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On the New Permian Bera Formation from the Bera District, Pahang, Malaysia

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Abstract

A new rock unit, the Bera Formation, is introduced for the newly found Permian strata exposed in the Bera District, Pahang. The lithology of the strata consists predominantly of mudstone/shale, siltstone and sandstone, with subordinate conglomerate. The lower part of the formation is made up of massive mudstone, thick to massive tuffaceous sandstone, siltstone and mudstone, and thinly bedded siliceous mudstone. The upper part of the formation consists of thinly to thickly bedded shale, siltstone, sandstone and conglomerate. Several fossiliferous horizons were discovered within the formation; they yield brachiopods, cephalopods, trilobites, bivalves, gastropods, fusulinids, plants and trace fossils. The faunal assemblages indicate a general Middle Permian age. The sedimentological and palaeontological aspects of the Bera Formation suggest a shallow marine depositional environment.

Formasi Bera Berusia Permian dari Daerah Bera, Pahang, Malaysia

Abstrak

Suatu unit batuan baru, iaitu Formasi Bera, telah diperkenalkan sebagai strata Permian terbaru yang terdedah di Daerah Bera, Pahang. Litologi strata terdiri daripada predominan batu lumpur/syal, batu lodak dan batu pasir, dengan sedikit konglomerat. Bahagian bawah formasi terdiri daripada batu lumpur masif, batu pasir, batu lodak dan batu lumpur bertuf yang tebal ke masif, dan perlapisan nipis batu lumpur bersilika. Bahagian atas formasi terdiri daripada perlapisan nipis ke tebal syal, batu lodak, batu pasir dan konglomerat. Beberapa horizon berfosil ditemui di dalam formasi; iaitu brakiopod, sefalopod, trilobit, bivalvia, gastropod, fusulinid, tumbuhan dan kesan surih fosil. Himpunan fauna menunjukkan usia Permian Tengah. Aspek sedimentologi dan paleontologi Formasi Bera mencadangkan sekitaran pengendapan laut cetek.

INTRODUCTION

The strata described in this paper are exposed in the Bera District, central Pahang, between the Tasik (Lake) Bera and Bukit (Hill) Bertangga. These strata have long been considered part of the Triassic rock formation, as seen in the official geological maps of the Geological Survey of Malaysia (1973; 1985). MacDonald (1970) considered that the geology of the area east of Tasik Bera belongs to the Lipis Group, which was originally proposed by Alexander (1959) for the Late Triassic areno-argillaceous rocks in the Kuala Lipis area. Cook & Suntharalingam (1970), on the other hand, thought that the geology of the area west of Bukit Bertangga, including the Tasik Bera, is similar to the Gemas (or Tenang) bed of Foo (1970); this was later considered part of the Semantan Formation by Kamal Roslan Mohamed (1996). Cook & Suntharalingam (1970) also reported the presence of the fusulinid *Parafusulina* sp. from limestone found near the Tasik Bera. This implies that the lower part of the Bera Formation may extend down to Kungurian age, but the exact location of this limestone horizon is unknown today. Tjia (in press) mentions that the folded and faulted rocks along the road-cut near Felda Sebertak (which is part of the Felda Rentam scheme) are part of the Semantan Formation. The present study indicates that the geology of the area east of Tasik Bera does not match with Jaafar Ahmad (1976)'s original definition of the Semantan Formation. The geology of the area between Tasik Bera and Bukit Bertangga differs significantly from that of the nearby Semantan Formation in term of sedimentology, palaeontology and structural trends. Therefore, the present authors would like to propose a new name, the "Bera Formation", for the newly discovered rock successions in the district, as described and discussed below.

DESCRIPTION OF THE BERA FORMATION

The following descriptions of the Bera Formation cover information recommended in the *Malaysian Stratigraphic*

Guide published by the Malaysian Stratigraphic Nomenclature Committee (1997) for establishing a new stratigraphic nomenclature.

Name and its origin

The Bera Formation is named after Tasik Bera in the Bera District, central Pahang, Peninsular Malaysia.

Age

The bulk of the Bera Formation is supposed to be Middle Permian (Roadian to Capitanian) in age, based on palaeontological data.

Type area

The type area is located east of Tasik Bera in the Bera District, Pahang Darul Makmur (Map Sheets 4157-Bera and 4158-Chenur).

Type section

The type section of the Bera Formation is exposed along the trunk road between Felda Sebertak and Felda Melati via Felda Bera Groups (Figure 1). The type section is a composite section exposed along the stretches between km 24.9–26.8 (the lower part), km 3.8–17.7 (the upper part) within Felda Bera Selatan I and II. (The kilometre measurement starts from the Felda Sebertak-Felda Bera Selatan junction).

