Provenance of Thapankaing Formation exposed in Thapankaing -Ohnlut Area, Madaya Township, Mandalay Region

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Abstract

The investigated area is situated in the eastern part of Madaya Township, Mandalay Region. It is bounded between North Latitudes 22° 12' to 22° 22' and East Longitudes 96° 14' to 96° 19'. The Thapankaing Formation is mainly composed of thin to thick bedded, buff to reddish brown, calcareous and siliceous sandstone with intercalated shale and siltstone. For petrographic studies, sandstone and mudstone samples in the Thapankaing Formation were collected during section measurement and nearly 40 samples of them were cut into thin section and studied under the microscope. On the basis of their mineralogical contents, the sandstones are classified as orthoquartzite, subarkose and protoquartzite. The presence of detritus quartz grains and sedimentary lithic fragments suggest that a component of provenance is older sedimentary rocks. Quartz arenites produced by persistent wave or current reworking were deposited on passive margins. Lithic sandstones are common in the foreland basin formed by thrust loading after continental collision. Thus the sediments of the Thapankaing Formation were derived from a recycled orogens.

Keywords: Thapankaing Formation, Provenance, Recycled orogens

Introduction

The investigated area is situated in the eastern part of Madaya Township, Mandalay Region. It is bounded between North Latitudes 22° 12' to 22° 22' and East Longitudes 96° 14' to 96° 19'. The research area is represented in one-inch topographic maps of 93-B/3, 93-B/4, 93-B/7 and 93-B/8. The location map of the research area is shown in figure (1).

The research area is situated between the Sagaing Fault to the west and the Shan Scarp Fault to the east. Stratigraphically, it is composed of the Chaung Magyi Group (Precambrian), Cambrian Unit (Cambrian), Ordovician Unit (Ordovician), Upper Plateau Limestone (Permian to Early Triassic) and Mesozoic Unit (Middle Triassic to Jurassic).

The present work emphasizes the provenance of the Thapankaing Formation (Middle Triassic?), based on the petrographic analysis.

Materials and Methods

The field studies are conducted during the dry season between November and April of the years 2009 and 2010. The geological map by Khin Maung Shwe (1973) was used as a base map for the study area and it was checked in detail during field works and corrections were made where necessary. Data from measured sections include observations on the thickness, primary structures, texture, composition of the units and the stratigraphic successions were then subdivided into stratigraphic units. While taping sections, major lithofacies components were identified and described.

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In addition, the representative samples were collected for further petrological and paleontological analysis. Hard and compact sandstones and limestone collected from the field traverse were cut into thin sections for microscopic study. The pointing of component grains was carried out to obtain modal composition and the petrographic classification. The terminology of the rocks follows the classification of sandstones after Pettijohn et al., (1987) and that of limestone after Dunham (1962) and Folk (1959).

