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Palaeoecological and Palaeogeographical Significance of the Rugose Corals from the Middle Devonian "Maymyo Formation" in Pyinoolwin Township

Khaing Khaing San

Abstract

In Myanmar, Middle Devonian coral bearing carbonate deposits are limited in Pyinoolwin Township, i.e. Padaukpin area and Pwepon area. At the generic level, most rugose corals from the "Maymyo Formation" including Padaukpin Limestone and Pwepon Limesone are widely distributed especially in the Old World Realm. Detailed palaeoecological study indicates that the abundant rugose coral fauna from the Middle Devonian "Maymyo Formation" may have lived in a warm, shallow, well-oxygenated seas having moderate to high wave energy probably situated near the margin of the carbonate platform adjacent to the basinal deposits in tropical to temperate zone. After death they had been transported and quickly deposited in a calm water environment on the continental slope.

Comparison of the rugose coral fauna in "Maymyo Formation" with those in other countries reveals that the rugose coral assemblages of the "Maymyo Formation" do not give any indication for a biogeographic relation to Gondwana or presumed Cinmerian blocks during the Middle Devonian. These fauna are definitely of the Rhenish-Bohemian region of the Old World Realm and quite different from the Australia fauna. On the basic of the faunal assemblages of the Middle Devonian "Maymyo Formation", Myanmar (especially Shan State of the western part of Sinoburmalaya) is interpreted as a massif belonging to the Gondwana domain which was separated from Gondwana by a wide ocean made it impossible for the benthonic organisms on the both flanks to freely migrate toward the opposing continental margin.

Key words: palaeoecology, palaeogeography, rugose corals, Middle Devonian.

Introduction

Within Myanmar, marine Middle Devonian limestones are exposed in very limited areas. They exposed as an isolated outcrop of only a few localities and so far well-preserved Devonian corals are only known from two localities; the Padaukpin and Pwepon areas, Pyinoolwin township (Fig. 1) which is geologically known as a part of the northen Shan State.

