



Rock magnetic properties and relative paleointensity stack between 13 and 24 kyr BP calibrated ages from sediment cores, Lake Moreno (Patagonia, Argentina)

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ABSTRACT

We conducted a detailed study of natural remanence and rock magnetic properties on three sediment cores from Lake Moreno (Patagonia, Argentina). Based on these measurements, we constructed a relative paleointensity stack for the period 13–24 kyr BP calibrated ages. Rock magnetic properties of the sediment cores showed uniform magnetic mineralogy and grain size, suggesting that they were suitable for relative paleointensity studies. The remanent magnetisation at 20 mT ($NRM_{20\text{mT}}$) was normalised using the anhysteretic remanent magnetisation at 20 mT ($ARM_{20\text{mT}}$), the saturation of the isothermal remanent magnetisation at 20 mT ($SIRM_{20\text{mT}}$) and the low-field magnetic susceptibility (k). Spectral analysis showed that the normalised records were not affected by local environmental conditions. The recorded pseudo-Thellier paleointensity was compared with records obtained from conventional normalising methods. Comparing the paleointensity curves with others obtained previously in other lakes in the area has allowed us to reach reliable conclusions about centennial-scale features.

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1. Introduction

Studies of lacustrine sequences have provided fundamental information about relative paleointensity (RPI) variations of the geomagnetic field. However, several tests for sedimentary paleointensity based on rock magnetic criteria (Banerjee et al., 1981; Tauxe, 1993) must be performed to establish reliability of the data. King et al. (1983) proposed the concept of “magnetic uniformity”, i.e. the absence of changes in relative grain sizes and concentrations. In order to minimize the effects of down-core variability, the natural remanent magnetisation (NRM) is normalised by some magnetic parameter. Different normalisers have been discussed (Tauxe, 1993), including anhysteretic remanent magnetisation (ARM), saturation isothermal remanent magnetisation (SIRM) and magnetic susceptibility (k), and numerous studies have been published (Brachfeld and Banerjee, 2000; Gogorza et al., 2004, 2006; Peck et al., 1996; Sagnotti et al., 2001; St-Onge et al., 2003; Blanchet et al., 2006; Macri et al., 2006; Richter et al., 2006;

Hofmann and Fabian, 2007). In order to test the reliability of the RPI data, the coherence function (Tauxe and Wu, 1990) between the normalised remanence and the respective normaliser is calculated. This quantitatively estimates the degree to which the normalised intensity records are biased by environmental variations in grain size and concentration.

Several authors argue that the appropriate demagnetisation of the NRM is the only important factor for constructing a reliable paleointensity from sediments (Levi and Banerjee, 1976; Valet and Meynadier, 1998). Tauxe et al. (1995) proposed the pseudo-Thellier method to determine if the records could be affected by unrecovered viscosity, which relies on comparing the NRM lost during demagnetisation and the ARM gained within the same range of coercivities. It has been argued that this method diminishes the environmental contamination of the paleointensity signal better than conventional normalising methods (Kruiver et al., 1999). In this paper, we compare the paleointensity obtained by the standard normalising method and the results obtained from one core with the pseudo-Thellier method. In addition, we perform rock magnetic analyses to study possible environmental influences on the sediment in the studied cores.

Improved knowledge about relative variations of the geomagnetic field over the last few hundred thousand years has allowed the construction of global reference paleointensity curves, which are

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useful for defining high-resolution age models in appropriate sedimentary sequences (Sagnotti et al., 2001; Guyodo and Valet, 1996). The research presented in this paper helps mitigate the extremely uneven global distribution of data.

Previous studies have been carried out at the local scale (Gogorza et al., 2004, 2006), and were successfully compared with records from other sites in the world (Brachfeld and Banerjee, 2000; Brachfeld et al., 2003; Constable, 1985; Peck et al., 1996; St-Onge et al., 2003). Some discrepancies were observed between previously reported results in the period 14–23 kyr BP calibrated ages. This study aims to determine whether these differences came from an incorrect time correlation or from different rock magnetic characteristics, and to refine our understanding of the temporal geomagnetic field intensity during this period.

2. Sedimentology

Lake Moreno is a closed basin of about 120,000 m², located on the eastern side of the Andean Patagónica Cordillera, at about 41°S 71°30'W (Fig. 1) and approximately 17 km northwest of San Carlos de Bariloche, Argentina. A land barrier divides the lake into two: west Moreno and east Moreno, respectively. The average annual temperature is about 8.7°C and the annual precipitation is between 150 and 180 cm/yr. This region presents one of the most marked humidity gradients of the world, clearly reflected by vegetation: from west to east, the moist forest is replaced by the Patagonian steppe in less than 50 km (Bianchi et al., 1999). It is related to series of large glacially carved lakes. The basement rocks of the basin crop out in the lake catchment area and show evidence of glaciation striation and some erratic blocks of different composition. The more ancient lacustrine sediments are on the top of these rocks; the sedimentary sequence consists of reddish clays thin layered with little clastic rocks (dropstones), especially at the bottom. These evidences indicate a glacial origin of the Lake Moreno and a glaciolacustrine origin of the reddish clays; the youngest sedimentary column is not present, due to the erosion. The present vegetation covers most of the glaciolacustrine sequence that lies over the lake coast. A more detailed description of the sedimentology of Lake Moreno is given in Gogorza et al. (2006).

