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3D-ambient noise Rayleigh wave tomography of Fogo volcano, Cape Verde

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Fogo is a volcanic island located in the Cape Verde Archipelago and is one of the most active volcanoes on Earth, with numerous historical eruptions. Fogo has been widely studied from different perspectives, yet detailed characterization of its seismic structure is still missing, since previous seismic studies chiefly focused on regional features or on magmatic-induced seismicity.

Seismic tomography has proven to be a powerful tool to determine the velocity structure in volcanic environments. The energy necessary to perform such studies can be obtained from the seismicity in volcano's vicinity or from ambient seismic noise. At short periods, it is challenging to get good surface wave dispersion measurements on waveforms resultant from earthquakes due to attenuation and scattering; waveforms retrieved from ambient noise cross-correlations are, however, especially useful to image crustal structure.

In this study we used 14 seismic stations from three different networks deployed on Fogo. Ambient noise cross-correlations were computed for all possible inter-station pairs among the same network, through the phase cross-correlation technique. The empirical Green's functions (EGF) were then obtained through the time-frequency phase-weighted stack. To decompose the EGFs in the time-frequency domain and thus obtain the dispersion curves of the Rayleigh waves, we applied the multiple filtering analysis (MFA). The Rayleigh wave fundamental mode group velocity curves were then picked manually and visually inspected for periods between 1 to 10 s. Tomographic inversions of the previously obtained group-velocity measurements were performed using the Fast Marching Surface Tomography package (FMST). To obtain the depth structure beneath Fogo, we extracted the values of velocity, from the set of 2D group-velocity maps, for 608 points of the grid, which are, in practical terms, local dispersion curves. The further inversion of these curves enables the construction of 1D S-wave velocity profiles for each node as a function of depth. The resulting 3D shear-wave velocity model shows two clear high-velocity anomalies: a stronger, well-defined tabular anomaly located between ~5 and 9 km of depth and beneath the entire island footprint, and a weaker but distinct anomaly located at 3–4 km of depth and only extending beneath the southwestern island sector, being absent in the northeast where the lowest

velocities are attained. We interpret these positive anomalies as the result of intrusions of denser, now cooled sills, pervasively below the island edifice (whose base is located at ~5 km) and within the underlying seafloor sediments and crust (where rheological, density and thermal contrasts favor the emplacement of such intrusions), and higher up within the island edifice, beneath the southwestern sector. This latter positive anomaly is consistent with surface deformation represented by the NW-SE Galinheiros normal fault, which cuts across the island and exhibits ~150 m of vertical displacement, with the southwestern block being elevated relatively to the northeastern one. This study presents the first 3D shear-wave velocity model for Fogo, providing new and better insights into the local volcano-tectonic structure.

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