Characterization of Primary Seals in Tuba Reservoir in Sabiriyah Field, North Kuwait*

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Abstract

The Tuba unit is part of the Middle Cretaceous Ahmadi Formation of Onshore Kuwait. It is a well-developed limestone reservoir with an Ahmadi Shale layer residing on the top as a regional seal. The Tuba Limestone has been divided into three units as Upper, Middle and Lower Tuba based on the sedimentological characteristics and the reservoir rock properties. The Formation was deposited in marine environments during the Late Albian-Early Cenomanian. Its thickness increases up to 400 feet towards the northeast.

The Lower Tuba unit consists of several transgressive-regressive cycles. It comprises the most variation in lithofacies compared to the other Tuba units. Argillaceous mudstone and wackstones dominate at the lower section and gradually merge into the Wara Shale Formation. Towards the upper section, it has much cleaner lithofacies consisting of pack-grainstones and grainstones with well-developed porosity and permeability for hydrocarbon bearing. The Middle Tuba unit was deposited in very low energy environments. It is represented mostly by argillaceous-rich lithofacies with poor reservoir quality. Normally, this unit is treated as a barrier between the Upper Tuba and Lower Tuba. The Upper Tuba unit of most wells drilled in the northern area has the best reservoir quality. It also has variable argillaceous content along with dominant wackstones and packstones.

The interpretation of seals for Tuba is reviewed in this article in terms of the integrated study of sedimentology, petrography, wells correlation, log data, RFT/Sampling, and cores (RCA and SCAL). The static and dynamic reservoir models recently built are also included to improve and assist analysis. The seals are identified in three categories: (1) Primary shale seals bounded at the top and bottom of Tuba through the entire field with extreme low permeability. (2) Shale seals which are mudstone-dominated with high argillaceous contents, recognizable in the Middle Tuba unit. (3) Localized diagenetic seals which were formed by subsequent diagenetic effects, specifically dissolution of matrix and calcite cementation resulting in reducing porosity and permeability. Some sealed faults have been interpreted as part of the structural seals which stop the hydrocarbon migration laterally.

Selected References

EI-Aziz, Sabry Abd, William Bryan, C. Vemparala, and S. Al-Rasheedi, 2014, Reservoir Characterization And 3D Static Model in Tight Carbonate, Open Up Reserves, Tuba Reservoir, Sabiriyah Field, North Kuwait: EAGE, 13IPTC-P-774-IPTC. Website accessed February 6, 2019.
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Salman Zaidi, and Ali Nasar Khan, 2009, Sequence Stratigraphy and Reservoir Architecture of Tuba in Sabriyah Field, North Kuwait: IPTC-13947-MS, Presented at International Petroleum Technology Conference, Doha, Qatar, December 7-9.

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Outline

- **Acknowledgments**
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  - Stratigraphy Section of Tuba
  - Sedimentological descriptions
- **Tuba Lithofacies**
- **Definition of Tuba Seals**
  - Correlation
  - Primary seals from shale layers
  - Middle Tuba mudstone seal
  - Other seals
- **Tuba Formation Fluid Properties and Reservoir Pressure**
- **Summary and conclusions**

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Acknowledgments

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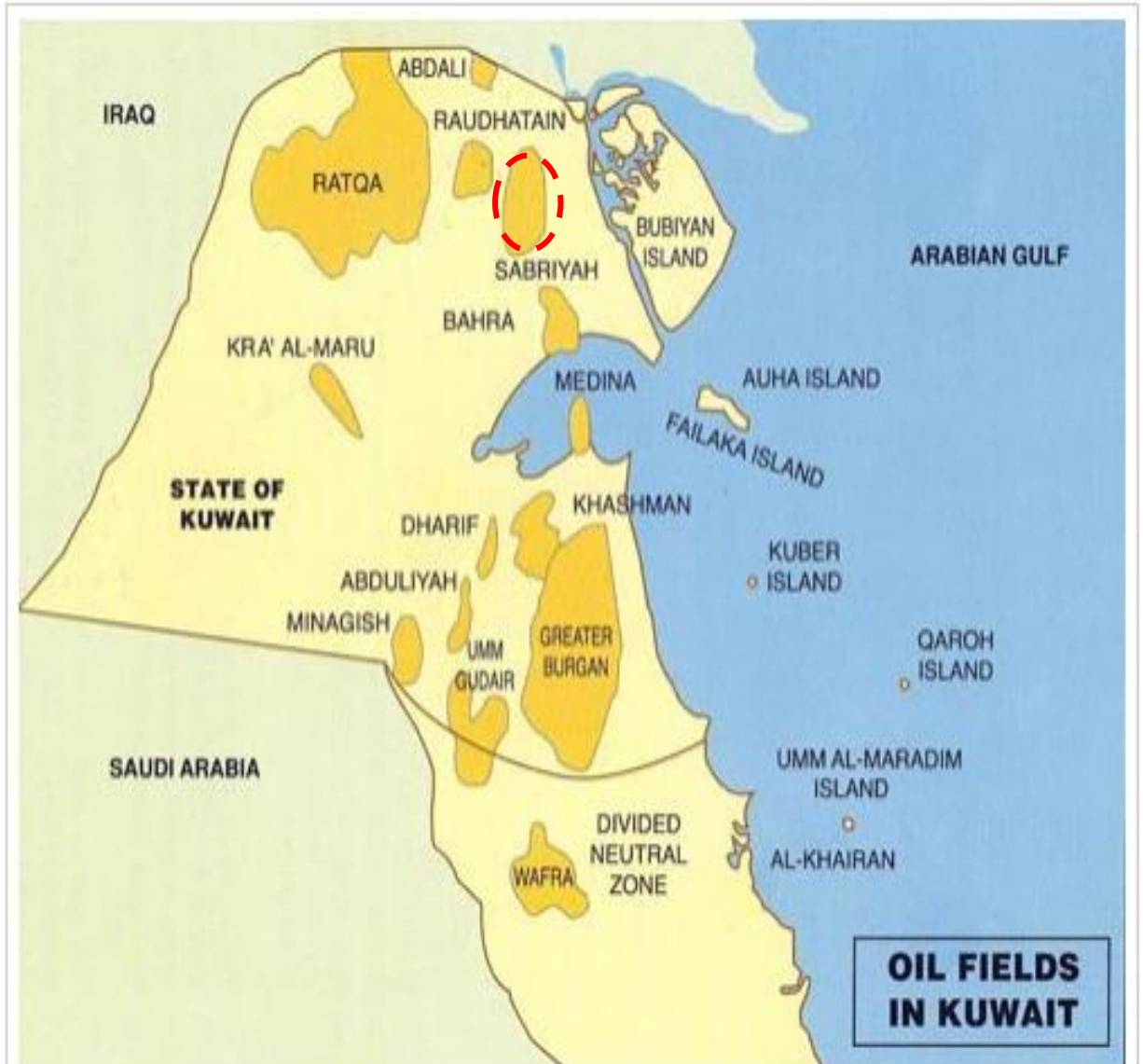
Also thanks to the colleagues for all supports through the study.

