Heavy Mineral Analysis of the Kyaukkok Formation Exposed at the Htaukshapin Area, Mibu Township, Magway Region

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Abstract

The study area is located in Htaukshapin area, Minbu Township, Magway Region. The research area is lying within the Minbu Basin which is a segment of the western margin of the Central Cenozoic Belt of Myanmar. The study area exposed Pegu Group (expectly Shwezattaw Formation) and Irrawaddy Formation. The purpose of the heavy mineral analysis of Kyaukkok Formation is to examine the nature of source rocks and source area, made in transportation of detrial particles and prevailing condition during the sediment deposition. At least fourteen heavy mineral species are identified in the sandstones of Kyaukkok Formation. They are zircon, tourmaline, rutile, hornblende, augite, chlorite, hypersthene, topaz, sillimanite, garnet, enstatite, staurolite, and opaque minerals. Euhedral crystals of zircon and hornblende in the study area were probably derived from acid igneous rocks. Hornblende (reddish brown variety) may be derived from basic igneous rocks and blue green variety may indicate low to high-grade metamorphic rocks. Rutile, rounded zircon may be derived from reworked sedimentary cycle.

Keywords: source rocks, source area, heavy minerals, unstable minerals, euhedral grains

Introduction

The study area is located at the southern part of Minbu Township, Magway Region. It lies between Latitude 20˚ 02' to 20˚10 ' N and Longitudes 94˚ 52' to 94˚ 56' E and using one inch topographic Map 84 L/16. The study area is covering an area of about 12 square miles. The location map of the study area is shown in Figure 1.

The study area is trending NNW-SSE parallel ridges ranging between 300-ft to 400-ft with intervening narrow valleys. Dendritic and parallel drainage pattern are developed in the study area. Satellite image, and drainage pattern of this area are shown in Figure 2& 3 respectively.

The main purposes of the heavy mineral analysis of Kyaukkok Formation is to examine the nature of source rocks and source area, made in transportation of detrial particles and prevailing condition during the sediment deposition.

The Htaukshabin oil Field is one of the well-known oilfields in Myanmar. According to the old records and reports, the earliest work done by Jame, 1909 (report L.J.5) and the latest was made by (Report K.K.M.8, N. H.2, M.M.O.T.1) in 1994.

At report T.C.T.3, TL.2, KW.3 (1962), Tinner, Loftin and Kyaw Win described the geology of the area between Sabwet Chaung and Yethaya Field. In the report M.T.6 (1968), Myo Thein observed the new evidence of following: Irrawaddy Formation was found to overlie Kyaukkok Formation across an unconformity. At report A.N.8, M.Nt.4 (1982), Aung Nyunt, Lawrence Ohn Thin and Myo Nyunt described the detailed geological mapping of Htaukshabin area. Lepper(1933), Chibber(1939) , Aung Khin and Kyaw Win (1969) described the stratigraphy of the study area. Theobald was first introduced the term Pegu Group to designate an important group of Oligocene-miocene deposit occupying most of the ground between the Ayeyarwaddy and Sittaung rivers. Yi Yi Moe (2003) also submitted the

