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Significance of *Monodiexodina* (Fusulininacea) in geology of Peninsular Malaysia

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Abstract: *Monodiexodina sensu stricto* is a very rare genus of the Fusulinacea which was found in the Permian deposits. Its distribution is restricted to a narrow sliver extended from the central of Afghanistan in the west to Japan, Eastern Russia and Malaysia in the east. Only three species of the genus have a wide distribution in the south Asia and Southeast Asia. They are *Monodiexodina sutschanica*, *Monodiexodina shiptoni* and *Monodiexodina kattaensis*. Their restricted geographic distribution may reveal their paleobiogeographic province which is very important for establishing paleogeography. *Monodiexodina shiptoni* is a good index fossil which was used as a zonal marker for the Artinskian, late Early Permian. The geographic distribution of the species suggests that the species were warm-water species which occupied the tropical or subtropical shallow seas. In Sibumasu block, only *Monodiexodina sutschanica* and *Monodiexodina shiptoni* were found in either limestone or calcite cemented sandstone which overlies the pebbly mudstone of glacio-marine origin. In East Malaya block, two species of *Monodiexodina* were found in the Sumalayang limestone. They are *Monodiexodina kattaensis* and *Monodiexodina shiptoni*. They are associated with many species of Fusulinacea. Their occurrence may give some clues to the evolution of the paleoclimate and tectonic history of the two blocks during the Permian.

INTRODUCTION

Monodiexodina is a very rare genus of the Fusulinacea. It first appeared in the Middle Cordilleran region, became widespread during the Sakmarian, and restricted to the Tethyan region during the Artinskian and the early Late Permian (Ross, 1967). There are two groups of *Monodiexodina*. The first is *Monodiexodina sutschanica* group which consists of *Monodiexodina sutschanica* (Dutkevitch), *Monodiexodina shiptoni* (Dunbar) and *Monodiexodina matsubaishi* (Fujimoto) which is considered as *Monodiexodina* proper. The second is *Monodiexodina kattaensis* group which includes *Monodiexodina kattaensia* (Schwager), *Monodiexodina bispatulata* Williams, *Monodiexodina prolongata* (Berry), *Monodiexodina steinmanii* (Dunbar and Newell), M*onodiexodina wanneri* (Schubert) and *Monodiexodina wanganensis* Sossina. This group is morphologically intermediate between *Monodiexodin*a strict sense and genus *Parafusulina* (Choi, 1973).

Recently, two species of *Monodiexodina, Monodiexodina sutschanica* and *Monodiexodina shiptoni* (plate 1) were discovered from the calcareous sandstone bed of the top part of Kubang Pasu Formation, at the excavation site of Timah-Tasuh Dam in Perlis (Basir Jasin and Koay, 1990). The

