

Facies, Petrography, Geochemistry and Reservoir Potential of the Upper Cretaceous Adaffa Formation, Red Sea Region, Saudi Arabia*

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Abstract

The Upper Cretaceous Adaffa Formation is the oldest sedimentary rock under the Suqah Group in the Red Sea Region of Saudi Arabia, and considered one of the target reservoirs in the subsurface. This Formation is nonconformably overlying by Proterozoic Basement and unconformably underlying by Usfan Formation in the subsurface at Jeddah. The outcrop distribution of the Adaffa Formation is poorly known, but seen at Midyan and Wadi Azlam Basin along the Red Sea coast. This work conducts an outcrop based study of the formation in the Midyan region, integrating field sedimentological investigation, thin section petrography, X-ray powder diffraction (XRD), X-ray fluorescence (XRF) and Scanning Electron Microscope (SEM) methods. The study aimed at understanding reservoir properties and potential of the Adaffa Formation.

Lithofacies comprise several meters of stacked (1) alluvial fan deposits with pebbly to coarse sand, (2) fluvial deposits of fine- to medium-grained cross bedded sandstone interbedded with thin shale and siltstone, and (3) shallow marine mixed siliciclastic and bioclastic carbonate deposits. The sandstones are medium- to coarse-grained, subrounded to rounded, well-sorted and somewhat fossiliferous. The carbonates contain ooids, peloids, bivalves, gastropods, brachiopods, foraminifera, other fossils and mineral grains. The carbonates are classified as packstone and grainstone with a little wackestone. Mineralogically, the carbonates are dominated by calcite, dolomite and aragonite, whereas sandstones are dominated by quartz with subordinate feldspar and mica. Post depositional diagenetic features such as grain alterations and dissolutions are also observed. The visual porosity is assessed as 15% to 20% with secondary porosity at higher percentages. The major elements encountered are Ca (44.82-89.33%), Si (1-41%), Mg (1-18%), S (1-10%), Fe (1-5%), Al (1-5%), Mn (1-2%), K (0-2%), Na (1%), and trace elements Ba, La, Ni, Co, Rb, U, Pb, Zn, Cu and Ti as less than 1%. The major oxide found is CaO (31% to 84%), along with SiO₂, MgO, SO₃, Al₂O₃, Fe₂O₃ and MnO as higher than 1%. Others such as Na₂O, P₂O₅, ZnO, BaO, La₂O₃, TiO₂, etc. are less than 1%. The diagenetic grain dissolutions might have played an important factor for enhancing porosity and reservoir potential. This outcrop analogue study helps provide understanding of reservoir heterogeneity and potential of the Adaffa Formation, and also may help provide new insight for prediction and guidance for minimizing exploration challenges.

References Cited

- Folk, R.L., 1980, Petrology of Sedimentary Rocks: The University of Texas at Austin, Texas Scholar Works, 190 p. Website accessed June 18, 2020.
<https://repositories.lib.utexas.edu/handle/2152/22930>
- Hughes, G.W.A.G., and R.S. Johnson, 2005, Lithostratigraphy of the Red Sea region: GeoArabia, v. 10/3, p. 49-126.
- Hughes, G.W., D.J. Grainger, A.J. Abu-Bshait, and M.J. Abdu-Rahman, 1999, Lithostratigraphy and depositional history of part of the Midyan region, northwestern Saudi Arabia: GeoArabia, v. 4/4, p. 503-542.
- Laboun, A.A., 2012, Did glaciers exist during Pleistocene in the Midyan region, northwest corner of the Arabian Peninsula?: Arabian Journal of Geosciences, v. 5/6, p. 1333-1339.
- Ziegler, M.A., 2001, Late Permian to Holocene paleofacies evolution of the Arabian Plate and its hydrocarbon occurrences: GeoArabia, v. 6, p. 445-504.



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KFUPM, Dhahran, Saudi Arabia.**

Date: November 2, 2019



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Outline

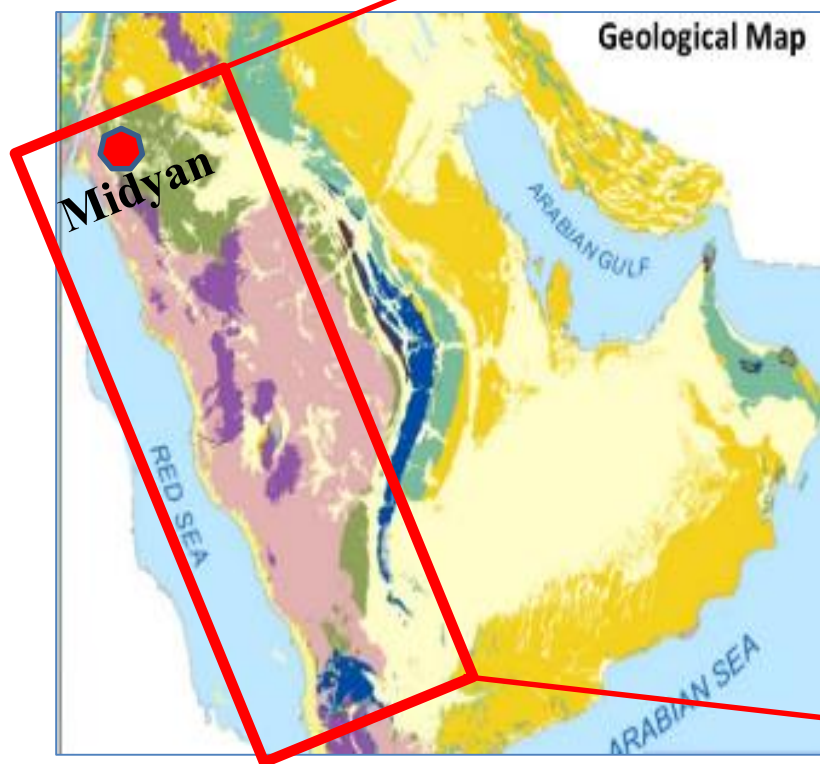
- **Introduction**
- **Geologic Setting**
- **Facies and Depositional Model**
- **Petrography**
- **Geochemistry**
- **Reservoir Potentiality**
- **Conclusion**