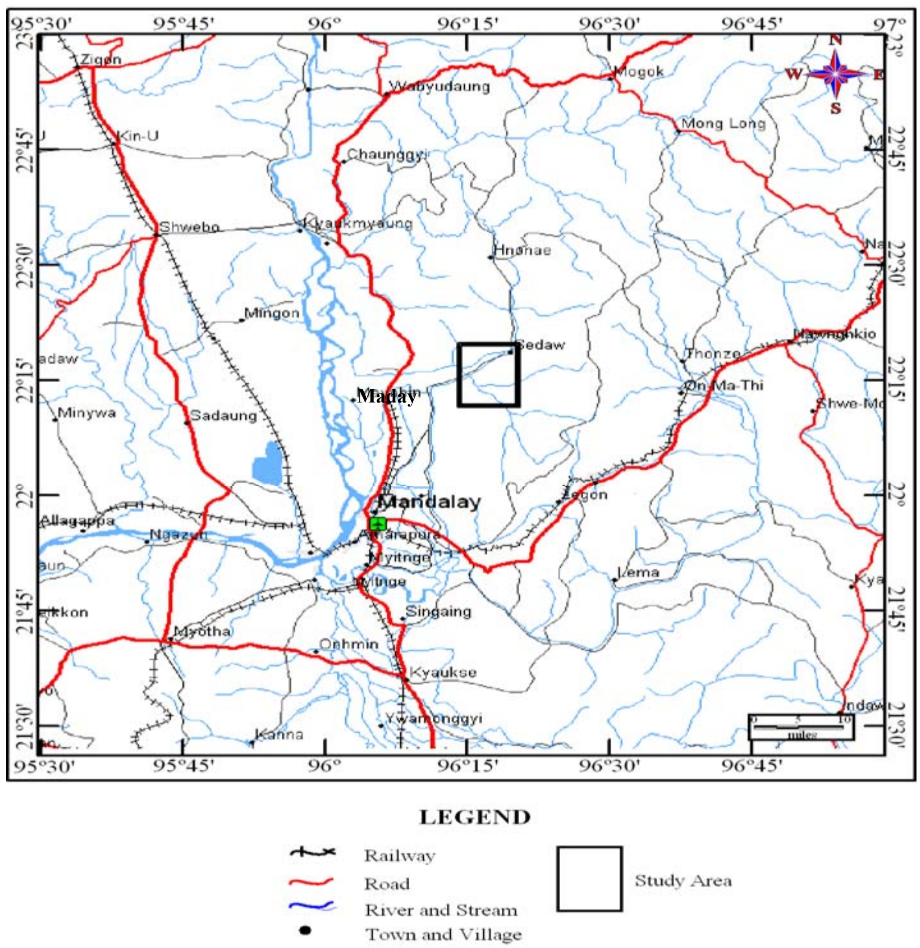

Figure (1). Location map of the study area

Stratigraphy

A succession of siliciclastic rocks and carbonate rocks representing a span of geologic time is exposed from older to younger; the Chaung Magyi Group, Cambrian Unit, Ordovician Unit, Upper Plateau Limestone Group and Mesozoic units. The younger sequence is composed of the Thaphangaing Formation, Kyaukpyataung Conglomerate and Kyunbin Mudstone. The geological map of the research area is shown in figure 2.

The Thapankaing Formation exposed in the western part of the study area is mainly composed of thin-to thick-bedded, buff to reddish brown, calcareous and silicious sandstone with intercalated shale and siltstone. It underlies normal stratigraphic contact with the Kyaukpyataung Conglomerate and overlies the Upper Plateau Limestone. Based on the stratigraphic position, the age of this formation can be regarded as ? Middle Triassic.