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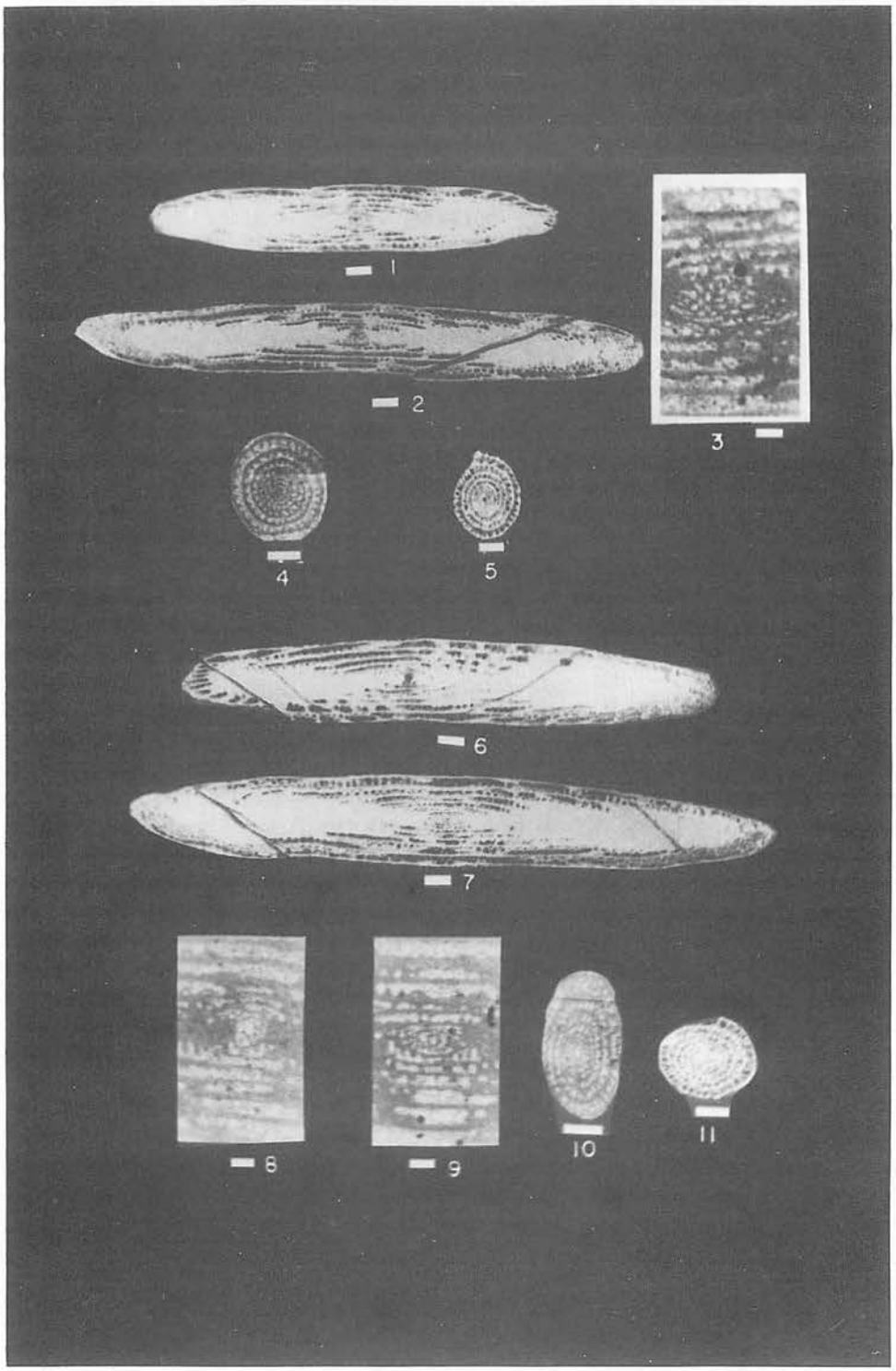
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occurrence of these species may offer some additional informations about the stratigraphy, paleoclimate, paleogeography, and tectonic of Peninsular Malaysia.

STRATIGRAPHIC DISTRIBUTION OF MONODIEXODINA

The species of *Monodiexodina* were recorded from the late Early Permian and early Late Permian of the Tethys region (Fig. 1). *Monodiexodina kattaensis* was restricted to the Artinskian stage (Choi, 1973; Igo *et al.*, 1979). *Monodiexodina shiptoni* has a slightly longer range compared to *Monodiexodina kattaensis*. It was found together with *Monodiexodina kattaensis* in Johor, Peninsular Malaysia and considered to represent the Artinskian stage (Igo *et al.*, 1979) but Dunbar (1940) described it from the Post Artinskian deposit of Karakorum. It is concluded that this species may have stratigraphic range from the Artinskian to Kungurian. *Monodiexodina sutschanica* was reported, associated with *Monodiexodina shiptoni* in northwest Thailand (Ingavat and Douglass, 1981) and northwest Peninsular Malaysia (Basir Jasin and Koay, 1990). Sosnina (1960) used *Monodiexodina sutschanica* as a zonal marker for the Kungurian of Shihote-Aline region, Russia. The stratigraphic distribution of the species may range from the Artinskian to Kungurian. *Monodiexodina shiptoni* and *Monodiexodina sutschanica* have a concurrent stratigraphic range. The occurrence of both species in northwest Thailand and northwest Peninsular Malaysia may probably represent the late Artinskian and Kungurian stages.

