

## The Lower Paleozoic Stratigraphy of Western Part of the Southern Shan State, Burma

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**Abstract:** Rocks of all periods of the Lower Paleozoic are exposed at the western part of the Southern Shan State, typically at the Pindaya and Bawsaing (formerly known as Mawson) ranges. The Cambrian rocks are recently discovered, the Ordovician and Silurian rocks have been systematically restudied and grouped into formal lithostratigraphical units.

The Cambrian (Upper), Molohein Group proposed here as a new lithostratigraphic unit, is essentially made up of clastic sediments, and composed of slightly metamorphosed micaceous, fine-grained, pinkish to brown sandstones, and light-colored quartzites as principal rock types, and coarse-grained, pinkish sandstones, grits, greywacke, conglomerates and dolomites as minor rock types. These rocks are exposed as the cores of Pindaya Range and Hethin Hill in Bawsaing Range. The discovery of *Saukiella* and related genera from the micaceous sandstones enabled the assignment of the unit as Upper Cambrian. The thickness of the group is about 3,500 feet. The lower boundary of the unit in contact with the Chaungmagyi rocks of the pre-Cambrian age (La Touche, 1913) is unconformable, while the upper boundary in contact with the lower boundary of the Lokeypin Formation (Ordovician) is gradational.

The Ordovician rocks of the Southern Shan State can conveniently be grouped into the Pindaya Group which includes the Pindaya Beds and Mawson Series of Brown and Sondhi (1933). The Pindaya Group, herein, could be differentiated into four newly proposed formations, viz., (from lowest to uppermost), Lokeypin Formation (essentially containing grey siltstones), Wunbye Formation (essentially containing bedded limestones with burrowed structures and interbedded grey siltstones), Nan-on Formation (essentially containing yellow to buff color siltstones and mudstones, and Tanshauk Member (containing purplish shales and siltstones) of Nan-on Formation.

The Silurian rocks are grouped under the newly proposed Mibayataung Group in whose contentions are Brown and Sondhi's *Orthoceras* Beds, Graptolite beds of Wabya, Kyauktap, and Mibayataung, *Tentaculites* beds, and other unnamed beds that occur between the Pindaya Group and Plateau Limestone. The Mibayataung Group is differentiated into Linwe Formation, Wabya Formation and Taungmingyi Member.

Linwe Formation, a formal lithostratigraphic unit, proposed for substitution of *Orthoceras* Beds of older usage, is made up of phacoidally textured, pink, purple and grey limestones, calcareous mudstones, silty shales and shales. *Michelinoceras* in the limestones, and graptolites in the shales, are universally present. The Wabya Formation, overlying the Linwe Formation, contains the profusion of graptolite fauna. The shales are typically soft to sub-indurated, micaceous, grey, light grey to light buff in color; black indurated shales and slates, which often pyritiferous are also common. Taungmingyi Member is introduced as a member of Wabya Formation, containing lens-shaped bodies of white quartzose sandstones in the shales, occurred near the top of the formation.

Mineralization, especially lead and zinc, occurs in the rocks of the Pindaya Group. Volcanic activities, as evidenced by the occurrence of rhyolites, rhyolitic tuffs, ash and bentonitic beds within the Wunbye Formation and at the upper horizon of the Wabya Formation, could have been sporadically active between the Ordovician and Silurian Periods.

### INTRODUCTION

The Southern Shan State is situated on the eastern part of Burma, as part of the Shan Plateau, which rises up to the general elevation of 4,000 feet above sea level. This mountainous region continues northwestward into the terrains of Northern Shan State and Yunnan, and southward into the mountainous regions of the Kayah State.

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The area under consideration in this paper is the western portion of the Southern Shan State, the western limit being the western flank of the Pindaya Range which in turn is the limit for the westernmost occurrence of the rocks of the Lower Paleozoic of the Southern Shan State, the eastern limit being the eastern flank of the Bawsaing Range, the northern limit being the Alegyaung (in Lawksawk township)—Ingyi (Ye-U subtownship) in the Pindaya Range, and Myozo—Thittetkon line in the Bawsaing Range; the southern boundary is the Heho—Kyone line (see Figure 1).

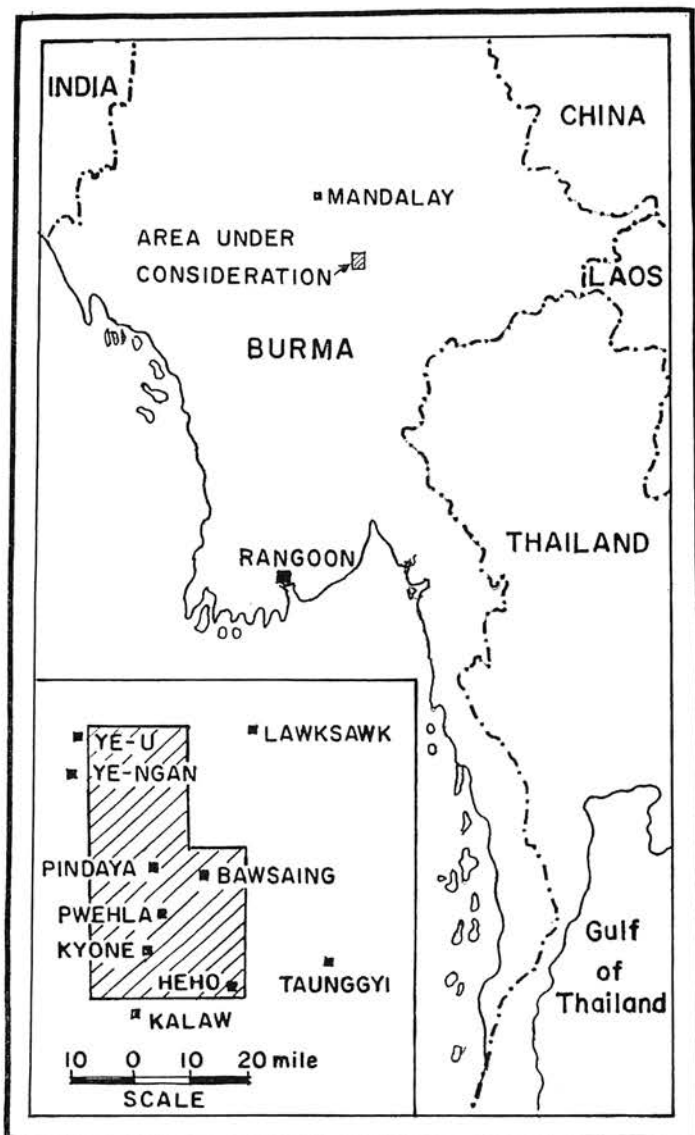


Fig. 1. Index Map Showing the area under consideration (cross-hatched) in this paper.

The gigantic features in the study area are the north-south trending Pindaya Range at the west and Bawsaing Range at the east, which are essentially built up with the Lower Paleozoic rocks. The former range is by far bigger, higher and more rugged than the latter, and it is the range where the type sections and localities are situated.

#### *Map Coverage*

Topographic maps (Map Nos. 93 C/12, southern portion of 93 C/16, 93 D/13 and 93 D/9) of the Burma Survey Department were used as base maps in geologic mapping. Grid references taken to six figures, the first three for the vertical grid lines, and the last three for the horizontal grid lines, are used for marking detailed locations of all samples. The study area falls in the Pindaya, Heho, Ye-ngan and Lawksawk townships. The total coverage being about 500 square miles.

