Annual Geological Conference '94
June 11–12, 1994, Kuala Terengganu, Malaysia

Discovery of Upper Permian carbonates from the Kenong Wildlife Reserve, Pahang, Malaysia

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Abstract: Carbonates from the Kenong area were found to contain Late Permian foraminifers and calcareous algae. These taxa can be correlated with similar forms reported from the Tethyan region, in particular to the Eastern Tethys. The fossil assemblages in these carbonates were fairly diverse and abundant and were interpreted to have inhabited warm shallow shelfal seas with open circulation. The predominance of limy-mud matrix and the poor sorting indicate that the environment was analogous to a mud bank that was formed on localized high.

INTRODUCTION

Several carbonate bodies located within the Kenong Wildlife Reserve of the State of Pahang were examined and Upper Permian foraminifers and algae were found. This finding and the occurrences of Upper Permian carbonate at Gua Panjang (Nuraiteng, 1993) and Upper Permian brachiopod-bearing shales in the Merapoh-Padang Tengku areas (Mohd. Shafeea, 1993) indicate that the distribution of Upper Permian strata in Pahang is areally concentrated to the northern part of the state i.e. from the vicinity of Kuala Lipis northwards to Gua Panjang (Fig. 1). The Upper Permian from Pahang can also be traced northwards into the southern part of the state of Kelantan to several localities along the Paloh and the Relai Rivers (Aw *et al.,* 1977).

LOCATION

The carbonate outcrops investigated in this study form a linear north-south trending belt located within the area drained by the Kenong River and its distributaries. The Kenong Reserve can be reached by boat from Kuala Lipis which is located to the west. Carbonate outcrops are found as small karstic hills and studies were carried out on three of the larger hills. The outcrops are, from the north to the south, Gua Kesong, Gua Tangga and Gua Tinggi (Fig. 1).

GEOLOGY OF THE AREA

The Kenong area is reported to be underlain by rocks belonging mainly to the Gua Musang Formation (Burton, 1973). This unit was an informal designation but due to its frequent referral in published and unpublished literature and the absence of an acceptable alternative, the Gua Musang Formation continues to remain as a valid lithostratigraphic unit. This formation is composed essentially of clastics (predominantly shales), carbonates and volcaniclastics. Late Permian brachiopods and Middle-Late Permian foraminifers have been found in the shales and carbonates (Jones *et al.*, 1966; Mohd. Shafeea, 1993; Nuraiteng, 1993). In addition, Early to Middle Triassic faunas were also reported from several localities within this formation (Jones *et al.*, 1966; Metcalfe, 1990). Thus the age of the Gua Musang Formation ranges from Middle Permian to Middle Triassic. However, despite the discovery of Late Permian and Triassic fossils, the Permian-Triassic boundary has as yet not been reported. This formation has been correlated with the Aring Formation in South Kelantan (Aw, 1990). Both formations are rich in volcanic rocks and parts of their ages overlap.

In the Kenong area, several Upper Permian carbonate hills outcropping in the vicinity along the Kenong River (Fig. 1) were mapped by the junior author (Abdul Hadi, 1992). A large, elongate body of rhyolitic tuff and vitric tuff was also reported

