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Traps Analysis and Petroleum Potential in Reggane Basin, Algeria

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1-Introduction

Reggane is an intracratonic basin located on the eastern edge of the West African craton. It is oriented NW-SE. Reggane basin is bordered to the north by Ougarta Mountains, to the east by the Ahnet basin, to the west by BouBernous spur, and to the south, it merges with the Eglabs massif. The juxtaposition of these two domains results from a collision (620 Ma) and closure of a Proterozoic-age paleo-ocean. Reggane basin covers an area of 140,000 km$_2$ and has an asymmetrical transverse profile. Reggane basin is characterized by a polyphase tectonic history and significant subsidence, allowing the deposit of more than 6000 m of Paleozoic sediments in its axial zone (Fig.1).

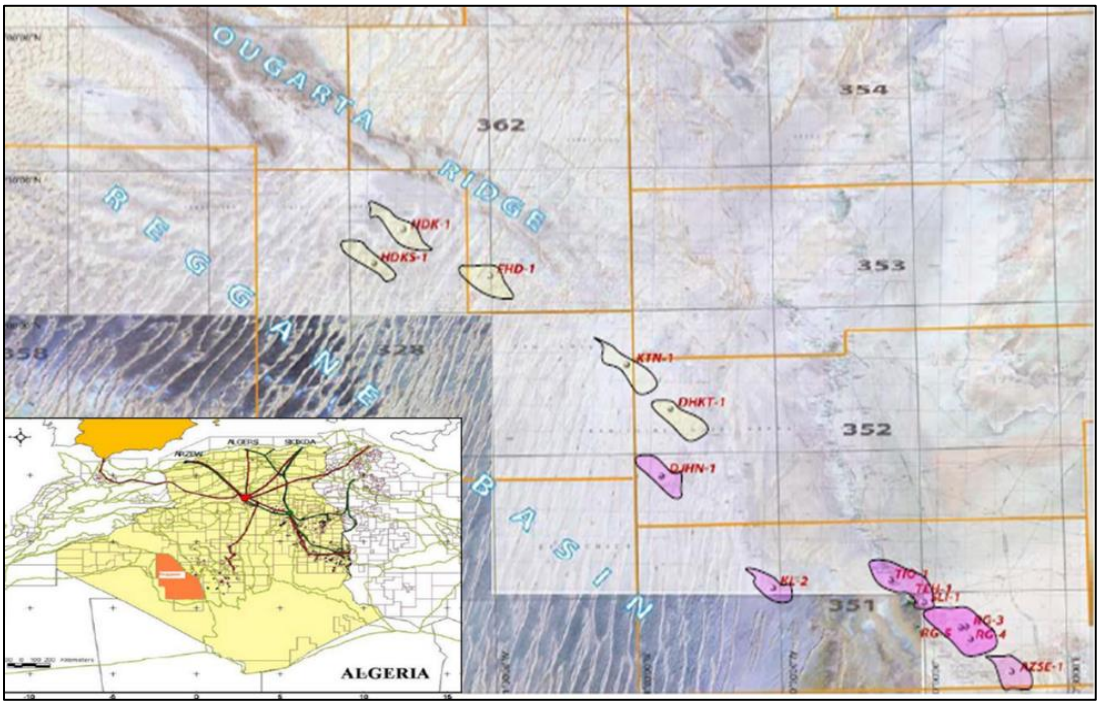

Figure 1: Area of study

2-Petroleum Systems

The Reggane basin is a gas province. The Cambro-Ordovician, Devonian, and Carboniferous reservoirs represent the most promising petroleum system. Most of the traps are linked to structures of complex geometry, leaning on reverse faults. The generation of hydrocarbons happened in the Paleozoic and probably during the overheating of the Jurassic period. The basin results from a superposition of several tectonic events from the Caledonian to the Hercynian. The Reggane basin's petroleum system is in the chart resumed below. The main reservoirs are in the northeastern part of the Reggane basin. They comprise the Ordovician, Devonian, and Carboniferous reservoirs. Gedinnian, Siegenian, and Emsian are primary reservoirs in the Reggane basin. The Carboniferous and Ordovician reservoirs became second objectives after gas discoveries in Kahlouche and Anzeglouf area (Fig.2).

