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Standard magnetic properties in three mountain lakes of northern Iberia, what is the influence of the major environmental processes?

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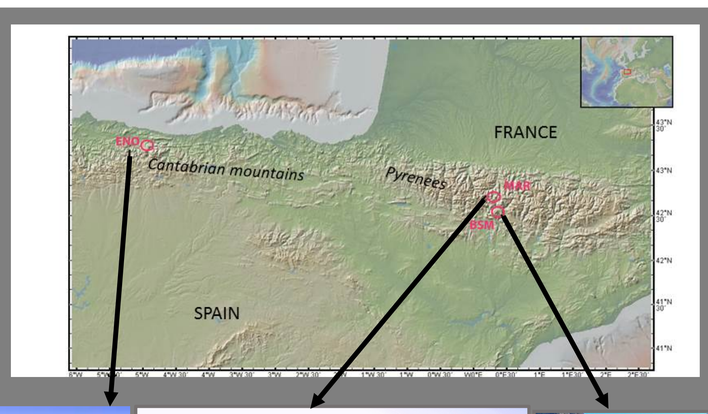
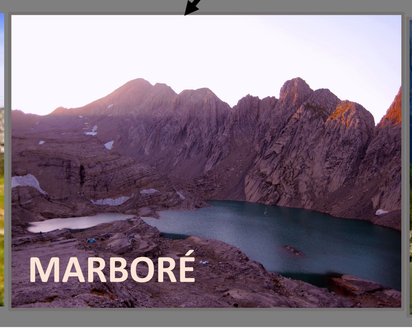
IPE Instituto Pirenaico de Ecología

CSIC Consejo Superior de Investigaciones Científicas

GOAL

A multi-proxy study of Enol Lake (Cantabrian mountains) and Marboré Lake and Basa de la Mora Lake (central Pyrenees) is here complemented by the analyses of magnetic indicators (magnetic susceptibility, and the magnetic signal due to "soft", as for example magnetite, and "hard" as for example goethite, ferromagnetic minerals) thus providing an excellent opportunity to (1) integrate magnetic properties as additional tools to reconstruct past environmental changes in northern Iberia and (2) investigate the subjacent processes that influence on the record and preservation of magnetic properties in lacustrine sediments from high altitude areas.