#### *Physiography*

On this part of the Shan State, Pindaya and Bawsaing ranges are the conspicuous land features. The former, being 24 miles in length and 8 miles in general width, plunges southwards at the area of Wabya Hill, widens and continues into the terrains passing into the northern Shan Plateau. The highest points of the range are located at the northern half whereby the Molohein and Ashe-myin-anauk-myin peaks have the elevations of (7,307) and (7,752) feet above sea level respectively.

The Bawsaing Range, taking its name from the mining town of Bawsaing, situated at the west of Pindaya Range, has its northern margin at Thittetkon and Myozo, and southern margin at Heho; maximum length and width being 20 and 6 miles respectively. The range has its highest point (5,464 feet above sea level) near the northern part.

Pindaya-Pwehla-Lawksawk lowland having an average width of about four miles in the east-west direction lies between the Pindaya and Bawsaing ranges.

The core and central part of the Pindaya Range are made up of the rocks of Molohein Group, and the flanks and southern portion by the rocks of the Pindaya Group, Mibayataung Group, and limestones and dolomites of the Plateau Limestone Group (Permo-Carboniferous). The Bawsaing Range is predominantly made up of limestones and siltstones of the Wunbye Formation; portions of northern, western and eastern flanks have the exposures of Linwe Formation; and Wabya Formation is exposed at the western flank.

Topographically, the ranges are rugged, constituting several peaks, gorges and ravines. The areas of southern half and northwestern portions of the Pindaya Range, and most of the Bawsaing Range, especially at its eastern portions where the limestones of the Wunbye Formation being extensively developed, exhibit karst topography. The areas of central and northern part of the Pindaya Range where the clastic sediments of Molohein Group are extensively developed, exhibit dendritic to subrectangular drainage patterns. Most streams of the ranges are fault-controlled streams.

#### *Previous Geological Observers*

Geologists from the Geological Survey of India did their pioneering and first systematic geologic works in this Pindaya—Bawsaing areas. On account of the lead and zinc deposits the Bawsaing area had been frequently visited by these geologists. Fedden (1865), Jones (1887), Middlemiss (1900), Clegg (1926), and Rundall (1928)

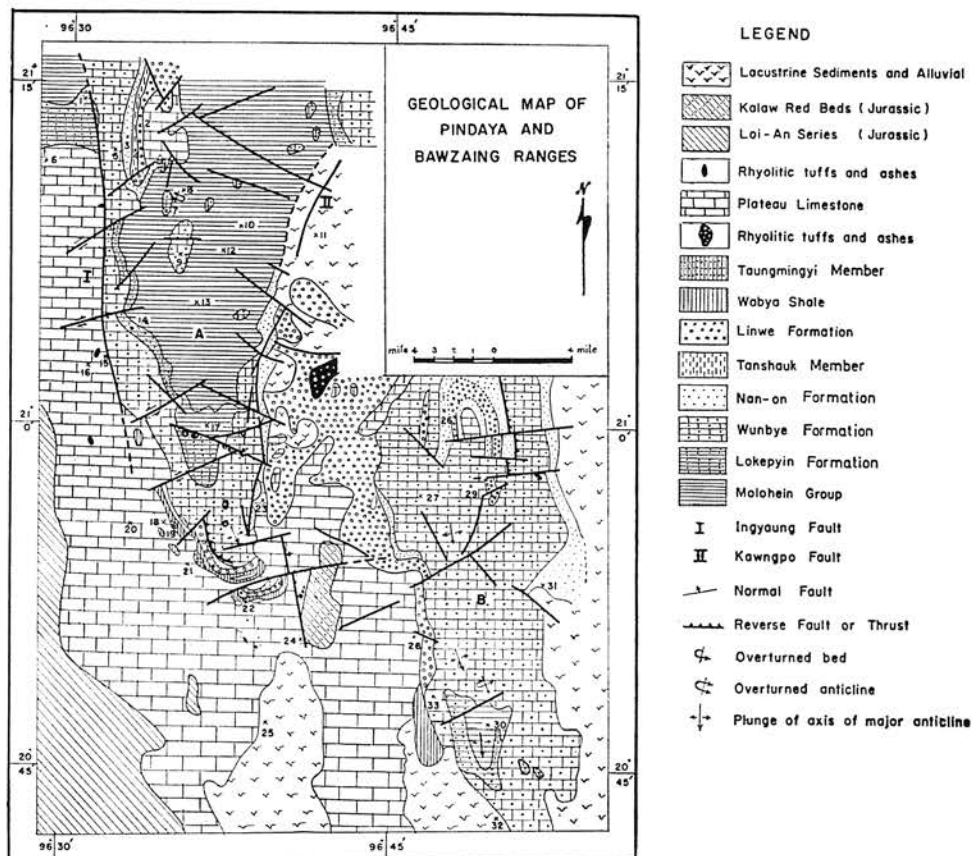


Fig. 2. Geological Map of the Pindaya and Bawzaing ranges. (After M.L. Thein, P.M. Than, W. Naing, M. Swe, T. Naing, S. Thein, M. Ko, Z. Thet, K.M. Wai, Y.Y. Nwe, W.W. Aye, Nanda Oo T.H. Mu, *et. al.*).

- |                                     |                        |
|-------------------------------------|------------------------|
| A -Pindaya Range                    | 16 Mying               |
| B -Bawzaing                         | 17 Menedaung           |
| 1 Ingyi                             | 18 Myindwin            |
| 2 Linne                             | 19 Taungmingyi         |
| 3 Nan-on                            | 20 Myinkyado           |
| 4 Tanshauk                          | 21 Yagyi               |
| 5 Wunbye peak (5143')               | 22 Wabya Hill (5409')  |
| 6 Kazet                             | 23 Pindaya             |
| 7 Padongaing                        | 24 Pwela               |
| 8 Hsinma-ngo                        | 25 Kyone               |
| 9 Taung-kha-mauk                    | 26 Thittetkon          |
| 10 Ywama                            | 27 Bawsaing            |
| 11 Kawngpo                          | 28 Kyaukfap            |
| 12 Molohein peak                    | 29 Bamu peak (5277')   |
| 13 Ashe-myin-anak-myin peak (7752') | 30 Hethin peak (5124') |
| 14 Lokeypyin                        | 31 Singyaung           |
| 15 Ingyaung                         | 32 Heho                |
|                                     | 33 Taungbat            |

gave their account on the rock types, mineral deposits and local mining industries. Brown (1931) was the first to describe the systematic regional geology of the Paleozoic rocks of the western part of the Southern Shan State, and drew the first geological map on the quarter inch scale. Later, Brown and Sondhi (1933) revised Brown's earlier paper and map to bring the geologic, paleontologic and stratigraphic data up to date. Brown and Sondhi's paleontologic accounts were those made by Reed (1932, 1936), Elles and Wood (1906). Regarding the geology of the Southern Shan State, Brown and Sondhi's work is monumental, and no such significant paper was published since then, except brief accounts given by Sondhi in Heron's General Reports (1935, 1936). Above facts were incorporated in the text-books written by Chhibber (1935) and Pascoe (1939).

