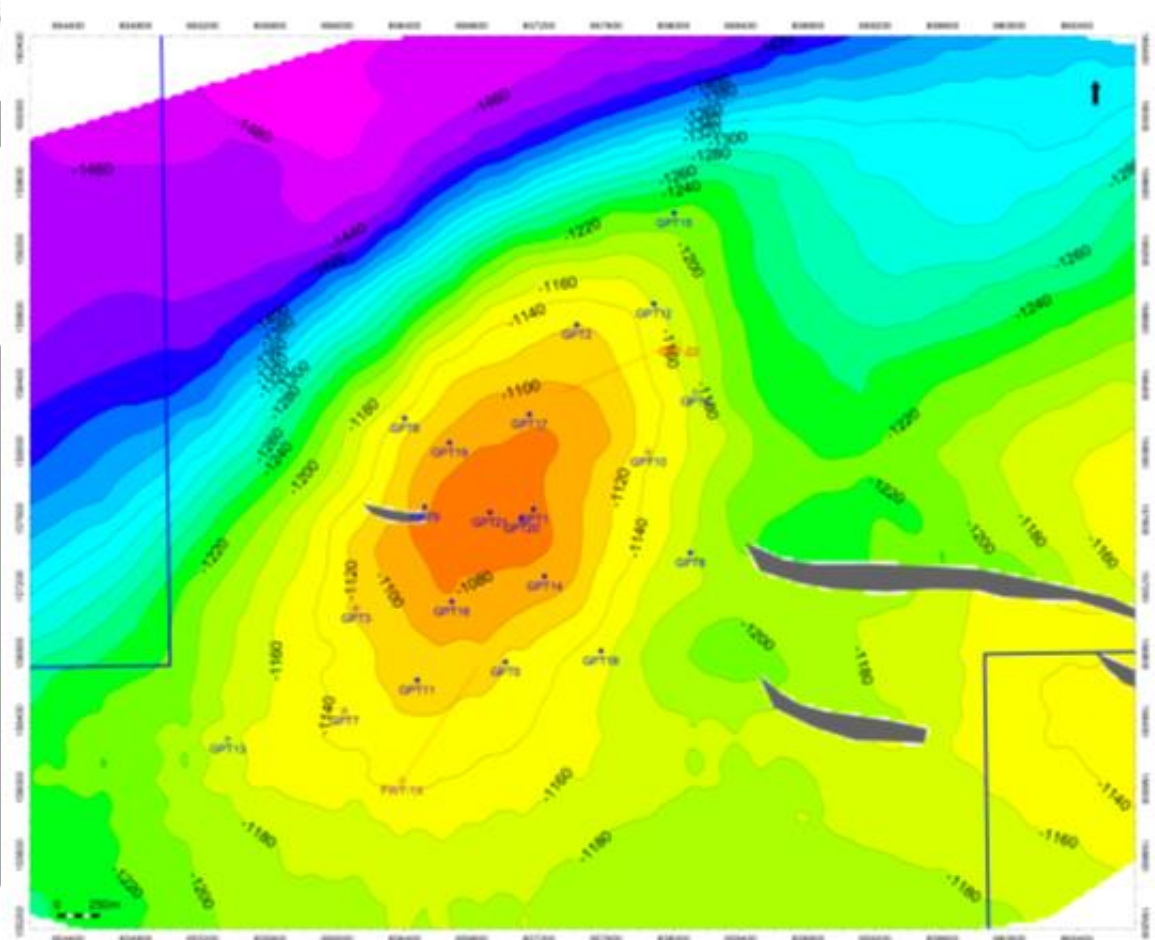
Bahariya reservoir



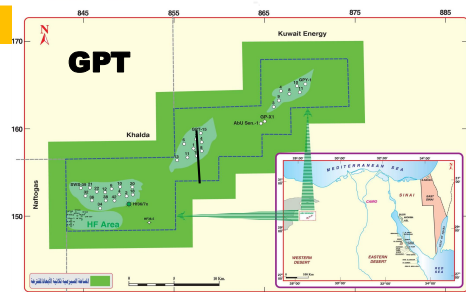
Seismic Amplitude Across GPT



GPT

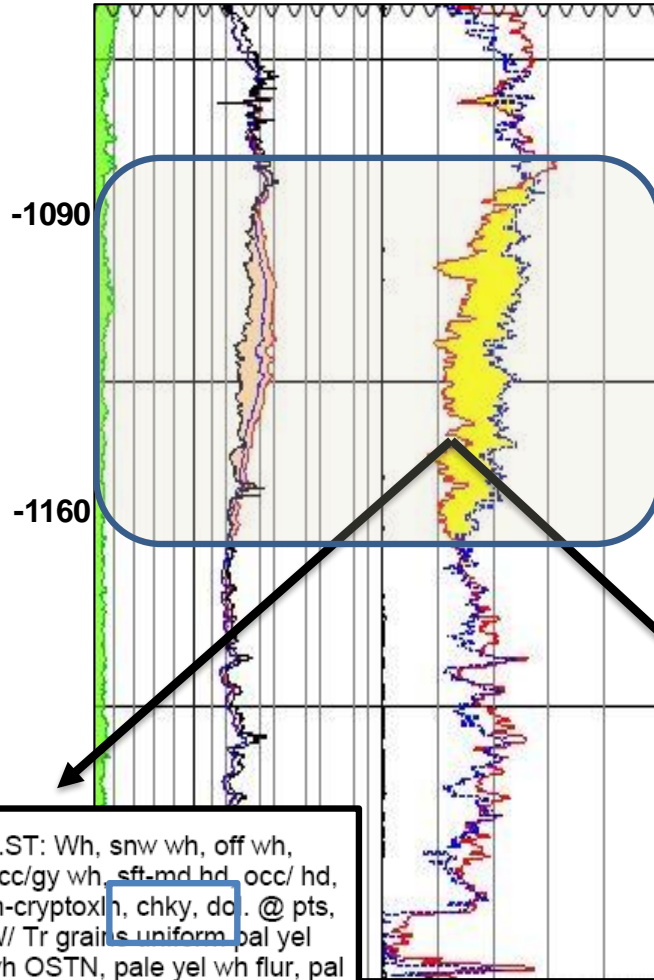
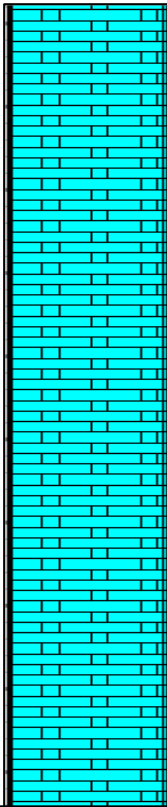


Structural depth map near top surface level of Khoman Formation.



Geological Characterization of Khoman

**Khoman formation
(A) Member**



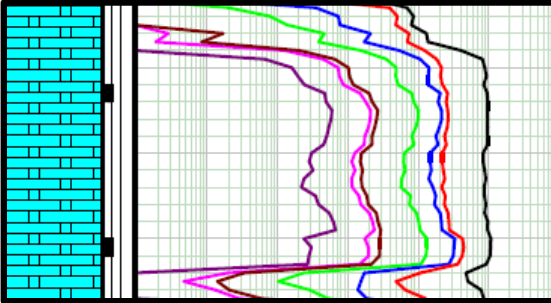
Upper Part

Argillaceous & Chalky Limestone

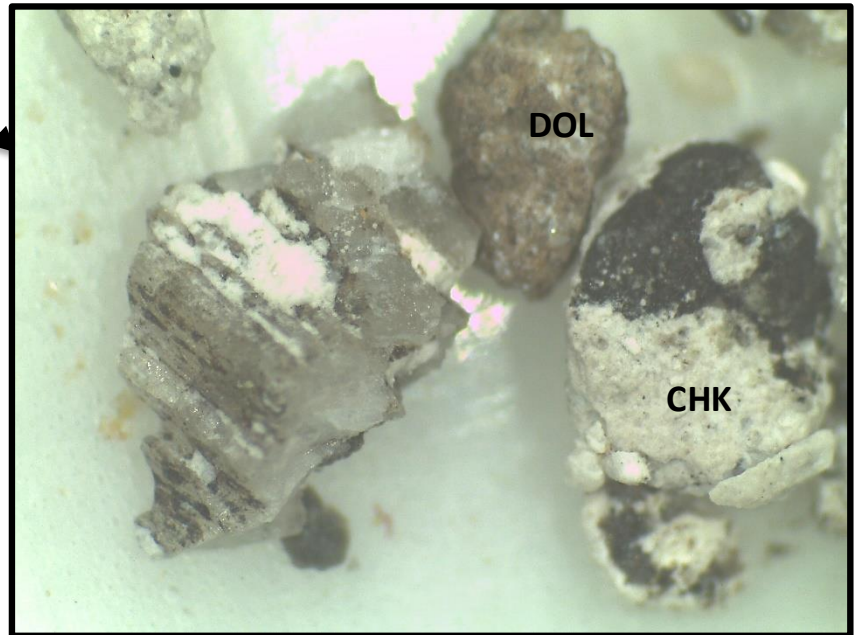
Middle Part

Dolomitic Chalky Limestone

Lower Part

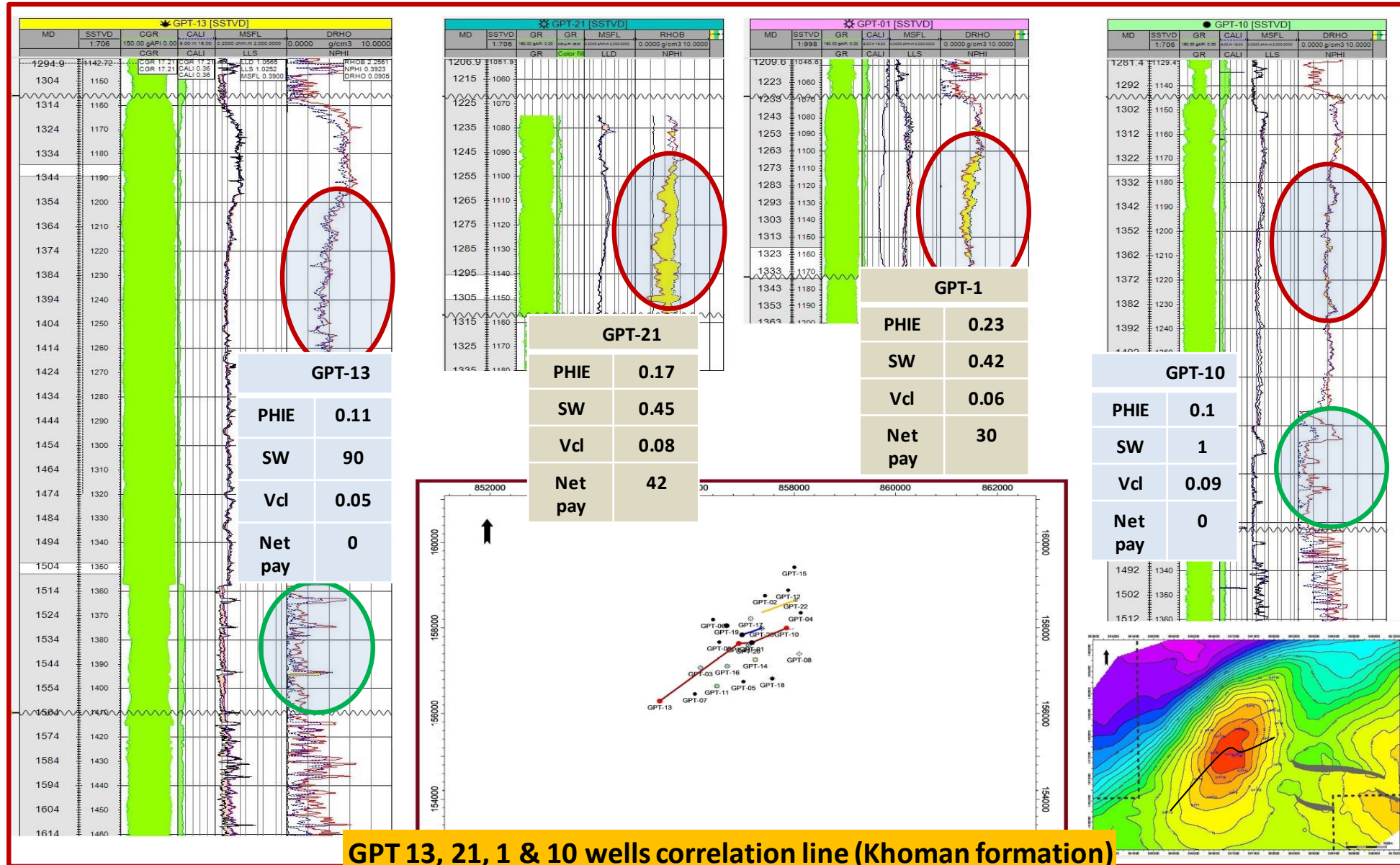


L.ST: Wh, snw wh, off wh, occ/gy wh, sft-md hd, occ/ hd, fn-cryptoxl, chky, dol. @ pts, W/ Tr grains uniform, pal yel wh OSTN, pale yel wh flur, pal yel wh strm cut, no crush cut, no R.R.