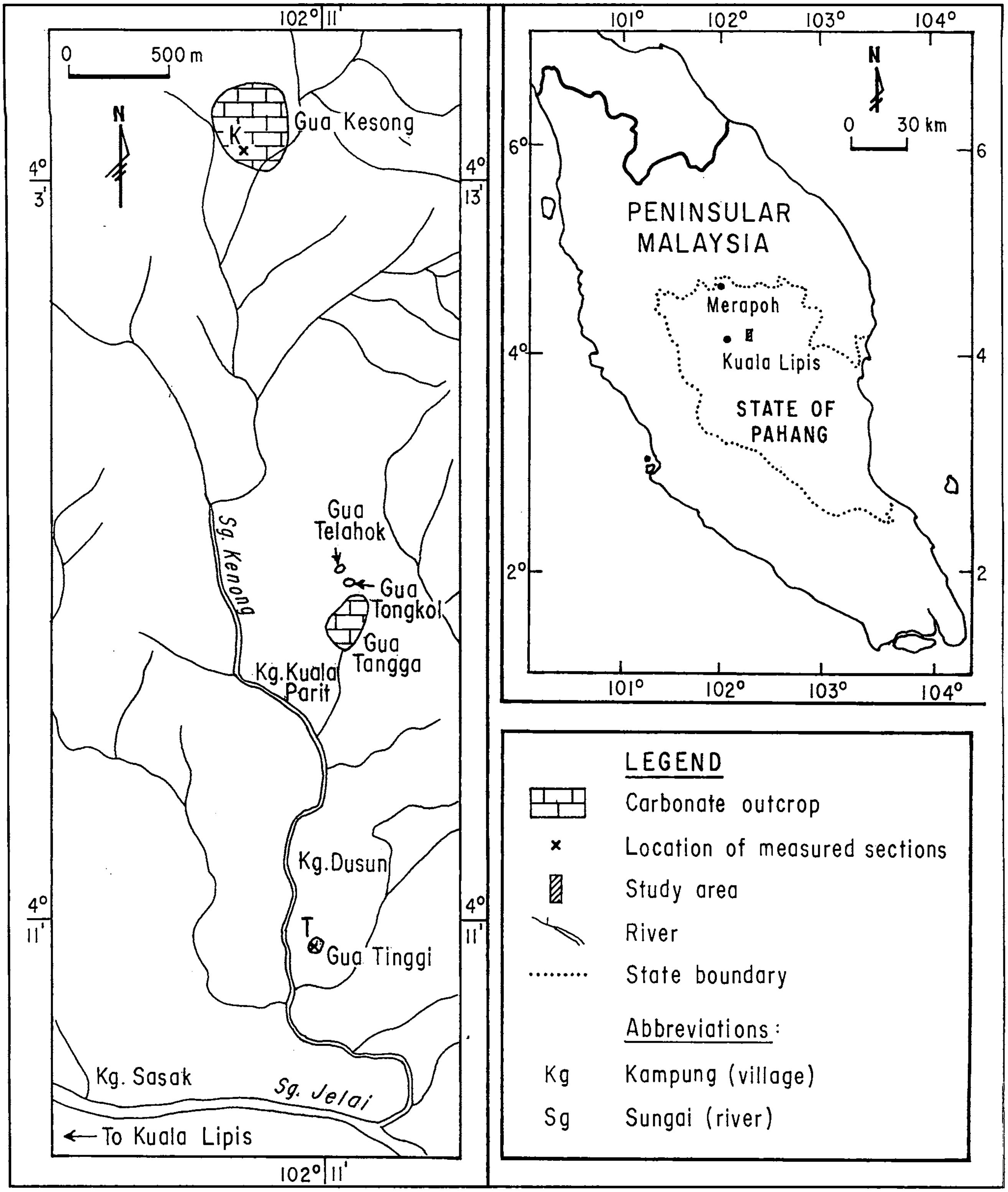


Figure 1. Location map of the study area.

from this area (Jasmi, In Fontaine *et al.*, 1992). The age and stratigraphic relationship of this volcanic body are presently unavailable. However, acid volcanics are widely distributed in the Gua Musang Formation and the possibility exists that the Kenong volcanic body could be an integral part of this formation. Fontaine *et al.* (1992) have also reported Anisian microfossils from the Kenong area.

Carbonates of the Kenong area

Carbonate rocks in the Kenong area appear massive. However, closer examination shows the presence of laminations and bandings composed of fossil remains. Due to the difficulties of assessing paleontological and sedimentary features in the field, most of the observations are drawn from thin-section examinations of samples collected. In general the majority of the carbonates are wackestones and packstones and they have undergone varying degrees of diagenetic alterations. Carbonates that are susceptible to diagenetic changes are generally fossiliferous.

Gua Kesong

The outcrop is about 85 m high and it is the highest topographic feature in the area. Three sections from the eastern, western and southern flanks of the hill were sampled respectively. Of these three sections, only the eastern one contains significant fossil finds.

Limestones from the eastern section (samples K31–K50) are grey to dark grey wackestones and packstones. They are rich in calcareous algal remains and benthic foraminifers.

Gua Tangga

The hill is located about 2.5 km south of Gua Kesong and has an elevation of about 60 m. Samples were taken from the southeastern flank of the hill. The calcilutitic limestones are poorly fossiliferous and no diagnostic taxa were found. Due to this, samples from this section are omitted from this study.

Gua Tinggi

This outcrop is 1.5 km south of Gua Tangga. The height of the hill is approximately 37 m and samples were collected from the northern and southern flanks of the hill. Samples from the southern flank are generally unfossiliferous calcilutitic limestones. Samples from the northern flank are composed of wackestones and packstones that exhibit changes in colouration and fossil content from the lower to the upper parts of the section. In the lower part of the section, limestones are light grey and contain skeletal remains of shell and crinoids. In the upper part of the section, limestones are dark grey and contain abundant algal remains and benthic foraminifers.

PALAEONTOLOGY

Biotic composition

Figures 2 and 3 document the distribution and relative abundance of microfossils from Gua Kesong and Gua Tinggi respectively. In Gua Kesong, the carbonates are characterized by the remains of various benthic fauna and calcareous algae. The latter together with smaller benthic foraminifera and echinodermal fragments are the common taxa found in most of the samples. Within the measured section, concentrations of calcareous algae (especially gymnocodiaceans and/or dasycladaceans) occur at several horizons. In the upper part of the section, these algal-rich layers contain abundant sphaerulinids and turriform gastropods. In contrast, algae-rich layers at the lower part of the section are associated with colaniellids. The gymnocodiaceans are dominated by *Gymnocodium* while the dasycladaceans are more varied. Faunal diversity in most samples appears to be moderately high.

In Gua Tinggi, the basal part of the measured section contains horizons rich in calcisponges but benthic foraminifers are either absent or a few in numbers. From the middle to the upper parts of the section, faunal diversity increases, with benthic foraminifers and calcareous algae being the common elements of the fossil assemblage. Concentrations of calcareous algae in thin layers are also present in the uppermost part of the section.

