

## **STRATIGRAPHIC PALEONTOLOGY OF THE MIDDLE DEVONIAN UNIT IN HSIPAW AREA, NORTHERN SHAN STATE**

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### **Abstract**

The next occurrence of the Middle Devonian Unit which is the equivalent unit of the Pwepon Limestone in Pyinoolwin Township, recognized in the Maymyo Formation, Hsipaw area, northern Shan State. It exposed as an isolated outcrops of only one soil-covered hill which is now seeing as road-cut section near Kontha village. Primary petrographic study indicate that the limestone varies essentially medium- to coarse, locally argillaceous, calcilutite with abundant biogenic debris in the middle part and an intraclastic biogenic calcilutite with fine- to medium-grained in the lower and upper parts. Microstylolites with iron stained argillaceous concentrations and brecciation are developed in places. The fossiliferous unit is laterally passed into dolomite or dolomitic limestone which is regarded as the sandwiched unit of the Maymyo Formation. Initial fossil studies have led to the recognition of rugose, tabulate and brachiopods faunal assemblages. These are solitary rugose corals of *Temnophyllum*, *Grypophyllum*, *Macgeea*, *Cyathophyllum*, *Acanthophyllum*, *Dohmophyllum* and abundant colonial rugose corals of *Argutastrea*; tabulate corals of *Alveolites*, *Coenites*, *Favosites* and brachiopods of *Spinatrypa*, *Atrypa*, *Desquamatia*, *Strophomena*, *Reticulariopsis*, *Athyris* and *Xystrostrophia*. This coral assemblage is quite similar to Pwepon Limestone but this unit is more argillaceous, fossiliferous, more abundant brachiopods and corals attain larger size. This unit is not previously described in Hsipaw area.

**Keywords:** Middle Devonian, Hsipaw area, tabulate and rugose corals

### **Introduction**

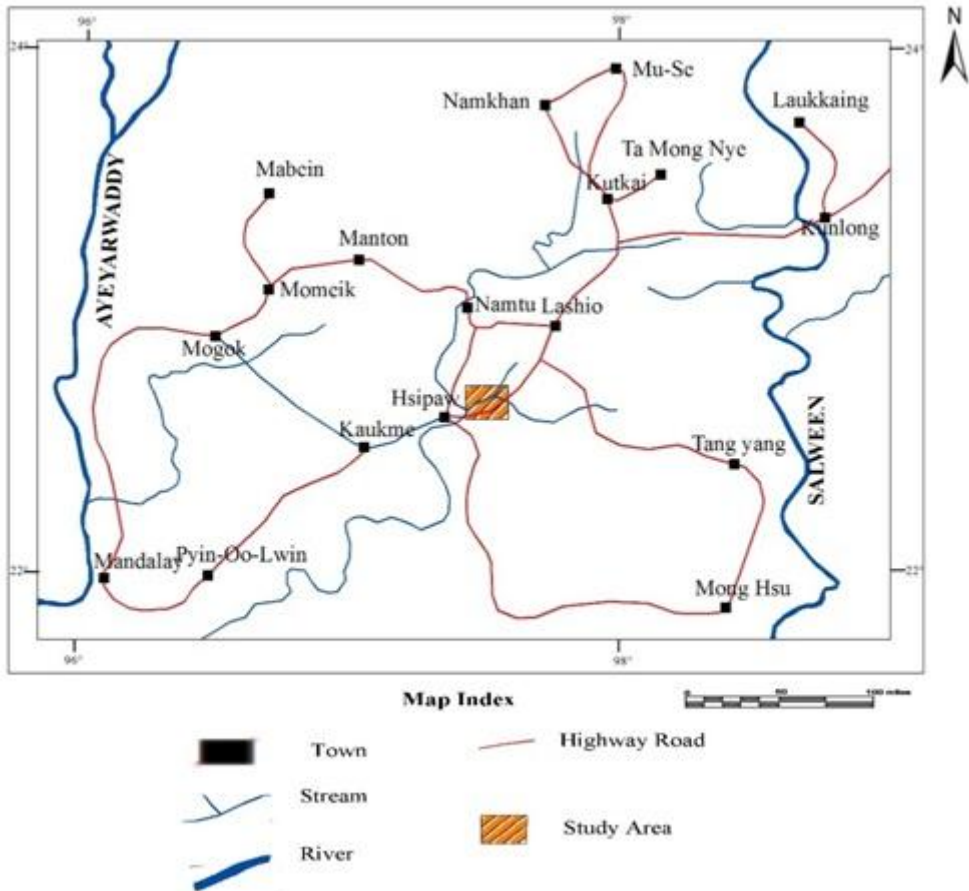
The study area, located in Hsipaw Township is bounded by north latitude 22°36'48" to 22°42'12" and East Longitude 97°24' to 97°32'20" in UTM map no. 2297 (6 - 10). It is about 5 miles long in the north-south direction and 11.18 miles wide in the east-west direction, approximately covering 55.35 square miles.

