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Climate reconstruction and environmental changes during the Holocene period based on a varved sediment record from Vouliagmeni lake, Corinth Gulf, Greece

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Background

The eastern Mediterranean region has long been a region of interest concerning palaeoclimatic (Kaniewski et al., 2013; Triantaphyllou et al., 2014) and palaeoenvironmental (Pavlopoulos et al., 2012; Kouli et al., 2012; Avramidis et al., 2017) studies, due to climate heterogeneity and complex atmospheric circulation patterns that produce regional precipitation and temperature fluctuations. Studies of coastal sedimentological environments allow the recognition of coastline changes and give information about the rate of sedimentation, eustatic sea level changes and tectonic movements.

Annually laminated lake sediments (varves), have proven to be excellent geoarchivies in order to interpret changes that occurred during the Holocene period, regarding elemental fluxes, palaeoclimate reconstruction, sea level fluctuation, tectonic activity etc. The distinct color, composition, texture structure and thickness, contained in all varve types, corresponds to different climatic driven mechanisms. Thus, the study of varved sedimentary records, can provide annually to seasonal climatic variations and mirrors sedimentological and environmental conditions taking place in the catchment.

Objectives

The study area is located at the east part of the Gulf of Corinth, an active rift and one of the most seismically active regions in the world. Until the 19th century, when an artificial channel was opened, lake Vouliagmeni lake completely separated from the sea. Anoxic conditions seem to prevail throughout the year, at least below 38 m water depth. Human occupancy in the area, as indicated from archaeological findings in the area, is recorded during the Bronze Age (3100-1700 BC) and Early Iron Age (1075-750 BC).

The aim of the present study is the high-resolution analysis of a 6m varved core retrieved from Vouliagmeni Lake, covering the last ~ 12000 years, in order to extract regional and long scale palaeoclimatic data.

Methods

Standard sedimentological analysis was conducted on 90 samples, including grain size analysis, Total Organic Carbon (TOC) and Calcium Carbonate content. For the X-ray Diffraction (XRD) analysis, a Brucker D8 device was used. XRF core log analysis was performed with a step of 0.5 cm, at the Institute of Geosciences at Kiel University (Germany), using an Avaatech system. Core scanning was performed with a Molybdenium tube set at 10 kV and 30 kV with an integration time of 60 second per measurement. The chronological framework of the core was determined by 8 AMS ^{14}C radiocarbon dating, combined with laminae counting. For the exact determination of each lamination boundaries as well as an estimation of the bulk density throughout the core, CT scanning was performed, at General University Hospital of Patras in Greece.

Results

Through varve counting in the sediment core, combined with the AMS radiocarbon dating, the accumulation rates in the study area seem to change at around 3 ka BP (Fig. 1). Varved sediments interrupted by non laminated silty clay sequences were recognized in all core Units. Calcite rich layers alternating with organic rich layers, correspond to summer and winter depositions. Varve thickness was determined through the CT scan models that were produced for the core and was used as a seasonal intensity interval.

Representative elemental ratios were constructed in order to recognize the different sedimentary processes taking place in the study area (Fig. 1). Some long-scale climatic events (8.2 ka BP, 6-5 ka BP, 3.2-3.8 ka BP) seem to be well reflected into the elemental composition of the core. Rb/Sr ratio which is a suitable indicator for precipitation/physical erosion in the catchment area, shows distinct climatic driven fluctuations. The aragonite rich laminations that occur in the core, are documented in the Ca/Sr ratio, with increased values distinguishing a terrigenous supply of $CaCO_3$. The S and Pb content were used for marine inundations.

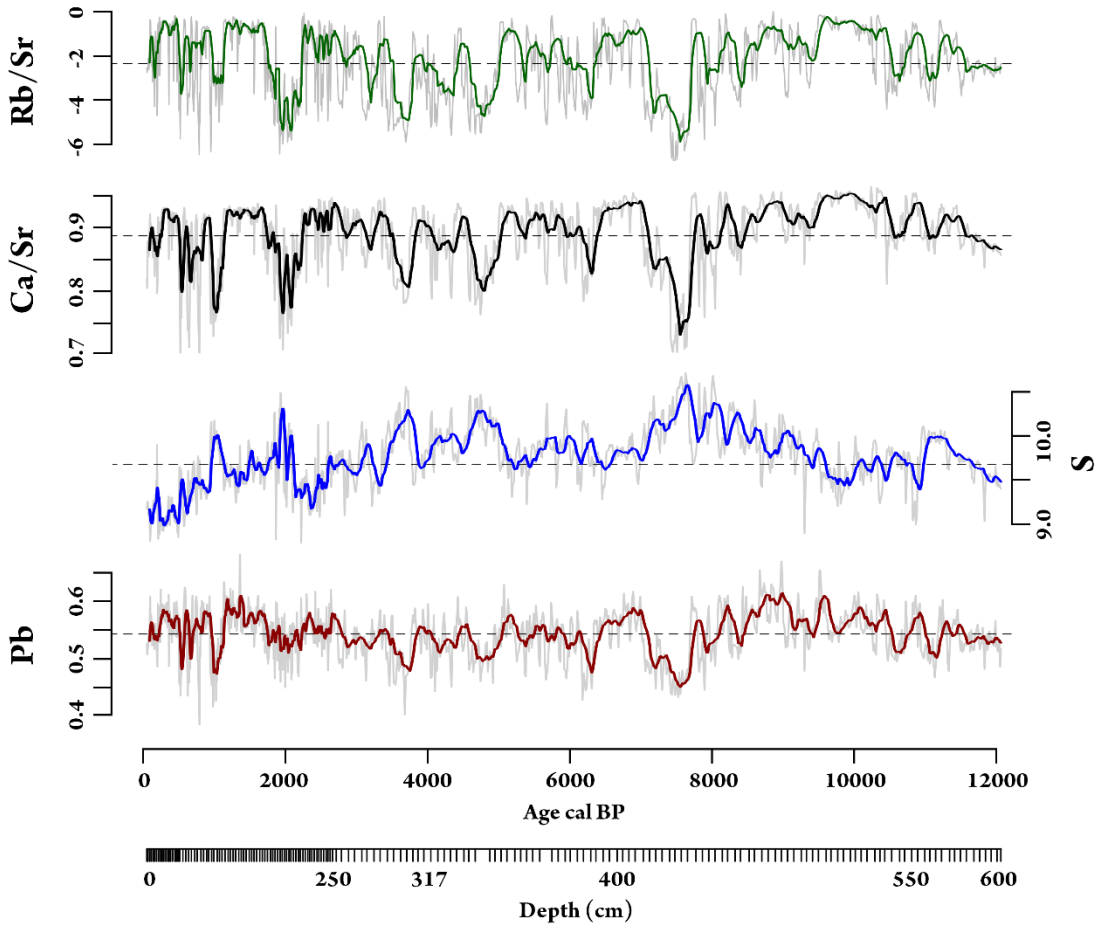

Figure 1. Representative geochemical proxies from Vouliagmeni core.

Conclusion

Vouliagmeni core, presents the oldest geoachive in Greece concerning varved sediments. Sedimentation rate of the study area seems to completely change at around 3000 cal BP and can be strongly associated with the relative sea level change at around that time. Paleoclimatic signals detected through the geochemical analysis conducted in the core, pronounce clear interaction between elemental composition and temperature/precipitation fluctuations. Future analysis and microscale examination especially in the varved sequences, will provide even more details regarding regional climatic fluctuations and will increase the spatial coverage on the already existing palaeoclimatic datasets.

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