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Revision of the Stratigraphy and Age of the Early Devonian Zebingyi Formation, Myanmar

Aye Ko Aung

Abstract

The Zebingyi Formation of Early Devonian (Pragian) age in the Zebingyi-Pyintha-Thondaung area which is geologically known as in part of the northern Shan State is revised with regard to its stratigraphy and age. The formation is now formally defined in accordance with the modern stratigraphic practice. It contains (30 to 170 metres) of shale, siltstone, limestone, and quartzose sandstone and is divisible into three members: Khinzo chaung Limestone Member, In-ni chaung Limestone Member, and Doganaing chaung Orthoquartzite Member. The Khinzo chaung Limestone Member which is the basal part of the Zebingyi Formation essentially made up of thin- to medium-bedded, gray to black, purple or red calcareous shale and siltstone partings with crowded dacryoconarid tentaculites (*Nowakia* and *Styliolina*), nautiloid cephalopods (*Michelinoceras*), brachiopods (*Plectodonta*, *Clorinda*, *Lissatrypa*), trilobites (*Cornuproetus*), graptolites (*Monograptus*), and burrows. The In-ni chaung Limestone Member consists almost entirely of medium- to thick-bedded light gray or milky white, flaggy, dolomitic limestone showing only few traces of highly crystallized fossil fragments. The Doganaing chaung Orthoquartzite is characterized by brown to reddish, thin- to medium-bedded quartzose sandstone with no fossils. In most places of the Pyin Oo Lwin township, the Zebingyi Formation directly overlies the Nyaungbaw Formation of Early Silurian (Llandovery-Wenlock) age and the contact between the two units seems to be gradational. However, any fossils indicating three stages (Ludlovian, Pridolian, and Lohkovian) in the area are not yet reported. It may allow to consider whether the existence of a possible disconformity between these two units or not. In the Zebingyi area, the Zebingyi Formation is unconformably overlain by the Thitsipin Limestone Formation (Plateau Limestone) of Permian age. The age of the Zebingyi Formation- Early Devonian is discussed on basis of fossil assemblages. The unit is correlatable with the contemporary Early Devonian Pa Samed Formation of southern Thailand and Mahang Formation of northwest Malaya.

Key words: stratigraphy, age, Early Devonian Zebingyi Formation.

Introduction

The current study concerns the sequence of the Zebingyi Formation. The unit is significant as it represents as the oldest Devonian unit in Myanmar and yields rich dacryoconarid tentaculite, brachiopod, cephalopod, trilobite, graptolite, bryozoa, and coral (Aung, 2000b). Initial mapping found that the Zebingyi Formation was restricted in the Zebingyi area. The detailed mapping of the area by the author and his final year B. Sc. Geology students from Mandalay University (1982-1984) allowed to recognize that the Zebingyi Formation is fairly widely distributed on the western margin of the Shan Plateau although it is exposed as a thin interrupted band. The tentaculites from the basal part of the Zebingyi Formation provided correlation of the formation with the others in the Shan State and neighbouring regions such as Thailand, Malaysia, and China.

The Zebingyi Formation is redefined herein and age of the formation is confirmed by its faunal evidences. To date, only a small number of papers have been published exclusively or in part on the stratigraphy or faunas of the Zebingyi Formation. Reed (1906) described the Lower Paleozoic fossils from northern Shan State including Zebingyi fauna, from those two graptolites were re-identified by Berry and Boucot (1972). Jaeger (1983) described some graptolites of the Zebingyi Formation from Pyintha. The Zebingyi area was mapped by La Touche (1913), Than Tun (1968-70), field parties of the Department of Geological Survey and Mineral Exploration (1977), geology student field parties from Mandalay University (1982-84, 1993), Han Khan Pau et al. (1993) studied microfacies of the Zebingyi Formation exposed in the vicinity of Zebingyi village; Kyi Soe (2000) described some graptolites of the Zebingyi Formation collected from Pebin Chaung section and Dagon University Geology field party (M.Sc. qualifying and final year Honours, 2000) made an extensive study on the stratigraphy of the Zebingyi Formation.

The present paper is the result of the research project on the "Geology and Mineral Resources of the Area between Htonbo-Pyin Oo Lwin (formerly Maymyo) undertaken between 1982 and 1984 led by then the Head of the Department of Geology, Professor Dr U Thein of Mandalay University. The present study was undertaken at the suggestion of Dr U Thein back in 1983. It commenced in 1984 with measuring stratigraphic sections along Kyinganaing chaung 31/4 milepost on Mandalay-Lashio car road, north of Kyaukpyadoe village. The work had been paused for six

years during the author's doctoral study at the University of Queensland, Australia. Then, the author revisited the Zebingyi area with M.Sc. (Qualifying) and final year Honours students from Dagon University in October, 2000.

