Importance of melt inclusions in study of carbonatites: Insight into Kerimasi melt evolution

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Using compositional data of melt inclusions (n=610) in three different plutonic rocks, we have reconstructed the geochemical evolution of the immiscible silicate and carbonate melt, and various crystalline phases in the subvolcanic reservoir of Kerimasi Volcano in the East African Rift. The results of microthermometric experiments for the melt inclusions combined with the relevant phase diagrams show a temperature-ranges from 1150-1000 through 1000-900 to 900-700 ºC for crystallization of the studied afrikandite, jacupirangite and calciocarbonatite, respectively. Silicate-carbonate liquid immiscibility occurred during the generation of carbonatite magmas from a CO_2-rich melilite–nephelinite parent magma to natrocarbonatite through calcic carbonatite magma at pressure range from 10 to 2 kbar. All these indicate that immiscible silicate and carbonate melts separated from the afrikandite body, which was followed by the formation of jacupirangite from these separated melts. Calciocarbonatite started to crystallize from the calcic carbonate melt that was physically separated during formation of jacupirangite. The fractionating mineral phase assemblage and the element partitioning systematics upon silicate–carbonate melt immiscibility are strongly depended on the parental magma composition. Our results indicate that preferential partitioning of oxidized sulfur (as SO_4^{2-}), Ca and P (as PO_4^{3-}) into the carbonate melt may promote the partitioning of Nb, Ta, Pb and all REE into this phase. However, changes in the partition coefficients of elements between minerals and the coexisting melts along the liquid line of descent are rather significant at Kerimasi. This is why, in addition to the REE; Nb, Ta and Zr are also enriched in Kerimasi calciocarbonatites. Volatiles were incorporated principally in nyerereite, shortite, burbankite, nahcolite and sulfohalite, as identified by Raman spectrometry. These extremely unstable minerals cannot be found in the bulk rocks, because of alteration by secondary processes. Based on these data, an evolutionary model is developed for Kerimasi plutonic rocks, which contributes to our better understanding of the petrogenesis of carbonatites and associated silicate rocks.