CHAPTER 4

DISCUSSION AND CONCLUSIONS

Geological structures are important in the field of petroleum exploration. The petroleum industry uses a variety of sophisticated techniques to find the subsurface structures that control the distribution of potential hydrocarbon. The Graben Trend area in the Arthit concession, northwestern margin of the northern Malay Basin, Gulf of Thailand is approximately 450 km^2 with 3D seismic data coverage. The basin formed by rifting in the Early Tertiary, along north-south (N-S) and northwest-southeast (NW-SE) normal faults making a series of asymmetric grabens and half-grabens. Sedimentation patterns and environment of deposition were strongly influenced by local sub-basin topography.

Balanced cross-section construction (Dahlstrom, 1969) is a very useful way to extrapolate surface structures to the subsurface. The basic concept of his method is that the geometric features of any constructed section must be retrodeformable. Cross-section balancing techniques were used in this study to validate existing seismic interpretation and to improve the understanding of the structural development and regional tectonics of the area. Comparison was made between restored sections and the Present-day geometry for any changes in cross-section length of sedimentary layers. There are three regional cross-sections restored sequentially to the geometry at the time of deposition of horizons H3 to H6. These restorations were integrated with well data and used to determine the timing of structural development and calculate the amount of extension during deposition of each horizon.

4.1 Discussion

4.71%, 2.65% and 3.56% accumulative extension took place during the deposition of horizons H3 to H6 (middle Early Miocene to late Middle Miocene) in sections AA’, BB’ and CC’, respectively. The difference in extension values could be attributed to seismic interpretation, folding, accuracy of bed-length measurement and geometrical variation of the structures within the study area.

The study area covers only parts of a rift zone. The observed changes in extension may be a result of lateral geometrical variation along the rift trend or strength variation of the Pre-Tertiary basement. In cross-section AA’ west-dipping faults dominate in the Graben Trend, whereas in cross-section CC’ most faults in the same structure are east-dipping. Kornsawan and Morley (2002) described that the area between fault systems with opposite polarities tend to have faults with small offsets. Therefore, small extension in cross-section BB’ may be a result of the presence of faults with offsets below the resolution of seismic data.

Another reason of the variation in extension was due to human error in bed-length measurement. The bed lengths were measured by hand and extension calculation may have, therefore, inherited a certain degree of inaccuracy. However, considering structural development at a regional scale the results from this study should be acceptable.

The study of structural development can be applied in the evaluation of favorable plays for this basin type as it helps in the interpretation of the timing of trap formation. There are many normal faults, conjugate faults and folding in the study area and there are potential structural traps to be further explored. According to Duval and Gouadain (1994), main oil generation and expulsion of the Oligocene lacustrine source at the basin depocenter occurred at about 16 Ma (late Early Miocene), while the Miocene coal and shale produced hydrocarbons at about 5 Ma (Pliocene). Most normal faults in this study can be related to potential structural traps because they formed before oil and gas generation and expulsion.

Potential traps in section AA' formed in the late Early Miocene in the footwalls of fault numbers 3, 4, 5, 9, and 13 (Fig.4.1). In the early Middle Miocene, footwall traps may have formed along fault numbers 7, 8 and 11(Fig. 4.2).

In section BB', the late Early Miocene traps have been observed at fault number 10 (Fig.4.3). The early Middle Miocene traps have been found along fault numbers 1 and 9 (Fig. 4.4). The late Middle Miocene traps developed along fault number 6 (Fig. 4.5).

In section CC', the late Early Miocene traps occurred along fault numbers 7-10 and 12-15 (Fig. 4.6). The early Middle Miocene traps are located along fault numbers 11 and 16 (Fig. 4.7). The late Middle Miocene traps are associated with fault numbers 1 and 3 (Fig. 4.9).

Three exploration wells have been integrated to the restored sections to evaluate the trap prediction above. Wells Y1, Y2 and Y3 are located at the cross-sections AA', BB' and CC', respectively (Fig. 2.1). These wells were tested with hydrocarbon.

Well Y1 penetrated intervals with gas, oil and water. The late Early Miocene traps are related with gas and the early Middle Miocene traps are related with water (Fig. 4.1).

Well Y2 penetrated intervals containing oil, water and dry sand. The late Early Miocene traps are related with water, the early Middle Miocene traps are related with dry sand and oil was discovered in the late Middle Miocene trap.