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Mandalay–Lashio road runs across the study area from southwest to northeast. It can be accessible by car or train in all seasons. The location map of the study area is shown in Figure (1).



**Figure 1:** Location map of the study area

### Methods of study

Before the field investigations have been carried out, the previous literatures and geological map were studied. The satellite image was used to obtain general nature of geology of the area and the best suitable traverse routes. One inches to 1000 m UTM topographic map is used as a base map. Numerous traverses across the regional structure were measured. The

representative samples and diagnostic fossils were systematically collected, properly marked and carefully packed for detailed laboratory investigations.

Representative rock and fossil samples were cut into thin section and these were studied under a polarizing microscopic identification of micro and mega fossils and detailed study to determine the type and age of the rock units. After that, fossils are classified and identified for systematic description.

### **Previous Works**

The numerous works have been done on the geology, stratigraphy and paleontology of northern Shan State. It is noteworthy that the following critical valuable tasks were carried out in the study area and its environs. La Touche (1913), Pascoe (1959), Brunnsweiler (1970) and Amos (1975) made a regional geology and the Post Silurian geology of Myanmar of the northern Shan State. Local studies are carried out by Khin San (2010) had done the work on the Hsipaw-Bawgyo Area, Northern Shan State for her PhD dissertation and Cho Cho Lwin (2002) & Zin Mg Mg Thein (2002) studied the geology and stratigraphy of the Hsipaw – Bawgyo Area for their M.Sc dissertation.

### **Result and Discussion**

The study area is mainly covered by carbonate and clastic sedimentary rocks of Late Paleozoic to Mesozoic age. There are five lithostratigraphic units of Formation rank;