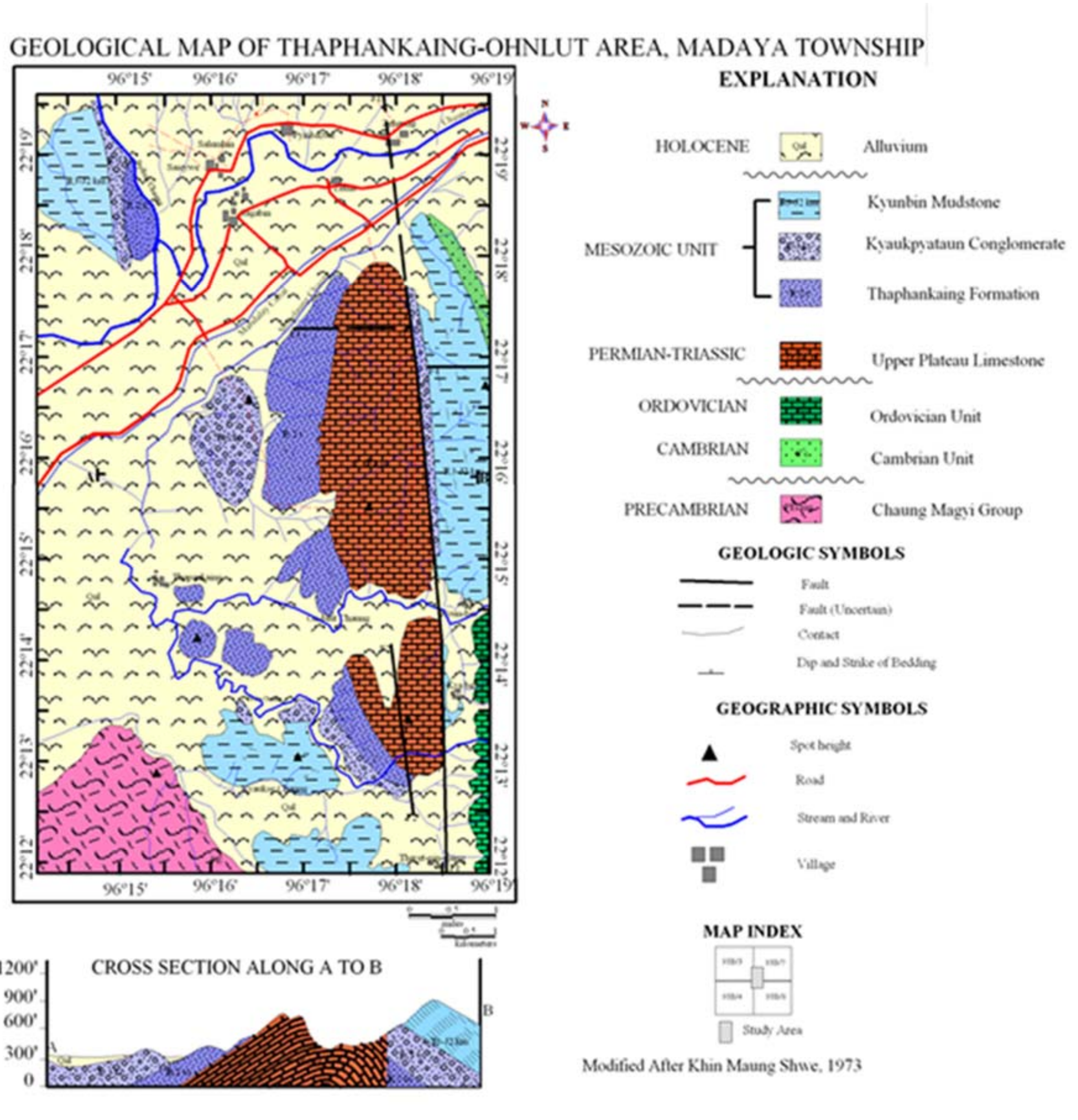

Figure (2). Geological Map of the research area. (Modified after Khin Maung Shwe,1973)

Petrography of Thapankaing Formation

General statement

The present area is composed of sedimentary rocks belonging to the Upper Plateau Limestone and the Mesozoic Units. For petrographic studies, sandstone samples from the Thapankaing Formation were collected during section measurement. Over 50 representative hand specimens of sandstone were collected and nearly 40 samples of them were cut into thin section and studied under the microscope. The present work attempts to describe the detailed petrographic studies for Thapankaing Formation.

Point counting of the sandstone thin-section was done for quantitative compositional analysis. The modal analysis was performed by counting more than 200 points per thin section, using the Gazzi Dickinson point-counting method (Gazzi, 1966; Dickinson, 1970). The analyzed sandstone samples are moderately to well sorted, and medium-grained. The framework grains of the sandstones are composed of monocrystalline quartz (Qm), polycrystalline quartz (Qp), K-feldspar, plagioclase, and rock fragments (Table 1). Detrital sandstones can be classified by their matrix content and mineralogical content (Pettijohn, 1987).On the basis of their mineralogical contents, the Thapankaing sandstones are classified as orthoquartzite, subarkose and protoquartzite.

Subarkose

Detrital fractions

In the microscopic study, the sandstone composed of 70-80 percent detrital grains and 2-3 percent matrix. The detrital grains consist of quartz, feldspar, rock fragments, mica and other minerals which are cemented by calcite (Fig.2). The detrital grains are moderately sorted, angular to subangular and rounded to subrounded. The boundaries between the grains are point contact and concavo-convex contact. The maximum grain size diameter varies from 0.1 to 0.8 mm. Quartz is the most common detrital mineral which comprises 75-80 % of detrital framework. Quartz is subangular to subrounded, moderately sorted and packing is good. They have concavo-convex contact dominant than the point contact. Most quartz grains are monocrystalline quartz. Polycrystalline quartz is less common. Thus, most of the quartz is derived from plutonic origin. The quartz grains show cloudy extinction. The average grained size of quartz is 0.25 mm.

Feldspar is the second most common minerals in detrital framework. They constitute 12% of detrital framework. Orthoclase feldspar is the most common constituent than plagioclase feldspar and microcline is less common. Generally they are angular to subrounded and subelongated detrital grains. A few of plagioclase feldspar shows polysynthetic twin and undulose extinction. Mica comprises 2 % of the detrital framework. Biotite micas are reddish brown color and elongate flakes (Fig 3). Mica is characterized by their alignment which is parallel to the bedding plane. Rock fragments represent 10 % of the detrital framework. Most of them are sedimentary rock fragments such as sandstone and siltstone. Other minerals are composed of 1 % of detrital framework.

Calcite occurs as primary cementing agent in these sandstones and forms 25 to 30 percent of the total rock volume. Most of the quartz grains are fractured and corroded by calcite cement (Fig 4). The grain boundaries of some quartz are coated by secondary iron cement. But in some places, fibrous calcite cement and primary marine calcite cement can be found as grain boundary.