Well Y3 penetrated intervals containing gas and water. The late Early Miocene traps are related with gas, the early Middle Miocene traps are related with gas and water showed up in the late Middle Miocene traps.

Therefore the potential structural traps formed in the late Early Miocene traps are located in sections AA' and CC. The early Middle Miocene traps are located in section CC' and the late Middle Miocene traps in section BB'.

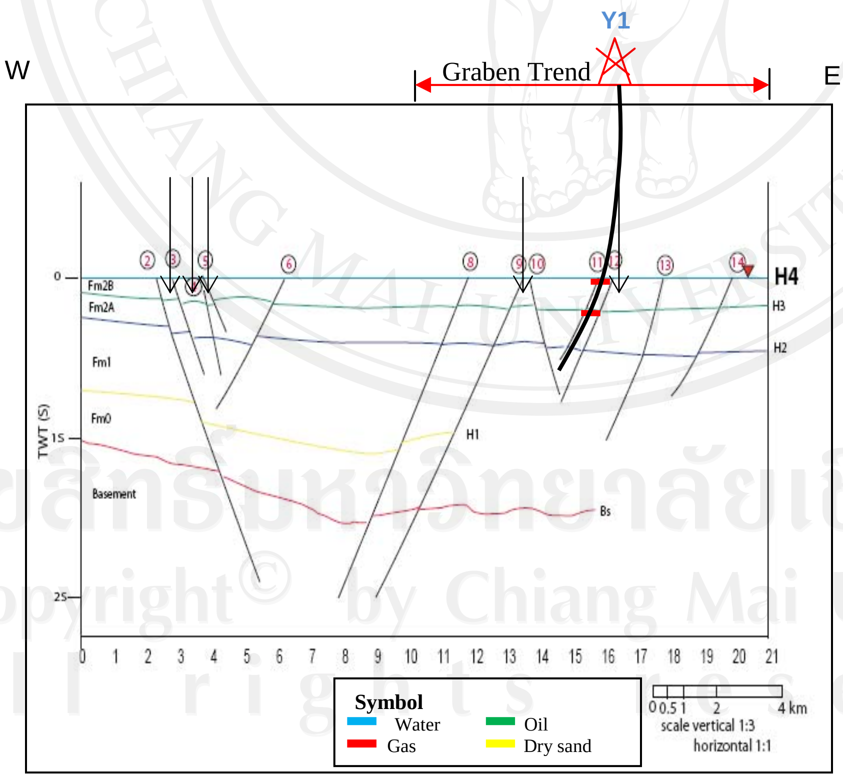

Fig. 4.1 Potential structural traps formed in the late Early Miocene in the footwalls of fault numbers 3, 4, 5, 9, and 13 in section AA'.

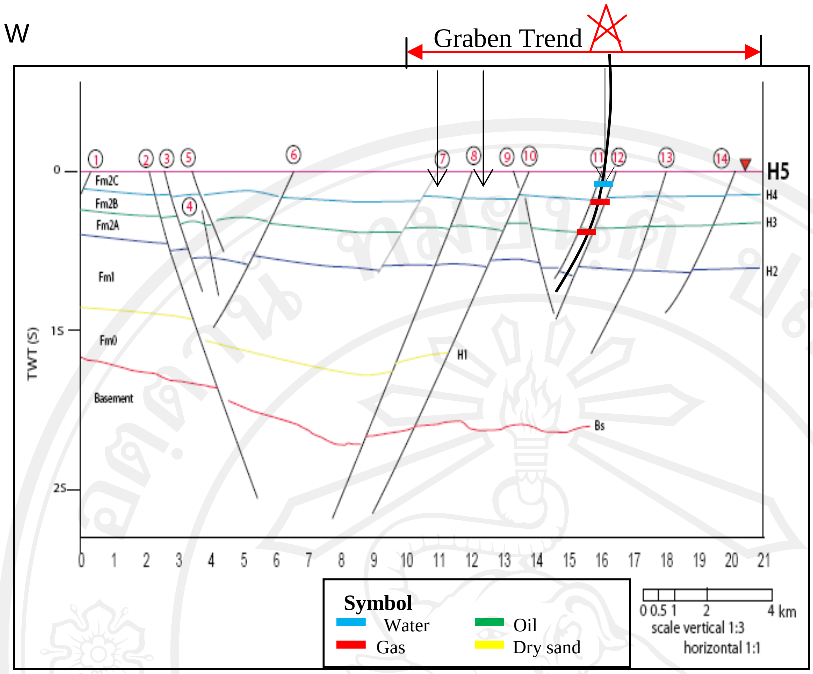

Fig. 4.2 Potential structural traps formed in the early Middle Miocene in the footwalls of fault numbers 7, 8 and 11 in section AA'.