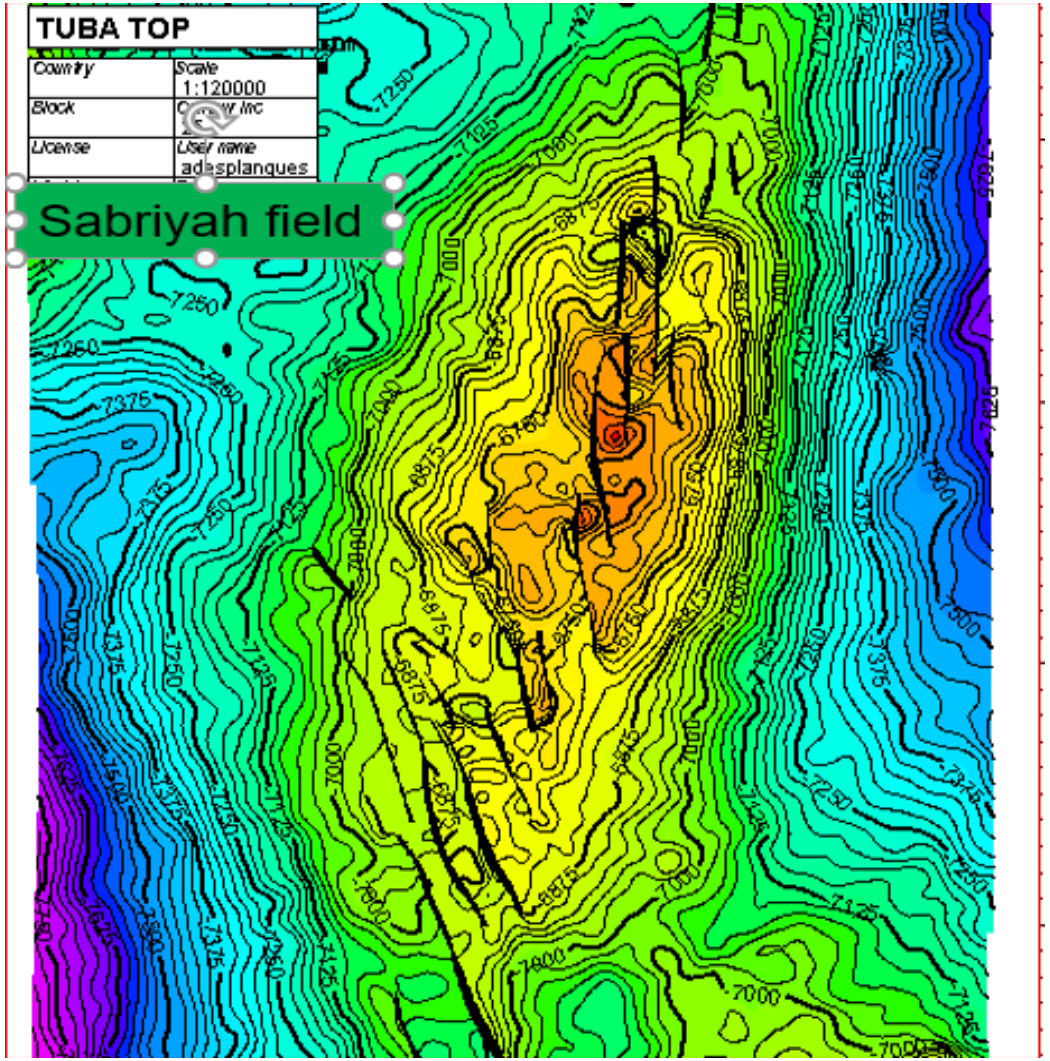
Introduction of Tuba Formation in Sabriyah Field, North Kuwait

Sabriyah Field was discovered in 1957



Introduction of Tuba Formation in Sabriyah Field, North Kuwait

- Tuba is well developed carbonate reservoir.
- Its thickness varies from 300ft up to 480ft towards north.
- It was deposited in a carbonate ramp.
- In pay zones, PHIE: 10-17% . PERM: 10-50mD.
- Zones of interest: Upper Tuba and Middle Tuba.

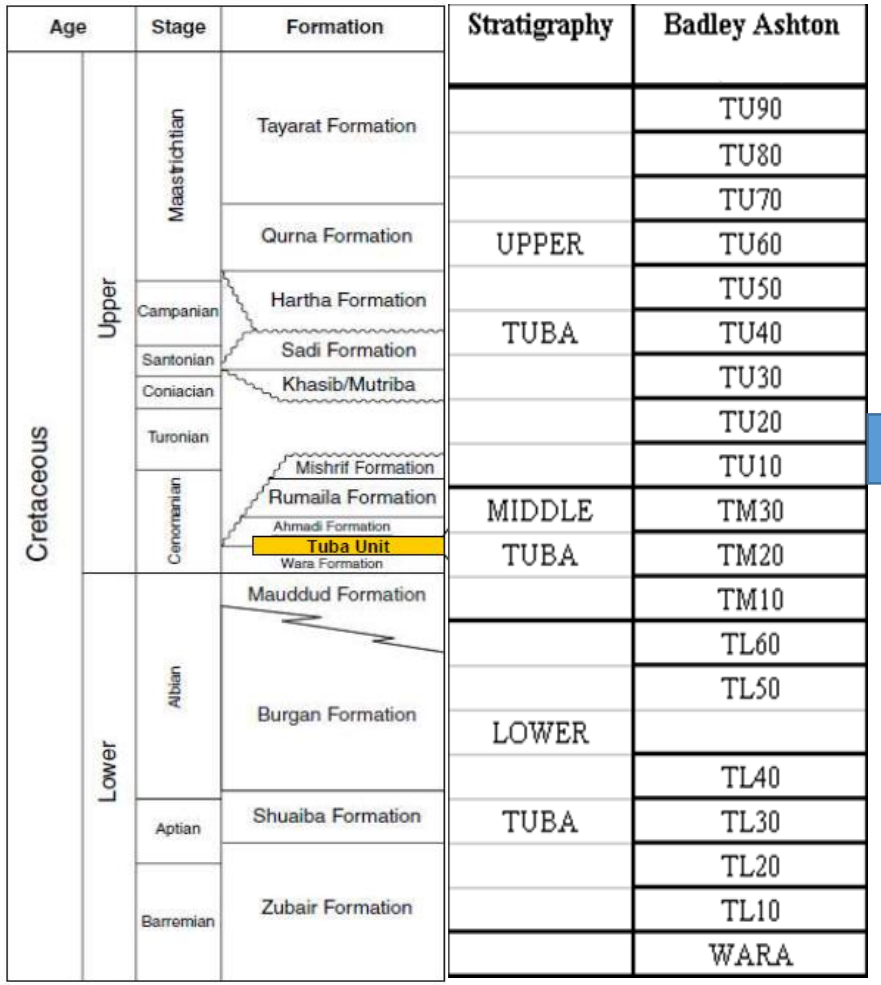


Sequence Stratigraphy and Reservoir Layering

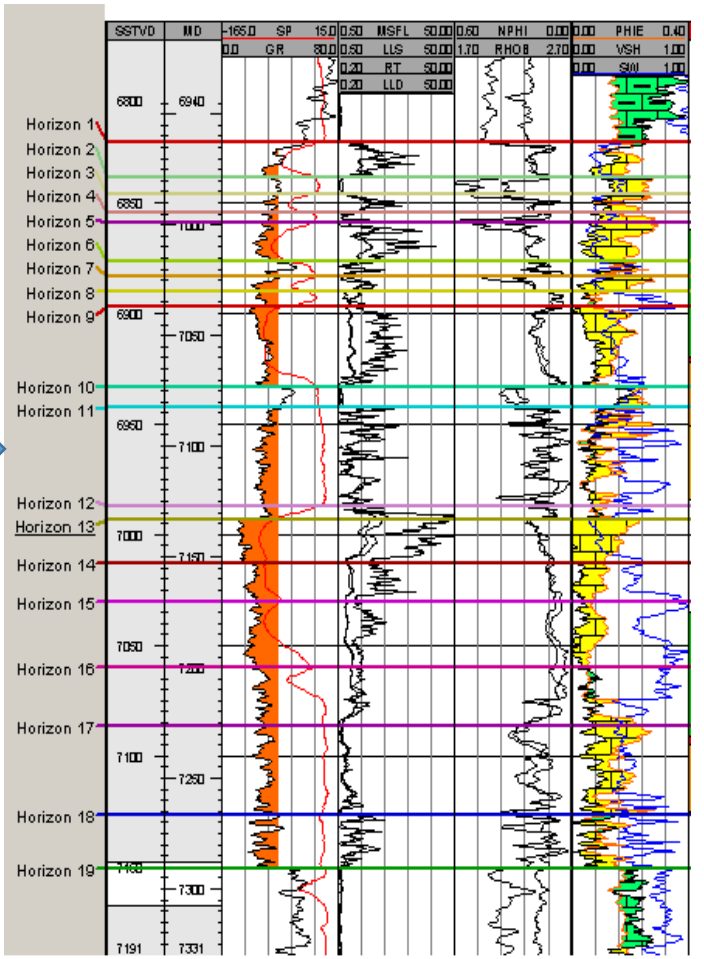
Upper Tuba: comprises highstand and transgressive systems tracts dominated by deep-mid to outer ramp and basin sediments

