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Green-core pyroxenes reveal multi-stage evolution of melilitites and nephelinites from the submarine flanks of Fogo, Cape Verde Archipelago

A. Dürkefälden (1) and T.H. Hansteen (2)

(1) GEOMAR, Kiel, Germany (antje-duerkefaelden@web.de), (2) GEOMAR, Kiel, Germany (thansteen@geomar.de)

Fogo Island, which belongs to the Cape Verde Archipelago, is one of the most active ocean island volcanoes worldwide. Recent primitive volcanism is well-known on the island itself, but has hitherto not been found in the submarine realm anywhere in the archipelago. However, glassy volcanic melilitite and nephelinite samples were dredged from morphologically young volcanic cones in depths of about 1500 – 2000 m on the submarine N and WSW flanks of Fogo, during the RV "Poseidon" cruise 320/2 in 2005. The bulk rocks contain about 10 – 12 wt.% MgO and have high Ni and Cr contents. The main phenocrysts are olivine with cores up to Fo_{88}andstrongly zoned clinopyroxene, which frequently contains green cores characterised by elevated acmite ($NaFe^{3+}$) contents (green-core pyroxenes). Such pyroxenes are an abundant phenomenon in alkaline basaltic rocks worldwide and thus of fundamental interest.

Clinopyroxene-melt barometry using mineral rims (Mg# 73-77) and groundmass glass compositions (Putirka et al., 1996) reveals a main stagnation and crystallisation level of the primitive melts within the uppermost mantle at pressures of 0.44 – 0.74 GPa (14 – 24 km depth). The occurrence of green-core pyroxenes, however, suggests a multi-stage evolution of the primitive magmas. In addition to the elevated acmite contents, these green cores show high Al^{VI}/Al^{IV} ratios, low Ti/Al ratios, low Cr_2O_3 concentrations, and low Mg-numbers (Mg# 54-68), which may reflect crystallisation from an evolved melt. Mineral-melt equilibrium calculations indicate that such cores could have been in equilibrium with phonotephritic to phonolitic melts similar to those occurring as lavas on Fogo and on the neighbouring Cadamosto Seamount. We tentatively performed clinopyroxene-melt barometry on various green cores and the corresponding phonotephritic to phonolitic rock compositions, and obtained pressures overlapping with those obtained from the rim and matrix glass pairs. Our data support the notion that the green-core pyroxenes started crystallisation in contact with evolved melts at upper mantle depths. We suggest that xenocrystic green pyroxenes were incorporated into the primitive melts during ascent and stagnation. The ascending melts probably passed and interacted with pockets of crystal-rich (tephri)phonolitic melts, entraining the future green cores. Our preferred model would require the existence of evolved alkaline magma chambers at upper mantle depths in intraplate settings worldwide.