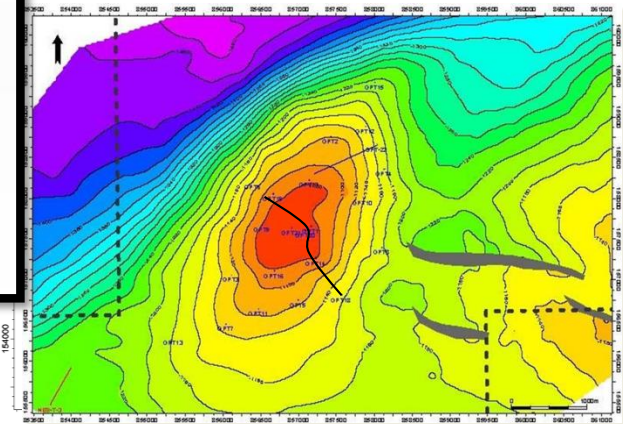
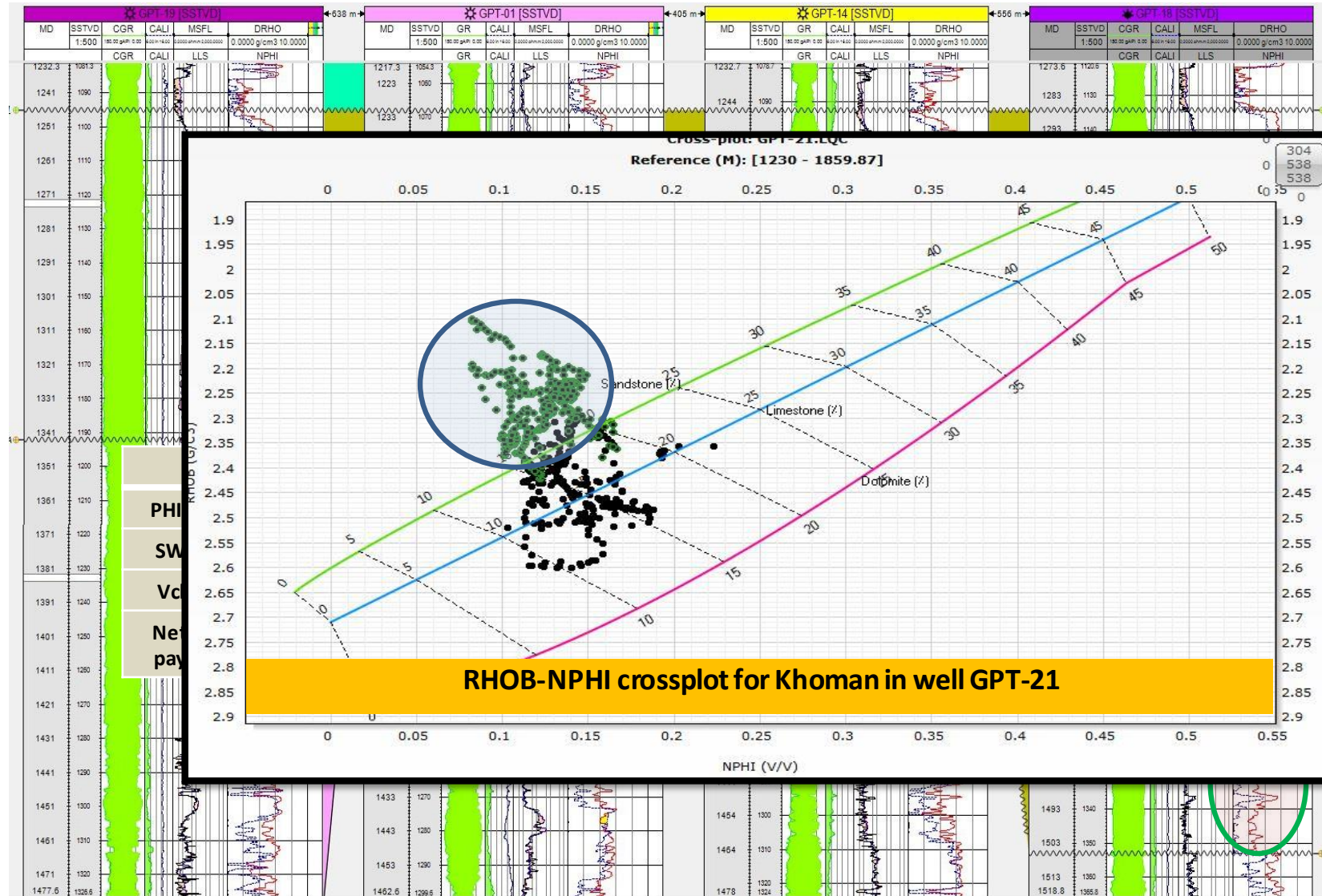


Petrophysical Characterization





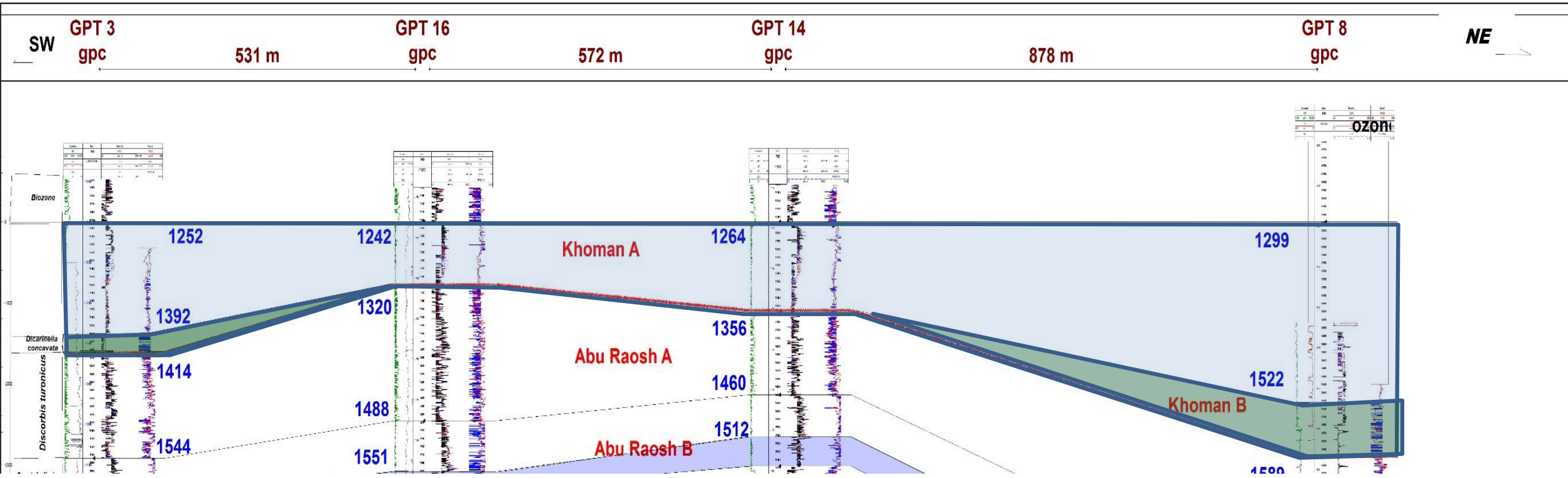
Petrophysical Characterization



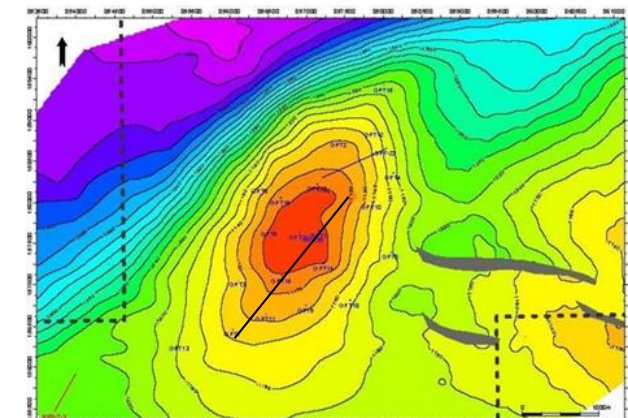
Correlation line between GPT 19,01,14&18 wells (Khoman formation)



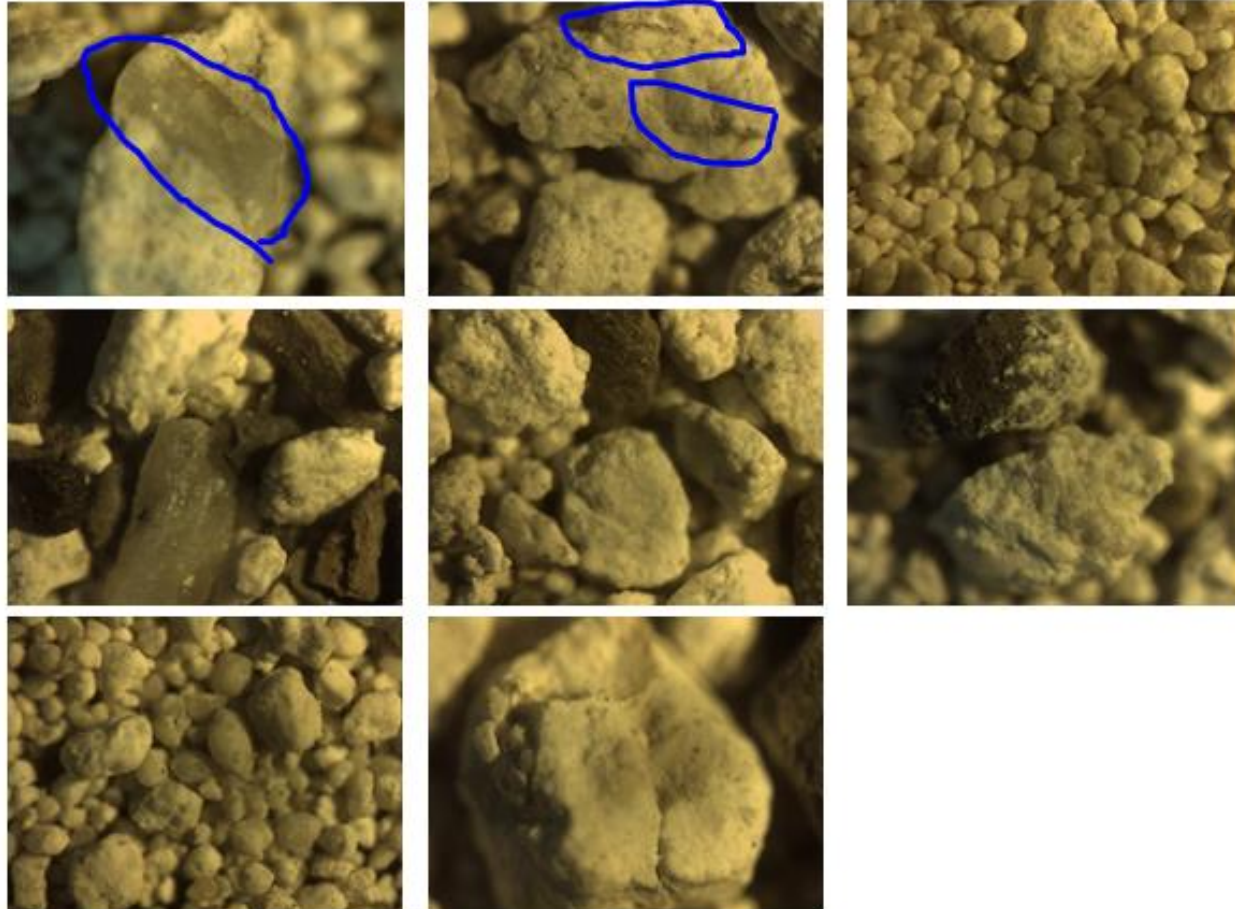
Bio-stratigraphic Correlation Across GPT Field



Bio-stratigraphic correlation line through GPT field (GPT-3,GPT-16,GPT-14&GPT-8)

