The age and paleobiogeography of brachiopod fauna discovered in pebbly mudstone at Kilim, Langkawi

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Abstract: A rich brachiopod fauna was recently discovered in the pebbly mudstone overlying sandstone and limestone at Kilim, Langkawi. The fauna comprised *Spirelytha buravasi* (Hamada), *Sulciplica thailandica* (Hamada), *Bandoproductus monticulus* (Waterhouse), *Lamniplica* cf. *sapa* (Waterhouse), *Rhynchopora* cf. *culta* Waterhouse, *Streptorhynchus* sp., *Arctitreta* sp., *Elasmata* sp. and *Trigonotreta* sp. The brachiopod assemblage is very similar to that of Ko Muk in Southern Thailand. The presence of *Bandoproductus monticulus* (Waterhouse) suggests an Early Permian (Late Asselian to Sakmarian) age for the Kilim pebbly mudstone and its fauna. Paleobiogeographically, the Kilim brachiopod fauna has a very close affinity with many other Early Permian south temperate or peri-Gondwana fauna. The faunal evidence strongly support the idea that the pebbly mudstone in the Singa Formation is of marine glacial diamictite.

INTRODUCTION

The Upper Paleozoic Singa Formation is exposed extensively especially in the southwestern part of Langkawi islands. Until recently, this formation is not very well known from the Langkawi main island. Rapid physical development in Langkawi Island lately has exposed a large volume of Singa Formation in the Langkawi main island. The Singa Formation is unique for the presence of pebbly mudstone which was considered as marine glacial diamictite (Stauffer and Mantajit, 1981; Stauffer and Lee, 1986). This marine glacial diamictite occurs abundantly in the Kentut and the Selang Members (Ahmad Jantan, 1973; Stauffer and Lee, 1986). Although trace fossils are abundant and are commonly associated with the glacial diamictite, body fossils have rarely been found from the same bed in Langkawi Islands. Apart from Jones (1978)'s report on the occurrence of several brachiopod localities on the northern part of Pulau Singa Besar and at Pulau Singa Kecil, the rest of the formation seems to be devoid of body fossils. For this reason, the age of the formation and the diamictite cannot be precisely determined.

The brachiopod fauna discussed in this paper come from the pebbly mudstone exposed in the southern part of Kilim shale quarry, about 14 km north of Kuah (Fig. 1). Basir Jasin *et al.* (1992) discovered bryozoan limestone from the same quarry which they considered to be a transition in between the Singa formation and the overlying Chuping formation. The bryozoan limestone fauna from this (Kilim) locality, which was mistaken by these authors as Bukit Durian Perangin, is mainly made of bryozoans with a few crinoids and brachiopods. Basir Jasin *et al.* (1992) suggested a late Early Permian (Artinskian) age for the fauna, based on the presence of bryozoan species *Streblascopora exillis* Sakagami which was previously described by Sakagami (1966, 1976) from the Early Permian (Artinskian) of Ko Muk in Southern Thailand.

GEOLOGICAL SETTING

The studied Kilim section represents the top part of the Singa Formation, although, as mentioned by Basir Jasin *et al.* (1992) it is very difficult to assign the section to any particular member of the formation as described by Ahmad Jantan (1973) in his unpublished MSc thesis. The very high content of calcareous substances in the Kilim rock unit seems to be incomparable with any other member of the Singa formation. Therefore, more detail study of the section must be carried out, should this unit be assigned to any particular member of the existing formation or to a new stratigraphic unit.

A rich brachiopod-bearing mudstone (pebbly mudstone) was discovered about 100 meters south-southeast of the bryozoan limestone locality described by earlier authors. The actual stratigraphic relationship between the previously described bryozoan limestone and this new fossil locality described herein is not exactly known due to the existence of several faults in between them. However, the occurrence of several other limestone beds and lenses in the lower horizon of the studied section (Fig. 2) indicated that there are no significant age differences between the bryozoan limestone and the pebbly mudstone. It should be noted that most of the limestone beds and lenses overlain by this pebbly mudstone/siltstone are also essentially made of bryozoan colonies, with a few crinoids and brachiopods.