GEOGRAPHIC DISTRIBUTION OF THE MONODIEXODINA

In the South Asian and Southeast Asian region, only three species of Monodiexodina were reported. They are *Monodiexodina kattaensis, Monodiexodina sutschanica* and *Monodiexodina shiptoni*. *Monodiexodina kattaensis* was first described by Schwager in 1887 from the Lower Productus Limestone of the Salt Range, Pakistan (Douglass, 1970). The species was also reported from Sumalayang Limestone, Johor, Peninsular Malaysia (Igo *et al.*, 1979) and from the Southern Kitakami Mountains, Japan (Choi, 1974).

Monodiexodina sutschanica was first described by Dutkevitch (1939) from the Suchan River, Primorsk, Russia. The species was also recorded from Shihote-Aline, Russia (Sossina, 1960), northwest Thailand (Ingavat and Douglass, 1981) and northwest Peninsular Malaysia (Basir Jasin and Koay, 1990). *Monodiexodina shiptoni* has a wide distribution. It was originally

Plate 1: Fig. 1-5, *Monodiexodina shiptoni*.
1-2, Axial sections (scale bar = 1mm).
3, Enlarged photograph showing proloculus (scale bar = 200um).
4-5, Median section (scale bar = 1mm).
Fig. 6-11, *Monodiexodina shiptoni*.
6-7, Axial section (scale bar = 1mm).
8-9, Enlarged photographs showing proloculi (scale bar = 200um).
10-11, Median section (scale bar = 1mm).

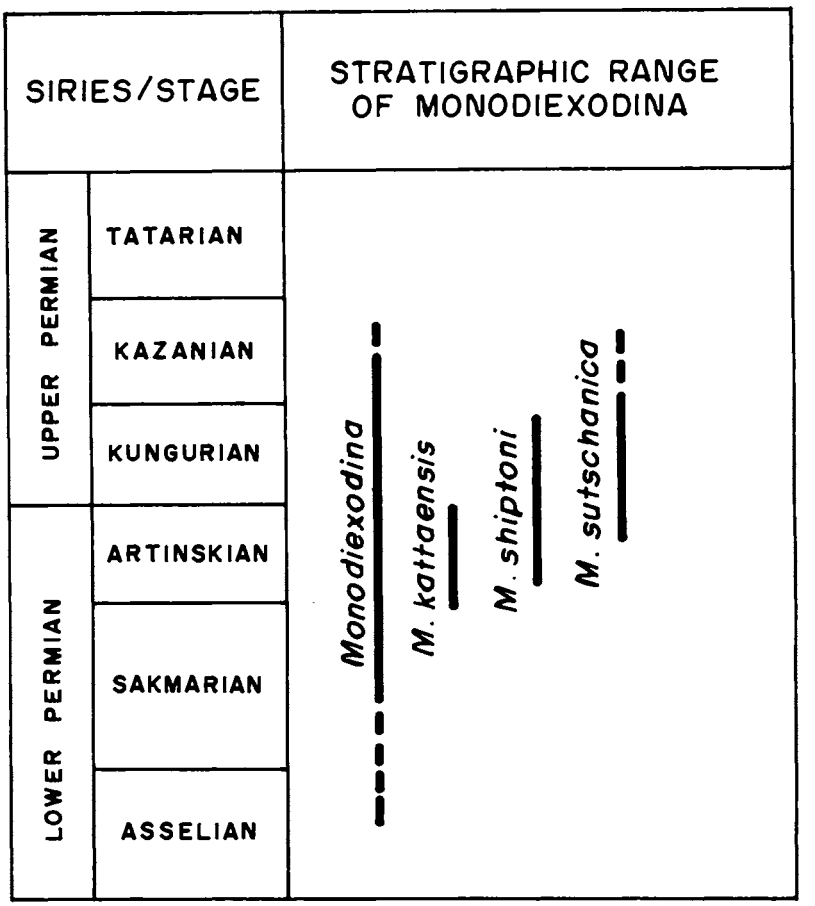


Fig 1. Stratigraphic distribution of the *Monodiexodina* species.

