CORE CORRELATION AND PRELIMINARY PALEOSECULAR VARIATION RESULTS FROM LACUSTRINE SEDIMENTS OF LAGUNA POTROK AIKE (PATAGONIA, ARGENTINA)

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ABSTRACT

Two parallel sediment cores from Laguna Potrok Aike, a maar lake located in Southern Patagonia, Argentina, were studied in order to investigate the direction changes of the Earth's magnetic field. The cores 5022-1A and 5022-1B were obtained in a distance of 8 m during the PASADO drilling campaign in 2008. Magnetic susceptibility (k) at low and high frequency of 340 samples were measured and analyzed to achieve the best possible correlation between these cores. The resulting k logs show a strong correlation (r = 0.64), which allows to combine both cores into one composite record. The directions (inclination and declination) of the stable remanent magnetization were obtained by demagnetizing the samples in an alternating field with growing steps. Inclination oscillates mainly between -36 and -88°. Only a few samples are out of these ranges. The age-depth model indicates that the studied samples span a period of 4800 yrs. An increasing trend is observed in both cores for the first 30 cm (360 yrs). Similar results were observed in other cores from Laguna Potrok Aike and other lakes in the area, and geomagnetic models confirmed them.

Keywords: Magnetic susceptibility, Secular variation, Late Holocene, Laguna Potrok Aike

RESUMEN

En este trabajo se estudiaron dos testigos paralelos para investigar los cambios en la dirección del campo magnético terrestre. En particular, el trabajo se llevó a cabo en sedimentos extraídos de la Laguna Potrok Aike. Es un lago maar ubicado en al sur de la Patagonia, Argentina. Los testigos fueron obtenidos durante una campaña de extracción en 2008 (PASADO 5022-1A y 5022-1B). La separación entre los testigos es de 8 m. Se midió la susceptibilidad magnética (k) a baja y alta frecuencia en 340 muestras. Se analizaron las curvas obtenidas para correlacionar ambos testigos. Las curvas muestran una muy buena correlación (r = 0.64), lo que permite combinarlos en un único testigo compuesto. La dirección (inclinación y declinación) de la magnetización remanente estable fue obtenida por desmagnetización por campos alternos en pasos sucesivos con campo máximo cada vez más intensos. La inclinación oscila, principalmente, entre -36 y -88°. Sólo muy pocas muestras se encuentran fuera de este rango. El modelo de edades utilizado indica que las muestras estudiadas abarcan un período de 4800 años. Se observa una tendencia creciente en ambos testigos en los primeros 30 cm (360 años). Se han observado resultados similares en otros testigos de esta laguna y en otros lagos de la Patagonia y también han sido confirmados por modelos geomagnéticos.

Palabras Clave: Susceptibilidad magnética, Variación secular, Holoceno tardío, Laguna Potrok Aike

Introduction

Sediment cores have shown to be useful for paleomagnetic studies, particularly, to understand the behaviour of the Earth's magnetic field (direction and intensity variations). Most of the studies were performed in the

Northern Hemisphere and only a few in the Southern Hemisphere. In the last 15 years we have reconstructed the changes of the geomagnetic field during the late Pleistocene to Holocene period (Gogorza *et al.*, 2002, 2012, Irurzun *et al.*, 2006, 2014).

Laguna Potrok Aike is a maar lake located in the Patagonian steppe, southern Santa Cruz, Argentina (51°57'S, 70°24'W, Fig. 1). The catchment area is mainly formed by glacial deposits and sedimentary rocks. The crater lake is almost circular, with a diameter of 3.4 km, a volume of 0.4 km^3 and a maximum water depth of 100 m (Zolitschka *et al.*, 2006). Several sites were drilled (Fig. 1), particularly, pilot samples from cores of sites 5022-1A, B and C were used for paleomagnetic studies to investigate their general behaviour (only pilot samples). The aim of this work is to study all samples from cores 5022-1A and B for the last 4800 yrs (170 samples from each core).

