

## PROVENANCE STUDY OF THE MIOCENE ROCK UNITS IN THE LETPANBYA-TAUNGNI AREA, KYAUKPADAUNG TOWNSHIP, MANDALAY REGION

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### Abstract

The study area lies in the Letpanbya village, Kyaukpadaung Township, Mandalay Region. It is bounded by North latitude 20° 45' 00" and 20° 50' 00" and East longitude 95° 15' 00" and 95° 26' 53" in the one-inch topographic map, 84P/5. This area is located in the Central Volcanic Line (CVL) and the northern continuation of the Bago Yoma. In the study area, Moza and Khabo Formations (Miocene age) are well exposed. They are occurred as Miocene age of Moza and Khabo Formations (Miocene age) (Upper Pegu Group). Moza Formation is composed of the thin to medium-bedded, fine to medium-grained, bluishgrey to buff colour sandstone are interbedded with greenish grey shale and clay. Medium scale planer type cross beddings sometimes with reactivation surface and mud drapes, hummocky cross stratifications are important sedimentary structures. Therefore, the sediments of the formation primary consist of alternating layer of sand and fluid mud, characteristic of tidal flat deposits. Fluid muds are more common in estuarine circulation. Khabo Formation fine to medium-grained and darkgrey to buff color and fairly consolidated sandstone. The Khabo Formation is easily recognizable due to the development of alkaline salts (efflorescence) which can be easily removed with a finger in the stream section. Some of the sandstones are show small cross-lamination, ripple drift cross-lamination, and seasonal bedding. The stratigraphic contact between the Khabo Formation and the Irrawaddy Formation is arbitrarily placed. Moza Formation are composed of 65% to 85 % detrital fragment and 15% to 35% chemical cement. The detrital grains are packed together with the calcite or iron oxide cement. Khabo Formation, about 69 % detrital elements are embedded in the calcite cement having about 30%. Heavy minerals consist of about 1% to 3% in sandstone of Khabo Formation. These are tourmaline, hornblende, pyrite, olivine, diopside and opaque minerals.

**Keywords:** Sedimentary rocks, Stratigraphy, Depositional environment, Petrography

### Introduction

Myanmar can be tectonically divided into four main provinces. These are Shan Tanintharyi Block, Central Cenozoic Belt, Western Fold Belt and Raking Coastal Belt (Chhiber, 1934 and Maung Thein, 1973). This area is located along Central Volcanic Line (CVL) and the northern continuation of the Bago Yoma.

In Myanmar, Tertiary sediments are mostly covered in the central part. The hydrocarbon prospects are found in Central Myanmar, so many geologists have been extensively studied the Tertiary rock in Central Myanmar Basin since 1909. Theobald (1873) first introduced the term "Pegu Group" to designate an important group of Oligocene-Miocene deposit in Myanmar Central Belt and subdivided into two parts by an important unconformity which approximated the Oligo-Miocene boundary (Chhibber, 1934). Myint Thein (1966) first studied the nomenclature of the formations in the study area and neighboring area. He investigated the "stratigraphy and structure of the Taungtalon area" which is situated on the northern part of the present study area.

