ROCK MAGNETIC STUDIES FROM THE RIO VALDEZ PALEOLAKE OUTCROUP (TIERRA DEL FUEGO, ARGENTINA): PRELIMINARY RESULTS

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ABSTRACT

We present preliminary results of a rock-magnetic study from a group of pilot samples collected along a sedimentary sequence called Río Valdez paleolake in central Tierra del Fuego Island, Southernmost Argentina. The aim of this work is to characterize these sediments in order to carry out future paleomagnetic and paleoclimatic studies, which are scarce in this region (Gogorza *et al*., 2012, 2013; Lisé-Pronovost *et al*., 2013). The results mainly include measurements of magnetic susceptibility in low and high frequency, natural remanence magnetization (NRM), isothermal remanent magnetization (IRM), saturation isothermal remanent magnetization (SIRM), back field and anhysteretic remanent magnetization at 100 mT (ARM). Associated parameters (ARM/k, SIRM/ARM and SIRM/k) were calculated. Additionally, we present results of magnetic NRM parameters measured with vibrating sample magnetometer (VSM). It was found that the main carrier of remanence is magnetite with the presence of hematite in very low percentage; also greigite was observed in a layer at the upper part of the sequence.

Keywords: Rock Magnetic Study, Tierra del Fuego, magnetite, greigite

Site Description and Sedimentology

The Río Valdéz paleolake outcrop is located close to mouth of Río Valdéz, at the south coast of Lago Fagnano (54° 35' S; 67°20' W). It develops at 62 m a.s.l. and 25 m above the lake shore (fig. 1a). It forms a 1.5 km^2 plain placed in between a morainic complex. The outcrop shows a 7 m depth of laminated silty-clay sediments with low content of laminated sands overlaid in erosive boundary by a 0.25 m of chaotic gravels in silty matrix. Each pair of rithmites show sets of 2 cm thick of dark clay and 0.5 thick of light silts (fig. 1b, d and e). Convolute laminations are only present at 2.75-3 m from the base. Few dropstones were observed (fig. 1c). Based on geomorphological and sedimentological characteristics the studied outcrop is interpreted as a rithmic glacio-lacustrine deposits formed among basal moraines made by the paleofagnano glacier, which occupied central Tierra del Fuego during the Last Glacial Maximum, ca. 25 ka B.P. (Coronato *et al*., 2009). Lateral moraines are located at the foot of the mountains, while basal moraines are besides the lake (fig. 1.f). The Valdéz paleolake is considered a small marginal glacial lake formed: a) while the Fagnano paleoglacier was melting-out and moraines formed, or b) when recessional moraines were deposited at the bottom of the valley, now submerged (Waldmann *et al*., 2010). The presence of dropstones allows us to interpret this deposit as an ice-contact lake. Although no radiocarbon data are still available for this outcrop, we estimate the time of the paleolake formation as <25>12 ka B.P. The basal age of neighboring peat-bogs was calculated at 12.1 ka B.P. (Coronato *et al*., 2009), indicating the ice disappeared from this area sometime before.

