SEISMIC STRATIGRAPHY ANALYSIS OF 2D SEISMIC CROSS SECTION IN ARAFURA SEA, PAPUA

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ABSTRACT

Arafura Sea is one of the shallow marines located in eastern Indonesia. This is accommodated based on the bathymetry map of Arafura which has a depth of up to 90 meters. Stratigraphy in eastern Indonesia is quite complex, consisting of rocks aged up to Paleozoic. There have been five tectonic events since Pre-Cambrian until now, namely the pre-rift, syn-rift, passive margins, convergence and compression. The 2D seismic cross section of line 5 acquired as the result of seismic data processing which is part of the Buru Formation consisting of shale siltstone, sandstone, limestone, calcareous sandstone aged from Late Miocene to Plio-Pleistocene. Bouguer Anomaly data from Buru Formation have a value of 1,8 – 2,2 gr /cc which shows fine grained sediments in the form of silt, clay, and sand which deposited on the continental shelf. 2D Seismic cross section of line 5 shows the direction of sediment deposition obtained from the south which continues to fill the geometry of the basin in the north and divided into 4 seismic facies based on the characteristics of the internal reflector, amplitude, frequency and continuity. From these characteristics, there is a process of changing depositional energy that tends to slow toward the center of the geometry space of the depositional basin so that the resulting sedimentation pattern is uniformed. A fault structure has been identified which is formed the compressional force due to the presence of convergent tectonics which is perpendicular to the direction of the bedding

Keyword: Arafura sea, 2D Seismic, Buru Formation, Seismic facies

INTRODUCTION

Arafura Sea are waters that covering the Arafura - Sahul continental shelf and located in the southern part of Papua to the border of the Australian continent. The northern boundary of these waters is the Seram Sea and Irian Jaya Island (Papua), while Australia's North Coast from the York Peninsula to the Don Peninsula is the southern boundary. In the western part, the waters of Arafura are bordered by the Banda Sea and the Timor Sea, while in the eastern part it is bordered by Dolak Island and the Don Peninsula.

Below the surface of Arafura Sea sediment packages are found, aged from Cenozoic, Mesozoic to Paleozoic. The bedrock in these waters is generally a pre-Cambrian sediment package that has undergone metamorphism.

The regional stratigraphy of the Arafura waters has 4 phases of depositional sequence, including Pre-rift, Syn-rift, Post-rift and Syn-Orogenic. (Pigram and Panggabean, 1984.) There are five tectonic events since the pre-Cambrian until now, namely the pre-rift, syn rift, passive margin, convergence and compression. Each event determines the conditions of the depositional environment and the stratigraphic sequence in this area (Aldha, T. & KJ Ho, 2008). Given that seismic reflection can provide an overview of stratigraphic conditions, subsurface structure, seismic facies and depositional environment.

RESEARCH METHOD

This study uses secondary data analysis methods sourced by research surveys conducted by the Pusat Penelitian dan Pengembangan Geologi Kelautan (PPPGL). The seismic data acquisition phase was carried out by an exploration team unit from the PPPGL on September 5, 2017 in the Arafura Sea area, Papua. This study used data of seismic line 5 based on figure 1. The results of the seismic data acquisition are raw data in the segD format which are then processed using Promax 2.0 software. The processed segD rawdata produces a 2D seismic cross section that will be analyzed and interpreted. Seismic stratigraphic analysis is carried out based on the division of the seismic facies using the ABC method (Ramsayer, 1979) which divides the seismic facies based on the characteristics of the visible reflector pattern and divides them based on the upper boundary sequence (A), the lower boundary sequence (B) and the internal reflector character configuration (C). There is supporting data for analysis and interpretation in the form of gravity analysis data for Arafura

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Sea based on research from Setiadi et al in 2019 and fossil analysis from LIPI in 2010.

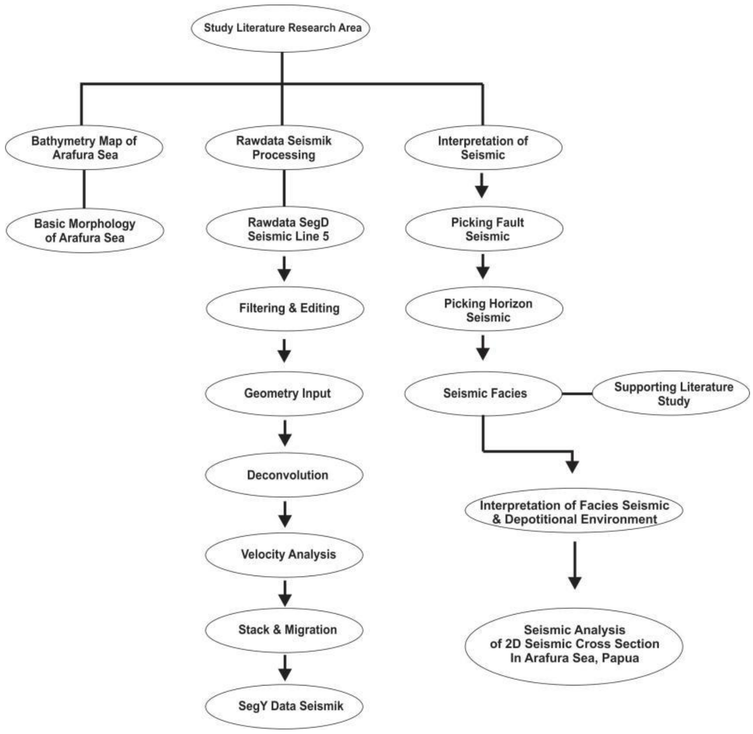

Figure 2. Research flow chart

RESULT AND DISCUSSION

Based on the bathymetry map in (Figure 3), the maximum depth is about 90 meters and there are many closures that show the morphography of the anticline. This geological condition proves that there is a fairly complex process in the research area so that other supporting data is needed to support seismic facies analysis such as gravity data and fossil analysis in the waters of the Arafura Sea.

