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Luminescence dating of glaciofluvial deposits linked to the penultimate glaciation in the Eastern Alps

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ABSTRACT

During the penultimate glaciation vast areas of the Alps were glaciated, with piedmont glaciers protruding into the foreland. In the easternmost part of the northward draining valleys of the Alps, the glaciers did not reach the foreland, but formed valley glaciers confined by the mountainous terrain. This also applies to the Ybbs valley, where samples for luminescence dating out of glaciofluvial gravel accumulations were taken at three locations along the present day river course. In a highly dynamic depositional environment, such as a glacier-fed river system, incomplete resetting of the luminescence signal is possible, in particular when transport distances are short. In such cases, quartz usually is the preferred mineral over feldspar, especially if dose rates are low and may theoretically allow obtaining quartz ages beyond 150 ka. Because previous research has shown, and as corroborated within this study, quartz from the research area exhibits analytical problems in the high age range. Therefore luminescence properties of coarse grain (100–200 μm) quartz and in addition K-rich feldspar were investigated with the aim to reconstruct the chronology of the glacial processes within the Ybbs catchment area. Issues of incomplete bleaching were pIRIR225 encountered and addressed by comparing quartz OSL, fading corrected K feldspar IR50 and pIRIR225 to identify reliable ages. Depositional ages based on quartz OSL and feldspar pIRIR225 signals revealed deposition of ice marginal kame terraces and glaciofluvial foreland terraces during late to middle MIS 6. In combination with results from previous studies, we could reconstruct the valley evolution during the Riss glaciation. Newly gained luminescence ages of the deglaciation in the easternmost Alps coincide with OSL dated deglaciation events in the Western Alps, indicating that climatic change along the north side of the Alps happened simultaneously.

1. Introduction

The Alpine region and its foreland played a major role in the investigation of Quaternary glacial and paleo-climatic processes since the beginning of the 19th century (Agassiz, 1841). At the beginning of the 20th century, Penck and Brückner (1909) developed the model of the "glacial series" in the German part of the northern Alpine Foreland (NAF), a concept that describes the genetic connection of basal till, terminal moraines and adjoining outwash gravels. From the vertical succession of four gravel terrace levels, they developed a morphostratigraphic model which attributes a glacial period to each of these geological units (old to young: Günz, Mindel, Riss, Würm). Based on three elevated, morphologically distinguishable gravel levels in the German NAF, the quadriglacial system was amended by three additional glacials (Biber, Donau, Haslach) by Eberl (1930), Schaefer (1953), and Schreiner and Haag (1982). This morphostratigraphic model is still used in some alpine areas, but has been fine-tuned and amended since then, especially in terms of the chronostratigraphic position of the deposits. However, clear genetic relations in terms of the glacial series often can be ambiguous due to the complete lack of sedimentary remains and the often only poor preservation, especially those of the oldest glacials which underwent several cycles of severe geomorphological changes during subsequent glaciations and interglacials.

In this study we investigated the optically stimulated luminescence (OSL) and infrared stimulated luminescence (IRSL) properties of glaciofluvial quartz (Q) and potassium rich feldspar (KFs) deposited during the penultimate alpine glaciation along the eastern alpine Ybbs River (Fig. 1C). For the first time luminescence

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ages from glaciofluvial sediments attributed to the penultimate glaciation from the eastern part of the alpine realm are presented.

1.1. Penultimate glaciation

Depending on regional lithostratigraphy, the penultimate glaciation is termed the late Saalian glaciation in northern Europe (Ehlers et al., 2011b), Illinosian glaciation in North America (Curry et al., 2011), Guxiang glaciation in the Qinghai-Tibetan plateau (Shangzhe et al., 2011), and the Riss glaciation in the classic stratigraphic approach in the Alps (Van Husen and Reitner, 2011a) – all attributed to the late Middle Pleistocene (Cohen and Gibbard, 2011). The most common chronostratigraphic interpretation is a time equivalence with Marine Isotope stage (MIS) 6, however, this is only rarely based on numerical dating. An important step towards a time constraint of the penultimate alpine glaciation was presented by Drescher-Schneider (2000), who could place a sedimentary sequence starting with a basal till to MIS 6–3 based on palynological findings. During the largest extent of the penultimate alpine glaciation, ice advanced into the NAF, where it formed piedmont-style glacier lobes in vast areas (Schlüchter, 1986; Ehlers et al., 2011a). At that time, glacier extent gradually decreased from west to east, with the most extensive piedmont glaciations in the foreland of the Swiss Alps (Fiebig, 2011). The type locality of sediments of the Riss glaciation, which is correlated with the penultimate glaciation, is located in the Riss valley near Biberach in Southern Germany (Penck and Brückner, 1909). Here, the deposits of the Rissian Rhine glacier record a total of three individual glacial advances (Older-, Middle- and Younger-Riss; Ellwanger et al., 2011). In connection with these terminal moraines of the Riss, two gravel terrace levels can be found: The “Upper High Terrace” (“Obere Hochterrasse”, Middle Riss) and the “Lower High Terrace” (“Untere Hochterrasse”, Younger Riss), with the “Upper High Terrace” gravels deposited unconformably above gravels and basal till of the Older Riss (Schreiner, 1989). A trichotomy of the Riss moraines is also observed in the Bavarian and Upper Austrian part of the NAF including two distinct terrace levels (Van Husen, 1977; Kohl, 1999; Doppler et al., 2011).

