PRELIMINARY ASSESSMENTS ON THE SENONIAN OUTRCROPS FROM SOUTH DOBROGEA

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Abstract. Four sites - Murfatlar, Nazarcea, Ovidiu and Palazu Mare (South Dobrogea) - with sedimentary marine deposits and dating back to the uppermost Cretaceous (Senonian) are described. The comparative analysis of the microfauna from these sites revealed a microfauna assemblage rich in foraminifera, ostracods and other fossil microorganisms in the chalk deposits from the Murfatlar quarry. Preliminary observations on the composition and quality (size, and ornamentation) of the microfauna led to paleo-ecological conclusions. We found that the associations are indicate a deep-marine paleosetting and relatively low water temperatures.

Keywords: Senonian, South Dobrogea, foraminifera, paleoenvironment.

Rezumat. Evaluări preliminare asupra aflorimentelor senoniene din Dobrogea de Sud. Sunt prezentate patru situri Murfatlar, Nazarcea, Ovidiu şi Palazu Mare (Dobrogea de Sud) ce deschid depozite de vârstă senoniană. Analiza comparativă a microfaunei din aceste situri a evidenţiat o asociaţie mult mai bogată în foraminifere, ostracode şi alte micro-organisme fosile în depozitele de cretă din cariera Murfatlar. Observaţiile preliminare asupra compoziţiei şi calităţii microfaunei au condus la concluzii de ordin paleo-ecologic, astfel asociaţia indicând condiţii bazinale în regim de ape adânci şi cu temperaturi relativ reduse.

Cuvinte cheie: Senonian, Dobrogea de Sud, foraminifere, paleomediu.

INTRODUCTION

The studied area, where the Senonian deposits are cropping out, is located in the eastern part of the Constanța County (Fig. 1), between Murfatlar (Basarabi) and Ovidiu – Palazu Mare (Siutghiol Lake), South-East from the

