SEDIMENTARY FACIES ANALYSIS OF THE KALAW FORMATION IN THE TIGYIT AREA, SOUTHERN SHAN STATE, MYANMAR

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Abstract

The study area is located in the Pinlaung Township, Southern Shan State. The study area is mainly composed of Cenozoic to Mesozoic clastic sediments and subordinate amount of Paleozoic and Mesozoic carbonate rocks. The sedimentary rocks are Nwabangyi Dolomite Formation (Late Permian to Early Triassic), Natteik Formation (Middle Triassic), Loi-an Group (Jurassic), Kalaw Formation (Cretaceous), and Hsi-hkip Formation (Pliocene). The Kalaw Formation is well exposed in the eastern and western parts of the study area mainly found at Myatheintan range and Tayoketaung range with the total thickness of Kalaw Formation is estimated about 645 m (21, 10 feet). Kalaw Formation comprises the clastic sequences of conglomerate, sandstone, siltstone, and subordinate shale. Kalaw Formation is divisible into three different members: Lower conglomerate-sandstone member, Middle sandstone-shale member, and Upper conglomerate member. Kalaw Formation consists of six lithofacies such as Massive clast-supported conglomerate, Massive matrix-supported conglomerate, Planar cross-bedded conglomerate, Ripple laminated sandstone, Thin-bedded sandstone interbedded with siltstone, and Massive siltstone respectively. These facies are representing of the Alluvial Fan Association, Channel Association, Overbank Association, and Flood Basin Association. The clastic sequences of the Kalaw Formation were deposited in the debris-flow dominated alluvial fan environment.

Keywords- *lithofacies, clast-supported conglomerate, matrix-supported conglomerate, alluvial fan*

Introduction

The study area is located in the Pinlaung Township, Southern Shan State and lies between (20º 24' N to 20º 30'N) and (96º 40'E to 96º 45'E). The location map of the study area is shown in figure (1). The study area is situated in the tectonic province of Shan-Tanintharyi Block or in the Eastern Highlands of Myanmar. In the study area, the Mesozoic clastics of Loi-an Group, and Kalaw Formation are bounded in the eastern part by the carbonate sediments of the Nwabangyi Dolomite Formation and; Natteik Formation in the central part by Hsi-hkip Formation. The main purpose of the present study is to interpret the depositional environment of Kalaw Formation exposed at the study area and to reconstruct the depositional model of the Kalaw sediments by carrying out the facies analysis.

Materials and Methods

The detailed stratigraphic measurements were carried out along the Tayoketaung and Myatheintan Range, Tigyit area, Southern Shan State. The examination and identification of lithofacies analysis of Kalaw Formation were done according to Miall (1978), Reading (1994), Reineck and Singh (1980), Tucker (2001), and Walker (1979).

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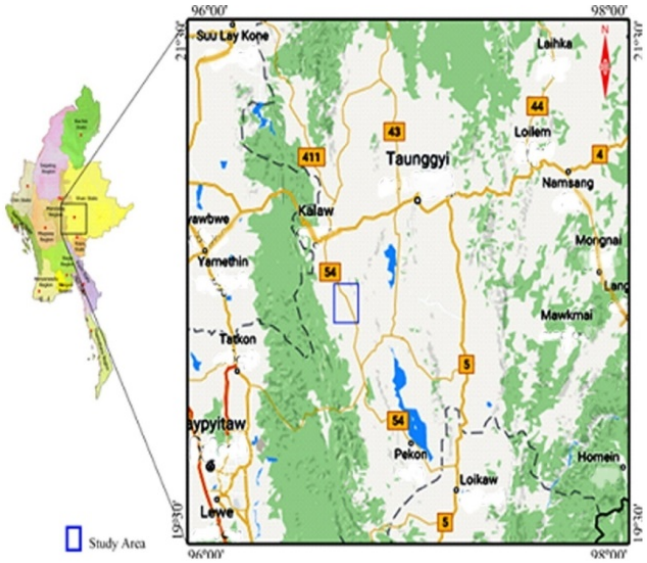


Figure 1 Location map of the study area

Results

A facies is a body of rock and it is defined on the basis of its distinctive lithologic features including colour, bedding, composition, texture, fossils and sedimentary structure (Reading, 1994). Each lithofacies represents on individual depositional environments. Therefore, lithofacies may be grouped into lithofacies associations or assemblages which are characteristics of particular depositional environment (Miall, 1978).