The field parties measured the sequences of the Zebingyi Formation along the small creeks from south to north, Pebin chaung, Myinthe chaung, Doganaing chaung, In-ni chaung and Khinzo chaung (chaung = creek in Myanmar language). Again in April, 2004, the type sections of each member of the Zebingyi Formation were stratigraphically re-measured in Doganaing chaung located between Zebingyi and Pebin villages by the author and the final year Honours (1995 and 1997 intake) and M. Sc. (Qualifying students) of Dagon University. In April and May, 2005, U Cho Oo and third year geology students of Dagon University (Zebingyi group, 2001 and 2002 intake) remapped the Zebingyi area and established a fairly complete reference section of the Zebingyi Formation at the shooting range of the Central Training Institute of Myanmar Police Force, Zebingyi, nearby the junction of Pebin chaung and Doganaing chaung. The study area, (Zebingyi-Pyinthathondaung) is situated between North Latitudes $21^{\circ} 52'$ - $22^{\circ} 55'$ and East Longitudes $96^{\circ} 17'$ - $96^{\circ} 22'$ and represented in the one-inch map 93 C/5 (1945). It lies in the vicinities of Zebingyi, Pyinthathondaung villages in Pyin Oo Lwin township, about 27 km south-east of Mandalay (Fig. 1) and is easily accessible by train or car throughout the year. A geological map drawn in 1982 by the author and geology students of Mandalay University and by U Cho Oo and geology students from Dagon University in 2005 is used as the base map (Fig. 2)

Stratigraphy

Zebingyi Formation

(redefined unit)

Derivation of name: After Zebingyi village located at 4km north of junction of Mandalay-Pyin Oo Lwin highway and Zebingyi car road (GR 841541) on one-inch topographic map, 93 C/5, Pyin Oo Lwin township, Mandalay Division.

Synonymy: Zebingyi Stage (La Touche, 1913; Krishnan and Jacob, 1955), Zebingyi Series (Pascoe, 1959), Zebingyi Beds (Pascoe, 1959; Amos, 1975;

Mitchell, 1977), Zebingyi Formation (with no formal definition) (IGCP, 1980, Brinckmann *in* Bender, 1983; Wolfart, *et. al.*, 1984).

Type section (newly selected): Doganaing chaung, approximately 2.5 km south of Zebingyi village, Pyin Oo Lwin township, Mandalay Division. Section base is at GR 860530 and top at GR 853527 in north Doganaing chaung (Fig. 3).