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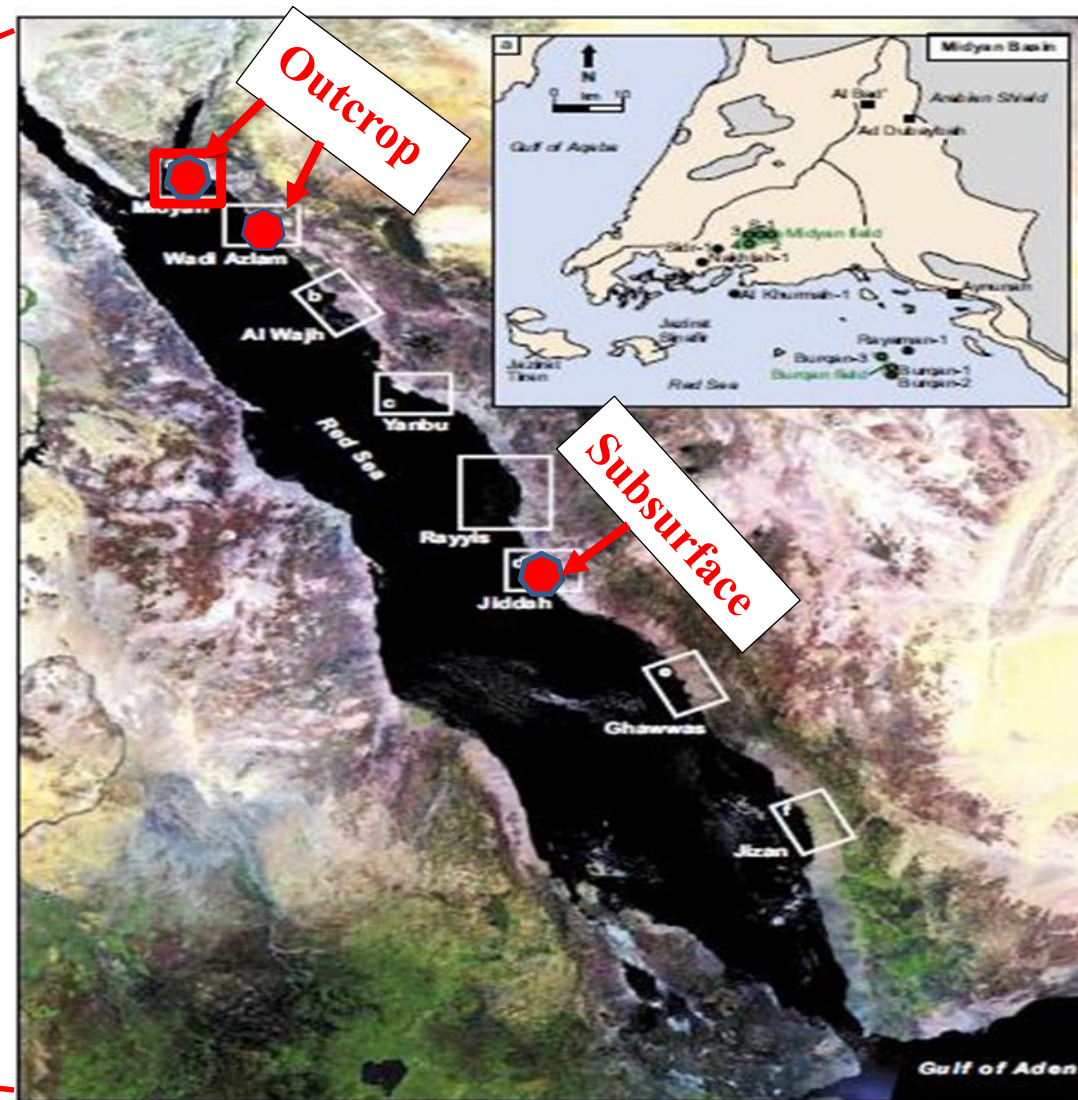
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□ Adaffa Formation



