Title	Petrography and Petrogenesis of Basalt exposed at Kyaukka, Kyiwin and Taungtalone Taung Area, Ayardaw and Monywa Townships, Sagaing Region
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Petrography and Petrogenesis of Basalt exposed at Kyaukka, Kyiwin and Taungtalone Taung Area, Ayardaw and Monywa Townships, Sagaing Region

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Abstract

The three localities of basalt exposed in the study areas is underlied by the Peguans and Irrawaddians. The ratio of CaO/Al_2O_3 (0.873 for samples KK 1-3; 0.965 for samples TT 1-3; 1.048 for samples KW 1-3) suggests that the basalts from the study areas are produced by the smallest extents and lowest pressure of melting. Laboratory data and field works reveal that Kyaukka and Taungtalone basalts would be considered alkaline, approximately whereas the Kyiwin basalt would be subalkaline more or less. This is pointed out that there are two distinct sources of magmas. Therefore, it may be concluded all basalt samples from the study areas are not produced at the same source. It is likely that the Kyaukka, Taungtalone and Kyiwin basalts are products of transitional condition from alkali olivine basalt to tholeiitic basalt type.

Key words: alkaline, subalkaline, transitional condition, alkali olivine basalt, tholeiitic basalt

Introduction

The study area is situated between North Latitudes 22° 06' 44.6″ to 22° 17' 06.6″ and East Longitudes 95°15' 15.2″ to 95°19' 49.7″, consisting parts of one-inch topographic map 84/N-7 and N-8 in Monywa and Ayardaw townships, Sagaing Region. It is also located between the Chindwin Basin, east of the Central Igneous Belt and in the Central Cenozoic Belt. It lies in the east Monywa Volcanic Line. The Pegu strata are completely surrounded by younger Irrawaddian rocks in the study area. Within the eleventh decades, many geologists have studied the geology of the study area in the various aspects, viz., stratigraphy, sedimentology and volcanology, etc. However, the detailed petrogenetic studies of the volcanic rocks of the area have not reported yet. The igneous rocks of the lower Chindwin area and geological map of the study area are shown in figures (1) and (2).

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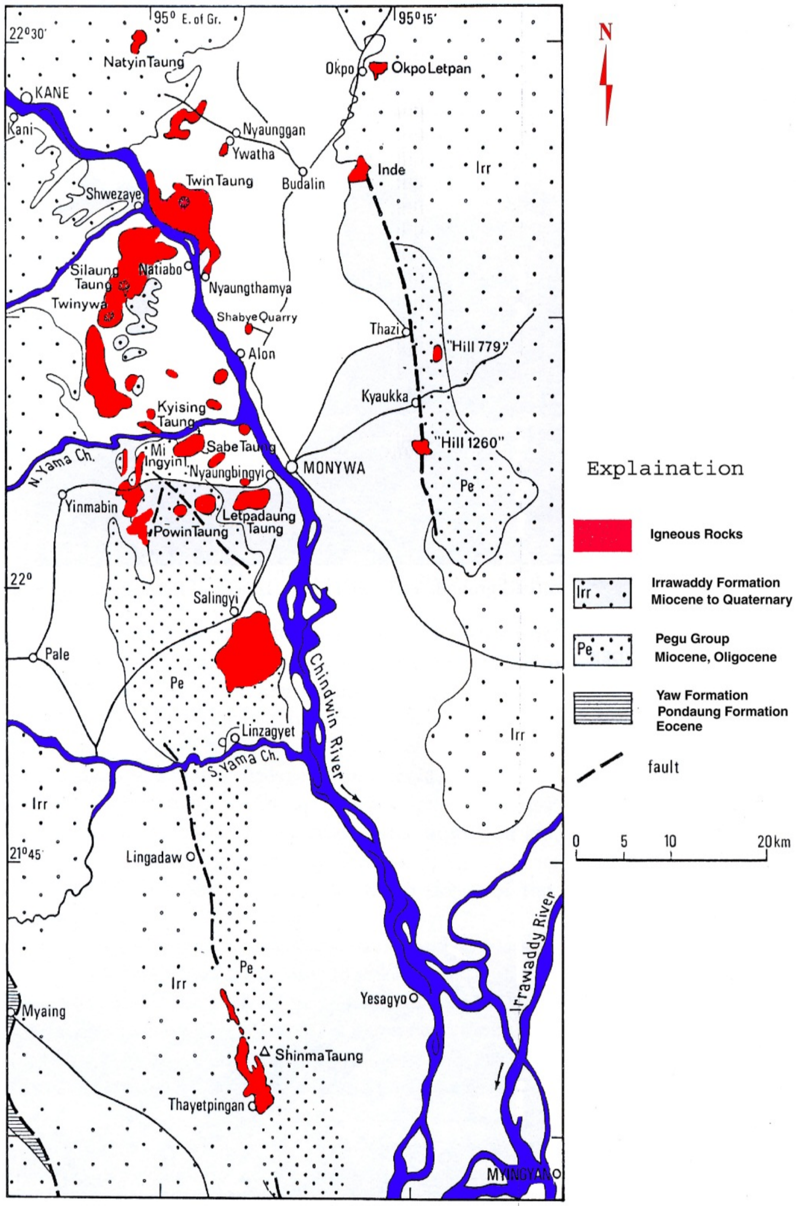


