Geol. Soc. Malaysia, Bulletin 44, July 2000; pp. 35-43

Geological significance of radiolarian chert in Sabah

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Abstract: Radiolarian cherts are found associated with ophiolitic rocks in the Chert Spillite Formation and as blocks within the chaotic deposits. The ophiolitic chert association in Kudat yielded seventeen radiolarian taxa. The radiolarian assemblage indicates that the age of the chert is Barremian-Aptian. Eighteen radiolarian taxa were identified from the chert samples collected from the chert block of the Wariu Complex. The radiolarian assemblage suggests the age of the chert is Albian. The age of the cherts ranges from Barremian to Albian. The chert blocks of the Wariu Complex were derived from the ophiolitic chert association. The radiolarian chert was originally deposited on oceanic crust close to spreading center. The ophiolitic chert association represents the oldest rocks in Sabah.

INTRODUCTION

Radiolarian cherts are found associated with ophiolitic rocks in the Chert Spillite Formation and as blocks within the chaotic deposits. The radiolarian cherts have been studied by many researchers (Leong, 1977; Basir Jasin and Sanudin Tahir, 1988; Basir Jasin, 1991; Basir Jasin, 1992; Basir Jasin and Sanatulsalwa Hasan, 1992; Aitchison, 1994). The age of the chert was thought to range from Valanginian to Barremian, Early Cretaceous.

Recently, more well-preserved radiolarian faunas were retrieved from the cherts. The aims of this paper is to review the age of the radiolarian assemblages and to interpret the possible environment of deposition based on rock assemblage and geochemical data.

GEOLOGICAL SETTING

The ophiolitic chert association (Chert Spilite Formation) consists of thinly bedded chert interbeds with very thin siliceous shale. The bedded chert is known as ribbon chert. The sequence is underlain by pillow lava, basalt, serpentinite and peridotite. The ophiolitic chert association is found as isolated outcrops mainly in Banggi Island, Kudat, Tandek, Telupid, Segama Valley and Pulau Timbun Mata (Fig. 1). At Bukit Pengaraban, Kudat, the chert overlies the basalt.

The chert blocks are found in the Wariu, Ayer, Kuamut and Garinono Complexes. The complexes are composed of blocks of tuffaceous sedimentary rocks, bedded mudstone, sandstone, chert, limestone, and volcanic rocks embedded in mud matrix. These chaotic deposits are considered to have diapiric origins (Mc Manus and Tate, 1986). The rock assemblage is considered as melange by Aitchison (1994). The melange is common in zones of arc-continent collision. The age of the melanges is Miocene (Liechti *et al.*, 1960). The chert blocks of the chaotic deposits originate from the ophiolitic chert association.

RADIOLARIA AND AGE

Ten radiolarian chert samples (Samples Ku1–Ku10) were systematically collected from an outcrop of ophiolitic chert association at Bukit Pengaraban's earth quarry near Kudat (Fig. 2). Seventeen taxa were identified (Plate 1). Stratigraphic distribution of the Radiolaria is shown in Table 1. The stratigraphic distribution of some selected taxa shows that the age of the chert from the ophiolitic chert association is Barremian-Aptian, Early Cretaceous (Fig. 3).

Five samples were collected from the chert block of the Wariu Complex exposed at a road cut near Timbang Menggaris. Eighteen taxa were identified (Plate 2):

Acanthocircus levis Donofrio & Mostler
Acanthocircus multidentatus (Squinabol)
Archaeospongoprunum sp.
Cryptamphorella conara (Foreman)
Dictyomitra gracilis (Squinabol)
Hsuum sp.
Orbiculiforma maxima Pessagno
Praeconocaryomma sp.
Pseudoaulophacus sculptus (Squinabol)
Rotaforma cf. *volatilis* O'Dogherty
Scadiocapsa speciosa (Squinabol)
Stichomitra communis Squinabol
Thanarla conica (Squinabol)

