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Near surface velocity analysis using distributed acoustic sensing data recorded during the drilling of a geothermal well

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The determination of seismic velocities and their distribution in the subsurface is the target of a large number of geophysical methods. We utilize distributed acoustic sensing (DAS) data, recorded during a 9 days long, continuous survey performed on the Reykjanes peninsula, Iceland, to investigate the shallow velocity structure of the area. DAS is an emerging technology to record temporal strain changes experienced by a solid body using fibre-optic cables as an equivalent to a linear, one component broadband seismometer array. Once a fibre-optic cable is installed, DAS systems can provide a dense channel spacing down to 25 cm.

Continuous data was recorded with a fibre-optic cable installed behind the 22 1/2" anchor casing of well RN-34 in the Reykjanes geothermal field. Useful signals were obtained up to a depth of approximately 190 m below surface with a trace spacing of one meter. During the DAS measurement drilling commenced for the 9 5/8" production liner in approximately 2500 m depth.

To investigate the velocity structure, we use sources provided by activities on the drill site e.g. falling objects. The seismic motion propagates along the fibre-optic cable downhole; we automatically pick amplitude maxima of waves in the records. We also apply seismic ambient noise techniques (seismic interferometry), although generally applied to data recorded at the surface. We apply the standard processing steps of seismic interferometry temporal normalization, spectral withening, and stacking. The virtual shot gathers reveal strong asymmetry between the causal and acausal part, which suggests that most of the noise is generated by the drill site itself. We discuss velocity estimations obtained from this study with others obtained by an active surface wave experiment using a fibre-optic cable at the surface.