Paleoenvironmental Study of Miocene Sediments from JTB-1 and NRM-1 wells, in West Ogan Komering Block, Meraksa Area, South Sumatra Basin

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Abstract. Paleodepositional study based on microfossil has been done on Miocene sediments from JTB-1 and NRM-1 wells, West Ogan Komering Block, Meraksa area, South Sumatra Basin. This study was carried out to test the different depositional environment of the well-known stratigraphic units in South Sumatra Basin, which was assumed to occur due to different structural position. In this study, stratigraphic unit classification was determined by their lithology characteristics, they are: Lahat Formation, Talangakar Formation, Baturaja Formation, Gumai Formation, and Airbenakat Formation. This study reveals that the shelf deposits, such as The Baturaja and Gumai Formation of NRM-1 well have thicker interval and indicate marine depositional environment compared to the same rock unit of JTB-1 well. The Baturaja Formation in JTB-1 well was deposited in a shallow neritic environment while at the NRM-1 well, it was deposited on a shallow neritic to middle neritic interval. The Gumai Formation interval at the JTB-1 well was deposited in middle neritic to outer neritic bathymetric zone while at the NRM-1 well; the entire interval indicates outer neritic sediment. Integrated study of microfossils analysis, stratigraphic and seismic correlation shows that the position of JTB-1 well is structurally higher than the NRM-1. It is consistent with the interval sediment in JTB-1 well which are generally thinner and interpreted as shallower marine deposit. The results from this study will give significant contributions for the hydrocarbon exploration and development in terms of improving knowledge of paleodepositional environment. Therefore, distribution, characteristics and hydrocarbon potential could be estimated more accurately as well as optimising the hydrocarbon recovery.

Keywords: paleoenvironmental, South Sumatra Basin, Baturaja, Airbenakat, Miocene

1. Introduction
The stratigraphy of the South Sumatera Basin has been established including its paleontology aspect by [1-3]. However, their studies are more focused on the regional development of the basin in terms of age determination and depositional environment. This study focuses on a more detail approach using biostratigraphy method that has been overlooked previously. Some preliminary results suggest there
are different aspects to the stratigraphy compared to the regional studies, in particular the depositional environment of each rock formation. Therefore a comprehensive biostratigraphy study is needed.

This study is mainly focuses on two wells in West Ogan Komering Block, Meraksa Area, South Sumatera (Figure 1) where there are indications of different depositional environments for the same formation due to the different structural level. Paleontological analyses have been performed to several samples representing the Baturaja and Gumai Formation from NRM-1 and JTB-1 wells which are only 4 kilometres apart. Previously, the Baturaja Formation is interpreted to be of Early Miocene age and the Gumai Formation age ranges from late Early Miocene to Middle Miocene. This study analyse the depositional environment by determining the benthonic forams association.

![Map of NRM-1 and JTB-1 wells in West Ogan Komering Block, Meraksa Area, South Sumatra Basin.](image)

**Figure 1.** NRM-1 and JTB-1 wells location map in the West Ogan Komering Block, Meraksa Area, South Sumatra Basin.

2. **Geological Setting**

According to [1,4-6] the South Sumatera Basin is a back-arc basin as a result of the Sundaland and Australian plate interaction. The basin is underlain by the pre-Cenozoic metamorphic and igneous rocks basement that is cross-cut by extensional faults that formed horst and grabens to accommodate thick sequence of Cenozoic sediments from Eocene to Quaternary [1].

2.1. **South Sumatera Basin Stratigraphy**

The following stratigraphy is summarised from [1] from old to young:

- **Lemat or Lahat Formation (Paleocene – Early Oligocene).** It consists of mainly shale with tuff intercalation and occasional coal layers, agglomerates and various coarse volcanic fragments.
- Talang Akar Formation (Late Oligocene – Early Miocene). The base of this formation is dominated by fluvio-deltaic sediments which consist of thinly layered shales and coals. The upper part consists of sandstone, shale with occasional coal layers that represent paralic – shallow marine sediments. Baturaja Formation (Early Miocene) is known to be dominated by reefal limestone that was developed in local highs and found to be more silty and muddy in the deeper facies.
- Baturaja Formation (late Early Miocene – early Middle Miocene) is dominated by reef and clastic limestone.
- Gumai Formation (late Early Miocene) is mainly consist of thick muddy and silty shale succession that indicate the increase the maximum sea level in the South Sumatera Basin.
- Air Benakat Formation (Middle Miocene) characterised by thick mudstone layers at the base and more sandstones layers towards the top of the formation.
- Muara Enim Formation (Early Miocene – Late Miocene) is dominated by mudstone and shale with occasional sandstones and coals layers.
- Kasai Formation (Late Miocene – Pliocene) consists of pumice, tuffs, tuffaceous sandstones and mudstones.

