Origin and time of Major Structure in Anisakan – Kangyigon Area, Pyinoolwin Township: an emphasis on the analysis of minor structure

Khaing Khaing San*

Abstract

The Anisakan – Kangyigon area is mainly composed of the Paleozoic sequence of Ordovician to Early Triassic rock units. This area is a fairly rugged terrain shaped by various geological processes especially folding, faulting, denudation and karstic processes. The whole structure is overturned anticline and syncline nearly NNE – SSW and NE – SW trend. All major faults are cut across the regional tectonic and topographic trend running nearly E – W. This area is structurally very complicated which is disturbed by the Shan – Burma Boundary fault zone. The present work deals with the interpretation of major structure and tectonic effect of the study area based on the analysis of minor parasitic folds in Nyaungbaw Formation. These folds are interpreted as shear folds which can identify the major shear strike-slip faults and estimate the time and setting of the major structure in this area.

Key words: structure, parasitic folds, shear folds, strike-slip fault

Introduction

The Anisakan-Kangyigon area which forms part of the western margin of the Shan Plateau, is situated about thirty miles east of Mandalay and about three miles southwest of Pyinoolwin. The area occupies part of the Pyinoolwin Township, Mandalay Region. It is located between the North Latitudes 21˚ 54′ to 22˚ 0′ and East Longitudes 96˚ 21′ to 96˚ 28′ in one inch topographic map 93C/5 (Fig. 1).

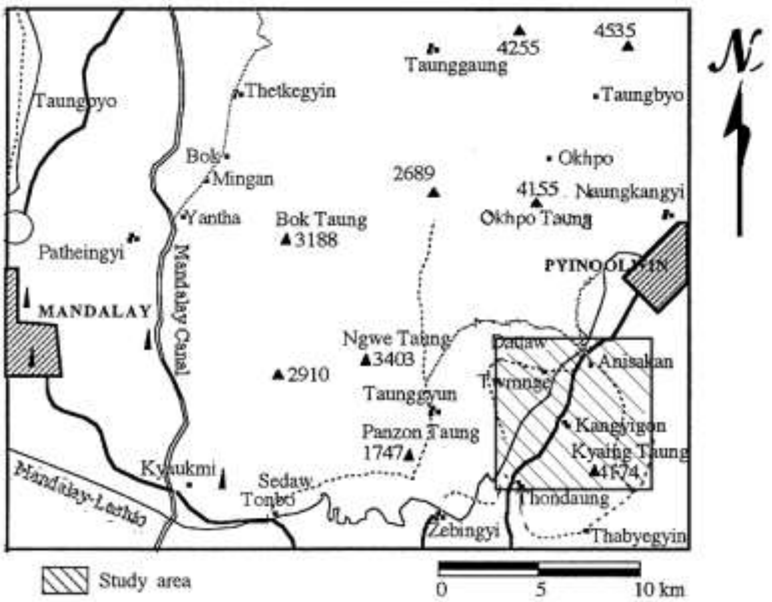

Figure 1. Location map of the study area.

The present area is mainly composed of Paleozoic sequence of Ordovician rocks (Sitha Formation and Kyaingtaung Formation), Silurian Nyaungbaw Formaton, Devonian Zebingyi Formation and Carbonifeous to Early Triassic Maymyo Dolomite. The present study is mainly emphasized on the major and minor geological structures to interpret the origin, time and setting of major structure in this area.

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* Professor, Dr, Department of Geology, Yadanabon University

Methods of Study

Several traverses across the regional structures were carried out. Traverses were made along the streams, cart-tracts and car-road where good exposures are developed. The nature and situation of the beds, bedding character, joint patterns, lithologic type, appearance of the rocks, evidences of faults and folds and faunal localities were observed and recorded by using a compass and plotted on the base map.

Minor folds in Nyaungbaw Formation are diligently observed and systematically measured, such as the detailed structure of parts of the folds as their trend, shape, types, fold axes direction, axial surface or axial plane dip amount and direction, plunge angle and plunge direction. Then, the measured data is plotted on the lower hemisphere of the Schmid's net to identify the styles and stages of deformation.

Results and Discussion

Major and Minor Geological Structure

In this area, the rock units are repeatedly exposed due to a series of nearly north-south trending major anticlinal and synclinal structures, and associated longitudinal faults and cross faults. The contacts between the rock sequences are gradational, conformable or tectonic. A regional unconformity is separated between the Zebingyi Formation and the Maymyo Dolomite.

