Acta Palaeontologica Romaniae (1997), 1.

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EARLY CRETACEOUS SHELF PALEOCOMMUNITIES OF CERNAVODĂ (SOUTH DOBROGEA, SE ROMANIA)

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Abstract: A qualitative and quantitative study was conducted concerning the Valanginian fossil association (microflora, microfauna and macrofauna) in the Cernavodă section, to reconstruct community structures, define and characterize the different paleocommunities (poli-, oligotaxic). Finally, the aim is to reconstruct the evolution of local assemblages in the intertidal-shallow subtidal environments, shown to have probably been influenced by short-term sea-level changes.

Key words: Valanginian, paleocomunity structure, environments, comunity changes

1. Introduction

The calcareous succession cropping out in the western side of the Hinog Hill, south-west of the town of Cernavodă (approx. 44°22' lat N, 28°22' long E; Fig. 1) represents one of the best studied Early Cretaceous deposits in Southern Dobrogea. On the right bank of the Danube, a continuous exposure of subhorizontal (slightly southward dipping, approx. 5°) limestone sequence, some 35-38 m thick, extends from the Cernavodă railway bridge upstream to the Cernavodă waterworks (for about 1.25 km). The distal, upstream part of the same exposure, from the Cernavodă waterworks to the Hinog valley mouth is actually densely vegetated, therefore not available for the study.

The Cernavodă outcropping sequence represents the main type section of the Cernavodă Formation (Neagu & Dragastan, 1984), although it exclusively comprises the upper part of this lithostratigraphic unit, namely the Alimanu Member sensu Avram et al. (1988) (Fig. 2.). The base of this member is not exposed in the studied section, being present in the 4 and 11 Hinog boreholes. The top of the succession is erosionally truncated and transgressively overlain by deposits of either the continental Gherghina Formation or the marine Ramadan Formation, both of Aptian age. On paleontological (mainly micropaleontological) grounds a Late Berriasian-Valanginian age was inferred for the Alimanu Member; The Cernavodă outcropping sequence is considered to represent only the Valanginian (Neagu & Dragastan, 1984; Avram et al., 1995-1996).

This sequence consists of zoogenous, muddy to clearly winnowed calcarenites and calcirudites that are usually richly fossiliferous. The main features of the lithology were described by Drăgănescu (in Avram et al., 1988), while more or less complete paleontological associations recovered from the Cernavodă outcrop were mentioned by Neagu et al. (1977), Dragastan (1980, 1985), Neagu & Dragastan (1984), Neagu (1984, 1994) and others; a comprehensive, reviewed assemblage list is given in Csiki (1996).

2. Methods and materials

The present study involves two different approaches. Firstly, an extensive list of previously reported/published or recently found/identified organisms was compiled for the Valanginian deposits of the studied section. A qualitative approach was afterward employed for the characterization and analysis of the local Valanginian fossil assemblage, to emphasize the general paleoecological features of this biota. The macrofauna was primarily used for this study, although some mentions will be done for the microfloristic and microfaunistic components, too. As no exact stratigraphic position was recorded for many previously reported taxa or specimens, no attempt was made to discriminate and characterize more exclusive subsets of the assemblage (e.g. Early versus Late Valanginian associations), although careful further collecting may result in such a study in the future.

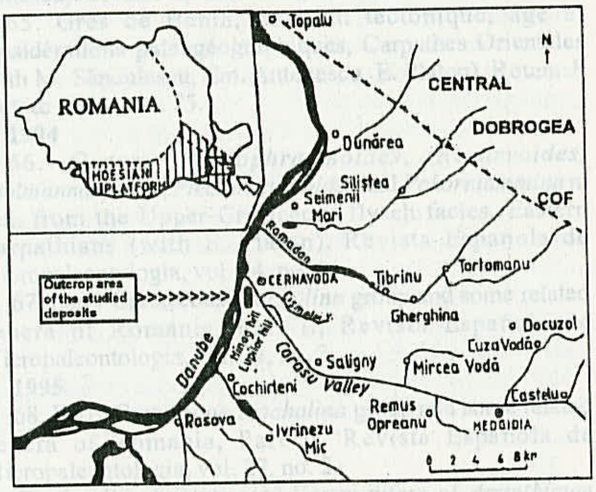
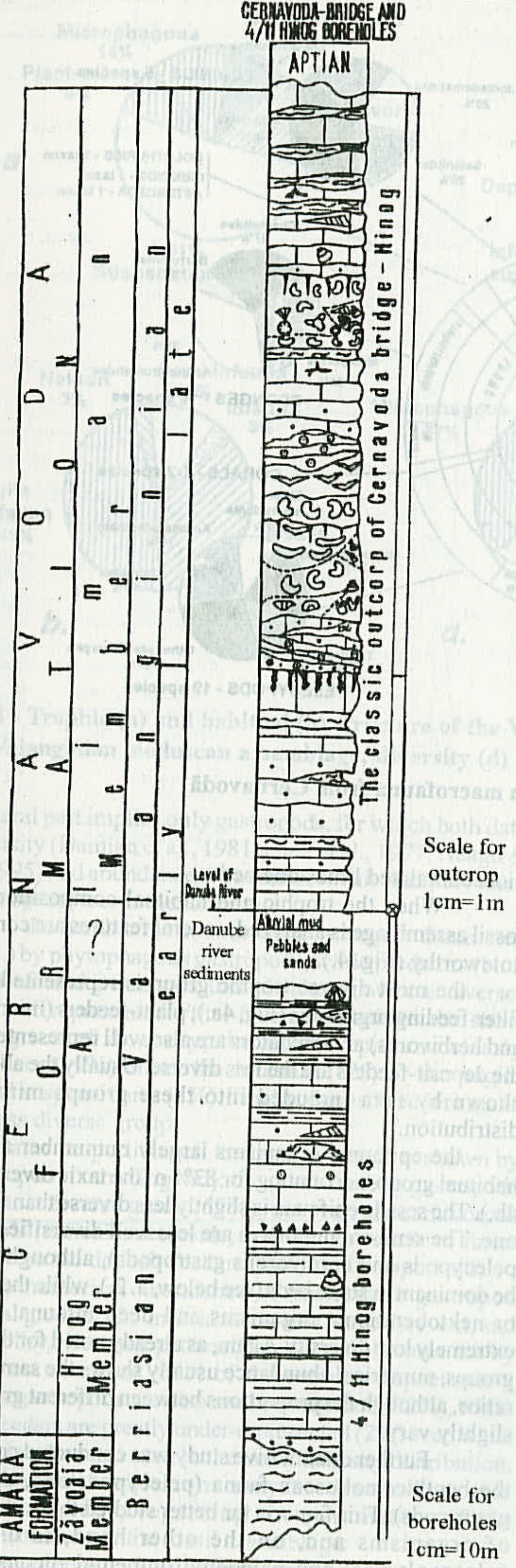