3. Data
Selected intervals from JTB-1 and NRM-1 wells that represent the Baturaja (16 samples) and Gumai Formations (7 samples) were acquired. In JTB-1 well the Baturaja Formation were acquired between 1028.5 m and 902 m and the Gumai Formation were acquired between 813 m and 766 m depth. In NRM-1 well the Baturaja Formation were acquired at depth between 1070.5 and 1007 m while the Gumai Formation was acquired from 950 m to 726 m depth. The average sampling interval is 2 metres. In this study, stratigraphic unit classification for Baturaja Formation and Gumai Formation were determined by their lithologic characteristics based on previous study such as [1] and [2].

4. Methods
Samples from cutting and cores were cleaned using H$_2$O$_2$ solution so that they are free from fine clastic fragments and the foraminifera fossil can be seen clearly under the microscope. The benthic foramin association are determined referring the catalogue published by [7]. In each sample the benthic forams association is utilised to determine the depth of the depositional environment based on the Bathymetric Zone of [8]. This study also determined the age of each rock unit based on [9] age zonation. Biostratigraphic correlation and interpretation then carried out to determine the cause of the difference in thickness based on isopach maps data, regional log correlation of Ogan Komering Block and depositional environment. Isopach maps and regional well correlation of Ogan Komering Block presented in this study are part of a larger research project that will be discussed in another paper.

5. Data Analysis
The analyses results are presented below; benthic foramin association is utilized to determine a particular depositional environment that can also be the marker of the depositional environment changes (Table 1 and Table 2).

5.1. JTB-1 well
1. 1030 – 955 m: inner neritic (shallow neritic) characterized by few diversity of planktonic and benthic foraminifers which dominated by *Ammonia umbonata* (Figure 2a) and *Elphidium crispum* (Figure 2b). *Ammonia umbonata* and *Elphidium crispum* are typical fossil found in the high-energy sandy environment.
2. 902 – 813 m: middle neritic characterized by moderate abundance of benthonic and planktonic foraminifers. Association of *Bulimina* sp. (Figure 2c), *Virgulina* sp. (Figure 2d), and *Lenticulina thalmani* (Figure 2e) that usually confirms the middle neritic environment.
3. 778 – 766 m: outer neritic based on the maximum abundant of planktonic foraminifers. Benthonic foraminifers such as: *Uvigerina peregrina* (Figure 2f), *Lagena* sp. (Figure 2g), and increasing amount of *Bulimina striata* confirms the outer neritic environment.

**Table 1.** Depositional Environment of Baturaja and Gumai Formation in JTB-1 well.

| No | Depth (m) | Formation | Age       | PALEOBATHIMETRY (Tipsword et al., 1966) |
|----|-----------|-----------|-----------|----------------------------------------|
|    |           |           | Planktonic Foraminifer Zone (Blow, 1979) | Foraminifera Datum | Supra-faunal (terrestrial) | Sub-faunal (0-100 m) | Middle Neritic (100-300 m) | Outer Neritic (300-500 m) | Upper Bathyal (500-1000 m) |
| 1  | 352       | Baturaja Fm. | N11 or younger | | | | | | |
| 2  | 360-362   | Airbenakat Fm. | Middle Miocene | | | | | | |
| 3  | 362-364   | | | | | | | | |
| 4  | 364-366   | | | | | | | | |
| 5  | 366-368   | | | | | | | | |
| 6  | 372-374   | | | | | | | | |
| 7  | 374-376   | | | | | | | | |
| 8  | 500       | | | | | | | | |
| 9  | 596-598   | | | | | | | | |
| 10 | 600-602   | | | | | | | | |
| 11 | 626.5     | | | | | | | | |
| 12 | 626-628   | | | | | | | | |
| 13 | 628-630   | | | | | | | | |
| 14 | 630-632   | | | | | | | | |
| 15 | 632-634   | | | | | | | | |
| 16 | 634-636   | | | | | | | | |
| 17 | 636-638   | | | | | | | | |
| 18 | 638-640   | | | | | | | | |
| 19 | 766-768   | | | | | | | | |
| 20 | 768-770   | | | | | | | | |
| 21 | 770-772   | | | | | | | | |
| 22 | 772-774   | | | | | | | | |
| 23 | 774-776   | | | | | | | | |
| 24 | 776-778   | | | | | | | | |
| 25 | 813       | | | | | | | | |
| 26 | 902.5     | | | | | | | | |
| 27 | 955       | | | | | | | | |
| 28 | 956       | | | | | | | | |
| 29 | 957       | | | | | | | | |
| 30 | 962       | | | | | | | | |
| 31 | 970       | | | | | | | | |
| 32 | 971.5     | | | | | | | | |
| 33 | 980-982   | | | | | | | | |
| 34 | 985       | | | | | | | | |
| 35 | 986.5     | | | | | | | | |
| 36 | 1002      | | | | | | | | |
| 37 | 1012.5    | | | | | | | | |
| 38 | 1014-1016 | | | | | | | | |
| 39 | 1020-1022 | | | | | | | | |
| 40 | 1022-1024 | | | | | | | | |
| 41 | 1028.5    | | | | | | | | |
| 42 | 1028-1030 | | | | | | | | |
| 43 | 1162-1164 | | | | | | | | |
| 44 | 1164-1166 | | | | | | | | |
| 45 | 1071.5    | | | | | | | | |
Table 2. Depositional Environment of Baturaja and Gumai Formation in NRM-1 well.