Interpretation of Bouguer Anomaly

The research team for the oil and gas basin of the Marine Geology Research and Development Center in 2017 conducted research using the sea gravity method in the Arafura waters. The total length of the path measuring gravity is approximately 2856 km. Bouguer anomaly is a combination of regional anomaly data processing and residual anomaly with various wavelength variations due to the influence of the rock composition in the research location from shallow waters to deep waters. The regional anomaly map is obtained from Bouguer Anomaly, the result of the upward continuation filter at the optimum continuation height of 6000 m. While the residual anomaly is obtained from the difference between Bouguer anomaly and Regional anomaly. Furthermore, a qualitative interpretation is carried out in order to determine the lateral anomaly changes based on the residual anomaly that has been obtained from the optimum upward continuation filter results. This qualitative interpretation is usually used to determine the straightness pattern of the structure.

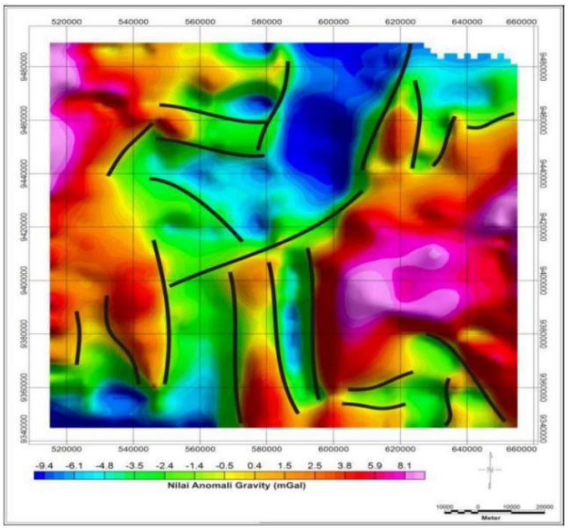

Figure 4. Structural Straightness Pattern Based on Residual Anomalies of the Southern Akimeugah Basin (Setiadi et al, 2019)

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In general, the straightness pattern of the structure has two main directions, namely the east-west and north-south directions in Figure 4. From this figure, it can be seen that the pattern with the east-west structure direction is probably due to the push force from the south (Australia) to the north, whereas the alignment structure pattern in a relative north-south direction is probably due to the inheritance of rocks with pre-Tertiary age from Australia which drifted to the Arafura Sea.

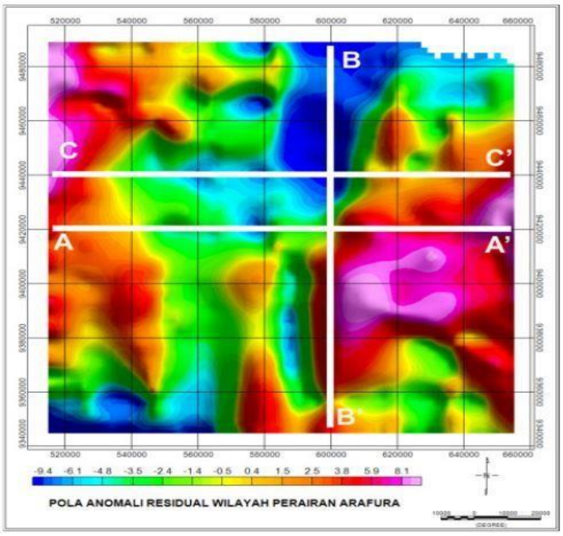

Figure 5. Cross-sectional Direction of 2D model, Akimeugah Basin, Southern Part of Papua (Setiadi, et al, 2019)

Based on the correlation of seismic data that has been made beforehand, where the 2D seismic data of Arafura Line 5 has a north-south direction which is the same as the cross-section direction of BB' based on figure 5. If it is correlated with the results of the residual anomaly section above, it is possible that the seismic section is included in the Buru Formation based on the density level of the Buru Formation which occupies the top strata in the regional stratigraphic conditions of Arafura waters which has a density value of 1.8 - 2.2 gr / cc based on figure 6. The Buru Formation consists of shale siltstone, sandstone, sandstone limestone, and limestone sandstone.

Interpretation of Depotitional Environment

Based on Figure 7, the process of data collection and analysis of fossil sample data was carried out by a team from the LIPI Oceanographic Research Center, Jakarta in May 2010 in Arafura Waters from the southeastern part of the Tanimbar Islands to the southern and eastern parts of the Aru Islands to around Dolak Island and Papua Island. Figure 7 shows that the species that are found evenly in almost all stations and in quite a number are Ammonia beccarii and Pseudorotalia schroeteriana. Based on the distribution of benthic foraminifera found, the characteristics of most of the Arafura waters are shallow, open water with medium to strong current energy levels. Apart from P. schroeteriana, other characteristic species were also found, such as from the genus Elphidium and Quinqueloculina. Based on the depth zone classification according to (Boltovskoy & Wright, 1976), the depositional environment is in the shallow sea - open sea in the inner - middle neritic zone with a depth of about 0 - 100 m.

