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Stratified basal diamicts and their implications for subglacial conditions in deeply incised bedrock troughs

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Deep bedrock troughs ("tunnel valleys"), formed below Pleistocene piedmont glaciers, serve as valuable archives of the Quaternary landscape evolution of the Northern Alpine foreland basin. The sedimentary infill of these troughs is often dominated by glacier retreat deposits (e.g. glacio-lacustrine silts), while the context of diamicts and gravels at the base, i.e. directly overlying bedrock, remain controversial with regard to their deposition in a subglacial or proglacial environment. We present results from a set of drill cores that recovered such coarse-grained basal units in a major buried bedrock-trough system in the Lower Glatt Valley, Northern Switzerland. The excellent core recovery has allowed a detailed lithological study combining macroscopic, microscopic and geochemical methods.

The macroscopic analysis revealed that the basal infill comprises diamicts segmented into ∼1-3 m thick layers by sorted interbeds. These interbeds consist either of i) clast-supported gravels interpreted as bedload or lag deposits, or ii) laminated sands and silts representing deposition dominated by low-energy settling. The thinly spaced stacking of sorted and stratified sediments results in a high vertical facies variability. The distinct changes in the energy levels at which the sorted interbeds were transported and deposited are interpreted to indicate alternating phases of a decoupled and coupled ice-bed-interface at the base of the overdeepening. This interpretation is supported by the microstructural analysis performed on thin-sections from diamictons of the basal unit, which reveal a polyphase (brittle and ductile) deformation of the diamicts. A primary indication for a subglacial origin of the deformation comes from an abundance of crushed grains, interpreted as resulting from in-situ fracturing of grains under high tensile stresses, typically attained at grain-to-grain contacts during subglacial deformation. Such a signature is unlikely to occur in a proglacial deposition scenario.

The combined macro- and microscopic evidence suggests that the diamicts originate from a soft deformable glacier-bed, while the sorted interbeds indicate depositional periods of meltwater flow and ponding during local decoupling at the ice-bed interface. The accretionary character of the stacking pattern suggests a repeated switching between a coupled and decoupled state with partial sediment preservation. Decoupling may occur during flotation of the glacier due to insufficient drainage of the glacier bed, or may be initiated by obstacles on the glacier bed. High basal water pressures are in agreement with the large hydrological catchment in the distal portion of the paleo-glacier, paired with the topographic low formed by the overdeepened subglacial basin. The sediments are thus excellent records of subglacial conditions in overdeepened basins.