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The shallow seismic structure of the Larderello geothermal field (Italy) as seen from Receiver Function analysis

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The Larderello field (Tuscany, Italy) is the oldest example in the world of geothermal energy exploitation for industrial purposes. Despite its century long history of exploration and exploitation, the deep structure (4-8km depth) of the Larderello field is still poorly known, due to (a) the lack of resolution of the applied exploration techniques and (b) the lack of interest in the investigation of deep geothermal reservoirs, given the abundant amount of energy extracted from the shallow reservoirs. Recently, the increasing demand of green-energy promoted a renewed interest in the geothermal industrial sector, which translated into new exploration efforts, especially to obtain a detailed characterization of deep geothermal sources.

We investigate the seismic structure of the Larderello geothermal field using Receiver Function (RF) analysis. Crustal seismic structures are routinely investigated using the RF methodology, where teleseismic P-wave are analysed to extract P-to-S converted phases that can be related to the propagation of the P-wave across a seismic discontinuity. We compute RF from 26 seismic stations, belonging to both temporary and permanent networks: the GAPSS and RETREAT experiments and the Italian Seismic Network. The RF data-set is migrated at depth and decomposed into azimuthal harmonics. Computing the first, k=0, and the second, k=1, harmonics allows to separate the "isotropic" contribution, due to the change of the isotropic properties of the sampled materials (recorded on the k=0 harmonics), from the "anisotropic" contribution, where the energy is related to the propagation of the P-wave through anisotropic materials (recorded on the k=1 harmonics).

Preliminary results allow us: (1) to infer the position of the main S-wave velocity discontinuities in the study area, mainly a shallow Tyrrhenian Moho and a very-low S-wave velocity body in the center of the Larderello dome, at about 5-15km depth; and (2) to map the presence of anisotropic materials at depth beneath the central part of the geothermal field. Our finding are discussed in relation to the distribution of local microseismicity recorded during the GAPSS experiment and to the geometry of the main seismic interfaces inferred from the analysis of active seismic data.