Middle Tuba: transgressive system track of outer ramp/basin carbonate

Lower Tuba: highstand systems track, cleaning upwards, carbonate ramp sequence

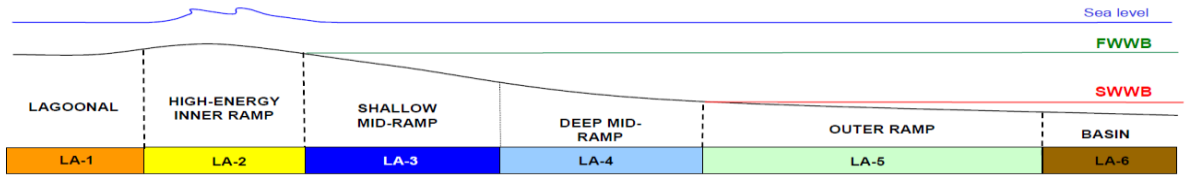


Stratigraphy	Badley Ashton
	TU90
	TU80
	TU70
UPPER	TU60
	TU50
TUBA	TU40
	TU30
	TU20
	TU10
MIDDLE	TM30
TUBA	TM20
	TM10
	TL60
	TL50
LOWER	
	TL40
TUBA	TL30
	TL20
	TL10
	WARA

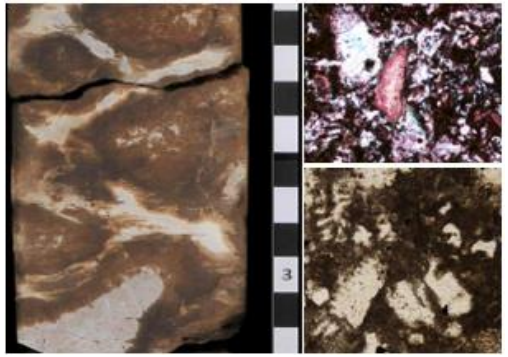


Sedimentological Descriptions For Tuba Units By Textural Lithofacies Scheme

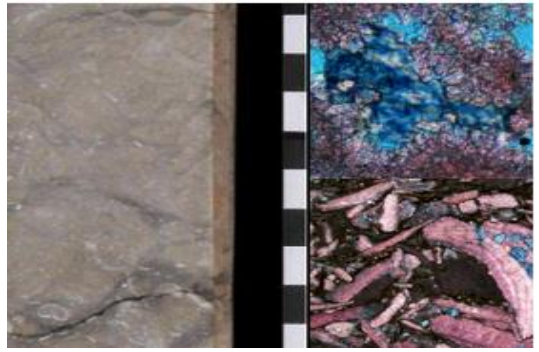
The lithofacies in Tuba are grouped in to lithofacies associations based on the depositional texture and skeletal assemblage:



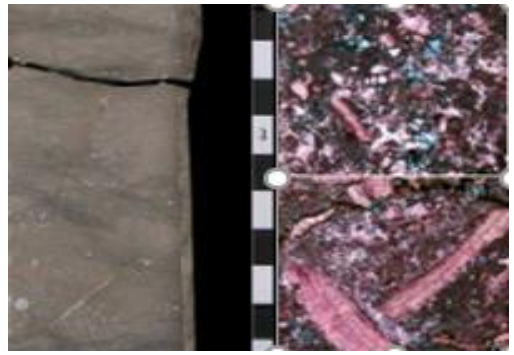
1. Lagoonal



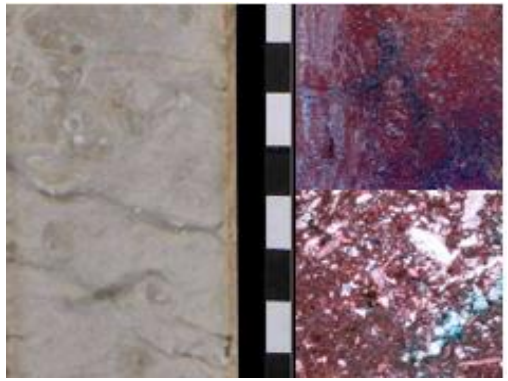
2. High-energy, inner ramp



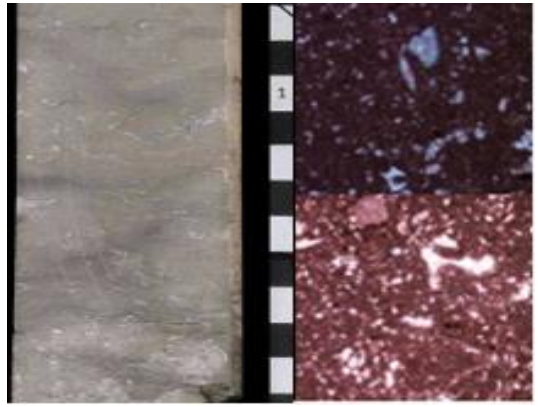
3. Shallow mid-ramp



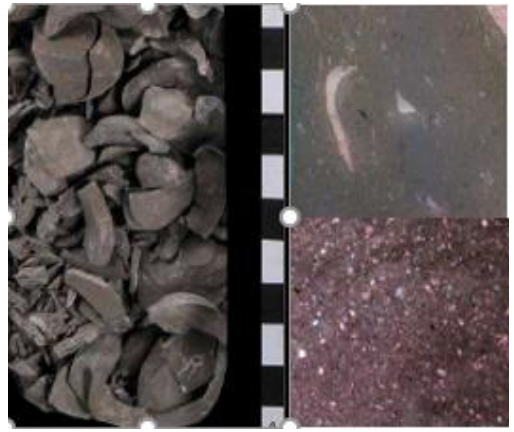
4. Deep mid-ramp



5. Outer ramp



6. Basinal



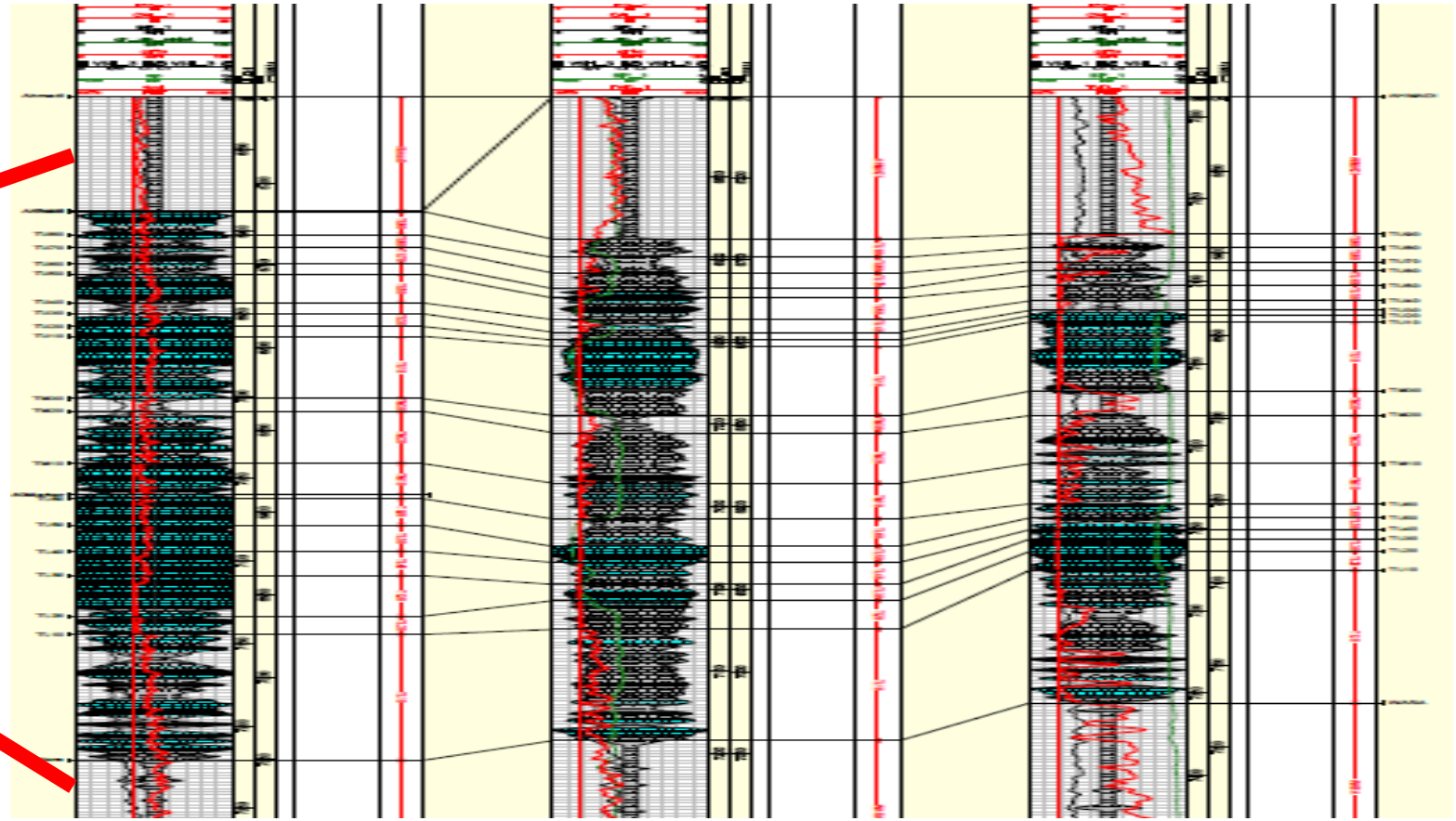
Characterization of Primary Seals in Tuba Correlations