This area lies along the western marginal zone of the Eastern Highland. The Shan-Burma Boundary Fault separates the Pre-Paleozoic and Paleozoic rocks of the Mogok Belt of Searl and Haq (1964). Therefore, the major structures are disturbed by the Shan Burma Boundary Fault zones. The study area is structurally very complicated and it is difficult to interpret. The regional strike trends nearly north to south being parallel to the general topographic trend. The area is generally dipping towards east with average amount of 30˚ affected by nearly N-S trending longitudinal faults and nearly E-W trending cross faults.

The area as a whole is highly folded, forming an overturned anticline and syncline. From the east to the west, two major folds are recognized in the area. They are the Nyanyintha anticline and Kangyigon syncline. A series of minor folds can be observed in the Paleozoic rocks of the area. West of the Nyanyintha village, some recumbent folds and curvilinear folds are well developed in the Nyaungbaw Formation. The tectonic sketch map illustrating the relation of lithologic distribution to the structural pattern is shown in Fig. 2.

Folds

The Nyanyintha anticline is named after the village of Nyanyintha for the anticline occupies in the vicinity of Nyanyintha village. The axis runs nearly from north to south, but it is slightly curved. It is an asymmetrical anticline of which the dips of the western limb are steeper than those of the eastern limb. Minor drag folds are common in the western limb especially near Nyanyintha pagoda hill. The rocks of the Sitha Formation form the anticlinal core. They are followed by the rocks of the Kyaingtaungs, Nyaungbaws, Zebingyis and Maymyo Dolomite. The Nyanyintha anticline is an overturned anticline. In the eastern limb of this anticline, all the lithologic units are dipping and younging towards east whereas in the western limb, the rock units become younger towards west but the beds are dipping towards

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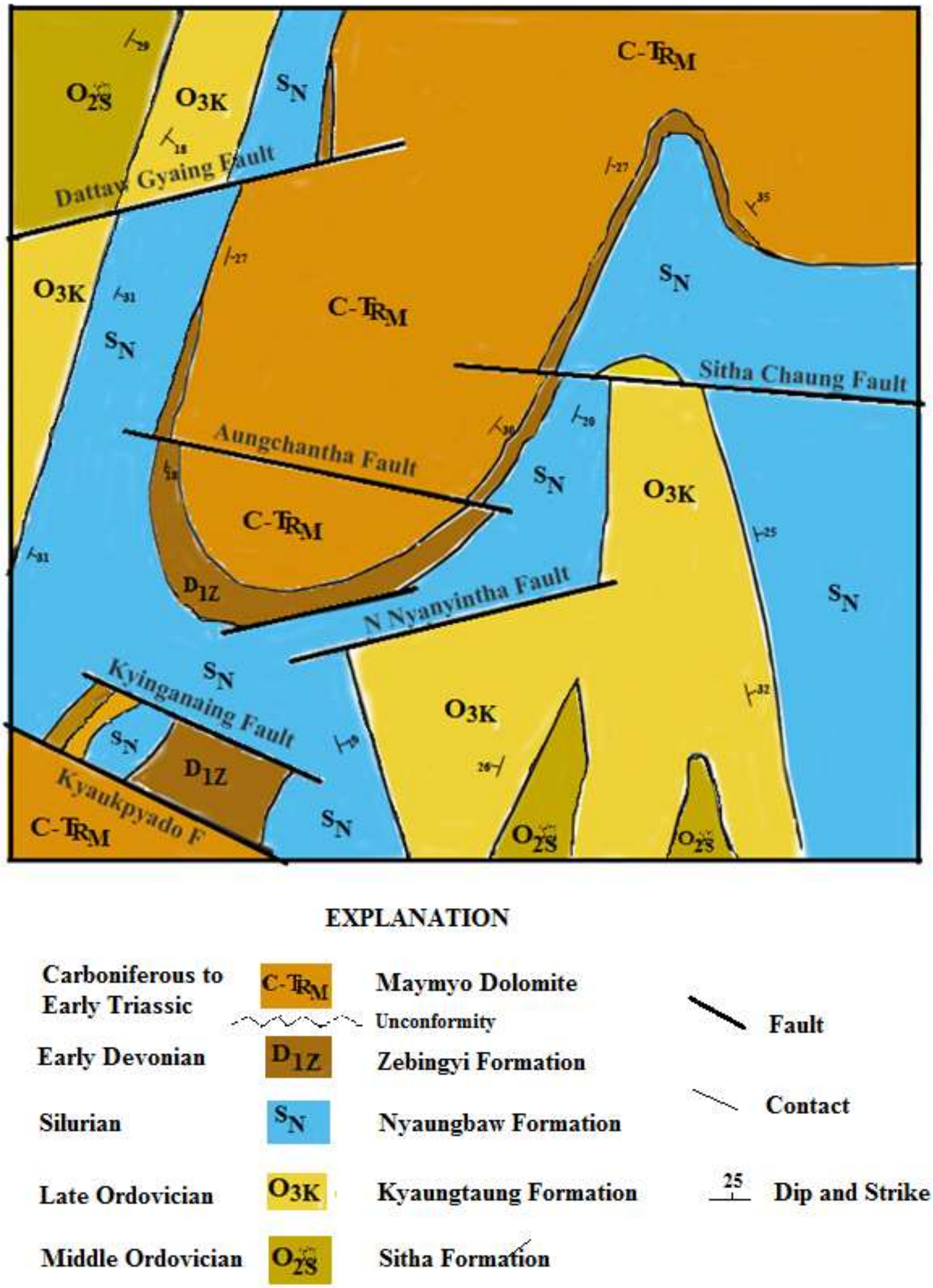