Age and correlation of the carbonates

In the course of our work, literature search has revealed that the benthic foraminifers and calcareous algae found in the Kenong area can be compared with similar taxa found in Upper Permian successions throughout the Tethyan realm and especially in the Eastern Tethys.

The occurrence of rare but relatively advanced *Palaeofusulina* at the base of Gua Tinggi and the uppermost part of Gua Kesong can be correlated with palaeofusulinids from South Kelantan (Aw *et al.*, 1977), North Thailand (Sakagami and Hatta, 1982; Ueno and Sakagami, 1991) and South China (Rui, 1979). A common feature of these palaeofusulinids is the possession of relatively larger tests with complex septal fluting. Such forms were reported to be restricted to the *Palaeofusulina-Reichelina* zone (Toriyama, 1973), *Palaeofusulina sinensis* zone (Kanmara and Nakazawa, 1973), *Palaeofusulina sinensis-Colaniella parva* zone (Ishii *et al.*, 1975) and *Palaeofusulina sinensis* subzone

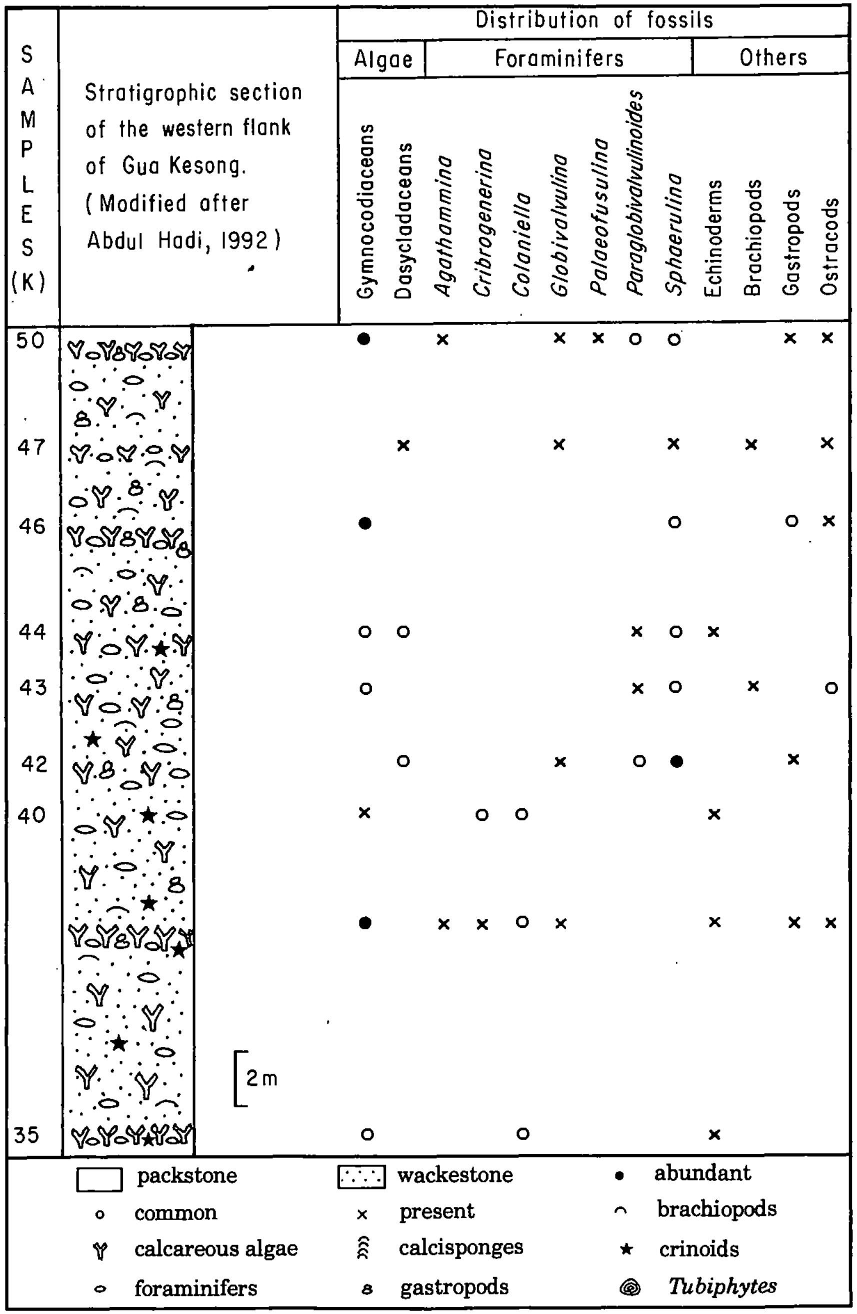


Figure 2. Distribution and relative abundance of foraminifers and calcareous algae in Gua Kesong.