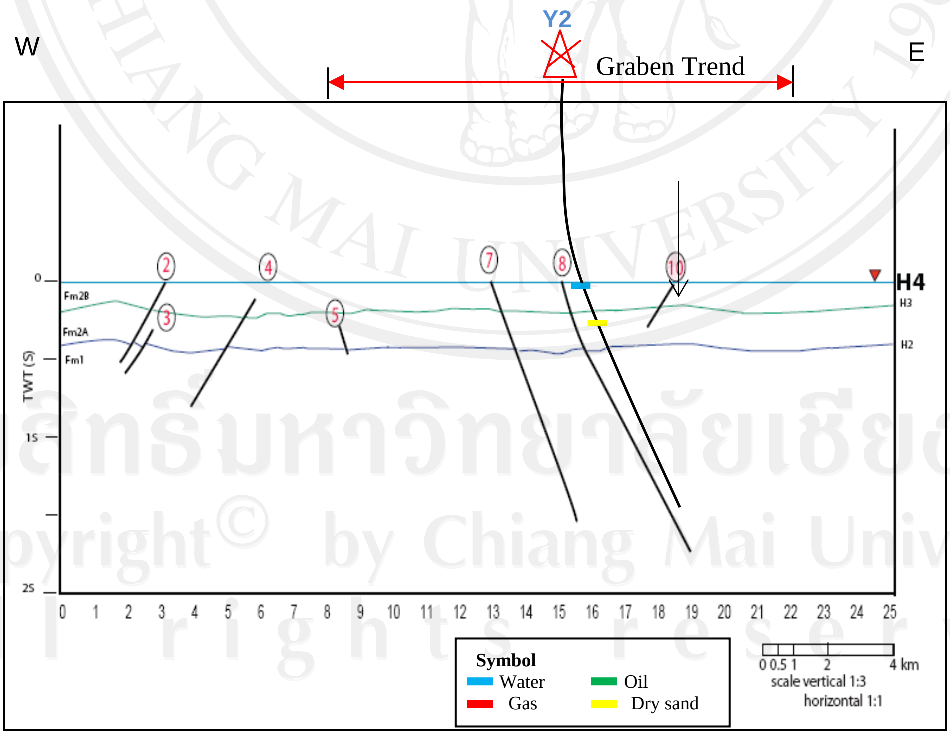

Fig. 4.3 Potential structural trap formed in the late Early Miocene in the footwall of fault number 10 in section BB'.