Assistant Lecturer, Dr, Department of Geology, Myinchan Degree College

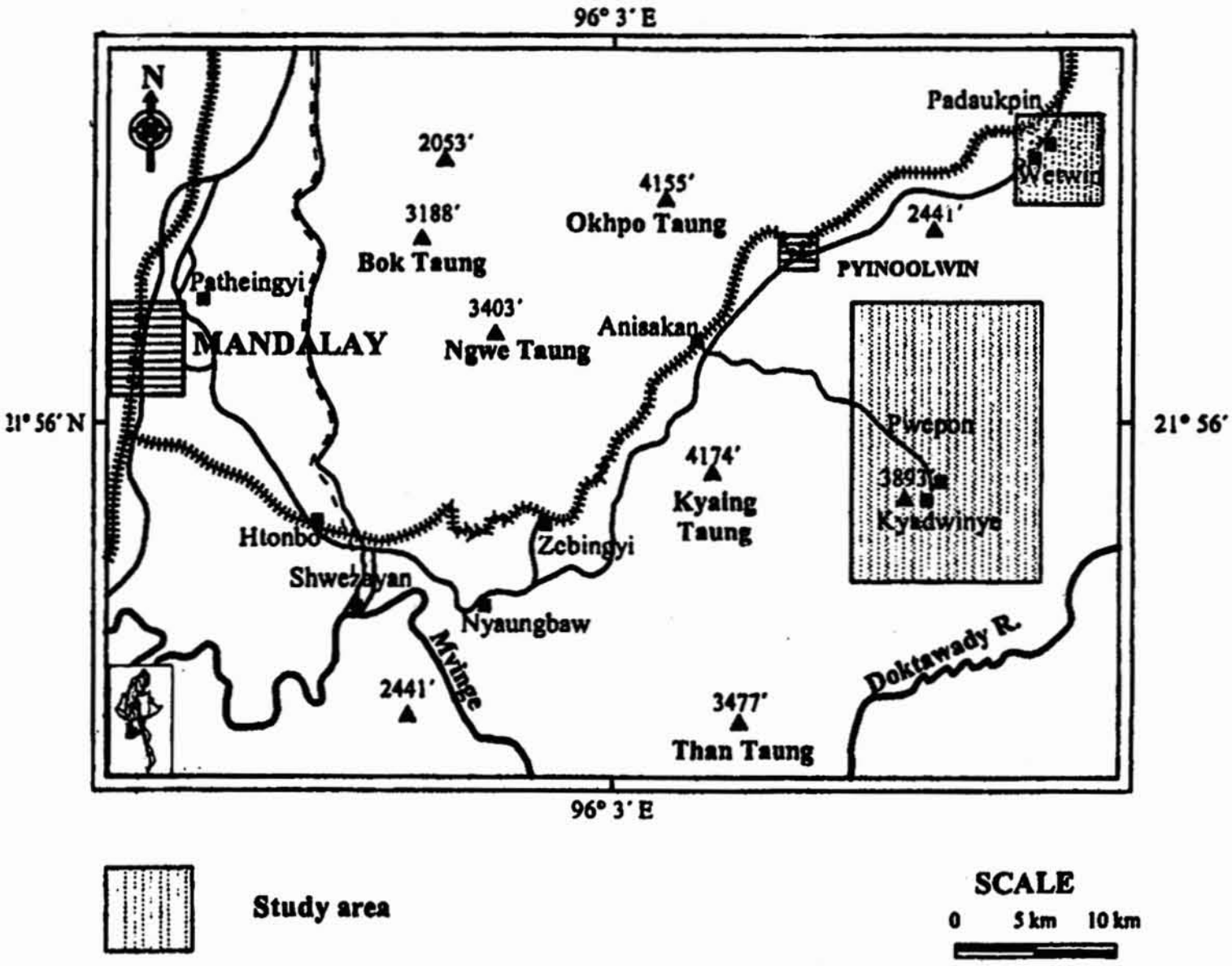

Figure 1. Location map of the study area.

The Middle Devonian "Maymyo Formation" is widely distributed in the Pyinoolwin Township. The rich rugose coral bearing Padaukpin Limestone and Pwepon Limestone are the sandwiched units of the "Maymyo Formation" on which more detailed study has been done (Reed, 1908, 1929; Aung, 1995; Khaing Khaing San, 2005). The present paper attempts to discuss the palaeoecological and palaeogeographical significance of the coral fauna.

Palaeoclimate

In this study, the coral fauna is very rich in individuals. Although non-dissepimented solitary forms including *Puanophyllum* and *Metrionaxon* are also occurred. *Metrionaxon* in Pwepon Limestone is small in size and a few specimens are occurred. *Puanophyllum* in Padaukpin Limestone is abundant and only a few of them are greater than 10 cm in diameter, mostly of medium or large size with maximum diameter up to 30 cm. So the corals lived in a normal shallow sea advantages to their growth.

In this study, the massive rugose corals are represented by *Phillipsastrea*, *Argutastrea* and *Hexagonaria*. *Phillipsastrea* are very abundant in Padaukpin Limestone and are usually large in size, greater than 10 cm high, and about or greater than 20 cm in diameter, the biggest individual being more than 50 cm in diameter and 18 cm height. *Argutastrea* and *Hexagonaria* in Pwepon Limestone are usually medium in size, the biggest individual being no more than 15 cm in diameter and height. All the features show that the coral fauna lived in an environment advantages to the formation of coral reef.

In the coral fauna of the Padaukpin Limestone, it is very common that rugose corals are enclosed by other fossils including stromatoporoids, tabulate corals and bryozoans. Small brachiopods and other small fossils may have lived on the exterior walls of the corals. In some enclosed individuals, the exterior wall well preserved, some others they are destroyed. In general, the enclosed parts tend to be well preserved, while the parts without fossil enclosure usually destroyed. This shows that other fossils had enclosed some corals before their exterior walls were destroyed, and some were enclosed after their walls had been destroyed. On this basis, it may be inferred that the coral fauna lived in a moderate to high wave energy environment.

In the coral fauna of the Pwepon Limestone, the rugose coral fauna are mainly composed of small, solitary corals in the lower part and then large solitary rugose corals along with stromatolites, tabulate corals, bryozoans and brachiopods. Up section, the rugose coral fauna are characterized by fasciculate and massive forms. Almost all the solitary corals in the Pwepon fauna are incompletely preserved. They are embraced to preserve within blocks that have subsequently been eroded, transported from their place of origin, and redeposited as allochthonous sediments downslope from their original habitat.