Distribution

The boundary between the Bera and Semantan Formations is not known to be exposed. However, as inferred from the topographic map, satellite image and general structural trends observed in the field, the western boundary of the Bera Formation is most likely a fault

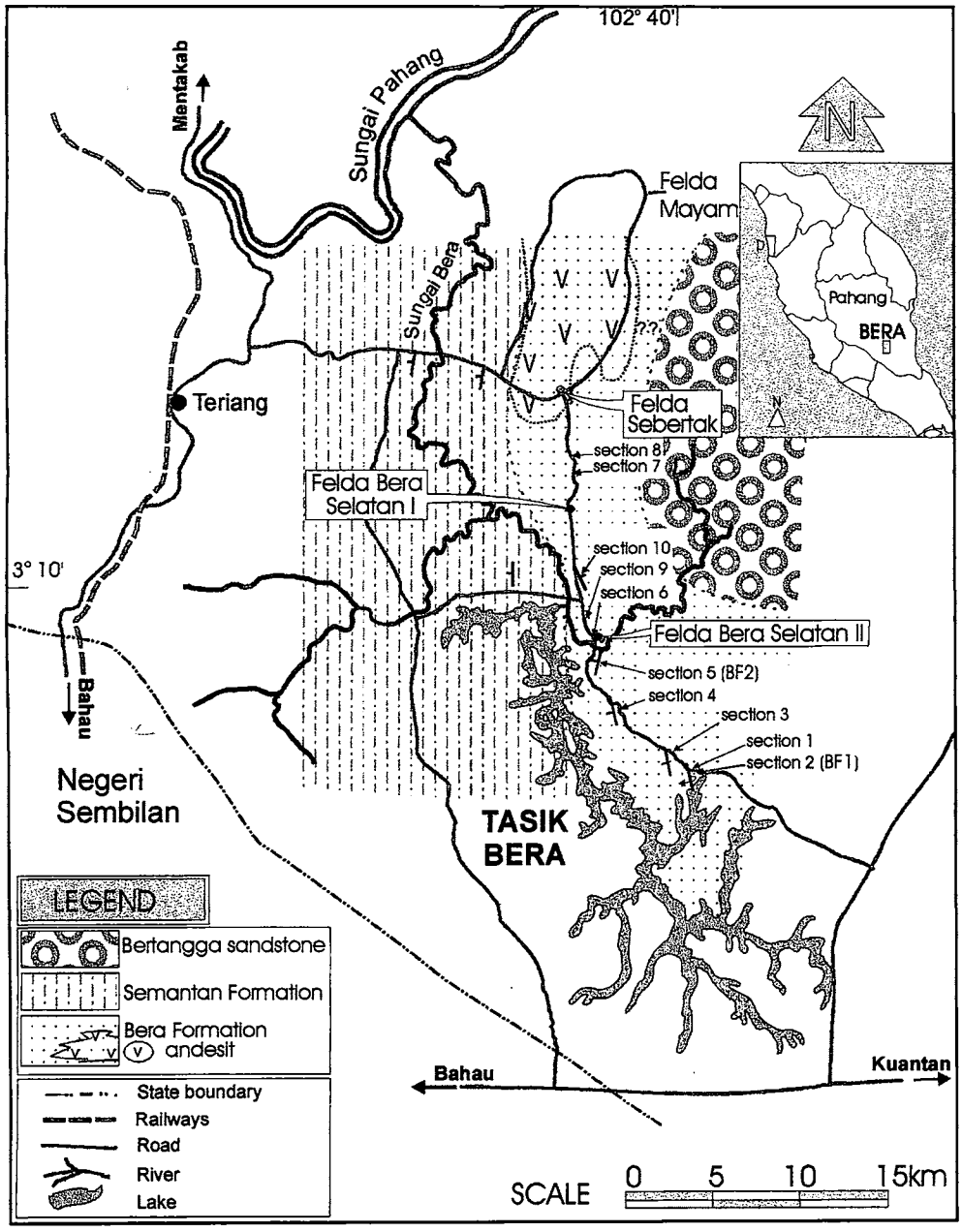

Figure 1: Distribution of the Bera Formation and its outcrop locations.

boundary against the Middle Triassic Semantan Formation. The boundary between the Bera and Bertangga Sandstone Formations is also not known to be exposed. The eastern boundary of the Bera Formation is probably marked by the western margin of the Bukit Bertangga ridge, which extends in the N-S direction and divides the Bera valley from the Chini valley. The northern and southern extents of the Bera Formation are also uncertain. In the north of the Bera area, a volcanic rock unit is extensively distributed. It was thought to be an extension of the late Permian andesite belt of the Jengka Triangle (Cook and Suntharalingam, 1970).

