

Petrological and geochronological studies of the volcanic rocks in the Muslim Bagh area, Pakistan

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Several type volcanic rocks occurred in the Muslim Bagh (MB) area, which were developed mainly in the Cretaceous period at a continental active margin of the northwestern India subcontinent: Bibai-basalt intruded into the sediment from the Indian subcontinent, Bagh Complex(BC) consisting of melange and basalt-chert unit, and metamorphosed basalts in the Muslim Bagh Ophiolite (MBO) sequence. However, the division among these volcanic rocks is insufficient in terms of whole rock composition, mineral composition, and mineral assemblage. Radiolarians age of the chert layer in the BC implies that tholeiitic basalt in the BC formed during late Jurassic (Sawada et al., 1995), but there are no direct geochronological data for tholeiitic basalt. In addition, hornblende K-Ar age 82-67 Ma reported from meta-dolerite and gabbro in the MBO (Sawada et al., 1995) is unclear whether formation or metamorphic ages. In this study, whole-rock composition, mineral composition, and K-Ar age were investigated to understand the origin and ages of volcanic rocks in the MB area. According to SiO_2 -($\text{Na}_2\text{O}+\text{K}_2\text{O}$) discrimination diagram, the Bibai-basalt and a part of BC-basalt belong to alkali rock series (Alk.), whereas the MBO basalt and the other BC-basalt belong to non-alkali rock series. The latter series were classified into tholeiitic rock series (Tho.) based on $\text{FeO}^*/\text{MgO}-\text{SiO}_2$ diagram. The Harker diagram indicate that the Bibai and BC(Alk.) basalts were rich in Ti and Nb, whereas the BC(Tho.)-basalt was rich in Cr. Alkali series rocks include abundant alkali feldspar, in contrast to plagioclase in non-alkali series rocks. The more metamorphic grade in the MBO-basalt increases, the more anorthite content in plagioclase and $\text{Mg}/(\text{Mg}+\text{Fe}^{2+})$ ratio in hornblende increase. The Bibai-basalt contains Ti-clinopyroxene and Ti-amphibole, and the BC-basalt includes Ca-clinopyroxene. Based on these occurrences, the volcanic rocks in this study area are divided into four types. The BC (Tho.)-basalt yielded the K-Ar feldspar ages of ca. 78 Ma and ca. 51 Ma, which is significantly younger than the late Jurassic previously considered. The former age represents the formation age, whereas the latter age from altered sample may represent the timing of accretion or an apparent age affected by argon loss. The MBO-basalt mainly yielded the K-Ar amphibole ages from 78 Ma to 71 Ma with one exceptional age of ca. 99 Ma. The ca. 78-71 Ma ages are interpreted as the formation age, because there are no clear differences between low-grade and high-grade metamorphosed samples. These ages are also similar with the U-Pb zircon age of ca. 80 Ma obtained from plagiogranite in the MBO (Kakar et al., 2012). The ca. 99 Ma age older than other samples may attribute to the influence by excess argon. The similarities in whole-rock composition and formation ages between the MBO-basalt and BC (Tho.)-basalt implies that the BC(Tho.)-basalt was originally formed with the MBO-basalt. Then, the MBO-basalt experienced the metamorphism during obduction of ophiolite, whereas the BC(Tho.)-basalt was accreted to Indian continent without the metamorphism.

Reference: Sawada et al., 1995, GSP, 12, 73-80; Kakar et al., 2012 Geology, 40, 1099-1102

Keywords: Pakistan, Volcanic rocks, The Whole rock composition, K-Ar age