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Peridotite xenoliths from Ethiopia: inferences on mantle processes from Plume to Rift settings

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A comprehensive petrological study has been carried out on Ethiopian mantle xenoliths entrained in Neogene-Quaternary alkaline lavas both overlying the Continental Flood Basalt area (Dedessa River – Wollega Region, Injibara – Gojam Region) and from southern Main Ethiopian Rift (MER – Mega, Sidamo Region) in order to investigate the mantle evolution from plume to rift settings.

Mantle xenoliths from the plateau area (Injibara, Dedessa River) range in composition from spinel lherzolite to harzburgite and olivine websterite, showing P-T equilibration conditions in the range of 1-2 GPa/950-1050 °C. These xenoliths show flat chondrite-normalized bulk-rock REE patterns, with only few LREE-enriched samples (LaN/YbN up to 5). Clinopyroxene (cpx) REE patterns are generally flat or LREE depleted (LaN/YbN down to 0.6). Sr-Nd isotopes on separated cpx mainly show compositions ($^{87}Sr/^{86}Sr < 0.7030$; $^{143}Nd/^{144}Nd > 0.5132$) approaching the Depleted Mantle end-member, or displaced ($^{87}Sr/^{86}Sr$ 0.7033-0.7034; $^{143}Nd/^{144}Nd$ 0.5129-0.5128) toward the Enriched Mantle components which also characterize the Ethiopian Oligocene plateau basalts. These characteristics indicate that most xenoliths reflect complex asthenosphere/lithosphere interactions due to plume-related refertilization processes, whose agents may be envisaged as mafic subalkaline melts that infiltrated and reacted with the pristine parageneses ultimately leading to the formation of olivine-websterite domains.

On the other hand, mantle xenoliths from southern MER (Mega) consist of spinel lherzolite to harzburgites showing various degree of deformation and recrystallization coupled with an extremely wide incompatible element distribution. Bulk rock Rare Earth Element (REE) patterns show generally flat HREE ranging from 0.1 x chondrite (ch) in harzburgites up to 2 x ch in fertile lherzolites, and are variably enriched in LREE, with LaN/YbN up to 41.5. The constituent clinopyroxenes have flat HREE distribution and LaN/YbN between 0.1 and 55, in general agreement with the respective bulk rock chemistry. Sr-Nd-Pb on separeted clinopyroxenes are $^{87}Sr/^{86}Sr$ 0.70220-0.70310, $^{143}Nd/^{144}Nd$ 0.51301-0.51379, $^{206}Pb/^{204}Pb$ 18.38-19.34 for lherzolites, and $^{87}Sr/^{86}Sr$ 0.70268-0.70326, $^{143}Nd/^{144}Nd$ 0.51275-0.51305, $^{206}Pb/^{204}Pb$ 18.46-18.52 for harzburgites, thus ranging in composition between the DM and HIMU mantle end-members. These data suggest variably carbonated alkali-silicate melt(s) as the main metasomatic agent(s) of southern MER xenoliths in agreement with what observed in other mantle xenolith occurrences set along the Red Sea and Gulf of Aden rifted continental margins which radiate from the Afar triple point.

The decidedly different types of metasomatic agents recorded in Ethiopian mantle xenoliths, from the CFB area to the Rift system, clearly reflect distinct tectonomagmatic settings, i.e. the plume-related Oligocene subalkaline magmatism and the Neogene rift-related alkaline volcanism.