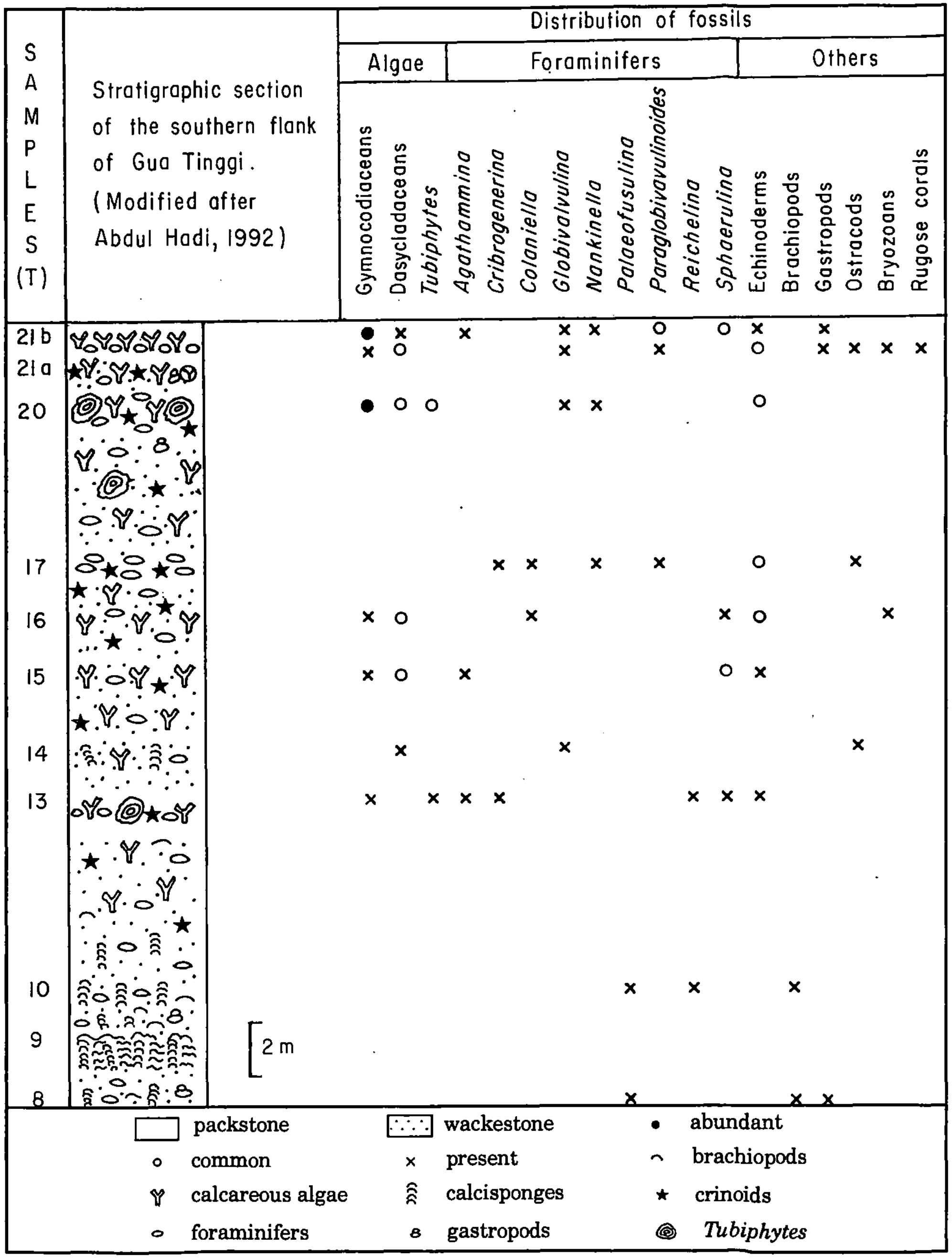


Figure 3. Distribution and relative abundance of foraminifers and calcareous algae in Gua Batu Tinggi.

(Rui, 1979). These zones though differing partly in their ranges were correlated with the uppermost part of the Upper Permian.

In Gua Batu Tinggi, *Palaeofusulina* occurs together with *Reichelina*. Such faunal association is reported to be common in the Upper Permian carbonate facies (Kanmera and Nakazawa, 1973). At Gua Kesong, *Palaeofusulina* is however associated with *Sphaerulina*, *Paraglobivalvulina* and other smaller benthic foraminifers. A similar co-occurrence of *Palaeofusulina* and *Paraglobivalvulina* has been found in the Upper Permian of North Thailand (Sakagami and Hatta, 1982). In addition sphaerulinids from Gua Kesong are similar to those reported from the Changxingian of Western Guizhou (Rui, 1979; Mu, 1981).

Palaeofusulinids were not found from the middle to the upper parts of the section at Gua Tinggi. However the occurrence of Upper Permian taxa such as *Colaniella cf. parva*, *Sphaerulina compacta*, *Paraglobivalvulina piyasini* and *Gymnocodium exile* clearly indicates that this part of the section still belongs to the Upper Permian. The absence of palaeofusulinids seems unlikely to have been governed by changes in facies as similar facies found at Gua Kesong do contain them. We suspect that their apparent absence here could be linked to the limited number of samples collected and sectioned.

