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Multicomponent seismic acquisition for the characterization of the groundwater system at Kurikka, western Finland

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Reflection seismic is indispensable in evaluating depth, lateral extent, and heterogeneity of the shallow aquifers related to e.g., glacial sediments. Kurikka area in western Finland is an example of a complex groundwater system. It is being studied for its potential to supply water to the nearby city of Vaasa (with around ~150000 people and large industries in the area). The confined aquifer is topped with soft lake sediments and clays. Below the clays, a mixture of sands and gravels extends down to the bedrock, which can be as deep as 70-100 m. Felsic rocks (granites, granodiorites) constituting bedrock are weathered, fractured, and faulted. Because of the sparse outcrops, mapping of the bedrock fracture zones was based on gravity data and boreholes. Location, dimension, and connectivity of those fractures constitute a big uncertainty in the groundwater flow modeling.

We performed a multicomponent seismic survey in October 2021 west of the town of Kurikka along 3 seismic profiles in order to characterize the fractured and weathered bedrock, as well as the internal structure of the aquifer and its seal. The seismic profiles were acquired along gravel roads and were crossing the inferred fractures and a zone of a rapid change of bedrock elevation. Besides the geological objectives, we tested the performance of the lightweight Vibroseis source (SeismicMechatronics Lightning) and the operational aspects of the Finnish national pool of seismic instruments (Flex-EPOS) consisting of nodal 3C recorders and 3C geophones (<https://wiki.helsinki.fi/display/FLEX/Large-N+Devices>). Lightning is an electrically driven seismic vibrator (E-vib) based on the linear synchronous motor principle. It weights ca. 90 kg and can be used in both P- and S-wave mode offering 1.3 and 1.8kN force, respectively, with a full-force sweep frequency of 8-400 Hz (capable of sweeping between 1-1000 Hz at lower force). All profiles were shot in P-wave and SH-wave mode, resulting in a comprehensive and good quality 6C dataset. Lightning source proved to provide useful first-break energy up to 600 m offset. A clear bedrock reflection can be correlated in P-P (vertical source – vertical component) and S-S (horizontal source – crossline component) shot gathers. Prominent reflections were also observed in the sediments, with a broadband frequency response (up to 200 Hz).

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