[PS]Polygonal Faults Implication on Carbonate Reservoir Characterization, Case Study: Abu El-Gharadig Basin, Egypt*

Munir El-Mahdy[1,2], Elhamy Tarabees[2], Ali Bakr[3], and Ali Farag[4]

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[1]Khalda Petroleum Company (KPC), Cairo, Egypt (munir.elmahdy@khalda-eg.com)
[2]Faculty of Science, Damanhur University, Beheira, Egypt
[3]Exploration Consultant, Egypt
[4]Faculty of Engineering, British University in Egypt, Cairo, Egypt

Abstract

Polygonal faults are unique, non-tectonic connected normal faults observed in many sedimentary basins worldwide. Although many scientists consider them as an important pathway for the fluid escaping, the impact of these faults on tight carbonate reservoirs is still poorly defined. The data obtained from the 3D seismic attribute and interpretation in line with the wire line logging interpretation of the Abu El-Gharadig Basin has revealed a network of extensional normal faults that affect the Middle Eocene chalk of the Apollonia Formation. This carbonate is considered a viable gas bearing reservoir characterized by its high porosity and low permeability. The aim of this study is to characterize the development of these faults and define their effect on the drainage character of the reservoir.

Structural analysis of these faults aids in the determination of the permeability and transmissibility of each fault zone. Based on the available data, the structural characterization of these faults is in accordance to the known structural feature “polygonal fault system”. Structural analysis elucidates low values of shale gouge ratio and high values of permeability for most of the fault zones. This could be applied to consider the polygonal faults in the Apollonia Formation as a permeable pathway for the fluid flow which improves the overall drainage character of the carbonate reservoir. This work illuminates the importance of the detailed structural analysis of faults to determine their impact on the reservoir characterization of tight, highly faulted, carbonate reservoirs.

POLYGONAL FAULTS IMPLICATION ON THE CARBONATE RESERVOIR CHARACTERIZATION CASE STUDY: ABU EL-GHARADIG BASIN, EGYPT.

Munir El-Mahdy[1]*, Elhamy Tarabees[2], Ali Bakr[3], Ali Farag[4], *munir.elmahdy@khalda-eg.com

1. Khalda Petroleum Company (KPC), Egypt.
2. Faculty of Science, Damanhur University, Beheira, Egypt
3. Exploration consultant.
4. Faculty of Engineering, British University in Egypt.

ABSTRACT

Polygonal faults are unique, non-tectonic connected normal faults observed at many sedimentary basins worldwide. Although many scientists consider them as an important pathway for the fluid escaping, the impact of these faults on tight carbonate reservoirs still poorly defined. The data obtained from the 3D seismic attribute and interpretation in line with the wire line logging interpretation of the Abu El-Gharadig basin has revealed a network of extensional normal faults affect the Middle Eocene chalky of the Apollonia formation. This carbonate is considered as a viable gas bearing reservoir characterized by its high porosity and low permeability. The aim of this study is to characterize the development of these faults and define their effect on the drainage character of the reservoir. The structural analysis of these faults aids in the determination of the permeability and transmissibility of each fault zone. Based on the available data, the structural characterization of these faults are in accordance to the known structural feature "polygonal fault system". Structural analysis elucidates low values of Shale Gouge ratio and high values of permeability for most of the fault zones. This could be applied to consider the polygonal faults in the Apollonia Formation as a permeable pathway for the fluid flow which improves the overall drainage character of the carbonate reservoir. This work illuminates the importance of the detailed structural analysis of faults to determine their impact on the reservoir characterization of tight, highly faulted, carbonate reservoirs.

Polygonal Faults

- Unique, non-tectonic connected normal faults developed mainly in passive margin or intracratonic basins
- Confined to a specific stratigraphic interval known as a "tier" i.e. it is a layer – bound structure.
- Characterized by random orientation of the faults in addition to their extension for a huge areas (Cartwright, 2011).
- Found mainly in low – energy depositional environment with a fine – grained sediments ranging from smectite clay to chalk.
- Many scientists referred to the important role of the polygonal faults as a pathway for the fluid escaping.
- In Egypt, the polygonal faults were recognized by Tewksbury et al., 2014 on an on-land exposure in the chalk of the Late Cretaceous Khoman formation at the Farafra Oasis, Egypt.
- The present study is a new report of the polygonal fault system in the Apollonia formation of the Abu El-Gharadig basin.

The Aim of study

- Evidence for the new presence of the polygonal fault system in subsurface carbonate reservoir in Egypt.
- Define the impact of these faults on the fluid flow characterization of the reservoir.

Abu El-Gharadig Basin

- It is an E – W trending intracratonic rift basin, considered as a part of the unstable tectonic shelf in the northern Western Desert of Egypt (Fig.1A)
- Abu El Gharadig basin has a very thick Paleozoic to recent sedimentary section which varies in its composition from continental, shallow marine and deep marine deposits.
- It is very mature hydrocarbon basin with over 95% of the oil and gas fields in the upper Cretaceous Abu Roash and Bahariya formations (Strating and Postuma, 2008).