The sedimentary rocks described in this paper formed the southeasternmost exposure of the quarried area. The block is separated from the bryozoan limestone described in Basir Jasin *et al.* (1992) by faults, trending more or less northwest-southeast. In places, the fault is marked by a brecciated and pulverised zone of several meters wide. In general, the hill in the southeastern corner of the quarry is mainly made of mudstone/shale interbedded with siltstone which are thinly bedded or lensoidal in forms. This interbedded unit is overlain by some thin to thickly bedded limestone, sandstone and shale. Overlying the interbedded mudstone/shale-siltstone unit is thick mudstone followed by pebbly mudstone and thick sandstone (Fig. 2). This sandstone unit is then succeeded by the discussed brachiopod-bearing pebbly mudstone. The topmost of the sequence, overlying the discussed brachiopod bed, is massive mudstone bed with scattered pebbles and fossils.

The brachiopod fauna was discovered in moderate to thickly bedded mudstone (Fig. 3) which is dark grey to greenish in colour. The basal part of this mudstone grades into siltstone or fine sandstone which is relatively richer in fossil content. Beside this poorly graded bedding at its base, the rest of the mudstone seems to be massive and structureless. Rare and isolated small pebbles and

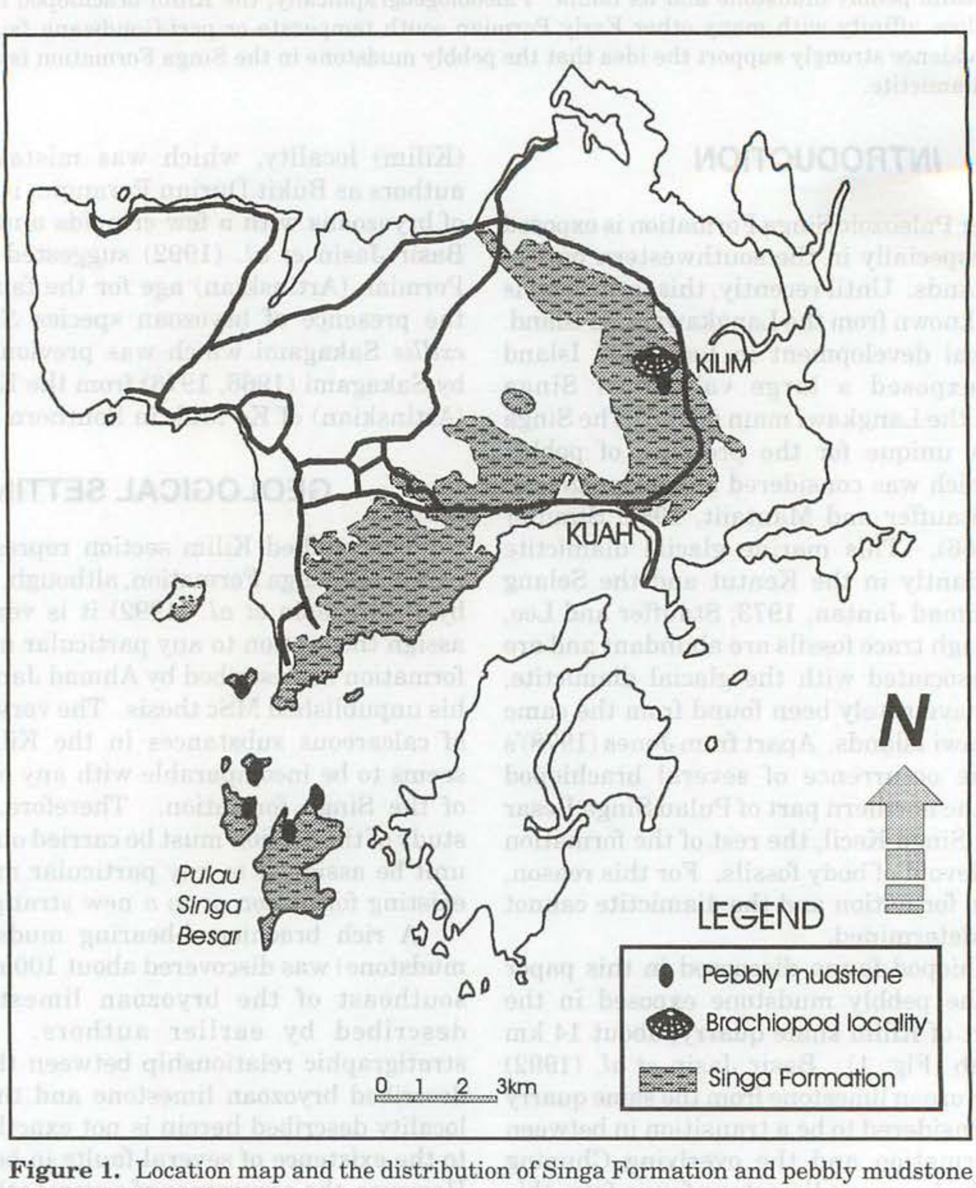

Figure 1. Location map and the distribution of Singa Formation and pebbly mudstone in Langkawi islands.

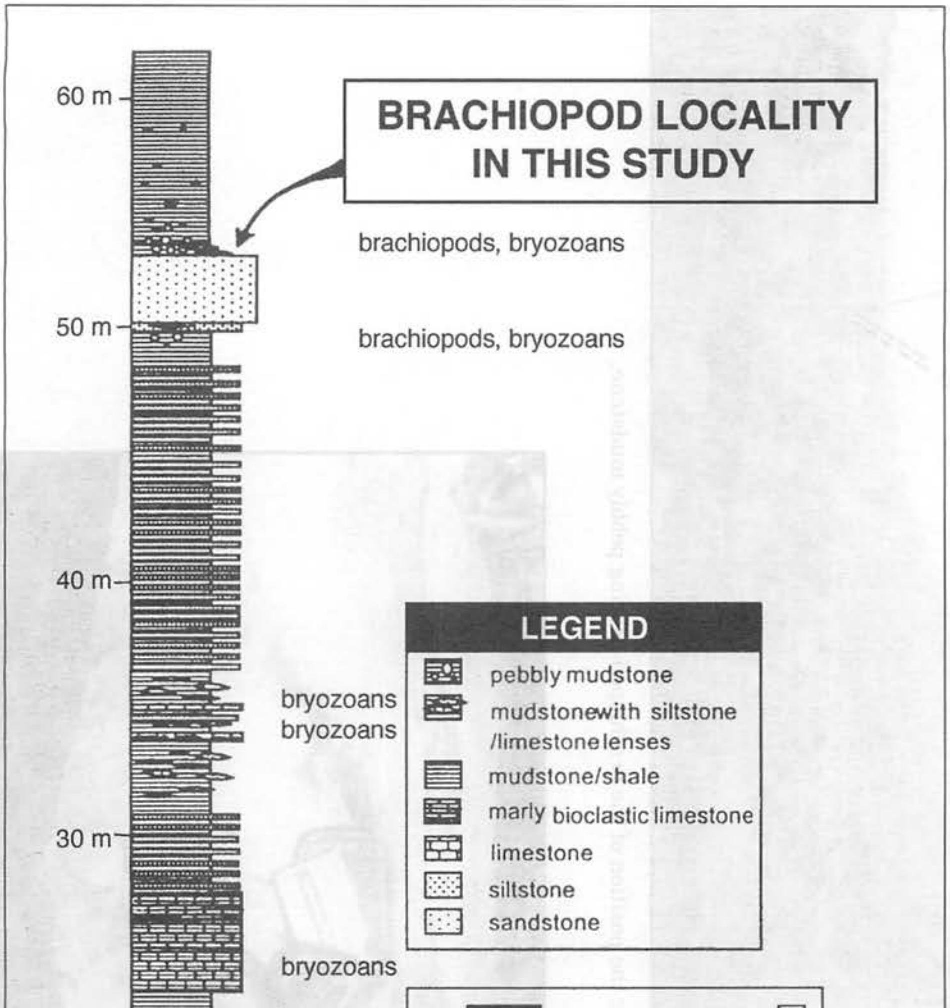

Figure 2. Stratigraphic log showing the position of the brachiopod-bearing pebbly mudstone.

