Occurrences of the Kalaw Formation in Yimi Area, Pinlaung Township, Southern Shan State

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Abstract

The present study area is situated in the Pinlaung Township, southern Shan State. The study area lies in the southern part of the Kalaw-Pinlaung Basin. It comprises the Plateau Limestone Group of Permian to Triassic age, Loi-an Group of Jurassic age, and Kalaw Formation of Cretaceous age. The Kalaw Formation can be subdivided into three members. The lower member of Kalaw Formation is an interbedded unit consisting of thin- to medium- bedded red sandstone, siltstone and shale. The good exposure of this member can be observed around the environs of Yegauk, Danrwe, Pinle and south of U-saung village and along the Pinlaung-Naypyitaw Car road. The middle conglomerate-sandstone member is an interbedded interval of medium- to thick-bedded, polymictic conglomerates and thin- to medium-bedded red siltstone and sandstone. Planar cross-beddings, pebble imbrication and gradded bedding occur in this member. This member well crops out near Htibwa Anau village, Yegauk monestry, near U-saung and along the Pinlaung-Naypyitaw Car road section. The upper member is a unit of thick-bedded to massive, hard, dark purplish to dark grey conglomerate intercalated with red siltstone.The conglomerates are poorly sorted and consist of limestone, dolomitic limestone, chert, red sandstone, and buff coloured sandstone pebbles which are cemented by red silt and sand. Upper conglomerate exposes near Zarka, Kyaungso, Ngwedaung, Htibwa Anau, Kondon, Shadein, U-saung, and near Yegauk villages.No fossil has been found from this formation in the study area. This unit unconformably overlies the Loi-an Group and the Plateau Limestone Group. On the basic of lithologic characters and stratigraphic position, the Kalaw Formation can be correlated with the Kalaw Formation of Khin Maung Win (1978), and Kalaw Red beds of MaungThein (2014). Therefore the age of the Kalaw Formation is thought to be taken as Cretaceous age.The sandstones of Kalaw Formation fall in the field of "Litharenite and Arkose" according to Pettijohn et.al, (1987) and it might be the deposit of large rivers, either alluvial or delta. It may be interpreted the conglomerate beds of the study area may be deposited as the alluvial or fluvial fan deposits.

Key words: Yimi area, Kalaw Formation, Cretaceous, Kalaw-Pinlaung Basin

Introduction

The present study area is situated in Pinlaung Township, southern Shan State. It is located in part of one inch topographic map 93D/16 and D/12. The area is bounded by Latitudes 20˚ 03´N to 20˚ 08 ´ N and Longitudes 96˚ 43´E to 96˚ 48´E. Since the Aungban-Loikaw and Pinlaung-Naypyitaw Car roads pass through it, the study area is readily accessible throughout the year. The location of the study area is shown in Fig. (1).

Purposes of Study

This paper is mainly intended: to investigate and describe the Kalaw Formation exposed in the area, to make a generalized petrologic analysis of the rocks, and to interpret the depositional environment.

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Materials and Methods

Before the field investigation has been carried out, literature survey and land sat image interpretation were done to delineate the major structural elements and possible lithologic boundaries in the area. In the