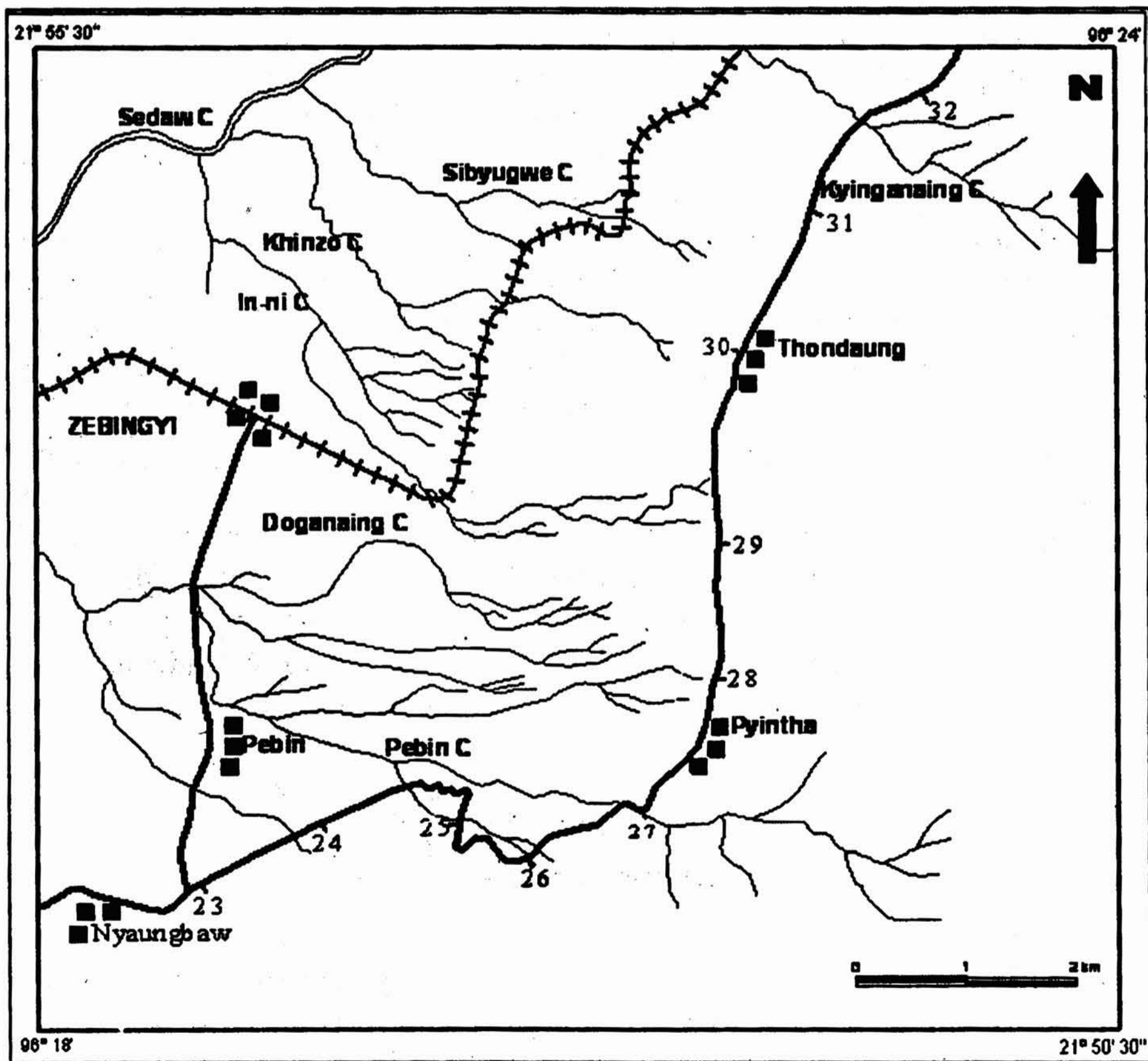


Fig- (1) Locality map of the Zebingyi-Pyintha-Thondaung area.

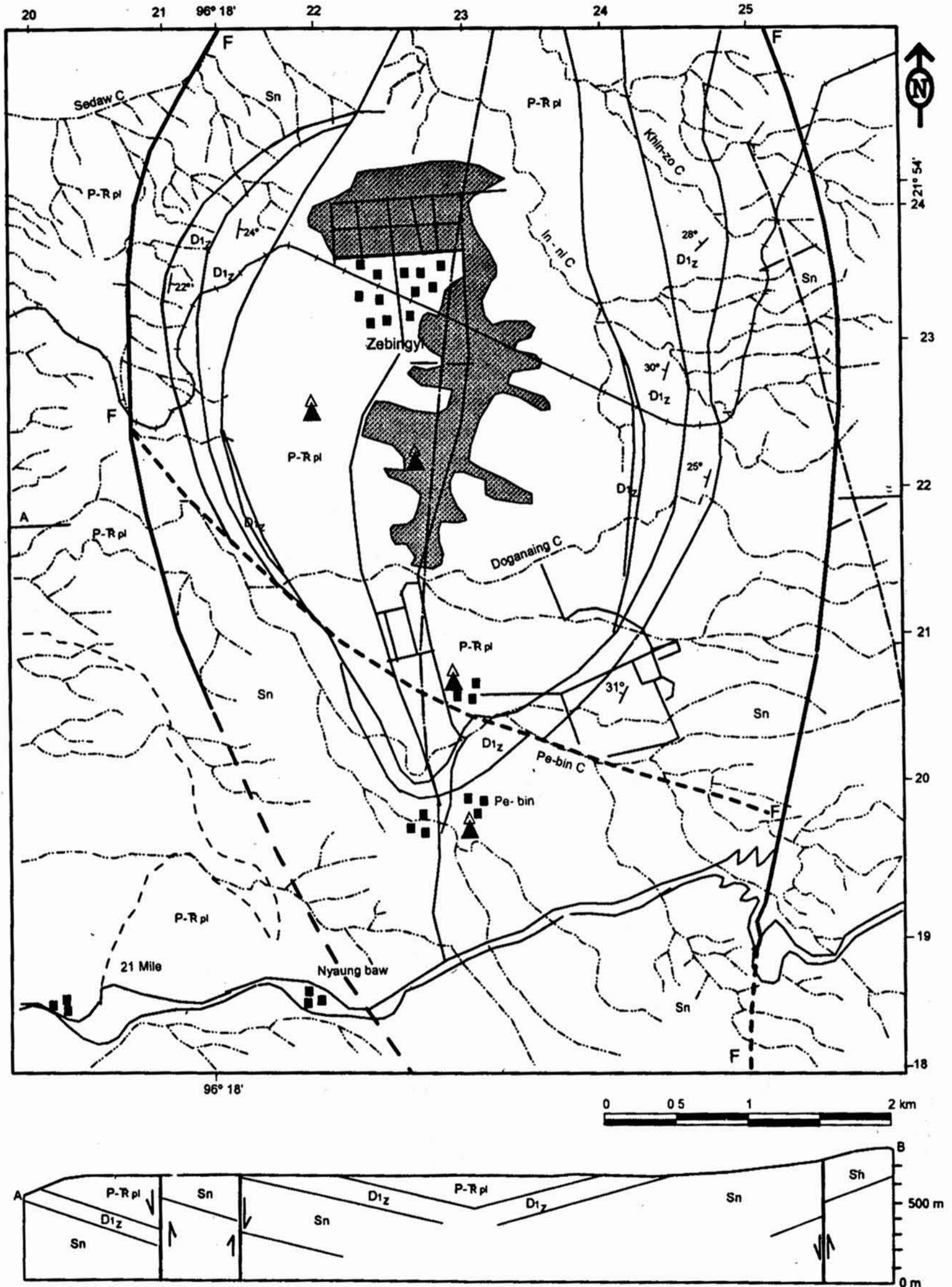


Fig- (2) Geological map of the Zebingyi area.
(Aye Ko Aung et al., 1982; Cho Oo et al., 2005)

