Correlation of the zonal schemes in the Quaternary sediments of the Bulgarian Black Sea shelf according to molluscs and ostracods

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Abstract. The Candona Ostracod Zone corresponds the Upper Chaudinian where the Dreissena rostriformis tschaudae Molluscan Zone is indicated. The Didacna crassa pontocaspia — Dreissena euxinica and Didacna crassa pontocaspia — Abra ovata Molluscan Concurrent-range-zones corresponding to the Cryptocyprideis bogatschovi Ostracod Zone are indicated respectively in the Middle Pleistocene, Old Euxinian and Uzunlarian Stages. The section of the Upper Pleistocenian (Karangatian) molluscan zones has not been presented for analysis of the Ostracod sequences.

The sequence of the molluscan and ostracod zones in the inner shelf has been broken by a barren zone which corresponds to the continental sediments, deposited in the early New Euxinian. The Loxoconcha lepida Ostracod Zone corresponds to the following in superposition Upper Euxinian Dreissena polymorpha — Dreissena rostriformis distincta Molluscan Concurrent-range-zone. The Hydrobia ventrosa — Monodacna caspia Molluscan Zone together with the following in superposition Mytilus galloprovincialis Zone comprise the sediments of the Old Chernomorian. The intervals occupied by the Cyprideis torosa Ostracod Zone correspond to these molluscan zones. The Falunia rubra — Loxoconcha granulata Ostracod Zone comprises the area occupied by the Spisula subtruncata triangula Molluscan Zone including also the upper parts of the Mytilus galloprovincialis Molluscan Zone.
Introduction

The Quaternary deposits of the inner shelf contain benthic organism associations (molluscs and ostracods) which are used as basis for distinguishing of concurrent biostratigraphic zones. The fossil content of each zone is different from the one of the adjacent zones mainly in the extent of halophilenes of the faunas. The age determination of sediments is possible due to the differences in the taxonomic composition of the zones. The molluscan and ostracod zones distinguished on the basis of the local vertical distribution and in a number of cases also of the individual abundance of the index taxa should be considered as local molluscan and ostracod zones.

For the purposes of this study the molluscs and ostracods from the core wells in the oil exploration areas were studied. These areas are: Nanevo (N-2, N-4 and N-5), Elisavetino (E-1, E-2, E-4 and E-5), Stefan Bogdanov (SB-1), Samotino Sea (Ss-1, Ss-3, Ss-4 and Ss-5) and Samotino East (Se-1, Se-3, Se-4A and Se-5) (Fig. 1). The well sections were sampled by S h o p o v. The samples of fractions finer than 0.5 mm were submitted to S t a n c h e v a. Separately and independently from the first author she published the results on the ostracod zones (S t a n c h e v a, 1989a, b). The molluscan zones were subject of two articles of S h o p o v (1993) and I l l o n o (1993). This is a joint article with a comparison of the local molluscan and Ostracod zones of the Upper Quaternary sediments in the North Bulgarian Shelf (I l l o n o, C h a t h o, 1994).

Correlation of the local molluscan and ostracod zonal schemes.

Pleistocene zones

Sediments of the Lower Pleistocene sediments were not deposited in the inner shelf zone. At this time a stratigraphic gap corresponding to the entire Chaudinian Age is observed here. A similar gap but of not so big range is established also in the outer shelf zone where in Upper Chaudinian sediments the Dreissenia rostriformis tschaudae Local Range-zone (S h o p o v, 1993; I l l o p o v, 1993) is indicated. The molluscan zone corresponds to the Candonina Ostracod Zone (composed by representatives of the subgena Candonina (Caspiolina), C. (Pontoniella), C. (Bakunella), C. (Typhlocyprirus) and C. (Reticulocandina?)) (S t a n c h e v a, 1989b). These correspondences are established in the Samotino East wells (Se-3, Se-4a and Se-5) (Fig. 1). The sediments of the molluscan and ostracod zones are naturally bordered on top and bottom through washings corresponding to the Günz and Mindel regression of the World Ocean.

In both shelf zones the sedimentation continued with deposition of the Middle Pleistocene. In the sediments of these subseries respectively the Didacna crassa pontocaspia — Dreissenia euxinica and Didacna crassa pontocaspia — Abra ovata Local Molluscan Concurrent-range-zones corresponding respectively to the Old Euxinian and Uzunlarian Regional Stages (S h o p o v, 1993) are indicated. No differences in the content of the species of the zonal associations caused by different habitat in the inner or outer shelf are observed. The Middle Pleistocene local molluscan concurrent-range-zones correspond to the Cryptocyprideis bogatschovi Local Ostracod Range-zone (S t a n c h e v a, 1989b).

