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Maturity Modeling of the Songkla Basin

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Abstract

Proven oil wells in Songkhla Basin make a thorough knowledge of the petroleum system in this area important to understand. This study focuses on source rock potential as one element of the petroleum system. Maturity modeling of Songkhla Basin has generated an overview of potential source rocks. The late and early Oligocene and Eocene (?) have good potential to become good source rocks. Further analysis of these three source rocks revealed that only the early Oligocene and Eocene source rocks have reached the oil generation phase. Maturity modeling indicated that source rock in Songkhla Basin is early to middle mature. Structural and depth control made the early Oligocene and Eocene source rock reach the mature stage only in some parts of the basin. A small mature area is located on the eastern flank of the basin and is controlled by the distribution of middle Miocene normal faults. The other mature areas are located in the basin depocenter.

Keywords: maturity, source rock, Songkhla Basin

1. Introduction

The Songkhla Basin lies to the south of Chumphon Basin and is separated from it by the Ko Kra Ridge. The study area is approximately 1800 sq km (Figure 1). The objective is to generate maturity models that correspond to the known characteristics and distribution of Songkhla Basin potential source rocks.

2. Methodology

This research was supported by data from five exploration wells and consisted of wireline logs, geological reports, biostratigraphy reports, a geochemical report and seismic lines. Stratigraphic features such as formation tops, ages, unconformities and thickness were defined by wireline logs, cutting samples, cores in some intervals, and palynological data. Interpretation of organic matter was conducted by visual and rock-eval pyrolysis analysis and kinetic parameters from each well. Interpretations of organic matter and kinetic parameters were always linked to depth.

Maturity profiles were generated from four of five existing wells and eleven pseudo-wells created to model areas that are not covered by the five wells. Assumptions about organic matter and kinetic parameter values between wells and stratigraphic correlation along the basin was used as the basis for input in the pseudo-wells (Figure 2).

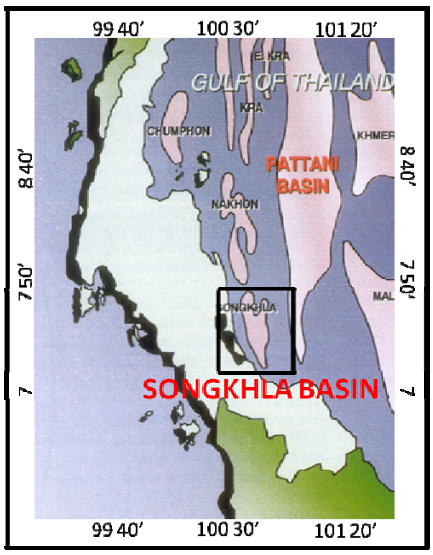

Figure 1. Location of the study area.

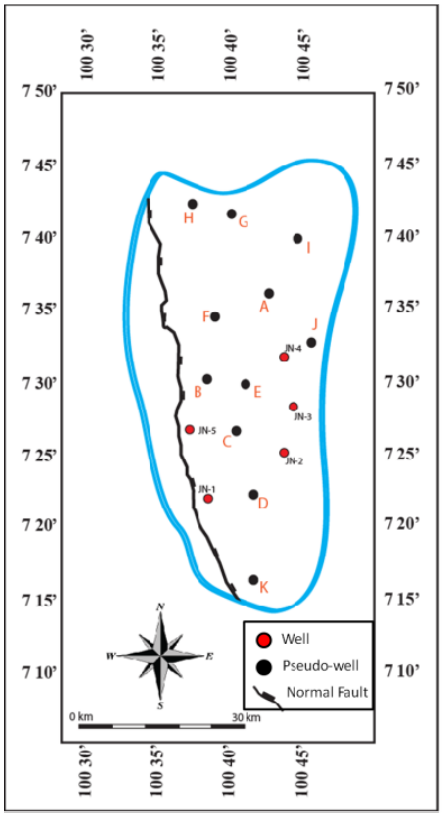

Figure 2. Well and pseudo-well distribution map.

