PETROGRAPHY AND DIAGENESIS STUDY OF THE OKHMINTAUNG FORMATION EXPOSED IN CHAUNG ZON AREA, PWINTBYU TOWNSHIP, MAGWAY REGION

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Abstract

The research area is located in Chaung Zon Village, Pwintbyu Township, Magway Region. Okhmintaung Formation is characterized by light grey, medium to coarse grained, thick bedded to massive type sandstones intercalated with thin-bedded mudstones and bluish grey shales are also occurred. The sandstones of the Okhmintaung Formation may be termed as "Sublithicarenite". Alteration of biotite to muscovite and oxidized biotite are more common in the Okhmintaung sandstone in the study area. The cementing material in the Okhmintaung sandstones are calcite and iron cements, glauconite, rutile and clay matrix. The common characteristics of late burial or phyllomorphic stage are the alteration of clay mineral into micas and the development of well crystallized phyllosilicate minerals.

Keywords: Stratigraphy, Petrography, Nomenclature of sandstone, Diagenesis, Diagenesis stage.

Introduction

Location and size

The study area is located between north latitude 20º 12′ 30″ - 20º 16′ 30″ and east longitude 94º 25′ 00″ - 94º 28′ 30″. It is situated about 16 miles (25.75 km) west of the Pwintbyu Township. It falls in 2094/7 (84 L/7) and 2094/8 (84 L/8) referring to UTM topographic maps. Pathein-Monywa Highway is passing through the eastern part of the study area. The location map is shown in Figure (1-A).

Literature survey

The Tertiary rocks of Myanmar had been studied by geologists since 1869, but geological investigation has not yet completed. Theobald (1873) introduced the term "Pegu Group" and subdivided into two parts by an important unconformity which approximated the Oligocene-Miocene boundary and non-marine Plio-Pleistocene "Fossil Wood Group of the Irrawaddian". The Minbu Basin of Central Cenozoic Belt, which includes the study area, was paid much attention by many geologists for primarily due to hydrocarbon prospects. As a result, the Tertiary rock units of Minbu Basin had been mapped and discussed by various geologists since 1800s and studied the stratigraphy, structure and oil prospects.

Aim and Objectives

- To prepare thin section for clastic rocks.
- To identify petrogenesis of sediments exposed in the study area by using the suitable advanced techniques possibly
- To take photograph all thin-sections and micro fossils

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Material and Methods

Suitable sandstone samples collected during field works are three dimensionally cut into thin sections and studied under a polarizing microscope. The detrital grains are identified by point counting on a slide and the modal composition is roughly estimated by comparing with percentage estimation charts of Folk *et al*., 1970 in Tucker, 2001.

Tectonic Framework of study area in the Minbu Basin

The study area is situated in the Central Cenozoic Belt of Myanmar (Chibber, 1934; Tainsh, 1950; Maung Thein 1976, 2010, 2014) which constitutes one of the four geotectonic belts of Myanmar. The study area is located in northwestern part of the Minbu Basins.

According to the tectonic model of Maung Thein (1983), Minbu Basin, a part of Central Myanmar Belt is associated to be a fore-arc related basin. The study area generally encompasses a small segment of the Minbu Basin. It is composed mainly of Oligocene and Miocene sediments.

The study area comprising is surrounded by Central Volcanic Line and Pegu Yoma in the east, by the Western Ranges in the West, by the Chindwin Basin in the north and, by the Thayetmyo Sentaxis in the south respectively.

The eastern part is composed of Miocene stratigaraphic sequence units and western part is Oligocene units. The study area is mainly composed of stratigraphic units from east to west; Irrawaddy Formation, Obogon Formation, Kyaukkok Formation, Pyawbye Formation, Okhmintaung Formation, Padaung Formation, and Shwezetaw Formation.

In the area, the Oligocene-Miocene succession is molassic in nature and generally dipping towards the east. The Miocene strata are constituted mainly of buff- coloured, fine- to medium-grained, thinly bedded sandstone intercalated with light gray to bluish gray shale, light gray to brown, medium- to coarse-grained, medium to thick bedded sandstone with minor gray shale and clay, bluish gray sandy clays with dispersed gypsum plates; concretionary bluish gray clays; intraformational conglomerate and subordinate sandstone.

