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Palaeoecological analysis of Berriasian ostracods of the central Crimea

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Key words: ostracods, Berriasian, palaeoecology, central Crimea.

Abstract. The author has completed a palaeoecological analysis of assemblages of ostracods, collected from the sections of the Berriasian deposits of central Crimea. The strata belonging to this stage are divided into four formations, and these into stratigraphic subdivisions of member rank, numbered 1–29. The members accumulated in deeper and shallower environments in a shallow marine basin, and are distinguished on the basis of the characteristic features of the composition of the ostracod complexes. Changes of temperature conditions and water mobility were identified.

INTRODUCTION

This work continues the analysis of assemblages of ostracods from the Berriasian deposits of central Crimea. Savelieva *et al.* (2014 – this volume) present data on the history of the study of Berriasian ostracods of central Crimea, on the factual data, methods of study, and lithological and palaeontological description of the composite Berriasian sections. This publication presents a palaeoecological analysis of the ostracod assemblages, which contributes to the description of the shallow-marine environment which existed in the basin.

The material studied consists mainly of benthic ostracods, closely associated with the near-bottom environment of the basin. This makes them a reliable indicator of the palaeoecological environment. The main environmental factors, influencing the systematic and quantitative composition, and the domination of one taxa over others, include water depth, salinity, hydrodynamic conditions in the basin, temperature conditions, substrate type, and organic carbonate and oxygen content of the water (Babinot, 1980; Neale, 1988; Whatley, 1988; Nikolaeva *et al.*, 1989; Dobrova, 1996; Andreev *et al.*, 1999; Whatley *et al.*, 2003 and others). The reconstruction of the palaeoenvironment is based primarily on the actualistic approach, where the environmental parameters of modern communities are extrapolated to the ancient fauna with certain assumptions (Sohn, 1964; Peypouquet, 1980; Benson, 1984; Schudack, 1999; Tesakova, 2008 and others).

PALAEOECOLOGICAL ANALYSIS OF OSTRACOD ASSEMBLAGES

A total of 85 species of ostracod, belonging to 33 genera of 16 families, were identified in the Berriasian deposits of central Crimea. Investigation of these ostracod assemblages included taxonomic, quantitative, taphonomic and palaeoecological analyses. The results of the taxonomic and quantitative analyses of the ostracods studied have been presented by the author previously (see Savelieva *et al.*, 2014, fig. 7

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– this volume; Arkadiev *et al.*, 2012). The ostracods are present throughout the whole section except sample 31-12-1 (Member 27).

The distribution of genera and species of ostracod in the sequence reveals changes in the systematic composition, including dominant associations at certain levels. This indicates a shift in environmental conditions in the basin. Based on the changes of dominant and associated genera, ostracod assemblages can be identified (Fig. 1, 2). The ostracod shells are mostly well preserved, without size differentiation; adult and larvae specimens are often present together, which indicates autochthonic burial. The principal component of the assemblages consists of smooth-walled eurybiontic specimens of the genus *Cytherella* Jones, 1849 (Sohn, 1964; Neale, 1976; Dobrova, 1996), which sometimes are dominant. Most of the *Cytherella* species are stenohaline. They live today in shallow waters in a salinity of 32–37‰ and in deep waters in a salinity of 34–35‰ (Sohn, 1964). Predominant among the sculptured forms are representatives of the Protocytheridae family (*Protocythere* Triebel, 1938; *Costacythere* Gruendel, 1966; *Hechticythere* Gruendel, 1974 and *Reticythere* Gruendel, 1978), with heavy shells, adapted to wave motion, typical of shallow environments (Shornikov, 1971; Neustrueva, 1981; Babinot, 1995). The relative thickness of the shell decreases when the depth increases. In modern forms the valves are thickest and the carapace is heaviest in those shallow waters with the coarsest sediment (Benson, 1984). The presence of numerous diverse specimens of the genus *Cytherelloidea* Alexander, 1929 – inhabitants of modern tropical and subtropical shallow waters – also suggests a shallow environment (Sohn, 1964; Schudack, 1999). They live under temperatures varying from 10°C in high latitudes to 30–32°C in the tropics (Sohn, 1964; Neale, 1973). The overwhelming majority of the taxa studied are typical of basins with normal salinity. Figure 3 shows genera of the ostracods studied and their relations to salinity and depth, based on the published literature (Morkhoven, 1963; Donze, 1971; Peypouquet, 1980; Benson, 1984; Colin, Oertli, 1985; Neale, 1988; Nikolaeva *et al.*, 1989; Dobrova, 1996; Kuznesova, Dobrova, 1997; Andreev *et al.*, 1999; Tesakova, 2010). Eurybiontic representatives of the smooth-walled groups: *Cytherella*, *Bairdia*, *Macrocypris*, *Bythocypris*, *Paracypris*, *Pontocypris* Sars, 1865 which are an essential element of deep-water bathyal and deeper conditions are marked separately (Benson, Sylvester-Bradley, 1971; Benson, 1974, 1984; Nikolaeva, 1984). Present individual genera may withstand salinity fluctuations or live in brackish or fresh-water environment.