As noted above, the rugose corals in the Pwepon Limestone are destroyed to various degrees, but most of them are preserved well enough to identify. Only in a few cases, solitary corals and corallites of fasciculate corals are parallel to each other, while in most cases they are randomly oriented, considerably varying in size and varying in diameter.

Among the 32 coral species recognized from the Padaukpin and Pwepon Limestones, most species are limited to Eifelian. Except the species of *Argutastrea pweponensis* n. sp., *Hexagonaria carinata* n. sp. and

Grypophyllum postprimum postprimum are the Givetian species from the upper part of the Pwepon Limestone. A comparison of the rugose coral species of Padaukpin and Pwepon limestones with the known occurrences of the corals in other areas indicates that the fauna of the Padaukpin Limestone is certain to be Eifelian and the fauna of the Pwepon Limestone ranges from Eifelian to possibly Givetian.

The state of preservation and the age of the rugose corals under discussion show that this fauna had partly undergone transportation before they were buried. The majority of the rugose corals described here, out of a total number of 32, 24 species are solitary forms. The fasciculate forms are second in number, containing 5 species altogether. The massive forms are only represented by 3 species. With regard to the number of individuals identified solitary forms are more than 75 percent, fasciculate forms more than 15 percent and massive forms about 9 percent. Yu and Kuang (1982) recognized two types of coral faunas in the Middle Devonian of South China in accordance with their living environments. The components and preservation of the Padaukpin and Pwepon fauna are similar to Beiliu coral fauna. So the coral fauna from these two areas may be lived near the margin of the carbonate platform adjacent to the shallow water basin.

Buried Environment

In Padaukpin area, the basal part of rugose coral fauna is characterized by small to minute rugose and tabulate corals, brachiopods, bryozoans and few crinoid ossicles. These fossils occur in the mudstone, shale or siltstone interbedded with calcareous limestone. The middle part is recognized by both solitary and colonial rugose corals, stromatoporoids, thick-shelled brachiopods, tabulate corals, bryozoans and crinoid ossicles within ferruginous limestone, argillaceous limestone and bioclastic limestone.

The unit becomes more calcareous in the upper part of the Padaukpin Limestone and the rugose corals and brachiopods attain larger sizes and greater specific and generic diversity. In some beds, coralla are found upright, indicating growth in low-energy environments and the muddy beds have rich in population of brachiopods. Some of the large solitary corals dominated in this part. The increase in weight may well have been helpful character in stabilizing corallites within the muddy sediments.

The genus *Phillipsastrea* with no dividing wall suggests the quiet depositional environment of these sediments.

The Pwepon Limestone mainly consists of micritic limestone, argillaceous limestone with nodular structure, bioclastic limestone and minor amount of shale and siltstone. The bioclasts contain broken fossil fragments of corals, brachiopods, crinoid stems and bryozoans, which are variable in size, irregular in shape and not rounded and hence fine matrix. The sedimentary grains, which are extremely variable in size were deposited in the same environment.

According to the sedimentological point of view, fossil bearing Pwepon Limestone are algal stromatolite wackestone-packstone, lithoclastic grainstone and spiculitic wackestone suggest the environment of shelf lagoon open circulation.The state of the preservation of fossils and the lithology of the rocks in the Pwepon Limestone indicate that they were formed in calm water, and the fossils as well as other coarse grains had been transported for only a short distance, and quickly deposited.

In conclusion, the most clearly defined geological factor influencing the nature and distribution of the rugose coral biofacies of the Padaukpin and Pwepon Limestones of the "Maymyo Formation" is the sedimentary environment. The associated sediments usually show that the water were shallow. The rugose corals of the Padaukpin Limestone were deposited under shallowing marine condition with low to moderate energy, periodically strong agitation possibly generated by storms.

The rugose corals of the Pwepon Limestone may have lived in warm, high-energy shallow water probably situated on the margins of a carbonate platform adjacent to shallow water basin. After death they had been transported and rapidly deposited in a calm water environment (shelf-lagoon open circulation).