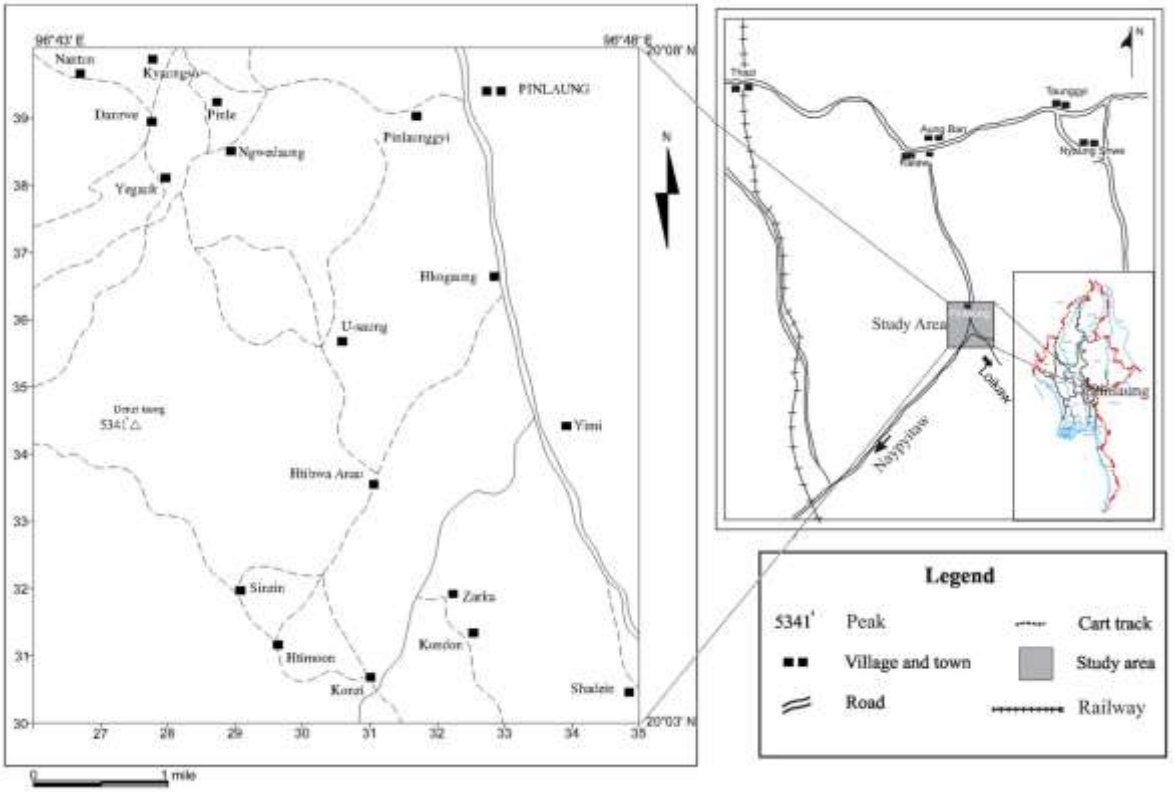

Fig. (1) Location map of the study area.

field, outcrop mapping was accomplished mainly with the aid of geologic compass and GPS Map 76. All rock samples collected during field survey were marked by Latitude and Longitude. The representative samples were thin-sectioned and prepared for petrographic interpretations. The optical characteristics of the samples were analyzed by the Polarizing Microscope. The visual estimations of the component grains were carried out to obtain the modal composition, and the petrographic classification.

Distribution and Lithology of Kalaw Formation

The study area is mainly composed of Mesozoic clastic sediments and subordinate amount of Paleozoic to Mesozoic age of carbonate rocks. In the present investigation, the Kalaw Formation is divided into three members: Lower sandstone-shale member, Middle conglomerate-sandstone member, and Upper conglomerate member.

Lower Sand-Shale Member

Lithology

The lower member of Kalaw Formation is mainly composed of thin- to medium-bedded red sandstone and thin, soft red siltstone and shale (Fig.2). The sandstones are fine- to medium-grained, well-bedded, moderately hard and compact. These sandstone beds are generally east dipping with dip amount of 10˚. Because of the iron cementation, the gross colour of this sandstone gives different shades of red to reddish brown colour. Desiccation cracks possibly formed by the secondary compaction, contraction and dehydration processes are also noted (Fig.3).

Distribution

The good exposure of this member can be observed around the environs of Yegauk, Danrwe, Pinle and south of U-saung villages and along the Pinlaung-Naypyitaw Car road.

Middle Conglomerate-Sandstone Member

Lithology

The Middle conglomerate-sandstone member is composed essentially of medium- to thick-bedded, polymictic conglomerates and thin- to medium-bedded red siltstone and sandstone (Fig.4). These conglomerate beds generally dip towards east with nearly horizon. The conglomerates consist of limestone, dolomitic limestone, chert, red sandstocoloured sandstone pebbles. These pebbles are well cemented with the reddish silty to sandy matrix. Most of the pebbles are subangular to rounded and some are flatten. They are poorly sorted and their sizes range from 9 inches to 0.5 inches in length. Dolomitic limestone pebbles have maximum length of 1.4 ft (Fig.5). Few interbeds of red gritty sandstone and siltstone are present in this member. Planar cross-bedding (Fig.6), pebble imbrications (Fig.7) and fining upward gradded bedding are frequently present (Fig.8). Sometimes small angular rock fragment beds interbedded with the red siltstone and fine-grained sandstone.

Distribution

This member well crops out near Htibwa Anau village, Yegauk monestry, near U-saung and along the Pinlaung-Naypyitaw Car road section.

Fig. (2) Reddish brown thin- to medium-bedded sandstone and siltstone interbedded unit of Kalaw Formation south of Yegauk village (20˚ 6′ 25.09″ N 96˚ 44′ 53.07″E)

Fig. (3) Dessication cracks on thin-to medium-bedded red sandstone of Kalaw Formation south of Yegauk village (20˚ 7′ 4.99″ N 96˚ 44′ 38.33″E)

Fig. (4) Interbedded unit of reddish brown thin- to medium-bedded sand and siltstone and conglomerate of Kalaw Formation at Yegauk monestry.

Fig. (5) Poorly sorted, subrounded conglomerate bed of Kalaw Formation near U-saung village (20˚ 5′ 54.95″N 96˚ 45′ 33.76″E)

Fig. (6) Planar cross-bedding occurred in thin- to medium-bedded sand, silt and conglomerate interbedded unit of Kalaw Formation near U-saung village

Fig. (7) Poorly sorted pebble imbrication occur in Middle conglomerate-sandstone member of Kalaw Formation near Htibwa Anau village (20˚ 5' 54.95"N 96˚ 45'33.76"E)

Fig. (8) Fining upward graded bedding observed in medium-bedded conglomerate bed of Kalaw Formation near Htibwa Anau village.

Upper Conglomerate Member

Lithology

This member is chiefly made up of thick-bedded to massive hard, dark purplish to dark grey conglomerate beds intercalated with minor red siltstone. Most of the pebbles are limestone, and the rest are red sandstone, siltstone, and chert. The pebble size is ranging from 1cm to the largest of about 60cm in length. These pebbles scatter in a red calcareous and red silt matrix. This member forms the protruding hills or pillars among the low lying ground area (Fig.9 & 10).