North

South

Ahmadi shale formation above the Tuba unit is more than 130ft, working as a regional seal field wide.

Wara shale connect to the basinal of Lower Tuba

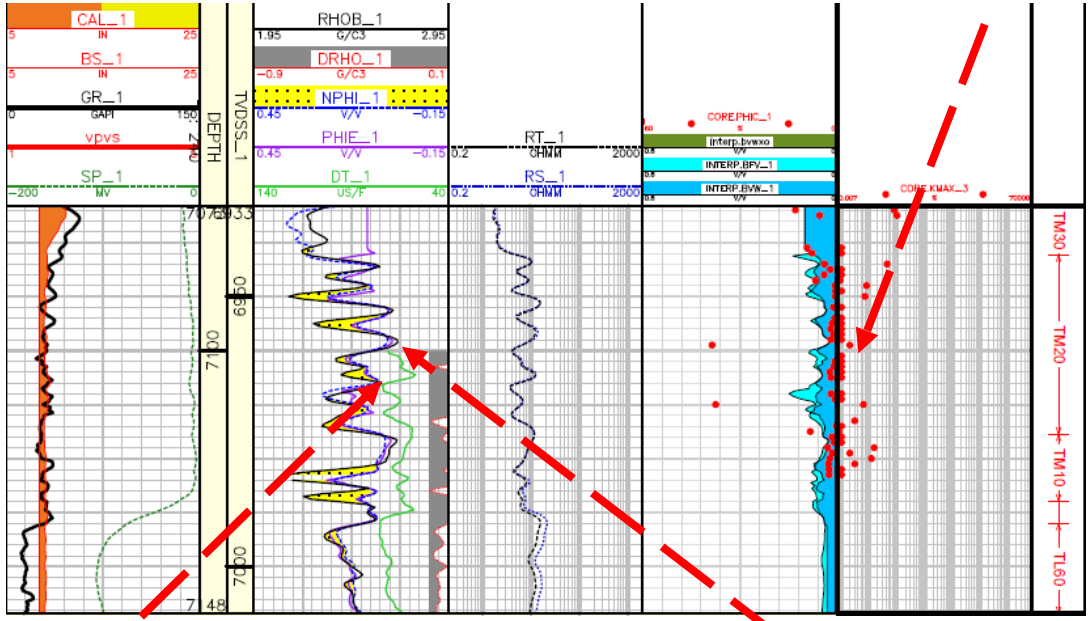


The correlation panels for Tuba unit through Sabiriyah Field show overall consistent open hole log response in multiple wells. There is an general thickening trend towards the northern part of the field.

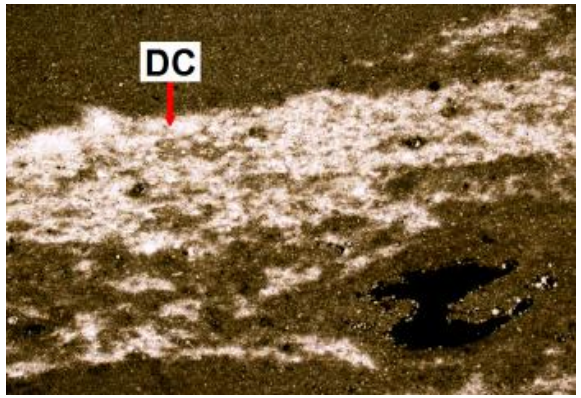
Mudstone Seals in Middle Tuba

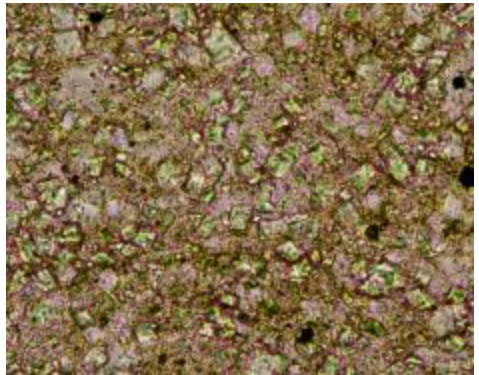
Middle Tuba unit is a Barrier between Upper Tuba and Lower Tuba with extremely low permeability(less than 0.1mD in average). It is mainly a dolomitized, Argillaceous-rich, bioturbated mudstone with a pseudo lamination.

