

FACIES DISTRIBUTION OF KAIS FORMATION IN “X” FIELD, SALAWATI BASIN, WEST PAPUA, INDONESIA

DISTRIBUSI FASIES FORMASI KAIS PADA LAPANGAN “X”, CEKUNGAN SALAWATI, PAPUA BARAT, INDONESIA

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Sari. Daerah penelitian lapangan “X” terletak di Formasi Kais, Cekungan Salawati, Papua Barat, Indonesia. Maksud dan tujuan dari penelitian ini adalah untuk menginterpretasikan fasies karbonat, beserta penyebarannya, baik secara vertikal maupun horizontal. Penelitian dimulai dengan penafsiran *litostratigrafi* menggunakan data *log* dan sayatan tipis, untuk membuat *type log*. Dilanjut dengan analisis sikuen stratigrafi dan *reef system* untuk menentukan penyebaran, dengan bantuan data seismik untuk dikorelasikan dengan sumur-sumur lainnya. Dari hasil analisis, terdapat 5 fasies pada daerah penelitian, yaitu: *Skeletal Debris Packstone-Wackestone*, *Coral Algal Grainstone – Boundstone*, *Skeletal Wackestone*, *Skeletal Packstone* dan *Coral Algal Packstone*. Terdapat pula 4 *reef system*, yaitu; *Back reef*, *reef crest*, *fore reef* dan *off reef*. Untuk mencapai tujuan akhir dari penelitian ini, maka dibuat peta penyebaran fasies.

Abstract. “X” field, the area of interest, is located in the Kais Formation, Salawati Basin, West Papua, Indonesia. The goal of this research is to acknowledge the carbonate facies, as well as its distribution, vertically and horizontally. The research began with an interpretation of the lithostratigraphy, using log and thin section data, to create a type log. It is then continued with an analysis of the stratigraphic sequence and reef system, to determine the facies distribution with the help of seismic data, in order to correlate with other wells. From this analysis, came 5 different facies in the area of interest, namely; *Skeletal Debris Packstone-Wackestone*, *Coral Algal Grainstone – Boundstone*, *Skeletal Wackestone*, *Skeletal Packstone* and *Coral Algal Packstone*. There were also 4 reef systems, namely; *Back reef*, *reef crest*, *fore reef* and *off reef*. This made possible of reaching the goal of creating a facies distribution map.

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BACKGROUND

In the Salawati Basin, oil was first discovered through Klamono Field, in the year 1936. Other investigations later revealed that the Salawati Basin is actually the growth structure of a carbonate body that caused draping, which created an anticline on the siliciclastic layer on top. Since then, the carbonate play type has been the main source of oil in this basin, until today. Hence, the further understanding of the facies distribution in this area, will enable for the lead to other undiscovered hydrocarbon reservoir in the Kais Formation.

REGIONAL GEOLOGY

The Salawati Basin is a foreland-type basin, in the direction of East – West, located Northern of the Indo-Australia Plate. It is restricted by the deformation zone of Sorong Sinistral Fault up North, and the Miosen Misool-Onin Geanticline down South. According to Awang H. Satyana (2001), the Salawati Basin has a history of basin polarity reversal (geometrical configuration). Until Miosen, it tends to tilt Southward, and after the reversal during Pliosen, the depocenter of the basin is now on the Northwest side. This basin reversal polarity is really important because of the effects on the structural development, hydrocarbon generation and migration as well as sedimentation after the reversal.

Regional Stratigraphy of Kais Formation

The Kais Formation was deposited during Early to Late Miocene. It consists of limestone that thinned out towards the source of sedimentation (West-ward), where the equivalent marl deposits were found from the Klasafet Formation. On top, formed the bodies of Kais reefs, that were older towards the East, which marked the transgression of the Kais reefs deposits itself. Kais Formation was deposited during varied deposition environments, from lagoonal, bank to deep-sea facies, which then created several types of carbonates; from low-energy, organic rich carbonate, to high reefal carbonate. All of this were deposited on top of Sirga Formation.

