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Potential and limitations of the Schmidt-hammer as a relative age dating tool for rock glacier surfaces

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In this study the use of the Schmidt-hammer, as a relative, fieldwork-based dating method, was evaluated by analysing previously published Schmidt-hammer results from 30 different rock glaciers of Lateglacial to Holocene age from different sites in Europe and Japan. Rock glaciers originate from thick debris accumulations (talus and/or till) in high-relief environments that are under cryogenic conditions for a substantial period of time. Surface morphology, extent, and shape are the cumulative result of their entire genesis and thus climatic past. Temporal dates regarding their initiation and evolution period are the key to valuable palaeoclimatic information. Precise dating of rock glacier is difficult and expensive but can be best achieved by applying an integrated approach, using a combination of relative (fieldwork-based methods: Schmidt-hammer rebound value, lichenometry, weathering-rind thickness; photogrammetry-based methods: displacement rates and interpolated streamlines) and absolute (luminescence, exposure/cosmogenic, radiocarbon) dating methods. Absolute dating of rock glacier surfaces is still at an early development stage, expensive and time consuming. Furthermore, these methods have their own suites of assumptions and errors. Relative dating methods are used more frequently and are substantially cheaper. A Schmidt-hammer is a light and portable low-cost instrument traditionally used for concrete stability testing by recording a rebound value (R-value) of a spring-loaded bolt impacting a surface. Beginning in the 1980s, this method has been increasingly applied in glacial and periglacial studies for relative rock surface dating. The obtained R-value gives a relative measure of the surface hardness and thus provides information on the time since surface exposure and degree of weathering. High values are indicative of a lower age and vice-versa. The 30 studied rock glaciers are located in the Swiss (n=10), Austrian (n=8) and Japanese Alps (n=5), in Northern Iceland (n=4), on the Faroe Islands (n=2) and in Northern Norway (n=1). The studied rock glaciers consist predominantly of metamorphic (orthogneiss, paragneiss, mica-schist) and igneous (andesite, basalt, granite) rocks. Therefore, the results at each study site allow a certain degree of comparison. The results show that the Schmidt-hammer method is a powerful tool in rock glacier dating. This is particularly true for large rock glaciers where multiple measurement sites along a longitudinal profile are sampled. R-value data from such profiles enable the establishment of relative chronologies with high temporal resolution. However, the most important limitation of the Schmidt-hammer as a relative age dating tool for rock glacier surfaces is the coarseness of the established chronologies due to high age errors.