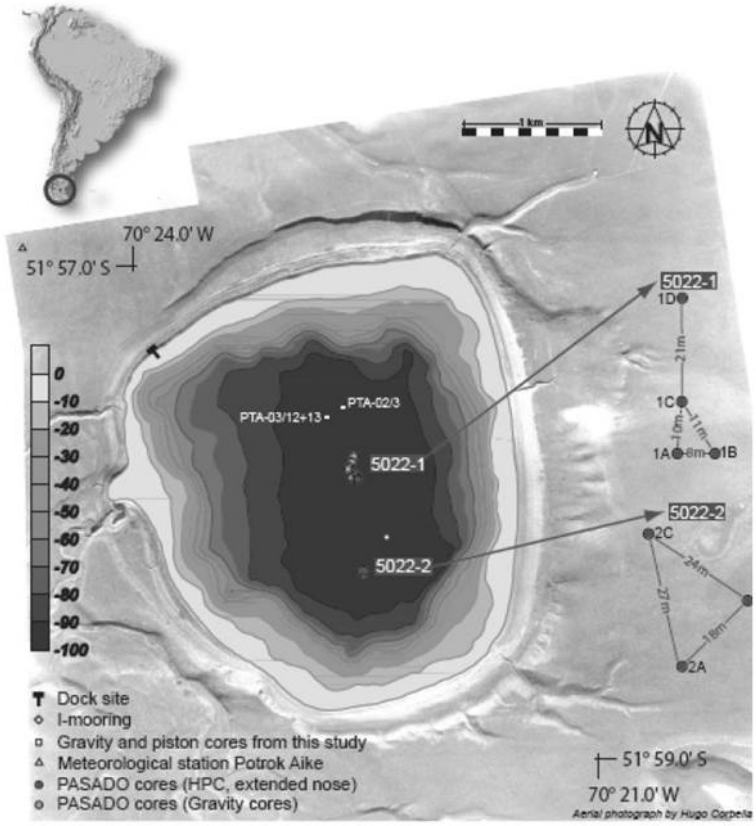

Figure 1. Location of Laguna Potrok Aike and coring sites (used in this work: 5022-1A and 5022-1B).

Methods

The cores were split lengthwise and sub-sampled with cubic plastic boxes. Magnetic susceptibility (k) measurements were made using a model MS2B susceptibility meter (Bartington Instruments). To determine the intensity and direction of the natural remanent magnetization (NRM, declination D and inclination I), the samples were measured in a JR6A Dual Speed Spinner Magnetometer. Alternating field demagnetization was made in a Shielded Demagnetizer (Molspin Ltd.) and for the determination of the characteristic stable direction of NRM, for each sample a principal component analysis (Kirschvink, 1980) has been applied. An age-depth model based on radiocarbon dates mainly from aquatic mosses and organic macro remains was established. The obtained results were compared with previous studies on this lake as well as with other lakes in the area and theoretical models.

Results and discussion

The k logs for both cores are shown with some correlation tie lines (Fig. 2). Core 5022-1A has an overlapping section between 2.15 and 2.55 m. In particular, the peak at 2.48 m can only be observed in one section from this core. The rest of the core can be entirely correlated with 5022-1B, identifying peaks and troughs. Core 5022-1B was used as a master core. Between two tie lines a linear correlation was used. Most of the values are in the range of 50 to 150 x10^{-5} SI with no particular trend. Henceforth, and because of the good correlation between the cores, both are shown together.