Nomenclature of sandstone

These rocks constitute mainly quartz (>75 %) and feldspar which exceeds rock fragments. All the grains are cemented by the chemical cements of calcite and hematite, and detrital clay matrix observed are very little. According to Pettijohn's classification, these sandstones may be defined as "subarkose".

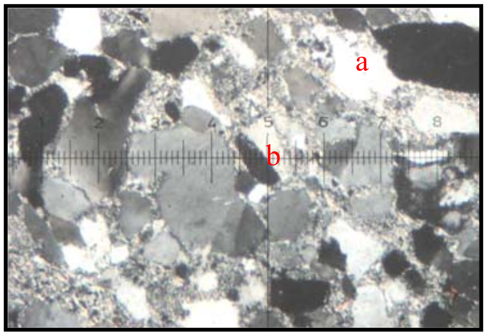

Figure (3).Monocrystalline quartz (a) and plagioclase feldspar (b) in subarkose in Thapankaing sandstone. (Under PPL 30x).

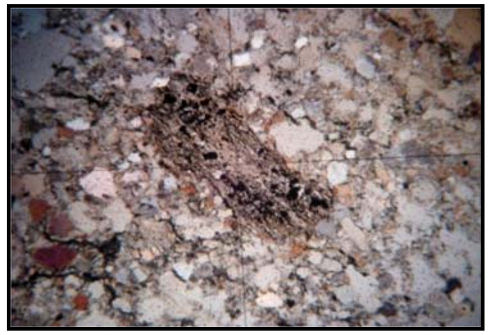

Figure (4).Biotite mica in subarkose of Thapankaing Formation (Under X.N 30x).

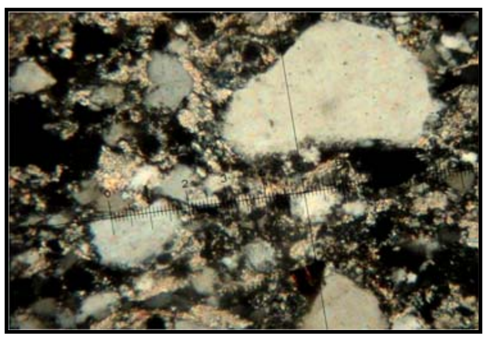

Figure (5). Sharp angular quartz, feldspar and rock fragment dispersed in fibrous calcite cement (Under PPL. 30x).

Table (1).Detrital modes from orthoquartzite, subarkose and protoquartzite of the Thanpankaing Formation.

Sp.No.								QFL%			QmFLt%		
	Qm	**Qp**	**K**	**P**	**Lm**	**Ls**	**M**	**Q**	**F**	**L**	**Qm**	**F**	**Lt**
TK1	70	7.8	5.3	1.2	3.5	12.2	2.5	77.8	6.5	15.7	70	6.5	23.5
TK2	65	10	4.8	3.5	7.5	9.2	2.0	75	8.3	16.7	65	8.3	26.5
TK3	72.7	3.3	8.8	1.2	4.7	9.3	2.0	76	10	14.0	72.7	10	17.3
TK4	70	5.5	7	2.7	3.3	11.5	1.4	75.5	9.7	14.8	70	9.7	20.3
TK5	68.5	8.5	8.5	3.2	5.5	5.8	1.5	77	11.7	11.3	68.5	11.7	20.0
TK6	68.5	8.5	6.3	4.2	7.2	5.3	2.7	77	10.5	12.5	68.5	10.5	21.0
TK7	69.7	6.3	5.5	2.5	5.6	10.4	2.5	76	8	16	69.7	8	22.3
TK8	70.4	8	6.2	2.2	5.4	7.8	3.2	78.4	8.4	13.2	70.4	8.4	21.2
TK9	69.5	3.5	7.5	2.5	7.1	9.9	2.1	73	10	17	69.5	10	20.5
TK10	73.3	4.5	7.5	1.3	5.2	8.2	2.6	77.8	8.8	13.4	73.3	8.8	17.9
TK11	75.5	11.5	8.7	0.8	1.2	2.3	0.6	87	9.5	3.5	75.5	9.5	15.0
TK12	73.5	6.5	9.5	1.5	5.2	3.8	1.0	80	11	9.0	73.5	11	15.5
TK13	77.2	8.8	9.6	1.5	2.2	5.7	1.5	81	11.1	7.9	77.2	11.1	16.7
TK14	75.5	4.4	9.7	1.4	3.2	5.8	1.0	79.9	11.1	9.0	75.5	11.1	13.4
TK15	73.2	7.3	12.0	1.5	2.9	3.1	1.9	80.5	13.5	6.0	73.2	13.5	13.3
TK16	80.3	16.2	0.2	0.8	1.2	1.3	0.4	96.5	1.0	2.5	80.3	1.0	19.0
TK17	81.2	13.8	0.7	0.9	1.1	2.3	1.6	95.0	1.6	3.4	81.2	1.6	17.2
TK18	82.4	13.3	1.2	0.3	1.3	1.5	1.5	95.7	1.5	2.8	82.4	1.5	16.1
TK19	88.4	8.1	1.5	0.5	0.8	0.7	1.2	96.5	2.0	1.5	88.4	2.0	9.6

