Geochemistry and Tectonic Implication of the Basaltic Rocks from Singu-Kabwet area,Mandalay Division

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Abstract

Basaltic rock samples were analysed for geochemical studies from several locations in Singu-Kabwet area. Major element data suggests that the Singu lavas are predominantly of basaltic trachyandesites and show the alkaline nature according to their position (Na_2O + K_2O) vs. SiO_2 diagram[TAS diagram]. However, the TAS classification may not accurately classify the rocks. Therefore, selected minor and trace elements (e.g, Ti, Zr, Y and Nb) are used to characterize the Singu basaltic rocks with respect to original composition and possible tectonic environment of formation. . The basaltic rocks in the study area are dominated by alkali basalts based on the immobile trace element concentrations. Major-trace element geochemistry displays geochemical characteristics of Within-Plate Basalts.

Key words: geochemical studies, alkaline nature, TAS diagram, tectonic environment, alkali basalts

Introduction

The study area is situated between Singu and Kabwet in Mandalay division. It is bounded by north latitude 22^o 32' to 22^o 45' and east longitude95^o 56' to 96^o 2'.This area lies on one inch topographic maps of 93-B/2 and 84-N/14. It covers approximately 100 square miles with 12.5 miles long and 8 miles wide. Some places can be reached by car and the others can be reached by motor-boat.

Method of Study

Due to the lack of detailed geological map of the study area, mapping is carried out during the field season and the representative samples of rocks units were collected. The sample localities, lithologic boundaries and distinctive structural positions are located by using GPS.

The major oxides and trace elements of representative samples with reference to the X-ray fluorescence spectroscopy (XRF) data were tested at Geochemistry Laboratory, Applied Geology Department, Yangon University and Physics Department, Mandalay University.

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Results and Discussion

Geochemical Studies

Fifty samples were collected from the several locations in the Singu-Kabwet area for geochemical analysis. Among them only twenty samples were analysed for the geochemical studies to trace the tectonic significance of the volcanic rocks exposed in the area.

X-Ray Fluorescence Spectrometry

Bulk rock analyses were run by the combined XRF (X-Ray Fluorescence Spectrometry). Geochemical data has been used to specify and characterize the lithologic units in this study. Geochemical analyses of major and minor oxides and trace elements were used in the determination of rock types and investigation of tectonic origins of extrusive rocks. XRF whole-rock analysis has been used to supplement petrographic criteria in the identification of lithologies.

Chemical Analysis by Using TAS Diagram.

Volcanic rocks of the study area are plotted on total alkalis versus silica (TAS) diagram of Le Bas et al. (1986) for the chemical classification of volcanic rocks. Major element data suggests that the Singu lavas are predominantly of basaltic trachyandesites according to their position in the (Na_2O + K_2O) vs. SiO_2 diagram. Figure 1 shows the compositional name for analyzed volcanic rocks using TAS diagram. This diagram is generally intended for use with selected fresh volcanic rocks without obvious signs of alteration evidence, and this chemical classification scheme is combined with the petrographic analysis and hand sample examination in this study.

All the analysed lavas from Singu are mafic with SiO_2 contents lower than 53%. Most of these mafic lavas display rather low contents in compatible trace elements (Cr, Co, Ni). In Le Bas et al.'s (1986) diagram (Figure 1) they plot within the field of phonotephrite, basaltic trachyandesite and trachybasalt. However, the Singu lavas are better classified using the K_2O-SiO_2 diagram [Pecerillo and

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Taylor, 1976] shown in figure 2. These basaltic lavas plots within the field of shoshonitic basalt except three samples which fall in shoshonite.

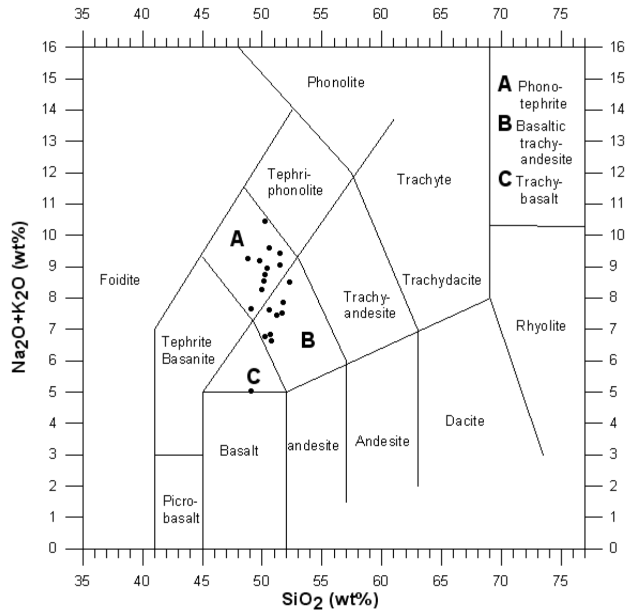

Fig. (1) Plot of the studied lavas in the classification diagram Na_2O + K_2O vs. SiO_2 [Le Bas et al., 1986]