Paper presented at GSM Annual Geological Conference '99

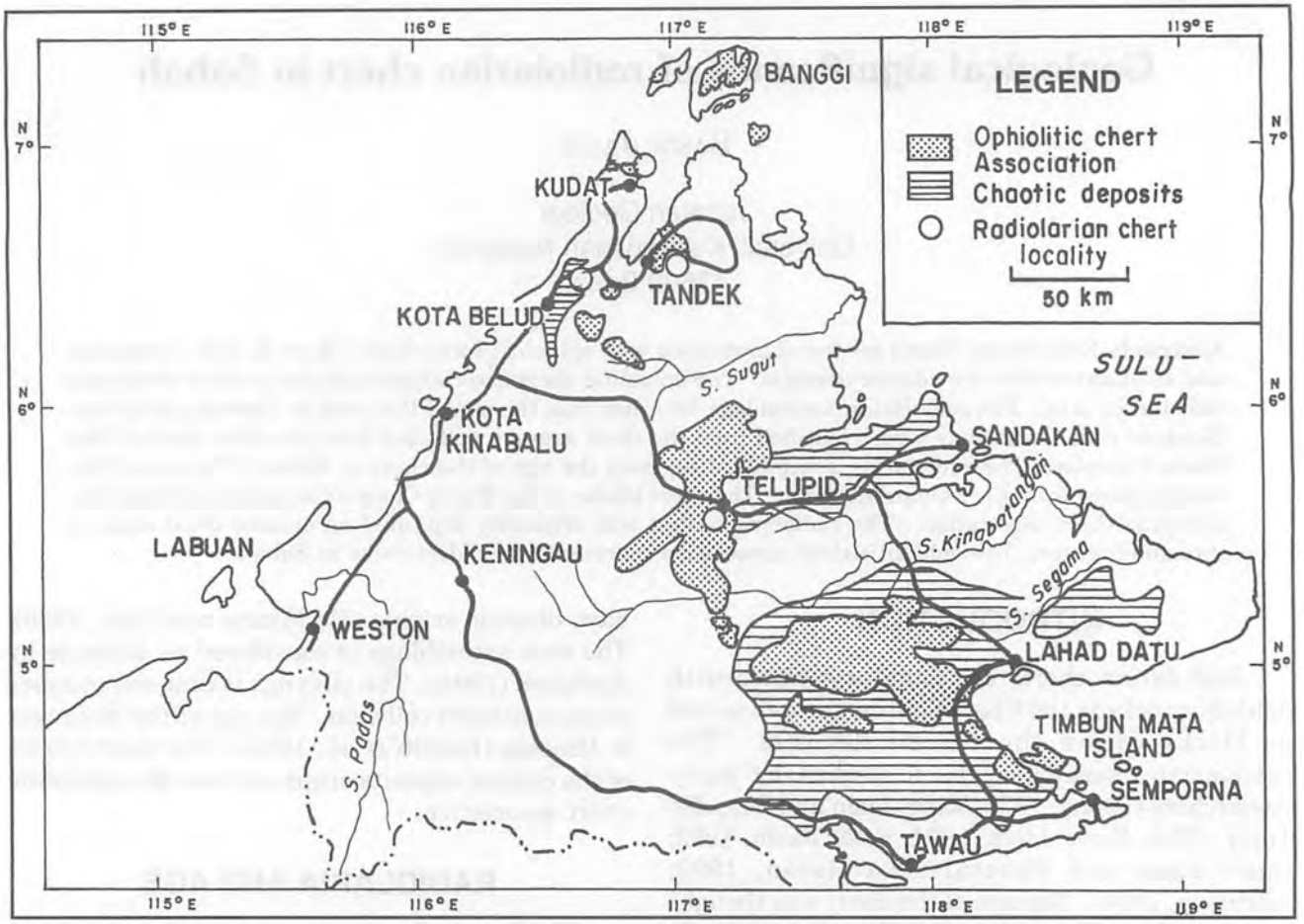


Figure 1. Map showing distribution of ophiolitic chert association, chaotic deposits and radiolarian chert locality.

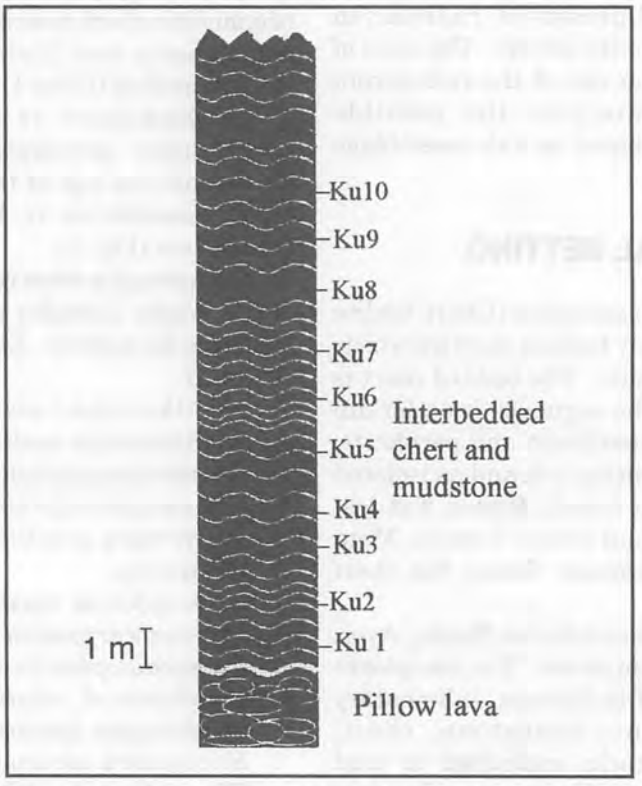


Figure 2. Lithologic log of the chert exposure at Bukit Pengaraban, Kudat.