Fig. 1 - Geographical setting of the studied area

Moreover, bearing in mind the uniformity of the deposits yielding the assemblage used for the study, also the regional scenario for the Late Jurassic-Early Cretaceous sedimentation proposed by Avram et al. (1995-1996), it was assumed that no large-scale changes occurred within the depositional environment or affected the biocoenoses of the Valanginian in the Cernavodă area, so that the conclusions drawn from the present analysis are reliable and actually reflect, without major distortions, the reconstructed elements of this past ecosystem and biota.

The second approach represents an attempt at achieving, for the first time, a smaller-scale study of these deposits and that of the included fossil assemblages to discriminate possible ecozones and community changes. Consequently, seventeen local sections were selected and logged. The selection of the sections was greatly influenced by outcrop accessibility (most of the outcrop is represented



by vertical cliffs), so that they are unfortunately unevenly distributed along the whole length of the outcrop. The distance between the individual sections varies from 10 to at most 360 m. The maximum occurs at the upstream end of the surveyed exposure near the Cernavodă waterworks, where the overhanging cliffs needed to be reduced and enclosed in concrete for stability reasons.

For each local column distinct lithons ("beds") were identified, measured and thoroughly studied from the lithological, sedimentological and paleontological points of view. An extensive macrofossil collection was carried out strata by strata and the relative abundance of the macro-organisms was recorded along with observations concerning the following aspects: in situ position of certain fossils, vertical and horizontal spatial relationships between individuals of the same taxon (e.g. evidence for gregarious behaviour, colonial nesting etc.) or between individuals of different taxa, presence of epibiontic organisms (usually serpulids), signs of predator-prey interactions or possible signs of transport and current sorting/alignment. Sedimentary structures, features of the discontinuities separating individual lithons and trace fossils (bioturbation, figurative ichnites) were also noted, as well as the lateral and vertical transitions of the lithofacies and biofacies within the beds. Finally, a composite lithological column was constructed by correlating the local sections. The correlation could be relatively easily made due to the high degree of lateral continuity of the strata and, especially, that of the discontinuity surfaces separating the individual lithons. Afterwards, taphocoenoses preserved in each of these beds were identified, their autochtonous (parautochtonous) or allochtonous nature assessed.

3. Results

3.1. Analysis of the Valanginian fossil assemblage of Cernavodă

The Valanginian fossil assemblage studied is both taxonomically diverse and numerically rich. It comprises a number of 175 lower level taxa recognized up to date, identified to either a generic or a specific level or only as indeterminate members of a higher-level taxon. The macrofauna (the main focus of the study) is the most diverse, accounting for approx. 58% of the low-level taxonomic richness, while the microfauna (represented mainly by forams) and the microflora (that includes cyanophycean,

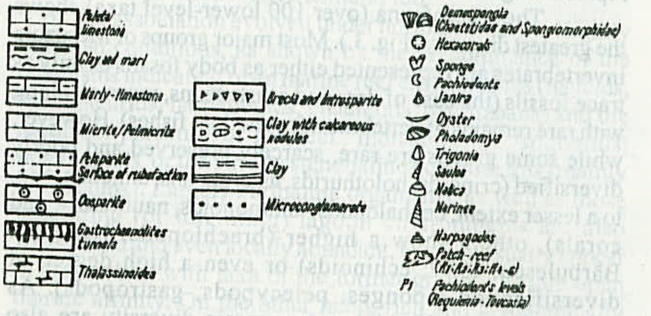


Fig. 2 - Lithostratigraphical column of the Early Cretaceous deposits at Cernavodă (after Dragastan)

