Petrography and Provenance Study of Letkat Sandstones (Early Miocene) in Paluzawa Area, Kalewa Township, Sagaing Region

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Abstract

The study area, situating in Kalewa Township, Sagaing Region, lies between latitudes 23°25'00" to 23°30'00"N and longitudes 94°18'30" to 94°23'30"E, in topographic map index of 84 I/7 and the areal extent is 69.83 square kilometers. It is mainly focused on petrography and provenance study of Early Miocene sandstones of Letkat Formation. Most of the Letkat sandstones fall in the field of lithic arkose and arkose. They consist of quartz, feldspar, mica, rock fragments with chemical cements of silica, calcite and iron oxide. As for the diagenesis sequence, early diagenetic features of clay coating, silica cementation and calcite cementation and the late diagenesis features such as feldspar authigenic, corrosion of grain by calcite and hematite pigmentation are also encountered. By the provenance study, the sediments are derivative of Dissected Arc, Basement Uplift, Recycled Orogenic and mix. The paleocurrent and petrographic studies point out that the sediments have been derived from the acid igneous rocks, low to high-grade metamorphic rocks and pre-existing sedimentary rocks. The possible source area for the Early Miocene Letkat sandstones is the Western Ranges and the nearby Igneous Belt of Myanmar.

Keywords: lithic arkose, arkose, diagenetic features, source area

INTRODUCTION

Location and Size

The Paluzawa area is situated in Kalewa Township, Sagaing Region. It lies between latitudes 23°25'00" to 23°30'00"N and longitudes 94°18'30" to 94°23'30"E, in topographic map index of 84 I/7 and the areal extent is 69.83 square kilometers (Figure.1).

Aims and Objectives

The present research will attempt to carry out petrographic analysis and provenance study of the Letkat Formation.

Previous Works

Win Swe, U.C. Thaepaw, Nay Thaung Thaung and Kyaw Nyunt (1972) studied the geology of part of the Chindwin basin of the Central Belt, Burma. Kyaw Linn Oo (2008) has carried out Ph.D Thesis titled of "Sedimentology of Eocene-Miocene Clastic Strata in the Southern Chindwin Basin, Myanmar".

Methods of Study

Standard petrographic thin sections for eight medium-grained sandstones were studied under polarizing microscope and points were by using a mechanical stage for the model analysis. Cement, matrix, heavy minerals, mica and miscellaneous grains were included in this count. Moreover, to classify the sandstones, the counted data of points were plotted on the

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triangular diagram according to the sandstone classification QFL plot of McBride (1963). And then, triangular plots of QtFL and QmFLt were applied for distinguishing provenances according to the subdivisions of Dickinson (1985).

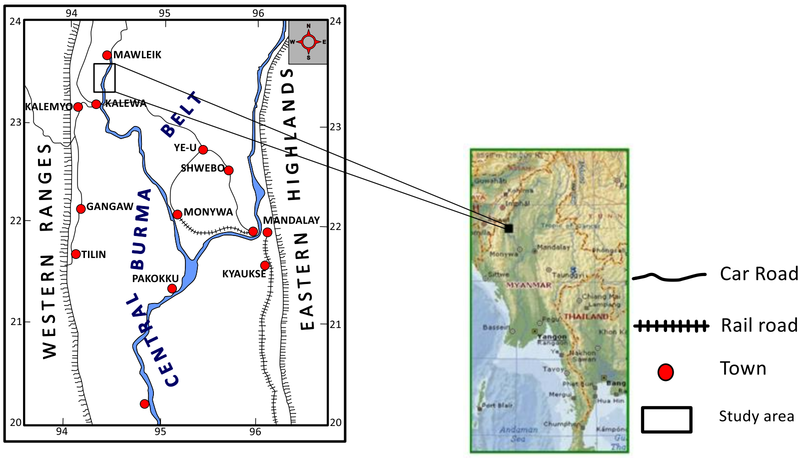
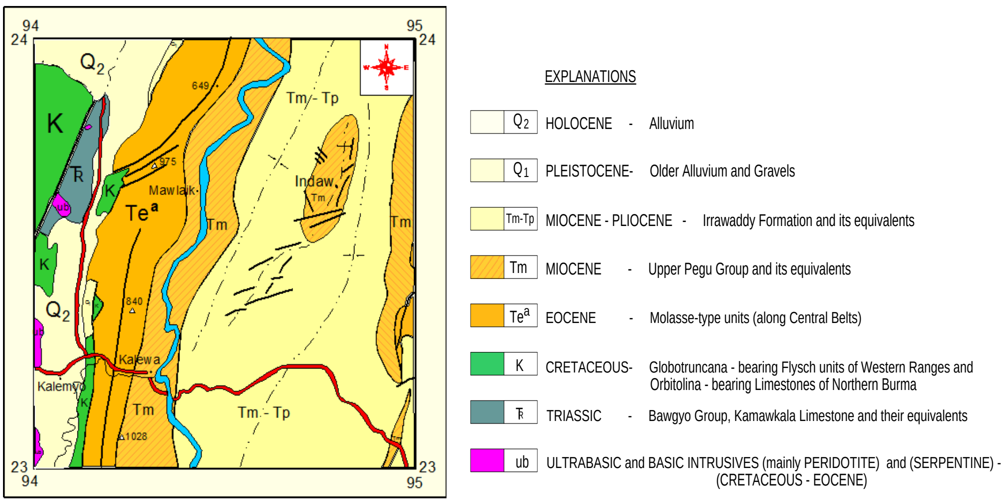


