PS Characterization of Fractured Reservoirs: Mapping Fracture Networks and Linking Fracture Density to Reservoir Properties using Core and Borehole Image Data a Case Study

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Abstract

The presence of fractures in Algerian oil and gas fields is critical for the effective flow of fluids within the system. Accurate identification, description, and categorization of fractures in these fields are crucial for assessing formations and production planning. While image logs offer valuable information for describing fractured reservoirs, they may lead to erroneous fracture interpretations if used alone. Therefore, a comparison with data obtained from cores is necessary to provide a complete characterization of the fracture network. This article describes the mapping of fracture networks in five case studies, accounting for the filtering effect caused by the imaging technique alone, using both core and borehole image data. The differences between the data from the two methods are highlighted, and the benefits of reconciling them to improve our understanding of the formation being studied are discussed. Distributing fracture characteristics across an entire reservoir is a significant problem due to the uneven and frequently sparse distribution of well-based fracture calibration. For distributing fracture parameters that are almost always undersampled, a link between well-based fracture density and other better-constrained reservoir properties must be established. To address this, comparisons between fracture density and petrophysical characteristics that may impact reservoir characteristics have been made.

Keywords:

Fracture characterization, Image logs, Fracture density, Fractures in core.

References:

Alagoz, E., Wang, H., Russell, R. T., & Sharma, M. M. (2020, June). New experimental methods to study proppant embedment in shales. In 54th US Rock Mechanics/Geomechanics Symposium. OnePetro.

Benayad, S., Park, YS., Chaouchi, R. et al. Parameters controlling the quality of the Hamra Quartzite reservoir, southern Hassi Messaoud, Algeria: insights from a petrographic, geochemical, and provenance study. Arab J Geosci 7, 1541–1557 (2014). https://doi.org/10.1007/s12517-013-0905-6

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Introduction

- ❑ The presence of fractures in Algerian tight oil and gas reservoirs significantly influences the fluid dynamics and is of utmost importance for ensuring efficient fluid flow within the system.
- ❑ Accurate identification, description, and categorization of fractures in these fields are crucial for assessing formations and production planning.
- ❑ Image logs offer valuable information for describing fractured reservoirs, therefore they may lead to erroneous fracture interpretations if used alone.
- ❑ A comparison with data obtained from cores is necessary to provide a complete characterization of the fracture network.
- ❑ This article describes the mapping of fracture networks in five case studies using both core and borehole image data, , accounting for the filtering effect caused by the imaging technique.
- ❑ The differences between the data from the two methods are highlighted, and the benefits of reconciling them to improve our understanding of the formation being studied are discussed.
- ❑ Finally, a connection between well-based fracture density and other reservoir properties that are better-constrained is made for distributing under-sampled fracture parameters.