Qm = monocrystalline quartz; Qp = polycrystalline quartz; K = K-feldspar;

P = plagioclase; Ls = sedimentary lithic fragments; Lm = metamorphic lithic fragments; M = matrix; Q = Qm+Qp, F = K + P; L = Ls + Lm; Lt = Qp + Ls + Lm.

Protoquartzite or lithicarenite

Detrital fractions

Microscopically, these sandstones have 60 to 70 percent of detrital framework and 30 to 40 percent of cement. Detrital matrix is scanty and it contains less than 3 percent of total rock volume. The detrital grains are quartz, feldspar, and rock fragments and very little heavy minerals (Fig 5). The minimum diameter of grain is 0.08 mm, the maximum is 1.5 mm and the average is 0.1 mm. Most grains are angular to subrounded and they generally have poorly sorted in nature. Detrital grains are set in the calcite and hematite cements. Mineral compositions and detrital percentages of these sandstones are shown in table (1).

Quartz is the most dominant detrital mineral, and comprising 70-75 % of detrital framework. They are angular to subrounded. Most of the quartz grains are monocrystalline. They show undulatory extinction and minute inclusions. They are often fractured. Therefore, these quartz grains may be recycled monocrystalline quartz grains formed from an older siliciclastic rocks leading to further loss of unstable quartz grain types. They have point contact and some surface have suture contact.

Rock fragment comprises 15-20 % of the detrital framework. The most common lithic fragments are fine grained sedimentary rocks and metasedimentary rock such as, shale, siltstone, sandstone, limestone, chert, schist and quartzite. Stable fragments of detrital chert and quartzite grains are more abundant than the other fragments of siltstone and shale. But volcanic rock fragment cannot be observed in these sandstones.

Feldspar grains are less abundant than rock fragment and form about 10% of the total detrital framework. Feldspar grains are chiefly orthoclase and most grains show the cloudy appearance due to the alternation process. But some plagioclase feldspar is clear and fresh. Biotite and muscovite comprises 3-7% of the total fractions. Biotite is more dominant than muscovite. Less than 2 percent of the total detital fractions are composed of heavy mineral grains.

Most of the void spaces are filled with calcite and the hematite cement occurs as a thin coating around grains. The matrix in these sandstones is very little and is a fine grained intergrowth of chlorite and sericite together with silt-sized quartz grains. The matrix, in places, is replaced by calcite cement and iron cement (Fig 6).

Nomenclature of sandstone

According to Pettijohn's (1987) classification, these sandstone may be classified as "protoquartzite" and according to Dott's classification these sandstone are named as "lithic arenites". It can be considered that quartz content is less than 80 % and rock fragment is (15-20 %) more than feldspar (5-10 %).

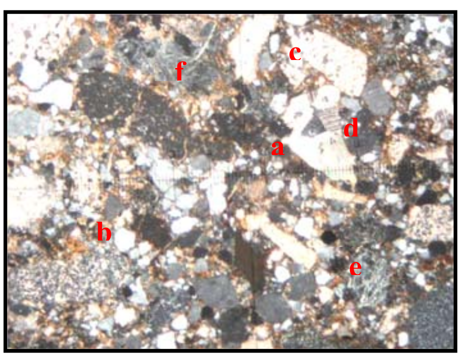

Figure (6).Several monocrystalline quartz (a), chert(b), polycrystalline quartz(c),plagioclase feldspar(d), orthoclase feldspar(e) and rock fragment (f) in protoquartzite (Under X.N 30x).