BASIC THEORY

The term carbonate rock can be translated to a rock that is made up of carbonate cement particles with a composition of carbonate mineral (Calcite and Dolomite) of more than 50% (K.J. Hsu, 1986). It is formed chemically, with the participation of organisms. Carbonate rocks classification is known to be the ideal reference when identifying facies, especially when using Dunham Classification, 1962 and Embry Klovon Classification, 1971.

- Grains are less than 10%: Mudstone,
- Grains are more than 10%: Wackestone,
- Grains and matrix (Interstitial mud): Packstone,
- Sparite cement instead of matrix, where the grains were bounded together during formation: Grainstone,
- Grains are bounded by algae, no parallel lamination with layers: Boundstone,

Facies of Carbonate Rocks

Facies is a body of rock that has several specific characteristics, seen from lithology, sedimentary and biological structures, where it exhibits different facies aspects of the existing body of rock below, above and around it. (Walker & James, 1992). According to Pomar (2004), carbonate facies can be categorized into 4 (Figure 3.1);

- Back-reef lagoon: A restricted area that is low-energy behind the reef crest or core.
- Reef core: The top of the reef, that is near sea-level and is prone to wave activities.
- Fore reef / Slope: A morphology that developed from the reef core, which created a layer of about 5 - 30°.
- Off reef / open shelf: A morphology that is similar to back-reef lagoon, except for very little bioturbation.

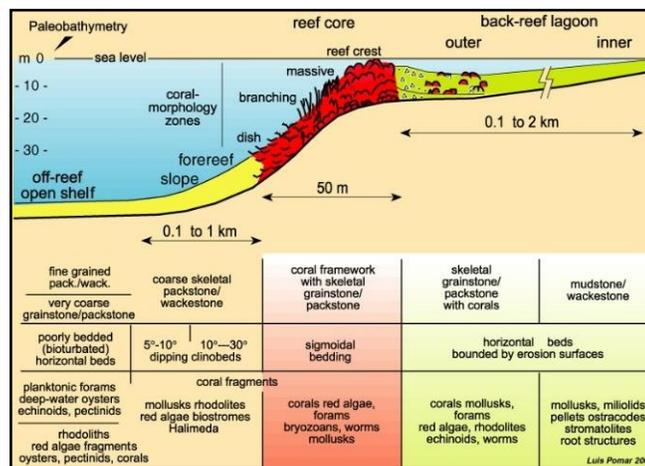


Figure 3.1 Carbonate Facies Model, Luis Pomar (2004)

Electrofacies of Carbonate Rocks

Electrofacies is a recording of response and characteristic of a specific wireline log. The main purpose of electrofacies analysis is to interpret the characteristics of carbonate growth, based on the trends of the wireline log, usually represented by the gamma-ray (GR) and resistivity log. Electrofacies are commonly used on the basis that each log can show the trend that is assumed as clay content. Carbonate growth is commonly categorized in accordance to its growth that is affected by the fluctuations of the sea-water level, namely; Start-up, catch-up, keep-up and give-up (Kendall, 2003). Trends from the GR log also helps in identifying facies, where each of these patterns will show difference in varied grain sizes from the analyzed lithology (Figure 3.2), such as progradation, retrogradation and even aggradation. Trend has a strong relationship with shape, because of the shape of the curve that is shown by the GR log; blocky (cylindrical), funnel-shaped, bell-shaped, symmetric and irregular.