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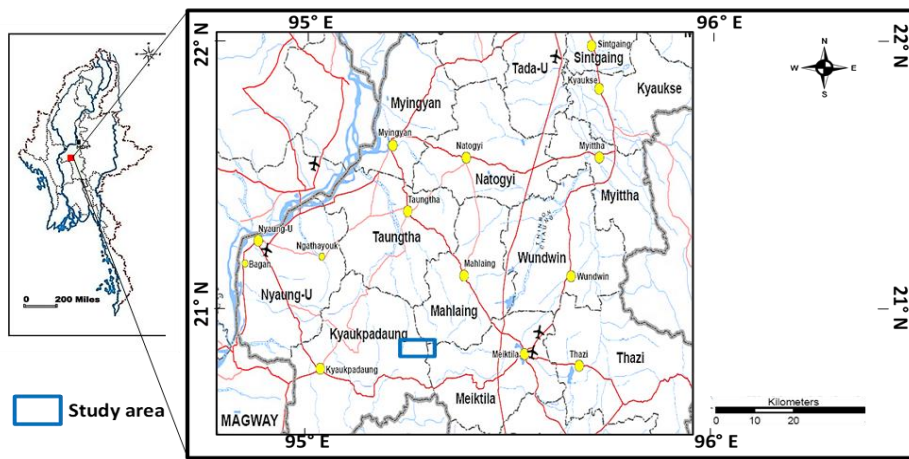
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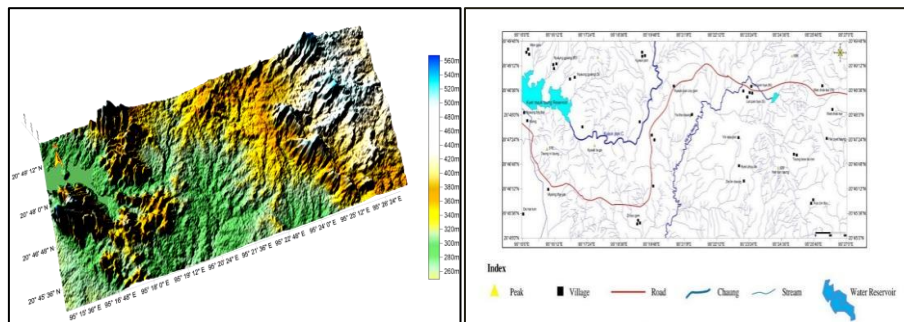
The research for this paper was undertaken over and nine month period June 2020 to February 2021. The research area lies in the Letpanbya village, Kyaukpadaung Township, Mandalay Region. It is bounded by North latitude  $20^{\circ} 45' 00''$  and  $20^{\circ} 50' 00''$  and East longitude  $95^{\circ} 15' 00''$  and  $95^{\circ} 26' 53''$  in the one-inch topographic map,84P/5. This area covers North-South 5 mile (8km) wide and East- West 12 (19km) mile long with an area of 60 square miles. As the Meiktila-Kyaukpadaung high-way is passing through the study area, it is easily accessible throughout the year in figure (1).

The western portion of the study area is situated at a higher than the eastern portion. The lowland is enveloped by alluvium soil and cultivation land. The drainage patterns are important features for the identification of lithology, lithology variations, morphology, geological structure and climatic conditions of the study area.



**Figure 1** Location map of the Letpanbya-Taungni Area, Kyaukpadaung Township, Mandalay Region.

Dendritic, radial and sub-parallel drainage patterns occur in the research area. The coarse texture dendritic patterns are mostly development in eastern part of present area due to lithologic character of the underlying clastic sedimentary rock in figure (2). The main stream in this area is Kyaukpon Chaung which flows in a northwestern direction across the regional topographic trends. Kyaukpon Chaung is a perennial stream that flows into Kyetmauktaung Dam to the west of Kyauktaga village in figure (2). This area is situated in the Central Myanmar with semi-arid climate. The Sha, Htanaung and scrub vegetation are commonly marked in the Moza Fomation. The scrub vegetation, the toddy plams and Htanaung are commonly observed in the Khabo Sandstone unit. Low-lying area is covered by alluvial deposits which are used as the cultivated field. Seasonal crops such as paddy and chilies are mainly cultivated.



**Figure 2** Three dimensional and Drainage Pattern of the Letpanbya-Taungni Area, Kyaukpadaung Township, Mandalay Region

## Methods of Study

The field traverses were made along the stream, cart track, and motor roads. Structural data such as dip, joint, fault and fold were studied and measured in the field by using Brunton Compass and GPS and plotted on the base map. The lithology, thickness of bed, nature of contact, sedimentary structures and texture of each formation are carefully measured and noted. The representative rock samples of well cemented sandstone rocks are prepared for thin section study. They were studied under a polarizing microscope. The collected fossils of the study area were identified and classified to know the exact age of the formation. The location map, regional geological map, geological map, drainage pattern of the study area, correlation table and stratigraphic measured section of the study area were drawn based on the previous works and field data

## Research and Discussion

### Stratigraphy

In the study area, a considerable thickness of the calcic sediments is well exposed. They are occurred as Miocene age of Moza and Khabo Formations (Upper Pegu Group) in table (1). The sedimentary deposits exposed in the present area are generally low topographic hills, composed of the Upper Pegu Group. In the field area, sedimentary rock units are exposed with the sequences of sandstone, shale, clay, and siltstone.