The Oligocene rocks are buff to light greenish gray and compact, fine- to medium-grained, massive sandstone, dark bluish gray clay and mudstone with fine-grained, hard and compact sandstone, greenish gray, fine to medium-grained, massive sandstone, sandy shale and silty sand. The gegional geologic setting of Chaung Zon area is shown in Figure (1-B).

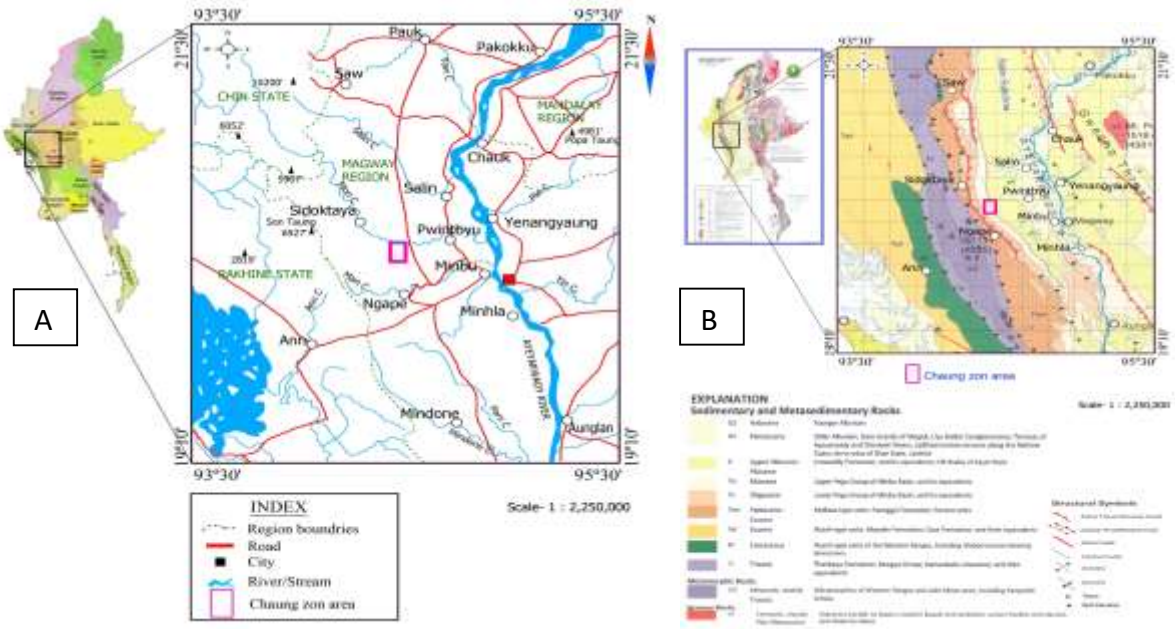

Figure 1(A) Location map of the Chaung Zon Area and (B) Regional geologic setting of the Chaung Zon area. (Source; Myanmar Geoscience Society, 2014)

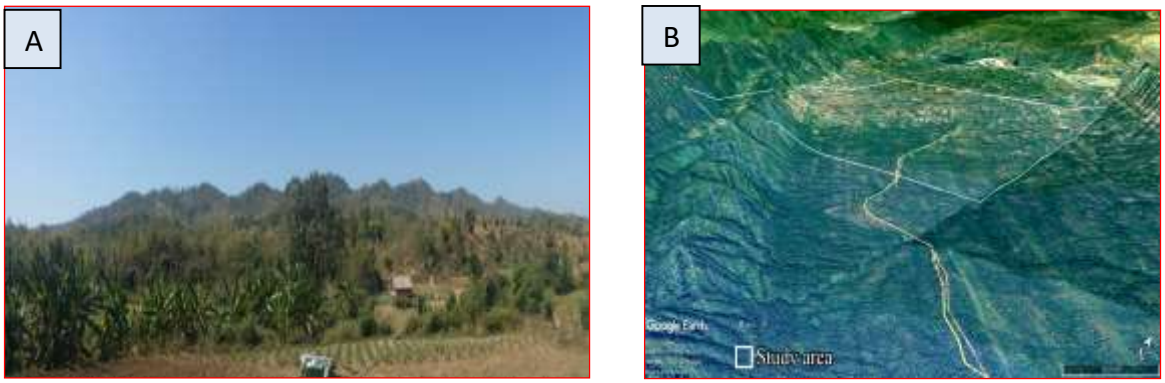

Figure 2 (A) Picturesque view of Kyunbotaung. (Facing to the Nroth), (B) 3D landset image and topographic features of Chaung Zon area. (Source; Google Earth, 2017)

