Fault Control on Hydrocarbon Distribution in North Carnarvon Basin, NW Shelf Australia

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Abstract

North Carnarvon basin was created due to the rifting in Mesozoic, which resulted in the separation between India and Australia. Key reservoirs of the area are Upper Triassic and Lower Cretaceous sandstones. There are many discoveries within these two reservoirs in southern part of the North Carnarvon basin, but all wells drilled in the northern part are dry. The dominant migration pathways from source to reservoir are faults. This study is aimed to check the possibility of lack of migration pathways or breach of fault seals. Seismic interpretation results show two types of faults in study area. First type is the rifting faults in Upper Triassic to Lower Jurassic strata that created the Triassic tilted fault blocks. Second type is the reactivated faults that cut to the Lower Cretaceous sandstone reservoir in southern part of study area and strongly affect the Upper Cretaceous to Tertiary strata in the zone of unsuccessful hydrocarbon exploration. The rifting faults are the main control of Triassic faulted block traps and the migration pathway from source to Upper Triassic and Jurassic reservoirs while the reactivated faults are the main control of migration pathway from source to Lower Cretaceous reservoirs in the central area and possible cause of hydrocarbon leak in the north most part.

Keywords: North Carnarvon basin, hydrocarbon distribution, rifting, reactivated fault.

1. Introduction

Carnarvon basin lies in NW shelf of Australia. The basin evolution is related to the rifting that separated India from Australia in Mesozoic (Mann et al., 2003). Upper Triassic and Lower Cretaceous sandstones are the two reservoirs separated by thick Jurassic shale sequence. The reported source rocks of the area are shale of Triassic and Jurassic age (Exon & Willcox, 1978 and Geoscience Australia 2010). Dominant play types in the area are tiled fault bounded sequences and migration pathways from source to reservoir are along deep faulted zones. There are many discoveries within Triassic sandstone but in the northeastern part, there is no gas discovery. The most important controlling factor for the distribution of the hydrocarbon might be faults. Therefore the present study is aim to explore the role of the faults for hydrocarbon distribution. This research will benefit the future exploration in the area and reduce the risk for exploration of hydrocarbon.

2. Method

In order to tie well and seismic synthetic seismograms were generated by using sonic and density curves. To identify major structures in the area vertical seismic sections were interpreted followed by time structure maps. I also prepared isopach maps to observe the variations in sediment thickness through different geological times. The tracked horizons were Upper Triassic (pre-rift), Upper Jurassic (syn-rift), Lower and Upper Cretaceous (post-rift).

3. Result

The results show horst, graben and half graben structure in Triassic fault blocks. Different fault patterns were observed in different part of the area. The southwestern part of study area is dominated by the half graben and minor horst structure while half graben, graben and horst structure are dominated in northwestern part of study area. In the central part, the dominant structure style is of half graben and graben structure. The southeastern part of study area is the horst structure. The Upper Jurassic sediments are unconformable to Triassic sediments, because of fault block tilting. This represents that the fault rifting started in Upper Triassic to Lower Jurassic. End of rifting was marked by onlap structure that was observed in the syn-rift package. Figure 1 shows that the southern part of the area has onlap in Upper Jurassic while the northern part of the study area show the onlap structure later than Upper Jurassic, probably within the Lower Cretaceous. Hence, the timing of cessation of the rifting may be Jurassic in the south and it might continue until Lower Cretaceous in the north.

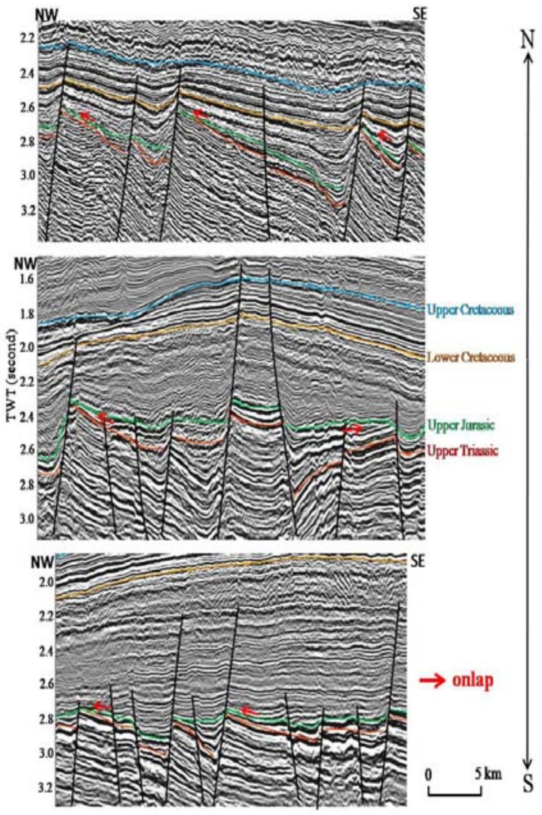

Figure 1. Faults evolution in the study area.