Study Area

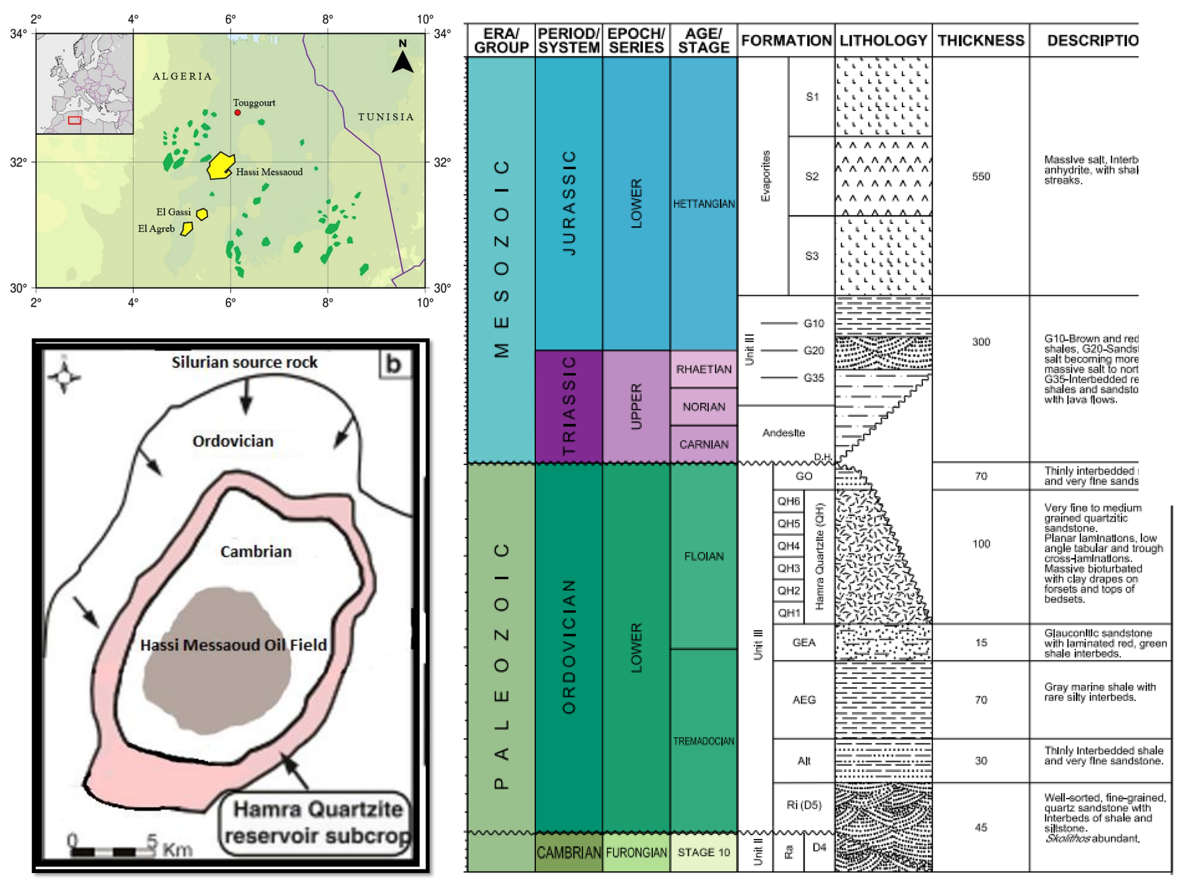

Fig. 1 Lower Ordovician play concept for the giant Hassi Messaoud oil field, Saharan Platform, Algeria (modified from Sonatrach and Schlumberger (2007))

Objectives

The primary goals of this investigation encompass the following:

- ❑ Enhance our understanding of the studied reservoir through the synergistic integration of core analysis and image log data.
- ❑ Conduct a comprehensive characterization of the fracture network through a comparative analysis of the fracture identification results obtained from core analysis with those derived from image logs.
- ❑ Overcome the limitations associated with the sparse nature of fracture data. By leveraging the relationships between well-constrained reservoir properties and fracture density

Methodology

Fracture Characterization through Core Analysis

- ❑ CS-1 is the vertical set, sub-parallel to the core axis (sub-vertical).
- ❑ CS-2 represents steeply dipping fractures with an angle of fracture-to-core axis of less than 35 degrees.
- ❑ CS-3 fractures set have a fracture-to-core axis angle of greater than 35 degrees.