Explanation

P-Tr pl	<p>"PLATEAU LIMESTONE GROUP" (Permian- Triassic) Thick-bedded to massive, light to dark grey calcitic or partly dolomitic, coralline and fusuline limestone.</p>
--Unconformity--	
D_1z^3	<p>ZEBINGYI FORMATION (Early Devonian) Doganaing Chaung Orthoquartzite Member thin- to medium-bedded, highly jointed, light blue, white buff and reddish brown orthoquartzite, no fossils.</p>
D_1z^2	<p>In-ni Chaung Limestone Member Medium- to thick -bedded, light to dark gray or pink, micritic or lithographic limestone with criss cross jointing no fossil.</p>
D_1z^1	<p>Khinzo Chaung Limestone Member Thin- to medium-bedded, dark grey, purple, silty limestone and shale, fossiliferous with crowded tentaculitids, brachiopods, nautiloids, graptolites, trilobites, bryozoa and burrows.</p>
Sn	<p>NYAUNGBAW FORMATION (Silurian) Medium- to thick-bedded light grey, green, purple, nodular limestone interbedded or intercalated with thin calcareous shale fairly fossiliferous with nautiloids, crinoids, brachiopods in the limestone and graptolites in the shale.</p>

Reference section: Nearby the junction of Pebin chaung and Doganaing chaung, at the shooting range of Central Training Institute of Myanmar Police Force, Zebingyi, Pyin Oo Lwin township, Mandalay Division. (Fig. 4) (Cho Oo, et al, 2005).

Map reference: One-inch topographic map 93 C/5.

Distribution: The unit is fairly widely distributed in northern Shan State. In the present area it is well exposed in the vicinity of Zebingyi village, Luwa taung, Tadachauk, Pebin chaung, Myinthe chaung, Doganaing chaung, In-ni chaung, Khinzo chaung, Zebyugwe chaung, on railway cutting east and west of Zebingyi railway station, milepost 406/1 - 406/2, 406/9. It is also exposed in the vicinities of Letpangon, Naungwe, Pyintha, Thondaung, Kyaukpyadoe, Kyinganaing, Kangyigon, Anisakan, Paungdaw,

Kyadwinye, Naungkangyi, Medaw, all in Pyin Oo Lwin township and Gokteik area in Naungcho township.

In southern Shan State, some good exposures of the Zebingyi Formation equivalent unit occur in Thayetpya chaung, east of Thayetpya (Maung Maung, 2005), near Nyaungbin chaung, Pindaya township; Kywetaung and Momakha ranges, Lawksawk township (Wolfart, 1984); Taungchun and Pinsin ranges, south east of Shwe-phone-pwint pagoda in Taunggyi town area (Aung, 2000a, 2004); Mibaya taung area south of Heho plain, Kalaw township (Wolfart, 1984) and Wan Heng, southern part of Loi-Lem district (Zaw Win et al., 2004).

Lithology: The section comprises 66 m of dense black, earthy limestone separated by layers of light-coloured, purple, black shale and buff-coloured siltstone. The base is marked by the change from light to dark gray lime-mudstone intercalated with wavy calcareous silt bands, which is the upper part of the Nyaungbaw Formation, to fine-grained, hard, sometimes brecciated, well bedded lime-mudstone intercalated with fissile, calcareous shale-siltstone (Khinzo chaung Limestone Member). The sequence of the Khinzo chaung Limestone Member is overlain by whitish to light gray, flaggy, thin-bedded, partially dolomitized unit (In-ni chaung Limestone Member). It is succeeded by thin-bedded, reddish brown quartzose sandstone (Dogaing chaung Orthoquartzite Member). The whole sequence of the Zebingyi Formation is unconformably overlain by thick-bedded to massive, light to dark blue, calcitic, fairly fossiliferous or partially dolomitic Permian limestone unit which is equivalent to the Thitsipin Limestone Formation (Garson et al., 1976) of the southern Shan State.

Relationship and boundary criteria: The contact between the Zebingyi Formation and the underlying Nyaungbaw Formation seems to be gradational. However, the interbedded unit to show a gradual changing in lithology i.e. from phacoidal limestone of the Nyaungbaw Formation to tentaculite-bearing fine-grained black lime-mudstone of the basal part of the Zebingyi Formation (Khinzo chaung Limestone Member) is rarely observed in each measured section of the area. It is merely noted that the content of silt bands forming a phacoidal structure, a typical character of the Nyaungbaw Formation noticeably decreases towards top of the formation and the boundary is well marked by the first appearance of tentaculites on medium-bedded black lime-mudstone. The relationship between the

Zebingyi and Nyaungbaw Formations will be detailed in discussion on the age of fauna of the Zebingyi Formation.