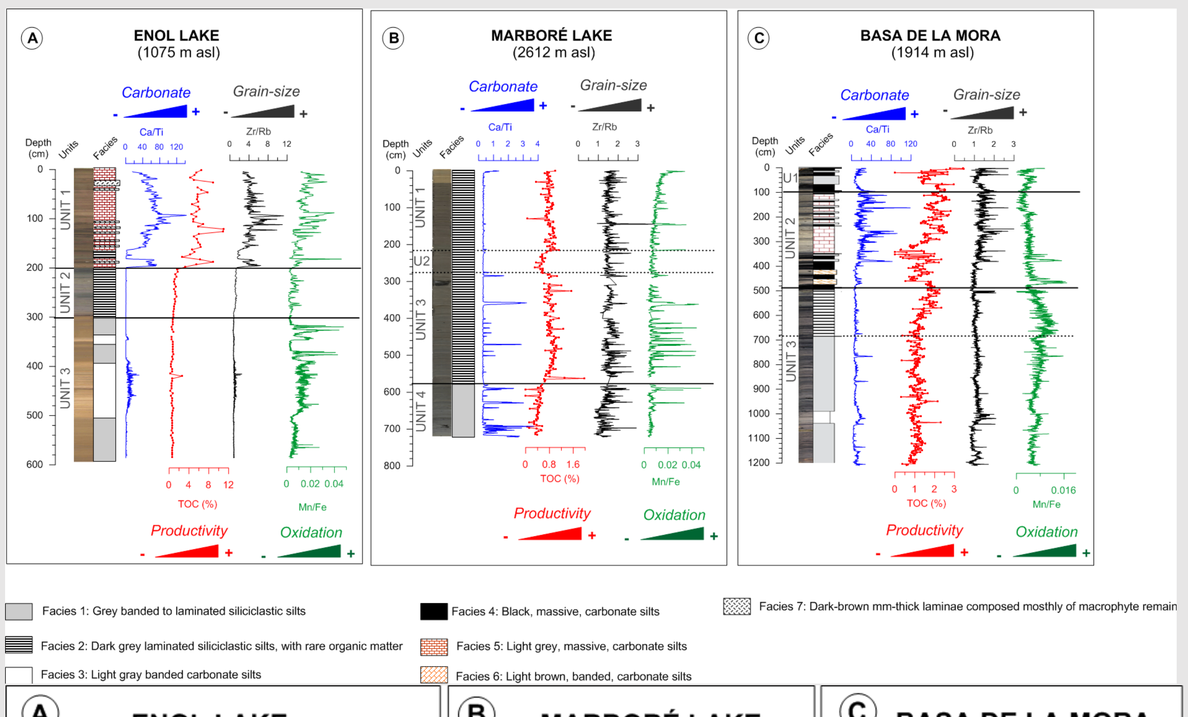
LOCATION

The three selected lakes are located in northern Iberian mountains. **Enol Lake** is located in the Eastern part of the Cantabrian Zone in a catchment dominated by Carboniferous limestones and detrital formations. **Marboré Lake** is located in the central part of the Pyrenean Internal Sierras, a range composed of carbonaceous Meso-Cenozoic rocks. **Basa de la Mora Lake** is located on Mesozoic limestones and sandy limestones. Triassic ophite formations in the watershed are the source of highly characteristic sediments (magnetite, Fe-oxide with high magnetic susceptibility) within the lake deposits.

RESULTS

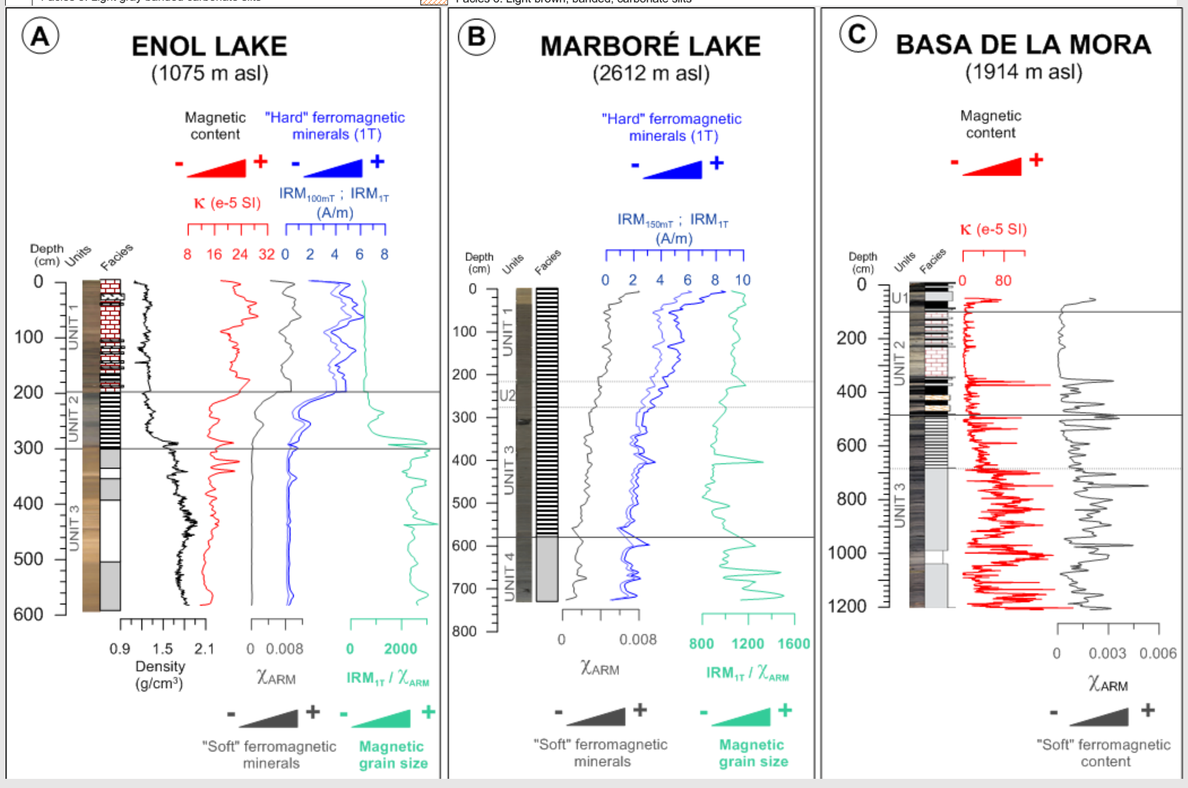
Sedimentology and geochemical ratios of the three lacustrine sedimentary sequences