A Late Permian age is also inferred for the entire section of Gua Kesong. The foraminiferal and algal assemblage here closely resembles those found at Gua Batu Tinggi.

PALEOENVIRONMENT

The carbonates of the study area generally show moderate to high diversity dominated by silt to granule-sized fusulinids and calcareous algae. The majority of the fusulinids are lenticular, subconical to spheroidal in shapes with multichambered tests. Fusulinid shapes have been likened to alveolinids (Ross, 1979; Cowen, 1983) and both these groups were widely distributed in fine-grained rocks. Spherical shapes of the former were viewed by Ross (1982) to be an adaptation towards the reduction of the test weight. This may explain the association of sphaerulinids and palaeofusulinids with limy-mud matrix, for despite their relatively large sizes they were able to adapt themselves to soft substrates. The keriothecal wall structure of some fusulinids were interpreted to be an adaptation to the presence of symbionts (Ross, 1982). This would imply that such fusulinids (e.g. sphaerulinids) inhabited environments that were within the shallow waters of the photic zone.

Fragments of calcareous algae are ubiquitous throughout the carbonate succession at Gua Kesong and Gua Batu Tinggi (with the exception of the sponge-enriched lower part). Their abundance in muddy facies and the overall poor sorting of the varied biotic components indicates that the fossil assemblages were *in situ* accumulations. This view is supported by the absence of breakage of fossil tests. The fragmentation of calcareous algae is however a likely consequence of their natural disintegration upon death. The dependance of calcareous algae on light for photosynthesis indicates that their environment was essentially within the shallow waters of the photic zone. Banner and Simmons (in press) estimated that the water depth of gymnocodiacean-rich facies to be about 5–15 m.

The gymnocodiacean and dasycladacean microfacies here can be compared to similar facies reported from the Permian of the Southern Alps (Elliot, 1955). Depositional environment for the latter was interpreted to range from the inner to the outer shelf with open circulation (Flugel, 1977). A likely modern analogue of the depositional environment of the Kenong carbonates is the Rodriguez bank. In the latter, calcareous algae (*Halimeda*) and benthic foraminifers are widely distributed in the muddy substrate. Water circulation in this shallow bank is open (Turmel and Swanson, 1976).

Thus, the depositional environment of the Kenong carbonates can be compared to a muddy bank that was developed on the shelf.

CONCLUSION

The Upper Permian carbonates of the Kenong area is interpreted to have been deposited in the warm shallow waters of the shelf. Changes in the depositional environment have resulted in the cessation of clastic sedimentation and the ensuing accumulation of carbonate sediments. Field evidences from the Padang Tengku area (Mohd. Shafeea, 1993) and from Gua Bama (Lim, pers. comm.) indicate that the carbonates there generally sit on volcanics/volcaniclastics. The basal contact of the carbonates in our study area is not seen but a large though undated rhyolitic body has been reported from the Kenong area (Jasmi, In Fontaine *et al.*, 1992). Thus the possibility exists that the Upper Permian carbonates here were deposited on volcanics/volcaniclastics. If this was indeed the case, then the volcanics could have acted as a paleohigh during the accumulation of the carbonates.

The biotic constituents of the Upper Permian carbonates represent typical Tethyan forms. Foraminifers, in particular the fusulinids, and calcareous algae bear strong resemblance to taxa reported from the eastern Tethyan areas.

SYSTEMATIC PALEONTOLOGY

Order Foraminiferida Eichwald, 1830
Suborder Fusulinina Wedekind, 1937
Superfamily Fusulinacea von Moller, 1878
Family Schubertellidae Skinner, 1931
Genus Palaeo*fusulina* Deprat, 1912
Palaeofusulina cf. *sinensis* Sheng, 1955
Plate 1, figs. 1, 2

Compare:

Palaeofusulina sinensis Sakagami and Hatta, 1982, p. 5–7, pl. 1, figs. 8–22. Ueno and Sakagami, 1991, p. 939–940, fig. 2:12–16, fig. 4:1.

Thin-sections studied

— tangential section: T10
sagittal section: K50

Description

Proloculus spherical, 0.05 mm in outside diameter. First volution tightly coiled. Test expands rapidly in the third volution. Septa strongly fluted throughout.

Dimensions

length = 1.88 mm; width = 1.18 mm

The true dimensions of the test is expected to exceed the above values which were measured from a tangential section.

Occurrence

Basal part of Gua Batu Tinggi and uppermost part of Gua Kesong.

Remarks

Spirotheka and septa of tests tend to be partly obliterated by diagenesis. However the morphological features of the test agree with *Palaeofusulina sinensis* reported from North Thailand.

Family Staffellidae A.D. Miklukho-Maklay, 1949
Genus *Sphaerulina* J.S. Lee, 1934
Sphaerulina compacta Rui Lin, 1979
Plate 1, figs. 3–5

Compare:

Sphaerulina compacta Rui Lin, 1979, p. 282–283, pl. II, figs. 29, 30.