Figure 1. Location map of the study area.

Regional Geologic Setting

Myanmar can be subdivided into four north-south trending linear geotectonic provinces, namely from east to west; the Eastern Highland (Shan-Tenasserim Highland), the Central Lowland (Central Cenozoic Belt), Western Ranges and Rakhine Coastal Belt (Maung Thein, 1973). The Central Belt includes the Irrawaddy, the Chindwin, the Sittaung valleys and the intervening low ranges. The study area is mainly composed of clastic sedimentary rocks with a general trend of nearly N-S direction. In this area, Middle Miocene rocks of Natma Formation are mostly cropped out along the central part which is conformably overlain by Early Miocene clastic sedimentary rocks of Letkat Formation and underlain conformably by Late Miocene clastic sedimentary rocks of Shwethamin Formation. In the Letkat Formation, the rocks are distributed especially along the stream section. The regional geology of the southern Chindwin Basin and its environs is shown in figure (2).



Scale 1 : 100000

Figure 2. Regional geologic setting of the study area from Geological Map of Myanmar (1977).

Stratigraphic Units

Paluzawa area is generally enveloped a small segment of the western marginal portion of the Chindwin Basin of the Cenozoic rocks. The area is composed of clastic sedimentary rocks of Yaw Formation (Late Eocene), Letkat Formation (Thitchauk Conglomerate Member and Nwa Taung Sandstone Member) and Natma Formation (Miocene age). Stratigraphic sequences of the study area are shown in table (1).

Table 1. Stratigraphic sequences of Paluzawa area.

AGE		STRATIGRAPHIC UNITS		THICKNESS (in feet)
MIOCENE	Middle	NATMA FORMATION		2500
	Early	LETKAT FORMATION	Nwa Taung Sandstone Member	2600
			Thitchauk Conglomerate Member	400
EOCENE	Late	YAW FORMATION		?

Letkat Formation

This formation is made up of two members with total thickness of 3000 feet. The descending order with corresponding thickness is as follows:

2. Nwa Taung Sandstone Member – 2600 feet

1. Thitchauk Conglomerate Member – 400 feet

Thitchauk Conglomerate Member: Quartz Pebble Conglomerate and white quartzose sandstone that crop out near the base of west-facing cliffs close to the east of Thitchauk village will be referred to as the Thitchauk Conglomerate Member of the Letkat Formation by Aung Khin and Kyaw Win (1968). The Thitchauk Conglomerate Member is remarkably persistent in lithology and thickness from the south border of the map area to the vicinity of Paluzawa Chaung in the west and Nanzalein Chaung in the north. North of Nanzalein Chaung, the thickness and proportion of quartzose sandstone increase more than the southern part of the map area. The approximate stratigraphic thickness of Thitchauk Conglomerate Member is about 400 feet. The contact between the Thitchauk Conglomerate and the underlying Yaw Formation is easily identified in the field. Aerial geology indicates that there is no apparent discordance between the Thitchauk Conglomerate and the underlying Yaw Formation and the overlying Nwa Taung Sandstone Member.

