Holocene Paleoclimatic Variation Inferred from Study of Sediments in the Gulf of Tunis (North Africa)

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Abstract

The lithological study of sediments from a 30 m length core, taken at the western part of the lake of Tunis, combined with the study of benthic macrofauna, helped to identify the different stages of evolution of this ecosystem and the associated climatic fluctuations throughout the period spreading the Tardi Würm (about 42,000 years) to the Holocene. The sedimentological study allowed distinguishing six main facies characterizing different depositional environments. The identification of the mineralogical composition of the Holocene sediments of the upper part of the core, helped to note presence and dominance of two main minerals detected in all samples which are Quartz and Calcite. The determination of TOC contents in samples of Holocene sediments shows the existence of three levels: a surface level with high TOC values (reaching 5.1%), a second level at which values decrease gradually (around 1.1%) and the bottom level with sandy sediment record values <1%.

Keywords

Lake of Tunis • Holocene • Paleoclimatic fluctuation XRD • TOC

1 Introduction

Changes in deposition processes over thousands of years are recorded in sediments and will be revealed by lithological, geochemical and/or biological studies [1, 6]. The lithological study of the filling modes of the aquatic systems associated with the study of the rate of preservation of the organic matter in the sediments is an important tool in the reconstruction of the paleogeographic evolution of these environments [10].

The actual morphology of the Gulf of Tunis is the result of its evolution during Holocene Period [9, 7]. The aim of this study was the use of lithological and organic investigation to record paleoclimate evolution in this south Mediterranean zone (Gulf of Tunis) during Holocene and its impact on the morphological evolution of the lake and its filling mode.

2 Materials and Methods

"Tunis Lake" is a small ecosystem directly connected to the gulf of Tunis. Previous studies confirm that the sedimentation rate in the lake of Tunis, measured at 70, and 210 cm are respectively 28 cm/1000 years and 70 cm/1000 years [7, 9]. These results allow the estimation of core dating.

This study focused on the first ten meters (covering Holocene period) of the thirty-meter depth core (SC4). This core was taken from the inner side of the lake.

The lithology of the core was described (microscopic and macroscopic observation), different samples were collected for analysis and macro-fossils descriptions were undertaken. Coarse fraction consisting of shells was separated by sieving. Fine fraction (<63 μ) was taken for mineralogical analysis (X-ray analysis). The bulk composition of the total organic fraction (TOC) contained in the sediments was determined using a Ströhlein Coulomat 702 apparatus.

3 Results

3.1 Lithological Changes and Climatic Fluctuations

The top of the core is made up of 35 cm of black vase. In depth, the lithological variation along the core is