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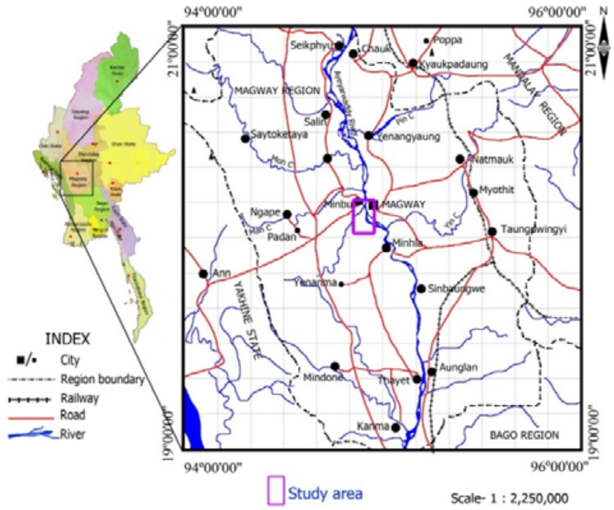
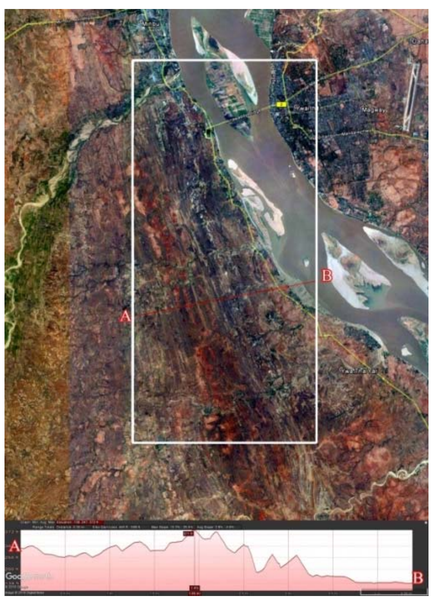
general geology and Data analysis of Htaukshabin Kanni oil field, in her M.Sc. Thesis, and Paing Soe (2011) mention about the Sedimentological Study and Depositional Environments of Upper Pegu Group in Minbu-Htaukshabin area, Magway Region, for his M.Res.(Thesis). Aung Phyo Wai (2011) described the Geology of southern Tabinyin-Minbu Township, Magway Region, for his M.Sc. (Thesis).





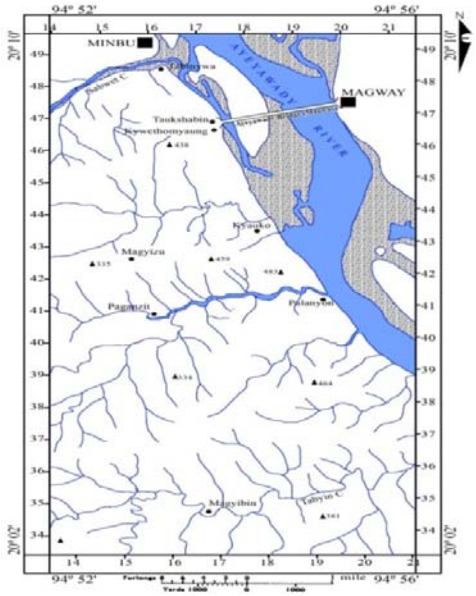


Figure (2). Satellite image of the study area

Figure (3). Drainage pattern of the study

The research area is lying within the Minbu Basin which is a segment of the western margin of the Central Cenozoic Belt of Myanmar. The regional geological map of the study area is shown in Figure 4. On the basic of lithology, stratigraphic position, and faunal content, four stratigraphic units can be classified which are in ascending order as (1) Padaung Formation (Middle Oligocene), (2) Okhmintaung Formation (Late Oligocene), (3) Pyawbwe Formation (Early Miocene), (4) Kyaukkok Formation (Early Miocene), (5) Obogon Formation (Middle Miocene) and (6) Irrawaddy Formation (Late Miocene-Pliocene). The stratigraphic succession of the present area is shown in Table 1.

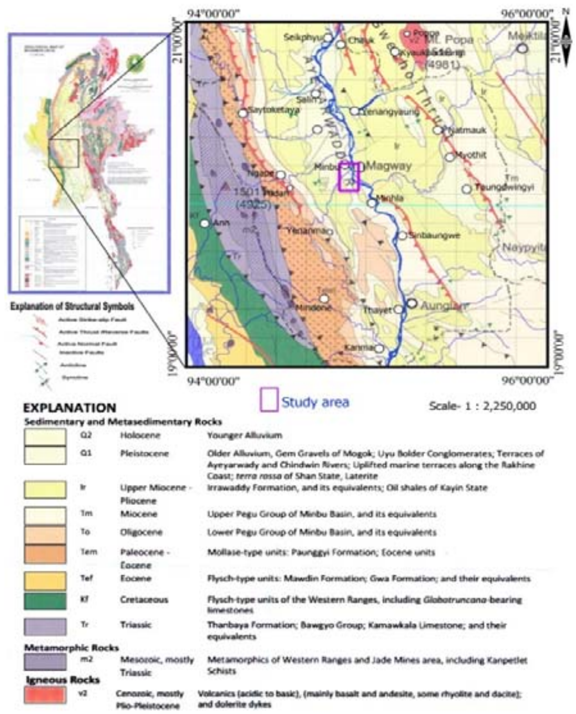


Figure (4). Regional geologic map of the study area and it's environ [Source: Geology of Myanmar (2014), complained and updated by MGS].