Distribution

In this area, Upper conglomerate exposes near Zarka, Kyaungso, Ngwedaung, Htibwa Anau, Kondon, Shadein, U-saung, and near Yegauk villages.

Fig. (9) Thick- bedded to massive coarse-grained red coloured conglomerate bed of Kalaw Formation near Htibwa Anau village (20˚ 04′ 37.92″N 96˚ 46′ 43.68″E)

Fig. (10) Thick- bedded to massive coarse- grained red coloured conglomerate bed of Kalaw Formation near Htibwa Anau village (20˚ 04′ 37.92″N 96˚ 46′ 43.68″E)

Stratigraphic Relationship

The Middle member conformably overlies the Lower sandstone-shale member and conformably underlies the Upper conglomerate member.

Kalaw Formation unconformably overlies the Plateau Limestone, and the Loi-an Group. This formation is faulted contact with the Loi-an Group west of Danrwe and Yegauk villages.

Fossil, Age, and Correlation

The stratigraphic position of the Kalaw Formation has been rather controversial as the proper fossils have not been discovered in this formation. Cotter (1924) stated that the Red Beds of Kalaw lie unconformably upon the Loi-an Series which contains undoubted Jurassic fossil, and the latter has been affected by earth movements which have not disturbed the Kalaw beds. Coggin Brown and Sondhi (1933) also accepted this succession and considered to be a Cretaceous age for the Red Beds on the basic of the so-called by Fox (1930). However, Kobayashi (1960) pointed out the differences in nature of distribution and structure between the Loi-an Coal Measures and the Red Beds. He accepted the Cretaceous age for the Kalaw Red Beds. Garson et.al (1976) assumed that the Kalaw Formation predates the Pan Laung Formation (Middle Jurassic to Lower Cretaceous), because no clasts of the Pan Laung Formation have been found in the conglomerate of the Kalaw Formation.

However, no fossil is found from this formation in the study area. This unit unconformably overlies the Loi-an Group and the Plateau Limestone Group. On the basic of lithologic characters and stratigraphic position, the Kalaw Formation can be correlated with the Kalaw Formation of Khin Maung Win (1978), and Kalaw Red beds of Maung Thein (2014). Therefore the age of the Kalaw Formation is thought to be taken as Cretaceous age.

Petrography

Petrographic studies of the selected sandstone and conglomerate samples collected from the Kalaw Formation were carried out in detail. Modal composition of the various grain types present were estimated by comparing the percentage estimation comparison charts, and the classification scheme of Pettijohn et al. (1987) was used in this petrographic study.

Sandstone

The sandstones of Kalaw Formation have 60 to 70 percent of detrital framework and 30 to 40 percent cement. Detrital matrix is scanty and it contains less than 2 percent of the total rock volume. The detrital grains are composed of quartz, feldspar, mica, various kinds of rock fragments and very little heavy minerals. The maximum diameter of grains ranges from 0.2 mm to 0.5 mm and minimum diameter of grains, 0.05mm to 0.1 mm. Most grains are angular to subrounded and generally have moderate to well sorted nature. As the grain contacts are tangential to concavo-convex, the sandstones of the Kalaw Formation have grain-supported frameworks. Detrital grains are set in calcite and hematite cements. Mineral composition and detrital percentages of these sandstones are shown in Table (1).

Table (1) Mineral composition and detrital percentages of the sandstones of Kalaw Formation

Sample no.	Quartz	Feldspar		Rock fragment	Mica	Heavy mineral
		K	P			
KL- 1	60	7	3	25	3	2
KL- 2	45	10	5	30	7	1
KL- 3	53	10	3	28	5	1
KL- 4	48	30	11	7	3	1
KL- 5	47	29	13	8	2	1
KL- 6	45	30	16	5	2	2

Detrital Fraction

Quartz is the most abundant mineral in these sandstones and it comprises 45 to 65 percent of the total grains. Most of the quartz grains are monocrystalline (Fig.11). They show undulatory extinction and some have minute inclusions. Some of the quartz grains are corroded by the cement and are often fractured. Nearly two thirds of the total quartz grains are of igneous origin and the rest are derived from metamorphic rocks.

Feldspar comprises 10 to 15 percent of the total fractions in medium-grained sandstones, but in the finer sandstones of Kalaw Formation it reaches over 45 percent. Of the different types of feldspar, potash feldspars, chiefly orthoclase, are more common than the plagioclase. Nearly all of the orthoclase shows a dull or cloudy nature and some grains include the bright specks formed by sericitization process (Fig.12). Some plagioplase feldspars show polysynthetic twin. Diagenetic replacement of feldspar due to the introduction of hematite cement occurs along the grain boundary.

