

## Provenance Study of Irrawaddy Formation at Singaing Area, Wetlet Township, Sagaing Region

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### Abstract

The area under the investigation is located in Sagaing Region, Wetlet Township, and lies between Ayeyarwady river in the east and Shwebo-Monywa plain in the west. The rocks exposed in the area are included mainly sedimentary rocks, Quaternary unit, and the serpentinites intrusion. The clastic sedimentary rocks belong to the Irrawaddy Formation which subdivided into gritty sandstone units (upper) and silty sandstone units (lower). This sandstone is mainly composed of quartz, feldspar, mica, rock fragment with iron cements. The lithic arkose of Irrawaddy Formation was river sand deposited under the fluvial and natural levee environment. These sandstones were transported from the near source area of high relief. The petrological study of Irrawaddy sediments was derived from a northerly source of high plutonic, sedimentary and gneiss-schist terrain, not far from the depositional basin. Sagaing ridge is topographically a narrow and straight ridge composed of metamorphic rocks and forms a local basement for overlying younger sediments. The regional structural trend is N-S. Sagaing fault is the major tectonic feature of the area cutting all lithologic units. Economically, sandstones are being used as construction materials. Sand and gravel are also used as construction materials such as beams and other utilities. Iron material can be refined from these sorts of iron concretion used as industrial material.

Keywords: *Singaing area, Irrawaddy Formation, gritty sandstone units, silty sandstone units*

### INTRODUCTION

Singaing-Ywadaw area is in Wetlet Township, Sagaing Region, on the west bank of Ayeyarwady River as shown in (Fig. 1). It occupies approximately the area bounded by Lat. 22°10' N and 22°15' and Long. 95°56'E and Long. 96°00' E in one-inch topographic map of 84N/16 from Burma department survey. The total coverage of the area is approximately 63 km<sup>2</sup>. To reach the study area, firstly from Yangon to Mandalay is accessible either by train or by car or by plane. But from Mandalay to the study area can be reached by the boat.

Geographically, the investigated area is bounded in the east by Ayeyarwady river and in the west by Monywa-Shwebo plain. North-south trending rolling hills are present and the highest peak is 447 ft located in the southern part of Singaing-Ywadaw village.

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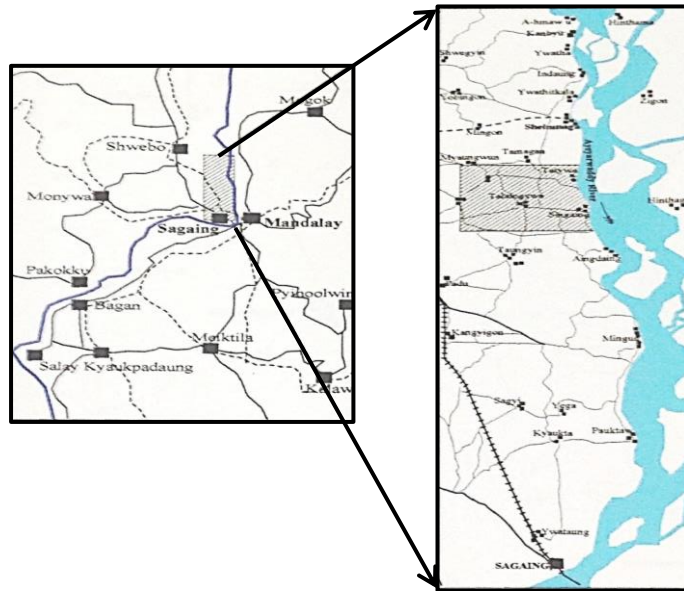


Fig. 1 Location map of the study area

### Regional Geologic Setting

The present study area is situated at the eastern margin of Central Burma Tertiary Belt. The area constitutes the northern extension of the Sagaing-Minwun metamorphic (Precambrian? and/or Paleozoic) which in north is seen as disconnected patches cropping out through the thin veiner of clastic sedimentary rocks (Miocene-Pleistocene). The Sagaing metamorphic rock is mainly psammitic and pelitic metasediments which exposed east of the Sagaing Fault. The Minwun metamorphic rocks contain pelitic metasediments and metaigneous rocks that exposed in the west of fault. The Paleozoic to Pleistocene age of sedimentary sequence are mainly composed of clastic sedimentary rocks belonging to Male and Irrawaddy Formation. These are unconformably overlain by Quaternary deposits. In some places, ultrabasic intrusions are present along the Sagaing Fault. According to previous workers (such as Kan Saw, 1976; Myint Thein et.al, 1983; Maw Maw Myint, 1993), the time of emplacement of the serpentinite is Triassic?.