4. Discussion

The area can be differentiated in the three zones. First is Gas & Oil prone area in the southeastern part of the study area. Second is Gas prone area, which is in the centre region of study area. Third is the northern part of the study area, which is dominated by dry wells. Combining the results here, I shall discuss about the model of hydrocarbon distribution in the study area.

Southeastern part of study area probably has two source rocks which are Upper Triassic gas prone source and Upper Jurassic Dingo claystone in east of this area, which produces gas & oil both. There is only one reported reservoir in Upper Triassic (Figure 2). In the central and southern part of study area, there are three gas reservoirs.

These reservoir sandstones are of Upper Triassic, Upper Jurassic and Lower Cretaceous age. On the other hand, there is only one proven source rock of Upper Triassic age in the area under discussion. The migration pathways from this single source to three reservoirs of different levels are different. Upper Triassic reservoir can be vertically charged from underlain Triassic source rock in southern part. The second reservoir, which is of Upper Jurassic age, can be charged from Upper Triassic source through faults. While the Lower Cretaceous reservoir can be charged through faults (Figure 3). In the northern part of the study area, there are dry wells and this part has many faults continuing up to Upper Cretaceous, which breached the seal in the part of the study area (Figure 4).

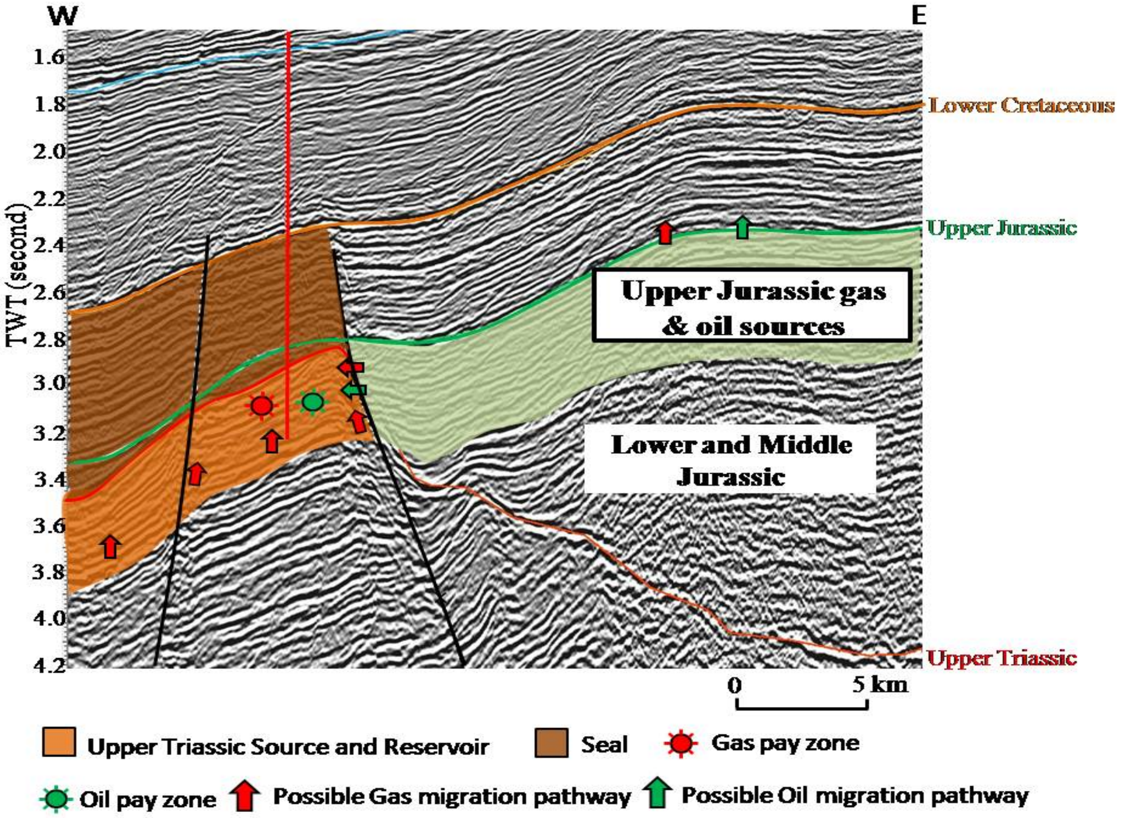

Figure 2. Possible migration pathway in the southeastern part of study area.

