Upper crustal structure of Madeira Island revealed from ambient noise tomography

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Abstract

We present the first image of the Madeira upper crustal structure, using ambient seismic noise tomography. 16 months of ambient noise, recorded in a dense network of 26 seismometers deployed across Madeira, allowed reconstructing Rayleigh wave Green’s functions between receivers. Dispersion analysis was performed in the short period band from 1.0 to 4.0 s. Group velocity measurements were regionalized to obtain 2D tomographic images, with a lateral resolution of 2.0 km in central Madeira. Afterwards, the dispersion curves, extracted from each cell of the 2D group velocity maps, were inverted as a function of depth to obtain a 3D shear wave velocity model of the upper crust, from the surface to a depth of 2.0 km. The obtained 3D velocity model reveals features throughout the island that correlates well with surface geology and island evolution.

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1. Introduction

Madeira Island is an intraplate volcanic island, located in the eastern North Atlantic Ocean, 700 km west of the Moroccan coast. It is a topographically very heterogeneous island, with an emerged area of 737 km² and a maximum altitude of 1861 m. It is connected to the Desert islands (25 km to SE) by the 400 m isobath and to the island of Porto Santo (40 km to NE) by the 3000 m isobaths (Fig. 1A). These islands are part of a region of raised seafloors that develops towards NNE, roughly tracing the magnetic anomalies up to the African plate limit. The Madeira Abyssal plain limits these hills to the West.

Madeira lies in a region of low seismicity rate (<40 events/yr) with events of low to moderate magnitudes (Ml < 4.0). The earthquake distribution is diffuse and can be seen in Fig. S1, available as an electronic supplement to this paper.

Although not a prominent swell (Ito and van Keken, 2007), the Madeira Island lies over a thermal swell (Sleep, 1990) composed of pyroclastic rocks in the Wo r i e n t e d r i f t s y s t e m ,...