described from the Karakorum Mountains by Dunbar (1940). It has also been reported from Afghanistan (Lys and Lapparent, 1971), Pamir (Leven, 1967), Karakorum, India (Reichel. 1940), northwest Thailand (Ingavat and Douglass, 1981) and Peninsular Malaysia (Basir Jasin and Koay, 1990; Igo *et al.*, 1979). The genus *Monodiexodina* was also recorded from the Qiangtang and Kunlun terranes in Tibet (Smith and Xu Juntao, 1988). The species of *Monodiexodina* have different faunal assemblage. In central Afghanistan, Pamir, Karakorum, Qiangtang and Kunlun, and Johor, Peninsular Malaysia (a part of East Malaya block), *Monodiexodina* were found associated with many other species of Fusulinacea. In the East Malaya block the species were found associated with *Cuniculinella globosa, Cuniculinella zulumartensis, Cuniculinella sp., Ciniculinella cf. tumida, Parafusulina granum-avenae, Schubertella pseudogiraudi, Schubertella kingi, Pseudofusulina quasifusuliniformis, Parafusulina sp., Nankinella sp., Stafella sp.,*

Parafusulina dronovi, Nagatoella sp., Pseudofusulina aff. dongvanesis, Schwagerina cf. otukai, Parafusulina murotbekovi, Parafusulina dutkevitchi, Parafusulina aff. vinogradovi, Minojapanella sp., Parafusulina chungi, Parafusulina johorensis, Eoparafusulina malayensis, and Parafusulina yini (Igo *et al.*, 1979). The faunas exhibit a high specific diversity and the faunal assemblage is very similar to those of Pamir (Leven, 1967). In northwest Thailand and northwest Peninsular Malaysia (Sibumasu block), the Fusulinacea is represented by only *Monodiexodina shiptoni* and *Monodiexodina sutschanica.* The high specific diversity in the former blocks suggests that they were located in the warm tropical Tethys sea probably near the equator. The low Fusulinacean diversity in the latter indicates the latitudinal differentiation of climate, which was probably located in the subtropical region.

Paleobiogeoprovince of the *Monodiexodina* can be located from its geographic distribution. It forms a sliver which extends from Pamir to Peninsular Malaysia. It covers the Pamir, Karakorum, Qiangtang and Kunlun, and Sibumasu (Sinoburmalaya) and East Malaya (Eastmal) terranes (Fig. 2). This province was probably represented a shallow shelf of the Tethys. The genus was not found in other part of Gondwana such as in Himalayan terrane or in Australia. This suggests that the genus was a warm-water fauna.

DISCUSSION

Monodiexodina in northwest Peninsular Malaysia was found at the top part of Kubang Pasu Formation in Perlis. This formation is isochronous with the Singa Formation of the Langkawi Islands. Both Formations were overlain by the Late Permian Cuping Formation which contain warm water Bryozoa of the Late Artinskian-Kungurian stage (Sakagami, 1970). Yancey (1985) recorded some Late Artinskian Bivalvia from H.S. Lee beds near Kampar, Perak, which exhibit a close affinity to the warm Tethyan biota of the Akasaka of Japan. The occurrence of both warm-water Bryozoa, Monodiexodina and Bivalvia in the Sibumasu block during the Artinskian suggests that the block was located in the warm-water region near equator.

The bed that contains *Monodiexodina* is stratigraphically overlying the diamictites of glacio-marine origin (Stauffer and Mantajit, 1981: Stauffer and Lee, 1986). The age of the diamictite beds in Singa Formation is not yet known. They are probably equivalent to the diamictites in south Thailand which were dated as late Asselian based on the brachiopod fauna (Waterhouse, 1982). The Asselian diamictites have also been recorded from the Lhasa and Himalayan blocks (Smith and Xu Juntao, 1988).