Figure (1) Igneous rocks of lower Chindwin area (Source: Bender, 1983)

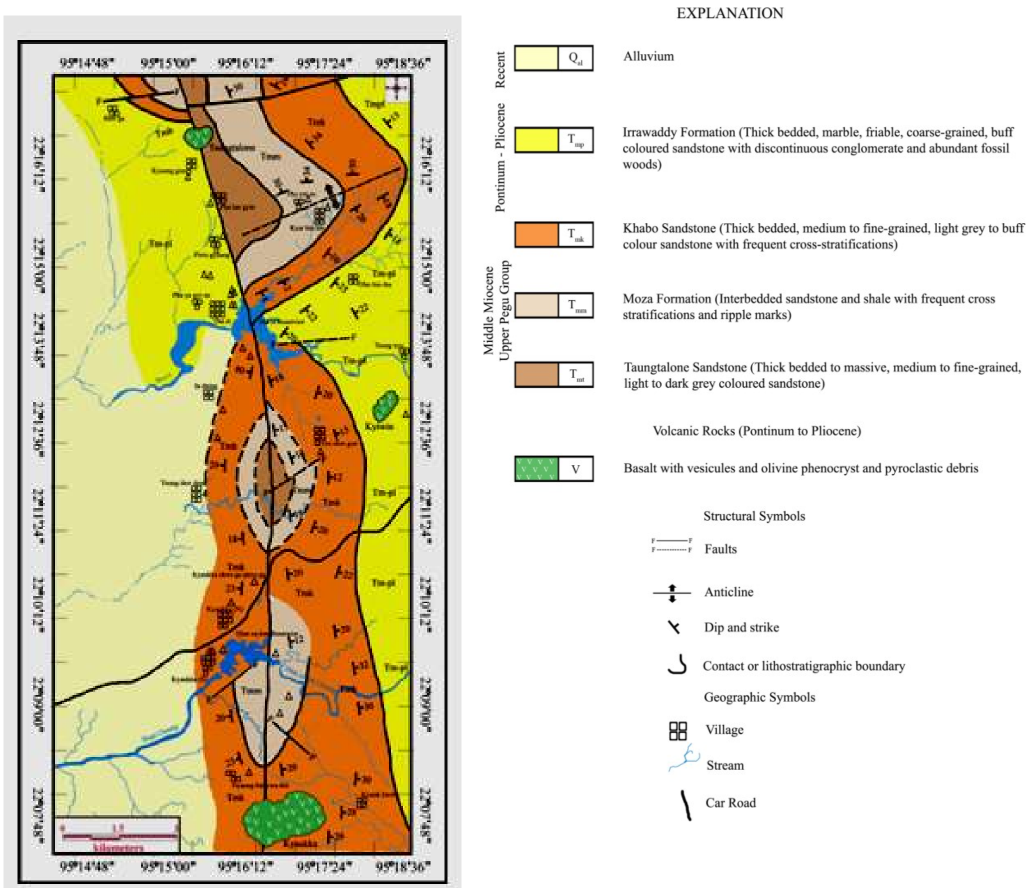


Figure (2) Geological map of the study area (Modified from Ba Maw, 1968 and Aung Win, 1986)

Objectives of the Study

The objectives of the present research are: (i) to explain the petrogenesis of the basalts exposed in three localities (ii) to compare the sources of basaltic magma and (iii) to identify types of basaltic rocks.