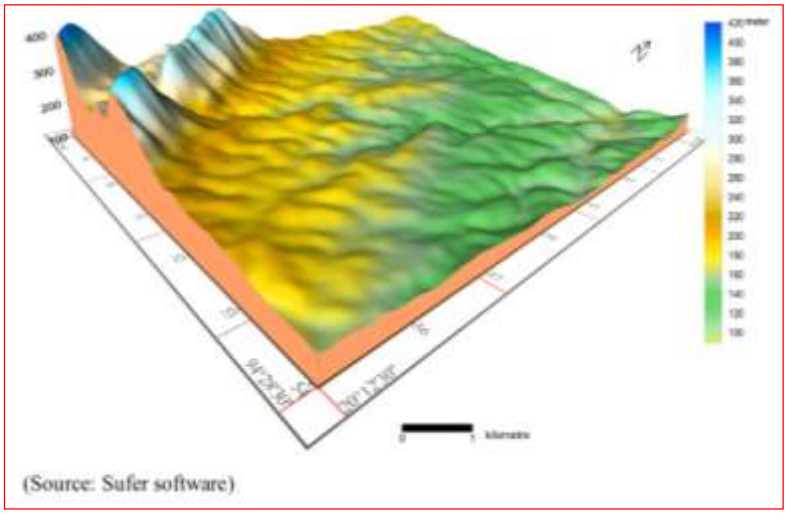

Figure 3 Evolution Development Map (EDM) of the study area.

Stratigraphy

General Statement

The study area, occupying a small segment of the western margin of the Inner-Myanmar Tertiary Basin, comprises mainly Oligocene-Miocene sediments deposited in marine to deltaic environments. The rocks sequence of the area in descending order are; Shwezetaw Formation (Early Oligocene), Padaung Formation (Early Oligocene), Okhmintaung Formation (Late Oligocene), Pyawbwe Formation (Early Miocene), Kyaukkok Formation (Middle Miocene), Obogon Formation (Late Miocene) and Irrawaddy Formation (Late Miocene to Pliocene). The author specialized the study of Okhmintaung Formation.

Okhmintaung Formation

The lower part of the Okhmintaung Formation is characterized by light grey, medium-to coarse-grained, thick-bedded to massive type sandstones intercalated with thin-bedded mudstones and bluish grey shales are also occurred. In the middle portion, dark grey-coloured, medium-to coarse-grained, thick-bedded sandstone intercalated with thinly mudstone is occurred. In the upper part, light grey, fine-to medium-grained, medium-to thick-bedded sandstones are found. Sand-balls or concretions and polyperthite concretions are also occurred in this upper part of lower portion. Shale partings are present in this sandstones bed.

Figure 4 The outcrop nature showing the Okhmintaung Formation, a) Light grey colored, medium-grained, thin to medium-bedded sandstones intercalated with 2-4 cm thick mud layer in the middle part (20° 15′ 51″ N - 94° 24′ 38″E), b) Dark brown to yellowish brown colored, medium- to coarse-grained, thick- to massive sandstones exposed in the middle part (20° 15′ 51″ N - 94° 24′ 38″ E) and c) Hard and competent sandstones exposure with tabular and planar type cross bedding structures in the lower part (20° 15′ 51″ N - 94° 24′ 38″ E)

