Stratigraphic Plays in Active Margin Basin: Fluvio-Deltaic Reservoir Distribution in Ciputat Half Graben, Northwest Java Basin*

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Abstract

The clastic reservoir that formed within Syn-Rift Phase-2 is fluvio-deltaic and equivalent to the Jatibarang Formation in terms of age. While there is no formal stratigraphic name for this formation, its lithology is similar to the Talang Akar Formation (TAF) in the Northwest Java Basin. Based on these references, it is preliminarily named the Pre-Talang Akar Formation (Pre-TAF) here.

Hydrocarbon discovery in this formation was initiated by structural exploration. In several fields, hydrocarbons have been discovered in stratigraphically trapped lenses of sandstone, especially in the base of the Ciputat Half Graben. Of the 12 wells drilled in that area, hydrocarbons in Pre-TAF were discovered in 11, although they were not drilled on a closure (structureless).

Field development strategy to produce Pre-TAF hydrocarbons is difficult to execute due to the stratigraphic trap configuration. Study of reservoir distribution in Pre-TAF will be done as part of the field development strategy even though it is difficult due to the thin reservoir.

Data and Method

This preliminary study has been conducted by applying geophysical interpretation and well data analysis. Geophysical methods applied include the re-interpretation of 3D seismic data and seismic attribute analysis. Rock physics modeling is difficult due to being below the tuning thickness. Seismic attribute is generated to determine reservoir distribution, however, reservoir thickness is below the tuning thickness which is a consideration in the attribute selection. In this circumstance, interpretation of reservoir distribution is conducted by applying the Average Instantaneous Frequency. Geologic frequency is simply the number of reflecting layers within the unit thickness of rock; higher geologic frequency means more layering (Brown, 2011).

Results and Discussion

Regionally, this study is focused on the Northwest Java Basin, which is part of the southern edge of the Sunda or Sundaland Microplate. Noble (1997) describes the configuration of the basement in the Northwest Java Basin which forms a series of half grabens with a north-south direction. The half grabens, also known as a sub-basin, such as Ciputat, Pasibungur, and Cipunegara, are formed in the early phase of rifting in the Eocene (Sribudiyani et al., 2003). In the Ciputat Sub-basin, structural patterns as proposed by Koesoemadinata (2005) are trending north-south.

Generally, the Ciputat Sub-basin began by rifting in the Middle to Late Eocene, and formed a half graben. The graben has been filled by lacustrine-fluvio sediment, including source rock deposition. Transgression occurs in Middle Oligocene to Middle Miocene when the fluvio-deltaic sediments of the Syn-Rift phase were deposited. Carbonate sediment was deposited in the Post-Rift phase. The sealing rocks were deposited over it during maximum transgression.

Formation of the compression structure occurred in Late Miocene until Pliocene (Satyana, 2005). Sediments in the Northwest Java Basin derive from the north and east parts of the Sunda Microplate (Atkinson et al., 1993). The stratigraphy of the Northwest Java Basin is similar to the South Sumatra Basin (Schlumberger, 1986; Figure 1).

Syn-Rift in this sub-basin is divided into two phases. Syn-Rift Phase-1 began with the deposition of the volcanic rock of the Jatibarang Formation and carbonate sediment was deposited over it in several locations. At the end of this phase, there was an erosional surface due to the hiatus before the Syn-Rift Phase-2.

Syn-Rift Phase-2 began with transgression and the fluvio-deltaic sediment of the Pre-Talangakar Formation (Pre-TAF) was deposited unconformably over carbonate and volcanic sediment of Syn-Rift Phase-1, followed by deposition of the Talangakar Formation. Carbonates of the Baturaja Formation were deposited conformably over it as Post-Rift sediment and then was covered by shale of the Cibulakan Formation during maximum transgression. The evolution of the Sub-basin is illustrated in Figure 2. Syn-Rift sediment is primary reservoir in this half graben.

Stratigraphically, the three rock units under the Pre-Talang Akar Formation (Pre-TAF) can be divided into Pre-Rift sediment, composed of igneous-metamophic rock (granite, monzonite, diorite and schist) and Syn-Rift Phase-1 sediment, composed of volcanic clastic and carbonate. Syn-Rift Phase-2 sediment consists of Pre-TAF and TAF deposited unconformably on the Syn-Rift Phase-1, followed by deposition of Post-Rift sediment.

Pre-TAF consists of sandstone, shale and coal. Sandstone is the primary reservoir. Based on petrographic analysis, sandstones can be classified as quartzwacke, and subarkose sublitharenite, deposited in a fluvio-deltaic environment. The Talangakar Formation (TAF) is composed of sandstone, shale, limestone, and coal; hydrocarbon was discovered in the lower zone.