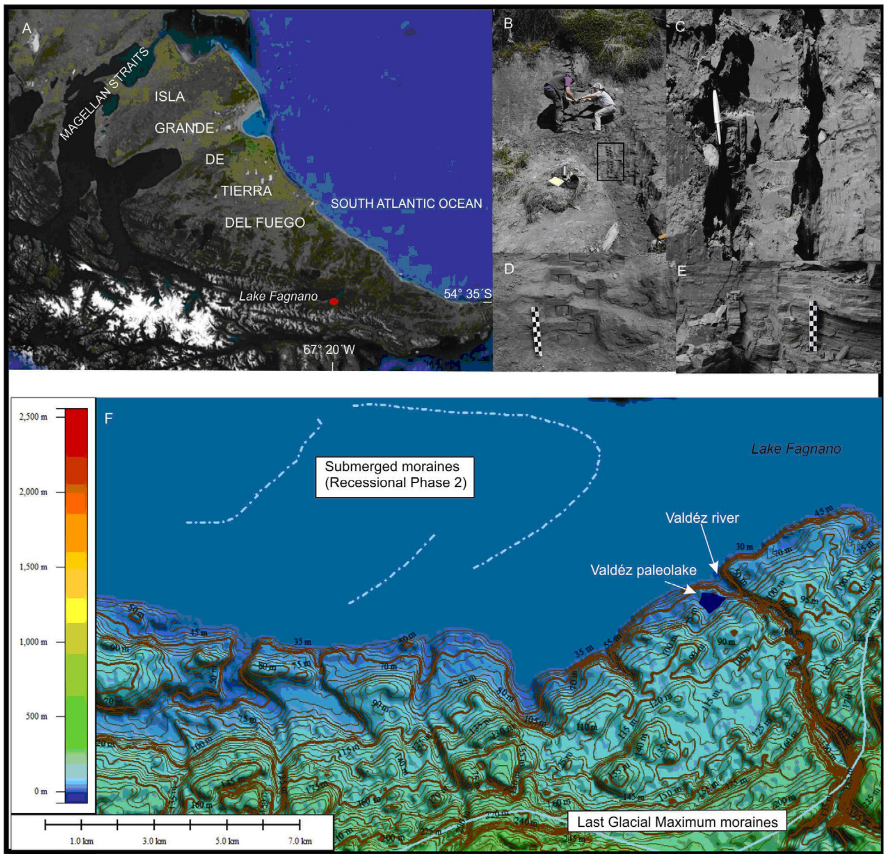

Figure 1.a. Río Valdéz paleolake location at the southern coast of Lake Fagnano; 1.b. sampled section (short profile); 1.c. Dropstones into massive silty-clays; 1.d. Detail of magnetic sampling (box in picture B); 1.e. Laminar structures and brown oxidized layers of fine sands; 1.f. Topographic map of the area showing the Valdéz paleolake position in relation to Last Glacial Maximum moraines at the foot of the mountains and recessional moraines beneath the lake level (after Coronato et al., 2009 and Waldmann et al., 2010).

Methods

Measurements were carried out at the laboratory of the Group of Paleomagnetism and Environmental Magnetism of National University of the Centre of Buenos Aires, Province, Argentina.

1. A sedimentary sequence of 401 cm length (RV2) was sub-sampled continuously with cubic plastic boxes (20 mm × 20 mm × 20 mm) that were pressed into the surface; ~~and~~ a total of 144 samples were obtained. Samples were taken one next to another; consequently, the different magnetic parameters that we plot are showing average values for the corresponding interval, although they are represented by a point located in the centre of the sample.

2. Magnetic susceptibility was measured at low frequency (k_{low} at 470 Hz) and high frequency (k_{high} at 4700 Hz). The difference between both measurements was used to calculate the frequency dependent susceptibility [$F = (k_{low} - k_{high}) / k_{low}$]. This parameter reflects the presence of very fine (< 0.03 μm for magnetite) ferrimagnetic grains in the super-paramagnetic state (SP) of the sediment record.

3. Stability of the magnetization was analyzed by alternating-field (AF) demagnetization. Samples were demagnetized successively at peak fields of 5, 10, 15, 20, 25, 30, 35, 40, 50, 60, 70 and 100 mT.

4. Acquisition of the anhysteretic remanent magnetization (ARM) was carried out with a direct field of 0.1 mT and an alternating field between 2.5 and 100 mT. After acquisition, the ARM was demagnetized stepwise using eleven successive steps at 5, 10, 15, 20, 25, 30, 35, 40, 50, 60, 70, 80 and 100 mT.

5. Acquisition of isothermal remanent magnetization (IRM) was determined in growing steps until 1.2 T reaching the saturation isothermal remanent magnetization (SIRM) and in growing steps back until cancelling the magnetic remanence. These measurements were used to calculate the S_{ratio} (IRM_{-300mT} / SIRM), the "hard" IRM (HIRM = ((SIRM + IRM_{-300mT}) / 2) / SIRM), and the remanent coercivity field (B_{CR}). SIRM was stepwise demagnetised using the same steps like for ARM.