Facies Description and Interpretation

Facies A: Thick-bedded, Clast-supported Conglomerate (Gci)

Facies A is characterized by thick-bedded, clast-supported conglomerate Figure 2. Thickness of a single bed varies 100 cm to 300 cm. Such conglomerates commonly are characterized by lenticular beddings and erosional surfaces with conspicuous relief. The clasts are subangular to rounded, poorly sorted and granule to cobble size up to 15 cm in diameter. The clast types are sorting is generally very poor. Subangular to subrounded pebbles have without preferred orientation, but sometimes platy grains are oriented vertically. The pebbles are of polymic type consisting of limestone clasts of the Plateau Limestone; red sandstones, siltstones, and quartzose sandstones of the Loi-an Group; and a few amount of igneous rock fragments. Clast-supported conglomerates are the predominant facies of stream flow or water-laid deposits within a proximal fan. This facies is interpreted as bed load deposition from stream flows entrenched into a fan (according to Miall, 1978).

Facies B: Thick-bedded Matrix-supported Conglomerate (Gm)

This facies is characterized by thick-bedded, matrix-supported conglomerate with assortment of many kinds of clasts Figure 3. Thickness of a single bed varies from 100- 300 cm. It can be traced laterally for a few meters with a non-erosional base. The clast size is ranging from a fraction of 0.5 cm to more than 15 cm in diameter. Sorting is generally very poor. Subangular to subrounded pebbles have without preferred orientation. These pebbles are cemented by reddish silty and sandy matrix. Facies B is well exposed at the Myatheintan Taung, and Tayoke Taung. Matrix-supported conglomerates are more characteristics of debris-flow or mud-flow deposits. The sediments were deposited by gravity-induced movement at sediment-

water mixture, in which large sediment blocks were embedded in a fine-grained matrix. According to Bull (1977) (in Walker, 1979), debris-flows form on steep slope (more than 10˚) with lack of vegetation, during short periods of very abundant water supply.

Facies C: Planar Cross-bedded Conglomerate (Gp)

This Facies is characterized by thick, polymic, clast-supported to matrix-supported conglomerate Figure 4. Large scale planar type cross-bedding are commonly present. The polymic clasts are poorly sorted and ranging in size from granule to pebble. Individual beds vary in thickness from 30 cm to 100 cm. These deposits never make thick layers, and they are invariably discontinuous. The nature of contact is sharp, flat, and concave. Horizontally laminated sandstone wedges are present. Facies C accumulates as discontinuous lenticular patches in the deeper parts of the channel showing lateral accretion. Coarse-grained, poorly sorted sediment seems to favor the formation of linguoid or longitudinal bar.

Facies D: Ripple-laminated Sandstone (Sr)

This facies is reddish brown colored, very fine-grained, well-sorted, and micaceous sandstone consists predominantly of current-ripples Figure 5. Individual beds range in thickness from 10 cm to 50 cm. The boundaries are sharp and commonly non-erosional. Ripple-laminated sandstones usually occur towards the tops of the channel units. They reflect relatively weak currents. The small wavelength and amplitude of ripple bedforms suggest the deposition in shallow water (Tucker, 2001). Thus, the facies D is a product of ripple migration and deposition (Reineck and Singh, 1980).

Facies E: Thin-bedded Sandstone Interbedded with Siltstone (Fl)

Facies E is characterized by thinly bedded, very fine-grained sandstones and siltstone interbeds Figure 6. The sandstone of this facies is 3 cm to 10 cm thick beds with very small ripples. Red colored, thinly laminated siltstones are interbedded with these sandstones. As this lithofacies is a multicycles of thin sandstone and siltstone, this facies represents an overbank or waning flood deposits. This interbedded assemblage is more likely suggestive of deposition by vertical accretion and may represent levee and splay deposits.

Facies F: Massive Siltstone (Fm)

Facies F is composed of thick-bedded to massive, soft and friable red siltstone which is intercalated with thin-bedded red shale Figure 7. This facies is interpreted as the deposit of subaerial waning flood flows and subaqueous suspension sedimentation. Colore is a valuable indicator of the drainage state of the floodplain and the level of the water table. Red color suggests an oxidizing early diagenetic regime (Reading, 1994).