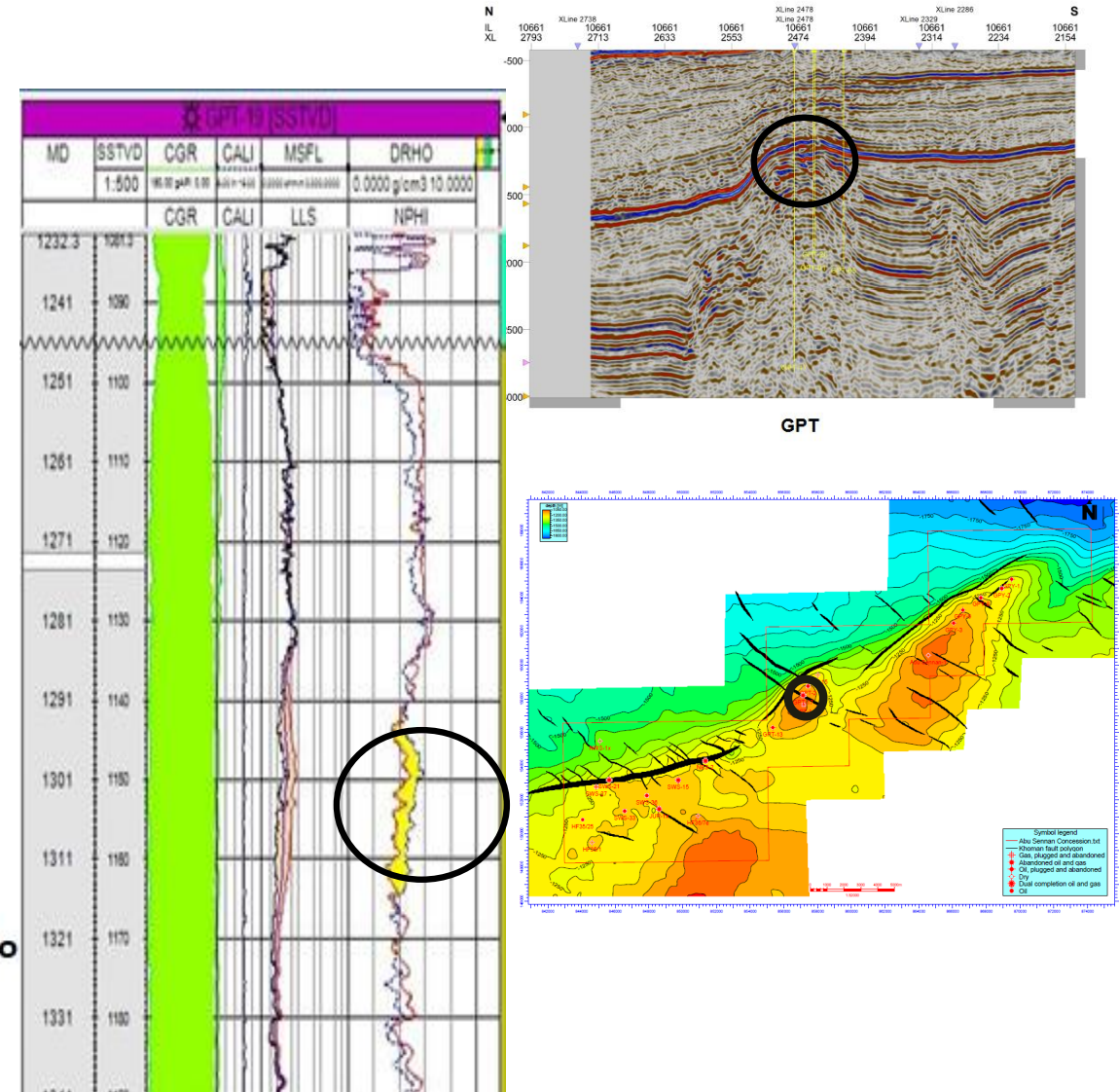


Khoman Diagenetic Features

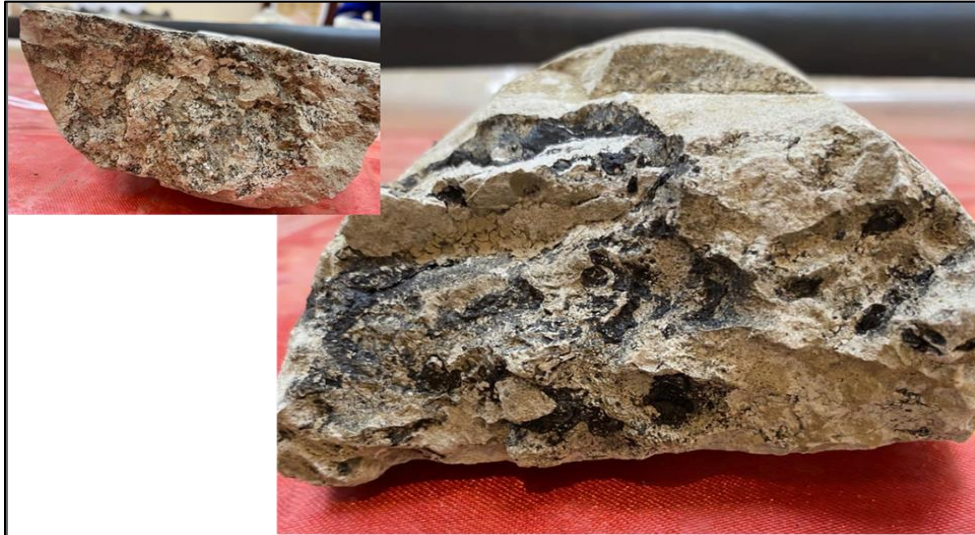


Limestone: chalky, white, milky white, greish white, massive, blocky, fossiliferous to highly fossiliferous , argillaceous, free pyrite, dolomitic and fractured at parts

GPT-19 (1290-1320) m MD)



Khoman Diagenetic Features

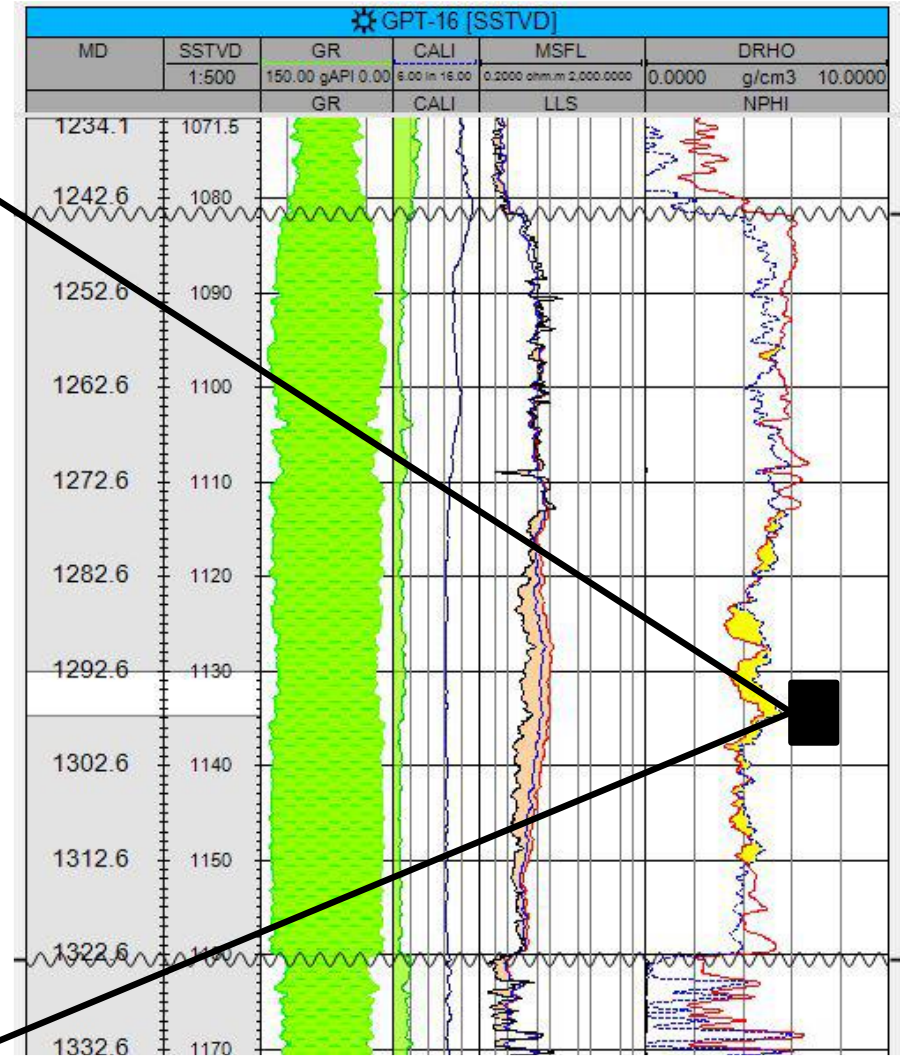
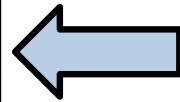


LIMESTONE
 LIGHT TO MEDIUM BROWN, CHALKY, DOLOMITIC AT PARTS
 BIOUTRBATED, POROUS, HI-ORGANIC MATTER CONTENT



MASSIVE & LAMINATED DOLOSTONE
 LIGHT TO MEDIUM GREY, DARK GREY
 CRYSTALLINE
 FILLED FRACTURED
 PYRITIZED

DIFFERENT STAGE S OF
 DOLOMITIZATION



GPT-16
 CUM. GAS: 2.156 BCF
 CUM. OIL : 41000 BBL

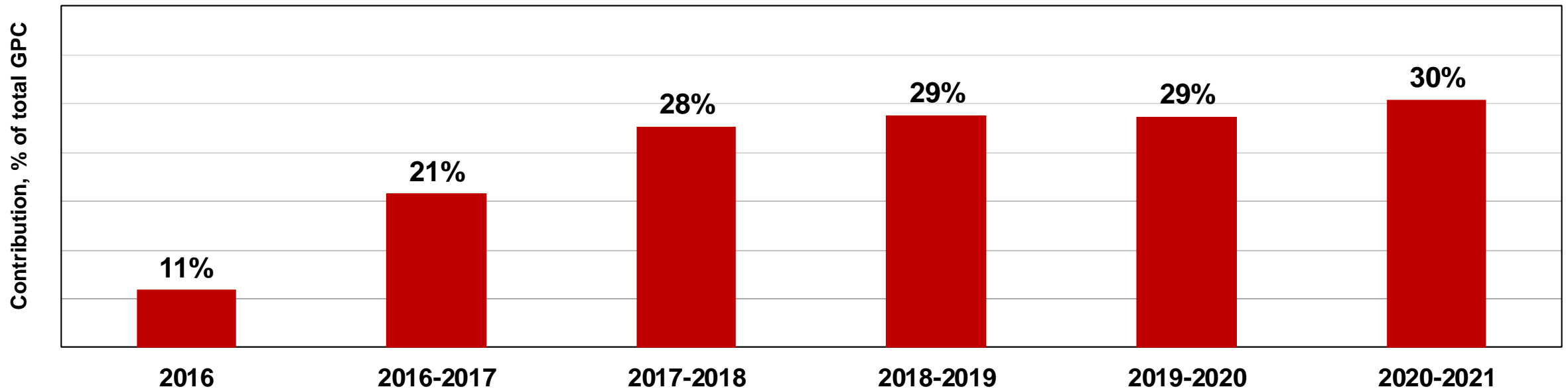
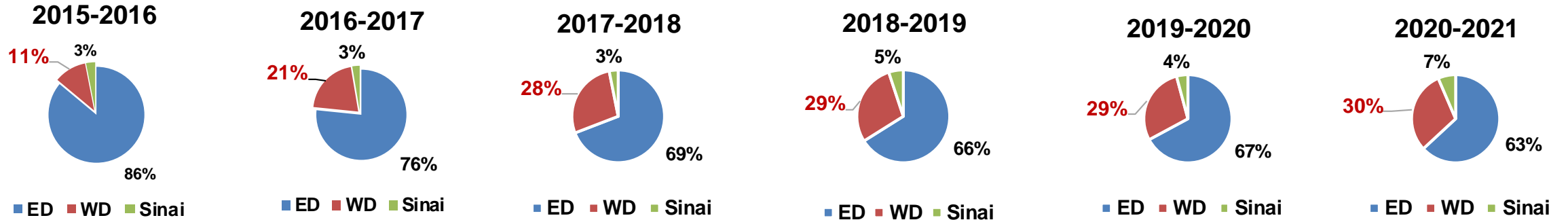


Production Performance



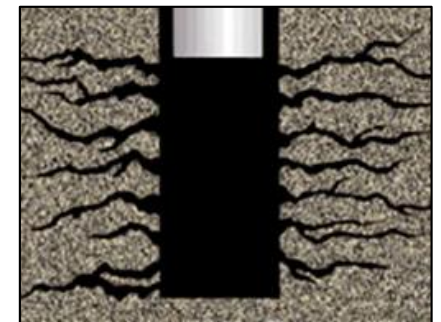
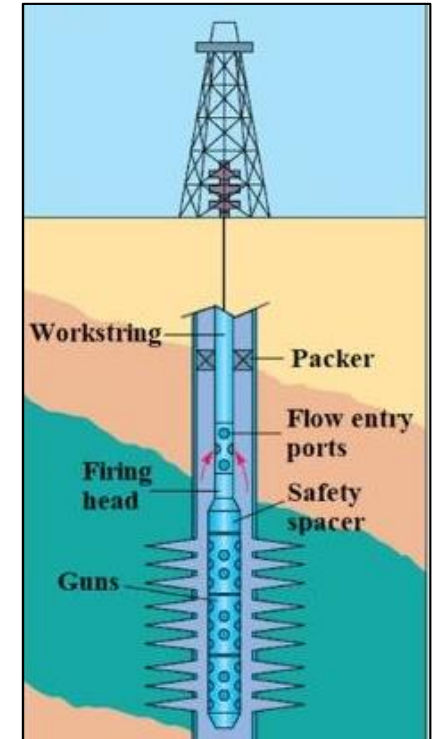


Contribution of Western Desert to GPC Profile



Khoman Completion Procedure

- TCP (tubing-conveyed) perforations were used to provide a deeper penetration.
- **Nitrified acid treatment was applied to:**
 - Control fluid loss properties and decrease water content
 - Accelerate the cleanup of the reaction products while flow-back
 - Provide suspending properties for fines and insoluble materials
- Chemical diverter was more efficient to sublime allowing the perforations to be residue free.
- **In GPT field, Khoman reservoir is completed through cased-hole wells.**
- **Barefoot completion** associated with **nitrified acid treatment** is recommended for exploiting Khoman reservoir.





