Student article

Economic vs Fractured Basement: A Case Study from North Sumatra Basin

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ABSTRACT

North Sumatra basin developed during the Early Tertiary (Eocene-Oligocene) as a result of an oblique subduction of the Indian Oceanic Plate underneath the Sundaland continental block. The basin is comprised of Tertiary to Recent sediments that were deposited over Pre-Tertiary basement. Typically, in many places basement consists of complex igneous and metamorphic rocks, but it is different in the North Sumatra basin. Underneath this basin, there are carbonates (dolomites or limestones) and sandstones including the Eocene Tampur Formation that have been called economic basement. Economic basement refers to rocks that have no economic prospectivity whilst the formation is comprised of the sedimentary deposits. The term economic basement in the North Sumatra Basin should be reconsidered because some data shows porosity development in pores and fractures, therefore making them potential reservoir that can receive hydrocarbon charge from proven petroleum system in the basin.

Keywords: *Economic Basement, Fractured Basement, North Sumatra Basin*

INTRODUCTION

Basement and crystalline basement are defined as the rocks underneath a sedimentary basin or those covered by sedimentary rocks. Nowadays, they are not merely the rocks which accommodate the sedimentary basins but also play a significant role as hydrocarbon reservoirs in several countries including Indonesia. For example, in the Beruk Northeast Field, Central Sumatra, which has produced about 2 million barrels of oil and in South Sumatra, where several gas fields are producing from the pre-Tertiary basement, collectively have estimated reserves of about 5 TCF (Koning, 2007). Those basements are called fractured basement because they have fractures through which hydrocarbons flow. Another terminology for describing basement is by using the term economic basement. An economic basement is defined as non-petroleum prospective sedimentary rocks that underlie a sedimentary basin.

North Sumatra Basin is one of several prolific basins in Sumatra, Indonesia. The basin was formed during Early Tertiary (Eocene-Oligocene) as a result of an oblique subduction. The research area is located in Malacca Strait, approximately 150km to the NNW of Medan, the capital city of North Sumatra Province (Figure 1). The pre-Tertiary basement at this location was categorized as economic basement (Beicip, 1977 in Darman and Sidi, 2000). Darman and Sidi (2000) described the basement as being composed of sandstones, limestones, or dolomites which are dense and fractured, without any metamorphic alteration. They are supposed to be less dense than igneous or metamorphic basement, but they are difficult to be traced and identified. The fact that the basement is fractured and possibly connected to a proven petroleum system means that they can be prospective for hydrocarbon exploration. The main objective of this study is to reconsider the basement of North Sumatra Basin as fractured basement and not only economic basement based on data presented in this article.



Figure 1. *Location of research area is shown by the red box (map from Google).*

DATA AVAILABILITY & SCOPE OF WORK

The primary data used in this study include seismic and well data. The seismic data was interpreted and used in building a geological cross section. The well data consist of wireline logs used in stratigraphic correlation and thin sections for describing lithology and pore characteristics and estimating the porosity. Secondary data include published work on the region by previous authors such as Anderson et al. (1993), whose lithostratigraphic subdivision has been used as a reference in this study (Figure 2). All of these data are used to support interpretation for basement prospectivity.

PRE-TERTIARY BASEMENT

The Pre-Tertiary rocks in the North Sumatra Basin consist of limestones and dolomites which underlie the Tertiary sediments. Previous authors suggested that within the Pre-Tertiary rocks, there are also sandstones, metasediments, tuffs, and granites. Drill cuttings from the study area reveal that these carbonates are typically wackestone-packstones, bioclasts, skeletal packestones with fracture and vuggy porosity ranging 5-10%. Porosity estimation from well data reveals porosity range from 5 to 25%. Nevertheless, Caughey and Wahyudi (1993) reported that despite some of the Pre-Tertiary sedimentary rocks were fractured, they are tightly cemented with calcite and quartz and show no reservoir potential. However, observation of core plugs and even dating from these "basement" shows that they are not easily recognized as basement and distinguishing them from the Tampur Formation is difficult.