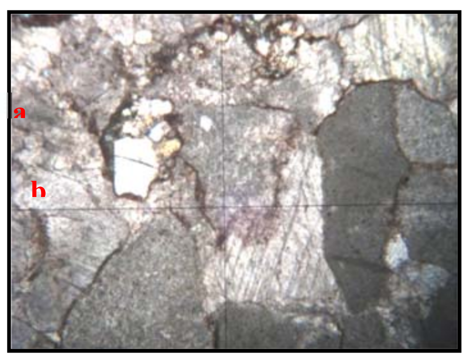

Figure (7). Monocrystallin quartz (a), and rockfragment (b) cemented by calcite in protoquartzite (Under X.N

Orthoquartzite or Quartz arenite

Detrital fractions

In thin section study, constituents of detrital framework of grains are held together. Quartz grains are composed of more than 95 percent of detrital framework. The other grains are minor amount of feldspar and heavy minerals. The maximum grain size is 1.5 mm, the minimum grain is 0.01 mm and the average grain size is 0.01 mm. They are subrounded to rounded and moderate to well sorted and have tangential contact (Fig 7).

Quartz is the most common detrital minerals, comprising 95 % of detrital framework. Monocrystalline quartz is 80 percent of the total quartz grains. They are subrounded and anhedral to euhedral form. They show adulatory extinction. Igneous quartz (volcanic and plutonic) is found to have micrite inclusion. Quartz grains are highly fractured and show concavo-convex and pressure solution contacts.

Muscovite is very rarely present and generally they are fresh. The lack of feldspar or the rare amount of feldspar shows the higher degree of compositional maturity of these sandstones.

Generally most grains have direct connection to each other and some are cemented by silica overgrowth. Silica cement is precipitated around the quartz grains and in optical continuity with it. The dust rings show the relic primary quartz grains.

Highly fractured, tightly interlocking of grains and authigenic overgrowth of silica cement indicate the well compaction of rocks and the precipitation of silica in these sandstones during diagenesis (Fig 8). The origin of the silica for this cementation may have been attributed to pressure dissolution from detrital quartz.

Nomenclature of sandstone

In these sandstones, quartz consists more than 95 percent of the detrital component and other mineral constituents are less than 5 percent. Moreover the cementing agent of these sandstones is silica cement **A**ccording to Pettijohn (1987) classification these sandstones may be classified as "orthoquartzite" and Dott's classification as "quartz arenites".

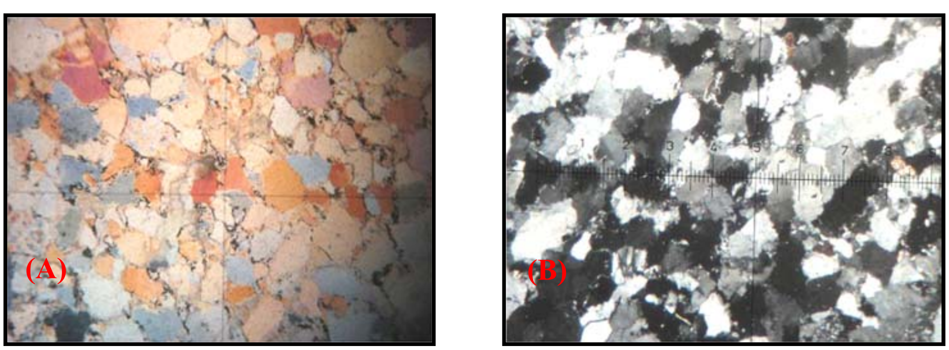

Figure (8). Orthoquartzite with rounded to subrounded monocrystalline quartz grzins showing moderate sorting (A) Under PPL and (B) Under X.N 30x.

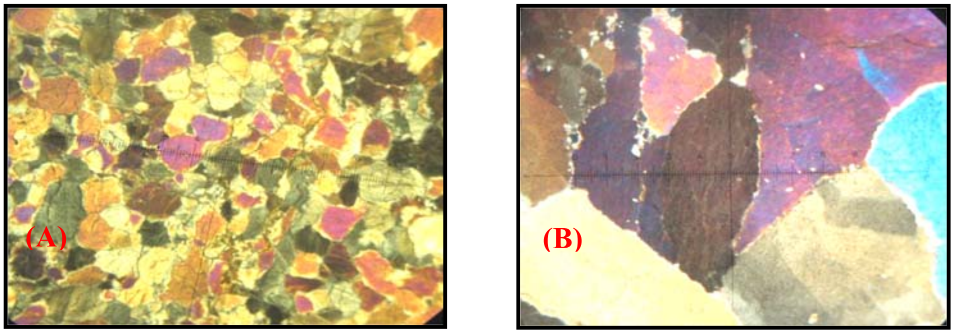

Figure (9).Highly fractured monocrystalline quartz grains (A) and authigenic overgrowth of quartz (B) in orthoquartzite of the Thanpankaing Formation (Under X.N 30x).