The Thitchauk Conglomerate Member comprises quartz pebble conglomerate and clean quartzose sandstone. Clasts of the conglomerate are mostly vein quartz and various coloured cherts. Fresh colour of the conglomerate and the sandstone is white, but generally they are iron-stained and appear pinkish, grayish white or yellowish brown at the outcrop. They both are resistant to weathering, but are easily erodable due to their poor induration. Sandstones are more friable than conglomerates. Large-scale cross-stratifications were noted both within sandstones and conglomerates. No fossils were collected from the Thitchauk Conglomerate Member. Therefore, no precise age of this unit is known. But the lithological and bedding character pointed out that this Member will be Early Miocene age and correlated with the Oligo-Miocene marine Pegu Group of the Minbu and Pakokku areas in the south.

Nwa Taung Sandstone Member: Massive, medium-to coarse-grained sandstone that form prominent scarps and ledges on the ridges between Kalewa and Thitchauk village will be referred to as the Nwa Taung Sandstone Member of the Letkat Formation by Aung Khin and Kyaw Win (1968). This unit forms a very rugged terrain with the south-facing steep along the west border of its belt of exposure and rugged dip slopes which often carry rock slides. Soil cover is generally not thick on this unit. The approximate stratigraphic thickness of Nwa Taung Sandstone Member is about 2600 feet. The contact between the Nwa Taung Sandstone and the overlying Natma Formation is conformable and sharp and is easily recognized both in the field and on the aerial photographs. The overlying Natma Formation begins with a shaly sequence which strongly contrasts to the massive sandstone beds of the Nwa Taung sandstone. Aerial geology indicates that there is no apparent discordance between the Nwa Taung Sandstone and the underlying Thitchauk Conglomerate.

The Nwa Taung Sandstone is composed dominantly of medium-grained sandstone (95%) with some shale intercalations or partings between massive sandstone beds which often exceeds more than 25 feet in thickness. The sandstones of this unit are gray colour, but weathered to light yellowish brown. Large-scale cross-bedded are common. Wood chips, mud clasts and quartz pebble conglomerate pockets or stringers are common within these sandstones. No fossils were collected from this unit. However, the lithological and bedding character pointed out that Nwa Taung Sandstone Member will be Middle Miocene in age and correlated with the Oligo-Miocene marine Pegu Group of the Minbu and Pakokku areas in the south.

Depositional Environment of Letkat Formation

(1) No proper fauna is present in Letkat Formation.

(2) Coarse to gritty, medium to thick bedded, pebbly gritty sandstones are present in this Formation.

(3) Sedimentary structures such as large-scale cross-stratifications, low-angle cross-bedding, planar cross-bedding and sand-mud interlayer were noted both within sandstones and conglomerates in exceptionally well exposed outcrops were observed.

(4) Extraformational quartz pebbles are also present.

PETROGRAPHY

Sedimentary petrography is the analysis of both depositional and diagenetic fabrics from thin sections, and includes mineralogical composition, grain and sediment provenance, and determination of the sequence of diagenetic events. Advances in understanding of stratigraphy and sedimentology of the southern Chindwin Basin have provided the framework for the petrography and provenance study which will allow more precise documentation of the tectonic environment of the source terrain during deposition.

Detrital Constitutes in Sandstones of Letkat Formation

These sandstones are mainly composed of quartz, feldspar, rock fragments, mica, accessory and heavy minerals embedded in calcite cement. Sandstones of Letkat Formation are mostly normal or paraconglomeratic framework. Letkat Sandstones comprise 70 to 80 % of detrital grains and 15 to 25 % of cement (Figure.3A). The maximum grain size varies from 0.1 to 0.25 mm and the minimum grain size varies from 0.03 to 0.05 mm. Most of these sandstones are poorly sorted to moderately and the detritus are angular to subrounded in shape.

