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Inferences on the shear wave velocity structure below the Reykjanes peninsula (SW Iceland) from transdimensional ambient-noise surface wave tomography

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We report on a Bayesian (i.e., probabilistic) inversion for the shear-wave velocity structure of the Reykjanes peninsula, SW Iceland. Travel times of Rayleigh waves traversing the peninsula served as input to the probabilistic algorithm. These Rayleigh waves were retrieved through the application of seismic interferometry to yearlong recordings of ambient seismic noise. The Reykjanes peninsula is well placed for this technique because it is surrounded by ocean, which implies a relatively uniform seismic noise illumination; the latter being a condition for accurate interferometric surface wave retrieval. The Bayesian algorithm uses a variable model parametrization by employing Voronoi cells in conjunction with a reversible jump Markov chain Monte Carlo sampler. The algorithm is entirely data-driven, meaning that, contrary to conventional deterministic tomographic inversions, the user does not need to define any regularization or parameterization parameters to solve the inverse problem.

The geology in the area of interest is characterized by four NE-SW trending volcanic systems, orientated oblique to the divergent plate boundary cutting across the Reykjanes Peninsula. These are from west to east; Reykjanes, Svartsengi, Fagradalsfjall and Krýsuvík, of which all except Fagradalsfjall host a known high-temperature geothermal field. We observe relatively high shear wave velocity patches close to the Earth's surface (top two kilometers) at the location

of these known high-temperature fields. These high velocity anomalies invert to relatively low shear wave velocities (in comparison to shear wave velocities in the same horizontal plane) at depths greater than 3 km. The latter low-velocity anomalies are relatively small below Reykjanes and Svartsengi. At depths of 5 to 8 km, a low-velocity anomaly extends horizontally below Reykjanes and Svartsengi, correlating relatively well with the inferred brittle-ductile transition below the high-temperature fields at 4-5 km depth. The low-velocity anomaly below Krýsuvík is much larger and coincides with a deep-seated low electrical resistivity anomaly. Horizontally, it coincides with the center of an inflation source at 4–5 km depth. For example, in 2010 this resulted in an uplift exceeding 50 mm/year, but several periods of alternating uplift and subsidence associated with increased seismicity have been observed in Krýsuvík since 2009. Our results both confirm and add details to previous models obtained in the area. Our study demonstrates the potential of Bayesian surface wave inversion as a complementary geophysical tool for geothermal exploration.