Seismic while drilling with a diamond drill bit in project DIVE DT-1B borehole in the Ivrea-Verbano Zone (Western Alps, Italy)

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A unique Seismic While Drilling (SWD) experiment, whereby a diamond coring drill rig as the seismic source has been conducted in the Val d'Ossola, Western Alps, Italy. For the SWD experiment 64 3C-sensors are employed in an array at the surface and the vibrational action of coring the rock acts as an active seismic source within the borehole. The maximum offset of the sensor array is 480 m with non-uniform spacing that increases with distance. The drilling operation took place from early October until mid-December 2022 and reached a depth of approximately 580 m. The seismic sensors recorded at a sampling rate of 1 ms, which is more than sufficient for an expected frequency of up to 200 Hz. The proposed SWD experiment is to evaluate the potential and limitations of the SWD method for diamond core drilling commonly utilized in scientific drilling projects with a focus on fundamental developments of the methodology and data processing techniques. Ideally the drill-bit seismic record should produce a seismic image around the bore hole and ahead of the drill bit. First it is important to determine if a signal can be detected, and to what depth, from a diamond core drill bit. In contrast to percussion or reverse circulation drilling, the diamond core drilling method produces a very weak signal. The seismic data is also heavily contaminated by coherent and random noises generated at the drill site, including rig engines, generators and mud-pumps, vehicles, and the movement of equipment. Separation of these coherent noises using radon transform has thus far failed and other wavefield separation methods are investigated. Using seismic interferometric methods for unknown source positions, we aim to detect the weak signal at known drill bit positions. This is promising especially at drilling depths where the drill-rig and drill-bit wave-fields are spatial or temporal separated from each other, due to their different origins and velocities. Interferograms are obtained using the cross-coherence method, which is applied to the recorded passive seismic data. These are computed from 30sec time windows of the continuous recordings and then stacked into the final interferogram to increase the signal-to-noise ratio. Instead of migration summation, semblance is measured for the interferometric migration process. For the migration process, a constant velocity model is sufficient in this hard-rock environment. The major noise sources that we image are the vibrations of the drill rig and power generator, which appear to mask the weaker signal from the drill bit. In an ongoing second experiment, we utilize grid power, reducing the noise sources to the mud-pumps, rotating string, and rig.