Table (1). Stratigraphic Succession of the study area

Lithologic Units	**Age**
Irrawaddy Formation	Late Miocene-Pliocene
Obogon Formation	Middle Miocene
Kyaukkok Formation	Early Miocene
Pyawbwe Formation	Early Miocene
Okhmintaung Formation	Late Oligocene
Padaung Formation	Middle Oligocene

Heavy Mineral Analysis of Kyaukkok Formation

General Statement

Heavy minerals are high-density accessory mineral constituents of siliciclastic sediments and they are found as the minor components in the sandstone. The heavy mineral grains 0.5 mm were studied and they rarely exceed one per cent of the total rock volume. They are very resistant to chemical weathering and mechanical abrasion. The heavy mineral grains contain both opaque and non-opaque detrital minerals. Their specific gravity is greater than 2.89g. The heavy minerals can be used as a guide to observe the source rock lithologic and their dispersal patterns. They are also useful in evaluating the diagenetic history as well as the pre-erosional weathering and tectonic history of source area (Lindholm, 1991; Tucker, 2001).

Method of Study

Heavy mineral grains were obtained from the sand fraction held in sieve size of (0.125mm). In order to remove iron and carbonate coatings, the sand fractions were boiled with oxalic acid and then treated with dilute hydrochloric acid. Then the heavy mineral grains were separated from the light minerals by using bromoform (specific gravity = 2.87) in a separator funnel. The obtained heavy minerals were washed and dried. The heavy minerals obtained were again separated by magnet into magnetic and non-magnetic grain. The glass slice was heated on a hot plate to melt enough Canada balsam to cover the slice. Pour the sample split on the slice and spread the grains using a wire probe. A Flame (match or Bunsen burner) applied briefly to the surface of the Canada balsam will destroy any bubbles. Then the heavy minerals were identified by using the petrographic microscope and determine the abundance of opaque grains as well as that of non-opaque grains. Using a mechanical stage, count 100 grains to determine the percent opaque, while at the same time counting the various non-opaque species. In addition, calculate the abundance of each mineral species present.

Description of Heavy Minerals Species

In the study area, the weight percent of the heavy mineral grains are various. Non-magnetic heavy minerals are more common than the magnetic heavy minerals. In magnetic heavy minerals, opaque volume percentages are more than the non-opaque volume percentages. In non-magnetic heavy minerals, non-opaque volume percentages are more than opaque volume percentages as shown in Figure 5. At least 14 heavy mineral species are identified in the sandstones of Kyaukkok Formation Table. 2. They are zircon, tourmaline, rutile, hornblende, augite, chlorite, hypersthene, topaz, sillimanite, garnet, enstatite, staurolite, and opaque minerals.

Zircon

Zircon occurs throughout the stratigraphic horizons of Kyaukkok Formation. Zircon in the study area is colorless, yellow and grey. The grain shape is characterized by prismatic good crystalline outline, broken euhedral, anhedral fragments, grains with gently rounded terminations to well-rounded forms and complete spheres.

Rounded zircon is more common than euhedral form. Some grains occur thick marginal zoning and contain gas, liquid and small euhedral inclusions. This mineral is abundant in Kyaukkok Formation.

Zircon is a remarkably widespread accessory mineral in rocks of crustal origin. It is particularly ubiquitous in silicic and intermediate igneous rocks. Zircon may reach high concentration in some beach sands and placers (Mange *et. al*., 1992).

Tourmaline

Tourmaline is an abundant stable mineral of the present area. The size, shape and colour of tourmaline in the study area are variable. Tourmaline displays a wide range of colours and these are, in general, indications of composition. Iron-bearing tourmalines are very dark (almost opaque) or deep blue, elbaites have light or deep blue (indicolite) and pink (rubellite) shades. Colour zoning is frequent. Euhedral to subhedral and prismatic grains of tourmaline occur. Tourmaline crystallizes in granites, granite pegmatites and in contact- or regionally metamorphosed rocks (Mange, *et. al*., 1992). Tourmalines are widespread in all types of detrital sediments and are ultrastable both mechanically and chemically.

