The Study of the Deepwater Clastic Depositional Systems and Reservoir Distribution in East Andaman Basin, Thailand

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Abstract

The Andaman Sea deepwater area is a challenging new exploration play for potential hydrocarbons in western offshore Thailand. Little is known of this area and this study focuses on depositional processes in the deepwater environments in an area of the East Andaman Basin where 3D seismic data has recently been acquired. This study focuses on the Middle to Late Miocene section in the early post-rift stage of the basin development. Deepwater depositional packages were identified which are potential reservoirs in this study area by using seismic facies analysis, thickness variations from time isochron of depositional packages and RMS amplitude extractions. The interpreted 3D model of the paleo-topography at the time shows three canyons incised into the South Sagaing fault scarp to the east which were the conduits for potentially course grained deepwater sediments into the area of interest. A total of five seismic horizons were mapped and 12 depositional packages identified which consisted of submarine talus / base of slope deposits, submarine channels and submarine fans, all of which relate to the three main submarine canyons. Up-dip erosion of the exposed Mergui Ridge acted as the potential source area for sediment that was re-worked and deposited within the deep marine environment in the study area. Reservoir potential based on seismic facies analysis of the seismically defined high amplitude packages is good based on comparisons with analogous features in other deepwater basins which have well data to confirm their lithologies.

Keywords: East Andaman Basin, turbidites, deepwater depositional processes

1. Introduction

This study focuses on an area within the East Andaman Basin, offshore Southern Thailand that has potential for hydrocarbon bearing reservoirs in a deep marine sedimentation system (Figure 1). Deep marine clastic sediment reservoirs are a relatively new concept in Thailand petroleum exploration and this basin is a frontier exploration area where no wells have been drilled to date. The basin has been within a deep marine environment since Early Miocene to present day with present water depth between 1000 to more than 2500 meters. The research interval focuses on the Middle to Upper Miocene section in an area where a newly acquired 3D seismic data set can be used to better understand basin topography and its control on the deep marine sedimentation processes.

2. Objectives

The aim of this study is to map the paleo-topographic and depositional features of the Middle to Upper Miocene stratigraphic interval including the mapping of submarine canyons, submarine fans and submarine channel systems. From this mapping the sediment supply direction and evolution of the deep marine clastic sedimentation can be interpreted and evaluated for its reservoir potential. The 3D seismic was the primary data set used with other support data including the regional 2D seismic data set, well data and previous study information.

