

## Graptolite Biostratigraphy of Linwe Formation in the Mibayataung area, Southern Shan State

Ye` Yint Aung<sup>1</sup> and Chit Sein<sup>2</sup>

### Abstract

Linwe Formation is widely exposed at the southeastern part of Mibayataung area, Kalaw Township, southern Shan State. The rock units are pink or purplish and grey, argillaceous limestones and calcareous shales with a highly developed phacoidal texture. *Michelinoceras* sp., burrows and crinoid stems are abundant in the purple and grey phacoidal limestone of Linwe Formation (Early Silurian) at the southeastern part of Mibayataung monastery. A total of 19 graptolite species were collected in the shale of Linwe Formation from the Mibayataung area. Among them, three graptolite assemblage zones are classified such as *Monograptus convolutus* zone, *Monograptus vesiculosus* zone and *Monograptus cyphus* zone. These shales can also be grouped into the parallel laminated shale and the wavy laminated shale. The *Monograptus turriculatus* zone includes *Monograptus turriculatus*, *Monograptus priodon* and *Monograptus lobiferous*. The *Monograptus vesiculosus* zone or *Monograptus cyphus* zone are consists of *Orthograptus vesiculosus*, *Monograptus gregarious*, *M. cyphus*, *M. modestus*, *Climacograptus rectangularis*, *C. typicalis* var. *atlanticus*, and *Petalograptus folium*. The *Monograptus convolutus* zone consists of *Monograptus convolutus*, *M. priodon*, *M. cyphus*, *M. triangulatus*, *M. incommodus*, *M. clintonensis*, *M. millepeda*, *M. gregarious*, *M. sedgwicki*, *Petalograptus folium*, *Rastrites peregrines*, *Rastrites* sp., *Climacograptus rectangularis*.

**Keywords:** Graptolites, Biostratigraphy, Linwe Formation, Mibayataung, Kalaw Township

### Introduction

Most of the Paleozoic and Mesozoic rock units are well exposed in the Mibayataung area, south-southwest of Heho, Kalaw Township, southern Shan State. Early Paleozoic rock units are common and are often well preserved in the eastern Mibayataung area. Although many previous workers (Brown & Sondhi, 1933; Reed, 1936; Myint Lwin Thein, 1973; Garson et al., 1974; Wolfart et al., (1984); Chit Sein, 1998; Kaung Sithu & Chit Sein, 2014) studied the geology and lithostratigraphy of the Early Paleozoic rocks of southern Shan State in the study area, the paleontological records are limited and poor. Therefore, the present study aims to classify the biostratigraphic zone of graptolites in the Linwe Formation of the Mibayataung area.

### Location

The study area is located about 14.4 km south-southwest of Heho, Kalaw Township, southern Shan State (Figure 1). It is also situated in the south-southeast part of the Inle Lake and it is demarcated between vertical grids 90 to 100 and horizontal grids 30 to 40 on topographic map no. 93D/14. It extends 8 km (20° 32' 30" N to 20° 37' 30" N) along the N-S and 8 km (96° 45' 00" E to 96° 50' 00" E) along the E-W with 64 square kilometers of total coverage.

