The Maradi Fault Zone (Oman): Revealing Complex Structural Elements with Multiple and Different Trapping Mechanisms, Awaiting Rediscovery

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Abstract

The Maradi Fault Zone (MFZ) is a key structural element in the Fahud Salt Basin (FSB), which is a prominent lithospheric suture that has been active throughout the Precambrian to the present. Hydrocarbons have been discovered along the MFZ, but the volumes are small, and several wells were not successful. The MFZ is a complex fault zone with different strands and changes in kinematics throughout its evolution. Different plays should be analyzed based on this new understanding which should be linked to a new model of hydrocarbon migration and entrapment. The MFZ defines different trap types with different geometries and kinematics in both basins, FSB and Ghaba Salt Basin (GSB), where several leads/prospects can be identified. These structures/closures are influenced by the deep-seated Ara salt and different tectonic events with extensional, compressional, and strike-slip movements. The lack of Wide Azimuth (WAZ) 3D coverage and the poor seismic quality have delayed any plans for future development.

Studies have been conducted on the MFZ based on fieldwork and using old seismic but since 2006, there have not been new publications, detailed maps, or studies. A more detailed mapping was required to better define the structural elements and the evolution of such a complex fault zone. Petroleum Development Oman (PDO) has acquired and processed many Narrow Azimuth (NAZ) and WAZ 3D seismic volumes since 2006 and produced a Megacell montage of several 3D seismic cubes. The Megacell merging allows full coverage of most of the MFZ. Utilizing the advanced WAZ 3D seismic semblance attribute and in-depth geological field studies and maps, this research provides a novel understanding and mapping of the MFZ. This research study will highlight the structures associated with the MFZ, their geometries, kinematics models, and trap styles. The study also shows a comprehensive analysis of the evolution, sense of motion, and trapping configurations of the MFZ throughout these different stages.

The most recent WAZ 3D seismic data reveals the entire structure and continuity of the MFZ for the first time. The MFZ is fully mapped to its near connection to the Haushi-Nafun line that cuts across the Al-Huqf uplift region. New maps have been generated and helped explain why some wells are unsuccessful. The Ibtikar accumulation in the Natih reservoir was the focus of detailed 3D mapping as a case study to define its structural elements. Also, the Natih horizon was mapped along the different strands of the MFZ. The character of the deformation shows that compartmentalization is a common issue for any new discoveries or re-evaluations.

These maps and fault geometries form the basis for our conclusions.

Our study shows the benefits and impact of WAZ seismic and processing towards reopening old frontiers which were initially considered too risky and difficult to understand. It also shows the importance of using detailed structural analysis and mapping to properly unravel the elements and trapping mechanisms of complex fault zones. Modern techniques of hydrocarbon extraction and careful management of greenhouse gases can provide a more energy-efficient future for Oman.