5. Hsipaw Red Bed (Late Jurassic)
4. Tati Limestone (Middle Jurassic)  
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3. Nwabangyi Dolomite Formation (Late Permian- Middle Triassic)
2. Plateau Limestone (Early - Middle Permian)  
~~~~~
1. Maymyo Formation (Middle Devonian)

Geological map of the study area is shown in Figure (2). The sandwiched unit of the Pwepon Limestone of the Maymyo Formation is described in detailed because this study is mainly emphasized on the fossiliferous Middle Devonian unit.

### **Stratigraphy of the Middle Devonian Unit**

In the study area, Maymyo Formation is the oldest unit of Middle Devonian age. This Formation is well exposed in northeast of San Lau (Apyin), east and southeast of San Lau (Atwin) village, miles post of 164/3 beside the Mandalay-Lashio car road, east of Sang hang village and west of NawngHken village.

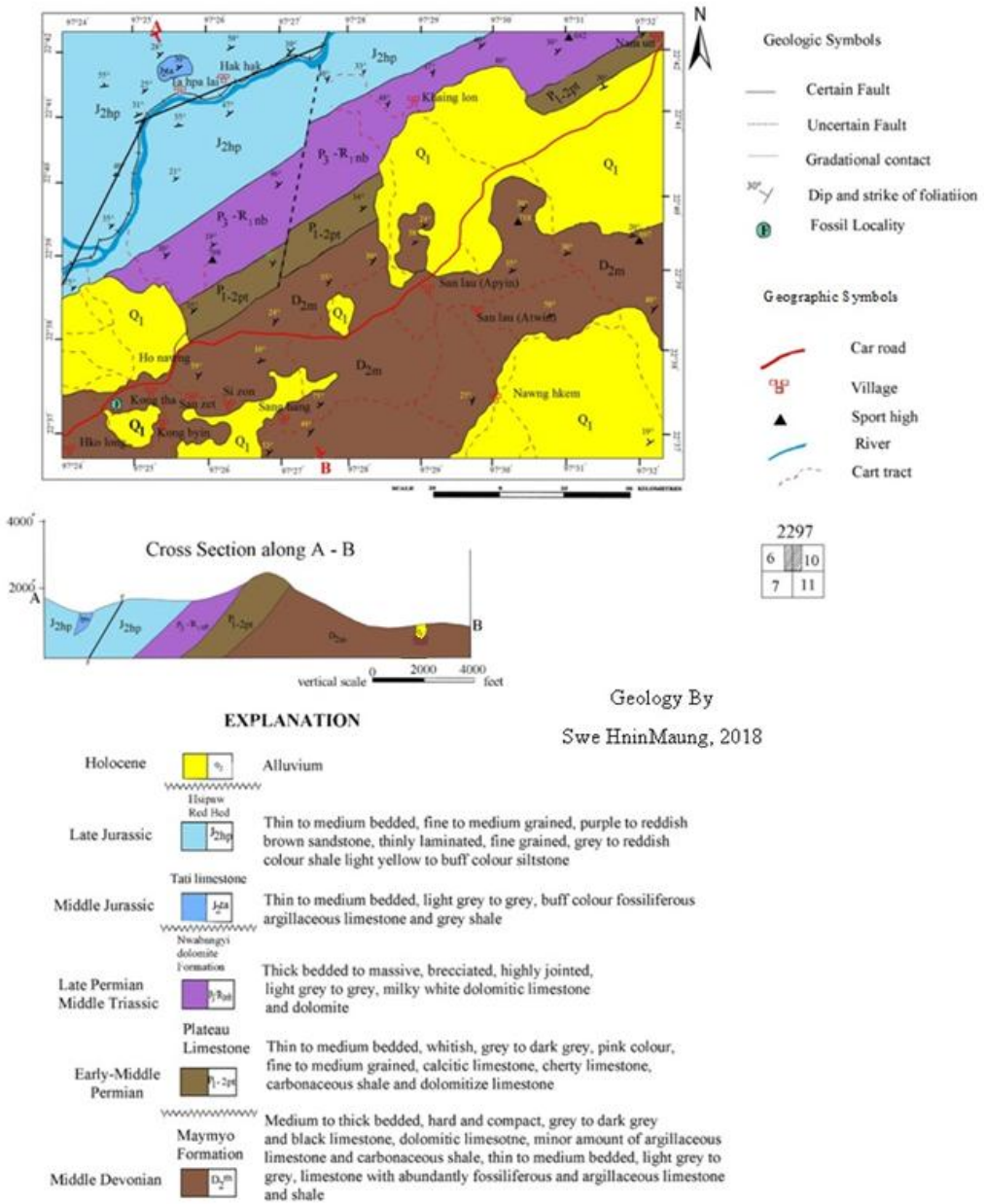


Figure 2: Geological map of the study area

This unit is mainly composed of dolomite, dolomitic limestone and minor amount of argillaceous limestone and carbonaceous shale (Figures.3-8). Thin to medium-bedded, light-grey to grey, limestone and argillaceous limestone with abundantly fossiliferous (rugose and tabulate corals and brachiopods) interbedded with buff-coloured shale and thin-bedded, black limestone unit are sandwiched between the limestone and dolomitic limestone. This sandwiched nature is clearly seen near Aungtheikhtee pagoda, west of Kontha village. This fossiliferous unit is considered as the equivalent unit of the Pwepon Limestone. The contact with the underlying unit cannot be seen because this unit is the oldest unit of the study area. The nature of boundary with the overlying Plateau Limestone is unconformable contact in the study area.

Maymyo Formation is rare in fossils because this Formation is subjected by highly brecciation and intensely dolomitization. But in the study area, gastropods, crinoid stems and corals can be observed in the Pwepon Limestone of the Maymyo Formation. On the basis of stratigraphic position, the lithologic character and the sandwiched unit of fossiliferous Pwepon Limestone is indicating Middle Devonian (Eifelian to Givetian) age.



**Figure 3:** Medium to thick bedded, light grey to grey, highly brecciated and well jointed dolomite and dolomitic limestone of the lower part of Maymyo Formation (N 22° 39' 24" and E 97° 28' 56")



**Figure 4:** Thick to massive grey to dark grey, highly brecciated and highly jointed dolomite and dolomitic limestone of the lower part of Maymyo Formation.(N 22° 38' 56" and E 97° 29' 20")



**Figure 5:** Iron stained in the bedding plain and joint plain of the dolomitic limestone in lower part of the Maymyo Formation (N 22° 38' 46" and E 97° 26' 25")



**Figure 6:** Medium to thick bedded, grey to light grey, calcitic limestone intercalated with siltstone of the upper part of the Maymyo Formation. (N 22° 39' 10" and E 97° 32' 05")



**Figure 7:** Hard and compact limestone with calcite veins in the Maymyo Formation. (N 22° 38' 16" and E 97° 28' 47")



**Figure 8:** Calcitic limestone with solution pits on the weathered surface of the Maymyo Formation (N 22° 39' 46" and E 97° 31' 50")

### **Pwepon Limestone**

In the study area, Pwepon Limestone is mainly exposed in the south western part. The best exposures of Pwepon Limestones occur the road cut section at the mile post (156/5) of the Mandalay-Lashio car – road (N22°53'36" and E96°40'50").