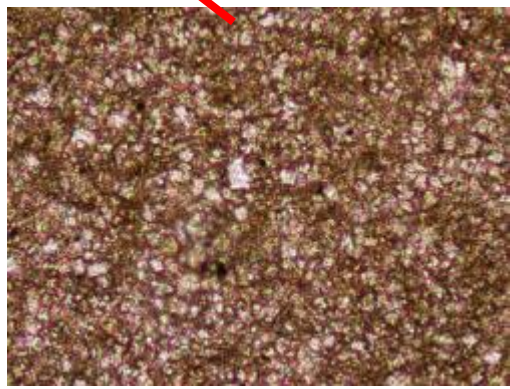
Core Perm



Thin-section scan from upper section of Middle Tube

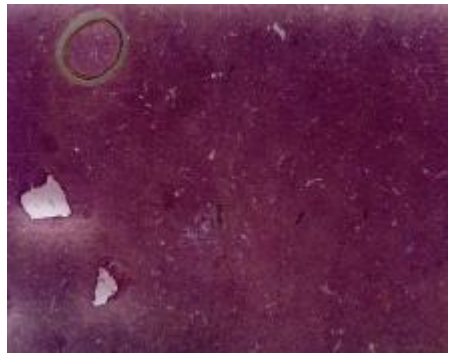


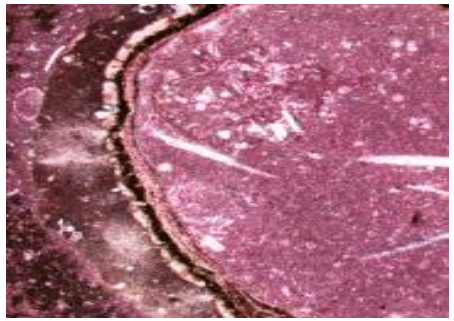


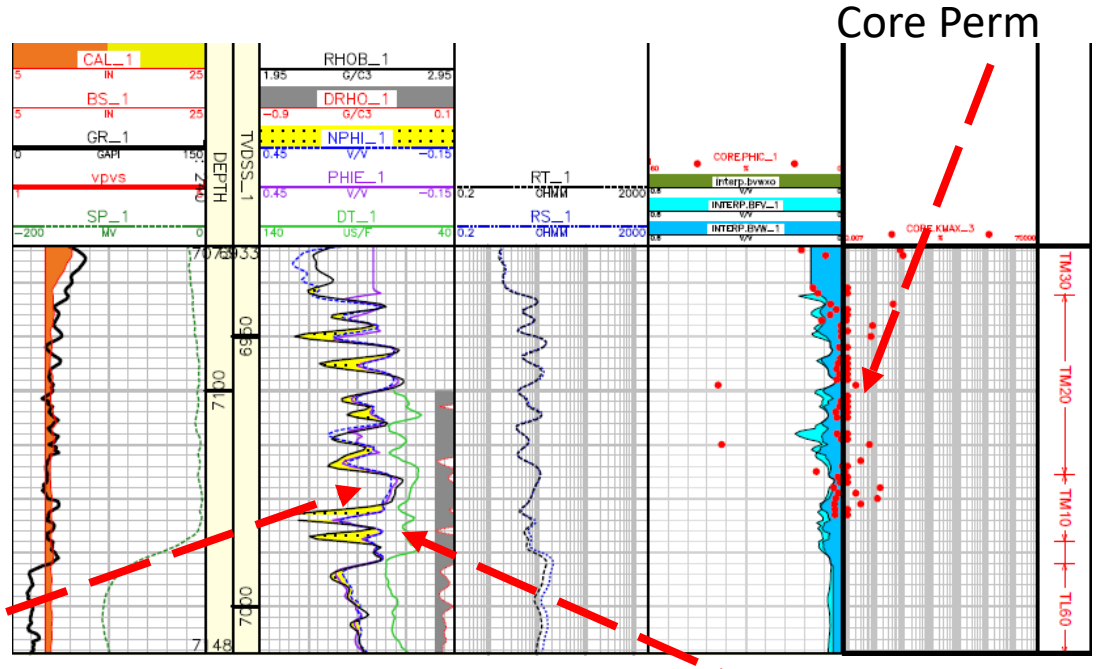


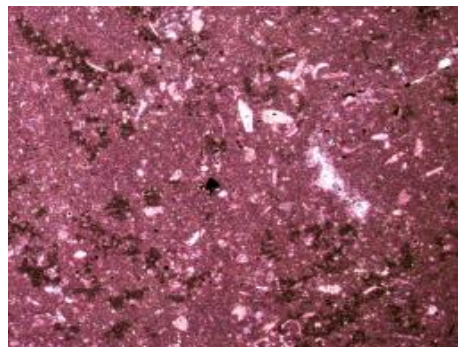
Mudstone Seals in Middle Tuba

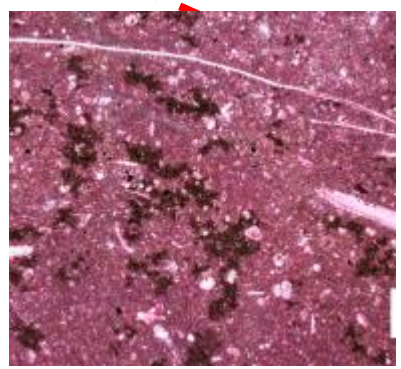
This is another thin-section of the core sample from TM10 which is the lower layer in Middle Tuba.
The sample is an argillaceous, skeletal-rich wacke-packstone , comprising abundant planktonic foraminifera , common echinoid and bivalve fragments, ostracods, minor benthic foraminifera, rare serpulids, and very rare, possible algal fragment within a largely non-porous micritic matrix with localised argillaceous-rich patches.
The lack of porosity make it possible to provide seal for Lower Tuba unit.