Figure 2. Tectonic sketch map illustrating the relation of lithologic distribution to the structural pattern (not in scale).

east. Therefore, the beds of the western limb are overturned. The closure is located near the Nyaungni village and Paungdaw village. The southern and central portions of this anticline are cut off by the South Nyanyintha fault and the Sitha Chaung fault.

The Kangyigon syncline is named after the Kangyigon village, where the synclinal trough area is developed. The axial trace of the Kangyigon syncline is probably N30˚E – S30˚W in direction. It is a north plunging overturned syncline. The closure is situated near Ingon and Dobin villages. The synclinal trough is occupied by the youngest Maymyo Dolomite. In this syncline, the lithologic units of the eastern limb become older towards east but the beds are dipping towards east. So, the beds in this limb are overturned. The northwestern part and the center of this syncline are cut off by the Dattaw Gyaing fault and the Aungchantha fault. The synclinal trough is displaced by the Kyinganaing Chaung fault. The minor tear fault (Kyaukpyado Chaung fault) separates the Kangyigon syncline and the Thondaung syncline.

Faults

In the study area, North Kyaukpyado Fault (F1) low-angle thrust fault and the seven cross-faults of dextral shear and sinistral shear strike-slip faults conjugate to the maximum stress (σ1) axis. The Sitha Chaung Fault (F5), Aungchantha Fault (F6), Kyinganaing Chaung Fault (F7) and Kyaukpyado Chaung Fault (F8) are sinistral shear strike-slip faults and the Dattaw Gyaing Fault (F2), Northeast Dathwekyauk Fault (F3) and South Nyanyintha Fault (F4) are dextral shear strike-slip faults. These faults cut the Nyanyintha anticline and Kangyigon synclinal structure on account of lateral splitting.

Joints

Joints cut through rocks of different lithology appear to be related directly to folds produced by deformation. These regular joint sets are thought to be formed by lateral compression and consequent extension in the same way as folds. In the formation of a fold by lateral compression, stretching by tension will take place on the outer arc of the fold. This process makes joints parallel to the fold axial trace along the hinge zone. In the study area, three sets of joints can be recognized; a strike-set (longitudinal joints), a dip-set (cross joints) and a conjugate set (oblique joints). On the basis of the recorded joint data, some interpretation for each unit can be concluded as the principal force which caused the folding, faulting and jointing in this area of Nyaungbaw Formation is N70˚W – S70˚E, Zebingyi Formation is N50˚W – S50˚E and Maymyo Formation is N60˚W –S60˚ E in direction respectively.

The origin of Major structure

The study area can be tectonically subdivided into two phases of deformation according to Fig. 3 and Fig.4, illustrating the plot of fold axes and their axial surfaces. They are mainly developed in the Nyaungbaw Formation and commonly exposed on the topmost part of the hill, south of the Nyannyintha pagoda. Folds are upright to overturn.

