Study on sedimentology of limestone and chert alternation depositional system in Moulmein Limestone (Permian), Hpa-an Area, Kayin State

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Abstract

The stratigraphic units exposed in the Hpa-an area is the Taungnyo Formation (Carboniferous to Early Permian) and the Moulmein Limestone Group (Permian). Their gradational contact is located at Kya-inn Hill, in which, the limestone unit of the Moulmein Limestone gradationally overlies on the clastic rocks of Taungnyo Formation. The Moulmein Limestone characterized the nature of well bedded, limestone and chert alternation pattern, and gradationally changed from the clastic unit. The clastic unit of the Taungnyo Formation composed mudstone, siltstone, sandstone, and calcareous mudstone, which were shut down due to the deep to shallow marine condition, and the global climate changed from cool to warm. The genera of brachiopod, forams, corals, bryozoans, echinoderms, and crinoids are collected from the Moulmein Limestone indicated shallow open marine environment within the photic zone under which. most form as biogenic particles in warm tropical (30-degree N to 30-degree S latitude) The carbonate unit of the bioclastic wackestone, bioclastic wackestone-packstone, mudstone facies are deposited under the carbonate productivity depth of light saturation zone between 10-20 m. The base of photic zone (nearly 100 m) is no carbonate productivity in which the shallow sea is cool in deeper condition, under which, the chert sediment deposited. The chert beds represent period of time with dominant accumulation of siliceous biogenic material at the sea floor. The Moulmein Limestone deposited under sea level fluctuation condition of above and below photic zone.

Keywords: Hpa-an, Moulmein Limestone, limestone and chert alternation, clastic shut down, carbonate productivity depth, chert precipitation, siliceous biogenic material

Introduction

The study area is located in southern part of Eastern Highland, Myanmar. The Kayin State of Map UTM Sheet no. 1697 /09 and one-inch topographic map No.94 H/9 (Fig. 1). The Upper Paleozoic (Carboniferous-Permian) rock units in Hpa-an area is the Taungnyo Formation and the Moulmein Limestone. The Moulmein Limestone consists predominantly of well-bedded, dark grey chert and limestone interbedded and argillaceous limestone. The Moulmein Limestone is underlain by the clastic sediments of the Taungnyo Formation which is composed of gray and yellowish shale, mudstone, yellowish or buff-coloured, fine-grained sandstone and siltstone with interbedded calcareous mudstone and marl. Bryozoans and Early Permian brachiopods were well preserved uppermost part of the buff-coloured siltstone and calcareous mudstone of the Taungnyo Formation. The field study and collected limestone samples ware studied detailed petrography of texture, composition, and fauna content by using petrographic polarizing microscope, and interpreted.

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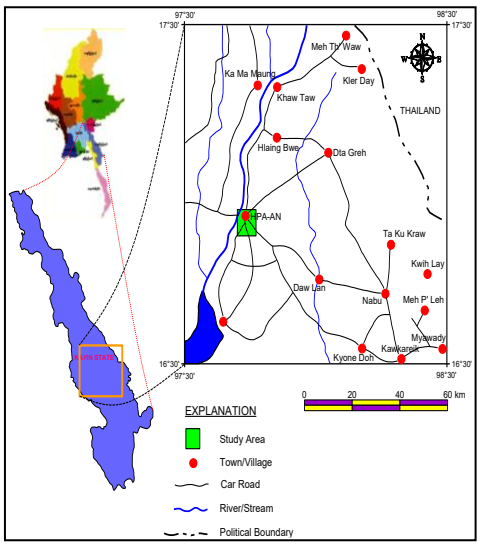


Fig. 1. Location Map of the Study Area

Regional Geologic Setting

Regional Geology of the study area and its environs is mentioned from Dr. Win Swe , 2012 (Figure 2). A sequence of argillite, quartzite and sandstone was grouped together by Leicester (Pascoe, 1959) as the Taungnyo Series named after the Taungnyo Range at the southern part of Mawlamyine. In Zwekabin Range, south of Hpa-an, an Upper Carbonferous fauna was recovered by Brunnschweiler (1970) from calcareous sandstone of the Taungnyo Series. It contains gastropod, brachiopod, bryozoans, corals and ostracods.

The carbonate sequence of the Shan State continues towards the south into the Kayah and Kayin State (Hobson, 1941) and further south in the area of Than Lwin, links up Moulmein limestone. The later had long been classified as Carboniferous or Permo-Carboniferous on the basis of a few megafossils.

The new fusulinid fauna are taken as positive evidence of the Permian age of Moulmein limestone. They form rugged mountains characterized by karstic phenomena (Chhibber, 1934) and rise up steep crags from the alluvial plains of the Than-Lwin river.

