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Seismic velocity uncertainties and their effect on geothermal predictions: A case study

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Geothermal exploration relies in large parts on geophysical subsurface models derived from seismic reflection profiling. These models are the framework of hydro-geothermal modeling, which further requires estimating thermal and hydraulic parameters to be attributed to the seismic strata. All petrophysical and structural properties involved in this process can be determined only with limited accuracy and thus impose uncertainties onto the resulting model predictions of temperature-depth profiles and hydraulic flow, too. In the present study we analyze sources and effects of uncertainties of the seismic velocity field, which translate directly into depth uncertainties of the hydraulically and thermally relevant horizons. Geological sources of these uncertainties are subsurface heterogeneity and seismic anisotropy, methodical sources are limitations in spread length and physical resolution. We demonstrate these effects using data of the EU-Horizon 2020 project DESCRAMBLE investigating a shallow super-critical geothermal reservoir in the Larderello area. The study is based on 2D- and 3D seismic reflection data and laboratory measurements on representative rock samples under simulated in-situ conditions. The rock samples consistently show P-wave anisotropy values of 10-20% order of magnitude. However, the uncertainty of layer depths induced by anisotropy is likely to be lower depending on the accuracy, with which the spatial orientation of bedding planes can be determined from the seismic reflection images.