Boundaries

The lower boundary of the Bera Formation is not known, as it is probably the oldest rock formation in the Bera area. As for the upper boundary, the Bera Formation is overlain unconformably by the Semantan and Bertangga Sandstone Formations. The sequences of the Upper Permian through Lower Triassic are obviously absent from the Bera area. This implies that there is probably a major unconformity between the Bera and the overlying Semantan Formation. The Bera Formation is also overlain unconformably by the gently dipping sequences of the possible Jurassic–Cretaceous Bertangga Sandstone Formation.

Correlation

The Bera Formation can be correlated with several known Middle Permian horizons in central Pahang. It is a lateral equivalence of the Sri Jaya Bed of Lee (1990) in Hulu Lepar area, Pahang. The Sri Jaya Bed, which can be divided into the Jempul slate, Luit tuff and Mengapur limestone is also of Middle Permian age based on fusulinid foraminiferas found in the Mengapur limestone (Lee, 1990; Jasin and Ali, 1991). The upper part of the Bera Formation is equivalent in age to the limestones at Jengka Pass and Kampung Awah limestones. These limestones bear late Middle Permian fusulinid foraminiferas (Fontaine *et. al.*, 1994).

Lithology

The Bera Formation consists predominantly of clastic rocks, including mudstone, shale, sandstone and siltstone, and subordinate conglomerate. The sandstone and siltstone in the lower part of the formation are predominantly tuffaceous. The lower part of the formation is exposed along several road-cuts in the southern part of the Felda Bera Selatan II (between km 24.9–26.8). The upper part of the formation is exposed along several road-cuts in the northern part of the Felda Bera Selatan II, the Felda Bera Selatan I, Felda Triang III and Felda Rentam. No formal subdivision of the formation is proposed at this stage, although the sediment in the lower part of the formation is generally finer in grain size compared to the upper part. In term of the structural trend, the strata of the Bera Formation are trending roughly towards N–S direction, with most of the strata dipping very steeply to the west. However, the strikes and dips of the strata from the uppermost part of the formation vary considerably due to deformation.

Lower Part — The lower horizons of the Bera Formation are exposed at several road-cuts between km 24.9 and km 26.8, where two major lithofacies can be recognized. They are the massive mudstone lithofacies and the thickly bedded tuffaceous sandstone–siltstone–mudstone lithofacies. The first lithofacies is almost entirely made up of massive mudstone, and is exposed along the roadcut from km 24.9 to km 26.3. The mudstone is dark grey to black in colour, commonly massive, but in places the presence of thin laminae of siltstone mark the bedding planes in this lithofacies. Some of the mudstone at km 24.9 seems to be highly siliceous. The second major lithofacies is made up of thickly bedded to massive tuffaceous sandstone, siltstone and mudstone. This lithofacies can be observed at two southernmost outcrops of the formation (km 26.5–26.6 and km 26.7–26.8 —Sections 1 and 2 in Figure 2). The content of tuffaceous material is higher, and thus is more obvious in the sandstone than in the siltstone and mudstone. Also found in this thickly bedded tuffaceous sandstone–siltstone–mudstone lithofacies is about 7 meter thick of thinly bedded siliceous mudstone. The tuffaceous siltstone and mudstone from the southernmost exposure (km 26.8—top of Section 2 in Figure 2) has been metamorphosed to metasiltstone and slate with well developed slaty cleavage. Based on the strike and dip alone, this metasediment seems to be the oldest unit of the formation, overlain apparently, by the massive mudstone lithofacies in the west. However, the presence of an inverted U-shaped dwelling burrow of a trace fossil at km 26.7–26.8, indicates that the southernmost part of the formation (at least the section at km 26.7–26.8 and perhaps also the nearby section at km 26.5–26.6) must have been overturned. There is, however, not enough field evidence to suggest weather the whole massive mudstone lithofacies is also overturned.