Carboniferous history of the Sibumasu block is not fully understood because a lack of fossils and paleomagnetic data. Based on the paleomagnetic

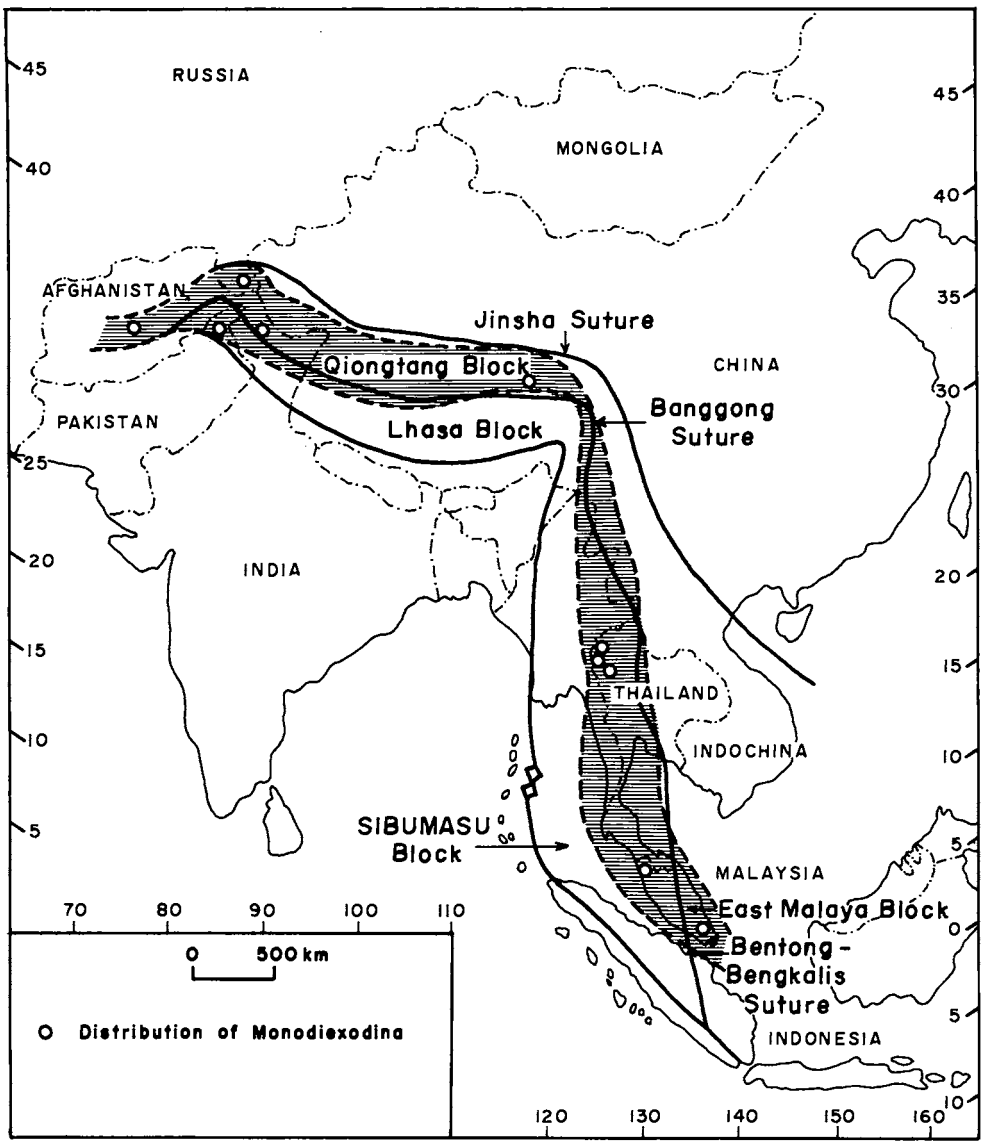


Fig. 2. Distribution of *Monodiexodina* and its probable paleobiogeographic province during the late Early Permian.

data of Yunnan, China, Wu Fang *et al.*, (1989) concluded that the Sibumasu block was located very close to Gondwana at paleolatitudes between 35°S and 45°S during the Late Devonian, while the South China Block was located at the equator.