In the section studied (Fig. 1) the lower levels of argillaceous deposits (Member 5) are absolutely dominated by the genera *Costacythere* and *Schuleridea* Swartz et Swain, 1946 (hundreds of specimens) with large and heavy shells, typical of a shallow water high energy environment; eurybiontic *Cytherella* are also numerous, and lesser numbers of warm shallow-water *Cytherelloidea* are present. *Cythereis* Jones, 1849, *Bythoceratina* Hornibrook, 1952 and *Quasigermani*-

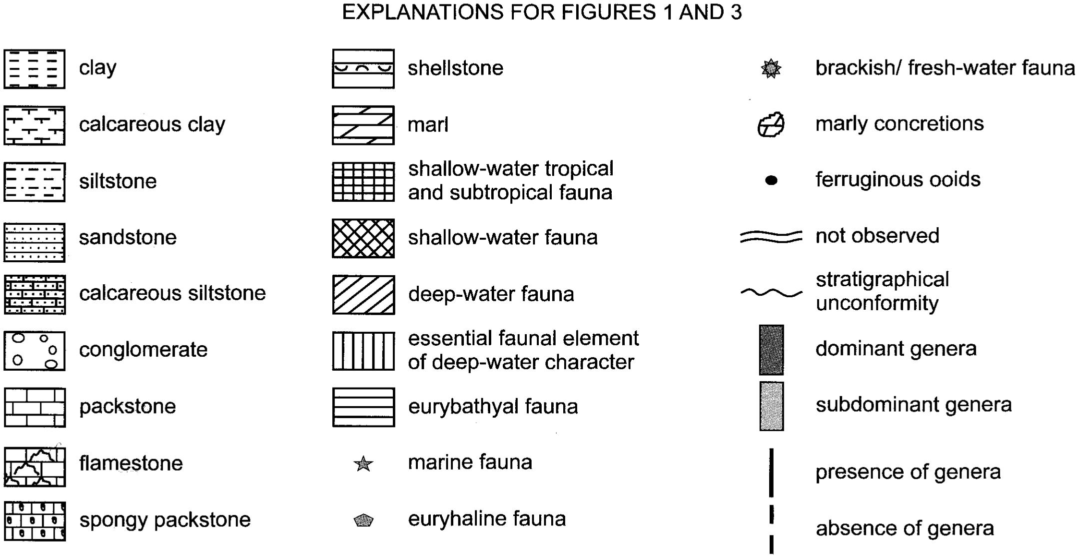
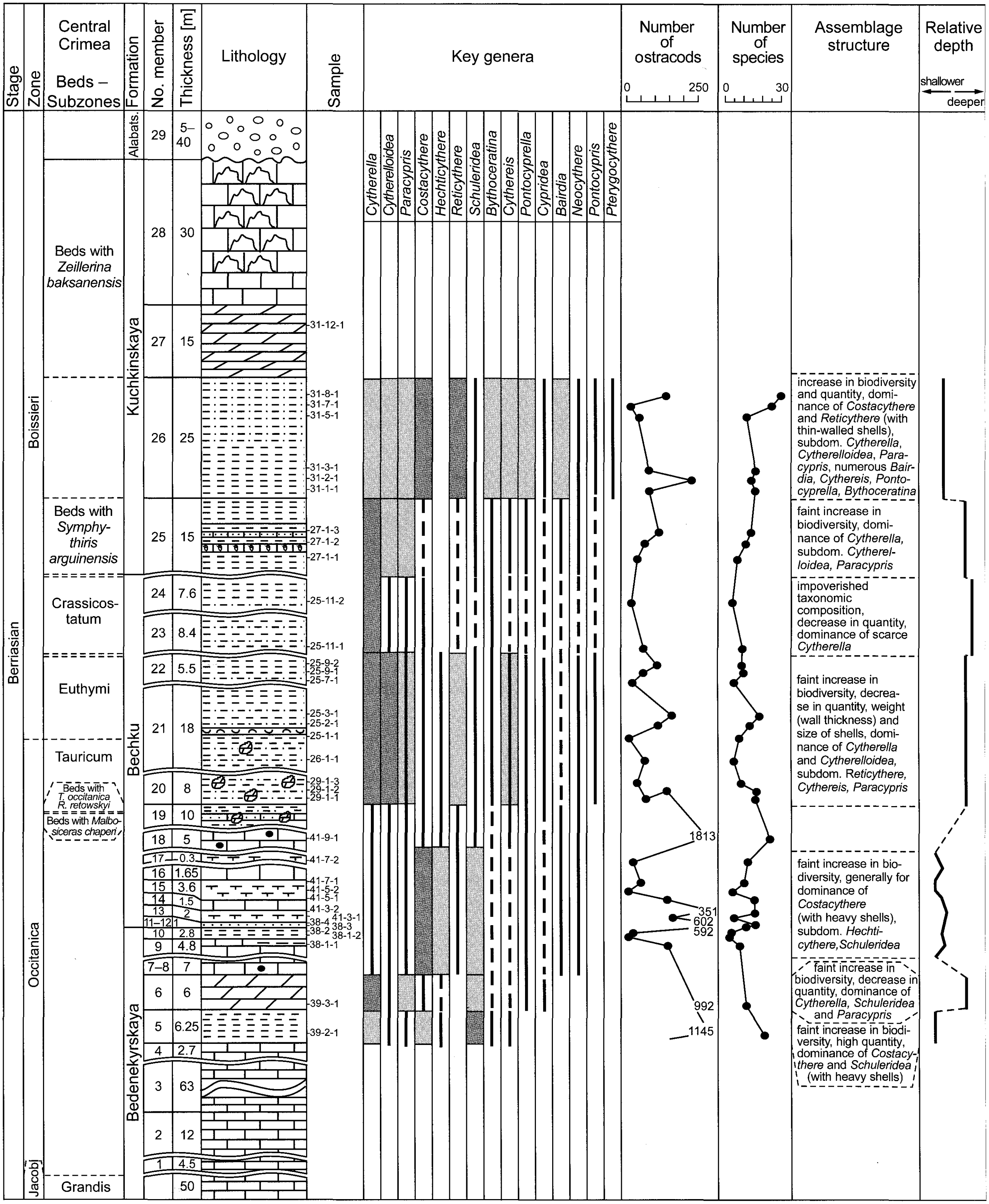


