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Götzenite- and combeite-bearing mineral assemblages in peralkaline nephelinite at Nyiragongo, East African Rift: Recrystallization around a degassing alkaline magma chamber

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In most igneous rocks, the high field strength elements (HFSE) titanium and zirconium reside in minerals such as ilmenite, titanite, zircon and baddelyite. In some highly peralkaline igneous rocks (agpaitic nepheline syenite, elpidite granite) these minerals are not stable, and the HFSE form complex, Na-, Ca- and volatile bearing silicate minerals.

The central crater of Nyiragongo volcano in the East African Rift has a semi-permanent lava lake which may be regarded as a high-level magma chamber open to the atmosphere. The lavas and pyroclastic rocks of Nyiragongo range in composition from olivine melilitite to nephelinite and minor alkali olivine basalt. The nephelinites range from metaluminous to peralkaline compositions, including strongly peralkaline combeite nephelinite. In fresh peralkaline nephelinite, titanium is hosted in different minerals or mineral assemblages with titanomagnetite $\pm$ perovskite $\pm$ Ti-rich clinopyroxene, but in some holocrystalline, thermally metamorphosed nephelinites, götzenite (ideally Na2Ca5Ti(Si2O7)2F4) is the main Ti-bearing mineral. Götzenite is stable with combeite (Na2Ca2Si3O9), diopside and kirschsteinite, which replace primary magmatic minerals and glassy groundmass. The compositions of coexisting nepheline and kalsilite suggest recrystallization temperatures between 500 and 600 ºC.

A chemographic analysis of the sub-solidus mineral assemblages of götzenite-bearing and götzenite-free peralkaline nephelinite suggests that götzenite is stabilized by elevated fluorine activity combined with moderately high (for nephelinite) silica activity. At increasing peralkalinity, götzenite is likely to break down to perovskite-bearing mineral assemblages coexisting with combeite. The presence of götzenite- and combeite-bearing nephelinite at Nyiragongo is due to the influence of fluorine-rich fluids degassing from magma stored in the lava lake.