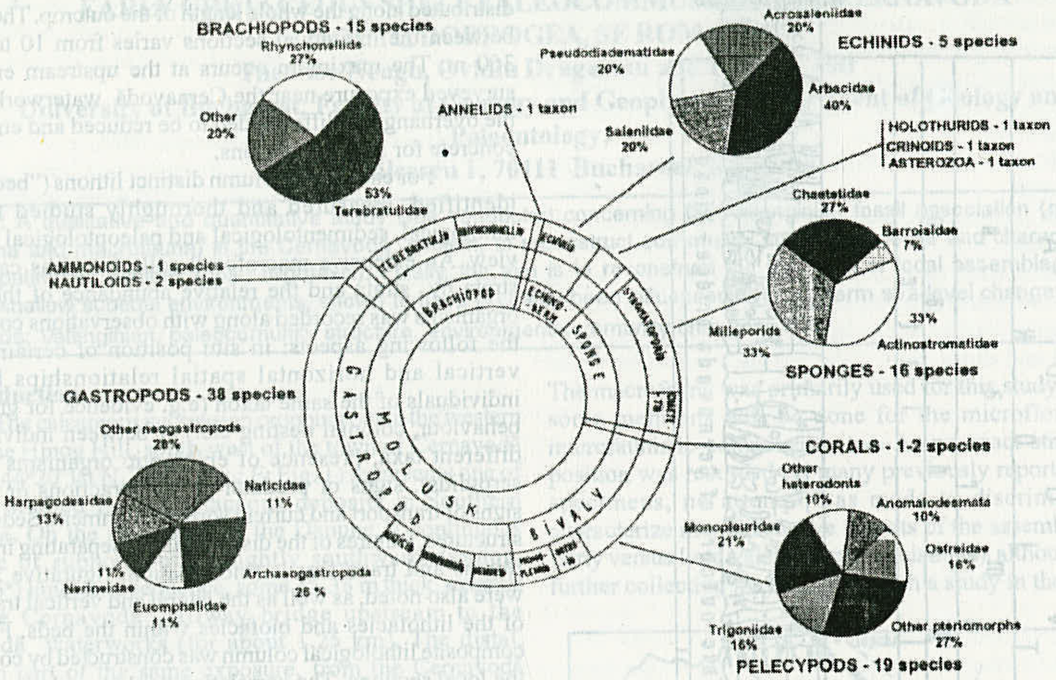


Fig. 3 - Diversity of the Valanginian macrofauna from Cernavodă

rhodophycean and chlorophycean algae) are less diverse (34% and 8% of the low-level taxic richness, respectively).

Among the algae, chlorophyceans largely dominate over the cyanophyceans (represented by the Rivulariaceae; Dragastan, 1980, 1988, 1990). Dasycladaceans are both diverse (47%) and abundant, while pseudoudoteaceans and rivulariaceans algae are present in a slightly lesser diversity (40%). There is a varied microfaunal association recorded from the Cernavodă outcrop (Neagu, 1979, 1984, 1994); among it the involutinines (represented mainly by trocholinids) largely dominate in taxic diversity - 40% of the recognized taxa - over cyclamminids - 18% - and other textulariines and even over miliolines - 22%; however, locally the miliolines are far more abundant than other groups, representing more than 50% of the assemblage.

The macrofauna (over 100 lower-level taxa) shows the greatest diversity (Fig. 3.). Most major groups of Mesozoic invertebrates are represented either as body fossils or only as trace fossils (the case of decapod crustaceans, worms), along with rare remains of vertebrates (pycnodont fishes). However, while some groups are rare, scarcely preserved and poorly diversified (crinoids, holothurids, asterozoans, annelids, and, to a lesser extent, cephalopods - ammonoids, nautiloids - and corals), others show a higher (brachiopods, Neagu & Bărbulescu, 1979; echinoids) or even a high degree of diversification (sponges, pelecypods, gastropods). As expected, taxa with higher taxonomic diversity are also numerically more abundant (in general), but extremely abundant in fossil-rich coquina or bioconstructed-bioaccumulated limestone beds.

When the trophic and habitual composition of the fossil assemblage is analyzed, several features are considered noteworthy (Fig. 4.):

- the most diverse trophic group is represented by the filter-feeding organisms (Fig. 4a.); plant-feeders (microphages and herbivores) and predators are also well represented, while the deposit-feeders are the less diverse. Usually the abundance shown by taxa included into these groups mirrors this distribution.

- the epifaunal organisms largely outnumber any other habitual group, accounting for 83% of the taxic diversity (Fig. 4b.). The sessile epifauna is slightly less diverse than the vagile one. The semi-infaunal taxa are less well diversified (mostly pelecypods and carnivorous gastropods), although they can be dominant in some beds (see below, 3. 2.), while the nektonic or nektobenthonic organisms and deep infauna show an extremely low diversity. Again, as already noted for the trophic groups, numerical abundance usually shows the same relative ratios, although the proportions between different groups may slightly vary.

