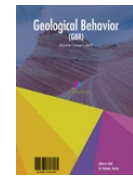




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Smaller benthic foraminifera Analysis of Kudat Formation, Kudat, Sabah: Preliminary Interpretation

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ABSTRACT

Small benthic foraminifera have been fully extracted from the mudstone of Kudat Formation, Kudat, Sabah. The Kudat Formation comprise thick-bedded, quartzose to feldspathic, locally calcareous sandstone, an overall abundance of lignitic and carbonaceous layers, and the presence of red shales and detrital calcarenites. A total of 22 mudstone samples of Kudat Formation in difference localities have been collected for foraminifera analysis. All samples are processed according to standard micropaleontological method. Twenty-five species of small benthic foraminifera consisting of the agglutinated and hyaline group have identified. Almost all mudstone samples of Sikuati Member and Matunggong Member are consisting of deep-sea agglutinated foraminifera assemblage indicative of bathyal to abyssal. K21 sample of Tajau member and K9 sample of Sikuati Member consist of deep-sea agglutinated foraminifera together with reworked calcareous foraminifera. Foraminifera analysis shows that the Kudat Formation sediment was deposited in deep marine setting ranging from bathyal to neritic.

1. INTRODUCTION

Foraminifers are one of the important microfossils to geologists. This fossil provides the most accurate means of age determination of rocks and environment of formation of the sediments of the past. Miocene foraminiferas are widespread in Sabah and have been studied by several researchers. These fossils usually can be found embedded in mudstone and limestone. The Kudat Formation are characterised by predominance of medium to thick-bedded, quartzose to feldspathic, locally calcareous sandstone, an overall abundance of lignitic and carbonaceous layers, and the presence of red shales and detrital calcarenites. This location has chosen because there is limited information about the paleontological studies from previous work of this fossil. The foraminifera assemblage and their taxonomy and their paleoenvironment have not been fully explored and need a details research to be conducted. Hence it's very significantly important to carry out a researched to this area. The aims of this research are to identify foraminifer's species and its oenvironment of deposition. This will focus benthonic foraminifera and all samples are collected from the field and process according to standard micropaleontological method.

GENERAL GEOLOGY

The Kudat Formation formerly known as "Miocene sediment" was firstly studied by Stephens (1956). Liechti et al. (1960) has been revised this formation and subdivided into several members (Garau, Tajau, Sikuati, Gomantong, Dudar, Sirar), but only Tajau and Sikuati Members can be identified in the field. This rock unit was reported an age Early Miocene and probably deposited in shallow to deep water environment. Sanudin and Baba (2007) and Sanudin et al. (2009) suggested the Kudat Formation is underlain by the Crocker Formation of Late Eocene to Early Late Miocene and then overlain by the Wariu Melange during Middle Miocene in age. This formation undergone intense deformation and produce complex fold pattern. Tectonic evolution of Kudat Peninsula has been studied and revised by several researchers (Stephen, 1956; Liechti, 1960; Abdullah et al., 1994; Tongkul, 1994; 2006). Tongkul (2006) informally divides the Kudat Formation into three lithological units namely, Lower Sandy Unit, Middle Muddy Unit and Upper Sandy Unit. Lower Sandy Unit is also referred as the Tajau Member consists of sandstone and mudstone with the sandstone dominance and occupying the northern tip of Kudat Peninsula Figure 1. The Middle Muddy Unit comprises sandstone and mudstone dominance with some occurrences of limestone bed and lenses. This unit was referred to previously as the Sikuati Member and cropped out at the middle part of

the Kudat Peninsula. The Upper Unit was exposed at the southern part of the peninsula and coinciding with Matunggong Member of Liechti et al. (1960). This unit consist of sandstone and mudstone of various proportions. Sanudin et al. (2009) revised the Tajau Member which consists of clastic and limestone facies. The clastic comprise thickly bedded sandstone interbedded with thin shale and the carbonate facies is locally fossiliferous and occasionally thinly bedded with calcareous shale. The limestone unit and calcareous shale from the Tajau Member contain abundance of Miocene foraminifera.