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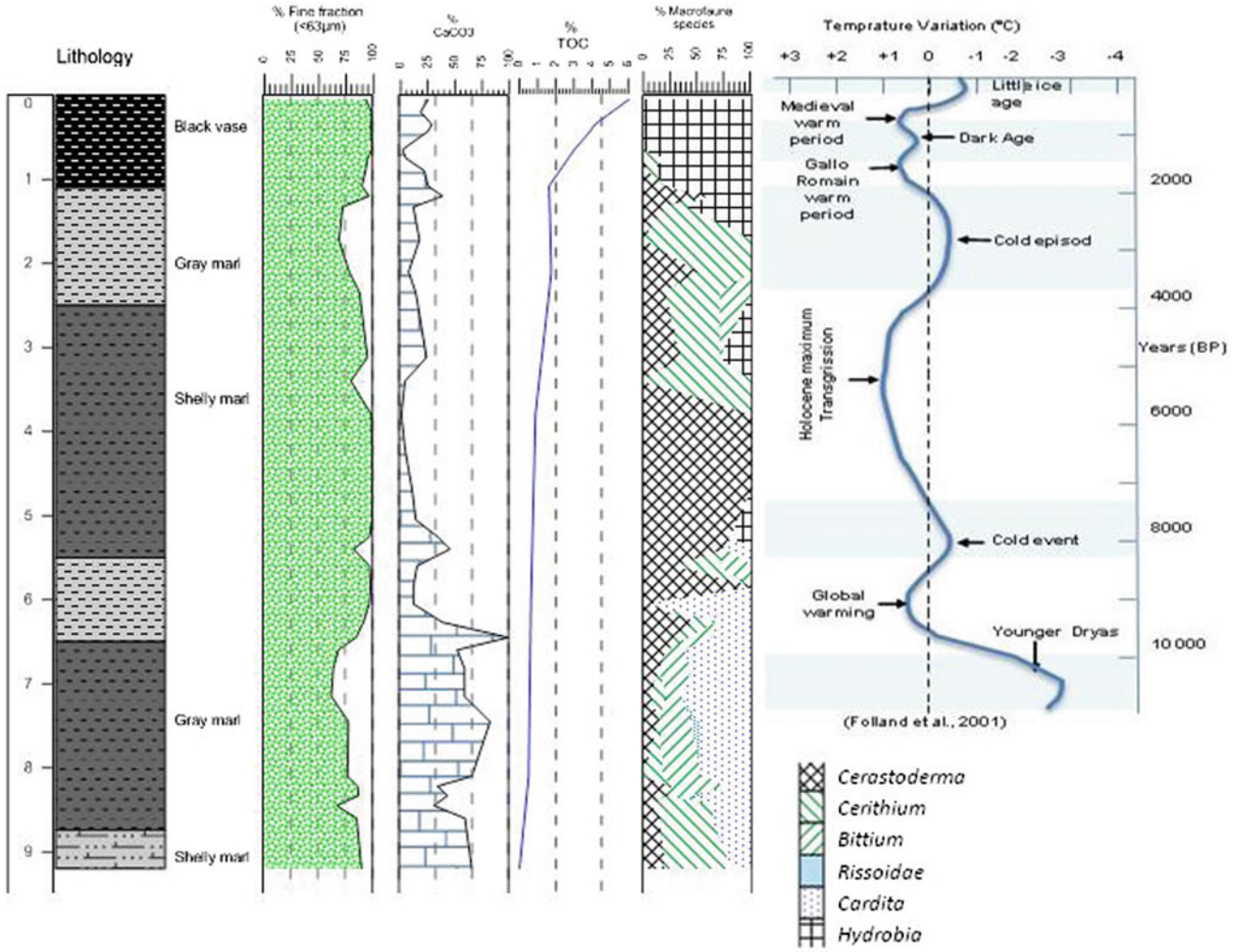


Fig. 1 A synthetic log representing the evolution of the filling in the lake during Holocene

characterized by alternating layers of gray sandy marl and layers of dark shelly marl. Compared to the diagram of temperature fluctuation during Holocene period [4] the cold events (early Holocene) are marked by sandy marly facies generally poor in shells. However the installation of warming episodes is always associated with the presence of shelly marl (Fig. 1).

3.2 Mineralogical Study of Holocene Sediments

Different diffractograms were used for the qualitative and quantitative characterization of minerals that form the Holocene deposits. Thus, it was observed that sediments crossed by the carrot, mainly consist of Quartz and Calcite, and a lesser amount of Aragonite and Dolomite.

In the upper part of the core, there is a predominance of quartz (around 50%). Calcite is present at a relatively low percentage (around 20%). This trend continues until about 6 m deep. Beyond this depth, sediments recorded relatively high percentages of calcite (reaching 95%).

3.3 Evolution of the Lake Environment Recorded by Macrofauna Study

Macro-fauna, representing the Holocene epoch [9, 3] shows a faunal association corresponding to three evolution stages (from bottom to top): closed lagoon environment, open lagoon environment and marine environment.

Species characterizing a closed lagoon environment are mainly represented by Hydrobia [5] and Cerastoderma [3]. These two species show a clear abundance in the upper part of the core.

Species indicating an open or semi-closed lagoon environment are mainly represented by Cerithium and Bittium [3]. These gastropods are abundant between 2 and 8.74 m and decrease in sandy sediments from 8.74 to 9.2 m.

Species of a marine environment which progressively replace the lagoon species are represented mainly by the Cardita species and by Rissoidae [8, 3].