The generalized stratigraphic section of the area compiled from Maw MawMyint (1993) are shown in Table.1.

Table.1 The stratigraphic successions of the study area.

<u>Stratigraphic Units</u>		<u>Geological Age</u>
Recent Alluvium	}	Holocene
Alluvium Deposit		
Terrace Deposits	Unconformity	Pleistocene
Irrawaddy Formation	Unconformity	Pontian to Villafranchian
	Unconformity	

Male Formation		Lower to Middle Eocene
~ ~ ~ ~ ~ Unconformity		~ ~ ~ ~ ~
Minwun Metamorphic		Middle to Upper Triassic
~ ~ ~ ~ ~ Unconformity		~ ~ ~ ~ ~
Metamorphosed Mesozoic		Lower Triassic (?)
Limestone Unit		~ ~ ~ ~ ~
~ ~ ~ ~ ~ Unconformity		~ ~ ~ ~ ~
Metamorphosed Paleozoic		Carboniferous to Permian
Limestone Unit		~ ~ ~ ~ ~
~ ~ ~ ~ ~ Unconformity		~ ~ ~ ~ ~
Sagaing Metamorphic		Precambrian to Lower Paleozoic
<b><i>Igneous Rocks</i></b>		
Granodiorite		Upper Cretaceous
Serpentinite		Precambrian to Lower Paleozoic

**Distribution of Rock Units**

Sedimentary rocks ranging from Middle Miocene to Recent were recognized in the mapped region. Tertiary strata thickness in northward is excess of 2500 feet. Clastic sediments of Tertiary age, namely Irrawaddy Formation are well exposed at the study area. Angular unconformity is observed between Quaternary and Tertiary rocks.

Serpentinite intrusions are found in the study area by the finer of tectonics. Deep seated origin of this body is brought up to the surface by regional tectonic process. The occurrences of ultramafic intrusion along the fault zone indicate that has been seated approximately 15 km depth. The distribution of rocks units is mapped in Fig.2.