Table 1. Stratigraphic distribution of Radiolaria from Bukit Pengaraban, Kudat.

	Ku1	Ku2	Ku3	Ku4	Ku5	Ku6	Ku7	Ku8	Ku9	Ku10
Pseudodictyomitra carpatica	X	X	X	X						
Ultranapora praespinifera	X	X								
Thanarla brouweri	X	X	X	X	X	X	X	X	X	X
Triactoma tithonianum	X	X								
Sethocapsa asseni	X	X	X							
Ultranapora sp.	X				X					
Dictyomitra communis	X	X	X	X	X	X	X	X	X	X
Acaeniotyle umbilicata	X				X	X				
Xitus spicularius	X	X		X		X	X	X		
Archaeodictyomitra lacrimula		X	X	X	X		X	X	X	
Thanarla pacifica		X	X	X	X					X
Pseudoeucyrtis hanni			X	X	X	X	X	X		X
Wrangellium puga				X						
Sethocapsa orca				X		X	X	X	X	
Podobursa typica				X	X		X	X	X	X
Pantanellium squinaboli						X		X		
Cryptamphorella conara							X	X	X	X

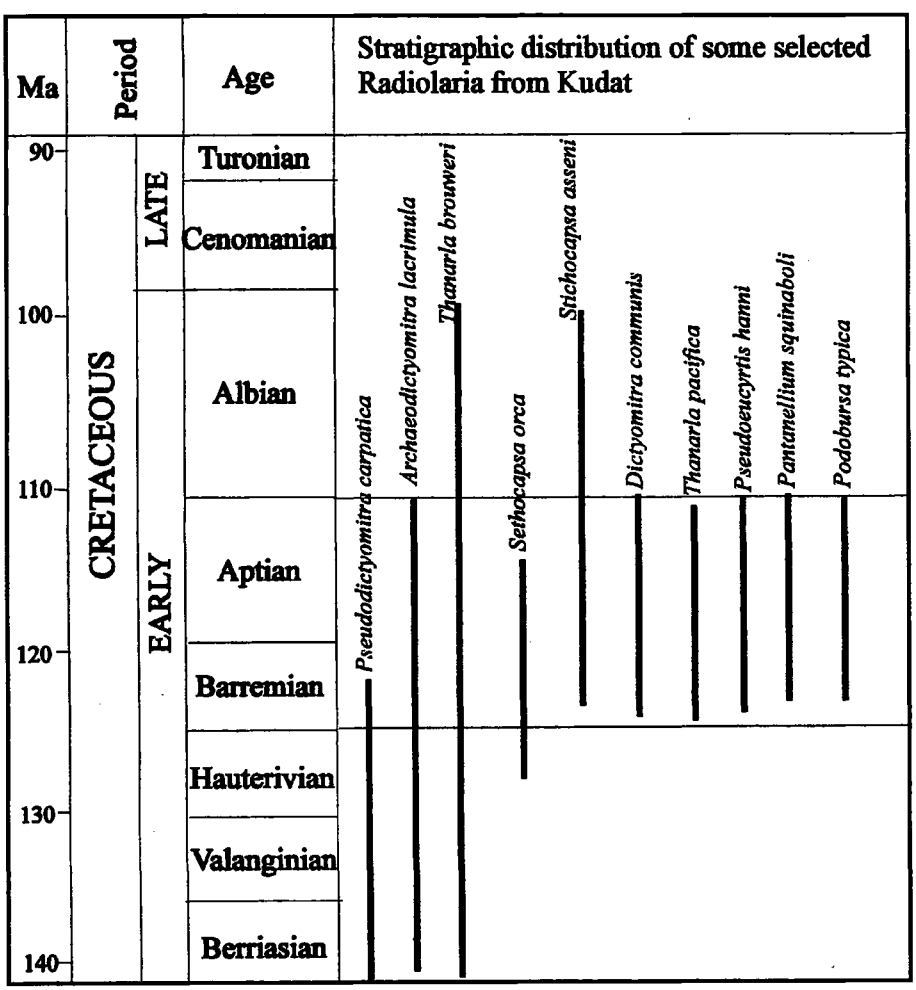
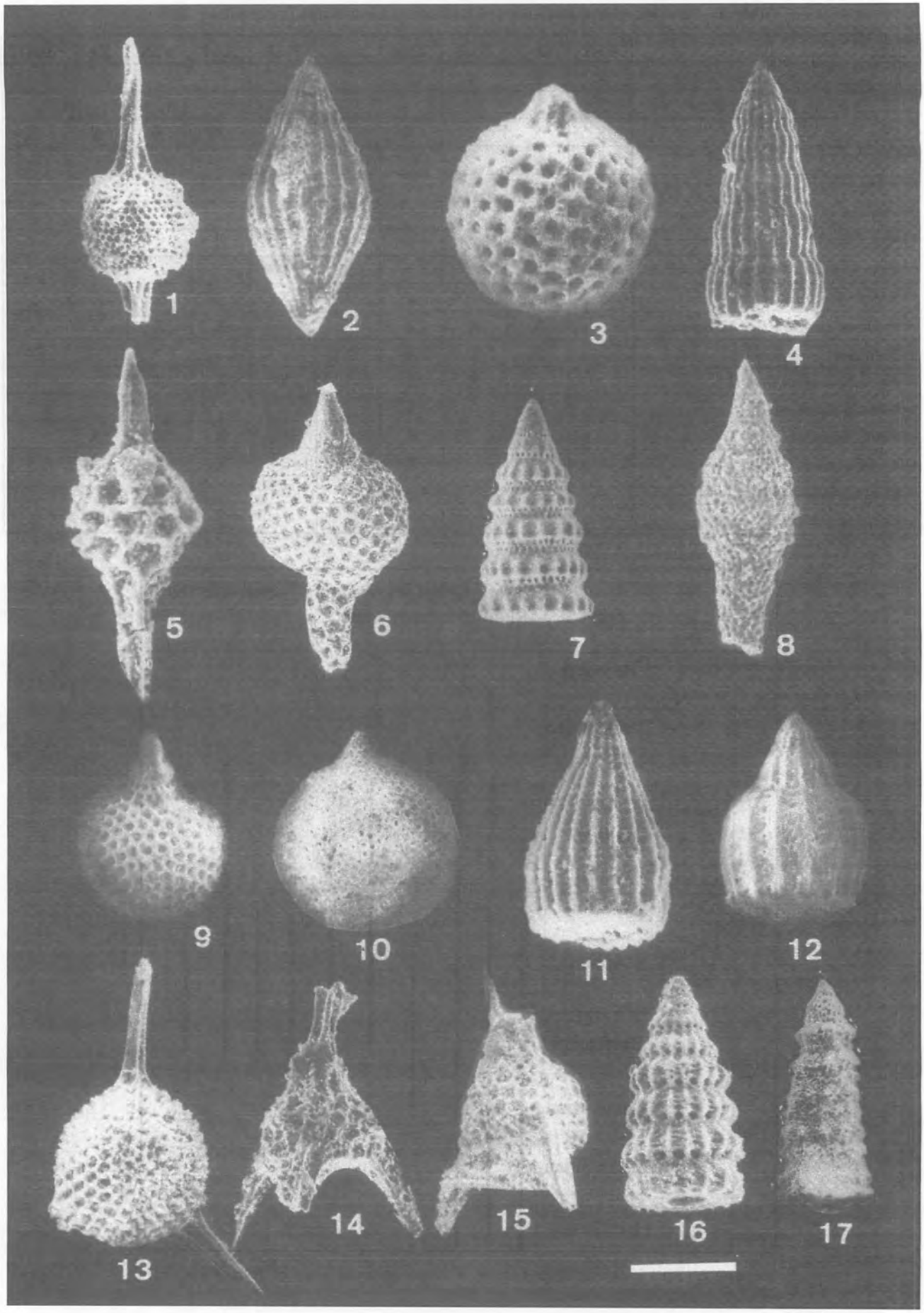


Figure 3. Stratigraphic distribution of some selected taxa of Radiolaria from Kudat (based on Baumgartner *et al.*, 1995).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Triactoma cellulosa Foreman
Triactoma sp.
Ultranapora praespinifera Pessagno
Ultranapora sp.
Xitus spicularius (Aliev)

Distribution of some selected taxa (Fig. 4) suggest that the age of chert block from the Wariu Complex is Albian.

The chert blocks of the Wariu Complex and the chert from the ophiolitic chert association are of the same origin. The age of the chert ranges from Barremian to Albian, Early Cretaceous. A detailed study is being carried out to find the precise age of the chert (Basir Jasin and Tongkul, in preparation). Elsewhere, the age of the chert may extend down to Valanginian (Leong, 1977; Basir Jasin, 1992). The chert and the ophiolitic suite form the oldest rocks of Sabah.

