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Oligocene-Early Miocene Planktonic Foraminifera from the Temburong Formation, Klias Peninsula, Sabah, Malaysia

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Oligocene-Early Miocene sedimentary rocks of the Temburong Formation exposed at the Klias Peninsula. The sediments samples consist of well-preserved planktonic foraminifera that's useful for age detemination of sedimentary formation. The objective of this study is to classify the taxonomy and biostratigraphy of planktic foraminifera in the Temburong Formation at study area. A total of nine shale samples from eight localities (Te01 to Te08) were collected along the Kuala Penyu-Menumbok road, Klias Peninsula. All samples were processes based on standard micropaleontological method. Twenty-eight species of planktic foraminifera were successfully recovered from the samples. The planktonic foraminifera are *Cassidulina* sp., *Cassigerinella chipaloensis*, *Catapsydrax dissimilis*, *Dentoglobоquadrina altispira altispira*, *Globigerina binaiensis*, *Globigerina ciperoensis*, *Globigerina praebulloides*, *Globigerina praevenezuelana*, *Globigerina selli*, *Globigerina* sp., *Globigerina tapuriensis*, *Globigerina woodi*, *Globigerinoides altiapertura*, *Globigerinoides primordius*, *Globigerinoides triloba triloba*, *Globigerinoides trilobus bullatus*, *Globoquadrina baroemoenensis*, *Globoquadrina dehiscens*, *Globoquadrina praedehiscens*, *Globoquadrina* sp., *Globoquadrina venezuelana*, *Globorotalia mayeri*, *Globorotalia obesa*, *Globorotalia opima nana*, *Globorotalia opima opima Bolli*, *Globorotalia* sp. and *Globorotalia siakanensis* Leroy. The foraminifera assemblage can be divided into three zones, P21/N2 *Globigerina angulisuturalis/Globorotalia opima opima* Zone, *Globigerinoides primordius/Globigerina kugleri* Zone N4 and *Globoquadrina dehiscens/Globoquadrina praedehiscens* Zone N5. Its concluded that the shale unit of the Temburong Formation from the Klias Peninsula was interpreted as a distal part of deep-sea fan deposited during the Upper Oligocene to Early Miocene (Chattian to Aquitanian).

Keywords: Upper Oligocene, Early Miocene, Planktonic Foraminifera, Temburong, Klias

I. INTRODUCTION

The research was conducted at the Klias Peninsula which is located at the south-western part of Sabah. The study area is underlain by Paleogene-Neogene sediment namely, the Crocker Formation, Temburong Formation, Setap Formation, Belait Formation and Liang Formation. Several geological and sedimentology studies have been conducted in Klias Peninsula but they have been inconclusive to the biostratigraphy studies (Abdullah & Tahir, 2013; Tan 2010; Wilson 1964). Wilson (1964) characterised the Temburong Formation

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as flysh deposit and dominantly an argillaceous sequence with rhythmic repetition of shale and siltstone, with some lenticular limestone. Wilson (1964) reported that the age of Temburong Formation is Oligocene to Upper Miocene based on planktonic foraminifera assemblage from Tenom, Pangi, Ulu Lakutan, Ulu Padas and Sipitang area, which are situated at the southern part of Sabah. However, none planktonic foraminifera extracted from the Temburong Formation at Klias Peninsula. Ever since there is no significant micropaleontological study has been conducted at the study area. This paper was focus on the biostratigraphy of planktonic foraminifera assemblage from the Temburong Formation at the Klias Peninsula.