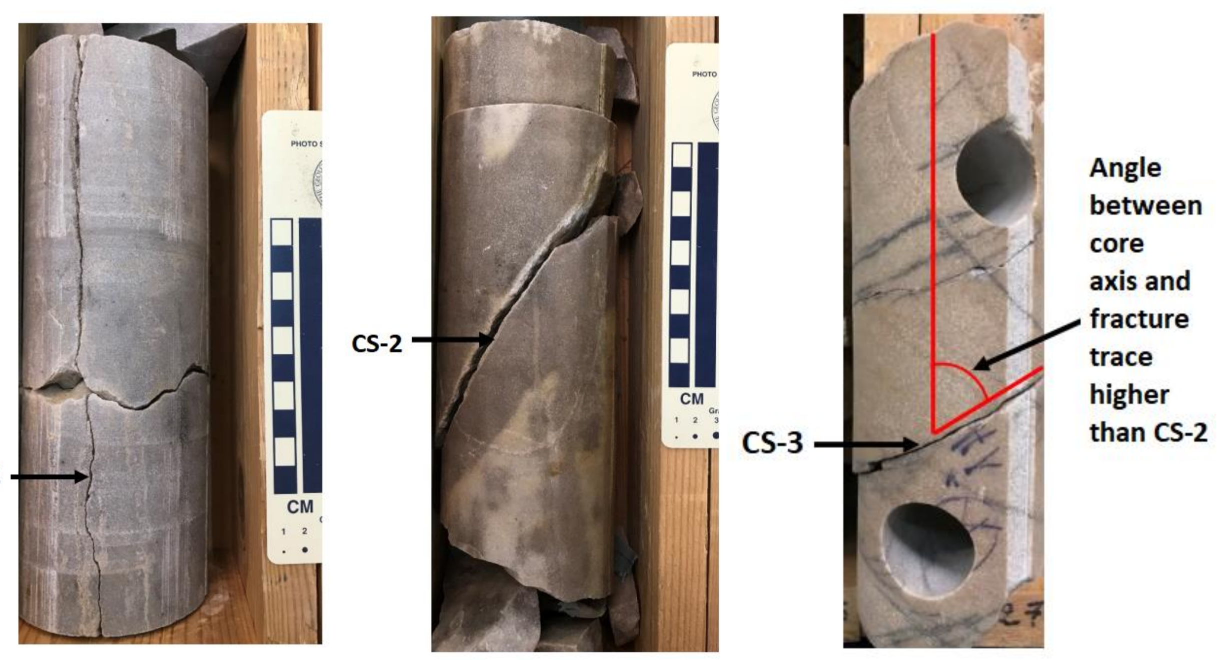

Fig. 2: Exemples of CS-1, CS-2, and CS-3 sets of fractures.

Integrating Core and Image Logs

- ❑ The orientation from the image log shows that both fracture sets have similar strike orientation
- ❑ One set is 10 degrees steeper than the other
- ❑ Varying aperture conditions : some fractures are open while other are partially open or closed.