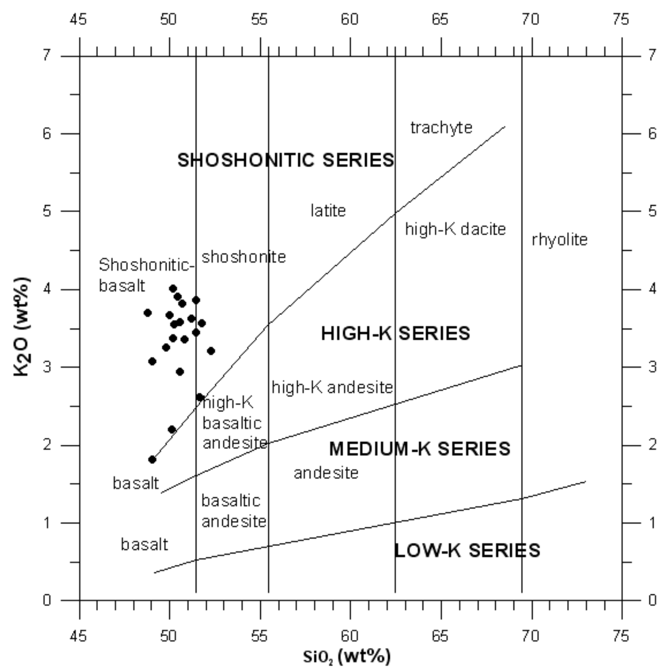

Fig. (2) Plot of the studied lavas in the classification diagram K_2O–SiO_2

[Peccerillo and Taylar, 1976]

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In figure 3, the alkali content that separates the subalkaline from the alkaline groups varies with the silica content of the rock. According to this figure, the samples show the alkaline nature. These are a limitation that most of the samples are enriched in silica content due to hydrothermal activity and alteration. So, some selected samples are applied in geochemical classification diagram.

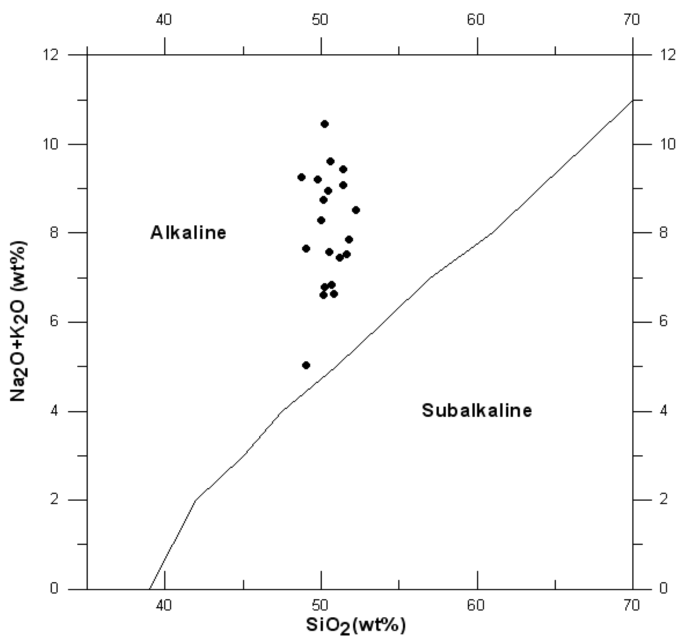

Fig. (3) Alkalis – silica plot showing the alkaline nature of the Singu Volcanics [After Irvine and Baragar, 1971]

Chemical Analysis by Using Selected Minor and Trace Element Diagrams

Most of the volcanic rocks have experienced various degrees and types of alteration. The TAS classification may not accurately classify the rocks because the TAS method depends upon Na and K concentrations which are relatively mobile elements. Therefore, selected minor and trace elements (e.g, Ti, Zr, Y and Nb) that are believed to be relatively immobile under conditions of metasomatism and low grade hydrothermal metamorphism are used to characterize the Singu basaltic rocks with respect to

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original composition and possible tectonic environment of formation (e.g., Pearce and Cann, 1973; Winchester and Floyd, 1977; Pearce, 1996; Jenner, 1996).