TAMPUR FORMATION

The name Tampur Formation has been used for all Pre-Oligocene carbonates in the North Sumatra Basin (Collins et al. 1996), but is commonly viewed as Eocene in age (Caughey and Wahyudi 1994, Ryacudu and Sjahbuddin 1994). However, the faunas on which this age is reportedly based have never been documented. Eocene *Nummulites* limestone is present in West Sumatra, in the Ombilin Basin. But, on the other hand, 'Basement' carbonate in the Singa Besar 1 well, just across the Malaysian border in Malacca Straits, contains the Middle-Late Permian foraminifer *Shanita* and other Permian fauna (Fontaine et al. 1992).

The Tampur formation was described by Ryacudu and Sjahbuddin (1994) as massive, partly biocalcarenites and calcilutites, common dolarenites, chert nodules and basal limestone conglomerates, that indicate deposits of an open marine sublittoral environment.

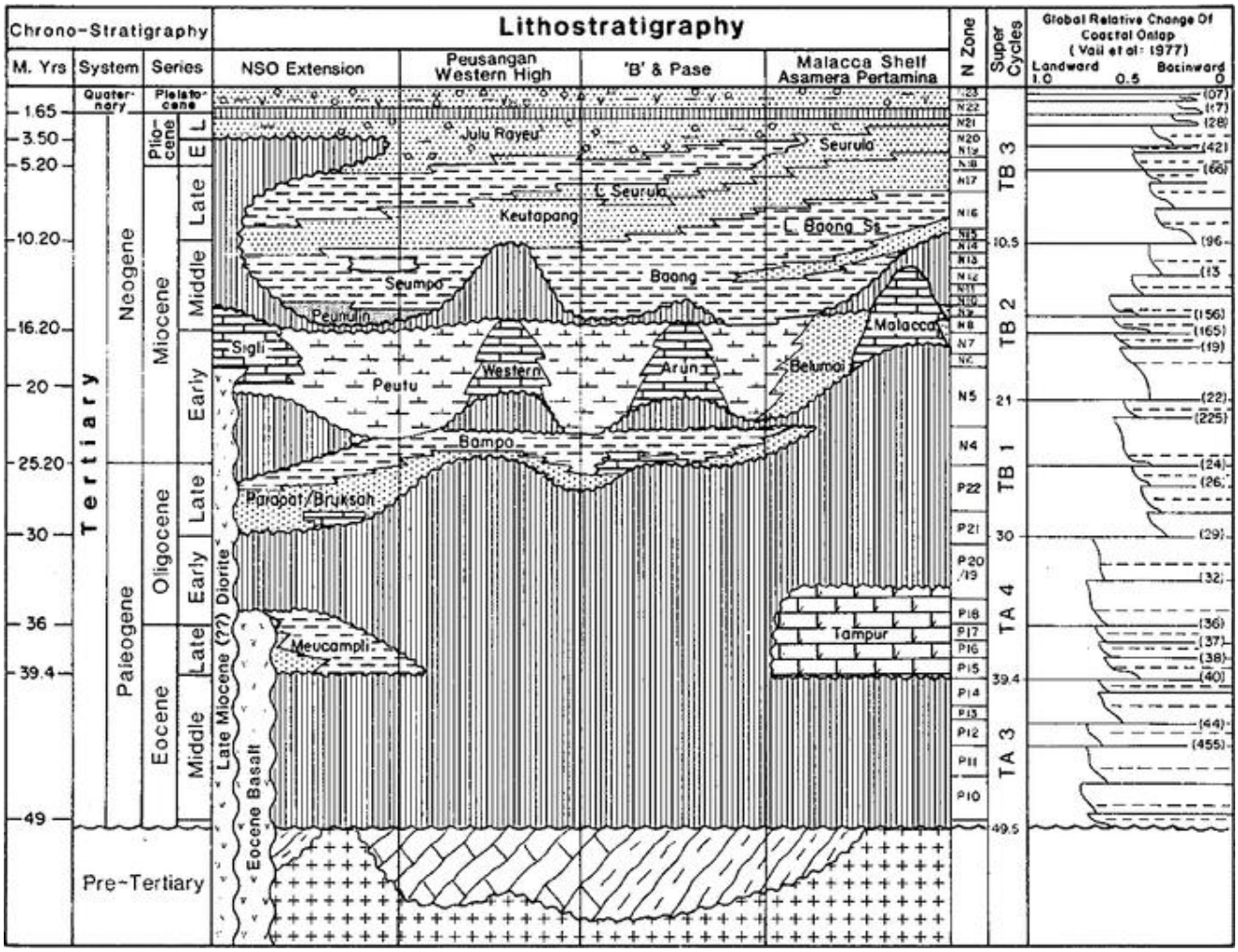


Figure 2. *Stratigraphic column of North Sumatra Basin (Anderson et al., 1993).*

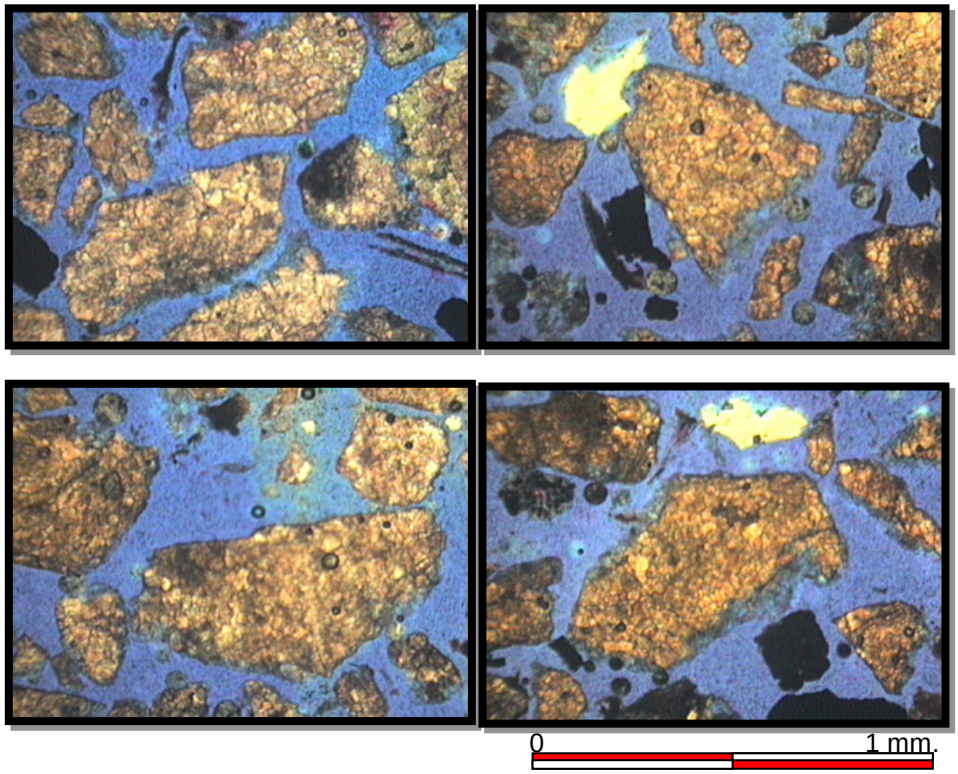


Figure 3. *Photo of thin sections in 5990' interval of basement carbonates with interparticle and fracture porosity, totaling 10% in porosity.*

From the reports of deep wells in the Aru and Langkat areas, it consists of limestones, commonly fractured and dolomitised (Ryacudu and Sjahbuddin, 1994). Collins *et al.* (1996) also stated that drill cuttings from the Tampur Formation consist of mudstones, skeletal wackestones, intraclast, oolite packstones, and grainstones. These descriptions show a slightly similar characteristic as those of the Pre-Tertiary basement rocks.

We may conclude that some of the basal limestones in the North Sumatra Basin are of well defined Pre-Tertiary (Permian) age, while Late Eocene limestones may be present as well, similar to the thin foraminiferal carbonates outcropping in the southwestern part of the Central Sumatra basin. If the Late Eocene age interpretation is the correct one, this means that the Tampur sediments are related to syn-rift phase and most likely distinct from the fractured basement carbonates (Collins *et al,* 1996).

SOURCE ROCK AND RESERVOIR CONSIDERATION

The Tampur Formation was deposited in an open marine shelf setting that generally is lean in organic matter and normally provides poor source material for large scale hydrocarbon generation (Ryacudu and Sjahbuddin, 1994). This means younger sediments are the only possible source for hydrocarbon generation, such as organic-rich shales in the Belumai Formation, Baong Shales, Bampo black shales and in the Meucampli Formation.