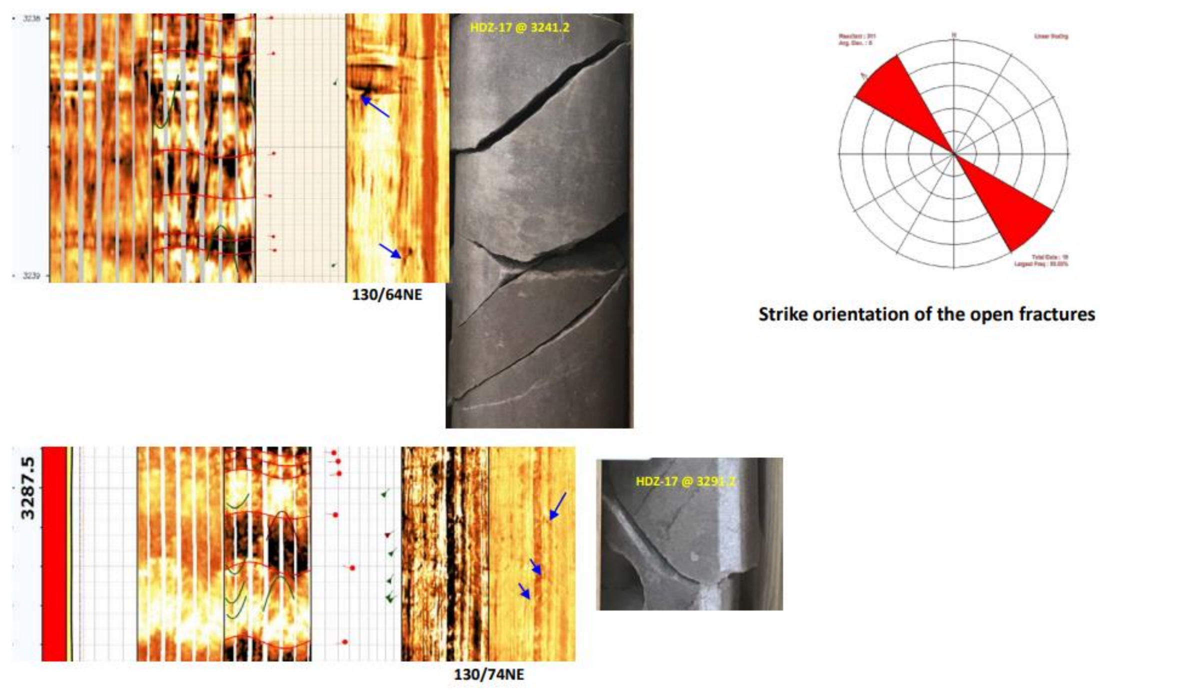

Fig. 3: CS-2 and CS-3 based on the angle of fracture with respect to core axis and bedding trace.

- ❑ In the image logs of most wells, high amplitude fractures have similar orientations to the low amplitude fractures

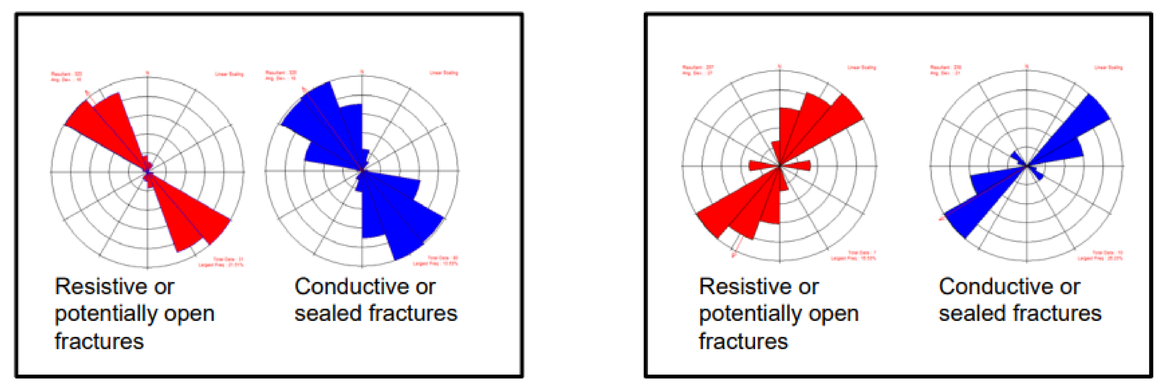

Fig. 4: Orientation of open and closed fractures from 2 wells.

Table 1: Comparison of measured aperture from cores and image logs.

	Core measured aperture	Image log aperture
CS-1	0.05 mm	-
CS-2	0.2 and 0.5 mm	0.15-0.4 mm
CS-3	0.2 to 0.5 mm	0.3-0.4 mm

Results

Open Fracture Orientations

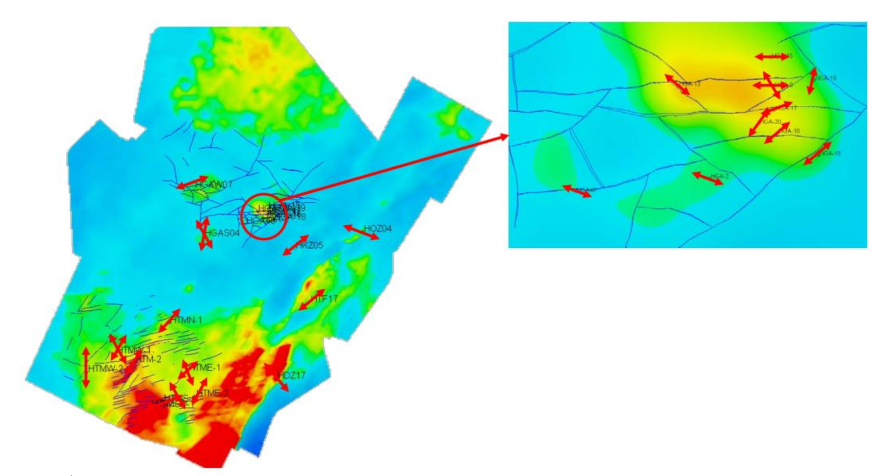

Fig 5:Map of dominant fracture orientations.