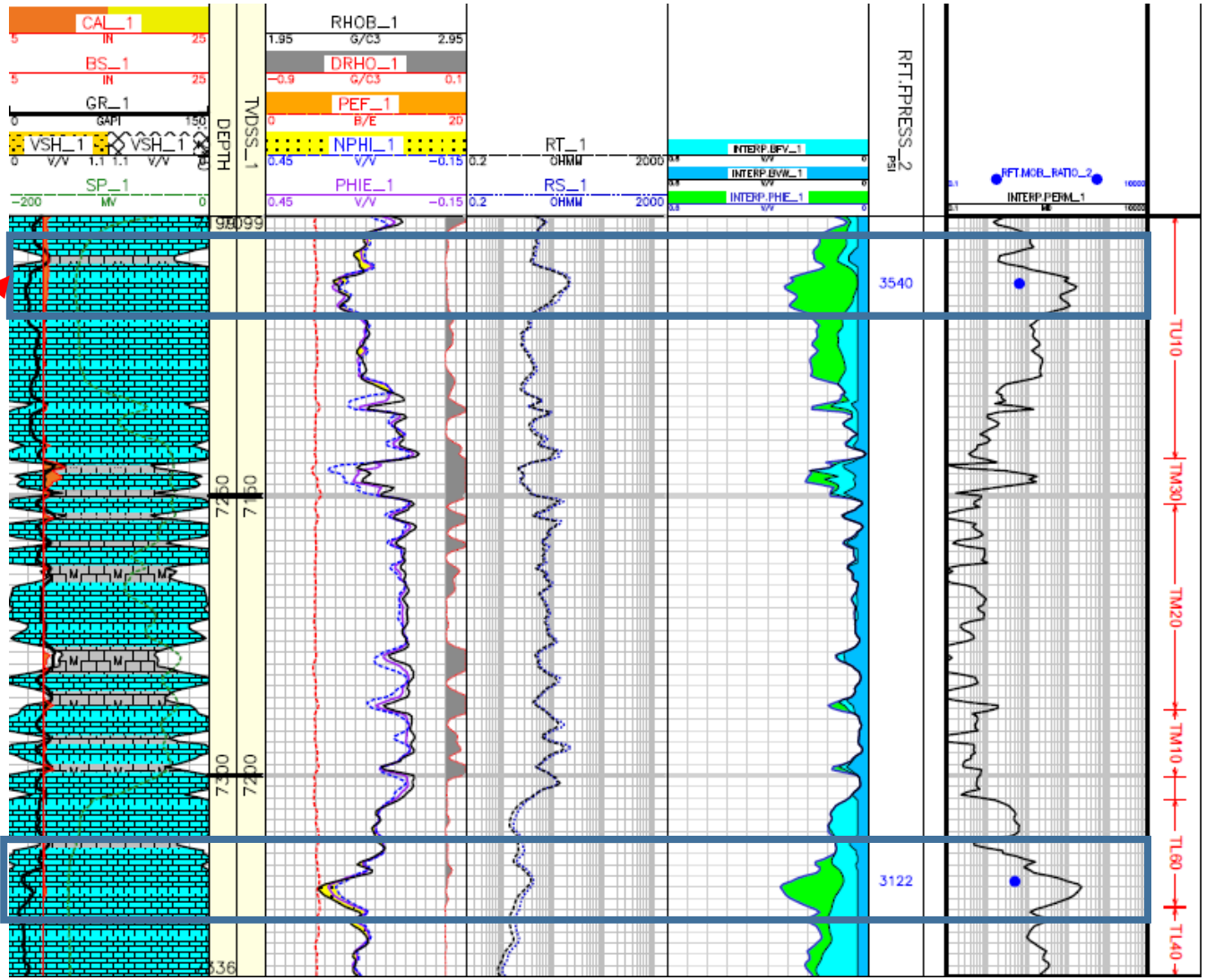






Mudstone Seals in Middle Tuba

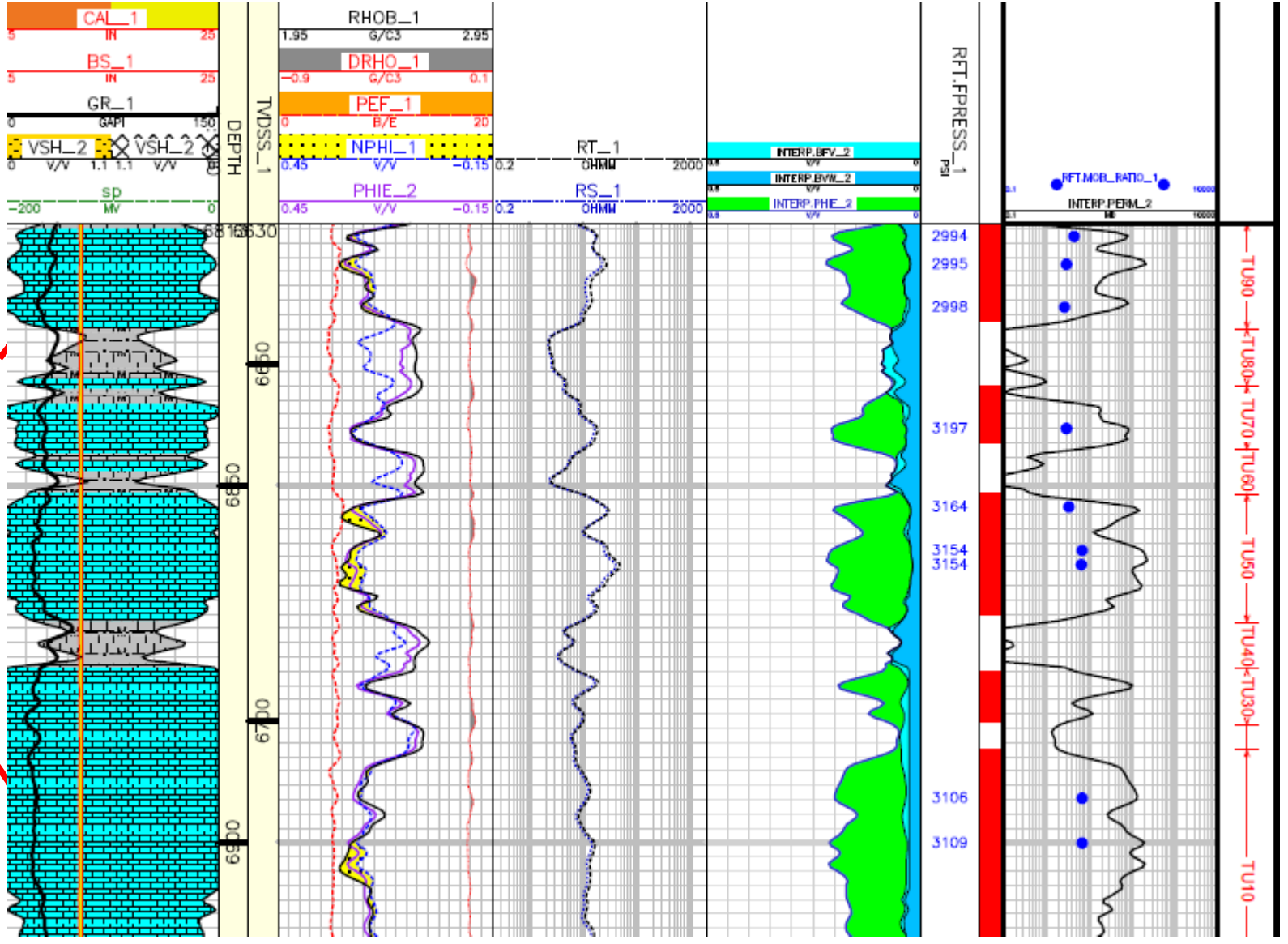
Layers with different pressures



Impermeable Middle Tuba Unit

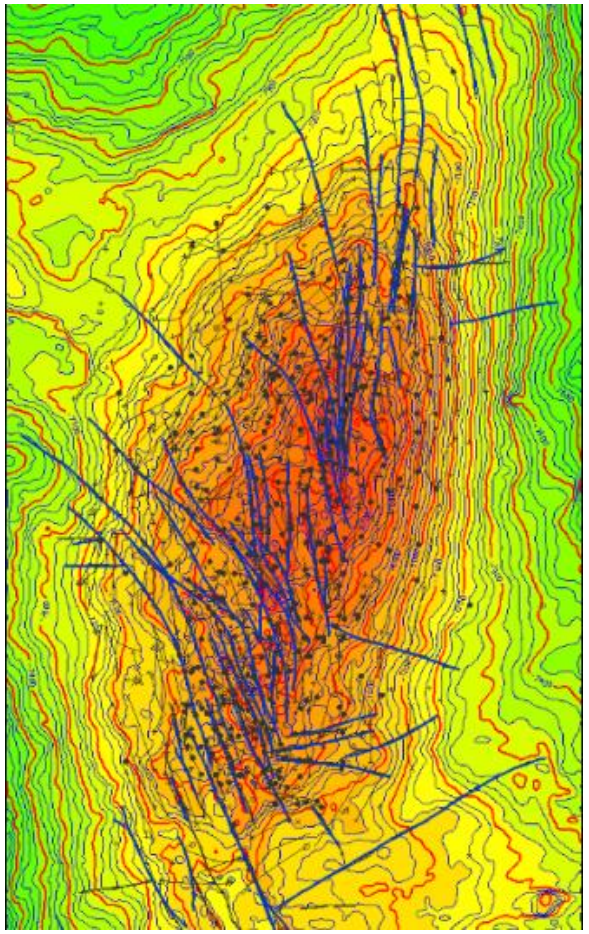
Diagenetic Seals Between Sub-layers within Upper Tube and Lower Tuba