#### *The Present Investigation*

The present study is based on the field works carried out from 1968 to 1970, made during the summer field seasons, in the western part of the Southern Shan State, for the project entitled "Reevaluation on the Geology and Mineral Resources of the Southern Shan State". Several field parties lead by the geology faculty members of Rangoon Arts and Science University under the supervision and guidance of the present author did geological mapping on the scale of two inch to one mile and fossil collecting. Messrs. Pe Maung Than, Win Naing, Min Swe, Soe Thein, Min Ko, Zaw Thet, Than Naing and Khin Maung Wae, and Misses Yin Yin Nwe, Nanda Oo, and Wae Wae Aye are among the faculty members, and Miss Tin Htay Mu, a graduate student, co-operatively and zealously put their energy, enthusiasm and hard work in geologic field mapping. Not less than a hundred third year geology major students assisted in the fields as part of their training in this research project. Only quarter inch geologic map is reproduced, here, to save space (see Figure 2).

Southern portion of the present area of investigation was mapped before by Brown and Sondhi while the northern portion, north of Latitude  $21^{\circ} 0'$  was unmapped before. The present map differs a great deal from that of Brown and Sondhi's.

### HISTORY OF STRATIGRAPHIC CLASSIFICATION AND CORRELATION

Brown (1931) drew a geologic map of the western part of the Southern Shan State and arranged the succession as follows:—

1. Alluvium
  2. Residual deposits
  3. Late Tertiary deposits
  4. Plateau Limestone (Devonian to Permo-Carboniferous)
  5. Pindaya Beds
  6. *Orthoceras* Beds
  7. Mawson Series
- } —(Ordovician)

Brown and Sondhi (1933) revised Brown's geologic map and stratigraphic classification as in Table 1.

Reed (1936) considered the Mawson Series to be of Lower to Middle Ordovician, and the Pindaya Beds to be of Upper Ordovician which has its fauna resembling the Chikunsan and Tsuibon faunas of South Korea. He placed the fauna of *Orthoceras* Beds in the Middle Ordovician, and correlated with the Nichiashan Formation of Yangtze region (China).

Table 1. Brown and Sondhi's (1933) tentative correlation of the Lower Paleozoic inliers of the Shan State

Age	Northern Shan equivalents	Pindaya inlier	Mawson (Bawsaing)—Heno—Mawnang region
SILURIAN			
Upper	Zebingyi Stage	..	<i>Tentaculites</i> Beds
Middle	..	..	..
Lower	Panghsapye Band	Wabya Graptolite Bed	(a) Mibayataung (b) and other (c) Graptolite Beds
			<i>Orthoceras</i> Beds
ORDOVICIAN			
Upper	Upper Naungkangyis	Pindaya Beds	Mawson Series
Middle	Lower Naungkangyis		

Pascoe (1939) supported Reed's view and placed the Pindaya fauna in the Upper Ordovician, and Kobayashi (1934) correlated this fauna with that of Tsuibon (Upper Ordovician) of South Korea. As for the *Orthoceras* Beds, Pascoe inclined to place it in the Middle to Upper Ordovician.

Kobayashi (1969) cited Reed's view regarding the Mawson Series and the Pindaya Beds, and pointed out that the cephalopods of the *Orthoceras* Beds seems to be allied to the *Sinoceras* (Middle Ordovician of central China) fauna and Toufangian fauna (Middle Ordovician of north China).

#### SUCCESSION AND CORRELATION

The newly proposed Molohein Group, comprising of pinkish or purplish micaceous sandstones and white or light pinkish and purplish quartzites, is underlain unconformably by a sequence of rocks believed to be belonged to the Chaungmagyi Series of La Touché whose age judged by the stratigraphic sequence is assumed to be pre-Cambrian (La Touché, 1913), and passing up gradationally to the siltstones of Lokepyin Formation. The newly discovered *Saukiella* and related genera of trilobites from these rocks indicate the Upper Cambrian age to this group. The rock units with undoubted Cambrian fauna, described here for the Molohein Group, occurring between the Chaungmagyi Series and the Pindaya Group, are new that have not been reported before.

The Pindaya Group, proposed herein, is equivalent to the Mawson Series and the Pindaya Group of older nomenclature. The Mawson Series and the Pindaya Beds were proposed by Brown (1931) and Brown and Sondhi (1933) as separate units for the Ordovician rocks of the Southern Shan State, the former being applied to those rocks that are exposed at the Mawson (now Bawsaing) Range, and the latter, applied to those rocks that are exposed at the Pindaya Range. However, the present detailed investigations and geologic mappings undoubtedly revealed the fact that the lithologic units of the above two ranges are the same which can only be treated under the same lithostratigraphic unit. The lithologic units are far more completely exposed at the Pindaya Range than at the Bawsaing Range. The Bawsaing Range is structurally very complex, and its stratigraphic succession could only be solved after the establishment of correct succession at the Pindaya Range. It is now evident that two different stratigraphic names for the Ordovician rocks of the same sequence, exposed at two different localities, is obviously unnatural and absolutely unnecessary.

In view of the above facts, it is necessary that continued adoption of both Mawson Series and Pindaya Beds for the Ordovician rocks of the Southern Shan State should have been abandoned, and revision of older concept of stratigraphic succession is urgently needed to avoid confusion and misinterpretation in geologic mapping and stratigraphic analysis.

Thus, the Pindaya Group is proposed herein, to apply for the Ordovician sequence of the Southern Shan State, which is wholly equivalent to the older nomenclature of both the Mawson Series and the Pindaya Beds. Lokepyin Formation, Wunbye Formation, Nan-on Formation, and Tanshauk Member of the Nan-on Formation are proposed to be included in the Pindaya Group. All the type localities and sections of these units are situated at the Pindaya Range. In doing so, the older usage of the Mawson Series and the Pindaya Beds should have been abandoned.

Mibayataung Group is a newly proposed lithostratigraphic unit to be applied for those rocks that occur between the Pindaya Group and the Plateau Limestone. Linwe Formation, Wabya Formation and Taungmingyi Member of the Wabya Formation are proposed to be contained in this group.

Linwe Formation is the formal lithostratigraphic substitution for the *Orthoceras* Beds of Brown (1931) and Brown and Sondhi (1933). *Orthoceras* Beds was applied by these authors to those rocks which are younger than the Mawson Series. They neither mentioned the upper horizon of the unit, nor indicated the field relationship with the Pindaya Beds, and had not designated the type locality and section. The above beds consist of hard, flaggy, bright-colored, red, pink or purplish, argillaceous limestones and calcareous shales with a highly developed phacoidal structure. Brown (1931) assigned its age to the Upper Ordovician, while Brown and Sondhi (1933) regarded it as Lower Silurian. Reed (1936) and Kobayashi (1969) regarded it again as Middle Ordovician, and Pascoe assumed its age to be ranging from Middle to Upper Ordovician.