Upper Part — The upper horizons of the Bera Formation are exposed at several road-cuts between km 3.8 and km 17.7. Although most of the strata from the upper part of the Bera Formation maintain a roughly N–S strike, the dip direction of the strata frequently changes from west to east, most likely because of faulting. Two major lithofacies can be recognised. The lower half of the succession is made up of interbedded sandstone–siltstone–shale lithofacies can be observed at several road-cut exposures between km 15.6 and km 17.7. The upper half, which is made up of mixed lithofacies can be seen at several road-cut exposures between km 3.8 to km 14.8. Isolated outcrops of the interbedded sandstone–siltstone–shale lithofacies are also found at several road-cuts between km 4.7 to km 7.7. The interbedded sandstone–siltstone–shale lithofacies consists of thin to thickly bedded shale, siltstone and sandstone with occasional massive tuffaceous sandstone and rare pebbly to conglomeratic sandstone. The thinly bedded (or laminated) sandstone–siltstone–shale laminae are often bioturbated. Some of the massive shale

bears mud concretions. The sandstone bodies are sometime lensoidal in shape. The mixed lithofacies consists of thick sandstone, pebbly sandstone, and thick to massive mudstone, pebbly mudstone and conglomerate. Most of the conglomerates are matrix-supported, with clasts range in size from gravel to boulder (or block which can reach up to 5 m long), and matrix ranges in size from mud to fine sand. The clasts are poorly sorted. The shape of the clasts ranges from highly angular to well rounded. The compositions of the clasts are mainly sandstone, siltstone and shale with rare quartz. Some larger blocks of interbedded sandstone-shale sequence were also found as clasts of these conglomerates. Sedimentary faults and slumps are also common within this lithofacies. Complexly folded and faulted sandstone and shale exposed at several road-cuts along the Triang – Felda Mayam road (all within the Felda Rentam) were previously considered by Tjia (in press) as part of the Semantan Formation. However, a productid brachiopod and poorly preserved fusulinid tests, found in sandstone bed in one of these outcrops suggest that these rock unit belongs to the Bera Formation.

Between the southern exposures (road-cuts between km 24.9–26.8) and northern exposures (road-cuts between km 3.8–17.7), there are a wide gap of non-exposure. Several isolated road-cut exposures at around km 21, however, exhibit a sequence of rhythmically interbedded tuffaceous sandstone–shale (Section 4 in Figure 2), which resembles deep-water turbidite sequence of the Semantan Formation. No fossil has been found from these isolated exposures.

Thickness

It is not possible to measure the thickness of the entire Bera Formation due to the discontinuous nature of the outcrops. This is also because both the basal and the topmost part of the formation are not exposed, and the upper part of the formation has been extensively deformed. The apparent thickness of the lower part (? member) of the formation is more than 700 m, with the massive mudstone lithofacies