Lithic fragments are common in medium-grained sandstones comprising 25 to 30 percent of the total detrital fraction, but fine-grained sandstones contain only 8 percent. The most common lithic fragments are fine-grained sedimentary rocks such as siltstone,

limestone, chert, and metasedimentary rock, quartzite (Fig.13). Stable fragments of detrital chert and quartzite grains are more abundant than the other unstable rock fragments of the siltstone. The rock fragments are generally oxidized and pigmented by hematite cement (Fig.13 & 14). Mostly muscovite comprises 3 to 7 percent of the framework. Bending and contorting of muscovite due to the introduction of hematite and calcite cements are frequently observed. Less than 3 percent of the detrital fraction is composed of heavy mineral grains of hematite, magnetite and hornblende.

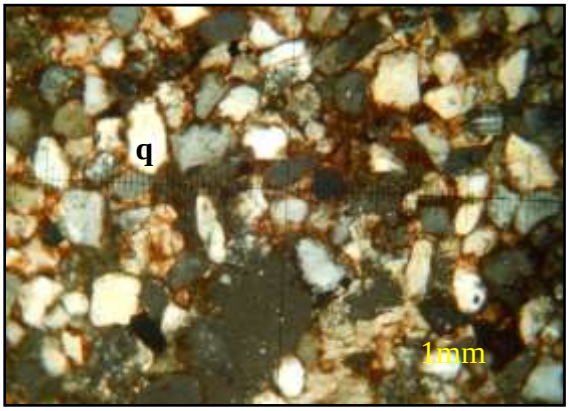

Fig. (11) Monocrystalline quartz (q) grains are corroded by cement in litharenite of Kalaw Formation (XN)

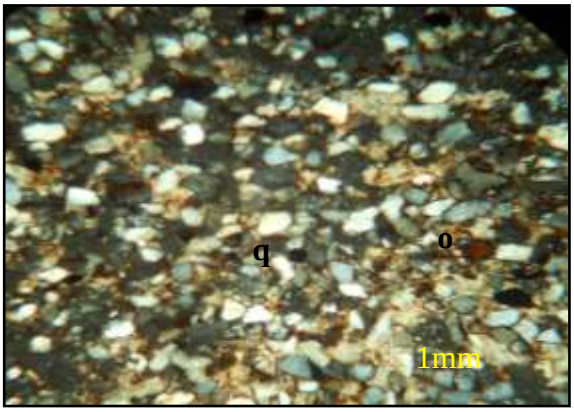

Fig. (12) Clear quartz (q), cloudy orthoclase(o) formed by sericitization in arkosic sandstone of Kalaw Formation (XN)

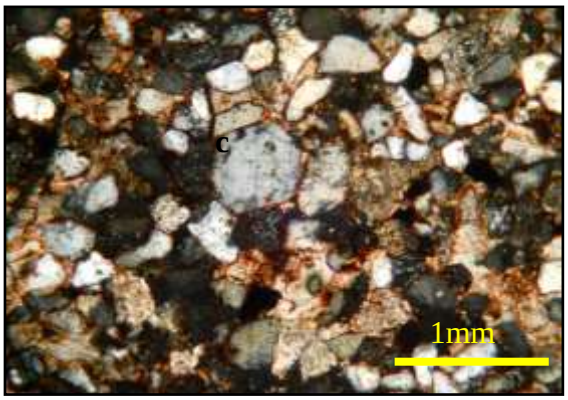

Fig. (13) Chert(c), siltstone(s), limestone (l) rock fragments cemented by iron in litharenite of Kalaw Formation(XN)

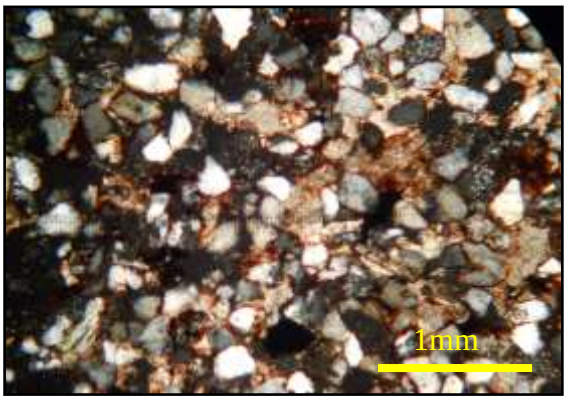

Fig. (14) Chert(c), hornblende (h), muscovite(m), quartz(q) cemented by iron and calcite cement in arkosic sandstone of Kalaw Formation (XN)

Cementation

There are two kinds of cement, hematite and calcite, generated in these sandstones. Calcite constitutes 20 to 30 percent and hematite comprises 5 to 10 percent of the rock. Most of the void spaces are filled with calcite and hematite cement typically occurs as a thin coating around the grains. Calcite forms drusy mosaic but hematite is chiefly amorphous.

Nomenclature

The sandstones of Kalaw Formation fall in the field of "Litharenite and Arkose" according to Pettijohn et.al, (1987) (Fig.15).

