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Paleo-Ice flow and overdeepenings in an Alpine setting: Examples from the Tyrolian Alps (Austria)

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Overdeepened valleys and basins are the most interesting features of former glacial action in Alpine areas. Understanding the formation of such phenomena are not only a scientific task but also an important challenge for a society increasingly exploiting sustainable natural resources even in remote areas. The feasibility of hydrogeological or geothermal projects, for instance, depends on the bedrock depth and the sedimentary infill of such valleys.

Generally, overdeepened valleys are formed in areas where the ice discharge was high, such as near the equilibrium line, at valley junctions, or at narrowings of the valley profile. The long known overdeepened tongue basins in the Eastern Alps are regarded as typical examples of the impact of high ice flow velocities combined with increased debris load and running water under hydrostatic pressure around the former (LGM, and older glaciations) equilibrium lines (e.g. van Husen, 2000).

However, within a highly dissected mountain topography like that of the Eastern Alps the existence of overdeepened valleys-parts supposedly also reflects changes in ice flow direction and velocity during glacial history within one glacial event (like the LGM) as well as during the Pleistocene. For example, ice flow in the phase of ice build-up at the beginning of major glaciations is controlled by the topography and trend of the valleys whereas during the climax of the big glaciations a mountain ice cap exists with a continuous discharge across water divides. Thus, the onsets of ice transfluences as well as the valley orientation in relation to the changing ice flow direction are regarded as major conditions for overdeepenings in an inneralpine setting.

Such a complex and changing pattern of ice flow will be shown by the example of the Inn valley and its tributary valleys in the S and E (valley of the Wildschönauer Ache and of the Brixentaler Ache). Based on extensive geological mapping and lithostratigraphy in combination with geophysical surveys, a model of the LGM ice flow, its variation and its effect on glacial erosion is developed. On the one hand the effect of topography on ice dynamics in terms of promoting ice build-up as well as restricting erosion is evident. For the tributary valleys, on the other hand, the biggest amount of glacial erosion most probably occurred during the phase of ice build-up. However, seismic data, especially seismic stratigraphy (Reitner et al., 2007), shows the limitations of paleo-glaciological models derived from the youngest sequence, in this case the LGM sequence, for explaining sedimentary remnants of older glaciations. According to our example shifts of, and changes in, the amount of glacial erosion in tributary valleys may best be explained by changes in the onset of ice transfluences during ice build-up. Hence, a step-by-step lowering of passes and cols (water divides) during pleniglacial conditions had a profound impact on the ice dynamics of the following glaciation and, thus, on the occurrence of overdeepenings.

Our model for a dynamic evolution of morphology presents an inverse relationship between the shaping of the surface and the subsurface and may only hold for a restricted area. However, this non-static view on glacier constellation and its change through time can explain the occurrence of unexpected overdeepenings or changes in erratic clast content elsewhere in dissected, formerly glaciated, Alpine landscapes.

References:

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