Digenetic feature of Thanpankaing Formation

The major diagenetic processes of Thapankaing Formation are (1) compaction and pressure dissolution, (2) calcite cementation, (3) grain coating and grain replacements and (4) formation of hematite cementation.

The framework materials such as mica, or collapsed due to the mechanical compaction during the exogenesis phase. The sutured contacts between the grains are produced by increasing the dissolution of grains at point contact. The stylolite seam may form due to the pressure dissolution of grain contact. This stylolite occurs between the grains in the subarkose sandstone and mudstone (Fig 9). The stylolite and pressure dissolution may be the phase of mesogenesis environment.

Calcite cement is well developed in the sandstone of Thapankaing orthoquartzite. Most of the sandstones are predominated by the eogenesis phase of poikiltopic calcite cement. Corrosion and replacement structure of quartz and feldspar by calcite are common (Fig 10). The clay coating of the detrital grains may be the earliest phase of eogenesis environment due to the relation between coating and cement or matrix. They are readily characterized under plane polarized light as dusty rim.

The breakdown of clay minerals released silica, calcium, sodium, iron and magnesium into the pore water which may be capable of transporting dissolved ionic species from adjacent mud rocks into sandstone (Burley et al., 1985). The hematite typically occurs as a very thin coating around the grains and develops within the biotite cleavage planes.

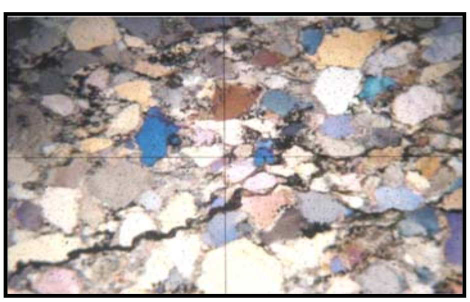

Figure (10).Photomicrograph showing the stylolite seam in subarkose (Under X.N 30x).

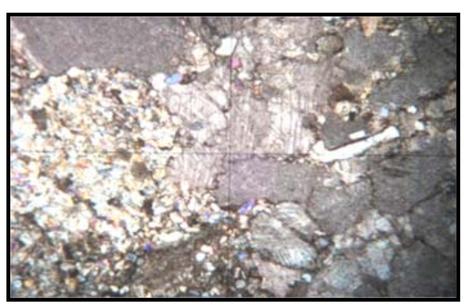

Figure (11).Corrosion of rock fragments in poikilotopic calcite cements in protoquartzite (Under X.N 30x).

Provenance of Thapankaing Formation

Sandstone provenance studies permit evaluation of the tectonic setting in which sedimentary sequence are deposited and can demonstrate evolution of source area through time (Dickinson and Suczeck, 1979; Dickinson et al., 1983). The sediments of the Thapankaing Formation were derived from a recycled orogens (Fig 11). Recycled orogens are uplifted and deformed supracrustal rocks, which form mountain belts (Tucker, 2001). The sediments from recycled orogens may filled adjacent foreland basins and remnant basin or be transported in major river systems to more distinct basin in ocean basins or in unrelated tectonic setting (Tucker, 2001).