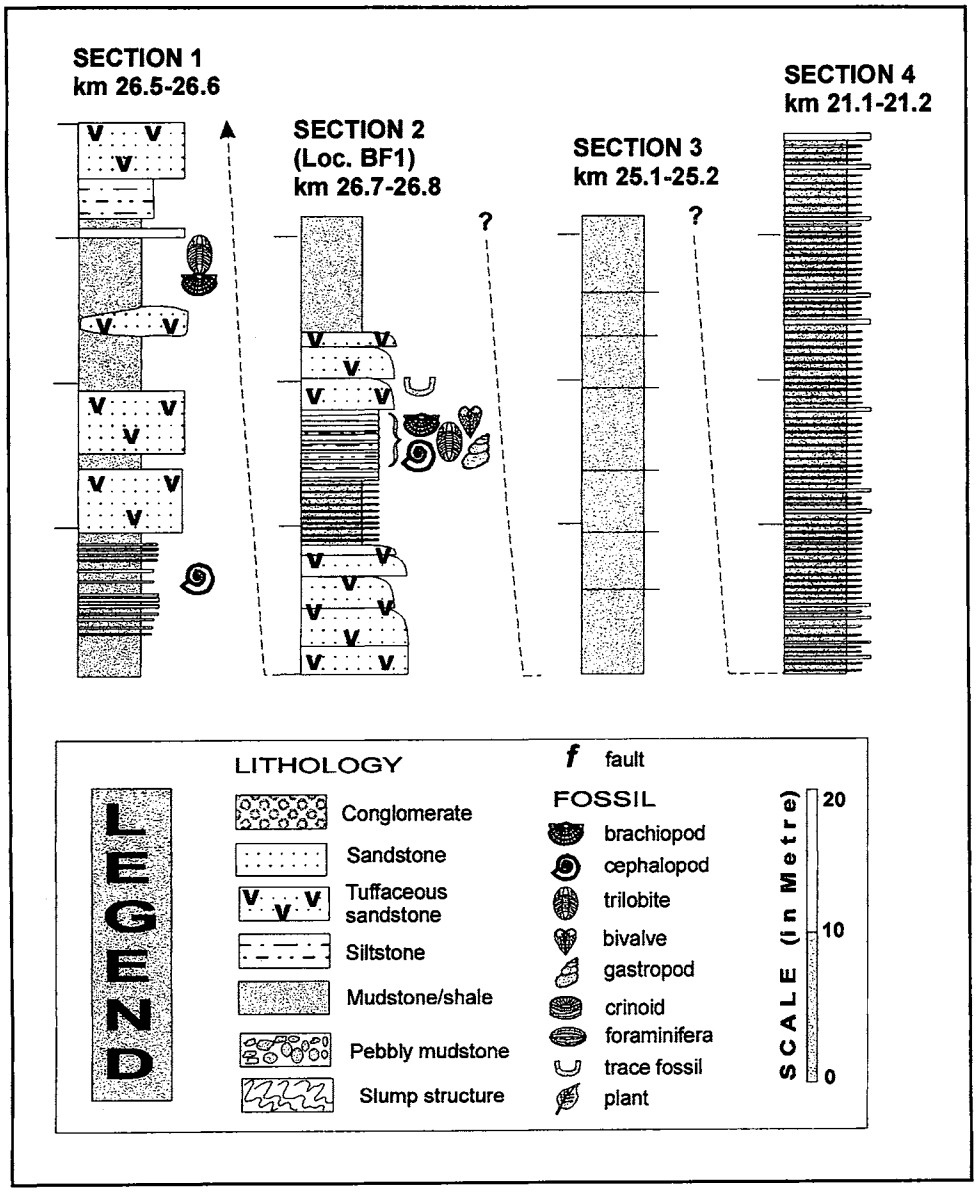

Figure 2: Sedimentological logs for major sections of the lower part of the Bera Formation.

made more than 600 m of it. However, the true thickness may be significantly reduced, if the strata are not entirely overturned, as discussed above. The thickness of the upper part of the formation is estimated to be more than 800 m, of which about 300 m is made of the interbedded sandstone–siltstone–shale lithofacies. The mixed lithofacies has the apparent thickness of more than 500 m thick. The true thickness of the upper part of the Bera Formation is very difficult to be obtained, because of numerous minor faults associated with the rock sequences.

Fossils

Up until this moment, fossils are found in all four major lithofacies of the Bera Formation except in the massive mudstone lithofacies of the lower part of the formation. Two major fossiliferous localities have been found in the study area, namely Locality BF1 (see Section 2 in Figure 2) in the lower part of the formation and Locality BF2 (see Section 5 in Figure 3) in the upper part of the formation. The fossils are dominated by brachiopods, and, to lesser extents, consists of cephalopods, trilobites, bivalves, gastropods, corals and fusulinid foraminiferas. Trace fossils and plant remains are also present. Some representative fossils from these two localities are shown in Figure 5.

In Locality BF1, the fossils were found in massive siltstone/shale (see Section 2 in Figure 2). They include the ammonoids, *Agathiceras* sp., *Tauroceras* sp. and *Bamyaniceras* sp., the brachiopods, *Martinia* sp. and linoproductids, the trilobite *Pseudophillipsia*? sp., bivalves, gastropods, corals and trace fossils. In Locality BF2, the fossils were found at several horizons in shale and sandstone (see Section 5 in Figure 3). They include the brachiopods, *Urushtenoidea chaoi* (Ching), *Spyridiophora gubleri* Termier and Termier, *Strophalosiina* sp., *Gubleria* sp., *Transennatia* n. sp., *Orthothetina* cf. *iljinae* Sokol'skaya, *Derbyia* sp. and *Linoproductus* sp., with a few gastropods, trilobite pygidia, trace fossils and plant remains.

Several other less fossiliferous horizons were also found in the Bera Formation. At km 26.5–26.6 (see Section 1 in Figure 2), a phillipsiid trilobite and a linoproductid brachiopod were found in a massive mudstone at the top part of the section, while an ammonoid *Agathiceras* sp. was found in shale at the lower part of the section. From the outcrop opposite the T-junction to the Lake Bera Resort at km 17.8, several fragments of linoproductid brachiopods and plants were found in tuffaceous sandstone. Fragments of productid brachiopods were also found in shale at km 16.2 (see Section 6 in Figure 3). At km 4.7 plants fragments are common. From the mixed lithofacies, several chonetid brachiopods were discovered in the black shale at km 9.8 (see Section 10 in Figure 4).