Before geophysical analysis, it was necessary to do tuning thickness analysis which was conducted to examine the seismic data sensitivity in order to display a more clear subsurface picture. It is expected to produce lithology boundaries in the seismic section. According to this analysis, the Pre-TAF reservoirs are thin layered sandstones which are difficult to perform advanced processing on, such as rock physics modeling, due to being below tuning thickness. Tuning thickness in this seismic data is 18.9 ms or 34.25 m, but reservoir thickness is around 4-7 m.

Brown (2011) has explained that frequency-derived attributes can be utilized to describe geologic frequency. Geologic frequency is simply the number of reflecting layers within a unit thickness of rock (Brown, 2011). In this circumstance, interpretation of Pre-TAF reservoir distribution has been conducted by applying the Average Instantaneous Frequency (Figure 3).

The attribute shows sedimentation pattern of the clastic reservoir validated by production wells. Low frequency thus correlates with better production from a clastic reservoir. Thicker sand-shale layering has lower frequency than thinner sand shale layering, even though the thickness of these layers is below tuning thickness.

The relationship between drainage, deposition, and fault segmentation in a half graben system has been illustrated by Gawthorpe et al. (1994). Accordingly, the sedimentation pattern within the Ciputat half graben, as illustrated by the Average Instantaneous Frequency attribute image, is a fluvio-deltaic system moving southeastward into the basin (Figure 3). Sediment provenance derives from the Sunda Microplate in the northwest, and in some places from the local highs (hangingwall drainage and footwall drainage).

Conclusions

According to our analysis, it can be concluded that Pre-TAF reservoirs are the primary clastic reservoir in the Ciputat half graben. Its sedimentation pattern follows the axial direction of graben, known as axial drainage. The sedimentation pattern of the Pre-TAF reservoir is of an axial fluvio-deltaic system along the Ciputat half graben, although in some places hangingwall and footwall drainage are derived from the Jatinegara High (hangingwall) and Rengasdengklok High (footwall).

Knowledge of the distribution of the Pre-TAF reservoir will assist in determining field development strategy and exploration activities in the Ciputat half graben; sandstone lenses have produced stratigraphic traps. This study is preliminary and there is still opportunity to apply other advanced methods and technology if supported by enhanced seismic and well data, so that distribution of Pre-TAF reservoirs can be determined in more detail.

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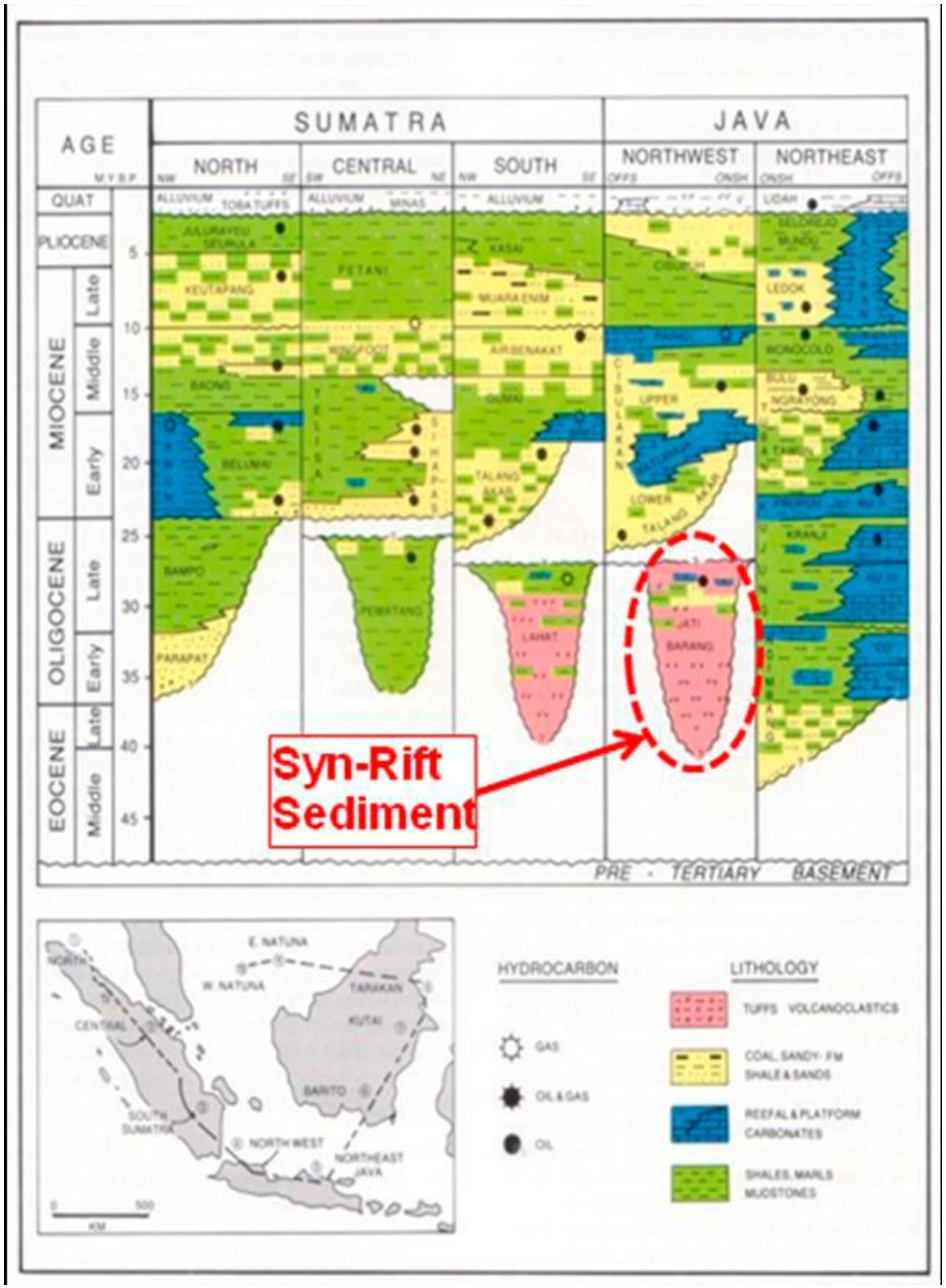