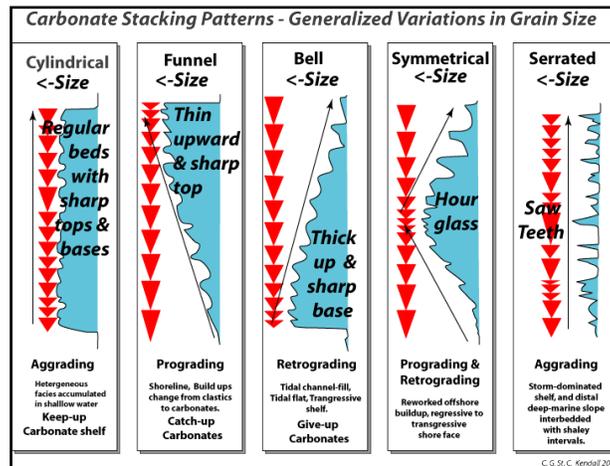


Figure 3.2 Electrofacies Model of Carbonate Rocks Explaining Carbonate Growth (Kendall, 2003)

Biofacies of Carbonate Rocks

There are 4 main components that make up a carbonate rock (Tucker, 1991); Non-skeletal grain, skeletal grain, micrite and cement. In the case of identifying the biofacies aspect, the skeletal grain is the most important component, because its an indicator as to the distribution of the carbonate-producing invertebrates during the geological time. Facies identification relying on the association of foraminifera microfossil, must be based on the foraminifera association as a whole, such as; Percentage of planktonic, miliolid, arenaceous form, large forams and also the association with the calcareous benthonics. It important to also take notice of the abundance and the variety, whether there is a dominant species or genus, preservation, size, test shapes, etc.

RESULTS AND DISCUSSION

In a research, the comprehensiveness of one's data is very important, where it can make or break the accuration of interpretation that will be done. In this study, the data used are log, thin section and seismic, curtosity of RH Petrogas Basin Ltd., subsurface departement.

Well Analysis

The log analysis was done in roder to identify the variation of facies as well as its distribution. The logs that were used in this analysis are; Gamma ray, resistivity, density and neutron. Simply put, if the GR value is low, it will either be Mudstone or Wackestone. If the GR value is high, it will either by Grainstone or Boundstone. (Figure 4.1).

