Quaternary Science Reviews 85 (2014) 1–19

Contents lists available at ScienceDirect

Quaternary Science Reviews

journal homepage: www.elsevier.com/locate/quascirev

Lake Neuchâtel (Switzerland) seismic stratigraphic record points to the simultaneous Würmian deglaciation of the Rhône Glacier and Jura Ice Cap

Matar Ndiaye [a,1], Nicolas Clerc [a,2], Georges Gorin [a,*], Stéphanie Girardclos [a,b], Julien Fiore [a,3]

[a] Earth and Environmental Science Section, University of Geneva, rue des Maraîchers 13, CH-1205 Geneva, Switzerland
[b] Institut des Sciences de l'Environnement, Université de Genève, route de Drize 7, CH-1226 Carouge, Switzerland

ARTICLE INFO

Article history:
Received 26 April 2013
Received in revised form
15 November 2013
Accepted 20 November 2013
Available online 15 December 2013

Keywords:
Fjord-lake
Perialpine lake
Glacial
Subglacial
Moraines
Glacier readvances
Glacio-lacustrine
Deltas
La Lance fault zone

ABSTRACT

Lake Neuchâtel, located at the foothills of the Jura Mountains in Western Switzerland, is one of the numerous perialpine lakes on the Swiss Plateau. It overlies a SW–NE trending paleovalley eroded during Quaternary glaciations through a branch of the Rhône Glacier extending northeastwards over the Swiss Plateau. This paleovalley, cut into Molasse siliciclastics and accessorily Mesozoic carbonates, was filled by late Quaternary sediments.

A grid of high-resolution seismic profiles (5-inch^3 and 1-inch^3 airguns) images at lake-scale the up to 200 m thick sedimentary sequence down to the bedrock. The latter is locally affected by a major strike-slip fault zone (La Lance) that has influenced glacial erosion. The infill consists of four seismic stratigraphic units (Units U1–U4), the shallowest two being subdivided into three subunits each (U3a,b,c and U4a,b,c). Units U1 and U2 are directly related to the Rhône Glacier and Jura Ice Cap activity. Unit U1 corresponds to acoustically chaotic subglacial deposits interpreted as tills (and locally eskers) and is associated to the Last Glacial Maximum (Würm Glacial Maximum, WGM) and probably to the beginning of deglaciation of the Rhône Glacier and Jura Ice Cap. Unit U2 is restricted to the central axis of the glacial paleovalley and reaches a thickness of over 100 m at some places. Its dominantly transparent seismic facies is interpreted as pro- to subglacio-lacustrine fine sediments deposited during the main phase of deglaciation. In the southern part of the lake, higher acoustic amplitudes indicate more compacted, coarser sediments forming a mound structure, interpreted as moraine deposits. This moraine facies points to phases of Rhône Glacier readvances during Unit U2, as seen in other perialpine lakes. With its continuous and subparallel reflections, Subunit U3a marks the beginning of a glacio-lacustrine, and later, lacustrine environment. Subunit U3a extends over the whole lake and contains two more localized subunits (U3b and U3c) displaying prograding and downlapping reflections, as well as signatures of mass transport deposits. These two subunits are interpreted as deltaic sequences from the La Mentue (Subunit U3b) and Areuse (Subunit U3c) tributary rivers. The base of these sequences marks the synchronous onset of a major melting phase in respectively the Rhône Glacier and Jura Ice Cap. Correlation with previously obtained core data indicates that the lower part of Unit U3 most certainly dates back to the Oldest Dryas and that the U3 depositional processes lasted at least until the end of the Younger Dryas and possibly until the Boreal biozone. By contrast with the deltaic seismofacies of the Mentue River (Subunit U3b), which stops close to the base of Subunit U4a, the Areuse River deltaic unit (Subunit U3c) continues to build up as Subunit U4c deposited synchronously with subunits U4a and U4b, probably because of the larger size, higher altitude and partly glacial nature of the catchment area of the Areuse River. Subunits U4a and U4b, with continuous and subparallel seismic reflections extending over the whole lake, are interpreted as lacustrine sequences. Correlation with previously collected sediment cores in Lake Neuchâtel and similar deposits in Lake Annecy dates the onset of lacustrine sedimentation sometimes between the end of the Younger Dryas and the Boreal biozones.

* Corresponding author. Tel.: +41 22 379 66 07.
E-mail address: georges.gorin@unige.ch (G. Gorin).
[1] Present address: Institute of Earth Sciences, BP 5396, Dakar-Fann, Senegal.
[2] Present address: Laboratoire de Géothermie – CREGE, Université de Neuchâtel, rue Emile-Argand 11, CH-2000 Neuchâtel, Switzerland.
[3] Present address: TOTAL, CSTJF, Avenue Larribau, 64000 Pau, France.

0277-3791/$ – see front matter
http://dx.doi.org/10.1016/j.quascirev.2013.11.017

This reconstruction of Lake Neuchâtel seismic stratigraphic infill, partly correlated with sediment data, sheds new light on the history of the northeastern branch of the Rhône Glacier and Jura Ice Cap deglaciation. In particular, it highlights the synchronous onset of clastic sediment input due to massive meltwater inflow from the two ice masses, leading to the formation of deltaic sequences during the Lateglacial.