Methods of study

Before going to the field, literature and topographic maps were studied as a base. One-inch topographic maps, such as 84N/7 and 84N/8, were used as the index map.

The locating and measuring for geological features, the GPS (Global Positioning System) and Brunton compass were used. To make a detailed measurement the features of volcanic rocks as well as sedimentary rocks were measured by using Brunton compass and GPS map76.

Detailed textural features and other petrographic characters of the rocks collected from these areas were studied in thin sections by using the polarizing microscope. Volume percentages of the constituent materials of various rock types were determined by point counting (visual) method. Moreover, X-ray Fluorescence (XRF) technique was used for the analysis of elemental concentrations in at least 9 samples of solids at Mandalay University.

Results

The study area is mainly composed of igneous and sedimentary rocks of Upper Pegu Group and Irrawaddy Formation. These sedimentary sequences are capped by the basalts. Basalts are formed by fissure eruption after the deposition of sedimentary sequences. The rock sequence of the present area is divided into, from older to younger, the three lithostratigraphic units of Upper Pegu Group (namely Taungtalone Sandstone, Moza Formation, Khabo Sandstone) (Middle Miocene), Irrawaddy Formation (Pontinum to Pliocene), and the igneous rocks (basalts) (Pontinum to Pliocene).

However, the present research focused on the petrogenesis of the basalts exposed in Kyaukka taung, Kyiwin taung and Taungtalone taung areas.

Petrography

Kyaukka Basalt: Kyaukka basalt is chiefly constituted of plagioclase 30%, olivine 35% and orthopyroxene 15% of total volume. Then, 5% are opaque minerals. In the matrix 15%, it contains plagioclase, magnetite and other minerals. In some samples, zircons, phenochrysts of olivine and orthopyroxenes (hypersthenes) are found.

Figure (3) (A) Volcanic breccias of basalt on northern flank of Kyaukka taung (B) Sieve textured plagioclase and large embayed clinopyroxene; the embayed clinopyroxene together with the sieved plagioclase suggests a mixing event (between XN, 40X)

Kyiwin Basalt: the plagioclase is a major constituent mineral. Clinopyroxene and olivine are the second constituent minerals. Other accessory minerals are magnetite, calcite and zoisite. Of the total volume, plagioclase 30% and clinopyroxene 25% are observed. The olivine is equivalent to clinopyroxene. The accessory minerals 20% are constituted of these rocks.

Figure(4) (A) Columnar basalt on the southern part of Kyiwin taung (B)Radiated aggregates of orthopyroxene (hypersthenes) crystals (between XN, 40X)

Taungtalone Basalt: the rock contains the plagioclase, orthopyroxene, olivine and opaque minerals. It consists of plagioclase 40%, orthopyroxene 30%, olivine 15%, opaque minerals 9% and other undifferentiated minerals 7%. The rock shows hypidiomorphic texture.

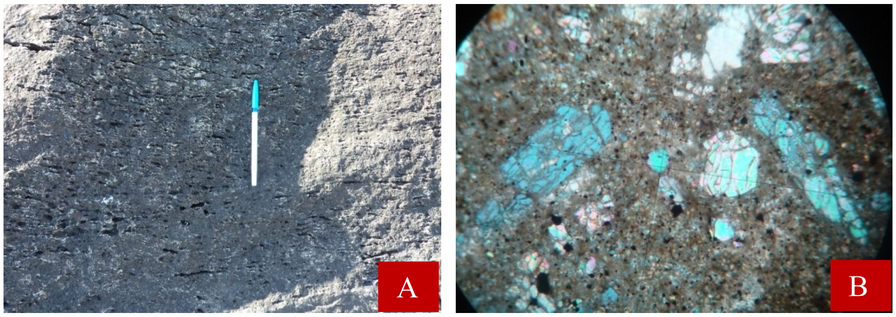


Figure (5) (A) Vesicular basalt exposed at Taungtalone taung (B) Phenocrysts of euhedral clinopyroxene and orthopyroxene (hypersthene) crystals (between XN, 40X)