Further quantitative study was conducted concerning the benthic molluscan fauna (pelecypods and, especially, gastropods). This fauna is far better studied than other groups of organisms and, on the other hand, is useful for paleoecological and paleoenvironmental reconstructions when studied from the point of view of community composition and structure (see for ex. Kojumdgieva, 1976);

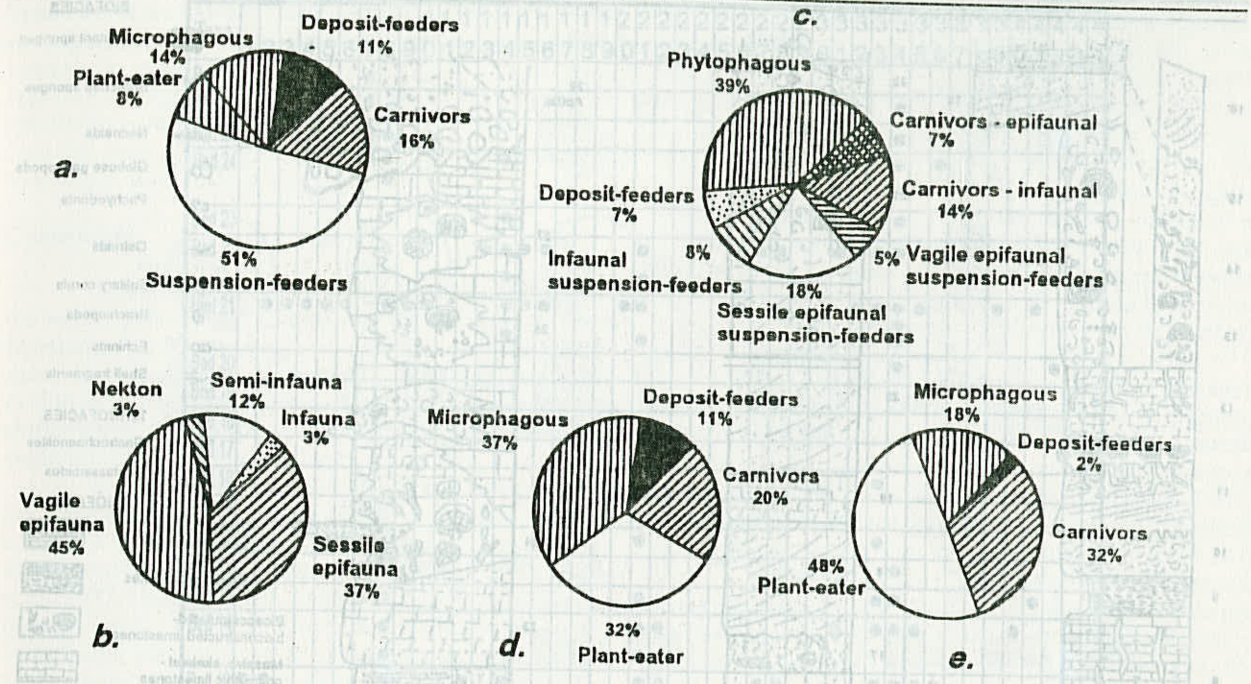


Fig. 4 - Trophic (a) and habitual (b) structure of the Valanginian benthic assemblage; (c) ecological groups in the Valanginian molluscan assemblage; diversity (d) and abundance (e) in the Cernavodă gastropod fauna

a collateral part implies only gastropods, for which both data on diversity (Damian et al., 1981, Pană et al., 1977, Neagu & Pană, 1995) and abundance are available. This study revealed further aspects worth mentioning:

- the benthic molluscan fauna is largely dominated (Fig. 4c.) by phytophagous gastropods, while predators (both epi- and infaunal gastropods, this latter being twice as diverse) are also well represented. Filter-feeding organisms also show high degrees of diversity; the sessile epifauna clearly outnumbers (19%) either the infaunal (8%) or the vagile epifaunal suspensivores (5%). Finally, deposit-feeders make up the less diverse group.
- the same proportions of the taxic diversity is shown by the gastropod fauna (Fig. 4d): the plant-feeding gastropods are the most diverse group (57%); but even the carnivorous gastropods (naticids, nerineids, ampulinids) are three times as diverse as the deposit-feeders (turritellids, apporhaids).
- the numerical abundance of the diverse gastropod ecological groups (223 individuals were counted) reveal, and even amplify, the same pattern (Fig. 4e.): herbivores are by far the most abundant (66% of the recovered specimens); predatory gastropods are also well represented (32%), while deposit-feeders are greatly under-represented (2%) even when compared to the ratio seen in the taxic diversity distribution.

Several conclusions may be drawn from this quantitative study, regarding the parameters of the paleoenvironment of the fossil assemblage:

a) the depositional setting of the sediments was represented by shallow water, intertidal to upper subtidal environments as demonstrated by the presence of typical inter- (patellids, hydrobiids, neritids) or upper- subtidal (pachyodonts, ostreids, scalids, phasionelllids, pleurotomariids, several brachiopods) taxa. The rich chlorophycean and pseudoudoteacean algal flora, as well as the abundance of the herbivorous organisms points to the presence of an extensive vegetal cover, thus indicating a photic domain of low bathymetry. When ecological groups are concerned, the predominance of the filter-feeding organisms (especially the sessile ones) and the high ratio of plant-feeding versus deposit-feeding organisms, as well as the taxic and ecologic diversity of the predators are also suggestive of a shallow water inner shelf environment (Boucot, 1981). Sedimentary structures (e.g. low-angle, large scale tabular cross-stratification), ichnofacies (with *Arenicolites*, *Thalassinoides*, *Gastrochaenolites*; Weimar & Hoyt, 1964; Sellwood, 1971) and characters of the early diagenesis point to such a depositional environment, too.