Analyses of rocks from the Singu area reveal the presence of distinct types of basalts. These basalts are distinguished by high TiO_2 (0.5 - 2.85%) and P_2O_5 (0.01 – 0.04%).

The Zr/TiO_2 -Nb/Y discrimination diagram (Winchester and Floyd, 1977) has shown that these types of basalts plot in the alkaline basalt field (Figure 4). On the basis of trace element ratios (Nb/Y versus Zr), the basaltic rocks in the study area can be classified as alkaline basalts (Figure5).

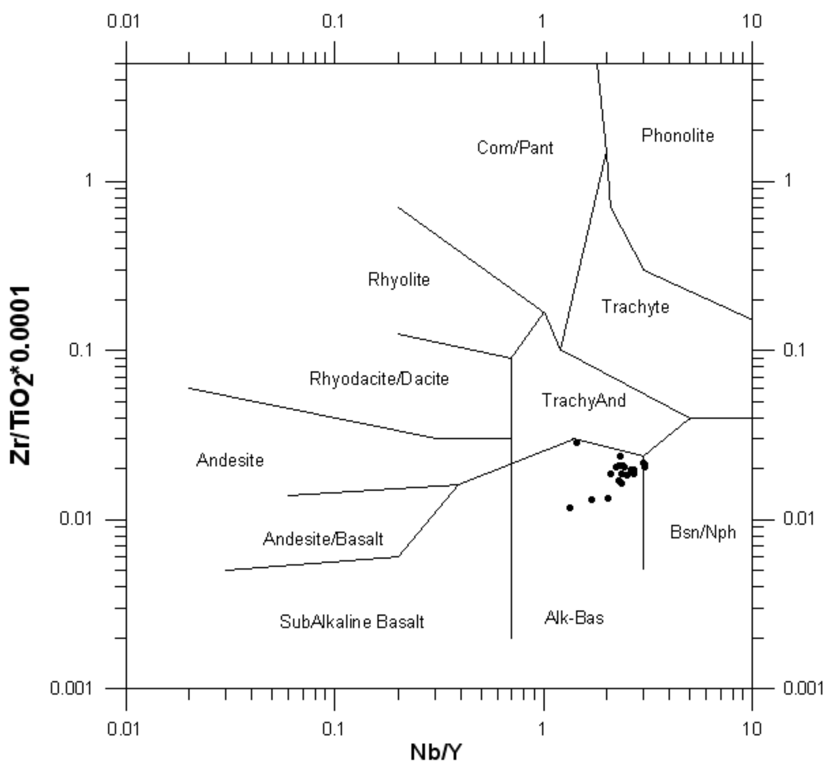

Fig. (4) Trace element discrimination diagram of studied rocks

[After Winchester and Floyd, 1977]

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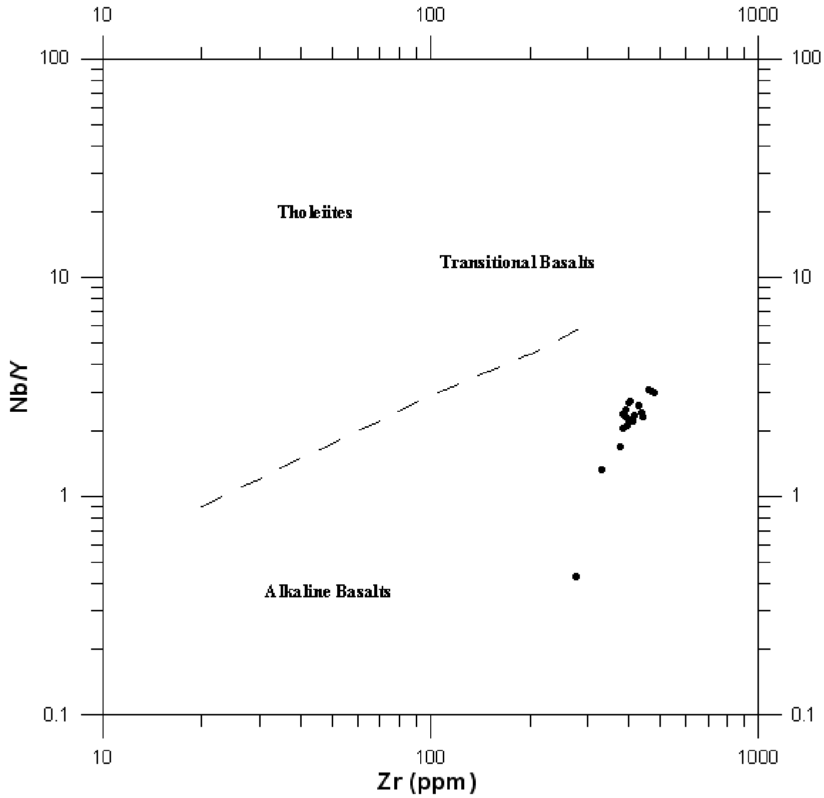