Depositional environment

Sediments of the Bera Formation was generally deposited in shallow marine conditions. This is supported by the presence of a shallow marine fauna consisting of trilobites, brachiopods, gastropods, bivalves and cephalopods at locality BF1. The presence of a U-shaped dwelling burrow of a trace fossil also indicates a relatively shallow water environment. However, the thinly bedded siliceous mudstone found at km 26.7 (see Section 2 in Figure 2) which resembles deep water turbidite sequences may suggest that the sedimentary basin was relatively deeper at some stages of the deposition. The massive siltstone and mudstone suggest that the deposition took place in a rather closed basin, which was rapidly filled up by excessive supply of fine-grained sediments. Meanwhile, the tuffaceous material in the sandstone and siltstone indicates the presence of volcanic activities in the surrounding regions.

The environment of deposition seems to be getting shallower towards the top of the formation. The bioturbated sandstone-siltstone-shale laminae (see Section 5 in Figure 3) represent a littoral environment, and the associated lenticular sandstones represent barrier bars. The abundance of shallow marine fossil fauna, including trilobites, brachiopods, gastropods, bivalves and fusulinid foraminiferas at locality BF2 strongly support this interpretation. Meanwhile, the presence of small-scale ripple marks and grazing traces indicate that in places a lower energy environmental condition prevailed. The regularly laminated siltstone and shale with plant fragments in Section 7 (Figure 3) may represent tidal flat deposits. The repeated coarsening-upward sequence in Section 6 (Figure 3) is suggestive of a prograding fan deposit probably from a localised deltaic environment.

The matrix-supported conglomerate with poorly sorted clasts, ranging in size from pebble to boulder in Sections 8, 9 and 10 (Figure 4) generally suggested a mass flow deposits. This is supported by the presence of slump structures within several horizons. Although the para-conglomerate and related slump structure may indicate a continental slope environment, the presence of chonetid brachiopods within one of the shale layers suggest that the depositional environment may be much shallower. This is supported by the presence of many highly angular clasts, which suggest that they have not been transported very far from their origin.

DISCUSSION

The bulk of the Bera formation is considered Middle Permian in age. This is based on the occurrence of an early Middle Permian ammonoid assemblage in Locality BF1, and a late Middle Permian brachiopod assemblage in Locality BF2. The ammonoid *Agathiceras* found in Locality BF1 is a very common genus in Permian rocks. Its range is Moscovian (late Carboniferous) through Wordian, with greatest abundance in the Roadian and Wordian (Glenister *et al.*, 1990). *Tauroceras* sp. found in Locality BF1 indicates a Wordian (early Middle Permian) age; the genus is stratigraphically restricted to the Wordian Stage (Zhou *et*

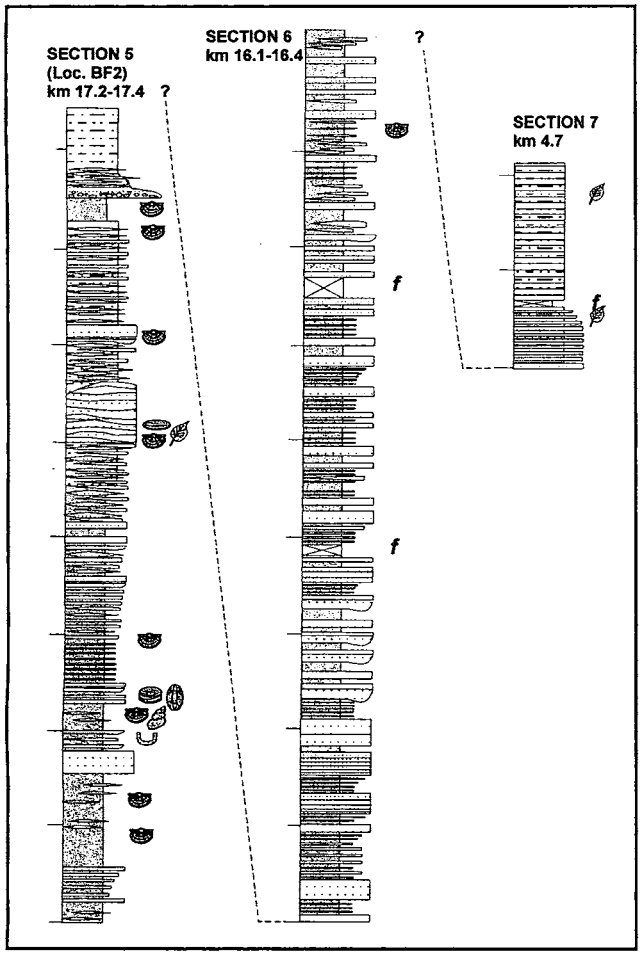

Figure 3: Sedimentological logs for major sections of the upper part of the Bera Formation.