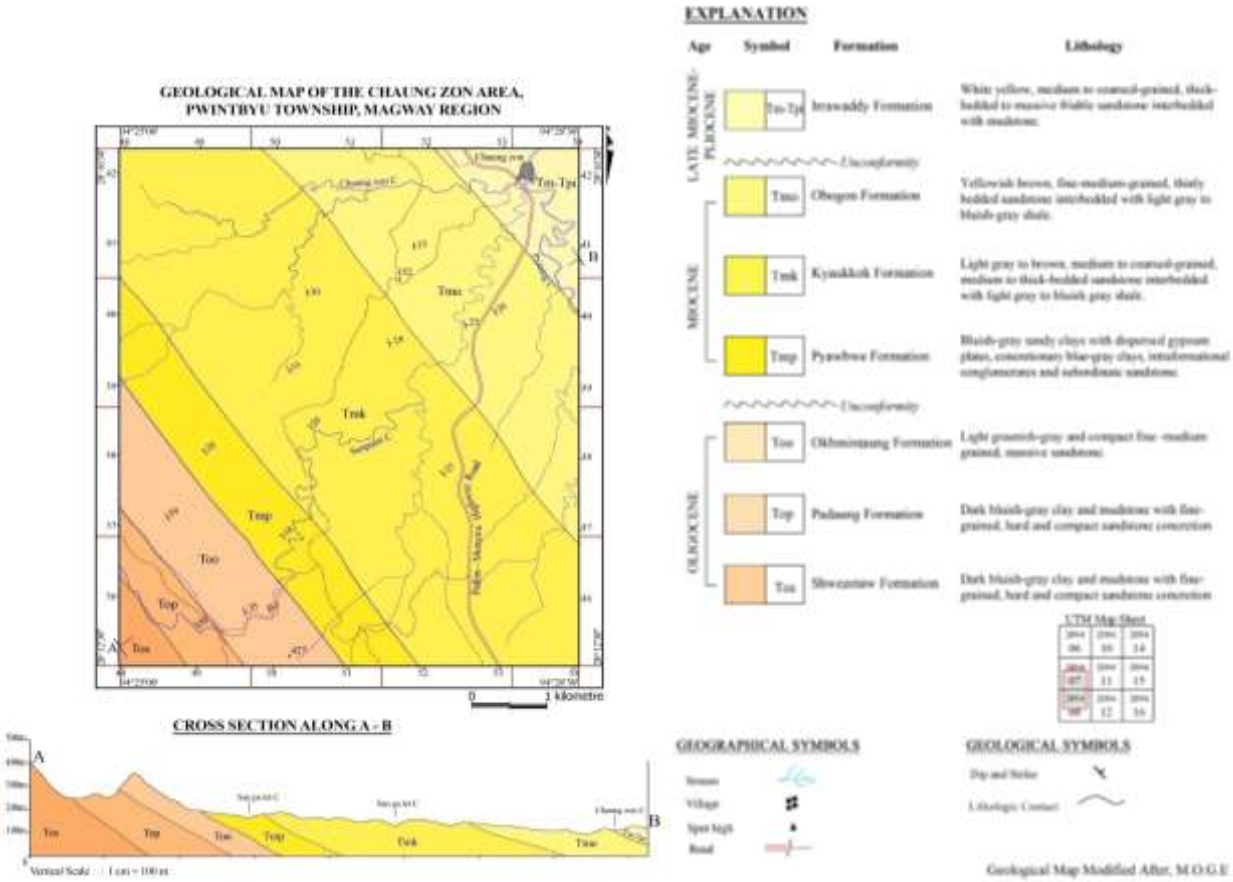

Figure 3 Geological map of the research area (Modified after MOGE)

Petrography

The percentage estimation of sandstones was shown in charts of Folk *et al*., 1970 in Tucker, 2001 (Table 1). The sandstones are classified according to the simple classification of sandstone (after Pettijohn *et al*., 1987 in Tucker, 2001). The sandstones of Okhmintaung Formation are composed of 55% to 72% detrital grains, 28% to 45% chemical cements and 2% to 5% of matrix. Detrital grains in these sandstones are generally moderately sorted and subangular to subrounded. The diameters of detrital grains are 0.1 mm to 2 mm.

Table 1 The detrital composition means of sandstones (in volume %) of Okhmintaung Formation of the study area. Quantitative models are recalculated from the data of thin slide.

Simple No.	Quartz	Feldspar	Rock Fragment	Total
Okh-1	60	18	22	100
Okh-2	66	14	20	100
Okh-3	60	20	20	100
Okh-4	72	14	14	100
Okh-5	70	10	20	100
Okh-6	72	10	18	100

Table 2 The detrital and cement composition of sandstones (in volume %) of Okhmintaung Formation.