Fig. (5) Trace element classification diagram of studied rocks

[After Lippard et.al., 1986]

This trace element classification variably agrees with the TAS classifications of (Figure 3). Using the trace element classification schemes, most of the basalts occur as alkali-rich types, suggesting that these basalts either experienced alkali enrichment by syn-eruptive hydrothermal activity or post –eruptive alteration.

Trace element data can also provide a means to determine the tectonic setting. Trace element analyses have been used in this study to investigate the tectonic origins of basalts from the study area. Y, Nb and Rb are utilized in tectonic discrimination diagrams as they are generally considered immobile under most metamorphic conditions.

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In the TiO_2 versus Y/Nb diagram (Floyd and Winchester, 1975), alkali basalts tend to have low Y/Nb, a feature used by Pearce and Cann (1973) for eliminating them from their discrimination diagrams. Thus a plot of TiO_2 versus Y/Nb (Figure 6) shows three fields-MORB, alkali basalts (this includes continental and ocean-island alkali basalts) and the continental tholeiites. No field is unique but there is only a small amount of overlap. Winchester and Floyd (1977) reported that the Y/Nb ratio is constant during metamorphism and alteration. On this diagram the basaltic rocks from the study area fall in the alkali basalts field (Figure 6).

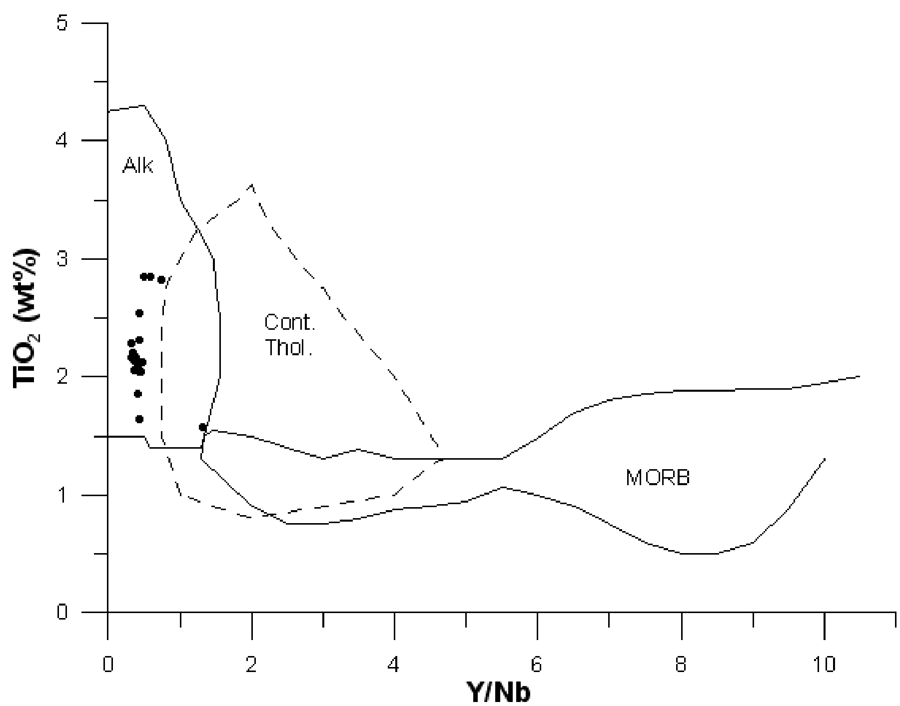

Fig.(6) The TiO_2 – Y/Nb discrimination diagram for basalts [adapted from Floyd and Winchester, 1975], showing the fields of alkali basalts (Alk), continental tholeiites (Cont. thol.) and MORB

The Ti versus Zr diagram includes three fields —— MORB, within-plate and volcanic arc (Pearce, 1996). From this trace element discrimination diagram, it is clear that all the basaltic rocks fall in within-plate (Figure 7).