Khinzo Chaung Limestone Member

(Newly defined unit)

Derivation of name: Khinzo chaung, a small creek flowing from southeast to northwest, approximately 2 km north of Zebingyi station, Pyin Oo Lwin township, Mandalay Division.

Synonymy: Lower Member of La Touche (1913), Lower and Upper parts of the Zebingyi Formation (Field Party, Geology, University of Mandalay, 1983), Lower and Middle Member of Myint Thein (1983), Unit A and C of Han Khan Pau et. al. (1993).

Type section: The type section of the Khinzo chaung Limestone Member is taken as continuous exposure of the unit in Khinzo chaung, approximately 2 km north of the Zebingyi station, from its base (at GR 859554) to its upper boundary (at GR 860558). Along the creek, 180m of medium- to thick-bedded dark grey to dense black lime-mudstone with calcareous silt partings with abundant tentaculites and nautiloids. An intensive burrowing action developed in the lower and middle part of the unit.

Map reference: One-inch topographic map 93 C/5 (second edition).

Distribution: The unit is widely distributed in northern Shan State. In Zebingyi area, it is well exposed in small creeks (Pebin chaung, south Doganaing chaung, locally named as Myinthe chaung, north Doganaing chaung (U Maung Gyi chaung), In-ni chaung, Khinzo chaung, on both limbs of the Zebingyi syncline. On the west, Luwataung area (railway milepost 401/17), Tadachauk stream-cutting, about five miles NE of Luwataung; on the east (railway mileposts 406/1 – 406/2, and 406/9. In Pyintha-Thondaung area, the unit outcrops repeatedly due to faulting (Fig. 2). The unit extends towards south of Pyintha, Letpangon and Naungwe areas. The unit is pachy in east and northeast of Anisakan. In north and northeast of Pyin Oo Lwin, Naungkangyi, and Medaw areas.

In southern Shan State, tentaculite-bearing unit corresponds the Khinzo chaung Limestone Member occurs near Nyaungbin chaung, northern part of the Pindaya township; Kywedaung and Momakha ranges, Lawksawk township; Mibaya taung area, south of Heho plain (Wolfart,

1984); Taungchun and Pinsic ranges, and south east of Shwe-Phone-Pwint Pagoda, Taunggyi town area (Aung, 2000a, 2004).

Lithology: Thin-to medium-bedded, very fine-to fine-grained lime-mudstone separated by thin layers of siltstone. Colour variation in both limestone and siltstone, dark gray, black, deep purple or red in the lower part. The thickness of individual bedding increases in the middle where dense black limestone (37cm) and silt (20cm) interbeds constituting *dacryocōnarid* tentaculites, nautiloids, brachiopods, and burrows. The beds become thinner towards top of the unit, thinly laminated black lime-mudstone common in this part.

In Pebin chaung, the unit is composed of fine-grained, thin- to medium-bedded lime-mudstone, buff to light gray in weathered surface and dark gray in fresh surface. The lower part of the unit consists of medium-bedded lime-mudstone with *Michelinoceras* of various sizes and ferruginous burrows, thin shale partings are occasional. The lower part of the unit is narrowly exposed only 6 m thick. The middle part is composed of black lime-mudstone (10-34 cm) interbedded with black carbonaceous siltstone and shale (16 cm), lamination is common. In places some siltstone beds of light to dark purple or gray in colour showing nodular bedding, tentaculitids occur throughout. This part is 8.8 m thick. In the upper part, thinly bedded, closely jointed, dark brown to dark gray lime-mudstone, siltstone and shale content remarkably decreases in this part. This part is only 4.8 m thick (Fig. 3).

In south Doganaing chaung (Myin Thae chaung), the lower part of the unit is characterized by medium-bedded, light blue to dark gray lime-mudstone intercalated with buff-coloured calcareous siltstone. Tentaculitids are abundant, ringed and unringed ratio is 10:3, the largest one is 7mm high and 2mm in smallest forms. This part is fossiliferous yielding a number of small brachiopods. The similar lithology still remain in the upper part except fossils are more abundant than in the lower. At 82m from base of the section, small cephalopods and numerous burrows of various sizes and shapes are common. This part is 27.7m thick.

In north Doganaing chaung, the lithology of the entire sequence is similar to that of the south Doganaing chaung. The only difference is that the laminated limestone is developed in the middle part than the later. The thickness of the Khinzo chaung Limestone Member in this section is 33m.

In In-ni chaung, the unit is narrowly exposed, it is however, well exposed in the tributaries of the In-ni chaung, immediately north of main stream. In this section only two isolated outcrops are exposed at 450m and 570m north of railway mile-post 406 (GR 860534). They are mainly made up of thin- to medium-bedded fine-grained lime-mudstone with calcareous shale intercalation. Tentaculitids of ringed and unringed types occur on bedding surface. The total thickness of this unit in In-ni chaung section measured 18m. In a small creek about 50m north of junction of In-ni chaung and water pipeline, the basal part of the unit yields interesting fossils, tentaculitids, thin-shelled minute brachiopods, trilobites, sponges and cephalopods. There, the unit is 32.2m thick.