Quartz

Detrital quartz constitutes 50 to 55 % of the total detrital fractions. Most of the quartz grains are non-equidimensional and subangular to subrounded in shape. In the total quartz population, 85 to 90 % is monocrystalline quartz and 10 to 15 % is polycrystalline quartz (Figure.3B). Monocrystalline quartz from this unit includes both non-undulatory quartz of normal igneous type and undulatory of metamorphic type, the latter is slightly more abundant than former. Mineral inclusions and some bubble inclusions (Figure.3C) are observed. Chalcedonic quartz (Figure.3D).

Feldspar

Alkali feldspars and plagioclase feldspars consist 30 to 40 % of the total detrital fractions. The former is 80 to 85 % and the latter is 15 to 20 % in total feldspar content. The varieties of feldspars such as orthoclase, plagioclase, microcline and perthite feldspar are investigated (Figure.3E and 3F) and (Figure.4A). Most of the feldspars are fresh but the sericitized feldspars and alteration to clay minerals are also noted. In some cases, encrustation of feldspar by algae coating is noted.

Rock Fragments

The rock fragments consist 5 to 15 % of the total detrital fractions. Most of the fragments are pre-existing sedimentary, metamorphic and igneous rocks. The fragments of chert (Figure.4B), siltstone, phyllite, schist and volcanic rock fragments (Figure.4C) are investigated. The conspicuous appearance of rock fragments compared to other detritus is the shape with better degree of rounding.

Mica

Biotite and muscovite mica are fairly common detrital fraction ranging from 5 to 15 % of the total framework grains. Biotite mica is much more dominant (Figure.4D). Some mica grains were bifurcated by the introduction of calcite cement and some are distorted by the compaction. Biotite altered to iron oxide along their boundaries is frequently observed (Figure.4E). Some biotite grains are bifurcated due to displacement of growth calcite cement (Figure.4F). The size of the mica flakes ranges 0.1 to 0.5 mm in length and 0.05 to 0.2 mm in width.

Cement

The chemical cement takes up 25 to 40 % of the total rock volume. The types of chemical cements are mainly calcite and iron oxide cement (Figure.5).

Nomenclature

According to the sandstone classification of McBride (1963), most of the Letkat sandstones can be named as lithic arkose and arkose (Figure.6).

Clastic Diagenesis

Diagenesis is the sum of those processes by which originally sedimentary clastic assemblages attempt to reach equilibrium with their environments (Burley, Kantorowitz & Waugh, 1985). Diagenesis phases for the rocks constituted in the area can be categorized as two phases; the early diagenesis, for processes taking place from deposition and into the shallow burial realm and the late diagenesis for those processes affecting the sediments at the deeper levels and on uplift.

Early Diagenesis

The characteristic diagenetic features include; clay coatings, silica cementation, calcite cementation, and formation of authigenic minerals.

Clay Coatings (chlorite rims): Diagenetic chlorite occurred as rims around the detrital grains in the Miocene sandstones and rarely as pore infillings (Figure.7) and occasionally as replacement of feldspars and lithic grains. The formation of chlorite is the earliest diagenetic process which is seen to predate the formation of the other diagenetic phases (Imam and Shaw, 1985). The clay rims can become impregnated with hematite or altered to other clay during diagenesis (Tucker, 1991). Clay may also filter into sandstone carried down by pore waters from muddy interbeds (Walker, R.G., 1978). The chlorite (clay) rims and pore infillings appear to form by direct precipitation and only where chlorites occasionally replaced lithic and feldspar grains is there and evidence of pre-existing minerals being altered to form clay (Imam and Shaw, 1985).