Al-Husseini, 2009

Introduction



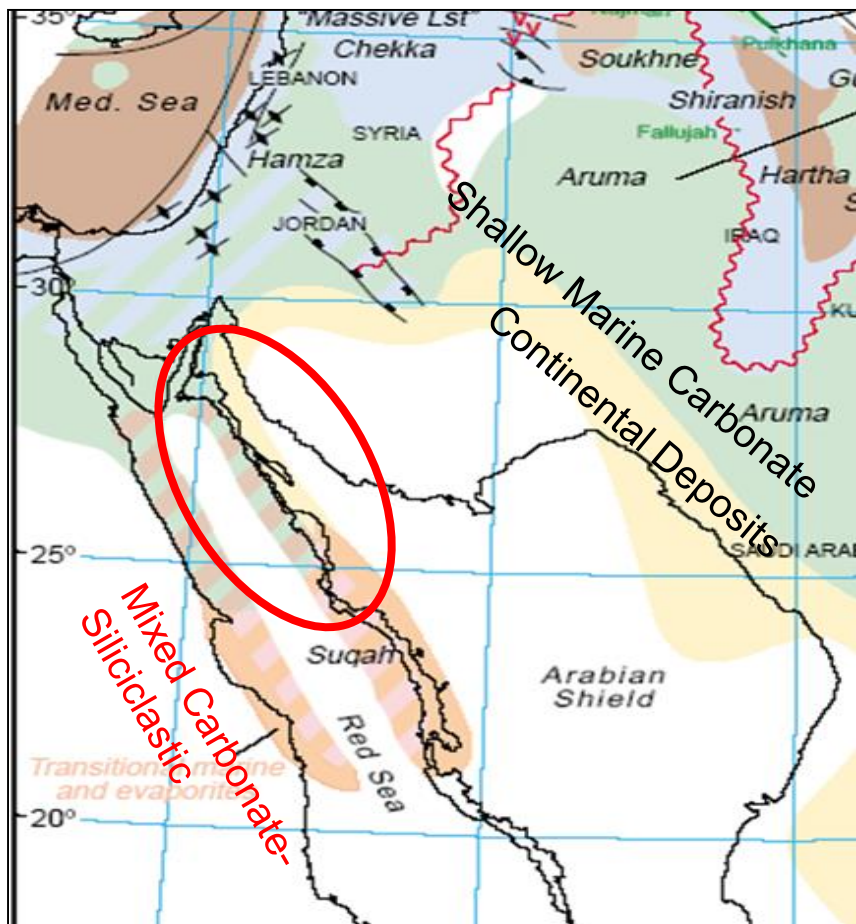
Hughes et al. 1999



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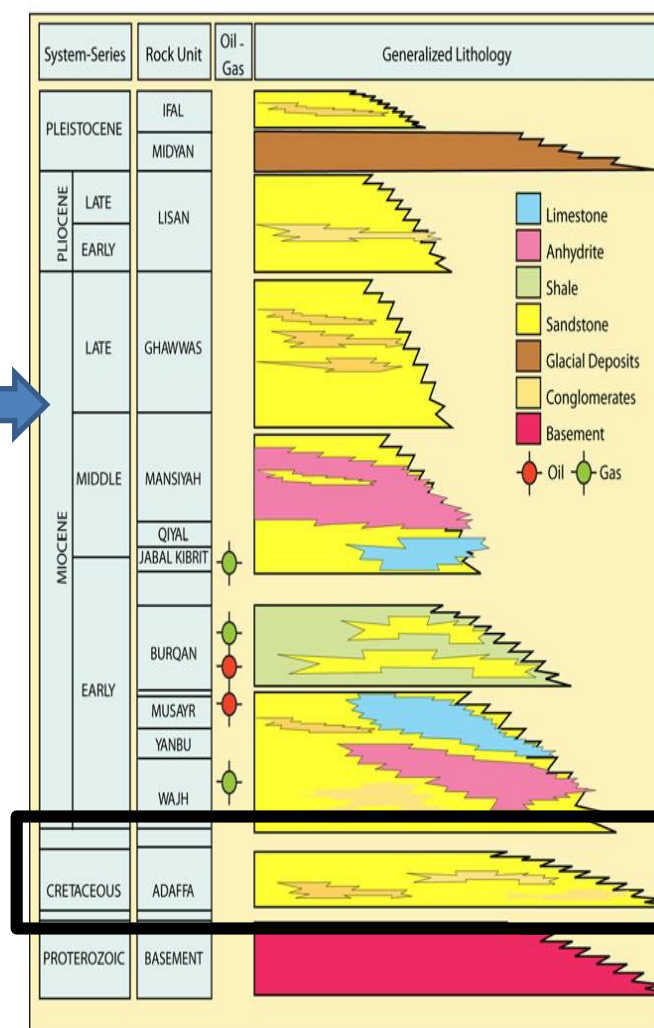
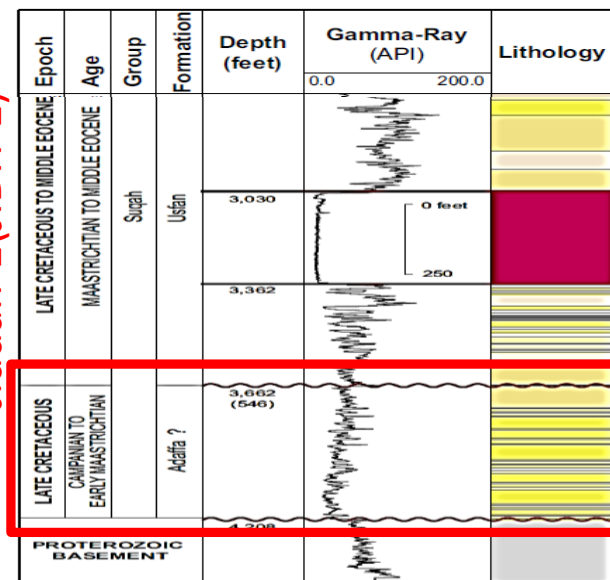
Geologic Setting



Ziegler, M.A., 2001



Jiddah-1 (JIDH-1)



Post-rift
Syn-rift
Pre-rift

Hughes et al. 2005 Laboun, A. A. 2012



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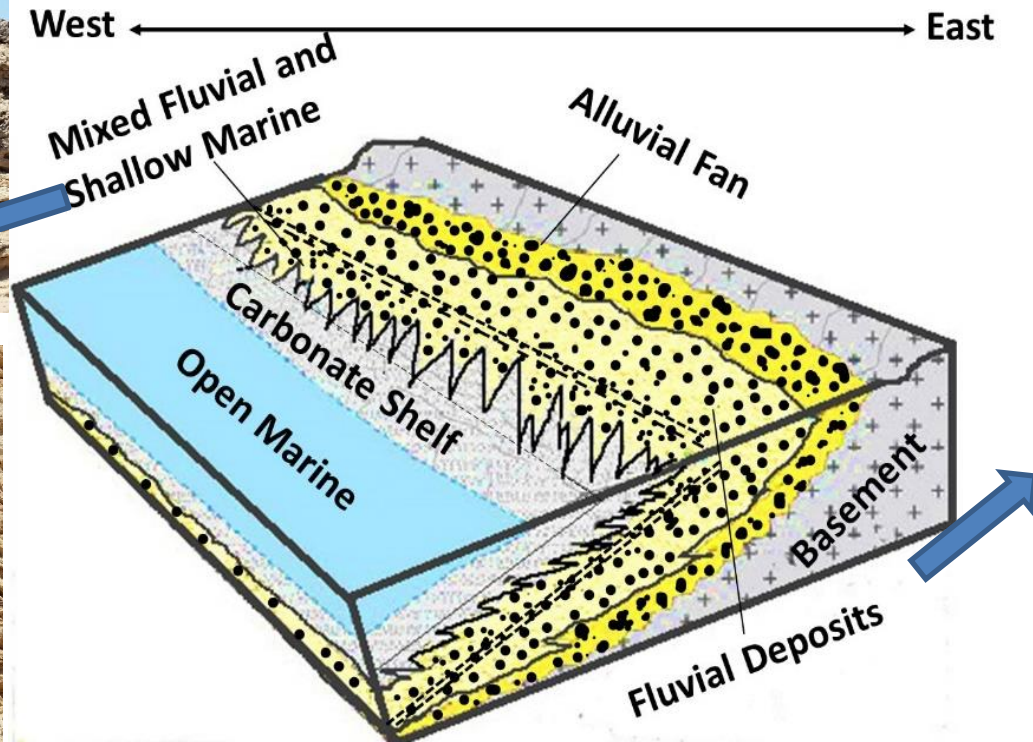
Depositional Model and Facies