Wilson (1975) recognized three types of carbonate shelf margins in geological history (Fig. 2). The type II may help to explain the characters of the coral fauna from the Padaukpin Limestone and Pwepon Limestone of the "Maymyo Formation". In this model, the slope is gentle and wave energy is quiet to moderate. The corals lived on the margin of the carbonate platform adjacent to a shallow water basin, and were destroyed and easily transported by the moderate wave energy along the gentle slope and quickly

deposited in the margin of the carbonate platform of shelf–restricted lagoon and shelf–lagoon open circulation.

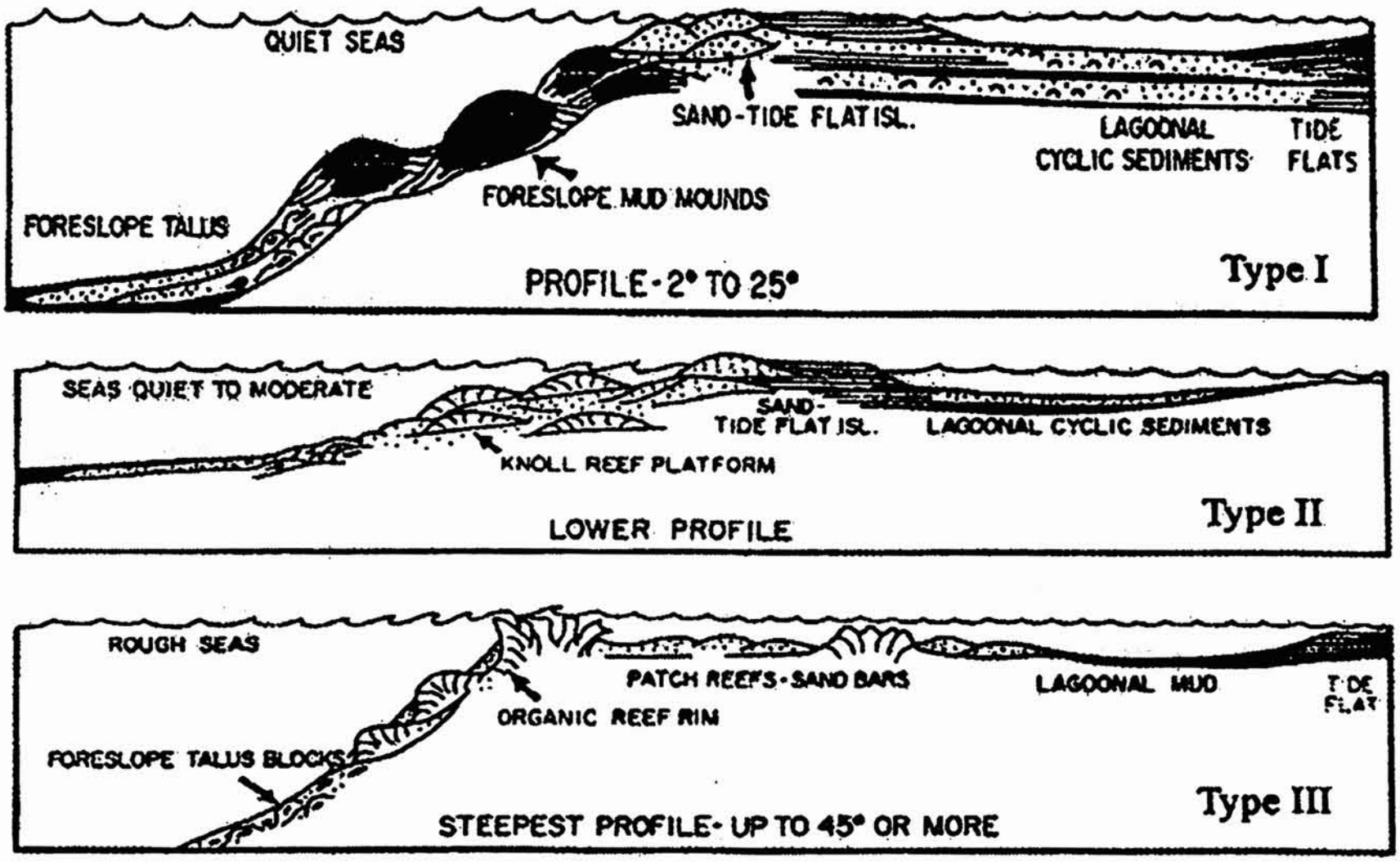

Figure 2. Three types of Carbonate shelf margin (after Wilson, 1975).

