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Age–depth relationship and accumulation rates in four sediment sequences from the Retezat Mts, South Carpathians (Romania)

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ABSTRACT

This study summarizes the results of radiocarbon dating and age-depth modelling in four mountain lakes (Brazi, Gales, Bucura and Lia) in the Retezat Mountains. Altogether 69 AMS ^{14}C measurements were performed on these deposits, mostly on terrestrial plant macrofossils. In several cases, plant macrofossils, aquatic animal remains (Cladoceran eggs) and bulk sediment were measured from the same depth allowing for the comparison of various sediment components in terms of their dating potential. Age-depth models were developed using both Bayesian modelling with the BACON and smooth spline curve fitting with the CLAM software. In this study Bayesian models are applied to identify outlier ^{14}C dates, while smooth spline models are used to model sediment accumulation age-depth relations, as these are more likely to follow natural deposition time changes of lake sediments. Changes in sediment deposition times (DT) in relation to catchment size and climate are also studied.

DT varied considerably in the late glacial (LG) part of the records. The sediment sequence characterised by high deposition rates during the late glacial (DT maximum around 100–110 years cm^{-1}) was defined by small catchment size (Lake Brazi, 6 ha; surface area: 0.5 ha). In contrast, much slower LG sediment deposition in the southern slope lake characterised by large catchment area (Lake Lia, 171 ha, 20 years cm^{-1}), principally reflecting strong erosion in these catchment areas at times when vegetation cover was scarce. Holocene was characterised again by variable DT values, but only Lake Gales showed extreme values: 62–110 years between 10,900 and 6050 cal yr BP, followed by much slower sediment deposition in the last 6000 years (av. 29 years cm^{-1}). Generally, sediment deposition times were largely dependent on the stability and vegetation cover of the slope in the case of high altitude deep lakes, while lower altitude, shallow lakes showed slower sediment deposition time in the early and mid-Holocene, when summer insolation was higher than today. This reflects that in these shallow lakes in-lake organic production probably increased with summer insolation, which was a significant driver in the rate of deposition.

1. Introduction

Numerous studies focused on late glacial and early Holocene environmental and climate changes in the Alpine regions of Europe (e.g. Preusser et al., 2007; Ortu et al., 2008; Schwörer, 2012; Moreno et al., 2014) over the last decades. Despite the large number of glacial lakes and intact nature of the Retezat Mts. (Southern Carpathians), this region received somewhat less attention so far regarding its late glacial and Holocene environmental and climatic history (Pop, 1966; PéterfiSt, 1974; Farcas et al., 1999; Braun et al., 2013; Magyari et al., 2013).

The Retezat Mountains were one of the most intensively glaciated regions in the Carpathians during the last glacial period (Reuther et al., 2007; Urdea et al., 2011; Ruszkiczay-Rüdiger et al.,

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2015). Furthermore, several glacier re-advances were detected during the late glacial (LG). Following the retreat of the glaciers a high number of lakes were formed in valleys. As most of the permanent lakes have been accumulating sediment since their formation, they offer an exceptional possibility for reconstructing late glacial and Holocene environmental and climatic changes in this region. However, to achieve this precise chronologies are essential.

Although radiocarbon dating is widely used in lake sediment chronology, dating the period with abrupt climatic and environmental changes associated with frequent changes in depositional environments proved to be challenging in many cases, particularly in high mountain lakes and in unproductive glacial environments (Andree et al., 1986; Wohlfarth, 1996; Turney et al., 1998, 2010; Wohlfarth et al., 1998; Kilian et al., 2002; Watanabe et al., 2009; Chang et al., 2011). To study the past ecosystem responses and climatic changes during the last glacial termination (Blockley et al., 2007; Rasmussen et al., 2014) precise dating of these events from different geographical regions is very important (Veres and Mîndrescu, 2013). Several quality assurance protocols have been recommended particularly by the INTIMATE group to achieve this goal (Lowe and Walker, 2000; Lowe et al., 2008; Walker et al., 2009; Reimer et al., 2013a). Several studies discussed the question of "best material" for dating, i.e. which sediment fraction is the most appropriate for dating (Wohlfarth et al., 1998; Walker et al., 2001) in order to decrease the number of errors due to possible contaminations in the course of sediment sampling and ^{14}C measurement.

