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LATE CRETACEOUS SEDIMENTARY ROCK IN BARITO BASIN, INDONESIA: LITHOLOGY, PALEONTOLOGY, AND PALEOENVIRONMENT

(Batuna Sedimen Berumur Kapur Akhir di Cekungan Barito, Indonesia: Litologi, Paleontologi, dan Lingkungan Purba)

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ABSTRAK

Cekungan Barito merupakan cekungan belakang busur yang terbentuk oleh fase rifting pada Awal Tersier, dimana batuan sedimen tertua pada cekungan ini diyakini memiliki umur Eosen Tengah hingga Oligosen Awal. Namun, pada penelitian ini akan dihadirkan bukti terbaru mengenai hadirnya batuan sedimen yang berumur lebih tua dari Kenozoik di Cekungan Barito. Penelitian ini dilakukan pada sumur Bongkang-2 sebagai data utama, serta lima sumur lain yang memiliki indikasi adanya sedimen berumur Pra-Tersier, dimana secara umum terletak pada bagian utara dari Cekungan Barito. Dengan mengintegrasikan data mud log, petrografi, paleontologi, serta data dip-meter, dilakukan identifikasi litologi, umur dan lingkungan pengendapan, dan kemudian dilakukan interpretasi mengenai lingkungan purba Cekungan Barito di umur Kapur Akhir. Berdasarkan analisis data, menunjukkan bahwa bahwa batuan sedimen Pra-Tersier yang ditemukan pada enam sumur yang dianalisis memiliki umur Cenomanian, yang ditunjukkan oleh kehadiran fosil foraminifera besar berupa Sulcoperculina sp. and Orbitolina sp. di sumur Bongkang-2, Hayup-1 dan Hayup-3, serta fosil spora dan polen berupa Cicatricosisporites dorogensis, A. tricornitatus, Aquilapollenites sp., Distaverrusporites margaritus and Classopolis cf. *classoides pada sumur Bagok-1 dan Bagok-2. Selain itu, berdasarkan analisis litologi, pada sumur Bongkang-2, Hayup-1 dan Hayup-2 berkembang litologi berupa batugamping, shale dan batupasir, sedangkan pada sumur Didi-1, Bagok-1 dan Bagok-2 berkembang litologi berupa shale dengan sisipan batupasir dan batuan piroklastik - vulkaniklastik. Kemudian, berdasarkan integrasi analisis litologi dan paleontologi diketahui bahwa pada umur Cenomanian, berkembang lingkungan terrestrial pada bagian barat Cekungan Barito, sedangkan pada bagian timur berkembang lingkungan laut dangkal.*

Kata Kunci: *Batuan sedimen Pra-Tersier, Paleontologi, Kapur Akhir, Cekungan Barito.*

ABSTRACT

The Barito Basin so far known as back-arc basin that formed by the rifting in Early Tertiary, which the oldest sedimentary rock in this basin is believed has a Middle Eocene to Early Oligocene age. However, this research will present new evidence regarding the existence of sedimentary rocks that are older than Cenozoic age in the Barito Basin. This research was carried out on Bongkang-2 well, as the main data, and other five wells which have an indication of the discovery of Pre-Tertiary sedimentary rocks, which are generally located in the northern part of the Barito Basin. Integration of mud log data, petrography, paleontology, and dip-meter data, resulting the identification of lithology, age and depositional environment, and then interpretation of the paleoenvironment of the Barito Basin in the Late Cretaceous is carried out. Based on the analysis of data, it is show that Pre-Tertiary sedimentary rocks found in the six wells analyzed has Cenomanian age, which is indicated by the presence of large foraminifera fossils in the form of *Sulcoperculina sp*. and *Orbitolina sp*. in Bongkang-2, Hayup-1 and Hayup-3 wells, as well as palynomorph fossils in the form of *Cicatricosisporites dorogensis, A. tricornitatus, Aquilapollenites sp., Distaverrusporites margaritus* and *Classopolis* cf. *classoides*

in Bagok-1 and Bagok-2 wells. In addition, based on lithological analysis, in the Bongkang-2, Hayup-1 and Hayup-2 wells lithology develops in the form of limestone, shale and sandstone, while in the Didi-1, Bagok-1 and Bagok-2 wells lithology develops in the form of shale with sandstone and pyroclastic – volcaniclastics rock intercalation. Then, based on the integration of lithology and paleontology analysis, it is known that in the Cenomanian age, terrestrial environments developed in the western part of the Barito Basin, while in the eastern part the shallow marine environment developed.

Keywords: Pre-Tertiary Sedimentary Rocks, Paleontology, Late Cretaceous, Barito Basin.

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I. INTRODUCTION

The Barito Basin so far known as Tertiary basin that formed by the rifting in Early Tertiary was caused by the Banggai Sula collision with southeast Sulawesi, resulting in Barito as the back-arc that started rifting in the Early Tertiary (Hall and Morley, 2004). The basin is located along the south-eastern edge of the stable Sundaland continent, separated by the Schwaner Complex in the western margin, Adang fault zone in the northern margin, and Meratus complex in the eastern margin.

Until now, it is believed that the oldest sedimentary rock making up the Barito Basin is the Tanjung Formation, which has a Middle Eocene to Early Oligocene age. Then, there have been no publications that prove the existence of sedimentary rocks developed below the Tanjung Formation in the Barito Basin. Some publications discussing Pre-Tertiary sedimentary rocks generally discuss Meratus Mountains, not the Barito basin, such as Sikumbang (1986).

Sikumbang (1986) made publications about Cretaceous sedimentary rocks in the Meratus Complex, which consist of the Early Cretaceous terrigenous sedimentary and carbonate rocks group, and then the Early Cretaceous to Paleocene volcanic - volcaniclastic rocks and turbidite group. Because of its close to the Barito Basin, it is possible that sedimentary rocks are also present in the Barito Basin, although until now there has been no publication that proves it.

