Source Area and Provenance Study of the Khabo Formation in Magyigan-Pindale Area, Mahlaing and Wundwin Townships, Mandalay Region

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Abstract

The Magyigan-Pindale area is located in the Mahlaing-Wundwin Townships, Mandalay Region. It is bounded by North Latitudes 21°02′ to 21°10′ and East Longitudes 95°46′ to 95°53′. The total area coverage is about 56 square miles (156.16 km^2). The study area is composed of the Miocene clastic sedimentary rocks. In this area, Moza Formation (Middle Miocene), Khabo Formation (Middle Miocene) and Irrawaddy Formation (Late Miocene to Pliocene) are found. The Khabo Formation underlies the Moza Formation and overlies the Irrawaddy Formation by an unconformity. The Khabo Formation are sandstones, siltstones, mudstones, shale, clay and intraformational conglomerates. The sandstones are more dominant than other. Suitable sandstone samples were three dimensionally cut into thin sections and studied under a polarizing microscope. According to the microscopic studies; quartz is more predominating mineral, both monocrystalline and polycrystalline quartz grains are noted. The monocrystalline quartz grains are more common than polycrystalline quartz grains. The feldspar such as the orthoclase, plagioclase, microcline and perthite feldspar are found. Calcium-rich feldspar is more common than sodium-rich feldspar. Various types of lithic fragments such as sedimentary rock fragments, volcanic rock fragments and metamorphic rock fragments are occurred. The Khabo Formation of sandstone may be termed as "**Arkose"** and **"Lithic arkose"**, according to the sandstone classification of Pettijohn et al. (1987). According to Dickinson of the QFL diagram, the Khabo Formation fall in the recycled orogenic provenance.

Key words: Miocene, Khabo Formation, Arkose, Lithic arkose, recycled orogenic

Introduction

The study area lies in the vicinity of Magyigan-Pindale villages, Mahlaing and Wundwin Townships, Mandalay Region. It is bounded by North Latitudes 21°02′ to 21°10′ and East Longitudes 95°46′ to 95°53′. It is bounded between vertical grid number 52 to 68 and horizontal grid number 18 to 32 of one-inch topographic map, 84 O/16. The total area coverage is about 56 square miles (156.16 km^2). Yangon-Mandalay Expressway Road passes through the western part of the study area, in nearly north-south direction. In the eastern part, the Meiktila-Pindale car-road is located, therefore the study area is easily accessible by car throughout the year. The location map of the study area is shown in figure (1).

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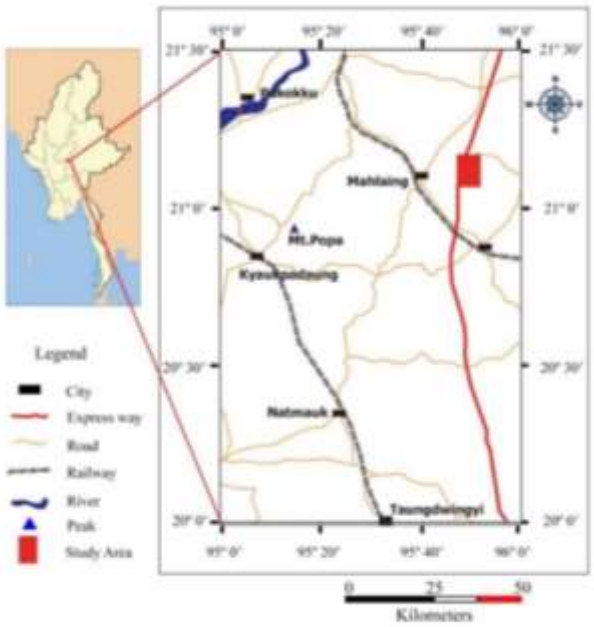

Figure (1) Location map of the Magyigan-Pindale Area

Regional Geologic Setting

Geotectonically, Myanmar can be subdivided into four main belts (Chhibber, 1934; Maung Thein, 1972; Win Swe, 1981; Bender, 1983); the Shan-Tanintharyi Belt, the Central Cenozoic Belts, the Western Fold Belt and the Rakhine Coastal Belt.