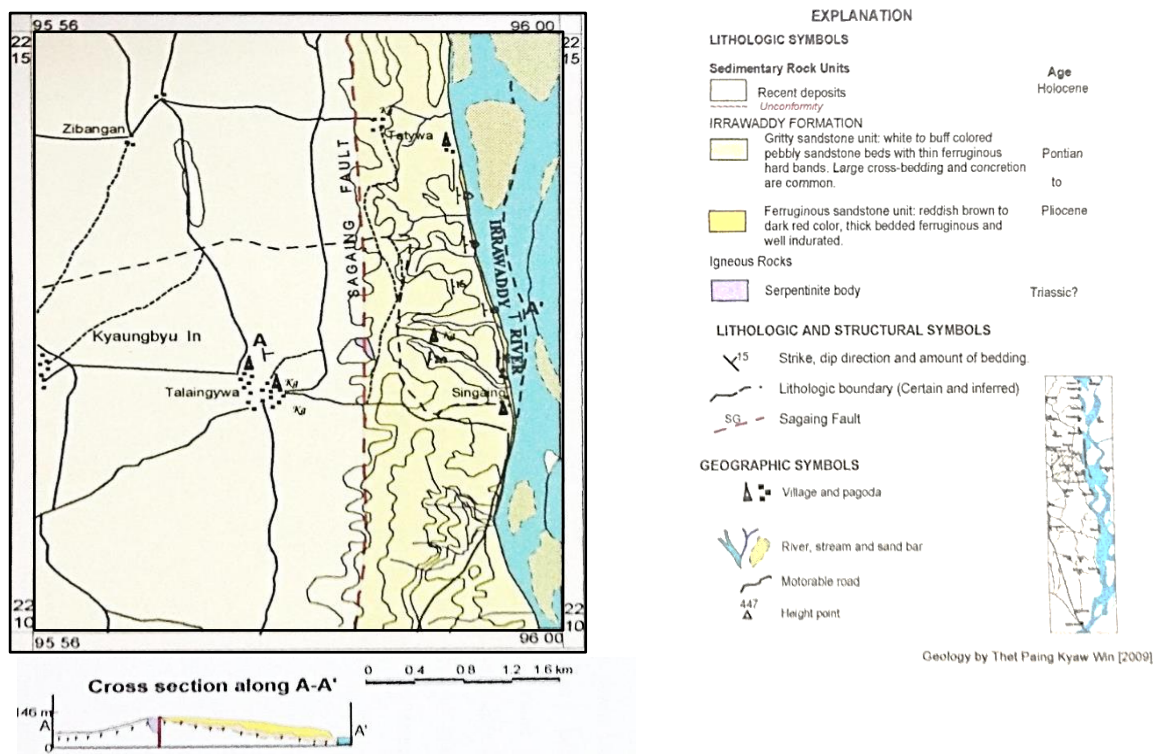


Fig.2 Geological map of the Sagaing Area, Wetlet Township, Sagaing Division

## Irrawaddy Formation

Massive, medium to coarse-grained, white to yellowish brown or buff colour fluvial sand rock, dark to light gray clays and sand of the fanglomerate in the mapped area may belong to the fluvial Irrawaddy Formation. The Irrawaddy Formation consists predominantly of sugar white, coarse-grained sandstones, gritty sandstones, pebbly sandstones, laterally impersistent conglomerate bands and a few interbedded white clays. The Irrawaddy sediments from narrow linear belt between Mazalechaung village passing through the Singaing village.

The Irrawaddy Formation can be divided into informal units which are seen in the study area.

### 2. Gritty sandstone units (upper member)

#### 1. Ferruginous sandstone units (lower member)

The Irrawaddy Formation dominantly fanglomerated with interstratified coarse-grained sandstone in the lower member and loosely cemented whitish sandstone in the upper member (Fig.3).

### 1. Ferruginous sandstone units

This unit is characterized a topographic feature of “mesa” which has been capped by the gritty sandstone unit of upper member. It is well exposed as flat plane under the upper member.

The ferruginous sandstone unit is thick bedded and more indurated compared to the upper member (Fig.4). These rocks are completely masked by blanket of upper unit of Irrawaddy Formation and older river terrace deposits. The lower units are reddish brown to dark red, indurated, pebbly sandstone. It is well exposed as flat plane closely along the west bank of Ayeyarwady River.



Fig. 3 Irrawaddy Formation from west bank of Ayeyarwady River.



Fig. 4 Ferruginous sandstone units (lower member) of Irrawaddy Formation near Ohm-pin Chaung

### 2. Gritty sandstone unit

This unit can be observed along the cliff of western bank of the Ayeyarwady river. This member can easily be seen in the area and the rock is dominantly sandstone of light tinges. It consists medium to coarse-grained, white to light grey colour, thick-bedded and

poorly indurated. This member consists predominantly of pebbly sandstones, gritty sandstones and laterally impersistent conglomerate bands and a few intercalated white clays (Fig.5 & 6). Sandstones concretions are present in the middle portion of this formation and they occur as stringers parallel to the bedding plane. Sandstones concretion is visible in size and shape and has 4 to 9 inches in diameter.

Gritty sandstone is interbedded with fine-grained sandstone and thick bedded with pebble sands. Fine-grained sandstones are thick bedded and buff colour on both fresh and weathered surface.

The cross-bedding occurred in these sandstone are well predominantly in the study area especially near Ohm-pin-chaung village. Trough type structures are more common than planar type. The thickness of stratified unit range 2 feet to 20 feet in the field. The individual cross-stratification layers have 1 inch to several inches. The cross bedded layers are very coarse, where the quartz pebbles are concentrated along these layers (Fig.7). Along the Sagaing Fault zone, all the upper members of Irrawaddy Formation are very friable (Fig.8).