However, this research will present new evidence regarding the existence of sedimentary rocks that are older than Cenozoic age in the Barito Basin. The evidence was found in the Bongkang-2 well with Late Cretaceous fossils occurrences. Referring to previous research (final well report), granodiorite basement rocks in the Bongkang-2 well should begin to be found at a depth of 3090 m based on cutting description. However, this research shows that at intervals of 3090 - 3200 m it is still in the form of sedimentary rocks, supported by the results of petrographic analysis and the discovery of planktonic and benthic foraminifera fossils.

This research was conducted by identifying lithology through petrographic analysis, and identifying the fossil content of foraminifera both small foraminifera and large benthic foraminifera at basement intervals in the Bongkang-2 well. In addition, this study also discusses some other evidence of Pre-Tertiary sedimentary rocks in the Barito Basin, from several wells that indicate the existence of these aged rocks (Figure 1). The well data will be re-interpreted and discussed into something more comprehensive to provide an overview of the lithology, age and paleoenvironment of Pre-Tertiary sedimentary rocks in the Barito basin.

According to Satyana (2017), the Pre-Tertiary sedimentary rocks is one of the future exploration targets in oil and gas development in Indonesia. The discovery of Pre-Tertiary sedimentary rocks in the Barito Basin raises new hopes for oil and gas exploration in this basin. This research is expected to be a preliminary study, and further research is needed to find out the potential of Pre-Tertiary sedimentary rocks in the Barito Basin.

II. METHODOLOGY

In this study, we conducted a petrographic and paleontological analysis of the Bongkang-2 well, where the data used was cutting data at intervals previously thought by Pertamina (1984) as basement rocks. Then, the analysis data on the Bongkang-2 well was combined with the results of a review of previous studies in several wells which identified Pre-Tertiary sedimentary rocks in the Barito Basin. At the Bongkang-2 well, an analysis was carried

out on each of the three samples for petrography and large benthic foram identification, as well as three samples for identification of small foraminifera (planktonic and benthic), which can be seen in Table 1. Whereas for a review of previous reports, available data resumes and references used can be seen in Table 2. The reviews were carried out on six wells, all of which are located in northern part of Barito Foredeep (Figure 1).

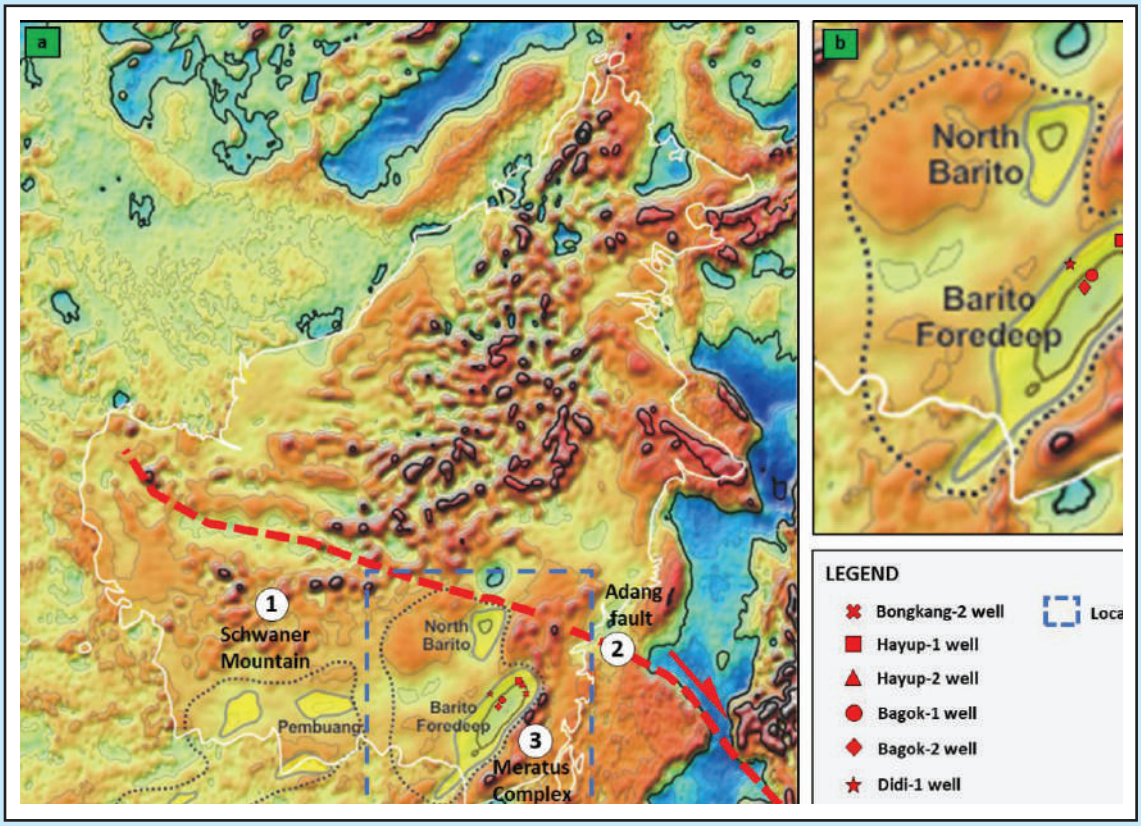

Figure 1
Location of well that analyzed and the main elements around Barito Basin, drawn on free-air gravity map from Smith and Sandwell (1997).

Table 1
Resume of sample analysed in Bongkang-2 well. The petrography analysis and large benthic foram identification were conducted on samples of 3142 m, 3172 m, and 3200 m, while the identification of small foraminifera was conducted on samples of 3132 m, 3162 m, and 3192 m. Red checklist shows the barren samples in paleontology analysis.