The Central Cenozoic Belt is separated by a Central Volcanic Line, into two troughs; eastern trough and western trough (Chhibber, 1934). The study area lies in the eastern trough and it is bounded by the Sagaing Fault to the east and the Kabaw Fault to the west.

In the study area, the clastic sediments of the Moza Formation (Middle Miocene), Khabo Formation (Middle Miocene) and Irrawaddy Formation (Late Miocene to Pliocene) were observed. The main rock types are sandstone, shales and clays with subordinate amount of siltstone and mudstone. Geological map of the Magyigan-Pindale area is shown in figure (2).

Previous Works

Myint Thein (1966) first studied the nomenclature of the formations in the study area and neighboring area. Moreover, the stratigraphic studies of the neighboring areas were carried out by Kyi Myint (1980). Thike Tun Thaw (1977), studied the sedimentology of the Mingon Taung area, Natogyi Township. Besides, the stratigraphy and sedimentology of the Natogyi-Taungtha area was also described by Bo San (1981). Moreover, Maw Maw (1993) studied the geology of the Taungpulu-Shwebawgyun area in Wundwin and Mahlaing Townships.

Purposes of Investigation

The purposes of investigation of the study area are as follows:

- To study the petrology of the sandstone of Khabo Formation in the study area,
- To interpret the provenance and diagenesis based on the petrography of the Khabo sandstone in the study area.

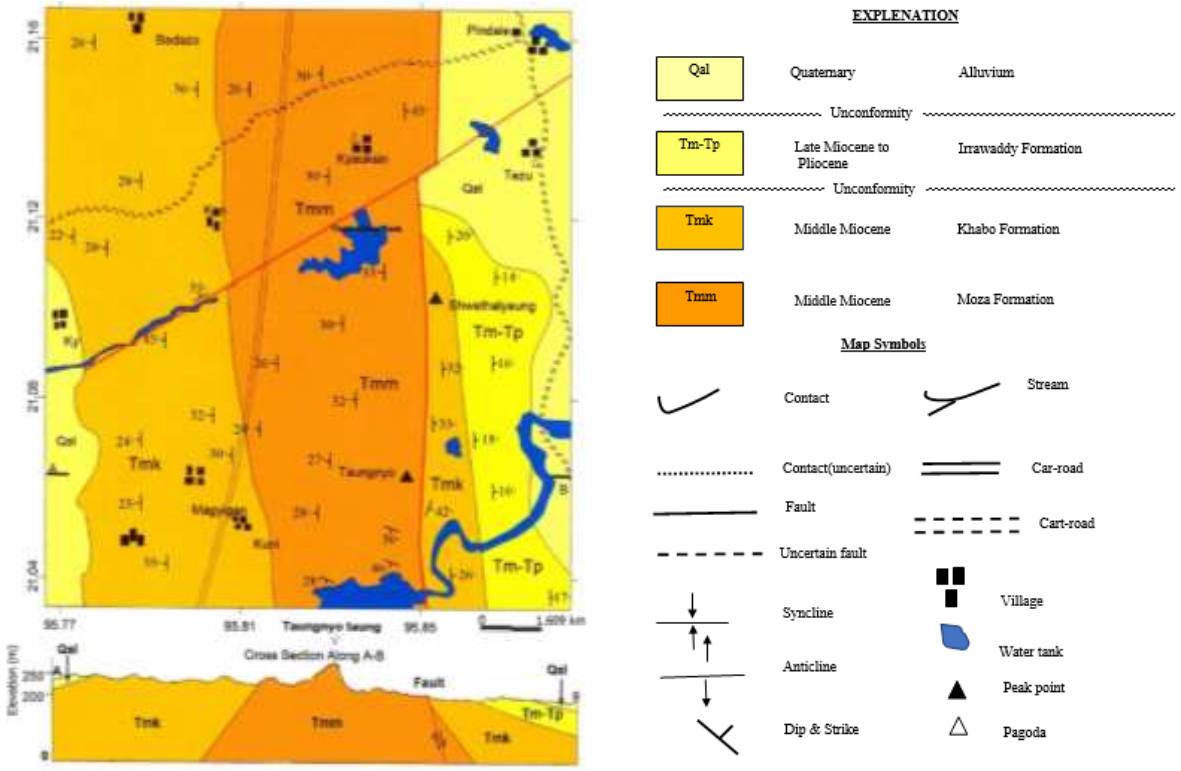

Figure (2) Geological map of the Magyigan-Pindale area
(Modified after Nilar Shein, 2013)

