Petrology and geochemistry of East-African kamafugites: constraints from inclusions in minerals

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A central problem linked to the origin of potassium-rich igneous rocks is a composition of their mantle source and regime of volatile components. Numerous experimental data suggest orthopyroxene (Opx)-free, clinopyroxene (Cpx)- and phlogopite (Phl)-bearing lithospheric mantle metasomatised by fluid with high proportion of H_2O to CO_2 as source rocks for kamafugites [1]. Our melt, crystal and fluid inclusion data suggest, in contrast, that Opx belongs to the early liquidus mineral association of mafurite and ugandite from East-African rift implying lherzolite or harzburgite source whose melting might have occurred at the presence of essentially CO_2- and probably F- and Cl-rich fluid.

Minerals and glasses were analyzed at 15-20 kV and 12-20 nA of beam current using a JEOL Superprobe JXA-8200 electron microprobe; the concentrations of Ni and Mn in selected Ol phenocrysts were acquired at 20 kV and 200 nA. There are two generations of olivine (Ol-1 and Ol-2) observed in both mafurite and ugandite. Ol-1 forms large (up to 3 mm), euhedral crystals, is Fo_{87-92} with low CaO contents (0.1-0.3 wt%) and coexists with Cr-rich spinel (Sp; Mg# = 0.55-0.61, Cr# = 0.79-0.87, 4.7-6.3 wt% TiO_2), Opx (Mg# = 0.89-0.92; Wo_{2-4}, En_{86-89}, Fs_{8-11}) and Cpx (Mg# = 0.84-0.89; Wo_{36-49}, En_{43-57}, Fs_{7-8}). Ol-2 (0.1-0.3 mm) is Fo_{81-91}, contains up to 1.2 wt% CaO and crystallized together with high-Ti Sp (Mg# = 0.45-0.55, Cr# = 0.38-0.81, 5.7-14.1 wt% TiO_2), Cpx (Mg# = 0.66-0.89; Wo_{46-48}, En_{31-48}, Fs_{5-24}), magnetite, perovskite, Phl, leucite or kalsilite. Crystallization of Ol-1 occurred at 2.5-3.0 GPa, 1150-1200°C and redox conditions (fO_2) corresponding to FMQ, while Ol-2 crystallized at ~0.5 GPa, 1100-850°C, and fO_2 of NNO to NNO+1.5. Fluid inclusions in Ol-1 are nearly pure CO_2 (triple point -57.0 ± 0.3°C). Experimentally homogenized melt inclusions in Ol-2 and Cpx contain 41-44 wt% SiO_2, 4-12 wt% Al_2O_3, 4-8 wt% CaO, very high concentrations of alkalis (8-14 wt% Na_2O, 7-14 wt% K_2O), F (0.7-1.6 wt%) and Cl (0.2-0.9 wt%).

The kamafugitic rocks studied are characterized by the lowest crystallization temperatures among known mantle-derived magmas and are believed to have originated from melting of metasomatized lithospheric mantle without significant overheating relatively the Earth's geotherm. Metasomatism of the source rocks was probably caused by melt or fluid with high CO_2/H_2O ratio.

References

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