**Table 1** Stratigraphic Succession of Miocene age in the Letpanbya-Taungni area.

Geological age	Group	Formation	Rocks Type	Structure
Middle-Miocene	Upper Pegu Group	Khabo Formation	darkgrey to buff color and fairly consolidated sandstone	cross-lamination, ripple drift cross-lamination, and seasonal bedding.
		Moza Formation	blueshitgrey to buffcolour sandstone	horizontal cross-lamination, lenticular bedding, sloe marking, Mud clasts

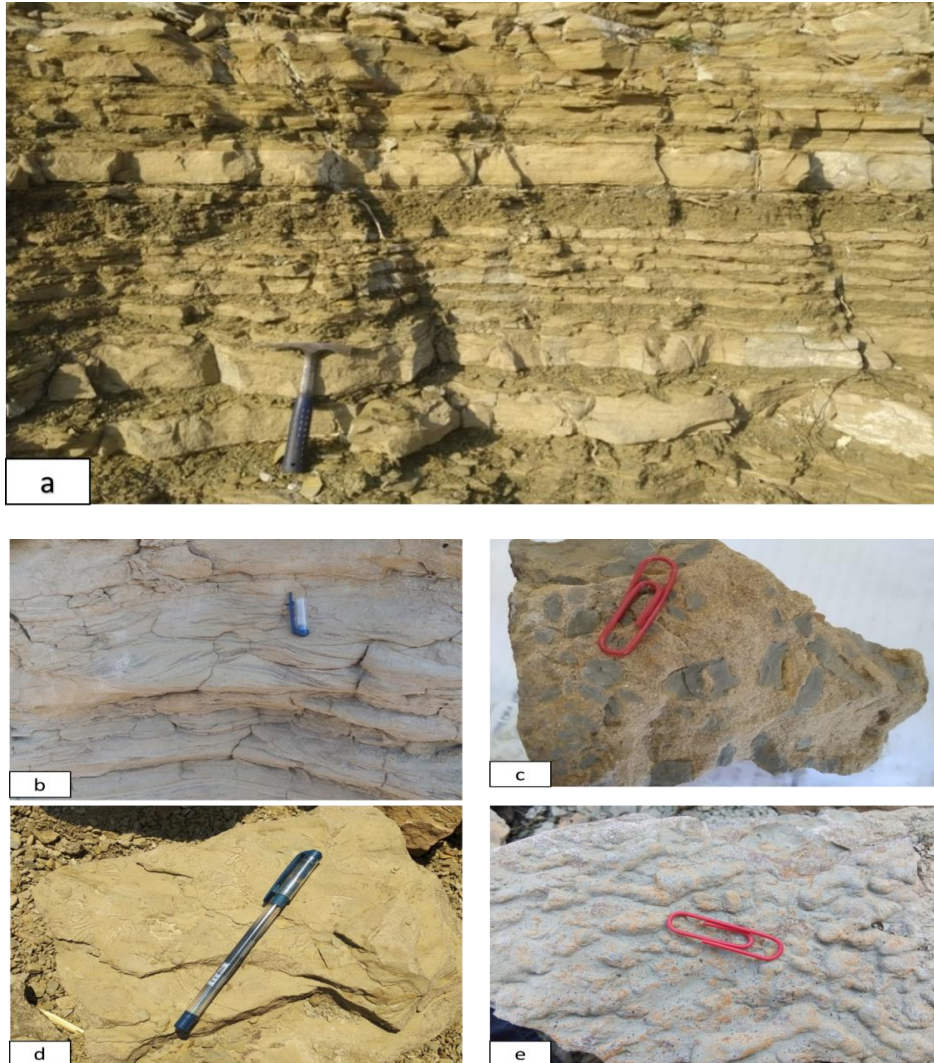
### Moza Formation

Moza Formation is distributed in Wetchokkon, Letpanbya, Natkan, and Yetmagon villages. It is composed of the thin to medium-bedded (10 to 90cm), fine to medium-grained, blueshgrey to buffcolour sandstone, interbedded with greenish gray shale and clay( 1 to 5cm) in figure (3a). In this formation, the common sedimentary structures are horizontal cross-lamination, lenticular bedding, sloe marking (load casts; flute casts), and mud clasts in figure(3b,c,d). Mud clasts with diameter of 0.3 to 2.5 cm are common in some sandstone. A band of Ichnofossils fragments consists of this formation in figure (3e).

### Depositional Environment

The Moza Formation consists of river channel deposits. Medium scale planar type cross beddings, sometimes with reactivation surfaces and mud drapes, hummocky cross stratifications are important sedimentary structures. Therefore, the

sediments of the formation primarily consist of alternating layers of sand and fluid mud, characteristic of tidal flat deposits. Fluid muds are more common in estuarine circulation. Fluid mud layers are interbedded with sandstone layers and given diagnostic sedimentary structures of this member including flaser, lenticular and wavy beddings. Sole markings and bi-directional ripples with mud drapes point out the rapid sedimentation of the sediments. The above mentioned characteristics strongly indicate that the sediments of the Moza Formation were deposited under estuarine environment.