A profile drawn through the Zwekabin Range reveals that the Moulmein limestone is about 1,000 meter thick.

Regionally, the research area, Zwekabin Hill is mainly composed of carbonate sedimentary rocks with a general trend of NNW-SSE direction. It belongs to the Moulmein Limestone of Permian in age.

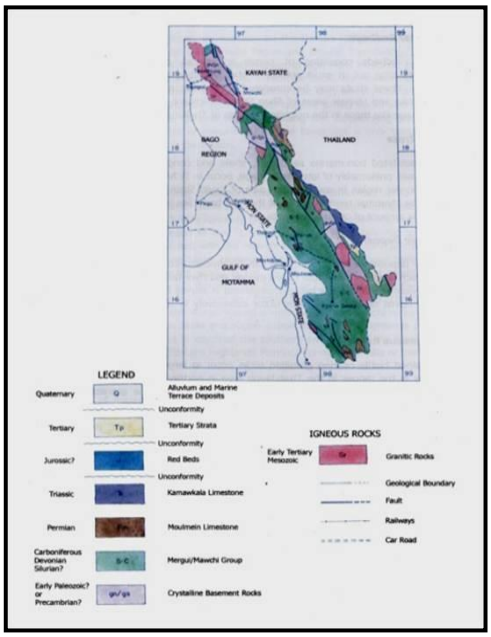


Fig. 2. Regional Geologic Setting of the study area (From Dr. Win Swe, 2012)

Materials and Method

It has been done the study of available papers of literature to study petrology of carbonate rocks. Topographic UTM map and GPS were used for the topographic elevations and location of sample collection in the field. By using the tape and compass for measuring the units and collection of rocks and fossil samples, and made by petrological analysis. The collected samples were prepared for thin- sections, and examined under the petrographic microscope to analysis the texture and constituent fauna, and classified the microfacies types according to Dunham (1962) and Flugel (2010). Some thin –sections were stain with Alizarin Red S to distinguish calcite and dolomite by using the technique of Dickson (1966).

Stratigraphy of the Hpa-an area

The stratigraphic units of the Hpa-an area composed Taungnyo Formation Carboniferous to Early Permian) and Moulmein Limestone (Permian), gradational contact with each other, Maung Thein, 2014 (Table 1). The nature of stratigraphic unit distribution in the Hpa-an area shows (Fig. 3).

Table (1) The stratigraphic classification of the Hpaan area (After Maung Thein, 2014).

Stratigraphic Units	Geological Age
Moulmein Limestone Group --------- Gradational contact----------	Permian
Taungnyo Formation	Carboniferous - Early Permian

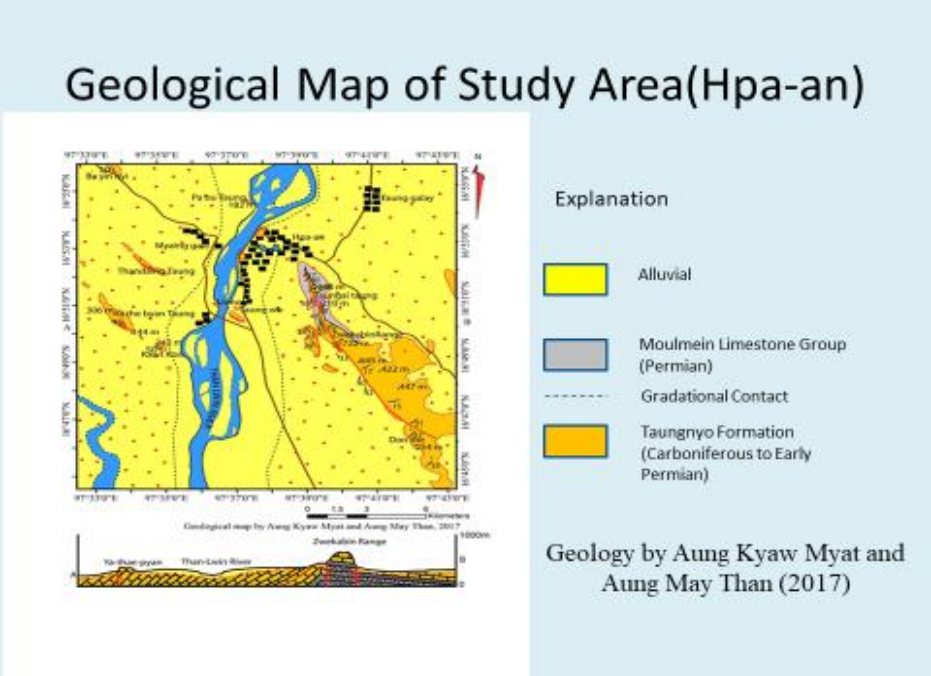


Fig. 3. Geological map of the study area, Hpa-an, Kayin State (after Aung Kyaw Myat and Aung May Than, 2017).