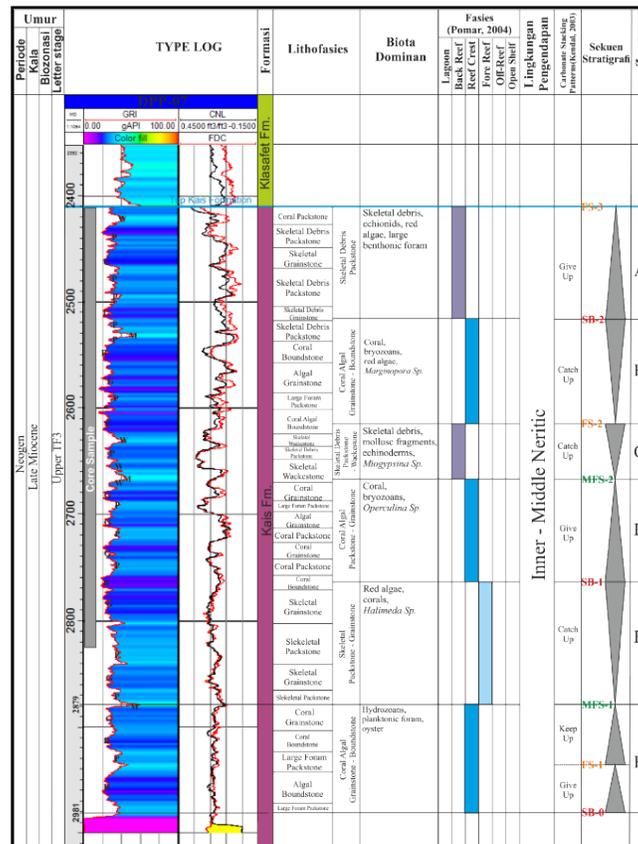


Figure 4.1 Summary of Analysis on Well DPP-07

The analysis reveals that there are 7 carbonate stacking patterns. SB-0 is a boundary between Sirga and Kais formation. Then carbonate give-up, where carbonate grows fining upwards. Whilst the sea level is relatively low and is still mixed with rocks from the body below, or the carbonate platform, until we find FS-1. Afterwards, came carbonate keep-up, where the growth is relatively stable due to the high sea level that is perfect for carbonate, which lead to MFS-1. Fourthly, came carbonate catch-up where it coarsens upwards, until SB-1. It was then continued with a carbonate give-up until MFS-2, then another carbonate catch-up until SB-2. In the end a flooding surface was found, which marks the boundary between Kais and Klasafet formation, where the Klasafet formation starts with content of marl.

Thin Section Analysis

The log of carbonate rocks do not simply mirror the lithology in reality, not as simple as siliciclastic rocks. This part is where the thin section comes in, as appears in **figure 4.1**. Not only will it approve or disapprove of the lithofacies from the log, but will also provide us with the data for biota analysis. This made possible to identify whether the facies is back-reef lagoon, fore reef, reef crest or off reef (Pomar, 2004). The biota analysis revealed that horizon F is Coral Algal Grainstone – Boundstone, therefore is in the reef crest facies. Then it retrograded to the fore reef facies in horizon E, with lithofacies of Skeletal Packstone – Grainstone. It then progrades back to reef crest facies in horizon D, with lithofacies of Coral Algal Packstone - Grainstone. Came along a retrograding pattern which brings horizon C further to back

reef facies, with lithofacies of Skeletal Debris Packstone - Wackestone. Reef crest facies was found again in horizon B, due to prograding, Coral Algal Grainstone - Boundstone. Lastly, back reef facies and lithofacies of Skeletal Debris Packstone in horizon A is the result of retrograding.

Sequence Stratigraphy and Facies Correlation

After the identification of carbonate stacking patterns were done on the key well of DPP-07, the similarity of log patterns, lithofacies and facies groups were used to correlate with 7 other wells. Hence, there are 2 stratigraphic sequences, where SB-0 is an unconformity between Kais and Sirga formation. SB-1 is a boundary between Skeletal Packstone – Grainstone with Coral Algal Packstone – Grainstone. Lastly, SB-2 is an unconformity between Coral Algal Grainstone – Boundstone with Skeletal Debris Packstone.

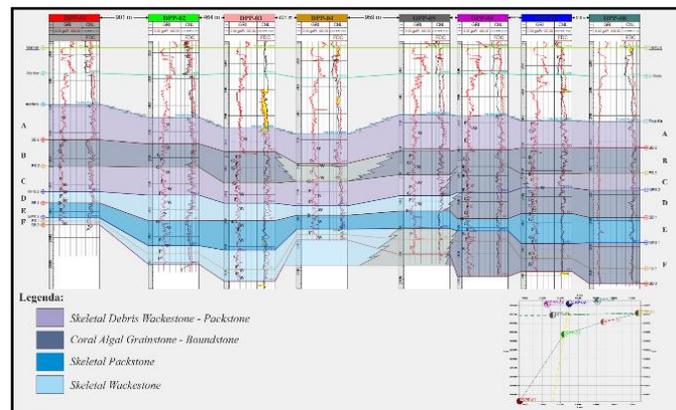


Figure 4.2 Correlation of Wells DPP-01, 02, 03, 04, 05, 06, 07 and 08 (Flattening on Textularia II)

This correlation was made possible with the help of a seismic interpretation that was given by RH Petrogas Basin Ltd. Then the 6 horizons (A through E) from the log correlation was interpreted on the seismic data as well. It revealed the carbonate build up of the Kais Formation in the East – West direction, and also the geometrical shape of the boundaries between horizons.