Relationship and boundary criteria: The Khinzo chaung Limestone Member forms the basal part of the Zebingyi Formation, overlying the Nyaungbaw Formation with a possible disconformity. The base is marked by dense black lime-mudstone thin shale partings containing abundant tentaculitids, cephalopods, and burrow structures. It is conformably overlain by the In-ni chaung Limestone Member of the Zebingyi Formation.

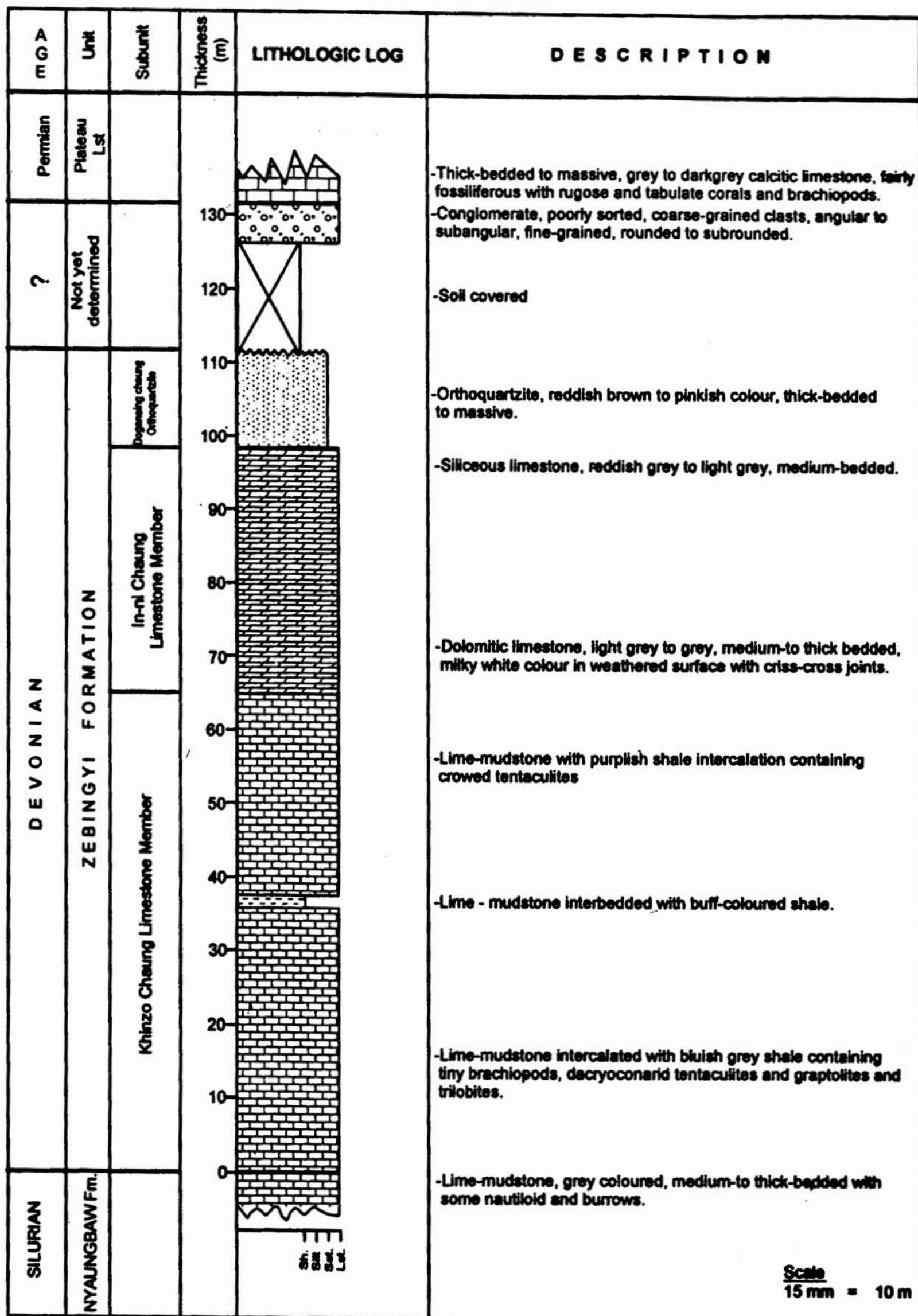


Fig-(3) Stratigraphic section of the Zebingyi Formation in the Doganaing Chaung (Myin Thae Chaung) (Aye Ko Aung et al., 2003)

