Geochemistry of quaternary lavas from the Main Ethiopian Rift – Constraints on continental breakup and rifting

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The Main Ethiopian Rift (MER) is part of the Afro-Arabian Rift System and is located within a transitional zone between continental and oceanic rifting. A bimodal suite of samples from eight volcanic centres within the rift-valley (Ayelu, Dofan, Hertali, Fantale, Kone, Bosetti, Gedemsa and Aluto, from NE to SW) have been analysed on their major and trace element as well as isotopic composition to constrain the spatial distribution and temporal evolution of their magma sources. This may provide insights on the mantle processes that are likely to control continental breakup and rifting within such a transition zone. Furthermore, the magma distribution within the lithosphere potentially controls their heat budget and thus their strength, which directly affects continental breakup and rifting.

Trace element patterns show a great similarity for samples within as well as between individual volcanic centres, suggesting a fairly homogeneous mantle source over the entire sampled range. REE patterns display steep slopes with La/Yb ratios between 5.7 and 14.7 in basalts, reflecting low degrees of partial melting of an enriched mantle source. Trace element patterns of evolved rocks from all locations indicate substantial olivine, clinopyroxene and plagioclase fractionation, which is confirmed by petrographical observations. Negative Sr anomalies, however, are insufficiently explained by fractional crystallisation and require additional processes such as crustal assimilation. The large amount of crystal fractionation observed indicates a long-term residence of primary magmas within the lithosphere and thus most likely considerable heating.

The $^{87}Sr/^{86}Sr$ values range from 0.70354 (Hertali) to 0.70493 (Fantale), $^{143}Nd/^{144}Nd$ ratios vary between 0.512741 (Aluto) and 0.512944 (Hertali). An overall correlation between Nd (and Sr) isotope ratios and latitude exists, with increasing ε_{Nd} values towards the northeast, which might reflect a slightly higher influence of a MORB source mantle close to the triple junction as was also suggested from geophysical data (Keranen *et al.*, 2004). Beside the first order geographical correlation, a relatively wide spread within the isotopic ratios is observed for some volcanic centres. This supports the hypothesis of crustal assimilation during magma ascent and crystal fractionation.

References

Keranen, K., Klemperer, S.L. and Gloaguen, R. (2004), *Geology* **32**, 949-952

Precipitous drop in the carbonated peridotite solidus between 14-16 GPa: Calcic carbonatites in the Earth's transition zone

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Rare-earth element fractionation in continental carbonatites and kimberlites indicates that the parental melts of these volcanic rocks were produced in the presence of a significant amount of residual garnet, which supports the general view that the magmas are produced by a low degree of partial melting at their source region in the mantle. Beneath the ocean basins, the presence of very CO_2-rich melts has been inferred on the basis of the geochemistry of alkalic ocean-island basalts and mantle xenoliths. Recent discoveries of diamond crystals containing transition zone and lower mantle crystalline assemblages indicates that perhaps the host kimberlites also originated in the transition zone and lower mantle. The existence of these magmas suggests melting in the Earth's deep interior. Knowledge of the topology of the relevant solidus near-solidus phase assemblages is critical for models of carbonatite and kimberlite magma genesis and storage of carbon in the mantle at high pressures. In this work, we report melting phase equilibria in the $CaO-MgO-SiO_2-CO_2$ ($CMS-CO_2$) system at pressures of 16-26 GPa, and focus on the peridotitic part of the composition space. At 16, 20, and 26 GPa, the melts are in equilibrium with wadsleyite + cpx + majorite + magnesite, ringwoodite + Ca-perovskite + majorite + magnesite, and Mg-perovskite + periclase + Ca-perovskite + magnesite, respectively, and the solidus is bracketed at 1500-1525, 1700-1750, and 1850-1900^{o}C, respectively. Majorite is produced on melting at 16 and 20 GPa, while Mg-perovskite is produced at 26 GPa. The most remarkable result of our work is that there is a steep drop (~150-170^{o}C) of the solidus temperatures of carbonated mantle assemblage at 16 GPa relative to that in the $CMAS-CO_2$ system at 14 GPa (1650-1680^{o}C). Concomitant with this temperature drop, the composition of the melt changes drastically, as it is relatively depleted in MgO (15-17 wt%) and highly calcic (36-40 wt%) at both 16 and 20 GPa. In fact, these melts are more calcic than the solidus melts either in the $CMAS-CO_2$ system in the 3-14 GPa range or in the carbonated eclogitic natural systems in the 3-10 GPa range. At 26 GPa, the melts again become magnesiocarbonatitic. The steep drop in the solidus temperature and the abrupt change to Ca-rich carbonatitic melts demands a thorough examination of carbonatitic melt formation at extreme depths in the mantle, the relationship of this melting to seismic tomography, enrichment processes in the melt source regions, and the relationship that CO_2-rich melts might have with each other, and with other magmas at various depths in the Earth's mantle.