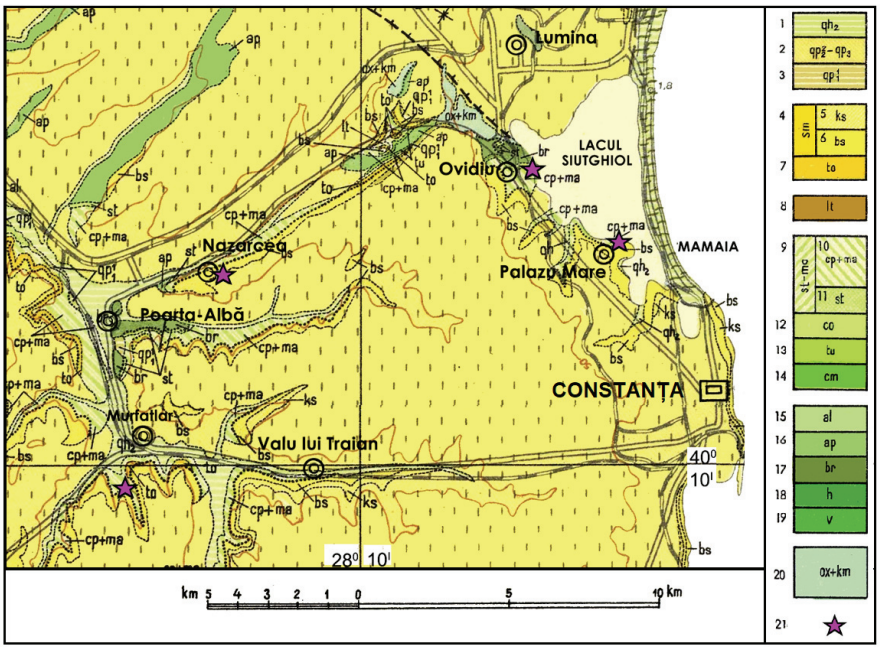

Figure 1. Studied sites of Senonian deposits and their location on the Constanța Folio 1:200.000 geological map (IGR – Chiriac & al., 1968); Legend: Quaternary: 1) Upper Holocene - alluvium, marine deposits; 2) Upper and Middle Pleistocene - loess; 3) Lower Pleistocene - gypsum clays; Sarmațian – 5) Kersonian – bioclastic and oolithic limestones; 6) Basarabian – limestones, bioclastic limestones, diatomites, clays, Nubecularia limestones; 7) Badenian – bioclastic limestones and clays; 8) Eocene – Lutețian – bioclastic limestones; Upper Cretaceous: 9) Senonian - chalk -10) Campanian-Maastrichtian - chalk with flint, limestone, marls; 11) Santonian – sandstones and micro-conglomerats; 12) Coniacian –limestones and marls; 13) Turonian –conglomerates and sandstones; 14) Cenomanian –conglomerates, sandstones, chalk; Lower Cretaceous –15) Albian – sands and glauconitic sandstones; 16) Aptian – sands, kaolinite, pebbles and zoogene limestones; 17) Barremian –zoogene and marly limestones; 18) Hauterivian – marly limestones; 19) Valanginian –limestones and marly lime; Upper Jurassic: 20) Oxfordian-Kimmeridgian -limestone with cherts, dolostone; 21) studied sites.

Năvodari – Poarta Albă chanel. The most representative Senonian outcrops are placed in the abandoned quarry of Murfatlar (approx. 40 m in thickness). Among the first biostratigraphic information, REUSS (1865), MACOVEI (1911), MACOVEI &

ATANASIU (1933) may be listed; later, more detailed studies were published by CHIRIAC (1956, 1968), NEAGU (1987, 1989, 1992), AVRAM et al. (1988, 1993, 1999), ION et al. (1998), MELINTE (2006). The newest analysis of the Senonian microfauna on the shores of the Lake Siutghiol belongs to ANTONIADE, STOICA and the undersigned team (2019).

MATERIALS AND METHODS

The investigation methods used are the classical ones used in micropaleontology. In order to highlight the richest setting of the Senonian deposits, as well as the interpretation of the palaeoecological evolution, "bulk" samples were taken from each site; the preparation and analysis of the samples was done by classical methods, finally comparing the associations between them. The palaeoecological analysis was done according to the latest studies in the field.

GEOLOGICAL SETTING

The deposits of the Senonian were partly (initially) attributed to the Murfatlar Formation of Avram (in GHENEA et al. 1984 and AVRAM et al. 1988). These deposits are characterized mainly by chalk and are transgressive on various other older sediments (Jurassic, Lower Cretaceous) and also transgressively support newer deposits (Sarmatian, Quaternary). The maximum thickness (of about 40 m) is reached in the Murfatlar quarry, where three different lithological terms (facies) have been described: a) basal quartz-phosphate microconglomerates; b) massive, friable glauconitic sandstones or chalky sandstones with *Inoceramus* remains; c) massive or bioturbated chalk, with black silicolites (cherts) at the top. All these lithofacial terms appear only in the Murfatlar site (stratotype of the formation). The microfauna is relatively rich in benthic and less planktonic foraminifera species. The association is completed by ostracods, echinoderm spines, fragments and shells of gastropods and bivalves. The fossil fauna indicates a lower Santonian-Campanian age. The microfauna as well as the nannoflora highlighted in the drillings made in the 80s, near the Poarta Albă – Năvodari channel (at Nisipari and Nazarcea), the presence of the upper Maastrichtian (uppermost Cretaceous, respectively upper part of the Senonian), as indicated by ION et al, 1998; MELINTE, 2006), belonging to the Nisipari and Nazarcea formations (only from drillings).

RESULTS SITES DESCRIPTION

Murfatlar site (Murfatlar Formation stratotype). The Murfatlar quarry is located on the southern outskirts of Murfatlar, south of the Danube-Black Sea channel (Fig. 2).

Figure 2. Murfatlar Quarry - Google-Earth.