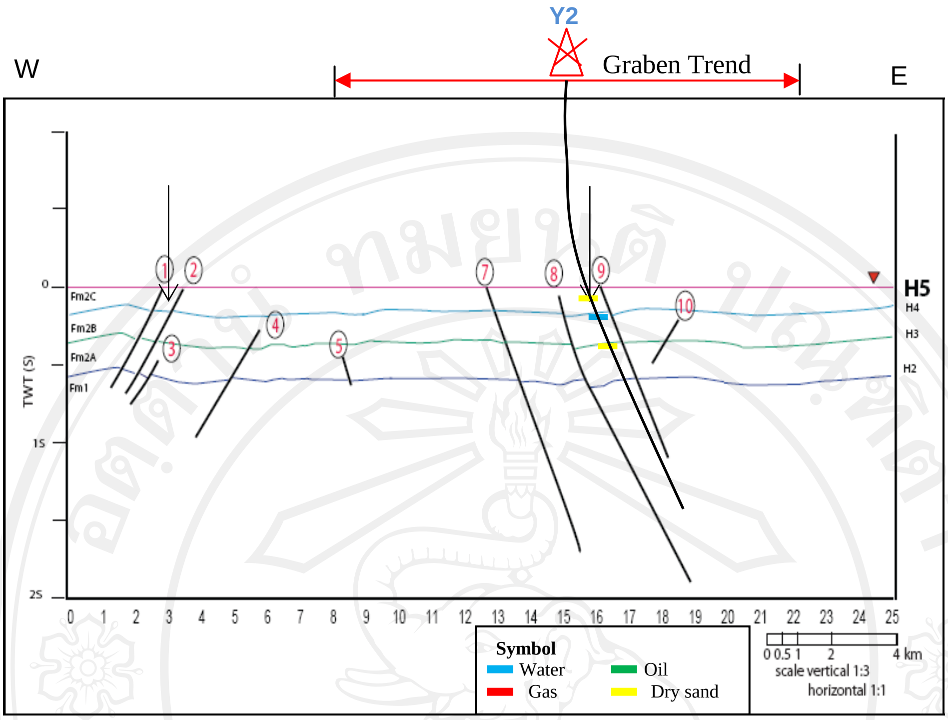

Fig. 4.4 Potential structural traps formed in the early Middle Miocene along fault numbers 1 and 9 in section BB'.

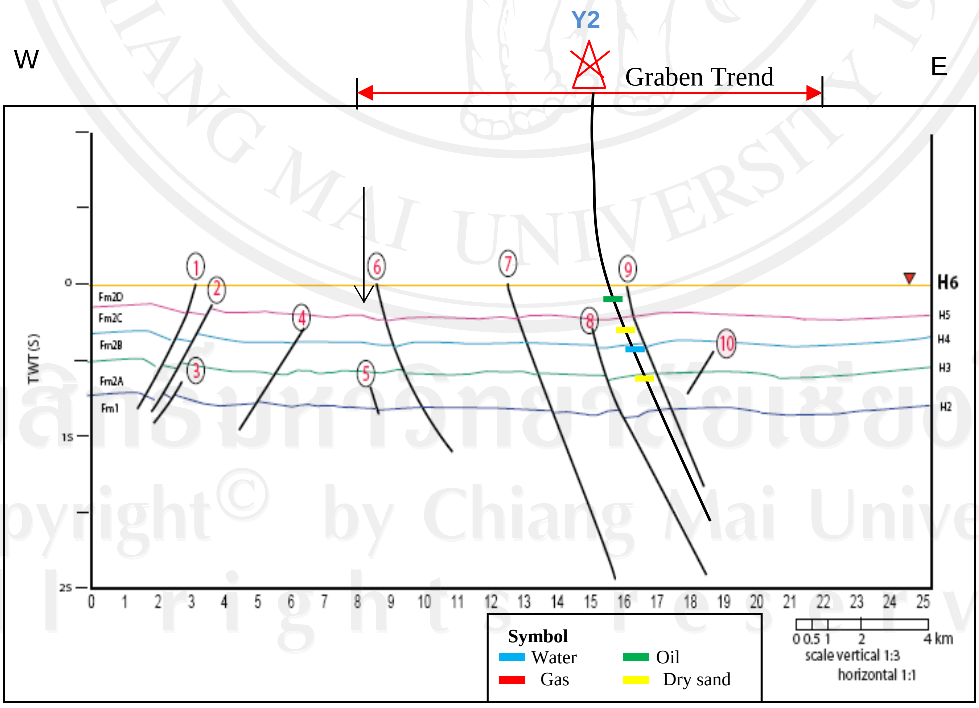

Fig. 4.5 Potential structural trap formed in the late Middle Miocene along fault number 6 in section BB'.