The ferruginous pebbly sand bands are a few inches to 2 feet thick and locally abundant as capable of this unit. These bands composed various pebble of quartz, gneisses, marble and fossil wood debris. Pebbles are angular to subangular and sizes are varying from a few cm to 4 inches and interbedded with gritty sandstone. Locally, loose pebbles are found in some place.



Fig. 5 Gritty sandstone units (upper member) of Irrawaddy Formation near Ohm-pin Chaung



Fig. 6 The gritty sandstone units of Irrawaddy Formation near Tatywa village (facing west)



Fig. 7 The quartz pebbles concretions in the upper member



Fig. 8 The friable sandstone unit of Irrawaddy Formation along the Sagaing Fault

### Sedimentary Structures

Sedimentary structure of cross bedding, ripple marks and concretions are recognized in the Irrawaddy Formation. Largely cross-bedded of the Irrawaddy sandstones are well predominant in the study area (Fig.9). The ripple marks are generally arranged in the form of parallel to subparallel ridges and troughs. Concretions are abundant in the Irrawaddy sandstones and usually occur along the bedding plane (Fig.10). Variable shape and size of sandstone concretions (a few inches to several feet in diameter) are easily visible because they stand out in the relief on the weathered or stream eroded surfaces.



Fig. 9 The cross-bedding structure in the upper Irrawaddy Formation  
 Fig. 10 The sandstone concretion occur along the bedding plane of Irrawaddy Formation

### Petrology Studies of Irrawaddy Formation

Petrological studies of Irrawaddy sandstone are undertaken to determine their composition and textural characteristics by thin sections. Each slide includes the categories of grains, matrix and cement. The rock nomenclature was used for the typical medium to coarse-grained pure sandstone by using the classification of Pettijohn (1957).

Irrawaddy sandstones are friable sandstone which is mainly composed of quartz, feldspar, mica, rock fragment and heavy minerals. Most of the detrital grains are angular and their roundness values from 0.1 to 0.3 (Fig.11). The grains of the Irrawaddy sandstones are generally subrounded to rounded and moderately to poorly sorted. These sandstones are characterized by a grain supported framework. Most of the quartz grains are more angular than the rock fragments. The maximum sizes of the detrital grains are 0.25 mm to 1.25 mm.

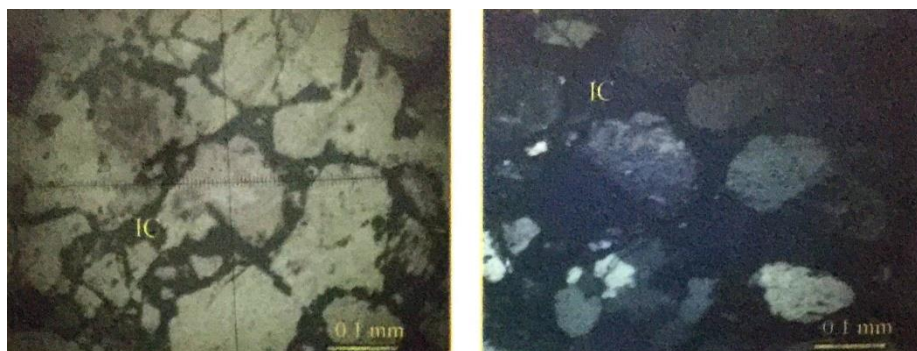


Fig.11 Photomicrograph showing the framework grains of Irrawaddy sandstone

### Detrital Fraction

**Quartz:** It constitutes 65 to 80 % of total detrital grains and 20 to 35 % of chemical cement in total rock volume. It is commonly founded both the monocrystalline and polycrystalline quartz grains. The former is more than the latter. The monocrystalline quartz constitutes 88 % of the total amount of quartz grains and polycrystalline quartz has 22 %. in this quartz grains, the inclusions of minerals and gas bubbles are exceptionally seen (Fig.12&13).