Layers with different pressures



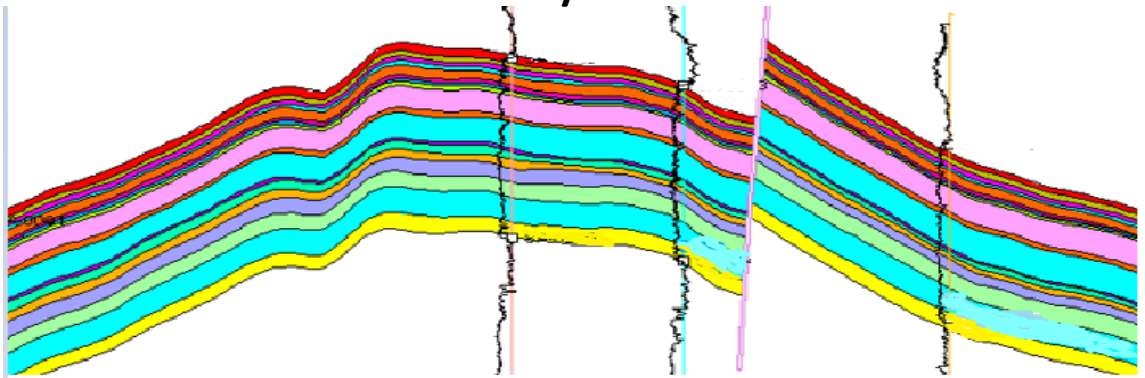
Impermeable Layers,Tu80,Tu 60, and Tu40

Characterization of Seals in Tuba Reservoir in Sabiriyah Field, North Kuwait

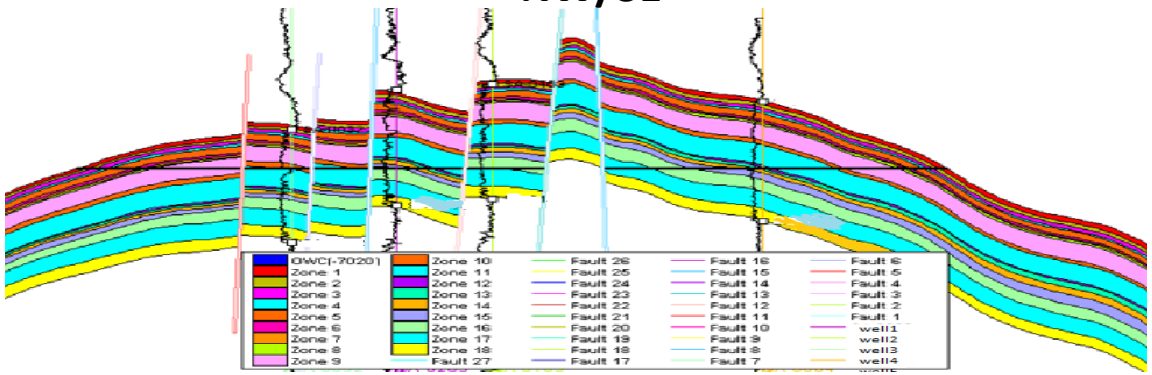


Faults at Tuba top

W/E

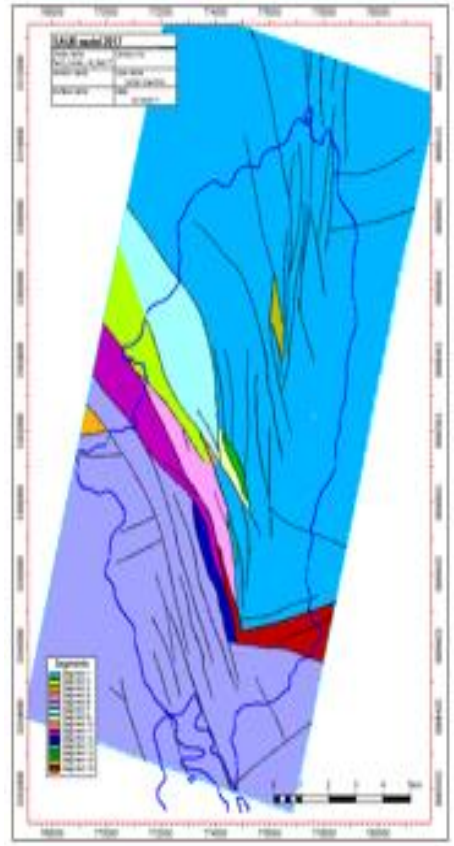


NW/SE



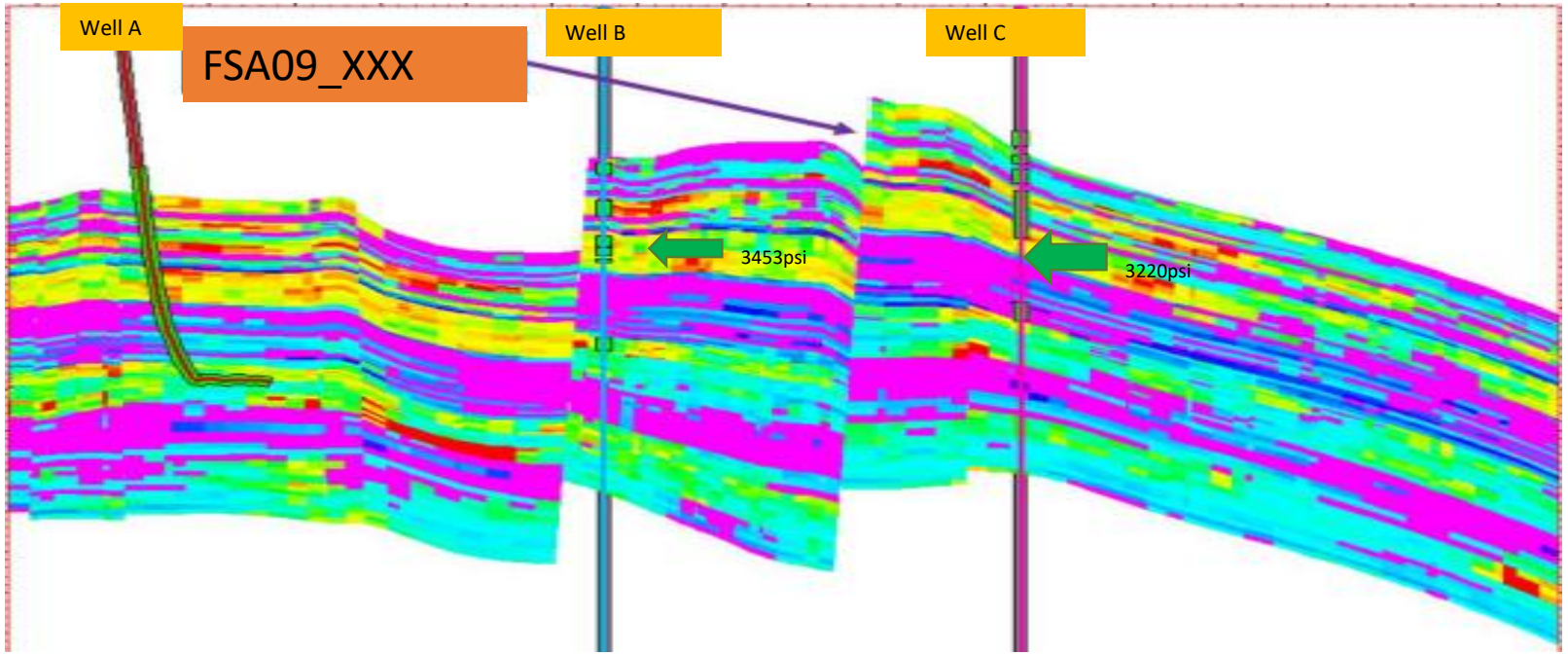
Some sealed faults have been interpreted at N/S direction based on the pressure and fluid samples area analysis.

Sabiriyah



Characterization of Seals in Tuba Reservoir in Sabiriyah Field, North Kuwait

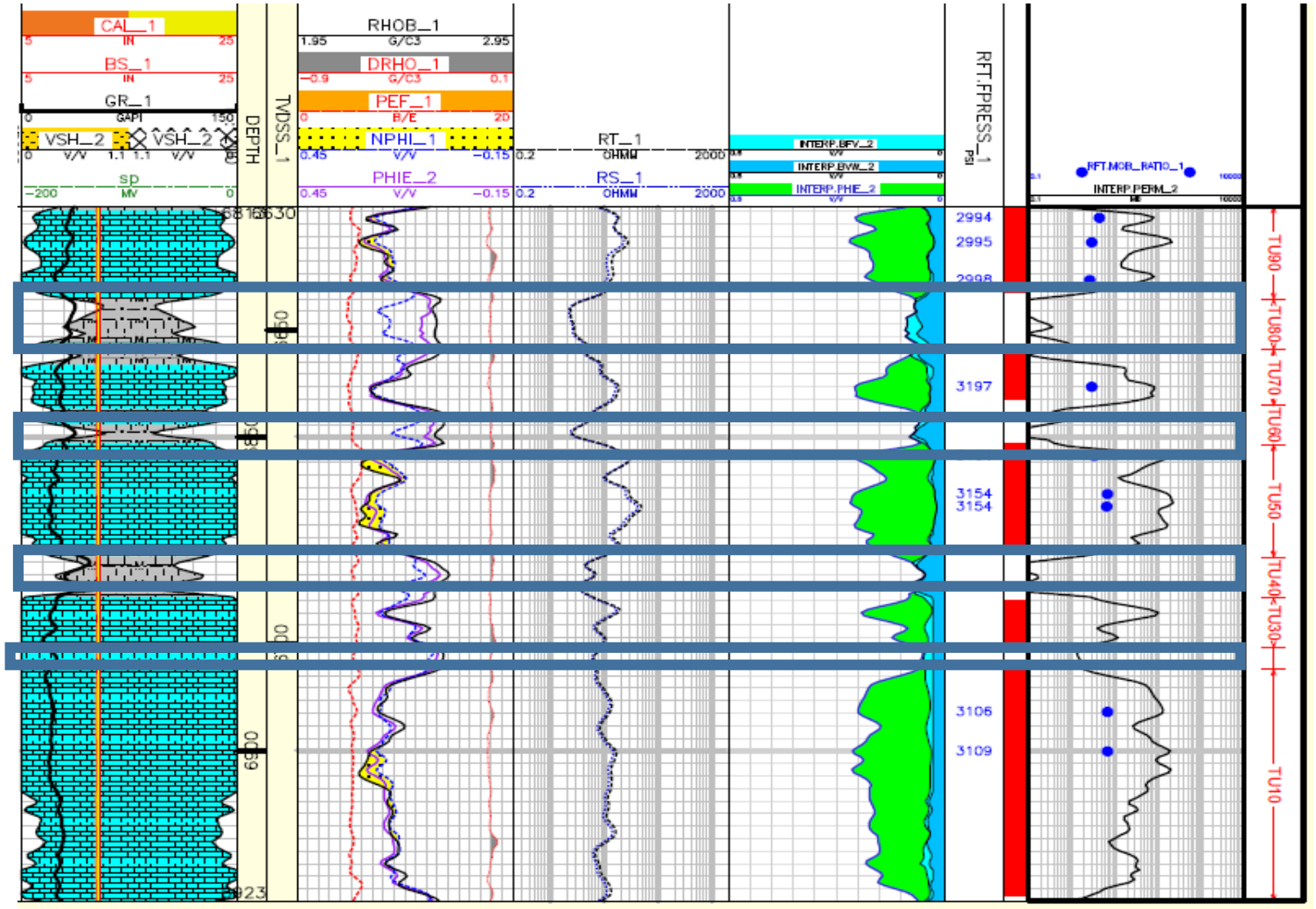
Sabiriyah



Well B and Well C both produce from the Upper Tuba unit with different reservoir pressure. the Fault in between is interpreted as a sealed fault.