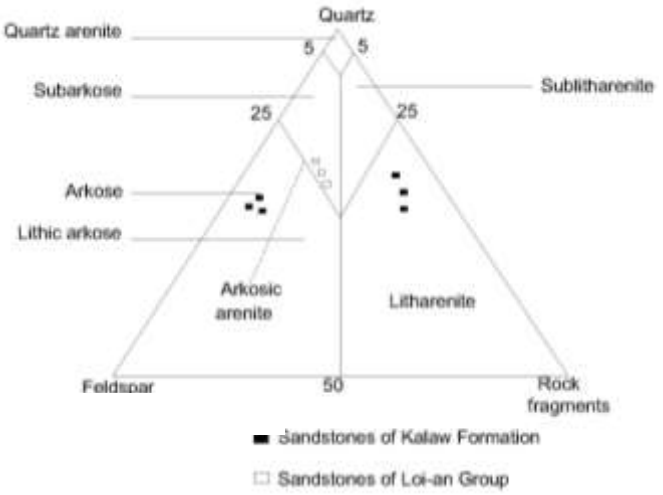

Fig. (15) QFR triangular plot of the sandstones of Kalaw Formation (After Pettijohn et al. 1987)

Possible Depositional Environment

According to QFL triangular plot after Dickinson (1985), sediments of the Kalaw Formation derived from the basement uplift or a recycled orogen (Fig.16). Basement uplift is an area of hight relief, which have been eroaded to deep levels. Monocrystalline mineral grain populations contain mainly monocrystalline quartz, orthoclase and plagioclase in order of decreasing abundance. Heavy minerals; hematite, magnetite and hornblende are constituted in these sandstones. Lithic types are dominated by chert, limestone, and siltstone. Therefore, the sediments of the Kalaw Formation were probably derived from the extensive crustal sedimentary terrain plus uplifted basement terrain of granitic composition. Their immature characteristics indicate the high rate of sediment production in source area followed by short to moderate transport distances.

Litharenite and arkosic sandstones of the Kalaw Formation are compositionally immature sandstone which contain many lbile grains, i.e. unstable rock fragments (siltstone and limestone), and much feldspar. Typically, compositional immature sediments are located close to their source area or they have been rapidly transported and deposited with little reworking from a source area of limited physical and chemical weathering. As litharenite are texturally immature with moderate sorting and angular grains, they have been taken place by mineral current activity. Moreover, litharenites of the Kalaw Formation comprise rock fragments of various types. These sandstones generally reflect a wider provenance, that of a large drainage basin which is most likely to have a diverse lithology. Therefore, the sandstones of the Kalaw Formation might be the deposit of large rivers, either alluvial or delta.

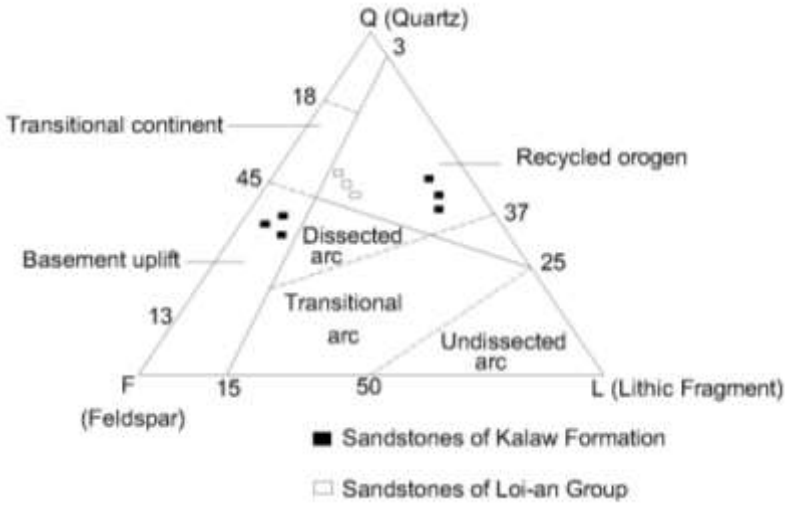

Fig. (16) QFL triangular plot showing the provances of the sandstones of Kalaw Formation of the study
area. (After Dickinson, 1985)

Conglomerate

The dominant lithology of Kalaw Formation is conglomerate. It is widely exposed throughout this formation. It exhibits thick-bedded to massive which intercalated and interbedded with red siltstone and sandstone. Their size ranges are variable (2 mm- 2.5 feet) and become larger in the southern part. Rounding is angular to subangular and often subrounded. It is polymictic conglomerate composed mainly of carbonate clasts, red sandstone (sometimes laminated), buff coloured sandstone, and chert. Criss-cross pattern joints are clearly observed on the dolomitic limestone pebbles. These pebbles are cemented by red coloured iron oxide matrix.

Microscopically, the conglomerate of Kalaw Formation has 80 to 90 percent of pebbles which are cemented by detrital matrix of red coloured ferrugenous silt, fine-grained sand, and locally sparry calcite cement. Thus it has orthoconglomeratic framework and detrital rock particles consist of carbonate clasts, chert, mudstone, and conglomerate clast itself.