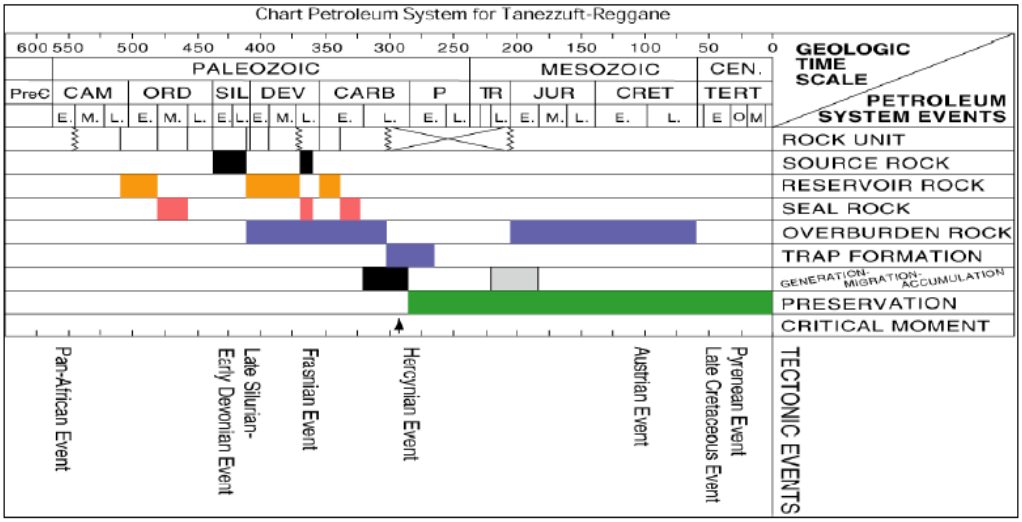

Figure 2: Petroleum system chart

3-Structural Framework

Two principal structural axes characterize the Reggane basin. This basin is oriented NW-SE, relatively asymmetric, with a southern flank plunging to the North and affected by rare faults. On the other hand, the northern side is intensely fractured (Fig.3). Two fault networks characterize the basin. The NW-SE constitutes the main fault set that appears along the north edge of the basin and has the same direction as the Ougarta mountains. The N-S faults set are in the SE part of the basin, constituting a transition zone between the Reggane basin and the Azzel-Matti slab. This N-S fault set includes an extension of the submeridian accidents in the Hoggar shield. Two other directions of less importance stand out: the E-W faults forming an accident relay along the edge of the basin with the Ougarta mountains and the NE - SW faults (Fig.4).