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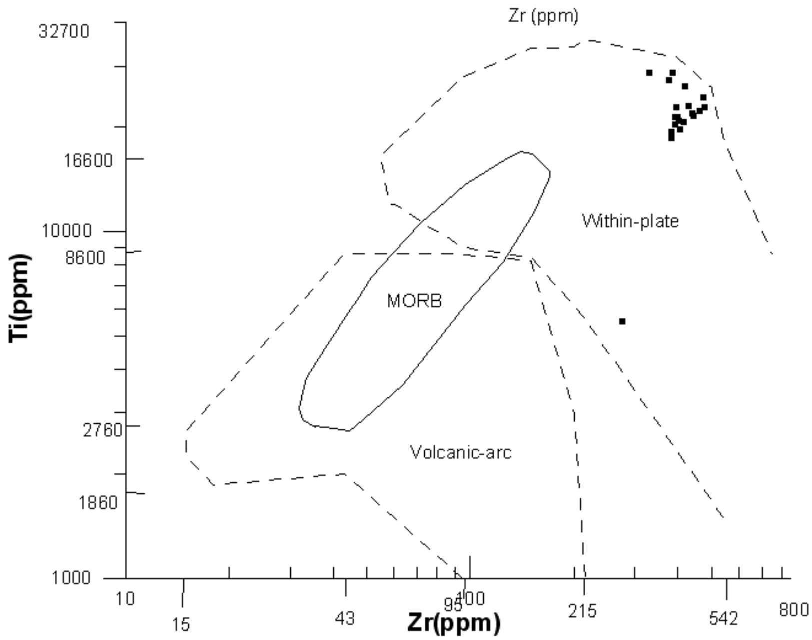

Fig. (7) Discrimination diagrams for basalts based upon Ti- Zr variations showing the fields of volcanic-arc basalts, MORB and Within-plate basalt.

[After Pearce, 1996]

The Ti/Y versus Nb/Y diagram (Figure 8) successfully separates the within-plate basalt group from MORB and volcanic-arc basalts, which overlap extensively on Ti-Zr plot. Within-plate basalts have higher Ti/Y and higher Nb/Y than the other types of basalt, suggesting the enriched mantle source relative to the sources of MORB and volcanic - arc basalts (Rollinson, 1996). Differences in Nb/Y ratio allow the within-plate basalt group to be further subdivided into tholeiitic, transitional and alkaline types. On this tectonic discrimination diagram, the Singu Volcanics have trace element characteristics of within-plate setting and more specifically in the “Alkaline” field of within-plate basalts.

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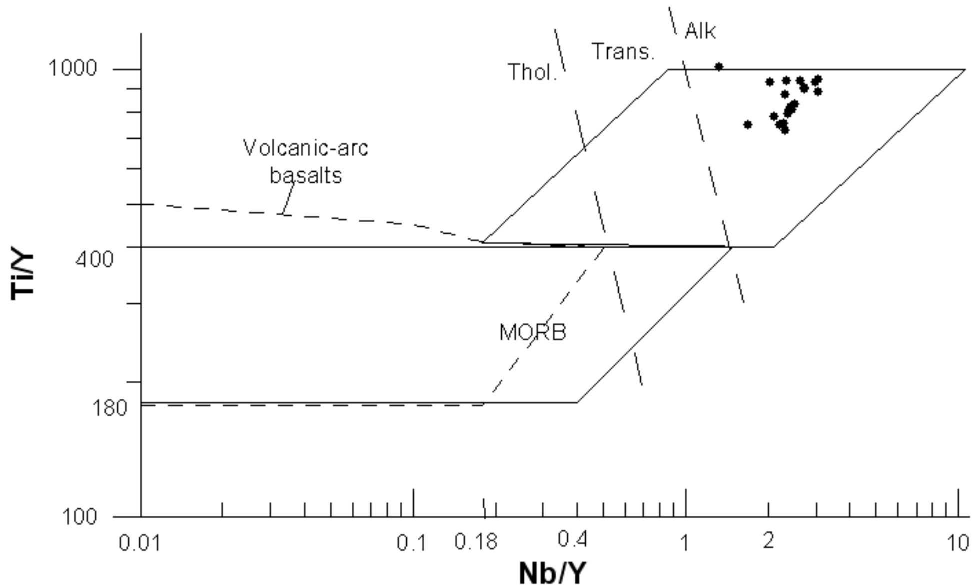

Fig. (8) The Ti/Y – Nb/Y discrimination diagram for basalts showing the field of within-plate basalts, MORB and volcanic –arc basalts. The within-plate basalts may be divided into tholeiitic (Thol.), transitional (Trans.) and alkali (Alk.) basalt types.[After Pearce, 1996]

The Ti- Zr- Y diagram (Fig.9) most effectively discriminates between within-plate basalts, i.e. ocean-island or continental flood basalts (field D) and other basalt types. Island arc tholeiites plot in field A and calc-alkaline basalts in field C. MORB, island-arc tholeiites and calc-alkaline basalts all plot in field B. From this trace element discrimination diagram, it is clear that all the basaltic rocks fall in within-plate basalt (field D).