Figure 2 Reddish brown colored, massive, clast-supported conglomerate of Kalaw Formation at Tayoke Taung (N. 20°26´ 12.1" and E. 96°43´ 35.8")

Figure 3 Reddish brown colored, massive, matrix-supported conglomerate of Kalaw Formation at Tayoke Taung (N. 20°26´ 12.1" and E. 96°43´ 35.8")

Figure 4 Reddish brown colored, clast-supported conglomerate to matrix-supported conglomerate with planar cross-bedding at Myatheintan Taung (N. 20°26´ 12.1" and E. 96°43´ 35.8")

Figure 5 Reddish brown colored, very fine-grained, well sorted sandstone consists predominantly of current ripples at Myatheintan Taung (N. 20°26´ 12.1" and E. 96°43´ 35.8")

Figure 6 Reddish brown colored, thin-bedded, very fine-grained sandstone interbedded with siltstone at Myatheintan Taung (N. 20°26´ 12.1" and E. 96°43´ 35.8")

Figure 7 Red colored, massive siltstone intercalated with red shale at Tayoke Taung (N. 20°28´ 5" and E. 96°43´ 37")

Lithofacies Association of Kalaw Formation

Facies associations are the essential building blocks of facies analysis. Individual facies vary in their interpretative value. Thus facies have to be interpreted, at the environmental level, by reference to their neighbors and are consequently grouped together as facies associations that are genetically or environmentally related. According to Miall (1978), two or more facies of the measured section are grouped into a facies association Figure 8. Four facies associations can be established here:

(1) Alluvial Fan Association

(2) Channel Association

(3) Overbank Association, and

(4) Flood Basin Association

(1) Alluvial Fan Association

An alluvial fan is a fan-shaped body of rather coarse detrital sediments, poorly sorted, built up by a mountain stream at the base of a mountain front where a steeper slope passes abruptly into a gentler slope.

Alluvial fan lithofacies association consists mainly of sediment gravity flow elements (SG), and less commonly of the gravel bar and bedform (GB), architectureal elements of Miall (1985). These deposits comprise three facies, facies A, B, and C which are made up of clast to matrix-supported conglomerates with minor sandstones. Lithofacies A, B, and C occur as thick tabular units. Facies A is the most dominant facies. These conglomerates are uncommonly grade up into coarse sandstone of facies C.

Massive, polymic paraconglomerate of facies B is the result of deposition by debris flows in alluvial fan and massive, polymic orthoconglomerate of facies A deposited in ephemeral alluvial fan channels.

(2) Channel Association

Braided channels are marked by successive divisions and rejoining of the flow around alluvial islands. These channels have active and inactive channels which occupy the deeper part of the river bed. Channel deposits including channel lag and channel bar deposits are formed mainly from the activity of river channels.

Channel association comprises mainly gravel bars and bedforms and subordinate downstream accretion deposits. Gravel bars of coarser-grained channel lag deposits, facies A and C, were firstly formed in the channel and later they become buried by the sandstone sheets of channel bar deposits. This facies association is the result of deposition by deposition of bedload and by deposition of migrating sinuous crested dunes under the lower flow regime condition.

(3) Overbank Association

Sediments of the overbank association are deposited on the river banks and are produced during flood periods. Natural levees are wedge-shaped ridges of sediments bordering stream channels. During high floods large quantities of flood water and sediment is diverted into an adjacent flood basin. Water may follow distinct channels cut across the bank through the natural levee deposits. These water-cut channels are crevasses.

Overbank lithofacies association consists mainly of the laminated sand sheets, architectural elements of Miall (1978). This facies association generally follows bar sediments and is a group of facies D, and E which is fine-grained sediment deposited from suspension by flood water. Facies D was buried by finely thin-bedded sandstone interbedded with siltstone of facies E formed with decreasing water level (lower flow regime).

(4) Flood Basin Association

Flood basin is the lowest lying part of a river flood plain. It is elongated and running parallel to the channel. It acts as settling basin, in which suspended fine-grained sediment settles down from overbank flows after the coarser sediments have been deposited on levees and crevasse splays.

