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(Un)Resolved contradictions in the Late Pleistocene glacial chronology of the Southern Carpathians - new samples and recalculated cosmogenic radionuclide age estimates

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Introduction

Application of cosmogenic nuclides in the study of Quaternary glaciations has increased rapidly during the last decade owing to the previous absence of direct dating methods of glacial landforms and sediments. Although several hundred publications have already been released on exposure age dating of glacial landforms worldwide, very few studies targeted the Carpathians so far (Kuhlemann et al, 2013a; Makos et al., 2014; Reuther et al, 2004, 2007; Rinterknecht et al. 2012).

There are many unresolved or contradictory issues regarding the glacial chronology of the Romanian Carpathians. Recently, some attempts have been made to develop an improved temporal framework for the glaciations of the region using cosmogenic ^{10}Be dating (Reuther et al. 2004, 2007, Kuhlemann et al. 2013a). However, these studies made the picture even more confusing because the local last glacial maximum, for instance, apparently occurred in asynchronous timing compared to each other and also to other dated glacial events in Europe (Hughes et al, 2013).

This situation is even more interesting if we take into account that the local glacial maximum tends to agree with the global LGM derived from the Eastern Balkans (Kuhlemann et al. 2013b), while the penultimate glaciation seems to significantly overtake the LGM advance over the Western Balkans (Hughes et al. 2011).

The primary candidate reasons to resolve these discrepancies are methodological, e.g. insufficient number of samples (one sample/landform) ignoring geological scatter of the data and the application of different half-lives, production rates and scaling schemes during the calculation of exposure ages. Systematic methodological uncertainties in computing exposure ages from measured nuclide concentrations have a significant impact on the conclusions concerning correlations of exposure-dated glacier chronologies with millennial scale climate changes (Balco, 2011). The changes in glacial timing generated by only using the most recent constants for the exposure age calculations has not been considered in the most recent review on the timing of the LGM (Hughes et al., 2013).

Main objective of our study is to utilize the potential offered by the cosmogenic in situ produced ^{10}Be dating to disentangle the contradictions in the available Southern Carpathian Late Pleistocene glacial chronology (Kuhlemann et al, 2013a; Reuther et al, 2004, 2007). We recalculate ^{10}Be data published by Reuther et al. (2007) in accordance with the new half-life and production rate of ^{10}Be. Besides, a new sample set has been collected to establish a precise chronological framework supported by in-situ exposure dating of several additional moraine generations.

Recalculation of previously published ^{10}Be exposure age data

It is important to realize the potential of exposure dated glacial chronologies to broader research questions, like climate reconstructions. However, this is only possible if the calculated exposure ages are internally harmonized in terms of ^{10}Be production rate, half-life and scaling scheme applied during the calculations.

We aim at harmonizing the existing ^{10}Be exposure ages related to the Southern Carpathian glaciations by a recalculation of published exposure ages of the region with the updated half-life of ^{10}Be (1.387±0.012)x10^6 years (Korschinek et al., 2010; Chmeleff et al., 2010) using two widely applied scaling schemes (Stone, 2000; and Dunai, 2001). This value is lower than the formerly accepted half-life of 1.51 Myr.

Concentrations of the samples published by Reuther et al. (2007) were measured at the ETH tandem facility in Zürich relative to laboratory standard S555 (Kubik and Christl, 2010). These were multiplied by 0.9124 to normalize to the 07KNSTD standard (Akçar et al., 2011; Schimmelpfennig et al., 2014). We assumed standard atmospheric pressure and a rock density of 2.7 g/cm^3.

During the recalculations we use the production rate of 4.03±0.2 atoms/g SiO_2/yr, the weighted mean of recently calibrated production rates in the Northern Hemisphere (Balco et al., 2009; Fenton et al., 2011; Goehring et al., 2012; Briner et al., 2012). This ^{10}Be production rate is lower than the production rates previously used in the studies of Reuther et al. (2007) and Kuhlemann et al. (2013a,b), resulting in recalculated ages older than in the original publications by at least 10–20% (Mentlik et al., 2013; Schimmelpfennig et al., 2014).

Results and discussion

According to the formerly published chronological data, the timing of the most extent advance in the Retezat Mountains has been estimated to MIS 4, or during the Rissian (MIS 6) glaciation, based on the relative chronology derived from pedological investigations (Reuther et al., 2004, 2007). However, the assigned in situ ^{10}Be exposure age of the lowermost moraines from the Fagaras Mts is 17.4±3.2 ka (Kuhlemann et al., 2013a). Intriguingly, the later value is in good agreement with the ^{10}Be exposure ages of moraine deposits of the second largest glaciation of the Retezat (with the oldest age: 16.6±1.8 ka) and Paring Mts (17.9±1.6 ka) (Urdea et al. 2011). This period tends to deviate from the peak expected for the Last Glacial Maximum (Hughes et al. 2013).

The recalculated moraine ages (using the polynomials of Stone, 2000) in the Retezat Mts. appear to be ca. 30% older than exposure ages calculated by Reuther et al. (2007). Accordingly, the age of the penultimate glaciation in the Retezat and Paring Mts. seem to be coincident with the global LGM (oldest recalculated exposure ages: 21.9±2.4 ka and 23.6±2.1 ka, respectively).

Surprisingly, we do not experience the expected unidirectional shift in the recalculated ages in the case of the data published by Kuhlemann et al. (2013a) for the Fagaras Mts. Here only one sample was dated by each landform, which makes data interpretation within a chronological framework highly uncertain. The only age data for the lowermost moraine was from the Southern side of the Range. Its recalculated value is 16.3±3.0 ka, very similar to the recalculated age of the second largest moraine (16.5±1.9 and 15.1±2.4; Northern and Southern side respectively), which makes the picture even more confusing.

New samples might help

After the revision of the former exposure dating results our study focuses on the glacial chronology of the Retezat Mountains. Collection of new samples for cosmogenic ^{10}Be exposure age determination occurred in the Stanisoara and Pietrele valleys on the Northern side of the Range. This sampling area coincides with that of Reuther (2007). Our objective is to determine the ^{10}Be exposure age of moraines outside the two most prominent and dated (Reuther et al., 2007) generations (M2 and M3) including the largest and oldest moraine (M1) and the landforms connected to the smaller ice advances (M4-5), which remained undated so far. The smallest moraines possibly have developed during a Holocene cooling phase.

Three boulder-samples were collected from the lateral moraine of the largest glacial advance (M1). Four boulders and a whaleback related to the second largest glacial advance (M2) were sampled. The end moraine of the M3 glacial advance is represented by three boulder-samples. Two samples were taken from the highest prominent lateral moraine most probably belonging to the M4 phase, and 2 samples were collected from boulders of the youngest moraine of a hanging cirque (M5?). Sample preparation occurred at MTA-CSFK-FGI and at CEREGE.

This work is essential to evaluate deglaciation history and glacio-climatological evidences of the area and to achieve a better understanding of local and regional climate oscillations. We will resolve the currently ambiguous chronology of the last glacial maximum (LGM) glacier extent in the Southern Carpathians.

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