No.	Formation	Depth	Analysis			
			Petrography	Paleontology		
				Large Benthic Foraminifera	Small Foraminifera	
					Planktonic	Benthic
1	BASEMENT	3132	-	-	v	v
2		3142	v	v	-	-
3		3162	-	-	v	v
4		3172	v	v	-	-
5		3192	-	-	v	v
6		3200	v	v	-	-

Table 2
Resume of availability data and their references

No.	Well	Pre-Tertiary Depth Interval (m)	References	Data			
				Mud Log	Petrography	Paleontology	Dipmeter Log
1	Bongkang-2	3090 - 3200	This study, Pertamina (1984)	v	v	v	-
2	Hayup-1	2148 - 2204	Shell Indonesia (1965)	v	-	v	-
3	Hayup-2	2320 - 2370	Shell Indonesia (1965)	v	-	v	-
4	Bagok-1	1456 - 1504	Pertamina & Bandung Institute of Technology (1987)	v	v	v	v
5	Bagok-2	1310 - 1610	Pertamina (1991)	v	-	v	v
6	Didi-1	1505 - 1745	Pertamina & Pexamin Pacific Inc. (1973)	v	-	v	v

Table 3
Resume of lithological data from six well that analysed

Well	Depth Internal (m)	Lithology		Reference
		Lithofacies	Petrography	
Bongkang-2	3090 - 3200	Interbedded sandstone and limestone	3142 m - Lithicwacke	
			3172 - Sandy allochemic limestone	This study
			3200 - Deformed clacareous lithicwacke	
Hayup-1	2148 - 2204	Limestone with quartzitic sandstone intercalation		Shell Indonesia (1965)
Hayup-2	2320 - 2370	Interbedded limestone and shale		Shell Indonesia (1965)
Bagok-1	1456 - 1504	Shale with sandstone and pyroclastic - volcaniclastic intercalation (intensively altered or low metamorphic rank)	1466 - Altered vitric - crystal tuff	Pertamina and Bandung Institute of Technology (1987)
			1468 - Altered vitric - crystal tuff	
Bagok-2	1310 - 1610	Shale with sandstone and pyroclastic - volcaniclastic intercalation (intensively altered or low metamorphic rank)		Pertamina (1991)
Didi-1	1505 - 1745	Shale with sandstone intercalation		Pexamin Pacific Inc. (1973)

In general, lithology identification is based on petrographic data and mud logs, where mud logs are generally used to determine lithofacies, while petrography is used to provide a more detailed description of lithology. In addition, dip-meter log data are also used to identify angular unconformity at the upper boundary of Pre-Tertiary sedimentary rocks. Then, for the determination of age and paleoenvironment based on paleontological data. The results presented in this study are the result of re-interpretation of the results of previous studies, where generally only changes were made in the name of lithology so that the naming was more consistent.

Generally, the name of lithology will refer to the classification of Pettijohn (1975), Mount (1985), Embry & Klovan (1971) and Cook (1965). For paleontology analysis, identification of large fossil foraminifera is referring to Boudagher - Fadel (2008). Planktonic foraminifera were referring to Bolli & Saunders (1989), while benthic foraminifera referred to Jones (1994) with conversion the fathom (fm) to meter unit and classified to paleobathymetry classification by Tipsword, et al., (1966). Then for palynomorph were refer to Muller (1968).

III. RESULTS AND DISCUSSION

In this study, we will discuss lithology, the present fossil content, and the paleoenvironment of Late Cretaceous sedimentary rocks in the Barito Basin.

A. Lithology

Lithology identification is based on mud log and/or petrographic data on each well, where the resume can be seen in Table 3.

Based on this study, in the Bongkang-2 well, Late Cretaceous sedimentary rock was found at a depth of 3090 - 3200 m, with lithofacies in the form of interbedded sandstone and limestone. Petrographic analysis was carried out at depths of 3142 m, 3172 m and 3200 m, that represent the lower, middle and upper intervals of Late Cretaceous sedimentary rock in Bongkang-2 well (Table 4).

The upper interval is represented by a sample at a depth of 3142 m (Figure 2a-b), showing lithology in the form of lithic wacke that dominated by granodiorite fragments (24%), quartz wacke (18%), quartz arenite (12%), schist (8%) and mudstone (4%).

The middle interval is represented by samples at a depth of 3172 m (Figure 2c-d), showing lithology in the form of sandy allochemic limestone that dominated by sandy micrite fragments (14%), wackestone (12%), mudstone (12%), and micritic sandstone (10%). In this sample, large amount of monocrystalline quartz minerals (12%) and large foraminifera (12%) were found.

The lower interval is represented by a sample at a depth of 3200 m (Figure 2e-f), showing lithology in the form of calcareous lithic wacke that has been deformed. The dominant fragments found were granodiorite (24%), mudstone (16%) and quartz arenite (12%), accompanied by schist (8%), sandy micrite (6%), quartz wacke (6%), and monocrystalline quartz minerals (6%), where fragments in this sample have undergone a process of alteration into chlorite minerals, and epidotes.

Based on petrographic analysis, it is known that the Pre-Tertiary sedimentary rocks in Bongkang-2 well are dominated by granodiorite fragments with an average abundance of 10% to 25%. This indicates that the possible main supply of Pre-Tertiary sedimentary rock is granodiorite basement, which is indicated as Kintap Granite according to Sikumbang (1986). In addition, other crystalline rock fragments such as actinolite schist and quartzite (Figure 3) are also found, which show that there is a supply of sediment from metamorphic rocks. Then, also found in a minor number of chert fragments which is indicated from Alino Group. The whole fragment can be found in the Meratus Mountains. Therefore, it is