The Pwepon Limestone is the sandwiched unit of the Maymyo Formation which laterally passed into dolomite or dolomitic limestone. It is the escaped unit of the dolomitization. It consists of thin- to medium-bedded,

buff colour, grey to black, fine- to medium-grained, soft and indurated, limestone, calcareous limestone, argillaceous limestone, carbonaceous shale and grey shale (Figures. 9-18). Where shale or argillaceous materials is dominated, fossils fragments (Corals and Brachiopods) are most abundantly occurred and easily extracted from this unit. Detailed description for measured section of the Pwepon Limestone is shown in Table (1). This unit is continuously exposed along Mandalay–Lashiocar road mile post (156/3) and (62) meter in thickness. The biostratigraphic columnar section of the Pwepon Limestone is shown in (Figure 19).

This Limestone is the fossiliferous unit containing a number of rugose and tabulate corals, brachiopods and crinoids. The following fauna are collected from the Pwepon Limestone of the study area; (plates 1-2).

**Coelenterata:**

**Rugosa:** *Temnophyllum pyinoolwinensis*, *Temnophyllum creber*,  
*Temnophyllum minimum*, *Macgeebirmanicum*,  
*Macgeebathycalyx*, *Macgeaeifeliana*,  
*Stringophyllum* sp., *Gurichiphyllum* sp.,  
*Grypophyllum* sp., *Argutastrea* sp.

**Tabulata:** *Favosites goldfusi*, *Alveolites suborbicularis*,  
*Alveolites aff. expatiate*, *Alveolites sillusa*  
*Coenites escharoides*, *Alocystis conigera*

**Brachiopoda:** *Spinatrypa* sp., *Uncinulus* sp., *Desquamatia* sp.  
*Reticulariopsis eifiensis*, *Athyris* sp., *Xyrostrophias* sp.,  
*Strophomena* sp., *Atrypa* sp., *Markitoechia* sp.



**Table 1: Detailed description for measured section of the Pwepon Limestone (arranged in stratigraphic order)**

Unit No.	Lithology (Brief Description)	Thickness (meters)	
		Unit thickness	Total From base
12	Medium- to thick- bedded, light grey to dark grey, calcitic limestone interbedded with light grey to grey argillaceous limestone	7	62.2
11	Medium- to thick- bedded, black limestone with calcite veins	4	55.2
10	Medium- to thick- bedded, light grey to dark grey, calcitic limestone interbedded with thin- to medium-bedded, light grey to grey argillaceous limestone	11	51.2
9	Thin- to medium- bedded, milky white, grey to light grey, highly jointed calcitic limestone	5.3	40.2
8	Thin- to medium- bedded, grey to light grey, argillaceous limestone	1.1	34.9
7	Thin- to medium- bedded, light grey to black limestone interbedded with grey to dark grey shale containing corals ( <i>Argutastrea</i> sp., <i>Gurichiphyllum</i> sp., <i>Alveolites</i> sp., <i>Coenites</i> sp.) and brachiopods ( <i>Markitoechia</i> ? sp., <i>Xystrophia</i> sp.)	9.5	33.8
6	Thin-bedded, black limestone interbedded with buff colored shale with corals ( <i>Cyathophyllum</i> sp., <i>Temnophyllum</i> sp., <i>Macgeea</i> sp., <i>Alveolites</i> sp., and <i>Coenites</i> sp.) and brachiopods ( <i>Spinatrypa</i> sp., <i>Atrypa</i> sp., <i>Reticulariopsis eifiensis</i> ,	5.2	24.3