3. Results and Discussion

There are three source rocks that were derived from lacustrine organic matter. The late Oligocene source rock has a slightly different character and lower potential than the early Oligocene and Eocene(?) source rocks. Average TOC content in all wells is fair to good, except for JN-3 which has TOCs of less than 0.5%. Tmax ranges from 410-450ºC and vitrinite reflectance between 0.3-1%.

The general maturation level in the Songkhla Basin is early mature to middle mature. Maturity modeling on all source rock intervals is middle mature for the late Oligocene source rock whereas some of the early Oligocene and Eocene (?) reached the oil generation window.

Oil generation started at 13.6-13 ma for the Eocene(?) source rock and 13-12.8 ma for the early Oligocene source rock. Mature source rocks were found only in JN-1 and JN-4 (Figures 3&4).

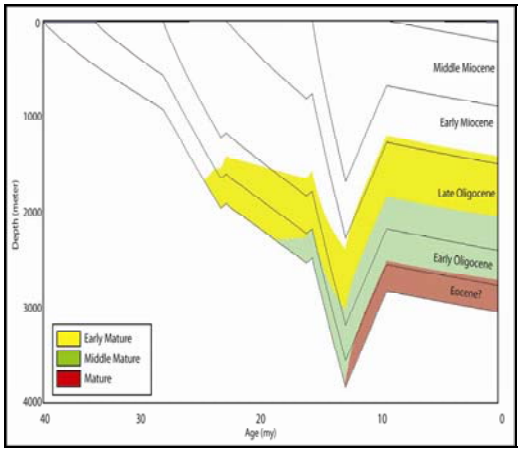

Figure 3. Maturity profile of Well JN-1.

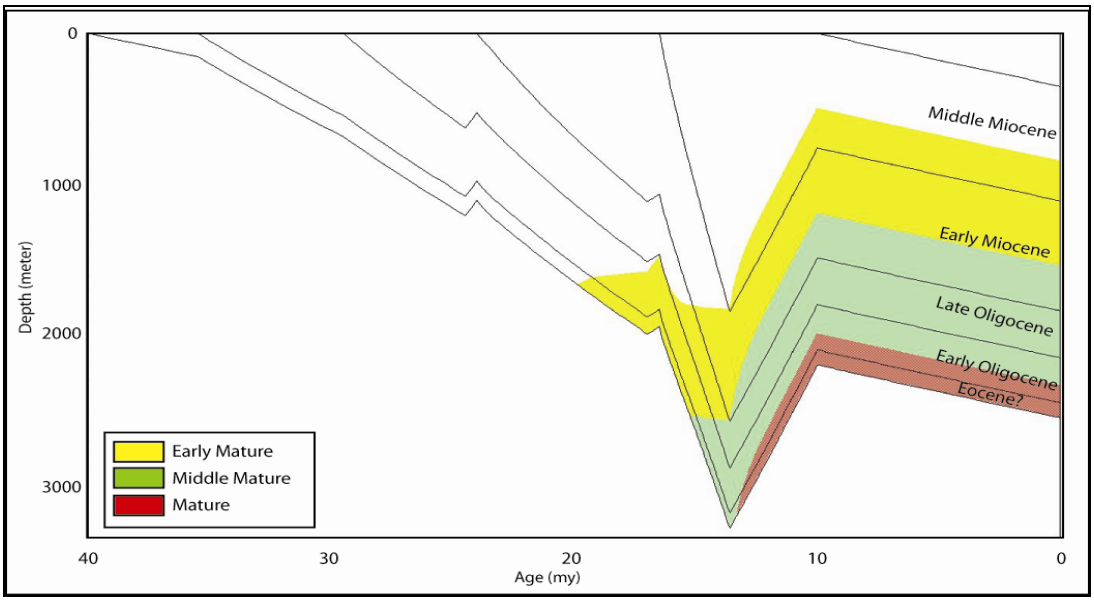

Figure 4. Maturity profile of Well JN-4.