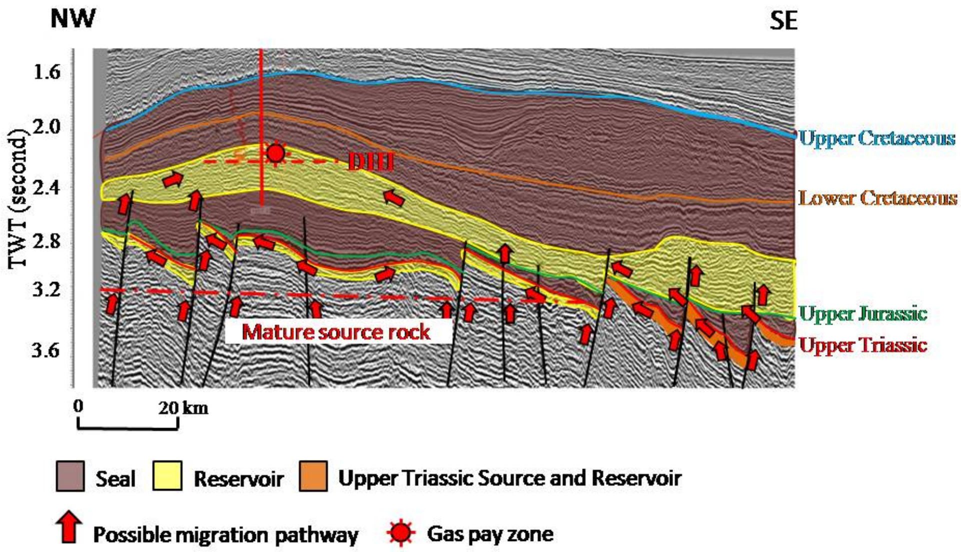

Figure 3. Possible migration pathway from Upper Triassic source to Lower Cretaceous reservoir.

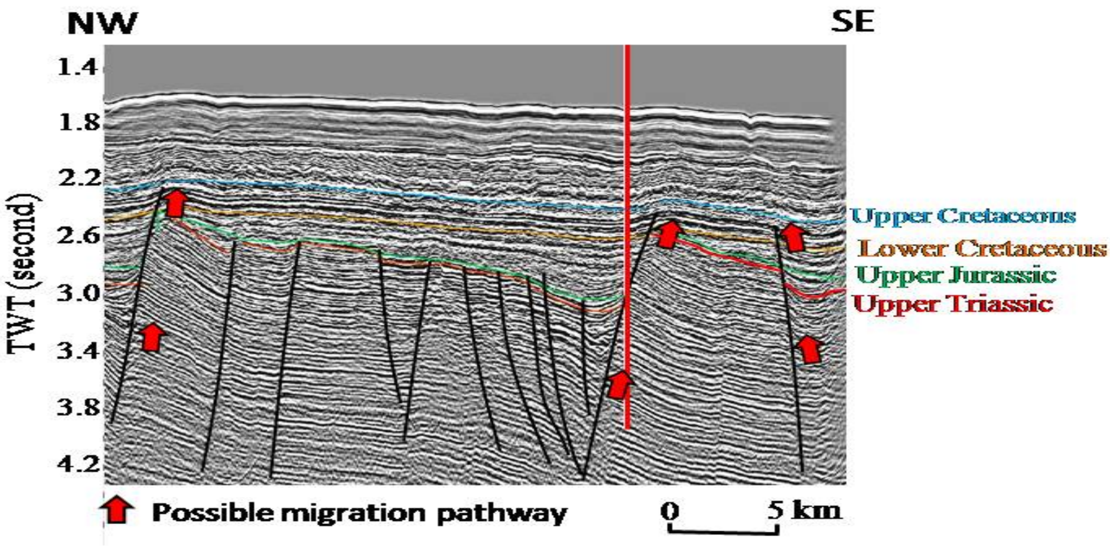

Figure 4. Possible hydrocarbon leak along faults in northern of study area.

5. Conclusion

Faults are the main factor to control the hydrocarbon migration in the area and there are two fault systems to control the hydrocarbon migration. First type is rift related faults, which started in Lower to Middle Jurassic and created the basins and tilted fault block traps in Triassic rock. The rifting faults control the hydrocarbon migration to trap in Triassic and Jurassic reservoirs. The second type of faults is reactivated ones in Cretaceous to Tertiary age. These are present only in the northern part of the area. The reactivated faults are the main factor for migration of the hydrocarbons from Upper Triassic source to Cretaceous reservoirs and possibly contribute to fault leaks in the northern part of the study area.

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