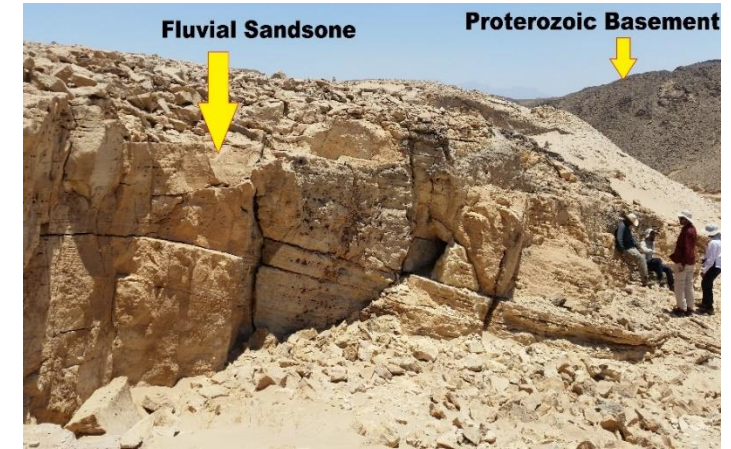
Mixed Carbonate & Sandstone



- Mixed Shallow marine bioclastic carbonates & siliciclastic Sandstone.



- Conceptual Depositional model of Adaffa Formation.



Fluvial Sandstone

Proterozoic Basement



- Fluvial deposits of fine to medium grained, cross bedded sandstone, interbedded with thin shale and siltstone.

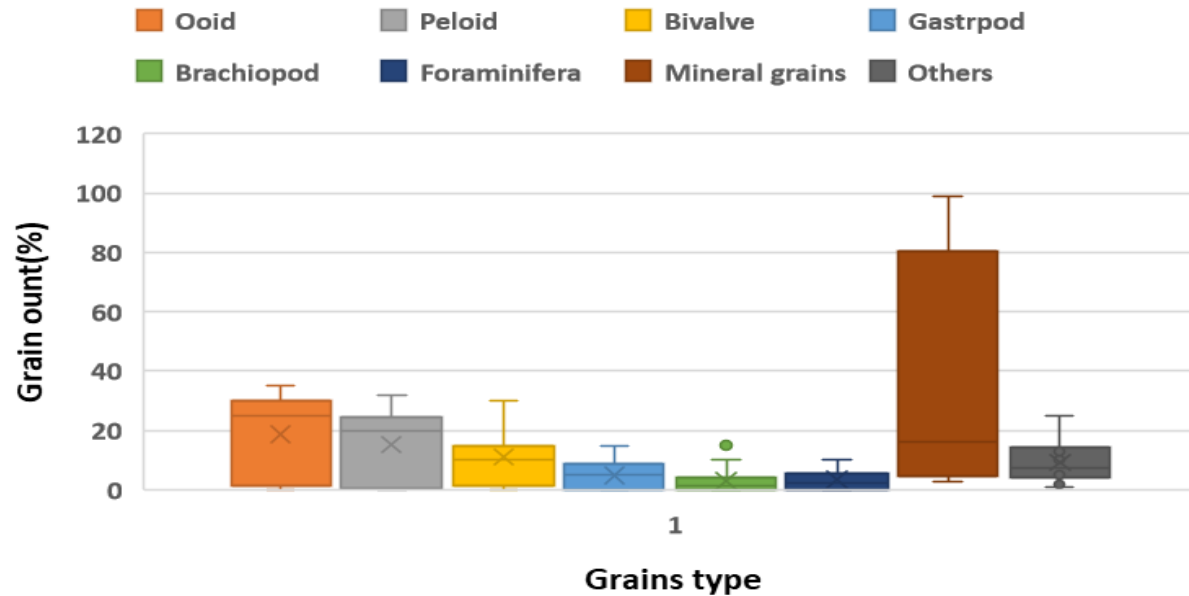


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Petrography

Variation of grain count(%)



- Visual Porosity varies from 5% to 25%
- Moldic, vuggy, intergranular and intra-granular, secondary porosity is higher %.

Dunham(1962) carbonate classification

Component not bound together during deposition

Carbonate Mud present

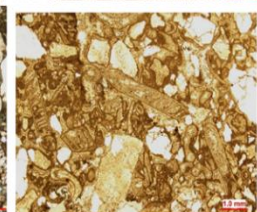
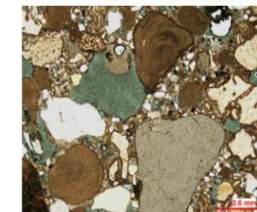
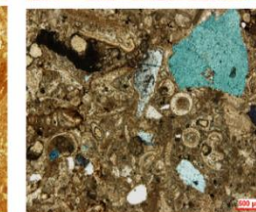
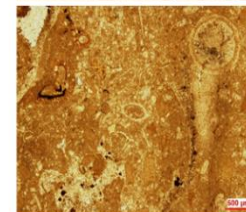
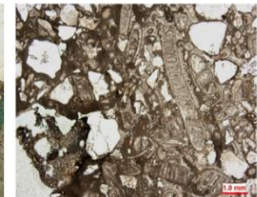
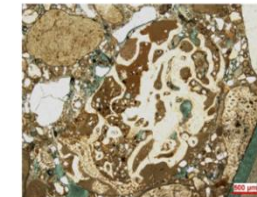
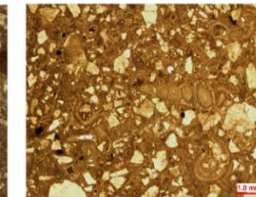
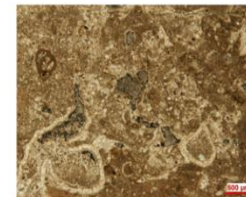
Lack Mud