Completion Procedure

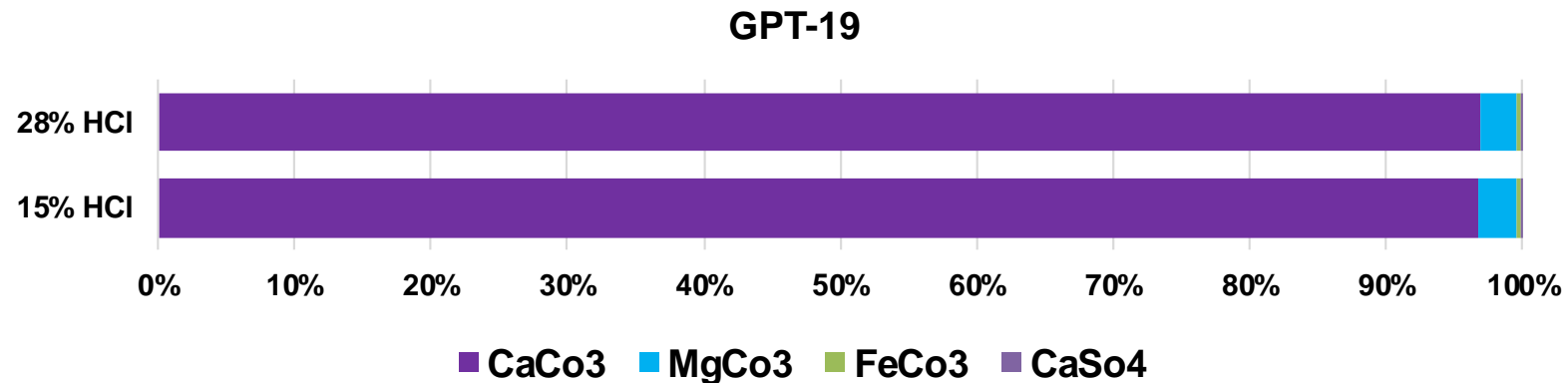
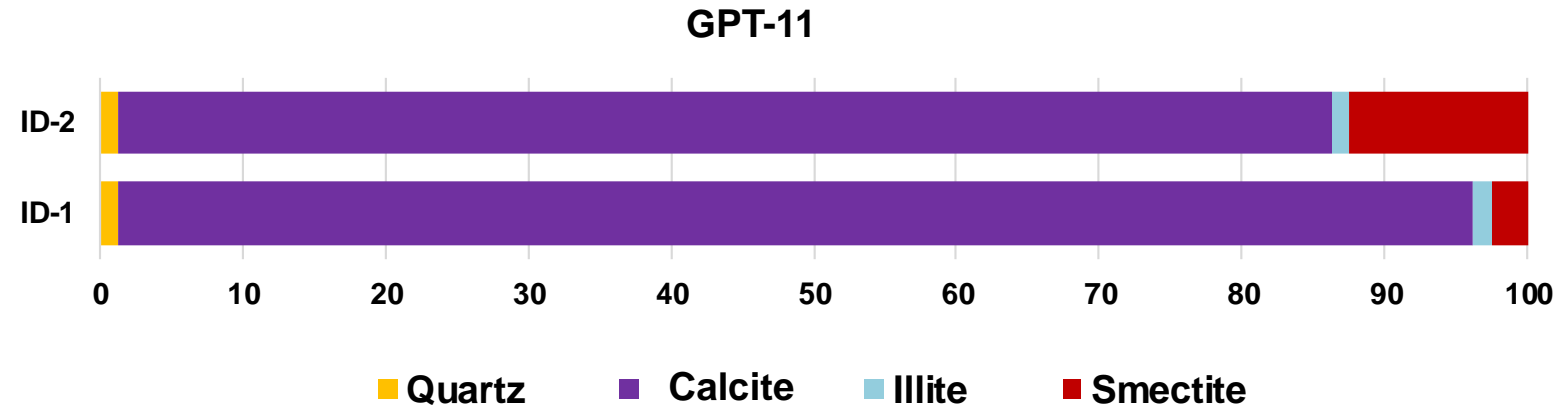


- **XRD analysis and HCl solubility:**

- XRD is performed to identify the types and relative quantities of minerals in the formation sample.
- Solubility was tested using 15% and 28% concentration

Solubility results:

Acid Concentration	Solubility, %
15% HCl	90
28% HCl	98.4

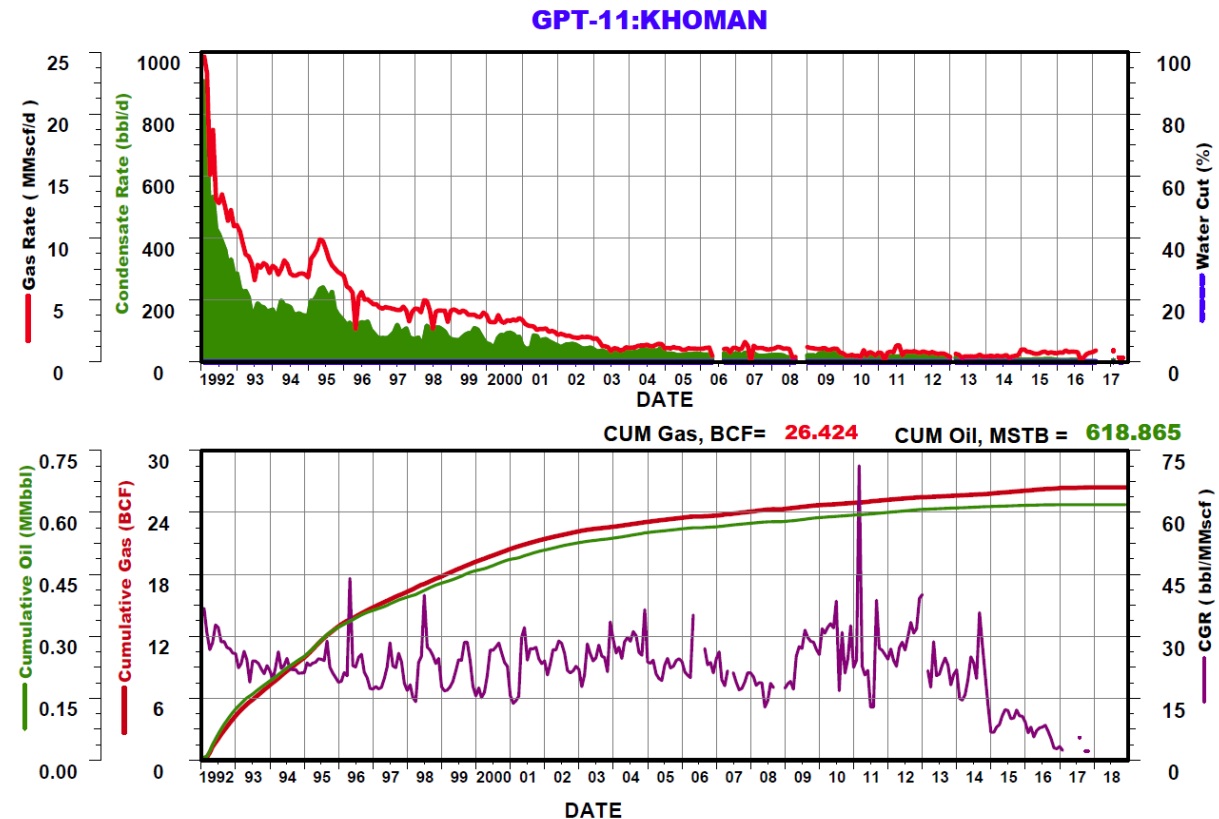
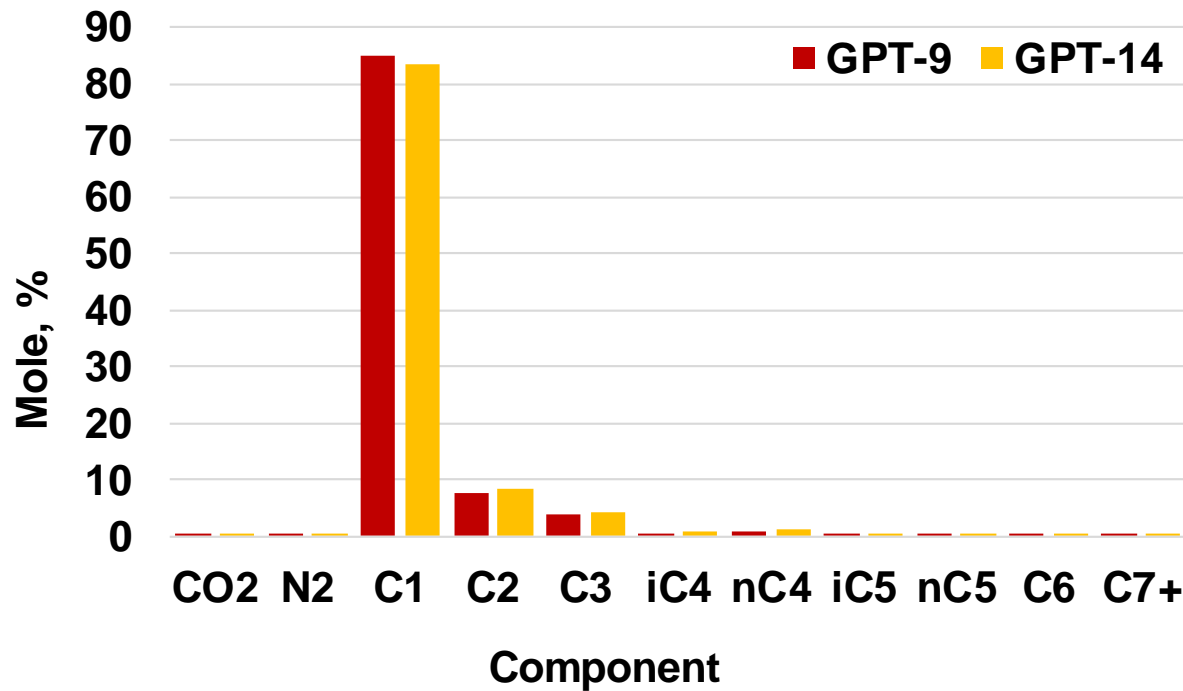




Gas Production Performance



- Khoman reservoir is stimulated at pressures that Not exceed fracture pressure (matrix).
- GPT-11 is the first well produced on Khoman reservoir.
- Gas composition confirms Khoman as a gas condensate reservoir with about 85% Methane.



