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The derivation of an anisotropic velocity model from combined surface and borehole seismic experiments at the COSC-1 borehole, central Sweden

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The Scandinavian Caledonides provide a well preserved example of a Paleozoic continent-continent collision, where the surface geology in combination with geophysical data provide control of the geometry of parts of the Caledonian structure. The project COSC (Collisional Orogeny in the Scandinavian Caledonides) investigates the structure and physical conditions of the orogen units and the underlying basement with two approximately 2.5 km deep fully cored boreholes in western Jämtland, central Sweden.
In 2014 the COSC-1 borehole was successfully drilled through the Seve Nappe Complex. This unit, mainly consisting of gneisses, belongs to the so-called Middle Allochthons and has been ductilely deformed and transported during collisional orogeny.
A major seismic survey was conducted in and around the COSC-1 borehole which comprised both seismic reflection and transmission experiments. Combined with core analysis and downhole logging, the survey will allow extrapolation of the structures away from the borehole. The survey consisted of three parts: 1) a high-resolution zero-offset Vertical Seismic Profile (VSP), 2) a multi-azimuthal walkaway VSP in combination with three long offset surface receiver lines, and 3) a limited 3D seismic survey.
Data from the multi-azimuthal walkaway VSP experiment and the long offset surface lines were used to derive a detailed velocity model around the borehole from the inversion of first arrival traveltimes. The comparison of velocities from these tomography results with a velocity function calculated from the zero-offset VSP revealed clear differences in velocities for mainly horizontally and vertically traveling waves. Therefore, an anisotropic VTI model was constructed, using the P-wave velocity function from zero-offset VSP and the Thomson parameters ε and δ. The latter were partly derived from ultrasonic lab measurements on COSC-1 core samples. Traveltimes were calculated with an anisotropic eikonal solver and serve as the basis for the ongoing application of imaging approaches like pre-stack depth migration techniques.