**Feldspar:** It contains 20 to 60 % of the total detrital fractions. Alkalifeldspar are more common than the others. The orthoclase feldspar present 75 % of the total amount of feldspar and 15 % are plagioclase and 10 % are microcline. Besides, some feldspar exhibits the dusty to cloudy appearance and this may be the products of slight weathering effects. Some are slightly altered to sericites or chlorites (Fig. 14), but it is scarcely noticed. So also, plagioclase feldspar and microcline are contained in the Irrawaddy sandstone and some mineral inclusion is present.

**Mica:** Mica constitute less than 2 % of detrital fractions. Both biotite and muscovite are observed in the sandstone.

**Rock fragments:** Rock fragments consist mainly of 2 to 5 % of total rock volume. They are of preexisting sedimentary, metamorphic and igneous rock fragments.

### Cements

**Calcite:** Calcite cement is the most prevalent cement of the Irrawaddy sandstones. it comprises 15 to 21 % of the total rock volume. The calcite cement is seen as the blocky cement and the boundary between these crystals display the line contact.

**Iron-oxide cement:** It can be observed in this sandstone. This cement is present as coating or encrustations on the detrital grains and may be found to be cement as masses in irregular pore spaces in some places. (Fig.15).



Fig.12 Mineral inclusions in quartz grain from upper Irrawaddy Formation

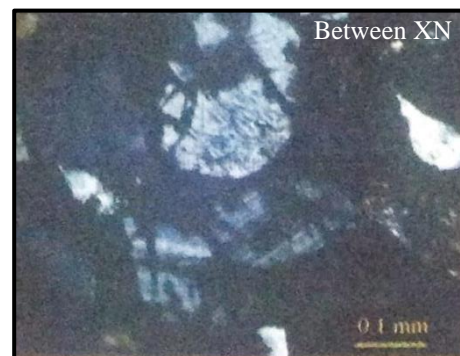


Fig.13 Mineral inclusions in quartz grain

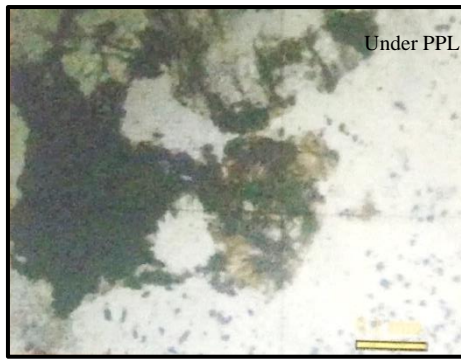


Fig.14 Feldspar mineral alter to clay mineral from upper Irrawaddy Formation

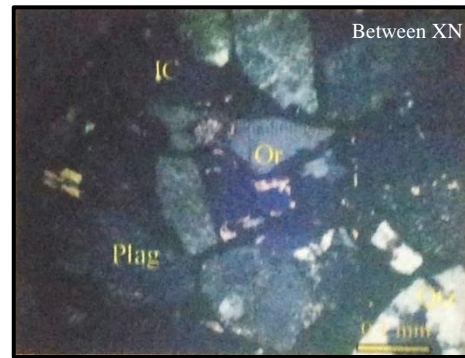


Fig.15 Many grains of feldspar cementing with iron-oxides

**Nomenclature**

According to the sandstone classification of M.C. Bride (1963), most of the Irrawaddy sandstone may be classified as the “lithic arkose”, see (Fig.16).

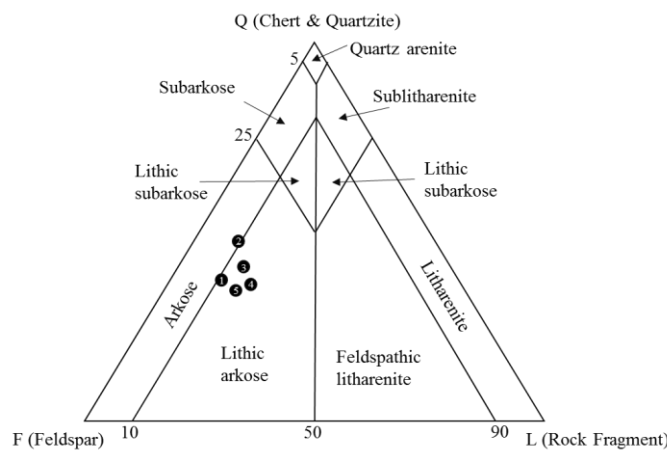


Fig.16 Composition diagram of sandstone of the study area after M.C.Bride (1963)