- ❑ In the HGA field, the dominant fracture orientations are broadly parallel to one of the three main fault orientations, namely NE-SW, E-W, and WNW-ESE.
- ❑ In the HTM field, one of the dominant fracture orientation is NE-SW, parallel to the NE-SW fault trend

Fracture Density (P32)

The term fracture intensity is used to express the area of individual fracture (A) surfaces per volume (V).

$$P_{32} = \sum A_i \div V$$

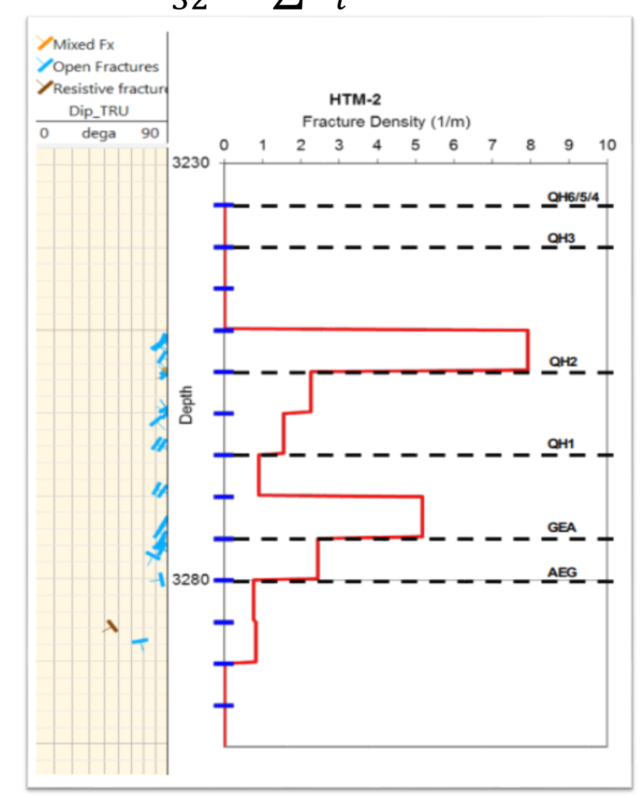

Fig.6. Continuous well log of the calculated fracture density of each well.

- ❑ Fracture density of each well is determined by dividing the well into 5-meter intervals based on significant stratigraphic units.
- ❑ A quantitative assessment has been conducted to estimate the fracture surface area per reservoir volume within each segment.
- ❑ Normalized interval lengths
- ❑ Mitigated potential sampling bias from orientation-based factors has been

Conclusions

- ❑ Most continuous and abundant fractures along the wellbore could be identified in both data sources.
- ❑ A comprehensive characterization of the prevailing set of fractures was achieved using a comparative analysis.
- ❑ The chronological sequence of CS-3 and CS-2 fracture sets could not be established. Both sets exhibit a planar configuration
- ❑ CS-1 fractures type are present in the core samples but absent in the image log data.
- ❑ It is plausible to consider the fault-parallel fracture set in the HTM field as a potential contributor to fluid flow.

Recommendations

It is recommended to enhance the quantity of calibration data in order to augment the level of certainty regarding the influence of natural fractures on fluid flow.

References

- Benayad, S., Park, YS., Chaouchi, R. et al. Parameters controlling the quality of the Hamra Quartzite reservoir, southern Hassi Messaoud, Algeria: insights from a petrographic, geochemical, and provenance study. Arab J Geosci 7, 1541–1557 (2014). https://doi.org/10.1007/s12517-013-0905-6
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