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A combined surface and borehole seismic survey at the COSC-1 borehole

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The ICDP project COSC (Collisional Orogeny in the Scandinavian Caledonides) focuses on the mid Paleozoic Caledonide Orogen in Scandinavia in order to better understand orogenic processes, from the past and in recent active mountain belts. The Scandinavian Caledonides provide a well preserved example of a Paleozoic continent-continent collision. Surface geology in combination with geophysical data provide control of the geometry of the Caledonian structure, including the allochthon and the underlying autochthon, as well as the shallow W-dipping décollement surface that separates the two and consist of a thin skin of Cambrian black shales.

During spring/summer 2014 the COSC-1 borehole was drilled to approx. 2.5 km depth near the town of Åre (western Jämtland/Sweden) with nearly 100 % of core recovery and cores in best quality.

After the drilling was finished, a major seismic survey was conducted in and around the COSC-1 borehole which comprised both seismic reflection and transmission experiments. Besides a high resolution zero-offset VSP (Vertical Seismic Profiling) experiment also a multi-azimuthal walkaway VSP survey took place. For the latter the source points were distributed along three profile lines centered radially around the borehole. For the central part up to 2.5 km away from the borehole, a hydraulic hammer source was used, which hits the ground for about 20 s with an linear increasing hit rate. For the far offset shots up to 5 km, explosive sources were used. The wavefield of both source types was recorded in the borehole using an array of 15 three-component receivers with a geophone spacing of 10 m. This array was deployed at 7 different depth levels during the survey. At the same time the wavefield was also recorded at the surface by 180 standalone three-component receivers placed along each of the three up to 10 km long lines, as well as with a 3D array of single-component receivers in the central part of the survey area around the borehole.

Here we present first preliminary processing results from the multi-azimuthal walkaway VSP survey and the data that were recorded along the three surface lines. The data quality is generally very good and the shot gathers show many clear and strong reflections up to six seconds two-way-traveltime.

In a first step the data set was used to derive a detailed velocity model around the borehole from the inversion of first arrival traveltimes, which is essential for the application of any further imaging approaches. This velocity model was compared to the available logging informations from the COSC-1 borehole and with velocity models derived from older existing high resolution reflection seismic profiles.

The further data processing will employ advanced seismic imaging techniques in order to image and characterize the small scale structures around the COSC-1 borehole including the analysis of anisotropic effects caused by aligned fractures and faults and their relation to the stress regime.