Figure 3. Outcrop at Kilim quarry showing the position of the brachiopod-bearing pebbly mudstone.

Figure 4. Rounded pebbles in mudstone matrix.

Table 1. Permian brachiopod species from pebbly mudstone in Thailand and Malaysia.

Brachiopod species	Ko Muk, Thailand (Waterhouse, 1982)	Kilim, Langkawi (this study)
Spirelytha buravasi (Hamada)	@	common
Bandoproductus monticulus (Waterhouse)	@	common
Sulciplica thailandica (Hamada)	@	common
Lamniplica cf. *sapa* (Waterhouse)	@	rare
Streptorhynchus sp.	absent	common
Rhynchopora cf. *culta* Waterhouse	@	rare
Arctitreta sp.	@	rare
Trigonotreta sp.	absent	rare
Jakutochonetes solita (Waterhouse)	@	absent
Elasmata sp.	@	rare

fossils are randomly distributed within this massive mudstone (Fig. 4). The pebbles are rounded to angular in shape, sometimes reaching 10 cm in size. They are of various origin including quartz, mudstone, sandstone, limestone and granitic igneous rocks. Some of the pebbles exhibit a very distinctive dropstone structure (Fig. 5A).

THE FAUNA AND THEIR AGE

The fauna is mainly made of brachiopods, with some cryptostome bryozoan like *Fenestella* and *Polypora*. Nine species of brachiopods were tentatively identified from this locality, detail description of the which will be published separately (Mohd Shafeea Leman *et al.*, in prep.). The brachiopod fauna comprised of *Spirelytha buravasi* (Hamada), *Sulciplica thailandica* (Hamada), *Bandoproductus monticulus* (Waterhouse), *Lamniplica* cf. *sapa* (Waterhouse), *Rhynchopora* cf. *culta* Waterhouse, *Streptorhynchus* sp., *Arctitreta* sp., *Elasmata* sp. and *Trigonotreta* sp. Almost all brachiopod genera found at Kilim, Langkawi were also found by Waterhouse (1982) from the pebbly mudstone of Ko Muk, Thailand, except for *Streptorhynchus* and *Trigonotreta* (Table 1). On the other hand, *Jakutochonetes* which is part of the Ko Muk brachiopod assemblage, is not found in the Kilim area. Some representatives of Kilim brachiopod fauna are shown in Figure 5B–K.

In terms of age, generally all the identified brachiopod genera are either of Permian or Permo-Carboniferous age. The presence of *Bandoproductus monticulus* (Waterhouse) suggests an Early Permian age for the Kilim brachiopod fauna and the pebbly mudstone/siltstone which bears them. According to Waterhouse (1982), the Ko Muk's species of *Cancrinelloides monticulus* is very similar to the Western Australian Early Permian (Upper Asselian) *Cancrinelloides lyoni* (Prendergast). Shii and Archbold (1993a) revised Waterhouse's *Cancrinelloides monticulus* as *Bandoproductus monticulus* and commented that the age of the Western Australian *Lyonia lyoni* fauna is slightly younger than it was considered by Waterhouse (1982). Thus, the Ko Muk's fauna was regarded as of late Asselian to Sakmarian age by Shii and Archbold (1993a, b, 1995).