Materials and Methods

The field traverses were made along the stream, cart tracks, and motor roads. The geological hammer, hand-lens, base map, sample bags, Brunton compass, tape, camera and clip-book are used in the field traverse. The present petrographic study mainly emphasizes on the Khabo Sandstone. For petrographic studies, 13 sandstone samples were systematically collected from Khabo Sandstone exposed in the Magyigan-Pindale area. Suitable sandstone samples were three dimensionally cut into thin sections and studied under a polarizing microscope.

Petrography of the Khabo Formation

Petrographic study of the sandstone is also widely used to determine the provenance and diagenetic processes. Petrographic study will give more precise information in delineation of the detrital and diagenetic rock components, interpretation of source area rock types and the origin and timing of diagenetic alterations. According to the microscopic studies, sandstone of the Khabo

Formation is medium- to coarse-grained, subangular to subrounded and moderately sorted detrital grains containing quartz, feldspar, rock fragments, mica and opaque minerals. The sandstone is constituent of about 60 to 65% of detrital grains and 30 to 40% of cement in the total volume of rock. The maximum diameter of the grains varies from 0.1 to 0.5 mm and the minimum diameter of the grain ranges from 0.02 to 0.2mm. The average grain diameter of the detrital fraction is 0.2 mm. Grain contact types of point, long, concavo-convex and suture contacts are observed between grains.

Quartz

Quartz is more predominating mineral in the studied sandstones and its content ranges from 30 to 40% of the total rock volume in the Khabo Sandstone. In the Khabo sandstone, both monocrystalline and polycrystalline quartz grains are noted. However, monocrystalline quartz grains are more common than polycrystalline quartz grains. Quartz from hydrothermal veins may be monocrystalline or polycrystalline but they characteristically possess numerous fluid-filled vacuoles (Tucker, M.E, 2001). The presence of monocrystalline quartz grains might indicate their derivation from plutonic and hydrothermal origin, whereas minor volcanic terrains are indicated by the presence of corrosion effect of some quartz grains. Polycrystalline quartz grains from a metamorphic source typically possess many crystals and intricately suture boundaries (Fig. 3A). Microscopically, the Khabo Sandstone includes plutonic, volcanic, metamorphic and sedimentary quartz. Metamorphic quartz is rarely seen. The presence of fractures in quartz grains indicates that these being compacted during earlier diagenetic stage.

Feldspar

Fresh to weathered detrital feldspar, comprises about 15 to 20% of the total rock volume. The feldspar such as the orthoclase, plagioclase, microcline and perthite feldspar are found. Feldspar can have a wide range of compositions from calcium-rich to sodium-rich, depending upon the composition of the host rock (Boggs, 2009). Calcium-rich feldspar is more common than sodium-rich feldspar. Plagioclase can be identified by its polysynthetic and multiple twinning (Fig. 3B). Carlsbad (or) simple twinning also occurs in some orthoclase feldspar (Fig. 3C). Microcline with cross-hatched twinning and perthite also contains as little amounts (Fig. 3 D and E).

Rock Fragments

Detrital rock fragments in sandstone provide the most important evidence of source rock lithology and durability of particles during transportation (Boggs, 2009). The rock fragments consist of 9 to 15% of the total rock volume. Most of the rock fragments occur as sub-angular to sub-rounded grains with various sizes. There are various types of lithic fragments such as sedimentary lithic fragments, igneous rock fragments and metamorphic rock fragments. Sedimentary rock

fragments are mostly composed of sandstone (Fig. 3 F). Most of igneous rock fragments are volcanic rock fragments (Fig. 3 G). Metamorphic rock fragments are rarely seen (Fig. 3 H).