In terms of stratigraphy, the difference between recent approaches in the Rhine glacier area (Ellwanger et al., 2011) and the stratigraphic approach in the Eastern Alps (e.g. Van Husen and Reitner, 2011a) is the timing and quantity of reconstructed glacials. While the German stratigraphic chart (Stratigraphic Table of Germany (2002)) subdivides the Riss into two discrete glacials separated by a full interglacial (Ellwanger et al., 1995; Miara et al., 1996; Rögner, 2008), Ellwanger et al. (2011) propose a new

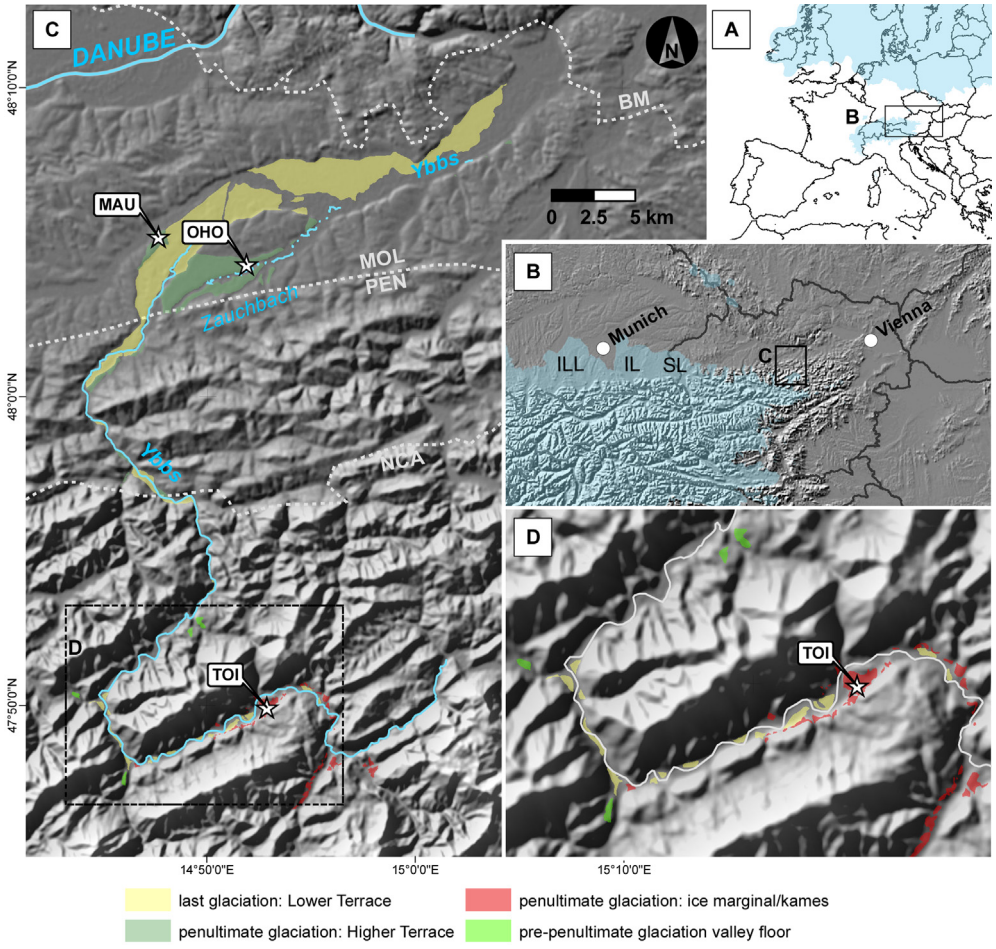

Fig. 1. A: Overview of the Alpine and Northern European ice extent during the penultimate glaciation (Ehlers and Gibbard, 2004) B: Ice extent of the Eastern Alps during the penultimate glaciation characterized by piedmont glaciers extending into the Swiss, German and Austrian NAF. Glacial cover of the easternmost part was not as extensive and glaciers often terminated within the mountainous area (e.g. Ybbs valley). ILL … Isar-Loisach glacier lobe, IL … Inn glacier lobe, SL … Salzach glacier lobe C: Study area. Quaternary units are redrawn according to Ruttner and Schnabel (1988), Krenmayr et al. (2006) and Untersweg et al. (2012). Dashed lines represent borders of major geological units (NCA = Northern Calcareous Alps of the Austro-Alpine mega unit, PEN = Penninic and Helvetic Units, MOL = Tertiary molasse, BM = Bohemian Massive). Investigate sites indicated by stars, MAU = Mauer, OHO = Oberhömbach, TOI = Tonibauer/Hochau. D: Detailed view of the inner alpine surroundings of sampling site TOI. Dashed rectangle in figure C indicates the position of the close up.