GEOCHEMICAL ANALYSIS OF THE CHERT SAMPLES

Major element compositions of nine chert samples were analysed by using X-ray fluorescence method. The results are shown in Table 2. The samples were collected from Tandek (T1–T5), Bukit Pengaraban (P), and Ruku-Ruku valley, Telupid (Fig. 1).

The cherts generally contain a high percentage of SiO_2, followed by Fe_2O_3 and Al_2O_3. The other elements are very low. Three major elements Fe_2O_3, Al_2O_3 and TiO_2 are used for interpreting the environment of deposition based on the discrimination diagram of Murray (1994).

ENVIRONMENT OF DEPOSITION

The ophiolitic suite of pillow basalt, serpentinite, peridotite is commonly capped by red radiolarian chert. This rock association is considered as an ophiolitic chert association by Jones and Murchey (1986). This association represents oceanic crust. The occurrence of thinly bedded chert indicates that environment of deposition was lacking in terrigenous supply and located far from continent.

Geochemical data from the cherts plot on the Fe_2O_3/TiO_2 vs $Al_2O_3/(Al_2O_3 + Fe_2O_3)$ discrimination diagram (Fig. 5) show that most of the points located in the field of near ridge and pelagic.

The rock association and the geochemical data indicate that the chert was deposited on oceanic crust. This suggests that the probable depositional environment was deep oceanic environment close to spreading centre. The occurrence of siliceous shale interbeds with chert indicates the presence of hemipelagic argillaceous material episodically transported by weak turbidity currents into the environment.

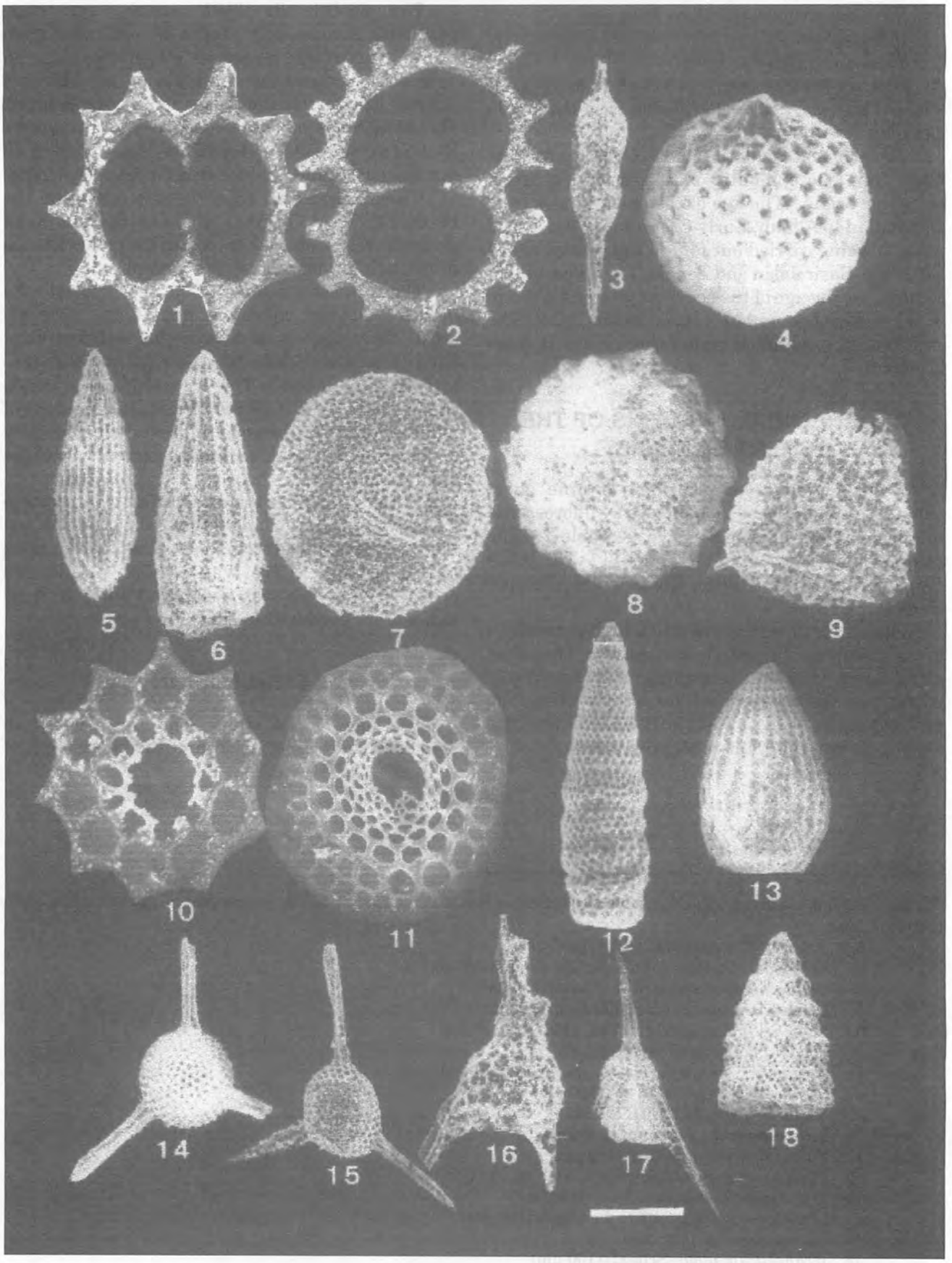
More than 98% of the radiolarian tests dissolve in the water column and on the seafloor (Jones and Murchey, 1986). The occurrence of radiolarian chert indicates that there was a high planktonic productivity which was associated with nutrient rich waters produced in upwelling zones.