Three principal lithologies are present in the sediment column of the lake, and are, from bottom to top: light reddish clayey silt (lithology A), light grey greenish clay (lithology B) and light grey clay (lithology C). Good correlation between the cores was established based on 28 tephra layers located mostly in the upper part and specific susceptibility records.

Two different facies can be recognized: a basal glaciolacustrine facies (which includes lithologies A and B and tephra layers) named the “Lake Elpalafquen” facies, and a younger lacustrine

facies (lithology C and tephra layers) or the “Lake Moreno” facies (Gogorza et al., 2006). The “Lake Elpalafquen” facies has been recognized in cores from other lakes of the area (El Trébol, Escondido and Mascardi), and outcrops at the Lake Nahuel Huapi coast (del Valle et al., 2000). These sediments represent sedimentation during Late Pleistocene times, when a large pro-glacial lake, Lake Elpalafquen (del Valle et al., 2000), existed in the region. On the other hand, the “Lake Moreno” facies represents lacustrine sedimentation with no direct glacial influence. These were deposited mainly during Holocene time, after the collapse of Lake Elpalafquen, which gave rise to the formation of the present lakes of the region.

3. Materials and methods

The three cores investigated in this study are labelled Imor-1, Imor98-1 and Imor98-2 (Fig. 1); they were collected with a push corer from the shoreline (a marshy site approximately 1 m above the present Lake Moreno level); the length of the cores varies from 2.5 to 4 m. Individual samples were taken by inserting an 8 cm³ cubic plastic box into the surface; 371 samples were collected.

The magnetic susceptibility at low frequency (specific, X_{lf} , and volumetric, k) was measured with the Bartington Instruments MS2 system. A Pulse Magnetizer model IM-10-30 ASC Scientific and a Shielded Demagnetiser Molspin Ltd. with an ARM device were used for IRM and ARM acquisition experiments. Remanence measurements for all samples were performed with a Spinner Fluxgate Magnetometer Minispin, Molspin Ltd.

NRM was systematically demagnetised by alternating field (AF) at 0, 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 60, 70, 80 and 95 mT. The median destructive field (MDF_{NRM}) was also determined. ARM was acquired in a peak alternating field of 95 mT with a steady bias field of 0.1 mT ($ARM_{95\text{ mT}}$) and was subsequently demagnetised to a peak AF of 95 mT using the same field steps as for NRM demagnetisation. IRM was acquired at room temperature in increasing steps up to 1.2 T reaching saturation (SIRM); subsequently, AF demagnetisation of IRM was measured using the same steps as for NRM demagnetisation. After that, a 1.2 T field was imparted at room temperature and progressive demagnetisation was applied up to 1.2 T for the DC experiment.

Sub-samples were taken from core Imor-1 for hysteresis measurements and thermal demagnetisation. The hysteresis parameters were obtained using a VSM Lake Shore 7300 with a maximum applied field of 1.5 T; we then calculated the magneto-granulometric indicative ratios of saturation remanence to saturation magnetisation (M_{RS}/M_S) and coercivity of remanence to coercive force (H_{CR}/H_C).

Thermal demagnetisation studies were carried out using a thermal specimen demagnetiser, model TD-48 ASC Scientific. Before

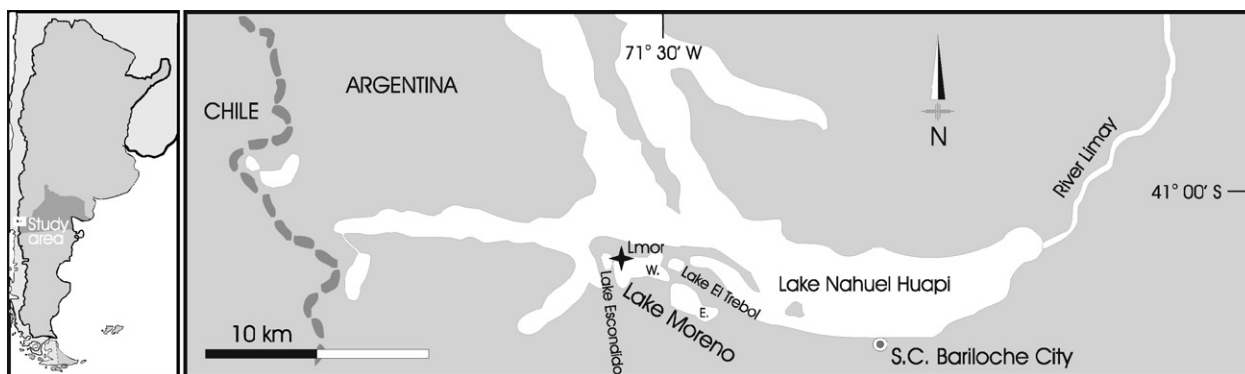


Fig. 1. Geographical location of Lake Moreno: W: west Moreno; E: east Moreno; + Lmor: coring sites.

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