Geochemical Study

The petrologists (Harker, 1909 and BVSP, 1981 in Raymond, 1995) have classified igneous rocks based on the occurrence in specific tectonic regions, i.e., Mid-Ocean Ridge Basalt (MORB), Ocean Island Basalt (OIB) or Back-Arc Basalt (BAB). The study area falls in the field of Back-Arc Basalt (BAB).

On the basis of mineralogy, Kennedy, 1933 in Raymond, 1995, noted two main types of basalts i.e., alkali olivine basalt or olivine basalt (silica undersaturation) and tholeiite (silica saturation) or tholeiitic basalt. Tholeiitic are hypersthenes-normative, whereas alkali olivine basalts are olivine- and nepheline-normative.

Sample Preparation for XRF

All basalt samples were collected from fresh outcrops, no float samples were taken. Some specimens were sent to laboratory and do chemical analysis with the aid of geochemical instruments. Firstly, a detailed petrography and mineralogy of representative specimens were studied using polarizing microscope. Secondly, sample pellets were analyzed using an ED-XRF method at SPECTRO X-LabPro, Physics Department, Mandalay University. The XRF analyzed each of the samples and printed out the results for the major and minor elements. The major elements analyzed were; *Si, Al, Ca, Fe, Mn, K, P,* and *Ti.* Unfortunately, *Na* and *Mg* were not analyzed by the XRF method. Results were reported in weight percent oxide. The trace elements analyzed were; *Ba, Ce, Cr, La, Te, Rb, Sr, Sc, Y, Zr,* and *Cd*. Then, the trace elements were changed from wt% oxide to *ppm* value. Rock samples that reported greater than 55% SiO_2 were not further studied as they were outside the chemical range for basalt. Finally, the resultant data help to make various petrographic diagrams.

Trace Element Geochemistry

According to XRF data, trace element data better displays source rock variation than bulk rock chemistry. Basalt samples show little variation.