Interpretation Seismic Cross Section

The cross section in Figure 9 is a section of the final result of P3GL seismic data processing on the 5 Arafura cross section. Based on regional geology, this seismic cross section is likely to be included in the Buru Formation based on the rock density value. This seismic depth is based on the two way travel time (TWT) value of 2,200 m / s. In the cross section, it can be seen that the direction of sediment deposition comes from the South which continues to fill the geometric basin space in the North. There are faults that form a normal fault pattern that ranges from a depth of about 100-2000 TWT. This fault is influenced by the compressional force due to the tectonic activity of Arafura, which is perpendicular to the direction of the bedding so that it forms a fault structure. The results of the analysis and interpretation are that the seismic section is in the Post Collision tectonic phase, this is indicated by the lack of tectonic activity found in the seismic section of the 5 line, the presence of the developing structure is also realtively not that massive with the characteristics of the depositional pattern which tends to be more stable. After the interpretation, the seismic section of the 5 Arafura line is divided into 4 seismic facies units, namely:

- **Unit Fasies 1 (C-C/SP)**

Based on figure 10, this facies unit consists of an upper and lower boundary in the form of a concordant which shows the alignment of the layer with the previous layer and there is no visible erosion plane at the seismic cross-sectional boundary. The sediment deposition pattern in this facies tends to move steadily from the south to the north which fills the geometric space of the depositional basin. The internal character of the reflectors in this unit is sub-parallel, this indicates that the sedimentation conditions are uniform and can indicate a channel fill filling zone influenced by ocean currents. This sub-parallel character indicates the geometry that occurs in shallow

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water. The characteristics of the seismic reflector tend to be high continuous and high amplitude which indicates the deposition of shale marine deposits which is influenced by the sedimentation energy which tends to be weak.

- **Unit Fasies 2 (C-DWN/SIG)**

Based on figure 11, this facies unit consists of an upper bound in the form of a concordant which is in line with the previous layer and there is no visible area of erosion in the upper plane of the sequence unit, then a lower boundary in the form of a down-lap which is the termination of the younger strata and the position is tilted down the slope above the strata. older, characterized sedimentation patterns that tend to be intensive. The internal reflector character of this unit is the sigmoid progression which indicates a deposition process in the slope zone along the continental margin which forms a layering pattern that spreads to the shelf margin, which generally consists of fine clastic rocks which are influenced by low energy during the deposition process due to low turbidity. current and low velocity current (Sangree, 1979). The characteristics of the reflector are high continuous and high amplitude which indicates a uniform deposit in the sedimentation process which forms a thicker bed pattern as a characteristic of the clinoform type.

- **Unit Fasies 3 (C-C/SIG)**

Based on figure 12, this facies unit consists of an upper and lower boundary in the form of a concordant which shows the alignment of the layer with the previous layer and there is no visible area of erosion at the seismic cross-sectional boundary. The sediment deposition pattern in this facies tends to move steadily from the south to the north which fills the geometric space of the depositional basin. The internal reflector character of this unit is the sigmoid progression which indicates a deposition process in the slope zone along the continental margin which forms a layering pattern that spreads to the shelf margin, which generally consists of fine clastic rocks which are influenced by low energy during the deposition process due to low turbidity. current and low velocity current (Sangree, 1979). The characteristic of the reflector is high continuous and high amplitude which indicates a uniform deposit in the sedimentation process which forms a thicker bed pattern as a characteristic of the clinoform type of seismic.

- **Unit 4 (C-C/SP)**

Based on figure 13, this facies unit consists of an upper and lower boundary in the form of a concordant which shows the alignment of the layer with the previous layer and there is no visible erosion plane at the seismic cross-sectional boundary. The sediment deposition pattern in this facies tends to move steadily from the south to the north which fills the geometric space of the depositional basin. The internal reflector character in this unit is sub-parallel, this indicates that the sedimentation conditions are uniform and can indicate a channel fill filling zone that is influenced by ocean currents. This sub-parallel character indicates the geometry that occurs in shallow water. The characteristics of the seismic reflector tend to be high continuous and high amplitude, which indicates the deposition of shale marine deposits which is influenced by the sedimentation energy which tends to be weak.

CONCLUSION

The cross section obtained as the final result of the seismic data processing of the Arafura 5 line, which is likely to be part of the Buru Formation with a two way travel time (TWT) value of 2,200 m / s. The Buru Formation generally consists of shale siltstone, sandstone, sandstone limestone and limestone sandstone. This lithology is supported by indications of fine-grained deposits supported by rock density data based on Bouguer Anomaly data which has a value of 1.8 - 2.2 gr / cc which indicates fine grained sediment. The discovery of the benthic foraminifera P. schroeteriana, Elphidium and Quinqueloculina indicates the depth zone, the depositional environment is in the shallow open sea in the inner-middle neritic zone with a depth of about 0 - 100 m. Based on the results of the analysis and interpretation of each seismic facies unit at the Arafura 5 cross section, there is a process of changes in depositional energy that tends to slow down towards the center of the settling basin geometry. This is also indicated by the characteristics of the internal reflector and the character of the seismic amplitude which tends to be medium-high and the external seismic shape that tends to be in the form of a wedge to sheet drapes which indicates a uniform sedimentation process.