6. Combined magnetic parameters were calculated (ARM / k, ARM / SIRM and SIRM / k).

A JR6A (Agico) was used for the paleomagnetic measurements and a Minispin spinner fluxgate magnetometer (Molspin Ltd.) was used for rock magnetic studies. Magnetic susceptibility was measured using a Bartington MS2 Susceptibilimeter, and an alternating field demagnetiser Molspin Ltd. was used to separate components of magnetization. A pulse magnetiser IM-10-30 (ASC Scientific) and alternating field demagnetizer (Molspin Ltd.) with an ARM device were used for IRM and ARM acquisition experiments, respectively.

Rock Magnetic Results

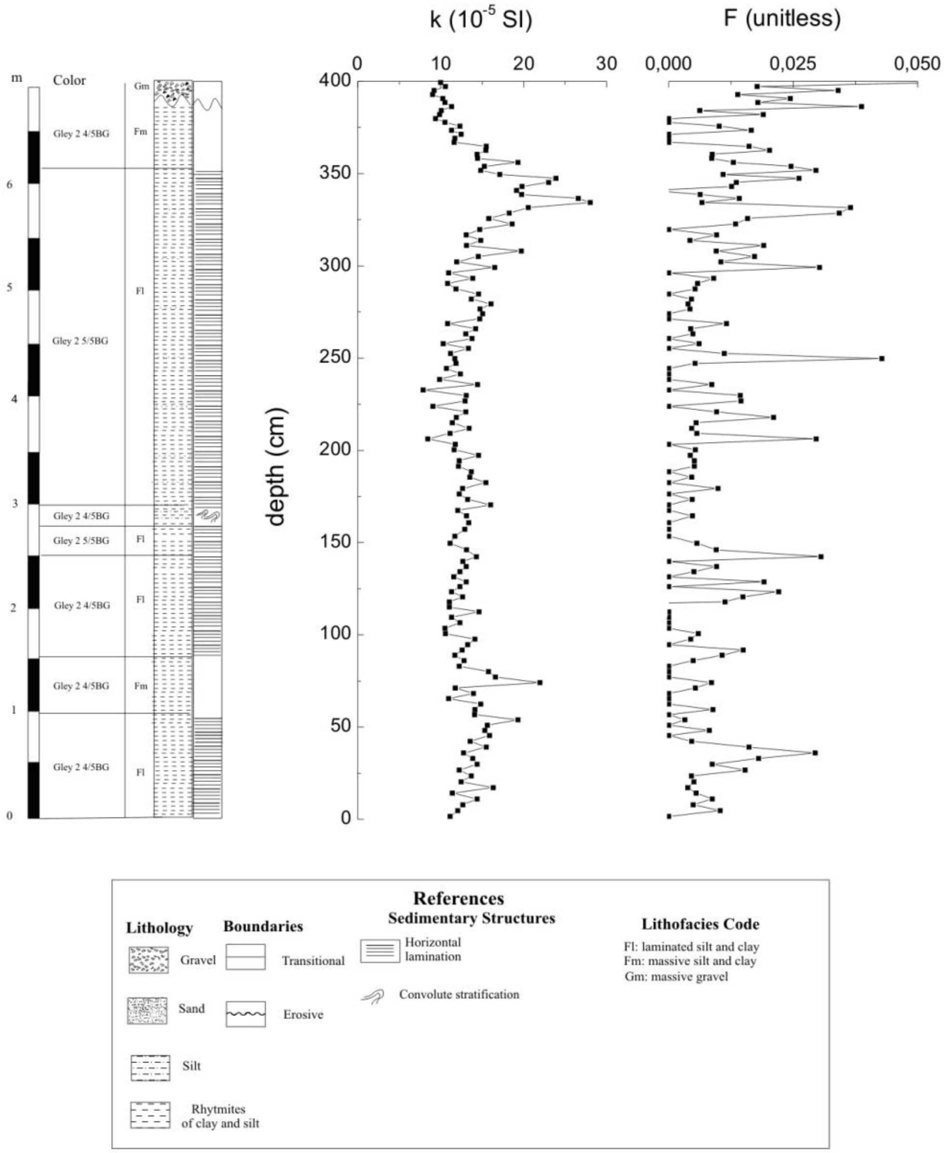

Figure 2. Lithology description and logs of magnetic susceptibility and F factor.

Rock magnetic parameters are investigated in order ~~is~~ to characterize the magnetic properties of ~~the~~ glaciolacustrine sediments as a tool to establish the paleomagnetic and paleointensity record during the deposition time, the recession of the Last Glacial Maximum (Coronato *et al*., 2009).