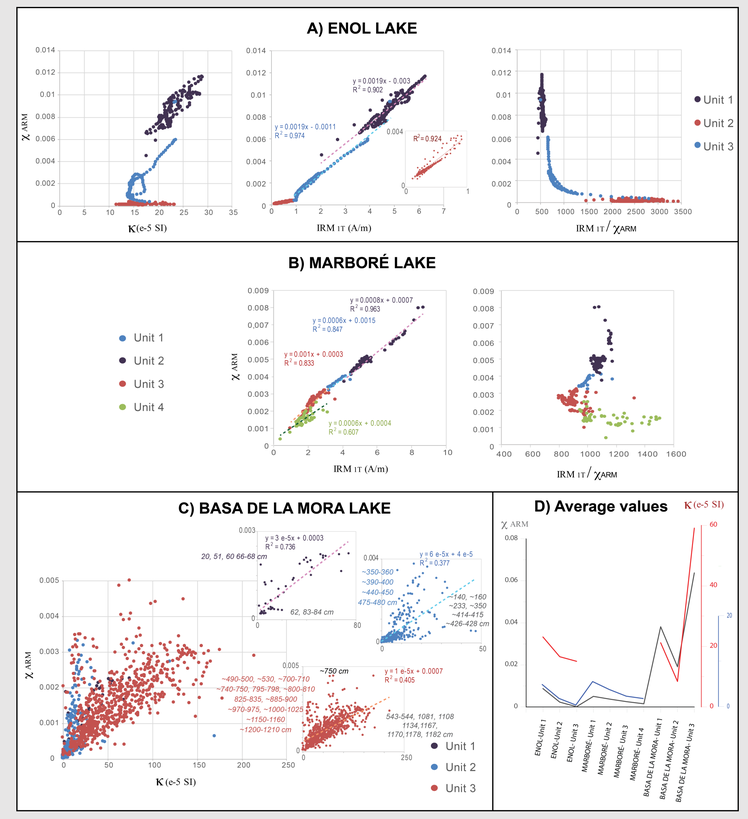
The three sequences are represented versus depth and four proxies are shown: Ca/Ti as an indicator of carbonate in the lake (authigenic or detrital); Total Organic Carbon (TOC) percentage as a proxy for productivity (in-lake or transported from the catchment), Zr/Rb ratio as grain-size information and Mn/Fe ratio as a redox indicator. Sedimentary facies and units are indicated.