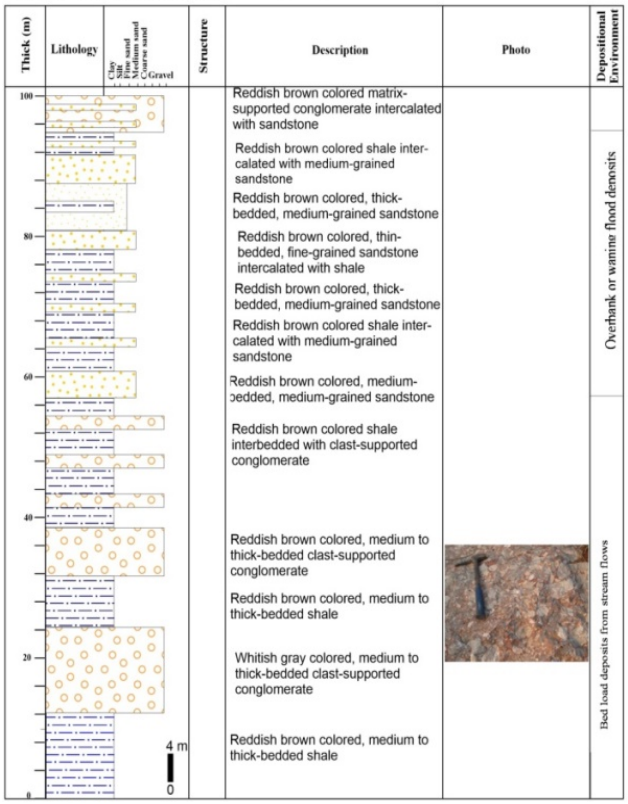
Lithofacies D, E, and F are grouped together as flood plain association. Massive siltstone of facies F is dominant. Flood basin deposits in the study area are rather thin and are sandwiched

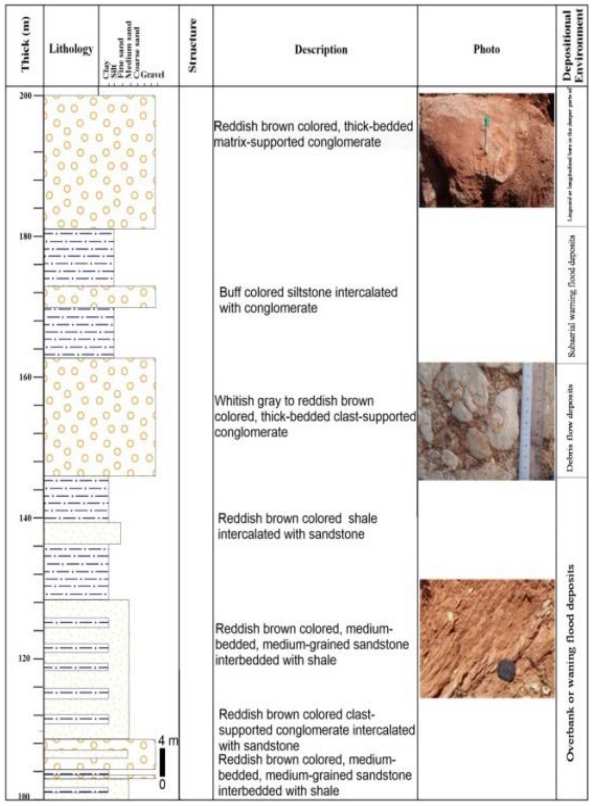
between channel deposits. This deposit is characterized by negligible organic matter content, somewhat reddish in colour. Flood basin deposit represents the long-continued accumulation of fine-grained suspended sediment.

