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Composition and melting conditions of primary basaltic magma from the Etendeka Province – new insight from olivine-hosted melt inclusions

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Information about the primary magma compositions, the nature of mantle components involved and the P-T conditions and degree of melting is of central importance to understanding mantle processes associated with continental breakup in the South Atlantic. Estimating primary compositions from geochemical models based on mineral and rock data is a common approach but subject to large uncertainties. A better alternative is direct study of melt inclusions trapped within early-formed crystals and isolated from the rest of the magma. Here we present data of olivine-hosted melt inclusions and their host crystals from the Henties Bay-Outjo (HOD) dyke swarm and Tafelkop lavas in the Etendeka province of NW Namibia. The prime target for our sampling was the HOD dykes that are interpreted to have been feeders to the Etendeka volcanics, and are characterized by the local presence of high MgO (picritic) compositions. The Tafelkop lavas represent the lowermost lavas in the Etendeka stratigraphy, are thought to be plume-derived, and are therefore of considerable significance for understanding mantle dynamics and magmatism in this province.

Preliminary microprobe results show that olivines with 85 mol.% forsterite or higher are common in the HOD dykes, while olivine in the lavas analyzed are less magnesian (Fo78 or lower). The presence of extremely Mg-rich olivines (up to Fo93.4) reported by Thompson and Gibson (2000), was re-confirmed in picritic dykes SW of the Brandberg Complex. We also found exceptionally Mg-rich olivines (up to Fo93.6) from other dyke localities as well, so the distribution of such high-Mg olivines appears to be larger than previously thought. Most olivines with Fo >85 are too Mg-rich to be in equilibrium with the whole-rock composition, indicating that the grains are entrained xenocrysts which crystallized from an earlier, much more magnesian melts.

Olivine-hosted melt inclusions are found in most examined samples including the xenocrysts with Fo > 90. Melt inclusions range in size from 10-70 microns, are typically round in shape and are partly or completely crystallized. Typical daughter minerals are Al-rich clinopyroxene , Al-rich orthopyroxene, and spinel (chromite). A second common group of inclusions contain a more silicic and hydrous assemblage of daughter minerals comprising quartz, alkali-feldspar, amphibole or a finely intergrown mixture of two- or more of these phases. These inclusions were only found hosted in olivines with forsterite contents of 70 mol % or lower, and clearly evidence trapping of a much more evolved liquid.

The presence of extreme MgO-rich olivines and a mafic daughter mineral assemblage in the entrapped melt inclusions indicates a komatiite parental composition for the most primitive HOD dykes. First-order modeling suggests mantle potential temperatures in excess of 1700°C (Thompson and Gibson, 2000). The nature and origin of these enigmatic melts is a main goal of this research.

References: Thompson, R. N. & Gibson, S. A. (2000). Transient high temperatures in mantle plume heads inferred from magnesian olivines in Phanerozoic picrites. Nature 407, 502-506.