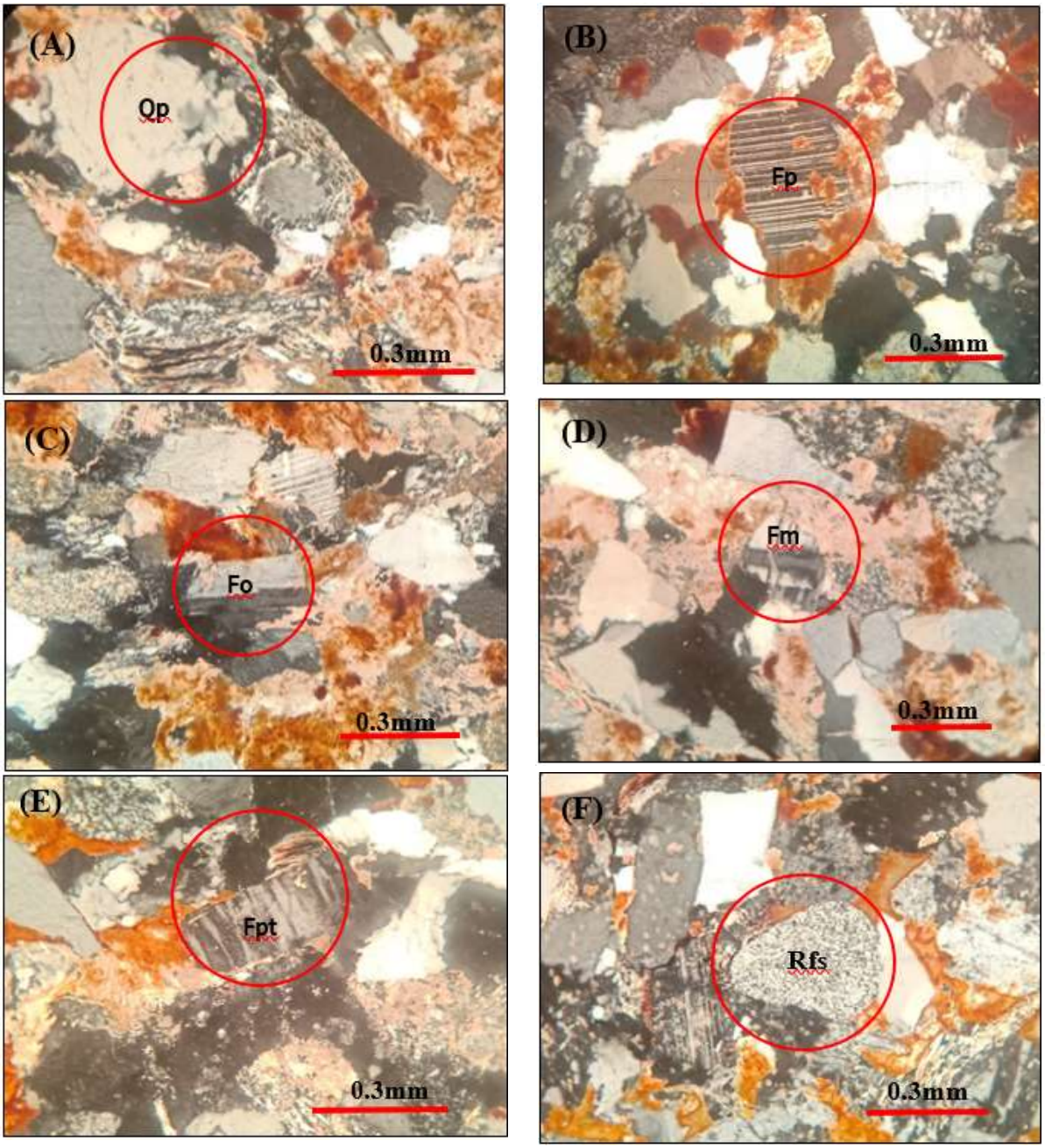

Figure (3) Photomicrographs showing (A) polycrystalline quartz (Qp) with intricately suture boundaries, (B) plagioclase feldspar (Fp) with polysynthetic twinning (C) orthoclase feldspar with carlsbad (or) simple twinning, (D) Microcline feldspar with cross-hatched twinning. (E) Perthite (Fpt), (F) subrounded sedimentary rock fragment (Rfs) in the sandstone of the Khabo Formation (Open circle) (under XN, 10x)

Mica

Mica minerals comprise 5 to 10% of the rock volume in the Khabo Sandstone. The micas are usually present as deformed mineral between grains of the more competent detrital minerals such as quartz and feldspars. Biotite is more common than muscovite. Mica grains are euhedral to

subhedral, elongated flakes and show reddish brown in color. Some biotite flakes are buckled, splited along cleavage laminae due to deformation. Some mica partly altered to chloride (Fig. 4 I) and show bifurcation (Fig. 4 J) due to the effect of compaction processes.