3.4 Study of the Organic Content of the Holocene Sediments

The distribution of the TOC along the core shows an evolution directly related to lithological changes previously defined [2, 1, 6].

High TOC values reaching 5.1% in surface sediments are related to the evolution of the lake during the Little Ice Age (about 500 years BP).

Beyond 0.4 m, during the Flandrian transgression, the TOC contents showed a slight decrease (values are around 1.1%). During the Würmian phase (characterized by cold weather), TOC remains relatively low (around 0.5%). The episode of warming seems to be associated to relatively high levels of organic matter.

4 Results and Discussion

Different investigations and analyses have enabled identifying and understanding climatic fluctuations that influenced morphological changes in the gulf (Fig. 2), from the end of the last glaciation to the Holocene (last 40 ka).

During this period the sedimentary column in the gulf shows three distinct successive environments of deposition attested by changes in the lithology and the content of organic sediment.

The Younger Dryas (cold event: 12,700–10,000 years) is represented in the gulf by the deposition of sandy marl. The mineralogical composition of these sediments indicates the importance of detrital deposits.

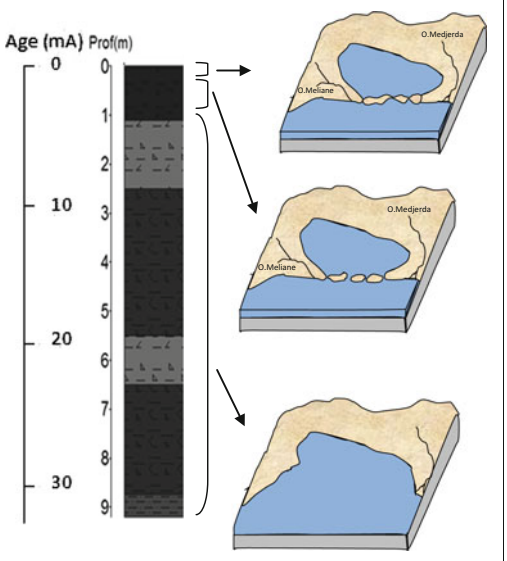
The sedimentary filling of the lake, during the **Holocene**, consists essentially of marl (carbonates are systematically the dominant mineral: about 50% of abundance) or vase materials. Macrofauna, that dominated these deposits, consists mainly of mollusk characterizing an open lagoon. Global warming at this epoch promotes the primary of organic matter production, essentially near the surface.

In the little ice age (500 years BP), sediments were dominated by benthic macrofauna charactering a closed lagoon environment. During this period, the climate and especially morphological conditions favor deposits rich in organic matter.

5 Conclusion

The results obtained from the study of sedimentary column of the Gulf of Tunis allow reconstituting the morphological evolution of the basin. This is clearly expressed through the differentiation of the three distinct evolution stages within the sedimentary column during the Holocene period: closed lagoon stage, open lagoon and marine environment.

The present new results are of a significant interest since they demonstrate that the study of sediments accumulating in aquatic environments, combined with the study of organic matter, may act as a perfect tool to trace the sedimentary evolution of an aquatic system. Additionally, this should help in the reconstitution of the paleogeographic and



Stage1 : (600 years BP-present), closed Lake
Climate: cold climate tending to warming to 150 years BP.
Lithology: black mud deposits
Characteristic fauna: dominance of mollusk (Hydrobia, Cerastoderma)

Stage2: (2000 years -600 years BP), open lake
Climate: varies between cooling and warming
Lithology: marl deposits
Characteristic fauna: dominance of Bittium and Cerithium

Stage3:
Climate:
- Warm climate (8000 years- 2000 years BP)
- Varying temperatures between cooling and warming (42000 years- 8000 years BP)

Lithology: facies with madrepores, sandy facies, marl facies poor of shells.
Characteristic fauna: marin mollusk+ madrepores

Fig. 2 Schematic representation of the different stages of Lake of Tunis

morphological history, and in assessing even the subtle changes in the physico-chemical (oxic vs. anoxic) conditions that prevailed during the basin history and which are in close relationship with the global climatic changes.

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