Magma Mixing and Tectonic Discrimination of Kyaukka Taung Basalts, Monywa Township, Sagaing Region

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Abstract

Kyaukka Taung area is situated 7 miles east of Monywa, Monywa Township, Sagaing Region. It is situated exactly in the eastern trough of the Central Myanmar Tertiary Basin, Shwebo-Monywa plain province. The peculiarly-shaped mound of the Kyaukka Taung is in the form of a flow that capped on the Pegu strata. Macroscopically, the basalt at Kyaukka taung is compact, fine-grained, and dark-green, dark-grey, reddish-grey in color, some of which are quite vesicular. Microscopically, Kyuakka basalts are porphyric and consist of olivine, plagioclase and diopside crystals. Ground masses are irregular and consist of feldspar laths, olivine and magnetite. The volcanic occurrence of Kyaukka taung capped the crests of the anticline and traversed by faults. In the K_2O vs. SiO_2 diagram, magmatic affinity of the basalts fall within the calc-alkaline series. In the total alkali ($Na_2O + K_2O$) vs. silica (SiO_2) diagrams, the basaltic samples fall between the field of trachy-basalt and basalt, but many of them fall in the basalt field. In Harker's variation diagram. The decrease in MgO, FeO*, and CaO as SiO_2 increases is consistent with the removal of early-forming minerals from the cooling liquid. So, fractional crystallization is responsible. But, Al_2O_3 and K_2O also increase as SiO_2 increases. K_2O, TiO_2, and P_2O_5 are relatively rich in the samples, and they are incompatible elements. Thus, crystal fractionation is not the only process and mixing of mafic magma (mantle melts) and silicic magma (crustal melts) may also be another dominant process. These characters are correspondent with subduction-related magma evolution. To infer the original tectonic/igneous setting, recently tested discrimination diagram of Vermeesch (2005) is used. In this discrimination scheme, all of the basalt samples fall in island-arc basalts (IAB) field.

Keywords: Porphyric, Calc-alkaline Series, Harker's variation diagram, Fractional Crystallization, Island- Arc Basalts.

Introduction

The Kyaukka Taung area is situated about 2 milles south-east of Kyaukka village, 7 miles east of Monywa, Monywa Township, Sagaing Region. The exposed rocks are covering about 9 km^2 and located within latitudes 22° 06′ 30″ N to 22°08′ 00″ N and longitudes 95° 15′ 30″ E to 95° 17′ 00″ E . It can be readily approached by motor-car throughout the year. However, it is closer to the vicinity of the Taunggya and Taungmadaw vilages in the mapped area. Taungmadaw village is situated at the western foot of Kyaukka Taung.

Shape and Dimension

The peculiarly-shaped mound of the Kyaukka Taung is in the form of a flow that capped on the Pegu strata. It is exposed as an elliptical outcrop with three blunted peaks, about 2 miles in length and 1 mile in width. Although the northern margin is slightly gentle, the southern part forms steep cliffs.

Regional Geologic Setting

The regional geologic setting is shown in figure (2). The present area is mainly composed of clastic sedimentary rocks. After all it is situated exactly in the eastern trough of the Central Myanmar Tertiary Basin, Shwebo-Monywa plain provinces. Aung Khin and Kyaw

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Win (1969) and Dr. Myo Min (1996) mentioned that sedimentation of Minbu Basin occurred in nonmarine sedimentation in the north and marine sedimentation in the south.All streams are radial and main streams are trending NE to SW and flowing into the Bukha chaung. Generally all streams are dry and occur as the temporary streams during a torrential raining period. Some streams and tributaries are blocked and built up as Kyaukka dams to irrigate for agro – forestry plantations of the Greening project for the Nine Districts in the Dry Zone of Central Myanmar. Kyaukka dam is constructed across the Htanzaloke chaung at the east of Kyaukka village.

Petrography

Macroscopically, the basalt at Kyaukka taung is compact, fine-grained, and dark-green, dark-grey, reddish-grey in color, some of which are quite vesicular.

Microscopically, Kyuakka basalts are porphyric and consist of olivine, plagioclase and diopside crystals. Ground mass are irregular and consists of feldspar laths, olivine and magnetite. Olivines are commonly distributed among the phenocrysts. They occurs as euhedral to subhedral crystals having 0.1 mm to 2.0 mm in diameter. Plagioclases are also euhedral to subhedral crystals having 0.05 mm to 0.1 mm in length.

