EGU22-10184, updated on 07 Jul 2022
https://doi.org/10.5194/egusphere-egu22-10184
EGU General Assembly 2022

Unveiling the heterogeneous structure of the upper-mantle beneath the Canary and Madeira volcanic provinces

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The Canary and Madeira archipelagos are two hotspots in the Eastern Atlantic (27º to 33º N) that are close (430 km) to each other. Their volcanism is thought to be caused by distinct mantle upwellings. Recent high resolution regional P-wave and S-SKS wave tomography images of the Ibero-western Maghrebian region show subvertical low velocity anomalies under the Canaries, the Atlas ranges and the Gibraltar Arc extending across all the upper mantle to the surface. The anomaly below the Canary archipelago and the Atlas are rooted beneath the mantle transition zone (MTZ) and appear to be connected to a broad and strong low-velocity anomaly in the lower mantle. Beneath Madeira, the slow anomaly has a blob-like shape and is only observed down to ~ 300 km depth, suggesting differences in the development stages of the upwellings at the origin of the two hotspots.

The globally observed 410 and 660 upper-mantle seismic discontinuities are primarily linked to mineral phase transitions in olivine and the study of their local depth variations constrains the intra-mantle heat and mass transfer processes. The presence of discontinuities that are not globally observed may indicate the presence of compositional heterogeneities. For example, a sharp discontinuity has been detected at a depth of around 300 km (named the X discontinuity) beneath several hotspots (including the Canaries one) that could prove that the dominant peridotitic mantle mantle is locally enriched in basalt compositions.

Here, we investigate the fine structure of the upper mantle beneath the Canary and Madeira volcanic provinces by means of P-to-S conversions at mantle discontinuities from teleseismic events recorded at 42 seismic stations (24 in the Canaries and 18 in Madeira). We compute 1304 high quality receiver functions (984 in the Canaries and 320 in Madeira) and stack them in the relative time-slowness domain to identify discontinuities in the 200-800 km depth range. Receiver functions are computed in different frequency bands to investigate the sharpness of the observed

discontinuities. From the analysis of stacked receiver functions, we obtain robust and clear converted phases from the globally detected 410 and 660 discontinuities beneath both volcanic provinces. However, a reflector at ~300 km depth is only observed beneath the Canaries. For the Canary's dataset we also detect multiples (Ppds, where d is the discontinuity depth) from the reflector at 300 km and from the 410 discontinuity while for the Madeira's one, we only detect multiples from the 410. This study allows for a detailed comparison between the two archipelagos. The analysis of arrival times and amplitude of detected phases helps constraining the depth, width, and velocity jump of the observed discontinuities. These parameters and their interpretation based on mineral physics will add new constraints to the understanding of the geodynamical context of the Canary Island and Madeira hotspots.

This is a contribution to project SIGHT (SeIsmic and Geochemical constraints on the Madeira HoTspot; Ref. PTDC/CTA-GEF/30264/2017). The authors would like to acknowledge the financial support of FCT through project UIDB/50019/2020 – IDL.