Palaeobiogeographical Significance

The abundant fauna under discussion is useful to clarify the relationship between the fauna in Padaukpin Limestone and Pwepon limestone of the "Maymyo Formation" and other regions during Middle Devonian.

In the Middle Devonian, the corals of the "Maymyo Formation" are abundant and moderate in diversity containing up to 20 genera on the basis of the classification of rugosa by Khaing Khaing San (2005). Among them, Cystiphyllidae, Amplexidae, Laccophyllidae, Ptenophyllidae, Disphyllidae, Phillipsastreidae and Cyathophyllidae are the most prosperous. They are widely distributed in Middle Devonian of Europe, Asia, Australia, North America and Africa (Table 1). Zaphrentidae, Goniophllidae and Stringophyllidae are the not abundant families in the Padaukpin and Pwepon areas.

Table 1. Correlation table of the Middle Devonian rugose coral genera of Myanmar with the world-wide occurrences of Devonian rugose corals (Modified after Oliver & Pedder, 1979)

No.	Taxon \ Area	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1	*Calceola*					√	√	√	√				√	√					√	√
2	*Cystiphylloides*				√	√		√					√						√	√
3	*Microplasma*				√			√											√	√
4	*Puanophyllum*							√											√	√
5	*Metrionaxon*						√	√												√
6	*Catactotoechus*					√		√					√						√	√
7	*Acanthophyllum*	√	√		√	√		√	√	√			√	√		√	√	√	√	√
8	*Dohmophyllum*	√			√	√		√	√				√	√	√	√	√	√	√	√
9	*Grypophyllum*	√	√		√		√	√	√	√			√	√	√	√	√	√	√	√
10	*Stringophyllum*	√			√	√		√	√	√		√	√	√	√				√	√
11	*Hallia*				√															√
12	*Aulacophyllum*		√		√	√			√				√	√						√
13	*Disphyllum*	√	√		√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
14	*Argutastrea*				√			√		√		√	√						√	√
15	*Spinophyllum*				√			√					√						√	√
16	*Temnophyllum*				√	√		√				√					√		√	√
17	*Hexagonaria*	√	√		√	√		√	√	√		√	√		√	√		√	√	√
18	*Phillipsastrea*	√	√		√	√	√	√		√	√		√	√		√			√	√
19	*Macgeea*	√	√		√	√	√	√	√	√	√		√		√	√		√	√	√
20	*Thamnophyllum*							√					√						√	√
21	*Zaphrentis*				√															√
22	*Heliophyllum*				√	√	√	√					√						√	√
23	*Endophyllum*							√		√			√			√				√
24	*Cyathophyllum*		√		√	√	√	√		√	√		√		√	√		√	√	√
25	*Peripaedium*	√			√			√		√									√	√

Geographical areas: 1. Western and arctic Canada and Alaska; 2. Great Basin (Nevada and parts of the surrounding states, New Mexico and western Sonora, Mexico); 3. Venezuela-Columbia; 4. Eastern North America (east of Transcontinental Arch) including south-eastern Canada and Chihuahua, Mexico; 5. North Africa (Morocco, Western Sahara, Mauritania, and Algeria); 6. Spain and Pyrences; 7. Europe (England, western and northern France, Belgium, Germany, northern Italy, Austria, Czechoslovakia, Poland, and Podolia and Volhynia, U.S.S.R); 8. Novaya Zemlya, Urals, Timan, Russian platform; 9. Turkey, Armenian S.S.R., Iran, Afghanistan; 10. Pakistan, India, Nepal; 11. Carnarvon and Canning Basins, Western Australia; 12. Eastern Australia and New Zealand; 13.Tien Shan, U.S.S.R; 14. Dzhungaro-Balkhash, U.S.S.R.;15. Altai-Sayan, U.S.S.R.; 16. Taimyr, U.S.S.R; 17. Indigiro-Kolyma, U.S.S.R.; 18. South China and Vietnam; 19. Myanmar

The genus *Heliophyllum* in Zaphrentidae was endemic to the Eastern American Realm (EAR) during the Middle Devonian but which spread into the Old World Realm (OWR) via North Africa, Europe and Asia. *Calceola* in Goniophyllidae also occurs in Europe, Africa, Asia and Australia. The most distinctive genus of this fauna being represented by *Calceola sandalina* has a wide distribution in the Eifelian of Europe especially Germany, Belgium, Austria, France and Poland (Birenheide, 1978). The occurrence of Stringophyllidae is from Middle Devonian of Europe, North Africa, Australia and China.