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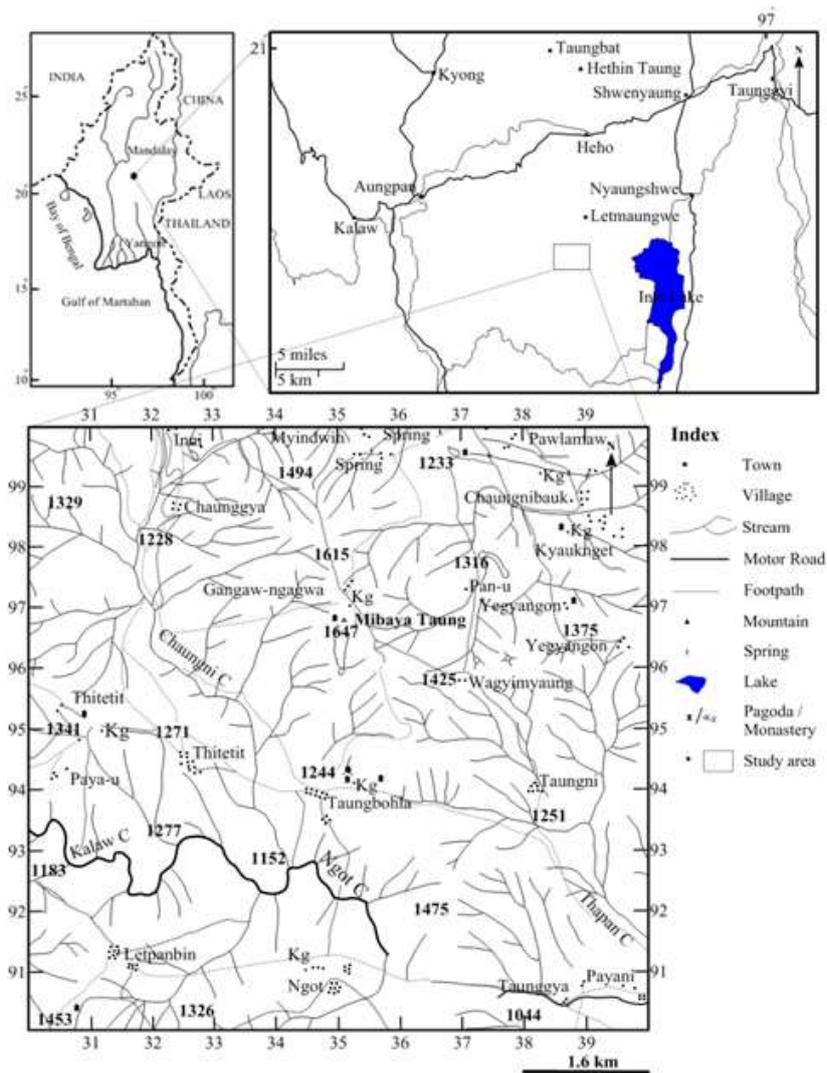


Figure (1) Location map of the study area

### Methods of study

The general traverses have been made to understand the different lithologic boundaries, and fossiliferous rock units from the area. The stratigraphic columnar sections were made by using Jacob's Staff method to demarcate the precise lithologic boundaries, to collect the rock samples from various rock units and to get the fossil distribution that will enable to describe the biostratigraphy with the reconstruction of the exact succession of Paleozoic rocks in the study area. The shale samples were peeled with the sharp chisel head for the extraction of graptolites. The fossils are very fragile and embedded in the carbonate rocks.

### Regional Geologic Setting

The study areas are located in the southern part of the Pindaya and Bawsaing ranges. Generally, Early Paleozoic strata are mainly covered with the marine invertebrate fauna in the Pindaya Range (Figure 2). The rocks are cropped out on both the north and south flanks of the Mibayataung.

The Early Paleozoic and Mesozoic rocks are well exposed in Pindaya and Bawsaing range. It is composed of rock units ranging from Precambrian to Permo-carboniferous in age.

The Early Paleozoic rock units are Chaungmagyi Group (Precambrian), Molohein Group (Cambrian), Pindaya Group (Ordovician), and Mibayataung Group (Silurian). Paleozoic to Mesozoic unit is Plateau Limestone Group (Upper Permian to Middle Triassic).

Precambrian rocks are mainly made up of low grade metasedimentary rocks and gneisses. The Chaungmagyi Group exists as a large inliers in the northern part of Pindaya range, where uncomfortably underlies beneath the Cambrian rocks. It is mainly composed of phyllite, slate, metagraywacke, quartzite, with minor amount of schist and thinly bedded marble. These beds are tightly folded, faulted, fractured and almost usually cut by quartz veins. They can be distinguished from those of the younger units by their highly tilted in the attitudes of beds, by the comprising of metagreywacke, phyllite, slate, quartzite, quartzose sandstone, basal conglomerate and their unfossiliferous nature.

The Cambrian rocks are represented by Molohein Group in the southern Shan State. The rocks of the Molohein Group consists of pink, purple and reddish brown, highly micaceous sandstone and well recrystallized pinkish white or purple white colour quartzites with subordinate amount of subgreywacke, gritty sandstone, phyllite, limestone and dolomite. Molohein Group was divided into two formations by Myint Lwin Thein (1973) such as Pandung Formation and Myet-ye Formation. Pandung Formation is the lowest unit of Molohein Group. It is dominated by whitish, pinkish, purplish, and buff colour quartzites. It also comprises a small amount of whitish or buff, subindurated, medium grained sandstones. Myet-ye Formation is the upper subunits of Molohein Group.

The Ordovician rocks developed in the Pindaya and Bawsaing range. The name Pindaya Group was first introduced by Myint Lwin Thein (1973) and he divided into four, subdivisions.

- 3a. Tanshauk Member
3. Non-on Formation
2. Wunbye Formation
1. Lokeyyin Formation

Lokeyyin Formation consists of medium to thick bedded, grey to buff, soft to indurated micaceous siltstone with minor occurrence of yellow to greenish marls and hard calcareous siltstone. These are interbedded with yellow siltstones at the lower part.