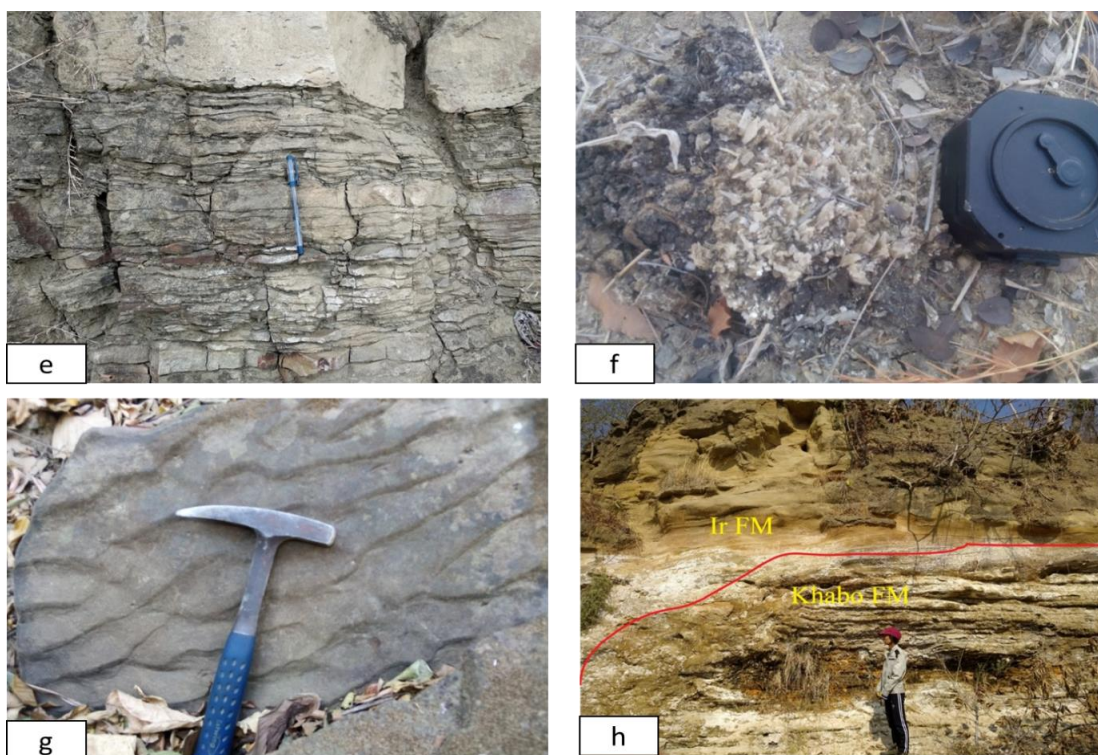
**Figure 3** (a) Thin to medium-bedded, bluishgrey to buff colour sandstone of the Moza Formation (N 20°48'47.96" E 95°25'43.48") (b) Cross-lamination on the bedding plane of sandstone in the lower member of the Moza Formation, (c) The mud clasts in the sandstone units of the Moza Formation (N 20°49'01.05" E 95°20'48.05"), (d) Trace fossil of upper most part of the Moza Formation (N 20°48'47.96" E 95°25'43.48").(e) Sole marking (load clasts) in the sandstone of the Moza Formation (N 20°48'.96"E 95°25'43.48").

### Khabo Formation

This unit is well exposed in the Dangyin, Wetahokkon, Kyaukpon and Kyetbyate villages and Yathedaung. Sandstones are more dominant in this unit than in the underlying Moza Formation. This member is composed of fine to medium-grained and darkgrey to buff color and fairly consolidated sandstone. They are compact and hard. It is intercalated with a minor amount of shale, clay and caliche layer in figure (4a). The Khabo Formation is easily recognizable due to the development of alkaline salts (efflorescence) which can be easily removed with a finger in the stream section. Some of the sandstones are show small cross-lamination, ripple drift cross-lamination, and seasonal bedding. The stratigraphic contact between the Khabo Formation and the Irrawaddy Formation is arbitrary.

