Carbon isotopes in OIB Mantle source

(https://doi.org/10.5880/fidgeo.2026.110)

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2. Citation

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Lo Forte, F.M.; Rizzo, A.L.; Aiuppa, A.; Sandoval Velasquez, A.L.; Romano, P.; Maffeis, A.; Frezzotti, M.L.; Casetta, F.; Ntaflos, T. (2026): Carbon isotopes in OIB Mantle source. GFZ Data Services. https://doi.org/10.5880/fidgeo.2026.110

3. Data description

The Atlantic Ocean hosts a number of intraplate volcanic islands that provide crucial information on mantle plume dynamics, volatile budgets, and the role of recycled components in the deep Earth. Among these islands, Sal (Cape Verde archipelago) and Madeira represent contrasting examples of ocean island basalt (OIB) magmatism. Both are situated above mantle domains associated with plume activity, yet they differ in age, geochemical signature, and eruptive history. Investigating volatile contents, specifically CO_2 concentrations and carbon isotope ratios ($\delta^{13}C$), is essential to constraining mantle source characteristics and understanding processes of melt generation and ascent. Analyses of olivine separates from Madeira, including wehrlite, dunite, and harzburgite, reveal CO_2 concentrations in the range of 4.1×10^{-7} to 9.8×10^{-7} mol/g, averaging approximately 6×10^{-7} mol/g. These values are high compared to other Atlantic islands such as the Canary Islands, underscoring Madeira's volatile-rich character. The $\delta^{13}C$ values are tightly clustered between –1.3‰ and –2.9‰, well above the canonical mantle range of –4‰ to –8‰. Together, these results indicate a mantle source with abundant carbon and minimal isotopic heterogeneity. By contrast, Sal samples yield distinctly lower CO_2 concentrations and more variable isotopic compositions. The reduced CO_2 contents highlight a volatile-poor character, while the $\delta^{13}C$ signatures deviate from mantle norms, suggesting the influence of recycled crustal carbon components. Although CO_2 values are not as elevated as those of Madeira, they nonetheless record measurable volatile release. Madeira's volatile-rich nature, coupled with its narrow isotopic range, points to a mantle source containing abundant primordial or recycled carbonates. The heavy $\delta^{13}C$ values, less negative than typical mantle, may suggest carbonate recycling or limited isotopic fractionation during degassing. The relatively high CO_2 concentrations and pCO_2 values further support the interpretation of a fertile, volatile-bearing mantle beneath Madeira. Sal, in contrast, reflects a more depleted mantle environment. The lower volatile concentrations may be the result of prior melt extraction, leaving behind a refractory source, or efficient degassing during magma ascent. Despite the above, the isotopic heterogeneity, with excursions beyond the canonical mantle range, also suggests the contribution of recycled crustal carbon. This aligns with geochemical models of the Cape Verde archipelago, where variable plume components and lithospheric interactions are thought to generate the wide isotopic range observed across islands.

This publication results from work conducted under the transnational access/national open access action at INGV-Palermo- Stable Isotope laboratory supported by WP3 ILGE - MEET project, PNRR - EU Next Generation Europe program, MUR grant number D53C22001400005.

3.1. Sampling method

Samples were obtained from Sal and Madeira islands. Samples include 5 harzburgites and 3 lherzolites from Sal and 1 dunite, 1 wehrlite and 1 harzburgite from Madeira island. Samples were properly prepared at the University of Palermo: all samples were crushed and sieved with the aim of hand-picking crystals of olivine and pyroxene with diameters > 0.5mm. A minimum of 1gr of olivines was collected for each aliquot. After picking, samples were transferred to the noble gas isotopes Laboratory of the INGV-Palermo in order to be cleaned ultrasonically in HNO3, deionized water and high-purity acetone; subsequently, olivine aliquots were accurately weighed.

3.2. Analytical procedure

Laboratory: *Noble gas isotope laboratory and Stable isotope laboratory at INGV–Palermo*

Samples were crushed and passed through sieves to isolate olivine, orthopyroxene and clinopyroxene crystals larger than 0.5 mm, from which at least 1 g of material was hand-selected for each aliquot. After selection, the crystals were sent to the noble gas isotope laboratory at INGV–Palermo. There, they underwent ultrasonic cleaning—first in a 10% HCl solution and then in deionized water—before being dried, weighed, and placed in a crushing apparatus composed of a stainless-steel holder and a hydraulic press capable of applying a single-step load of about 200 bar. During crushing, a glass sampler submerged in liquid nitrogen captured CO_2 by freezing it. The system was maintained under vacuum (10^{-3}–10^{-4} mbar) using a pumping unit. Afterwards, the sampler was connected to a glass vacuum line equipped with an MKS 626B Baratron® Absolute Capacitance Manometer (10^{-3} to 10 mbar range) for CO_2 purification and quantification (mol/g). The purified CO_2 was then recollected in the same sampler—brought to atmospheric pressure using pure helium—and delivered to the stable isotope laboratory for isotopic analysis. The final results are expressed as CO_2 concentrations (mol/g) and $\delta^{13}C$ values (‰ relative to VPDB).

4. File description

Data is reported in *2026-110_Lo-Forte-et-al_data.xlsx*. δ13C is reported in parts per mille (‰ relative to VPDB). The measured CO2 is expressed in mol/g.