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Linking uplift and volcanism of the Borborema Province, northeast Brazil

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The Borborema Province, in northeast Brazil, is characterised by low-relief elevated plateaux sitting at ~800 m above sea level. This elevated region coincides with a positive long wavelength free-air gravity anomaly, lithospheric thickness less than 120 km, and small negative anomalies in some seismic tomographic models. Positive residual depths are observed in oceanic floor to the north and east of the area. Alkaline volcanism occurs throughout the Borborema Province between ~40-13 Ma, and between ~12-1 Ma on the Fernando de Noronha archipelago immediately offshore. Inverse modelling of drainage networks is used to constrain spatial and temporal patterns of uplift of the Borborema Province. River profiles are extracted from the SRTM database and modelled using a simplified version of the stream-power formulation. This model predicts that most uplift occurred within the last 30 Ma, in agreement with independent observations of uplift such as elevated marine sedimentary rocks of Cretaceous age and thermochronologic data. Further, we use forward and inverse modelling of major, trace and rare earth element concentrations of volcanic samples to constrain depth of melting and melt fraction. This study contains 90 samples from the Borborema Province and Fernando de Noronha, including 32 new XRF and ICP-MS analyses. Only samples with SiO_2 > 40 wt% and MgO > 7 wt% were selected in order to minimise complications associated with fractional crystallisation. We assume adiabatic melting of asthenospheric mantle. The mantle source composition is set in accordance with the average isotopic compositions of volcanic samples. In this way, we determine melt fractions of < 2% at ~70 km depth, which is consistent with a background mantle potential temperature of 1315 °C. We then extract radially averaged shear wave velocity profiles from four tomographic models. Anomalously slow velocities are observed in all models between 100 and 200 km depth. By converting shear wave velocity profiles to temperature profiles, we calculate lithospheric thicknesses of 70-120 km and mantle potential temperatures of 1280-1330 °C. Our results are consistent with an upper mantle upwelling generating both surface uplift and volcanism of the Borborema Province. No anomalously hot mantle material is required, but low lithospheric thickness likely plays a key role in the distribution of uplift and volcanism.