### Depositional environment

Khabo Formation, medium to thick-bedded, greenish gray shale, clays and siltstone are mostly intercalated with sandstone. Sandstones are compact and hard. This formation contains current ripples migrate in the direction of the current due to erosion and deposition. Burrows are abundant in the sand and mud layers. Khabo sandstones are occurred cross bedding, with some flat bedding and cross-lamination. The Letpanbya area is situated in central Myanmar and has a semi-arid climate.



**Figure 4** (a) The sandstone intercalated with minor amount of shale, clay and caliche layers in the Khabo Formation (N20°46'33.52" E95°26'21.27"), (b) The structural contact between the Irrawaddy Formation and Khabo Formation seen at the Kyaukpon Chaung (N 20°48'51.11", E 95° 19'47.60"), (c) Current ripple in the Khabo Formation (N 20°47'19.56" E 95°23'33.34"). (d) Gypsum is formed in Khabo Formation.

The above mentioned characteristics strongly indicate that the sediments of the Khabo Formation is deposited in a river dominated fluvial environment in figure (4b). Abundant sedimentary structures are present in this member. The dominant sedimentary structures include current ripple marks and cross bedding in figure (4c). In the lower part of the Khabo Formation, gypsum layers occur locally in figure (4d).

### **Microscopic study of Moza Formation**

Microscopically, the sandstones of the Moza Formation are composed of 65% to 85 % detrital fragment and 15% to 35% chemical cement in table (2). The detrital grains are packed together with the calcite or iron oxide cement. The detrital fragments are composed of quartz, feldspar, mica, heavy minerals and rock fragments. Most detrital grains are subrounded to subangular, moderately sorted and fine to medium-grained.

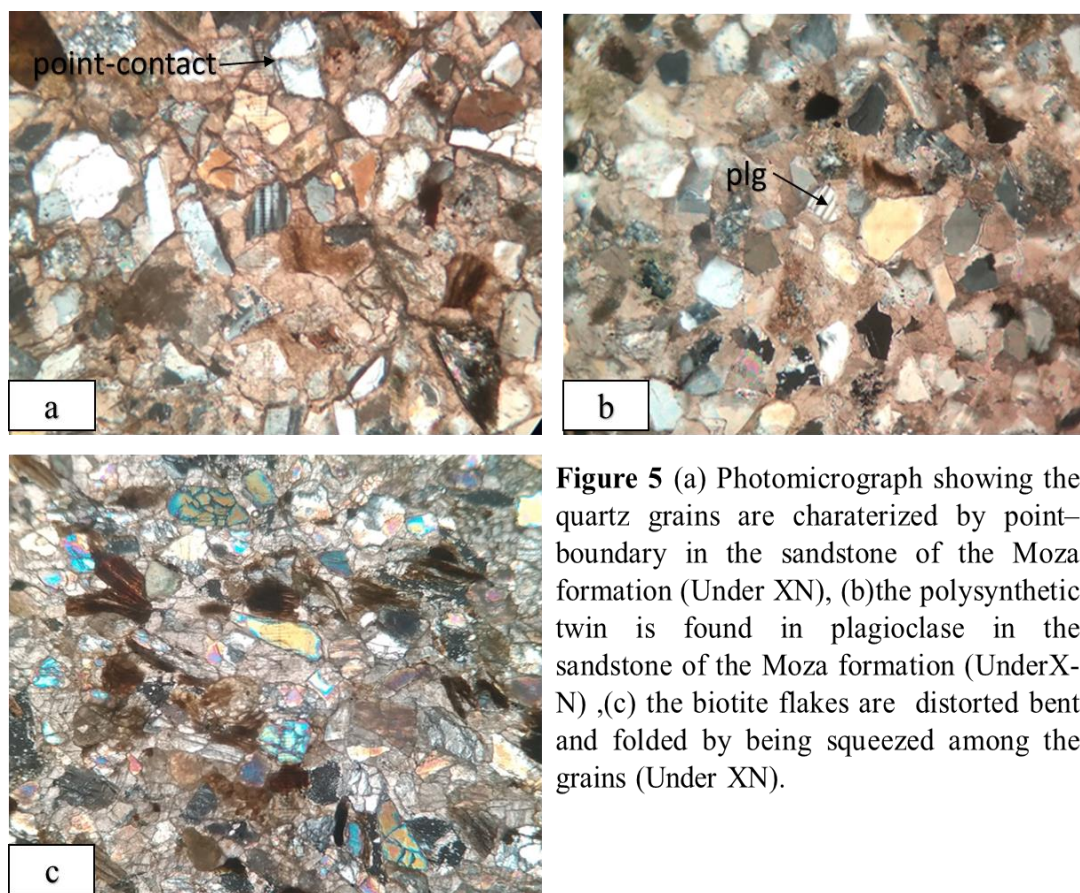
Quartz is the dominant grain and comprised 55% to 65 % of the total detrital fraction. It is composed of monocrystalline quartz and minor amount of polycrystalline quartz grains. Monocrystalline quartz grains are subrounded to subangular in figure (5a). A few quartz grains show corrosion features and calcite cement.