Thin-sections studied

— axial section: K46
parallel section through polar end: K46

Description

Test spherical. Initial volutions tightly coiled with short axis of coiling, lenticular shape with subrounded margins. Later volutions with broadly rounded margins and development of spherical test. Up to 8 volutions observed. Septa straight to slightly curved, numerous. Fine alveolar wall.

Dimensions

K46: length = 1.24 mm; width =1.44 mm; form ratio = 0.86

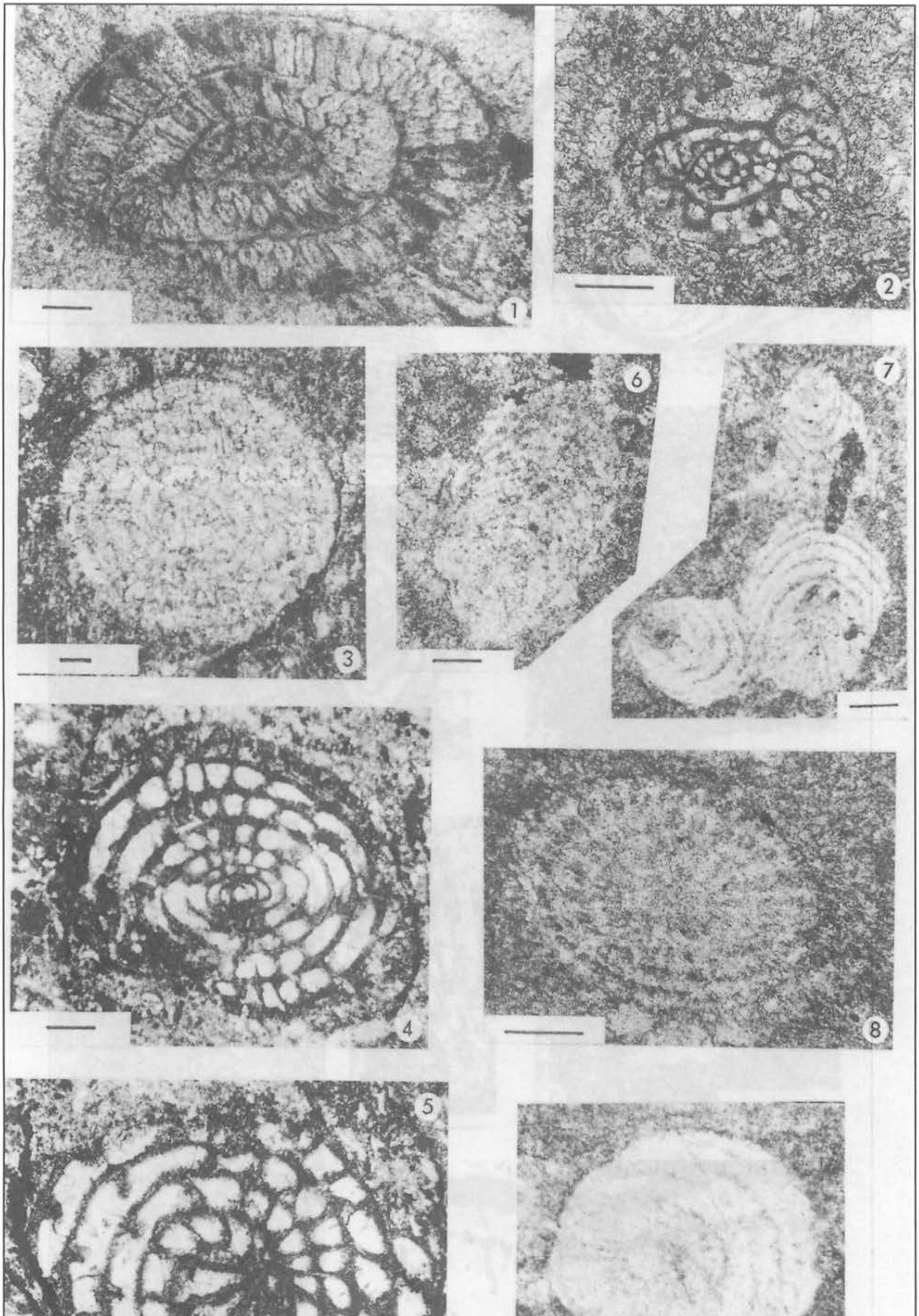
Occurrence

Abundant in the middle to upper parts of the sections from Gua Kesong and Gua Batu Tinggi. This form was first reported from the Changsingian of Western Guizhou.

Remarks

Sphaerulina compacta from Western Guizhou has up to 10 volutions. Of our specimens, the inner volutions of K42 are diagenetically obliterated, while the outermost volutions of K46 appeared to be crushed. Otherwise, the dimensions and the morphological features of the Kenong and Guizhou taxa are identical.