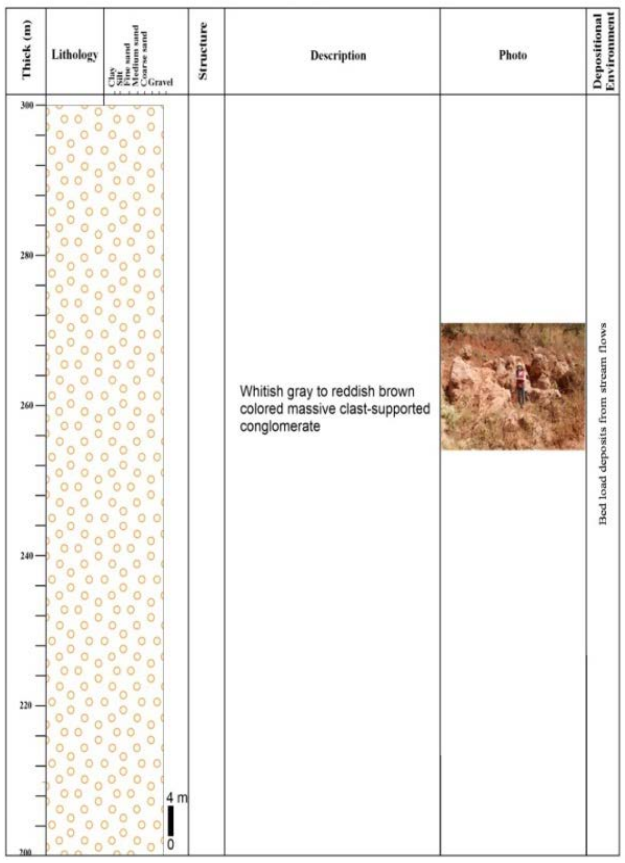
Table 1 Lithofacies of Kalaw Formation exposed at the Tigyit Area

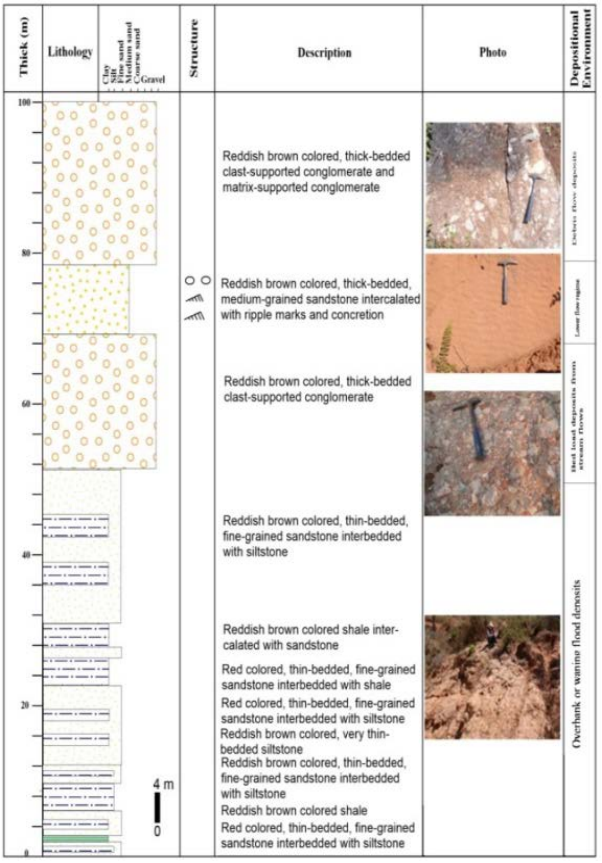
	Facies	Grain size	Bed Thickness (cm)	Structures	Boundaries	Interpretation
A	Massive clast-supported conglomerate	Granule to cobble, diameter up to 15 cm	100-250 cm	Massive	erosional	Bed load deposits from stream flows
B	Massive matrix-supported conglomerate	Granule	100-250 cm	Massive	Sharp and erosional	Debris flow deposits
C	Planar cross-bedded conglomerate	Granule to pebble	30-100 cm	Planar cross-bedding	Sharp and erosional	Lower flow regime
D	Ripple laminated sandstone	Fine-grained	10-50 cm	Current ripple	sharp	Ripple migration and deposition (lower flow regime)
E	Thin-bedded sandstone interbedded with siltstone	Very fine-grained	3-15 cm	Lack	sharp	Overbank or waning flood deposits
F	Massive siltstone	Silt size	10-300 cm	Massive	sharp	Warning flood deposits

Location/Date : (20°25' 59.6" - 20° 26' 10.3" & 96° 43' 28"- 96° 43' 30.0")
Formation : Kalaw Formation
Measured by : (Along Tayoke Taung)