CONCLUSION

The age of the chert sequence from both ophiolitic chert association and the chert block of

Plate 1. Radiolaria from ophiolitic chert association, Bukit Pengaraban, Kudat (scale bar in μm is indicated in parentheses).

1. *Acaeniotyle umbilicata* (Rust) (100 μm)
2. *Archaeodictyomitra lacrimula* (Foreman) (100 μm)
3. *Cryptamphorella conara* (Foreman) (50 μm)
4. *Dictyomitra communis* (Squinabol) (100 μm)
5. *Pantenellium squinaboli* (Tan) (100 μm)
6. *Podobursa typica* (Rust) (133 μm)
7. *Pseudodictyomitra carpatica* (Lozyniak) (110 μm)
8. *Pseudoeucyrtis hanni* (Tan) (100 μm)
9. *Sethocapsa asseni* (Tan) (100 μm)
10. *Sethocapsa orca* Foreman (200 μm)
11. *Thanarla brouweri* (Tan) (100 μm)
12. *Thanarla pacifica* Nakaseko & Nishimura (100 μm)
13. *Triactoma tithonianum* Rust (100 μm)
14. *Ultranapora praespinifera* Pessagno (100 μm)
15. *Ultranapora* sp. (100 μm)
16. *Wrangellium puga* (Schaaf) (100 μm)
17. *Xitus spicularius* (Aliev) (110 μm)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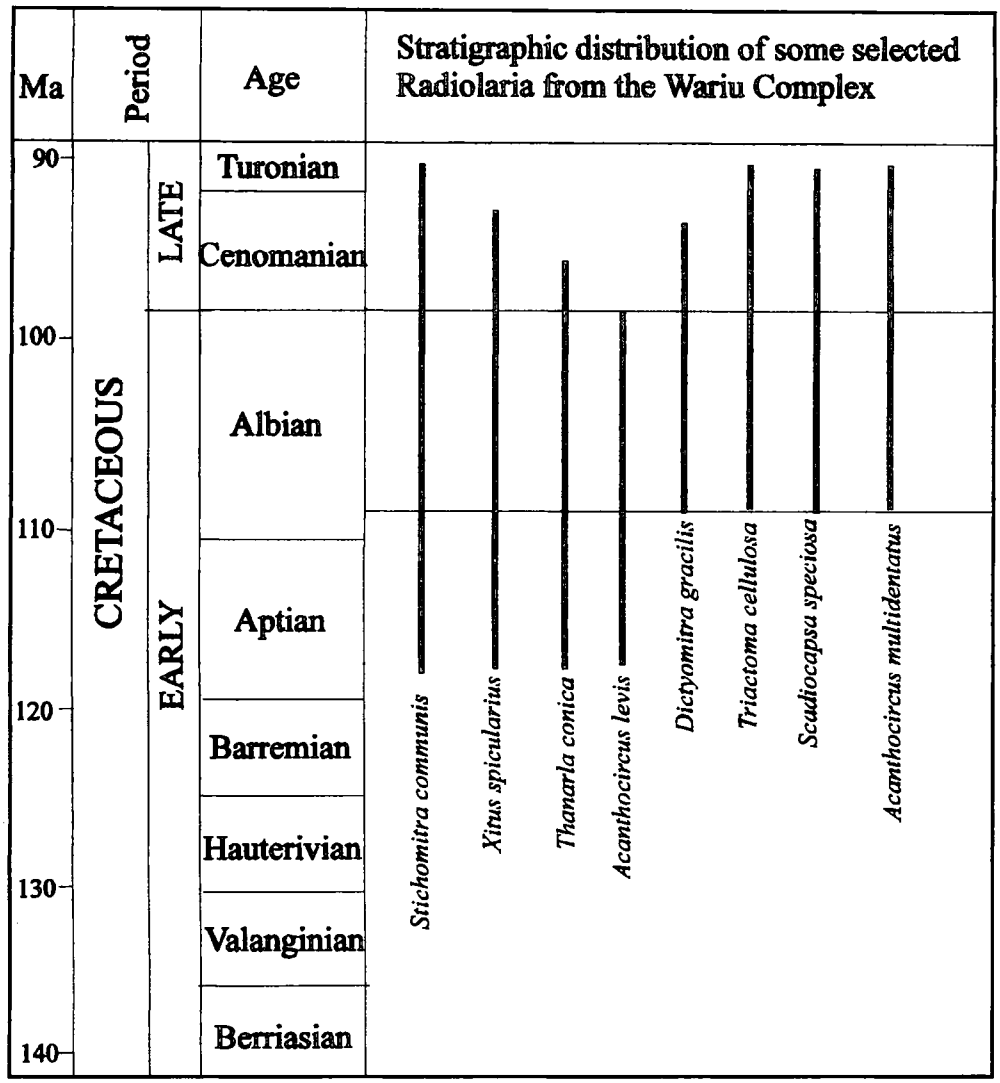

