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Constraining the Composition of the Subcontinental Lithospheric Mantle Beneath the East African Rift: FTIR Analysis of Water in Spinel Peridotite Mantle Xenoliths

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Abstract:
The East African Rift System was initiated by the impingement of the Afar mantle plume on the base of the non-cratonic continental lithosphere (assembled during the Pan-African Orogeny), producing over 300,000 km^3 [1] of continental flood basalts ~30 Ma ago. The contribution of the subcontinental lithospheric mantle (SCLM) to this voluminous period of volcanism is implied based on basaltic geochemical and isotopic data. However, the role of percolating melts on the SCLM composition is less clear. Metasomatism is capable of hybridizing or overprinting the geochemical signature of the SCLM. In addition, models suggest that adding fluids to lithospheric mantle affects its stability [e.g. 2, 3]. We investigated the nature of the SCLM using Fourier transform infrared spectrometry (FTIR) to measure water content in mantle xenoliths entrained in young (1 Ma) basaltic lavas from the Ethiopian volcanic province. The mantle xenoliths consist dominantly of spinel lherzolites and are composed of nominally anhydrous minerals, which can contain trace water as H in mineral defects. Eleven mantle xenoliths come from the Injibara-Gojam region and two from the Mega-Sidamo region. Water abundances of olivines in six samples are 1-5ppm H_2O while the rest are below the limit of detection (<0.5 ppm H_2O); orthopyroxene and clinopyroxene contain 80-238 and 111-340 ppm wt H_2O, respectively. Two xenoliths have higher water contents – a websterite (470 ppm) and dunite (229 ppm), consistent with involvement of ascending melts. The low water content of the upper SCLM beneath Ethiopia is as dry as the oceanic mantle [2] except for small domains represented by percolating melts. Consequently, rifting of the East African lithosphere may not have been facilitated by a hydrated upper mantle. [1] Hoffman et al., 1997 Nature 389, 838–841. [2] Peslier et al., 2010 Nature 467, 78-81. [3] Lee et al., 2011 AREPS 39, 59-90.

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