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Sedimentary and microfaunal evolution in the Quaternary deposits in El Akarit river mouth (Gulf of Gabes, Tunisia): Paleo-environments and extreme events

Soumaya Ben Rouina [a, b, *], Maria Angela Bassetti [b, **], Jamel Touir [a], Khaled Trabelsi [a], Serge Berne [b]

[a] University of Sfax, Faculty of Sciences of Sfax, Laboratory Water, Energy, Environment (L3E), Tunisia
[b] University of Perpignan Laboratory CEFREM, France

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ABSTRACT

The quantitative study of ostracod and benthic foraminifera assemblages coupled with sedimentary facies, of the AK1 core (6 m-long) retrieved from the El Akarit prodelta (Gulf of Gabes, SE Tunisia) at an elevation of 0 m, enabled us to better understand the dynamics of depositional environments and to identify different stages of the Akarit river mouth evolution. Two major steps were identified: the first (>40,000 yr BP) possibly coincides with the Marine Isotope Stage 5e, onlapping continental Pleistocene deposits. It allowed the settlement of an open lagoon rich in marine microfauna that has become progressively more confined. The second one, late Holocene in age (last 3000 yr BP) is the succession of three extreme events episodes, characterized by very high-energy hydrodynamics and possibly linked to the occurrence of major storms and/or floods.

1. Introduction

In coastal-deltaic areas, relative sea-level changes are governed by deltaic subsidence, global mean sea-level changes, extreme events, e.g. storms, floods and by vertical accretion due to sedimentation. In southeastern Tunisia, coastal marine deposits of MIS 5e (the Last Interglacial) made up two distinct lithostratigraphic units, which are separated by an erosional surface. The lower unit consisted of quartz-rich sands whereas the upper unit is composed of carbonate deposits as described by Jedoui et al. (2001). For the late Holocene, along the southeastern coast of Tunisia recent study reveals that the local relative sea level has risen between 0.24 and 0.48 m ± 0.10 m over the last 2000 yr (Anzidei et al., 2011). It may have risen at an average rate of about 0.1–0.2 mm/yr over the last 3000 yr, before the industrial period (Fleming et al., 1998).

Quantitative analyses of modern microfauna and sedimentological parameters have been used for the paleoenvironmental reconstruction of late Quaternary subsurface successions in the Mediterranean (Boomer and Eisenhauer, 2002; Horton et al., 2007; Sarr et al., 2009; Carboni et al., 2010; Nachite et al., 2010; El Hmaidi et al., 2010; Di Bella and Casieri, 2011).

Ostracods and benthic foraminifera live in a wide variety of aquatic environments, marine, brackish and (only ostracods) fresh water (Debenay et al., 2000; Boomer and Eisenhauer, 2002).

The most important parameters controlling the benthic foraminifera distribution are food availability and dissolved oxygen concentration (Jorissen et al., 1995; De Rijk et al., 1999, 2000; Murray, 2001). In shallow water environments benthic foraminifera assemblages are influenced by additional factors, including substrate type, temperature and salinity (Jorissen, 1988; Samir et al., 2003; Hyams-Kaphzan et al., 2008; Phipps et al., 2010).

Similarly, distribution of ostracods assemblage is influenced by the water physical–chemical properties (salinity, temperature, pH, dissolved oxygen), as well as hydrodynamic conditions and the nature of substratum (Ruiz et al., 1996; Bekkali and Nachite, 1997; El

* Corresponding author. University of Sfax, Faculty of Sciences of Sfax, Laboratory Water, Energy, Environment (L3E), Road Soukra km 3.5, BP1171, Sfax 3000, Tunisia.
** Corresponding author.
E-mail addresses: soumayabenrouina@Gmail.com (S. Ben Rouina), maria-angela.bassetti@univ-perp.fr (M.A. Bassetti), jamel.touir11@gmail.com (J. Touir), trabkhalfss@yahoo.fr (K. Trabelsi), serge.berne@univ-perp.fr (S. Berne).

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Hmaidi et al., 2010; Carbonel, 1982; Laprida, 2001; Nachite et al., 2010).

Few studies have been carried out, on ostracods and especially benthic foraminifera from Quaternary sediments extracted from marine lagoons, lakes or estuaries in Tunisia.

Carbonel and Pujos (1981); Jouirou (1982) studied the ostracods occurring in the surface and subsurface sediments of the lagoon of Ghar El Melh, the Sebkha of Ariana and Tunis lake. They used ostracod assemblages to reconstruct the Holocene evolution of the environments, mainly based on the changing environmental conditions (salinity) related to marine-*vs* freshwater supply. Lachenal (1989) describes different Holocene ostracod assemblages (phytal, opportunist and ubiquitous taxa) from the cores of the Gulf of Gabes, enabling to recognize different ostracod associations related to regressive-transgressive phases since the Last Glacial maximum. According to Ruiz et al. (2006), three main groups of ostracods may be distinguished in the recent samples in El Melah lagoon:

- Freshwater to slightly brackish assemblage: *Candona* spp., *Cypridopsis vidua, Cyprinotus salinus*, *Heterocypris salina* and *Ilyocypris gibba.*
- Strongly brackish assemblage: *Cyprideis torosa* (smooth ornamentation), *Cytherois fischeri*, *Leptocythere castanea* and *Loxoconcha elliptica.*
- Marine assemblage: *Aurila convexa*, *Bairdia longivaginata*, *Cytheretta adriatica*, *Cytheridea neapolitana*, *Heterocytherideis albomaculata*, *Loxoconcha rubritincta*, *Pontocythere turbida*, *Semicytherura* spp., *Tenedocythere prava*, *Urocythereis margaritifera* and *Xestoleberis* spp.

