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Advanced seismic imaging of overdeepened alpine valleys

Thomas Burschil (1), Hermann Buness (1), David Tanner (1), Gerald Gabriel (1), Charlotte M. Krawczyk (2,3)
(1) Leibniz Institute for Applied Geophysics, Hannover, Germany , (2) now at Helmholtz Centre Potsdam, GFZ German Research Centre for Geosciences, Potsdam, Germany, (3) TU Berlin, Berlin, Germany

Major European alpine valleys and basins are densely populated areas with infrastructure of international importance. To protect the environment by, e.g., geohazard assessment or groundwater estimation, understanding of the geological structure of these valleys is essential. The shape and deposits of a valley can clarify its genesis and allows a prediction of behaviour in future glaciations. The term “overdeepened” refers to valleys and basins, in which pressurized melt-water under the glacier erodes the valley below the fluvial level. Most overdeepened valleys or basins were thus refilled during the ice melt or remain in the form of lakes.

The ICDP-project Drilling Overdeepened Alpine Valleys (DOVE) intends to correlate the sedimentary succession from boreholes between valleys in the entire alpine range. Hereby, seismic exploration is essential to predict the most promising well path and drilling site.

In a first step, this DFG-funded project investigates the benefit of multi-component techniques for seismic imaging. At two test sites, the Tannwald Basin and the Lienz Basin, the Leibniz Institute for Applied Geophysics acquired P-wave reflection profiles to gain structural and facies information. Built on the P-wave information, several S-wave reflection profiles were acquired in the pure SH-wave domain as well as 6-C reflection profiles using a horizontal S-wave source in inline and crossline excitation and 3-C receivers.

Five P-wave sections reveal the structure of the Tannwald Basin, which is a distal branch basin of the Rhine Glacier. Strong reflections mark the base of the basin, which has a maximum depth of 240 metres. Internal structures and facies vary strongly and spatially, but allow a seismic facies characterization. We distinguish lacustrine, glacio-fluvial, and deltaic deposits, which make up the fill of the Tannwald Basin. Elements of the SH-wave and 6-C seismic imaging correlate with major structures in the P-wave image, but vary in detail. Based on the interpretation, two possible drilling sites are suggested for DOVE that will also prove the seismic interpretation and explain differences in P- and S-wave imaging.

First results for the intermountain Lienz Basin are available from four parallel P-wave sections which show the asymmetric basin shape. The sedimentary base is well imaged down to ca. 0.6 km depth, and internal reflectors point to a diverse fill. Here, S-wave imaging produces less distinct sections and requires more sophisticated processing.

In summary, P-wave imaging is suitable to map overdeepened structures in the Alps while S-wave imaging can contribute additional information.