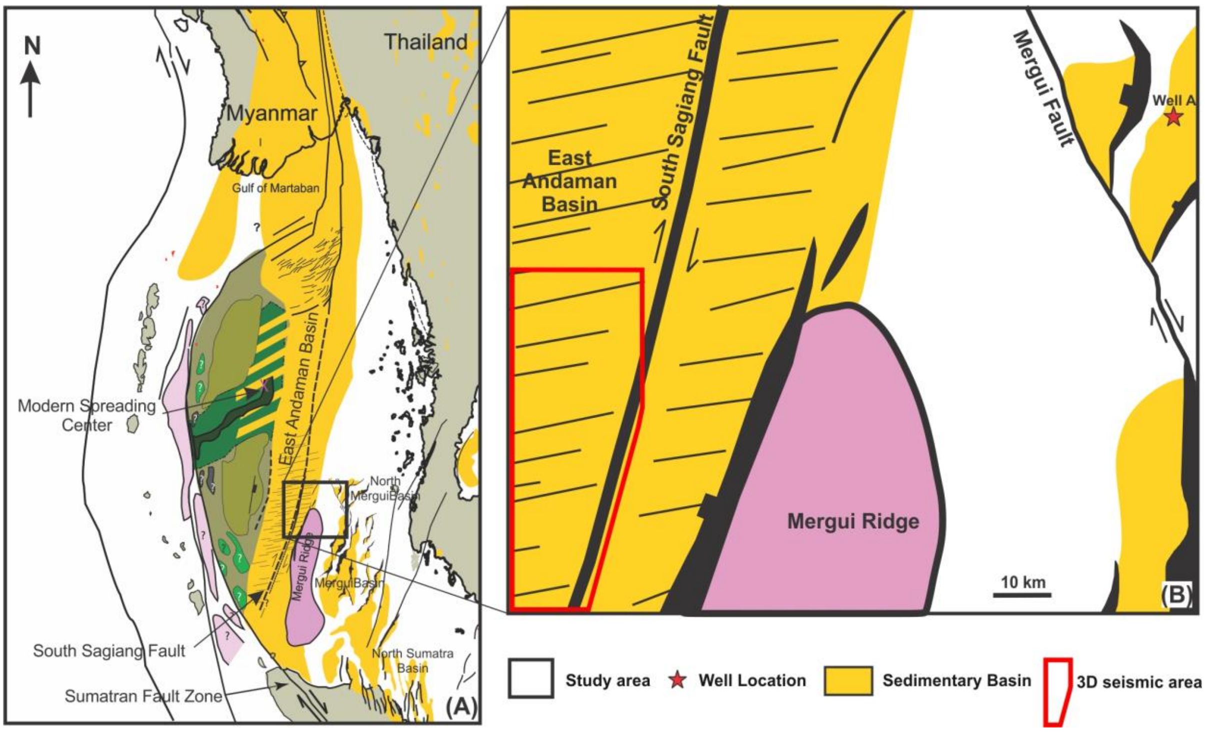

Figure 1. (A) The location of East Andaman Basin offshore Thailand and tectonic elements of the area. (B) A detailed map of the tectonic elements in the study area with location of 3D seismic highlighted. (Modified from Srisuriyon and Morley, 2013).

3. Database and Methods

This study mainly used 3D seismic reflection data set which covered part of the East Andaman Basin and a portion of regional 2D seismic reflection data near well A and extending to the area of the 3D seismic data. Well data which included well logs, mud logs and a biostratigraphy report were used to correlate lithology and ages of the sequences to the seismic data in study area. Kingdom and Interactive Petrophysics software were use for this research for working on seismic and well log data respectively. The data quality is good for interpretation in both seismic and well log data.

4. Results

Five seismic horizons were interpreted on the 3D data set. Each horizon was chosen to reflect significant structural or sedimentary events within the interval of interest in the basin. The horizon interpretation was complicated by the complex structure of the highly faulted area related to the syn-rift. Reactivation of many of the faults continued through to the top of Upper Miocene. Two key horizons were correlated from well A located approximately 100 kilometer to the NE (Figures 2). These were defined as the Top Early Middle Miocene (Hz2) and the Top Upper Miocene (Hz5) and they bound the top and base of the stratigraphic interval which showed the greatest potential for hosting deepwater reservoirs in the area. Figure 2A indicates that the South Sagaing fault was active before Mid Miocene and had a considerable influence on depositional systems in the area through the Upper Miocene, and continuing through to the present. It is the up-dip boundary for the interval of interest in this study. The interpreted seismic horizons are representative of the structural and stratigraphic style of the area of interest. A generally wedge-shaped section of sediment was deposited on the downthrown side of the South Sagaing fault, its thickest part close to the fault escarpment.