Contact Relationship and age of flow

The volcanic occurrence of Kyaukka taung capped the crests of the anticline and traversed by faults. The contact between the Kyaukka basalts and Upper Pegu strata of upper most middle Miocene age is clearly exposed at the immediate foot of the southern slope of Kyaukka taung. The basaltic lava, trending east-west, intruded across the strikes of the sedimentary rocks. The basaltic boulders on the slopes are usually vesicular, whereas those of the core are compact and are without vesicues. The sizes of the boulders are two and half feet to 15 feet in diameters.It is also evidenced that the apparent age obtained by K-Ar determination of the intrusion of biotite porphyry from Monywa area was 5.8 million years, middle Pliocene (The Mining Agency Government of Japan:1972). Therefore, igneous activity in the Lower Chindwin area is assumed to have occurred from late Tertiary to Recent.

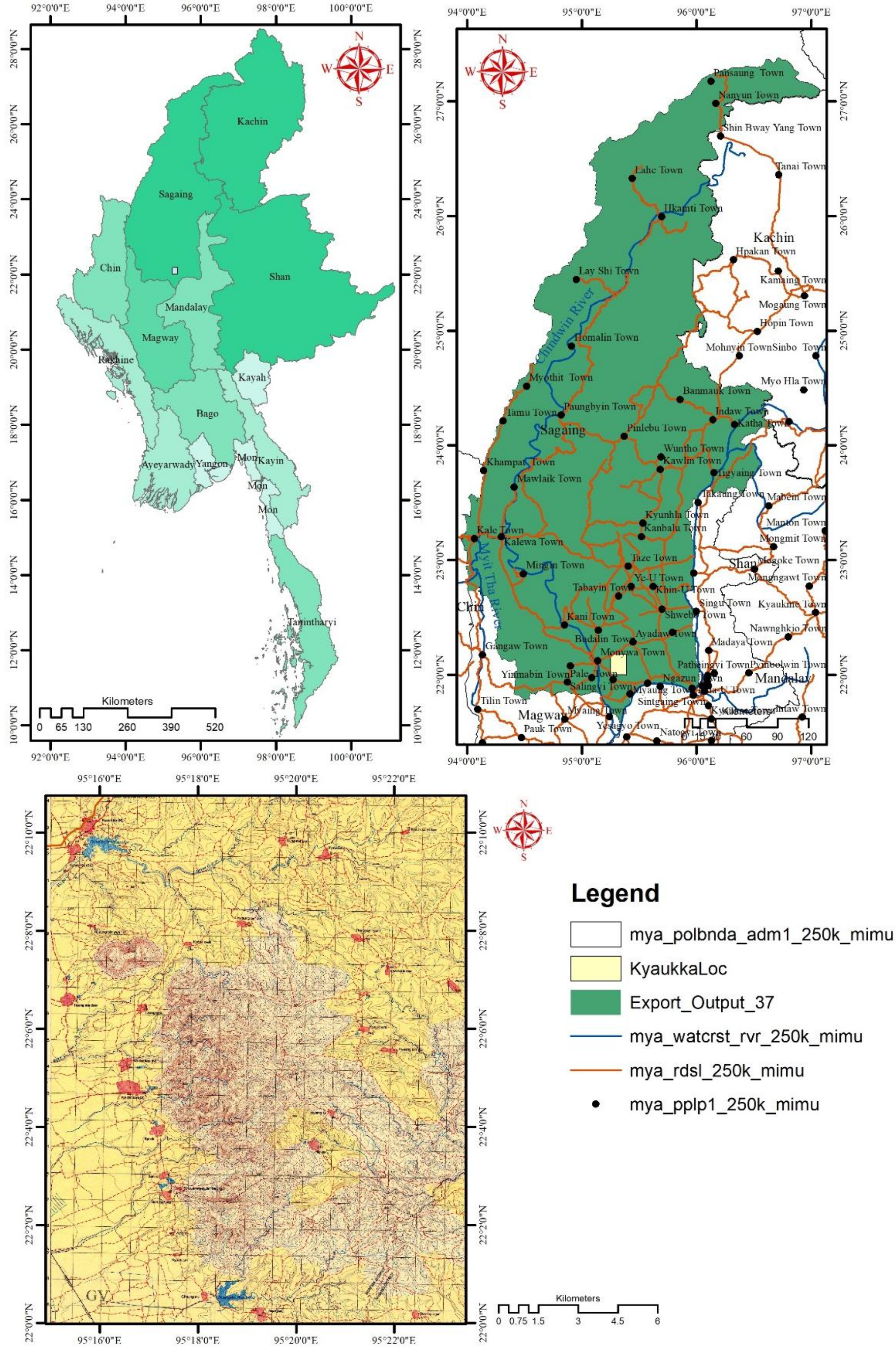


Figure 1. Location map of the study area and the corresponding UTM map

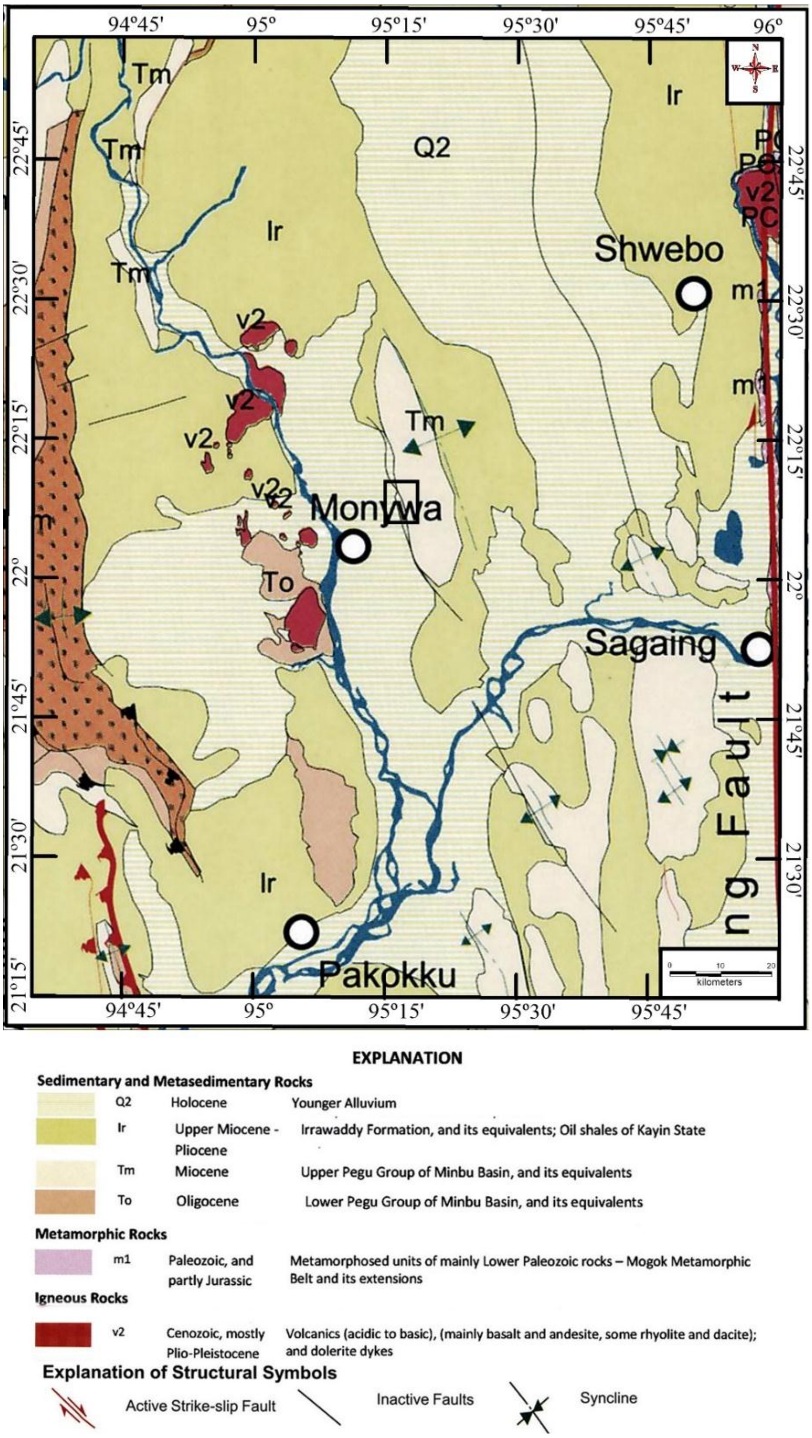


Figure 2. Regional geologic setting of the Shwebo-Monywa plain provinces

Figure 3. Panoramic view of Kyaukka Taung (taking from the N-E)