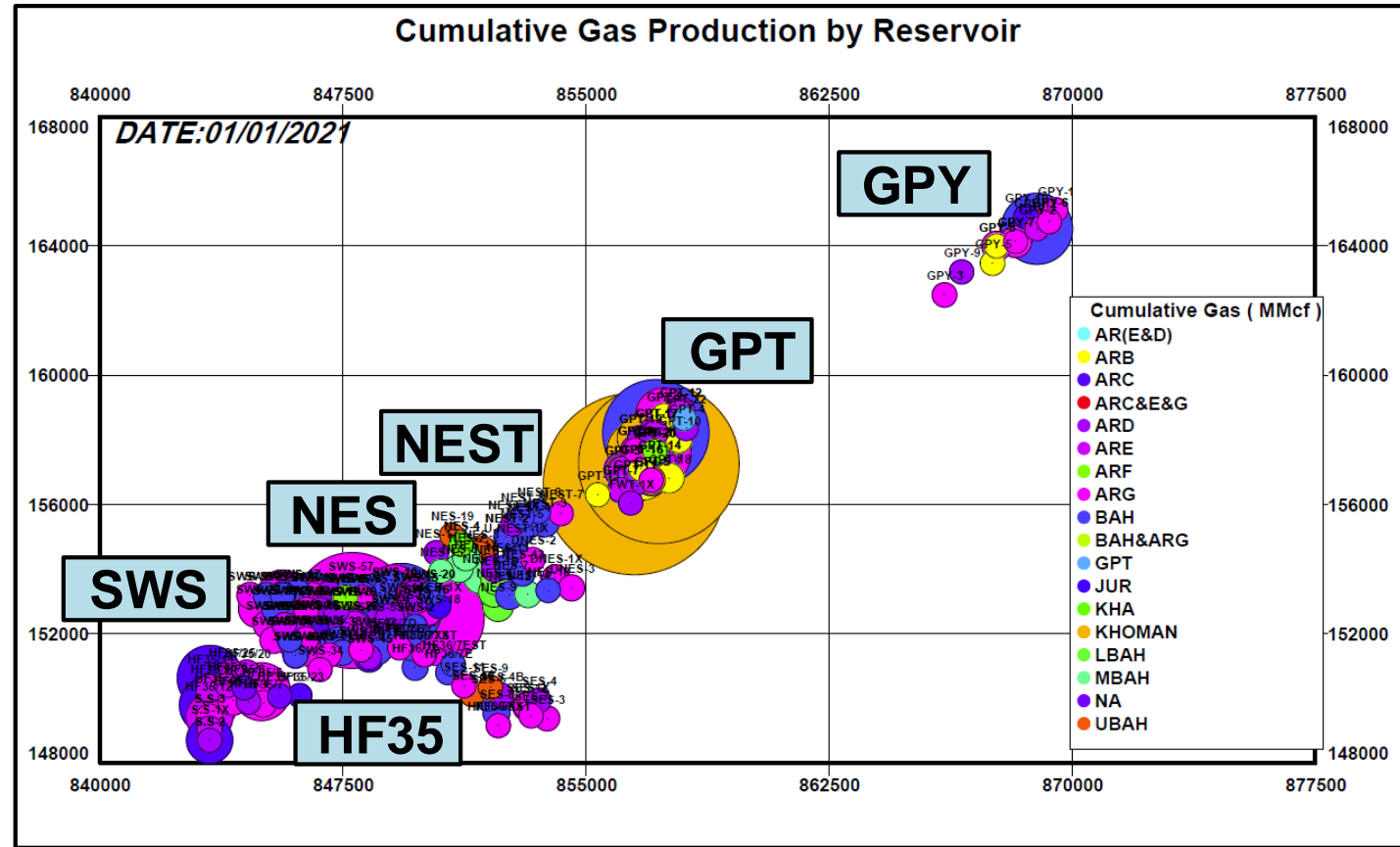
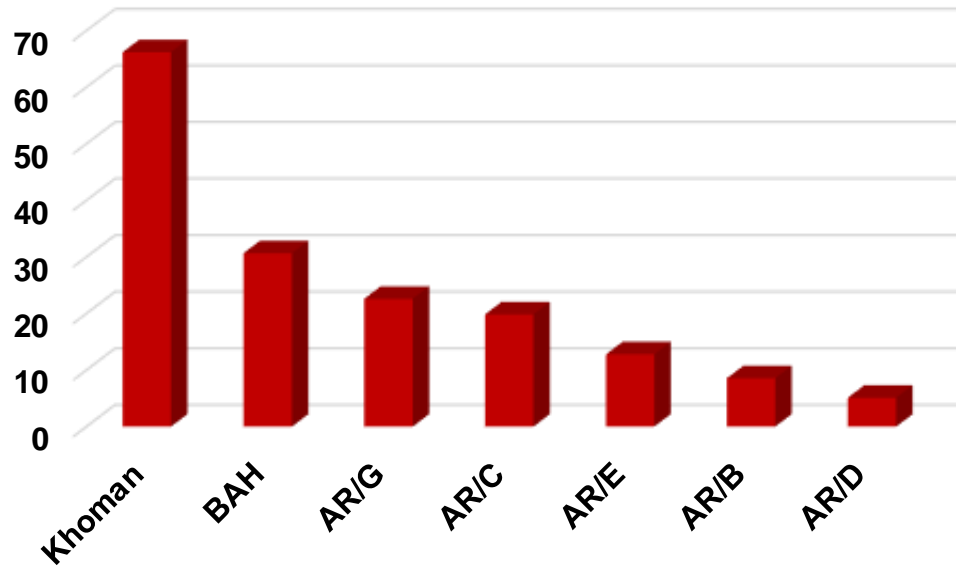


Cumulative Gas Production by Reservoir



- Khoman reservoir shows the highest cumulative gas production throughout all Western Desert reservoirs (**40% of total gas production**) followed by BAH (**18%**).

Cumulative Gas, BCF

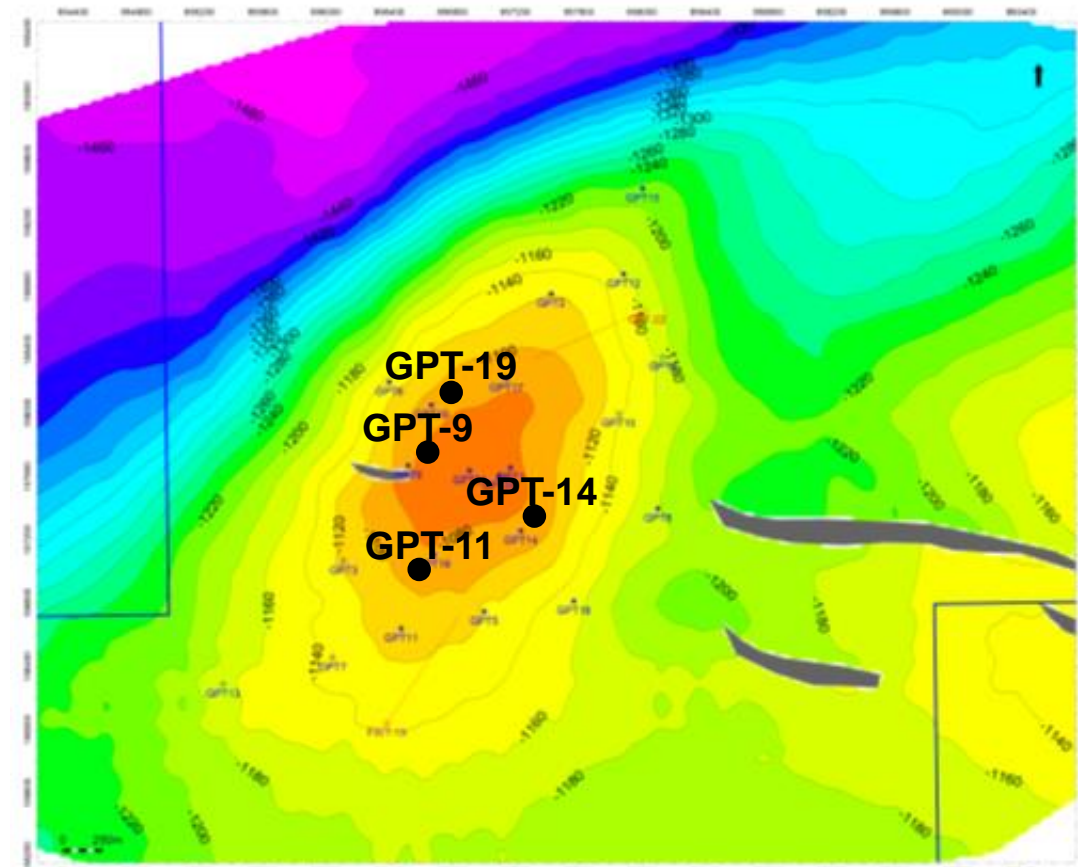
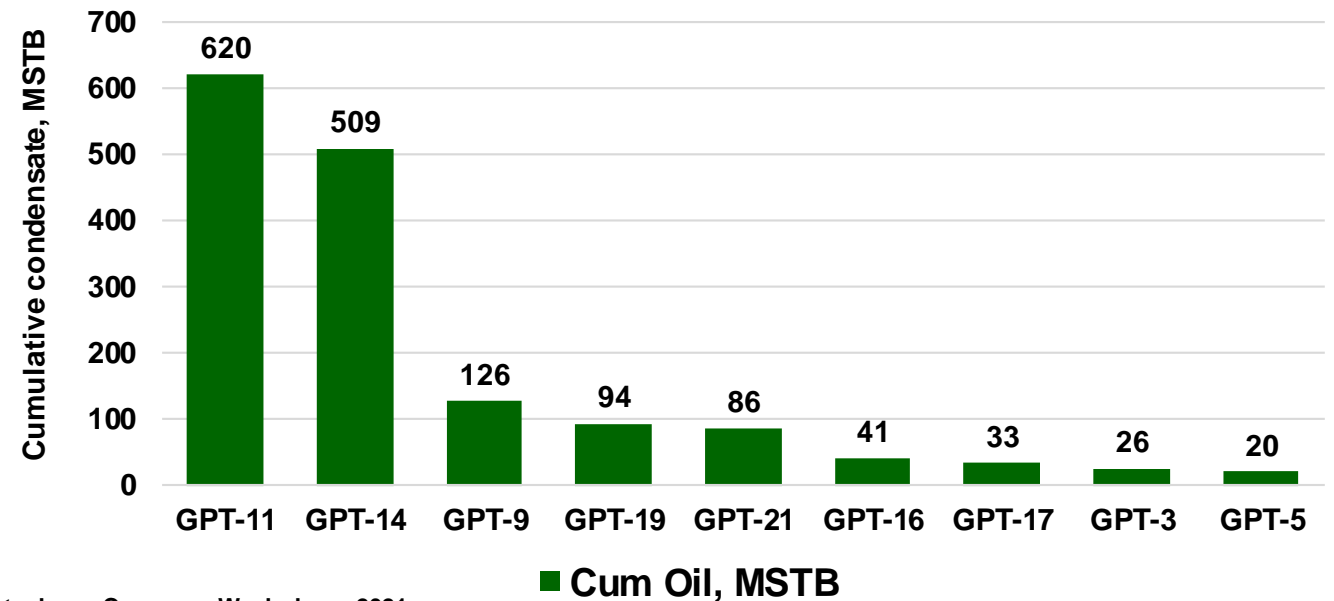
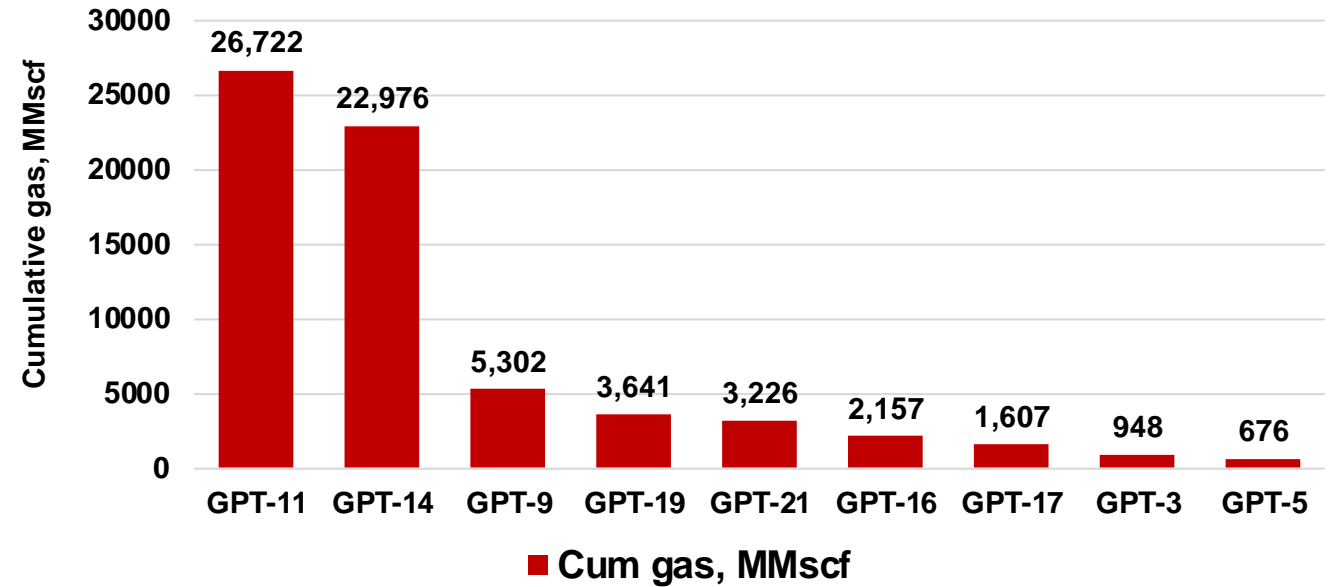




Khoman Production Analysis



- Wells GPT-11, GPT-14, and GPT-9 show the highest cumulative production throughout Khoman reservoir.