Thick bedded Ordovician limestone, dolomitic limestone and dolostone of Wunbye Formation are mostly distributed in the Pindaya range with subordinate occurrences of siltstone and silty limestone. These are typically exposed at the southern western part of the range. Limestones are finely crystalline, grey to bluish grey and complex networks of burrow are dominated at these limestone. This formation consists of thick succession of thickly bedded limestone, siltstone and dolomite. The siltstones are thin, medium-thick bedded, yellow to light grey and soft to indurate with thin banding of light greenish siliceous marlstone. Thick bedded to massive dolomite sub-units are highly jointed with criss-cross pattern. This formation is thickest and mostly wide-spread among the Formation of Pindaya Group.

Non-on Formation consists of yellow to buff, light orange siltstones, mudstones and marlstones generally subindurated to soft. This formation very rich in fossiliferous especially cystoids stem, orthid brachiopods, bryozoans, sponges (in limestone) and trilobites have been recognized.

The Silurian rocks are represented by Mibayataung Group which is conformable with the Tanshauk Member of the Nan-on Formation below, and is overlain by the massive

limestones and dolomites of the Plateau Limestone Group. The group is divided into two formations with one named member.

2a. Taungmingyi Member

2. Wabya Formation

1. Linwe Formation

Linwe Formation consists of hard, flaggy, brittle, brightly-coloured, red, pink or purplish, argillaceous limestones and calcareous shales with a highly developed phacoidal texture. *Michelinoceras* sp. (former literature under the name *Orthoceras*) species are very rich as unique features. Usually they contain the remains of large crinoid stems and numerous specimens of orthoceratid nautiloids, shell fragments, tiny brachiopods, sponges and bryozoans and cephalopod shell fragments. Locally they are interbedded with strata of yellow, sandy mudstones with poorly preserved fossils.

Wabya Formation consists of grey, light grey to white, subindurated shale and mudstone. Graptolites are abundant in this formation. Most of the shales and slaty shales are rhythmic lamination in some places at the investigated area. Phacoidal limestone or calcareous mudstones or purple shales of the upper part of Linwe Formation are contact with the lower boundary of Wabya Formation. The topmost member of the formation consists of loosely cemented orthoquartzite named as Taungmingyi Member. This member from the Wabya Formation occurs near the upper boundary of Wabya Formation. That is well sorted, very poorly cemented, fine to medium grained massive quartzite. Hematites are interbedded with the quartzite at the study area.

Plateau Limestone Group is mainly composed of grey to brown colour, fine to medium grain, massive and criss-cross joint pattern dolomitic limestone. The fusulinids are common in the Plateau Limestone. The age of the Plateau Limestone Group is Upper Permian to Middle Triassic.

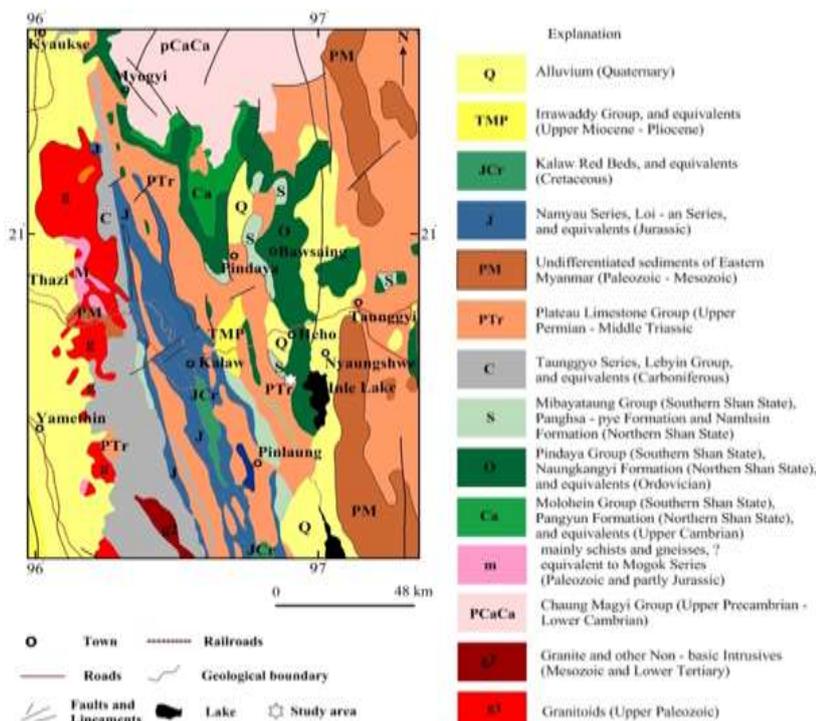


Figure (2) Regional geological map of the study area (cited from Geological map of Burma, Bender, 1983)

