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PALAEOENVIRONMENT AND ARCHAEOLOGY: THE USE OF DIATOM ANALYSIS IN ARCHAEOLOGY

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ABSTRACT. Diatoms are being used increasingly to assess short- and long-term environmental change, because they are informative, versatile, flexible, and powerful ecological indicators. Diatoms respond rapidly to changes in many ecological characteristics. The assemblages are usually diverse and therefore contain considerable ecological information. For this reason, and because it is easy to obtain large numbers of individuals, robust statistical and multivariate procedures can be used to analyze assemblage data. Methods for collecting, analyzing, and presenting data have advanced rapidly in the past 10 years.

Introduction

Although diatom analysis has been used in archaeological science for over 40 years (Battarbee, 1988; Juggins, Cameron, 1999) similar studies in Bulgaria are scarce (Temniskova, Doitcheva, 1989; Ognjanova-Rumenova, 1995; Ognjanova-Rumenova, Zaprjanova, 1998; Ognjanova-Rumenova et al., 1998; Ognjanova-Rumenova et al., 1999). Diatoms are single-celled microscopic plants belonging to the algal division Bacillariophyta (Round et al., 1990). They feature a distinctive, highly ornamented cell wall composed primarily of glass (SiO_2). Each cell wall is made of two main pieces, called valves, and belt-like elements, that hold the valves together, called girdle bands. The taxonomy of diatoms is based on the unique, ornamented structure of the valves, and it is the valves that are measured and counted in ecological studies of diatom communities.

Diatoms are key components of nearly all fresh and saline environments. All species are good indicators for a range of water quality variables, because they have narrow optima and tolerances for many environmental variables: habitat, salinity, pH of the water, nutrient, temperature, saprobity, etc. Diatoms respond quickly to environmental change because they immigrate and replicate rapidly. A small number of examples is chosen that best illustrate the application of diatom analysis in archaeological studies: the relation between culture and environment (the analysis of the archaeological sediments and processes of site formation), as well as – the analysis of the other isolated structures and archaeological artefacts.

Site-based palaeoenvironmental reconstructions

Knowledge of the local environment of a site is essential if its socioeconomic function is to be fully understood. One of the best examples of the collaboration between diatomists and archaeologists comes from the excavations in the Bay of Sozopol. The history of the settlement in Sozopol is well-documented by extensive archaeological and historical data (Draganov 1995; Angelova, Draganov, in press). Archaeological excavations were carried between 1990 and 1993. The study area included two zones of investigation: Sozopol 1 and Sozopol 2 (Fig. 1). Eight more or less connected squares, 5 by 5 meters in size, were excavated in these zones. Three of the squares contained only Early Bronze Age material (A, C, E); two contained Early Bronze Age and under a hiatus, Chalcolithic material (B and F), and three contained only Chalcolithic material (D, G, H). A complete synthesis of the results of diatom analysis of the profiles in squares 'D' and 'F' were already published (Ognjanova-Rumenova, 1995; Ognjanova-Rumenova, Zaprjanova 1998; Ognjanova-Rumenova et al. 1999).

This study aims to show the advantages of multidisciplinary investigation of sediments in an attempt to reconstruct the palaeoecological conditions and processes. Diatoms and chrysophycean stomatocysts have been used to retrace the palaeoenvironmental changes, i.e. climate, local sea-level changes, land-use and trophy during the Chalcolithic and Early Bronze Age.

The diatom flora comprises only recent species. Totally 173 taxa (species, varieties and forms) were identified. The vertical distribution and the relative abundance of the species in the diatom succession were studied and the diagrams were presented separately for squares "D" and "F" (e.g. Fig. 2). The investigated florae from these two squares had a group of common species that allows correlation – 57 species, varieties and forms (30.6%).

Chrysophycean stomatocysts were the second major siliceous microfossil group present in the investigated sediments. These were endogeneously-formed siliceous stomatocysts (also called statospores or resting cysts) which have been widely believed to be taxon specific. During the Schrader investigation (Schrader, 1978) of the Black Sea sediments abundant chrysophycean stomatocysts were occurring in almost all diatomaceous samples. They were classified into group A (with smooth exterior) and group B (with rough exterior or with scattered spines). An ecological tendency was observed, deduced by the diatom composition, that group A dominated in freshwater assemblages and group B – in brackish and marine assemblages. Changes in trophic status, expressed in different primary production, change the composition of diatom assemblages. These changes coincide with the variation in the percentage ratio – total sum of diatom frustules/fossil chrysophycean stomatocysts (Smol, 1985).