Assignment of an Ordovician age for the *Orthoceras* Beds seems to be counting on the supposedly occurrence of typical Ordovician fossils, such as *Actinoceras*, *Receptaculites*, *Endoceras* and *Cyrtoceras*, etc. that had been collected by Brown. However, after checking on the original fossil localities of Brown, it is now found out that the above fossils were not collected from the rocks of the *Orthoceras* Beds, but from the limestones of the Pindaya Group. Thus, it is probable that due to lack of detailed field mapping, Brown could have been mistaken the Pindaya limestones inliers to be of the rocks of the *Orthoceras* Beds. Present thorough search also confirms the absence of such Ordovician fossils in the *Orthoceras* Beds. Furthermore, it is now discovered that *Monograptus* occurs in the micaceous shales and silty shales that interbeddedly occur with the phacoidal limestones. The present Silurian age assignment for the Linwe Formation (including *Orthoceras* Beds) agrees with that of Brown and Sondhi (1933). Again, as it is now attempted to correlate the Linwe Formation with the Nyaungbaw Limestone of the Northern Shan State, it fits with the idea of Sun (1948) who referred the latter unit to the *Cameroocrinus* bearing Jenhochian Formation of Yunnan having Lower Silurian age.

The essence of the lithologic character of the *Orthoceras* Beds was clearly indicated by the occurrence of beds of phacoidally textured rocks in association with the *Orthoceras* species. However, the present field investigations revealed the fact that these phacoidal rocks in association with the *Orthoceras* occur not only at one horizon in the stratigraphic sequence as was assumed by the previous authors, but at two or more

horizons, which are separated by the graptolite bearing shales of considerable thickness. This clearly points out that the *Orthoceras* Beds cannot be taken as a formal lithostratigraphic unit to be served for geologic mapping.

Evidently, the usage of *Orthoceras* Beds bears no value in lithostratigraphic nomenclature, and its application in geologic mapping can seriously involve erroneous results. Also, if viewed from the light of modern practice of stratigraphic nomenclature (ISSC, 1969) the term *Orthoceras* Beds would be regarded as informal, which was established and used based on insufficient stratigraphic data and field evidences. Thus, it is now highly necessary that this usage should be substituted by an appropriate lithostratigraphic unit.

In view of the above facts, it is attempted here, to introduce the Linwe Formation as a formal lithostratigraphic unit name to be used in place of the *Orthoceras* Beds, and applied to those rocks which are conformably overlying the rocks of the Pindaya Group and conformably underlying the grey shales of Wabya Formation. The new Linwe Formation comprises the phacoidally textured argillaceous limestones and calcareous mudstones (of the *Orthoceras* Beds) plus grey graptolite bearing shales which occur between the horizons of phacoidally textured rocks.

Wabya Formation is a newly proposed legalised lithostratigraphic unit which conformably overlies the Linwe Formation. Taungmingyi Member is differentiated as a member of Wabya Formation which contains the lens-shaped bodies of white and bluish grey quartzose sandstones that occur in the grey shales of the Wabya Formation at the upper horizon.

The stratigraphic succession of the rocks of the Lower Paleozoic of the Southern Shan State, and correlation with units of other areas are shown in Tables 2 and 3.

Table 2. Present status of stratigraphic classification of the Lower Paleozoic rocks of the western part of the Southern Shan State

Geologic Age	Brown & Sondhi (1933)	Reed (1936)	Present Classification
SILURIAN			MIBAYATAUNG GROUP
Upper	<i>Tentaculites</i> Beds	<i>Tentaculites</i> Beds	Other unnamed beds
Lower-Upper			Taungmingyi Member
Lower	(a) Mibayataung (b) and other (c) Graptolite Beds <i>Orthoceras</i> Beds	Graptolite bearing shales and slates of Southern Shan State	Wabya Formation Linwe Formation (Comprising <i>Orthoceras</i> Beds)
ORDOVICIAN			PINDAYA GROUP
Upper	Pindaya Beds, Mawson Series	Pindaya Beds	(Comprising Mawson Series and Pindaya Beds)
Middle		<i>Orthoceras</i> Beds	Tanshauk Member
Lower-Middle		Mawson Series	Nan-on Formations Wunbye Formation Lokepyin Formation
CAMBRIAN			MOLOHEIN GROUP
Upper			

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Table 3. Stratigraphic Succession of the Lower Paleozoic rocks of the western part of the Southern Shan State and correlation of the units with those of the Northern Shan State and West Yunnan

Geologic Age	Southern Shan State	Northern Shan State	West Yunnan (Formation)
<b>SILURIAN</b>	<b>MIBAYATAUNG GROUP</b>		
Lower-Upper	Taungmingyi Member		
Lower	Wabya Formation Linwe Formation	Panghsa-pye Beds Nyaungbaw Limestone	Lower Jenhochiao
<b>ORDOVICIAN</b>	<b>PINDAYA GROUP</b>		
Upper	Tanshauk Member Nan-on Formation	Hwe-Maung Purple Shales Upper Naungkangyi Stage	Upper Pupiao
Lower-Middle	Wunbye Formation Lokeypin Formation	Lower Naungkangyi Stage	Lower Pupiao
<b>CAMBRIAN</b>	<b>MOLOHEIN GROUP</b>		
Upper		Pangyun Series	Paoshan

## MOLOHEIN GROUP

Sondhi in Heron's reports (1936, 1937) noted the occurrence of shales, sandstones, phyllites, quartzites and mica-schists in the northern part of the Pindaya Range of Yengnan and Lawksawk townships which he put them in the Chaungmagyi Series (pre-Cambrian). Except for this short note, no other account or map had been published for this northern Pindaya Range, whose terrain which is highly dissected by deep ravines and gorges down to 4,000 feet below the level of the crests, and highest peaks rises up to well over 7,000 feet, is extremely rugged, mostly covered by impenetrable jungles and forests, and thus, practically virgin in geologic sense.

The sequence of rocks exposed at this central and northern portion of the Pindaya Range is, herein, regarded as a distinct suite of lithostratigraphic unit that occur between the Pindaya Group and the typical Chaungmagyi Series. Thus, the name, "Molohein Group" is proposed to be applied for such sequence. This group consists of pinkish, purplish or reddish brown, highly micaceous, and very slightly regionally metamorphosed sandstones, and granular or well recrystallised quartzites of white, pinkish white or purplish white color. Subgreywacke, gritty sandstones, phyllites, dolomites, limestones and conglomerates are minor units. Highly jointed, finely crystalline, thick bedded and dark bluish grey dolomite occur as lens-shaped bodies near the upper horizon of the Molohein Group. Conglomerates, usually made up of the quartzite pebbles of the underlying Chaungmagyi Series occur at or near the base of the group. Two major units, viz., the micaceous sandstones and quartzites can be differentiated, the former appears at the higher horizon whose exposures are well seen at Hsinmango peak (6,910 feet above sea-level), Satte, and at western and southern parts of the Sugyi range. The unit of quartzites underlying the micaceous sandstones, occurs at the Molohein and Ashe-myin-anauk-myin ranges.

The detailed lithostratigraphic classification of the Molohein Group is still under way. The upper boundary of the group which is common with the lower boundary of the Lokeypin Formation is easily definable in the fields, as the lithology of the two units are different. The siltstones of the Lokeypin Formation is bright yellow when

weathered and grey when fresh and is markedly distinct from the reddish, pinkish or brownish color of the micaceous sandstones of the Molohein Group. As both of the rocks belonging to these rock units are soft, they are easily weathered, and perfect fresh exposure of the contact is rarely seen in the fields. However, the differences in soil color is helpful in demarcating the boundary; the soil of the micaceous sandstone gives brown color while that of the siltstones of the Lokeypin Formation gives yellow color. The lower boundary of the Molohein Group which is related to the Chaungmagyi Series is placed at the unconformable contact between the two units. Conglomeritic beds with pebbles of dark-grey quartzites of the Chaungmagyi Series often occur at the base of the group.