Taungnyo Formation

Lithology: The rocks are gray and yellowish shale, mudstone, buff-coloured, fine-grained sandstone and siltstone, calcareous mudstone and marl. At Kya-in hill, well observed the uppermost part of the unit was changed to limestone beds when the clastic unit orderly to carbonate and gradationally change to Moulmein Limestone (Fig. 4).

Fauna and Age: The calcareous sandstones at the top of the sequence contains gastropods, brachiopod (*Dictyoclostus,Mesolobus(?), Spirifer* spp.), bryozans, corals and ostracods and indicates an upper Carboniferous age (Brunnschweiler,1970). *Spinomartinia prolifica* assemblage occur in the yellowish coloured siltstone unit of the Taungnyo Formation exposed along the northwestern flank of the Zwekabin Range. These fauna assemblage indicates that the Taungnyo Formation is up to Early Permian (Late Sakmarian) (Zaw Win and Kyaw Htin Khine,2006). The three brachiopod biozones namely as *Arctitreta-Bandoproductus* Zone, *Spinomartinia prolifica* Zone and *Horridonia timanica* Zone from the Taungnyo Formation of Zwekabin Range which are regarded as Early Permian (Sakmarian to Kungurian) (Ohnmar Soe Yin et al., 2017).

Fig. 4. Gradational contact of Taungnyo Formation and Moulmein Limestone at the Kya-in Hill, Hpa-an Township, Kayin State.

Moulmein Limestone Group

Distribution: This unit mainly composed in the Zwekabin Range and isolated rugged hills in the Hpa-an area.

Lithology: It is mainly composed of well-bedded dark grey, fossiliferous limestone, chert intercalated limestone, and dolomitic limestone. Chert significantly common in the form of bands, layers, nodules and patches. Dark coloured chert bands formed as nodules contracted along bedding planes and coalescing to form continuous irregular layers (Fig. 5a, b).

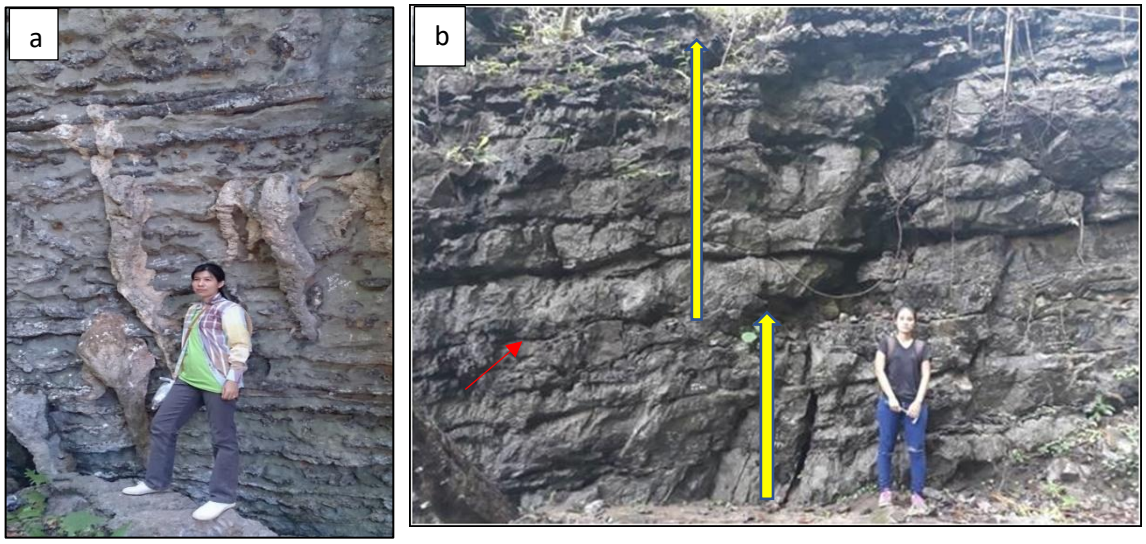


Fig. 5a, b. The outcrop nature of the Moulmein Limestone, (a & b) chert and limestone interbedded unit shows dark colour chert bands stand out differential weathering pattern, note with slightly irregular to wavy margins within limestone, and (c) thinning upward sequences of the Moulmein Limestone noted nodular and wavy bedding nature (red arrow), at the path near top of Mt Zwekabin, Hpa-an Township, Kayin State.