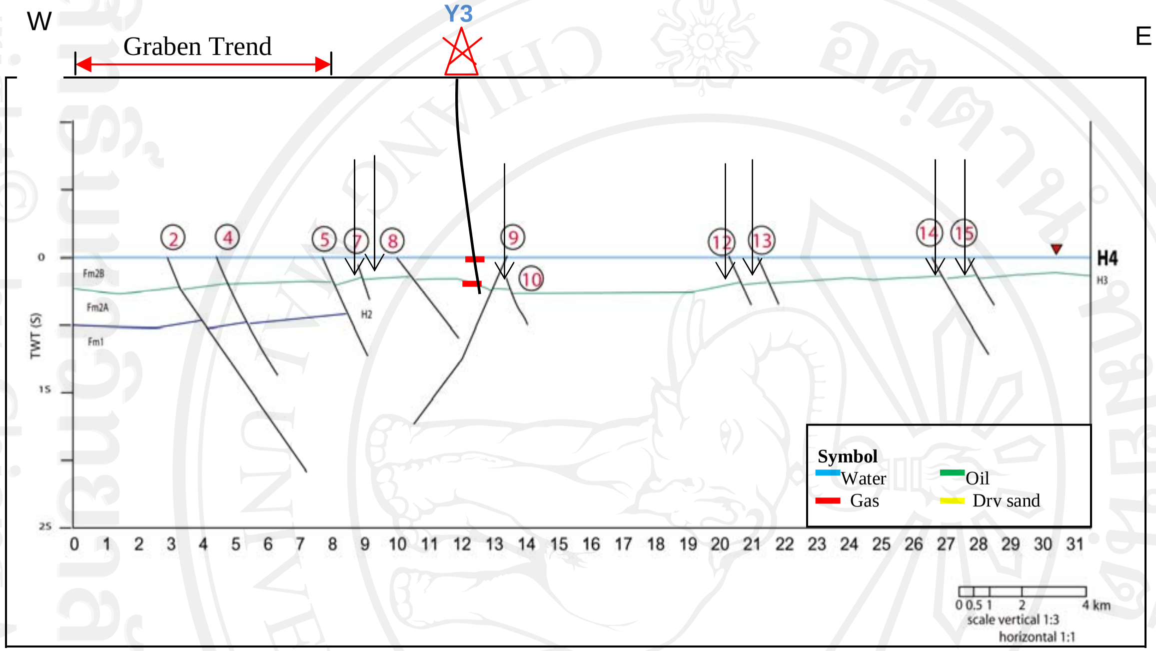

Fig. 4.6 Potential structural traps formed in the late Early Miocene along fault numbers 7-10 and 12-15 in section CC'.

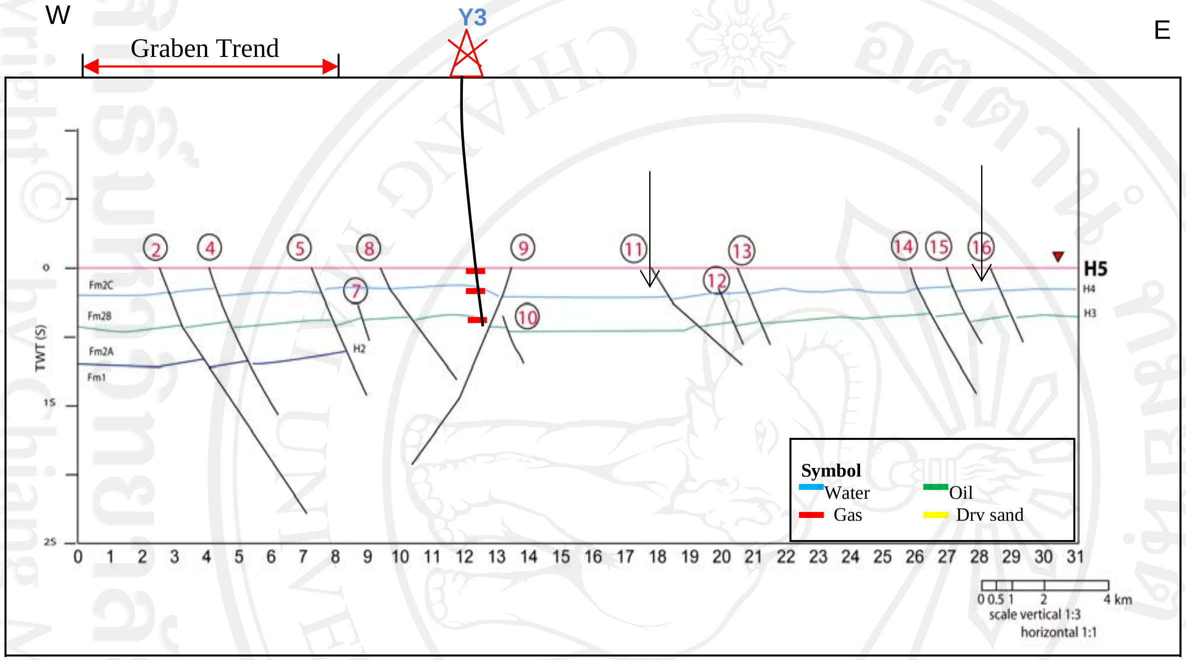

Fig. 4.7 Potential structural traps formed in the early Middle Miocene along fault numbers 11 and 16 in section CC'.