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ATTACHMENT

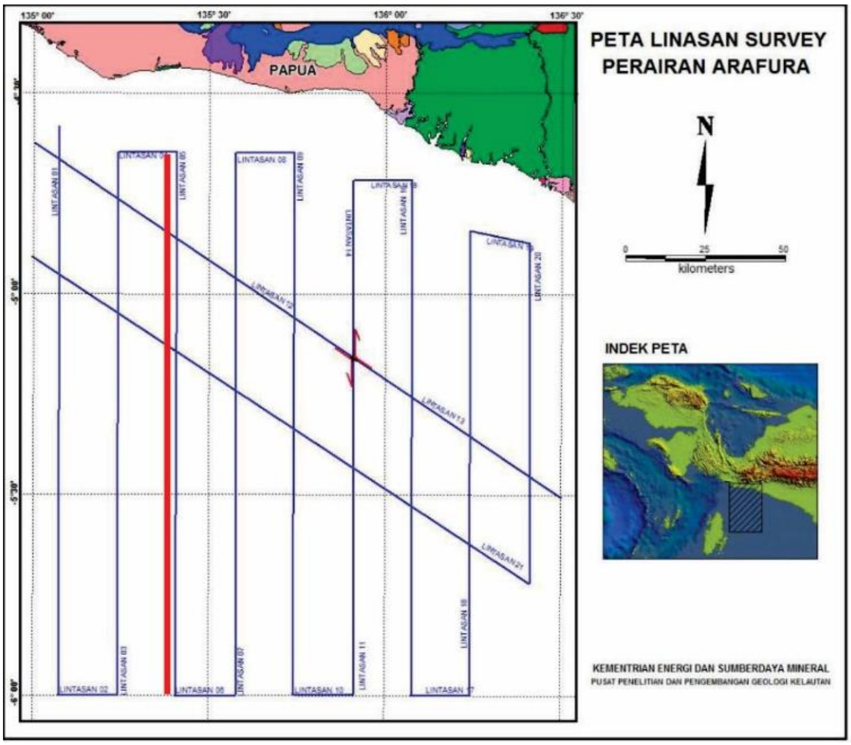

Figure 1. Survey trajectory map of the Arafura Sea

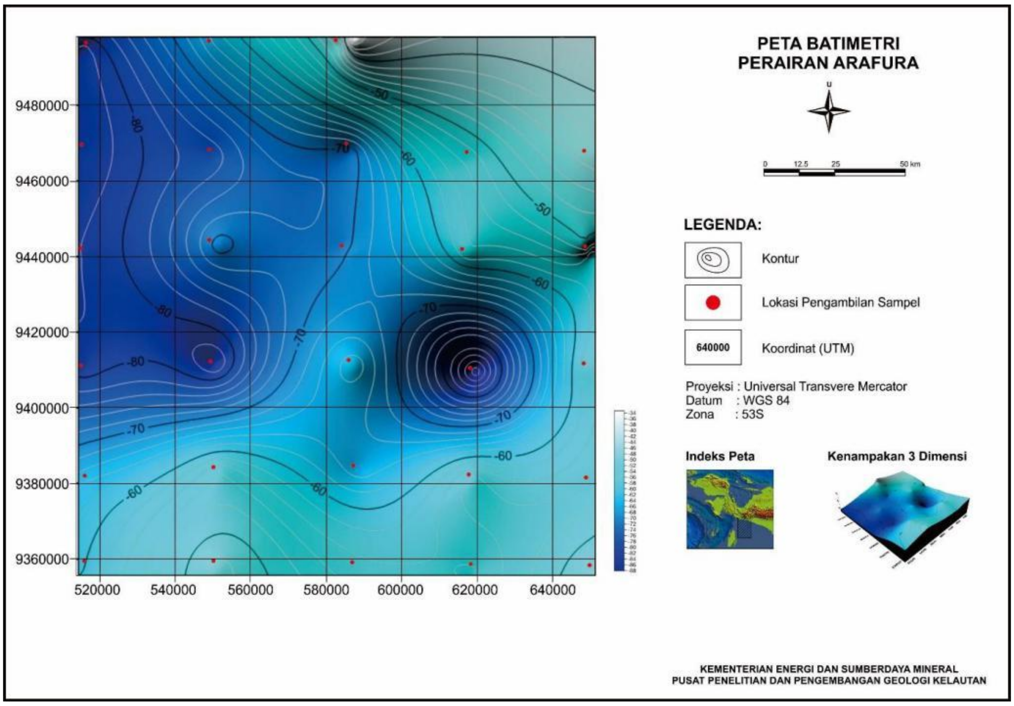

Figure 2. Bathymetry map of the Arafura Sea

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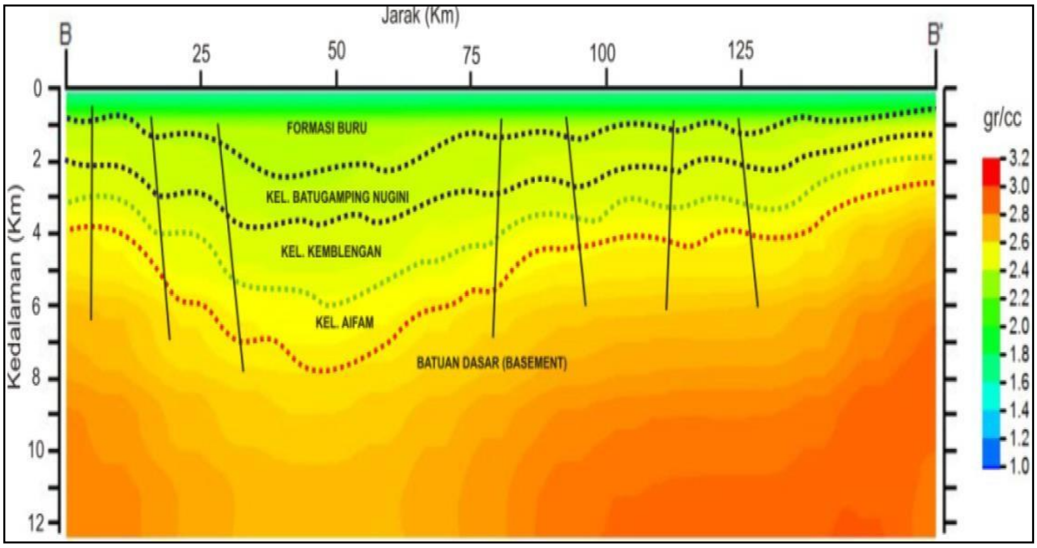