The lithologic characters of the lower units of the Molohein Group and the upper units of the Chaungmagyi Series are exceedingly similar and difficult to distinguish from one another. But, subtle and reliable distinguishing features could be noted if one observes very carefully. The micaceous quartzites or quartzose sandstones of the lower units of the Molohein Group are white or pinkish white when fresh and is different from the whitish grey or grey micaceous sandstones or quartzites of the upper units of the Chaungmagyi Series. There are also occurrences of thin bands of greywackes, marlstones silty shales and slates in the micaceous sandstones or quartzites of the upper units of the Chaungmagyi Series, the nature of which are absent in those of the Molohein. The lithology of the lower horizons of the Chaungmagyi Series having dark-colored quartzites, greywackes, slates and metasediments are markedly distinguishable from the light-colored rocks of the Molohein Group.

#### *Type Locality, Distribution and Thickness*

The name of the Molohein Group is taken from the Molohein Peak (7,307 feet above sea-level), situated about four miles west of Kawngpo village, in Lawksawk township. Grid co-ordinates of the type locality is 153 609 on the Topographic Map No. 93 C/12. The rocks of this group are exposed at central, northern, and north-eastern portions of the Pindaya Range in Pindaya, Ye-ngan and Lawksawk townships. Significant mountain ranges with the Molohein exposures are:- Sugyi (6,081 feet), Ashe-myin-anauk-myin (7,752 feet), Molohein, Kyauktalone, and Hsinmango (6,910 feet). At Bawsaing Range, the Molohein rocks are exposed at the Hethin hill (5,124 feet), situated at the southern portion of the range, where reddish or purplish feldspathic sandstones and whitish quartzose quartzites underlying the siltstones of the Lokeypin Formation, occur as the core of the Hethin anticline.

Stratigraphic thickness of the Molohein group is about 3,500 feet.

#### *Content*

The pinkish or purplish, micaceous, fine-grained sandstones exposed at the Hsinmango peak, which is placed at the upper horizon of the Molohein Group, contains abundant remains of tiny trilobites, viz. *Saukiella junia* (Walcott) var. A. Winston and Nicols, 1967, *Saukiella* Sp. A, *Eosaukia buravasi* Kobayashi 1957 and *Drumapsis texana* Resser, 1942.

#### *Age and Correlation*

Above trilobite fauna is allied to the fauna of the *Saukiella* subzone (an upper zone of *Saukia* zone) of Trempealeauan Stage (uppermost Cambrian) of Wilberns Formation, central Texas (Winston & Nicols, 1967). On lithological and stratigraphical grounds, the Molohein Group can be correlated with the Pangyun Series (La Touche, 1913) of the Northern Shan State, having quartzites, feldspathic grits, green-

ish slates or purple slaty shales. Hsinmango fauna is allied to the Tarutao faunule (Upper Cambrian) which occurs in the pinkish, micaceous sandstones exposed on the west coast of Tarutao Island, Peninsular Thailand (Kobayashi, 1957).

### PINDAYA GROUP

Brown (1931) introduced the term 'Pindaya Beds' for the calcareous shales, slates and thin bands of argillaceous limestones exposed at the Pindaya Range. His northern limit is Menedaung. At the same time, he named another unit as 'Mawson Series' to apply for those rocks not different from those of the Pindaya Beds exposed at the Bawsaing Range (formerly known as Mawson highlands), which is situated at about seven miles east of the Pindaya Range. These were redescribed by Brown and Sondhi (1933), without further attempt for clarification of lithologic differentiation of the above units.

Present systematic investigations carried out by the faculty members of the Geology Department of Rangoon Arts and Science University, found out that the lithologic types of the Pindaya Beds and the Mawson Series are the same, and there is no need to keep the two units under two different names which caused tremendous confusion in stratigraphic mapping and interpretation. Thus, the name Pindaya Group is proposed here to be used in place of the Mawson Series and the Pindaya Beds.

The newly introduced term, 'Pindaya Group' is a formal lithostratigraphic unit, comprising essentially of thick-bedded, burrowed, pelletal or silty limestones with irregular silt specks or laminae, and the grey or yellow siltstones. These rocks are well exposed at the Pindaya Range in Pindaya, Ye-ngan and Lawksawk townships, and at Bawsaing Range in Heho township. Apart from the present area, they also are extensively distributed at Letmaungkwe Range, Taunggyi Range and at the areas situated at south and northwest of Lawksawk.

The lower limit of the group is the lower boundary of Lokeypin Formation which in contact with the Molohein's micaceous, pinkish or purplish sandstones can be recognized without much difficulty in the field. In case of absence of fresh exposures this boundary can be drawn at the contact of bright yellow soil which is derived from the former unit and the grey soil which is derived from the sandstones of the latter unit.

The upper limit of the group which is in contact with Linwe Formation of the Mibayataung Group is placed at the upper boundary of the Tanshauk Member of the Nan-on Formation where pink or purple shales and siltstones occur. These shales and siltstones are about 170 feet in thickness at the type area, but usually not more than ten feet in thickness in most areas, and could practically be taken as the key bed separating between the Pindaya Group and the overlying unit.

Type localities of the formations and member of the group are located at the northwestern part of the Pindaya Range, in Ye-ngan township. The age of the Pindaya Group is regarded to be Lower to Upper Ordovician.

### Lokeypin Formation

#### *Name Derivation*

Lokeypin Formation is named after the village of Lokeypin, situated at about three miles northeast of Myaing in Ye-ngan township. The village itself stands on the formation.

*Type Section, Distribution and Thickness*

Type outcrop of the Lokeyin Formation is situated at Lokeyin, which is extending eastwards till reaching the Pwenya stream. This outcrop extends southwards up to Pwenya village and is exposed at Menedaung. At north, it occurs at North Padongaing and Satte villages, and at Theingon and Ingyi villages, located at about one mile east of Ye-U. At Bawsaing Range it is exposed on the flanks of Hethin hill. The stratigraphic thickness measured at the type locality is about 1,500 feet.

*Lithology*

Lokeyin Formation at its type locality comprises of a succession of medium to thick bedded, grey to buff, soft to indurated, micaceous siltstones. On account of weathering the siltstones give bright yellow color which is very distinctive for the formation. Subordinate rock types are yellowish, buff to greenish marl, and hard bands of micaceous and brownish sandstones interbedded with the yellow siltstones that occur at the lower horizon. At Menedaung, the formation exhibits little variation in lithic character, whereby, soft, thin to medium bedded, yellow siltstones interbedded with calcareous mudstones are predominant. Vein quartz often occurs within the siltstones. Lithologic variation of the formation as a whole is very slight.

The upper boundary of the Lokeyin Formation is determined at the first appearance of limestone bed of typical Wunbye character. The lower boundary of the formation is drawn at the transitional zone of the yellow or grey siltstones of the Lokeyin Formation and the pinkish, micaceous sandstones of the Molohein Group. Both the upper and lower boundaries are seen at the type area.

*Content*

Abundant orthid brachiopods.

**Wunbye Formation***Name Derivation*

This formation is named after the Wunbye Hill (5,143 feet above sea-level), located at about two miles southwest of Linwe village, in Ye-ngan township.

