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Reconstructing recent environmental changes from proglacial lake sediments in the Western Alps (Lake Blanc Huez, 2543 m a.s.l., Grandes Rousses Massif, France)

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Abstract

The evolution of high-altitude glaciers and human activities in the Grandes Rousses massif is documented by high-resolution seismic reflection profiling and multiproxy analysis of short sediment cores in proglacial Lake Blanc Huez. These lacustrine data are compared with historical chronicles, geomorphological features and glaciological studies in this region of the western Alps and they allow the documentation of recent environmental changes. The specific geometry of high-amplitude reflections in the uppermost seismic unit, the lithology of short cores and the available limnological data in the lake suggest that clastic particles eroded by the glaciers and transported in suspension by glacial melt waters in early summer essentially develop homopycnal flood events in the lake. A conceptual model linking fluctuations of glacier equilibrium line altitudes in the catchment area with sedimentary facies retrieved in the lake basin is proposed. This approach allows reconstructing continuous glacier fluctuations since AD1820–1850 and suggests several phases of glacier fluctuations during the Little Ice Age (LIA). These reconstructions are based on changes in lacustrine sediment laminations, density, magnetic susceptibility, reflectance spectra, organic matter and Arsenic content. The age-depth model of short sediment cores is provided by ^{210}Pb, ^{137}Cs and ^{241}Am radionuclide dating. This chronology is further supported by identifying in lacustrine sediments the impact of (i) the nearby M 5.3 Corrençon earthquake in AD 1962, (ii) the development of the ski resort at high-altitude close to the lake and (iii) the last advance of glaciers during the LIA in AD1820–1850 and the following phase of glacier retreat observed in the alpine region at the end of the LIA in AD 1880. Frequent sandy layers enriched in organic matter and associated with fluctuations in the Arsenic concentrations may result from hydraulic remobilisation of Middle Age mine tailings at the lake shore by snow melt or heavy rain fall events during the LIA.

Keywords: French Alps; Proglacial lakes; Little Ice Age; Seismic stratigraphy; Glacier fluctuations; High-altitude mining activities

1. Introduction

The interaction of climate and human impact on Holocene environmental changes in the Alpine region and on clastic sediment delivery to lake basins is frequently

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discussed (Wessels, 1998; Noël et al., 2001; Dearing et al., 2001; Chapron et al., 2002; Dearing and Jones, 2003; Arnaud et al., 2005). On the one hand, millennial-scale Holocene climate fluctuations have been documented by lake-level fluctuations, archeological and palynological records from many small lakes in the Jura Mountains and several larger peri-alpine lakes in the NW French Alps and in the Swiss Plateau (see Magny et al., 2003; Magny, 2004; Holzhauser et al., 2005 for a review). Within radiocarbon dating uncertainties, cold and wet periods favouring high-lake levels match well-documented Swiss and Austrian glacier advances and tree-line decent in the Central and Southern Alps. Holocene glacier fluctuations in the French Western Alps still need to be reconstructed in more detail. However, these Holocene cold and wet periods match a continuous reconstruction of enhanced Rhone River flooding activity in the peri-alpine Lake Le Bourget (Fig. 1A) draining the Mont Blanc glaciers (Arnaud et al., 2005; Chapron et al., 2005). Since the end of the Late Bronze Age (i.e. 2800 yrs cal BP), a drastic increase in clastic sedimentation and some periods with enhanced flood deposits in this proglacial lake may result from increasing land use within this large alpine drainage basin. Hence, one way to disentangle the impact of climate and land use in this alpine region is to investigate high-altitude catchments dynamics, from a source-to-sink perspective, and to further document sedimentary processes associated with glacier advances and enhanced glaciofluvial regimes.

