Improved seismic imaging of Quaternary overdeepened valleys in the European Alps

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In the Pleistocene, glacier excavated Quaternary valleys and basins worldwide. If these valleys were incised below the fluvial erosion level, we speak of overdeepening. In the Alpine range, classical tongue basins in the mountain foreland and intra-mountainous longitudinal valleys often show an overdeepened character. Subsequent to erosion, glacial, lacustrine, and fluvial deposits refilled the troughs. These sediments preserve the climatic setting of the post-glacial sedimentation. The project Drilling Overdeepened Alpine Valleys (DOVE), funded by the International Continental Scientific Drilling Program, intends to derive the climatic history of the Alps and to correlate the environmental conditions across the mountain range. Overdeepened valleys are our targets of investigation to enhance seismic imaging techniques. Our goals, in the context of DOVE, are to specify the sedimentary succession in detail and, hence, to derive erosion and sedimentation processes.

To this goal, we conducted several reflection seismic surveys at representative locations using P-wave and S-wave technology. High-resolution P-wave imaging enabled us to perform a seismic facies interpretation in the Alpine foreland Tannwald Basin TB (Germany), aided by a research borehole from the nineties (Burschil et al., 2018). LIAG's 4 t vertical vibrator was used as a source. The dense acquisition scheme (2.5 m geophone/5 m source spacing) combined with prestack depth migration allowed us to image previously hidden details in the sedimentary succession. We determine, among other things, displaced molasse units during ice advance and eskers. Seismic imaging additionally benefits from S-wave techniques, e.g. by twice the resolution. We used a horizontal vibrator truck (4 m spacing) as source and two 120 m long landstreamer with horizontal geophones (1 m spacing) as receiver spread. Tailored processing strategies are essential for varying imaging purposes (Burschil & Buness, 2019). In the TB, S-waves are cost-efficient compared to P-waves. We are able to image shallow structures up to a few metres below surface, at which depth ground-penetrating radar reaches its penetration limits and is too shallow for P-wave reflections. A 3-D S-wave survey with 3-component geophones and two horizontal sources, i.e. the electro-dynamic micro-vibrator ELVIS, shows the basin base in ca. 140 m depth using maximum offsets of 70 m only (3 m point/9 m line spacing for both sources and receivers). The DOVE drilling in the TB is scheduled for 2020.

High-resolution data acquired with same parameters in the inner-alpine Lienz Basin (Austria) unraveled the geometry and sedimentary succession of this overdeepened basin (Burschil et al., 2019). The former indicates that the glacial erosion took place before the glacial maximum and the latter let us estimate a maximum paleo-water depth during lacustrine sedimentation. Seismic data of the Basadingen overdeepened valley (Switzerland) are being analysed at present.

References

Burschil et al. (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 & Buness (2019). S-wave seismic imaging of near-surface sediments using tailored processing strategies. Submitted to Journal of Applied Geophysics.

Burschil et al. (2019). Unravelling the shape and stratigraphy of a glacially-overdeepened valley with reflection seismic: the Lienz Basin (Austria). Swiss Journal of Geosciences, online first, https://doi.org/10.1007/s00015-019-00339-0.