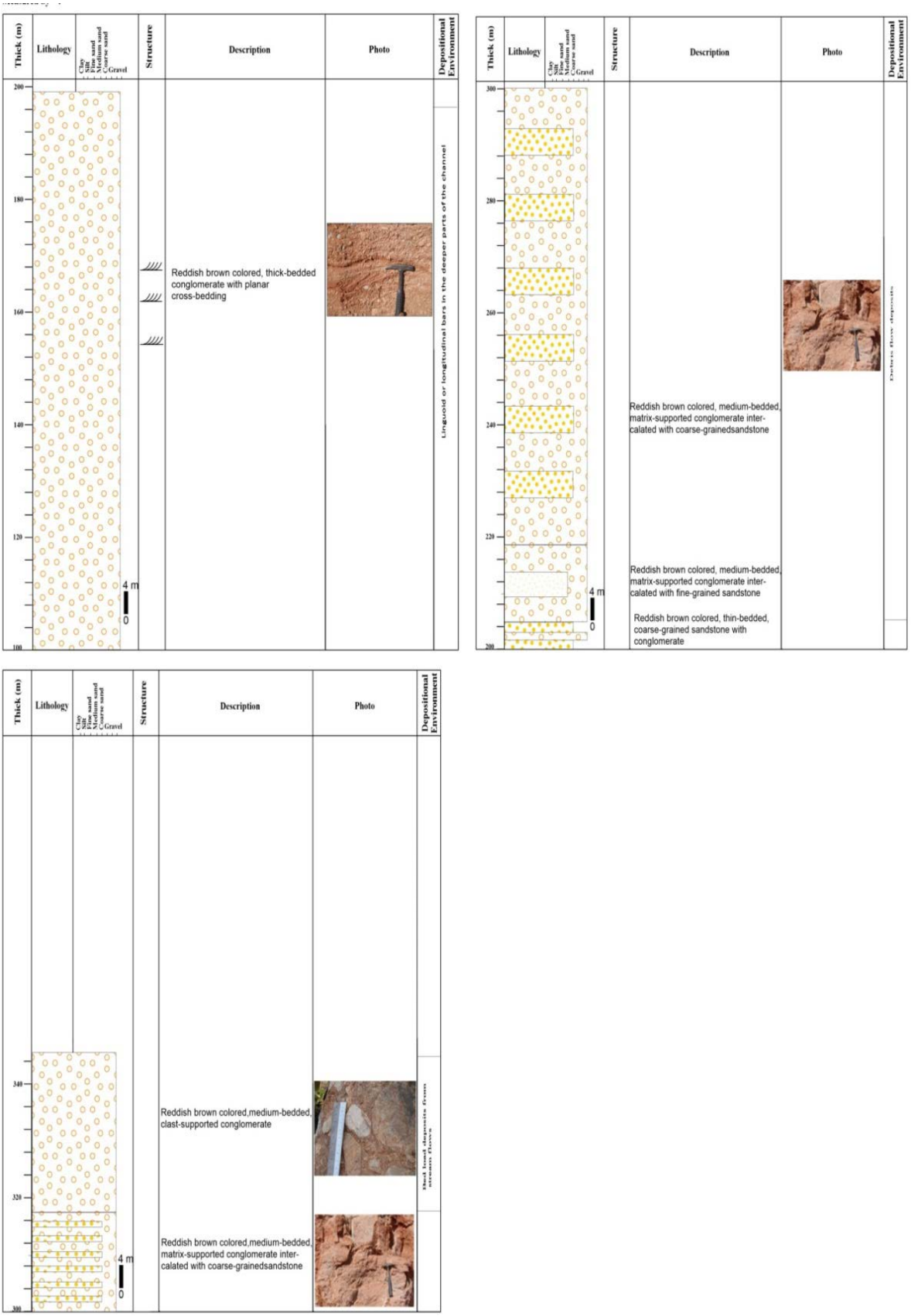


Figure 9 Detailed facies section of the Kalaw Formation (Measured along the Tayoke Taung and Myatheintan Taung sections)

Discussion

A facies analysis of the Mesozoic clastic of Kalaw Formation has revealed four facies associations assigned to two major depositional environments, which are:

(1) Debris flow dominated alluvial fans that spread sediments westward from the fault-bounded basin margin and