There are no specific permeability and porosity data taken from Tampur Formation. However, from cutting description of a well near Aru Bay-1, where 85 meters of thick, fractured dolomites that may correlate to the Tampur carbonates have been drilled, the estimated secondary porosity is around 5-10% (Ryacudu and Sjahbuddin, 1996).

INTERPRETATION

Pre-Tertiary basement in the North Sumatra Basin is difficult to be distinguished from Tampur Formation, because it is comprised mainly of wackestone-packstones. At 5990' and deeper interval in a well (Figure 3), thin sections mostly show that the wacke-packstone is composed of calcite and other minerals, with grains size of around 0.05-0.2mm, subangular-subrounded in grain shape, grain supported and poorly supported, point contact. Matrix consists of carbonate. Cements consist of sparry calcite type. The rock contains interparticle and fracture types porosity totaling 10%. Another thin section also shows moldic and vuggy porosity. With the integration of well and core porosity that ranges 5-20%, the described characteristics are likely similar to those of Tampur carbonates.

From correlated seismic section (Figure 4) between wells, it can be interpreted that the Tampur Formation is laterally widely distributed. Structural and stratigraphic traps may exist in the

Tampur Formation. Considering reef buildups could occur along the shelf margin, the fractured Tampur Formation located on the highs as seen on Figure 4 and 5 might contain fair to good porosity and permeability if they had been exposed. This makes them highly prospective for reservoir. The shales of Lower Baong Formation could be the cap rock for the Tampur carbonates reservoir along with its entrapment.