The first style of deformation is recognized by NE-SW trending isoclinals folds (shape). Most folds are polyharmonic folds showing chevron type tight folds (Fig.5). The distinct shear planes juxtaposed some folds and are parallel to the axial surface of minor folds. Some shear planes wedged- out and bedding slip also occur. Therefore, they are interpreted as shear folds in which bedding slip may be due to the attachment of shear along the weak planes

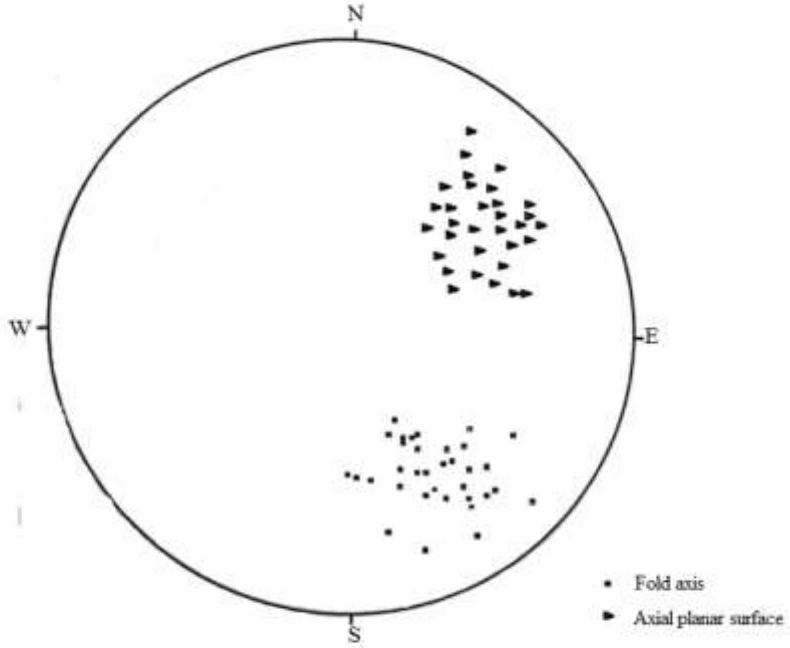

Figure 3. Plot of fold-axes and their axial surfaces on lower hemisphere of the Schmid's net (First Stage)

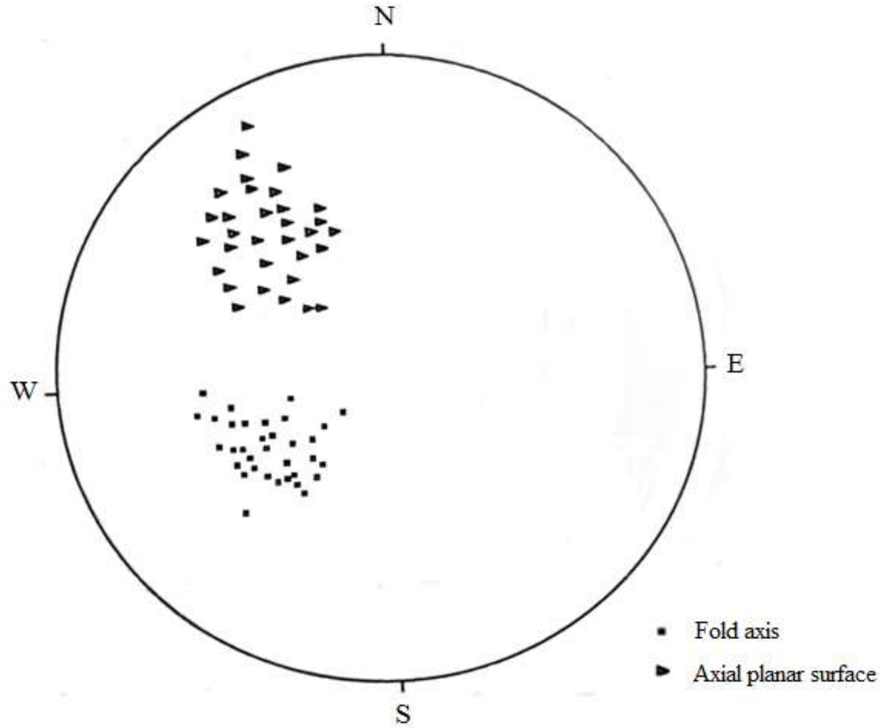

Figure 4. Plot of fold-axes and their axial surfaces on lower hemisphere of the Schmid's net (Secondt Stage)

of bedding (Fig. 6). In some places, the axial planes of minor folds are parallel to some shear surfaces (S_1) (Fig. 7) which are shallower than the bedding (S_0) (south of Nyanyintha pagoda). This fact supports that some are overturned folds which are interpreted as parasitic structure of the major overturned folds. The inverted stratigraphic succession also supports that the major structure is overturned.