A complete coincidence of the zonal association of the Middle Pleistocene Didacna crassa pontocaspia — Dreissenia rostriformis euxinica Local Molluscan Concurrent-range-zone corresponding to the Old Euxinian Stage with the Cryptocyprideis bogatschovi Local Ostracod Range-zone in the well sections of Elisavetino and Nanevo areas (E-1, E-2, E-5, N-4 and N-5 (Fig. 1) is established. The local ostracod association of the Cryptocyprideis bogatschovi Zone consists only of Caspian according to type and salinity fauna and no differences in its species composition at least what concerns salinity are observed. In this case the association reveals also coincidence with the intervals occupied by the Didacna crassa pontocaspia — Abra ovata Local Molluscan Concurrent-range-
Fig. 1. Correlation of the zonal schemes in the Quaternary sediments of the Bulgarian Black Sea shelf according to molluscs and ostracods.
zone corresponding to the Uzunlarian Regional Stage. Such cases are observed in the well sections Elisavetino and Samotino East (E-1, E-4, Se-3 and Se-4A) (Fig. 1). The sediments of the two regional stages are deposited in the time of the Mindel interglacial time and are connected with a gradual transition. The upper and lower boundaries of the molluscan and ostracod associations are clearly marked with discontinuances due to the Mindel-Ris glaciations.

The Upper Pleistocene (Karangatian) molluscan zones are established only in one location of the inner shelf — the section of well MS-8g in the inner part of the Burgas gulf (Хрісчев, Шопов, 1979). At this place three superpositioned local molluscan concurrent range-zones connected with gradual vertical transitions are established: *Corbula gibba — Rissoa parva Zone, Paphia senescens — Cardium tuberculatum Zone* and *Cardium edule — Bittium reticulatum Zone*, corresponding to the three sub-stages of the Karangatian Regional Stage. The section of well MS-8g has not been presented for analysis of the ostracod sequences.

The Karangatian sediments are formed during the Ris-Würmian interglacial time. Their lower boundary (in the settings of the Bulgarian inner shelf) represents gradual transition to the underlying Uzunlarian sediments and their upper boundary is clear and connected with the large Würmian Grimaldian (for the Black Sea — Postkarangatian) regression of the World Ocean.

The sequence of the molluscan zones in the inner shelf has been interrupted by a barren zone which corresponds to the continental deposits of the first half of the Würmian regression — in the Early New Euxinian. During most of the Late Pleistocene (Karangatian and Early New Euxinian) a stratigraphic gap is observed also in the outer shelf zone.

Two associations are observed in the Upper Euxinian *Dreissena polymorpha — Dreissena rostriformis distincta Local Molluscan Concurrent-range-zone* — one in the inner and one in the outer shelf. Within the association of the inner shelf dominating species is mainly the first index species and within the association of the outer shelf — mainly the second one. Within both associations other Caspian species of the zonal association composition have also significant role. The *Loxoconcha lepida Local Ostracod Range-zone (Stancheva, 1986b)* corresponds to the Upper Euxinian *Dreissena polymorpha — Dreissena rostriformis distincta Local Molluscan Concurrent-range-zone*. Its zonal association consists only of Caspian species. Such correspondences are established also in the well core in the areas Elisavetino, Nanevo, Samotino East and Samotino More (E-2, E-4, E-5, N-2, N-4, N-5, Se-3, Se-5, Ss-1, Ss-3 and Ss-4) (Fig. 1).

The Upper Euxinian sediments are deposited during the Post-Würmian interglacial time. The lower and upper boundary of these deposits are very distinct and are connected with the discontinuances caused by the large Postkarangatian regression and the smaller Middle Euxinian transgression which marks the beginning of the Holocene in the shelf. The lower boundary of the Old Chernomorian *Hydrobia ventrosa — Monodacna caspia Local Molluscan Concurrent-range-zone* corresponding to the *Cypriidea torosa Local Ostracod Range-zone (subzone A)* is divided by the upper boundary of the Upper Euxinian Substage (*Dreissena polymorpha — Dreissena rostriformis distincta Local Molluscan Concurrent-range-zone* corresponding to the *Loxoconcha lepida Local Ostracod Range-zone*) with a stratigraphic gap of approximately 2 000 years.

### Holocene zones

The climatic changes after the Würmian glaciation led to restoration of the connection of the Black Sea with the World Ocean. This Holocene transgression in the Black Sea basin caused increasing of the salinity level of the sea to its contemporary values (18‰). The latter determines the subsequent change of the molluscan associations which, starting from the Holocene, become more and more halophilic.

The association of the *Hydrobia ventrosa — Monodacna caspia caspia Local Molluscan Concurrent-range-zone* consists of species used by Невеская (1965)
to characterize the Bugazian-Vityasevian layers of her scheme. Despite the qualitative differences in the species composition of the communities in Bugazian-Vityasevian times this subdivision has mainly theoretical character and it would be difficult to be applied especially in the Bulgarian shelf settings. There are a number of reasons for this but the main one comes from the impeded Holocene transgression in its initial moments which causing low values of sedimentation. As consequence the associations, although formed in different times are practically often buried together, i.e. the well known phenomenon of faunal condensation in minimum sediment volume is observed. This is the reason for the establishing of the then dying Caspian species Monodacna caspia caspia (Eichw.) and the eurihaline Mediterranean species Hydrobia ventrosa (Ma.tg.). Within the zonal association of the inner shelf — in siltstone muds and sands in the Burgas, Pomorie, Nesebar and Varna gulfs a near coastal association with dominating species Hydrobia ventrosa (Mtg.) is formed. In the inner shelf zone the zonal association is characterised with stable presence of Caspian species (mainly Monodacna caspia caspia (Eichw.)) and relatively lower quantitative representation of the Mediterranean species.