Three successive phases could be distinguished in the Bay development during the Chalcolithic and the Early Bronze Age. During the first phase sediments deposited in diatom zones A (squares “D” 2.20-0.70 m and “F” 1.80-1.40 m). The taxonomical composition was poor and most diatom representatives were with low abundance. With regard to the habitat - benthic-epiphytic species prevailed and the depth of the Bay ranged between 1-3 m. The diatom flora was freshwater/brackish. The active water reaction is neutral to slight alkaline. Appearance of some acidophilic species proved the processes of rotting in the littoral zone, which indicated an anthropogenic influence. These results coincided with the sediment lithology of the profiles (clay sediments and lack of fossil molluscs) and with the results of the archaeological excavation (remains of the Chalcolithic settlement on this level). Traces of human activity were also confirmed by the diatoms/chrysophycean stomatocysts ratio.

In the second phase (diatom zones B: squares “D” (0.70-0.10 m) and “F” (1.30-0.90 m) the Bay was marine/brackish. The development of marine and planktonic species had significantly increased and the depth of the bay ranged between 6-10 m. The active water reaction was neutral, but the peaks in the presence of alkaliphilic species proved high carbonate content of the water. These data coincided with the mollusc development. Eutrophic conditions have probably changed at that time as a proof of human activities of the ancient settlement. Decrease of the *Chaetoceros* spp. resting spores and chrysophycean stomatocysts was caused by an influx of marine/brackish water and a decrease of nutrients. The hiatus in the archaeological stratigraphy on this level was probably due to a rise of the sea-level and inundation of the ancient settlement with marine/brackish water. In this second phase the subzone Ba was included in the sediments of square “F” (0.90 m). During this period the Bay had no direct contact with the sea and the marine influx was limited.

During the third phase (diatom zone C, square “F” (0.80-0.10m) the hydrological conditions in the bay had changed once more. The depth of the Bay ranged between 3-8 m and it was formed under the influence of a post-Chalcolithic regression. Diatom flora indicated marine/brackish environment and the salt content of the water was near 30‰. The active water reaction was neutral. An insignificant increase in the quantity of the chrysophycean stomatocysts on this level proved a new eutrophic change. This increase coincided with the changes in the archaeological stratigraphy – the emergence of a new Early Bronze Age village (Draganov, 1995).

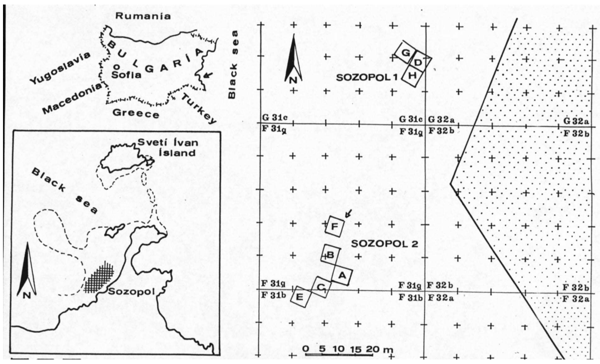

Fig. 1. Map of the area with location of the coring site (the map is redrawn from Draganov, 1995)

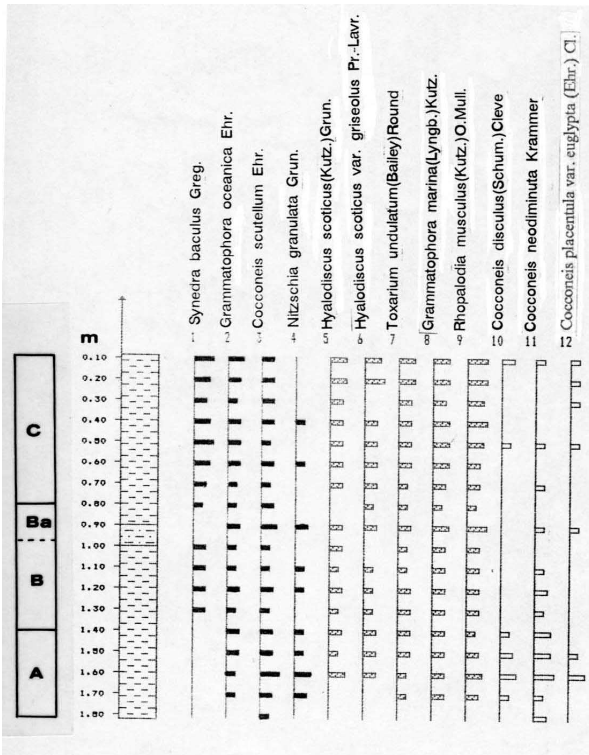

Fig. 2. Diatom diagram from square “F”, the Bay of Sozopol, showing the succession of the most common taxa

