Fluid inclusions and volatile-rich minerals in nephelinite as tracers of fluids beneath the NW African Craton (Saghro volcanic field, Anti-Atlas, Morocco)

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Fluid inclusions and volatile-bearing minerals in intraplate alkaline lavas attest of the presence of fluids and/or volatile-rich liquid in the mantle. These fluids/liquids may be derived from asthenospheric plumes, metasomatized subcontinental lithosphere or subducted material, and are therefore key elements to understand magma genesis and mantle dynamics. To address the question of the origin and composition of deep fluids, we investigated whole-rock and mineral geochemistry and fluid inclusion study of mafic alkaline lavas from the Saghro volcanic field (NW African Craton).

The mafic lavas are nephelinites with phenocrysts of olivine (Fo_{90-82}), clinopyroxene (Mg# = 87–49), nepheline, magnetite (Xulvö = 0.19–0.21) and volatile-rich minerals: phlogopite, apatite (F = 1.0–2.9 wt.%, Cl = 0.11–0.26 wt.%, SO_2 = 0.06–0.42 wt.%), and pyrrhotite (N_{FeS} = 0.90–0.98). The mineral assemblage and composition constrain the pre-eruptive conditions of nephelinite at oxidized redox state ($\log fO_2$=NNO–NNO+1) and 1000-1100°C (cpx-melt equilibria). Nephelinites are mafic alkaline silica-undersaturated lavas (Na_2O+K_2O = 2.1–6.2 wt.%, SiO_2 = 37–43 wt.%, Mg# = 70–62). Their high Ca/Al (1.0–1.5) and Zr/Hf (44.2–55.9) ratios, high incompatible element concentrations and negative anomalies in K, Zr, Hf and Ti suggest a carbonatite-metasomatised peridotite source.

Primary fluid inclusions are present in olivine (Fo_{90-85}) as (i) isolated or trails of translucent fluid inclusions; (ii) dark isolated inclusions with daughter minerals of nepheline ± apatite, and (iii) multi-phased inclusions with fluid and daughter minerals of nepheline ± apatite ± magnesite ± phlogopite. Microthermometry and Raman spectrometry study of translucent inclusions indicates pure supercritical CO_2. Assuming a temperature of 1100°C, the trapping pressure for pure CO_2 system is in the range 300–1050 MPa.

Our study indicates that fluid and/or volatile-rich silicate liquid (C-O-H-S-Cl-F) is involved during the genesis and evolution of alkaline magma. Thus fluid-rock interaction may have been an important process beneath the NW African craton, leading to metasomatised mantle with CO_2–rich carbonatitic components.