Slide no	Qtz	Fel	Mica	Rx fg	Hev ml	Calcite cement	Iron cement	Mtx	Other detrital	Total
Okh-1	31	5	3	8	3	30	12	3	5	100
Okh-2	30	10	4	12	2	27	10	2	3	100
Okh-3	18	8	4	8	3	40	10	4	5	100
Okh-4	31	6	3	6	2	36	9	3	4	100
Okh-5	30	5	4	10	3	29	10	5	2	100
Okh-6	31	5	3	9	4	25	11	6	5	100

Quartz

Detrital quartz grains comprise 55% to 72% of total volume of the rock. Most are monocrystalline quartz grains which form subangular-to subrounded. Most of the monocrystalline quartz grains possess unit extinction where the whole crystal is extinguished uniformly under crossed polar. Some of the grain show undulated extinction where extinction is not uniform but sweeps across the crystal as it is rotated from 6° to 15°. Undulated extinction usually is a reflection of a stain in crystal lithic (Fig 5. a & c). Some crystals incorporated with mineral inclusion (Fig 6. a & b). They may be volcanic origin (Fig 5. a, c & 6. a). Polycrystalline quartz grains are straight boundaries represent up to 10% of total rock volume.

Most of quartz grains are monocrystalline represent up to 40% of total rock volume. When the boundaries between the crystals are sutured this is a characteristic of quarts from a metamorphic source. Composite quartz from igneous sources have straighter crystal boundaries. Some quartz grains are irregularly fractured.

Feldspar

Feldspar occupies 10% to 20% of the total detrital population. They are generally fresh and some are moderately weathered. Most of them are show angular, subangular to subrounded, and subsequent to elongated shape. Alkali feldspar are more common than calcic plagioclase, partly because they are more resistant to chemical weathering and partly because the ultimate source of many terrigenous rock is granite or gneiss, in which the feldspars are mainly the alkali verity. Orthoclase crystals usually break along the twin planes so that the simple Carlsbad twinning is rarely seen. Plagioclase can be identified by its polysynthic and multiple twinning. Feldspars with overgrowth are found (Fig 7 b & d).

Rock fragments

The various rock fragments dominate a significant portion of the detrital grains averaging about 18% to 25% of the total volume. The various types of rock fragments are chert, clay, volcanic rock fragments are also observed in the sandstone of Okhmintaung Formation. The sedimentary rock fragments other than chert are relatively uncommon because they usually break down fairly easily into their components grains. Some large sandstone fragments, in which the component particles are all quartz, are clearly distinguishable even with PPL. Some metamorphic fragments formed elongated grains (Fig 5.d) which are classified as the slate fragments. The contrast with the composite quartz grains of igneous and metamorphic sources, where individual crystals are also found (Fig 6. b & 7. b). They are angular, subangular to subrounded and range in grain size from 0.5 mm to 1.5 mm and some are coated by iron cement.

Mica

Both biotite and muscovite comprise 4% to 10% of the detrital framework. Biotite and muscovite are well observed in Okhmintaung sandstones. Biotite flakes dominant. They show preferred orientation. Bifurcation of biotite mica and some biotite alter to glauconite in Okhmintaung sandstones (Fig 5.5 b). Biotite range in grain size about 0.15 mm to 0.2 mm in diameter. Some biotites are partly altered to chlorite, glauconite (Fig 5.4 b) and muscovite and iron oxide.

Heavy mineral

Heavy minerals comprise about 1% to 2% of the total rock volume. Heavy minerals grains composed of glauconite, magnetite, rutile, zircon, tourmaline and other opaque minerals. Glauconite grains are rounded to subrounded and range in size from 0.1mm to 0.3mm and most of heavy minerals are coated by calcite cement and iron cement.

Bioclasts

Biogenic fragments, both micro- and macro-fossils are present in the fossiliferous sandstones, especially, some samples no.5 and 6 of the Okhmintaung sandstones. They constituted more than 15 % the total rock volume of in this slide and include foraminifera, gastropods, bivalves and enchoids (Fig 7.c).

Cement and Matrix

In the Okhmintaung Formation, calcite cement constitutes about 25% to 40% and 3% to 10% iron cement of the total rock volume. The detrital fragments are firmly welded by calcite cement (Fig 5. c &d and 6. a, b, c & d and 7.a). Generally, the cement is filling of the pore spaces and some are voids remain. The boundaries of the calcite cement are showing sharp and straight characters, while some show curve to slightly sutured boundaries. Replacement of some silicate minerals by calcite cement is a common feature in this sandstone. Some detrital grain such as quartz, feldspar, and mica are markedly corroded and replaced by calcite. In this formation, iron oxide, hematite and clay matrix are also observed. The occurrence of the hematite cement as inclusion in the calcite cements and as scattered grains along the detrital grain boundaries. A few sandstones have a matrix of carbonate mud.