Carbonate clasts are dolomite, dolomitized biomicrite, pelloidal limestone, and micritic limestone. Foraminiferal (Miliolid) occurs in biomicrite pebble of Kalaw Formation (Fig.17). Gastropod shell fragments filling with calcite observed in biomicrite pebble of Kalaw Formation (Fig.18). Brachiopod and other fossil shell fragments can be seen in biomicrite pebble of Kalaw Formation (Fig.19). Authigenic idiomorphic quartz crystals set in a lime mudstone clast observed in the conglomerate of Kalaw Formation (Fig.20). Subrounded dolomite, micrite, biomicrite are cemented by silt in conglomerate of Kalaw Formation (Fig.21). Subrounded dolomitized biomicrite, dolomitized micrite are cemented by silt (Fig.22). Subrounded marble, conglomerate clast, dolomitized micrite are cemented by silt (Fig.23). Subrounded dolomitized micrite and biomicrite are cemented by sparry calcite (Fig.24). Pelloidal limestone and micrite are cemented by sparry calcite (Fig.25). Subrounded laminated mudstone, dolomitized micrite, dolomite, angular micrite and chert are cemented by sparry calcite cement and sand-sized quartz (Fig.26). Subangular micrite, angular chert, subrounded micrite are also cemented by sand in conglomerate beds of Kalaw Formation (Fig.27). Dolomite and micrite are cemented by sand and iron in conglomerate beds of Kalaw Formation (Fig.28).

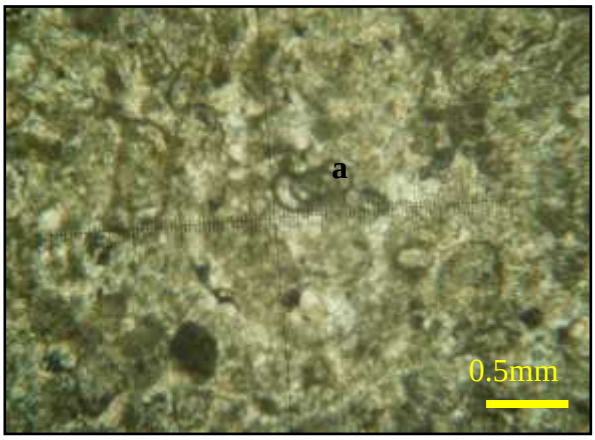

Fig. (17) Foraminifera (Miliolid)(a) bioicrite clast in conglomerate of Kalaw Formation (XN)

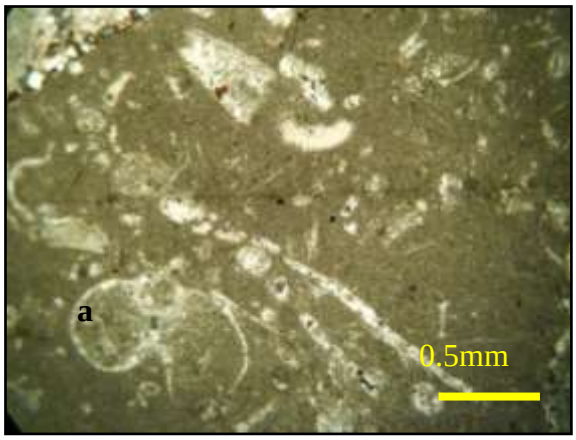

Fig. (18) Gastropod shell fragments(a) in biomicrite pebble of Kalaw Formation (XN)

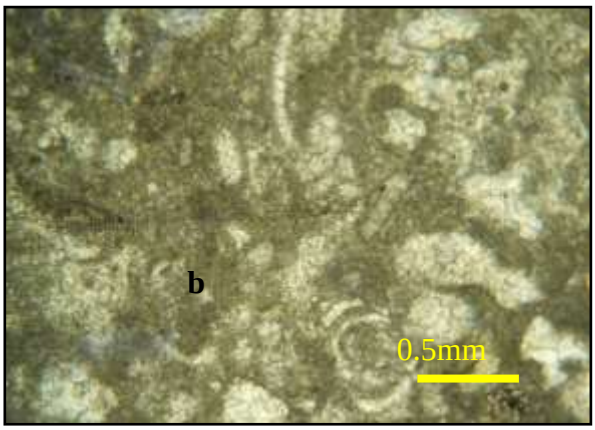

Fig. (19) Brachiopod shell fragments(a) filled with calcite in biomicrite pebble of Kalaw Formation (XN)

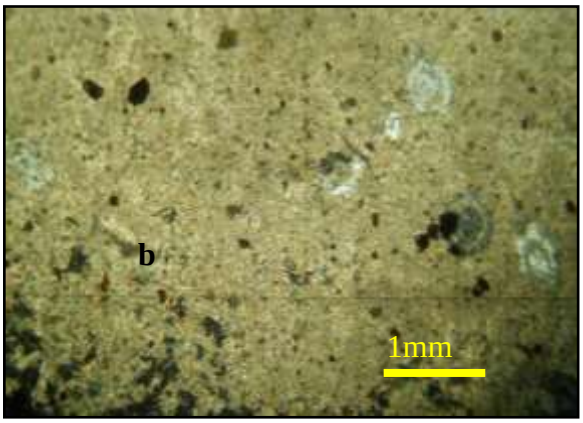

Fig. (20) Authigenic idiomorphic quartz crystals in a lime mudstone pebble of Kalaw Formation (XN)