Meanwhile, Basir Jasin *et al.* (1992) suggested that the age of the bryozoan limestone nearby as of late Early Permian, based on the same bryozoan fauna found by Sakagami (1966, 1976) from Ko Muk of Thailand. Sakagami (1966, 1970) described some bryozoans from the limestone of Ko Muk and suggested a Late Artinskian age for the fauna, which is slightly older than the fauna described by him from Pulau Jong, Langkawi (Sakagami, 1963). Sakagami (1966, 1976) regarded the Ko Muk bryozoan fauna as closely related with the Western Australian Early Permian (Late Artinskian) bryozoan fauna from Wandagee Formation (Carnavon Basin) and Nookanbah Formation (Canning Basin).

With respect to the pebbly mudstone and cold water brachiopod fauna, Archbold *et al.* (1993) stressed that the cold-water element is noticeably absent in the late Artinskian of Western Australian. The late Artinskian bryozoan limestone of Ko Muk

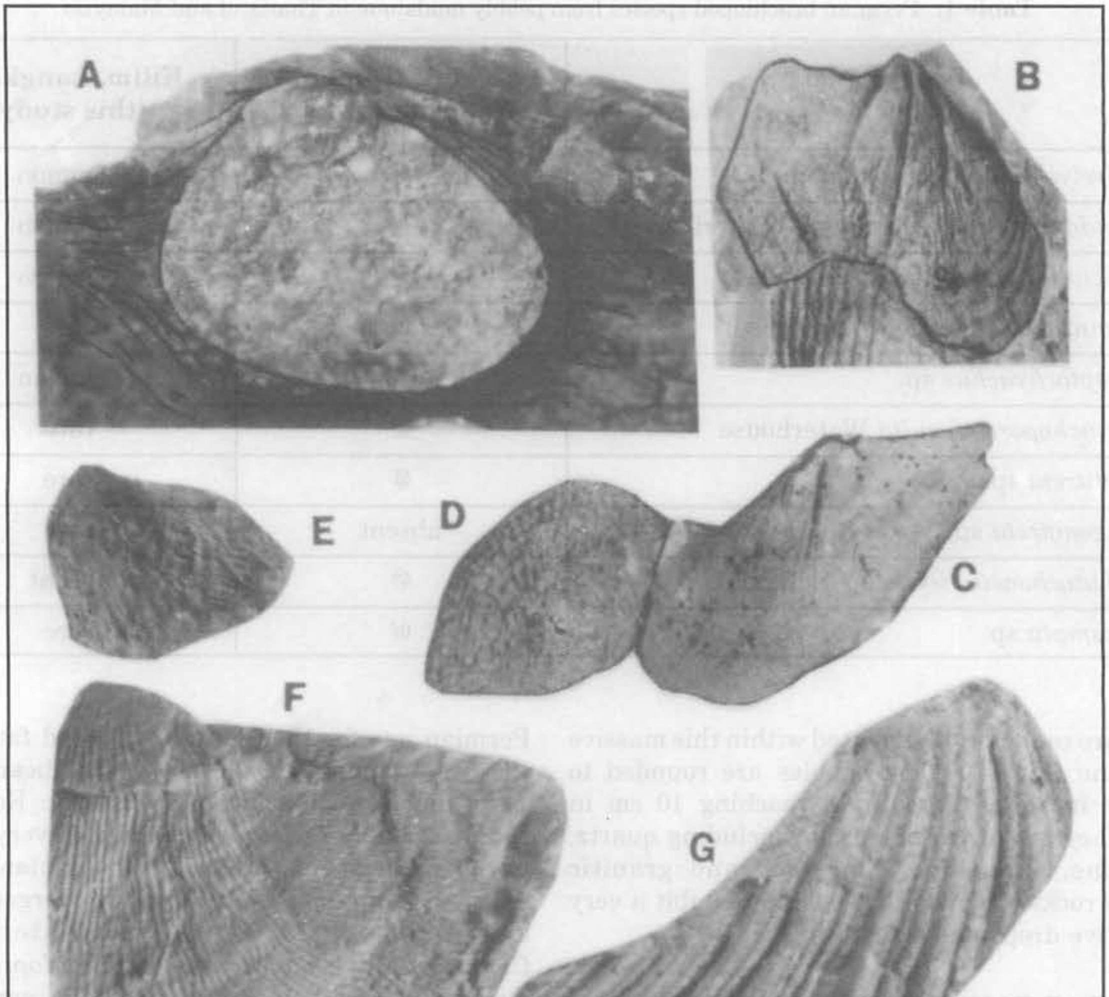

Figure 5. (A) Rounded granitic pebble with dropstone-like structure, (B, C) Ventral valve of *Spirelytha buravasi* (Hamada), (D) Ventral valve of *Bandoproductus monticulus* (Waterhouse), (E) Ventral valve (rubber cast) of *?Bandoproductus* sp., (F) Ventral valve (rubber cast) of *Streptorhynchus* sp., (G) Ventral valve (rubber cast) of *Trigonotreta* sp., (H) Dorsal valve of *Rhynchopora* cf. *culta* Waterhouse, (I, J) Dorsal valve (rubber cast) of *Sulciplica thailandica* (Hamada), (K) Dorsal valve of *Lamniplica* cf. *sapa* (Waterhouse).

Table 2. Distribution of brachiopod genera in Permian latitude.

Genera	Polar (N)	Temperate (N)	Tropical	Temperate (S)	Polar (S)
Spirelytha				@	@
Bandoproductus				@	@
Sulciplica				@	@
Lamniplica				@	@
Streptorhynchus		@	@	@	
Rhynchopora	@	@	@	@	
Arctitreta	@	@		@	@
Trigonotreta				@	@
Elasmata				@	@
Total	2	3	2	9	7
Percentage	22.2%	33.3%	22.2%	100%	77.7%

(part of the Ratburi Limestone) which is stratigraphically relatively younger than the brachiopod-bearing pebbly mudstone (Waterhouse, 1982, Tantiwanit *et al.*, 1983) also lacks the cold-water element. The age differences between the bryozoan limestone suggested by Basir Jasin *et al.* (1992) and the brachiopod fauna in this study should be seriously considered in any future revision. Both the bryozoan and brachiopod fauna from this locality, therefore, should be re-examined in detail in order to solve the problem regarding their precise age and stratigraphic relationship.