In the northern part of this quarry there is also the archaeological site "Basarabi-Murfatlar cave ensemble". In this abandoned quarry, deposits of pure, massive chalk, about 35 meter-thick, crop out (Fig. 3). The Senonian chalk deposits belong to the Murfatlar Formation (AVRAM, 1988) and are transgressively disposed over the Lower Cretaceous deposits (Cernavodă Formation). At the base, along a maximum thickness of 5 meters, the deposits are conglomerate or sandstone, quartz or glauconitic, gradually passing to the massive chalk, and at the top, chalk contains flint (blackish silicolites). Sarmatian limestones and Quaternary deposits are discordantly disposed over the chalk deposits. The massive chalk contains rich microfauna represented by planktonic and benthic foraminifera, along with fragments of *Inoceramus* sp., echinoids and siliceous sponges, dated Santonian- lower Campanian (MACOVEI, 1911; CHIRIAC, 1956; NEAGU, 1987, 1989, 1992; AVRAM et al., 1988; DRAGASTAN et al., 1998).

Figure 3. Murfatlar Qarry: A- Quarry overview with location of sampled levels; B - D.- Details of sampled intervals (red arrows - sampled intervals);

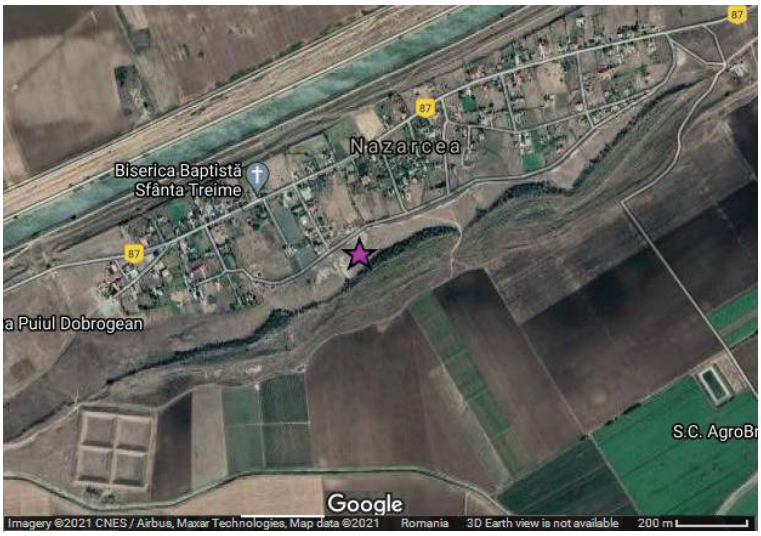

Figure 4. Nazarcea site (outcrop) location on the Google-Earth map.

Figure 5. Nazarcea site (outcrops) –A) large view and B-C) details with sempled succesions.

Nazarcea site. The investigated outcrop is located near the village of Nazarcea, in the commune of Poarta Albă (Fig. 4). The chalk deposits in this area can be seen over a distance of several tens of meters (Fig. 5), on the slope at the south-eastern edge of the village and have a sandy character. No macrofauna remains were found.

Palazu Mare site. In the Palazu Mare area, the Senonian deposits crop out on the shores of Lake Siutghiol (Fig. 6A). Lithologically, they are characterized by chalky deposits, which are crumbly (Fig. 6B), without flints. Sarmatian limestone with *Nubecularia* is disposed transgressively and discordantly above. The macrofauna is absent.