b) The association evolved under normal marine to slightly brackish conditions, as shown by the predominance of the organisms indicating open marine reef environments (naticids, monopleurids, harpagodids, chaetetids, hydrozoans) and the recurrent presence of the reef indicators as trigoniids, brachiopods or the strictly stenohaline echinoderms (mainly sea urchins). Largely eurihaline organisms, as well as those inhabiting (or tolerating) lagoon environments are also widespread and even locally abundant, but they usually appear in association with taxa of the former group, of more open marine affinity. On the other hand, rich and taxonomically diverse assemblages usually mark normal marine environments (Boucot, 1981).

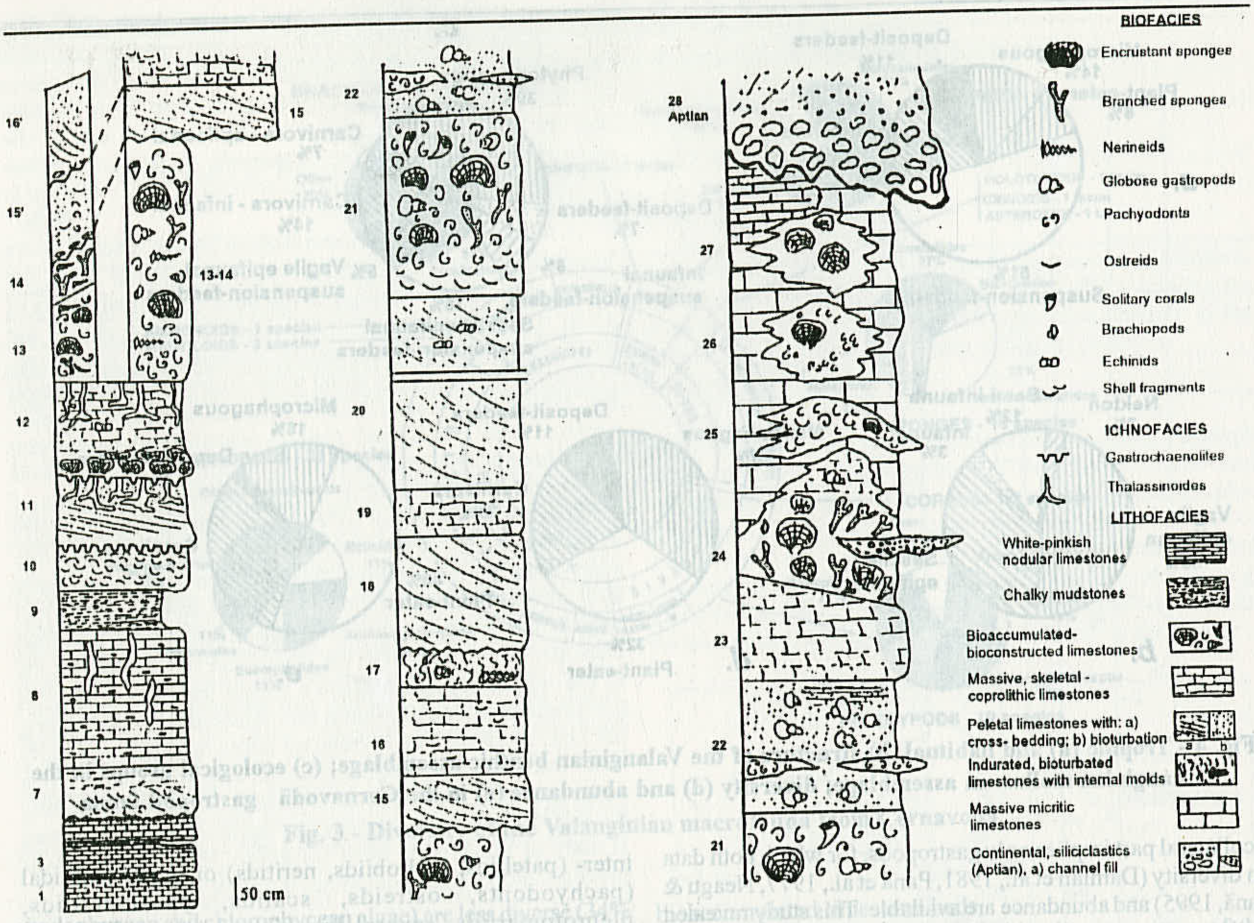


Fig. 5 – Small-scale synthetic lithological column of the Cernavodă outcrop

c) A high degree of water turbulence associated to a reduced amount of turbidity are indicated by the relative abundance of those taxa adaptations (large size, thick-walled shells) for fairly rough waters and by the presence of taxa usually confined to such environments (patellids, neritids, trochids, hemicidarid echinids, chaetetids and demospongids of encrusting, massive, globose morphology; Grossu, 1986, Davitasvili, 1956, Boucot, 1981). The large number and diversity of filter-feeding organisms (sponges, brachiopods, pelecypods) and that of plant-eating gastropods also point to a nearshore, fairly agitated environment with a reduced terrigenous influx (thus low turbidity).

