Constraints on the evolution of the heat and primordial He flux from the Iceland mantle plume

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Basalts with $^3He/^4He$ > 10 R_A provide evidence that the Earth still contains primordial volatiles that were trapped during accretion. These basalts are typically hotter than those generated in the convecting upper mantle supporting the contention that they are sourced at the core-mantle boundary and brought to surface in upwelling mantle plumes. Palaeogene picrites from the proto-Iceland plume (PIP), have high $^3He/^4He$ (52 R_A) and melt temperatures (1500°C). Modern Iceland basalts have a maximum $^3He/^4He$ of ~34 R_A and maximum temperatures of 1400°C, attesting to a decrease in the flux of heat and primordial ^3He with time. We have made new $^3He/^4He$ and temperature measurements from Miocene basalts from Vestfirdir – the oldest basalts exposed on Iceland - to determine how the Iceland plume has evolved.

The highest $^3He/^4He$ (42 R_A) is midway between the starting plume and modern Iceland values, demonstrating that $^3He/^4He$ appears to have decreased (monotonically) with time. Al-in-olivine data yield crystallisation temperatures of 1138-1350°C, significantly less than that of PIP and modern Iceland picrites. The apparent 50°C increase of the Iceland plume temperature in the last 15 million years contrasts strongly with the decrease of $^3He/^4He$. This suggests that the heat and primordial ^3He are decoupled in the Iceland plume. This may reflect the different sources (i.e. heat from the core, ^3He from the deep mantle) or different diffusion rates of heat and He across the core-mantle boundary. Either way, the apparent lack of covariance implies that fluctuations in mantle plume temperature and $^3He/^4He$ with time do not *a priori* record the mantle plume flux.