Marine Geology 370 (2015) 125–135

Contents lists available at ScienceDirect

Marine Geology

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

Changes in distal sedimentation regime of the Rhone delta system controlled by subaquatic channels (Lake Geneva, Switzerland/France)

Katrina Kremer [a,*,1], Juan Pablo Corella [a,2], Michael Hilbe [b], François Marillier [c], David Dupuy [c], Gregor Zenhäusern [d], Stéphanie Girardclos [a]

[a] Department of Earth Sciences and Institute for Environmental Sciences, University of Geneva, Rue des Maraichers 13, 1205 Geneva, Switzerland
[b] Institute of Geological Sciences, Oeschger Centre for Climate Change Research, University of Bern, Baltzerstrasse 1 +3, 3012 Bern, Switzerland
[c] Institute of Earth Sciences, University of Lausanne, Geopolis Bldg., 1015 Lausanne, Switzerland
[d] Forschungsinstitut zur Geschichte des Alpenraums (FGA), Stockalperschloss, Alte Simplonstrasse 28, 3900 Brig, Switzerland

ARTICLE INFO

Article history:
Received 3 April 2015
Received in revised form 9 October 2015
Accepted 17 October 2015
Available online 20 October 2015

Keywords:
Sublacustrine channels
Turbidite
Delta
Lake Geneva
Rhone River

ABSTRACT

Seismic reflection profiles combined with sediment cores reveal centennial changes in the proximal and distal sedimentation regime in the Rhone River delta system (Lake Geneva), which is dominated by sublacustrine channels. From detailed analyses of the thickness distribution of depositional units and the occurrence of turbidites, at least two shifts of the primarily active sublacustrine channels are inferred for the past 1500 years. The first northward shift is dated at 1480 ± 20 cal AD and was likely linked to a centennial flood in the Swiss Rhone Valley that occurred in 1469 AD and acted either as a direct cause or as a preconditioning factor favoring the shifting. A shift back southward in 1720 ± 90 cal AD may have been caused either by long-term human impact related to the first embankment constructions on the Rhone River or by a natural event such as the 1755 AD Brig earthquake or the centennial flood of 1640 AD. Another important change in the sedimentation regime occurs in 1775 ± 125 cal AD when the onset of Rhone turbidite deposition is recorded in the distal sediments. This relative "progradation" of the Rhone turbidites is certainly due to the disconnection of the Vieux Rhone branch before 1826 and the subsequent first Rhone River correction, starting in 1863 that led to the present single active Rhone subaquatic channel.

1. Introduction

Submarine channel or canyon systems on continental margins serve as pathways for turbidity currents and other gravity flows transporting sediments to depositional areas in the deep basins (Kolla 2007). In large clastic lakes, the subaqueous flow of incoming rivers may develop meandering channels or canyons on their submerged delta slopes and distal fan lobes that are similar to their marine counterparts (Mulder and Chapron 2011). The activity of subaquatic channels with regard to gravity flows is often controlled by the position of the river mouth, which can shift regularly similar to avulsion in the river systems (Reitz et al. 2010). The river mouth position in turn is influenced by external factors that control the course of the river bed, such as regional tilting, changes of the drainage systems due to earthquakes, sediment deposition and avulsion during major floods (Wells and Dorr 1987), as well as continuous sediment accumulation (Migeon et al. 2006). Human impact, such as river embankments, river channelizing and river deviations, can also drastically change the pathways and the regime of the sublacustrine turbidity currents and thus influence the entire sublacustrine delta system (Anselmetti et al. 2007; Loizeau and Dominik 2000; Syvitski et al. 2009; Wirth et al. 2011). Understanding the timing and causes of shifts in subaquatic delta-related channel systems is important because they control the depositional patterns in the more distal areas of these environments. In the specific framework of paleoflood reconstruction (Gilli et al. 2003; Glur et al. 2013; Mulder and Chapron 2011; Mulder et al. 2001a, 2001b; Wirth et al. 2013) and paleoseismic reconstruction (Goldfinger et al. 2012; Nelson et al. 2012), for instance, the influence of the river/delta/canyon system evolution on the spatial variability of event-related deposits in the basin needs to be constrained as a prerequisite to the interpretation of any clastic sedimentary record.

In this study, we present a synthesis of seismic reflection and sediment core data from the distal parts of the Rhone delta system in Lake Geneva with the aim to reconstruct the evolution of its sedimentation regime during the last 1500 years.

* Corresponding author.
E-mail address: katrina.kremer@erdw.ethz.ch (K. Kremer).
[1] Present address: Geological Institute, ETH Zurich, Sonneggstrasse 5, 8092, Zurich, Switzerland.
[2] Present address: Institute of Physical Chemistry Rocasolano (IQFR-CSIC), 28003 Madrid, Spain.