## Stratigraphy

Generally, five lithostratigraphic units are found in the study area (Table 1). The stratigraphy of the Mibayataung area is as follows;

Table (1) The stratigraphic succession of the study area

Succession	Age
<i>Terra rossa</i>	Pleistocene
~~~~~Unconformity~~~~~	
Plateau Limestone Group	Permian to Middle Triassic
~~~~~Unconformity~~~~~	
Mibayataung Group	Silurian
Wabya Formation	Early to Late Silurian
Linwe Formation	Early Silurian
Pindaya Group	Ordovician
Nan-on Formation	Late Ordovician
Wunbye Formation	Middle Ordovician

### Linwe Formation

#### Name derivation

The name was first given by Myint Lwin Thein (1973), after the Linwe Village about the 24 km (15 miles) northeast of Ywa-ngan Township, southern Shan State. Type section is located grid co-ordinates (085728) on Topographic map no. 93 C/12.

#### Distribution

This formation is mainly distributed at the central part of the study area (Figure 3). Linwe Formation is also exposed at the southeastern part of Mibayataung monastery. The good localities are southeast of Mibayataung (357964), and west of Wagymyaung (366978). This formation is trending nearly NNW-SSE and the northern extension of the rocks are limited by fault.

#### Lithology

This formation mainly composed of hard, flaggy, brittle, brightly colour, red, pink or purplish and grey, argillaceous limestones and calcareous shales with a highly developed phacoidal texture. *Michelinoceras* sp. and ostracods are mainly observed in the area. Usually they contain the remains of large crinoid stems and numerous specimens of orthoceratid nautiloids. Locally, they are interbedded with strata of yellow, sandy mudstones with poorly preserved fossils.

Linwe Formation can be discriminated into two distinct units in the study area such as (1) Phacoidal limestone and (2) Graptolite-bearing shale.

#### (I) Phacoidal limestone

The rocks of this unit are mainly made up of phacoidally limestone in the study area. These limestones can be subdivided into two subunits such as (a) Purple phacoidal limestone and (b) Grey phacoidal limestone.

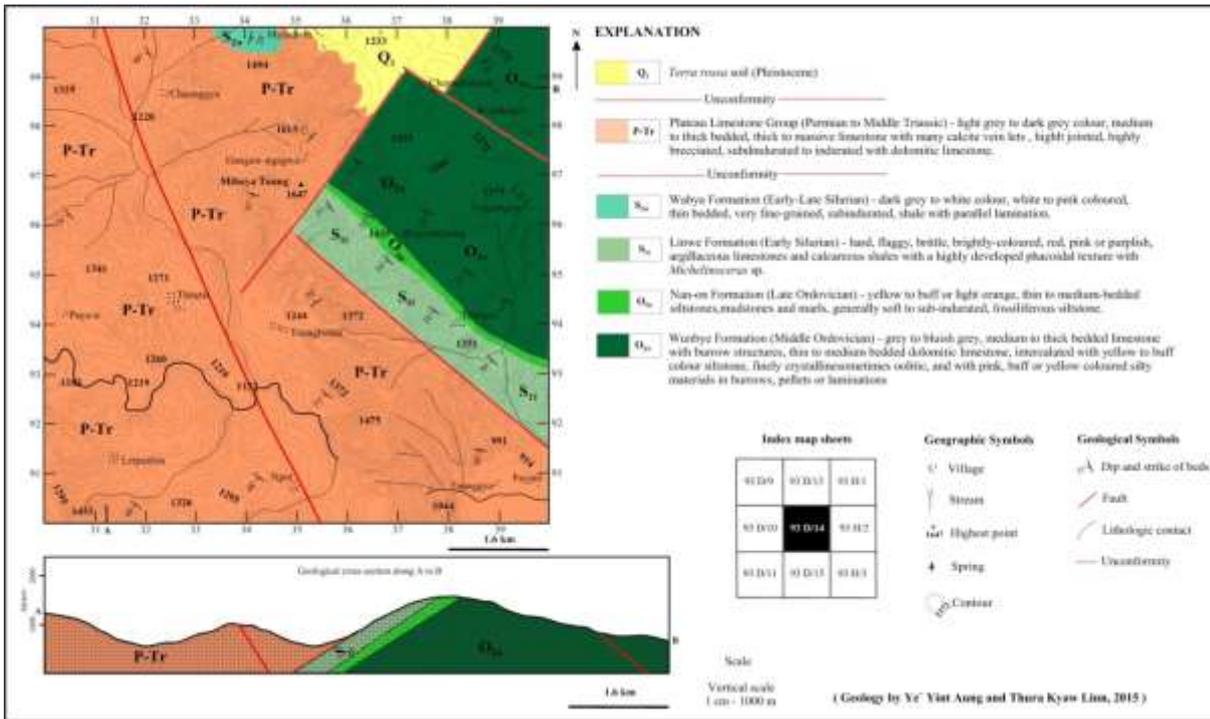


Figure (3) Geological map of the Mibayataung area, Kalaw Township, southern Shan State