Figure 1. Regional stratigraphy of West Indonesian Basin; Schlumberger (1986).

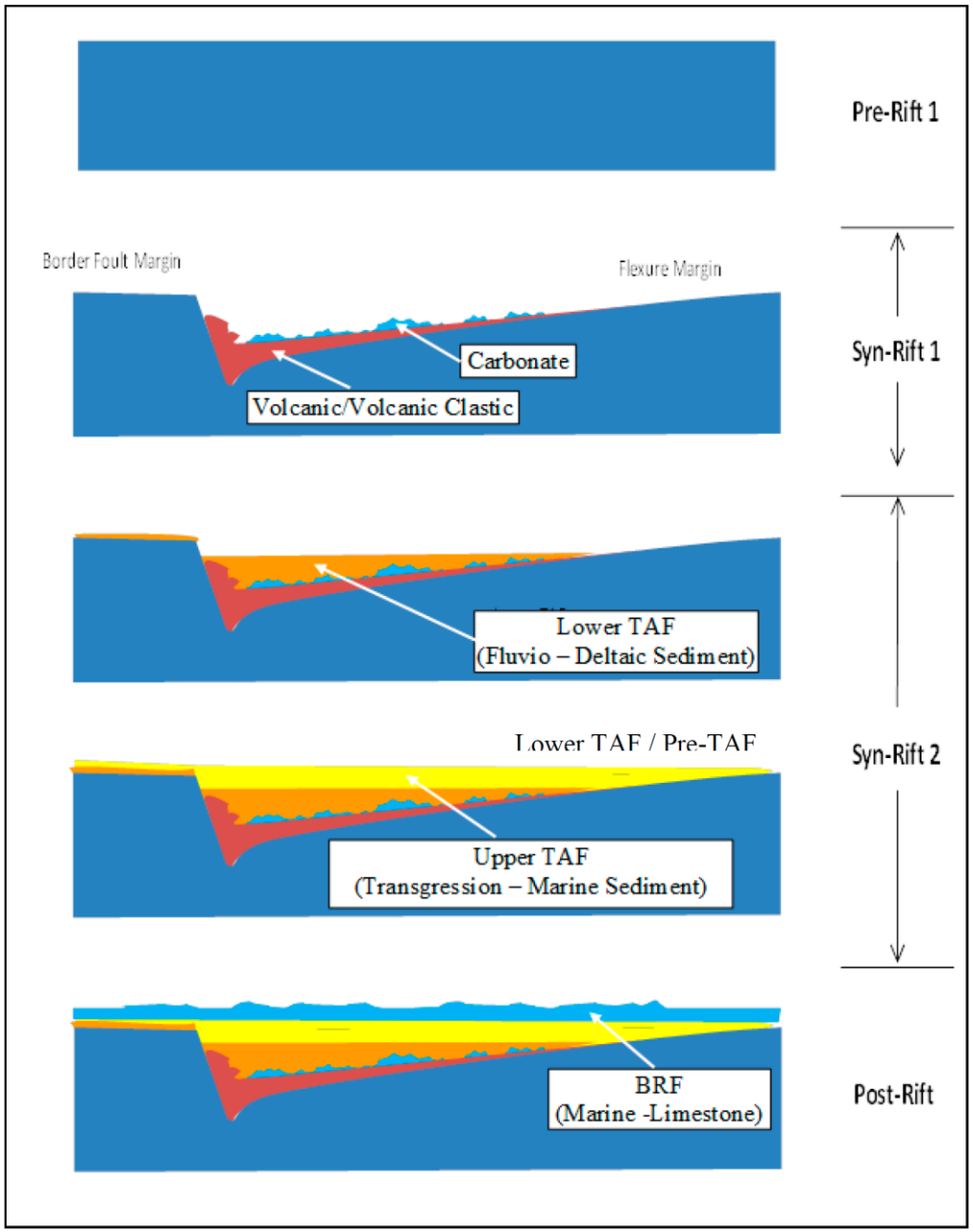

Figure 2. Illustration of Pre-Rift to Post-Rift evolution in Ciputat Sub-Basin.