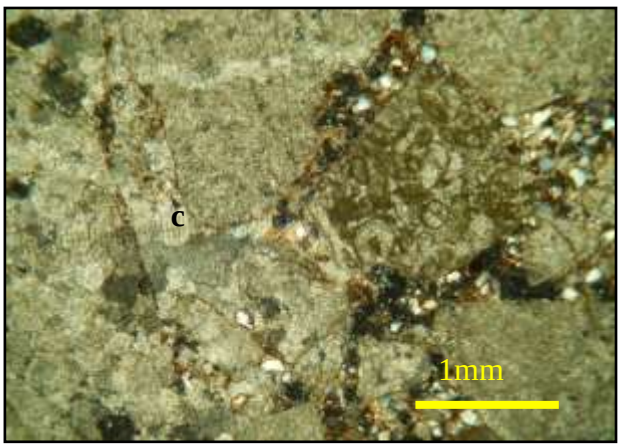

Fig. (21) Subrounded dolomite(a), micrite(b), biomicrite(c) cemented by silt in conglomerate of Kalaw Formation (XN)

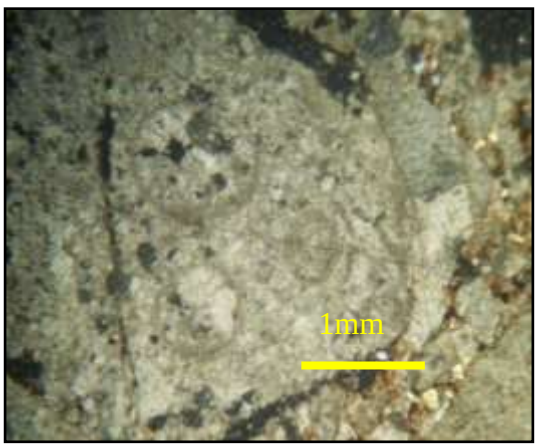

Fig. (22) Subrounded dolomitized biomicrite(a), dolomitized micrite(b) are cemented by silt matrix (XN)

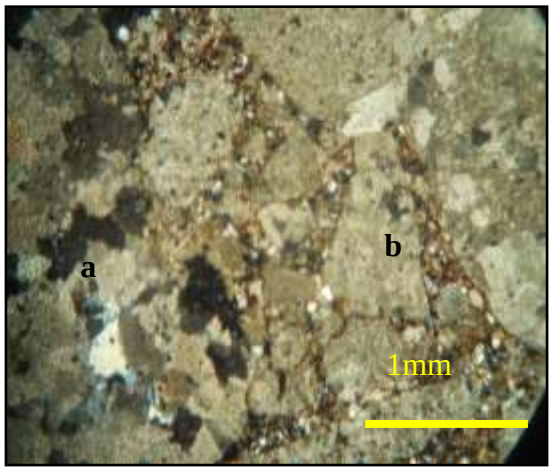

Fig. (23) Subrounded marble(a), conglomerate clast(b), dolomitized micrite are cemented by silt matrix (XN)

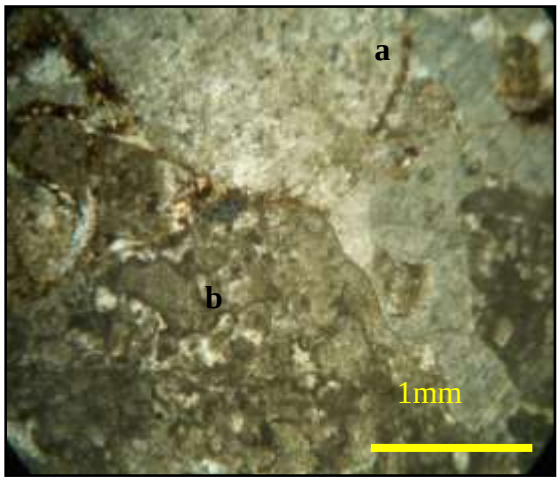

Fig. (24) Subrounded dolomitized micrite(a) and biomicrite(b) are cemented by sparry calcite (XN)

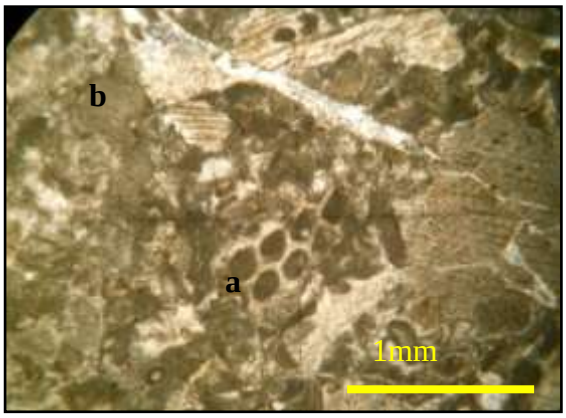

Fig. (25) Pelloidal limestone(a) and micrite (b) cemented by sparry calcite (XN)