Figure 6. Interpretation of the Cross Section Model 'BB' in the 2D Model of the Cross Section (Setiadi et al, 2019)

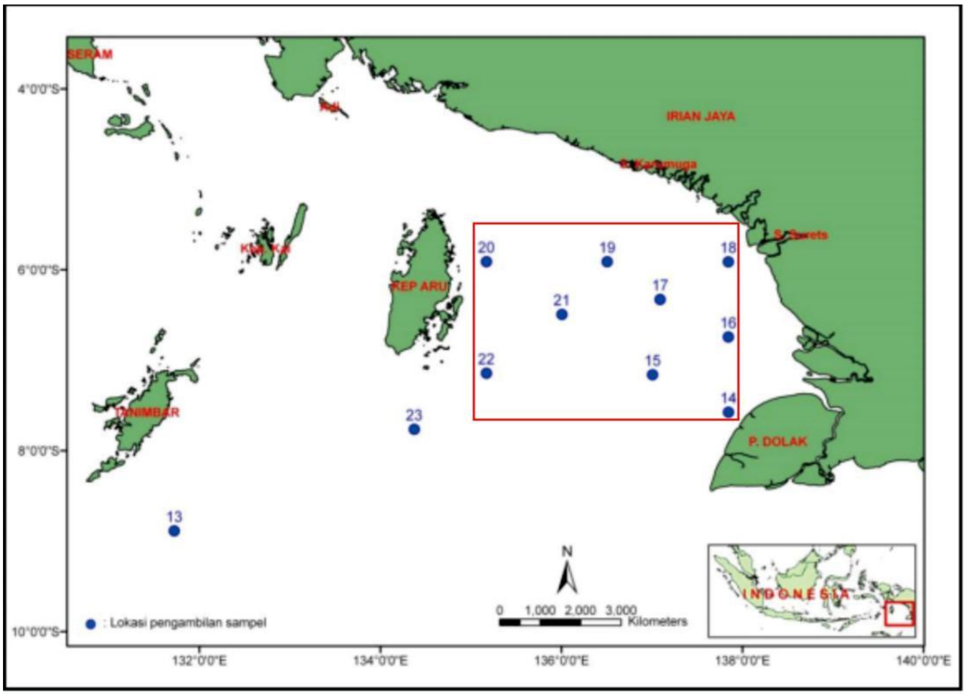

Figure 7. Locations of fossil sampling in Arafura Waters (Natsir M. S, and Rubiman. 2010)

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Foraminifera Benthic	Sampel										
	13	14	15	16	17	18	19	20	21	22	23
Ammonia beccarii (Linnaeus)	-	104	21	46	121	69	14	116	131	111	14
Amphistegina lessonii	-	-	-	-	-	-	-	-	-	-	1
Anomalina rostrata (Bradyi)	21	-	-	-	-	-	-	-	-	-	-
Asterorotalia trispinosa	-	-	-	-	-	-	-	-	-	1	-
Astocolus reniformis (d'Orbigny)	6	-	-	-	-	-	-	-	-	-	-
Bolivina earlandi (Parr)	82	-	-	-	2	-	-	-	-	-	-
Bolivina spathulata (Williamson)	26	16	-	-	41	4	-	-	-	-	4
Bolivina subspinecens (Cushman)	12	-	-	-	-	-	-	-	-	-	-
Cancris oblongus (Cushman)	40	-	48	-	-	-	-	-	-	18	-
Cibicides berthelotianus (d'Orbigny)	-	-	-	-	-	-	2	-	-	-	-
Cibicides molis	-	-	-	-	-	-	-	-	-	14	-
Discorbinella biconcavus (Parker & Jones)	-	-	-	-	-	-	-	-	-	-	2
Elphidium craticulatum	-	-	-	-	-	-	-	6	9	41	-
Elphidium crispum	-	-	7	-	-	8	4	-	-	29	-
Eponides berthelotianus (d'Orbigny)	-	12	-	-	-	-	-	-	-	-	-
Fissurina exsculpra (Brady)	-	-	-	-	1	-	-	-	-	-	-
Guttulina dawsoni (Chusman and Ozawa)	-	-	-	-	-	-	2	-	-	-	-
Gyroidina neosoldanii	-	-	-	-	-	-	2	2	-	-	2
Hoglundina elegans (d'Orbigny)	-	-	-	-	6	-	2	4	-	-	-
Lagena gracillisima (Sguenza)	1	-	-	-	-	-	-	-	-	-	-
Nonion sp.	8	12	-	-	-	-	24	2	-	-	2
Oolina apiculata (Reuss)	-	-	-	-	-	2	-	-	-	-	-
Operculina ammonoides	-	-	-	-	-	-	-	12	12	-	1
Planispinoides bucculantus (Brady)	-	-	-	-	-	-	-	-	6	-	-
Planorbulina sp. (d'Orbigny)	-	-	-	-	-	-	-	-	-	-	3
Pseudopolymorphina ligua (Rosmer)	-	-	-	-	-	-	2	-	-	-	-
Pseudorotalia schroeteriana	-	40	-	28	30	24	3	21	6	64	2
Quinqueloculina cultrate	-	-	-	-	2	-	-	-	-	-	-
Quinqueloculina granulocostata	-	-	-	-	-	4	-	-	-	3	-
Quinqueloculina parkery	-	2	-	-	1	3	-	-	-	8	1
Quinqueloculina seminulum	-	-	-	-	-	2	-	-	-	8	2
Quinqueloculina sp.	-	-	-	-	1	-	-	-	-	4	-
Rosalina sp.	-	-	-	-	-	-	-	-	-	-	2
Spiroloculina communis	-	-	-	-	-	2	-	-	-	-	3
Textularia pseudogramen	-	-	-	-	-	-	-	-	-	-	2
Triloculina tricarinata	-	-	-	-	-	-	-	-	-	-	8
Young miliolidae	4	-	-	-	-	2	-	-	-	-	-