Facies Distribution

From the correlation done above, it is concluded that there are 6 different horizons in accordance to the different facies. Horizon F is the bottom horizon, which is the starting point for the carbonate growth, with the Sirga Formation under it. Hence it's dominated by shale, marl and pelagic limestone. Group facies of this horizon is Skeletal Wackestone that is spread out widely from south to north, which indicates that it was an area with low energy. The log pattern is fining upwards and continuous growth in the same grain size, give-up and keep-up (Kendall, 2003) (**Figure 4.3**). Facies of this horizon F is lagoon (Pomar, 2004).

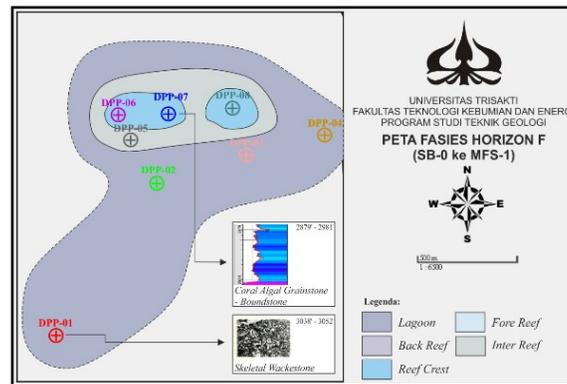


Figure 4.3 F Horizon, Facies Map (SB-0 to MFS-1)

Horizon E is restricted by MFS-1 at the bottom and SB-1 on top. Facies of this horizon is Skeletal Packstone, that is spread out widely from north to south. The log pattern is coarsening upwards, or catch up (Kendall, 2003) (Figure 4.4). Facies of this horizon is fore reef (Pomar, 2004).

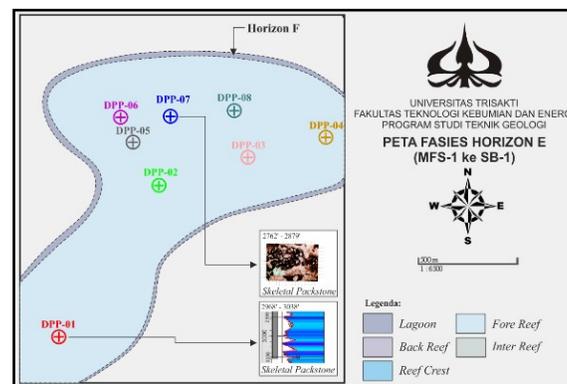


Figure 4.4 E Horizon, Facies Map (MFS-1 to SB-1)

Horizon D is restricted with SB-1 at the bottom and MFS-2 on top. Facies group of this horizon is the repetition of Skeletal Wackestone facies of Horizon F, that is widely spread from the north to south. Log pattern is fining upwards, or give-up (Kendall, 2003) (Figure 4.5). Facies of this horizon is lagoon (Pomar, 2004).

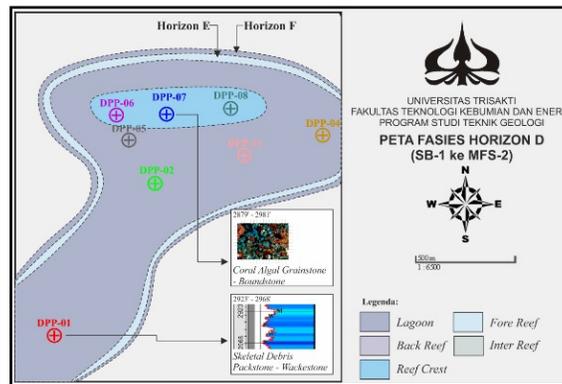


Figure 4.5 D Horizon, Facies Map (SB-1 to MFS-2)

Horizon C is restricted by MFS-2 at the bottom and FS-2 on top. Facies group of this horizon is Skeletal Debris Packstone – Wackestone, that is wide spread from north to south, with log pattern that is coarsening upwards, or catch up (Kendall, 2003) (Figure 4.6) Facies of this horizon is backreef (Pomar, 2004).