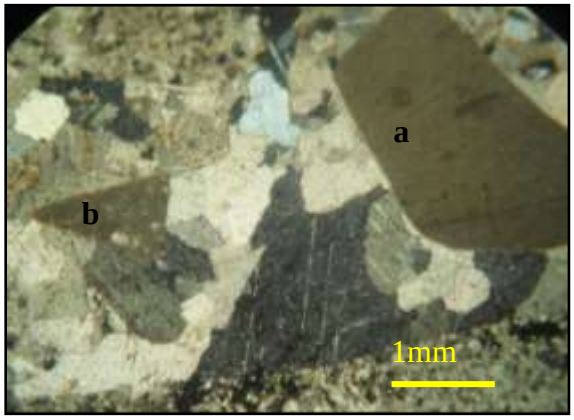

Fig. (26) Subrounded laminated mudstone(a), dolomitized micritesss, dolomite, angular micrite(b) and chert(c) are cemented by sparry calcite cement and sand-sized quartz(d) (XN)

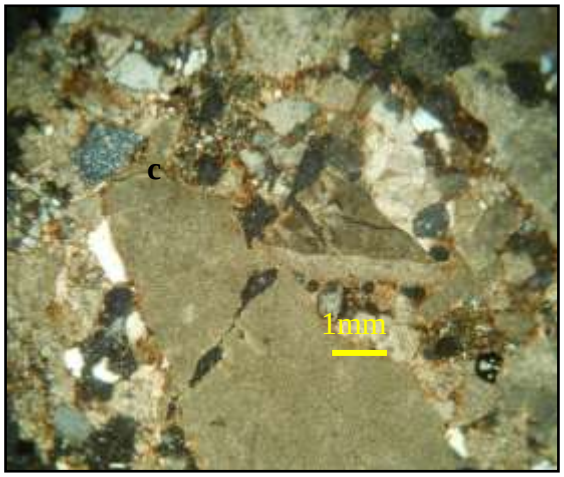

Fig. (27) Subangular micrite(a), angular chert(b), subrounded dolomitized micrite(c) cemented by ferrugenous sand in conglomerate of Kalaw Formation (XN)

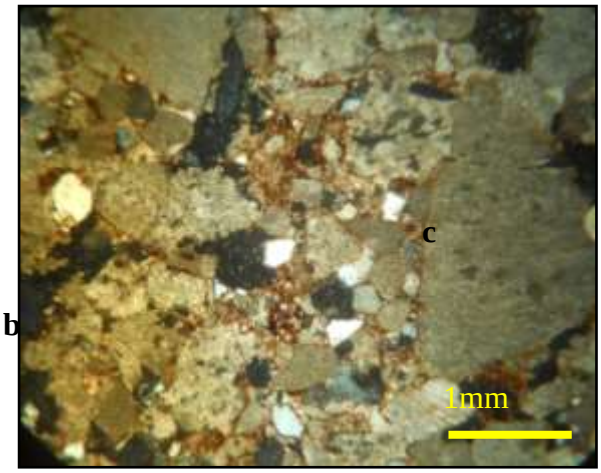

Fig. (28) Dolomite(a) and micrite(b) cemented by sand and iron in conglomerate of Kalaw Formation (XN)

Possible Depositional Environment

The conglomerates are clast supported, poorly sorted with a matrix of silt-sized material. These conglomerates are thought to have been created by debris flow on high angle slopes with large amount of rock debris accumulation which probably associated by the intense source area erosion and denudation. Rate of sedimentation is probably very high. Conglomerates are mainly composed of various sizes of Plateau Limestone rock fragments including micrite, biomicrite which are generally cemented by iron oxide coated silt-sized and sand-sized matrix. Red colour iron oxide coatings are also clearly seen in thin section. It generally indicates the oxidizing environment. Evidence of marine fossils are still lacking in the Kalaw Formation. The absence of marine fossils and their highly oxygenated nature probably indicate that these sediments were deposited on continental area under humid condition. It may be considered that these debris flow deposits had been rapidly transported and deposited during sedimentation process. Siltstone and sandstone which are interbedded with the conglomerate beds also indicate the difference in hydrodynamic condition. Moreover, the source area become gradually uplifting so as to be underwent intense denudation process. Sedimentary structures such as desiccation cracks indicate that they are of continental origin. Low angle cross-stratification indicates fluvial sediments (Reineck & Singh, 1980). Maung Thein (2014) regarded that Kalaw Red Beds were deposited as fanglomerates.

On the basis of observed criteria, it may be interpreted the conglomerate beds of the study area may be deposited as the alluvial or fluvial fan deposits.

Conclusion

The sandstones of Kalaw Formation are litharenite and arkose. The conglomerate of Kalaw Formation has 80 to 90 percent of pebbles which are cemented by detrital matrix of ferrugenous silt, fine-grained sand, and locally sparry calcite cement. Thus it has orthoconglomeratic framework and detrital rock particles which consist of carbonate clasts, chert, mudstone, and conglomerate clast itself. On the basis of observed criteria, it may be interpreted that the conglomerate beds of the study area may be deposited in the alluvial or fluvial fan. This unit unconformably overlies the Loi-an Group. There is no fossil found from this formation. On the basis of the lithologic characters and stratigraphic position, the Kalaw Formation of the study area can be correlated with the Kalaw Formation of Khin Maung Win (1978), and Kalaw Red Beds of Maung Thein (2014). Therefore the age of the Kalaw Formation is thought to be taken as Cretaceous age.

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