Figure 4. Flow structure and gas bubbles escaping in less viscous basaltic magmas near the surface of the flow

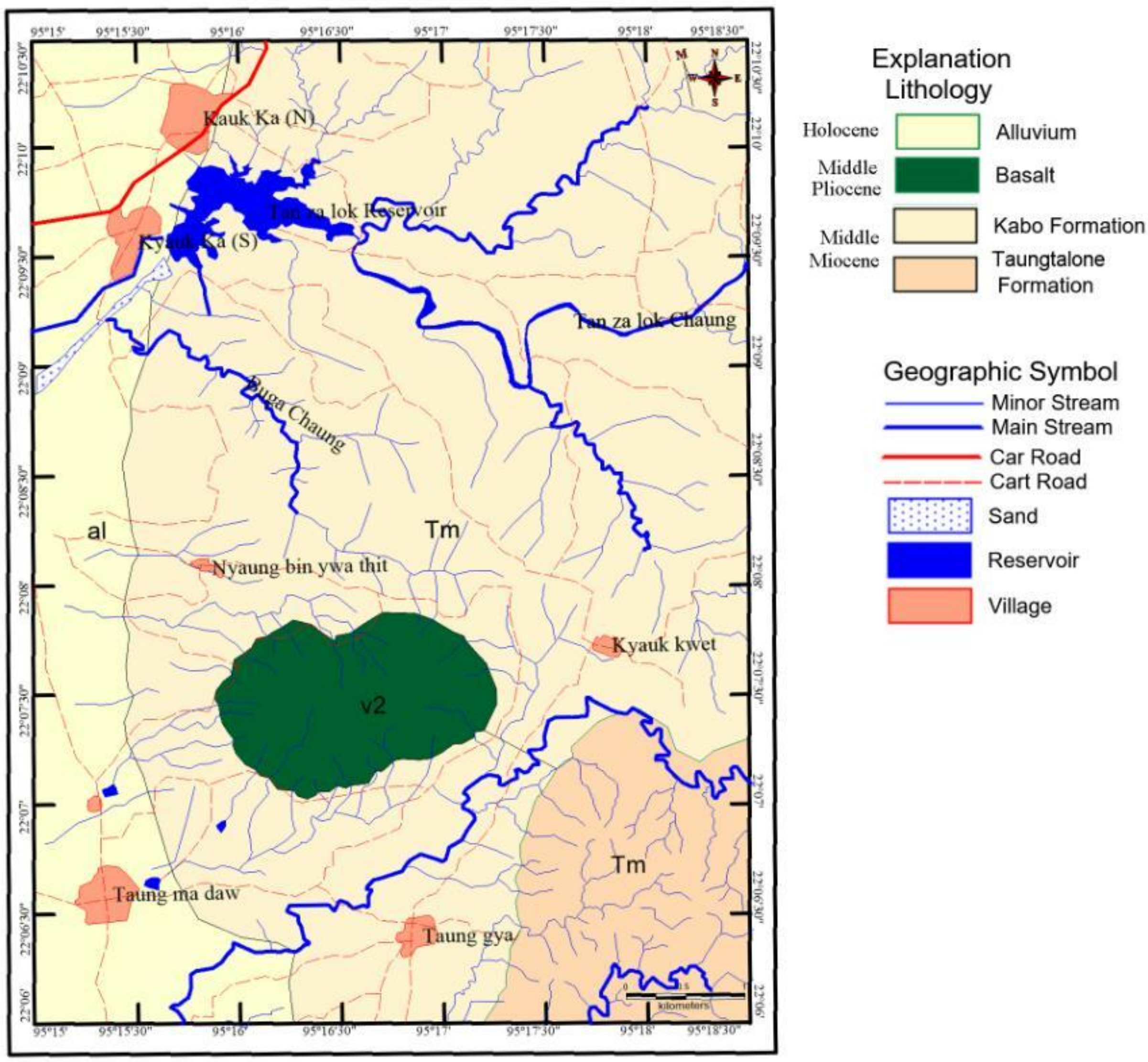


Figure 5 Geological map of the study area (after Win Myint (2010,Ph.D, Thesis)

Analytical methods (WDXRF Analysis)

WDXRF analysis was carried out at University Research Center in Mandalay University. Rocks samples were crushed by jaw crusher and sieved to 63 μm. Then the powders were bined by lithium borate ($Li_2B_4O_7$), pressed and dried. Finally, the pellets were analyzed by the Supermini200 benchtop wavelength dispersive X-ray fluorescence (WDXRF) spectrometer from Rigakuto perform the traditional calibration method of copper ore concentrate.