II. GEOLOGICAL SETTING

Geology of Klias Peninsula consists of five lithostratigraphic units of Paleogene-Neogene sediment namely; Crocker Formation, Temburong Formation, Setap Formation, Belait Formation and Liang Formation (Wilson, 1964; Abdullah & Tahir, 2013). The Temburong Formation is composed mainly a flysh-type argillaceous deposit of siltstone and shale with intercalations of slightly calcareous pelagic shale. The age of the Temburong Formation is ranged from Oligocene to Upper Miocene by Wilson (1964). The age of the Crocker Formation has been determined mainly from intercalations of the Temburong Formation. The boundary between the Crocker and Temburong Formation was not exposed but the Temburong Formation probably overlies the lower part of the Cocker Formation (Wilson, 1964). The lithology of Temburong Formation is more argillaceous facies than the Crocker formation, which is arenaceous facies. The Temburong Formation overlain by the Setap Formation in Klias Peninsula reported by Wilson (1964), but the contact between this two units has not been observed. The Temburong and Crocker Formation were interpreted as turbidite deposit of deep marine environment (Wilson, 1964; Tate, 1994; Madon, 1997; Hutchison, 2005; Abdullah & Tahir, 2013). The Setap Shale composed mainly of mudstone with some thin limestone layers and sandstone bands and the age of the formation is Upper Miocene. The Belait Formation consist of conglomerate, cross-bedded sandstone, coal measures and interbedded sanstone, siltstone, and shale and its overlies the Setap Shale in Klias Peninsula. The Belait Formation is deposited in fluvial to open shallow marine environment. The age of Belait Formation is Upper Miocene to Pliocene (Wilson, 1964). The youngest rock unit is the Pliocene Liang Formation composed coarse conglomerate sand lenses with sandy clays and lignitic clay which is overlies the Belait Formation in Klias Peninsula. This formation interpreted as fluvial environment which is deposited during Pliocene.

III. MATERIALS AND METHODS

Nine samples (Te01 to Te08) from eight localities were collected along the Kuala Penyu-

Menumbok road at Klias Peninsula (Figure 1). The outcrops consist of dominantly thinly bedded of shale and interbedded with thin bedded of moderate to fine sandstone and siltstone. All samples were crushed into small pieces of sizes ranges 1 to 10mm and then place it in 1000ml beaker cover with distilled water. After that add one or two spoonful's of Na_2CO_3, and boiled it for several hours. The samples were then washed, sieved and then dried. Planktonic Foraminifera were separated from the matrix by picking up by small brush and place it in Frank slides. Planktonic foraminifera were analysed by using binocular microscope and the well-preserved specimen is photographed by scanning electron microscope (SEM) (Amstrong & Brasier, 2005).

IV. RESULTS AND DISCUSSION

A total of 28 planktic foraminiferal species were identified from 9 sample of difference localities. Foraminifera species are listed in Table 1 for sample Te01, Te02-1, Te02-3, Te03 and samples Te04, Te05, Te06, Te07 and Te08 are listed in the Table 2. The identification of taxonomy of planktic foraminifera are based on Stainforth *et al*. (1975), Kennett and Srinivasan (1983), and Bolli and Saunders (1985). Twenty-eight species of *planktic foraminifera are; Cassidulina* sp., *Cassigerinella chipaloensis*, *Catapsydrax dissimilis*, *Dentogloboquadrina altispira altispira*, *Globigerina binaiensis*, *Globigerina ciperoensis*, *Globigerina praebulloides*, *Globigerina praevenezuelana*, *Globigerina selli*, *Globigerina* sp., *Globigerina tapuriensis*, *Globigerina woodi*, *Globigerinoides altiapertura*, *Globigerinoides primordius*, *Globigerinoides triloba triloba*, *Globigerinoides trilobus bullatus*, *Globoquadrina baroemoenensis*, *Globoquadrina dehiscens*, *Globoquadrina praedehiscens*, *Globoquadrina* sp., *Globoquadrina venezuelana*, *Globorotalia mayeri*, *Globorotalia obesa*, *Globorotalia opima nana*, *Globorotalia opima opima Bolli*, *Globorotalia* sp. and *Globorotalia siakanensis* Leroy.