Fig. 1. Characteristics of ostracod assemblages in composite section of Berriasian of central Crimea


Stage
Zone
Central Crimea
Beds – Subzones
Formation
No. member
Thickness [m]
Lithology
Sample
Key genera
Number of ostracods
0 250
Number of species
0 30
Assemblage structure
Relative depth
shallower
deeper
Berriasian
Boissieri
Occitanica
Jacobi
Beds with Zeillerina baksanensis
Beds with Symphythiris arguinensis
Crassicostatum
Euthymi
Tauricum
Beds with T. occitanica R. retowskyi
Beds with Malbosiceras chaperi
Grandis
Alabats.
Kuchkinskaya
Bechku
Bedenekyrskaya
29 5–40
28 30
27 15
26 25
25 15
24 7.6
23 8.4
22 5.5
21 18
20 8
19 10
18 5
17 0.3
16 1.65
15 3.6
14 1.5
13 2
11–12 1
10 2.8
9 4.8
7–8 7
6 6
5 6.25
4 2.7
3 63
2 12
1 4.5
50
-31-12-1
-31-8-1
-31-7-1
-31-5-1
-31-3-1
-31-2-1
-31-1-1
-27-1-3
-27-1-2
-27-1-1
-25-11-2
-25-11-1
-25-9-2
-25-9-1
-25-7-1
-25-3-1
-25-2-1
-25-1-1
-26-1-1
-29-1-3
-29-1-2
-29-1-1
-41-9-1
-41-7-2
-41-7-1
-41-5-2
-41-5-1
-41-3-2
-38-4
-38-2
41-3-1
38-3
38-1-2
-38-1-1
-39-3-1
-39-2-1
Cytherella
Cytherelloidea
Paracypris
Costacythere
Hechticythere
Reticythere
Schuleridea
Bythoceratina
Cythereis
Pontocyprella
Cypridea
Bairdia
Neocythere
Pontocypris
Pterygocythere
1813
351
602
592
992
1145
increase in biodiversity and quantity, dominance of Costacythere and Reticythere (with thin-walled shells), subdom. Cytherella, Cytherelloidea, Paracypris, numerous Bairdia, Cythereis, Pontocyprella, Bythoceratina
faint increase in biodiversity, dominance of Cytherella, subdom. Cytherelloidea, Paracypris
impoverished taxonomic composition, decrease in quantity, dominance of scarce Cytherella
faint increase in biodiversity, decrease in quantity, weight (wall thickness) and size of shells, dominance of Cytherella and Cytherelloidea, subdom. Reticythere, Cythereis, Paracypris
faint increase in biodiversity, generally for dominance of Costacythere (with heavy shells), subdom. Hechticythere, Schuleridea
faint increase in biodiversity, decrease in quantity, dominance of Cytherella, Schuleridea and Paracypris
faint increase in biodiversity, high quantity, dominance of Costacythere and Schuleridea (with heavy shells)