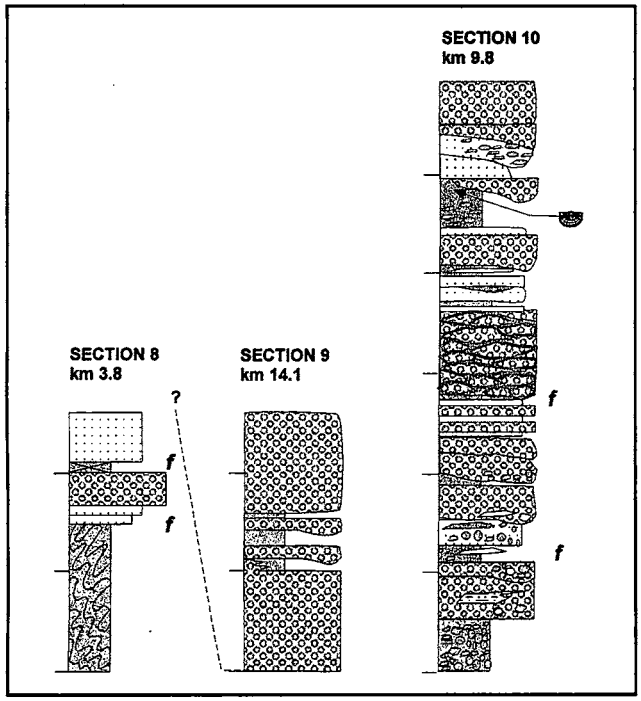

Figure 4: Sedimentological logs for major sections of the mixed lithofacies of the uppermost part of the Bera Formation.

al., 1999). Lee (1980) described the ammonoids, *Agathiceras suessi* Gemmellaro, *Adrianites elegans* Gemmellaro and *Tauroceras* cf. *scrobiculatum* (Gemmellaro) from Sungai Cheroh, western Pahang, of which he considered a Wordian age in view of affinities to the Sicilian Sosio fauna. The horizon of Locality BF1 may be correlated to that of Sungai Cheroh, based on the presence of *Tauroceras* in both units, and thus the former is also assigned to be a Wordian age. The brachiopod assemblage in Locality BF 2 suggests a late Middle Permian age, most likely a lower Capitanian. This fauna has close linkage to that of the Sisophon Limestone, west Cambodia, particularly to *Yabeina–Lepidolina* beds of its Member C (referred to the four member division of Ishii *et al.*, 1969). This is indicated by three of the Bera brachiopod species, *Urushtenoidea chaoi*, *Spyridiophora gubleri* and *Transennatia* n. sp., being shared with the Sisophon fauna. The palaeontological report describing this brachiopod fauna is in preparation.

The lithology of the Bera Formation differs considerably from those of the adjacent Semantan and Bertangga Sandstone Formations. The Bera Formation can be distinguished from the overlying Semantan Formation by its less tuffaceous sediments, irregular interbedding of sandstone and shale, and the presence of massive siltstone/ shale. The sediments of the Bera Formation were deposited in a shallow marine environment as discussed above, whereas the bulk of the Semantan Formation is interpreted to be deeper water turbidite facies (Metcalfe *et. al.*, 1982; Kamal Roslan Mohamed, 1996). Bivalves usually dominate the macrofauna of the Semantan Formation, while brachiopods dominate the Bera Formation. The strata of the Bera Formation are structurally more highly deformed than those of the adjacent Semantan Formation. The Bera Formation has, in places, developed isoclinal folds (Tjia, in press) with generally steeply dipping strata and well-developed slaty cleavages. In contrast, the beds of the adjacent Semantan Formation dip more gently, with open folds and poorly developed slaty cleavages. The fact that the Late Permian through Early Triassic sequences are apparently absent from the Bera area suggests that there is probably a depositional hiatus, and/or a structural break between the two formations.

The Bertangga Sandstone Formation can be distinguished from the Bera Formation by the presence of red mudstone (or red bed), channel (fluvial) filling ortho-conglomerate and sandstone typical of a non-marine origin. The beds of the Bertangga Sandstone Formation have a very gentle dip angle, compared to those of the Bera Formation.

