

## Th-U age dating of carbonate cement in Quaternary talus successions, Northern Calcareous Alps (Austria)

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In the Northern Calcareous Alps, the calcite cements of lithified Quaternary talus relicts were age-dated by the Th-U method. The determined cementation ages in total comprise a range between about 480 ka to about 5 ka. This implies that the Riss-Würm interglacial age assigned in many cases to lithified talus relicts is obsolete.

In the Northern Calcareous Alps, relicts a few tens of meters to about a kilometre in size of lithified talus successions are common. Over a hundred years, these talus relicts repeatedly triggered speculations on their palaeoclimatic and geomorphic significance. All hypotheses, however, suffered from lack of age control. The age-dating of the talus successions was set back by their lack of „conventional“ time markers (such as fossils or organic remnants) and by absence, in most cases, of a clear-cut chronostratigraphic context. By analogy to the well-preserved alluvial fan-to-talus succession of the Höttinger Brekzie near Innsbruck, if stratigraphic relations did not indicate otherwise, these talus relicts were commonly assigned to the Riss-Würm Interglacial. Th/U age-dating of the carbonate cements of the lithified talus relicts at present provides the only possibility to deduce „minimum depositional“ ages (or “half-bracket” depositional ages) for the talus successions. We sampled successions of talus from NCA for cements. From these, 22 were suited for Th/U dating.

To test the correctness of the Th-U ages derived from the impure cements, two approaches were chosen. (1) Cements of samples of successions of well-established Holocene age were dated. All of these samples yielded ages within the Holocene. (2) “Internal controls” of the method, such as (a) the „closed system check“ ( $^{230}\text{Th}/^{238}\text{U}$  vs.  $^{234}\text{U}/^{238}\text{U}$  activity ratios), and (b) the fit (Pearson’s correlation coefficient) of the regression line of sub-samples in Rosholt diagrams ( $^{230}\text{Th}/^{232}\text{Th}$  vs.  $^{234}\text{U}/^{232}\text{Th}$  activity diagrams), and (c) the fit of calculated single age of sub-samples to the age as deduced from the regression line in the Rosholt diagram.

The Th-U ages of carbonate cement necessarily are cementation ages that post-date deposition of their host sediment by an unknown interval of time. The samples from the Holocene and the stratigraphic setting of some of the age-dated Pleistocene samples, however, suggest that cementation ages in most cases provide valuable minimum constraints on depositional ages. For a sample of pebbly alluvium, however, a substantial lag between deposition and cementation must be inferred. We infer that, in this case, cementation was

associated with an adjacent tufa-depositing spring that became active only well after deposition of the fluvial gravels. In another case, for a crust of impure, wet (?active) flowstone on the wall of a bedrock gorge, an apparently „impossibly“ high age resulted; this latter location will be further sampled.

Age-dating of the calcite cement of a talus relict at Teufelsgäss yielded 480 ka. Despite the high age, in the Rosholt diagram, sub-samples plot close to the regression line. In the “closed system check”, the activity ratios of sub-samples plot into a tight cluster. Both the close fit of the regression and the clustering of activity ratios strongly suggest that the system had remained closed after crystallization. To our knowledge, this is the highest known numerical cementation age of a talus succession in the Alps.

Our Th-U cementation ages of the sampled talus successions in total comprise a range between 480 ka to 5 ka. This indicates that the Riss-Würm interglacial position mostly assigned by tradition to lithified talus is obsolete (save those cases where such an age can be established by other data). Both the Holocene samples and the Pleistocene samples from well-established chronostratigraphic context suggest that cementation in many cases proceeds fairly closely after deposition, with a potential lag of a few ?tens to a few thousands of years. Because cementation necessarily post-dates deposition, this implies that the lithified talus relicts of the NCA in total formed over a significantly longer interval of time than previously assumed.