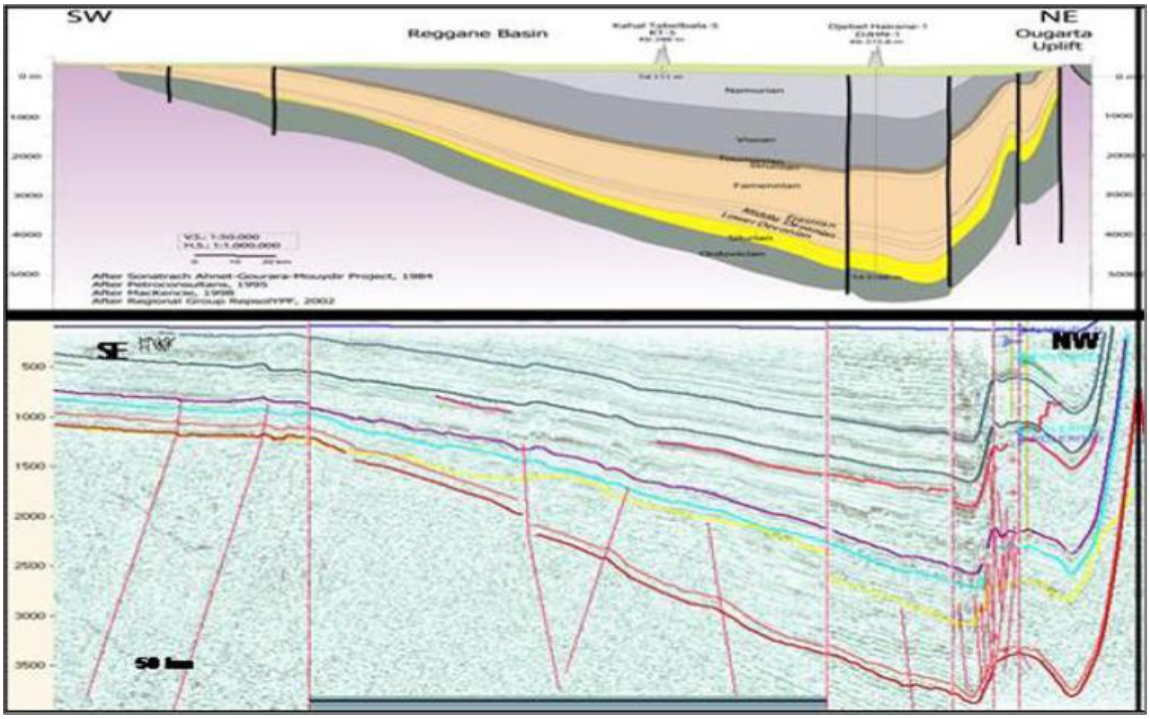

Figure 3: Cross-section NW-SE in Reggane Basin

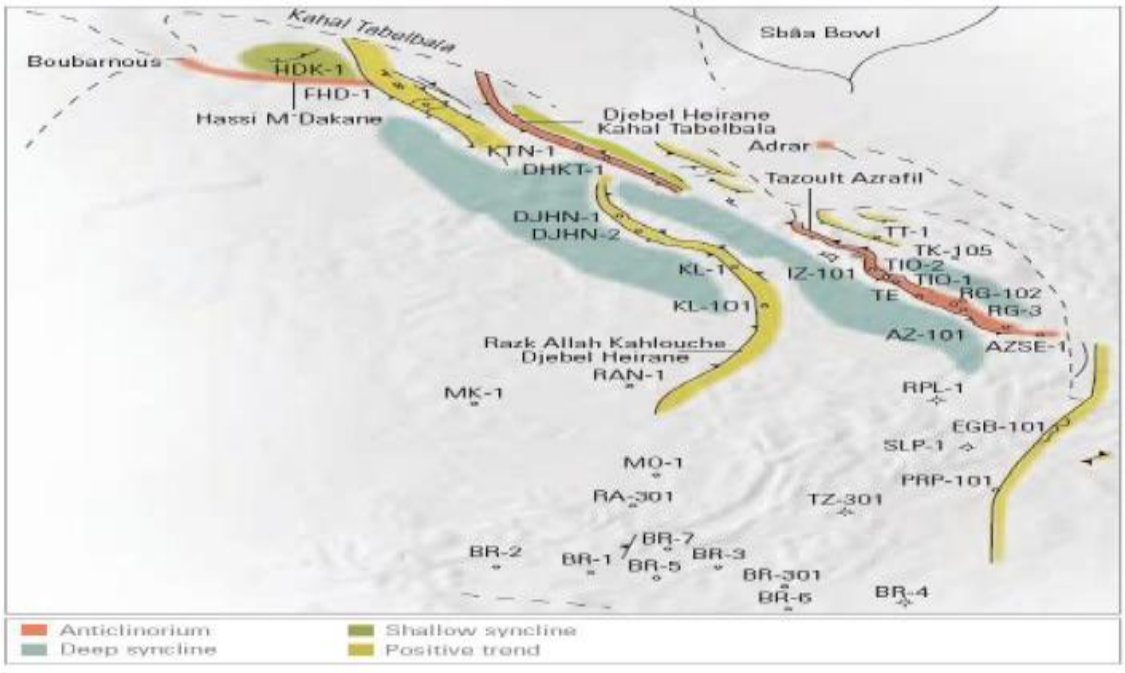

Figure 4: Fault system and main fields in Reggane Basin

4-Trap Analysis

The structural analyses of major traps underlined in the Reggane basin confirm that:

- Basement faults control all anticlinal structures of the Paleozoic cover.
- Positive structures vary in their origin.