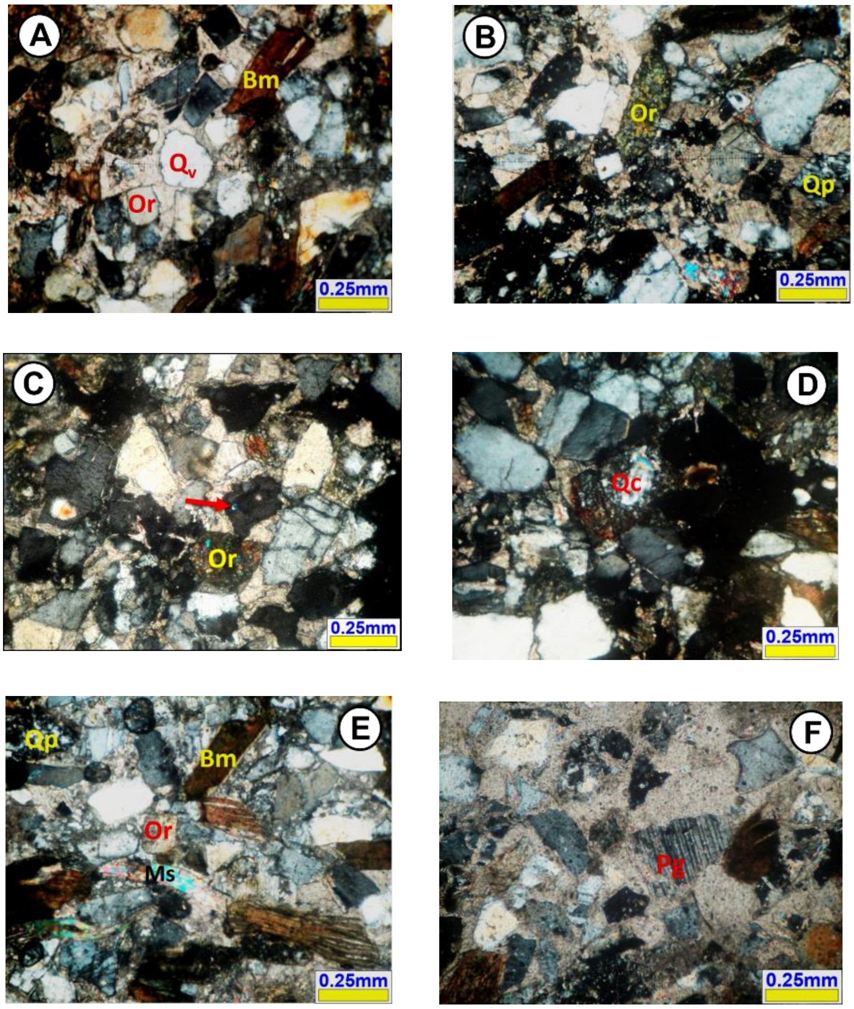


Figure 3. Photomicrographs showing the detrital constituents in sandstones of Letkat Formation (between X.N); (A) detrital quartz, feldspar (Or), biotite mica (Bm) and volcanic quartz (Qv) with good crystal outline in calcite cement (Loc.833998); (B) polycrystalline quartz (Qp) and weathered orthoclase (Or) (Loc.853042); (C) mineral inclusion (arrow) and weathered feldspar (Or) (Loc.859040); (D) chalcedonic quartz grain (Qc) embedded in calcite cement (Loc. 859040); (E) orthoclase (Or), biotite mica (Bm), muscovite mica (Ms) and polycrystalline quartz (Qp) (Loc.833998); (F) fractured plagioclase (Pg) embedded in calcite cement (Loc.833998).