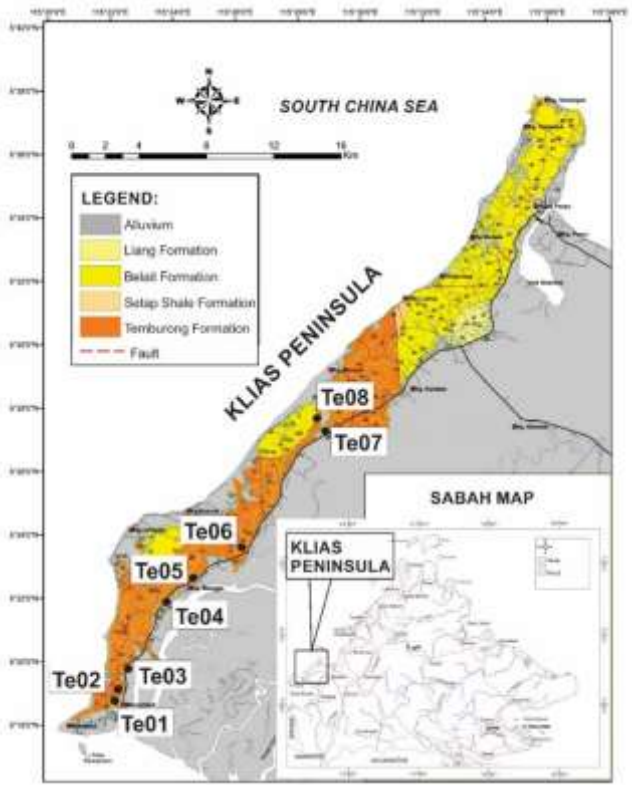

Figure 1. Location of study area and the geological Map of Klias Peninsula modified from Wilson (1964)

Table 1 List of planktonic foraminifera in the sample of Te01 to Te03

	Planktonic Foraminifera Species	Sample			
		Te01	Te02-1	Te02-3	Te03
1	*Cassidulina* sp.	1			
2	*Cassigerinella chipaloensis*	1		1	
3	*Catapsydrax dissimilis* (Cushman & Bermudez)	5	4	7	
4	*Dentogloboquadrina altispira altispira* Cushman & Jarvis		5	4	
5	*Globigerina binaiensis* Koch			4	
6	*Globigerina ciperoensis* Bolli			3	
7	*Globigerina praebulloides* Blow	13	10	62	2
8	*Globigerina praevenezuelana* Blow & Banner	9			
9	*Globigerina selli* (Borsetti)			2	
10	*Globigerina* sp.	3	16	9	
11	*Globigerina tapuriensis* Blow & Banner			1	
12	*Globigerina woodi* Jenkins				
13	*Globigerinoides altiapertura* Bolli				
14	*Globigerinoides primordius* Blow & Banner	10	41	27	6
15	*Globigerinoides triloba* (Reuss)	4	6	39	
16	*Globigerinoides trilobus bullatus* Chang& Chang			10	
17	*Globoquadrina baroemoenensis* (Leroy)	13		14	
18	*Globoquadrina dehiscens* Chapman, Parr & Collins		6	4	
19	*Globoquadrina praedehiscens* Blow & Banner		3	13	
20	*Globoquadrina* sp.	3			
21	*Globoquadrina venezuelana* (Hedberg)	6		13	
22	*Globorotalia mayeri* Cushman & Ellisor	8	3	19	
23	*Globorotalia obesa* (Bolli)	2	3		
24	*Globorotalia opima nana* Bolli	9			
25	*Globorotalia opima nana* Bolli, transition *Continuosa* Blow	10	3	13	
26	*Globorotalia opima opima* Bolli	5			
27	*Globorotalia* sp.				
28	*Globorotalia siakanensis* Leroy				

Table 2 List of planktonic foraminifera in the sample of Te04 to Te08

	Planktonic Foraminifera Species	Sample				
		Te04	Te05	Te06	Te07	Te08
1	*Cassidulina* sp.					
2	*Cassigerinella chipaloensis*					
3	*Catapsydrax dissimilis* (Cushman & Bermudez)			2		
4	*Dentogloboquadrina altispira altispira* Cushman & Jarvis					
5	*Globigerina binaiensis* Koch					
6	*Globigerina ciperoensis* Bolli					
7	*Globigerina praebulloides* Blow				2	2
8	*Globigerina praevenezuelana* Blow & Banner					
9	*Globigerina selli* (Borsetti)					
10	*Globigerina* sp.	5	6	8	8	
11	*Globigerina tapuriensis* Blow & Banner					
12	*Globigerina woodi* Jenkins	2	3			
13	*Globigerinoides altiapertura* Bolli	6	8			
14	*Globigerinoides primordius* Blow & Banner	18	23	2	2	3
15	*Globigerinoides triloba* (Reuss)	7	14			
16	*Globigerinoides trilobus bullatus* Chang& Chang					
17	*Globoquadrina baroemoenensis* (Leroy)					
18	*Globoquadrina dehiscens* Chapman, Parr & Collins			1		
19	*Globoquadrina praedehiscens* Blow & Banner					
20	*Globoquadrina* sp.					
21	*Globoquadrina venezuelana* (Hedberg)					
22	*Globorotalia mayeri* Cushman & Ellisor				5	
23	*Globorotalia obesa* (Bolli)	7	8			
24	*Globorotalia opima nana* Bolli					
25	*Globorotalia opima nana* Bolli, transition *Continuosa* Blow					
26	*Globorotalia opima opima* Bolli					
27	*Globorotalia* sp.	2	4			8
28	*Globorotalia siakanensis* Leroy					5

V. BIOSTRATIGRAPHY

The stratigraphic distribution of foraminiferal species are based on Stainforth *et al*. (1975), Kennett and Srinivasan (1983), and Bolli and Saunders (1985). The foraminifera assemblages are also compare to foraminiferal zones established by Blow (1969) and Wade *et al*. (2011).

