Can we detect carbon rich mantle reservoirs?

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The Earth's surface inventory of carbon is critical for maintaining the planet's habitability, yet the majority of Earth's carbon is likely sequestered in the solid Earth. Understanding how Earth's shallow carbon cycle evolved requires an assesment of the total carbon accreted, how it was distributed between Earth's reservoirs, and how these reservoirs continue to exchange carbon.

The low carbon content of Earth's depleted upper mantle has been well constrained by primitive olivine hosted melt inclusions and the $CO_2/^3He$ ratios of magmatic fluids. Using mass balance constraints we show that either the lower mantle is considerably more carbon rich, or the Earth has lost much of its initial carbon inventory. Distinguising between these scenarios is crucial for understanding the development and maintenance of Earth's shallow carbon cycle.

We assess the carbon content of the lower mantle using new melt inclusion datasets from Iceland, sampling both primordial and recycled mantle material. By comparing carbon concentrations with lithophile element concentrations we find evidence that carbon rich material is transported in the Iceland plume. Furthermore, we demonstrate that such datasets provide only a low bound on the true carbon content of the lower mantle, due to fundamental limits imposed by magma mixing, degassing and inclusion decrepitation. Using a global compilation of melt inclusion analyses we argue these processes occur ubiquitously and are likely to limit our ability to robustly resolve high mantle carbon using melt inclusion datasets. By combining these observations with global mass balance constraints we derive new estimates of the carbon content of primordial and recycled mantle material.