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Subsurface seismic imaging with a hammer drilling source at an exploration drilling test center in Örebro, Sweden

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Seismic imaging while drilling technology offers possibilities of imaging ahead of the drill-bit, which could be useful for determining when to go from hammer drilling to core drilling. Moreover, seismic images of the surrounding rock can improve geological models which could be then used to guide drilling programs.

A seismic imaging while drilling field test was carried out in August 2020 at the I-EDDA Test Center next to the Epiroc factory in Örebro, which is an outcome of the EIT Raw Materials funded project “Innovative Exploration Drilling and Data Acquisition (I-EDDA)”. The purpose of the test presented here was to determine if the signals from hammer drilling can be used for seismic imaging around the drill-bit. The I-EDDA test site has been extensively investigated with geophysical investigations, geological mapping and diamond core drilling, and it therefore represents an ideal location to perform the proposed feasibility study.

The data were recorded along a west-east oriented line consisting of 45 active 1C vertical geophones with a spacing of about 2 m and the rig located approximately in the middle of the profile. A reference signal, which is usually recorded by the pilot sensor fixed to the top of the drill string to be used to convert geophone recordings to impulsive-like seismic data, was not available. The passive recordings on the surface were thus correlated with the trace from the geophone closest to the rig.

After data pre-processing and cross-correlation, the shot-gathers were vertically stacked over the length of a drill pipe to achieve further signal improvement. A comparison with the results of a modelling study shows certain agreement. However, it has to be noted that the velocity model obtained from earlier studies and used to generate the synthetic data set here is rather a simple one and the noise level in the real data set is still significant, in spite of careful processing. Besides the strong contamination by the rig noise, more typical for data with smaller offsets, the mono-frequency waveform footprints present in the cross-correlograms, which have been observed in similar experiments where a trace from the nearest geophone was used to approximate the bit signal, could also play a role. The recent results from the active seismic studies conducted at the site have not detected any clear reflections within the bedrock, which further hinders the quality assessment of the seismic signal.

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