Nomenclature

Okhmintaung sandstone have less than 75% of quartz grains, feldspar comprise 10% to 20% and rock fragments 14% to 20% of the total detrital grains. When the sandstone composition is plotted in the triangular diagram of the Pettijohn *et al.,* (1987), all the sandstones of the Okhmintaung Formation may be termed as “Sublithicarenite” seen in Figure (8).

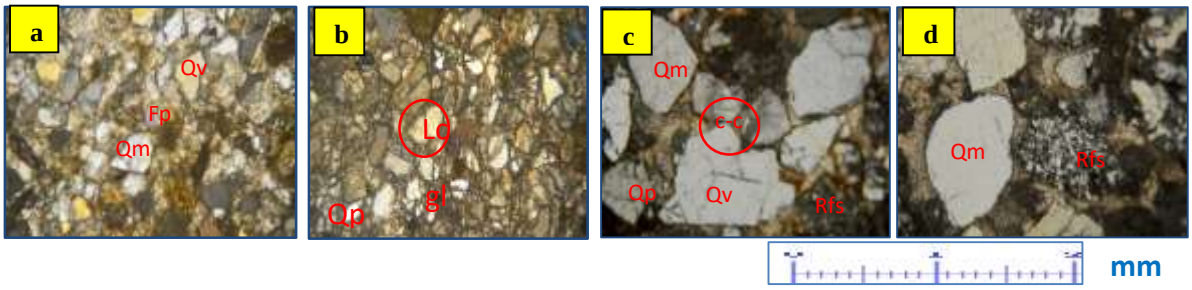

Figure 5 Photomicrographs of sandstones from Okhmintaung Formation. a) and b) Subangular to subrounded quartz grains(Qm, Qp & Qv), plagioclase feldspar (Fp), chert (cht) rock fragment (Rf) and glauconite (gl) which are single crystals, taken with plane-polarized and the matrix between sand grains contain iron oxide and calcite, c) and d) Quartz crystal may sometimes incorporate minerals inclusion and some volcanic quartz (Qv) show uniform or straight extinction and rounded by light brown matrix. Sedimentary rock fragments (Rfs) are found. Quartz grains are found in concave-convex contact, point contact and suture contact. Polycrystalline quartz (Qp) grains are large and rounded boundaries. Concave-convex (c-c) contact also occurred

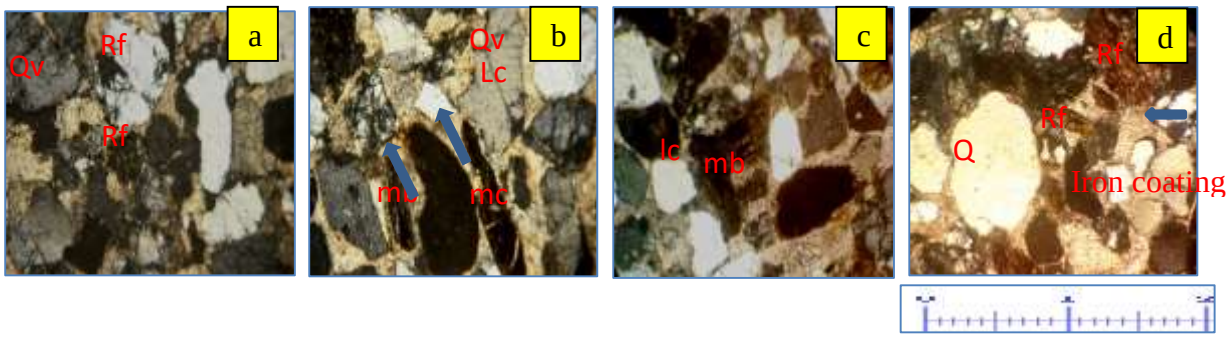

Figure 6 Photomicrographs of sandstones from Okhmintaung Formation. a) and b) Some metamorphic quartz (mQ) show cross-hatch fracture and straight boundaries and volcanic quartz grains (Qv) are long contact and tangential contact. Biotite micas (mb) are long and fracture features in this sandstones. The detrital grains in this sandstone are parallel orientation. c) and d) Quartz overgrowth (Qm) thin oxide and or thin oxide or clay coating between the grains and the overgrowth is visible (PPL). A single-crystal quartz grain with strongly undulate extinction; grain extinguishes completely with more than 5° of stage rotation (XN); volcanic rock fragments with small laths of plagioclase feldspar and a very finely crystalline matrix. Biotite micas (mb) and rock fragments (Rf) are coarse-grained metamorphic rocks often schistose.