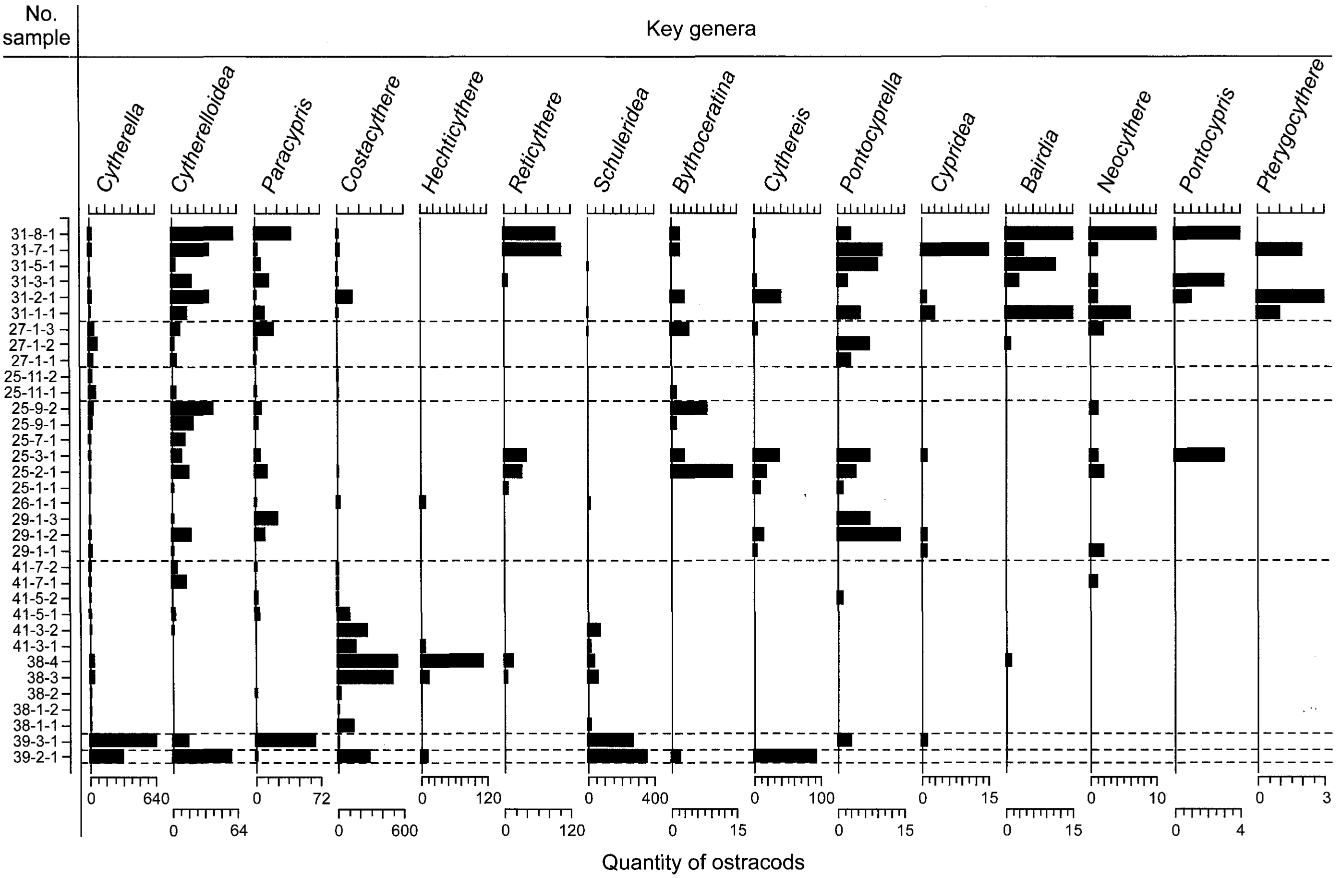


Fig. 2. Dynamics of change in the quantity of ostracods in the section

Individual representatives are not presented in the figure because of large scale