Table 4
Resume of petrography analysis of Bongkang-2 well

Sample code	Lithology	Classification	Composition																							
			Mineral					Rock Fragment										Bioclast			Matrix		Cement / Replacement			
			Monocrystalline quartz	Polycristalline quartz	Plagioclase	Chlorite	Epidote	Quartz arenite	Quartz wacke	Mudstone	Wackestone	Sandy Micrite	Micritic Sandstone	Schist	Chert	Quartzite	Granodiorite	Small foraminifera	Large benthic foram	Coral	Detrital Clay	Carbonate matrix	Calcite	Dolomite	Oxide mineral	Quartz overgrowth
BKG-02 3142	Lithic wacke	Pettijohn (1975)	16	6	Tr	Tr	Tr	12	18	4				8			24				4		2			3
BKG-02 3172	Sandy allochemic limestone	Mount (1985)	12					4		12	12	14	10		4	4			12		2	4	3			
BKG-02 3200	Deformed Calcareous lithic wacke	Mod.Pettijohn (1975)	8		Tr	Tr	Tr	12	6	16		6		8			24				3	7	2		4	3

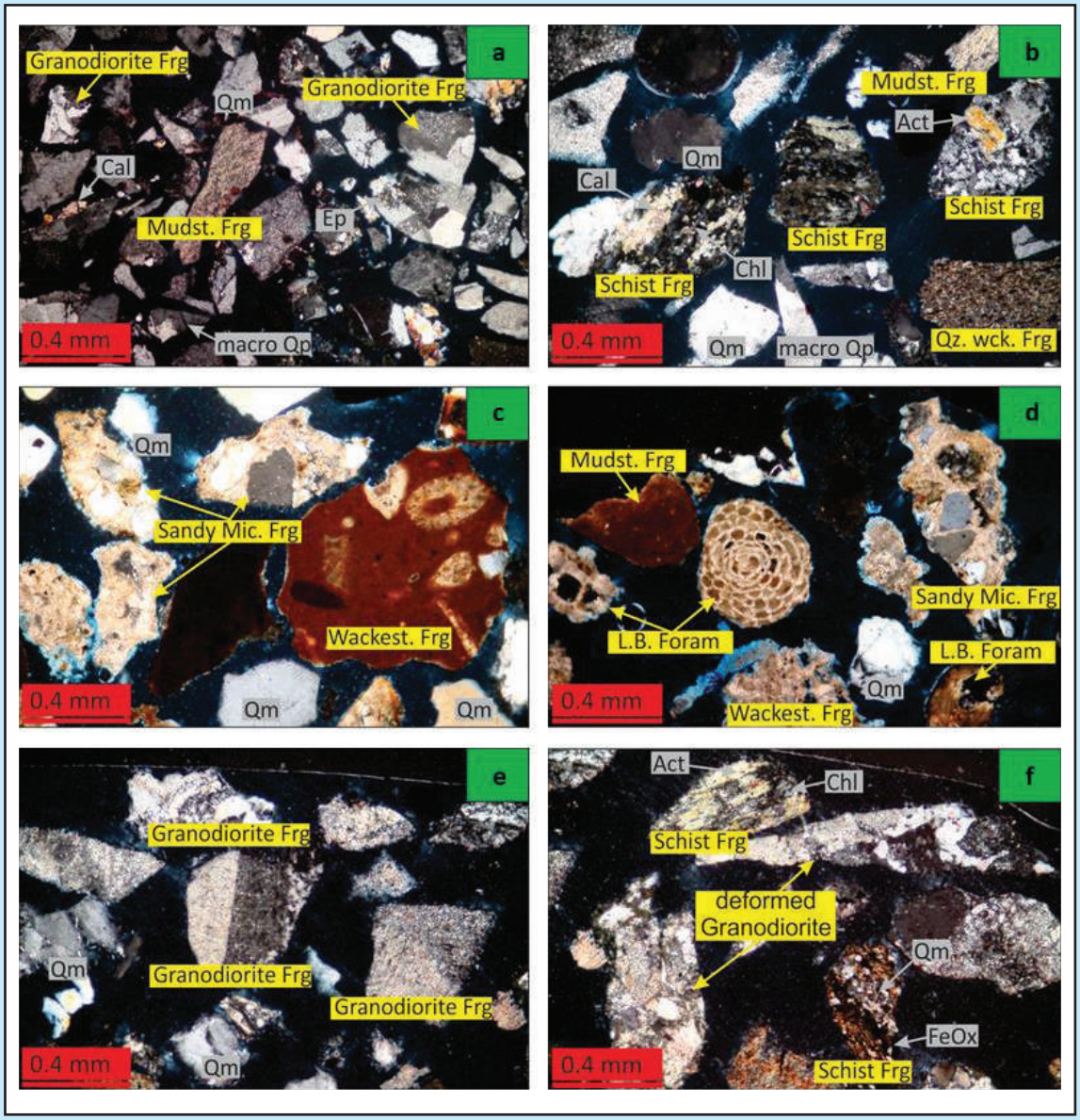

Figure 2
Petrographic appearance in Bongkang-2 well. (a-b) sample of 3142 m, showing lithology in the form of lithic wacke, (c-d) sample of 3172 m, showing lithology in the form of sandy allochemic limestone, and (e-f) sample of 3200 m, showing lithology in the form of calcareous lithic wacke.

interpreted that at the Late Cretaceous, the Meratus Mountains have been exposed to the surface and become the main supply of Pre-Tertiary sedimentary rocks in the Barito Basin, specifically the Tanjung Area.

Based on the review, in Hayup-1 and Hayup-2 wells, Late Cretaceous sedimentary rock was found at depths of 2148 - 2204 m and 2320 - 2370 m, respectively (Shell Indonesia, 1965). There are no petrographic data on these two wells. Based on mud log data, lithofacies develop in the Hayup-1 well in the form of limestone with quartzitic sandstone intercalation, whereas in the Hayup-2 well, lithofacies develop interbedded limestone and shale.

