Seismic imaging in the puzzle of overdeepened Alpine valleys

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Glacial erosion has formed overdeepened valleys and basins, spread over the entire Alpine realm. Subsequent to their erosion, glacial, lacustrine, and/or fluvial deposits have (partly) refilled these troughs. The International Continental Drilling Program (ICDP) funds the project "Drilling Overdeepened Alpine Valleys" to investigate the spatio-temporal evolution of past glaciations in the European Alps by the analysis of the sedimentary succession of overdeepened valleys.
Seismic imaging can can contribute to decipher this puzzle. High-resolution seismic reflection methods reveal the sedimentary succession and project 1-D borehole information spatially. Here, we reveal the erosional and sedimentation history of two Quaternary basin: The Tannwald Basin, Germany (TB; Burschil et al., 2018) and the Lienz Basin, Austria (LB; Burschil et al., 2019). The TB is bedded in Tertiary molasses in the Alpine foreland. Seismic imaging unravels the 240 m thick sedimentary succession, from bottom to top: basal till, allochthones molasses units, basin fines and till of the Dietmanns Fm. (Hosskirchian-Rissian stage), till sequences of the Illmensee Fm. (Rissian-Wurmian stage), and gravel/coarse sand. From that, we hypotheses plucking and deposition of large-scale molasse blocks during glacial erosion. The LB, surrounded by the High Tauern and the Gailtal Alps, is one of the deepest basins in the Eastern Alps (>600 m). Seismic imaging allows us to quantify a local overdeepening of 146 m as part of the Upper Drau Valley that shows >530 m overdeepening. A reverse slope of the basin base exceeds the estimated gradient of the ice slope during last glacial maximum (LGM) that lead to a freezing of subglacial meltwater. Consequently, we infer that glacial erosion has taken place pre-LGM. The sedimentary succession comprises from basin base to surface: basal till with slumping, lacustrine sediments, fluvial deposits of various facies, coarse clastics, and gravel/coarse sand. The overdeepened structure let us estimate a minimum paleo-water depth of 216 m at the beginning of the lacustrine sedimentation that fits well to 246 m of lacustrine deposits.
In conclusion, seismic imaging is a powerful tool to unravel details of the genesis of overdeepened valleys. We demonstrate the method at two diverse examples of overdeepened basins, one in the Alpine foreland and the other inner-Alpine.

References

Burschil T., Buness H., Tanner D., Wielandt-Schuster U., Ellwanger D. & Gabriel G. (2018). High-resolution reflection seismics reveal the structure and the evolution of the Quaternary glacial Tannwald Basin. Near Surface Geophysics, 16(6), 593-610

Burschil T., Tanner D., Reitner J., Buness H. & Gabriel G. (2019). Unravelling the shape and stratigraphy of a glacially-overdeepened valley with reflection seismic: the Lienz Basin (Austria). Swiss Journal of Geosciences, https://doi.org/10.1007/s00015-019-00339-0