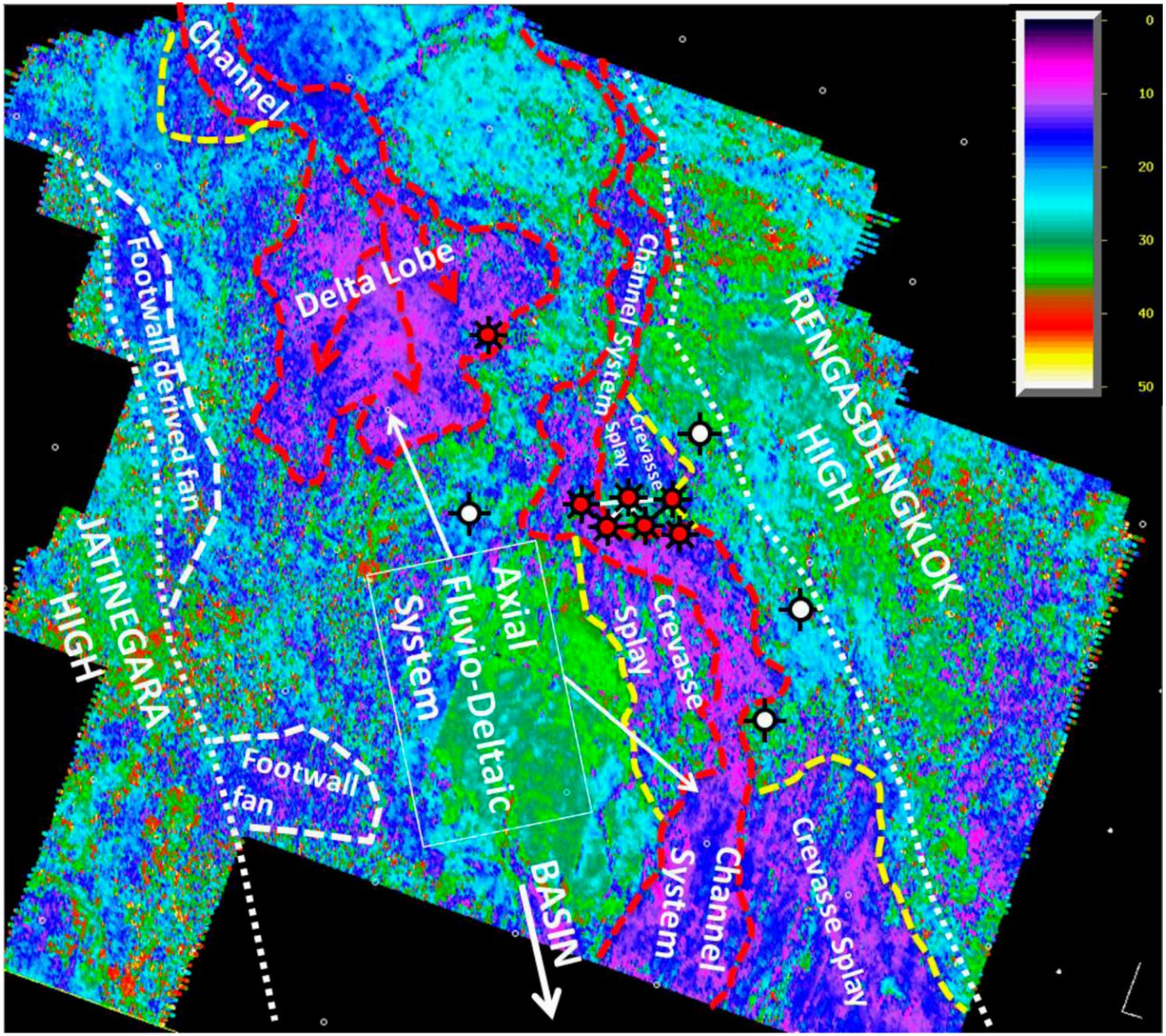

Figure 3. Average Instantaneous Frequency attribute map extracted from 25 ms window, showing Pre-TAF reservoir distribution.