Plate 1. Figures 1, 2. *Palaeofusulina* cf. *sinensis* Sheng (Scale Bar = 0.2 mm)
1 — Tangential section showing complex and closely spaced septal fluting. Sample T10.
2 — Oblique section showing small proloculus and tightly coiled early volutions. Outermost volutions are not preserved. Sample K50.
Figures 3–5. *Sphaerulina compacta* Rui (Scale Bar = 0.2 mm)
3 — Test completely recrystallized, organic traces outlining volutions of test. Sample K42.
4 — Axial section showing initial short axis of coiling and later development of spherical test. Outermost volutions are crushed. Sample K46.
5 — Parallel section through polar end, sample K46.
Figures 6–9. *Colaniella* cf. *parva* (Colani) (Scale Bar = 0.2 mm)
6 — Longitudinal section, sample K40.
7 — Longitudinal to partly oblique section, sample K35.
8 — Transverse section showing primary and secondary radial partitions. Sample K35.
9 — Oblique transverse section, sample K38.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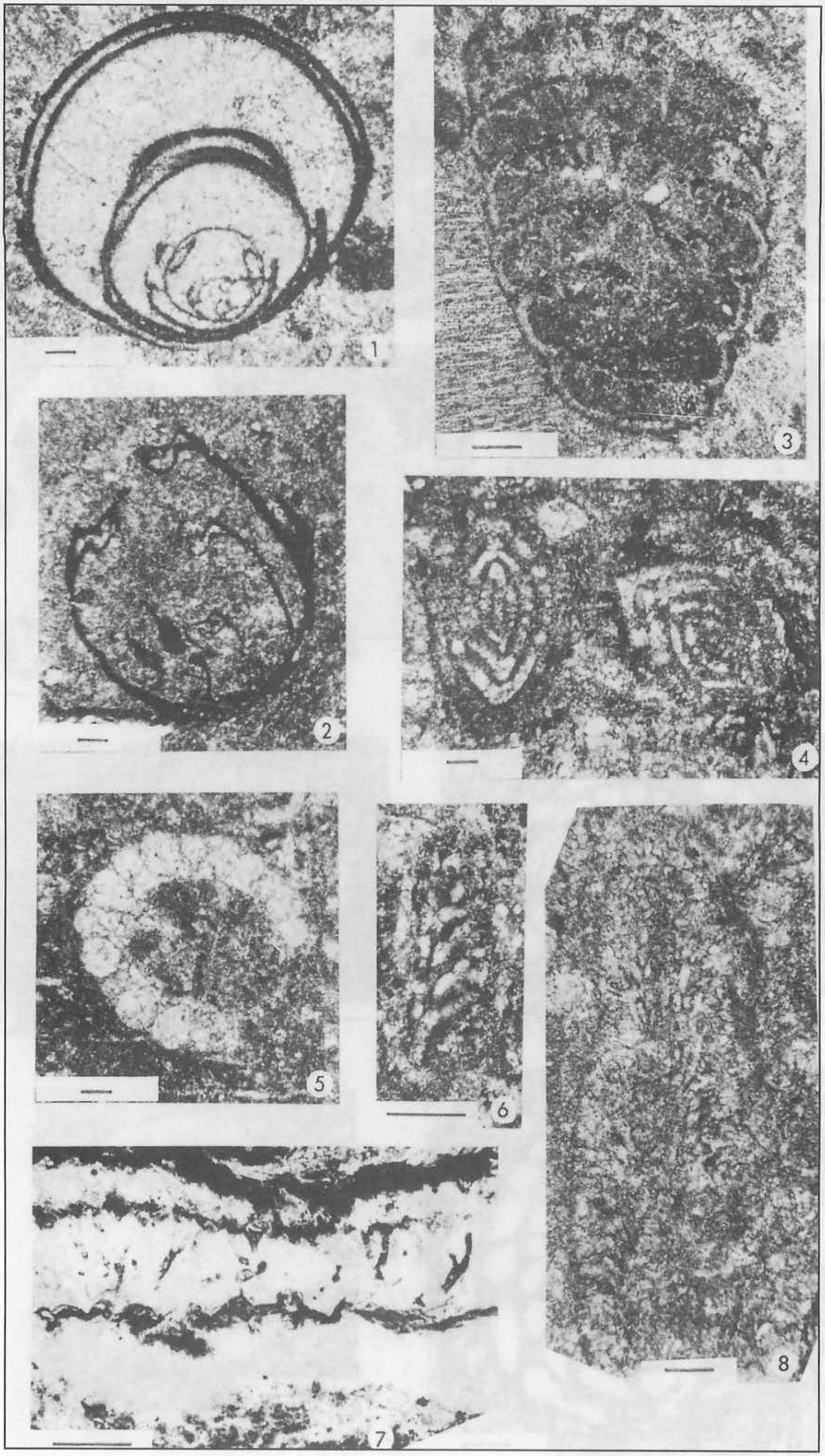
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Superfamily Colaniellacea Fursenko, 1959
Family Colaniellidae Fursenko, 1959
Genus *Colaniella* Likharev, 1939
Colaniella cf. *parva* (Colani), 1924
Plate 1, figs. 6–9

Compare:

Colaniella parva Ishii *et al.*, 1975, pl. 1, figs. 1–3; pl. 4, fig. 4. Sakagami and Hatta, 1982, p. 8–9, pl. III, figs. 13–16.