Figure 4. Stratigraphic distribution of some selected taxa of Radiolaria from the Wariu Complex (based on O'Dogherty, 1994).

Plate 2. Radiolaria from the chert block of the Wariu Complex (scale bar in μm is indicated in parentheses).

1. *Acanthocircus levis* Donofrio & Mostler (133 μm)
2. *Acanthocircus multidentatus* (Squinabol) (133 μm)
3. *Archaeospongoprunum* sp. (133 μm)
4. *Cryptamphorella conara* (Foreman) (50 μm)
5. *Dictyomitra gracilis* (Squinabol) (133 μm)
6. *Hsuum* sp. (100 μm)
7. *Orbiculiforma maxima* Pessagno (100 μm)
8. *Praeconocaryomma* sp. (133 μm)
9. *Pseudoaulophacus sculptus* (Squinabol) (100 μm)
10. *Rotaforma* cf. *volatilis* O'Dogherty (100 μm)
11. *Scadiocapsa speciosa* (Squinabol) (133 μm)
12. *Stichomitra communis* Squinabol (100 μm)
13. *Thanarla conica* (Squinabol) (100 μm)
14. *Triactoma cellulosa* Foreman (133 μm)
15. *Triactoma* sp. (133 μm)
16. *Ultranapora praespinifera* Pessagno (100 μm)
17. *Ultranapora* sp. (200 μm)
18. *Xitus spicularius* (Aliev) (133 μm)

Table 2. Major element composition of some selected chert samples from ophiolitic chert association.

	T1	T2	T3	T4	T5	P	R1	R2	R3
SiO_2	92.70	93.33	91.36	96.99	91.39	92.78	94.60	91.04	77.52
Al_2O_3	0.96	2.11	2.44	0.58	1.70	2.26	1.65	2.45	5.58
Fe_2O_3	2.84	1.82	2.74	1.31	3.05	1.84	0.87	3.12	7.78
TiO_2	0.11	0.13	0.11	0.04	0.08	0.10	0.08	0.06	0.26
MgO	0.16	0.03	0.23	bdl*	0.38	0.34	0.22	0.52	1.81
CaO	0.07	0.07	0.08	0.11	0.13	0.02	0.02	0.06	0.05
Na_2O	0.12	bdl*	0.15	bdl*	0.34	0.59	0.05	0.05	0.08
K_2O	0.31	0.66	0.82	0.13	0.29	0.64	0.23	0.09	1.83
MnO	0.72	0.33	0.26	0.11	0.29	0.02	0.01	0.02	0.07
P_2O_5	0.04	0.05	0.07	0.02	0.07	0.03	0.02	0.07	0.08
LOI	2.23	2.38	1.78	0.90	1.34	1.83	2.24	2.43	4.94
Total:	99.70	100.88	100.04	99.95	99.04	100.45	99.97	99.91	100.00
Key major element ratios									
Fe_2O_3/TiO_2	25.82	14.00	24.90	32.75	38.12	23.10	20.16	52.00	13.36
$Al_2O_3/(Al_2O_3 + Fe_2O_3)$	0.25	0.54	0.47	0.31	0.36	0.55	0.66	0.44	0.42

bdl* — below detection limit
Sample P from Bukit Pengaraban, Kudat
Samples T1–T5 from Tandek
Samples R1–R3 from Ruku-Ruku valley, Telupid