5	Thin-bedded, grey limestone interbedded with grey shale containing abundant brachiopods ( <i>Strophomena</i> sp., <i>Spinatrypa</i> sp., <i>Atrypa</i> sp., <i>Athyris</i> sp., <i>Uncinulus</i> sp.) and corals ( <i>Macgeea</i> sp., <i>Temnophyllum</i> sp., <i>Favosites</i> sp., <i>Alveolites</i> sp., and <i>Coenites</i> sp.)	2	19.1
4	Grey shale containing small brachiopods	1.2	17.1
3	Medium-bedded, light grey to black, hard and compact limestone containing corals with <i>Stringophyllum</i> sp., <i>Grypophyllum</i> sp., <i>Alveolites</i> sp. and <i>Coenites</i> sp.	2.3	15.9
2	Thin- to medium bedded, grey to black, argillaceous limestone intercalated with shale containing corals	7.6	13.6
1	Thin- to medium -bedded, light to dark grey, argillaceous limestone	6	

The occurrence of above faunal assemblage indicates that the age of the Pwepon Limestone in this area can properly be designated as the Middle Devonian (Eifelian to Givetian).

This Limestone can be correlated with the Padaukpin coral reef of La Touche (1913), Padaukpin Biostrome of Anderson (1969), Padaukpin Limestone Member of Aye Ko Aung (1995), Padaukpin Limestone of Khaing Khaing San (2005), Pwepon Limestone of Khaing Khaing San (2005) and Aye Ko Aung (2012).



**Figure 9:** Medium-bedded, light grey to buff colored shale and argillaceous limestone containing abundant tabulate and rugose corals in the lower part of the Pwepon Limestone (N 22° 37' 45" and E 97° 25' 20")



**Figure 10:** Well-bedded, argillaceous limestone interbedded with light grey to grey shale containing abundant tabulate and rugose corals in the lower part of the Pwepon Limestone (N 22° 37' 46" and E 97° 25' 22")



**Figure 11:** Thin to medium bedded, grey to buff colored argillaceous limestone intercalated with shale containing abundant corals and few brachiopods of the lower part of Pwepon Limestone (N 22° 37' 50" and E 97° 25' 24")



**Figure 12:** Medium to thick bedded, light grey to grey, buff colour highly jointed calcitic limestone of the Pwepon Limestone (N 22° 37' 30" and E 97° 25' 05")



**Figure 13:** Thin to medium bedded, light grey to buff colour, argillaceous limestone in the middle part of the Pwepon Limestone (N 22° 37' 32" and E 97° 25' 10")



**Figure 14:** Thin- to medium-bedded, yellowish to buff colour argillaceous limestone intercalated with carbonaceous shale in the middle part of the Pwepon Limestone (N 22° 37' 36" and E 97° 25' 51")



**Figure 15:** Medium-bedded, dark grey to black carbonaceous limestone intercalated with grey shale in the middle part of the Pwepon Limestone (N 22° 37' 38" and E 97° 25' 19")



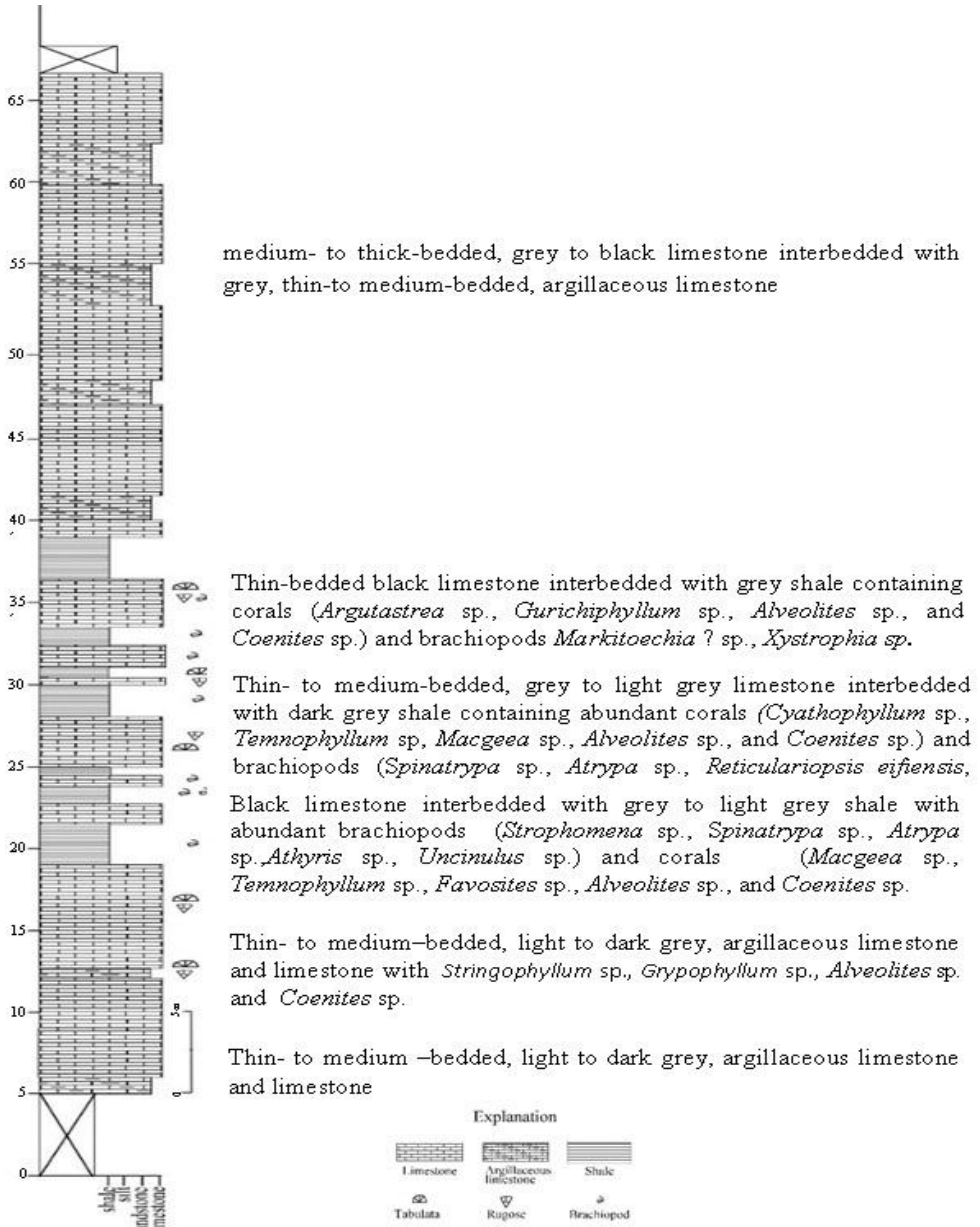
**Figure 16:** Medium- to thick-bedded, grey to buff colored argillaceous limestone and calcitic limestone intercalated with the thinly bedded carbonaceous shale of the upper part of Pwepon Limestone (N 22° 37' 48" and E 97° 25' 29")



**Figure 17:** Medium- to thick-bedded, grey to dark grey calcareous limestone with abundant calcite veins in the upper part of the Pwepon Limestone (N 22° 37' 41" and E 97° 25' 16")



**Figure 18:** Medium-bedded, dark grey limestone with iron stained mud cracks on the bedding plane of the upper most part of the Pwepon Limestone (N 22° 37' 50" and E 97° 25' 41")



**Figure 19:** Stratigraphic measured section of the Pwepon Limestone with the occurrence of fossils (mile-post 156/3 furlong) along Mandalay - Lashio Car-road; base at N 22° 37' 28" and E 97° 25' 18" and top at N 22° 37' 48" and E 97° 25' 29".



## Plate 1



All corals from Middle Devonian, Pwepon Limestone, Hsipaw, northern Shan State