Fauna and Age: Common fossils of brachiopods, corals, crinoids, bryozoans, gastropod and fusuline foraminifera are abundant. The fossil content and stratigraphic position of the Moulmein limestone suggested to Permian (Guadalupian) age. The biotic association of coral faunas (solitary and rugose corals) and fusuline fauna (*Parafusulina*, *Eopolydiexodin*a and *Yangchienia*) from Moulmein Limestone are regarded as Middle Permian (Wordian to Capitanian).

Petrology of limestone and chert interbedded unit

Description:The limestone interbedded with nodular to bedded chert bands are the most conspicuous characteristic of Moulmein Limestone. The chert content is more pronounce upper than lower parts. The bioclastic wackestone, bioclastic wackestone-packstone, and mudstone facies are observed, contains high diversity of fauna assemblages (Fig. 6a). The main bioclastic constituent fauna are bryozoan (Fig. 6a, 8), crenoids, brachiopods (Fig.9, 10, 11), corals, fusulinids, and no oolite and intraclastic grains. The mega fossils are stand out at the bedding surface, and undifferentiated micro-filamentous with peloid grainstones are also found (Fig. 6b). At the Kamawnyaw Taung, the clonial coral of Huayunophyllum? occurred (Fig. 7a).

The chert beds represent period of time with dominant accumulation of siliceous biogenic material at the sea floor. Recrystallization during burial stage diagenesis is has been largely in situ. The chert bands in limestone shows dissolution seams between beds with slightly irregular to wavy margins within limestone (Fig. 5a, b, c).

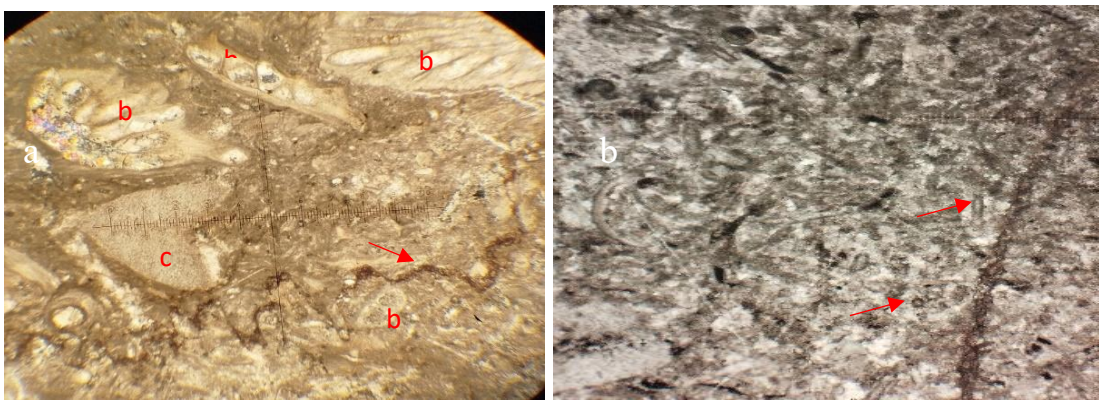


Fig. 6. a. Photomicrographs of the bioclastic wackestone-packstone shows bryozoan (b), and echinoderm fragments (c) cemented by micrite and calcite spar cement filled in the pore space. Note the reddish brown coloured microstylolite seam (arrow) with insoluble residues. (6.b). bioclastic peloidal wackestone shows thin shell bioclasts of ostracods (middle left) and peloidal grains (upper right) cemented by microspar. Moulmein Limestone, Zwekabin Range, Hpa-an.

Interpretation: The component microfacies are micrite, bioclastic wackestone, bioclastic wackestone-packstone, and dolomite. The mega fossils of brachiopod, coral, crenoides, and larger foram are mainly cemented by microcrystalline calcite cement (micrite). The presence of micritic matrix indicates slow sedimentation rate in low energy environment. The high diversity of fauna may indicate open marine setting and the predominance of bryozoans suggests intertidal to subtidal depositional setting in areas of low sedimentation (Flugel, 2010). In the upper part the Zwekabin section, micritic limestone are interbedded with dark colour chert in which the fusulinid fauna bearing packstone is commonly observed as a main component (*Parafusulina* sp., Pseudofusulina sp.). According to Flugel (2010) these larger benthic foraminifers are common in shallow marine environment within the photic zone.