In El Hisha lagoon, Ben Rouina et al. (2011) demonstrate the existence of three ostracod assemblages: (1) Brackish assemblage made up by *Cyprideis torosa* and *Loxoconcha elliptica*. (2) Lagoonal assemblage involving *Xestoleberis aurantia* and *Leptocythere fabaeformis*. (3) Marine assemblage containing *Loxoconcha rhomboidea, Callistocythere descripiens, Aurila prasina, Aurila convexa, Urocythereis oblonga, Semicytherura incongruens, Hiltermanicythere rubra, Neocytherideis* and *Cushmanidea elongata*. Two distinct assemblages of benthic foraminifera are also described: (1) Lagoonal-brackish assemblage (*Ammonia tepida, Ammonia parkinsoniana, Haynesina germanica, Milliamina fusca, Siphonaperta aspera, Elphidium excavatum* and *Cycloforina contorta*). (2) Marine assemblage (*Ammonia beccari, A. aoeten, Asterigerina gierichi, Elphidium crispum, E. advanum, Eponides repandus* and *Quinqueloculina seminula*).

In both Sebkha of El-Guettiate and Sebkha of Dreîaa subsurface sediments, Zaïbi et al. (2011, 2012) indicate three ostracod assemblages (1) Marine association containing *Aurila prasina*, *Cushmanidea elongata*, *Urocythereis oblonga*, *U. favosa*, *Basselerites berchoni*, *Semicytherura incongruens*, *S. paradoxa*, *S. sella*, *S. ruggierii*, *Carinocythereis carinata, Paracytheridea depressa*, *Callistocythere discrepans*, *Hiltermannicythere emaciate* and *Neocytherideis fasciata*. (2) Lagoonal association, comprising *Xestoleberis aurantia*, *Leptocythere fabaeformis* and *Cytherois fischeri*. (3) Brackish estuarine association subject to estuarine influence as indicated by *Cyprideis torosa* and *Loxoconcha elliptica*. Two associations of benthic foraminifera are identified: (1) coastal association (*Quinqueloculina bicostata, Q. seminulum, Elphidium advenum Spiroloculina* sp.); (2) Lagoonal association (*Ammonia tepida* and *A. parkinsoniana*).

As a continuity of these works, in the western Mediterranean, our study focuses on the distribution of ostracods and benthic foraminifera in the northern part of the Gulf of Gabes. The aim of this paper is reconstructing the evolution of paleoenvironments in the El Akarit River mouth during the Quaternary in relation with sea level changes and possibly extreme events (storms and floods) and possible link with climate conditions.

2. Geomorphology and geological setting

El Akarit river mouth (34°7′0″ N and 10°1′0″ E) is located in the Southeastern part of the Tunisian coastline, 27 km North of Gabes city (Fig. 1). It is widely opened on the Gulf of Gabes and characterized by a tidal range in the order of 2 m. The delta is characterized by tidal channels and tidal bars. The *schorres* and *slikkes* are poorly developed.

The coast has a straight regular shape with a general northwest/south-east direction, from El Oued Akarit up to Zarat. The El Akarit delta plain is made up of clayey and sandy sediment deposits interstratified by pebble lenses, gypsum crusts and palaeosoils. The riverbanks are composed of two distinct formations (Page, 1972): At the bottom, the El Akarit Formation dates Late Pleistocene, and at the top the Demna Formation dates Holocene. The boundary between these two formations is erosional. (Fig. 2). The average slope of the river in its downstream part is about 2%.

3. Materials and methods

Coring was carried out using a hydraulic drill belonging to the company Sfax Thyna Survey. A 6 m-long core (AK1) was retrieved from the north rim of the El Akarit river mouth (34° 07′11.5″N and 10° 01′07.5″ E, elevation 0 m). After photographing the sediment, a visual description of the different lithological units of the core was performed. In the laboratory, samples were taken every 5 cm (120 samples) for micropaleontology and sedimentology analysis.

3.1. Grain size distribution

Grain size analyses were carried out by means of a Coulter LS230 microgranulometer, which determines particles grain-sizes between 0.1 and 2000 μm. Four ranges were used to classify the grain sizes: clay (<3.9 μm), coarse silt (>3.9 μm and<63 μm), very fine sand (>63 μm and <125 μm), fine sand (>125 μm and <250 μm). Calculation of grain size parameters such as mean, sorting, skewness and kurtosis was based using Folk and Ward (1957) equations:

- Mean: an arithmetic average of a series of values.
  o $Mz\ (Phi) = (Q16 + Q50 + Q84)/3$
- Standard Deviation (Sorting): the square root of the average of the squares of deviations about the mean of a set of data.
  o $\sigma\ (Phi) = (Q84-Q16)/4 + (Q95-Q5)/6.6$
- Skewness: the quality, state, or condition of being distorted or lacking symmetry.
  o $Sk = (Q16 + Q84 - 2Q50)/2\,(Q84-Q16) + (Q5 + Q95 - 2\,Q50)/2\,(Q95-Q5)$
- Kurtosis: the quality, state, of condition of peakedness or flatness of the graphic representation of a statistical distribution.
  o $K = Q95-Q5/2.44\,(Q75-Q25)$

The signification of the divers grain size parameters are shown in Table 1.

3.2. Micropaleontology

120 Samples, previously dried and weighed, were washed using two sieves meshes 150 μm and 63 μm. Identified ostracods and benthic foraminifera associations are compared to those cited in the Tunisian and Mediterranean coast.

Taxonomic identification of the benthic foraminifera is based on Loeblich and Tappan (1987, 1994); Cimerman and Langer (1991); Hottinger et al. (1993); Sgarrella and Moncharmont-Zei (1993); Cearreta and Murray (1996). The support for taxonomical identification of ostracods is provided by Bonaduce et al. (1975); Llano