In Bagok-1 well, Late Cretaceous sedimentary rock was found at a depth of 1456 - 1504 m (Pertamina and Bandung Institute of Technology, 1987). Lithofacies present in the form of shale with sandstone and pyroclastic - volcaniclastics intercalation which have undergone intensive alteration (low rank metamorphism). The same lithofacies develop in the Bagok-2 well (interval 1310 - 1610 m) which is

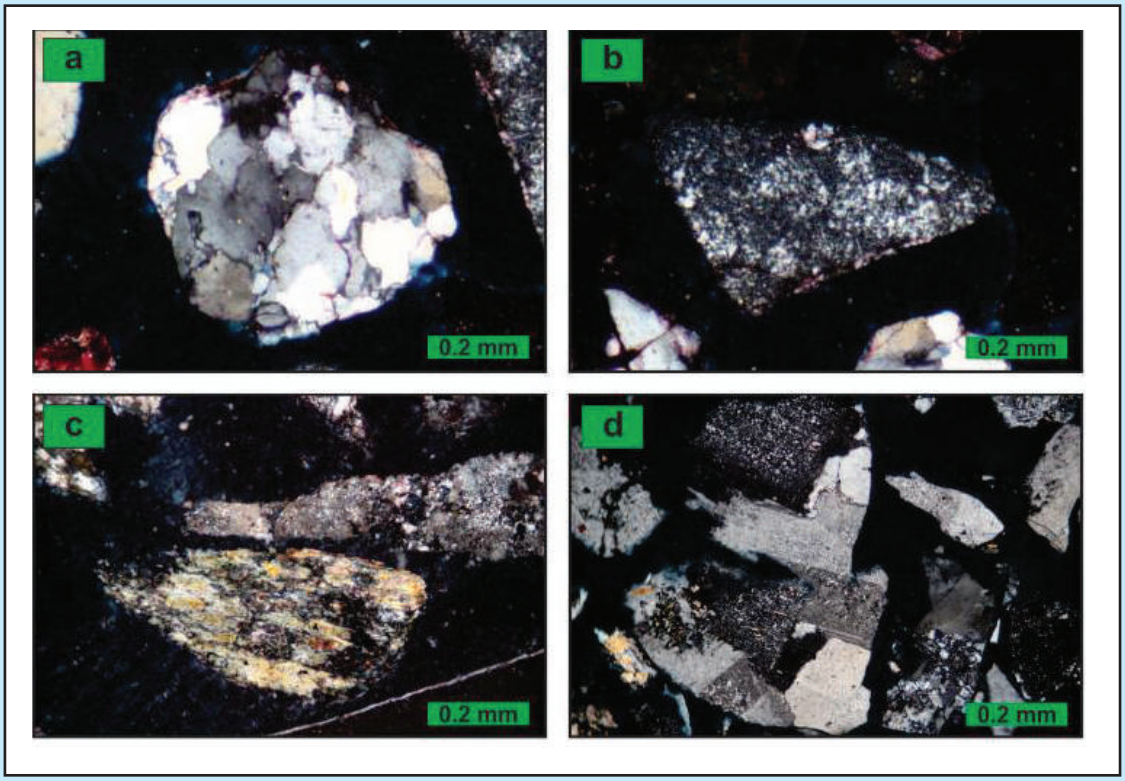

Figure 3
Rock fragment that found in Bongkang-2 well. (a) quartzite, (b) chert, (c) actinolite schist, and (d) granodiorite.

Table 5
Resume of petrography analysis in Bagok-1 well
(re-write from Pertamina and Bandung Institute of Technology, 1987)

No.	Depth	Lithology	Classification	Composition											
				Mineral						Matrix		Secondary Mineral			
				Quartz	Feldspar	Biorite and Amphibole	Opaque mineral	Rock Fragment	Bioclast	Detrital clay	Volcanic glass	Classic	Sericite	Chlorite	Microcrystalline quartz
1	BGK-1-1466	Altered vitric - crystal tuff	mod. Cook (1965)	3	7	3	3		6		78	v	v	v	v
2	BGK-1-1468	Altered vitric - crystal tuff	mod. Cook (1965)	10	5	3	2	5			75	v	v	v	

not far from the Bagok-1 well. Whereas in Didi-1 well located in the west of Bagok-1 and Bagok-2 well, lithofacies present were shale with sandstone intercalation (Pexamin Pacific Inc., 1973).

Based on petrographic analysis on the Bagok-1 well by Pertamina & Bandung Institute of Technology (1987), lithology was found in the form of vitric - crystal tuff that was undergone intensive alteration (Table 5). The dominant minerals found were feldspar and quartz, then biotite, amphibole and opaque minerals in minor abundant, with a matrix in the form of volcanic clay that was altered to sericite (Figure 4). Intensive volcanic glass to sericite (same terminology with illite) alteration and the presence of chlorite

indicate high diagenetic temperature (mesogenesis) at this interval. Due to the lack of petrographic appearance displayed, as well as less detailed descriptions, it is difficult to re-interpret petrographic data at Bagok-1 wells. Therefore, petrographic results cannot provide provenance information, as was done with the Bongkang-2 well.