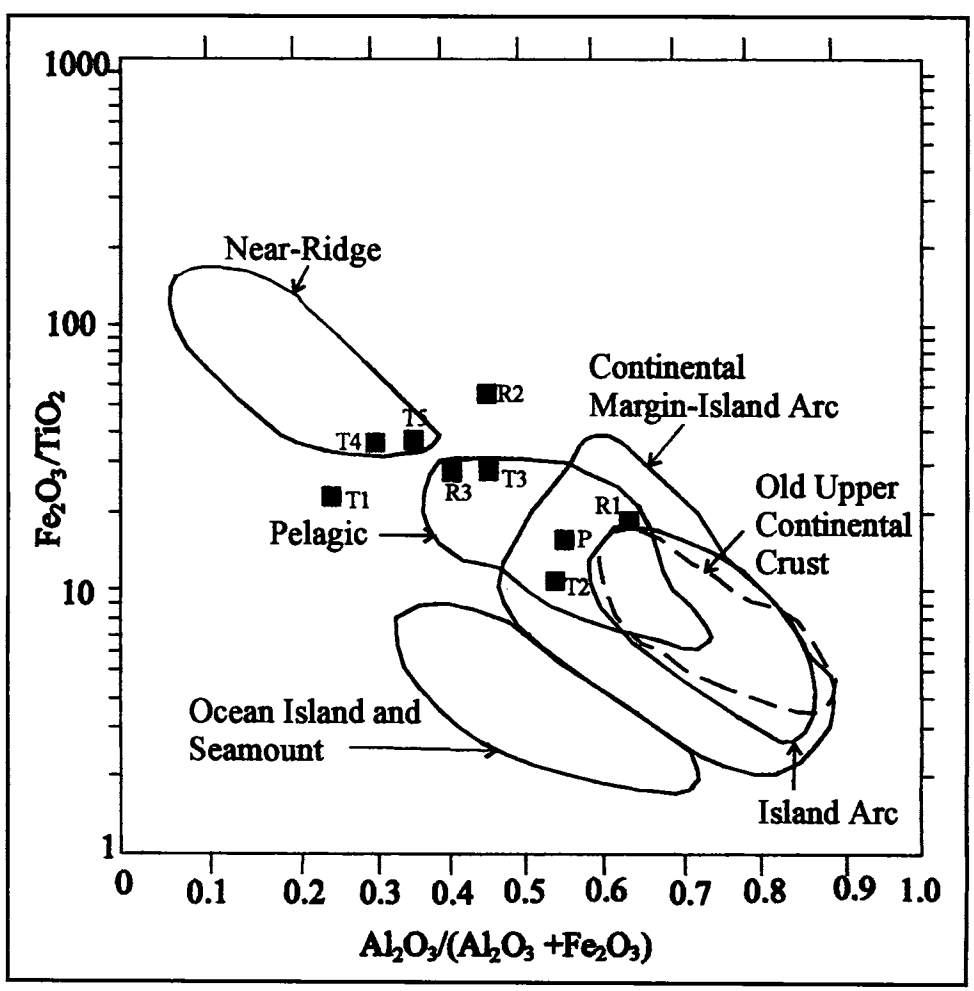

Figure 5. Geochemical data of cherts plot on Fe_2O_3/TiO_2 vs $Al_2O_3/(Al_2O_3 + Fe_2O_3)$ discrimination diagram of Murray (1994). Samples T1–T5 from Tandek, P from Bukit Pengaraban and R1–R3 from Ruku–Ruku valley, Telupid.

the Wariu Complex ranges from Barremian to Albian. This may represent the whole age of the ophiolitic chert complex.

The radiolarian chert is a biogenic chert of pelagic origin. It was deposited in an oceanic environment close to spreading centre and episodically received supply of hemipelagic mud transported by weak turbidity currents.

The ophiolitic chert association represents the oceanic crust which forms during the Early Cretaceous. It is the oldest rocks in Sabah.

ACKNOWLEDGEMENT

I would like to thank En. Mohd. Yaakob Ismail and Hj. Abdul Aziz Ngah their help in SEM photography of radiolarian specimens and XRF analysis of the chert samples. I thank En. Ibrahim Mohd. Dom for his assistance in preparing the map.

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Manuscript received 5 August 1999