**(a) Purple phacoidal limestone**

Purple phacoidal limestone occupies the basal part of the Linwe Formation and its lower boundary is in contact with upper boundary of Nan-on Formation of buff colour siltstone. Purple phacoidal limestone is mainly composed of purple colour medium to coarse-grained, thick bedded phacoidally textured limestone (Figures 4 - 5). These purple phacoidal limestones intercalated with the calcareous siltstone and shale in the upper part. *Michelinoceras* sp., crinoid stems, shell fragments are characteristic faunas in this units.



Figure (4) Massive red, purple phacoidal limestone of Linwe Formation in SSE of Mibayataung monastery (20° 35' 58.9" N, 96° 47' 42.7" E)



Figure (5) Medium to coarse-grained, thick bedded, purple phacoidal limestone of the Linwe Formation in SSE of Mibayataung monastery (20° 35' 21.0" N, 96° 47' 47.4" E)

**(b) Grey phacoidal limestone**

Grey phacoidal limestone consists of hard, flaggy, grey colour, medium to coarse-grained, medium to thick bedded phacoidal limestone (Figure 6). This subunit is overlain by the lower part of Plateau Limestone Group. *Michelinoceras* sp., burrows, crinoid stems and other shell fragments are found in this subunit (Figure 7).

## (II) Graptolite-bearing shale

The graptolite shale is mainly composed of grey colour, subindurated, slaty shale with wavy and parallel laminations (Figures 8 & 9). The thickness of this shale is 111.2 meters. This unit is widely distributed at the northeastern part of the Mibayataung Monastery. The graptolites, *Monograptus cyphus*, *M. incommodus*, *M. triangulatus*, *M. convolutus*, *M. lobiferous*, *M. priodon*, *M. turriculatus*, *Orthograptus vesiculosus*, *Climacograptus typicalis* var. *atlanticus* and *C. rectangularis*, are abundant in this subunit (Figure 10).



Figure (6) The grey phacoidal limestone of Linwe Formation in NNW of Wagymyaung Village (20° 35' 33.2" N, 96° 48' 10.3" E)



Figure (7) Crinoid stem fragments in grey phacoidal limestone of Linwe Formation (20° 35' 53.6" N, 96° 48' 4.7" E)



Figure (8) Very thin bedded, dark grey to white colour shale unit of the Linwe Formation at 800 m SE Mibayataung monastery (20° 35' 45.0" N, 96° 47' 56.1" E)



Figure (9) Fine-grained, thin bedded, grey to white colour parallel laminated shale with concretion of the Linwe Formation about 800 m SE of Mibayataung monastery (20° 35' 43.2" N, 96° 47' 50.6" E)

### Stratigraphic relationship

The lower boundary of Linwe Formation is in contact with the last appearance of buff colour siltstone of the Nan-on Formation. The upper boundary is marked the first appearance of the Wabya Formation in Wabya area. However, the upper boundary of the Linwe Formation is unconformable in contact with the Plateau Limestone near the Mibayataung monastery.

### Faunal content

*Michelinoceras* sp., crinoid stems and other shell fragments are observed in the Phacoidal limestone. Graptolites are common in graptolite shale such as *Monograptus convolutes*, *M. cyphus*, *M. triangulatus*, *M. incommodus*, *M. clintonensis*, *M. millepeda*, *M.*

*gregarius*, *M. sedgwicki*, *M. turriculatus*, *M. pridon*, *M. lobiferous*, *Petalograptus folium*, *Rastrites peregrine*, *Rastrites* sp., *Orthograptus vesiculosus*, *Mesograptus modestus*, *Climacograptus typicalis* var. *atlanticus*, *C. rectangularis*, *C. parvus*.

### Age and correlation

According to graptolites assemblages, the age of the Linwe Formation is considered as the Early Silurian (Llandoveryan) age. It can be correlated with the Nyaungbaw Formation of northern Shan State (Myint Lwin Thein, 1973).