- Structures generated from pure compression happen when the normal faults oriented perpendicular to the Ougartian stress (N040°) are reactivated in reverse and the creation of anticlines against faults (Fig.5).

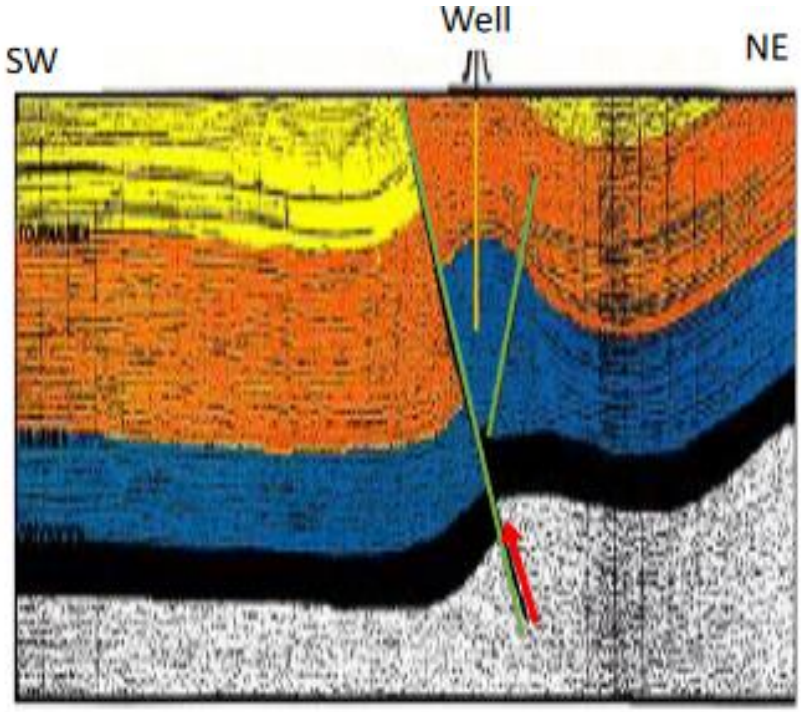

Figure 5: Structure anticlines against fault

- A half-graben is exposed to compression with the rising of the bottom compartment and the creation of anticlines against fault (Fig.6).