CONCLUSION

The above discussions elaborate significant differences between the rock unit described in this paper and the neighbouring Semantan and Bertangga Sandstone Formations, thus implying that this rock unit cannot be

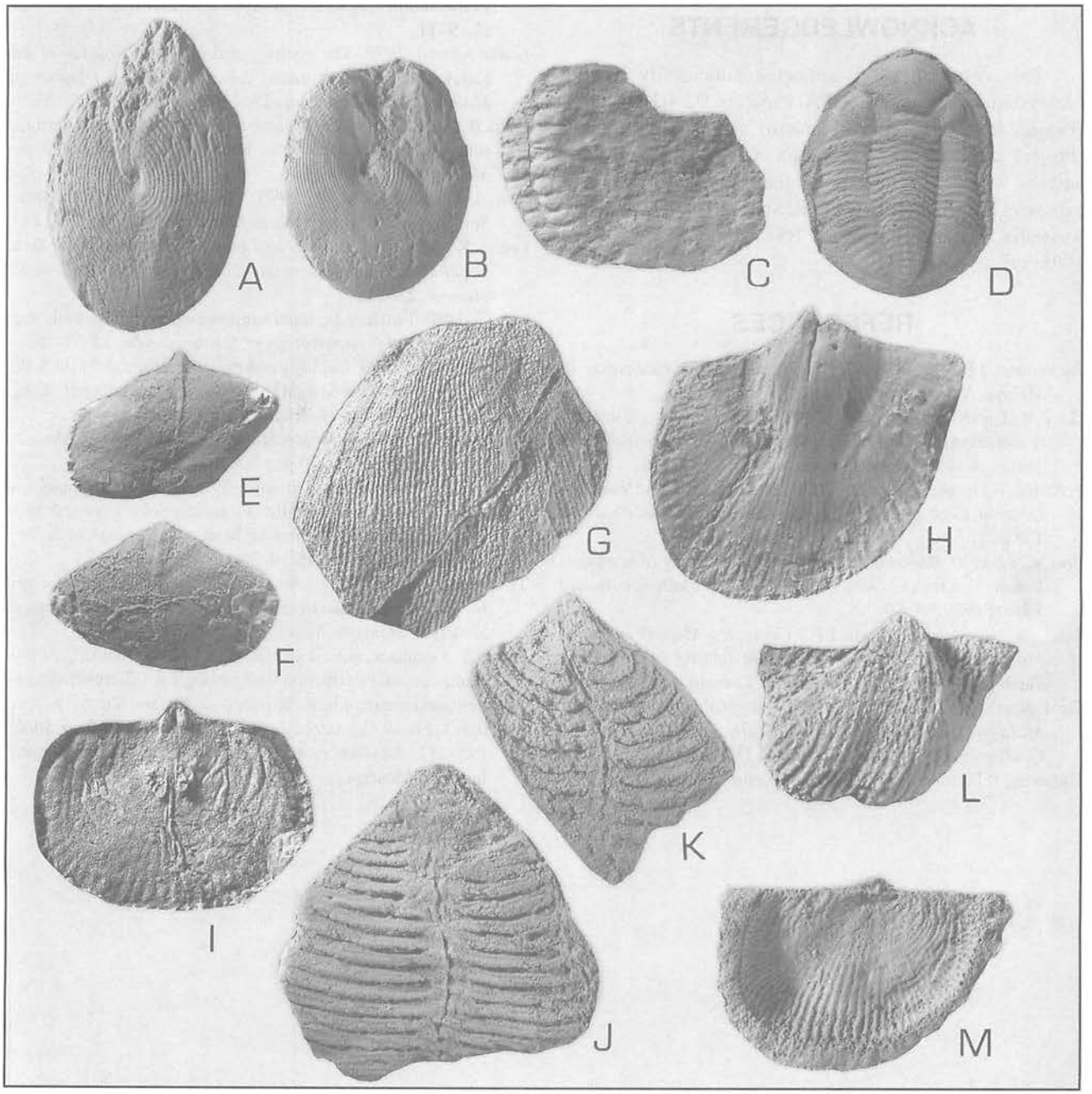

Figure 5: Some representative Permian fossils of the Bera Formation. A–F from Locality BF1; A–B, *Agathiceras* sp., x1.0, C, *Bamyaniceras* sp., x2.5, D, *Pseudophillipsia*? sp., x 1.0, E–F, *Martinia* sp., x2.0. G–M from Locality BF2; G, *Linoproductus* sp., x1.5, H, *Derbyia* sp., x2.0, I, *Urushtenoidea chaoi* (Ching), x2.0, J–K, *Gubleria* sp., x1.3, L, *Transennatia* n. sp., x3.0, M, *Strophalosiina* sp., x1.5.

assigned to any of them. Therefore, this rock unit of Middle Permian (Roadian to Capitanian) age, which is mappable in the Bera District should be assigned to a new formation, proposed here as the Bera Formation.

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