The polycrystalline quartz is grouped into metamorphic and igneous quartz on the basis of their grains orientations, boundaries of composite grains, and types of inclusion. Among these grains, igneous quartz grains are more abundant. Igneous derived from polycrystalline quartz grains are noted by their moderate to slightly undulose extinction. They display straight boundaries between individual grains and no distinct crystallographic orientation. Polycrystalline metamorphic quartz grains are characterized by composite with point, suture and crenulated boundaries in figure (5a).

Feldspar consists of 15% to 30% of the total detrital fractions. They are subhedral to subangular grains of plagioclase, orthoclase and microcline. The sandstone is mainly composed of 40% plagioclase feldspar. The size of feldspar range from 0.2 to 0.5 mm. Grains of microcline are mostly fresh parallel twin and polysynthetic twin in figure(5b). Calcite cement was found filling in corroded feldspar.

The sandstone in Moza Formation is composed of mica 8 % of total detrital framework. Moreover, biotite and muscovite mica are common in the sandstone. Mica grains are subhedral to euhedral flakes. Most biotite flakes are irregularly bifurcated. Muscovite also occur as thin and small flakes. The biotite flakes are distorted, bent and folded by being squeezed among the grains in figure (5c).

There are various types of the lithic fragments. The sandstone is composed of rock fragments, such as sedimentary, igneous and metamorphic. These rock fragments consists 5% to 10% of the total detrital fraction. Volcanic fragments include quartz, lath of muscovite and feldspar. There are non-planar fabric. Metamorphic rock fragments are composed of quartz and mica having a preferred planar fabric. Sedimentary rock fragments are composed of chert, argillite shale, siltstone are also present. Heavy minerals contain more than 1 % of the sandstone of the Moza Formation. These minerals include hornblende, hematite, zircon, mica, tourmaline and garnet. The interstitial pore spaces among the detrital fractions are commonly filled with calcite, iron-oxide cement and silica cement.



**Figure 5** (a) Photomicrograph showing the quartz grains are characterized by point-boundary in the sandstone of the Moza formation (Under XN), (b) the polysynthetic twin is found in plagioclase in the sandstone of the Moza formation (Under X-N), (c) the biotite flakes are distorted bent and folded by being squeezed among the grains (Under XN).

**Table 2** Minerals composition of sandstone under microscope (Moza Formation).

Simple No	Mz.1	Mz.2	Mz.3	Mz.4	Mz.5
Composition	Composition in volume %				
Quartz	65	55	60	66	57
Feldspar	15	18	16	14	13
Rock Fragment	5	7	5	6	10
Mica	3	2	4	2	3
Accessory Minerals	1	1	2	1	2
Cement	10	14	11	9	13
Matrix	1	3	2	2	2
Total volume (%)	100	100	100	100	100