Shale Sample Te01 located at Kuburan Cina road at South of Klias Peninsula. This sample consist of *Cassidulina* sp., *Cassigerinella chipaloensis*, *Catapsydrax dissimilis* (Cushman & Bermudez), *Globigerina praebulloides* Blow, *Globigerina praevenezuelana* Blow & Banner, *Globigerina* sp., *Globigerinoides primordius* Blow & Banner, *Globigerinoides triloba* (Reuss), *Globoquadrina baroemoenensis* (Leroy), *Globoquadrina* sp., *Globoquadrina venezuelana* (Hedberg), *Globorotalia mayeri* Cushman & Ellisor, *Globorotalia obesa* (Bolli), *Globorotalia opima nana* Bolli, *Globorotalia opima nana* Bolli transition Continuosa Blow and *Globorotalia opima opima* Bolli. The occurrence of *Globorotalia opima nana* Bolli and *Globorotalia opima opima* Bolli indicated P21/N2 of *Globorotalia opima opima* Zone of Blow Zones.

Te02 section consist of two samples (Te02-1 and Te02-3) collected from Kg. Bakarang. Sample Te02-1 collected at the lower part of Te02 section. This sample comprise *Catapsydrax dissimilis* (Cushman & Bermudez*), Dentogloboquadrina altispira altispira* Cushman & Jarvis, *Globigerina praebulloides* Blow, *Globigerina selli* (Borsetti), *Globigerina* sp., *Globigerinoides primordius* Blow & Banner, *Globigerinoides triloba* (Reuss), *Globoquadrina praedehiscens* Blow & Banner, *Globorotalia mayeri* Cushman & Ellisor, *Globorotalia obesa* (Bolli), and *Globorotalia opima nana* Bolli transition *Continuosa* Blow. This assemblage is indicative of *Globigerinoides primordius* Blow & Banner Zone (N4) of Blow Zone.

Shale sample Te02-3 located at the upper part of Te02 section contain of *Cassigerinella chipaloensis*, *Catapsydrax dissimilis* (Cushman & Bermudez), *Dentogloboquadrina altispira altispira* Cushman & Jarvis, Globigerina *binaiensis* Koch, *Globigerina ciperoensis* Bolli, *Globigerina praebulloides* Blow, *Globigerina selli* (Borsetti), *Globigerina* sp., *Globigerina tapuriensis* Blow & Banner, *Globigerinoides primordius* Blow & Banner, *Globigerinoides triloba* (Reuss), *Globigerinoides trilobus bullatus* Chang& Chang, *Globoquadrina baroemoenensis* (Leroy), *Globoquadrina dehiscens* Chapman, Parr & Collins, *Globoquadrina praedehiscens* Blow & Banner, *Globoquadrina venezuelana* (Hedberg), *Globorotalia mayeri* Cushman & Ellisor, *Globorotalia opima nana* Bolli transition Continuosa Blow. *Globoquadrina dehiscens /Globoquadrina praedehiscens* Zone of N5 was identified in this sample by the presence of *Globoquadrina dehiscens* and *Globoquadrina praedehiscens*.

Shale sample Te03 was collected from the Kg. Melingkai area. Only two species were identified from this sample i.e. *Globigerina*

praebulloides Blow and *Globigerinoides primordius* Blow & Banner. The occurrence of planktonic foraminifera was limited. Because of the present of *Globigerinoides primordius* in this sample, it could be in *Globigerinoides primordius* Zone of N4.

Sample Te04 was located at the Kg. Manggis section which consist of *Globigerina* sp., *Globigerina woodi* Jenkins, *Globigerinoides altiapertura* Bolli, *Globigerinoides primordius* Blow & Banner, *Globigerinoides triloba* (Reuss), *Globorotalia obesa* (Bolli), and *Globorotalia* sp. The same assemblage was found in sample Te05 which sampel was taken from Kolam Udang. This foraminifera assemblage assigned to N4 of *Globigerinoides primordius* Zone of Blow Zones.