*Type Section, Distribution, and Thickness*

The type section is established between the point located at the eastern margin of Ingyi village (grid co-ordinates:— 741 745 on Map. No. 93 C/12) and the point bearing the grid co-ordinates of 078 728, situated at about one half mile north of western margin of Nan-on village.

This formation has the largest distribution and thickness among the formations of the Pindaya Group. At the Pindaya Range it is tremendously exposed on both eastern and western margins, and southern half of the range, and also as isolated outliers on rocks of the Molohein Group at Taungkhamauk (grid co-ordinates: 133 610), Yandwin (grid co-ordinates: 187 643) and Naungwo (grid co-ordinates: 168 660).

Bawsaing Range is predominantly built up with the rocks of the Wunbye Formation. This unit continues southwards to Mawnaing, Bawnin and Letmaungkwe Range, situated at south of Heho. It is also distributed at the western scarp of Taunggyi Range, Montawa Cave and White Crow Lake area.

The stratigraphic thickness at the type area is 5,390 feet (see Table 4).

*Lithology*

Wunbye Formation at its type locality consists of a succession of thick-bedded limestones, siltstones and dolomites. The limestones are finely crystalline, grey to bluish grey, sometimes oolitic, and with pink, buff or yellow colored silty materials in the forms of burrows, specks, pellets or irregular and regular laminations; burrow structure is most typical of these limestones. The siltstone subunits are thin, medium to thick-bedded, yellow to light grey, and soft to indurated; sometimes thin bands of hard and light greenish siliceous marlstone occur within the siltstones. The dolomite subunits are usually thickbedded, often massive, but generally with laminations, and with highly jointed surfaces in criss-cross pattern; color is usually bluish grey or grey with sub-metallic lustre, although on weathered surfaces it appears dull; finely crystalline although often oolitic; the dolomites are not usually extended laterally for a very long distance.

More or less similar suite of lithologic types are seen at other localities with slight changes in proportions of limestones to siltstones subunits. As for an example, limestone subunits are far more numerous and predominant than the siltstone subunits along the Myaing—Lokepyin section. Similarly, the same nature is seen at the Baw-saing Range, while the reverse case is seen at the Letmaungkwe Range. It is also noted that, the dolomite subunits which although are common at the type section, are nearly absent at the Myaing—Pwenya section. Thus, it is evident that there are lateral variations involving the occurrences of the subunits of limestones, siltstones and dolomites of the Wunbye Formation.

The lower boundary of the formation in common with the upper boundary of Lokepyin Formation is determined at the horizon of the first appearance of distinctive limestone beds with burrow structures or silty specks; and the upper boundary is determined at the last horizon of such limestone beds.

*Content*

Abundant orthid brachiopods, *Actinoceras*, *Ormoceras*, *Armenoceras*, *Endoceras*, *Receptaculites*, *Lophospire*, *Helicotoma* and stromatoporoids.

**Nan-on Formation***Name Derivation*

Nan-on Formation is named after the village of Nan-on (grid co-ordinates: 080 720 on Topographic Map. No. 93 C/12) in Ye-ngan township.

*Type Section, Distribution, and Thickness*

The type section of this formation is established at the area located between the grid co-ordinates of 078 728 and 080 728 where both the upper and lower boundaries are being exposed. The distribution of this formation is generally limited. From the type locality it extended southwards and exposed at Tanshauk and Kyaukhngat. At the northeastern area of the Pindaya Range, it occurs very extensively. It is also seen on the southwestern margin of the Pindaya Range at Nyaungchidaik; and on the southeastern margin of the range at Yegyanzin (formerly known as Yeosin, see Reed, 1936; Brown & Sondhi, 1933). At the Bawsaing Range, it occurs extensively on the north at Thittetkon, northwest of Nyaunggaing and at neighborhood of Myozo; on the western margin of the range at Kyeindaw, and on the eastern margin at Sinchaung. Stratigraphic thickness of the formation at the type area is 443 feet (see Table 4).

Table 4. Measured type section of the Wunbye Formation, Nan-on Formation, Tanshauk Member of Nan-on Formation, and Linwe Formation. The section is measured between Ingyi and Linwe villages, Ye-ngan township.

Formation	Subunits	Description	Thickness feet (meters)
Linwe Formation	13	Shales, buff and pink color	84.5 ( 25.8)
	12	Limestones, phacoidal, pink	5.4 ( 1.6)
	11	Shales, buff to grey	234.0 ( 71.3)
	10	Limestones, phacoidal, grey, argillaceous, thick-bedded	258.5 ( 78.8)
	9	Shales and siltstones, grey soft to sub-indurated, interbedded with argillaceous, grey limestones	869.0 ( 264.9)
	8	Limestones, phacoidal, grey, argillaceous	41.0 ( 12.5)
	7	Limestones, phacoidal, pink, lithographic	52.8 ( 16.1)
	6	Shales, purple, soft	54.2 ( 16.5)
	5	Limestones, purple, argillaceous	27.7 ( 8.4)
	4	Shales, purple, soft	25.2 ( 7.7)
	3	Limestones, phacoidal, pink	25.7 ( 7.8)
	2	Shales, purple, soft	28.0 ( 8.5)
	1	Limestones, phacoidal, pink	20.0 ( 6.1)
			1725.6 ( 526.0)
Tanshauk Member of Nan-on Formation	1	Siltstones and shales, pink and purple, soft, interbedded with buff and yellow siltstones	169.9 ( 51.8)
Nan-on Formation	1	Siltstones, yellow to buff color, micaceous, highly fossiliferous	442.9 ( 135.0)
Wunbye Formation	28	Limestones, light grey, silty, lithographic to finely crystalline	139.3 ( 42.5)
	27	Siltstones with limestones bands	371.5 ( 113.3)
	26	Limestones, bluish grey, silty, burrowed, medium to thickbedded	425.8 ( 129.8)
	25	Dolomites and siltstones interbedded	262.2 ( 79.9)
	24	Siltstones, pink and yellow, subindurated	81.8 ( 24.9)
	23	Dolomites, finely crystalline, bluish grey, massive, with silt laminations	116.2 ( 35.4)
	22	Siltstones, yellow	83.8 ( 25.5)
	21	Dolomites, bluish grey	84.9 ( 25.9)
	20	Limestones, light grey, lithographic, silty, with laminations	111.1 ( 33.9)
	19	Limestones and siltstones interbedded	499.1 ( 152.2)
	18	Dolomites, bluish grey, massive to thick bedded	105.3 ( 32.1)
	17	Limestones, grey, thick bedded, burrowed, silty	34.8 ( 10.6)
	16	Dolomites, bluish grey, finely crystalline to oolitic	89.4 ( 27.3)
	15	Limestones, with interbedded siltstones and dolomites	1158.3 ( 353.1)
	14	Siltstones, yellow, with minor amount of interbedded limestone bands of 3-5 feet	129.8 ( 39.6)
	13	Dolomites, light bluish grey, finely crystalline, partially oolitic	182.5 ( 55.6)
	12	Limestones, burrowed, silty, light grey, thick-bedded, sheared	32.6 ( 9.9)
	11	Dolomites, light grey, finely crystalline, thick bedded	65.1 ( 19.8)