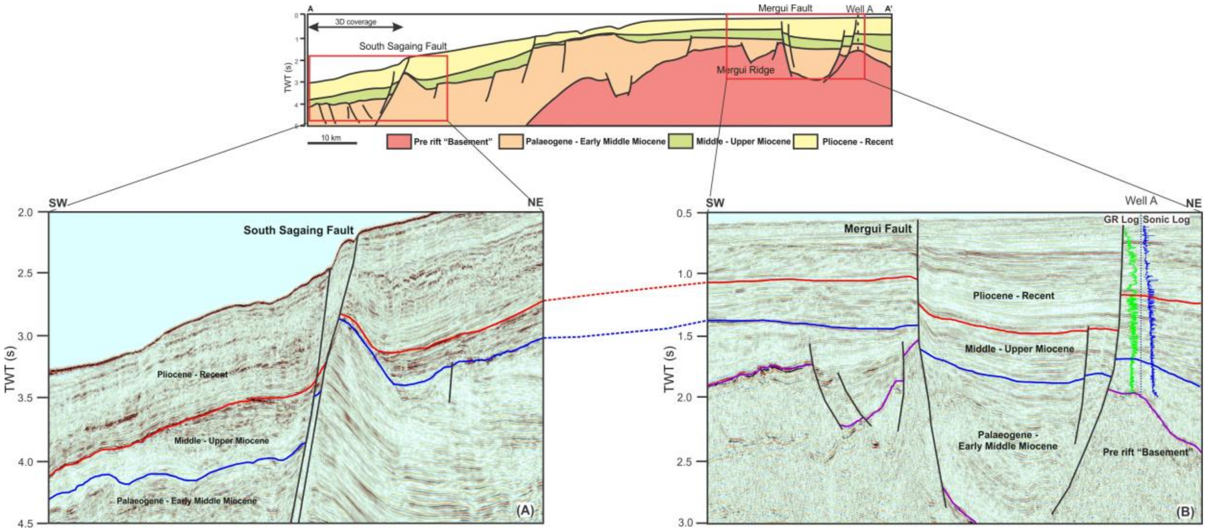

Figure 2. The 2D seismic sections show the correlation of two key horizons from well A to the 3D seismic data area. The cross-section shows the location of each seismic section (A) and (B).

High amplitude reflection packages are observed intermittently in a background of overall low amplitude. These high amplitude packages are of interest as they represent possible reservoir quality sands within a predominant fine grained depositional environment.

Time structure maps were generated for each seismic horizon and time isochron maps were generated for the intervals between horizons. The time structure map for seismic horizon 2 (Hz2) (Figure 3A) is the key structural map to show paleo-topography which controlled sediment distribution during this time.

Time isochron maps and the RMS amplitude extractions linked to the interpreted intermediate horizons, were used to support the interpretation of the internal depositional features and the potential reservoir distributions. Based on this analysis, 12 depositional features were categorized in the study area and they are summarized in Figure 4 within a chronostratigraphic framework. The RMS amplitude map extracted from interval between Hz2 and Hz3 show submarine channel and submarine fan feature in Figure 5.

The 3D models of the seismic horizons were generated to better understand the basin paleo-topography and how it effects the depositional style of the deep marine clastic sediments.

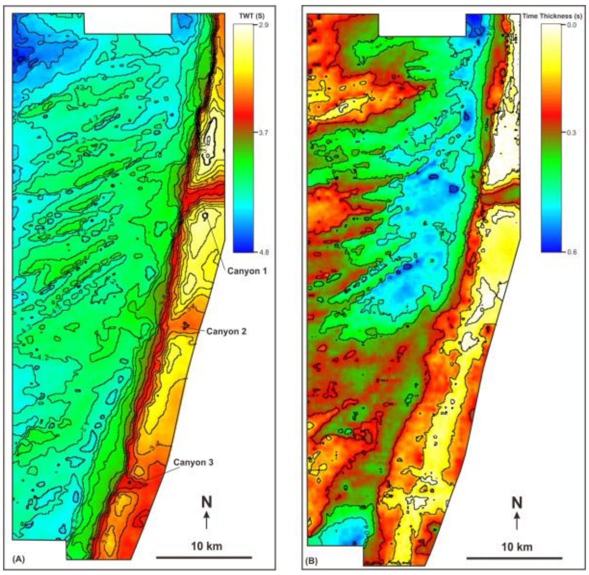

Figure 3. (A) Time structure map of the top syn-rift (Hz2) with location of three canyons. (B) The time isochron map of the stratigraphic interval of interest, the Early Middle Miocene to the top Upper Miocene (Hz2 to Hz5).

The sediment depositional episodes during this period (Figure 6) show a clear underlying structural control of the-depositional geometries in the deeper deposits (Figure 6C) which continuous into the middle section (Figure 6B) related to Hz3. There is a clear effect of structural control on depositional feature in channel 3b. Even in the upper depositional unit associated with Hz4, structural control is evident on the depositional feature in channel 4a (Figure 6A).

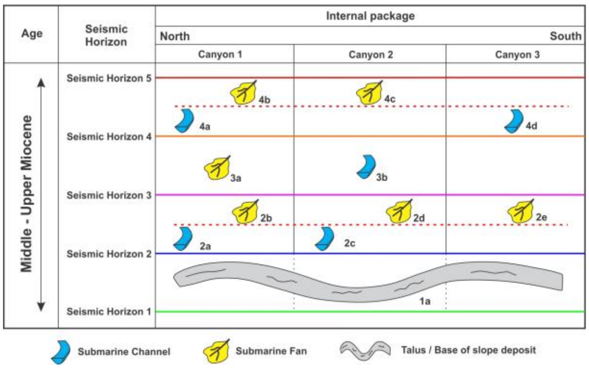

Figure 4. The simplified chronostratigraphic section of study area with internal depositional features.