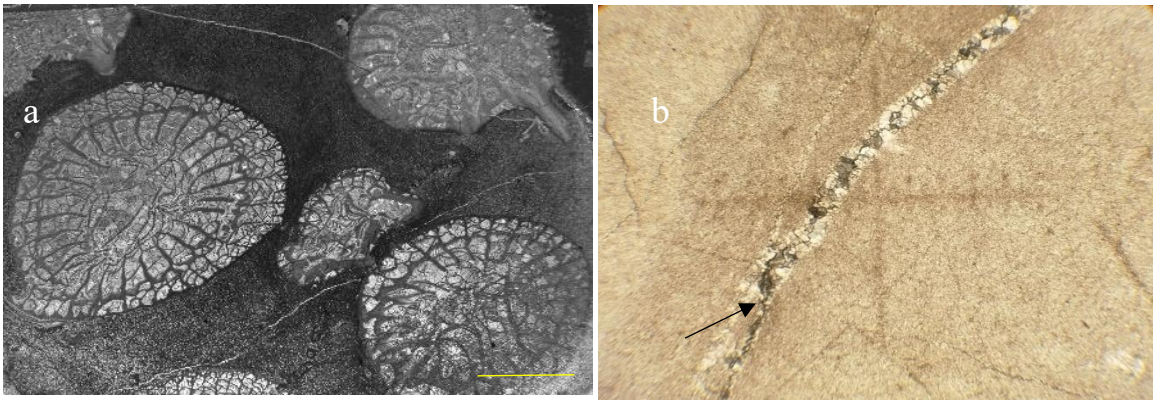


Fig.7. a. Thin section photograph of the colonial coral (? Huayunophyllum) the Moulmein Limestone, at Kamawnyaw Taung. Note axial structure very simple, narrow, anular parts of tabulae wide. Scale bar is 1 cm, (7b) mudstone microfacies with secondary calcite vein filled with bladed calcite spar lies on the wall of pore space (arrow).

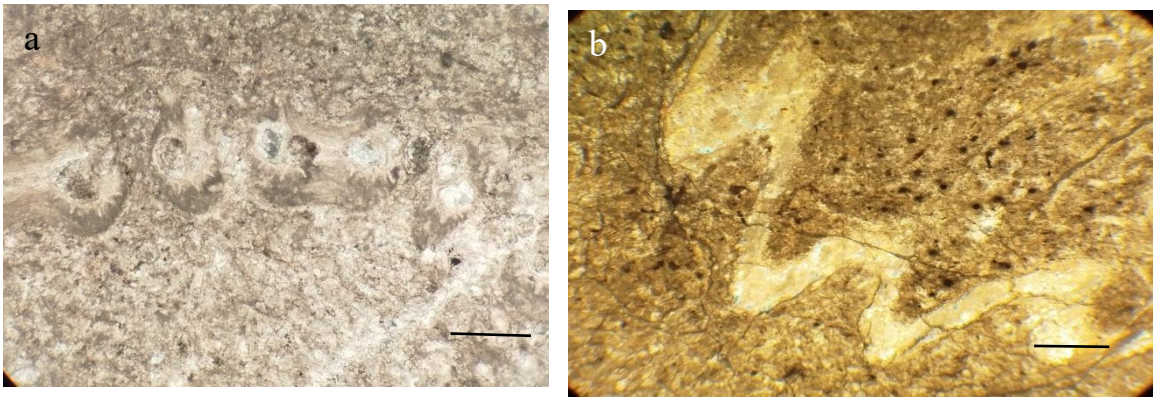


Fig. 8. a & b. Photomicrographs of the bioclastic wackestone shows (8.a) fenestrate bryozoan and (8. b) large brachiopod shell cemented by micrite. Moulmein Limestone, Zwekabin Range, Hpa-an. Scale bar is 0.5 mm

The chert beds represent period of time with dominant accumulation of siliceous biogenic material at the sea floor. Recrystallization during burial stage diagenesis is has been largely in situ. There are no chert replacement in the limestone microfacies indicate the nodular and banded cherts are deposited by the siliceous biogenic material at the sea floor under shallow marine condition respect to the carbonate sedimentation.

Discussion

Discussion on lithology

The Moulmein Limestone is mainly composed the limestone and chert interbedded unit deposited at the early Permian in age where the environment is shallow marine warm condition.

Limestone: The carbonate productivity (carbonate precipitation) depth of light saturation zone between 10-20m which is light saturation zone for warm condition to precipitate the calcium carbonate and also biogenic particles in warm tropical condition between 30-degree N to 30-degree S latitude (Fig 9).