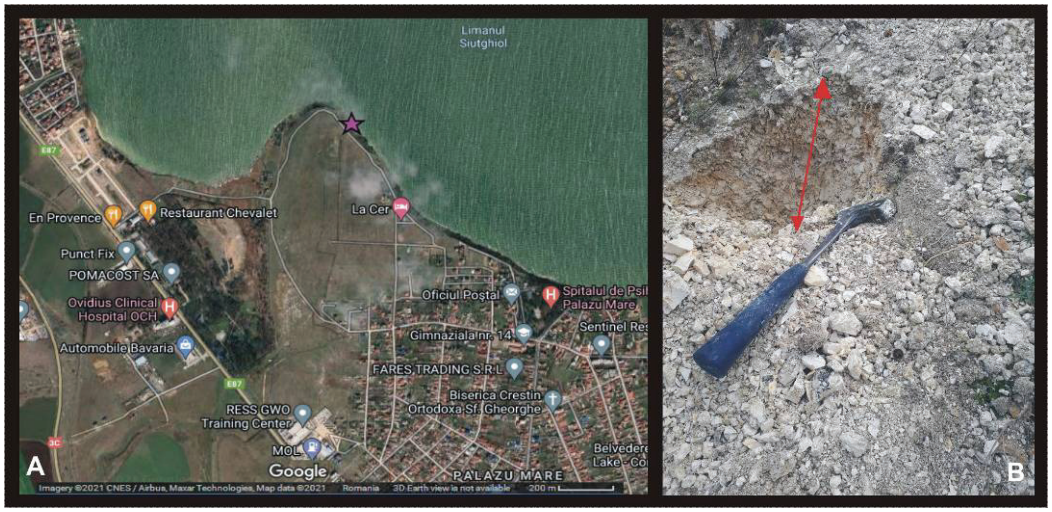

Figure 6. A - Palazu Mare outcrop location (violet star) on the Google-Earth map (satellite image); B - Detail of sampled deposits.

Ovidiu site. In the Ovidiu area, chalk deposits crop out on the shores of Lake Siutghiol (Fig. 7A). The sampled outcrop is located in the immediate vicinity of houses in the area. The chalk deposits have a "relatively massive" appearance, being slightly sandy and friable (Fig. 7B) open about 2.5 m thick and are covered by Sarmatian limestone. The macrofauna is absent.

Figure 7. A - Ovidiu outcrop location on the Google-Earth map (satelite image); B - Outcrop view on the Siutghiol Lake shore.

Identified microfauna in the analysed sections.

The samples taken from the Murfatlar Quarry, Nazarcea, Palazu Mare and Ovidiu outcrops provided a rich association of foraminifera. The association is completed by ostracods, echinoderm spines, fragments and shells of gastropods and bivalves (Murfatlar assemblage in Fig. 8). The identified foraminifera are represented by both agglutinated and calcareous benthic species, as well as planktonic species. Part of this association, coming only from the Ovidiu and Palazu Mare sites (Fig. 9), was recently presented (ANTONIADE & al., 2019).

Among the agglutinated benthic foraminifera, 23 species belonging to 15 genera were identified. These include the species: *Acruliammina eugeniae* Neagu, *Bulbophragmium irregulare* (Roemer), *Spiroplectammina baudouiniana* (d'Orbigny), *S. flexuosa* (Reuss), *Spiroplectinella dentata* (Alth), *Eggerellina brevis* (d'Orbigny), *E. subsphaerica*

Figure 8. Microfaunal association found in the chalk samples from the Murfatlar

(Reuss), *Vialovella oblonga* (Reuss), *Gaudryina cretacea* (Karper), *G. laevigata* Franke, *Heterostomella foveolata* (Marsson), *Tritaxia dubia* (Reuss), *Tritaxia sp*., *Arenobulimina obliqua* (d'Orbigny), *A. puschi* (Reuss), *Ataxophragmium concavum* (Marie), *A. crassum* (d'Orbigny), *Orbignyna campanica* (Jukova), *O. variabilis* (d'Orbigny), *Dorothia conula* (Reuss), *D. pupa* (Reuss), *Marssonella oxycona* (Reuss) and *Textularia bolivinoides* Reuss.