Figure 5. Localized minor fold due to the major intense shearing in the Nyaungbaw Formation (grid: 943591).
Figure 6. Shear plane in the argillaceous limestone of the Nyaungbaw Formation (grid: 944591).
Figure 7. Juxtaposed of parallel minor fold along the shear plane in the grey green limestone of the Nyaungbaw Formation (grid: 948587).
Figure 8. Sheath-like folds in the grey green limestone of the Nyaungbaw Formation (grid: 943591).

According to Fig 3, most of these folds plunge north to northeast direction with gently to moderately plunging fold axes. They also have a northeast to northwest dipping axial surface with moderately inclined planes. Folds and their axes are wrapped along their axial surfaces. They have a curved hinge line and the variation of direction in axial planar surface also suggests that they are sheath folds (Fig.8). Folds are SE vergent. Some folds are intensely folded (Fig. 9) and conjugate, they may be commonly associated with thrusts and sheath folds in the first stage of deformation.

The second style of deformation is recognized by nearly north-south trending open folds that developed within the transpressional zone of the strike-slip faults. Most of these folds plunge in north to northwest direction with gently plunging fold axes (Fig.4). They also have a northeast dipping axial surface with gently to moderately inclined planes. The west vergency of major folds in the study area indicates the westward transport direction of rocks.

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Two different styles of deformation can be easily recognized; One style of deformation is represented by the tight, polyharmonic, chevron type folds and interpreted as "shear folds". The geometry of folds showing sheath-like folds indicates the intense major shear zones.

The other style of deformation is represented by the open, broad, parallel folds (Fig.10) and interpreted as "flexure- slip folds". The geometry of folds reveals that the bedding slip indicates the distinct Major uplifting movements.

Although the styles of deformation are different, based upon the origin of folds, all folds are interpreted as production under one phase deformational process. Tight, polyharmonic chevron style folds are developed due to intense shearing within the wide, local strike-slip shear zones. Open, parallel, flexure-slip folds are developed due to final uplift after the major intense shearing.

One phase deformation is revealed by the following facts;

(1)The trend of fold axes of the major tight overturned folds in the present area is not different from the trend of fold axes of major flexure-slip folds.

(2)The Middle Paleozoic (Nyaungbaw Formation, Zebingyi Formation) and the Upper Paleozoic (Maymyo Dolomite) are wrapped within the parallel minor fold axial planes or they are deformed simultaneously by the major folding.

(3)Tight, polyharmonic chevrons as sheath-likefolds are locally developed within the major intense shear zones, i.e., Nyannyintha area. Moreover, they are commonly developed within the more incompetent lithology mostly is the Nyaungbaw Formation.

(4) The plot of fold axes of polyharmonic, tight folds are not quite different from the open, broad folds (Figs. 3 & 4).

Time and setting of major structure

The main tectonic events in Myanmar were folding in the late Cambrian, late Paleozoic, late Mesozoic and Tertiary. The Ordovician-Silurian succession is broadly folded along NNW trending axes and overlain unconformably by a very thick carbonate sequence of Permian and early Mesozoic age with folding on the same axes as the earlier formations.

The folds affect both the Ordovician-Silurian units and the Pre-Jurassic Formations, that unconformably overlain them, but to different degrees. Although the Permian-Jurassic rocks dip in the same directions as the underlying Ordovician and Silurian rocks, they dip less steeply. This is particularly well displayed in Kangyigon syncline, where the difference in inclination is about 15˚ to 20˚.

During Early Pre-Cambrian, only the northeastern part of Myanmar probably existed as a part of the Eurasian plate. Since then, the geological development of Myanmar, in general, may be regarded as the accumulated result of the various geological processes that have taken place through successive geological periods along westward shifting subduction zones between the Eurasian and India plates. The Paleozoic sediments of Eastern Highland were laid down in the shallow marginal sea.