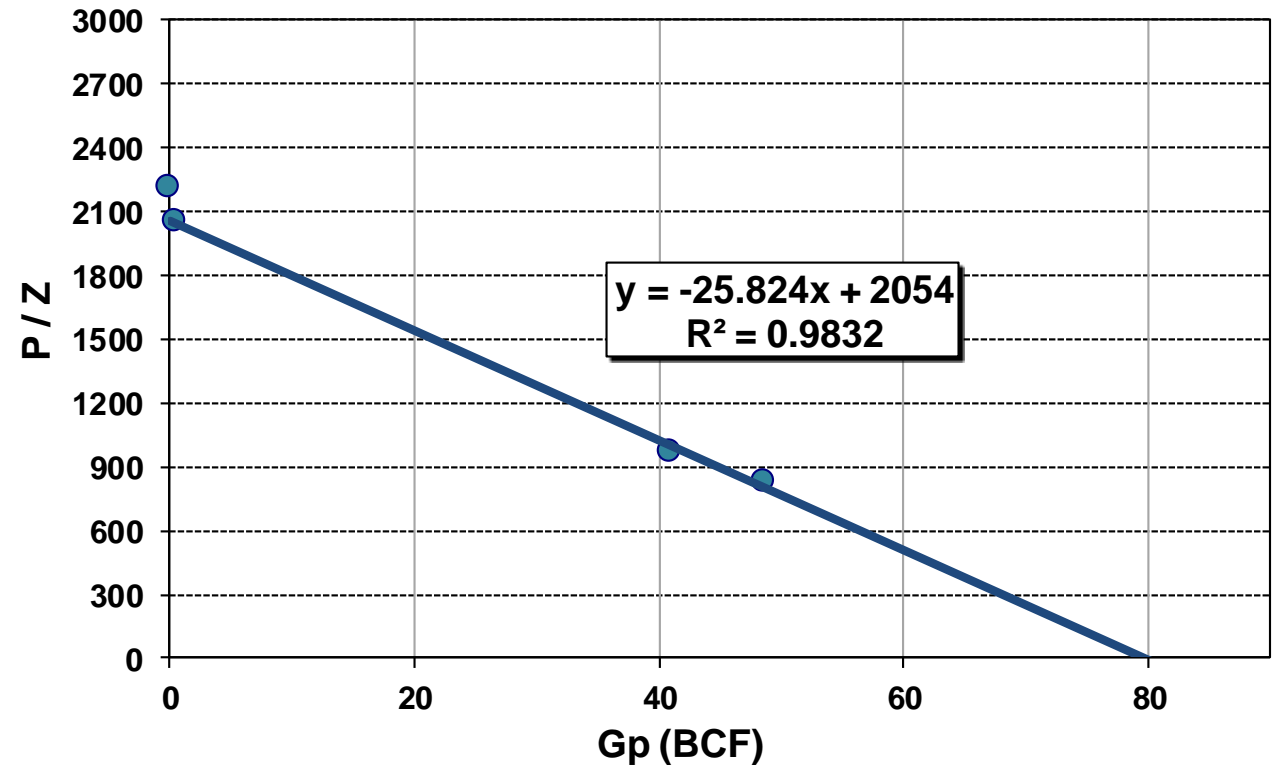
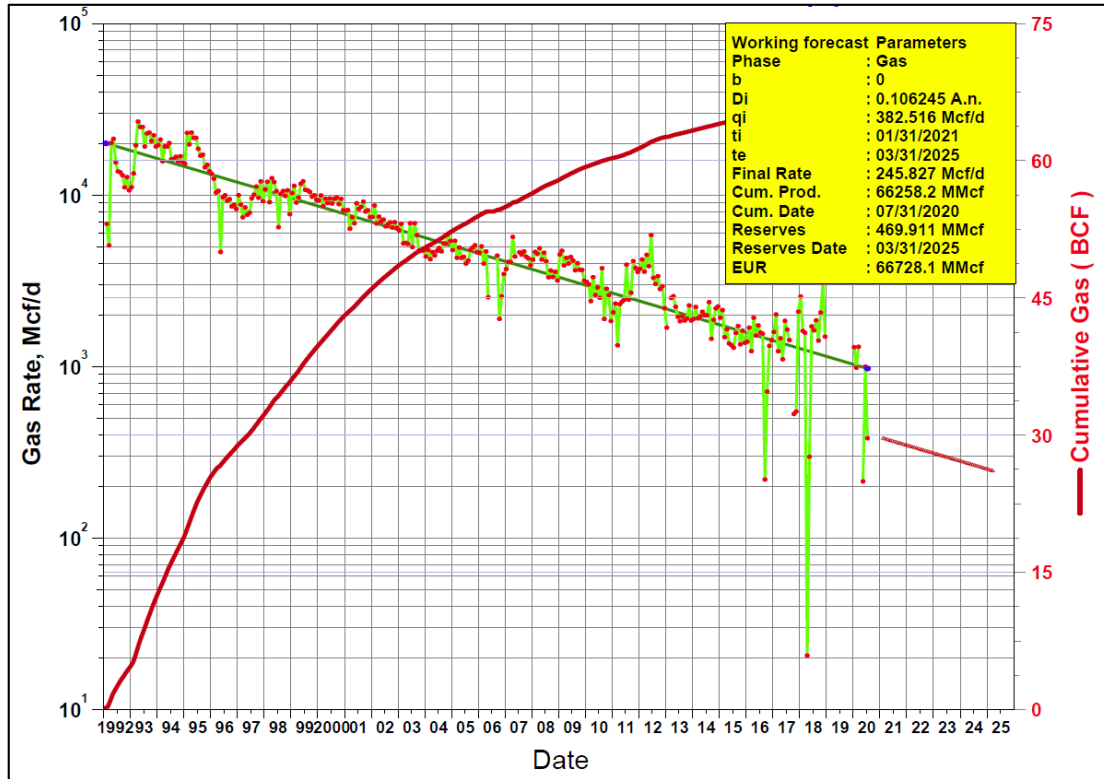


Khoman Recovery Efficiency (GPT Field)



- Estimated volumetric OGIP: 85 BCF
- Material balance OGIP: 79 BCF
- Cumulative Gas Production: 66.25 BCF

- Recovery Factor: 83.8 %OGIP
- Annual decline rate: 0.1 (/year)

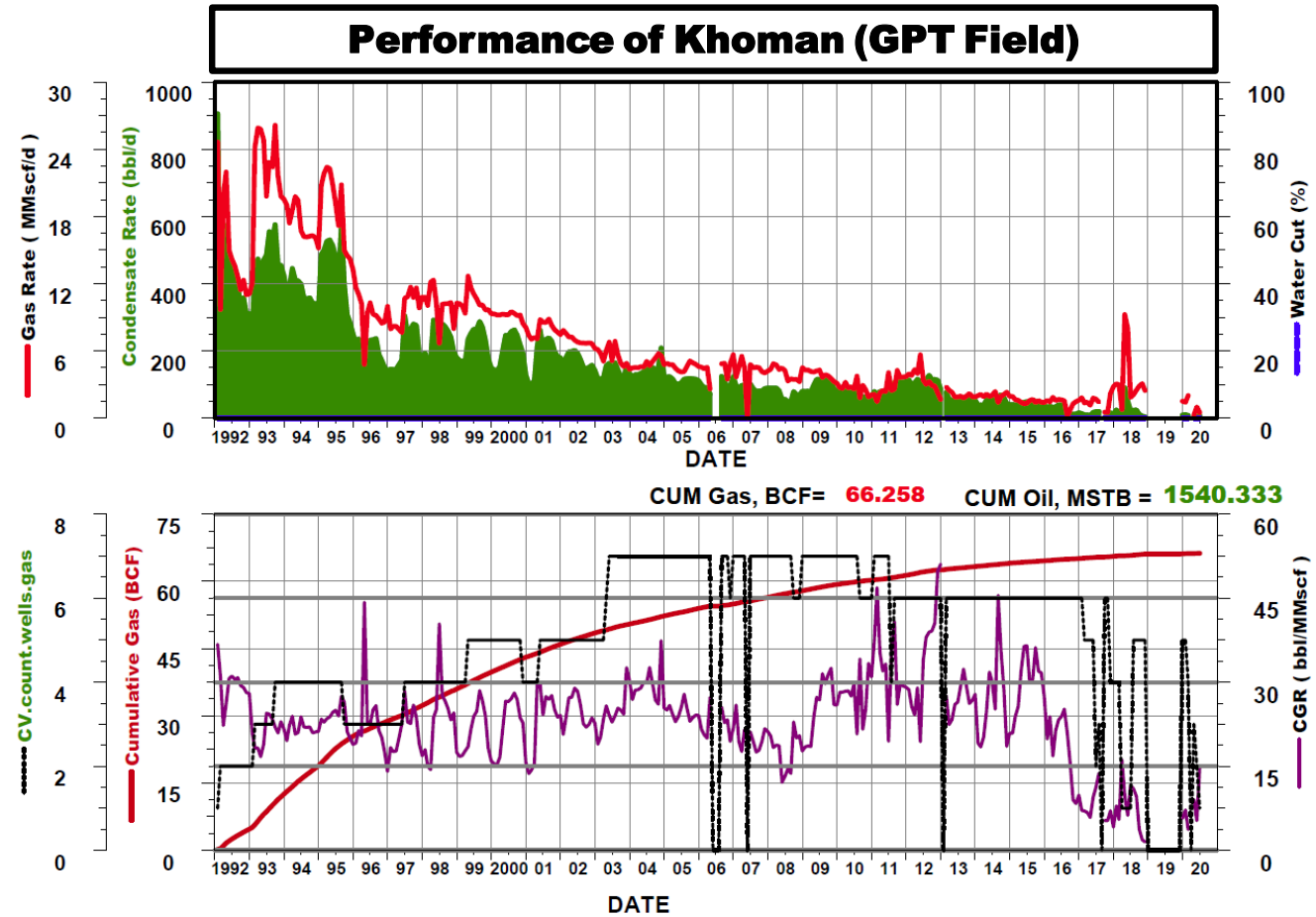




Khoman Production Performance



- Reservoir driving mechanism is gas expansion drive.
- The performance does not water production.
- Condensate gas ratio is ± 25 bbl/MMscf.