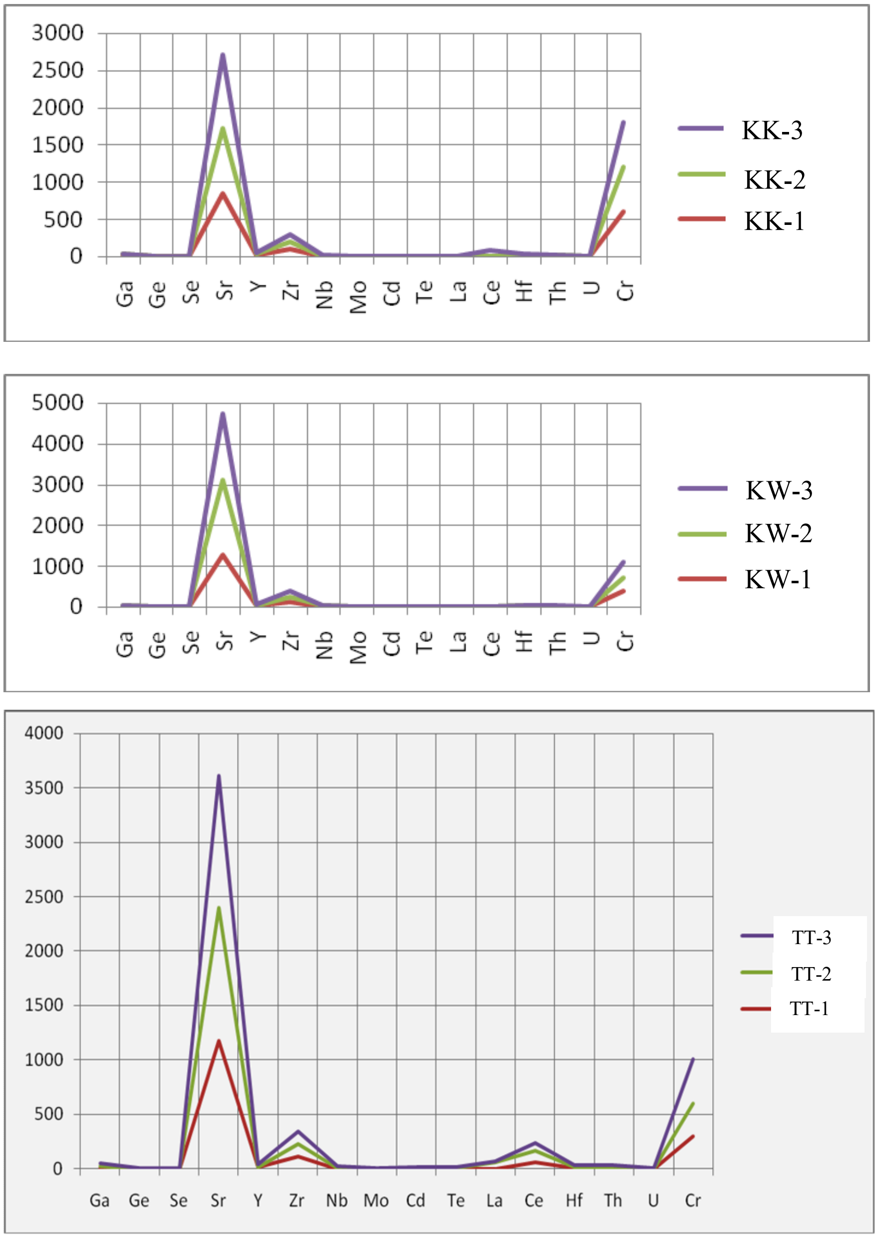
Figures (6 a, b & c) show that the content of Sr is dominant in Kyiwin basalt and the Ce is the least concentration. The Cr content is the most percentage in Kyaukka basalt and Taungtalone basalt is similar to Kyiwin basalts. The trace element Zr content is the same in all basalts. At Taungtalone basalt is contented in Ce trace element concentration more than others. These facts indicate that magma composition can vary depending on variation of physical parameters (e.g., Temperature and Pressure) as well as the length of residence time in the magma chamber (Winter, 2010). The reasons for this variation and types of change will be investigated as follows.

Irvine (1977) states that when low oxygen fugacity is imposed on a spinel species, the Cr^{3+} that stabilizes spinel is reduced to Cr^{2+} which then dissolves and is absorbed into olivine (Takahashi and Kushiro, 1983). Thus, low oxygen fugacity should result in basalt that is both tholeiitic and high in chromium.

The ratio of CaO/Al_2O_3 (0.873 for samples KK 1-3; 0.965 for samples TT 1-3; 1.048 for samples KW 1-3) suggests that the basalts from the study area are produced by the smallest extents and lowest pressure of melting (Clein and Langmuir,1989).

Based on the high chromium tholiitic basalts, it is possible there was a time of lower fugacity for individual areas, perhaps playing a minor role in the chemical variation. However, oxygen fugacity (disappearance of oxygen from magma chamber) seems not to be the major contributor to variation of basalt composition.

The percentage of melt is another factor that can strongly influence the chemical composition of basalts. The effect of this variable can generally be assessed by examining the partition of trace elements into crystallizing mineral phases, for example, chromium into olivine.



Figure(6). Diagrams of Trace element variation of (a) Kyaukka basalt
(b) Kyiwin basalt and (c) Taungtalone basalt (all values are in ppm)