tes Gruendel, 1964 have shells with spines, which is characteristic of the inhabitants of muddy substrates (Babinot, 1995; Tesakova, 2010). Larvae of various age generations are also present, but they are also quite thick-walled. The finest fractions (0.094–0.3 mm) mostly contain fragments of large shells, the thinner-walled shells being extremely rare. Individual deep-water specimens of the genus *Paracypris* are present. Similar assemblages are known to be characteristic of shallow-water parts of the basin with moderately active hydrodynamic conditions. Similar assemblages were recorded in SW Crimea (Belbek river, Bechku Formation, Tauricum Subzone) (Arkadiev *et al.*, 2012). The Bechku Formation consists of sandstones and siltstones interbedded with packstones, formed under shallow water nearshore environments (upper sublittoral zone). This is confirmed by the presence of shellstones composed of shells of bivalves, gastropods, ammonites and rounded quartz pebbles and wood debris. Half-burrowing, burrowing and sedentary forms of bivalves are dominant (Klikushin, 1971).

At higher levels, the dominant genera change with a gradual expansion of the taxonomic composition and a reduction of the numbers of individual specimens. Predominance of the genus *Schuleridea* with large and heavy shells, a sharp increase in the number of eurybiontic *Cytherella* and deep-water *Paracypris*, and isolated *Costacythere*, are typical of the marly deposits (Member 6). Apparently, there was a small deepening of the marine basin, but the near-bottom currents remained active. J.-F. Babinot created a Cenomanian model of the main carbonate platform palaeoenvironments and their ostracode type-assemblages from the North Tethyan margin of southwestern Europe (Babinot, Lethiers, 1984; Babinot, 1995). The dominance of smooth *Cytherella* and the increasing of number of deep-water *Paracypris* indicate conditions close to open marine (type-assemblages 1), but a large number of heavy shells of *Schuleridea* are characteristic of the outer and inner carbonate platform (type-assemblages 3, 5) (Babinot, 1995).

In the argillaceous, marly and sandy deposits of members 9–17, dominant *Costacythere*, numerous *Hechticythere* Gruendel, 1974, rare *Cytherelloidea*, and individual *Paracypris* are present. The number of specimens of the genus *Costacythere* varies from level to level: from individuals (Member 10, partly members 15 and 17) to hundreds of specimens (both entire shells and valves, and numerous fragments) (members 9, 11–12, 13, lower part of Member 15). There are significantly less specimens of the genera *Cytherella* and *Schuleridea*. Specimens of other genera are rare, often isolated, occurring at various levels, mostly in the upper part of Member 13 and above: *Bairdia* M'Coy, 1844, *Eucytherura* G. Mueller, 1894, *Paranotacythere* Bassiouni, 1974, *Acrocythere* Neale, 1960, *Metacytheropteron* Oertly, 1957 and others. In the finest fractions (0.094–0.3 mm) fragments of larger shells with a large amount of quartz grains predominate (members 11 and 12, upper portion of members 13 and 17). Apparently, there were periodic insignificant fluctuations of depth and activity of the near-bottom currents, and movements of the shoreline during the deposition of members 13–17. Pokorny (1971) recorded a dependence of the diversity of marine benthic ostracods on shoreline changes in relatively shallow seas: diversity of ostracods increases during transgression and decreases during regression (Pokorny, 1971; Ballent, Whatley, 1996). The shallow near-shore environment is characterized by a considerable fluctuation of environmental factors delimiting the existence and abundance of community components.

The upper terrigenous part of the section (members 20–26) is characterized by a significant reduction of the weight (wall thickness) and size of ostracod shells: *Costacythere*, *Reticythere*, *Schuleridea*. The latter decreases in amount, down to just individuals. The finest fractions (0.094–0.3 mm) are characterized by a wide variety of thin-walled shells: *Eucytherura*, *Paranotacythere*, *Acrocythere*. Such smaller sizes of shells were noted by Neale (1966), who attributed it, hypothetically, to the higher calcium carbonate content of the water. V. Pokorny suggested that small sizes of shells could be caused by a low oxygen content of the water which could be related to very quiet sedimentation (Weaver, 1978). Apparently, the living conditions of ostracods became more favorable, which may be related to a small deepening of the basin, and, primarily to the calmer hydrodynamic environment.