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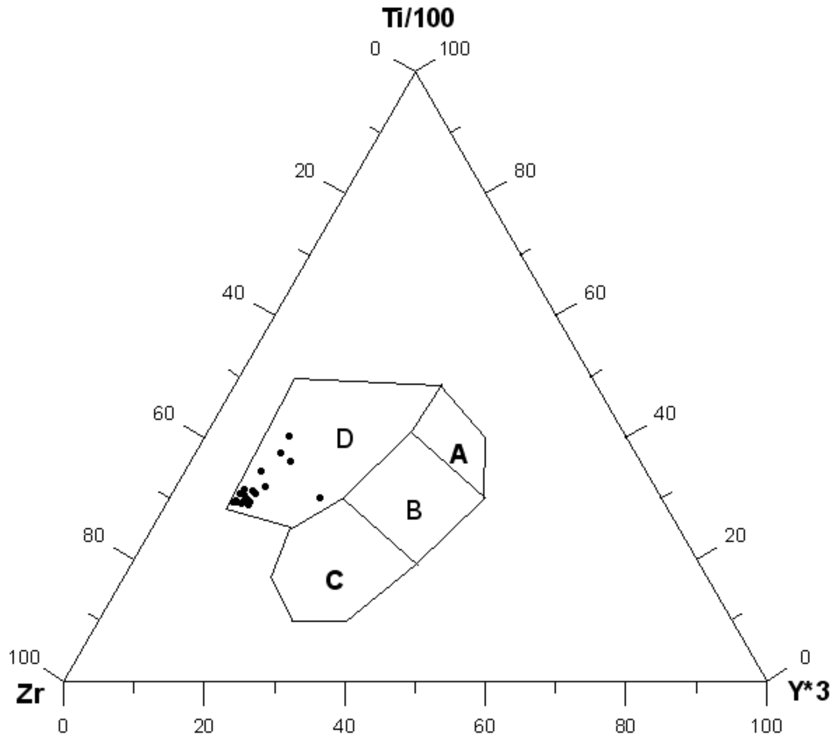

Fig. (9) The Ti-Zr-Y discrimination diagram for basalts [after Pearce and Cann, 1973]. A is the field of island –arc tholeiites, C is the field of calc-alkali basalts, D is the field of within-plate basalts and B is the field of MORB, island-arc tholeiites and calc-alkali basalts.

On a triangular plot of Zr/4, 2×Nb and Y (Figure 10), Meschede (1986) showed that four main basalt fields can be identified. Within-plate alkali basalts plot in field A; within-plate tholeiites plot in fields AII and C. E- type MORB plots in field B whilst N- type MORB plots in field D. Volcanic-arc basalts also plot in fields C and D. The several areas of overlap mean that only within-plate alkali basalts and E- type MORB can be identified without ambiguity. According to this diagram, the basaltic rocks from the study area fall in within- plate alkali basalts (field A).

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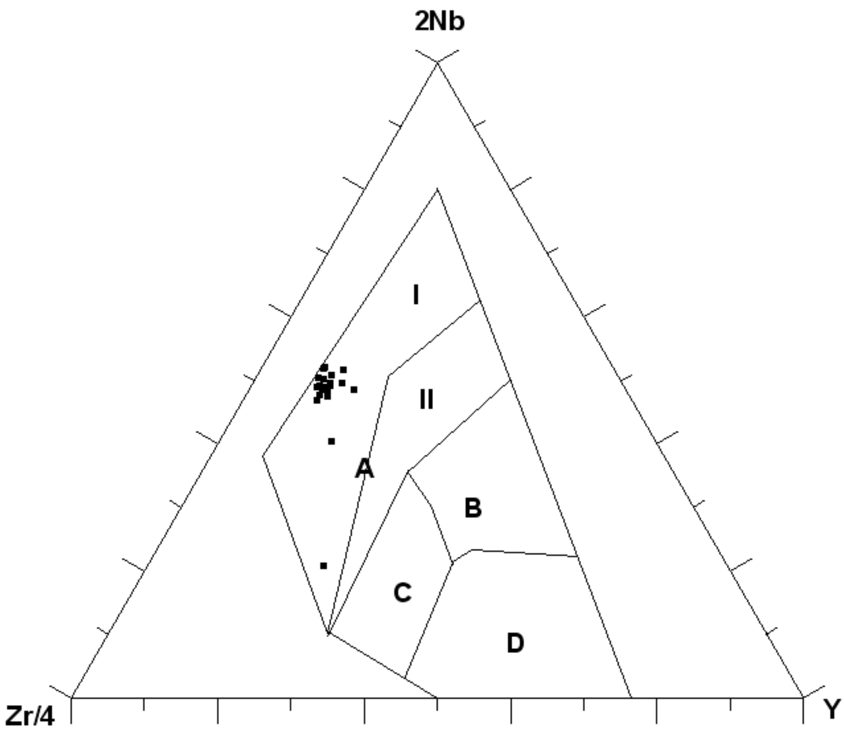