Hornblende

Hornblende is characterized by it is short or slender prisms, irregular or rectangular fragments, to long thin flakes. Some grains may be thick and massive, platy or bladed, others are partially fibrous or are sometimes intergrowth with another amphibole, rarely with pyroxene phases. Hornblende is the most unstable minerals and exhibitsthe saw-teeth mark by intrastratal solution. Grains of volcanic origin are often euhedral and have terminations at one or both ends (Mange and Maurer, 1992). Characteristic hornblende colours are bluish green, brown green and brown. They are present in a large variety of igneous and metasedimentary rocks. The forms and colours of hornblende grains in the Kyaukkok sandstones are brown green and euhedral grains (Fig.3.1c). They may be volcanic origin.

Rutile

It is a slightly common mineral in all rock samples. Rutiles are subhedral to anhedral and subrounded to rounded grains. Rutile has color variation from grains and show deep blood red color in the center of the grain and a thick black hole surrounds the grain. Rutiles can be distinguished from cassiterites by its very high relief and strong pleochroism. Well rounded rutiles indicate recycled sedimentary source rock (Mange and Maurer, 1992).

Garnet

Garnet occurs as colourless and subrounded to rounded. Dissolution features such as surface pitting and its high relief, together with isotropic character. The population of garnet varies from 3 to 5% of the total heavy minerals. According to Mange and Maurer (1992), garnet is common in a variety of metamorphic rocks and is also present in plutonic igneous rocks, pegmatites, in ultramafic varieties and in some acid volcanic. In sediments, almandine is the most widespread garnet.

Augite

Augite occurred in the study area is dominantly euhedral or subhedral and short or long slender prisms with terminations at one or both ends. Volcanic augites may show embayments or corrosion. Sometimes with conchoidal fractures or grooves on their surface. Compositional zoning is fairly common. They appear in various shades of green and sometimes brown or yellowish brown. Augite is wide spread in various ultramafic and intermediate igneous rock types and is particularly common in gabbros, dolerites, andesites and basalts, and also in some peridotite.

Hypersthene

Hypersthene in the study area occurs as colourless, shades of brown and green. It shows short stubby prism with termination at one end and rounded form or octagonal basal section. Grains are either sharp, angular or their corners may be rounded. Thicker grains exhibit vivid second- and third-order polarization colours with numerous colour bands. The mineral shows parallel extinction. According to Mange and Maurer (1992), hypersthene is common in both extrusive and intrusive basic to intermediate igneous rocks (gabbro norites, basalt, andesite and dacite) and metamorphic rocks.

Topaz

Topaz grains are also found in the present study area. It shows colorless and sub-angular to sub-rounded. The surface of the grains is commonly marked by crescent-shaped indentations. Fluid or opaque inclusions are present. Most detrital grains are colorless with a noticeable. It shows parallel extinction. They display clear interference figure with lower order interference colours. According to Mange and Maurer (1992), topaz is formed primarily in granite, granite pegmatite and in greisen. High-temperature veins and ore deposits as well as vugs, cavities and fissures of acid-rocks may also contain topaz.

Epidote

Epidote occurs mostly as short prismatic euhedral grains and subrounded grains. Some grains shows rounded outline and yellowish green color (Fig.3.1i).They have a fairly high relief. Epidote is common and widely distributed minerals in many types of igneous and metamorphic rocks. Epidote is the index mineral of the albite, actinolite, epidote, chlorite zone of the green schist-facies regional metamorphic (Mange and Maurer, 1992).

Enstatite

It is dominantly long or short stumpy prisms, irregularly terminated prismatic fragments, or more rarely anhedral debris. Enstatite is essentially colourless. Some large thicker grains may have a pale green. Extinction of prisms and longitudinal cleavage fragments is parallel. It is diagnosed by moderate relief, lack of colour, prismatic morphology, cleavages, frequent lamellar structure and parallel extinction.

