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Rock glaciers originating from mass movements: A new model based on field data

J. M. Reitner (1) and A. Gruber (2)

(1) Geologische Bundesanstalt / Geological Survey of Austria, Sedimentary Geology, Wien, Austria (juergen.reitner@geologie.ac.at, 0043 7125674 56), (2) Geological Survey of Austria (alfred.gruber@geologie.ac.at)

The morphological and geological conditions for the formation of rock glaciers in Alpine environments seem to be clear according to our present knowledge (BARSCH, 1996; HAEBERLI et al. 2006). All known examples derive from porous more or less coarse grained sedimentary bodies, either from moraines or, in most cases, from talus fans. In the latter case the debris accumulation originates overwhelmingly from physical weathering, rock falls or rock avalanches in proximity to rockwalls. However, in the course of geological mapping in the crystalline areas of Eastern and Northern Tyrol (Schober Gruppe, Tuxer Alpen) we found an additional setting. Some relict rock glaciers occur directly at the bulging toe of bedrock slopes, which had been affected by deep-seated gravitational slope deformations (REITNER, 2003; GRUBER, 2005). Furthermore rock glaciers are also present in ridge-top depressions and similar graben-like features that originated from gravitational processes in jointed bedrock. In all these cases talus fans with debris accumulation are missing in the source area of those rock glaciers.
According to our model the disintegration of jointed rocks by creeping mass movements resulted in an increased volume of joint space. This enabled the formation of interstitial ice under permafrost conditions. Increased ice saturation led to the reduction of the angle of internal friction and finally to the initial formation of a rock glacier. Abundant material was provided for the further movement and thus for formation of quite large rock glaciers due to the previous and maybe still ongoing slope deformation. Most rock glaciers of this type originated from mass movements of sagging -type (Sackung sensu ZISCHINSKY, 1966), which illustrates the continuous transition from gravitational to periglacial creep process in high Alpine areas.
All studied examples are of Lateglacial age according to the altitude in correspondence to the known amount of permafrost depression compared to modern time. Thus, on the one hand such rock glaciers postdate the formation of the mass movements, which enable a chronological constraint of this phenomenon on the base of our knowledge of climate history. On the other hand, those examples with rock glaciers linked at various altitudes with mass movements also mirror former stepwise permafrost degradation, where rock glacier formation moved to higher altitudes. In this respect, and envisaging a rising permafrost boundary, rock glacier formation on slopes affected by mass movements should be anticipated for the future.

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