BIOGEOCHEMICAL RECORDS OF PALEOENVITONMENTAL CHANGES IN RÍO SECO LAKE, SIERRA NEVADA

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SITE DESCRIPTION

Río Seco (37º 03'N, 3º20'W) is a small (0.4 ha), oligotrophic, and shallow (Zmax=2.90 m) lake of glacial origin located at 3,040 m a.s.l. in the Sierra Nevada Mountains (southern Spain). The lake is ice covered from around October-November until June-July. The lake presents total Secchi disk visibility during the ice-free period. It is a fishless lake, it does not stratify and the food web is very simple. The algae community is mainly composed of diatoms, chrysophytes and chlorophytes. The lake bedrock basin is siliceous, composed mainly by micaschists. The catchment area is partially covered (~15%) by alpine meadows and the lake border is covered by bryophytes.

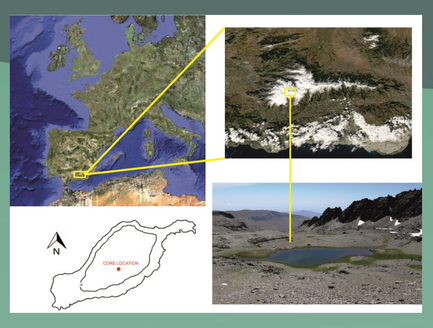

Fig 1. Location of Río Seco Lake

SAMPLING AND DATING

Sediment core was collected from the deepest part of the lake in September 2008 with a percussion corer. Core (16 cm) was photographed, sectioned in the field (0,5 cm) and frozen until laboratory analysis (-80ºC). It was dated by radionuclide Cs-137 and Pb-210.

MATERIAL & METHODS

For pigments analyses- 1 g of fresh sediment were placed in 10 ml of 100% acetone, extracted by sonication (10 min, 50/60 Hz) in darkness, and centrifuged (5 min, 3500 rpm). Pigments extracts were flowed up under N2 until dryness, and anayzed by HPLC. Loss On Ignition (LOI 550ºC, 4h) was determinated to calculate the concentration of pigments identified (µg pigment*gOM-1). CD/TC ratio were analyzed as the sum of all breakdown products of native chlorophyll a and b divide by the sum of all carotenoids.

Elemental C and N were analyzed by a CARLO ERBA EA 1108 CHNSO Elemental Analyzer. 40K activity was realized by gamma spectroscopy. Grain size particle was determined by X-ray diffraction with GALAY modelo CIS-1. Temperature anomalies was calculated by long instrumental temperature series.

Statistical analyses – Fossil pigments abundances were log transformed. Pearson correlations between pigment concentrations, LOI percentage, C/N molar ratio, CD/TC ratio, grain size, temperature anomalies and radionuclides were performed. *P* values less than 0.05 were considered significant. Variables were log or square-root transformed for the analyses and Bonferroni correction applied.