Purple and grey phacoidal limestone unit of this area can be compared with Nyaungbaw Limestone in the northern Shan State (Myint Lwin Thein, 1973) and the *Camerocrinus*-bearing Lower Jenhochian Formation of Yunnan (Sun, 1948). Moreover, Linwe Formation of this area can be correlated with the Setul Limestone Formation in the Langkawi islands near the Thailand-Malayan border (Myint Lwin Thein, 1973).

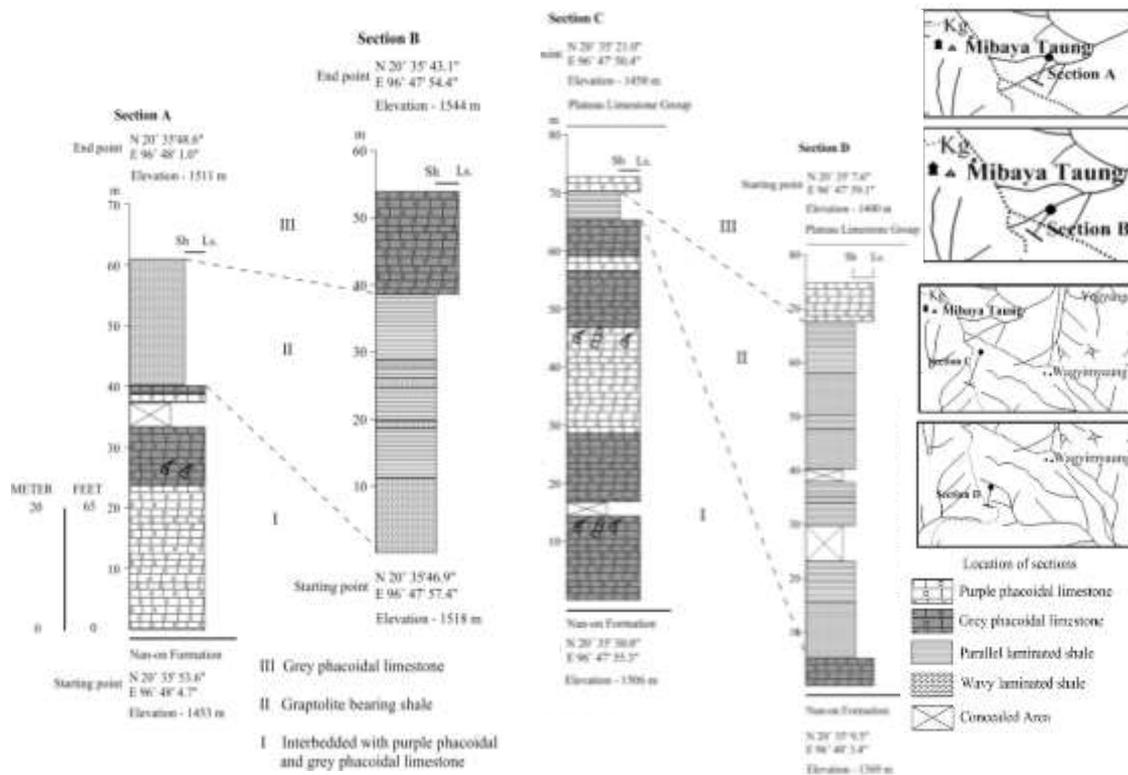


Figure (10) Individual stratigraphic measured sections of the Linwe Formation in Mibayataung area

### 3.4 Biostratigraphy of graptolites

Silurian graptolite shales are widespread in the eastern part of Mibayataung and western part of Myindwin Village. The detailed stratigraphic measured sections were made by using Jacob's staff method in the study area. Graptolites includes *Monograptus pridon*, *M. triangulates*, *M. incommodus*, *M. lobiferus*, *M. clintonensis*, *M. gregarius*, *M. sedgwicki*, *M. cyphus*, *M. turriculatus*, *M. convolutes*, *M. millepeda*, *M. modestus*, *Rastrites peregrinus*, *Orthograptus vesiculosus*, *Climacograptus typicalis* var. *atlanticus*, *C. rectangularis*, *C. parvus*, *Climacograptus* sp., and *Petalograptus folium* (Plate 1). On the basis of the

stratigraphic columnar sections (Figure 11), three biostratigraphic zones are recognized such as *Orthograptus vesiculocus* or *Monograptus cyphus* zone, *Monograptus convolutus* zone and *Monograptus turriculatus* zone.

