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3D high-resolution reflection seismic imaging of the crystalline bedrock below Ävrö Island, Sweden

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We carried out high-resolution reflection seismic measurements on Ävrö Island, southeastern Sweden, with the main objective to map shallow hydraulically conductive fracture zones within the predominantly granitic crystalline rock. This area has been targeted by the Swedish Nuclear Waste Management Company (SKB) as a possible storage site for high-level radioactive waste . The seismic data were acquired along two crossing 2D profiles. Additionally, the dynamite-source signals were also recorded by a fixed receiver array located at the crossing point of the two 2D profiles. Furthermore, a number of shots were fired within this array, providing a limited 3D coverage of the shallow subsurface under and around the location of the receiver array. Various shallow reflections dipping up to 40 degrees could be identified on the resultant 2D seismic sections. In particular, a prominent sub-horizontal reflection of limited extend at around 240 ms two-way travel time (around 700 m depth) was observed below the array. The aim of our analysis was now to use the recorded limited 3D data set to delineate the location and extension of this reflector in three dimensions. A subset of the reflection-seismic data covering an area of 900 x 600 m within and around the receiver array was subjected to 3D reflection-seismic processing. We employed a processing scheme that includes amplitude balancing, surface-consistent deconvolution, bandpass-frequency filtering, application of top-mute functions and velocity filtering. The application of refraction-static corrections proved to be a crucial step in the processing sequence to compensate for the effect of the in size and composition highly variable unconsolidated cover. Subsequently, we tested pre- and post-stack migration routines to gain a seismic image with spatially correctly located reflections. In spite of the non-optimum acquisition geometry, it was possible to obtain a clear 3D image of the sub-horizontal reflector at around 230-240 ms travel time (around 700 m depth).

The high-amplitude reflection seems to originate from a strong impedance contrast. In crystalline environments, such strong contrasts may be observed at interfaces between felsic and mafic rocks. Thus, we suggest that this high-amplitude and in its extend limited reflection originates from a folded lens of mafic rock.