| No | Depth (m) | FORMATION | AGE | Planktonic Foraminifera Zonation (Blow, 1979) | FORAMINIFERA DATUM | BIOZONATION MARKER | PALEOBATHIMETRY (Tipsword et al., 1966) |
|----|-----------|-----------|-----|---------------------------------------------|-------------------|-------------------|---------------------------------------------|
| 1  | 628-630   | Air Benakat Fm. | 1.18 | N13 - N? | Globorotalia mayeri | N6 - N8 | Middle Miocene |
| 2  | 630-632   |  | 1.18 | N13 - N? |  |  |  |
| 3  | 632-634   | Gumai Fm. | Middle Miocene | N9 - N13 | Orbulina universa | N9 - N13 | Middle Miocene |
| 4  | 634-636   |  | 1.18 | N9 - N13 |  |  |  |
| 5  | 638-640   |  | 1.18 | N9 - N13 |  |  |  |
| 6  | 726       |  | 1.18 | N9 - N13 |  |  |  |
| 7  | 770       |  | 1.18 | N9 - N13 |  |  |  |
| 8  | 771.5     |  | 1.18 | N9 - N13 |  |  |  |
| 9  | 774       |  | 1.18 | N9 - N13 |  |  |  |
| 10 | 774-776   |  | 1.18 | N9 - N13 |  |  |  |
| 11 | 778-780   |  | 1.18 | N9 - N13 |  |  |  |
| 12 | 942-946   |  | 1.18 | N9 - N13 |  |  |  |
| 13 | 946-948   |  | 1.18 | N9 - N13 |  |  |  |
| 14 | 948-950   |  | 1.18 | N9 - N13 |  |  |  |
| 15 | 1007      |  | 1.18 | N9 - N13 |  |  |  |
| 16 | 1009.5    |  | 1.18 | N9 - N13 |  |  |  |
| 17 | 1010.5    |  | 1.18 | N9 - N13 |  |  |  |
| 18 | 1013      |  | 1.18 | N9 - N13 |  |  |  |
| 19 | 1015      |  | 1.18 | N9 - N13 |  |  |  |
| 20 | 1017.5    |  | 1.18 | N9 - N13 |  |  |  |
| 21 | 1020      |  | 1.18 | N9 - N13 |  |  |  |
| 22 | 1022.5    |  | 1.18 | N9 - N13 |  |  |  |
| 23 | 1027      |  | 1.18 | N9 - N13 |  |  |  |
| 24 | 1029      |  | 1.18 | N9 - N13 |  |  |  |
| 25 | 1030      |  | 1.18 | N9 - N13 |  |  |  |
| 26 | 1032      |  | 1.18 | N9 - N13 |  |  |  |
| 27 | 1034.5    |  | 1.18 | N9 - N13 |  |  |  |
| 28 | 1036      |  | 1.18 | N9 - N13 |  |  |  |
| 29 | 1039      |  | 1.18 | N9 - N13 |  |  |  |
| 30 | 1044      |  | 1.18 | N9 - N13 |  |  |  |
| 31 | 1046.5    |  | 1.18 | N9 - N13 |  |  |  |
| 32 | 1056      |  | 1.18 | N9 - N13 |  |  |  |
| 33 | 1062.5    |  | 1.18 | N9 - N13 |  |  |  |
| 34 | 1064      |  | 1.18 | N9 - N13 |  |  |  |
| 35 | 1068      |  | 1.18 | N9 - N13 |  |  |  |
| 36 | 1070.5    |  | 1.18 | N9 - N13 |  |  |  |
5.2. NRM-1 well
1. 1.070.5 – 1.044 m (BRF): middle neritic based on moderately abundant of planktonic and benthic foraminifers. Benthonic foraminifers association that consists of *Bolivina* sp. (Figure 3a) and *Cibicides* sp. (Figure 3b) confirms the middle neritic environment.
2. 1.039 – 1.027 m (BRF): inner neritic (shallow neritic) characterized by less diverse of planktonic and benthic foraminifers which is dominated by *Ammonia umbonata* (Figure 3c).
3. 1.022.5 – 1.007 m (BRF): middle neritic based on moderately abundant of planktonic and benthic foraminifers. *Bolivina* sp. and *Cibicides* sp. association marked the middle neritic environment.
4. 950 – 726 m (GUF): outer neritic indicated by optimum abundance of planktonic foraminifers. Benthic foraminifers index in this interval are *Uvigerina peregrina* (Figure 3d) and *Bulimina striata* (Figure 3e).