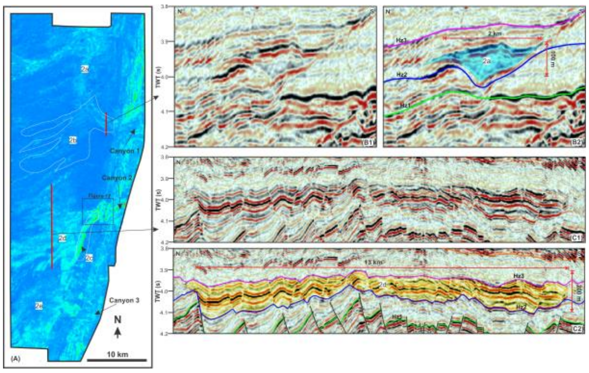

Figure 5. (A) The RMS amplitude map extracted from Hz2 and Hz3 show channel and fan features. (B1) and (C1) show uninterpreted seismic sections through packages 2a and 2d respectively (see Figure 8). (B2) and (C2) show interpreted seismic sections which highlight the submarine channel and submarine fan respectively.

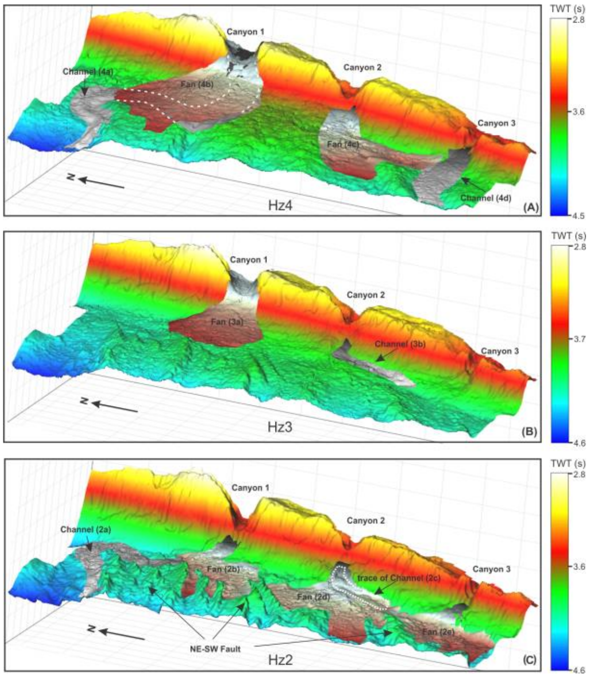

Figure 6. 3D model show basin fill at three different times with the submarine channels and fans deposited follow structural control and related to the feeder canyons.

5. Discussion

The deepwater packages interpreted in the study area are linked to three main canyons to the east of the basin which cut through the South Sagiang Fault scarp which forms the eastern boundary of the study area within the East Andaman Basin. An area of erosion up-dip across the Mergui Ridge is interpreted to have supplied sediment to both Mergui Basin in the east and East Andaman Basin to the west of the ridge (Jha et al, 2012). Eroded and re-worked Paleogene to Early Middle Miocene deltaic sediments are the potential source for the deepwater clastic sediments in study area. Evaluating the distribution of potential reservoirs in these deepwater deposits is dependent on seismic facies analysis. The general seismic character of the Middle - Upper Miocene sequence is low to medium amplitude reflectors with a wedge shaped geometry, parallel internal reflections and showing isolated but distinct high amplitude packages with channel and fan shaped geometries. Three distinct seismic characteristics of depositional packages and the package geometries are interpreted which consisted of, first, the submarine talus / base of slope deposits shown in package 1a, second, the channel packages and third, the fan packages. The interpretation of fan type following Mutti (1985) suggests the submarine fans for this area can be characterized as Type I turbidite system and from the fan morphology these supra-fan lobes are located in mid-fan area based on Normark, 1978 (Figures 7 and 8).

