Journal of South American Earth Sciences 66 (2016) 232–247

Contents lists available at ScienceDirect

Journal of South American Earth Sciences

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

New records of late Holocene tephras from Lake Futalaufquen (42.8°S), northern Patagonia

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ARTICLE INFO

Article history:
Received 17 August 2015
Received in revised form
30 November 2015
Accepted 17 December 2015
Available online 20 December 2015

Keywords:
Tephra
Lake sediments
Southern Volcanic Zone
Patagonia
Argentina

ABSTRACT

In regions with limited knowledge of the historical volcanic record, like remote areas in the Andean Southern Volcanic Zone, the definition of reliable age-depth models for lake sequences represents a valuable tool for tephra layers dating. In Lake Futalaufquen (42.8°S), Northern Patagonia, a short sedimentary sequence was extracted after the AD 2008 Chaitén eruption with the purpose to analyze the records of volcanic eruptions at these poorly studied latitudes. The sequence was dated by ^{210}Pb, ^{137}Cs, and ^{14}C techniques. Five tephras were identified for the last 1600 years, restricted to the last 5 centuries. Sedimentology, morphology, and geochemical properties allowed the characterization of the tephras and their correlation with tephras recently identified proximal to the sources, mainly from Chaitén and Huequi volcanoes, and Michinmahuida accessory cones, representing the first distal records reported of these tephras. Furthermore, tephras modeled ages obtained by the sequence age-depth model shrink the ages for the volcanic events, like a potential cycle of activity from Michinmauida accessory cones during AD 1530 ± 55, one eruption from Huequi volcano at AD 1695 ± 50, and a possible recent eruption from Chaitén at AD 1775 ± 40. Additionally, the work contributes to improve the regional volcanic records knowledge, basic for volcanic hazard assessment.

1. Introduction

Tephra layers are widely used as time-synchronous horizons, linking and dating different geological, palaeoclimatic, or archaeological archives. This requires detailed tephra characterization of either physical properties evident in the field or morphological, mineralogical, and geochemical analyses performed in the laboratory, obtaining a 'fingerprint' for each tephra layer (Lowe, 2011). The complete characterization is particularly useful when proximal, medial, or distal tephra-fall deposits need to be correlated, usually allowing their association with dated events or with other characterized tephras. This technique is commonly used in active volcanic regions where the high eruptive frequency makes that volcanic deposits become a common component in sedimentary sequences (Steinhauser et al., 2007; Lowe, 2011; Bertrand et al., 2014; Daga et al., 2014). Sometimes, proximal deposits are obliterated by following eruptions, and medial to distal records would help to improve the volcanic record if they are well preserved (Fontaine et al., 2007).

In this way, lakes become the appropriate systems for tephra preservation due to its nearly continuous sediment accumulation, avoiding strong superficial processes, and providing consequently useful records of the lake depositional history, offering exceptional stratigraphical and chronological control (Wulf et al., 2004; Fey et al., 2009; Fontijn et al., 2014). Tephrochronology has proved to be a valuable tool to develop consistent chronological frameworks in sedimentary sequences, being a basic issue for palaeoenvironmental (Shane, 2000; Chambers et al., 2004; Wastegard, 2005) and, mainly in this region, for paleoseismological studies (Moernaut et al., 2014; Van Daele et al., 2015). This technique is particularly useful in Patagonia to date short sedimentary sequences, due to low ^{210}Pb fluxes limiting ^{210}Pb dating method (Ribeiro Guevara et al., 2003; Arnaud et al., 2006). However, in regions frequently affected by volcanic eruptions but poorly studied, where there is an incomplete knowledge of the historical eruptions and its deposits, this kind of correlations between tephras and the volcanic source could be a difficult task. The combined application of dating techniques, as isotope and

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http://dx.doi.org/10.1016/j.jsames.2015.12.003
0895-9811/

radiocarbon methods, could provide high temporal resolution records throughout the Holocene. Such chronological frameworks determined for lake sequences represent a valuable tool in the establishment of tephra layers age due to the application of modern methods as Bayesian analysis (Okuno and Nakamura, 2003; Lowe, 2011; Watt et al., 2011a). These contribute to improve the regional volcanic record knowledge, considered the basis for volcanic hazard assessment.

The Northern Patagonia Andean Range is situated in the Southern Volcanic Zone (SVZ) of the Andes, a region with several active volcanic systems during historical times. Although diverse research works have been carried out, the data available is scarce in many regions of the SVZ regarding the identification and characterization of volcanic events and pyroclastic distribution patterns, not allowing to building a consistent tephrochronological framework in these regions. This is the case of Los Alerces National Park (LANP) and nearby region (Fig. 1). Different studies were prompted at these latitudes mainly after the volcano Chaitén eruption in 2008, improving the knowledge of volcanic events from a considered almost inactive volcano. These recent works recognize pyroclastic deposits from until now unknown eruptions for the last centuries from Yate, Huequi, Chaitén, and Michinmahuida volcanoes (Fig. 1) (Watt et al., 2011a, 2011b, 2013; Amigo et al., 2013; Lara et al., 2013; Moreno et al., 2014). Even though, the geochemical characterization of these recently identified tephras is scarce, and ages are imprecise.