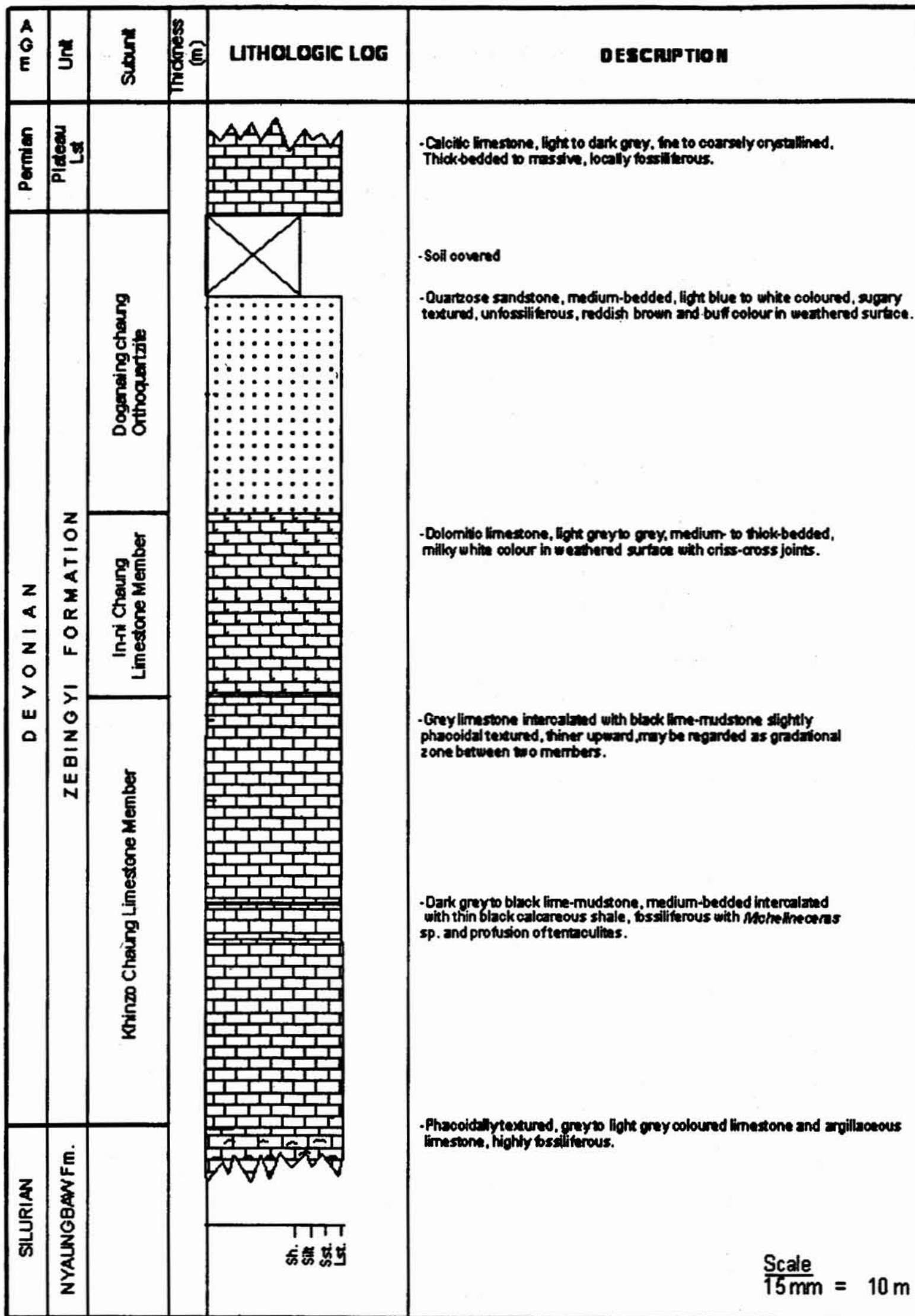


Fig-(4) Stratigraphic section of the Zebingyi Formation near the junction of Doganaing Chaung and Pe-bin Chaung (After Cho Oo et.al, 2005)

Fauna content and age: Abundant dacryoconarid tentaculites (*Nowakia acuaria*, and *Styliolina* sp. suggests Early Devonian (Pragian). The brachiopods (*Plectodonta* sp. cf *P. forteyi*, *Clorinda* sp. cf *C. wongwannichi*, *Lissatrypa* sp.) and trilobites (*Cornuproetus* sp. cf *Cornuproetus sculptus*, ?*Iliaenus* sp.) Assemblage is very closely compared to that of the Early Devonian (probable Early to Middle Emsian) Pa Samed Formation of southern Thailand (Boucot et al. 1999) and Middle Emsian Satun Province of southwestern Thailand (Fortey, 1989). The tentaculites of the Zebingyi Formation are closely compared with those from the tentaculite-bearing Devonian unit of the Taunggyi-Taungchun range (Aung, 2000a). The graptolite fauna (*Monograptus actopus* and *Monograptus helmckeii*) were described from the Zebingyi Formation, Pyintha area are suggestive of Early Devonian (Late Pragian-?Early Emsian) (Jaeger, 1983). The trilobite species *Phacops taungtalonensis* Tint and Wai, 1970 discovered in the lower part of the Zebingyi Formation from Kangyigon area has been reported from Siegenian to Pragian of the Medaw area, Pyin Oo Lwin township (Tint and Wai, 1970). A very useful conodont (*Eognathodus sulcatus*), a zonal form of *sulcatus* Zone was recently discovered (Aung, in prep.) from silicified limestone lenses of the lower part of the Zebingyi Formation in Kangyigon area suggesting an Early Devonian (Pragian) age.