Thin-sections studied

— axial sections: K35, K40
transverse sections: K35

Description

Arcuate, uniserial chambers, strongly overlapping. Only 9 to 11 chambers were preserved; earlier chambers tend to be diagenetically obliterated. 15–16 primary radial partitions reaching center of the test. Secondary radial partitions inserted in between primary ones.

Dimensions

K40: length =1.14 mm; width = 0.65 mm

Remarks

Ishii *et al.* (1975) reported that this taxon has three sets of radial partitions. However the preservation of the specimens from our study area does not enable us to determine whether the third set of radial partitions are present or absent. Nevertheless, the Kenong colaniellids have tests with dimensions and shapes resembling *Colaniella parva* reported from South Kelantan, North Thailand and Japan.

Superfamily Palaeotextulariacea Galloway, 1933
Family Biseriamminidae Chernysheva, 1941
Genus *Paraglobivalvulina* Reytlinger, 1965
Paraglobivalvulina piyasini Sakagami and Hatta, 1982
Plate 2, figs. 1, 2

Compare:

Paraglobivalvulina piyasini Sakagami and Hatta, 1982, p. 11–12, pl. 5, figs. 1–24, text-figs. 1, 2.

Thin-sections studied

— longitudinal section: K42
transverse section: T21b

Description

Spherical test, later chambers enveloping earlier ones and expanding rapidly. Short interseptal partitions developed on ventral side of test. Characterized by hook-shaped apertural tongue.

Dimensions

K42: length = 1.8 mm; width = 1.6 mm

Occurrence

Common in the upper parts of the sections from Gua Kesong and Gua Tinggi. This taxa is reported from the Upper Permian of North Thailand in association with *Palaeofusulina sinensis* and *Colaniella parva* (Sakagami and Hatta, 1982).

Remarks

Specimen from K42 is smaller than those illustrated by Sakagami and Hatta from Thailand. However larger forms with width exceeding 2 mm were also observed (e.g. Plate 2, fig. 1).

Plate 2. Figures 1, 2. *Paraglobivalvulinoides piyasini* (Sakagami and Hatta) (Scale Bar = 0.2 mm)
1 — Oblique section, sample T21a.
2 — Longitudinal section showing characteristic hook-shaped apertural tongues. Sample K42.
Figure 3. *Cribrogenerina* sp., longitudinal section, sample T17 (Scale Bar = 0.2 mm)
Figure 4. *Nankinella* sp., axial section, sample T21b (Scale Bar = 0.2 mm)
Figure 5. *Atractyliopsis* sp., transverse section, sample T15 (Scale Bar = 0.2 mm)
Figure 6–8. *Gymnocodium exile* Mu (Scale Bar = 0.2 mm)
6 — Longitudinal section showing cortical branchlets arising from medullary filaments. Branchlets pinch and swell. Sample K46.
7 — Longitudinal section of silicified segment. Interiors of branchlets infilled with organic materials. Branchlets terminate into cup-shaped pores. Pitch is crushed. Sample K46.
8 — Longitudinal section of segment with rounded terminal end, well preserved medullary filaments and cortical branchlets. Sample K38.

Division Rhodophyta
Family Gymnocodiaceae Elliot,
Genus *Gymnocodium* Pia, 1920
Gymnocodium exile Mu Xi-nan, 1981
Plate 2, figs. 6–8

Compare:

Gymnocodium exile Mu Xi-nan, 1981, p. 40, pl. III, figs. 9, 10.

Thin-sections studied

— longitudinal sections: K38, K46

Description

Elongate, cyclindrical segments with rounded terminal ends. Centers of medullary (pith) poorly calcified but well-preserved elongate, subparallel filaments 0.04 mm in diameter are seen just beneath the cortical areas. These filaments diverge outwards (35–53 degrees) towards the cortex and subdivide in the cortex. Cortical branchlets initially inclined to the axis of the segment but gradually becoming more reclined until they are almost normal or gently inclined to the surfaces of the segment. Branchlets subdivide twice at small acute angles (19–25 degrees) and terminate as cup-shaped pores 0.03–0.05 mm diameter. Branchlets pinch and swell, are thinnest immediately prior to and after branching and widening thereafter.

Dimensions of segments

K38: length > 2.2 mm; width = 0.55–0.67 mm; width of cortex = 0.15–0.17 mm
K46: length > 3.37 mm; *width > 0.37–0.6 mm; width of cortex = 0.18–0.27 mm
*medullary of K46 is squashed

Occurrence

Ubiquitous throughout the sections studied but are especially concentrated in some layers. This species was first reported from the Upper Changsingian of Western Guizhou.

Remarks

This species is very similar to *Gymnocodium bellerophontis* in the dimension of the cup-shaped pores but differs from it by the strong degree of branching in the cortex and resultant closer packing of the cup-shaped pores.

ACKNOWLEGEMENT

We thank Ching for drafting the figures and Azmi for the preparation of the plates. We are grateful to Alex-Mark Sanders and Dr. Katsumi Ueno for bringing into our attention relevant references.

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Manuscript received 18 October 1994