Figure 8. The number of benthic foraminifera found in samples originating from Arafura waters

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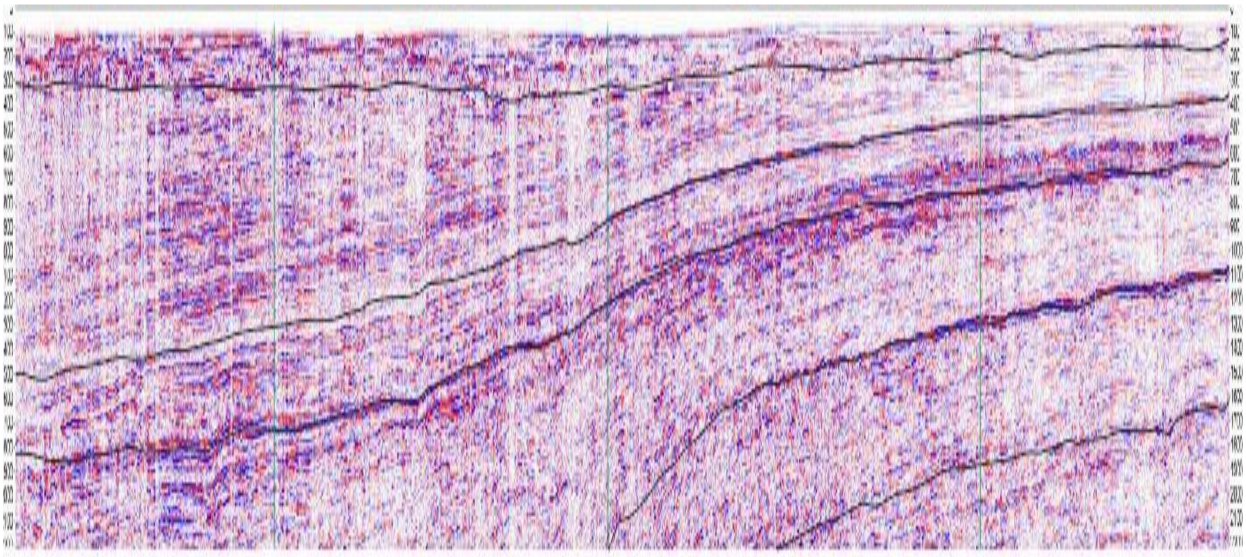