Staurolite

They occurs as irregular, angular, somewhat platy, often fractured grains which show poorly defined cleavage traces.Staurolite has bright yellowish colours in shades of pale yellow through golden yellow to dark yellowish brown. It is difficult to observe the the extinction angle. Prismatic fragments and euhedral crystals show parallel extinction.It is one of the easily identifiable detrital minerals. High relief, combined with shades of yellow or yellowish brown, and distinct pleochroism are diagnostic.

Sillimanite

Sillimanites in the study area show thin slender and fibrous form. The particle size of sillimanite ranges from 0.03 to 0.05 mm. Some of the crystals are bent. Prismatic grains are colourless and some appears with a pale brown hue. Staurolite, kyanite and andalusite in a heavy mineral suite may indicate the presence of sillimanite. Sillimanite crystallizes in high-temperature metamorphic derivatives and occurs in sillimanite-cordierite gneisses and biotite-sillimanite hornfelses. It is also present in granulite facies rocks. High-grade regional metamorphism of politic rocks also produces sillimanite (Mange and Maurer, 1992).

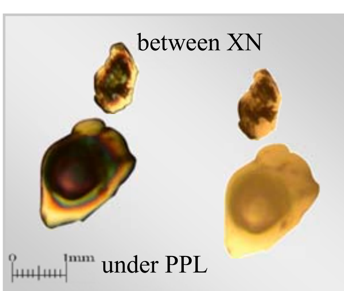
Chlorite

Chlorite in the study area shows thin flaky basal cleavage plates of round, oval or irregular shape, often with curled margins. Some grains may be shredded. It exhibits various shades of green, sometimes in a patchy arrangement. The distinctive features of chlorite are mica habit, green colour and low birefringence. Chlorite is widespread in low-grade metamorphic rocks and is most common in the greenschist facies. In igneous rocks, chlorite is generated by the hydrothermal alteration of ferromagnesian minerals. Weathering processes can also produce chlorite and in sedimentary rocks it often forms authigenically during diagenesis (Mange and Maurer, 1992).

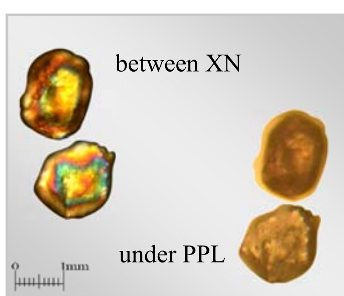
Opaque, magnetic heavy minerals are magnetite, pyrite, hematite, ilmenite and chromite.

Table (2). Heavy mineral species of the sands exposed in the Kyaukkok Formation

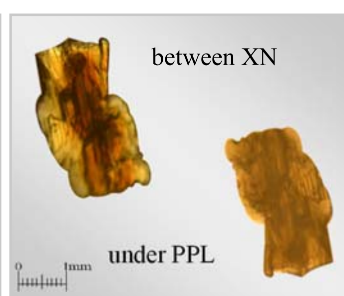
Heavy Mineral Species	**Kyaukkok Formation**			
	No.1	**No.2**	**No.3**	**No.4**
Zircon	9	10	13	12
Tourmaline	9	8	9	7
Rutile	3	3	6	7
Hornblende	6	7	6	5
Augite	2	3	3	4
Garnet	10	9	7	9
Hypersthene	4	5	4	4
Epidote	3	4	3	2
Sillimanite	3	3	3	5
Topaz	11	10	13	13
Enstatite	3	3	2	2
Staurolite	5	3	2	2
Chlorite	4	5	4	2
Opaque minerals	28	27	25	26