The Hydrobia ventrosa — Monodacna caspia Local Molluscan Concurrent-range-zone together with the following Mytilus galloprovincialis Local Molluscan Range-zone comprise the sediments of the Old Chernomorian of the Chernomorian Regional Stage. The intervals occupied by the Cyprideis torosa Local Ostracod Range-zone (Stancheva, 1989a) correspond to these molluscan zones. The ostracod association of the zone is characterised by dominating presence of the index species. The zone is subdivided into two subzones since it is not always possible two associations of the ostracod association to be distinguished and for that reason the zone is divided into two subzones A and B.

Subzone A occupies a lower stratigraphical level. The ostracod association is characterized mainly with species known from the Upper Euxian Loxoconcha lepida Local Ostracod Range-zone. In addition to the dominating index species Caspian species participate in the zonal association. In the zonal association of subzone B appear Mediterranean species such as Loxoconcha granulata Sars, Falunia rubra (Müller), etc. The boundary between these subzones is assumed in the sections of the first appearance of the Mediterranean species. The following correspondence of the local ostracod zones to the local molluscan zones within the range of the Old Chernomorian sediments has been established. Complete or nearly complete coincidence of the interval occupied by the ostracod subzone A with the lower part of the Hydrobia ventrosa — Monodacna caspia caspia local Molluscan Concurrent-range-zone is observed in the well-sections in the areas Elisavetino, Nanevo and Stefan Bogdanov (E-1, E-2, E-4, E-5, N-2, N-4, N-5, SB-1) (Fig. 1). In the wells in the areas Samotino East and Samotino the presence of the zonal association of the ostracod subzone A has not been established. The intervals corresponding to these zones are either not sampled or competent ostracod fauna has no been observed in them, especially the abundance of the index species Cyprideis torosa (Jones).

The zonal association in subzone B corresponds to the upper parts of the Hydrobia ventrosa — Monodacna caspia caspia Local Molluscan Concurrent-range-zone and to the lower parts of the Mytilus galloprovincialis Local Molluscan Range-zone and thus the upper boundary of the Cyprideis torosa Local Ostracod Range-zone (subzone B) lies from several centimetres to several tenths of centimetres higher than the lower boundary of the Mytilus galloprovincialis Molluscan Range-zone. Such a complete or nearly complete coincidence is observed in the sections of nearly all wells in the studied areas. The upper boundary of the Cyprideis torosa Local Ostracod Range-zone is assumed in the sections on the basis of quantitative domination of the index species of the following ostracod zone.

The upper part of the Falunia rubra — Loxoconcha granulata Local Ostracod Concurrent-range-zone corresponds to the uppermost local molluscan concurrent-range-zone. In addition to the index species some Mediterranean species participate in its
zonal association (Stancheva, 1989a). This zone comprises the area occupied by
the Spisula subtruncata triangula Local Molluscan Range-zone and the upper parts of
the Mytilus galloprovincialis Local Molluscan Range-zone. In the wells in the Samotino
More, Samotino East and Stefan Bogdanov areas this zone comprises the whole in-
terval occupied by the mentioned molluscan zone. Probably this incongruity is a
result of the nontypical fauna of the ostracod subzone B in these sections which makes it
difficult to assume a boundary between the Falunia rubra — Loxoconcha granulata
Local Ostracod Concurrent-range-zone and the Cyprideis torosa Local Ostracod Range-
zone.

Two cases of interaction are observed: (a) the part of the Falunia subra — Loxo-
concha granulata Ostracod Zone with diverse marine fauna corresponds to the Spisula
triangulla Molluscan Zone. When present, the Caspian species are separate and rede-
posited. Amonia beccarii is present in thousands in this samples; (b) the lower part of
the zone corresponding to some or other extent to the Mytilus galloprovincialis Mollus-
can Zone is characterised mainly with presence of the two index species generally in
small number and with separate representatives of some Mediterranean or Caspian spe-
cies. The number of Amonia beccarii decreases to several hundreds or even several tenths.

The sediments of the Cernomorian Regional Stage are formed during the warm
postglacial (Postwürmian) time. The lower parts of the stage (Old Chernomorian
Substage) are characterized with mixed eurihaline Mediterranean and Caspian mollus-
can and ostracod species. The deposition of the sediments of the New Chernomorian
Substage started about 3 500 years ago. These deposits contain stenohaline (for the
Black Sea) Mediterranean molluscan and ostracod fauna.

Conclusion
The difference in the time of studies of the ostracod (1989) and molluscan (starting
1991) zonal standards made our work to some extent difficult. Some incongruity such
as lack of samples from same intervals subjected to molluscan and ostracod analysis
are observed. The sections of these wells are not shown on Fig. 1. These samples were
probably lost during transportation or subsequent laboratory analyses. Nevertheless
an amazing coincidence in the position of the two types of boundaries is observed.
Together with the regional disturbances these boundaries in their entity form the mol-
luscan and ostracod zonal schemes.

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