The first Miocene foraminifera study has been conducted by Van der Vlerk (in Stephen 1956) and only several species of benthic and planktonic foraminifera have been recorded. Liechti et al. (1960) firstly introduced the Kudat Formation and interpreted to be Early Miocene age based on scare paleontological evidence. This research will provide data for Miocene foraminifera from the Kudat Formation, foraminifera assemblage and environment of deposition.

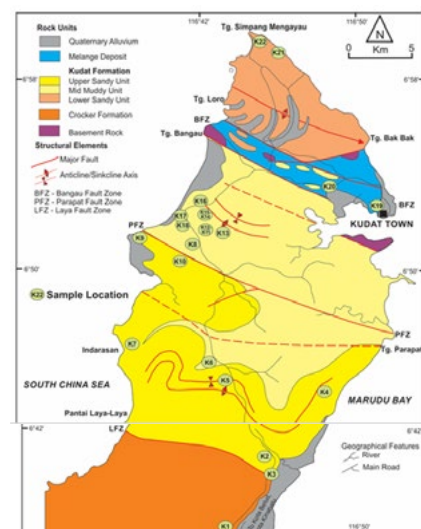


Figure 1 Geological map of Tongkul (2006) and foraminifera sample location

METHODOLOGY

A total of 22 samples of mudstone (K1-22) and have been collected from the Tajau Member (K9, K21, K22), Sikuati Member (K8, K10-20) and Gomantong Member (K1 to K7 Sampling locations have been photograph and record at geological map. The sampling localities were shown at Figure 1. Preparation samples of smaller benthic foraminifera for micropaleontological analysis are based on Armstrong & Brasier (2005). All mudstone and shale samples were crushing into small fragments (1cm to 2cm) before boil it with mixture of distiller water and sodium bicarbonate for three to four hours. After that the samples were rinsed with fresh water and dried. Foraminifera faunas were picked and identified under binocular microscope. Well-preserved specimens were photographed by High Performance Microscope for further examination. The identification of planktic and smaller benthic foraminifera species are based on previous research (Holbourn et al. 2013; Kaminski et al. 2005; Kender et al. 2008; Osterman & Spiegler 1996).

RESULT AND DISCUSSION

Only eighteen mudstone samples contain foraminifera and six samples were barren. The samples contain 25 species of small benthic foraminifera consisting of the agglutinated and hyaline group (Table 1). The illustrations of selected foraminifera are shown at Figure 2. Meanwhile planktic foraminifera were absent in all mudstone samples. Hence there are no significant index fossil have been found, so the age determination of the rock units of Tajau member, Sikuati Member and Gomantong Member still unclear. The smaller benthic foram that have been analysis for paleoenvironment indicator.

Sample K1 is represent the Crocker Formation. This sample consist of Bathysiphon sp., Caudammina excelsa, Haplophragmoides nauticus, Haplophragmoides walteri, Hormosina globulifera, Lituotuba lituiformis, Nothia robusta, Psammosiphonella sp., Psammosphaera sp., Reticulophragmium acutidorsatum, Reticulophragmium amplexens, Rhabdammina sp., Rhizammina sp., and Trochammina sp. Bathysiphon and Haplophragmoides were dominant species and this assemblage is interpreted as Bathyal to abyssal of a deep-sea marine Kaminski et al. (2005) and Holbourn et al. (2013).

Tajau Member (Lower Sandy Unit) of sample K21 consist of Bathysiphon sp. Caudammina excelsa, Marsipella sp. Psammosphaera sp. Rhabdammina sp. This assemblage indicates of Lower Bathyal to abyssal. The occurrence of Amphistegina sp., Amphistegina radiata, and Ammonoidea sp., with some fragment of coral and bryozoans were indicative of neritic environment. Sample K22 was barren. The foraminifera assemblage of Tajau Member is not fully explored because lack of significant samples to represent the Tajau Member. More studies and sampling in different localities are need in the future to determine paleoenvironment or bathymetry of Tajau Member from the foraminifera analysis.

