Is plume shape variability real? Evidence from Tristan-Gough-Discovery

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The classic mantle plume “head and tail” model fits only 6+ hotspot tracks on Earth and it is a matter of current debate whether other hotspot tracks are formed by plumes. Recent numerical models of thermochemical plumes depict highly variable plume shapes including stalled mid-mantle plume heads, where the tracks from secondary plumelets would indicate only a plume tail. However, field evidence is needed to confirm the existence of plume shape variability. The Tristan-Gough hotspot track is one of the few consistent with the “head-tail” model. However, the young end of the Walvis Ridge, formed after the plume moved to an off-ridge position, is represented by diffuse, low volume volcanism over a width of ~400 km in contrast to the typical ~200 km wide and compact plume tracks of other “head-tail” plumes. Neither spreading rate, change to off-ridge position or a reduction in buoyancy flux can explain this change in morphology.

We present new Sr-Nd-Pb-Hf isotope and trace element data on Tristan, Inaccessible, Gough and two related seamounts. Tristan and Gough show similarities, but in multi isotope-trace element space their sources are distinct. Seamount samples from the Tristan subtrack overlap with Walvis Ridge DSDP Sites 527-528, suggesting that these signatures were longlived in the Walvis-Tristan plume system. Seamounts on the Gough subtrack suggest the Gough signature has persisted for at least 19 Ma. Gough is also geochemically identical to Discovery Seamount and the end-member of the Discovery anomaly on the mid-Atlantic Ridge (MAR) located some 800 km to the south. He-Ne isotopes of samples from the Discovery anomaly on the MAR indicate a lower mantle contribution. The Gough-Discovery signature differs from the common mantle component FOZO or C, thus, overlap in Sr-Nd-Pb-Hf space is a strong indication for a related source. Either Walvis-Tristan-Gough are formed by a single, laterally heterogenous plume that transposed its shape into a broad plume. Or, Gough-Discovery are formed from plumelets off a broad mid-mantle plume. In either case, plume shape variability is indicated.

The $^{40}Ar/^{39}Ar$ system in young glass (Arico Formation, Tenerife): Implications for partitioning of excess Ar between glass and sanidine

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Dating sanidine in young volcanic rocks is a routine method for obtaining precise and accurate ages in young volcanic systems. However, we know little of the chemical and petrologic controls on the argon concentrations and isotopic composition in volcanic glass, or partitioning between glass and sanidine. Glass is also a desirable phase for dating, as it is the most representative of primary magma composition, however, historically it has been problematic in analytical terms to achieve reliable ages (generally due to excess argon, alteration and/or devitrification of the glass, and Ar loss).

The Arico ignimbrite, Tenerife, Canary Islands (previously dated at 686±10 ka; [1]), was erupted in dry conditions and is thus less likely to be affected by hydration and potassium or argon loss subsequent to eruption. Glass and sanidine from the ignimbrite were analyzed for atmospheric argon compositions prior to irradiation and combined with new age data obtained from multiple step heating experiments.

Excess ^{40}Ar ($^{40}Ar_E$) was detected in all glass samples, (1–10 ppb), but there was no correlation between $^{40}Ar_E$ in the glass and total gas age obtained from the co-existing K-feldspar. Using this information and a conservative minimum age for the Arico Formation of 600 ka, the partition coefficient K_D ($K_D = {}^{40}Ar_{ex(sanidine)}/40Ar_{ex(glass)}$) can be constrained to be less than 10^{-2}. A correlation between the concentrations of $^{40}Ar_E$ and atmospheric derived ^{36}Ar in the glass suggests a consistent mechanism of incorporation of atmospheric and $^{40}Ar_E$ prior to eruption.

[1] Brown, R.J., Barry, T.L., Branney, M.J. Pringle, M.S., & Bryan, S.E. (2003) *Geol. Mag*. **3**, 265-288.