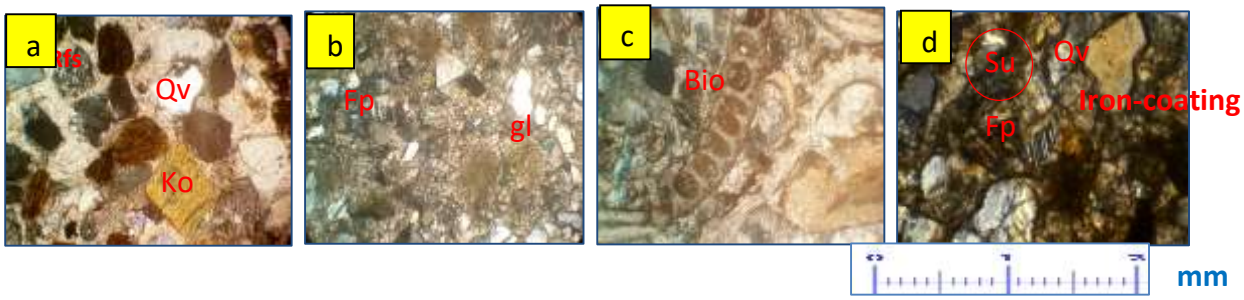

Figure 7 Photomicrographs of sandstones of Okhmintaung Formation. a) Quartz overgrowth (Qv) thin oxide and or clay coating between the grains and the overgrowth is visible (PPL). Sedimentary rock fragments (Rfs) source from sandstones. Orthoclase feldspars (Ko) are cloudy appearance due to alteration. b) & d) Partially dissolutated feldspar grains and glauconite (gl) are occurred and overgrowth quartz grain crystal (Qv) also present. Fractured quartz with embayment indicating igneous derivatives. Plagioclase feldspars (Fp) are polysynthetic and multiple twinning. c) Foraminiferal occur in fossiliferous sandstones.

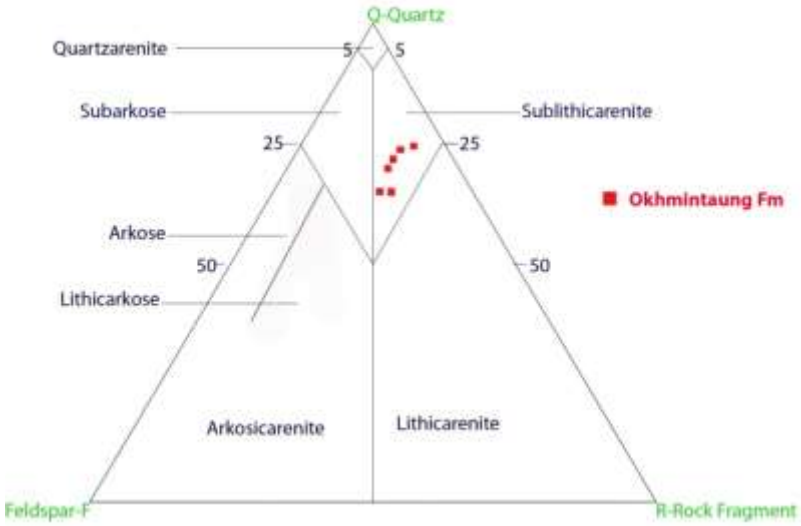

Figure 8 Compositional diagram of sandstone of Okhmintaung Formation (After Pettijohn et al., 1987)

Diagenesis of Okhmintaung Formation

Compaction: The first stage of diagenesis is the compaction of the sediment. It increases the density of the sediments. It occurs in all loose aggregate as the clasts rearrange themselves under moderate pressure. Pore-water in the voids between grains is expelled in the processes and compaction by repacking may reduce the volume of a body of sand by around 10% (Nichol, 2009). Before cementation compaction take place dominantly by mechanical processes, resulting slippage between individual grains reorientation and subsequences fractures of some grains.

Cementation: Quartz cement often occurs as overgrowth on the original quartz grains. Calcite cement is composed of 16% to 51% of the total rock volume. Calcite is soluble in surface water and therefore cemented sandstones often have their cement partially dissolved. Dissolution of calcite cement results in the secondary porosity. Iron oxide cement comprises 5% to 11% of total rock volume. Some iron oxides are the next common and may be cementing material in the sandstone.