(2) A gravelly braided river, prograding south

These two major environments are illustrated in the depositional model Figure 10. The right hand side of the model is a belt of coalescing alluvial fans with lobes of debris flow in the upper fan areas. Under favourable conditions thick deposits of alluvial fans are produced and preserved as marginal facies of the basin of deposition (Reineck and Singh, 1980). The alluvial fans in the study area are dominated by debris flow deposits (Facies B) with relatively fewer water-laid deposits (Facies A). As alluvial fan sediment essentially represents the conglomerate of local provenance (older rock fragments of Nwabangyi Dololmite Formation, Natteik Formation, and Loi-an Group), there is little transport and sorting. Presence of large siltstone and carbonate clasts which were susceptible to weathering suggests that sediment underwent weathering and transport prior to deposition on the fans. Red coloration occurs in alluvial fan deposits, and point to a semi-arid paleoclimate. Therefore, the alluvial fan sedimentation in the study area was strongly influenced by two factors: the semi-arid climate and the active tectonic setting.

These fan deposits are associated with gravelly braided river deposits of mountainous region. Three facies associations; channel association, overbank association, and flood basin association assigned to a gravelly braided river system. In this system, massive, clast-supported conglomerate (Facies A) is the predominant facies in conglomerate units. Planar cross-bedded conglomerate (Facies C) makes up about 20% of the conglomerate. These conglomerate units grade into finer-grained sediments. The coarser-grained character of channel lag and bar deposits can be assumed that the sediment transport and sediment discharge were rather high. The grained size –gradually decreases upwards, and the degree of sorting improved upward. But, in some sequences, fine-grained sandy layers are intercalated in the coarsest and bars. This shows the variability of sequences due to rapid shifting of channels and bars. The development of thin flood basin deposits which were sandwiched between channel deposits indicates the braided nature of streams with their rapid rates of lateral migration.

The above facies assemblages are probably resembles the proximal reaches of gravelly braided river (comparable to Donjek type of Miall, 1978). Deposits of this type are characteristic of climatic extremes (semi-arid), in which large amounts of coarse detritus are produced, and plant cover is sparse.

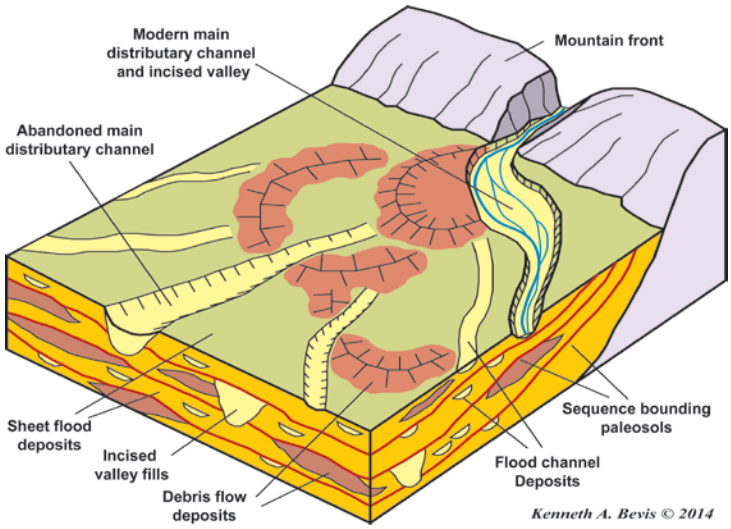


Figure 10 Depositional Model of debris flow-dominated alluvial fans and a gravelly braided river for the sedimentary sequences of Kalaw Formation (based on Kenneth A. Bevis @ 2014)

Summary and Conclusion

The study area is located in the Pinlaung Township, Southern Shan State and lies between (20º 24' N to 20º 30'N) and (96º 40'E to 96º 45'E). In the Tigyit area, the Mesozoic clastics of Loi-an Group, and Kalaw Formation are bounded in the eastern part by the carbonate sediments of the Nwabangyi Dolomite Formation and; Natteik Formation in the central part by Hsi-hkip Formation. In the Kalaw Formation, six lithofacies can be classified and grouped into four lithofacies associations. On the basis of facies associations, the depositional environment of the Kalaw Formation may be regarded as debris-flow dominated alluvium fan deposits and braided river deposits.

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