RESULTS & DISCUSSION

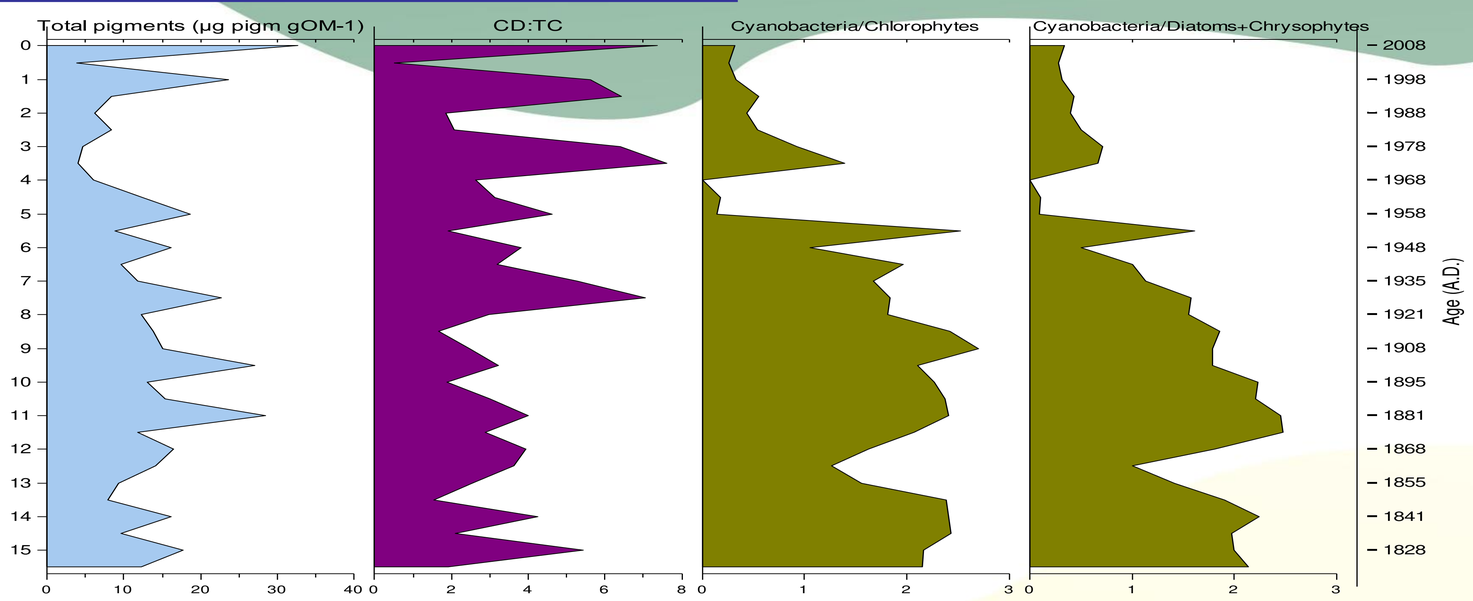

Fig 2. Changes in stratigraphic profile of total pigments (µg*gOM-1) and ratios (CD/TC, cyanobacteria/chlorophyll and cyanobacteria/diatoms + chrysophytes) in Río Seco lake.

PIGMENTS: The sedimentary-pigment record from Río Seco Lake revealed marked changes in lake primary production and community algal composition during the last 200 years

The concentration of the specific pigments for diatoms and chrysophytes and for chlorophytes shows a similar temporal evolution (r2= 0.842; p<0.001) while that for cyanobacteria was no correlated to any other pigment concentration. Zeaxanthin temporal evolution indicates cyanobacteria dominance throughout the 19th century. At the beginning of the 20th century, zeaxanthin concentration significantly decreased and diatoms-crysophytes and chlorophytes become the main algal groups over the second half of the 20th century (Fig 2).

OTHER VARIABLES: In general, the 19th century shows more stable conditions than the 20th century in the core. The period between 1920-1970 shows very changing conditions mainly reflected in indicative variables of organic matter abundance and source, such as LOI percentage, elemental C and C/N atomic ratio. LOI and elemental C showed a high positive correlation (r=0.745; p<0.001) indicating the organic matter source of C.