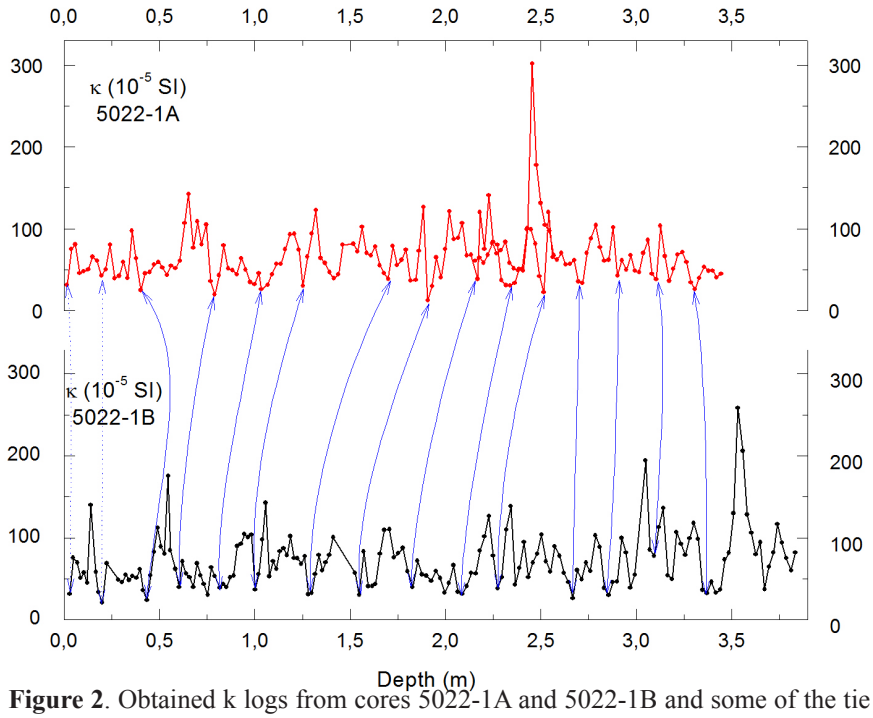

Figure 2. Obtained k logs from cores 5022-1A and 5022-1B and some of the tie lines used for correlation.

Figure 3 shows the AF demagnetisation for sample 4 from core 5022-1A as an example of the results for this type of measurements. The samples show a viscous remanent magnetization, which can be deleted with applied fields of 5 to 10 mT. The stable remanent magnetization has been derived from principle component analysis (Kirschvink, 1980) with four to six demagnetization steps. The samples have a maximum angular deviation (MAD) lower than 5º indicating that the directions (I and D) obtained are reliable.

The constructed age-depth model indicates that the sediments span the last 4800 yrs B.P. In order to see the repeatability of the results, the inclination record was compared with published logs from Laguna Potrok Aike (Fig. 4). Our results were compared with the records of Lisé-Pronovost *et al.* (2013) and Gogorza *et al*. (2011) (for the last 2 kyrs B.P) and Gogorza, *et al.* (2012) (for the rest of the record). Due to a different stacking process, the inclination scale is different, but the general trend can be compared. In this work, no stacking process was applied. For both records, three peaks at 4700, 4300 and 4160 yrs B.P., a period of relative high values at around 3000 yrs B.P. and an increasing trend for the topmost 750 yrs B.P. can be identified.

These results were compared with other records from Argentinean Patagonia: Lake El Trébol (Irurzun *et al.*, 2006) and Lake Escondido (Gogorza *et al.*, 2002). As in the previous case, the records are stacked so the variations have less amplitude. The three records show high values from 4300 to 4150 yrs B.P. and a low at

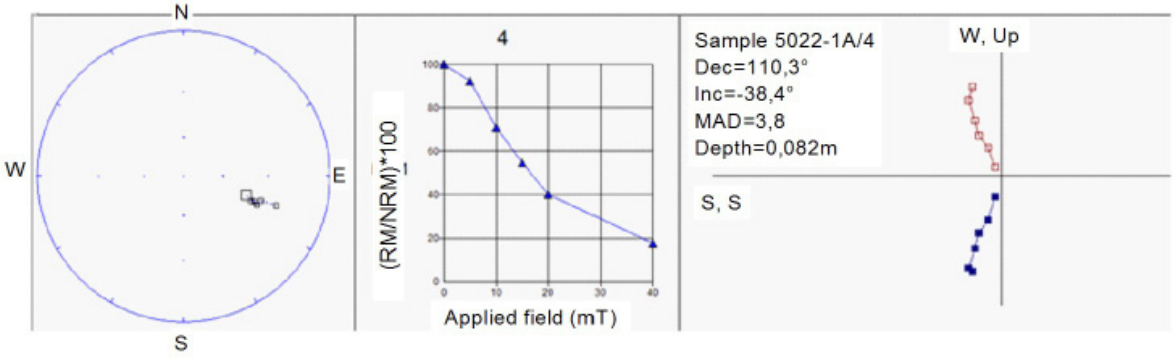

Figure 3. AF demagnetisation results for one sample from cores 5022-1A. The rest of the samples show a similar behaviour.