**(1) *Monograptus convolutus* zone**

This assemblage represents the *Monograptus convolutus*, *M. priodon*, *M. cyphus*, *M. triangulatus*, *M. incommodus*, *M. clintonensis*, *M. millepeda*, *M. gregarious*, *M. sedgwicki*, *Petalograptus folium*, *Rastrites* sp., *Rastrites peregrines*, *Climacograptus rectangularis*. These species are abundant from the parallel to discontinuous laminated shales of Linwe Formation. This zone occurs in the middle part of the measured sections. The age of *Monograptus convolutus* is indicated Early Silurian (Llandovery). The distributions of *Monograptus convolutus* zone are 3 m to 30 m in section. All specimens are collected from the Linwe Formation.

**(2) *Orthograptus vesiculosus* zone (or) *Monograptus cyphus* zone**

The species of this zone are recognized at the lower part of the sections (Figure 11). The graptolite assemblage represents *Orthograptus vesiculosus*, *Monograptus gregarious*, *M. cyphus*, *M. modestus*, *Climacograptus rectangularis*, *C. typicalis* var. *atlanticus*, and *Petalograptus folium*. Therefore, the age of this assemblage can be assumed the lower Llandovery. All species are abundantly collected from the slaty shale of Linwe Formation.

**(3) *Monograptus turriculatus* zone**

The zone of *Monograptus turriculatus* zone is found in the south-southeast of Mibayataung monastery (Figure 11). This zone occurs at 1518 m above sea level within the upper part of the parallel laminated shale and parallel laminated shale. *Monograptus turriculatus* zone consists of *Monograptus turriculatus*, *Monograptus priodon* and *Monograptus lobiferous*. These species are less common in the upper part of wavy laminated shale. The occurrences of this zone are 10 m to 40 m in section. The age of the *Monograptus turriculatus* zone is considered to Early Silurian (Llandovery).