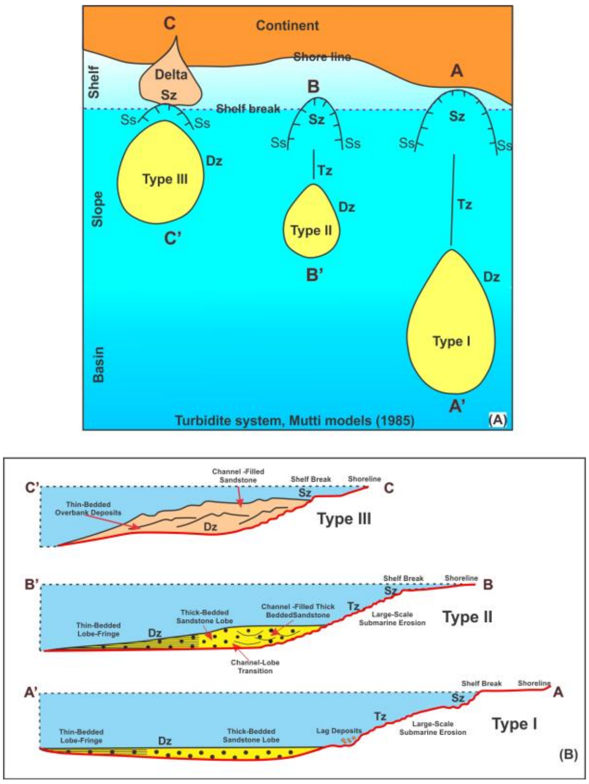

Figure 7. Turbidite system models of Mutti (1985) shown in plan view (A) and cross section (B). Sz = Source zone, Ss= Slump scar, Tz = Transport zone and Dz = Depositional zone.

The interpretation of the fan type based on these two models of both type I turbidites and supra-fan lobes in mid-fan area suggests that these deposits can be sand rich.

An example to further support this interpretation is shown by the seismic sections and interpretation of a submarine fan and channel from the Upper Cretaceous Kyrre Formation, Norway (Jackson, 2007, Figure 9) compared to the fans interpreted in this study. From this field where well data is calibrated to the seismic features, submarine fans and channels consist of sandstone. From this information we can use the seismic data from the North Sea as an analog to indicate potential lithologies that might be encountered in the study area.

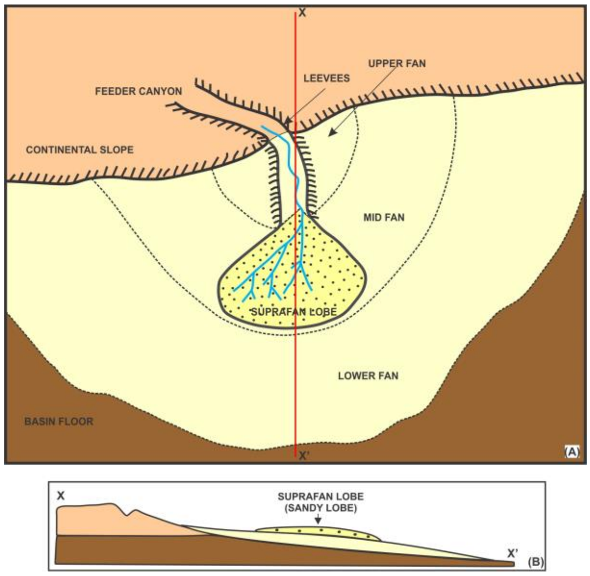

Figure 8. Modern submarine fan morphological features (A) and cross-section (B) (After Normark 1978).

6. Conclusions

In this study a total of 12 deepwater depositional packages within the Middle – Upper Miocene were mapped. These packages were interpreted to have variable clastic reservoir potential for petroleum accumulation in this time interval in East Andaman Basin. All packages were related to 3 main feeder canyons that brought the clastic sediment from the Mergui Ridge to the east into the basin and were deposited within deep marine environments (slope to basin) during the Middle to Upper Miocene.