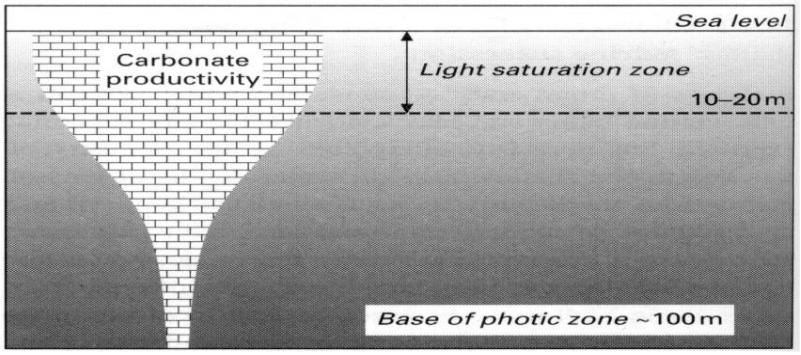


Fig. 9. The relationship between water depth and biogenic carbonate productivity which is greatest in the photic zone.

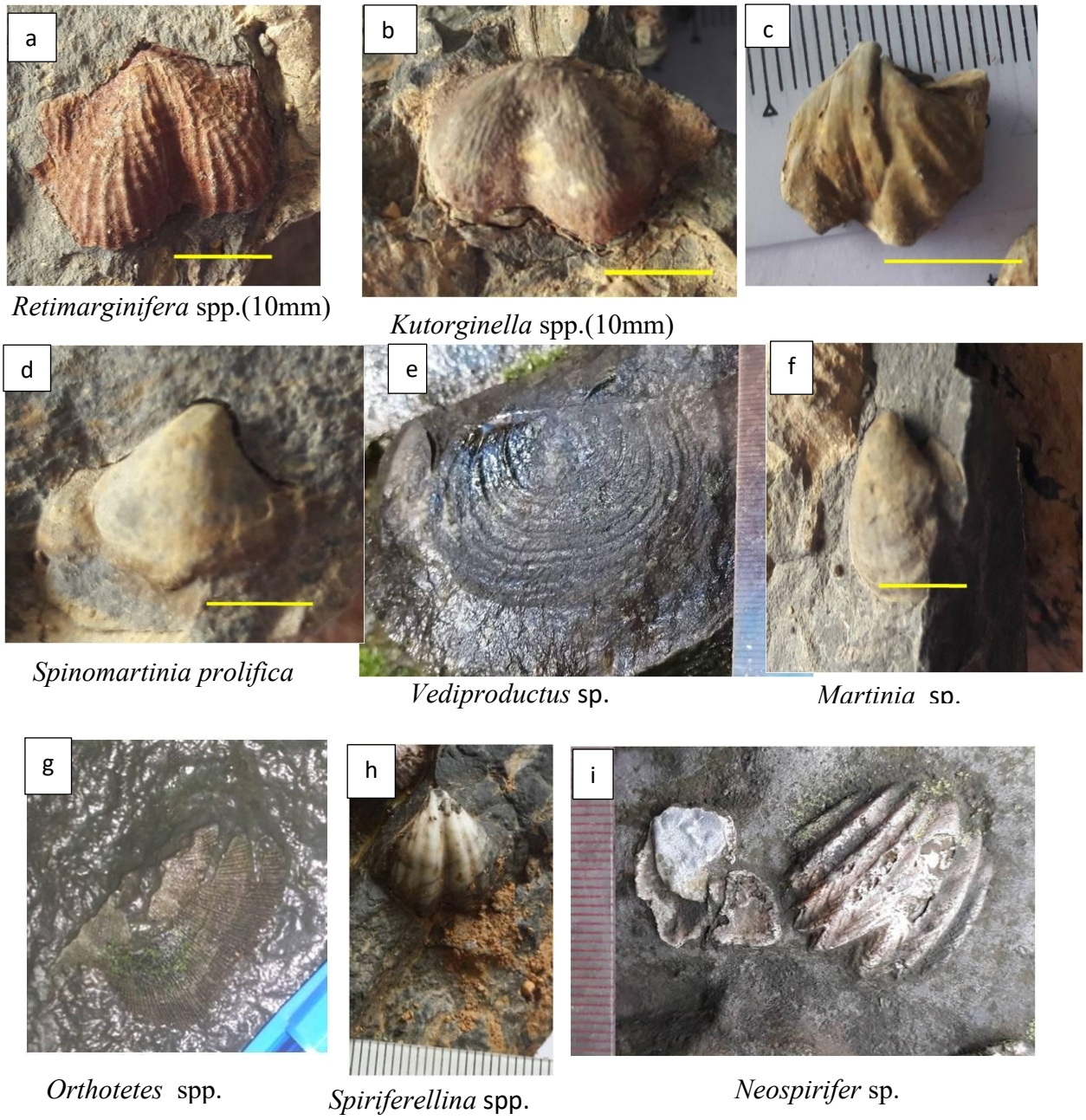
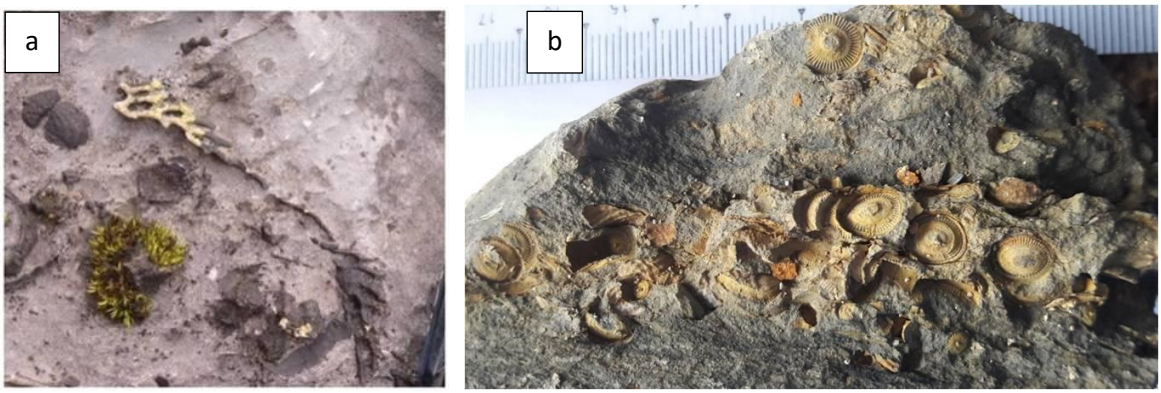
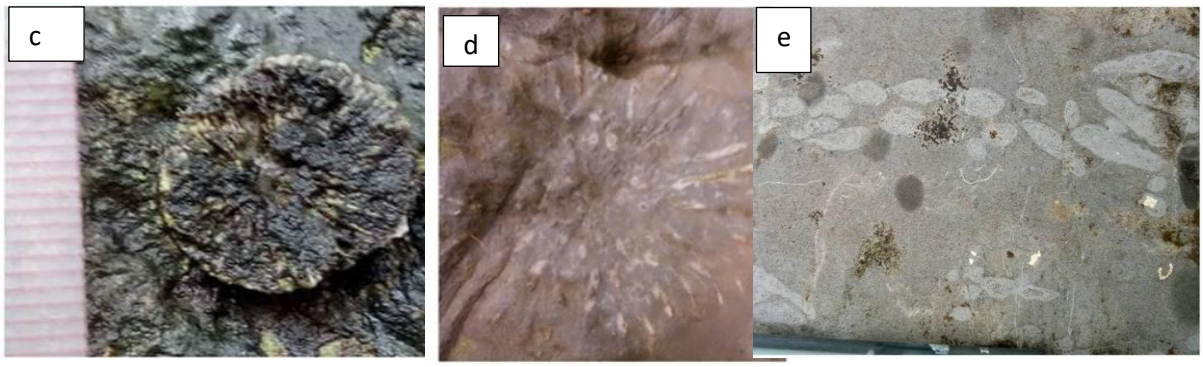