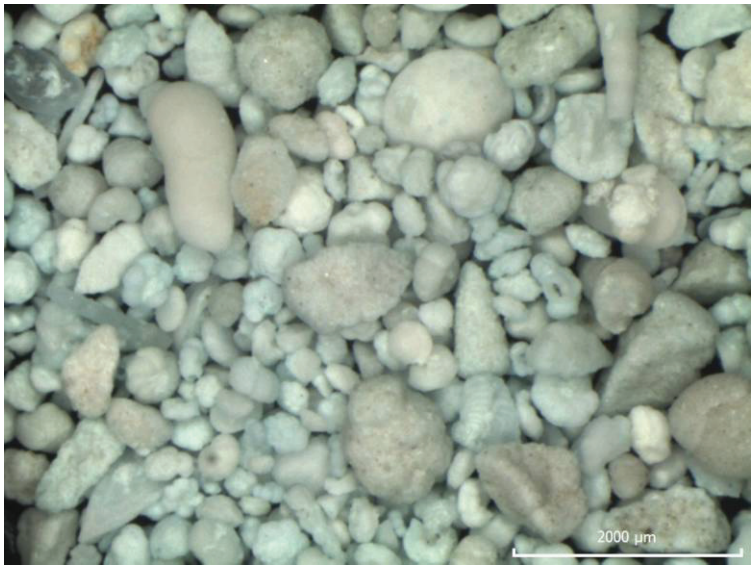

Figure 9. Microfaunal association found in the chalk samples from Palazu Mare - Ovidiu.

Calcareous benthic foraminifers are represented by 21 genera, respectively 32 species: *Laevidentalina nana* (Reuss), *Prodentalina oligostegia* Reuss, *Dentalina sp.*, *Nodosaria aspera* Reuss, *Nodosaria intercostata* Reuss, *N. obscura* Reuss, *Frondicularia archiaciana* d'Orbigny, *Frondicularia sp., Lenticumina rotulata* (Lamarck), *Lenticulina exarata* (Hagenow), *Lenticulina sp., Neoflabellina rugosa caesata* (Wedekind), *Palmula inversa* (Beissel), *Marginulina hagenowi* (Reuss), *Marginulina seminotata* Reuss, *Citharinella decksi* Reuss, *Marginulinopsis ensis* (Reuss), *Vaginulinopsis trilobata* (d'Orbigny), *Ramulina globotubulosa* Cushman, *Ramulina novaculeata* Bullard, *Bolivinoides culverensis* Barr, *Loxostomum eleyi* (Cushman), *Eouvigerina aspera laevigata* Marie, *Eouvigerina gracilis* (Egger), *Praebulimina reussi* (Morrow), *Praebulimina ventricosa* (Brotzen), *Praebulimina sp., Eponides sp*., *Viveja beaumontianus* (d'Orbigny), *Cibicides excavata* (Brotzen), *Pullenia reussi* Cushman & Tod, *Quadrimorphina allomorphinoides* (Reuss), *Globorotalites michelinianus* (d'Orbigny), *Gyroidinoides umbilicatus* (d'Orbigny), *Stensioeina gracilis* Brotzen, *Stensioeina pommerana* Brotzen, *Pseudogavelinella clementiana* (d'Orbigny), *Gavelinella pertusa* (Marsson) and *Lingulogavelinella stelligera* (Marie).

Benthic foraminifera are predominant elements, from a quantitative point of view, playing an important role in the reconstruction of the paleoenvironment. Calcareous benthic foraminifera are also very diverse, but some of them have taxonomic problems (the same species is described by different authors under other names, species reassigned to other genera). The species *Laevidentalina nana* and *Prodentalinaoligostegia* are frequently found in microfaunal associations in the analysed samples. These species were initially classified in the genus *Dentalina*., mentioned in the

deposits of the upper Santonian and lower Campanian ages, respectively. *Lenticulina rotulata*, also present in the association, was mentioned in the Cretaceous deposits of Dobrogea under the name *Lenticulina comptoni* (NEAGU, 1992). The species *Viveja beaumontianus* is also mentioned by NEAGU (1992) as *Cibicides beaumontianus*, *Gavelinella clementiana* and *Stensioina exsculpta gracilis* are also unacceptable species, in the opinion of DUBICKA & PERYT (2014), HAYWARD et al. (2021), these being included in the genera *Pseudogavelinella*, respectively *Stensioina gracilis*.