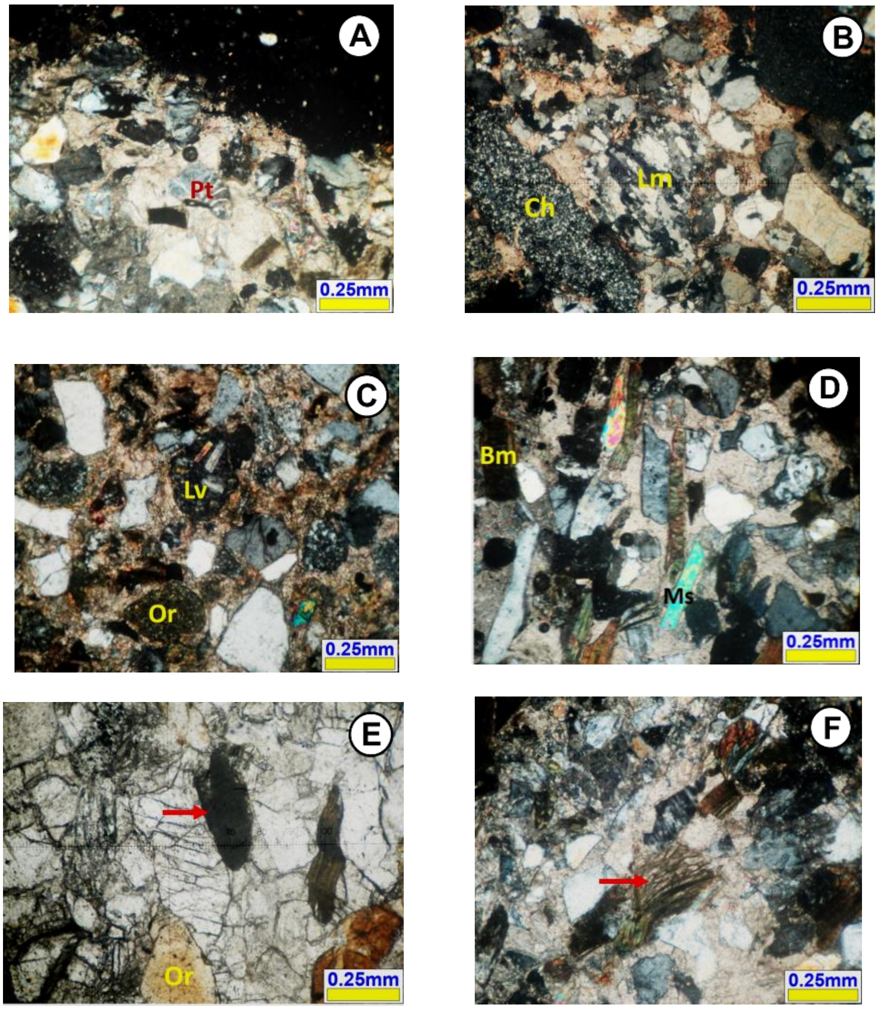


Figure 4. Photomicrographs showing the detrital constituents in sandstones of Letkat Formation; (A) perthitic feldspar (Pt) embedded in cement (between X.N) (Loc.833998); (B) chert (Ch) and metamorphic rock fragment (Lm) embedded in calcite cement (between X.N) (Loc.821999); (C) volcanic rock fragment (Lv) and weathered orthoclase (Or) embedded in calcite cement (between X.N) (Loc.853042); (D) more abundant of biotite mica (Bm) than muscovite mica (Ms) in calcite cement (between X.N) (Loc.833998); (E) biotite altered to iron oxide (arrow) and weathered orthoclase (Or) (Under PPL) (Loc. 841001); (F) bifurcated biotite grains due to displacement of growth calcite cement (arrow) (between X.N) (Loc. 833998).

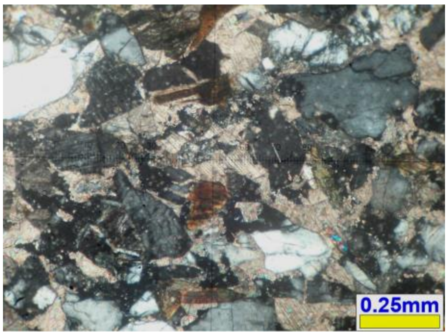


Figure 5. Photomicrograph of calcite cement (between X.N) (Loc. 836978).

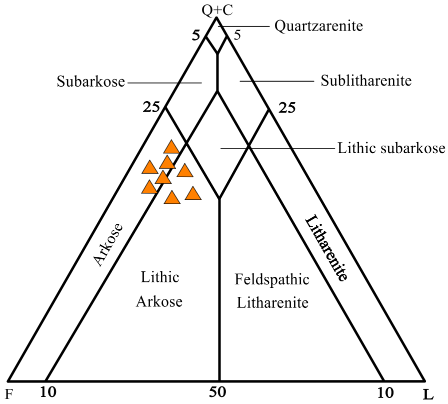


Figure 6. Ternary diagram of Letkat sandstones showing apparent shift in composition from lithic arkose and arkose (After McBride, 1963).