The pressed powder technique was used to prepare these powder samples. It is the most commonly used method for powder samples in XRF spectrometry analysis as it is simple, economical, consumes less time, and requires low skill level.

The Supermini200 with Pd target X-ray tube was used to perform the calibration for the elements of Cu, Cd, As, Ag, Bi, Pb, and Zn. Tube condition was 4 mA and 50 kV and path atmosphere was in vacuum. 15 rock samples were utilized as references.

Whole Rock Geochemistry

Major oxides and trace element composition of 15 basalt samples are shown in Table 1 and Table 2 respectively. The studied samples show silica content ranging from 46.8 to 49.9

wt% with an average value of 48.43wt%. Al_2O_3 contents of the samples show a range between 11.51 and 14.95 wt% with an average value of 13.37 wt%. The K_2O contents in the samples range from 0.87 to 1.36 wt% with an average value of 1.16 wt%. FeO have a narrow range between 8.31 and 10.02 wt%.

Contents of compatible elements (Ni and Cr) range from 55 - 100 ppm and 168 - 322 ppm, respectively. These values are relatively lower than that of primary mantle melt (i.e., Ni > 200 ppm, Cr > 400 ppm).

Table 1. Major oxide compositions by XRF analysis

Samples	SiO_2	TiO_2	Al_2O_3	Fe_2O_3	FeO	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5
Kk- 1	46.8	1.61	12.73	3.11	9.50	0.074	8.98	7.79	3.36	1.08	0.339
Kk- 2	48.4	1.69	12.67	3.19	8.66	0.0607	9.18	6.79	3.28	1.07	0.313
Kk- 3	48.9	1.62	13.02	3.12	8.90	0.0751	9.3	6.94	3.29	1.02	0.316
Kk- 4	48.3	1.53	13.00	3.03	8.74	0.0729	7.7	7.27	3.43	1.36	0.35
Kk- 5	48	1.67	13.37	3.17	9.19	0.0962	9.04	8.31	3.25	1.14	0.279
Kk- 6	48.2	1.75	13.39	3.25	9.56	0.0908	9.36	7.62	3.30	0.87	0.303
Kk- 7	48.3	1.73	14.95	3.23	8.69	0.091	8.84	6.1	3.29	1.20	0.353
Kk- 8	48.2	1.73	14.51	3.23	8.57	0.0659	8.86	6.92	3.53	1.17	0.336
Kk- 9	48.3	1.65	14.60	3.15	9.04	0.0661	9.34	7.38	3.58	1.22	0.0328
Kk- 10	48.1	1.73	13.95	3.23	8.31	0.061	9.05	6.98	3.43	1.17	0.0322
Kk- 11	48.4	1.72	13.38	3.22	9.61	0.0744	9.04	6.04	3.68	1.60	0.0307
Kk- 12	48.9	1.67	13.60	3.17	10.02	0.061	8.23	6.78	3.42	1.02	0.329
Kk- 13	48.7	1.67	12.64	3.17	8.90	0.0712	8.82	6.95	3.18	1.30	0.349
Kk- 14	49.1	1.67	13.24	3.17	9.16	0.0695	9.05	7.3	3.36	0.96	0.33
Kk- 15	49.9	1.67	11.51	3.17	9.33	0.0659	8.85	6.33	4.94	1.14	0.344

Table 2. Trace element compositions (ppm) by XRF analysis

Samples	**V**	**Cr**	**Ni**	**Cu**	**Zn**	**Sr**	**Ba**
Kk- 1	83	230	97	33	nd	424	369
Kk- 2	nd	202	73	36	nd	381	nd
Kk- 3	145	322	75	52	23	386	nd
Kk- 4	106	209	70	45	nd	293	nd
Kk- 5	261	290	80	41	24	415	nd
Kk- 6	nd	271	100	39	27	445	nd
Kk- 7	127	238	71	37	33	352	436
Kk- 8	321	205	75	42	22	387	322
Kk- 9	76	213	55	43	27	377	313
Kk- 10	155	234	56	40	25	383	nd
Kk- 11	255	207	76	52	30	394	385
Kk- 12	121	195	73	38	nd	398	334
Kk- 13	nd	260	75	42	24	400	451
Kk- 14	158	272	72	nd	nd	449	nd
Kk- 15	83	168	71	31	27	357	368