Fig. 10. a-,. The early Permian brachiopods from the limestone unit of the lowermost part of the Moulmein Limestone, Zwekabin Range, Hpa-an, Kayin State.





Solitary rugose coral (? *Cyathoxonia*) Colonial tabulate coral Fusulinides (*Parafusulina* spp.) (*Syringopora*)

Fig. 11. a-e, The mega fauna of the Moulmein limestone, at the lower part of the unit, Zwekabin Range, Hpa-an, Kayin State. (after Ohnmar Soe Yin et. al., 2017).

Chert: The Moulmein Limestone mainly composed chert and limestone interbedded unit. Chert is fine-grained siliceous sedimentary rocks have banded and nodular form. Bedded cherts are generally 1-10cm thick, with slightly irregular to wavy margins, within limestone (Fig.5a & b). Nodular cherts are ovoid to irregular nodules very variable in size (long diameter 1-30cm) commonly contracted along bedding planes, and coalescing to form continuous irregular layers (Fig.5a & b).

The bedded cherts are seasonal influence in the carbonate sediment aggradation-progradation event when the shallow shelf sea level is above photic zone. The chert bands represent period of time with dominant accumulation of siliceous biogenic material at the seafloor. Recrystallization during burial diagenesis is has been largely in situ. The black colour is due to preservation of organic carbon.