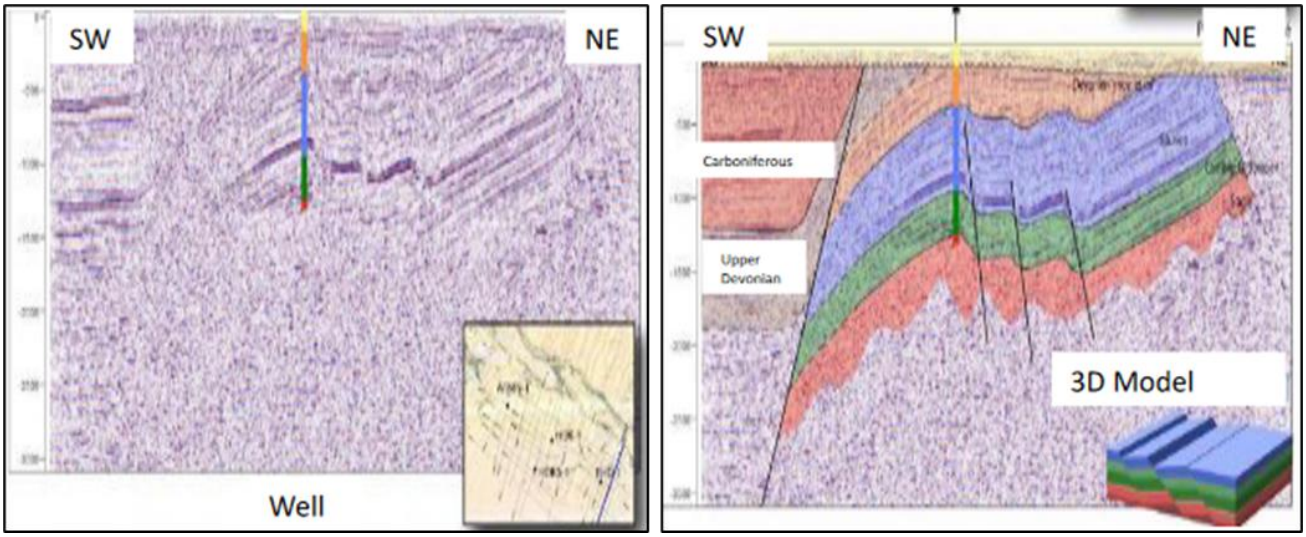

Figure 6: Anticline against fault structure and normal faults

- A graben is subjected to pure compression to create a symmetrical Pop-up anticline (Fig.7).

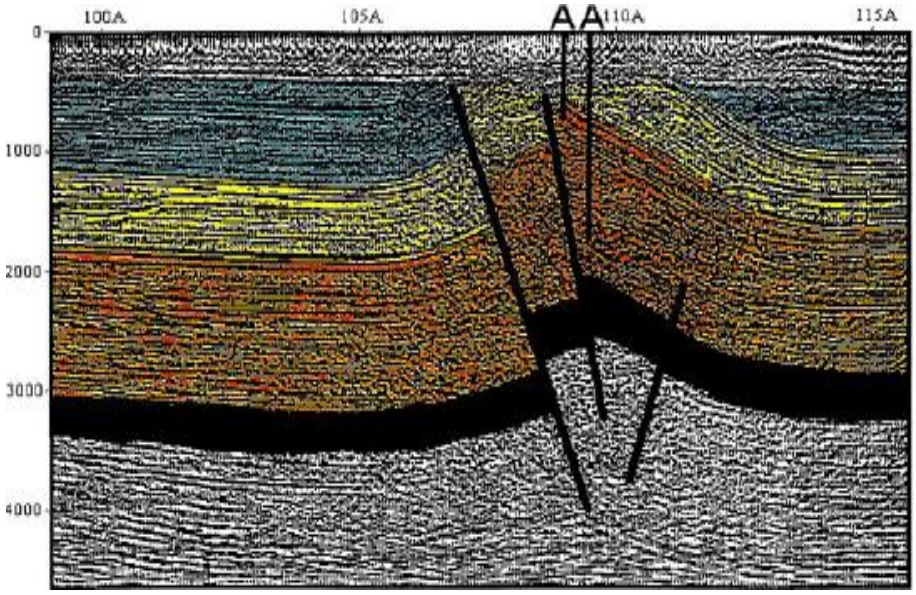

Figure 7: symmetrical Pop-up anticline

- Structures generated by transpression happen when the basement submeridian faults, oriented obliquely to the Ougartian stress (N040°), are reactivated in dextro-inverse and create sub anticlines parallel to the faults (Fig.8).