In-Ni Chaung Limestone Member

(Newly defined unit)

Name derivation: After In-ni chaung flowing from southeast to northwest, approximately 1.6 km north of Zebingyi village.

Synonymy: The upper unit of Pascoe (1959), Middle Member of Myint Thein (1983).

Type section: The type section of the unit is taken in In-ni chaung where the unit is well exposed. The section base is marked at GR 860534 to top GR 847547. It is 70.3m thick in the type section.

Map reference: One-inch topographic map 93 C/5 (second edition)

Distribution: The unit is widely distributed in the Zebingyi area, in north Doganaing chaung, south Doganaing chaung (or) Myin Thae chaung, and In-ni chaung. This member is not exposed in Pebin chaung. It may possibly be due to the structural control, i.e., there is a fault system developed

nearby Pebin chaung. It is evidenced by the presence of slicken sides and sheared plains on the bedding surfaces.

Lithology: In In-ni chaung (type section), the unit is medium- to thick-bedded dolomitic limestone and partly dolomitized in places. It is trending NNW-SSE with fairly gently dipping (30°) west. The limestones are milky white in colour in weathered surface and light gray or pink when they are fresh. The criss-cross joints are found in the outcrop. It is 70.3m thick in this section. There are some fossil fragments found in some outcrops but they are extremely poor in preservation and highly crystallized possibly due to dolomitization.

In south Doganaing chaung (Myin Thae chaung), the Member is flaggy, medium- to thick-bedded (40-170cm), slightly dolomitized. The beddings are trending NNE-SSW and dipping 35° W. Light to dark gray in colour and criss-cross joints are common in the bedding plane. The base of the unit often shows phacoidal structure. The relict fossil fragments of the crinoid stems and tentaculitids still remain. In this section the unit is 25.5m thick.

In north Doganaing chaung section, the In-ni chaung Limestone Member is flaggy, partly dolomitic, medium- to thick-bedded trending NNE-SSW with 45° W dipping. Light gray in weathered surface and whitish in fresh surface. Criss-cross joints are also common in the bedding surfaces. It is 29m thick and there is no fossils in this sequence.

Fauna content: Only some highly crystallized fossil fragments were found.

Relationship and boundary criteria: The Upper Member of the Zebingyi Formation is not exposed in In-ni chaung section. However, it is well exposed in north Doganaing chaung, south Doganaing chaung sections and also exposed on the slope, 10m south of Pebin chaung. In all of these sections, there is a sharp contact between the In-ni chaung Limestone Member and the overlying quartzose sandstone unit which is the Upper Member (Doganaing chaung quartzose sandstone Member) of the Zebingyi Formation. The similar appearance is also seen between this unit and the underlying Khinzo chaung Limestone.

Doganaing chaung Orthoquartzite Member

(Newly defined unit)

Name derivation: After Doganaing chaung, approximately 1 mile (1.6km) south of Zebingyi village, Pyin Oo Lwin township.

Synonymy: Upper Member (Myint Thein, 1983), Unit E (Han Khan Pau et al., 1993).

Type section: In the Doganaing chaung between GR 856528 (base) and GR 853527 (top), approximately 1.6km south of Zebingyi village, Pyin Oo Lwin township, Mandalay Division. The unit is 4m thick in this section.

Map reference: One-inch topographic map 93 C/5 (second edition).

Distribution: In the Zebingyi area, the unit crops out in south Doganaing chaung (Myin Thae chaung), north Doganaing chaung and on the slope, 10m south of the Pebin chaung. It is not exposed in In-ni chaung.

Lithology: The Doganaing Chaung Orthoquartzite Member is relatively homogeneous.

In south Doganaing chaung (Myin Thae chaung) it consists of thin- to medium-grained quartzose sandstone, thinner upwardly showing sugary texture and lensoid character in the middle part of the outcrop, unfossiliferous. Buff and reddish brown in weathered surface and whitish and light blue when it is fresh. It is 5.5m thick in this section.

In north Doganaing chaung (type section), the Member is constituted of similar lithology as in south Doganaing chaung. The only difference is that each bed is much thicker, more compact and less total thickness (4m) in the former than the later.

Fauna content: No fossils are found in this unit.

Relationship and boundary criteria: In the present area, the unit is unconformably overlain by the Permian calcitic and partly dolomitic limestone equivalent to the Thitsipin Limestone Formation (Garson et al., 1976) of southern Shan State and it overlies conformably the In-ni chaung Limestone Member of the Zebingyi Formation.

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