**Figures:** a-b. *Macgeea*, s. c-d. *Temnophyllum* sp., e. *Grypophyllum* sp., f. *Cyathophyllum* sp., g. *Stringohyllum* sp., h. *Gurichiphyllum* sp., i. *Argutastrea* sp., j. *Alveolites* sp., k. *Favosites* sp., l. *Coenites* sp., m. *Aulocystic* sp.

## Plate 2



All figures from the Middle Devonian, Pwepon Limestone, Hsipaw, northern Shan State

**Figure:** a. *Strophomena* sp.; b. *Spinatrypa* sp., c. *Atrypa* sp., d. *Athyris* sp., e. *Markitoechia* ? sp., f. *Xystrophia* sp., g. *Uncinulus* sp., h. *Reticulariopsiseifiensis*, i. *Desquamati* sp., j. *Spinatrypa* sp., k. *Desquamati* sp.

## Paleontology of the Pwepon Limestone

The Pwepon Limestone is the sandwiched unit of the Maymyo Formation. It is laterally passed into dolomite or dolomitic limestone. The lower most part of the Pwepon Limestone is thin-bedded, light grey argillaceous limestone and thin- to medium-bedded, grey to dark grey limestone with abundant calcite vein. The first occurrences of corals (*Stringophyllum* sp., *Grypophyllum* sp., *Alveolites* sp. and *Coenites* sp.) occur in thin-bedded, light grey to grey argillaceous limestone and limestone. The fossils are abundantly occur in medium-bedded, light grey to black, hard and compact limestone interbedded with grey shale containing abundant brachiopods (*Strophomena* sp., *Spinatrypa* sp., *Atrypasp.*, *Athyris* sp., *Uncinulus* sp.) and corals (*Macgeea* sp., *Temnophyllum* sp., *Favosites* sp., *Alveolitessp.*, and *Coenites* sp.).

The middle part of the Pwepon Limestone is also fossiliferous with corals (*Cyathophyllum* sp., *Temnophyllum* sp., *Macgeea* sp., *Alveolitessp.*, and *Coenites* sp.) and brachiopods (*Spinatrypa* sp., *Atrypasp.*, *Reticulariopsiseifiensis*, *Desquamatiasp.*) which occur in thin- to medium-bedded, light grey to grey limestone interbedded with dark grey shale. The abundant colonial rugose corals of *Argutastrea* sp. and solitary *Gurichiphyllum* sp., tabulate corals of *Alveolitessp.*, and *Coenites* sp.; and brachiopods of *Markitoechia* ? sp., *Xystrophiasp.* occur in thin-bedded, black limestone interbedded with grey shale. The upper most part of the Pwepon Limestone is interbedded unit of limestone and argillaceous limestone containing a few fossil fragments of tabulate corals and small brachiopods.

## Age of the Fauna

The Padaukpin fauna designated as Eifelian age by Reed (1908). Anderson *et al.* (1969) described systematically the Padaukpin brachiopod fauna referring to conodont and foraminifera. The Padaukpin fauna has marked affinity with the Eifelian brachiopod fauna of the Western Europe and was regarded to be of Eifelian age. Aye Ko Aung (1995) described some new rugose coral fauna from Padaukpin and Pwepon area which closely resemble with the Eifelian rugose corals of North Queensland and Southern China. Khaing Khaing San (2005) described and illustrated the rugose corals from



Padaukpin and Pwepon Limestones and pointed out that they have close affinities with contemporaneous fauna in Europe, South China and Australia and designated the age of the Padaukpin Limestone as Eifelian. Khin Nyein Chan Thar (2017) also studied the rugose corals from Padaukpin Limestone, Lashioarea and assigned the Middle Devonian. Comparison of the rugose coral fauna occurrence of Padaukpin, Pwepon, Lashio and Hsipaw areas is shown in Table (2).