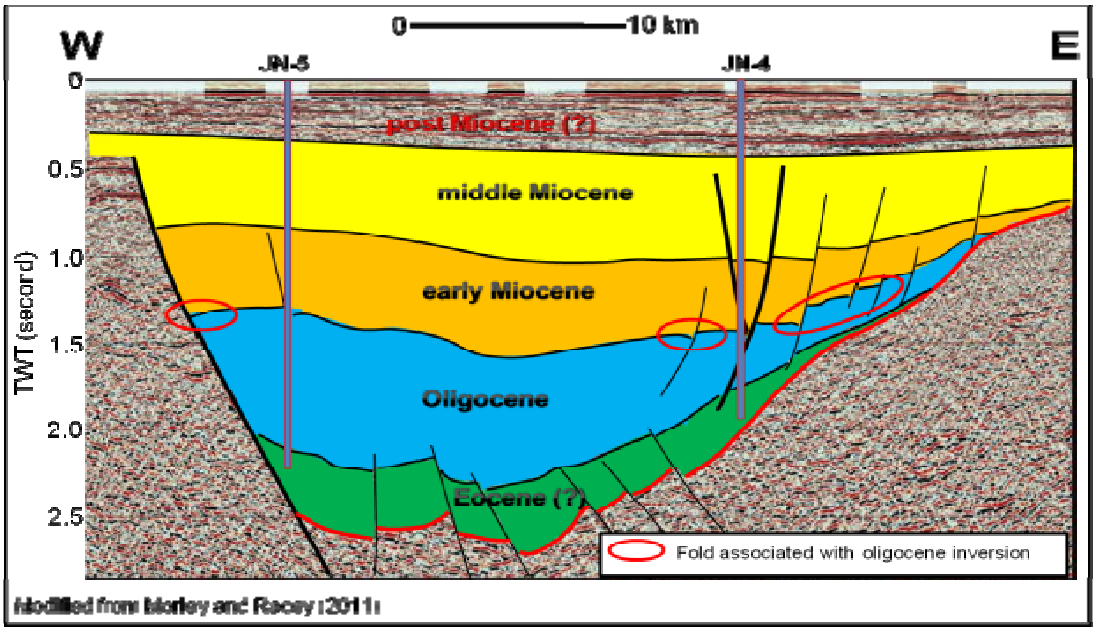

Figure 5. East-west seismic cross-section.

There is no direct relationship between depth and maturity. Some east-west cross-sections indicate the western part of the basin is less mature than the east, although the deepest part of the basin is located to the west. A comparison between wells indicated there is a slightly different tectonic history in the western and eastern parts of the basin.

Relative well positions were attached to an east-west seismic section interpreted by Morley and Racey (2011; Figure 5). Uplift occurred in the post-Oligocene as evidenced by folds associated with inversion. This confirms the uplift at 24 ma indicated by maturity profiles.

The appearance of normal faults that started in the middle Miocene in the eastern part of the basin suggests that after erosion ended about 16.5 Ma, the tectonic system changed from compressional to extensional. This extensional activity confirms the subsidence on the maturity profiles that started at 16.5 ma. An extensional structural style is more clearly visible in the eastern part of the basin.

This leads to the assumption that the major subsidence in the west was thermal. In contrast, combined thermal subsidence and normal faulting in the east lead to the higher subsidence rates after 16.5 ma in the Songkhla Basin maturity profiles.

The combination of thinner source rocks and more extension produced weak zones in the east, resulting in higher heat flow compared to the west, which is why the western part of the basin is less mature than eastern part.

4. Conclusions

Lacustrine organic matter dominated the Eocene(?) and the Oligocene source rocks whereas slightly different conditions prevailed for the late Oligocene source rock interval, which had some influence from terrestrial environments.

The early Oligocene is an oil-prone potential source rock. Although the Eocene(?) source rock still has potential to become an oil source, it generally has lower values compared to the early Oligocene source rock. One advantage of the Eocene source rock is it is located deeper than the early Oligocene source rock.

Even though early mature to middle mature is the dominant maturity level around the basin, there are areas where oil generation is at the mature level. These are concentrated in the depocenter. There also is an area with the mature oil generation phase in JN-4 in the eastern part of the basin.

Middle Miocene normal faults played an important role in maturity. At the same depth, eastern source rocks tend to be more mature than those in the west

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6. Reference

Morley, C.K., and Racey, A., 2011. Tertiary Stratigraphy. In: The Geology of Thailand, A. Barber and M. Ridd (eds.), Geological Society of London.