Mineral composition control on inter-mineral iron isotopic fractionation in granitoids

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Previous studies suggested that increase of iron isotope fractionation between high-silica melts and crystallizing minerals is the key to understand the heavier Fe isotopic compositions of high-silica granitic rocks relative to that of dioritic-granodioritic ones. But it is unclear how the β factors of minerals change with the composition variation of their co-existing melts. This study reports elemental and iron isotopic compositions of feldspar and its coexisting minerals from four Dabie I-type granitoids to evaluate the factors that control inter-mineral Fe isotopic fractionation in granitoids. The order of heavy iron isotope enrichment is feldspar > pyrite > magnetite > biotite ≈ hornblende. Feldspar has heavier iron isotopic compositions than its co-existing magnetite (Δ^{56}Fe plagioclase−magnetite = +0.376‰ to +1.084‰, Δ^{56}Fe alkali-feldspar−magnetite = +0.516‰ to +0.846‰), which can be attributed to its high Fe^{3+}/Fe_{tot} ratio and low coordination number (tetrahedrally-coordinated) of Fe^{3+}. $\Delta^{56}Fe_{magnetite-biotite}$ of coexisting magnetite and biotite ranges from 0.090‰ to 0.246‰. The large variations of inter-mineral fractionation among feldspar, magnetite and biotite strongly depend on mineral compositions. The $\Delta^{56}Fe_{plagioclase-magnetite}$ and $\Delta^{56}Fe_{alkali\text{-}feldspar-magnetite}$ are positively correlated with albite mode in plagioclase and orthoclase mode in alkali-feldspar, respectively. This could be explained by different Fe-O bond strength in feldspar due to different $Fe^{3+}/\Sigma Fe$ or different crystal parameters. The $\Delta^{56}Fe_{magnetite-biotite}$ increases with decreasing $Fe^{3+}/\Sigma Fe_{biotite}$ and increasing mole $(Na+K)/Mg_{biotite}$, indicating a decrease of β factor in low $Fe^{3+}/\Sigma Fe$ and high (Na+K)/Mg biotite.

High-silica leucosomes from Dabie migmatites with a feldspar accumulation petrogenesis have higher δ^{56}Fe values (δ^{56}Fe = 0.424‰ to 0.567‰) than leucosome that represents pristine partial melt (δ^{56}Fe = 0.117 ± 0.016‰), indicating that accumulation of feldspar could account for high δ^{56}Fe values of these rocks. High δ^{56}Fe values are also predicted for other igneous rocks that are mainly composed of cumulate feldspar crystals, e.g., anorthosites. Feldspar accumulation, however, cannot explain high δ^{56}Fe values of most high-silica granitoids reported in the literature, based on their low Sr, Ba contents and negative Eu anomalies.