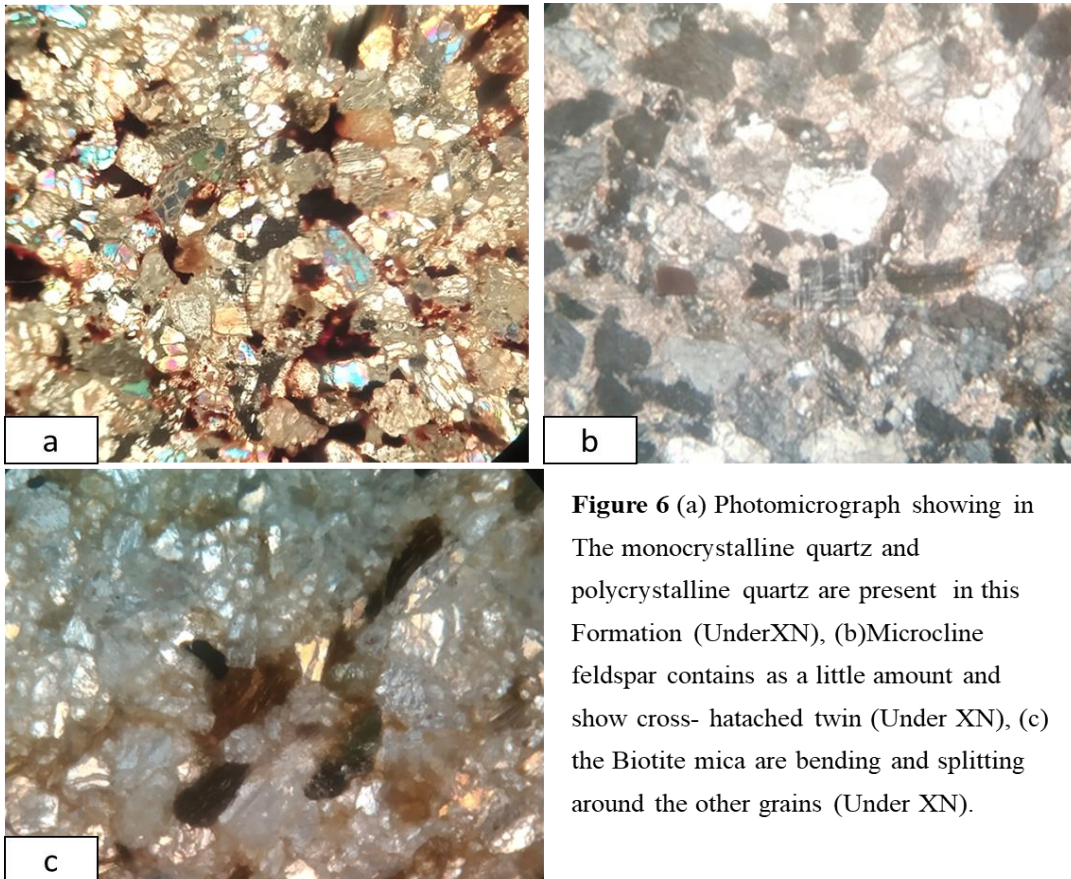
### Microscopic Study of Khabo Formation

Microscopically, in the Khabo Formation, about 69 % detrital elements are embedded in the calcite cement accounts for approximately 30% in table (3). The texture is mostly found subrounded to subangular, well-sorted, and medium to coarse. The maximum diameter of the detrital grains range from 0.8 to 0.4 mm and the minimum diameter 0.2 to 0.5 mm.

Quartz is the chief constituent mineral of detrital grains, comprising about 55% to 60% of the total detrital fraction. Both monocrystalline quartz and polycrystalline quartz are presented in this formation in figure (6a). Monocrystalline quartz are subangular to subrounded grains and their grains size ranges from 0.6mm to 0.2mm. Monocrystalline quartz is more commonly found than the polycrystalline quartz. The contact between monocrystalline quartz grains is concave-convex. The polycrystalline quartz grain have tangential and straight contacts.

The feldspar such as the plagioclase, orthoclase and microcline feldspar, makes up 10% to 25% of the total detrital fraction. Microcline feldspar contains a small amount of inclusion and show cross-hatched twin in figure (6b). About 2% to 5 % of biotite and muscovite occur in the sandstone of Khabo Formation unit. Biotite is more common than muscovite. Biotite flakes are bending and splitting around the other grains in figure (6c). Some biotite are altered to hematite.