Conclusion

The most rugose coral fauna of the Padaukpin Limestone and Pwepon Limestone are widely distributed especially in the Old World Realm. In direct comparison with coral assemblages of the Padaukpin and Pwepon Limestons and other regions, there is no obvious difference in composition from Rhenish Mtns, and generic composition is closely comparable to that of the Eifel Hills (Schröder, 1997).

A very similar fauna is also known from the Ardennes and Holy Cross Mtns. including *Heliophyllum* in the Upper Eifelian (Coen-Aubert, 1996; Wrzolek, 1993). The only striking difference is the records of *Phillipsastrea hlawaii* Aung, 1995 which is of Eifelian age, whereas the genus is regarded as index fossil for the upper most Givetian and Frasnian in Western Europe.

However, with the exception of *Phillipsastrea*, such an assemblage does not give any indication for a biogeographic relation to Gondwana or presumed Cimmerian blocks during the Middle Devonian. These fauna are definitely of the Rhenish-Bohemian region in the Old World Realm and quite different from Australia fauna. (Khaing Khaing San et al., 2004).

Already the first description of Devonian fossils from the Padaukpin and Wetwin by Reed (1908, 1929) revealed the strong similarities between the fauna from the Rhenish Mountains and those from Padaukpin as numerous species are very similar or been identical with Eifelian taxa recorded from the Eifel Hills. This fact has also been known to Anderson et al. (1969) for the brachiopods and stressed as well for the rugose corals by Aung (1995). According to Anderson et al. (1969), the fauna has to be regarded as strictly "Rhenish-Bohemian".

Remarkably, during the Lower Paleozoic there are strong analogies concerning the Shan State as well as the western European Avalonia craton as Cambrian and Ordovician trilobite fauna (Boucot, 1988) which are of Gondwana origin are common to both areas, whereas the Middle Devonian fauna are obviously dominated by Rhenish assemblages. The clue for the changing faunal affinities should probably be found in the Lower Devonian times, when the Shan State was probably still influenced by Gondwana fauna. A key position for the understanding of Devonian biogeography lies in the Lower Devonian fauna as coral provinciality was highest during that time.

The Sinoburmalaya block (also known as the Shan-Thai block or the Sibumasu block) is an elongated continental block with a Proterozoic basement extending from northwest Sumatra in the south through western Malaysia, Peninsular Thailand and Peninsular Burma, northwest Thailand, the Shan State of Myanmar, western Yunnan in Bijing in the north. This block is bordered by the Changning-Menglian-Nan River- Raub- Bentong suture zone in the east, and by the Bijiang-Longling-Ruili-Mandalay-Sagaing Fault Zone in the west (Hutchison, 1975; Mitchell, 1981; Metcalfe, 1984, 1986, 1988, 1990; Barr and Macdonald, 1987; Fang, 1991).

According to Fang (1994), the Paleozoic geological history of the Sinoburmalayan block can be divided into three stages: Cambrian-Ordovician stage with Australian faunal affinities, Silurian-Devonian stage with Rhenish-Bohemian faunal affinities and Carboniferous-Permian stage as an independent biotic province, which is different from both peri-Gondwana land and Cathaysian biotas, in the Tethyan realm. The Siniburmalaya is rifted away from Gondwana land in the Middle Ordovician or earlier and is sutured to the East Asian continent in the Late Permian and Early Triassic.

On the basic of the faunal assemblages of the Padaukpin and Pwepon Limestones of the "Maymyo Formation", Myanmar, separation of the western part of the Sinoburmalaya (especially Shan State of Myanmar) from Gondwana land may be in the Lower Devonian.

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