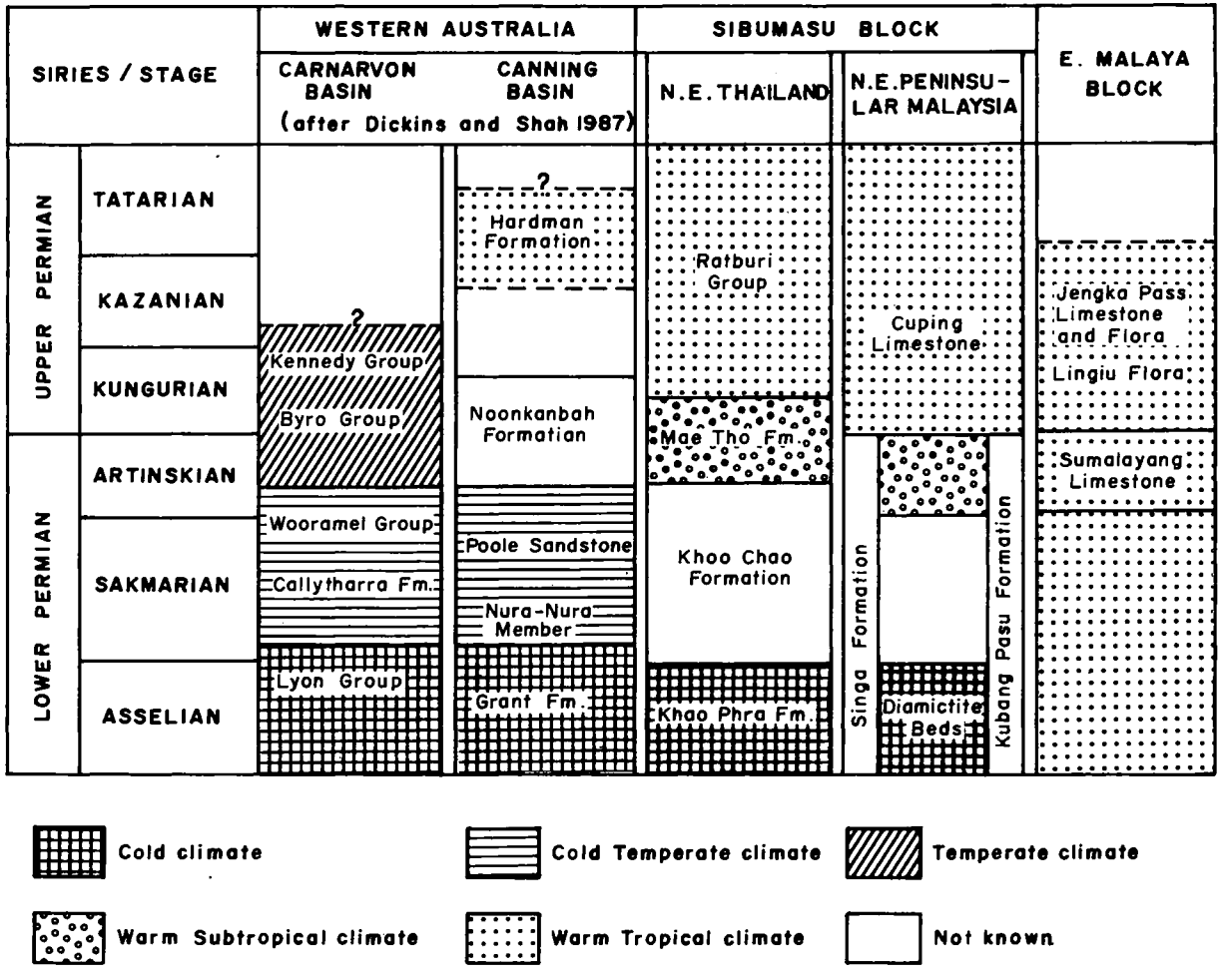
The information retrieved from the Permian sedimentary sequence of this part of the Sibumasu block suggests a paleoclimatic change from cold climate during the Asselian to warm sub-tropical climate in the Artinskian and Kungurian, and became warm tropical climate throughout the late Permian and Triassic. The same trend of paleoclimatic change was observed in Western Australia (a part of Gondwana) where the cold period was characterised by glacial deposit during the Asselian and early Sakmarian and became warmer (subpolar or temperate climate) in the later part of Permian (Frakes, 1979; Dickins and Shah, 1987).

