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Ice, sediments and plants: Paraglacial adjustment of lateral moraine slopes in time and space

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Worldwide, glaciers are retreating and enlarge glacier foreland areas made up of unstable sediments. A variety of non-glacial processes reworks these sediments, including periglacial processes but also landsliding and water soil erosional processes. Lateral moraines are a hotspot of paraglacial reworking in glacier forelands, however, they have been considerably less studied than glaciofluvial floodplains. Consequently, it is not well understood which factors control paraglacial adjustment of lateral moraine slopes in time and space. Paraglacial adjustment is considered to be completed either once the geological norm of denudation is attained, glacial sediments are exhausted or colonized by vegetation. However, recent research found that paraglacial adjustment can continue below dense vegetation cover of the ecosystem engineer Dryas octopetala with bound solifluction (Draebing and Eichel, 2017; Eichel et al., 2016, 2017). Thus, a new indicator for the completion of paraglacial adjustment is required.

We address these research gaps by combining geomorphic and ecologic methods on lateral moraines in the Turtmann glacier foreland (Switzerland), including a permanent plot survey, soil sampling and geomorphic mapping (Eichel et al., in review). Multivariate statistical analysis of permanent plot data showed that ecosystem engineering, material properties and slope geomorphometry are the most important controls for the occurrence of geomorphic processes and landforms. Furthermore, our data demonstrate that geomorphic processes are often absent once vertical vegetation structure and soil horizons develop, which are therefore valuable indicators for completed paraglacial adjustment.
Based on our results, we developed a conceptual model of ‚paraglacial process and landform succession' in time with four stages: (i) dead ice melt, (ii) gullying, (iii) solifluction and (iv) stabilisation. In space, the geomorphic maps show that paraglacial adjustment is heterogeneous and depends on the identified controls. A diverging paraglacial adjustment was detected for distal and proximal slopes (Draebing and Eichel, minor revisions). On distal slopes, the solifluction stage can occur immediately after deglaciation, while on proximal slopes solifluction can only start once a 'biogeomorphic feedback window' (Eichel et al., 2016) is reached.

Hence, our research links para- and periglacial processes and enhances the understanding of present-day landscape development in cold regions.

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