**Age of Irrawaddy Sandstone**

According to De Terra (1934, Pg.280), the rocks of the Irrawaddy Formation of Central Burma range from Pontian to Villafrachian, i.e., from Upper Miocene to Pleistocene. No fossils were collected from the Irrawaddy strata and therefore their age could not be ascertained.

**Provenance Study**

To establish the provenance, the petrographic and petrological criteria are investigated from sandstone samples of the study area. For a modal analysis of sandstone, the percentages of various combinations of grains are plotted on triangular diagram. Triangular plots of QFL, QmFLt, QpLvmLsm, and LmLv Ls were drawn from the point counting data. All modal analysis data are recalculated to produce the categories of grains parameter proposed by Graham et. al (1976). The interpretation follows the procedures of Dickison (1985) and



Ingersoll and Suczek (1979). When QFL, QmFLt triangles of Dickinson (1985) is applied, the data plots fall in the field of recycled orogenic and dissected arc (Fig.17& 18).

QpLvLsm and LmLvLs diagrams of Ingersoll and Suczek (1979) showing the data plots fall in the rifted continental margins, collision suter belts and mixed magmatic arc & subduction complexes (Fig.19&20). Recycled orogens are uplifted and deformed supracrustal rocks, which form mountain belts, and they mostly consist of sediments but include volcanic and metasediments. Dissected are included the continental and island arcs associated with subduction and these are areas of volcanic, plutonic rocks and metamorphosed sediments.

The sandstones of study area are mainly composed of quartz, feldspar, and lithic fragments. Most of the quartz grains are subangular to subrounded in shape and without undulatory extinction. These are of thought to be of plutonic igneous derivations. Moreover, the feldspar present in these rocks is orthoclase and some microcline which are indicators of plutonic origin. The fragments of sedimentary rocks and rounded quartz grains are also encountered in these rocks. The present of metamorphic rock fragments like phyllite, schist and minerals like epidote and garnet are indicatives of a source area affected by a progressive regional metamorphism. Hornblende, biotite, muscovite, microcline, myrmekite feldspar, perthite feldspar and hematite are constituted in the sandstone of study area which affected the acid plutonic igneous rocks. The categories mentioned above are the indicator of the probable provenance area of the investigated area.

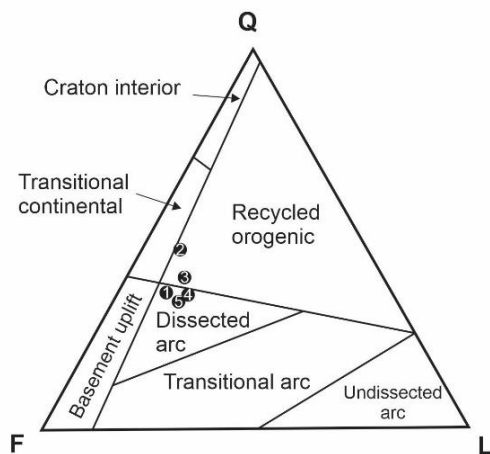


Fig.17 QFL diagram of the Irrawaddy sandstone from the study area (after Dickinson, 1985)

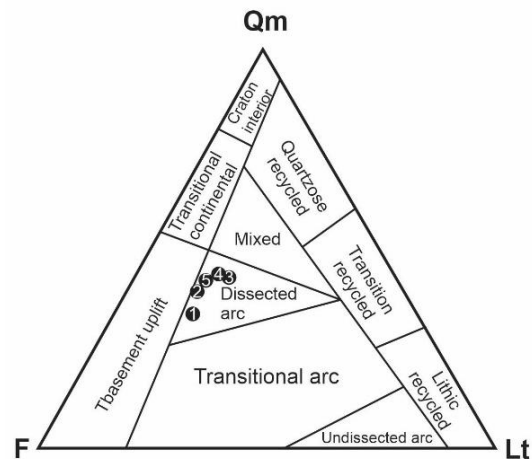


Fig.18 QmFLt diagram of the Irrawaddy sandstone from the study area (after Dickinson, 1985)