Sample Te06 comprise *Catapsydrax dissimilis* (Cushman & Bermudez), *Globigerina praebulloides* Blow, *Globigerina* sp., *Globigerina woodi* Jenkins, *Globigerinoides altiapertura* Bolli, *Globigerinoides primordius* Blow & Banner, *Globigerinoides triloba* (Reuss), *Globoquadrina dehiscens* Chapman, Parr & Collins, *Globorotalia mayeri* Cushman & Ellisor, *Globorotalia* sp. and *Globorotalia siakanensis* Leroy. The sample was taken from Kg. Sinapokan. The presence of *Globoquadrina dehiscens* and *Catapsydrax dissimilis* indicate of age N5 of *Globoquadrina dehiscens /Globoquadrina praedehiscens* Zone.

Sample Te07 located at the Kg. Kepayan shows occurrence of planktonic foraminifera. The foraminfera are *Globigerina praebulloides* Blow, *Globigerina* sp., *Globigerinoides primordius* Blow & Banner, and *Globorotalia mayeri* Cushman & Ellisor, this assemblage represents the *Globigerinoides primordius* Zone (N4) by the appearance of *Globigerinoides primordius* species.

Four species of planktonic foraminifera from Sample Te08 which located at the Kg. Layong. The four species are *Globigerina praebulloides* Blow, Globigerina sp., *Globigerinoides primordius* Blow & Banner, *Globorotalia* sp. and *Globorotalia siakanensis* Leroy. The appearance of *Globigerinoides primordius* in this assemblage indicate of *Globigerinoides primordius* Zone (N4).

Based on the analysis of planktic foraminifera from the nine samples (Te01-Te08) of eight difference localities, three foraminifera zone of Blow Zone (1969) have been identified. The photomicrograph of index fossils are shown at Figure 2. The first zone is P21/N2 of *Globigerina angulisuturalis/Globorotalia opima opima* Zone of Blow Zones which recorded in sample Te01 section cropping out at Kuburan Cina road. The index fossil *Globorotalia opima opima* was presence in the sample but *Globigerina angulisuturalis* was absent. The presence of *Globorotalia opima opima* and *Globorotalia opima nana* indicate of P21/N2 *Globigerina angulisuturalis/Globorotalia opima opima* Zone.