3. 2. Valanginian benthic paleocommunities in the Cernavodă area and their evolution

As already mentioned (see Chapter 2), this part of the study implied detailed mapping of the classic outcrop near the Cernavodă railway bridge (Fig. 2.) together with an intensive, bed-by-bed collection of the macrofauna. The activity resulted in:

a) a small-scale detailed synthetic lithological column (Fig. 5.); the description of the individual lithons, with details concerning the main lithology, sedimentary structures, features of the lithon boundaries, ichnofacies, are given in Csiki (1996); and

b) A succession of benthic faunal assemblages, recorded bed by bed, of which only the most representative taxa are shown in Fig. 6.

These separate assemblages were considered as being either paleoecological communities (if the assemblages are mostly autochtonous, so that the composition of the taphocoenoses largely reflects the composition of the once living communities) or taphonomically produced associations. The vertical (i.e. temporal) changes in community composition and structure were identified and correlated, whenever possible, with changes in lithology (i.e. paleoenvironmental shifts that occurred in the depositional area) and with those previously reported for microorganisms (forams, Neagu & Dragastan, 1984; algae, Dragastan, 1980).

When analyzing the distribution of organisms within the synthetic lithological column of Cernavodă , three different types of associations can be singled out:

a) Polytaxic associations, with more than 20 lower-level benthic taxa. These are found in Beds 12 and 24; Bed 13, with 19 taxa, represents a transitional case (see below, b). Taphonomic features (sponges found in growth position, great number of unbroken, uneroded shells, pachyodont nests) suggest that this association is largely autochtonous (or at most parautochtonous), therefore it is considered to represent a paleocommunity. The polytaxic paleocommunity can be