The results from this study provide an improved understanding of the Middle –

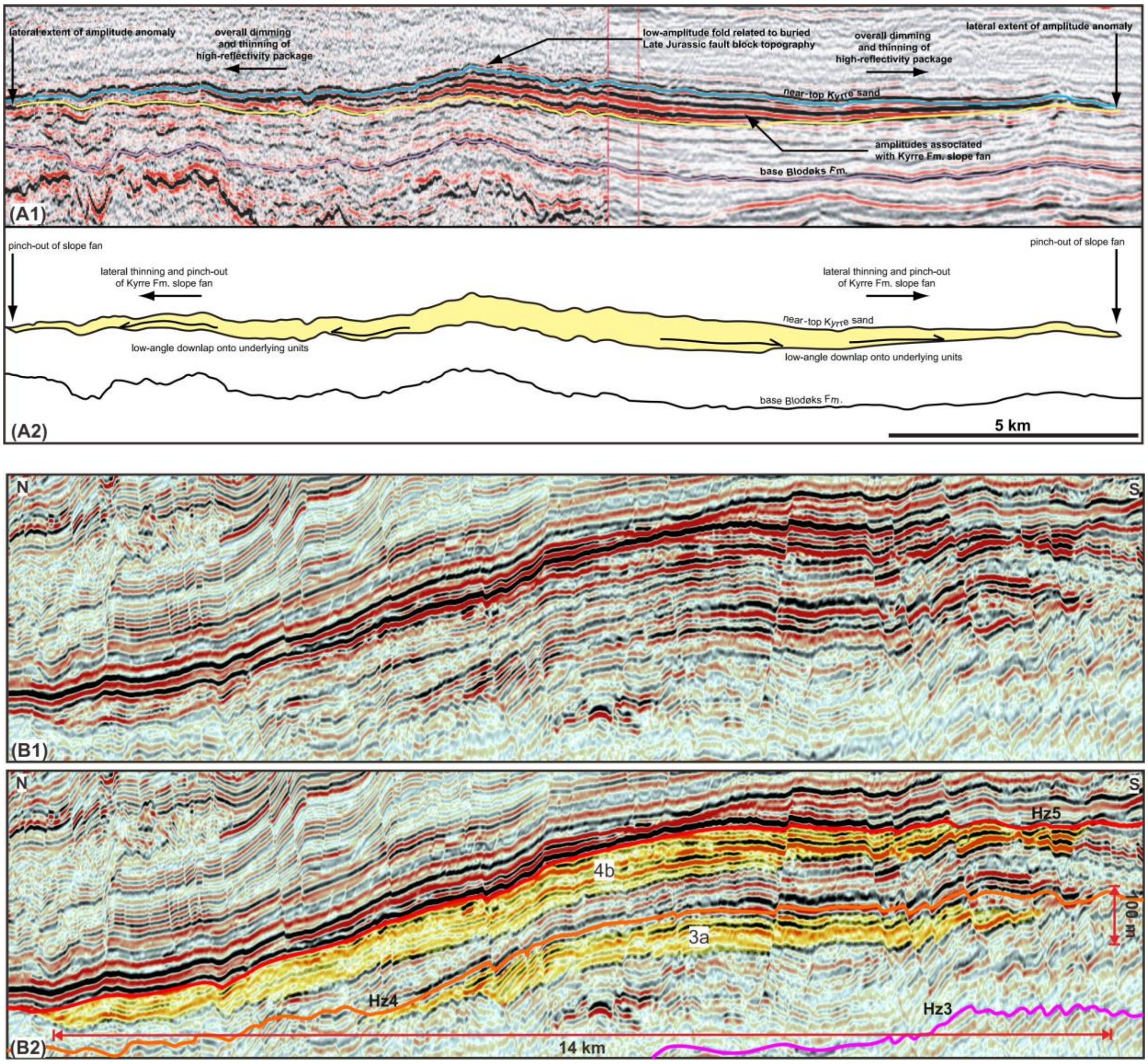

Figure 9. (A1) The seismic sections and (A2) interpretation of a submarine fan from Upper Cretaceous Kyrre Formation, Norway (Jackson, 2007) compared to fan from study area (B1) show the uninterpreted seismic sections through packages 4b and 3a, (B2) show interpreted seismic sections which highlight the two submarine fans (4b and 4c).

Upper Miocene potential for petroleum reservoirs in the East Andaman Basin.

The presence of base of slope deposits, submarine channels and fans implies the potential for sand storage on the slope to basin of this area. The submarine fans and channel fill are potentially good reservoirs observed from the high amplitude packages in RMS amplitude maps whereas the base of slope deposit package has much poorer potential to be a reservoir rock.

7. Acknowledgements

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8. References

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