Table 3. Normative minerals

Samples	Ap	Ilm	Or	Ab	An	Mt	Di	Ol	Hy
Kk-01	0.80	3.06	6.39	28.39	16.49	4.51	16.19	14.05	7.51
Kk-02	0.74	3.21	6.33	27.77	16.67	4.63	12.09	9.75	14.12
Kk-03	0.75	3.08	6.03	27.81	17.76	4.52	11.81	10.29	14.47
Kk-04	0.83	2.91	8.04	29.02	16.06	4.39	14.41	11.14	8.01
Kk-05	0.66	3.17	6.74	27.46	18.54	4.59	16.91	17.29	2.15
Kk-06	0.72	3.32	5.13	27.90	19.18	4.71	13.49	14.96	8.30
Kk-07	0.84	3.29	7.08	27.83	22.48	4.68	4.43	11.30	14.86
Kk-08	0.80	3.29	6.93	29.90	20.28	4.68	9.58	15.89	5.81
Kk-09	0.08	3.13	7.24	28.70	20.15	4.57	13.14	20.49	0.00
Kk-10	0.08	3.29	6.94	29.00	19.22	4.68	12.26	15.34	5.24
Kk-11	0.07	3.27	9.44	31.12	15.28	4.67	11.76	20.95	0.24
Kk-12	0.78	3.17	6.06	28.92	18.75	4.60	10.39	10.75	13.81
Kk-13	0.83	3.18	7.68	26.88	16.39	4.60	12.80	9.07	14.34
Kk-14	0.78	3.17	5.67	28.46	18.21	4.60	12.85	11.03	12.67
Kk-15	0.81	3.17	6.76	36.13	5.84	4.60	18.91	17.95	0.00

In the total alkali ($Na_2O + K_2O$) vs. silica (SiO_2) diagrams, most of the rock samples fall in the basalt field, but some also fall in trachy basalt. The samples are also discriminated by using the K_2O vs. SiO_2 diagram and magmatic affinity of the basalts fall within the calc-alkaline series in this diagram. So, volcanic activity at Kyaukka Taung is probably related to the subduction zone.

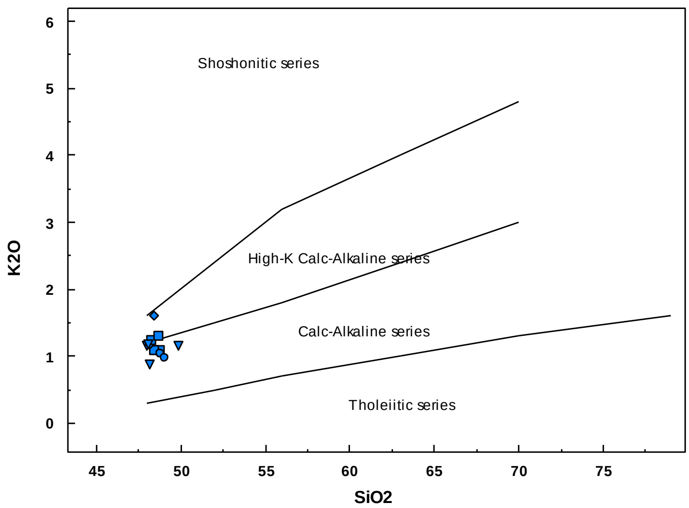


Figure 6. K_2O vs SiO_2 variation diagram (after Peccerilo and Taylor, 1976)