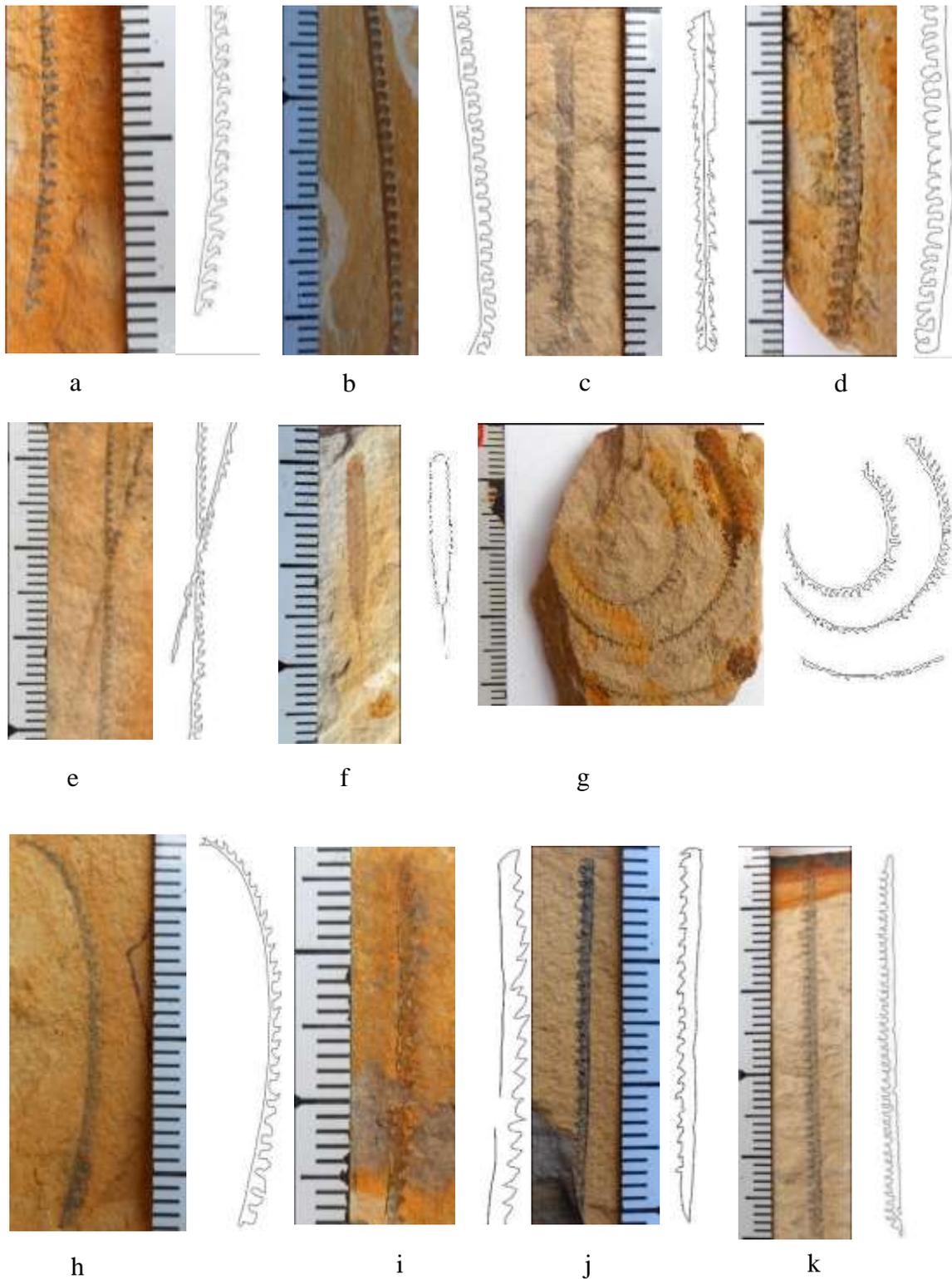


Plate (1) Graptolites in the shale of Linwe Formation in the Mibayataung area.

- (a) *Monograptus triangulatus*, (b) *Monograptus priodon*, (c) *Orthograptus vesiculosus*,  
 (d) *Monograptus lobiferous*, (e) *Monograptus incommodus*, (f) *Mesograptus modestus*,  
 (g) *Monograptus convolutus* (h) *Monograptus millepeda*, (i) *Monograptus gregarious*, (j)  
*Monograptus sedgwicki*, (k) *Monograptus clintonensis*

## Conclusion

The study area is located about 14.4 km south-southwest of Heho, Kalaw Township, southern Shan State. Linwe Formation mainly composed of hard, falggy, brittle, brightly colour, red, pink or purplished and grey, argillaceous limestones and calcareous shales with a highly developed phacoidal texture. Linwe Formation of the Mibayataung area is trending NNW-SSE direction, and parallel to the Nan-on Formation. In the study area, Linwe Formation can be discriminated into two distinct units: (i) Phacoidal limestone (ii) Graptolite bearing shale. Phacoidal limestone is divided into two subunits. They are purple phacoidal limestone and grey phacoidal limestone. On the basis of the stratigraphic columnar sections of Linwe graptolite shale, three biostratigraphic zones are recognized such as *Orthograptus vesiculocus* or *Monograptus cyphus* zone, *Monograptus convolutus* zone and *Monograptus turriculatus* zone.

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## References

- Bender, F., 1983. *Geology of Burma*: Gebruder Borntraeger Berlin, Stuttgart, 293 pp.
- Brown, J. C., & Sondhi, V. P., 1933. The geology of the country between Kalaw and Taunggyi, Southern Shan States. *Rec. Geol. Surv. India*, **67** (2): 166-248.
- Chit Sein, 1998. *Systematic and stratigraphic paleontology of Silurian fossils assemblages (Graptolites) of Wabya, Kyauktap and Miabayataung areas, southern Shan States*: (Unpublished) M.Sc., Thesis, Department of Geology, University of Yangon, 104 pp.
- Garson, M.S., Amos, B.J. & Mitchell, A. H. G., 1976. The geology of the area around Neyaungga and Ye-ngan, Southern Shan States, Burma. - *Overseas Mem. Inst. Geol. Sci.*, **2**: 70 pp.
- Kuang Sithu and Chit Sein, 2014. Depositional Environment of Kalaw Red Beds in the East of Yegyanzin Area, Pindaya Township, *Hinthada University Research Journal*, **5** (1): 63-73.
- La Touche, 1913. Geology of the Northern Shan States - *Mem. Geol. Surv. India*, **39** (2): 1-379, 28 pls., 3 maps, 11 figs.
- Myint Lwin Thein, 1973. The Lower Paleozoic strarigraphy of western part of the Southern Shan States, Burma. *Bull. Geol. Soc. Malaysia*, **6**: 143-163.
- Reed, F.R.C., 1936. The Lower Paleozoic faunas of the Southern Shan States. *Palaeont. Indica*, New Series, **21** (3): 1-130.
- Sun, Y.C., 1948. The early occurrence of some Ordovician and Silurian cystoids form western Yunnan and its significance. *Pal. Noviat.* **1**.
- Wolfart, R., U Myo Win, Saw Boiteau, U Myo Wai, U Peter, U K Cung and U Thit Lwin, 1984. Stratigraphy of western Shan Massif, Burma: *Geologishes Jahrbuch, Hannover*, **57**, 3-92.