Fig.(10) The Zr-Nb-Y discrimination diagram for basalts, [After Meschede, 1986]. The fields are defined as follows: A I, within-plate alkali basalts; A II, within-plate alkali basalts and within-plate tholeiites; B, E- type MORB; C, within-plate tholeiites and volcanic-arc basalts; D, N- type MORB and volcnaic-arc basalts.

The La- Y- Nb triangular diagram (Cabanis and Lecolle, 1989) (Figure 11) consists of three main fields — volcanic- arc basalts, continental basalts and oceanic basalts. Volcanic- arc basalts plot in field I and are subdivided into calc-alkali basalts (IA) and island – arc tholeiites (1C). Field 1B is where the two plot together. Field 2 characterizes continental basalts and field 2B may define continental back-arc tholeiites, although this subdivision is based upon a single value. Field 3 defines oceanic basalts and is subdivided as follows. Fields 3D is N-type MORB, field 3C and 3B E- type MORB (also known as P- type MORB) and field 3A is defined by alkali basalts. There is some evidence that La is mobile under hydrothermal conditions and so highly altered and metamorphic rocks may show some distortion relative to the La apex. In this triangular diagram, the basalt samples fall in alkali basalts from intercontinental rift (3A).

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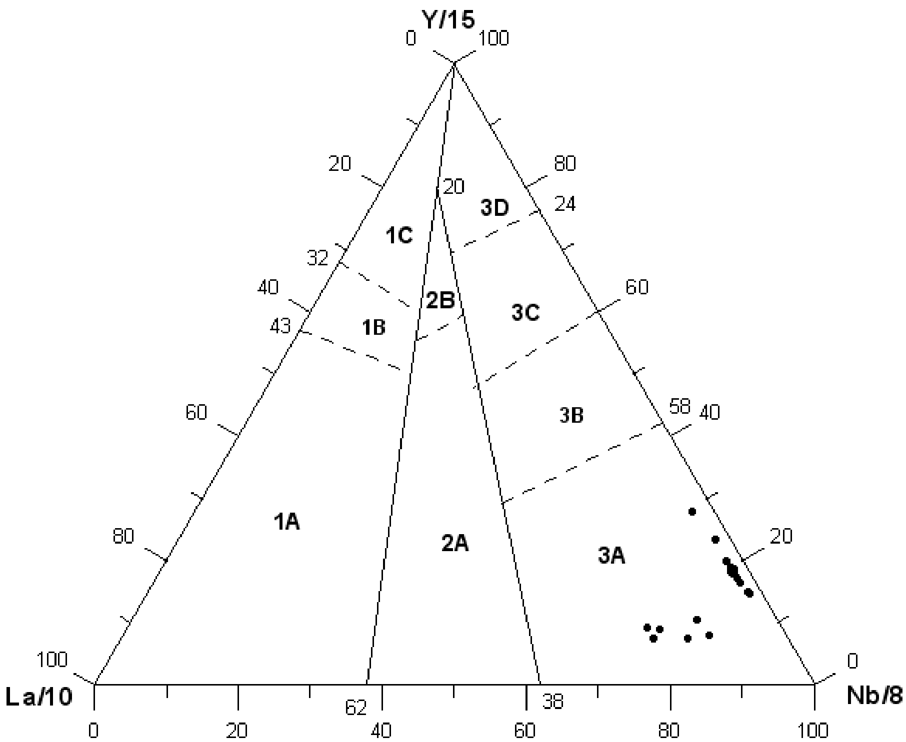

Fig.(11) The La/10 – Y/15 – Nb/8 discrimination diagram for basalts [after Cabanis and Lecolle, 1989]. Field 1 contains volcanic-arc basalts, field 2 continental basalts and field 3 oceanic basalts. The sub-divisions of the fields are as follows: 1 A, calc-alkali basalts; 1 C, volcanic-arc tholeiites; B is an area of overlap between 1 A and 1 C; 2 A continental basalts; 2 B back-arc basin basalts; 3 A, alkali basalts from intercontinental rift; 3 B, 3 C, E – type MORB (3 B enriched, 3 C weakly enriched); 3 D, N-type MORB.