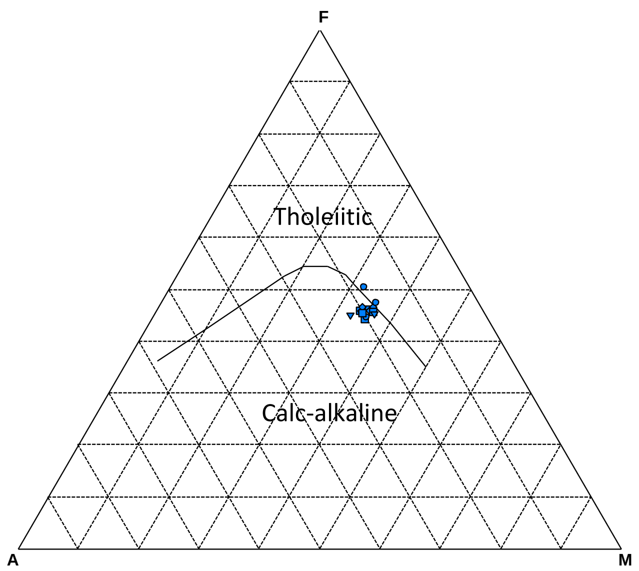


Figure 7. AFM diagram in which A (alkalis: $Na_2O + K_2O$), F ($FeO + Fe_2O_3$), and M (MgO) plot as the corners of the triangle

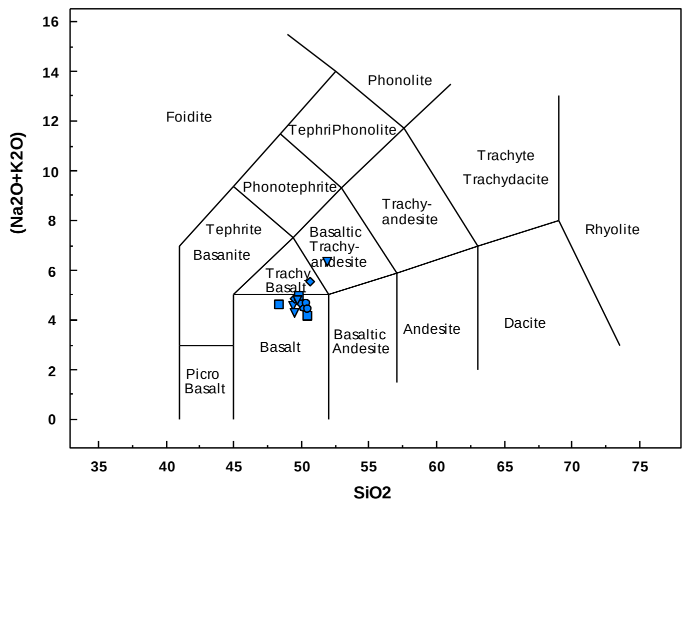


Figure 8. Chemical classification and nomenclature of volcanics based on total alkalis versus silica ("TAS"). After Le Bas et al. (1986) and Le Maitre et al. (2002).