Down-core plots of k and F of the sequence are shown in Figure 2 along with the lithology. Magnetic susceptibility vary between 10 and 28 × 10^{-5} SI, it shows an oscillating behaviour around 12 × 10^{-5} SI from the bottom to approximately 320 cm, except for a peak observed at about 334 cm. F values vary between 0 and 0.03 showing that SP materials are not important.

Sixteen pilot samples from different lithology were selected in order to measure the others magnetic parameters. Magnetic susceptibility (k), anhysteretic (ARM) and isothermal (IRM) remanent magnetization mostly reflect changes in magnetic concentration within the sediment. They show a constant behaviour around 4 mA/m (ARM) and 250 mA/m (SIRM) between 0 and 300 cm depth, they increase at about twice at 300 cm depth, displaying a high peak at about 334 cm in all the records and gradually declining towards the upper part of the sequence. NRM displays a high at 370 cm. The similarity of the curves would illustrate the influence of the magnetic concentration and grain size on the NRM, as expected for a magnetic mineralogy dominated by magnetite.

Figure 3 shows the stepwise acquisition of isothermal remanence in fields up to 1.2 T. All samples -except 114 (334 cm) and 140 (390 cm)- display similar results documenting that about 90% of the SIRM is obtained between 150 and 200 mT. This indicates that low-coercivity minerals are the dominant magnetic carriers. Progressive removal of SIRM by back-field demagnetisation indicates that B_{CR} varies between 30 and 38 mT (Fig. 4), except for sample 140 (391 cm) for which the value of B_{CR} is 76 mT. According to Peters and Dekkers (2003), these results agree ~~s~~ with the characteristic average value of pure magnetite between 8 and 60mT. The B_{CR} values, a little higher than the characteristic value of pure magnetite, could be explained by the presence of oxidized titano-magnetite, greigite (Roberts and Turner, 1993; Reynolds *et al*., 1994) and/or antiferromagnetic minerals in low concentrations, or by the relative decrease in the grain size.

Parameters S and HIRM are interpreted to reflect the dominant magnetic minerals and, in particular, to differentiate between soft magnetite and hard hematite minerals (Anderson and Rippey, 1988). Both range from 0.92 to 0.98 and from 0.007 to 0.038 (fig. 4) respectively, which suggest the predominance of low-coercivity minerals like (titano-) magnetite or greigite and the contribution of antiferromagnetic minerals (hematite-type) is not significant (Oldfield, 1991). These parameters can also be influenced by grain size variations; higher values are related to coarser grained ferrimagnetic particles (Stockhausen and Zolitschka, 1999).

The SIRM/k ratios are between 1 and 3 kA/m for all the pilot samples, except for 114 (334 cm) are consistent with predominance of (titano-) magnetite (fig. 4).

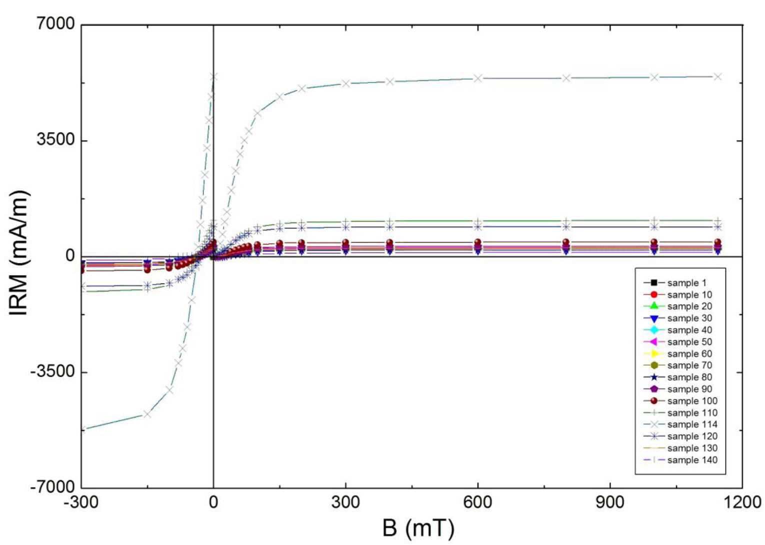

Figure 3. IRM acquisition curves of a group of pilot samples.