Mud supported
>10% grain

Grain supported,
Small grain

Grain supported,
Large grain

Grain supported
small grain



Wackstone

Packstone

Rudestone

Grainstone

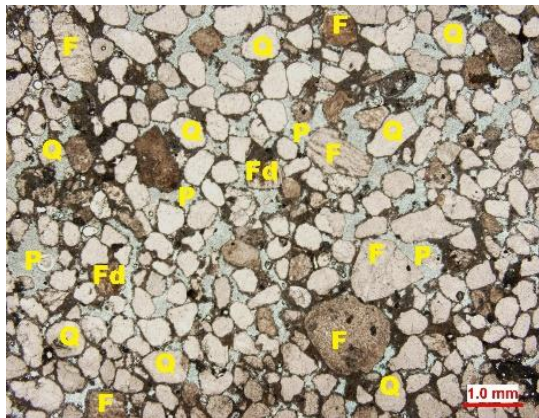


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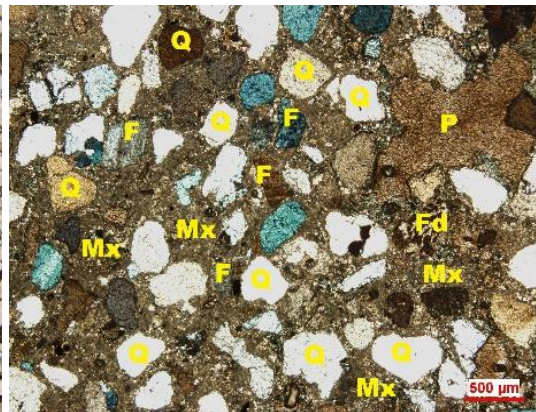
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Petrography

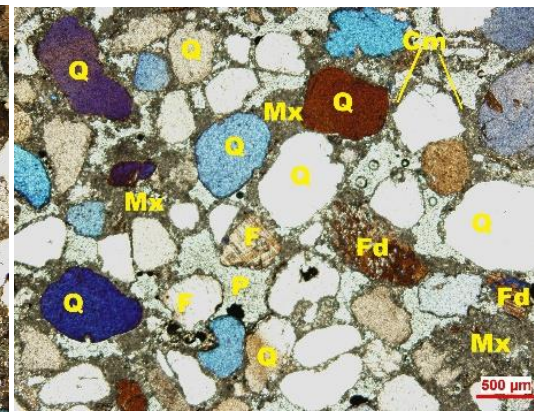
□ Sandstone classification (Folk, 1980)



Quartz-arenite

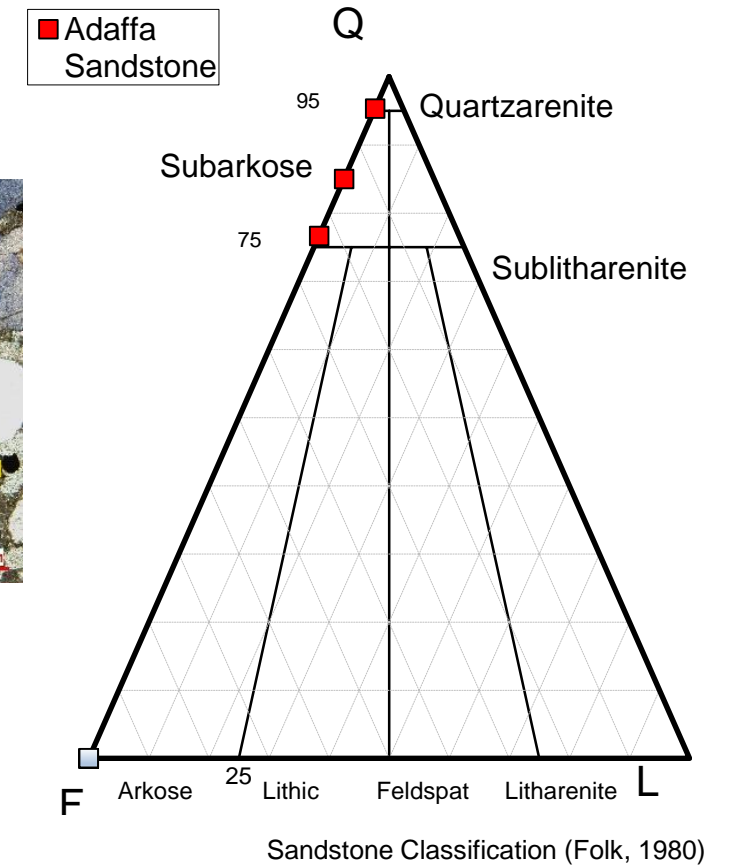


Sub-Arkose



Quartz-arenite

□ 16-21 % visual porosity



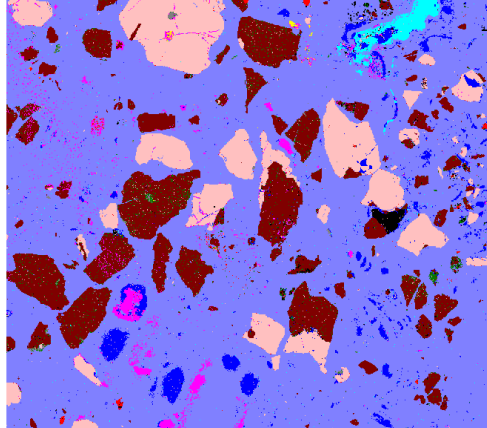


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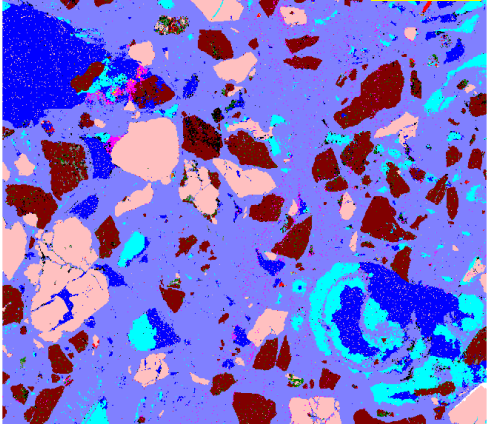
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Petrography