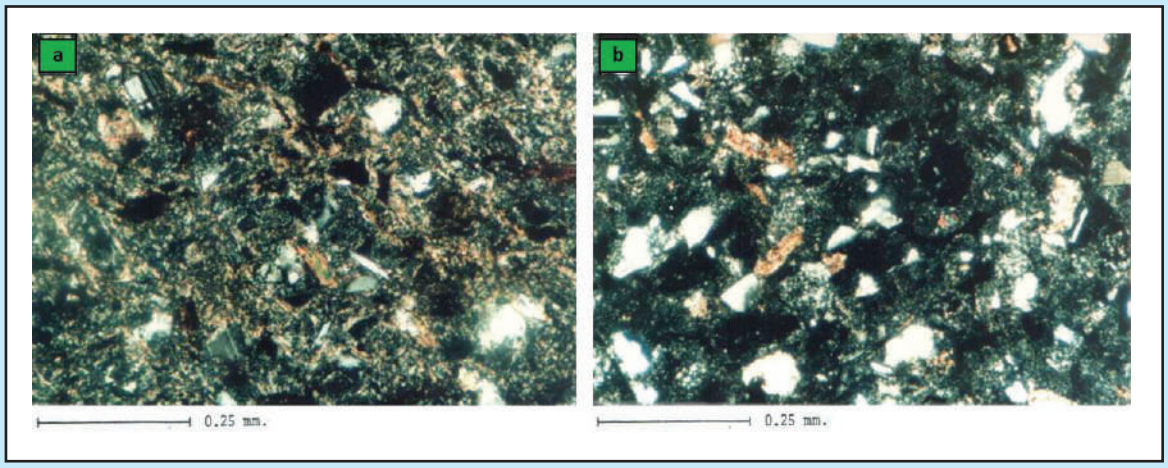

Figure 4
Petrographic appearance in Bagok-1 well (Pertamina and Bandung Institute of Technology, 1987). (a) sample of 1466 m and (b) sample of 1468 m, showing lithology in the form of altered vitric – crystal tuff.

Table 6
Resume of paleontological data from six well that analysed

Well	Depth interval (m)	Fossil content			Age	Paleoenvironment	Reference
		Planktonic Foraminifera	Benthic Foraminifera	Palymomort			
Bongkang-2	3090 - 3200	Rotalipora cf.brotzeni, Rotalipora cf. ticinensis, and whiteinella cf. inornata	Sulcoperculina sp. and Orbitolina sp.		Cenomian, Late Cretaceous	Inner-middle neritic or Backreefshelf	This study
Hayup-1	2148 - 2204		Orbitolina concava, Orbitolina sp., and Miliolidae sp.		Cenomian, Late Cretaceous	Backreefshelf	Shell Indonesia (1965)
Hayup-2	2320 - 2370		Orbitolina sp., and Miliolidale sp.		Cenomian, Late Cretaceous	Backreefshelf	Shell Indonesia (1965)
Bagok-1	1456 - 1504			Cicatricosispaorites dorogensis A. tricornitatus Aquilapollennites sp., Distaverrusporites margaritus and classopolis cf. classoides.	Cenomian, Late Cretaceous	Continental supralittoral	Pertamina and Bandung Institute of Technology (1987)
Bagok-2	1310 - 1610			Aquilapollenites sp., Cicatricosisporites dorogensis, and Distaverrusporites margaritus	Cenomian, Late Cretaceous	Continental supralittoral	Pertamina (1991)
Didi-1	1505 - 1745			Plantremains (can not identified)	Pre-Tertiary (?)	Continental	Pexamin Pacific Inc. (1973)

B. Fossil Content

Based on the results of paleontological analysis of Bongkang-2 well (this study) and the review of paleontological data from Hayup-1, Hayup-2, Bagok-1, Bagok-2, and Didi-1 wells, age and paleoenvironment were identified from Pre-Tertiary sedimentary rock intervals. Interpretation of the age of these Pre-Tertiary sedimentary rocks use fossil data of palynomorphs, planktonic and large benthic foraminifera, while paleoenvironment interpretation uses benthic foraminifera and palynomorph fossil data.

Resume of age and paleoenvironment of late cretaceous sedimentary rock in several well can be seen in Table 6.

In the Bongkang-2 well, paleontological data at the Late Cretaceous age interval were obtained on this study (Table 7).

Based on paleontological data, it is known that the Pre-Tertiary sedimentary rocks in the Bongkang-2 well have Cenomanian age, marked by the presence of large benthic foram fossils in the form of Sulcoperculina sp. (Figure 5a-b) and Orbitolina sp. (Figure 5c). It is also supported by the discovery of planktonic foraminifera fossils (Figure 6a-c) in the form of Whiteinella cf. inornata, Rotalipora cf. ticinensis, and Rotalipora cf. brotzeni. Because the shell is cemented quite intensively making identification of the planktonic foraminifera species quite difficult, and increases uncertainty. Therefore, large benthic foram species are the main reference in determining Cenomanian age, not planktonic foraminifera species. Based on its age, it is suspected that the limestone found in the Bongkang-2 well is or is equivalent to the Batununggal Formation, according to Sikumbang (1986).

Then, based on the presence of benthic foraminifera species in the form of Milliolina rupertiana (Figure 6d) and the large benthic foram mentioned above, this interval is believed to be formed in the inner - middle neritic environment, or backreef shelf.

In this study also found species Astrononion stelligerum and Melonis

Table 7
Distribution of planktonic foraminifera and benthic foraminifera in Bongkang-2 well

No.	Formation	Fossills	Depth	Planktic Foraminifera: Rotalipora cf. brotzeni	Rotalipora cf. ticinensis	Whiteinella cf. inornata	Benthic Foraminifera: Orbitolina sp.*	Sulcoperculina sp.*	Astrononion stelligerum	Melonis affinis	Milliolina rupertiana	Specimens	Age	Paleobathymetry: Terrestrial	Littoral	Shelf: Inner	Shelf: Middle	Shelf: Outer	Slope: Upper	Slope: Middle	Slope: Lower Abyssal
1	Pre-Tertiary Rock	Barren	3132			1					1	2	Cenomanian - Coniacian								
2			3162	2	1	2			1	1	2	7	Cenomanian								
3			3172				4	4				8	Cenomanian								
4			3192									0	-								