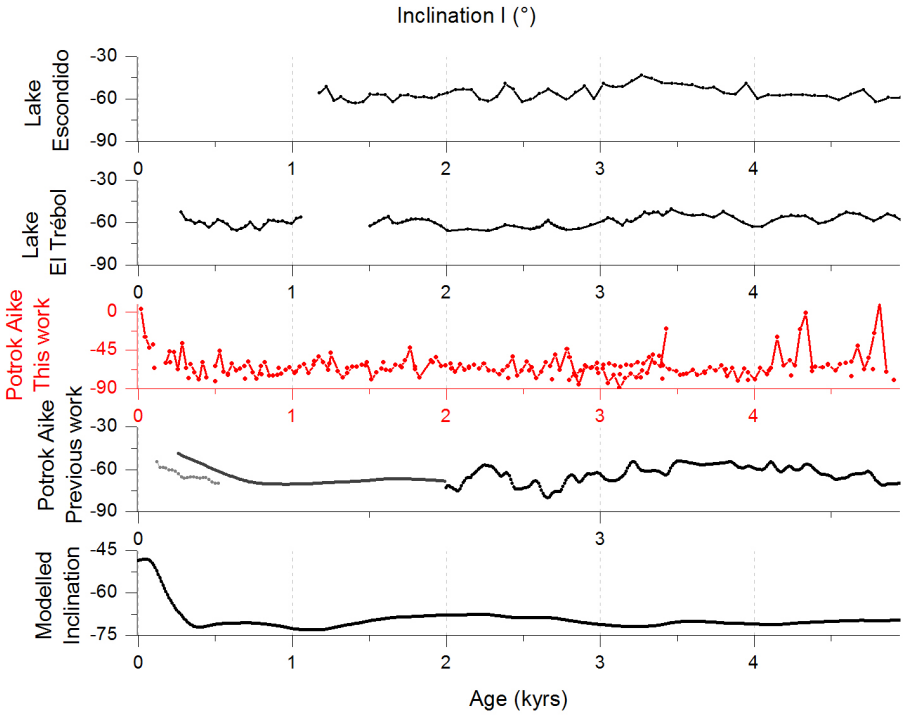

Figure 4. Inclination results from this and from previous studies on Laguna Potrok Aike (grey: Gogorza *et al.*, 2011; dark grey: Lisé-Pronovost *et al.*, 2013 and black: Gogorza *et al.*, 2012), Lake El Trébol (Irurzun *et al.*, 2006), Lake Escondido (Gogorza *et al.*, 2002) and from models (The GEOMAGIA50 database, Donadini *et al.*, 2006 and Korhonen *et al.*, 2008).

4000 yrs B.P. The relative high value at 3000 yrs B.P. is only found in Lake El Trébol. Finally, from 3000 to 1100 kyrs B.P. an oscillatory behaviour is observed in Lake Escondido and Laguna Potrok Aike.

The comparison with models (from GEOMAGIA50 database) shows a good agreement for the last 2000 years. Only small variations are observed in the modelled record at 4300 yrs B.P. and a high at 3500 yrs B.P. is just implied in Laguna Potrok Aike. The high at 2200 yrs B.P. is observed in the previous results from Laguna Potrok Aike but not in this work. The opposite occur at 760 yrs B.P. where high values are found in this study. For the first 380 yrs B.P. the modelled inclination predicts the increasing trend observed in this work.

Conclusions

Our results indicate that both cores can be correlated in detail and combined into one composite record. The directions of the records, particularly the inclination (I) shows similar trends, peaks and troughs as many other records from the area and the model. It is necessary a complete study (samples older than 4800 yrs B.P.) to reconstruct a definitive paleosecular variation curve for Laguna Potrok Aike in order to compare with lakes El Trébol and Escondido, and to use it as a dating tool as well as a contribution to worldwide paleosecular models.

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