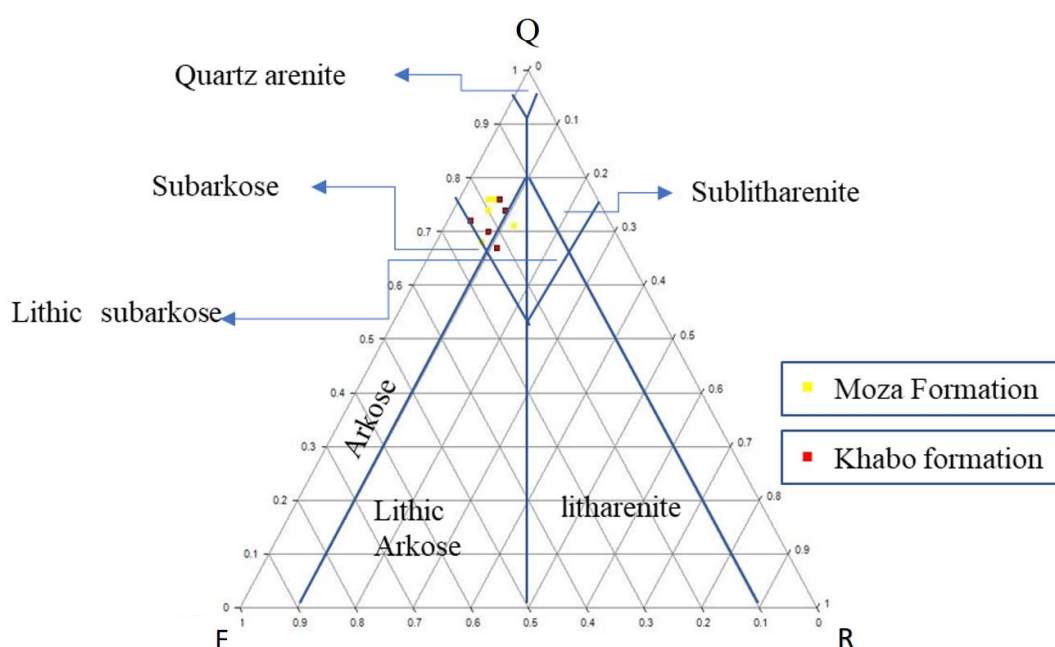
In Khabo Formation, sandstone are composed about 3% to 15% of rock fragments. These fragments are chert, schist, shale and minor amount of volcanic rock fragments. Volcanic rock fragments are more abundant in Khabo than in Moza Formation, and are characterized by lath-shaped crystals of plagioclase embedded in a groundmass. Heavy minerals consist of about 1% to 3 % in sandstone of Khabo Formation. These are tourmaline, hornblende, pyrite, olivine, diopside and opaque minerals. According to petrographic study, the rock can be classified as "subarkose" after Pettijohn et.al. (1975) shown in figure (7).



**Figure 6** (a) Photomicrograph showing in The monocrystalline quartz and polycrystalline quartz are present in this Formation (Under XN), (b) Microcline feldspar contains a little amount and show cross-hatched twin (Under XN), (c) the Biotite mica are bending and splitting around the other grains (Under XN).

**Table 3** Minerals composition of sandstone under microscope (Khabo Formation).

Simple No	Kb.1	Kb.2	Kb.3	Kb.4	Kb.5
Composition	Composition in volume %				
Quartz	62	58	64	57	60
Feldspar	19	17	14	18	13
Rock Fragment	4	7	6	9	8
Mica	3	2	3	2	3
Accessory Minerals	1	1	2	1	1
Cement	9	13	9	11	13
Matrix	2	3	2	2	2
Total volume (%)	100	100	100	100	100

**Figure 7** QAF Ternary diagram plots showing the sandstone of Moza Formation and Khabo Formation from different types of provenances after Pettijohn et.al. (1975).

### Conclusion

This area is located along Central Volcanic Line (CVL) and in the northern continuation of the Bago Yoma. The study area lies in the Letpanbya village, Kyaukpadaung Township, Mandalay Region. Moza Formation is composed of the thin- to medium-bedded, fine- to medium-grained, bluish grey to buff colour sandstone are interbedded with greenish grey shale and clay. Various types of silt marking (load casts; flute casts and mud clasts) are found and composed of 65% to 85 % detrital fragment and 15% to 35% chemical cement. Quartz is the dominant grain and comprised 55% to 65 % of the total detrital fraction. Khabo Formation is composed of fine to medium-grained and dark grey to buff color and fairly consolidated sandstone. Sandstones are more dominant in this unit than in the underlying Moza Formation. Some of the sandstones are shown small cross-lamination, ripple drift cross-lamination, and seasonal bedding. The Moza Formation consists of river channel deposits. Microscopically, in the Khabo Formation, about 69 % detrital elements are

embedded in the calcite cement accounts for approximately 30%. Both monocrystalline quartz and polycrystalline quartz are presented in this formation. The contact between monocrystalline quartz grains is concave-convex. The polycrystalline quartz grain have tangential and straight contacts. Rock fragments contain about 3% to 7% percent are found in sandstone of Khabo Formation. These fragments are chert, schist, shale and minor amount of volcanic rock fragments. Volcanic rock fragments are more abundant in Khabo than in Moza Formation, and are characterized by lath-shaped crystals of plagioclase embedded in a ground mass.

### Acknowledgements

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