Planktonic foraminifers are much less subordinated (11 species) compared to benthic ones, in terms of abundance of genera and species, the following taxa being encountered: *Planoheterohelix globulosa* (Ehrenberg), *Laeviheterohelix pulchra* (Brotzen), *Globigerinelloides ehrenbergi* (Barr), *Contusotruncana fornicata* (Plummer), *Globotruncana bulloides* Volger, *Dicarinella asymetrica* (Sigal), *Globotruncanita elevata* (Brotzen), *Marginotruncana angusticarenata* (Gandolfi), *Marginotruncana marginata* (Reuss), *Marginotruncana undulata* (Lehman) and *Costellagerina pilula* Belford.

In the planktonic association we observe the presence of the species *Dicarinella asymetrica*, rare in the northern part (Siutghiol) and *Globotruncanita elevata*, index species for the Santonian - lower Campanian. In the analysed samples the species *Dicarinella asymetrica* is rare in Palazu Mare, while *Globotruncanita elevata* is much more abundant, being found in all analysed samples. Considering the presence of these species, it can be concluded that the microfaunal association identified in the analysed samples can be classified in the Biozone with *Dicarinella asymerica* (Santonian) and the Biozone with *Globotruncanita elevata* (lower Campanian). The biozonation used in this paper is the one used by ROBANOWSKI & CARON (1995) and NEAGU (1987), regarding planktonic foraminifera.

Palaeoecological observations

Cretaceous marine systems are characterized by well-stratified bodies of water, providing niches for a variety of life strategies (LECKIE, 1989). The identified planktonic foraminifera species can be grouped as follows:

- fairing forms, represented by *Globotruncana, Globotruncanite, Marginotruncana, Contusotruncana*.
- trochospiral forms with or without marginal hull: *Dicarinella*.
- small, flat spiral shapes with compressed to swollen chambers: *Globigerinelloides*.
- thin, bevelled, microperforated forms with fine surface: *Laevihetrohelix* and *Planoheterohelix*.