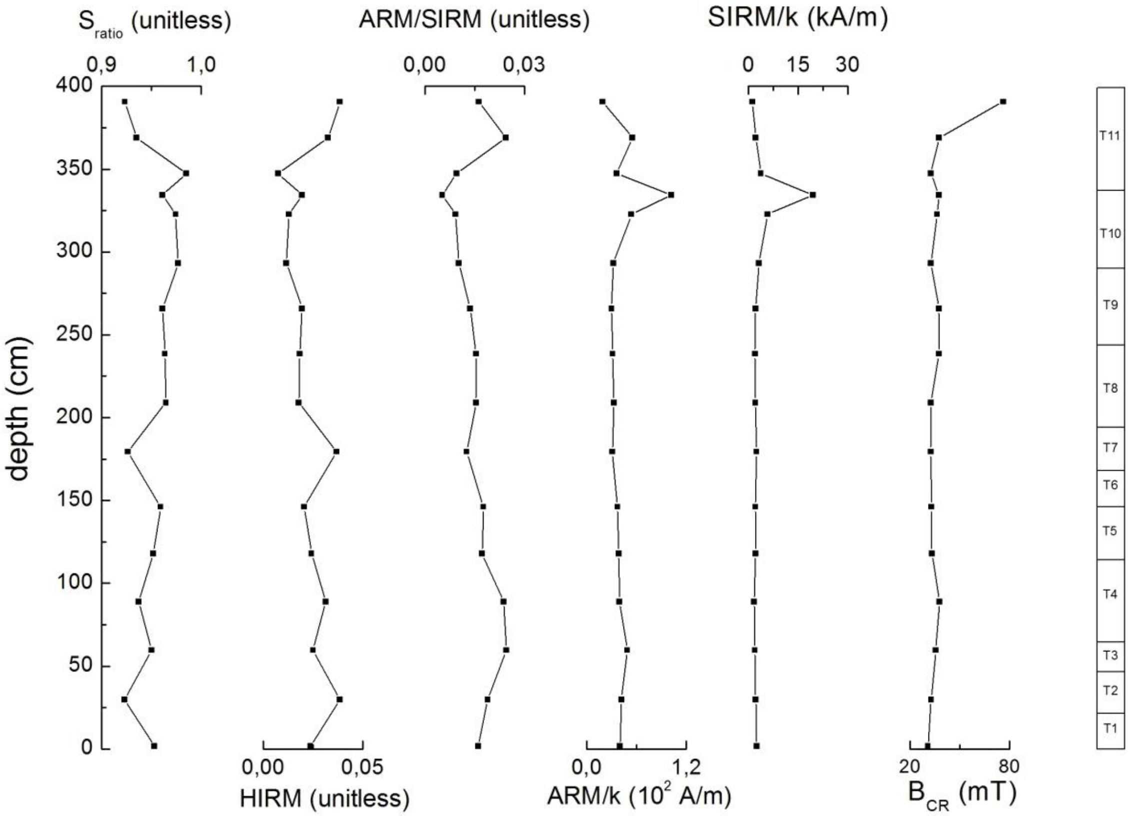

Figure 4. Down-core variation of selected rock magnetic properties from core RV2. Logs of S (unitless), HIRM (unitless), ARM/SIRM (unitless), ARM/k (10^2 A/m), SIRM/k (kA/m), B_{CR} (mT) vs. depth.

While the magnetic susceptibility and the remanent magnetisations (NRM, ARM, IRM) depend on both the concentration and the magnetic grain size, the ratio ARM/SIRM and ARM/k reflect changes in grain size (Hunt *et al*., 1995). The grain size proxies vary with similar amplitudes throughout the record (fig. 4). Nonetheless, there is a gradual coarsening trend from 0 to 300 cm depth followed by a slight trend towards finer magnetic grains during the last 50 cm. The slight differences among ARM/SIRM and ARM/k behaviours would be associated to the presence of paramagnetic minerals along the sequence. It is necessary to be cautious in analysing the differences in sample 114 (334 cm) due to the changes in magnetic mineralogy.

Acknowledgements

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