Schmidt-hammer exposure-age dating (SHD) of Lateglacial rock glacier systems near the eastern margin of the European Alps

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Rock glaciers are widespread permafrost landforms in Austria. Various rock glacier inventories list more than 4500 rock glaciers in the country; some 30-40% of them are intact. Relict (permafrost free) and pseudo-relict rock glaciers (sporadic and isolated permafrost particularly near the root zone) prevail in number. Rock glaciers are commonly formed over a period of several ka. Dating such landforms helps to understand palaeoclimatic conditions. In this study three rock glaciers consisting of gneiss were dated applying the Schmidt-hammer exposure-age dating (SHD) method. The rock glaciers are located at three neighbouring cirques in the Seckauer Tauern Range named Reichart Rock Glacier (RRG, area 1.26 km^2, length 1800 m, elevation range 1520-1940 m a.s.l.), Schöneben Rock Glacier (SRG, 0.11 km^2, 750 m, 1715-1905 m a.s.l.), and Dürrtal Rock Glacier (DRG, 0.08 km^2, 850 m, 1750-1980 m a.s.l.). RRG is one of the largest rock glaciers in Austria. All three landforms are influenced by lenses of permafrost at present (as indicated by ERT). During the LGM the Seckauer Tauern were covered by valley glaciers and deglaciation occurred presumably already early in the Alpine Lateglacial period. An analogue N-type Schmidt-hammer (proceq) was used for measuring the surface strength of stable blocks at the rock glacier surface by recording a rebound value (R-value) of a spring-loaded bolt. The R-value gives a relative measure of the surface hardness and hence time since exposure to weathering. Eight (RRG) or six (SRG, DRG) Schmidt-hammer measurement sites (with 50-100 individual readings) aligned along longitudinal transects (=former central flow line) between a talus slope (with relatively fresh boulders) in the root zone and the frontal ridge were measured. Mean R-value differences of 30.5 at RRG, 25.1 at SRG, and 20.7 at DRG were revealed along the three transects. The differences between the lowest and the highest R-value at the rock glaciers itself were 19.0 at RRG, 15.2 at SRG, and 10.5 at DRG. The differences in R-values between the talus slopes and the uppermost Schmidt-hammer site at the rock glacier were 11.5 at RRG, 9.9 at SRG, and 10.2 at DRG. No high-quality age control points are available at the studied rock glacier. Therefore, an age-calibration curve cannot be established. An age-calibration curve for gneiss has been established previously for a rock glacier c.110 km west of the study area yielding a mean decrease of 1.46 R/1 ka. This allows the estimate that the rock glacier formation period in the study area stretched over a period of several ka. Not unlikely, the formation of the rock glaciers was initiated already during the Gschnitz stadial (Heinrich 1 ice rafting event) dated to 15.4 ka BP or even earlier. SRG is the oldest rock glacier possibly starting to form during the later part of the Lateglacial ice decay-phase. At least 7-8 ka ago the stabilisation of the uppermost part of the three rock glaciers was accomplished. This rather late stabilisation might be also related to the thermally inert response of coarse rock glacier systems.