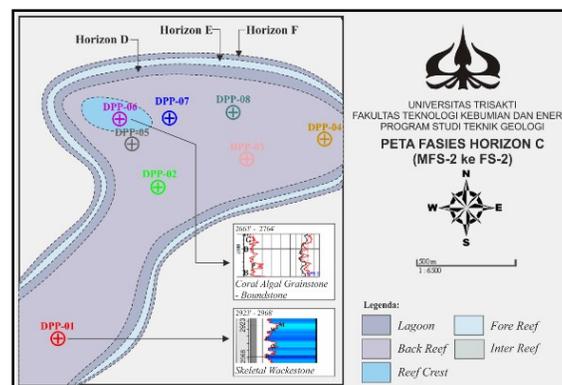


Figure 4.5 C Horizon, Facies Map (MFS-2 to FS-2)

Horizon B is restricted by FS-2 at the bottom and SB-2 on top. Facies group of this horizon is Coral Algal Grainstone – Boundstone, that is found in all 8 wells. Log pattern seen is coarsening upwards, or catch-up (Kendall, 2003) (Figure 4.6). Facies of this horizon is reef crest (Pomar, 2004).

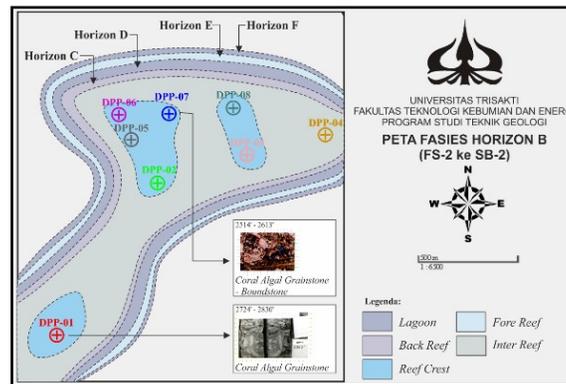


Figure 4.6 B Horizon, Facies Map (FS-2 to SB-2)

Horizon A is restricted by SB-2 at the bottom and top of Kais Formation on top, which is the boundary with Klasafet Formation. Facies group of this horizon is Skeletal Debris Wackestone – Packstone, that is a repetition of facies of horizon C. Log pattern seen is fining upwards, or give-up (Kendall, 2003) (Figure 4.7), that ends on top of Kais Formation. Top Kais itself is known as a flooding surface, that is marked by dominant lithology of marl and clay on the start of Klasafet Formation.

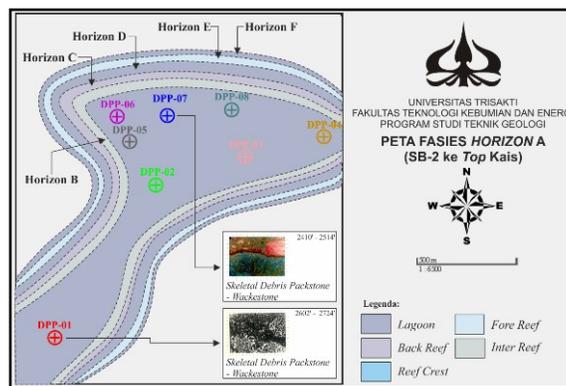


Figure 4.7 A Horizon, Facies Map (SB-2 to Top Kais)

CONCLUSIONS

Facies of “X” field in the Kais Formation, Salawati basin, has 4 identifiable facies, namely; Skeletal Debris Wackestone – Packstone, Coral Algal Grainstone – Boundstone, Skeletal Packstone and Skeletal Wackestone (Embry & Klovan Classification, 1971). There fossil in the area of interest contains large foraminifera and several skeletal such as coral platy or branching, red algae, molusca, bryozoa and bivalves. The fossils mentioned above are used to interpret the reef system from the carbonate body. Reef system of the carbonate body itself are lagoon, back reef, reef crest and fore reef (Pomar, 2004).

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