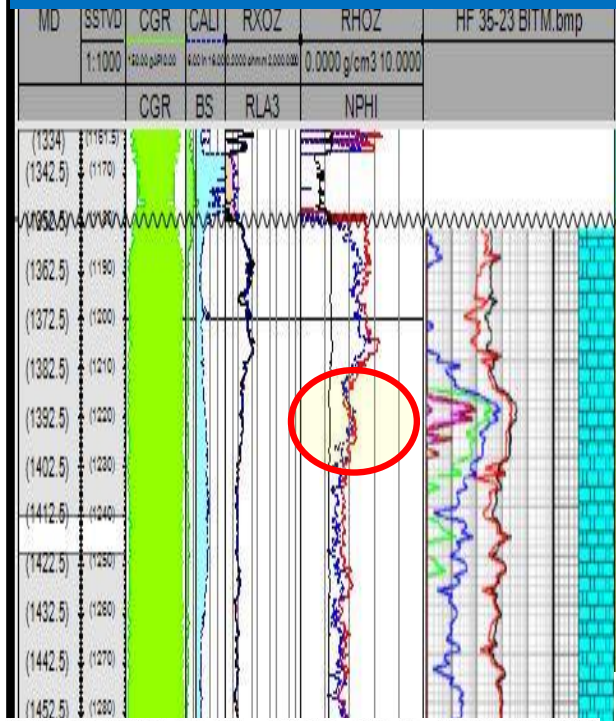
Way Forward



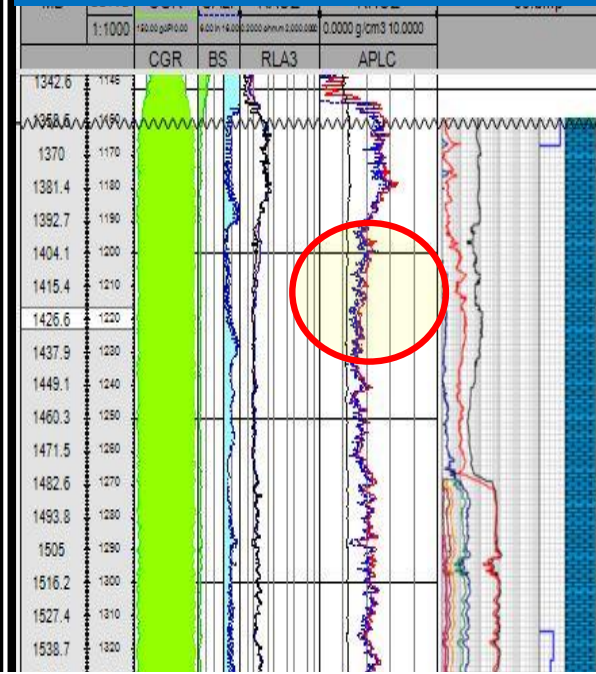
Khoman Regional Correlation



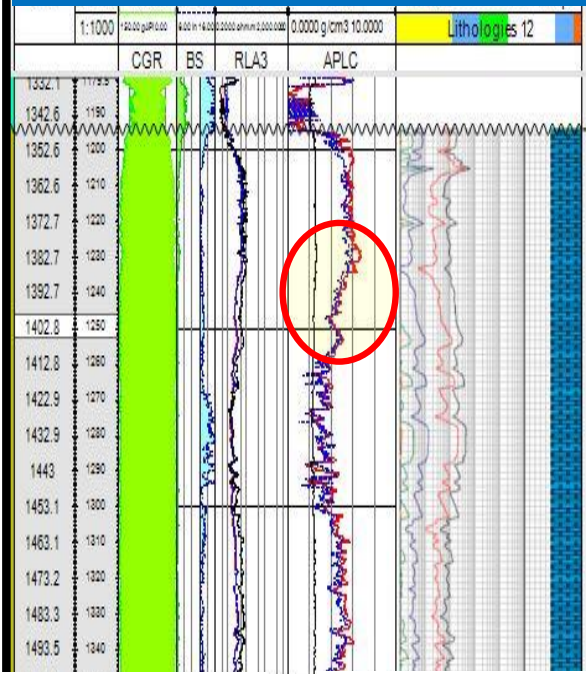
HF Field



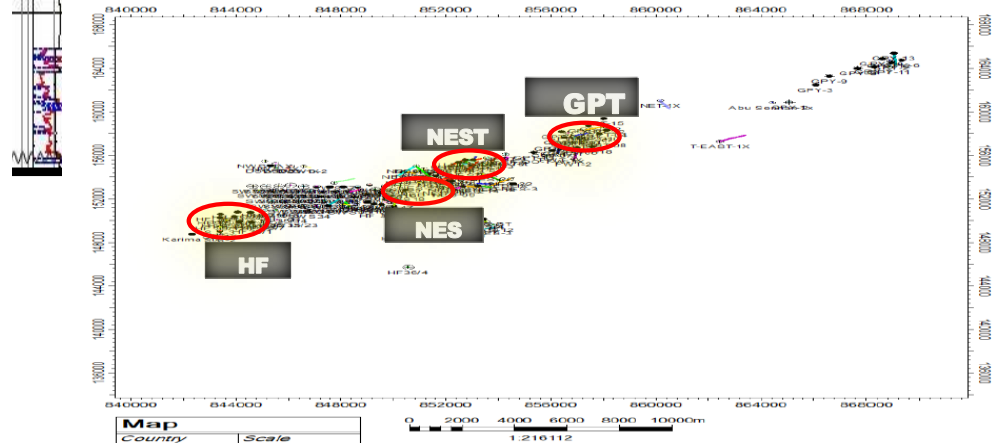
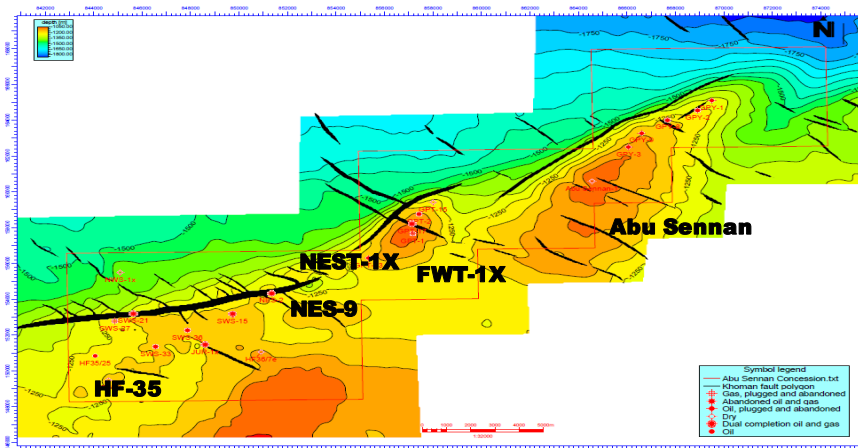
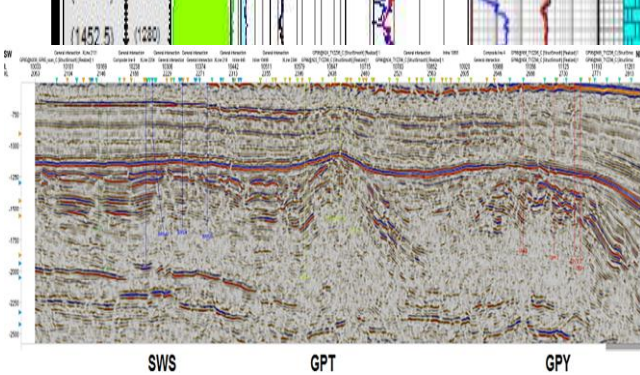
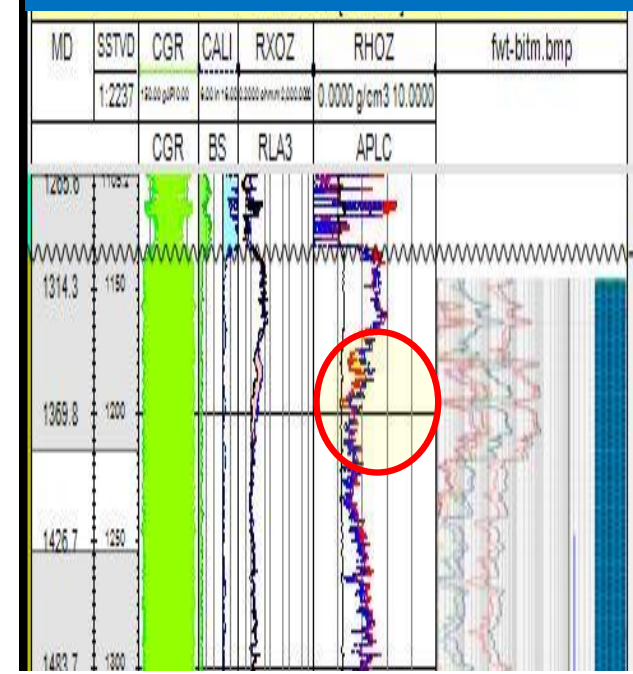
NES Field