Figure 9. Intensely folded minor folds and shear plane in the Nyaungbaw Formation (grid: 943591)

Figure 10. Open, broad, parallel minor fold in the Nyaungbaw Formation (grid: 949588)

The Eastern Highlands of Myanmar consist of Pre-Cambrian and Paleozoic sedimentary rocks which were deformed and metamorphosed through recurrent orogenic movements in Proto-Asia. From the end of the Paleozoic, the geological evolution of Myanmar was affected by the mode plate convergence along the margin of the present Southeast Asia. Paleozoic is chiefly distributed within the Eastern Highlands and consists of lower and upper parts intervened by an unconformity during the Late Silurian and Devonian, which was a manifestation of the Caledonian Orogeny.

Also, there is no stratigraphic break between the Silurian and Devonian because of the Silurian Nyaungbaw Formation and the overlying Early Devonian Zebingyi Formation is gradational in contact. Due to the absence of Zebingyi Formation between the Silurian Nyaungbaw Formation and the overlying Maymyo Dolomite in many places, there is an apparent erosional surface. In this case, the Maymyo Dolomite may be included in the Devonian strata. It indicates that the stratigraphic hiatus between the Silurian and Devonian rock sequence. The Caledonian movement might be influenced.

Extensive metamorphism and intrusion of granitic batholiths chronicled the Caledonian Orogeny from the Late Silurian through Devonian, during which the northern Shan Plateau suffered deformation.

Around the end of the Paleozoic, a gentle tectonic movement with little considerable metamorphism brought about an uplift of the Eastern Highlands and fracturing of brittle Maymyo Dolomite.

On the other hand, there is an erosional surface below the Carboniferous strata due to the absence of paleontological and stratigraphical records of Late Devonian strata. It indicates that the stratigraphic hiatus is present below the carboniferous strata. So, Hercynian Orogenic uplift is influenced.

Wolfart (1984) stated that uplift and erosional processes particularly in the central part of the Shan Massif were due to Hercynian orogeny. According to Garson et. al. (1976), the lack of Devonian and Carboniferous rocks are due to early Permian Hercynian movements causing uplift and heavy erosional activities in the area of southern and central Shan Massif prior to the deposition of the Permian Thitsipin Limestone Formation, the hiatus between the Thitsipin Limestone Formation and the lower Paleozoic rock is clearly documented by the fact that several different Paleozoic rock units are unconformably overlain by the Thitsipin Limestone Formation.

Myint Thein et. al. (1996) proposed that the west dipping subduction of the Indochina Block under the Shan-Thai Block caused by the compressional regime and plutonic-volcanic arc in Shan-Thai border during the early Indosinian Orogeny (Early Triassic). Due to the arrival of the Indian Plate which was rifted from the Gondwana land in the Late Triassic, the subduction zone ceased and a new eastward-dipping subduction zone appeared in the west, in the western ranges of Myanmar. The collision of the Indochina Block and Shan-Thai Block occurred in the east, in Thailand. The Mesozoic sediments of Shan-Thai Block has been accumulated around the eastern part of Tethys Sea under temperate and/or tropical climates. The Indosinian orogenic uplift might be importantly developed.

The present author also agrees that the initial uplift of the Shan Plateau begins during Caledonian and Hercynian orogenic movement proposed by Wolfart (1987) because the results of the this research indicate the intense deformation and lack of Late Devonian and Carboniferous rocks in the Shan Massif. But, intense deformational episode may happen in the main Indosinian orogeny. The Indosinian Orogeny happens at the same time as the initial collision of India and Asia initiating the Himalayan uplift. Therefore, the author also suggests that the main phase of deformation developed in the area is related to the Indosinian Orogeny.

Conclusion

Anisakan – Kangyigon area as a whole which is mainly composed of the Paleozoic rocks is broasly folded. The fold axes trending roughly in N-S direction are parallel to the regional topographic trend of the area. This study is mainly emphasized on the analysis of the minor parasitic folds which are abundantly observed in the Nyaungbaw Formation situated near the Nyanyintha pagoda hill. They have the variable axial planar surface and some folds with curved hinge line. It indicates that the fold axes are rotated to the shear direction and they are interpreted as shear folds along the shear surface. The major structure also observed the dextral shear and sinistral shear strike-slip faults cut across the overturned folds on account of lateral splitting. Therefore, it can be concluded that two styles of deformation are recognized in the present area which may be affected by the syn-tectonic and post-tectonic movements and the area subjected to considerable tectonic activity related to the Early Himalayan Orogenic period.

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