Silica Cementation: One of the most common types of silica cement is quartz overgrowth (Figure.8). Silica cement is precipitated around the quartz grains and in optical continuity, so that the grain cement extinguishes together under cross polarizer (Tucker, 1991). Silica cementation can occur at low temperatures of the earth's surface, such as the vadose environment. The origin of silica cementation is having frequently been attributed to pressure dissolution because pore solutions become enriched in silica which is then precipitated as overgrowths when supersaturation is achieved (Tucker, 1991). The two most probable sources of silica to form the quartz overgrowths are pressure solution and the transformation of smectite to illite in the adjacent interbedded shale units (Towe, 1962). Quartz overgrowth in sandstones without pressure dissolution effects may reflect significant upward migration of silica-rich solutions, or indicate another source of silica. Possible source is dissolution of silica dust, other silicate and biogenic source.

Carbonate cementation: Calcite is one of the most common cements in sandstones of the study area (Figure.9). The source of the $CaCO_3$ may be the pore water itself, but in marine sandstones, much is probably derived from dissolution of carbonate skeleton grains (Tucker, 1991). The two main types of calcite cements are poikilotopic crystals and drusy calcite spar in which both are iron-rich cement. The precipitation of Fe-rich carbonate cements has been explained as a consequence of diagenetic origin and redox reactions in adjacent precipitation of (iron) carbonate cement.

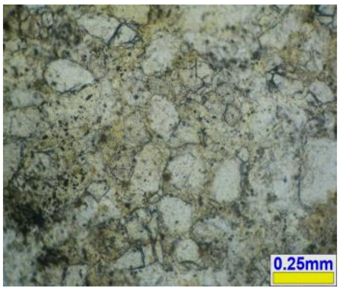


Figure 7. Photomicrograph showing the authigenic pore filling clay (chlorite) (under PPL) (Loc.823999).

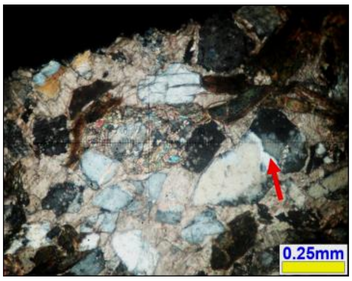


Figure 8. Photomicrograph showing quartz overgrowth (silica cementation) nature (arrow) (between X.N) (Loc. 836999).

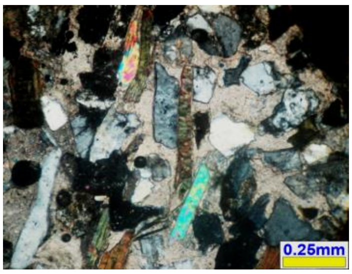


Figure 9. Photomicrograph showing the detrital grains are cemented by calcite (between X.N) (Loc. 833998).

Late Diagenesis

In the late diagenesis, the microscopic features such as feldspar authigenesis, replacement of clay minerals, and corrosion of grain by calcite.

Feldspar authigenesis: In many types of sandstone, alteration of feldspars to clay minerals and chlorite (Figure.10) can occur. They are most common in potash feldspars. For authigenic feldspars, alkaline pore waters rich in Na^{+} or K^{+}, Al^{3+} and Si^{4+} are largely derived from hydrolysis and dissolution of less stable grains within the sediment.

Replacement and corrosion of grain by calcite: Calcite commonly partially replaced and corrosion of grain (Figure.11) can be observed in Miocene sandstones of the study area. The detrital framework grains appear to float in Fe-calcite cement, and there is also evidence of corrosion by the cementing fluid along the outer margins of the grain (Imam, and Shaw, 1985). Dolomite rhombs were locally noted in Miocene sandstones.

Hematite pigmentation: Many terrigenous types of sediment are colored red through the presence of hematite. It is also developed within biotite cleavage planes and in some cases replaces the biotite (Figure.12). Iron is supplied by intrastratal dissolution of detrital silicates such as hornblende, augite, olivine, chlorite, biotite and magnetite (Tucker, 1991). The hematite is chiefly amorphous or consists of micron-size crystals. These features of the hematite, together with the absence of hematite coatings at grain contacts indicate a diagenetic origin (Tucker, 1991).

