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Constraints on Volatile Concentrations in Flood and Shield Lavas from the Afro-Arabian LIP

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Large Igneous Provinces have often been implicated in mass and minor extinction events, driven in part by short term sulphur-mode cooling and long term carbon-mode warming. The Afro-Arabian LIP is a compositionally zoned and diachronously emplaced continental flood basalt, with peak ages of 31-29Ma in the north of the Ethiopian highlands and 26-22Ma to the south. This protracted and pulsed eruption is contrary to LIP models wherein the bulk of flood volcanism occurs in a 1Myr timeframe, and is perhaps linked to cooling and faunal turnover at the Oligo-Miocene boundary, for which volatile delivery plays a role.

We present the first volatile dataset for the Afro-Arabian LIP from c.150 olivine- and pyroxene- hosted melt inclusions spanning temporal and compositional provinces within the flood basalts and overlying shield volcanoes. We use a combination of SIMS and EPMA to quantify the "igneous quintet" of magmatic volatiles (H_2O, CO_2, F, Cl, S) in glasses from both unhomogenised and rehomogenised melt inclusions. Additionally, we present reconstructed CO_2 concentrations using Raman Spectroscopy in rehomogenised melt inclusions where vapour bubbles are present. These results are used to extrapolate a preliminary volatile budget for the LIP, in combination with LIP volume estimates from GIS calculations.

Using concentrations of 1wt% CO_2 and a preserved LIP volume of ~230,000km^3 over Ethiopia, we present a conservative budget of ~3500-6000 GtC outgassed over the lifetime of the Afro-Arabian LIP. These results are comparable to the Deccan Traps (3300-6600 GtC) [1], and lower than estimates from NAIP (18,000-40,000 GtC) [2] and the Siberian Traps (20,000-88,000 GtC) [2]. We propose that the muted climate response for Afro-Arabia can be, in part, explained by flux. LIP time-averaged fluxes are insubstantial on per annum timescales [2] and it is recognised that in order to constrain impacts on climate, volatile budgets must be evaluated alongside eruption histories. For pulsed LIPs like Afro-Arabia, where time-averaged estimates yield 1-2 MtC/y over a 10Myr timescale (a fraction of modern day global volcanic outgassing), it is crucial to evaluate pulses individually in order to assess climatic impacts.

[1] Hernandez Nava et al (2016)
[2] Saunders et al (2016)