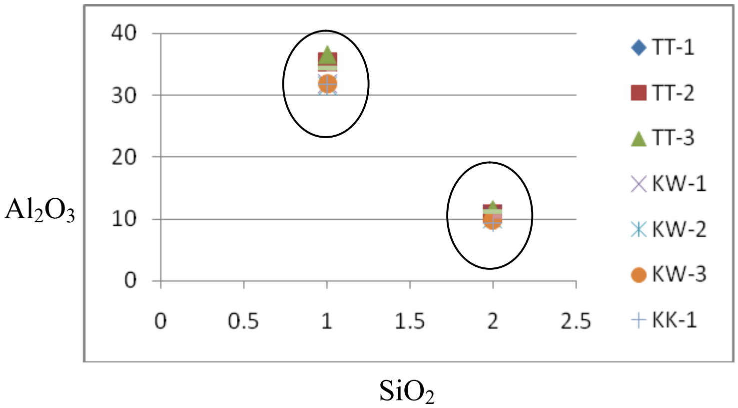


Figure (7). Al_2O_3 vs SiO_2 graph for basalts (The greatest variation in alumina and silica suggests variable depth.)

It has been observed through melting experiments that high-alumina basaltic liquids are not a product of a low-pressure fractionation (Ringwood, 1975). A graph (Figure 7) was constructed, plotting Al_2O_3 vs. SiO_2, using basaltic samples. The greatest variation in alumina and silica suggests variable depth. Kyaukka and Kyiwin basalts were also higher in alumina than Taungtalone basalt. This fact indicates that liquid fractionation of the Kyaukka and Kyiwin basalts happened at lower pressures than that of the Taungtalone basalts.

Origin of basalts

Normative mineralogy was not examined due to the lack of Mg and Na on XRF data. Again a wide variation in composition is present for the basalts, spanning olivine tholeiite to tholeiite fields. Kyaukka and Taungtalone basalts are dominantly olivine tholeiite while Kyiwin basalt is dominantly tholeiitic. Laboratory data and field works revealed that approximately Kyaukka and Taungtalone basalts would be considered alkaline, whereas the Kyiwin basalt would be subalkaline. This fact indicates two distinct sources for the magmas. This is because evolutionary trends restrict the line of decent for fractionating basaltic magma to either the alkaline or sub-alkaline portion. To generate both alkaline and sub-alkaline rocks requires differences in melting depth; the alkaline rocks representing a deeper source (Winter, 2004), and/or changes in the oxygen fugacity of the magma chamber.

Therefore, it may be concluded that all basalt samples of the study area are not produced at the same source. It may result that the Kyaukka, Taungtalone and Kyiwin basalts are products of transitional condition from alkali olivine basalt to tholeiite basalt type.

Furthermore, Kyaukka basalts and Taungtalone basalts are all similar in geochemistry. The diagrams show that trace element concentrations are limited variation between suggesting more than a single source for all basalts.

It has been observed that all basalts in the study area have distinct alkali olivine basalt to tholeiitic basalt trend. The diagram constructed Kyaukka basalt samples (Figure 6 c) showed that a small percentage of samples fall within the tholeiitic field.

Discussion and Conclusion

The trace element geochemistry and field observation indicate that the study area falls in the field of Back-Arc Basalt (BAB). The Cr content is the most percentage in Kyaukka basalt and Taungtalone basalt is similar to Kyiwin basalts. The trace element Zr content is the same in all basalts. At Taungtalone basalt is contented in Ce trace element concentration more than others. These facts indicate that magma composition can vary depending on variation of physical parameters (e.g., Temperature and Pressure) as well as the length of residence time in the magma chamber.

Low oxygen fugacity should result in basalt that is both tholeiitic and high in chromium in Kyaukka basalt. The ratio of CaO/Al_2O_3 of all basalt in the study area suggests that the basalts from the study area were produced by the smallest extents and lowest pressure of melting.

Laboratory data and field works revealed that approximately Kyaukka and Taungtalone basalts would be considered alkaline, whereas the Kyiwin basalt would be subalkaline that indicate two distinct sources for the magmas. This is because evolutionary trends restrict the line of decent for fractionating basaltic magma to either the alkaline or sub-alkaline portion. To generate both alkaline and sub-alkaline rocks requires differences in melting depth; the alkaline rocks representing a deeper source (Winter, 2004), and/or changes in the oxygen fugacity of the magma chamber. Therefore, it may be concluded all basalt samples of the study area are not produced at the same sources. It may result that the Kyaukka, Taungtalone and Kyiwin basalts are products of transitional condition from alkali olivine basalt to tholeiite basalt type.

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