Here we report the results of AMS ^{14}C measurements and age-depth models of four lake sediment sequences from the Retezat Mountains in the South Carpathians. In these mountains catchment bedrock is composed of granite and granodiorite (Berza, 2004). Radiocarbon method is widely used for dating lake deposits formed in high mountain environment. The lake sediments, particularly their Holocene sections are rich in organic matter allowing for the dating of sufficient number and quality of samples. The installation of a new MICADAS accelerator mass spectrometer (AMS) with gas ion source interface in Hungary (Molnár et al., 2013b) and the connected state of the art AMS sample preparation laboratory (Molnár et al., 2013a) allowed us to date samples with very low carbon content, and use a high variety of sample material (bulk organic, charcoal fragments, organic plant remains, pollen, insect fragments). Age-depth models based on these radiocarbon dates are essential, since they form a common basis for the evaluation of the large array of multi-proxy records obtained from the same sediment sequences, most of which are described in other papers of this thematic journal issue (Buczkó et al., this issue; Magyari et al., this issue; Tóth et al., this issue).

2. Regional setting

Retezat Mts. are located in the western part of the Southern Carpathians (45°20′ N, 22°23′ E) with 466 km^2 total surface area. These mountains possess the highest number of glacial lakes in the Carpathians (58 permanent lakes, Jancsik, 2001). Four of them (Lia, Bucura, Brazi and Gales) were selected for palaeoenvironmental studies from different altitudes (Fig. 1). Two of them (Lia and Bucura) are situated on the southern slope of the mountains, while Lake Brazi and Gales are located on the northern slope (Fig. 1; Table 3).

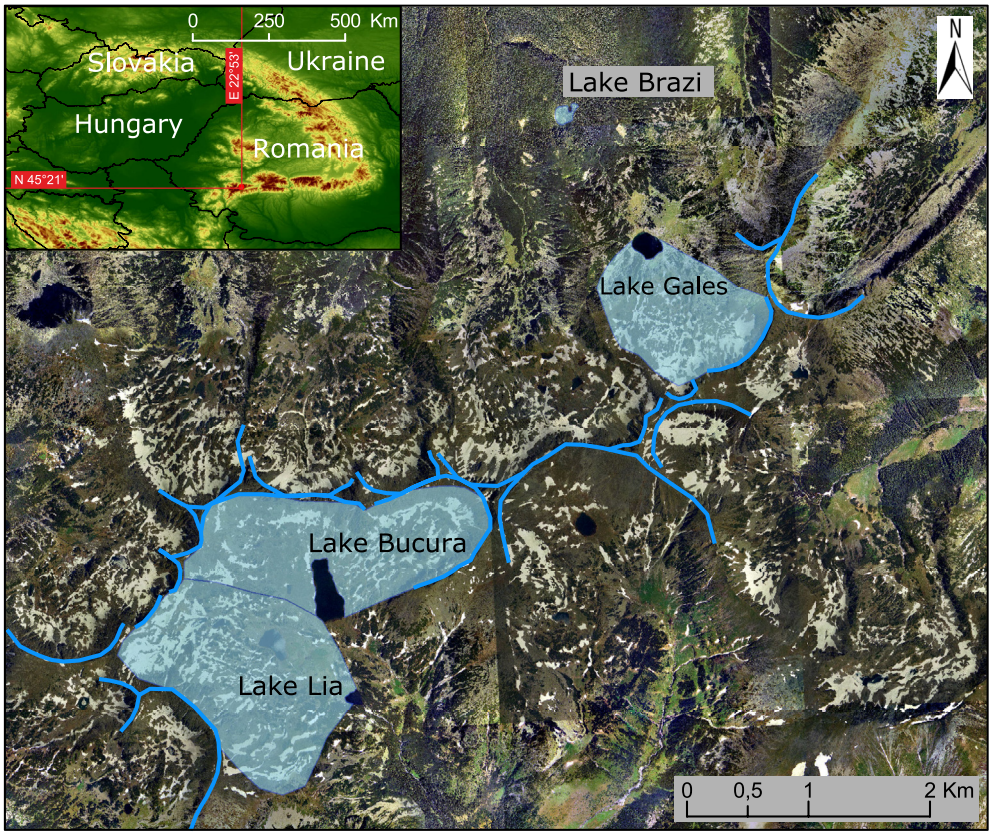

Fig. 1. Location map of the studied lakes with catchment areas (blue shadow), blue lines highlight the margins of cirques along the main ridge formed by glacial erosion. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

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