http://dx.doi.org/10.1016/j.margeo.2015.10.013
0025-3227/

2. Regional and sedimentological setting

Lake Geneva is the largest perialpine lake in Western Europe with a surface area of 580 km^2 and a volume of 89 km^3 of freshwater. Its basin was formed by glacial erosion during the Pleistocene (Wildi and Pugin 1998). The two main rivers feeding Lake Geneva are the Rhone and the Dranse River (Fig. 1). Using geochemical and petrophysical analysis the Rhone and Dranse turbidites can be distinguished as the drainage areas present different outcropping rocks. Dranse turbidites are characterized by high Ca/Ti ratios because of the predominance of carbonate, marl, flysch and moraine sediments in the catchment, whereas Rhone turbidites are characterized by high values of magnetic susceptibility due to the mainly igneous and metamorphic rocks such as granites, ophiolites, gneiss and micaschists from the Alpine geological nappes

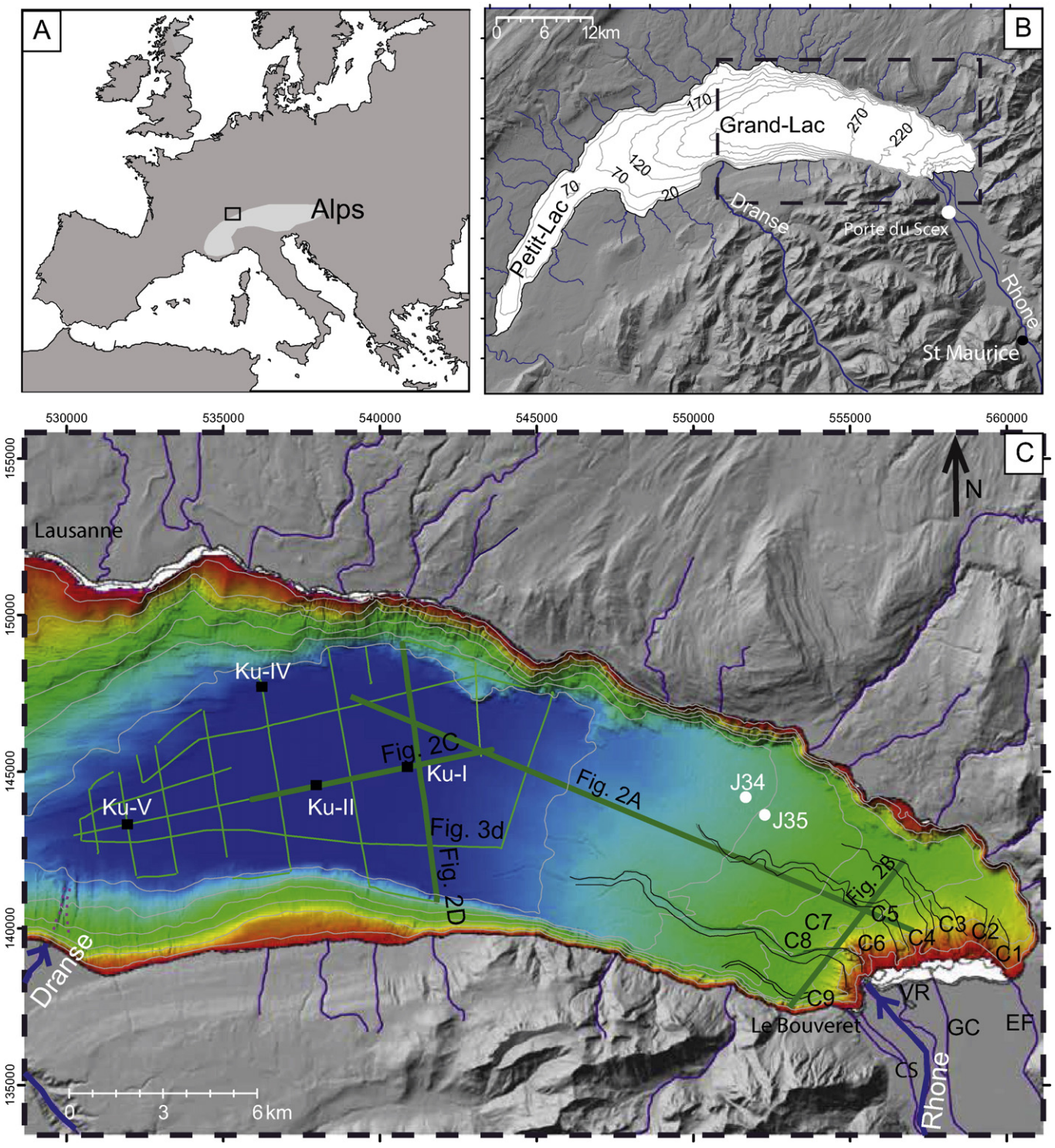

Fig. 1. A) Lake Geneva is located at the northern margin of the Swiss and French Alps. B) Bathymetric overview (in meters) of the lake and its two sub-basins: the 'Grand-Lac' and 'Petit-Lac'. C) Multibeam bathymetry map of the eastern part of the Grand-Lac (data courtesy: Direction générale de l'environnement, Canton of Vaud) with grid of seismic reflection profiles (lines) and sediment cores (squares). Bold lines refer to the seismic profiles shown in Fig. 2. Present channels in the delta are numbered from C1 to C9 following Sastre et al. (2010). Sediment cores J34 and J35 from Loizeau (2010) are located in the northern part of the Rhone delta (dots). Small channels entering the lake: EF: Eau Froide; GC: Grand Canal; VR: Vieux-Rhone, and CS: Canal Stockalper.