NEST Field

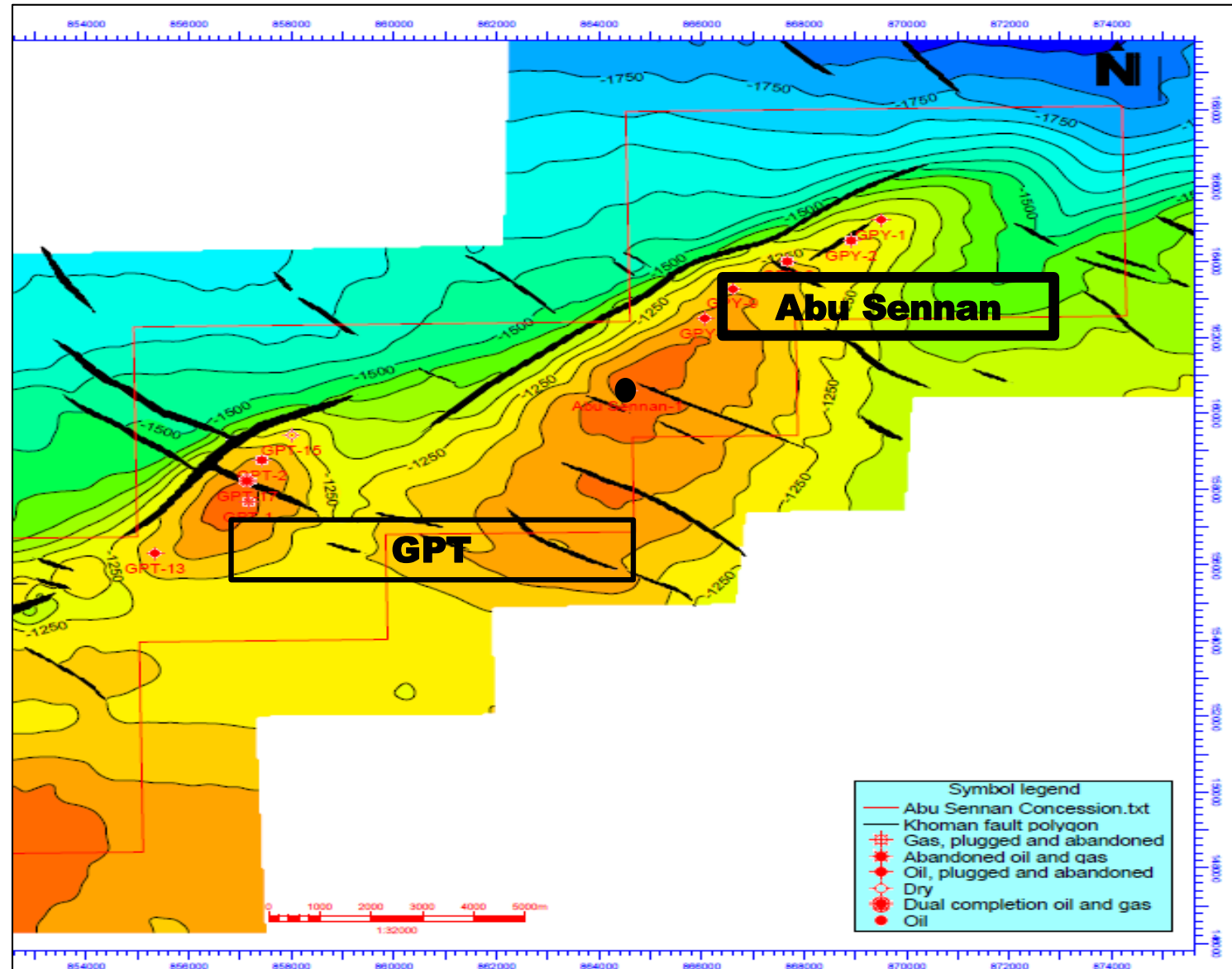


FWT Field



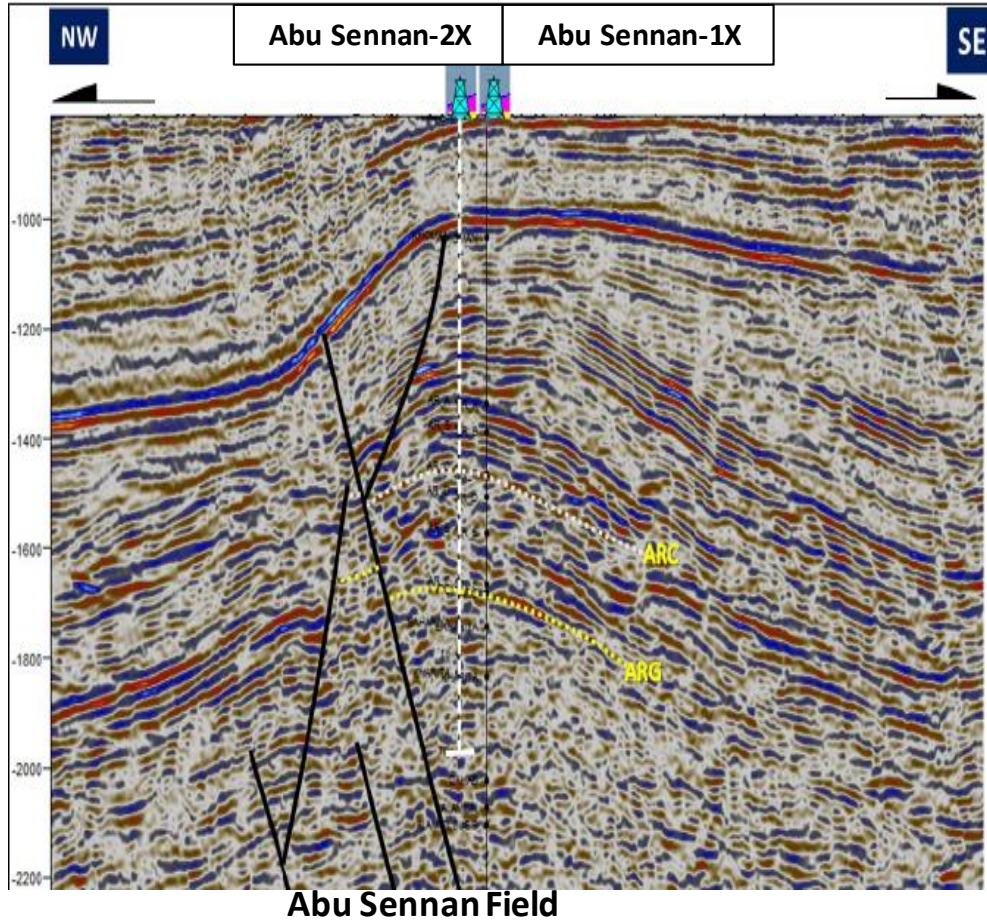


Abu Sennan Structure



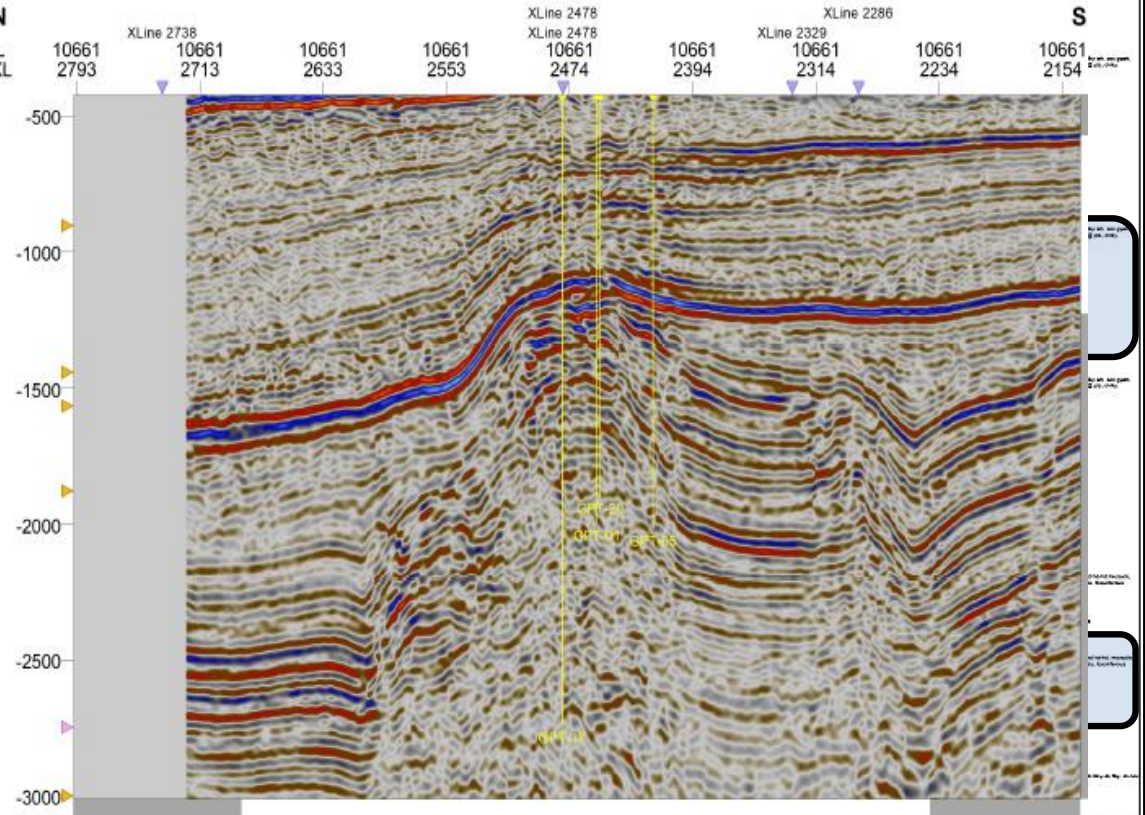
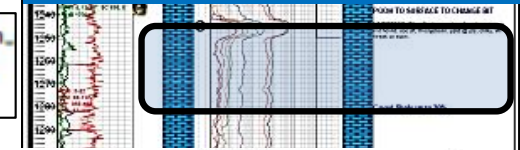


Khoman Potential



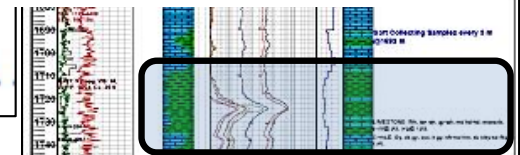
LIMESTONE: Wh, off wh, snw wh, milky wh, ooc gywh, md hd-hd, ooc sft, fn-cryptoxin, pstd @ pts, chiky, W/ Weak oil stain.

Abu Sennan-2X



GPT

LIMESTONE: Wh, off wh, snw wh, milky wh, ooc gywh, md hd-hd, ooc sft, fn-cryptoxin, pstd @ pts, arg @ r.pts.
SHALE: Gy, dk gy, ooc. lt gy, sft-md frm, sb blk-y-sb flky, calc.

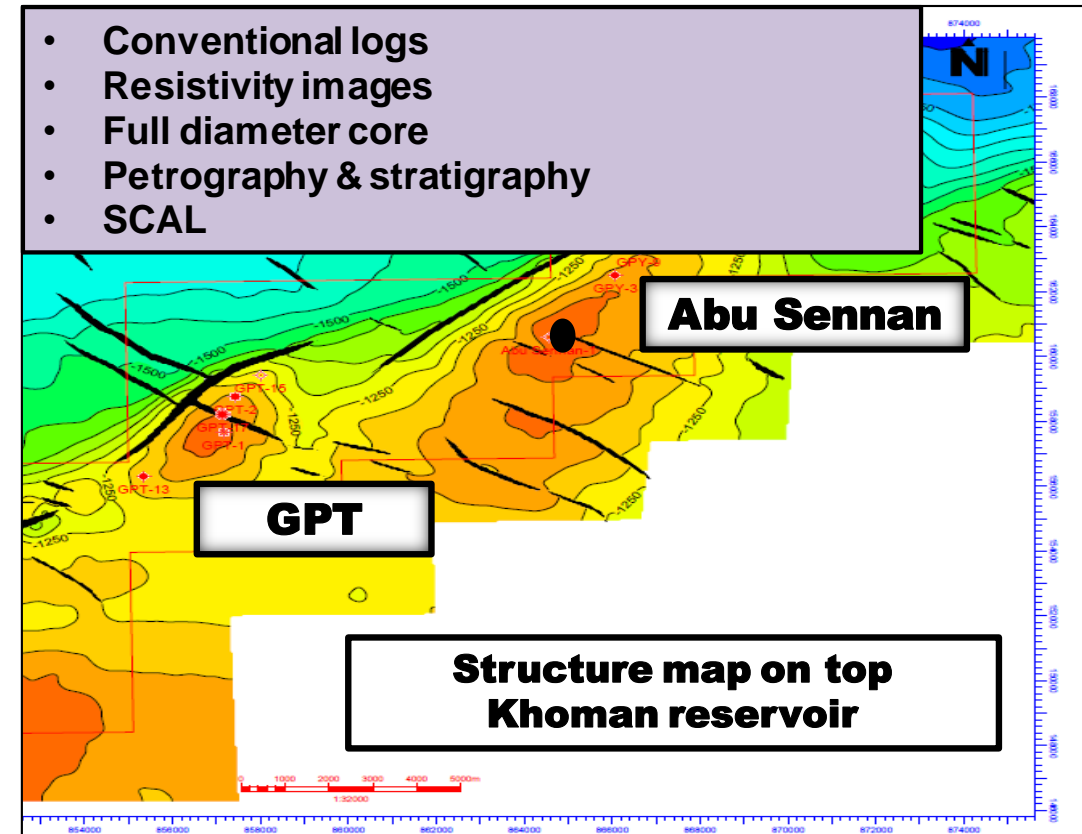
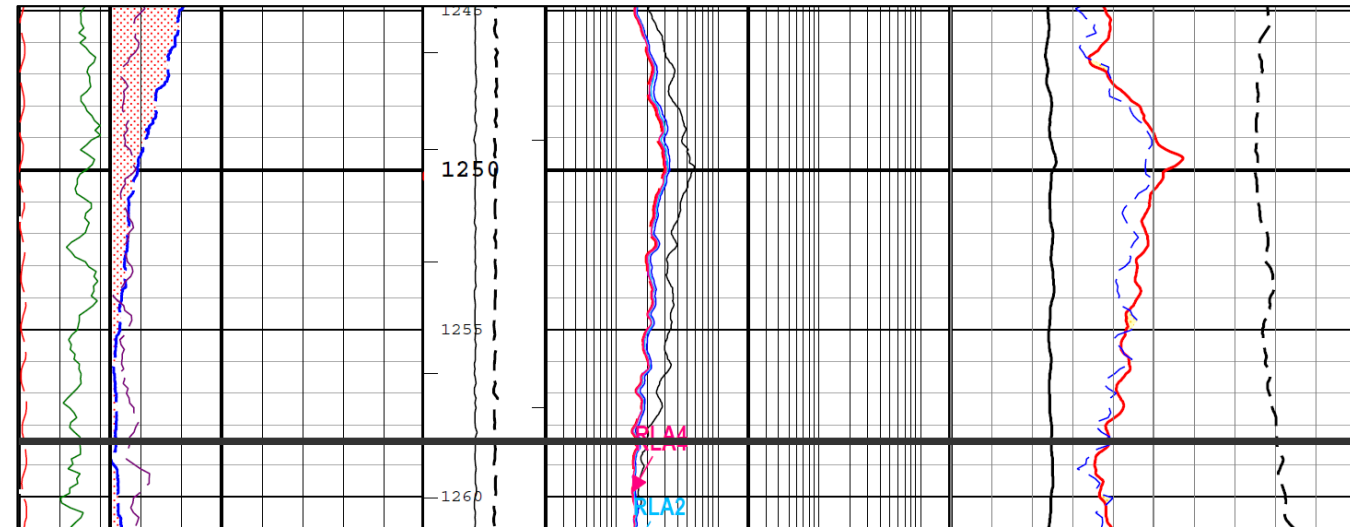
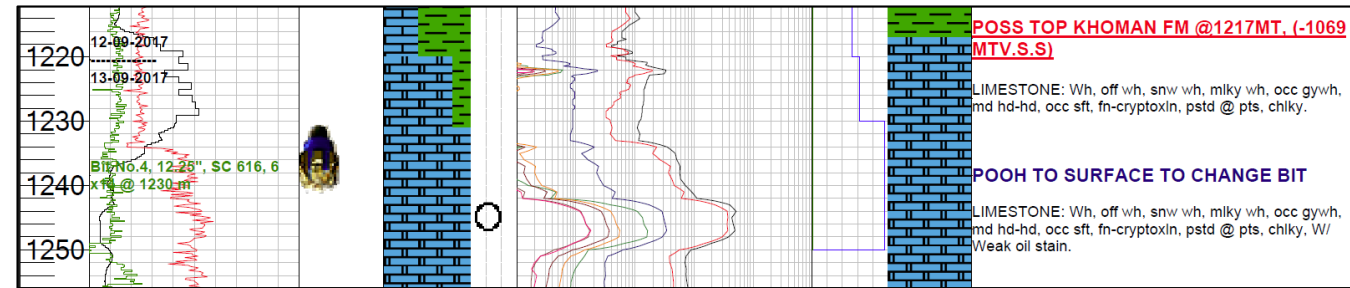




Khoman Development Plan



- Appraising the pop-up structure of Abu Sennan field.
- Testing well Abu Sennan-2 through Khoman reservoir
- Planning to drill a new appraisal well to confirm the reservoir extension & HIIIP.

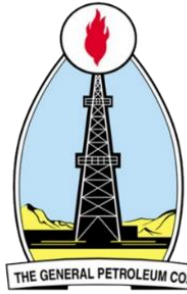




Conclusions & Recommendations



- Integrated evaluation of GPT field proved different perspectives for Khoman Formation as good reservoir and showed GPC's success story.
- Khoman potential is related to pop-up structures with high seismic amplitude and diagenesis features of the reservoir .
- It should be taken into consideration for the future development plan of Western Desert province because of its promising production performance.
- Barefoot completion associated with nitrified or foamed HCl acid treatment is expected to improve the productivity of Khoman reservoir.



Thank You & Questions