AD4(Packstone) 2.9%



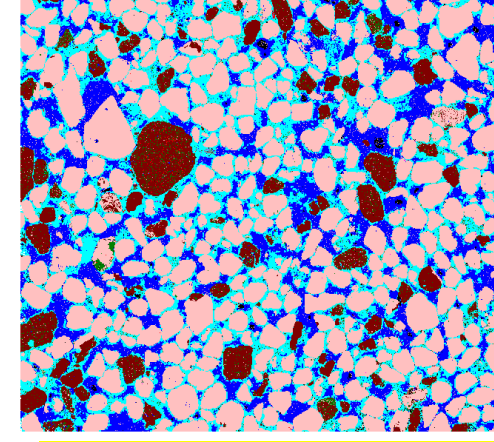
AD3(Grainstone) 9.7%



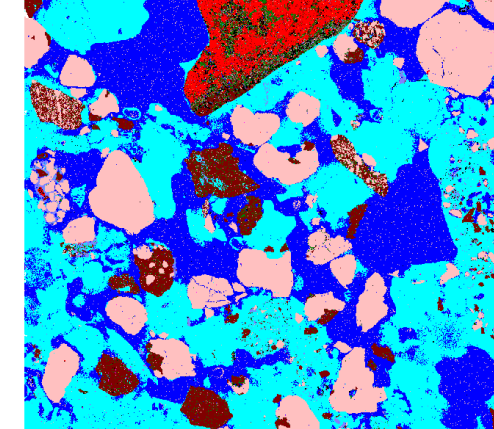
Mineral Name

	Background
	Quartz
	Feldspars
	Calcite
	Dolomite
	Siderite
	Clay Minerals
	Mica
	Pyrite
	Gypsum
	Heavy Minerals
	Porosity
	Others