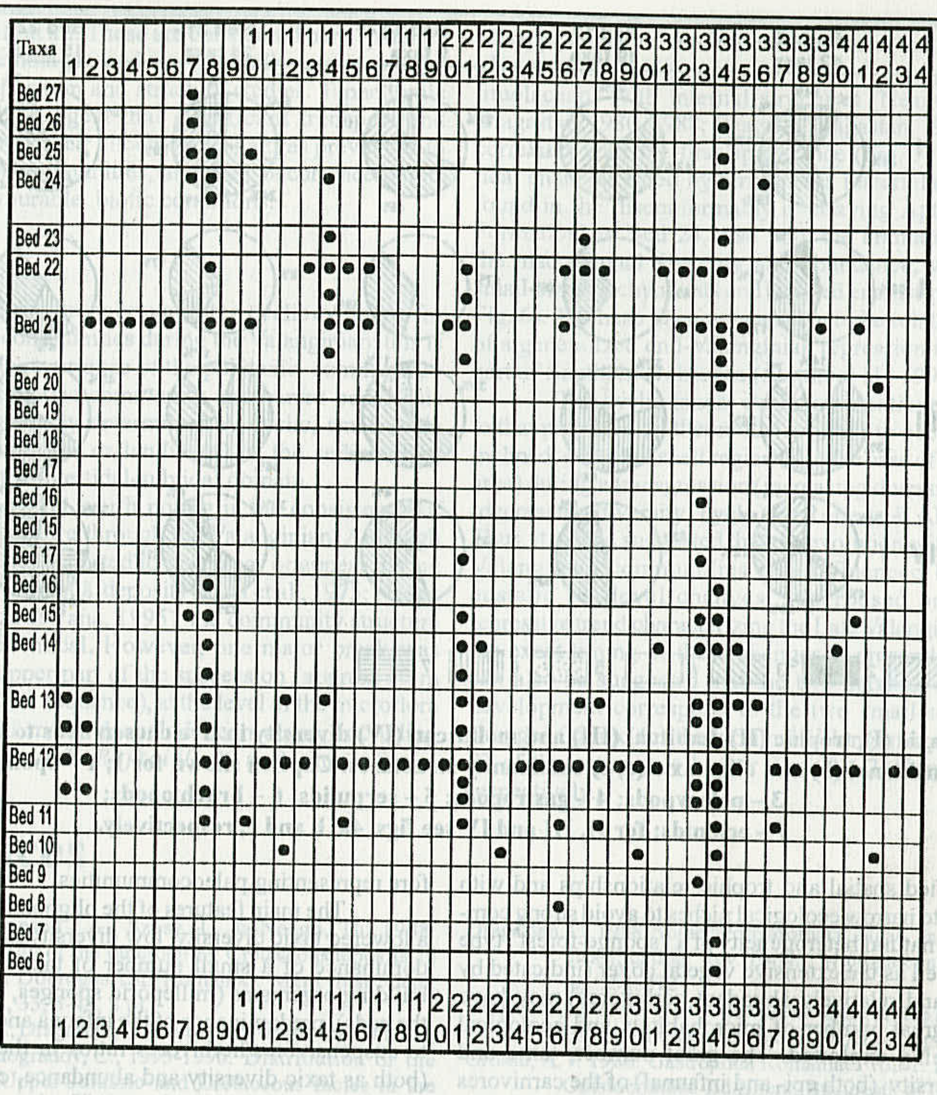


Fig. 6 - Distribution of the most important benthic invertebrates in the Valanginian section of Cernavodă . Taxa are labelled as follows: 1-*Granatiparietes*; 2-*Actinostromaria*; 3-*Axiparietes*; 4- *Siphostroma*; 5-*Varioparietes*; 6-*Stylina*; 7-encrustant sponges; 8-*Steinerella*; 9-*Barroisia*; 10-solitary corals; 11-apporhaid; 12-*Natica*; 13-*Trochonatica*; 14-*Ampullospira*; 15- harpagodids; 16-*Harpagodes (Desorites)*; 17-*Harpagodes (Jaccardites)*; 18-*Harpagodes (Bancilites)*; 19-pleurotomariid; 20-trochid; 21-*Nerinea*; 22-*Nerinella*; 23-*Phasionella*; 24-*Fusus*; 25-*Pleurotoma*; 26-*Serpula*; 27-cardiid; 28-*Lima (Plagiostoma)*; 29-*Neithea*; 30- *Pleuromya*; 31-*Pholadomya*; 32-trigoniids; 33-*Ostrea*; 34-*Monopleura*; 35-*Matheronia*; 36- brachiopode; 37-*Lamellaerhynchia*; 38-*Nucleata*; 39-*Cyrtothyris*; 40-*Praelongithyris*; 41- *Sellithyris*; 42-echinids; 43-*Acrosalenia*; 44-*Pseudodiadema*. Bullets mark number of species recovered from the respective bed.

characterized by: the great diversity of the benthic macrofauna, extreme diversity and abundance of frame-building organisms (sponges, bivalves; solitary and colonial corals may be sometimes present, too), high diversity index (defined as the ratio of identified taxa to number of recorded specimens; Mongin, 1990). These polytaxic communities are associated with bioaccumulated limestone or coquina facies, dominated by encrusting sponges (stromatoporids, chaetetids), with subordinate and usually marginally placed milleporids (*Steineria, Steinerella*); the sedimentary facies represent moments of high environmental stability, favourable to the development of a "sponge-forest" type bottom (Boucot, 1981).

The most abundant organisms in these polytaxic communities are the frame builders (sponges and pachyodonts), while gastropods and pelecypods are the most diverse groups (Fig. 7a,d); brachiopods are less diverse and rare, and echinoids occur only in Bed 12. The same diversity is shown when either trophic or habitual groups are concerned; this points to the existence of a complex community structure,

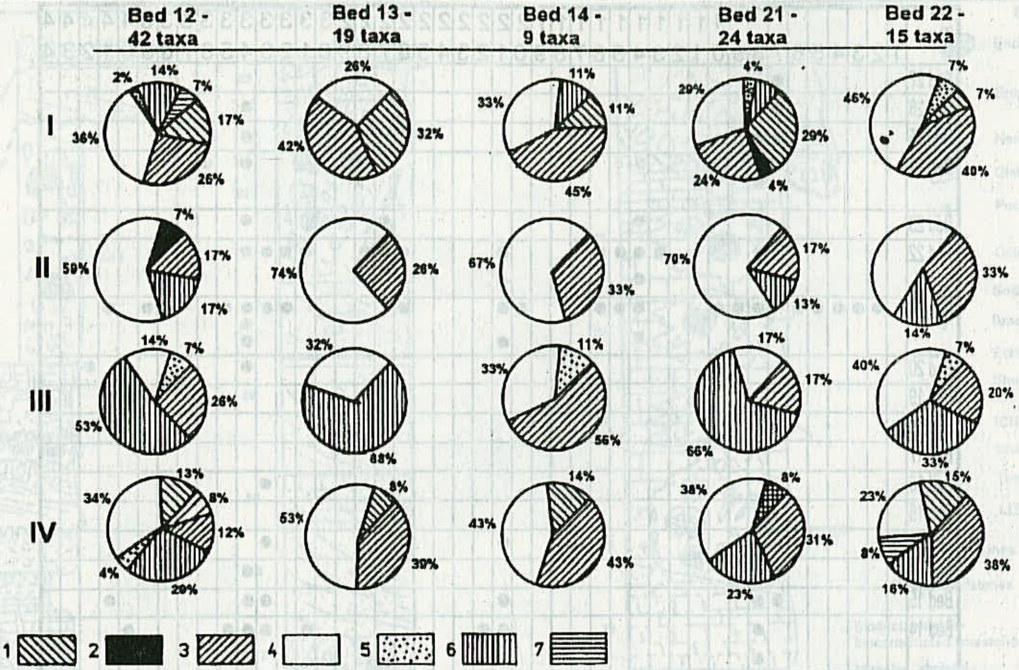


Fig. 7 - Taxic (I), trophic (II), habitual (III) and molluscan (IV) diversity in five chosen beds to show polytaxic (a, d), transitional (b) and oligotaxic (c, e) community structures. Caption shown for I; 1 – sponges; 2 – corals; 3 – pelecypods; 4 – gastropods; 5 – serpulids; 6 – brachiopods; 7 – echinids; for II, III and IV see figs. 4a, b and c, respectively.

with diversified spatial and trophic relationships and with taxa adapted to narrow ecological niches to avoid strong competition. The natural heterogeneity of a "sponge-forest" type bottom, as well as the extensive vegetal cover (indicated by the diverse and relatively abundant herbivores) may have provided a great number of microhabitats and ecological niches to being exploited. The great number, taxic and habitual diversity (both epi- and infaunal) of the carnivores indicate an advanced carnivore specificity and niche partitioning.