Figure 10. Photomicrograph showing authigenic chlorite mineral altered from feldspar (arrow) (under PPL) (Loc.821999).

Figure 11. Photomicrograph showing the detrital grainsare dissolution by calcite (arrow) (between X.N) (Loc. 833998).

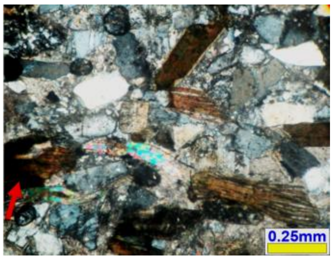


Figure 12. Photomicrograph showing the iron oxide (hematite) develop within biotite cleavage planes (arrow) (between X.N) (Loc.833998).

PROVENANCE STUDY

Point counting data were recalculated to produce the grain parameters proposed by Graham et al., (1976). The mean paleocurrent direction of the Early Miocene rocks exposed in the study area is 170°. This indicates that the possible provenance is situated somewhere in the NNW of the study area.

Moreover, petrographic and petrological criteria were used to determine the provenance. Triangular plots of QtFL and QmFLt were drawn from the point counting data. When QtFL diagram of Dickinson (1985) is applied, the data plot falls in the field of dissected arc, recycled orogenic, basement uplift and used QmFLt diagram, fall in the dissected arc, mix and basement uplift (Figure.13 and 14).

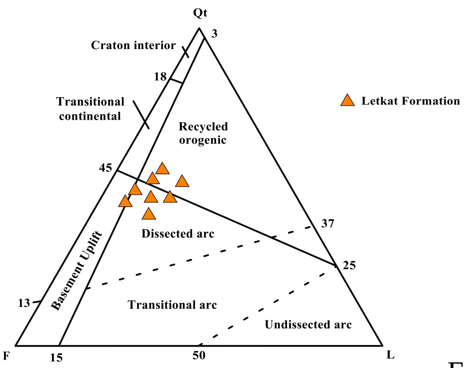


Figure 13. Triangular plot of QtFL showing the selected sandstone suites derived from different types of provenances after Dickinson (1985).

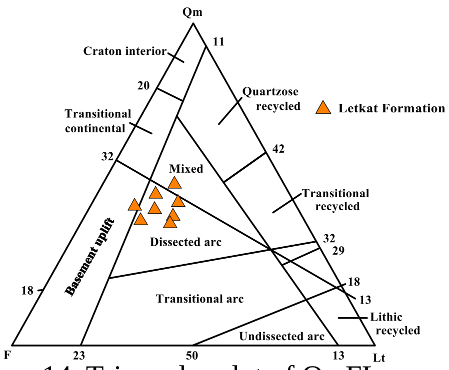


Figure 14. Triangular plot of $QmFL_t$ showing the selected sandstone suites derived from different types of provenances after Dickinson (1985).

CONCLUSION

The modal analysis of the Early Miocene sandstone of Letkat Formation documents in composition that are dominated by more quartzo-feldspathic and rich in metamorphic lithic fragments including medium to high-grade metamorphic lithic fragments. This suggests a granitic source and a characteristic of erosional unroofing of magmatic arc or deep level of erosion down to the plutonic root. The abundant subrounded monocrystalline quartz grains in the sandstones of Early Miocene reflect mechanical weathering and relative long transport. The content of volcanic lithic fragments in the Early Miocene samples suggests erosion of arc rocks. The provenance study carried out by using triangular plots of QtFL and QmFLt of Dickinson (1985), recalled that the sediments were derivatives of dissected arc and foreland uplift of recycled orogen provenances with varying proportions of feldspar and lithic populations in time that are related to the erosional fluxes from the uplifting of Indo-Burman Range and relative sea-level changes.

To sum up, in accordance with the paleocurrent directions and petrographic studies, the sediments of the study area are akin to the Western Ranges and the nearby Igneous Belt of Myanmar.

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