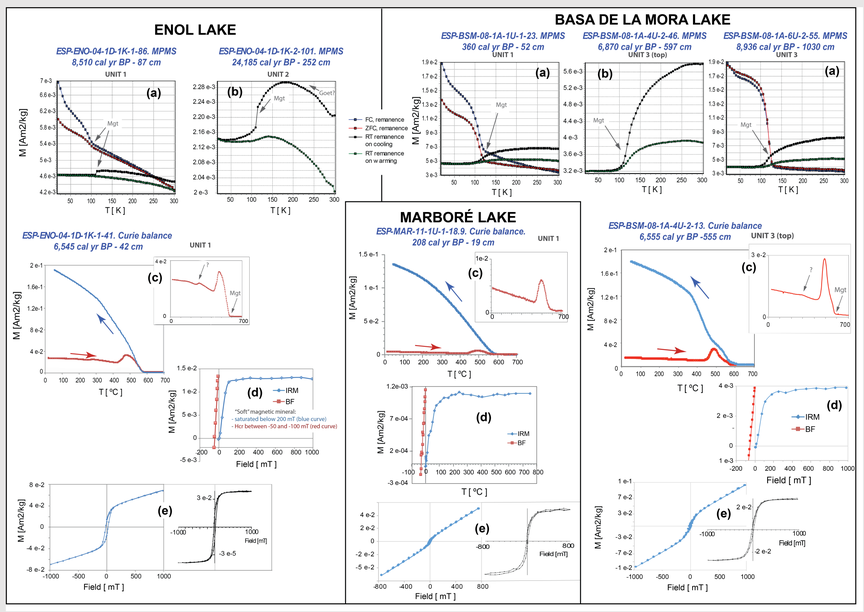


Physical properties of the three lakes

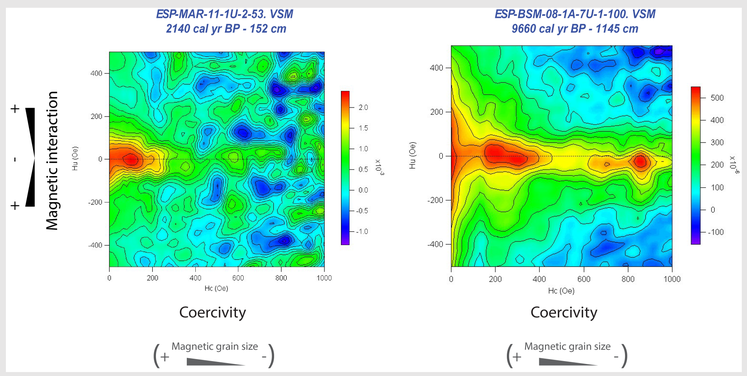
Density (g/cm^3), magnetic susceptibility (k) in e-5 SI, and ARM normalized by the DC fiel (c_{ARM}) "soft" magnetic mineral content, isothermal remanent magnetization at 100 mT and 1T in A/m ("hard" magnetic mineral content) and IRM_{1T}/ χ_{ARM} ratio. B) Marboré Lake: ARM normalized by the DC field (χ_{ARM}), isothermal remanent magnetization at 150 mT (light blue, left) and 1T (dark blue, right) in A/m and IRM_{1T}/ χ_{ARM} ratio. C) Basa de la Mora Lake: magnetic susceptibility (k) in e-5 SI, and ARM normalized by the DC field (χ_{ARM}).







Samples analyzed in the MPMS and Curie balance, age and composite depth are shown. (a) remanence on cooling (black), remanence on warming (green), field cooling –FC– (blue) and zero field cooling –ZFC– (red); (b) remanence on cooling (black), remanence on warming (green); (c) thermomagnetic curve; (d) IRM acquisition and back-field; (e) hysteresis loops, uncorrected (blue) and corrected (black). Results from from Marboré Lake sample (c and d) were presented in the Supplementary material in Oliva-Urcia et al. (2018). Mgt: magnetite, Goet: Goethite.



First-order curve FOR) diagram from Marboré and Basa de la Mora Lakes

Magnetite is in all samples, sharp decrease at 120 K (Verwey crystallographic transition) and 580ºC (Curie temperature of magnetite) in the thermomagnetic curves performed in the MPMS and the Curie balance respectively

Bi-plots of the magnetic properties for A) Enol Lake, B) Marboré Lake and C) Basa de la Mora Lake, in italics depths where values are higher (coloured) and lower (grey) respect to the linear trend-line. D) Average values of the magnetic properties for each sedimentological Unit.

CONCLUSIONS

The combination of geochemical and magnetic analyses reveals their importance to show how the different processes and rocks of the catchment area affect the information stored on the magnetic minerals in mountainous lakes.

The almost concomitant variation of the magnetic properties with depth in the three northern Iberian lakes and the bi-plot information reveal that the concentration of strong magnetic magnetite, is the main cause for those variations. Goethite may be present in Enol Lake and "hard" magnetic minerals (hematite, goethite) are also deduced at certain depths in Enol and Maboré Lakes, probably linked to high oxidant conditions at the bottom of the lake.

Hematite is also observed in Unit 3 of Basa de la Mora Lake by smear sections. Their presence is not detected by the thermomagnetic curves. To infer the origin of such strong magnetic magnetite grains in the three lakes we have deduce the presence of SP grains (by the thermomagnetic curves) that suggest new formation of magnetite. Therefore, aerobic conditions are inferred for the three lakes, in Enol connected to high organic content and in Marboré Lake due to ice cover variations and mixed waters in the lake. The presence of PSD/MD grains can be related to the detrital source. In the case of Basa de la Mora lake, detrital input of ferromagnetic minerals is probably the main source for the observed magnetic values.

The new and revisited data reinforce the necessity of provide geochemical information together with the magnetic properties in order to proper interpret the variations of the latter.

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