It can thus be concluded that this type of community shows many features of the "high-diversity communities" of Boucot (1981) that characterize domains with minor fluctuations of the environmental parameters, favourable to the development of benthic life. At Cernavodă, polytaxic communities inhabited subtidal environments with shallow (trochids, pleurotomariids, pachyodonts, ostreids), warm waters, fairly well oxygenated and situated in the photic zone (large numbers of herbivores), with high water turbulence (large number of suspensivores, specific sponge morphology).

b. Oligotaxic associations are present in Beds 11, 14, 22, 24, possibly also 10; these show a smaller diversity (usually 8-10, but no more than 15; Fig. 7c,e). The assemblage from Bed 13, although twice as diverse (Fig. 7b), is also included here, as the community structure bears at least as much resemblance to the oligotaxic than to the polytaxic community structure. Taphonomic features suggest that these are also mainly in situ assemblages (branching sponges in growth position, infaunal taxa preserved in the sediments), therefore representing paleocommunities.

The main features of the oligotaxic communities are: a lowered taxic diversity, low diversity indices, quantitative dominance of a small number of taxa (usually 1-2), rare building organisms (milleporid sponges, only at the base of the beds), predominance of the infauna and higher carnivores to suspensivores/herbivores ratios in the molluscan fauna (both as taxic diversity and abundance, correlated with the absence of epifaunal predators). The increase in this ratio is usually correlated with the increase of the number of soft-bodied, mostly infaunal organisms (worms, crustaceans; Kojumdgieva, 1976).

This type of communities characterize (Mongin, 1990) oligotypic domains with fluctuating, unstable environmental conditions; they correlate with changes in lithofacies either to fine-grained, peletal-grapestone-bioclastic muddy limestones (13-14, 22) or to calcarenits displaying low-angle, large scale tabular cross-bedding (11) and incised tidal channels (24).

Thus, it can be concluded that oligotaxic communities either: 1) post-date polytaxic ones, their take-over being favoured by the deepening of the basin and turning to a more quiet, muddy sedimentation that invades the former sponge forests and interrupts their development, or 2) represent phases of depth reduction and shift toward more nearshore, intertidal environments with transient beach or supratidal deposits. Both phenomena represent a departure from a stable environment favourable to the great development of the benthic life to more hostile ones.

c) Finally, some beds provided scarce, fragmented fossils or no macrofossils at all. These are considered here "patchy" or "barren" assemblages and are generally unsuitable for community composition and structure studies. Taphonomic features strongly suggest that significant transport and reworking occurred; their allochtonous natures prevent us to consider them as communities, and their occurrence points to strongly unfavourable biotic conditions.

Conclusions

This analysis strongly suggests a cyclic evolution for the benthic paleocommunities during the Valanginian; this is represented by the recurrence of the polytaxic community - succession of oligotaxic community and barren beds. This evolution is presumably determined by cyclic, small-scale shifts (either basinward or landward) of the sedimentary environments in the intertidal-subtidal domain.

Another aspect worth noting is the consistency of the community structure through the Valanginian. Although some taxa have been reported to disappear or appear during this stage in the Cernavodă deposits (Pană et al., 1975; Neagu et al., 1977; Neagu & Pană, 1995), the community structure remains largely identical. However, one major break was identified in the upper part of the succession (approx. 30 m above the base of the sequence), at the level of the microflora (disappearance of many dasycladacean algae, including *Salpingoporella* and *Rajkaiella*) and microfauna (disappearance of the trocholinids from the *Andersenolina elongata-alpina* group, also that of a large part of the lituolaceans with internal structure) (Neagu et al., 1977; Dragastan, 1980, 1988; Neagu & Dragastan, 1984). The break correlates with the first appearance (Fig. 5) of the incised tidal channels filled by terrigenous material (similar to that found in the disconformably overlaying Aptian Gherghina Formation) in Bed 24, also with the dramatic reduction of the macrofaunal diversity and abundance, with only rare, small-sized pachyodonts and isolated encrusting sponges (see Fig. 6). All these phenomena seem to be related to the onset of a generalized end-Valanginian regression in the northern part of Southern Dobrogea (Avram et al., 1995-1996).

The cyclic faunal evolution mentioned corresponds to that proposed on theoretical grounds to occur in a slightly inclined, extended shelf region (also the case of the Cernavodă area) during a transgression (increasing diversity)-regression (decreasing diversity) cycle (McRoberts & Aberhan, 1997). Thus, it can be suggested that the evolution of the Cernavodă Valanginian communities was influenced by short-term eustatic sea-level changes, superposed on the general regressive trend characterizing the Late Valanginian; although the exact timing of these changes is presently unknown, it can also be suggested that the two maxima of benthic life development correspond to the two small-scale sea-level changes figured for the terminal Valanginian, cycles 22 and 23 of the supercycle Lower Zuni B - 2 (Haq et al., 1988), respectively.

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