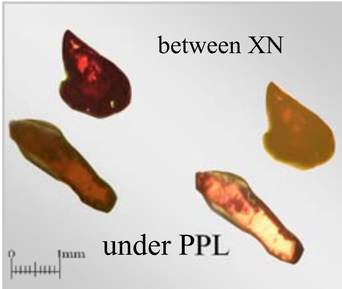
Zircon



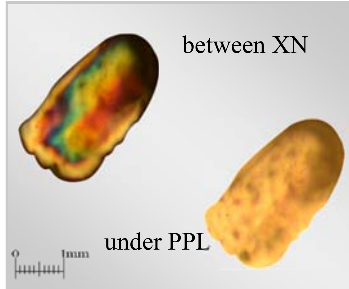
Tourmaline



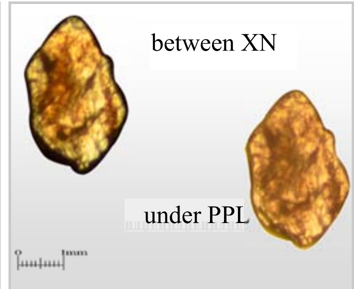
Hornblende



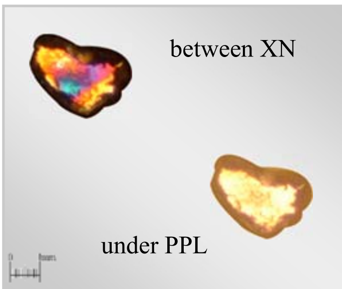
Rutile



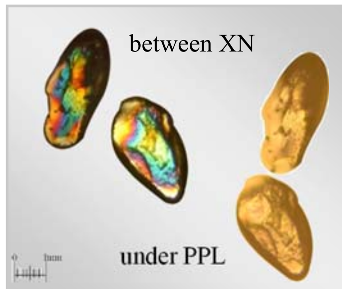
Garnet



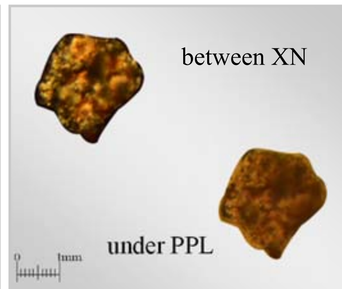
Augite



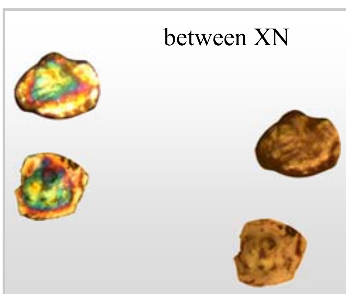
Hypersthene



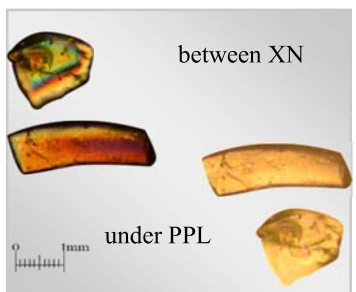
Topaz



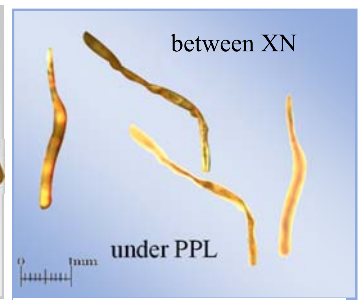
Epidote



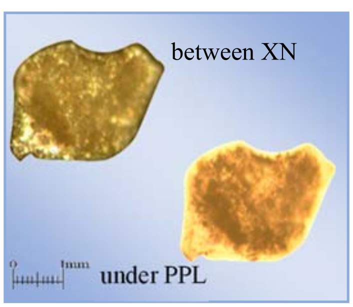
Enstatite



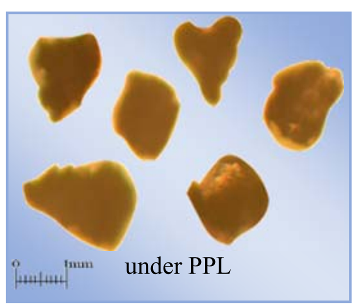
Staurolite



Sillimanite



Chlorite



Opaque minerals

Figure (5). Showing collected heavy minerals in the Kyaukkok Formation

Table (3). Percentages of zircon, tourmaline, rutile, ZTR maturity and maturity index

Heavy Mineral Species	**Kyaukkok Formation**			
	No.1	No.2	No.3	No.4
Zircon	15	18	20	23
Tourmaline	25	23	15	12
Rutile	5	7	13	13
ZTR maturity	11.25	10.26	22.22	24.88
Maturity index (ZTR/r)	0.13	0.11	0.29	0.33

(ZTR- zircon, tourmaline and rutile, r-rest of the other heavy minerals)