Formation	Subunits	Description	Thickness feet (meters)
	10	Limestones, grey, finely crystalline, thick-bedded, silty, burrowed	119.4 ( 36.4)
	9	Limestones and dolomites interbedded	215.6 ( 65.7)
	8	Dolomite, light greyish blue, finely crystalline, partially oolitic, massive	267.7 ( 81.6)
	7	Limestones and siltstones interbedded	146.4 ( 44.6)
	6	Siltstones, yellow, interbedded with grey limestones and marlstones	118.7 ( 36.2)
	5	Limestones, grey, thick bedded to massive, oolitic, laminated, silty, occasionally interbedded with massive dolomites	232.5 ( 70.9)
	4	Limestones and siltstones interbedded	121.2 ( 37.0)
	3	Dolomites, bluish grey, finely crystalline, massive	1.7 ( 0.5)
	2	Siltstones, yellow, micaceous, thick-bedded, laminated	140.9 ( 43.0)
	1	Limestones and siltstones interbedded	51.8 ( 15.8)
			5389.6 (1643.2)

Thittetkon Sponge Beds (Reed, 1936; Pascoe, 1959) falls in the contention of the Nan-on Formation. Reed's correlation of Thittetkon Sponge Beds with the Lower Naungkangyi Stage of the Northern Shan State is unacceptable in the light of detailed works on stratigraphic succession of the Southern Shan State. These beds neither have direct stratigraphic relationships nor obvious faunal affinities with the Naungkangyi rocks, but in actuality they are having stratigraphic continuity and lithologic similarity with the Nan-on Formation.

#### *Lithology*

The Nan-on Formation at the type locality consists of yellow to buff or light orange, thin to medium bedded siltstones, mudstones and marlstones, generally sub-indurated to soft. Occasional occurrences of micaceous, siltstones of light buff to whitish color with pink or purple specks differentiate this unit from the yellow siltstones of the Wunbye Formation. In some areas, thin bands of laminated and argillaceous limestones occur interbedded with the siltstones. This formation is highly fossiliferous.

The lower boundary of the formation is marked at the contact of the siltstones with the topmost limestone bands of the Wunbye Formation which have burrow or pelletal structures filled with silty materials, or silty laminations. The upper boundary is demarcated at the point of first appearance of purple band of the overlying Tanshauk Member.

#### *Content*

Abundant cystoids, orthid brachiopods, bryozoans, sponges and trilobite genera, such as *Iliaenus* and *Sphaerocoryphe*.

#### **Tanshauk Member**

##### *Name Derivation*

This member is introduced as a member of Nan-on Formation, and is named after the village of Tanshauk, situated at about one mile south of Nan-on.

*Type Section, Distribution, and Thickness*

The type section of Tanshauk Member is located along the cart road situated at about one quarter of a mile northwest of Linwe village. This is also exposed at west of Nan-on and Pegin, at Tanshauk and South Kyaukhngat villages. At the southern Pindaya Range, it is exposed at one half mile north of Nyaungchidauk village (grid co-ordinates: 150 345 on Topographic Map No. 93 D/9). At other areas, this member appears as thin sequence of beds generally less than ten feet in thickness, which can be used as the key bed demarcating the Pindaya Group and the overlying units. The rocks of the Tanshauk Member lies on top of the yellow siltstones or shales of the Nan-on Formation. The stratigraphic thickness measured at the type section is 170 feet (see Table 4).

*Lithology*

This member consists of purple or pink, soft, laminated, thin to medium-bedded siltstones, calcareous shales and calcareous mudstones. The characteristic feature of this unit is the purple or pink color exhibited by the siltstones or shales.

The lower boundary of Tanshauk Member is determined at the horizon of first occurrence of purple or pink shales or siltstones overlying the yellow or grey siltstones of the Nan-on Formation. The upper boundary is marked at the horizon of last occurrence of purple or pink shales or siltstones below the horizon of first occurrence of phacoidal limestone or grey shales of Linwe Formation.

**MIBAYATAUNG GROUP**

The Mibayataung Group is a newly proposed lithostratigraphic unit, comprising essentially of phacoidally textured, pink, purple or bluish-grey, argillaceous limestones and calcareous mudstones, buff color mudstones, pink or purple shales, grey shales and slates. The lower limit of the group is marked at the lower boundary of Linwe Formation where the phacoidally textured rocks or grey shales of this formation are in contact with the purple or grey shales or siltstones of Tanshauk Member which is the top-most unit of the Pindaya Group. The upper boundary of the Mibayataung Group is placed at the unconformable contact of grey shales of Wabya Formation or quartzites of Taungmingyi Member with the massive limestones or dolostones of the overlying Plateau Limestone Group.

In the contentions of Mibayataung Group, Linwe Formation, Wabya Formation together with Taungmingyi Member, and other unnamed beds that would have been occurred somewhere else outside the present area, between the Pindaya Group and the Plateau Limestone Group, are considered.

*Type Locality, Distribution, and Thickness*

The name of the Mibayataung Group is taken from the Mibayataung Hill (grid co-ordinates: 351 961 on Topographic Map No. 93 D/11), situated at about 9 miles due south-south-west of Heho. As rocks of both Linwe and Wabya formations are extensively developed at this area, the name, Mibayataung, is rightfully applied for the lithostratigraphic group name. However, due to the structural complexity exhibited by the rocks at this areas, type localities of the contained formations are not established there.

The rocks of the group is well exposed at Linwe, Pegin and Kyauktaw on the western margin; at Wabya on the southern margin; and at Kyauksu and Kya-in-kan

on the eastern margin of the Pindaya Range. At Bawsaing Range, they are exposed at Pakin, Pawmyin, Payani, Thayetpya, Naung-lwe and Kyauktap on the western margin; at Myozo and Htandape on the northern margin; and at Sinchaung on the eastern margin. Outside the present area, they are extensively exposed at Natdaw, Pawlamaw, Mibayataung and Wagymyaung, located at southwest of the Heho plain, at the areas between Lawksawk and Bawsaing, and at the hilly tracks situated at east of Shwenyaung—Kunlon plain.

The stratigraphic thickness of the group is at least 2,500 feet.

#### *Content*

*Michelinoceras* species in the phacoidally textured limestones and calcareous mudstones, and abundant graptolites in the shales are, universally present. Graptolites, listed by Reed (1936), included *Monograptus*, *Mesograptus*, *Orthograptus*, *Climacograptus* and *Clyptograptus* species. At the upper horizons, *Tentaculites*, associated with *Styliolina clavulus* and *Eutomis* cf. *phalanga* occur.

#### *Age and Correlation*

The fauna contained in the rocks of the Mibayataung Group indicates the Lower to Upper Silurian age. The lower units of the group (Linwe Formation) could be correlated with the Nyaungbaw Limestone, and the upper units (Wabya Formation and other unnamed beds) possibly are homotaxial equivalents of the Panghsa-pye Beds and other overlying units of the Northern Shan State (La Touche, 1913; Pascoe, 1959).

### **Linwe Formation**

#### *Name Derivation*

The name of this formation is taken from the village of Linwe, located in Ye-ngan township where the rock types of the formation are fully developed. The Linwe Formation is proposed to contain the phacoidally textured limestones and mudstones of informally named 'Orthoceras Beds' and the graptolite shales associated with such rocks.