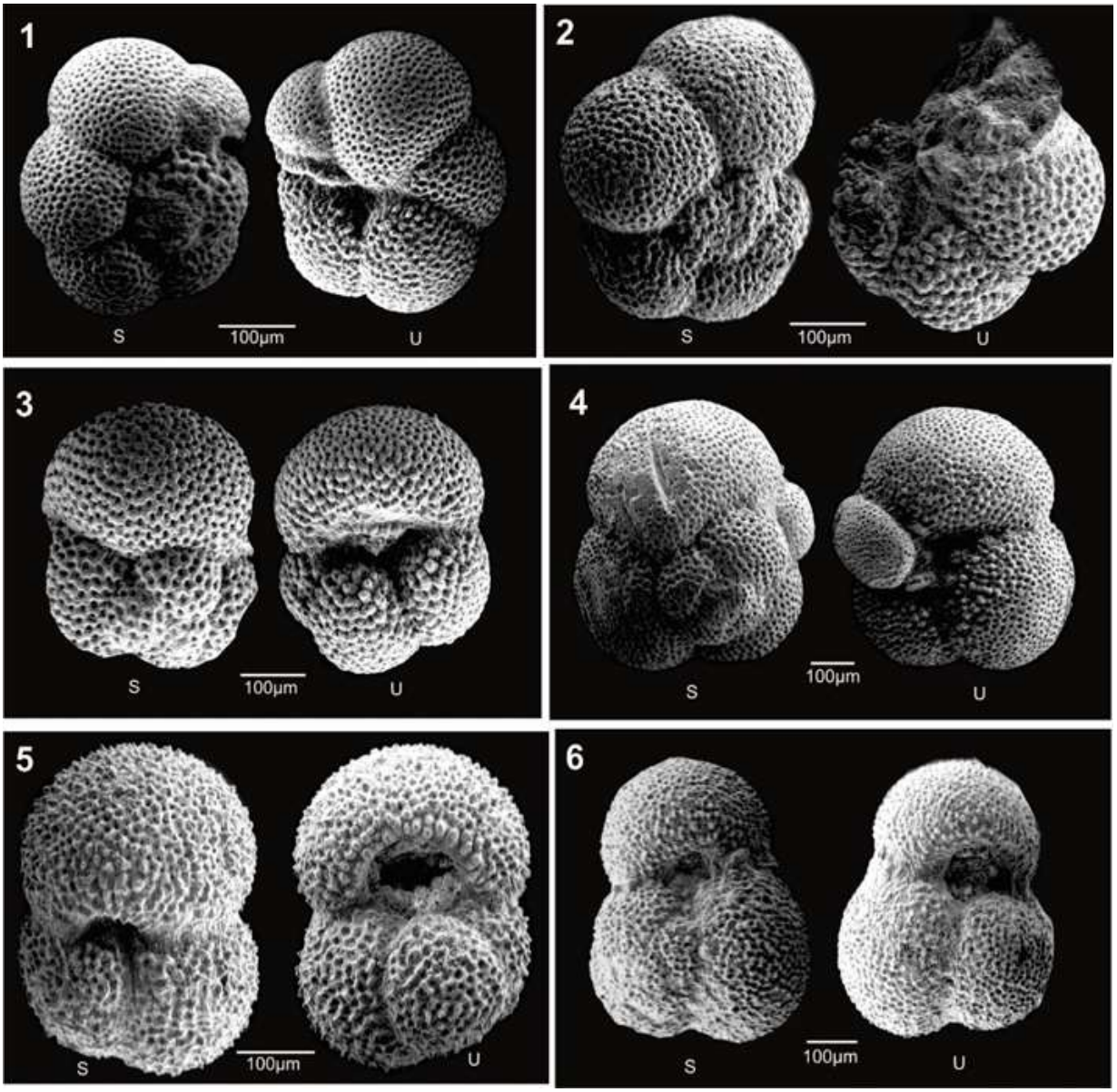

Figure 2. Planktic Foraminifera; S = dorsal view, U = ventral view: 1-2) *Globorotalia opima opima*, 3) *Globoquadrina dehiscens*, 4) *Globoquadrina praedehiscens*, 5-6) *Globigerinoides primordius*.

The second zone is *Globigerinoides primordius*/*Globigerina kugleri* Zone (N4). This zone represents by samples Te02-1, Te03, Te04, te05, Te07 and Te08 at five difference localities (Kg. Bakarang, Kg. Melingkai, Kg. Manggis, Kg. Kepayan, Kg. Layong). All the samples have occurrence of *Globigerinoides primordius* species but has no evidence of appearance of *Globigerina kugleri* in all samples. The third zone is known as *Globoquadrina dehiscens* /*Globoquadrina praedehiscens* Zone (N5). This zone characterized by the presence of *Globoquadrina dehiscens* and *Globoquadrina praedehiscens* which are appear in upper part of Te02 section (sample Te02-3) and in sample Te06.