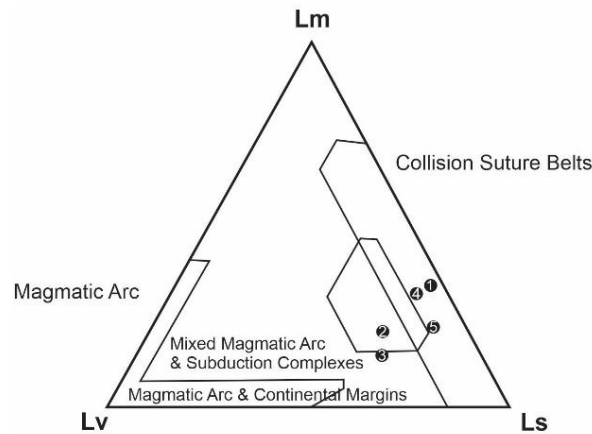


Fig.19 Ternary diagram showing Lithic fragment composition (LmLvLs plots) of sandstone of Irrawaddy Formation

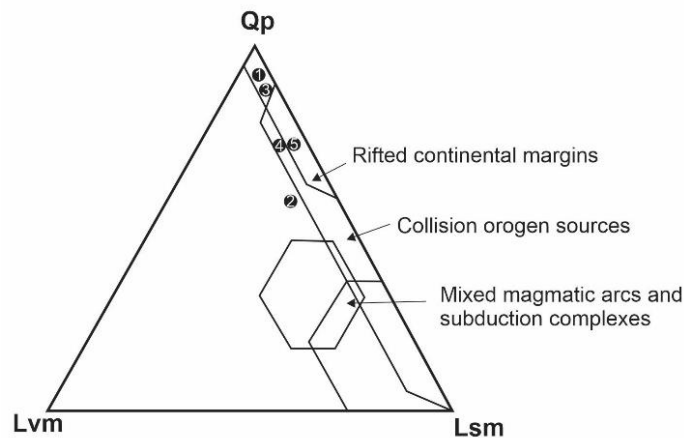


Fig.20 QpLvmLsm diagram of Ingersoll and Suczek (1979) showing different type of provenances

### CONCLUSION

The investigated area constitutes the northern extension of the Sagaing-Minwun metamorphic served as basement on which Mesozoic and Cenozoic rocks were laid down. Tertiary and Quaternary rocks are unconformably overlain by these metamorphic rocks.

The Irrawaddy Formation are coarse-grained, ferruginous sands with fossil wood fragment. Tertiary clastic sedimentary rocks of Irrawaddy Formation are mainly composed with two members: gritty sandstone unit (upper member) and ferruginous sandstone unit (lower member). The upper member is locally covered by conglomerate unit. Structurally, there exist a major strike-slip fault Sagaing fault trending nearly N-S and crossing the middle part of the whole area. The common primary sedimentary structures involve current ripples, parallel laminations and cross-bedded and sandstone concretions is the secondary structures. Serpentinite (Triassic) are exposed in the study area along the Sagaing fault zone because of the friction of fault plane.

The sandstone of Irrawaddy Formation is mainly consisted of quartz, feldspar, mica, rock fragments with iron oxide and calcite cemented. The Irrawaddy sediments were poorly sorted, and these sandstones were formed in fluvial and natural levee environment. With reference to MC. Bride's 1963 classification the sandstone falls within the field of lithic arkose.

The provenance study carried out by using triangular plots of QFL and QmFLt of Dickinson 1985, recalled that the sediments were recycled orogenic and dissected arc. QpLvLsm and LmLvLs diagrams of Ingersoll and Suczek showing the data plots fall in the rifted continental margins, collision suture belts and mixed magmatic arc & subduction complexes.

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