#### *Type Section, Distribution, and Thickness*

The type section of the Linwe Formation is located at and neighborhood of Linwe village (grid co-ordinates: 085 725 on Topographic Map No. 93 C/12). This formation is rather widely distributed at both Pindaya and Bawsaing ranges, and also at the Taunggyi Range and Taunggyi Crag. The total thickness of the formation at the type section is 1,725 feet (see Table 4).

#### *Lithology*

The Linwe Formation consists of a succession of purple, pink and grey color, phacoidally textured limestones, argillaceous limestones, calcareous mudstones and shales. The purple and pink color, phacoidal texture and the universal occurrence of *Michelinoceras* (former usage, *Orthoceras*) species are the unique features of the limestones and calcareous mudstones. Grey is also not an uncommon color exhibited by these rocks. Majority of the shales are, grey, micaceous and with abundant graptolite remains, while some of the shales exhibits purple color. There are lateral variations of rock types within the formation. The limestones might appear as a thick unit at one place and disappear laterally to be replaced by grey or purple shales. The phacoidal limestone and calcareous mudstone units usually occur at two or more horizons along the stratigraphic sequence, which are separated by the thick sequence of shale units.

The lower boundary of Linwe Formation is determined at the horizon of contact of phacoidally textured limestones or grey shales with the purple siltstones or shale of the underlying Tanshauk Formation. The upper boundary is demarcated at the horizon of last occurrence of the phacoidal limestones or purple shales of the formation which is in contact with the lower boundary of the Wabya Formation.

#### *Content*

This formation characteristically bears the specimens of *Michelinoceras* in the phacoidal limestones and calcareous mudstones. *Monograptus* and *Climacograptus* profusionally occur in the shales.

The fauna of Linwe Formation is remarkably distinct from that of the underlying Pindaya Group. *Actinoceras*, *Ormoceras*, *Armenoceras* and *Endoceras* which are common in the latter unit are totally absent in the former; and *Michelinoceras* which is abundant in the former is practically lacking in the latter. Also, the profusion of graptolites in the former and absence of these in the latter is outstanding, and the brachiopods which are common in the Pindaya Group are relatively rare in the Linwe Formation.

#### *Age and Correlation*

The age of Linwe Formation, judging from the graptolites and stratigraphic sequence, is considered to be Lower Silurian. This formation is rightfully correlated with the Nyaungbaw Limestone (La Touche, 1913) of the Northern Shan State, and the *Camerocrinus* bearing Lower Jenhochian Formation of Yunnan (Sun, 1948).

### **Wabya Formation**

#### *Name Derivation*

Wabya Formation is named after the Wabya Hill (5,408 feet above sea-level) situated at the southern portion of the Pindaya Range, where the rocks of this formation including the lower and upper boundaries are fully exposed.

#### *Type Section, Distribution, and Thickness*

The type section is located at the northern slope of the Wabya Hill (grid co-ordinates: 177 308 on Topographic Map No. 93 D/9). The Wabya Graptolite Bed, Kyauktap Graptolite Bed and part of the Graptolite Beds of Mibayataung of Brown and Sondhi (1933) fall in the contention of Wabya Formation. The formation is well exposed at the southwestern limb of the Pindaya Anticline, between Yagyi and Nyaungchidauk, at the low plains between Bawsaing and Pindaya, and at Wagymyaung and Mibayataung, located at south of Heho; it is also exposed at southwest of Taunggyi town. The stratigraphic thickness at the type section is 890 feet.

#### *Lithology*

The Wabya Formation comprises of light grey, soft to subindurated, micaceous or non-micaceous shales and silty shales, with sub-ordinate amounts of black slaty shales, slates, bentonitic and ash beds, and at some places crushed and friable anthracitic coal. Coal beds are exposed at Yagyi (grid co-ordinates: 302 343 on Topographic Map No. 93 D/10) in Ye-ngan township, Megya (grid co-ordinates: 316 205 on Topographic Map No. 93 D/9) in Heho township.

The lower boundary of Wabya Formation which is in contact with the upper boundary of Linwe Formation is determined at the horizon of last occurrence of the

phacoidal limestones or calcareous mudstones, or purple shales of the latter. The upper boundary is marked at the plane of unconformity situated below the Plateau Limestone Group.

#### *Content*

Profusion of graptolites including *Monograptus*, *Orthograptus*, *Glytograptus* and *Climacograptus*. The age of the graptolite fauna is determined to be Lower Silurian (Reed, 1936).

### **Taungmingyi Member**

#### *Name Derivation*

This member is introduced as a member of the Wabya Formation, and is named after the village of Taungmingyi, situated at about one and one half miles east of Myinkyado, in Ye-ngan township.

#### *Type Section, Distribution, and Thickness*

The type locality is Taungmingyi village itself, spotted by the grid co-ordinates: 120 375 on Topographic Map No. 93 D. It is also distributed at the southern portion of the Pindaya Range on western, southern and eastern peripheries. The stratigraphic thickness at Taungmingyi village is about 300 feet. Quartzites of the Taungmingyi Member occur as lens-shaped bodies near the upper horizon of the Wabya Formation.

#### *Lithology*

Taungmingyi Member comprises of well-sorted, fine to medium-grained, very poorly cemented, massive quartzites. Thick-bedded, bluish or grey, well indurated quartzites also occur. Hematite and jasperite nodules or bands are common at some places, occurring interbeddedly with the quartzites.

### **IGNEOUS AND ASSOCIATED ROCKS**

Rhyolitic tuffs and volcanic ashes occur interbedded with the rocks of Wunbye Formation, at the neighbourhood of Menedaung, Waboye, Panzeinbin, Pame and at the areas situated at west of Bawsaing. At some areas, as in Waboye and Menedaung, the rhyolites and rhyolitic tuffs occur along the major fault zones. This would indicate that some of the volcanic rocks are genetically related to the faults.

Volcanic tuffs and ashes are also commonly associated with the Silurian Wabya Formation, typically at Tadagyi (situated at about four miles northeast of Pindaya town), and at the stream sections situated at about two miles southeast of Kyauktap. Bentonitic and ash beds occur along the stream sections located northwest of Bawsaing, northeastern part of Naung-lwe, and at southeast and southwest of Kyauktap, within the upper horizon of the Wabya Formation.

Volcanism, as evidenced by the occurrence of these rocks, is assumed to be sporadically active between the Ordovician and Silurian Periods.

### **MAJOR STRUCTURE**

The geology and structure of the Pindaya Range are described in detail by Thein *et al* (1970). Normally, it is a south plunging anticline, but the northern half of the

range is very complex, having overturned and recumbent folds, and systems of faults at diagonal directions. At the northwestern portion of the range, the whole sequence from the Pindaya Group to the Plateau Limestone Group, extending over the distance of five miles in width, had been overturned, and dips eastwards instead of westwards.

The structure of the Bawsaing Range is more complex. The range in the general sense appears as a double plunging structure, plunging south as well as north, though the area of north plunging is very narrow as compared to the south plunging area. Both east and west directed forces interplay at the southern and northern areas so that the limbs are more or less overturned, while the force directed from the east is highly prevalent at the northern portion so that the beds are successively overturned towards the west.

The Pindaya plain situated between the Pindaya Anticline and the Bawsaing Anticline is apparently a syncline, which in detail appears to be complex.

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