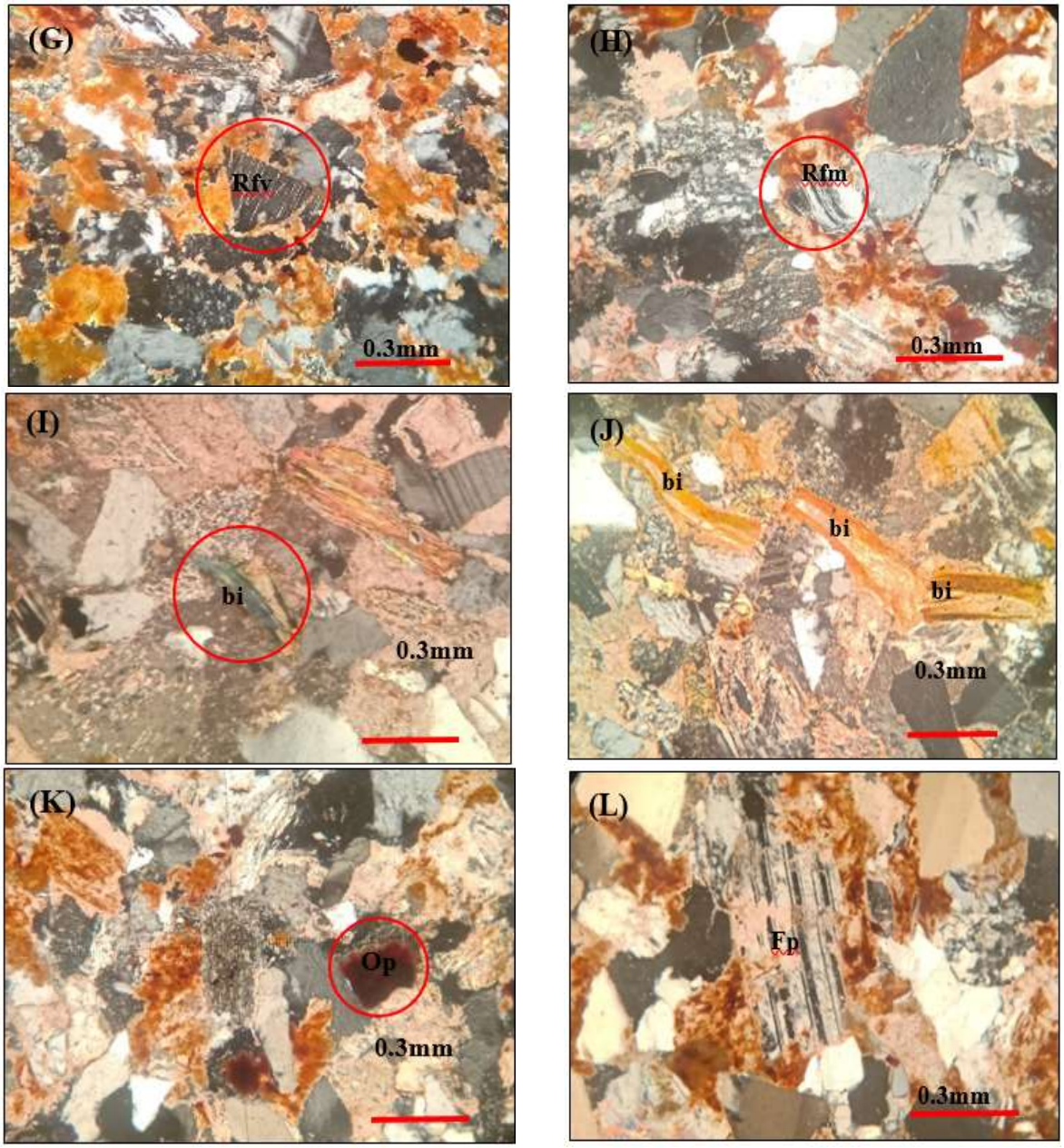

Figure (4) Photomicrographs showing (G) volcanic rock fragments (Rfv) (open circle) (H) metamorphic rock fragments (Rfm) (Open circle), (I) biotite flakes partly altered to chloride in the calcite cement (open circle), (J) biotite mica buckled and replacement of calcite cement and show bifurcation, (K) Opaque (op) mineral (Open circle), (L) plagioclase feldspar with replacement of calcite cement in sandstone of the Khabo Formation (under XN, 10x)

Other minerals

Approximately, 2% of the opaque are observed in Khabo Sandstone (Fig. 4 K). It is coated by calcite cement. Opaque grains are also seen both of under PPL and XN in the microscope

Cement

In the Khabo Sandstone, it composed of up 30 to 40% of the total rock volume. Calcite and iron-oxide cement are observed in this formation. Iron-oxide is more common than the calcite cement. In some feldspar and biotite, fracturing and deeply corrosion is formed by calcite cement (Fig. 4 L).

Nomenclature