The paleoclimatic change in the Sibumasu block was very distinct compared to those of Western Australia (Table 1). This indicates that the Sibumasu block was a part of the Gondwana continental shelf during the Asselian (early Early Permian) and started to drift towards equatorial Tethys during the late Asselian or early Sakmarian. It was in the subtropical region during the Artinskian-Kungurian and reached the tropical region during the Late Permian. According to Wu Fang *et al.*, (1989), the Sibumasu block has undergone a large cumulative rotation of about 160° before it reached the present position.

Metcalfe (1988) considered *Monodiexodina* as a cool-water form because it was found in the Early Permian sediments just above the diamictite beds. The horizon that contains *Monodiexodina* and the diamictites beds are stratigraphically separated by approximately 14 million years interval. The geographic distribution of the genus suggests that it was a warm-water fauna. The base of Cuping Limestone is now considered to be Kungurian in age (early Late Permian) and cool Oxygen-18 isotopic temperature introduced by Rao (1984) for the limestone is now questionable because the occurrence warm-water bryozoa has also been reported from the limestone (Sakagami, 1970).

The East Malaya blocks have a different history. The Carboniferous floras and faunas of the East Malaya block were of warm-water type, and of Euramerian aspect (Metcalfe, 1988). The Permian Fusulinacea and floras belong to the tropical Tethys and Cathaysia respectively (Igo *et al.*, 1979; Kon'no and Asama, 1970; Asama, 1984). This suggests that the East Malaya block was in the tropical Tethys during the Carboniferous-Permian time. The pre-Carboniferous history of the East Malaya block was not fully understood. Metcalfe (1988) suggested that this block may have originated in Gondwana and have drifted northwards earlier than the Sibumasu block. More Fossils and paleomagnetic informations are needed to confirm this.

Table 1. Representative Permian sequence showing correlations and province during the late Early Permian.



The occurrence of *Monodiexodina shiptoni* in both Sibumasu and East Malaya blocks during the Artinskian suggests that both blocks were probably close to each other. They were probably separated by a narrow sea. The Sibumasu block was obliquely converged to East Malaya block during the Late Permian-Early Triassic where both block were dominated by warm-water fauna (Metcalfe, 1988). The convergence of the blocks was probably occurred along the Bentong-Bengkalis suture (Tjia, 1989). This convergence caused severe deformations and metamorphism of the Permian and older rocks as suggested by Harbury *et al.*, (1990). Harbury *et al.*, (1990) concluded that the major orogenic event took place in the Late Permian and not in the late Triassic as suggested by Mitchell (1981), and Sengor (1986). The Triassic rocks of the Semantan and Kaling Formations exhibit less deformation compared to those of Permian and older rocks. The Bentong-Bengkalis suture was probably an active dextrally strike-slip fault until the Late Triassic. The movement of the strike-slip fault resulted the opening of Triassic pull-apart basin and triggered widespread volcanic activities which supplied tuffaceous material to the central belt.

CONCLUSION

Monodiexodina shiptoni and *Monodiexodina* sutschanica have a range from the Artinskian to Kungurian. They are good stratigraphic markers. Their occurrence may be used to indicate the age of sediments. The occurrence of the species at the top of Kubang Pasu Formation suggests that the age of the Kubang Pasu and Singa Formations may extend up to the Artinskian (late Early Permian) or Kungurian (early Late Permian). The geographic distribution of the genus suggests the Monodiexodina was a warm-water genus which occupied shallow marine of Tethys during the late Early and early Late Permian.

The distribution of the species is restricted to a sliver extends from the central Afghanistan, Pamir, Karakorum, Qiangtang and Kunlun, northeast Thailand and Peninsular Malaysia. This was probably representing a mobile belt of Gondwana continental shelf which reached the subtropical or tropical regions of the Tethys during the Artinskian and Kungurian. The high diversity of Fusulinacea in those central Afghanistan, Pamir, Karakorum, Qiangtang and Kunlun and East Malaya blocks suggests that these blocks were in the tropical region during this time and the Sibumasu block was probably in the subtropical region. The Sibumasu and the East Malaya blocks were close together during the Artinskian and both blocks were probably in Tethys and were separated by only a narrow seaway. Finally both blocks were sutured along the Bentong-Bengkalis suture during the late Permian. The Bentong-Bengkalis suture was probably representing a dextrally strike-slip fault which was active during the Permian and Triassic.

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