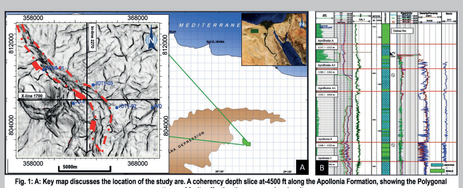

Fig. 1: A: Key map discusses the location of the study are. A coherency depth slice at-4500 ft along the Apollonia Formation, showing the Polygonal patterns of faults affecting the concerned rock units
B: Detailed composite wireline log of JDT-4 well with the top of the main Apollonia members

Apollonia Formation

- In Abu El-Gharadig basin, Apollonia formation is an Upper Paleocene to Middle Eocene formation, overlain by Dabaa shale (Oligocene) and underlain by the limestone of Khoman Formation (Upper Cretaceous).
- It is divided into four members, A, B, C & D. Apollonia A & C members have the most porous gas – bearing carbonates while B and D members are mainly shale (Fig.1B).
- The pay zones are composed mainly of pelagic chalky limestone with terrigenous clays ranging from 0% (clean chalky limestone) – 35% (marl)
- Conventional core measurements show a permeability ranging between 0.01 and 0.90mD; whereas porosity ranges between 14.9% and 39.80%.

Methods

- An integrated workflow of geophysical seismic techniques and wireline logging interpretation is discussed in fig. (2).

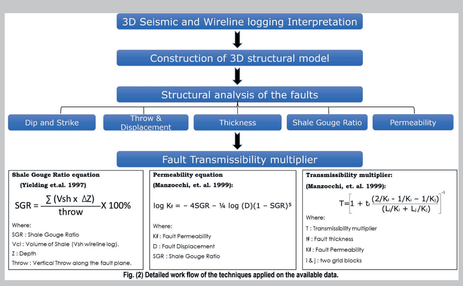

Fig. (2) Detailed work flow of the techniques applied on the available data.

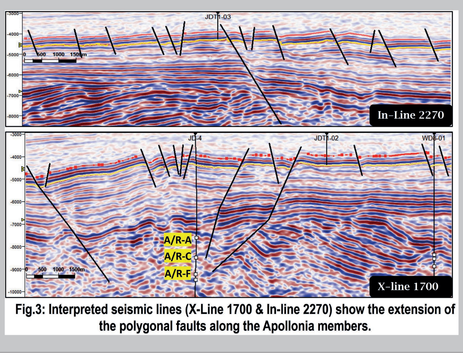

Fig.3: Interpreted seismic lines (X-Line 1700 & In-line 2270) show the extension of the polygonal faults along the Apollonia members.

Results

- An array of closely spaced normal faults bounded by the fine – grained sediments (chalk and clay) is reported in the upper two members of the Apollonia formation (A & B) (Fig.3).
- They cover the whole area of the seismic volume (about 1100 km²) and it is assumed to extend along the north east portion of the Abu el-Gharadig basin.
- These faults have a polygon shape in map view, with a maximum displacement of 40 – 80m and faults dip between 27° – 88° with random dip and strike directions (Fig.4).
- Structural analysis shows a narrow fault zone thickness for the faults with Shale Gouge Raito (SGR) ranging from 0 to 30% and permeability range from 0.34 to 1.45 mD. It describes most of the faults zone with an open transmissibility multiplier (Figs.5 & 6).

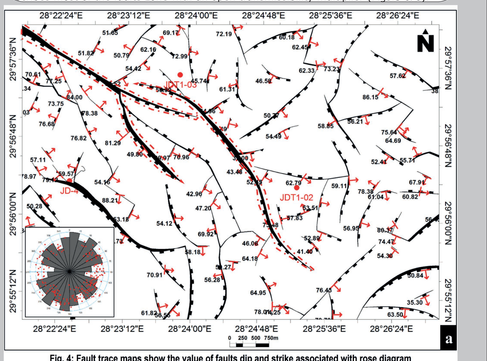

Fig. 4: Fault trace maps show the value of faults dip and strike associated with rose diagram

Discussion and Conclusion

- The characteristics of the structural features in the study are strongly consisting with the typical characteristics of the polygonal fault systems observed at many other sedimentary basins worldwide.
- The Polygonal faults are new structural style affected a shallow, gas-bearing carbonate reservoir of the Apollonia formation in the Abu El-Gharadig basin, Egypt.
- These faults behave as a permeable pathway for the flow of the fluid across the reservoir.
- Determination of this structural style is important in reservoir development and horizontal well planning in the exploration planes.

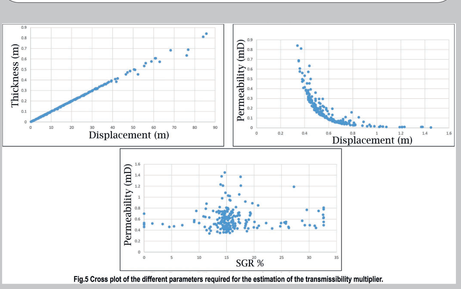

Fig.5 Cross plot of the different parameters required for the estimation of the transmissibility multiplier.

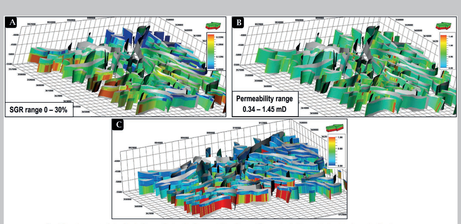

Fig.6 Development of the Shale Gouge Ratio (A); Permeability (B); and Transmissibility multiplier (c) along the Faults zones

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