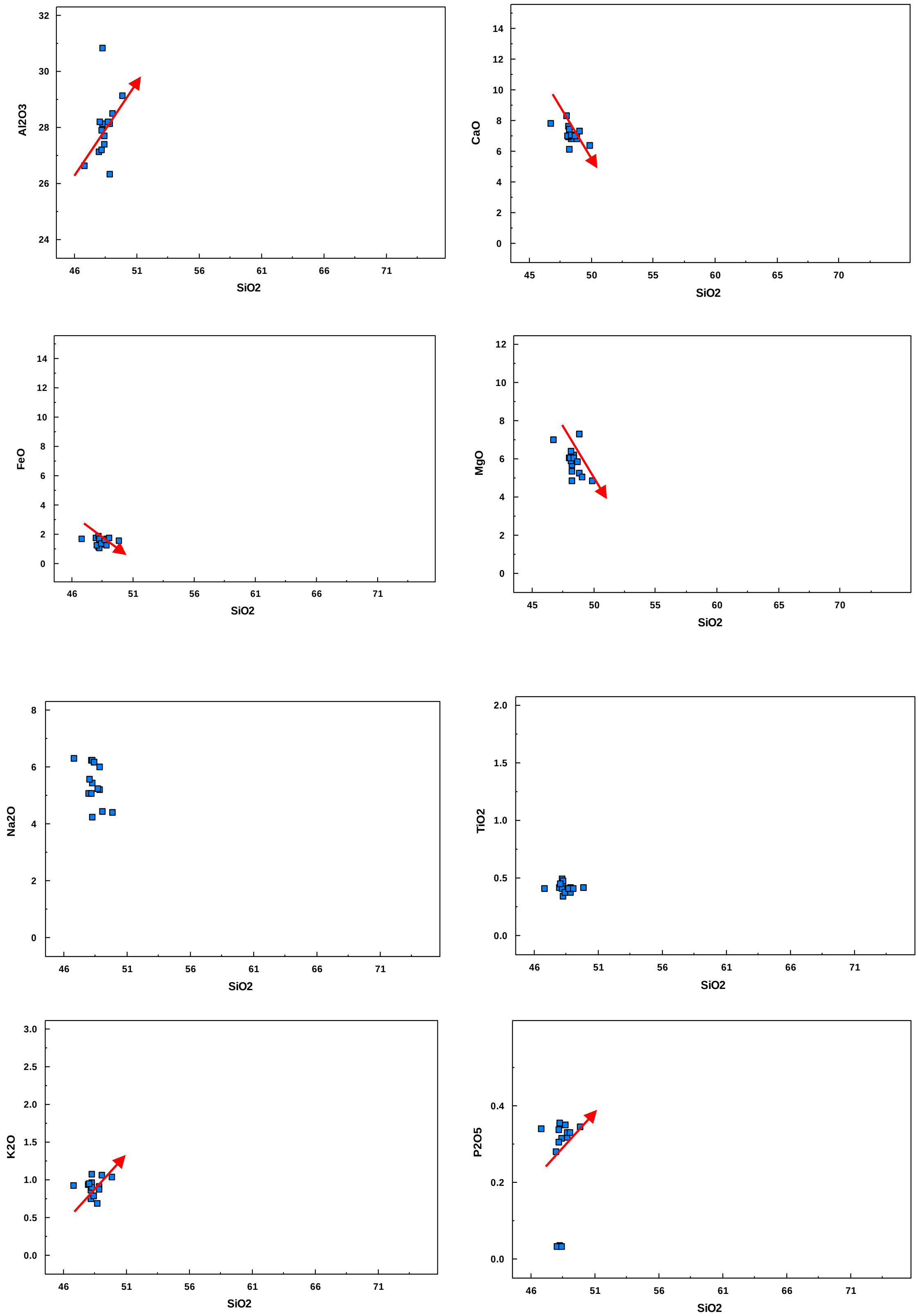
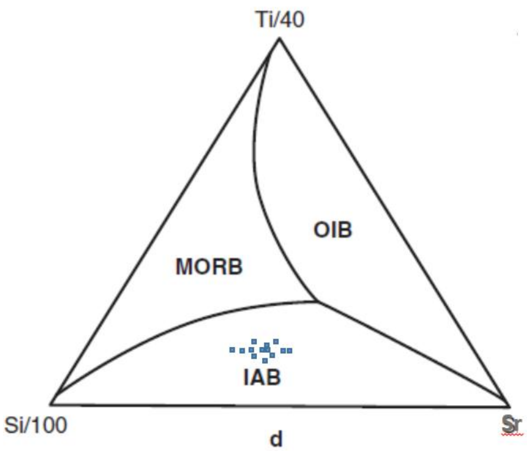


Figure 9. Plots of major elements vs. SiO_2 (Harker diagram) for Kyaukka Taung basalt samples

In Harker's variation diagram (Figure 9), the decrease in MgO, FeO*, and CaO as SiO_2 increases is consistent with the removal of early-forming minerals from the cooling liquid. So, fractional crystallization is responsible for the trends shown in Figure 9. But, Al_2O_3 and K_2O also increase as SiO_2 increases. K_2O, TiO_2, and P_2O_5 are relatively rich in the samples, and they are incompatible elements. Thus, crystal fractionation is not the only process and mixing of mafic magma (mantle melts) and silicic magma (crustal melts) may also be another dominant process. This characters are correspondent with subduction-related magma evolution.



Explanation

MORB mid-ocean ridge basalts
OIT ocean island basalts
IAB island-arc basalts

Figure 10 Discrimination diagrams used to infer tectonic setting of ancient (meta-) volcanics. after Vermeesch (2005)

To infer the original tectonic/igneous setting, recently tested discrimination diagram of Vermeesch (2005) is used. This discrimination diagram is a statistically more rigorous way than the customary method of drawing boundaries by eyes. The Ti-Si-Sr system provided the best linear fit to his database of 756 oceanic basalts of known tectonic affinity. In this discrimination scheme, all of the basalt samples fall in island-arc basalts (IAB) field.

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