1. Introduction

Lake Neuchâtel (Fig. 1) is one of the numerous elongated perialpine lakes in Europe, which were formed by glacial overdeepening during the Quaternary glaciations (Finckh et al., 1984). These lakes acted as sedimentary depocentres during phases of glacier retreat. Because of severe erosion during the last Würmian glaciation, the present-day sedimentary infill of these lakes consists essentially of glacial and lacustrine sediments associated with the last deglaciation and relatively thin Holocene deposits.

Using single-channel recording systems, different authors have studied the Würmian glacial to post-glacial sedimentary infill of perialpine lakes, particularly in Lake Geneva (Houbolt and Jonker, 1968; Vernet and Horn, 1971; Vernet et al., 1974; Moscariello et al., 1998), Lake Annecy (Van Rensbergen, 1996; Van Rensbergen et al., 1998; Beck et al., 2001) and Lake Le Bourget (Van Rensbergen, 1996; Van Rensbergen et al., 1999). Some echosounder profiles were also locally acquired in the Holocene sequence of Lake Neuchâtel by Schwalb (1992) and Schwalb et al. (1994). Similarly, Finckh et al. (1984) have investigated the bedrock form of various European lakes.

More recently, the use of multi-channel high-resolution 2D (and locally 3D) seismic reflection has considerably improved the data quality and interpretation in some periglacial lakes, particularly in Lake Geneva (e.g., Morend, 2000; GirardclosS, 2001; Baster, 2002; Morend et al., 2002; Baster et al., 2003; Beres et al., 2003a; Girardclos et al., 2005; Scheidhauer et al., 2005; Dupuy, 2006; Fiore, 2007; Fiore et al., 2011). The same technique has been used in Lake Neuchâtel by Beres et al. (2003b) and Gorin et al. (2003), where various glacio-lacustrine sedimentary units resulting from the last deglaciation period (Würm) have been distinguished and the nature of the underlying substratum highlighted.

Following the work of Gorin et al. (2003), which concentrated on central Lake Neuchâtel, more seismic data were acquired to cover the entire lake. In this paper, we integrate all existing high-resolution seismic data of Lake Neuchâtel in order to investigate in detail the stratigraphy of the sedimentary infill overlying the glacially-eroded Tertiary Molasse (and locally Mesozoic carbonate) bedrock. This infill can be subdivided into several glacial to post-glacial depositional sequences, including deltaic and lacustrine units. Finally, our data also highlight the signature of the major strike-slip La Lance fault zone (Fig. 1).

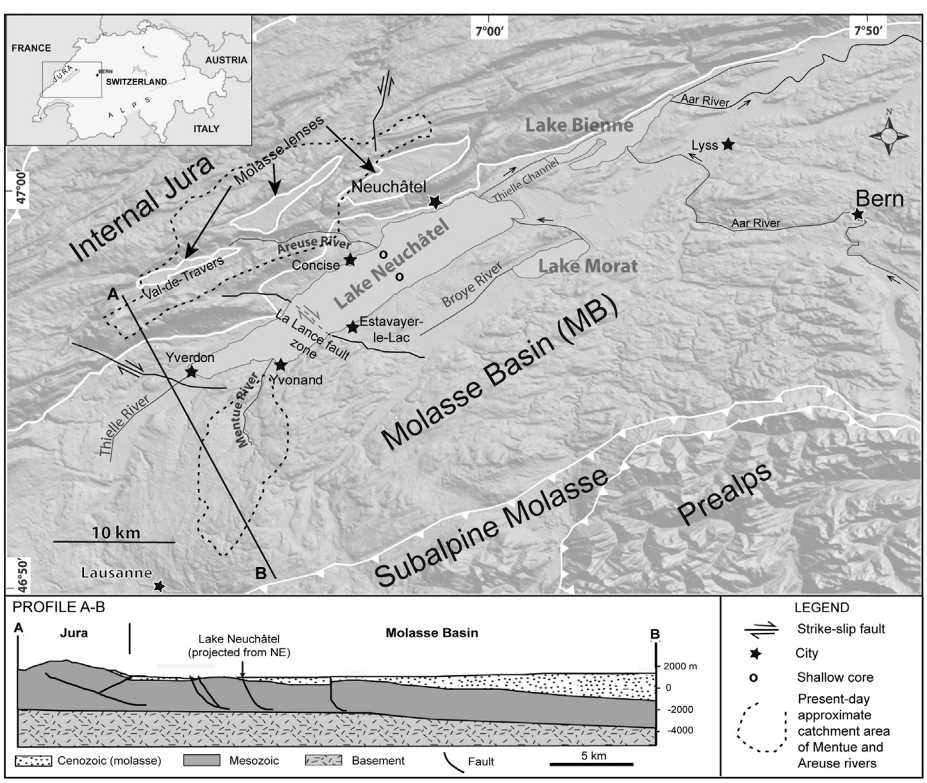

Fig. 1. Lake Neuchâtel location map with main cities, hydrology and hillshaded relief in background (Swisstopo data). Main thrust faults, strike-slip faults and tectonic contacts are included in the megatectonic framework. Present-day catchment areas of Mentue and Areuse rivers after respectively Zwahlen (1981) and Blant et al. (2011). Geological profile A-B across the Jura and Swiss Molasse Basin modified after Sommaruga (1997).