Late Cretaceous

Forereef shelf

* Large benthic foram

1 Possibly reworked

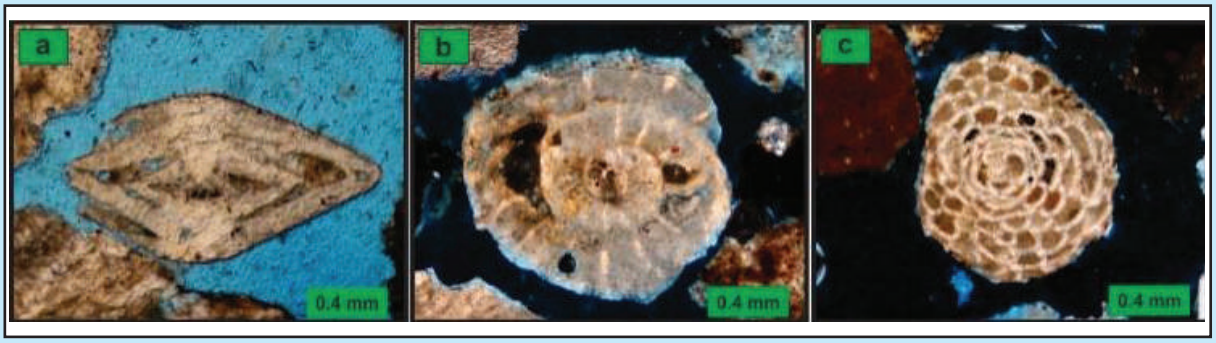

Figure 5
Fossil of large benthic foraminifera found in Late Cretaceous sedimentary rock in in Bongkang-2 well. (a-b) Sulcoperculina sp., and (c) Orbitolina sp.

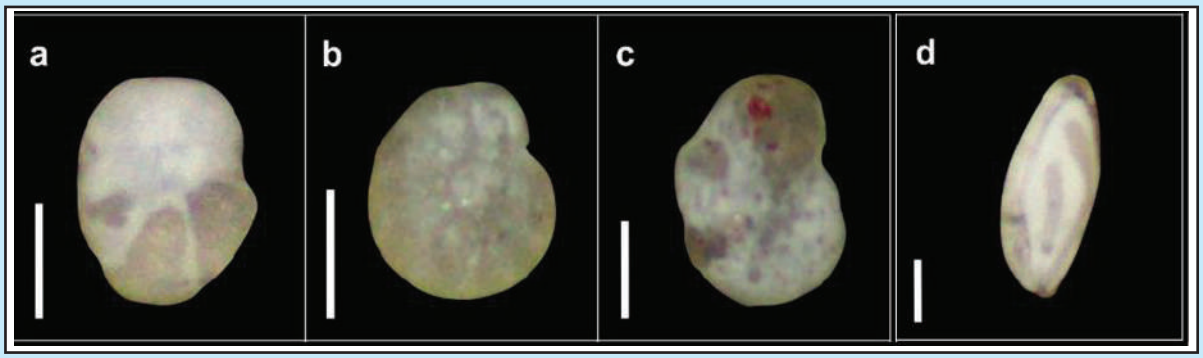

Figure 6
Fossil of planktonic (a-c) and benthic (d) foraminifera found in Late Cretaceous sedimentary rock in Bongkang-2 well. (a) Whiteinella cf. inornata, (b) Rotalipora cf. ticinensis, (c) Rotalipora cf. brotzeni, and (d) Miliolina rupertiana.

Table 8
Systematics paleontology of Late Cretaceous fossil found in Bongkang-2 well

Phylum	Foraminifera	Foraminifera	Foraminifera	Foraminifera	Foraminifera	Foraminifera
Class	Globothalamea	Globothalamea	Globothalamea	Globothalamea	Globothalamea	Tubothalamea
Order	Loftusiida	Rotallida	Rotallida	Rotallida	Rotallida	Miliollida
Suborder	Orbitolinina		Globigerinina	Globigerinina	Globigerinina	Miliolina
Superfamily	Orbitolinidaei	Orbitolinoidea	Rotaliporoidea	Rotaliporoidea	Rotaliporoidea	Hauerinidae
Family	Oribitolininae	Lepidorbitoididae	Rotaliporoidea	Rotaliporoidea	Hedbergellidae	-
Subfamily	Oribitolininae	Lepidorbitoididae	Rotaliporidea	Rotaliporinea	Hedbergellidae	Miliolina
Genus	Oribitolina	Sulcoperculina	Rotaliporinae	Pseudothalmanninella	Whiteinella	Miliolina
Species	Orbitolina sp. (D'Orbigny, 1950)	Sulcoperculina sp. (Thalmann, 1939)	Rotalipora (Thalmanninella brotzeni (Sigal, 1949)	Rotalipora (Pseudothalmannilla) ticinensis (Gandolfi, 1942)	Whiteinella inornata (Bolli, 1957)	Miliolina rupertiana (Brady, 1981)

affinis, but based on the age that tends to be younger and the appearance of test that tend to be different (minor cementation) it is suspected that the species is a fossil collapse from a younger layer. The systematics paleontology of species that found in this study can be seen on Table 8.

Then based on the review, in Hayup-1 and Hayup-2 wells, the age and paleoenvironment of Late Cretaceous sedimentary rock were identified from the presence of large benthic foram fossils in the form of Orbitolina concava, Orbitolina sp., and Miliolidae sp. which were found at depths of 2148 - 2204 m and 2320 - 2370 m, respectively (Shell Indonesia, 1965). The presence of these species indicates the age of the Cenomanian with the environment in the form of a Backreef shelf (Shell Indonesia, 1965).

Furthermore, in Bagok-1, Bagok-2, and Didi-1 wells, the age and paleoenvironment of Late Cretaceous sedimentary rock are identified from the palynomorph fossil content. In the Bagok-1 and Bagok-2 wells, palynomorph species were found in the form of Cicatricosisporites dorogensis, A. tricornitatus, Aquilapollenites sp., Distaverrusporites margaritus and Classopolis cf. classoides, which shows Cenomanian age with a continental - supralittoral environment (Pertamina & Bandung Institute of Technology, 1987). Whereas the Didi-1 well only found plant remains with an abundant amount but could not be identified, so it could not be determined with certainty the age of the interval (Pexamin Pacific Inc., 1973). However, it is believed that the Pre-Tertiary sedimentary rocks in the Didi-1 well have the same relative age as the Bagok-1 and Bagok-2 wells, which are limited by the same angular unconformity (based on log dip-meter data) found in the three wells.

