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Schmidt-hammer exposure-age dating (SHD) of periglacial landforms and its potential for palaeoclimatic and morphodynamic interpretation

Stefan Winkler
University of Würzburg, Department of Geography and Geology, Würzburg, Germany (stefan.winkler@uni-wuerzburg.de)

The potential of periglacial landforms in the context of palaeoclimatic interpretation seems non-controversial due to their connection to climate-driven permafrost conditions. Their utilisation for this purpose may, however, involve specific challenges. Many periglacial landforms represent transitional processes of certain duration rather than clearly defined single events. This complicates their palaeoclimatic interpretation along high risks of postdepositional disturbance by frost-related processes. The latter causes problems for any application of (numerical) dating techniques. For example, although *per se* suited for often boulder-dominated periglacial landforms, cosmogenic radionuclide dating (CRN) faces the problem that large sample sizes would be required to achieve reliable ages.

Schmidt-hammer exposure-age dating (SHD) has been successfully utilised for periglacial landforms during the past years. If independent age data allow establishing local/regional SHD age-calibration curves, it offers the fundamental advantage of obtaining large sample sizes (hundreds or even thousands of boulders). This is crucial for dating diachronous landforms or landforms potentially affected by postdepositional disturbance.

To highlight the potential of SHD the results of investigations on patterned ground and related features on Juvflye in Jotunheimen (South Norway) will be presented. Detailed chronological constraints on their age and period of active formation are still lacking, only their 'fossil' appearance noted in previous studies. Other information is, however, available, for example the present distribution of permafrost or its variability during the Holocene.

By applying a reliable local SHD age-calibration curve all studied patterned ground features seem to have become stabilised and inactive prior or around the onset of the Holocene Thermal Maximum. Whereas an altitudinal gradient with slightly longer activity at higher altitude was detected with sorted circles, no similar signal was detected for sorted stripes. Preliminary results from ongoing investigations point towards similar or even older ages for large solifluction lobes on Juvflye. Recent mophodynamic activity is restricted to minor frost-related processes and include micro-scale frost sorting features and solifluction terracettes.

Formation of all patterned ground features has ceased at the onset of the Holocene Thermal Maximum **despite** the fact that at least middle and higher altitudes of Juvflye have been underlain by permafrost during the entire Holocene (and still are). Their stabilisation seems, therefore, independent of fluctuations of the lower limit of permafrost. A lowering of the permafrost limit during late Holocene cooling towards the 'Little Ice Age' shows no influence with any recent activity

restricted to micro-scale features only.

Summarising, even with numerous questions related to the formation of the periglacial landforms on Juvflye still existing, SHD stabilisation ages challenge the general application of large patterned ground features as palaeoclimatic indicators for permafrost. From a morphodynamic point of view the occurrence of permafrost *per se* cannot be the sole factor for efficient formation of patterned ground. Factors such as soil moisture, availability of suitable substrate etc. need to be taken into account. The formation of patterned ground and related large-sized periglacial landforms could well have be restricted to a relatively limited time period immediately following deglaciation during early Holocene.