**Table 2: Correlation of the present described genus of Hsipaw area with the previously described Middle Devonian genus of Myanmar.**

No.	described rugose corals from Myanmar	Padaukpin area (Khaing Khaing San, 2005)	Pwepon area (Khaing Khaing San, 2005)	Lashio area (Khaing Khaing San <i>et al</i> , 2017)	Hsipaw area (Present study)
1	<i>Calceola</i>	√		√	
2	<i>Cystiphyllodes</i>	√			
3	<i>Puanophyllum</i>	√	√		
4	<i>Metrionaxon</i>		√		
5	<i>Catactotoechus</i>	√	√		
6	<i>Acanthophyllum</i>		√	√	
7	<i>Dohmophyllum</i>		√		
8	<i>Grypophyllum</i>		√	√	√
9	<i>Strigophyllum</i>	√		√	√
10	<i>Disphyllum</i>	√	√		
11	<i>Argutastrea</i>		√		√
12	<i>Spinophyllum</i>	√			
13	<i>Temnophyllum</i>	√	√	√	√
14	<i>Hexagonaria</i>		√		
15	<i>Phillipsastrea</i>	√	√		
16	<i>Macgeea</i>	√	√	√	√
17	<i>Thamnophyllum</i>	√			
18	<i>Heliophyllum</i>	√			
19	<i>Cyathophyllum</i>	√	√	√	√

No.	described rugose corals from Myanmar	Padaukpin area (Khaing Khaing San, 2005)	Pwepon area (Khaing Khaing San, 2005)	Lashio area (Khaing Khaing San <i>et al</i> , 2017)	Hsipaw area (Present study)
20	<i>Peripaedium</i>	√	√	√	
21	<i>Enallophrentis</i>			√	
22	<i>Gurichiphyllum</i>			√	

In this study, brachiopod fauna (*Strophomena* sp., *Spinatrypasp.*, *Atrypasp.*, *Athyris* sp., *Markitoechia* ? sp., *Xystrophia* sp., *Uncinulus* sp., *Reticulariopsiseifiensis.*, *Spinatrypa* sp. and *Desquamatiasp.*) are the same with brachiopods from Padaukpin area described by Anderson *et al.* (1969).

Most of the genus of tabulate corals in this area are long-range. *Favosites* first appear in Upper Ordovician but it ranges to Middle Devonian in Cosmopolitan and Devonian from Myanmar. *Alveolites* and *Coenites* are the occurrence of Silurian to Devonian in Cosmopolitan and Middle Devonian (Eifelian) from Myanmar. *Aulocystis* is the Devonian of N. America, Europe, Asia, Australia and Middle Devonian (Eifelian) from Myanmar.

The rugose corals of *Gurichiphyllum* occur in Middle Devonian-Upper Devonian of Europe and West Australia. The type species of *Gurichiphyllum* is Middle Devonian from Poland, Skaly. *Grypophyllum* is the occurrence of Middle Devonian from Europe, Asia and Australia and N. America. *Stringophyllum* first appeared in Early Devonian, Europe and also Middle Devonian in Europe, North Africa and Australia. *Temnophyllum* is the Givetian genus of Europe, but it also observed in Middle Devonian (Eifelian) of Padaukpin Limestone, Myanmar. *Macgeea* is the occurrence of Middle to Late Devonian from Europe, Asia, North America and North Africa. *Macgeebirmanica* is the Eifelian fauna of the Padaukpin Limestone in Myanmar. *Argutastrea* occurred in Latest Eifelian to Early Givetian in Australia; Eifelian to Givetian in Germany, Myanmar, China; Givetian in France; Givetian to Frasnian in Belgium and Eifelian to Frasnian in USSR (Hill, 1981). Based on the above fauna evidences strongly indicate that the age of the corals from the study area is Middle Devonian (Eifelian to Givetian) and close resemble with South China and Europe.