Analysis of other isolated structures and archaeological artefacts

During the archaeological excavations in a cave of an island in the Durankulak Lake a Miocene sequence outcropped. Because of the lack of fossil diatom remains, our study deals with the sedimentary development of the island and the investigation focuses on the changes in the chemical composition of the sediments. The island was located within the boundaries of the Eastern Paratethys during the Middle Miocene. This area is related to the border region of the Varna-Balchik depression according to the palaeogeographic division of Kojumdgieva & Popov (1981). The border region was a comparatively stable and erased stripe, which enclosed the depression from the West and from the North. During the Middle Miocene this palaeogeographic area was a shallow shelf; periodically overflown by the water of the Eastern Paratethys. The concentration of many components, particularly of carbonates (mostly magnesium carbonate) was so high that in the end of the Middle Miocene a vast chemical sedimentation of calcite and dolomite took place (Kojumdgieva, 1983).

The investigated sediments, described in the cave of the island in the Durankulak Lake, belong to the Odara Formation (Popov, Kojumdgieva, 1987). The limestone matrix yields fossil remains of mollusca *Plicatiforma fittoni fittoni* (Orb.) which biostratigraphic range provides a useful age reference. This taxon has been reported as index species of zona *Plicatiforma fittoni fittoni* and it has been dated as Late Middle Miocene (Sarmatian stage, Bessarabian substage) or about 11 Ma (Popov, Kojumdgieva, 1987; Harzhauser, Piller, 2007). The description of the investigated profile (Fig. 3) is published separately (Ognjanova-Rumenova, in press)

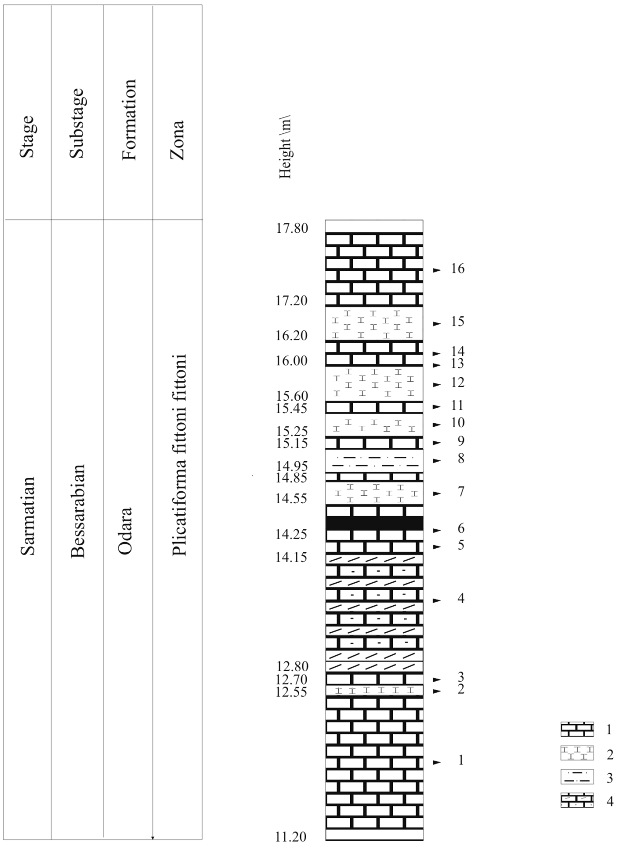

Fig. 3. Geological profile of the island in the Durankulak Lake

This analysis proved three types of sedimentary rocks, which alternated in the sequence: limestones (with calcite and goethite); chalk (with chemical origin) and dolomites. What could be the probable anthropogenic use of these deposits?

▪ *the porous limestones, filled with goethite*: along with the hematite, the goethite is one of the widespread ferrous oxides, which could be used for painting in pottery production;

▪ *dolomites*: most sedimentary dolomites are calcium rich and could be used as a substance for calcium and magnesium whitening, also for fireproof material in ancient dwellings;

▪ *chalk*: the investigated chalk is with chemical origin and could be used for limecast in ancient dwellings.

The direct application of diatom analysis to archaeological artefacts is best represented in the field of pottery sourcing and typology (Juggins, Cameron, 1999). Diatoms often survive the low temperature firing process used in the manufacture of prehistoric pottery; diatom analysis therefore offers a novel and potentially powerful method for identifying clay sources and provenance of finished pottery. Unfortunately, the method is not without problems. Diatom concentrations in pottery can be very low and valves are often poorly preserved (Hakansson, Hulthén, 1988). Pieces of the 'test pottery' were collected from the Durankulak settlement. The samples were broken and then treated following the methods of Ognjanova-Rumenova (1991). The slides contained very small and unidentifiable fragments of diatoms, which could not be determined.

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