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Formation and evolution of a metasomatized lithospheric root at the motionless Antarctic plate: the case of East Island, Crozet Archipelago (Indian Ocean)

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Sitting atop the nearly stagnant Antarctic plate (ca. 6.46 mm/yr), the Crozet archipelago midway between Madagascar and Antarctica constitutes a region of unusually shallow (1543-1756 m below sea level) and thickened oceanic crust (10-16.5 km), high geoid height, and deep low-velocity zone, which may reflect the surface expression of a mantle plume.
Here, we present new major and trace element data for Quaternary sub-aerial alkali basalts from East Island, the easterly and oldest island (ca. 9 Ma) of the Crozet archipelago. Crystallization at uppermost mantle depth and phenocryst accumulation have strongly affected their parental magma compositions. Their trace element patterns show a large negative K anomaly relative to Ta-La, moderate depletions in Rb and Ba with respect to Th-U, and heavy rare earth element (HREE) depletions relative to light REE. These characteristics allow limits to be placed upon the composition and mineralogy of their mantle source. The average trace element spectrum of East Island basalts can be matched by melting of about 2 % of a garnet-phlogopite-bearing peridotite source. The stability field of phlogopite restricts melting depth to lithospheric levels.
The modelled source composition requires a multistage evolution, where the mantle has been depleted by melt extraction before having been metasomatized by alkali-rich plume melts. The depleted mantle component may be sourced by residual mantle plume remnants stagnated at the melting locus due to a weak lateral flow velocity inside the melting regime, whose accumulation progressively edifies a depleted lithospheric root above the plume core. Low-degree alkali-rich melts are likely derived from the plume source. Such a mantle source evolution may be general to both terrestrial and extraterrestrial environments where the lateral component velocity of the mantle flow field is extremely slow.