In the Cr versus Y diagram (Pearce, 1996), Cr is compatible in the mineral olivine, orthopyroxene and clinopyroxene and the spinels in a basaltic melt. The low levels of Cr in volcanic-arc rocks therefore are either a function of a different amount of mantle melting from MORB and/ or a difference in the fractionation history. The precise cause is difficult to define. Y is also depleted in island – arc basalts relative to other basalt types, for a given degree of fractionation. Thus a Cr vs. Y plot

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(Figure 12) discriminates effectively between MORB and volcanic arc basalts, with only a small amount of overlap between the two fields. Within-plate basalts, on the other hand, overlap the fields of MORB and volcanic- arc basalts. The wide range of Cr values in the volcanic-arc basalt field is most efficiently obtained through crystal fractionation, indicating that Cr is a useful fractionation index in these rocks. According to this discrimination diagram, the Singu volcanics belong to within-plate basalts (WPB).

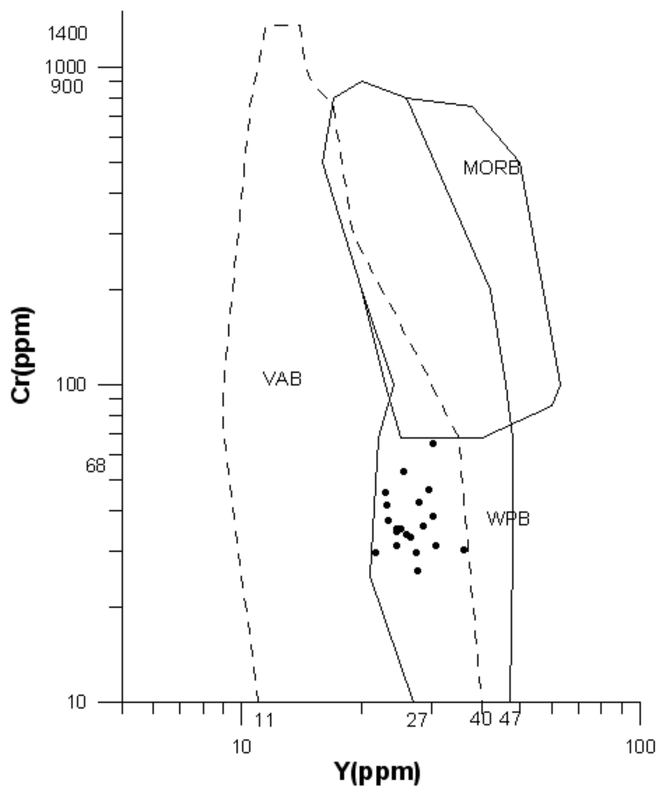

Fig.(12) The Cr-Y discrimination diagram for basalts [after Pearce, 1996], showing the field for MORB, volcanic-arc basalts(VAB) and within-plate basalts (WPB).

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Summary and Conclusion

The study area is located between north of Singu and south of Kabwet, Mandalay division. It is situated between north latitude 22° 32' to 22° 45' and east longitude 95° 56' to 96° 2' and covers part of 93-B/2 and 84-N/14 one inch topographic map. Geochemical analyses of major and minor oxides and trace elements were used in the determination of rock types and investigation of tectonic origins of extrusive rocks. . Major element data suggests that the Singu lavas are predominantly of basaltic trachyandesites according to their position in the (Na_2O + K_2O) vs. SiO_2 diagram. Selected minor and trace elements (e.g, Ti, Zr, Y and Nb) are used to characterize the Singu basaltic rocks with respect to original composition and possible tectonic environment of formation. Using the trace element classification schemes, most of the basalts occur as alkali rich types, suggesting that these basalts either experienced alkali enrichment by syn-eruptive hydrothermal acitivity or post-eruptive alteration. Trace element analyses have been used in this study to investigate the tectonic origins of basalts from the study area. Y, Nb and Rb are utilized in tectonic discrimination diagrams as they are generally considered immobile under most metamorphic conditions. Major-trace element geochemistry display geochemical characteristics of Within-Plate Basalts.

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