The sandstones of the Khabo Formation in the Magyigan-Pindale area may be termed as "**Arkose"** and **"Lithic arkose"**, because quartz is contained less than 75% and the feldspar constitute more than 25% and exceed rock fragments according to the sandstone classification of Pettijohn et al. (1987). The detrital composition of selected sandstone samples of the Khabo Sandstone in the Magyigan-Pindale area (Table 1). The detrital composition of the sandstone in the study area plotted in a QFL diagram is shown in figure (5). According to Dickinson of the QFL diagram, the Magyigan-Pindale area of the Khabo Formation fall in the recycled orogenic provenance (Fig .6).

Table (1) Modal analysis of detrital composition (in volume %) of selected sandstone samples for the Khabo Formation exposed in the Magyigan-Pindale area

Sample Number	Quartz	Feldspar	Rock Fragments	Classification
K_1	60	30	10	Arkose
K_2	58	30	12	Arkose
K_3	56	29	15	Lithic arkose
K_4	65	26	9	Arkose
K_5	63	27	10	Arkose
K_6	60	28	12	Arkose
K_7	58	28	14	Lithic arkose
K_8	61	29	10	Arkose
K_9	62	29	9	Arkose
K_{10}	62	27	11	Arkose
K_{11}	64	26	10	Arkose
K_{12}	59	27	14	Lithic arkose
K_{13}	63	28	9	Arkose

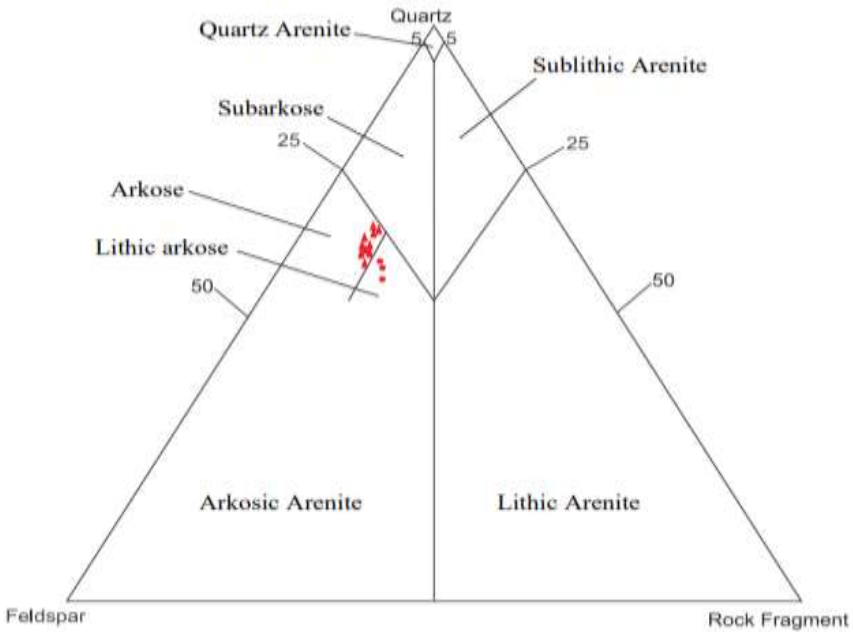

Figure (5) QFL diagram of sandstones from the Khabo Formation in the Magyigan-Pindale area *(Pettijohn et al., 1987)*