Replacement: The process of practically simultaneous capillary solution and deposition by which as new mineral of partly or wholly differing chemical composition may grow in the body of an old mineral or mineral aggregates. In the study area, calcite cement is corroded and wedge apart to the detrital quartz and feldspar.

Authigenesis: Authigenesis is formed when new minerals are crystallized in the sediment or rock during diagenesis. These new minerals may be produced by reaction involving phase already present in the sediment, through precipitation of material introduced in the fluid phase, or a chemical reaction between primary sedimentary minerals and ions is introduced by the fluids. This process overlaps with weathering and cementation, usually involves recrystallization and may result in replacement.

Result and Discussion

1. Okhmintaung sandstone has less than 75% of quartz grains, feldspar comprise 10% to 20% and rock fragments 14% to 20% of the total detrital grains. When the sandstone composition is

plotted in the triangular diagram of the Pettijohn *et al.*, (1987), all the sandstones of the Okhmintaung Formation may be termed as "Sublithicarenite".

2. ***Redoxomorphic Stage:*** This stage is characterized by all the reflection due to oxidation and reducing in the sediments during and immediately after burial. The reaction in this stage occurs along the sediment in which total iron content exceeds 3%. Alteration of biotite to muscovite and oxidized biotite are more common in the Okhmintaung sandstone in the study area.
3. ***Locomorphic Stage:*** During this stage, precipitation of mineral matter fill in the pore spaces and replacement of detrital mineral grains are significant. The cementing material in the Okhmintaung sandstones are calcite and iron cements, glauconite, rutile and clay matrix. Pore spaces between the detrital grains are also filled by silica cement.
4. ***Phyllomorphic Stage:*** This stage is the last stage of diagenesis which involves authigenesis of some minerals. The common characteristics of late burial or phyllomorphic stage are the alteration of clay mineral into micas and the development of well crystallized phyllosilicate minerals. Biogenic fragments, both micro- and macro-fossils are present in the fossiliferous sandstones, especially, some samples no.5 and 6 of the Okhmintaung sandstones.

Summery and Conclusion

The study area is located between north latitude 20º 12′ 30″ - 20º 16′ 30″ and east longitude 94º 25′ 00″ - 94º 28′ 30″. It is situated about 16 miles (25.75 km) west of the Pwintbyu Township. It falls in 2094/7 (84 L/7) and 2094/8 (84 L/8) referring to UTM topographic maps. The lower part of the Okhmintaung Formation is characterized by light grey, medium-to coarse-grained, thick-bedded to massive type sandstones intercalated with thin-bedded mudstones and bluish grey shales are also occurred. In the middle portion, dark grey-coloured, medium-to coarse-grained, thick-bedded sandstone intercalated with thinly mudstone is occurred. In the upper part, light grey, fine-to medium-grained, medium-to thick-bedded sandstones are found. Sand-balls or concretions and polyperthite concretions are also occurred in this upper part of lower portion, Shale partings are present in this sandstones bed.

Detrital quartz grains comprise 55% to 72% of total volume of the rock. Most are monocrystalline quartz grains which form subangular-to subrounded. Feldspar occupies 10% to 20% of the total detrital population. They are generally fresh and some are moderately weathered. The various rock fragments dominate a significant portion of the detrital grains averaging about 18% to 25% of the total volume. Both biotite and muscovite comprise 4% to 10% of the detrital framework. Biotite and muscovite are well observed in Okhmintaung sandstones. Heavy minerals grains composed of glauconite, magnetite, rutile, zircon, tourmaline and other opaque minerals. Calcite cement constitutes about 25% to 40% and 3% to 10% iron cement of the total rock volume. When the sandstone composition is plotted in the triangular diagram of the Pettijohn *et al.*, (1987), all the sandstones of the Okhmintaung Formation may be termed as "Sublithicarenite".

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Redoxomorphic Stage is characterized by all the reflection due to oxidation and reducing in the sediments during and immediately after burial. The reaction in this stage occurs along the sediment in which total iron content exceeds 3%. During the ***Locomorphic Stage***, precipitation of mineral matter fill in the pore spaces and replacement of detrital mineral grains are significant. ***Phyllomorphic Stage*** is the last stage of diagenesis which involves authigenesis of some minerals. The common characteristics of late burial or phyllomorphic stage are the alteration of clay mineral into micas and the development of well crystallized phyllosilicate minerals.

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