Goldschmidt 2025 Abstract
https://doi.org/10.7185/gold2025.31647

Heavy carbon in Iceland's primordial reservoir

JOSHUA J SHEA[1], OLIVER SHORTTLE[1], JOHN MACLENNAN[1], ERY C HUGHES[2], GLENN GAETANI[3] AND BRIAN DAVID MONTELEONE[3]

[1]University of Cambridge
[2]Te Pū Ao GNS Science
[3]Woods Hole Oceanographic Institution

Carbon degasses early during basaltic magma ascent, making direct estimates of mantle carbon challenging. To circumvent this, geochemical proxies such as CO_2/Ba are used to infer magmatic carbon inventories and mantle reservoirs. Recent work suggests that the ancient mantle, sampled by deep-rooted plumes, may harbour carbon concentrations up to 20 times higher than the shallow mantle [1]. However, these results rely on CO_2/Ba and whether CO_2 is only altered by degassing compared to similarly incompatible elements, and not processes that may disrupt this proxy, such as magma mixing [2]. Here, we report the first high-precision $\delta^{13}C$ values, along with major and trace element data from bubble-free olivine-hosted melt inclusions from Miðfell, Iceland, a high $^4He/^3He$ locality linked to a deep mantle primordial reservoir [3-5]. Our results indicate evidence for pre-entrapment CO_2 degassing as evidenced by $CO_2/Ba < 23$, which fractionates $\delta^{13}C$ toward upper mantle values ($\delta^{13}C$ -7.5 ± 1.4 [6]), yielding $\delta^{13}C$ of -2.74 to -8.66 ‰ with $CO_2 < 1114$ µg/g. In contrast, inclusions with CO_2 between 425 and 1850 µg/g and higher CO_2/Ba between 91 and 219 preserve primary $\delta^{13}C$ values ranging from $\delta^{13}C$ 0.58 to -2.92 ‰, reflecting an isotopically heavy carbon source distinct from the upper mantle. These findings support the presence of a deep and distinct carbon-rich primordial reservoir beneath Iceland consistent with a cosmochemical source. This has important implications for reconstructing mantle carbon inventories and refining volatile cycles.

[1] Miller et al. (2019) Earth and Planet. Sci. Lett. 523:115699
[2] Mathews et al. (2017) Earth and Planet. Sci. Lett. 480:1-14
[3] Mukhopadhyay (2012) Nat. 486:7401
[4] Péron & Mukhopadhyay (2017) Earth and Planet. Sci. Lett. 593:117655
[5] Péron et al. (2021) Nat. 600:7889
[6] Moussallam et al. (2025) Comm. Earth and Env. 6:1