Organic and non-organic geochemistry analysis and paleoenvironment reconstruction in sediment cores of the lake Bolătău-Feredeu (Romania)

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Introduction

Paleoenvironmental and paleoclimate research are among the most popular themes in geosciences. Laminated lacustrine sediments are a response to paleoclimate and paleoenvironmental changes and record this information in organic and inorganic components. Lake sediments provide proxy information at local and regional scales. Lacustrine sediment archive provides an opportunity for collaboration between several disciplines. This research is focused on the analysis of organic and non-organic geochemical data extracted from a young lake sediment sequence (~last 500 yrs).

Study site and chronology

The study area is located in the East Carpathians, in the southwestern sector of Feredeului Mts. (Romania). This study investigates Lake Bolătău-Feredeu, one of the Millenial lakes of Bukovina, with 0,3 ha lake surface and 31 ha catchment area. The sediment cores were collected during April of 2013 when the lake surface was frozen. The sediments were drilled with two different type of corer instruments (Russian corer and a gravity corer). The corer parameters were similar (the d=6.5 +/-0.1 cm and the S= 33.2 ± 0,6 cm2) and the sampling points were very close. The cores were documented, described and photographed. The overlapping region of the two cores fitted perfectly based on the comparison of characteristic zones of the cores (Mîndrescu, 2010 & 2013).

The chronology was based on Pb-210 ages for the top 20 cm and 8 AMS 14C ages. The model built using the P_Sequence function of the Oxcal v.4.2 (Bronk Ramsey, 2009) software. The age model validated based on the two Cs-137 fallout events (nuclear weapon test 1963 & Chernobyl NPP accident 1986) (Karlik et al., 2018).

Methods

The key parameters measured along the sediment profile were elemental concentration and ratios, n-alkane composition of saturated hydrocarbon fraction and particle size distribution.

Element analysis. The samples were measured with a RIGAKU Supermini wavelength dispersive X-Ray fluorescence spectrometer with Pd X-ray tube 50 kV excitation voltage and 40 anodes current. EZScan measuring method and 40 minutes measurement time was applied to measure elements from fluorine to uranium.

Organic geochemistry. The entire saturated HC fraction was analyzed by gas-chromatography using a Fisons 8000 GC with Flame Ionisation Detector using the following parameters: injector temperature: 310°C split: 1:10, DB-TPH 30x0.32x0.25 column, detector temperature: 310°C. The oven was kept at 60°C for 1 min, then heated up to 150°C (20°C/min), then up to 330°C (6°C/min) for 5 min. To avoid the potential bias due to the variable amount of saturated HC subsamples, the changes in the alkane composition will be evaluated using well-known indices calculated as ratio between summed peak areas of certain alkane groups. (Karlik et al., 2018).

Particle size analysis. Particle size distribution was determined using a Fritsch Analysette 22 Microtech Plus laser diffraction particle size analyzer, which measures in the range of 0.08 µm - 2.0 mm. Samples were treated for carbonate and organic matter removal according to USDA (United States Department of Agriculture) NRCS method (Burt, 2004). Three particles/pieces (ca. 1 g) were taken from each treated sample. Five minutes of ultrasonic treatment and sodium-pyrophosphate (55 g l-1) was applied to allow a complete dispersion of the specimens. Refractive index and the imaginary part were assumed to be 1.54 and 0.01 (Eshel et al., 2004; Varga et al., 2015). The percentage of sand (2000–50 µm), silt (50–2 µm) and clay fractions (below 8 µm) were reported, according to a modified USDA texture classification scheme (Konert & Vandenberghe, 1997).

Findings

~1500 A.D. -1620 A.D. Decrease in woody vegetation
Herbaceous species replaced the closed forest vegetation in the catchment area based on n-alkane distribution, corroborated by LOI, sulfur and phosphorus indices.
1600 A.D. – 1700 A.D. Effect of cold period on the catchment
Based on n-alkane indices, bioproduction in the catchment area decreased, which is reflected by the sand fraction peak as well as the low phosphorous content. Phosphorous data show a signal in the coldest period between ~ 1629 A.D. and 1650 A.D.
1700 A.D.-1780 A.D. Stable period in the catchment
An apparent stable period was found between1700 A.D. and 1780 A.D., showing only a slight decrease of the herbaceous contribution, presumably caused by the undisturbed growth of the woody plants. However, rapid changes may influence herbaceous vegetation without significantly impact woody plants, resulting in decreasing herbaceous contribution.
1760 A.D. – 1860 A.D. Deforestation under a cold period
The modelled temperature dataset indicates a cold period. The non-organic datasets, especially phosphorus, sulphur, sand fraction distribution and calculated weathering indices helped to understand the exact course of the deforestation event which started around 1811 A.D. and ended around 1820 A.D. In this short period a lot of organic matter arrived into the lake from the catchment area. This significant deforestation also changed the weathering conditions.
1860 A.D. – 2010 A.D. Modern landscape change
Human activity was observed in the area as an additional factor in the lake-catchment system. The anthropogenic effect was confirmed by several parameters: LOI %; S; weathering indices.

The vegetation showed stages of natural forestation during this period: first the herbaceous contribution increased in the catchment area then it was displaced by woody vegetation.

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