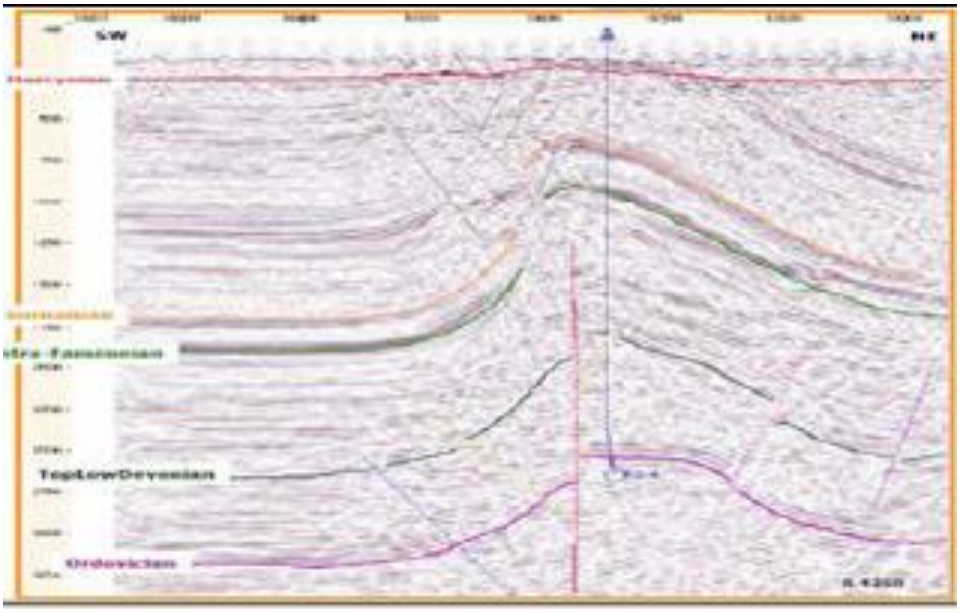

Figure 8: dextro-inverse faults and create sub anticlines parallel to the faults.

- Back-overlap ascends at the connection of the ramp with the Frasnian-Famennian clays formations, specifically at the level of the Atinim North structure located to the NW of the Reggane basin (Fig.9). This zone occurs in most cases where the overlapping deformation is associated with a back-overlapping commonly called the triangular zone or “triangle zone.”

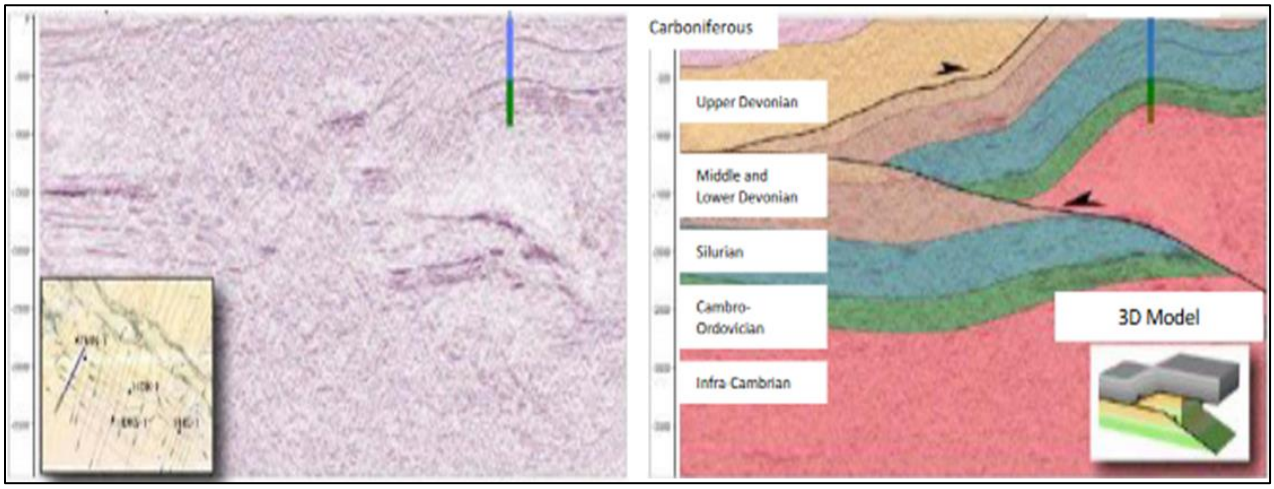

Figure 9: Overlapping deformation associated with a back-overlapping (triangular zone)