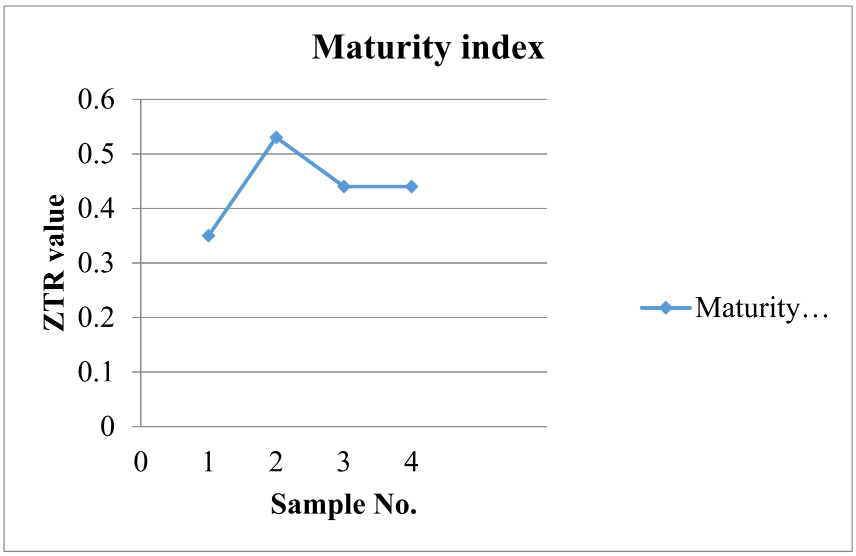


Figure (6). Variations in ZTR maturity index of the Kyaukkok Formation exposed in the study area.

Result and Discussion

The purpose of the heavy mineral analysis is to examine the nature of source rocks and source area, made in transportation of detrital particles and prevailing condition during the sediment deposition. The nature and relative abundance of grains, establishing index minerals and maturity index are analyzed for the source rock, depositional history, stratigraphic relationship and tectonic activities. In the study area, heavy mineral distribution reveals the following characters:

(1) In the Kyaukkok Formation, stable minerals are abundant such as opaque, sillimanite, tourmaline, rutiles and zircon.

(2) Unstable grains such as hornblende grains are the more abundant in sample No. 1, 2, and 3. The maturity index of heavy mineral suits is the lowest in sample No. 1, but highest in sample No. 2 as shown in (Fig 3.2). [Maturity index is calculated using the

formula, ZTR/r (ZTR means rutile, tourmaline, and zircon and means the rest of the heavy mineral species)].

(3) Euhedral and well-rounded grains of zircon, rutile, and tourmaline are associated together.

(4) Hack-saw or dog tooth termination is commonly observed in the hornblende heavy grains.

Above mentioned factor (2), the unstable minerals have no resistant to weathering and diagenetic processes. But, the presence of such minerals indicates that the sediments were derived from the near source area rapidly or from the area which consisted of mass of such minerals. Higher maturity index may indicate that heavy minerals came from a long way or there was abundance of stable minerals in source area.

According to factor (3), there may be at least two sources for the sediments. Euhedral grains may be from the primary source and the rounded grains may be from the older sedimentary units or the source was located at a long way.

On the basis of factor (4), there was influence of the intrastratial solution on the heavy minerals and may decrease the unstable minerals.

The heavy minerals obtained from all samples are generally similar in mineralogical aspects. Their percentage is slightly varied from each other. This appears to indicate that the provenance has remained unchanged.

The association of euhedral and well-rounded grains of garnet, rutile and zircon shows that sediments were derived from sedimentary, igneous, and metamorphic rocks. The association of topaz and tourmaline may indicate the source of granite, and pegmatite.

The association of staurolite, blue green hornblende, epidote and sillimanite may indicate metamorphic rock source. These minerals possibly concluded that, were derived from Mogok Metamorphic Belt.

According to Lindholm (1991), euhedral crystals of zircon and hornblende in the study area were probably derived from acid igneous rocks. Hornblende (reddish brown variety) may be derived from basic igneous rocks and blue green variety may indicate low to high-grade metamorphic rocks. Rutile, rounded zircon may be derived from reworked sedimentary cycle.

Acknowledgement

We would like to express our gratitude to Professor and Head, Department of Geology, Yangon and Magway University, for their encouragement to accomplish this paper.

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