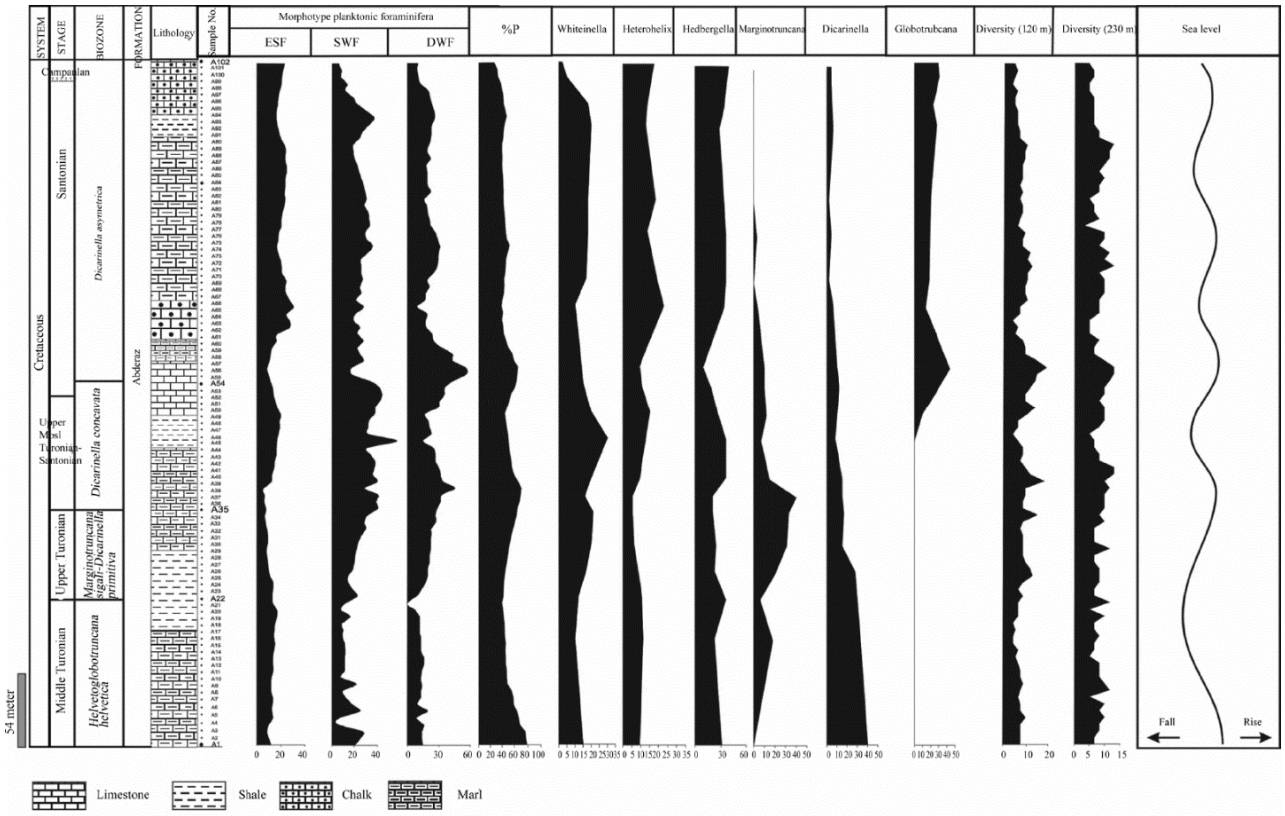

Figure 10. Changes in percentage of the selected planktonic foraminifer genera within the sediments of the Abderaz Formation type section. M1 = epicontinental sea forms (ESF), M2 = shallow water forms (SWF), M3 = deep water forms (DWF), %P = percentage of planktonic foraminifera (planktonic to benthic foraminifera ratio) (after ARDESTANI et al., 2013).

The distribution of planktonic foraminifera depends on the temperature and density of surface waters. Tests with different shapes were used to separate and identify specimens found in certain depth ranges in the water column

(ARDESTANI et al., 2013). Based on different depth zones, three groups of planktonic foraminifera have been identified (PETRIZZO, 2002; ARDESTANI et al., 2013):

- "shallow surface water forms (SWF)" - forms that prefer shallow water;
- "intermediate water forms (IWF)" - intermediate forms;
- "deep water form (DWF)" - deep water forms (Fig. 10 - Abderaz Formation - Northeastern Iran)

Among the forms that prefer shallow, surface waters, we mention the species *Laevihetrohelixglobulosa* and among the foraminifera that prefer "intermediate" waters we mention the species *Planoheterohelixpulchra*, *Globigerinelloides. Heterohelicides* are considered opportunistic species, which indicate unstable conditions and generally prefer eutrophic environments. They are also thought to be indicators of stressful environments (LECKIE, 1987).

Forms that prefer deep water are represented by species with trochospiral and ornamental tests, such as *Contusotruncana fornicata*, *Globotruncana bulloides*, *Dicarinella asymetrica, Globotruncanita elevata, Marginotruncana angusticarenata, M. Marginata* and *M. undulata*.

Species of the genera *Cibicides, Stensioeina*, *Gavelinella* and *Eponides*, represented by planconvex, rounded trochospiral and spherical tests are indicators for environments with hydrogen peroxide.

Calcareous benthic foraminifera with thin-walled, elongated-flattened and tubular tests, represented by taxa of the genera *Praebulimina, Laevidentalina, Dentalina* are disoxic indicators. *Lenticulina* and *Pullenia* are intermediate indicators.

CONCLUSIONS

Based on biostratigraphy studies, the lower Santonian-Campanian age is proved. The comparative analysis of the microfauna in the sites revealed a much richer association in foraminifera, ostracods and other fossil microorganisms in the chalk deposits from the Murfatlar quarry. From the same outcrop, the macrofauna association indicative for the aforementioned age were described by Macovei (1911) and Chiriac (1956). Preliminary observations on the composition and quality of the microfauna led to paleo-ecological conclusions on the paleosetting. The analysed sections show associations of diversified benthic foraminifera (DWAF), as well as abundance of calcareous benthic ones. Taxa of the genera *Dorothia, Marsonella* appear alongside calcareous benthic foraminifera such as *Nodosaria* or *Lenticulina*. Benthic calcareous foraminifera are also very diverse, both groups indicating deep waters paleoenvironment.

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