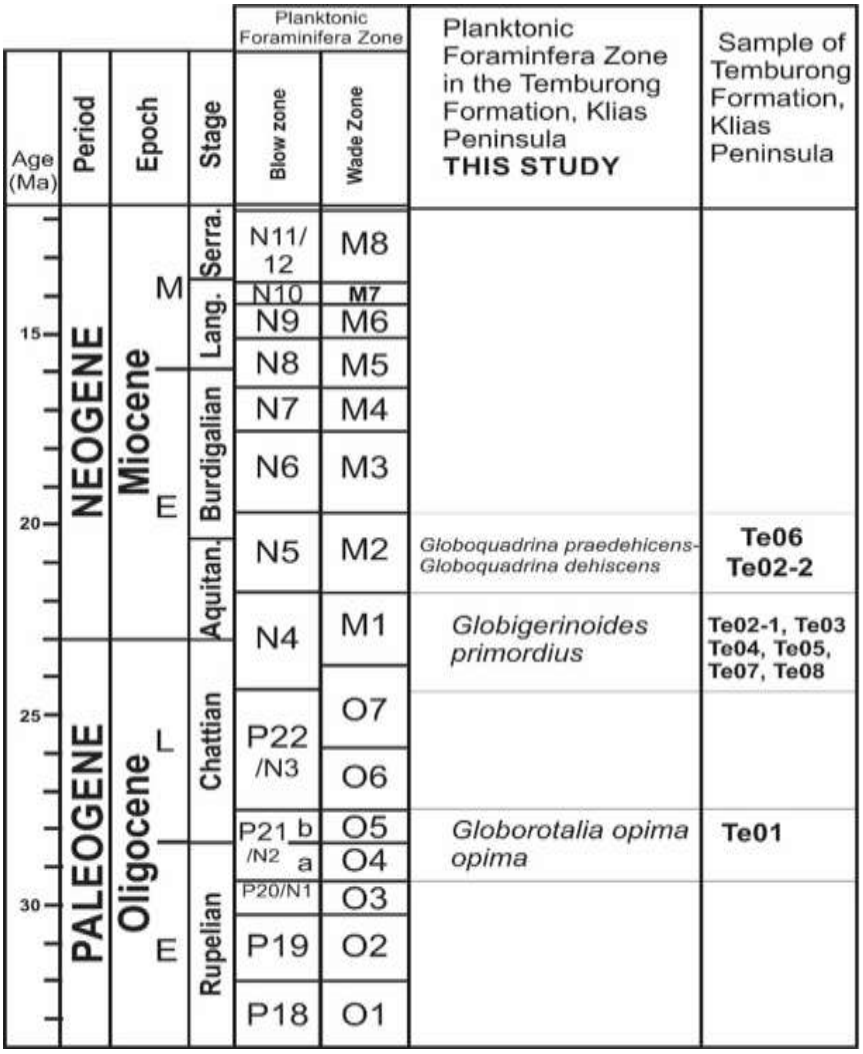

Figure 3. Stratigraphic distribution of planktic foraminifera from the Temburong Formation at Klias Peninsula

VI. STRATIGRAPHY OF THE TEMBURONG FORMATION AT KLIAS PENINSULA

Three foraminifera zone have been identified (P21/N2, N4 and N5) from the shale sample from eight difference localities (Figure 3). In Blow Zone, the P21/N2 *Globigerina angulisuturalis/Globorotalia opima opima* Zone was range from Middle to later parts of Oligocene. The age of *Globigerinoides primordius/Globigerina kugleri* Zone (N4) is Earliest Miocene or part of Aquitanian and *Globoquadrina dehiscens /Globoquadrina praedehiscens* Zone (N5) was date as Early Miocene to or to Earliest Burdigalian. Based on these three zones of planktonic foraminifera, we can conclude that the age of the Temburong

Formation at the Klias Peninsula range from Upper Oligocene to Early Miocene. Wilson (1964) reported the age of Temburong Formation range from Tcd to Te_5 of Letter Stage or equivalent to Oligocene to Upper Miocene based on planktic foraminifera from Padas Valley which located at the southern part of Sabah. Late Oligocene (Td) or Early Miocene (Te_1-Te_4) of larger benthic foraminifera have been reported by Adam in Wilson (1964)

collected from Ulu Lakutan, Melikut River and Padas Valley. The latest studies on planktonic foraminifera of Temburong Formation from Padas Valley reported by Asis *et al*. (2015), which suggested P22/N3 zone based on planktonic foraminfera zone of Bolli and Saunders (1985). The specimen of *Globigerinoides sicanus* N7 (Bolli & Saunders, 1985) suggested by Asis *et al*. (2015) probably distorted specimens of Globigerina spesies, so the age should be in P22/N3 zone characterised by the presence of *Globigerina ciperoensis* P22/N3 (Bolli & Saunders, 1985) zone or equivalent to *Globigerina angulisuturalis* zone (P22/N3) of Blow (1969) Zone. The planktonic foraminifera analysis from the Temburong Formation at Klias Peninsula slightly older compared to the age suggested by Wilson (1964). The age of Temburong Formation could not reach up to Upper Miocene and it should be not younger than Early Miocene stage.

VII. SUMMARY

Three planktonic foraminifera zones were identified from eight localities of shale unit at Klias Peninsula. The three zones are P21/N2 *Globigerina angulisuturalis/Globorotalia opima opima* Zone, *Globigerinoides primordius/Globigerina kugleri* Zone (N4) and *Globoquadrina dehiscens/Globoquadrina praedehiscens* Zone (N5). The shale unit of the Temburong Formation from the Klias Peninsula was interpreted as a distal part of deep-sea fan deposited during the Upper Oligocene to Early Miocene (Chattian to Aquitanian).

VIII. ACKNOWLEDGMENT

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