THE PALEOBIOGEOGRAPHIC SIGNIFICANCE OF THE FAUNA

Most of the brachiopods, especially the spiriferids have very thick shells, a phenomenon which might reflects the influence of cold climate to the biota. Many faunal elements of the Early Permian Gondwanaland like the eurydesmid bivalves and brachiopods have developed a very thick shells.

For paleobiogeographic analysis, the distribution of the discussed genera (i.e. those brachiopod genera found at Kilim) within different paleolatitudes during the Permian time is tabulated in Table 2.

Table 2 shows a very interesting and significant paleobiogeographic distribution of these brachiopod genera. The paleobiogeographic distribution of Kilim brachiopod genera can be summarize as follows:

- 66.6% of the brachiopod genera were endemic to the south temperate/polar region only.
- all brachiopod genera (100%) has been recorded from the south temperate region, while 77.7% of the brachiopod genera has been recorded from the south polar region.
- the very high correlative index with the fauna from Southern Hemisphere, suggested that the Kilim brachiopod fauna should belong to the Gondwana or peri-Gondwana fauna.
- the brachiopod fauna enhances a link between Northern India, Southern Thailand, Malaysia and Western Australia as part of temperate peri-Gondwana during early Permian time.

CONCLUSION

The discovery of the Kilim brachiopod fauna should clear some of the earlier doubt about the positioning of the western belt of Peninsular Malaysia which is part of the Sibumasu Block during the Early Permian (Late Asselian to Sakmarian) time. The presence of the cold/temperate brachiopod fauna together with the pebbly mudstone/siltstone should strongly support the glaciogenic origin of the pebbly mudstone/siltstone of the Singa Formation. This will linked all the peri-Gondwana blocks very nicely from northern India to Southern Thailand, Langkawi and Australia.

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