Figure 9. Interpretation of 2D Seismic Cross Section Line 5

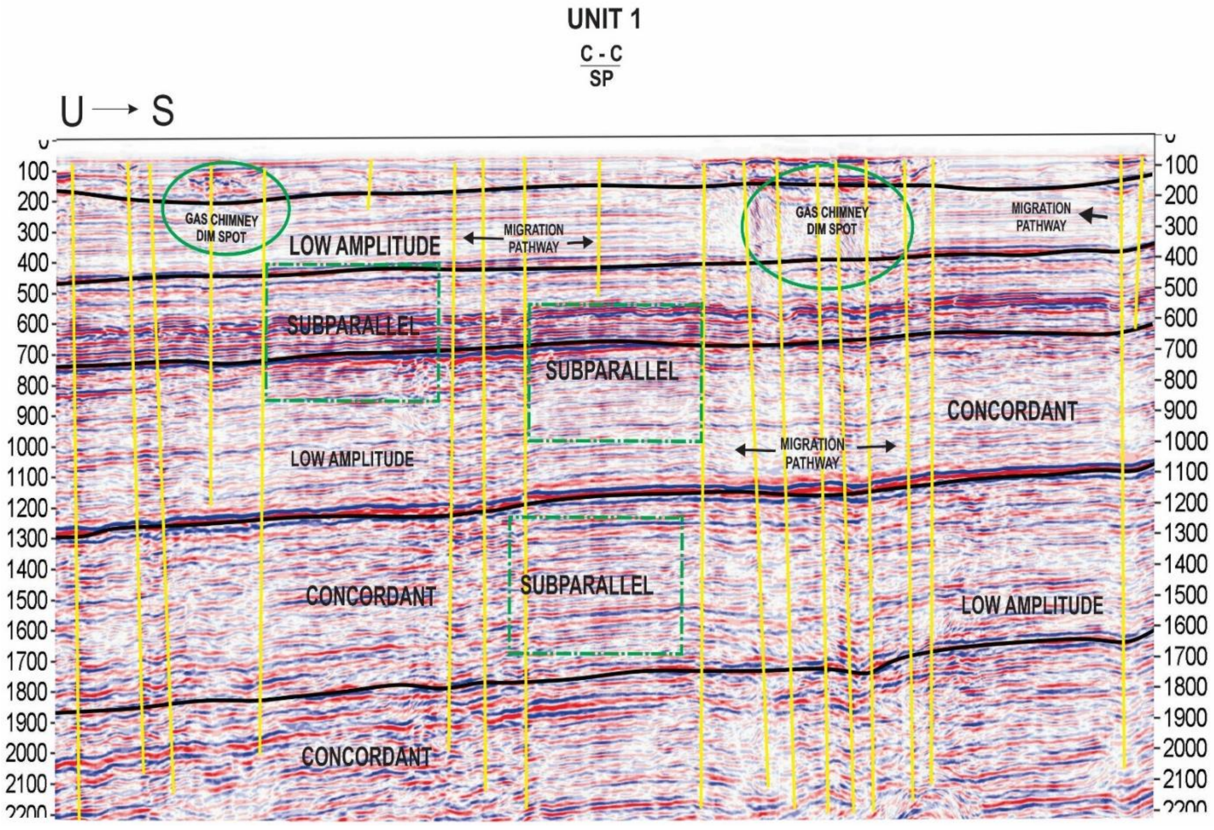

Figure 10. Interpretation of 2D Seismic Cross Section Line 5 Unit 1

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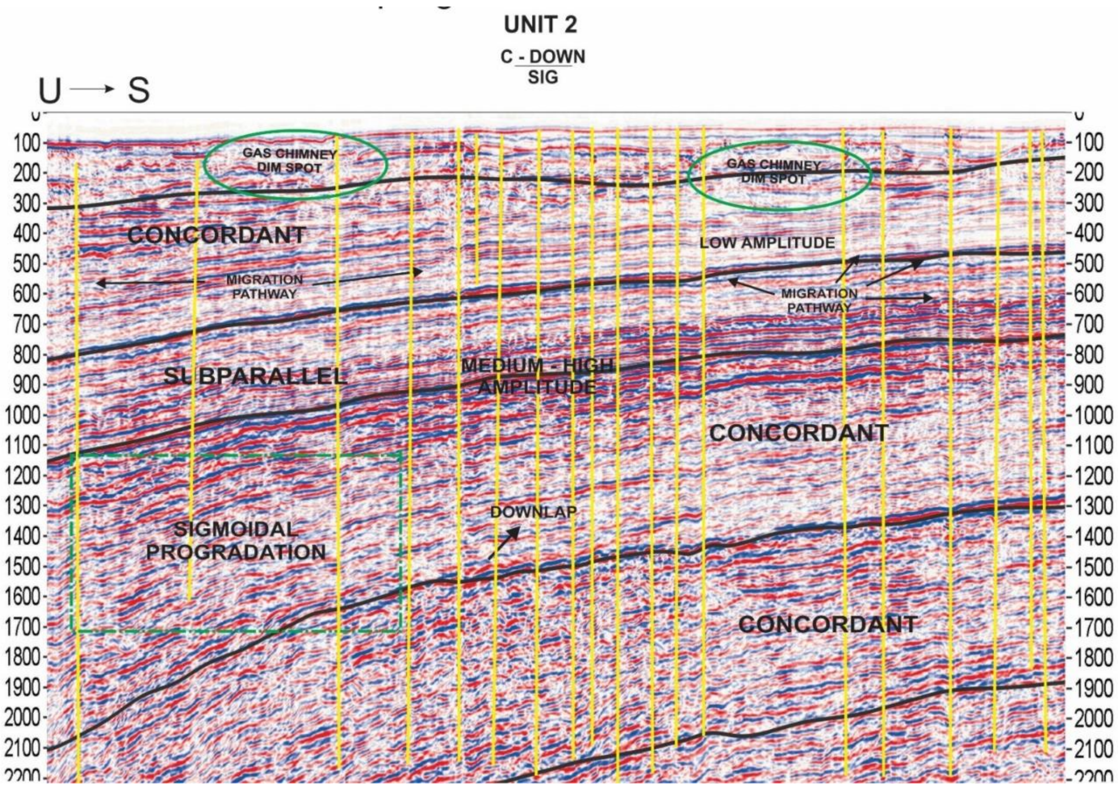

