CO_2-rich nephelinite differentiation and carbonate-silicate immiscibility (North Tanzanian Divergence)

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North Tanzanian Divergence is the first stage of continental break-up of East African Rift and one of the most concentrated areas of carbonatite magmatism with Natron basin in the North (2 Ma-present - Lengai) and Manyara basin in the southern part (0.4-0.9 Ma). The Manyara basin has volcanic activities with mafic magmas as melilitites (Labait), Mg-nephelinites and carbonatite (Kwaraha), and more differentiated magmas as Mg-poor nephelinites (Hanang) recording deep magmatic environment and differentiation in the crust of CO_2-rich alkaline magmas.

Melilitite and Mg-nephelinite with olivine-cpx-phlogopite record mantle environment at 1.5 GPa-1300°C with water content in melt of 0.1- 0.4 wt% H_2O (1-4 ppm in olivine, FTIR). Although fractional crystallization can be considered as an important process during ascent, leading to Mg-poor nephelinite with cpx-melanite-nepheline, complex zonation of cpx (e.g. abrupt change of Mg#, Nb/Ta, and H_2O) recorded open system with multiple carbonate-rich silicate immiscibility and melilititic melt replenishment. The low water content of cpx (25 ppm H_2O; FTIR) indicates that 0.3 wt% H_2O was present during carbonate-rich nephelinite crystallization at crustal level (600 MPa - 1050°C). The interstitial melt entrapped as melt inclusions (MI) in nepheline evolved to CO_2-rich and H_2O-poor phonolitic composition with 6 wt% CO_2 and 1 wt% S at $\log fO_2$=FMQ+1 to 1.5 ($Fe^{3+}/\Sigma Fe$=0.3 - $S^{6+}/\Sigma S$=0.55, XANES). At 200 MPa, phonolitic melt in MI reaches carbonate saturation and immiscibility process leads to trachytic melt with high CO_2, S and halogen content (0.43 wt% CO_2, SIMS; 2 wt% S, 0.84 wt% Cl; 2.54 wt% F) and very low H_2O content (<0.1wt%, Raman) and an anhydrous Ca-Na±S,K carbonate liquid. The Ca-Na carbonatitic liquid in Mg-poor nephelinite represents an early stage of the evolution path towards carbonatitic magmatism as observed in Kwaraha and Lengai.

Manyara volcanism has similarities with the Natron volcanism with multistage evolution and silicate-carbonatite magmatism but differ by their volatile components (up to 10 H_2O wt% in Lengai nephelinite). This can be interpreted in term of depth of partial melting with H_2O-CO_2 lithospheric mantle source (Natron) and deep anhydrous CO_2-rich asthenospheric mantle source in the southern part of rift initiation (Manyara) and percolation of deep CO_2-rich silicate liquid leading to lithospheric mantle metasomatism.