ADT1 (Quarzarenite) 16.5%



ADL1(Rudestone)27.4%



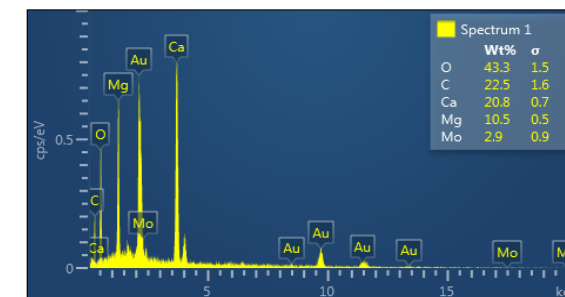
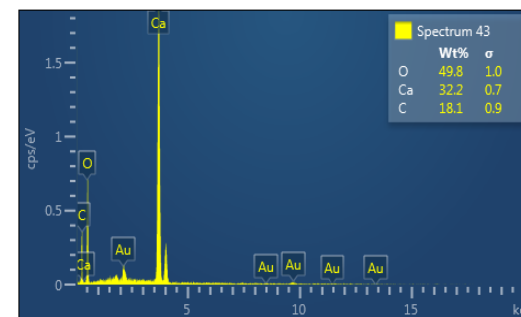
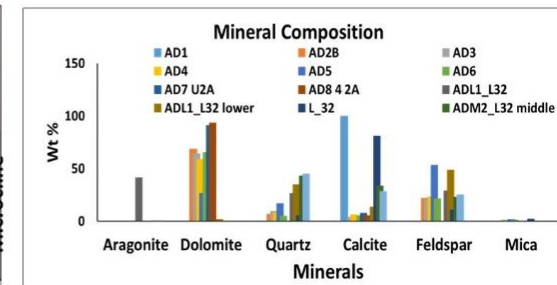
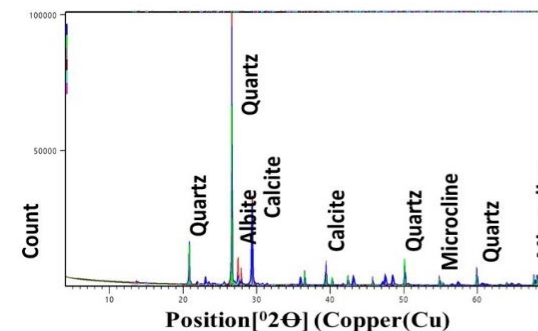
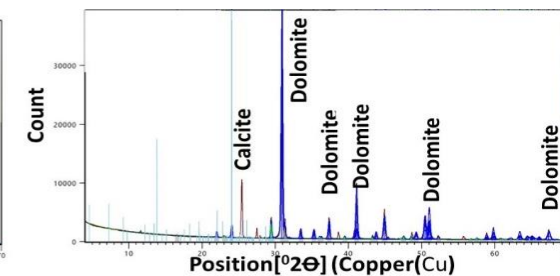
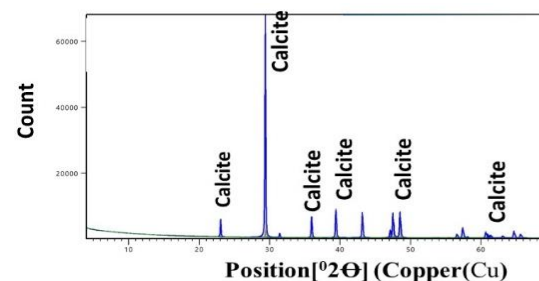
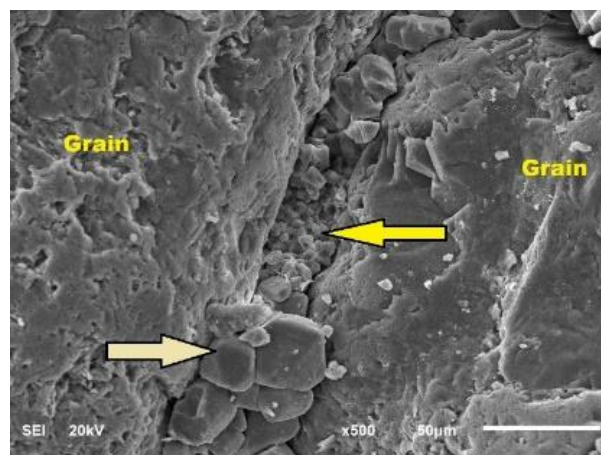
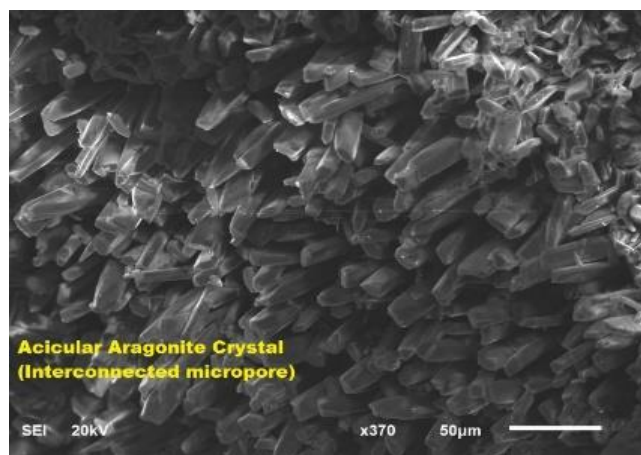
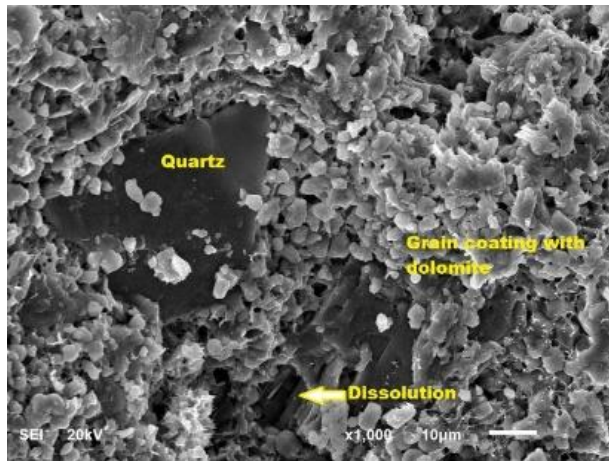
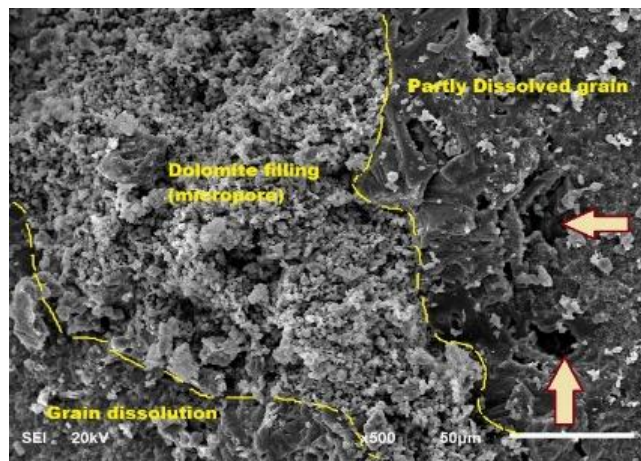
- Porosity 2.9 to 27.4 %
- Porosity higher due to calcite dissolution, less due to Dolomitization
- In Quartz-arenite, intergranular porosity is higher.