5-Conclusion

Surface and subsurface observations show that the Hercynian event is the main phase that structured the Reggane basin. The foreshortening could be aged post-Namurian, with a NE-SW direction of foreshortening (N040). The Hercynian phase, especially and possibly the post-Hercynian phase, impacts the petroleum system. The reactivation of faults can indeed lead to the dismigration of the hydrocarbons trapped in the Hercynian anticlines. The maximum horizontal stress (SHMax) has an NW-SE direction except for the Atinim structure, located at the extreme NW of the Reggane basin, where the maximum horizontal stress is oriented NE-SW at the ATM-1 well. This can be interpreted by a change in the SHMax stress regime, the existence of a fault or volcanic intrusion. Two large sets of fractures are perceptible on these structures through the seismic data, and the borehole imaging logs: more dominant NW-SE oriented fractures and NE-SW oriented fractures probably resulting from Hercynian orogenic movements. Fractures having the same direction as the maximum horizontal stress are generally conductive (open) and therefore contribute to the improvement of the petrophysical parameters of the Lower Devonian reservoirs. At the same time, those which are perpendicular to SHmax are generally resistive (closed) and thus constitute permeability barriers.

Theory / Method / Workflow

The geochemical studies show that the basin has a vast petroleum potential. However, new wells' exploration and drilling are still low compared to other basins in the Algerian Saharan platform. 3D seismic, seismic attributes, and borehole imagery will bring new insights into this basin.

Results, Observations, Conclusions

Surface and subsurface observations show that the Hercynian event is the main phase that structured the Reggane basin. The foreshortening could be aged post-Namurian, with a NE-SW direction of foreshortening (N040). The Hercynian phase especially and possibly the post-Hercynian phase has an impact on the petroleum system. The reactivation of faults can indeed lead to the dismigration of the hydrocarbons trapped in the Hercynian anticlines. NW-SE fractures are as well visible on borehole imagery, curvature analysis as in 2D, 3D seismic, they are generally open, it would be preferable to implant the future wells near the NW-SE faults which can generate fracture corridors favoring the maximum productivity of the Lower Devonian reservoirs by matrix and natural fractures

Novel/Additive Information

This work brings new insights for the successful exploration and decreases the exploration risks in this Reggane basin.

Acknowledgments

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References

Ait Kaci A. (1990). Evolution lithostratigraphique et sédimentologiquedes monts d'Ougarta pendant le Cambrien (Sahara Algérien Nord Occidental). Thèse de 3ème cycle, IST-USTHB, 193p.

Arab, M & S. Djezzar. (2011). Hydrocarbon potential in Reggane Basin, Oil Mediterranean Conference (OMC), Italy.

Bazalgette L. (2004). Relations plissement/fracturation multi échelle dans les multicouches sédimentaires du domaine élastique/fragile Thèse doct. Univ, Monpellier II, p252.

Beicip, (2008). Fracture characterization of the Reggane field, final report, prepared for Repsol.

Beuf, S., et al. (1968). Une conséquence directe de la structure du bouclier africain: l'ébauche des bassins de l'Ahnet et du Mouydir au Paléozoïque inférieur: Publications de Service Géologique de l'Algérie, Bulletin, n. 38, p. 103-131,

Boualam, A., S. Djezzar, V. Rasouli, M. Rabiei (2019). 3D Modeling and Natural Fractures Characterization in Hassi Guettar Field, Algeria. 53rd American Rock Mechanics Association Symposium, NY, USA

Collomb P. et M. Donzeau. (1974). Relation entre kink-bands décamétriques et fractures du socle dans Hercynien des monts d'Ougarta (Sahara Occidental, Algérie). Tectonophysique, 24, 213-242.