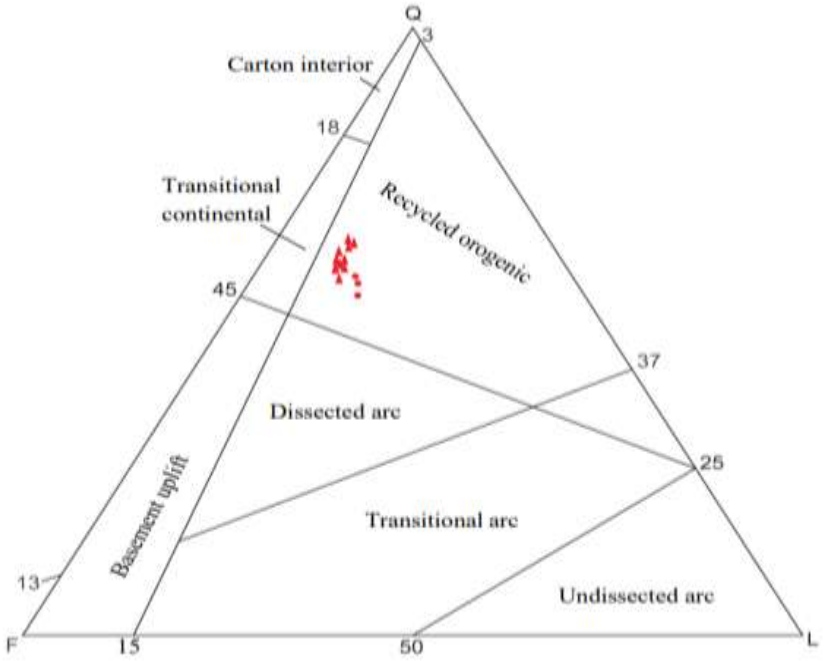

Figure (6) QFL ternary diagram showing selected sandstone samples derived from different types of provenances after Dickinson (1985) (Q = Quartz, F = Feldspar, L = Rock fragments)

Results and Discussion

Provenance may be indicated by some detrital components such as quartz, feldspar, and rock fragments. The presence of monocrystalline quartz grains might indicate their derivation from plutonic and hydrothermal origin. Polycrystalline quartz indicates the highly strained (Pettijohn et.al,1972). If the components of polycrystalline quartz exhibit sutured boundaries, it indicates metamorphic source. Polycrystalline quartz grains from a metamorphic source typically possess many crystals and they are usually elongate, with a preferred crystallographic orientation (Tucker, 2001).

Plagioclase feldspar are particularly common in volcanic rocks. Perthitic and microcline feldspar are derived from slowly colling plutonic rock such as granite. The presence of sedimentary rock fragments, igneous rock fragments and low- to high- grade metamorphic rock fragments occurring in lithic grains indicate a granitic source as well as sedimentary and metamorphic source terrains. Alteration of some biotite into chlorite indicate the early stage of diagenesis. In few samples sutured and concavo-convex contacts of grain also indicate diagenesis changes. Recycled orogenic are uplifted and deformed supracrustal rocks which form mountain belts and volcanic and metasediments.

Conclusion

The study area is falling into the central Low Land and the rocks exposed the whole area are mainly clastic sedimentary rocks of Miocene to Pliocene age. This work emphasizes on the petrography of sandstones from Khabo Formation. According to the sandstone classification of Pettijohn et al. (1987), most of the sandstones of the Khabo Formation in the Magyigan-Pindale area may be termed as "**Arkose"** and **"Lithic arkose"**, because quartz is contained less than 75% and the feldspar constitute more than 25% and exceed rock fragments. In the QFL diagram, the Magyigan-Pindale area of the Khabo Formation fall in the recycled orogenic provenance.

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