Figure 2. JTB-1 well’s benthic foraminifera.

Figure 3. NRM-1 well’s benthic foraminifera.
6. Discussion
1. The stratigraphic correlation suggests that the Baturaja and Gumai Formation in the NRM-1 well that were deposited in the deeper shelf environment have thicker sequence compared to the same formation in JTB-1 well.
2. The Baturaja Formation in JTB-1 well was deposited in a shallow neritic environment while at the NRM-1 well the fossil association suggest that it was deposited in a shallow neritic to middle neritic interval.
3. The Gumai Formation interval at the JTB-1 well was deposited in middle neritic to outer neritic environment while at the NRM-1 well the entire interval indicates outer neritic sediment.
4. Integrated study of microfossils analysis, stratigraphic, isopach thickness maps (Figure 4) and regional log correlation (Figure 5) shows that the position of JTB-1 well is structurally higher than the NRM-1. They are most likely to be deposited on the remnant of local highs that was formed by the extensional faults. It is consistent with the interval sediment in JTB-1 well which are generally thinner and interpreted as shallower marine deposit. The isochron and isopach maps of the Baturaja and Gumai Formations supports the interpretation by showing a generally thicker Baturaja and Gumai Formation around the NRM-1 well compared to the JTB-1 well. As written in the methods chapter, “isopach maps” and ”regional well correlation of Ogan Komering Block” presented in this study are part of a larger research project that will be discussed in another paper.

The results from this study will give significant contributions for the hydrocarbon exploration and development in terms of improving knowledge of paleodepositional environment. Therefore, distribution, characteristics and hydrocarbon potential could be estimated more accurately as well as optimising the hydrocarbon recovery. Therefore, distribution, characteristics and hydrocarbon potential could be estimated more accurately as well as optimising the hydrocarbon recovery in order to maximize produceable hydrocarbon.

![Figure 4](image-url)

Figure 4. Baturaja Formation and Gumai Formation isopach maps in Ogan Komering Block. The color bar (on the upper right corner of the map) indicate sediment thickness. Blue and red represent thick and thin sediment thickness respectively.
Figure 5. Regional log correlation of Ogan Komering Block.
7. Conclusions
The Baturaja Formation was deposited in a shallow neritic environment and shallow – middle neritic environment in JTB-1 well and NRM-1 well respectively. The Gumai Formation was deposited in middle - outer neritic and outer neritic environment in JTB-1 and NRM-1 well respectively. The Baturaja and Gumai Formation in the NRM-1 well are thicker and located in a deeper marine shelf environment compared to JTB-1 well. Future exploration should consider these new findings in order to better constrain the paleodepositional environment of the two formations.

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9. References
[1] Pulunggono A, Suparman A, Assegaf A and Purwanto T 1990 Geology of Garba Area and surrounding, South Sumatra (Jakarta: Universitas Trisakti)
[2] Barber A J, Crow M J and Milsom J S 2005: Sumatra: Geology, Resources and Tectonic Evolution. Geological Society Memoir No. 31 (London: The Geological Society), p 86-97
[3] Wibowo S S, 2015: Studies of geochemistry and maturity modeling on the Talangakar source rock at Tungkal block, South Sumatra Basin. Bulletin Geologi 42, p 199-215
[4] Katili J.A 1973 Geochronology of West Indonesia and Its Implication on Plate Tectonics, Tectonophysics
[5] Katili J.A 1975 Volcanism and Plate Tectonics in The Indonesia Island Acr. Tectonophysics
[6] Pulunggono A and Cameron N.R 1984 Sumatran Microlpates, Their Characteristics and Their Role in The Evolution of The Central and South Sumatra Basin, Proc 13th Ann. Conc. IPA, Jakarta, Mei
[7] Rauwenda P J, Morley R J and Toelstra, S R 1984 Assessment of Depositional Environment and Stratigraphy on the Basis of Foraminifera Paleoecology (Singapore: Robertson Research International Limited)
[8] Tipsword H L, Setzer F M and Smith L F 1966 Interpretation of Depositional Environment In Gulf Coast Petroleum Exploration From Paleoecology and Related Stratigraphy (Houston: Gulf Coast Association of Geological Societies XVI)
[9] Blow W H 1969: Late Middle Miocene to Recent Planktonik Microfossils. 1st, Geneva Proceeding Leiden, F.J. Brill 1, p 199-422