Magnetic susceptibility and biotite composition of granitoids of Amritpur and adjoining regions, Kumaun Lesser Himalaya

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Felsic magmatism in Amritpur and adjoining localities of Kumaun Lesser Himalaya is represented by Palaeoproterozoic (~1890 Ma) Bt-Ms granitoids and quartz feldspar porphyries, referred to as Amritpur granitoids (AG) and Amritpur porphyry (AP) respectively. The AG are porphyritic and equigranular as well, and extend from Suraijula (west) to Barhoan (east) in the Nainital district of Kumaun Lesser Himalaya. The Main Boundary Thrust (MBT) forms the southern boundary of AG, and quartzite-metabasalts association is exposed in the north. The equigranular variety of AG, referred to as Amritpur leucogranite (ALG) dominates over porphyritic ones, and is medium- to coarse-grained, hypidiomorphic, mainly composed of K-feldspar (perthite), quartz and plagioclase (sericite). Muscovite is present associated with biotite but varies in proportion ranging from rare to noticeable amount. The magnetic susceptibility (MS) measurements of AP and AG were carried out in the field on smooth rock surfaces using hand-held SM–20 magnetic susceptibility meter. The obtained MS value (SI unit) was further corrected according to the degree of the rock-surface unevenness. Primary biotites from ALG were analyzed by wavelength dispersive electron-probe microanalysis. Ferrous and ferric iron from total iron (FeO) of biotite was estimated following charge-balance procedures.

The MS values of AP vary from 0.399 to 0.912×10^{-3} SI unit with an average of 0.528×10^{-3} SI (N=17), which typically represent ilmenite series ($\chi \leq 3.0\times10^{-3}$ SI) granite (Ishihara 1977). Medium-grained ALG measures relatively lesser MS values (χ= 0.003-0.148×10^{-3} SI) with an average of 0.062×10^{-3} SI (N=55) compared to coarse-grained ALG which vary from 0.025 to 0.195×10^{-3} SI with an average MS of 0.117×10^{-3} SI (N=18), both being related to ilmenite series granite. Coarse-grained gneissic AG, exposed at places, record the MS values ranging from 0.295 to 0.527×10^{-3} SI with an average MS value of 0.379×10^{-3} SI (N=26). Porphyritic AG, an older lithounit, are xenolith-bearing and xenolith-free, and their MS values range from 0.368 to 0.629×10^{-3} SI and from 0.142 to 0.247×10^{-3} SI with average MS of 0.522×10^{-3} SI (N=10) and 0.190×10^{-3} SI (N=10) respectively. The observed MS variations of porphyritic AG appear related with xenolith incorporation, which might have slightly oxidized the porphyritic AG. The MS values of AP and AG including the ALG typically correspond to ilmenite series granites, and the noted MS variations may be related with their differing contents of ferromagnesian minerals, ilmenite and textural variations. The AG including the ALG are typically peraluminous (S-type) consistent with their nature similar to ilmenite series granites. About 60% of whole-rock data (N=13) of AP (Gupta et al. 1994; Nautiyal and Rawat 1990) are metaluminous (I-type) despite of their exclusively ilmenite series nature. In Japan nearly all the ilmenite series are I-type, and it has been observed that magnetite-/ilmenite-series classification is not exactly equivalent to the I-/S-type classification in terms of alumina saturation index (ASI).

The ALG biotites have ΣX variation between 1.02 and 1.25 atoms in their structural formulae, which are dominantly contributed by potassium. The observed ΣX values more than one in ALG biotites may be due to the replacement of K by the elements Ba, Rb and Cs. Biotites of ALG plot into the field of primary biotite crystallized in felsic magma but scatter at and above the Ni-NiO buffer. However, presence of ilmenite and substantially low MS values (0.003-0.157×10^{-3} SI) of ALG suggest the prevalence of elevated reducing conditions during the evolution of ALG magma. The ALG melt was further reduced at emplacement level as evident by the presence of graphite pods and patches hosted in the ALG near the contact with country-rocks. The biotites of ALG are ferri-biotites showing enrichment in siderophyllite component, which is commonly available in crustally-derived felsic melt. The ALG biotites in terms of MgO-FeO^t Al_2O_3 components show the compositional similarity with the biotites unaccompanied with ferromagnesian minerals, which further suggest their crystallization in crustally-derived felsic magma. The FeO^t/MgO ratio of biotite from ALG varies from 2.93 to 4.94 with an average of 4.00 suggesting the nature of host ALG magma similar to peraluminous (S-type) melt (Abdel-Rahman 1994). Biotites in ALG magma exhibit a negative FeO-Al_2O_3 correlation (**Figure 1**) suggesting dominance of 3Fe~2Al substitution in producing Al-rich biotites, but the substitution of 3Mg~2Al mostly vital in calc-alkaline and peraluminous magma system cannot be unambiguously inferred.

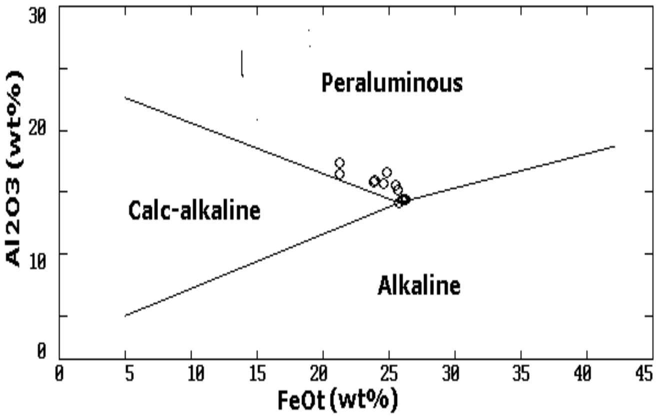

FIGURE 1. Bivariate Al_2O_3 vs. FeO^t plot for biotite(o) hosted in ALG. Biotites from ALG mostly plot in the field of biotites crystallizing in peraluminous (S-type) felsic magma. Fields are taken from Abdel-Rahman (1994)

Japanese and many other granitoids are emperically divided into magnetite and ilmenite series granites using bulk Fe_2O_3 (wt%) / FeO (wt%) ratio of 0.5 at SiO_2 content of 70 wt%; $Fe_2O_3/FeO > 0.5$ magnetite series, $Fe_2O_3/FeO < 0.5$ ilmenite series (Ishihara 1979). Bulk Fe_2O_3/FeO ratio of AP (N=13) indicates proportion of 6:7 for magnetite to ilmenite-series in the silica range of 59.82 to 75.37wt%, suggesting that ilmenite series more-or-less equals the magnetite series for AP. On the other hand Fe_2O_3/FeO ratio of AG (N=17) varies from 0.01 to 0.18 except one sample (Fe_2O_3/FeO =0.87) in the SiO_2 range of 67.08 to 78.74 wt %, which indicates that most AG are ilmenite series granites and are in accordance with the observed MS values. Ilmenite series nature of AG is consistent with their peraluminous (S-type) nature, whereas AP represents both peraluminous (S-type) and metaluminous (I-type) as well. Biotite compositions from ALG suggest their evolution and stability in peraluminous (S-type) felsic melt, and hence it can be concluded that the ALG magma is essentially derived by the partial melting of crustal protolith (metapelite), which subsequently evolved under reducing environment most likely prevailed during pre-Himalayan syntectonic orogeny.

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