Figure 11. Interpretation of 2D Seismic Cross Section Line 5 Unit 2

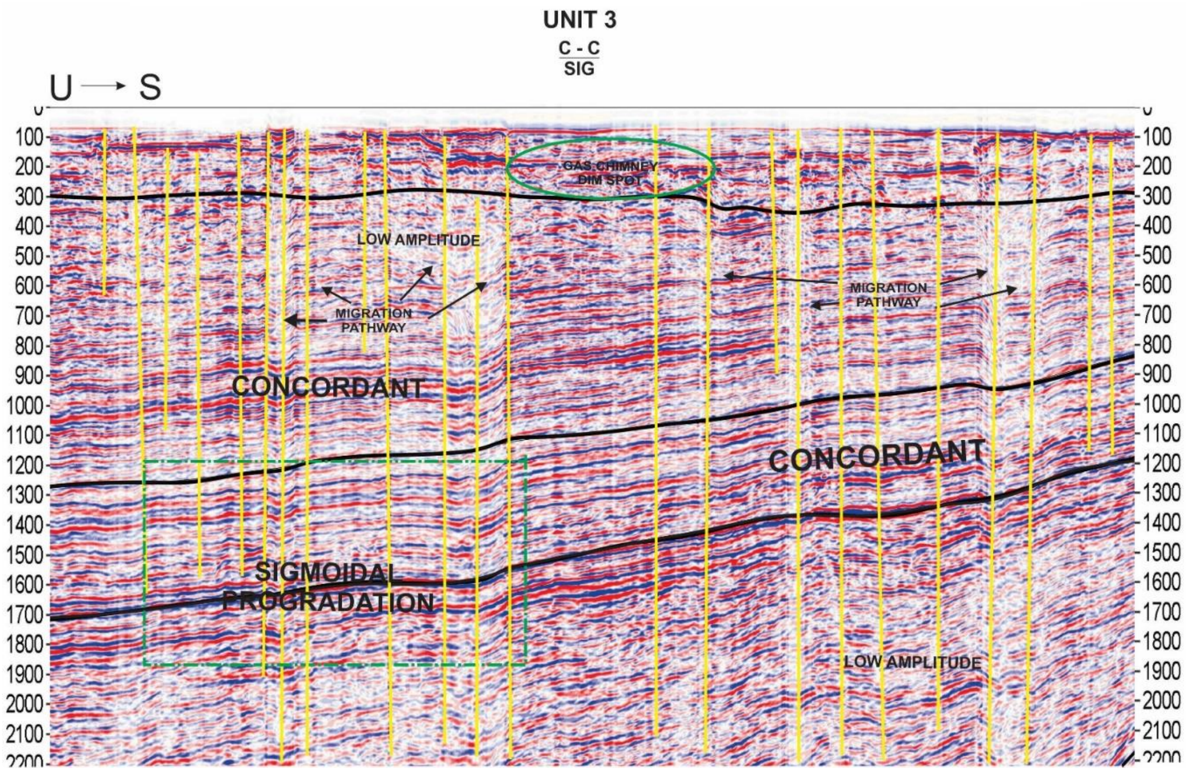

Figure 12. Interpretation of 2D Seismic Cross Section Line 5 Unit 3

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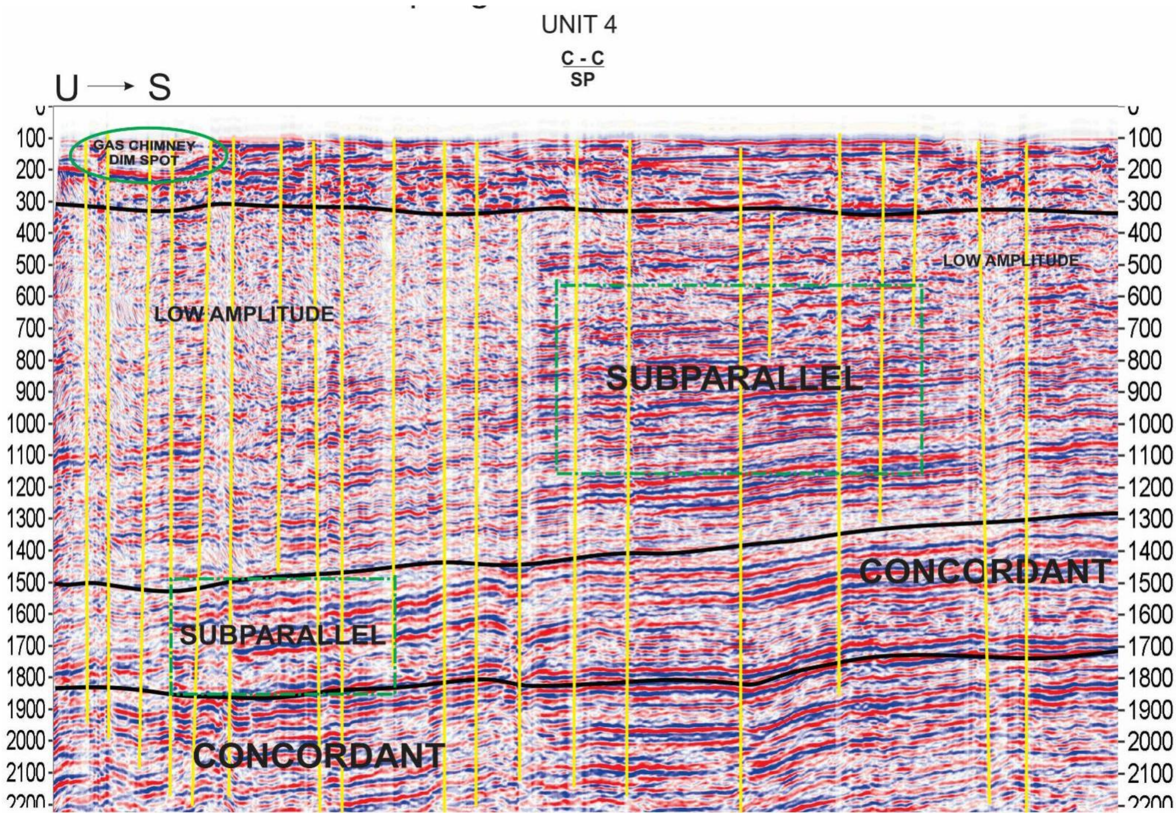

Figure 13. Interpretation of 2D Seismic Cross Section Line 5 Unit 4

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