C. Paleoenvironment of Barito Basin in Cenomanian Age

Based on the results of a review of lithology data, age and paleoenvironment of the Late Cretaceous sedimentary rock intervals in the Bongkang-2, Hayup-1, Hayup-2, Bagok-1, Bagok-2, and Didi-1 wells, paleoenvironment interpretation was carried out at the Barito Basin at the age of Cenomanian. However, the reconstruction made in this study is still quite general because it is only based on relatively small amount of lithology data, age and depositional environment. Therefore, with more detailed and more comprehensive data it is possible to have different interpretations from the paleoenvironment reconstruction made in this study.

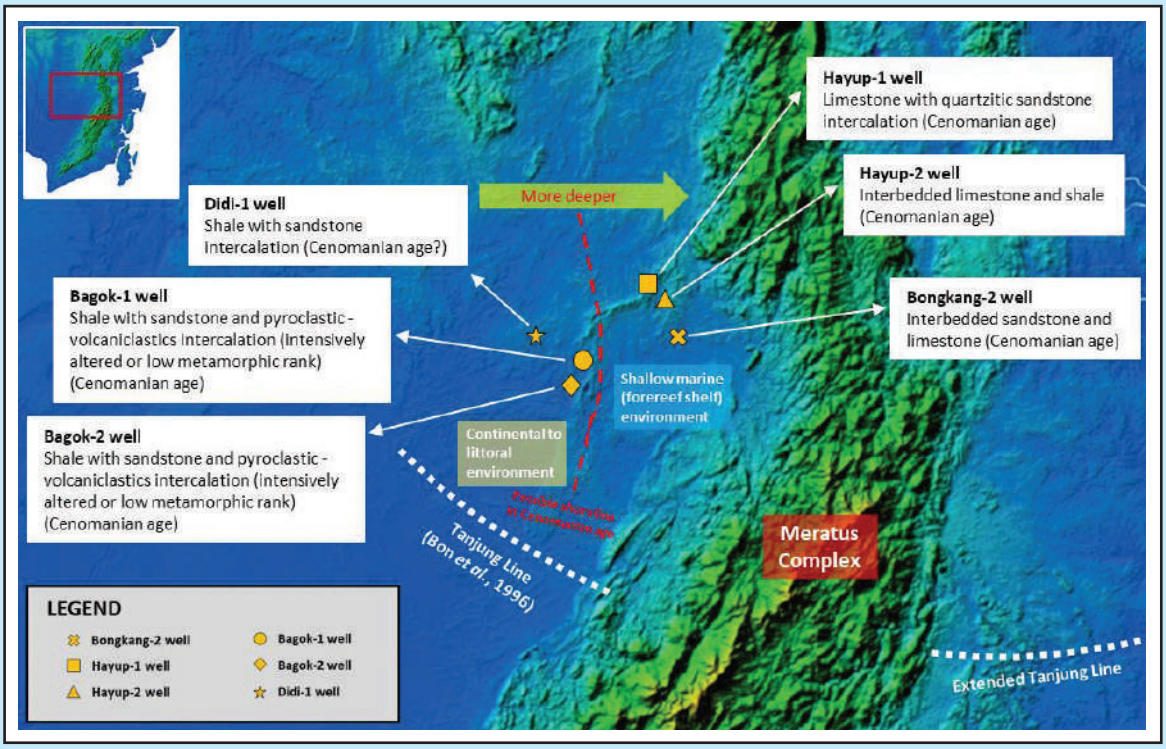

Figure 7
Paleoenvironment of Barito Basin in Cenomanian age, Late Cretacous, based on lithology and paleontology data.

Paleoenvironment of Barito Basin in Cenomanian age can be seen in Figure 7. From this figure, it can be seen that on the western side of the Barito Basin, terrestrial environments (continental to littoral) are developed which are shown by non-carbonate lithology, not found marine fossils, and the dominant content of palynomorph fossils. Then on the east side it is believed to develop a shallow marine environment (backreef shelf) which is based on the large benthic foraminifera fossil content, as well as the limestone commonly found. Possibly, the paleo-shoreline at the age of the Cenomanian in the Barito Basin is located slightly east of the Bagok-1 and Bagok-2 wells.

IV. CONCLUSION

Based on the results of this study, it is known that Pre-Tertiary sedimentary rocks are found in the wells of Bongkang-2, Hayup-1, Hayup-2, Bagok-1, Bagok-2 and Didi-2, which are located in the northern part of Barito foredeep.

Based on the paleontological analysis, it is shows that Pre-Tertiary sedimentary rocks found in the six wells analyzed has Cenomanian age, which is indicated by the presence of large foraminifera fossils in the form of Sulcoperculina sp. and Orbitolina sp. in Bongkang-2, Hayup-1 and Hayup-3 wells, as well as spore and pollen fossils in the form of C. dorogensis, A. tricornitatus, Aquilapollenites sp., D. margaritus and Classopolis cf. classoides in Bagok-1 and Bagok-2 wells.

Based on the lithological analysis, it is known that in the Bongkang-2, Hayup-1 and Hayup-2 wells lithology develops in the form of limestone, shale and sandstone, while in the Didi-1, Bagok-1 and Bagok-2 wells lithology develops in the form of shale with sandstone and pyroclastic – volcaniclastics rock intercalation.

Based on the integration of lithology and paleontology analysis, it is known that in the Cenomanian age, terrestrial environments developed in the western part of the Barito Basin, while in the eastern part the shallow marine environment developed.

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