Present research investigates new tephra records in a lacustrine sedimentary sequence extracted from Lake Futalaufquen, in LANP, covering last 1600 years. The sequence was dated with ^{210}Pb, ^{137}Cs and ^{14}C techniques, allowing the chronological framework for a reliable dating of the tephras identified. The sedimentology, mineralogy, morphology, and geochemistry of the primary products isolated from these tephras were analyzed by visual inspection of the sequence, X–ray diffraction, Scanning Electron Microscopy (SEM), and Instrumental Neutron Activation Analysis (INAA), aiming to provide a full characterization to support correlation with volcanic sources.

2. Study site

Lake Futalaufquen (42°49′S, 71°43′W) is an oligotrophic lake located in LANP in the Andean Range, northern Patagonia, at 518 m

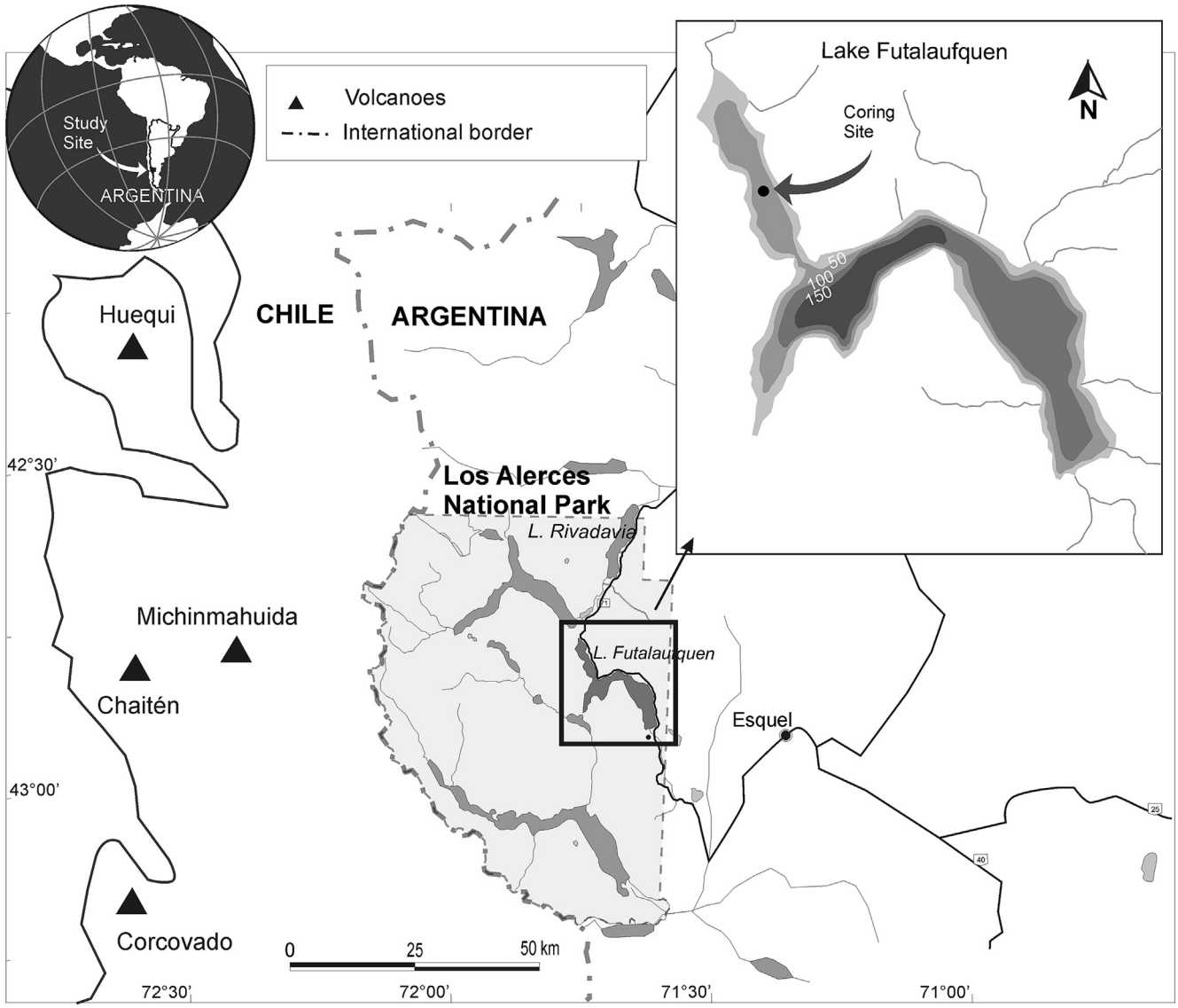

Fig. 1. Location of Lake Futalaufquen in Los Alerces National Park (LANP), Argentina, and its potential volcanic ash sources.