Conrad & al. (1984). Evolution sédimentaire et structurale du bassin Ahnet-Timimoun-Bechar (sahara Algérien) au cours du Carbonifère ; données paleoclimatiques, , bull. soc. Geol. France, 1984, (7), T XXVI, n°6 p. 987-994.

Connolly N & al. (2007). Integrated reservoir characterization of cored and uncored Devonian (Lochkvian, Pragian, Emsian) and Carboniferous (Tournaisian) intervals in Zerafa and Reggane Djebel Hirane permit areas, Algeria (wells ECF-1, ECF-2, KTN-1, and DHKT-1), vol.1 &2, 2007, Badley Ashton.

Daoudi, M & S. Djezzar (2011). Caractérisation des reservoirs du Dévonien inferieur dans la region de Reggane Nord. Rapport interne Sonatrach.

Djezzar, S. (2012). Impact de la fracturation naturelle sur la productivité des réservoirs du Dévonien inférieur dans le bassin de Reggane, Sahara Occidental, Algérie. Thèse Magister. Ed. USTHB. -Alger: USTHB,2012.-93 p.: ill.; 30 cm. + CD-Rom.

Djezzar, S., V.Rasouli, A.Boualam, M. Rabiei. (2019). Size Scaling and Spatial Clustering of Natural Fracture Networks Using Fractal Analysis. 53rd American Rock Mechanics Association Symposium, NY, USA.

Djezzar, S., V. Rasouli, A. Boualam, M. Rabiei. (2020). An integrated workflow for multiscale fracture analysis in reservoir analog. Arab J Geosci.13, 161.https://doi.org/10.1007/s12517- 020-5085-6

Djezzar, S., A. Boualam. (2020). Fractures Characterization and Their Impact on the Productivity of Hamra Quartzite Reservoir (Haoud-Berkaoui field, Oued-Mya basin, Algeria). 54th American Rock Mechanics Association Symposium, Co, USA.

Djezzar, S., A. Boualam. (2020). Analysis and modeling of tight oil fractured reservoir. SEG 2020 Annual Meeting, Tx, USA

Drai, W. (2011). Etude structural du prolongement Sud de Djebel Kahal Tabelbala (Bassin de Reggane; Essai de restauration de la deformation hecynienne. Mémoire de Master II, USTHB.

Fabre J. (2005). Géologie du Sahara occidentale et centrale. Musée royal de l'Afrique centrale (Ed), Tervuren, Belgique. 572p.

Haddoum, H. (1997). Le Sahara central dans les régions de l'Ahnet et de Bled El Mass: Une zone mobile hercynienne. Résumé, 3ème Séminaire de Géologie Pétrolière, Algérie, 82-83.

Hamidou M. (1999). évaluation des prospects des périmètres de Tasfalout, Reggane. (Rapport interne SH/EXP).

Issad M. (1996). Géodynamiques du Bassin de Reggane. Evolution structurale, typologie des structures et étude de la subsidence. Rapport interne SONATRACH.

Issad M. (2000). Potentiel petrolier du bassin de Reggane. Rapport Sonatrach interne

Khodjaoui A. (2008). Le Dévonien inférieur du bassin de Reggane (Sahara occidental algériens): sédimentologie, biostratigraphie et stratigraphie séquentielle. Mémoire de Magister, Université M'hamed Bouguerra de Boumerdes, 126 p.

Repsol. (2009). Feasibility study of Reggane Nord project, Reggane field.

Sonatrach-Schlumberger (2007). WEC Algeria.

Zazoun, R. (2001). La tectogenèse hercynienne dans la partie occidentale du bassin de l'Ahnet et la région de Bled El-Mass, Sahara Algérien: un continuum de déformation. Journal of African Earth Sciences, Vol.32, N°4, 869-887