Over the past decades, Matthews and Karlén (1992), Leeman and Niessen (1994), Leonard (1997), Ariztegui et al. (1997), Nesje et al. (2000) and Dhal et al. (2003) have demonstrated in various mountain ranges of the world that

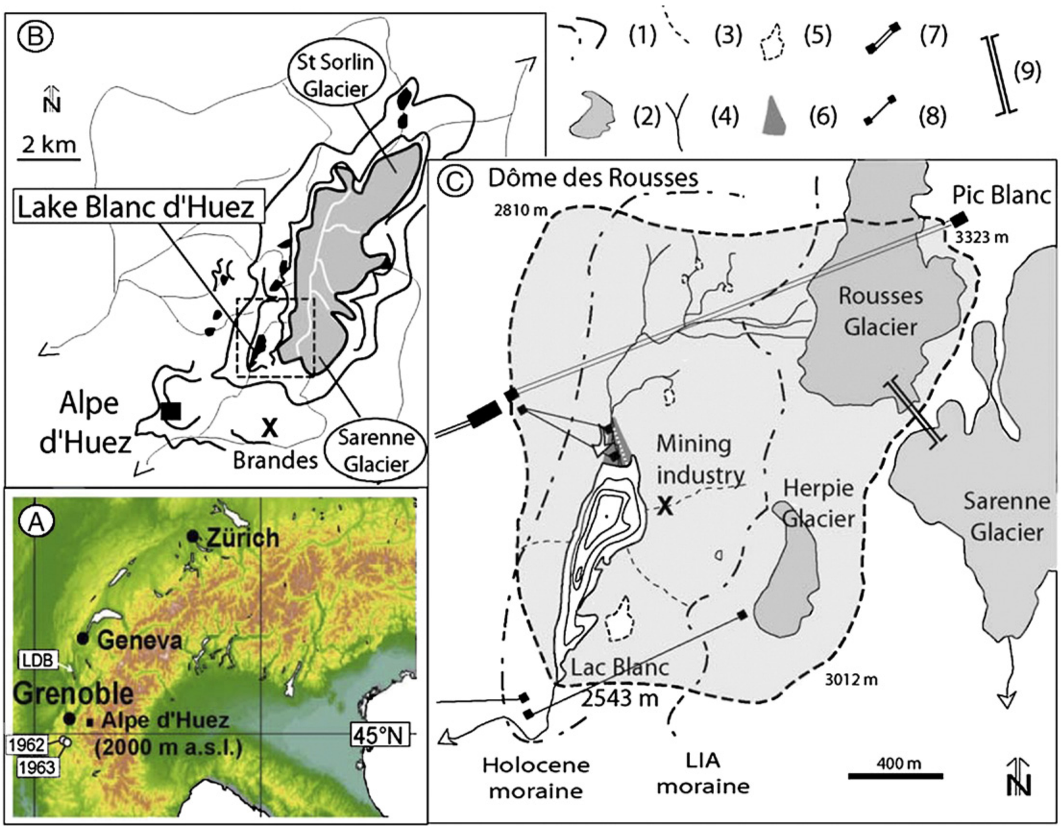

Fig. 1. Location of Lake Blanc Huez and Alpe d'Huez ski resort in the Western Alps. Lake Blanc Huez is located at c. 50 km from Lake Le Bourget (LDB) in the alpine foreland and from the epicentres of Corrençon (AD 1962) and Monteynard (AD 1963) earthquakes discussed in the text (A). Lake Blanc Huez was submitted to Middle Age mining activities concentrated in the SW part of the Grandes Rousses Massif and especially in the Brandes village (B). In the massif two glaciers are instrumented (St. Sorlin and Sarennes) and several belts of moraines were previously documented as discussed in the text. Lake Blanc Huez is a narrow basin 37 m deep (C) and its catchment area (dotted line) include Rousses and Herpie glaciers, their Little Ice Age (LIA) moraines and an earlier stage of glacier fluctuation in the Holocene. This catchment was also significantly submitted to human activities, such as the change of the main tributary's position in 2003 (white dashed line) for the displacement (white arrow) of a ski lift (black line). (1) frontal moraines; (2) glaciers; (3) temporary torrents; (4) torrents; (5) shallow lakes; (6) alluvial plain; (7) gondola; (8) ski lift and (9) tunnel built to connect the Sarennes glacier with the ski resort. Isobaths in Lake Blanc Huez are 10 m.