An isotopic glimpse of the lithospheric mantle beneath the East African Rift System

WENDY R. NELSON[1]*, STEVEN B. SHIREY[1] AND TANYA FURMAN[2]

[1]DTM, Carnegie Institution of Washington, Washington, DC USA (*correspondence: wnelson@dtm.ciw.edu)
[2]Dept. of Gesciences, Pennsylvania State University, University Park, PA 16802, USA

Discerning the influence of various source components (mantle plumes, mantle lithosphere, crust) contributing to >30 Myrs of volcanism in the East African Rift System is difficult because the composition, age, and extent of the lithospheric mantle beneath Ethiopia have remained enigmatic. To better understand the potential role of the lithosphere, we analyzed Re-Os and PGE's of whole rock powders and Sr-Nd-Pb-Hf on clinopyroxene separates of peridotites from NW and S Ethiopia. The peridotites range from lherzolites to harzburgites and websterites. Compared to fertile mantle, all samples have low Os (0.73-2.55 ppb) and Re (0.004-0.075 ppb) concentrations, excepting one websterite (0.56 ppb Os, 0.37 ppb Re). Lherzolites are mildly unradiogenic ($^{187}Os/^{188}Os$ = 0.1236-0.1286) and overlap compositionally with 30 Ma high-Ti flood basalts in NW Ethiopia (0.1247-0.1329 [1, 2]). However, the peridotites have high ε_{Nd} (12.6-18.5), high ε_{Hf} (13.8-27.6), low $^{87}Sr/^{86}Sr$ (0.7019-0.7029) and variable $^{206}Pb/^{204}Pb$ (17.1-17.9 and 18.7-19.3) which, except for Pb, contrasts sharply with flood basalt compositions (ε_{Nd} = 4.7-6.7 [3]; ε_{Hf} = 12.1-13.5 [2]; $^{87}Sr/^{86}Sr$ = 0.7037-0.7043 [2, 3]. This difference demonstrates the lithospheric mantle did not contribute significantly to the production of Ethiopian high-Ti flood basalts. Instead, these flood basalts are derived from the upwelling Afar plume.

Lherzolite model ages calculated for the Re-Os and Sm-Nd isotopic systems vary widely: Re-Os T_{MA} = 0.2-0.6 Ga with one outlier at 1.35 Ga; Sm-Nd T_{DM} = 0.3-0.5 Ga and 1.2-2.6 Ga. Both the model ages and isotopic composition of the peridotites are consistent with mantle xenoliths from Eritrea [4] and Jordan [5]. Not only do the xenolith suites in Afro-Arabia all record the 500-900 Ma Pan-African orogeny, the range in model ages preserve evidence for an earlier, widespread Proterozoic metasomatic event that previously introduced heterogeneities in the lithospheric mantle [5].

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Did the AD 1452 Kuwae eruption have global climatic impact?

K. NÉMETH[1]*, S.J. CRONIN[1] AND I.E.M. SMITH[2]

[1]Massey University, Palmerston North, New Zealand (*correspondence: k.nemeth@massey.ac.nz)
[2]The University of Auckland, Auckland, New Zealand

The eruption and formation of Kuwae caldera, Vanuatu, was inferred to have induced a major atmospheric impact and climate cooling event in the mid-15th century [1]. C14 dating of charcoal from non-welded ignimbrite deposits on the adjacent Tongoa Island, provided an age of AD 1425 [2], later recalculated to AD 1452 and linked to sulphur spikes of ice cores from Greenland and Antarctica [3]. Oral traditions [4] were linked to this catastrophic event, and more-recently tsunami deposits locally as well as on Futuna, Wallis and Efate Islands [5]. Volatile, halogen and sulphur analyses, along with assumptions of the eruption volume based on the caldera dimensions indicate that the Kuwae magma could have been strongly climate-forcing [1]. However, the interpretation of this caldera was formed in a single huge volcanic event may be too simple, based on its complex double-shape and deposit geometry and sedimentology [4]. New stratigraphy, along with whole rock, major element composition of juvenile pyroclasts from the eruptives of Kuwae caldera show evidence for multiple explosive events with very similar compositions, separated by soil-forming breaks. This implies that the caldera was formed in a series of eruptions of the same type of magma, some potentially submarine. The most recent of these events (the AD1452 event) produced a basal basaltic andesitic and capping dacitic ignimbrite in localised areas from multiple apparent vent locations at the edges of a complex caldera. Its volume was probably half to a quarter of whole-caldera estimates (c. f., 1), but its impact was clearly globally relevant in terms of atmospheric chemistry. Earlier explosive eruptions at this centre may also have been violent enough to also generate high eruption columns and a series of earlier atmospheric cooling events. Further dating and geochemical study of this volcano is required to evaluate its past climatic influences and evaluate its potential for future large-scale events of a similar nature.

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