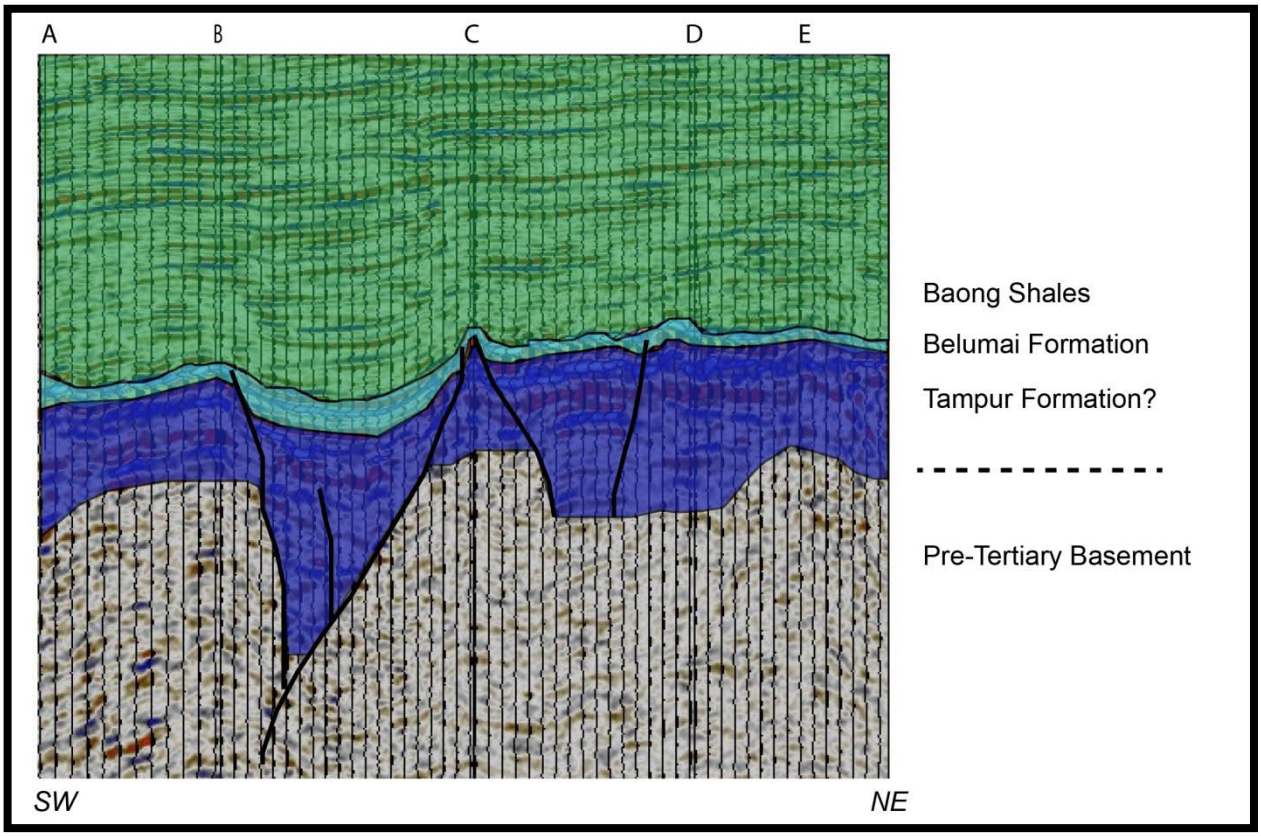


Figure 4. *Seismic section of "A" to "E" Well.*

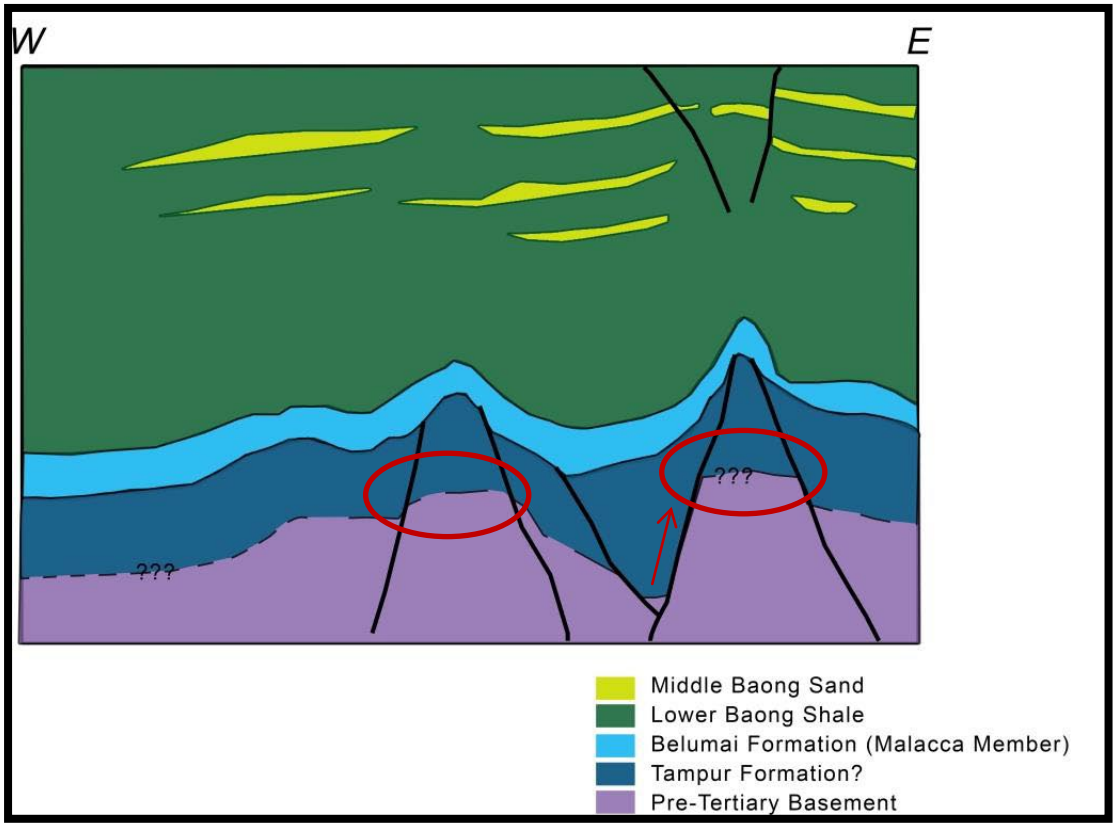


Figure 5. *Cross section of the study area, red circles indicating the possible accumulation of hydrocarbon for basement fractured. Red arrow indicating the migration pathway.*

CONCLUSION

Under certain circumstances, the presence of carbonates in the North Sumatra Basin basement, whether Eocene Tampur Formation or older Pre-Tertiary constituents, suggest that the basement is not an economic basement but fractured basement with potential to be reservoir. However, this study only covered a small portion of the basin and further work is required to prove the prospectivity of the fractured basement.

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