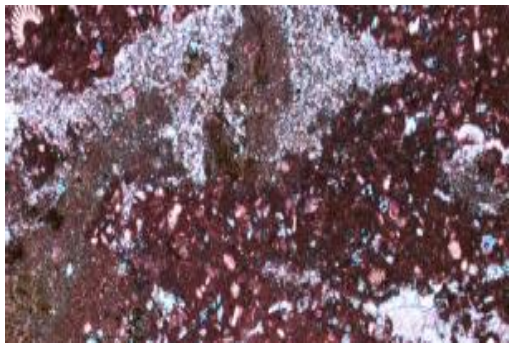
Characterization of Seals in Tuba Reservoir in Sabiriyah Field, North Kuwait

Due to the diagenetic processing, rock properties of some sub-layers in the Tuba unit have changed



Seals between Tuba sub-layers

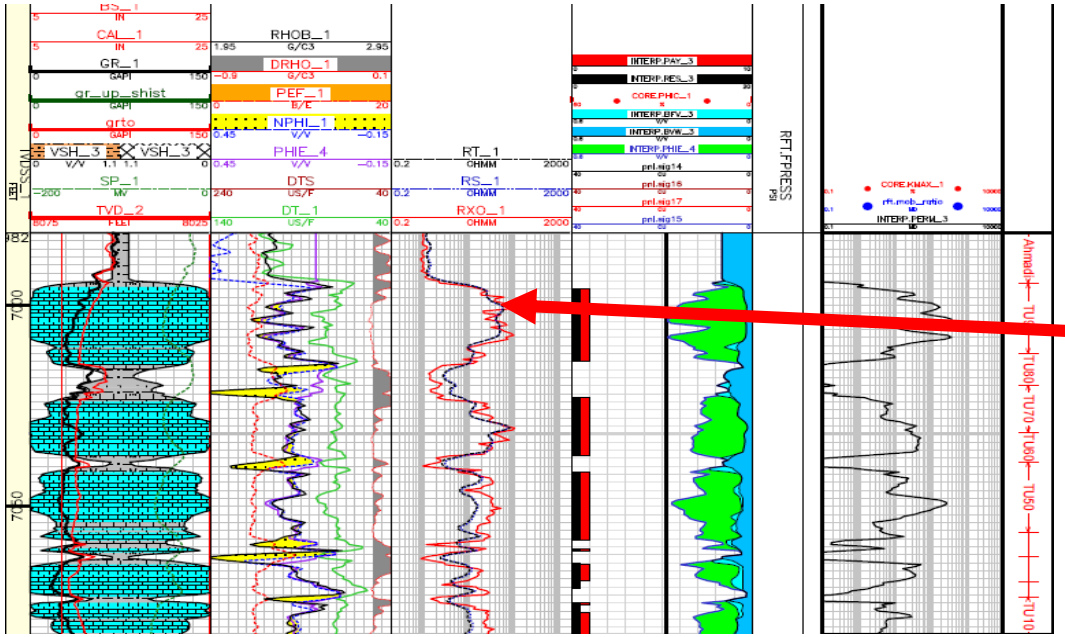
TU80,TU60,TU40 and TU20 are represented by localized argillaceous, bioturbated and skeletal wacke-packstone with an abundant, non-porous micritic matrix.

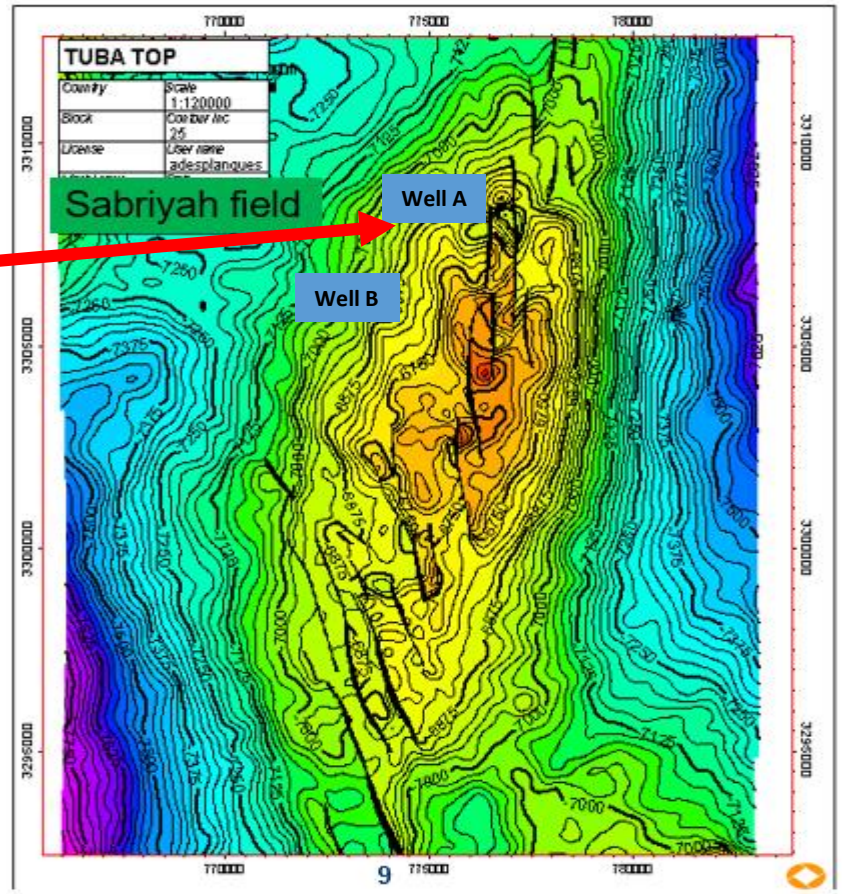


Characterization of Seals in Tuba Reservoir in Sabiriyah Field, North Kuwait

Tar has been identified from cores of well A and well B which are close to the flank. Movable oil is found at the layers below the Tar zones and above OWC

The presence of Tar layers reduce the permeability of reservoirs and become part of seals.





Characterization of Primary Seals in Tuba Reservoir in Sabiriyah Field, North Kuwait

Summary

The seals in Tuba reservoir are identified as

1. Primary shale seals bounded to the top and bottom of Tuba formation through entire field with extreme low permeability.

2. Shale seals which are mudstone dominated with highest argillaceous contents, well recognizable in Middle Tuba unit.

3. Other seals

- Impermeable sub-layers formed due to the digenetic events/phases.
- Sealed faults.
- Existing of the Tar layers.

Characterization of Primary Seals in Tuba Reservoir in Sabiriyah Field, North Kuwait

Challenges and opportunities

Improving the reservoir performance by Acid Frac

It is a common practice to apply acid frac to the tight carbonate reservoirs. Muti-stage frac could be used to avoid the impermeable layers.

Horizontal or high angle wells option

Increasing reservoir contact by drilling more high angle wells.
It has been applied to other carbonate reservoirs in Sabiriyah Field.

Optimized injection plan is required

The pressure sink in the north field can be managed by water injection. Detailed reservoir study is required to support injection performance.

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Second EAGE/AAPG Hydrocarbon Seals of the Middle East Workshop
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