Upper Sandy Unit (Matunggong Member) is represent by sample K2 to K7 and sample K9 to K10. Sample K3 has no significant fossil has found. All samples contain agglutinated foraminifera except for sample K9. The foraminifera fossils are; Ammosphaeroidina sp., Bathysiphon sp., Haplophragmoides nauticus, Haplophragmoides walteri, Hormosina globulifera, Lituotuba lituiformis, Nothia excelsa, Nothia robusta, Nothia sp., Psammosiphonella sp., Psammosphaera sp., Reophax pilulifer, Reticulophragmium acutidorsatum, Reticulophragmium amplexens, Rhabdammina sp., Rhizammina sp., Saccamina sp. and Trochammina sp. This assemblage is indicator of Bathyal to abyssal environment. Bathysiphon occurred almost in all samples. The Haplophragmoides was dominant in sample K6 and K7 suggest an environment of bathyal to abyssal. Sample K9 comprise of Bathyal to Neritic species. This sample was dominated by Marsipella elongata, with some mixing of neritic assemblage namely Amphistegina sp., Amphistegina radiata, and Ammosphaeroidina sp., gastropod and fragment of coral and bryozoans. All specimens of neritic fossils were in poor preservation or undergo some dilution fragmented. These could be reworks fossils that redeposit in deep sea setting.

Eight samples were collected at Middle Sandy unit or Sikuati Member. The samples are, K11-17 and sample 8, only sample 13-17 contain significant foraminifera meanwhile sample 8 was barren. Among the foraminifera species namely Ammosphaeroidina sp., Bathysiphon sp., Nothia robusta, and Trochammina sp. Neritic to Bathyal. Bathysiphon and Nothia were common in the samples with minor occurrence of Ammosphaeroidina and Trochammina. This assemblage is indicator of bathyal to abyssal. Foraminifera assemblage of Kudat Formation shows the paleoenvironment or bathymetry ranging from bathyal to abyssal for Matunggong Member and Sikuati Member except for sample K9 which has mix deep to neritic environment. This assemblage has similar assemblage to Crocker Formation in southern part of Kudat. Only one sample that represent the Tajau member

and the result shows a mixing assemblage of neritic to bathyal environment.

Table 1 Distribution of Foraminifera species in the samples.

SAMPLES	AGGLUTINATED SPECIES										HYALINE		OTHERS					
	Bathysiphon sp.	Caudammina excelsa	Haplophragmoides nauticus	Haplophragmoides walteri	Hormosina globulifera	Lituotuba lituiformis	Nothia excelsa	Nothia robusta	Nothia sp.	Psammosiphonella sp.	Psammosphaera sp.	Reophax pilulifer		Reticulophragmium acutidorsatum	Reticulophragmium amplexens	Rhabdammina sp.	Rhizammina sp.	Saccamina sp.
K1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
K2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
K3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
K4	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
K5	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
K6	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
K7	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
K8	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
K9	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
K10	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
K11	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
K12	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
K13	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
K14	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
K15	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
K16	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
K17	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
K18	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
K19	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
K20	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
K21	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
K22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
K23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

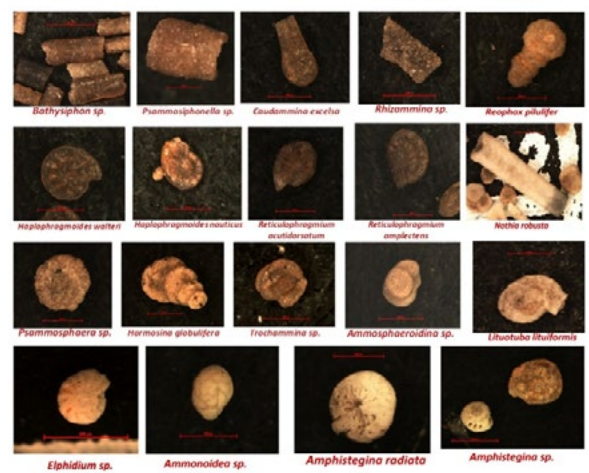


Figure 2 illustration of smaller benthic foraminifera from the Kudat Formation.

CONCLUSION

The small benthic foraminifera of deep-sea agglutinated are present in mudstone samples of Sikuati Member and Matunggong Member. The Tajau member of sample K21 and sampel K9 of Sikuati Member consist of deep-sea agglutinated foraminifera together with reworked calcareous foraminifera. Foraminifera assemblage from the Kudat Formation was in deep marine setting ranging from bathyal to neritic.

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