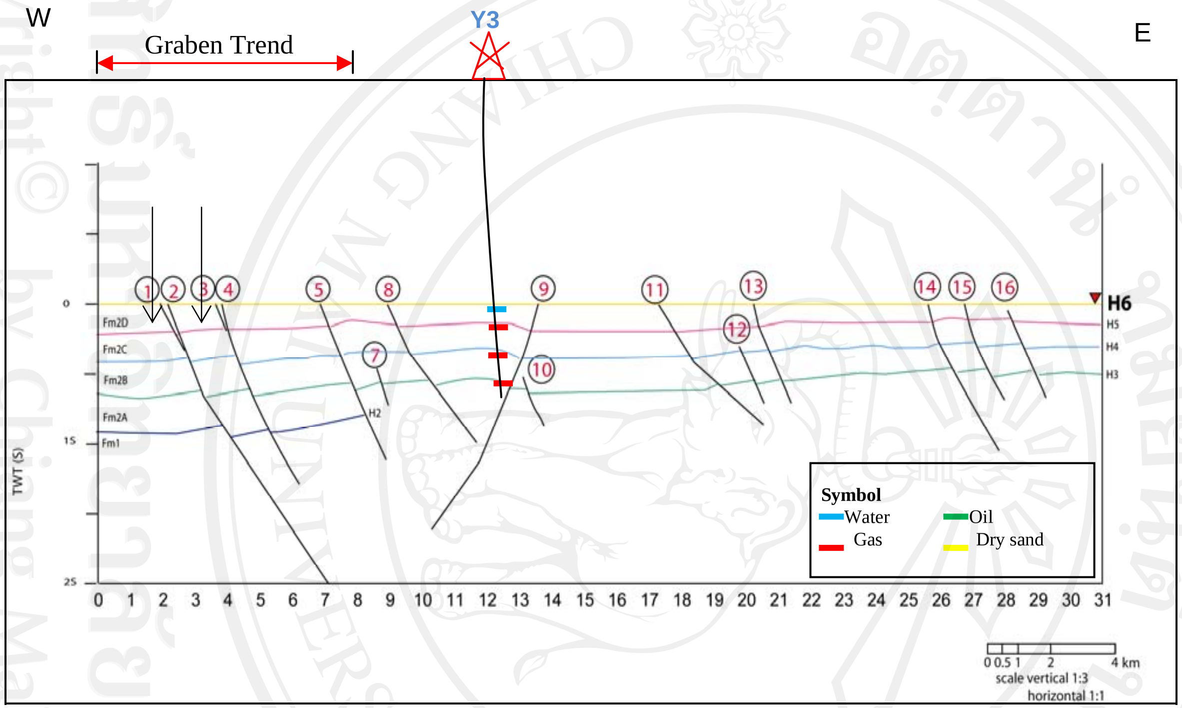

Fig. 4.8 Potential structural traps formed in the late Middle Miocene associated with fault numbers 1 and 3 in section CC'.

4.2 Conclusions

The structural development and its control on sedimentation can be summarized as follows:

1. E-W extension resulted in the formation of N-S trending grabens and half-grabens.
2. Prior to the Miocene many normal fault cuts developed in Graben Trend.
3. During the deposition of horizons H3 to H6 (middle Early Miocene to late Middle Miocene) the extension observed in the Graben Trend is 0.96 kilometers or 4.79% in the northern part, 0.65 kilometers or 2.67% in the middle part and 1.80 kilometers or 3.60% in the southern part at the location of sections AA', BB' and CC' respectively. Normal faults controlled the location of sedimentary depocenters. Large fault displacement can be related to thick sections of formations 0 and 1.
4. The early extension of 0.22%-1.16% occurred in the late Early Miocene after the deposition of Formation 2B. The dominant extension occurred in the northern part of this area. Large displacement of fault numbers 2 and 8 in section AA' resulted in thickening of formations 0 and 1 in the syn-rift succession. In the early Middle Miocene, after the deposition of Formation 2C, 1.06%-1.17% extension occurred. The subsequent regional extension resulted in laterally uniform deposition of formations 2A, 2B and 2C in the post-rift succession. In the late Middle Miocene after the deposition of Formation 2D, 0.53%-1.79% extension occurred. Maximum extension occurred in the northern part of the area at this stage. In the Late Miocene, after the deposition

of formations 2E and 3, 0.53-1.8% extension occurred with a maximum observed in the southern part of the area.

5. Most faults terminated upward at or near the top of Formation 3, above which sedimentary strata were probably deposited during a passive thermal subsidence period.
6. Cross-section restoration can be used to predict the location of potential structural traps with a certain degree of limitation regarding structural variation and data resolution.