## **Conclusion**

This study is the new occurrence of the Middle Devonian fossiliferous unit in Hsipaw area, northern Shan State. This unit is previously described as the Nwabangyi Dolomite Formation (Late Permian to Middle Triassic) and present study is the first to inform the occurrence of Middle Devonian unit in Hsipaw area. The fauna occurrence (corals and brachiopods) of Middle Devonian unit in this area is closely similar with Padaukpin Limestone in Padaukpin area, Pyinoolwin Township except the occurrence of *Grypophyllum*, *Gurichiphyllum* and colonial rugose coral of *Argustastrea* sp. which are the occurrence of Pwepon Limestone in Kyadwinye area. The fauna of the study area is also similar with Lashio area by the same occurrence of *Grypophyllum*, *Strigophyllum*, *Temnophyllum*, *Macgeea*, *Cyathophyllum* and *Gurichiphyllum*. The present study of the stratigraphy and fauna occurrence of rugose corals, tabulate corals and brachiopods from this Limestone suggest Middle Devonian (Eifelian to Givetian) age and probably to designate the Pwepon Limestone but this unit is more argillaceous, fossiliferous, more abundant brachiopods and corals attain larger size.

## **Acknowledgements**

We are greatly indebted to Acting Rector, Dr. Kyaw Tun, Pro-Rectors of Dr. Yaw Han Tun and Dr. Hla Hla Tin, Lashio University for their permission to carry out this research work. We greatly appreciate the help of Professor Dr. Marie Coen-Aubert, Belgium for her supporting the literatures of the corals.

## References

- Anderson, M.M., A.J. Boucot and J.G. Johnson (1969) Eifelian brachiopods from Padaukpin, northern Shan States, Burma, *Bull.Br. Mus. Nat. Hist*, 18:107-163
- Amos, B.J. (1975) Stratigraphy of Some Upper Paleozoic and Mesozoic carbonate rocks of the eastern Highlands. *Newsl. Stratigr*, 4(1): 49-70.
- Aye Ko Aung (1995) New Middle Devonian (Eifelian) rugose corals from Myanmar. *Journal of Southern Asia Earth Science*, 11 (1): 23-32.
- Aye Ko Aung (2012) The Paleozoic Stratigraphy of Shan Plateau, Myanmar: An Updated Version, *Journal of M. G.S., V5, No.1, (Special volume)* 1-73.
- Brunnschweiler, R.O. (1970) Contributions to the post-Silurian geology of Burma (Northern Shan State and Karen State).-*Jour. geol. Soc. Australia*, 17:59-79, 10 fig.; Sydney
- Hill, D., (1981) Rugosa and Tabulata In Teichert. C. (ed), *Treatise on Invertebrate Paleontology*, Part F, Coelenterata, Supplement. 1:F1-429. The Geological Society of America. Inc and University of Kansas, Boulder, Colorado and Lawrence, Kansas.
- Khaing Khaing San (2005) *Middle Devonian Rugose Corals of the Padaukpin Limestone, Pyinoolwin Township, Mandalay Division*. PhD Thesis (unpublished), University of Mandalay, 282p, 40 figs, 40 plates.
- Khin Nyein Chan Thar (2017). *Paleontology of the Middle Devonian Unit exposed at the Mehan-Kawngkye area, Lashio Township, northern Shan State*. MSc Thesis (unpublished), Lashio University.
- Khin San (2010) *Mode of Occurrence and Origin of Pannyo Evaporite, Hispaw – Bawgyo Area, Northern Shan State*. Ph. D. Thesis (unpublished), University of Mandalay, 132p.
- La Touche, T.H.D. (1913) Geology of the Northern Shan States- *Mem. Geol. Surv. India*, 39, 2:1-379, 13 tap: Calcutta.
- Pascoe, E.H. (1959) *Manual of the Geology of India and Burma*; 3rd ed. V.2, Govt., India press.
- Reed, F.R.C.(1908) The Devonian faunas of the northern Shan States. *Memory of Geological Survey of India*.2:1- 183.