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Petrography

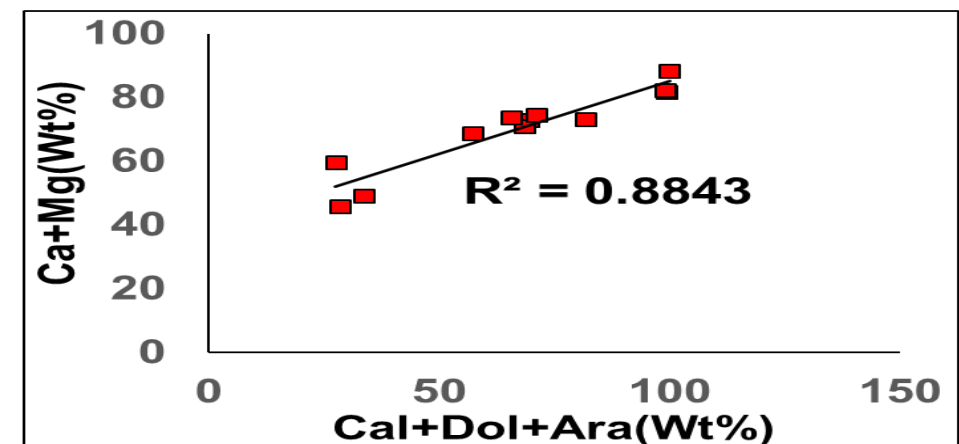
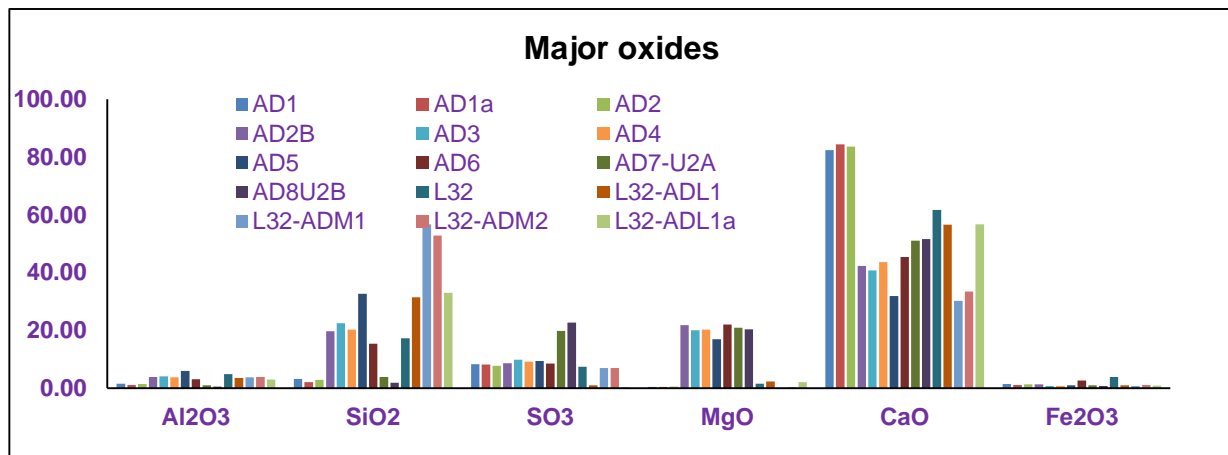
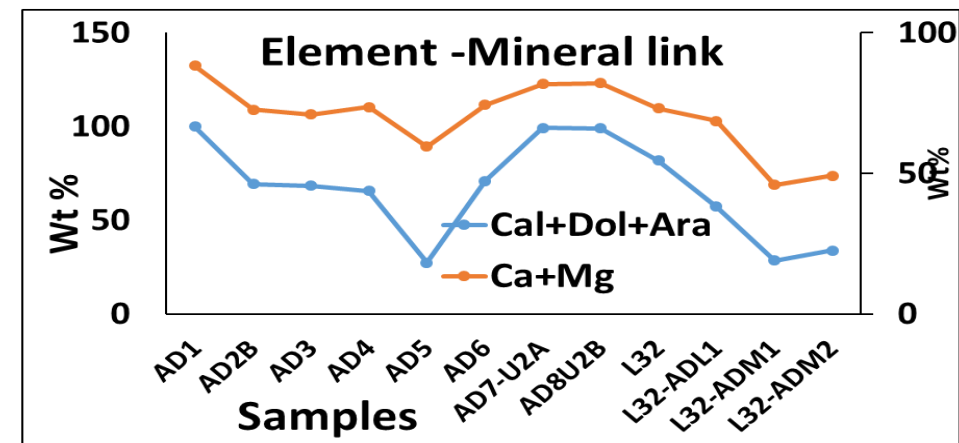
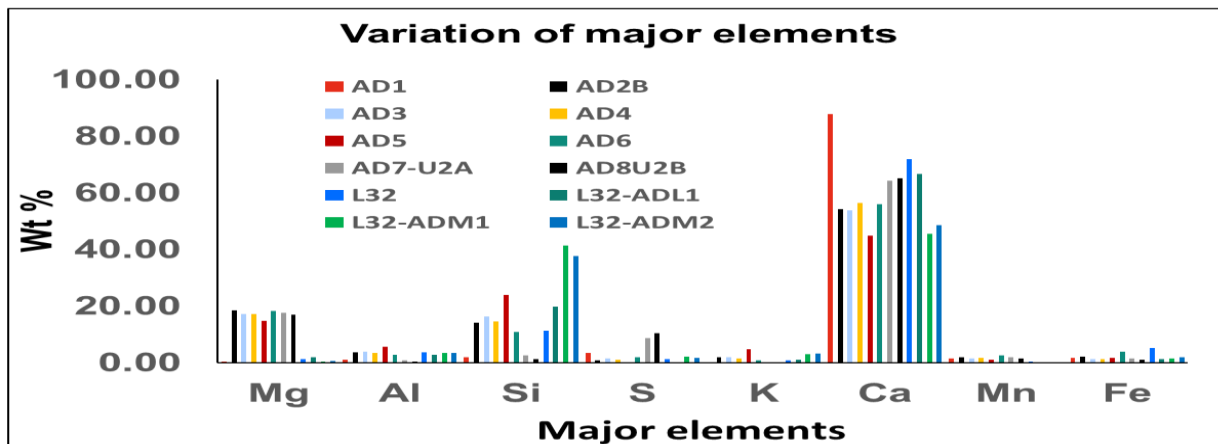




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Geochemistry





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Reservoir Potentiality

- Fluvial coarse grained sandstone and shallow marine siliciclastic and calcitic carbonates as a reservoir rocks.
- The dolomitic carbonate having low porosity may not be considered as reservoir rock, whereas calcitic carbonate having high porosity (up to 27%) may be considered as good reservoir rocks.
- The sandstone shows 16-21 % porosity also may be considered as good quality reservoir. Here, the permeability could not be measured due to lack of plug samples.
- There are considerable interconnected micropores.
- The diagenetic grain dissolutions might have played major role for higher percentage of secondary porosity result in good quality reservoir. The grain coating also played role as preserving the primary porosity.
- As red sea region is the present target of hydrocarbon exploration, this outcrop scale to microscale facies analysis might provide understanding of reservoir heterogeneity and potentiality of the Adaffa Formation.



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Conclusion

- Fluvial sandstone and shallow marine siliciclastic and calcitic carbonates as a reservoir rocks.
- The porosity 3% to 27% as moldic, vuggy, intergranular and intra-granular type, where secondary porosity is higher percentage.
- The diagenetic grain dissolutions might have played major role for higher percentage of secondary porosity result in good quality reservoir. The grain coating also played role as preserving the primary porosity.
- This outcrop scale to microscale facies analysis might provide understanding of reservoir heterogeneity and potentiality of the Adaffa Formation and also may provide information to guide for predicting exploration challenges in subsurface.