Discussion on petrology

Biogenic carbonate production is inhibited by the presence of clastic material, so the areas of low input of detritus are potential sites for carbonate deposition. At the end of Carboniferous time, the clastic input of Taungnyo Formation was shut down, and marine transgression condition may be suitable for carbonate sedimentation of Moulmein Limestone through the Permian. The amount of biogenic carbonate produced is determined by the productivity within the food chain are dependent on the availability of light, and penetration by sunlight is controlled by the water depth and the amount of suspended material in the sea (Fig.9). Photosynthetic organisms typically flourish in the upper 10 to 20 metres of the sea. This shallow region of high biogenic productivity is referred to as the carbonate factory (Fig. 9). Increased or reduced salinity inhibits production and the optimum temperature is around 20 to 25°C. The chert in the Moulmein Limestone is not secondary replacement because of the chert bands are sharp contact with limestone and the chert nodules and bands are coalescing to form continuous irregular layers (Fig.5a & b).

Discussion on paleontology

The brachiopods are the most abundant and diverse benthonic fossil group in the Paleozoic oceans it was the last appearance of the end of Carboniferous and Early Permian period that the Early Permian brachiopods maintained their diversity and abundance during Phanerozoic (Fig. 10,11). The *Spinomartinia prolifica* Zone was established based on its abundance from the Ko Yao Noi Formation, which was considered to a part of Chihsian of South China (Waterhouse, 1981) which was considered Lebyin Group at Lebyin area and also

present study area of the Taungnyo Formation in the Zwekabin Range (Kyi Pyar Aung et. al., 2018). And also, Ohnmar Soe Yin et. al. 2018, studied the Early Permian biotic association from the Moulmein Limestone in Pawtaw Taung, Hpa-an Township point out the sedimentary environment under low latitude condition of Sibumasu Terrain. The brachiopods, bryozoan, corals, and crinoids of common bioclasts in the limestone units are dominant benthonic fossil groups in the Paleozoic oceans. These biogenic particles diversity indicate shallow, warm, sea condition of tropical low latitude (between 30-degree N and 30-degree S).

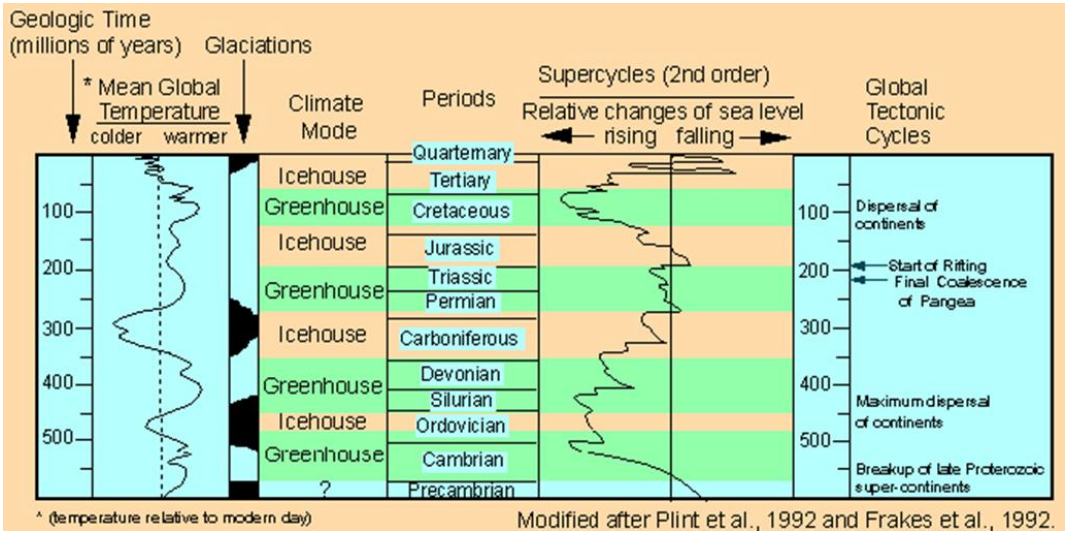


Fig. 12. The mean global temperature and relative changes of sea level curve in geological history.

Conclusion

At the end of Carboniferous time, mean global temperature was initially changed from cold to warmer, climate mode condition moves from icehouse to greenhouse, and the relative sea level is falling condition (Fig. 12). At the time of Permian, the Moulmein Limestone unit deposition was favorable condition as the global warming and relative change of sea level falling to shallow marine environment. The major component of microfacies are bioclastic wackestones, mudstone indicate the low energy condition.

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