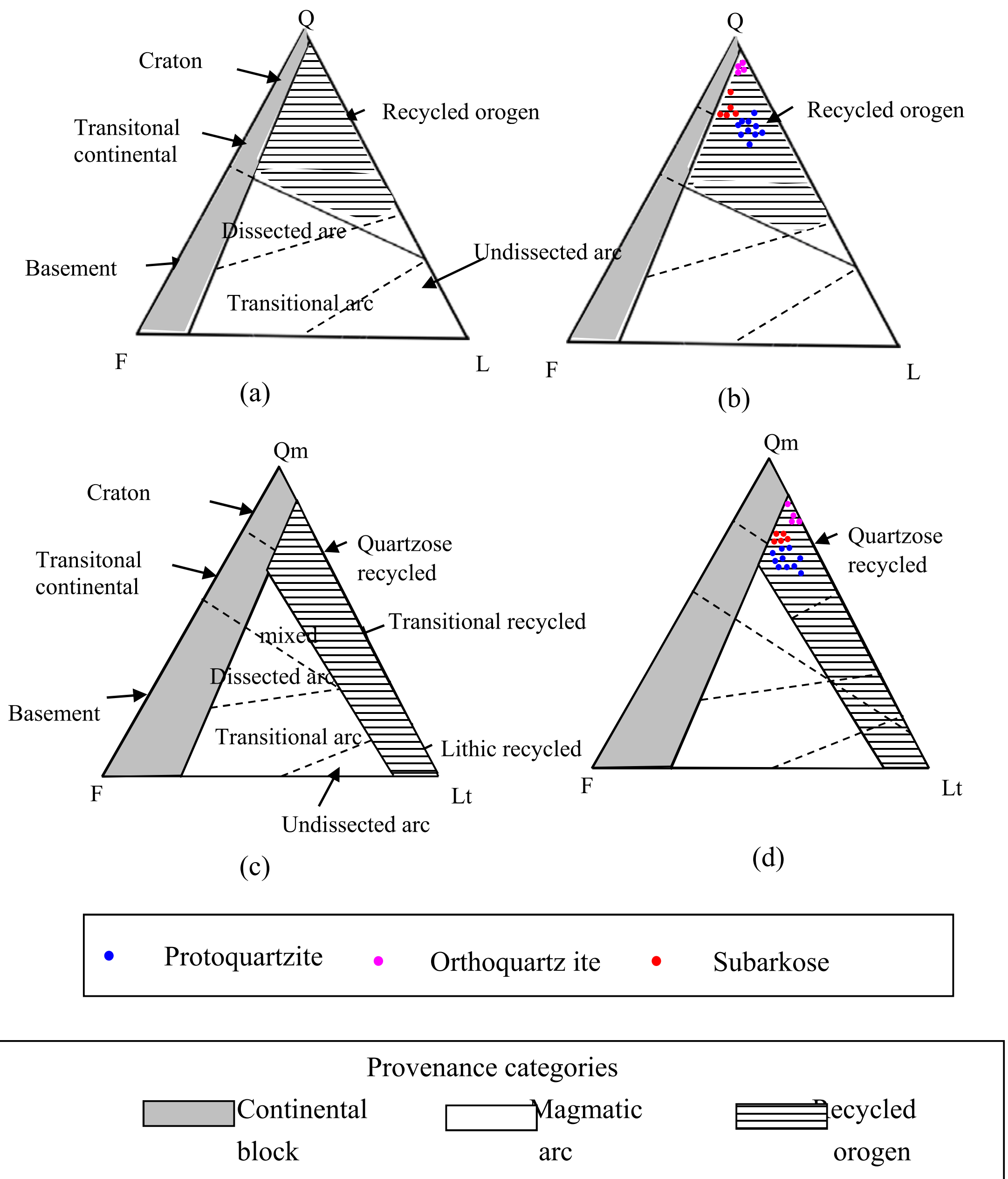

Figure (12). QFL and QmFLt plots (a) and (c) Provenance fields of Dicknson et al. (1983), (b) and (d) Provenance fields of sandstone from Thanpankaing Formation

The high proportion of subrounded to rounded quartz, as well as the dominance of K feldspar over the plagioclase feldspar suggests that the source area was exposed to prolonged weathering and that the sediment is at least partly multicyclic. The presence of detritus quartz grains and sedimentary lithic fragments, such as quartz arenites, siltstones, shale, suggest that a component of provenance is older sedimentary rocks. Lithic grains that dominate in recycled orogens sandstone derived from continental collision mountain belts (Garzanti, 2008).

M.E. Tucker (2001) stated that many quartz arenites are the products of extended periods of sediment reworking. Quartz arenites produced by persistent wave or current reworking were deposited on passive margins. Lithic sandstones are common in the foreland basin formed by thrust loading after continental collision.

Summary and Conclusion

Stratigraphically, the sequence of the Mesozoic Unit has been divided into three formations: the Thapankaing Formation Formation, the Kyaukpyataung Conglomerate and the Kyunbin Mudstone. Thapankaing Formation begins with coarse-grained, well-bedded protoquartzite and it fines up to fine-gained orthoquartzite resulting the fining upward sequence. Many quartz arenites are the products of extended periods of sediment reworking. Quartz arenites produced by persistent wave or current reworking were deposited on passive margins. Lithic sandstones are common in the foreland basin formed by thrust loading after continental collision. Thus the sediments of the Thapankaing Formation were derived from a recycled orogens.

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