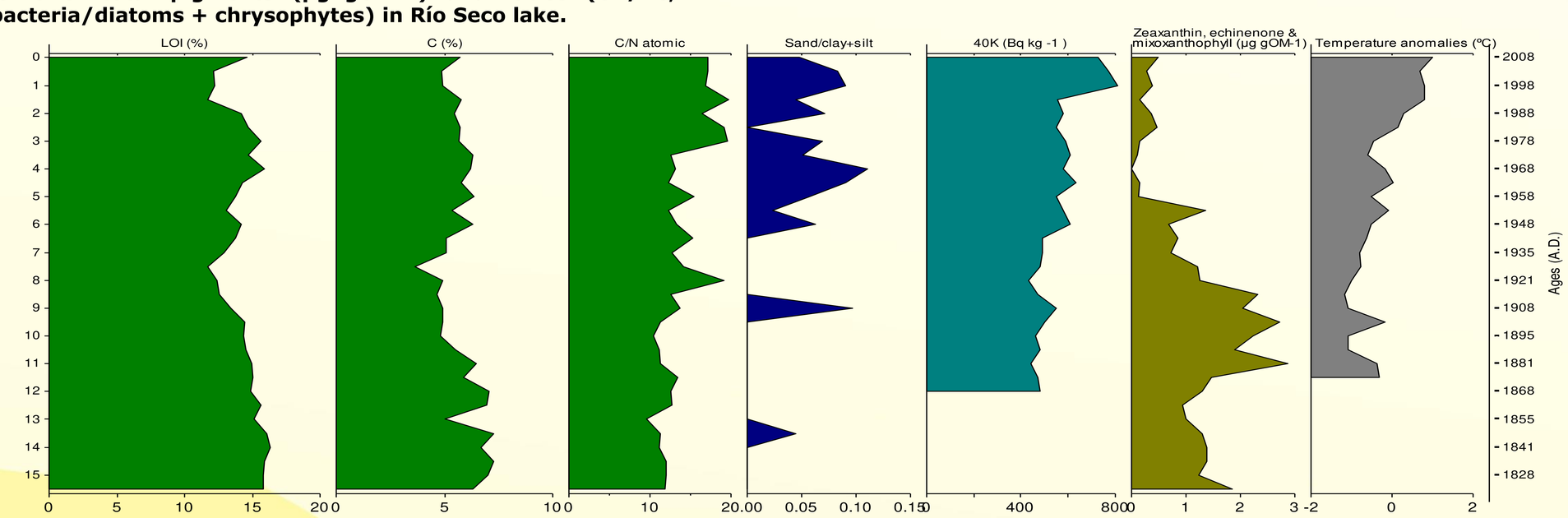

Fig 3. Temporal evolution of LOI (%), elemental C (%), C/N atomic ratio, Sand/clay+ silt ratio, 40K activity (Bq*kg-1), cyanobacteria pigments indicators (µg*gOM-1) and temperature anomalies (TºC) in Río Seco lake.

C/N show marked variations due to small size of catchment basin and its scarce vegetation-covered area. This variable indicates an algal-terrestrial origin of the organic matter, and show higher values from 1960s to present time. The variation in sand/clay+silt ratio reflects fluctuations in catchment basin conditions and climatic changes in Río Seco Lake. The average presence of sand fraction to up-core coincides with the increase of the sedimentation rate at 6.5 cm (ca. 1941), and the positive correlation between sand and temperature (r=0.444; p<0.05) and sand and 40K activity (r=0.534; p<0.01) indicate enrichment of the lake water by terrigenous components, which might occur from a significant increase of melt-water inflow by climatic warming. Negative correlations of Cyanobacteria pigments with C/N ratio (r=-0.557; p<0.001), sand/clay+silt ratio (r=-0.579, p<0.001) and temperature values (r=-0.511; p<0.05) suggest an alteration of lake catchment area. Total pigments concentration shows a marked decrease from 1960s to late 1990s and present a negative correlation with sand:clay+silt ratio (r=-0.366; p<0.05). On the other hand, CD:TC ratio, an index of quality of pigments preservation, show worse preservation conditions from 1960s to present time.

The changes in the algal community since 1960 could be notably associated to climate change by way of longer ice-free period influencing the physical and chemical lake characteristics. The shift in algal composition related to the geochemical variables analyzed (C/N and sand/clay+silt) and climate data (temperature anomalies).

1.-Cyanobacteria community could partially response to climate change. A warmer condition could cause ecologically important changes in lake heat balance and modify its development through decline growing conditions and changes in habitat availability.

2.- Temperature fluctuations in high mountain lakes could cause reduction in ice-cover affecting the catchment basin condition, observed in geochemical variables evolution.

3.- Total pigments and CD:TC index profile confirm a lower pigments preservation due to dilution and/or resuspension of sediment, indicative of alteration of lake catchment.

Akcnowledgments
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