The argillaceous deposits (members 20–22) are dominated by eurybiontic *Cytherella* and *Cytherelloidea*, inhabitants of modern tropical and subtropical shallow waters, and numerous *Cythereis*, *Reticythere*, deep-water *Paracypris* and *Pontocyprella*, *Neocythere* and *Bythoceratina*. The latter show the highest species diversity in modern shallow tropical seas, and usually live on the surface of loose silty or sandy substrates (Shornikov, 1981). Also a small number of silty and sandy substrate inhabitants of the genus *Neocythere* Mertens, 1956 were encountered, with longitudinal and transverse ribs on their shells. The specimens of the genus *Cythereis* ornamented with spines, also lived on a silty substrate (Tesakova, 2010). Therefore, the ostracod assemblage indicates a calm environment with poor substrate sorting and weak near-bottom hydrodynamics, which is also confirmed by well preserved thin-walled shells (including valves), and the simultaneous occurrence of both adult and various generations of larval specimens of some species.

Taxa of ostracods			Central Crimea	
Orders	Families	Genera	Relation to salinity	Relation to depth
Platycopida	Cytherellidae	*Cytherella*	☆	▥
		Cytherelloidea	☆	▦
Podocopida	Bairdiidae	*Bairdia*	☆	▥
		Bythocypris	☆	▥
	Macrocyprididae	*Macrocypris*	☆	▥
	Pontocyprididae	*Pontocypris*	☆	▥
		Pontocyprella	☆	▨
	Paracyprididae	*Paracypris*	☆	▥
	Cyprideidae	*Cypridea*	✹ ⬠	▩
	Bythocytheridae	*Bythoceratina*	☆	▤
		Patellacythere	☆	▤
	Cytheruridae	*Eucytherura*	☆	▤
		Stillina	☆	▤
		Paranotacythere	⬠ ☆	▤
		Orthonotacythere	☆	▤
		Cytheropteron	☆	▤
		Eocytheropteron	☆	▤
		Metacytheropteron	☆	▤
	Progonocytheridae	*Neocythere*	☆	▩
		Macrodentina	⬠ ☆	▩
	Neurocytheridae	*Fuhrbergiella*	☆	▩
	Pleurocytheridae	*Acrocythere*	☆	▤
		Vocontiana	☆	▤
	Protocytheridae	*Protocythere*	☆	▩
		Reticythere	☆	▩
		Hechticythere	⬠ ☆	▩
		Costacythere	☆	▩
	Trachyleberididae	*Cythereis*	☆	▤
		Rehacythereis	☆	▤
		Quasigermanites	☆	▤
	Brachycytheridae	*Pterygocythere*	☆	▩
	Cytherideidae	*Kusanbayella*	⬠ ☆	▤
	Schulerideidae	*Schuleridea*	⬠ ☆	▩

Fig. 3. Ostracods genera of Berriasian of central Crimea and its relation to salinity and depth

Explanations in Figure 1

An impoverished ostracod association (members 23, 24) is encountered higher in the section. It is dominated by scarce *Cytherella*, with few genera: *Cytherelloidea*, *Para-*

cypris, *Macrocypris*, *Costacythere*, *Bythoceratina*. The living conditions of the ostracods became less favourable, most likely due to increased depth of the basin and, possibly, cooling of the near-bottom waters. *Cytherelloidea* belongs to the filter-feeding Platycopida which have a survival advantage in times of reduced oxygen (Whatley, 1995). *Cytherelloidea* appears to work well as a warm-water indicator. *Cytherella*, another genus of the filter-feeding Platycopida, is much more cold-water tolerant than *Cytherelloidea.* Species of this genus dominate the OMZ (the Oxygen Minimum Zone) in modern oceans at depth of about 1000 m, where there are water masses considerably colder than those in the upper 100–200 m. Oxygen dissolution rather than water temperature might be one of several controlling factors for their distribution (Schudack, 1999).

The appearance of sponge packstone (Member 25) indicates a change in the dynamics of the basin. The lack of the water dynamic effects and the presence of significant amounts of sludge components show that the depth of the formation of sponge packstone was below 50 m (below storm wave baseline). Sponge bioherms grow where the bottom current conditions needed to transport the slurry and food supply of sponges are present (Arkadiev *et al.*, 2014). The ostracod assemblage of the sponge packstone (Member 25) is characterized by the predominance of the eurybiontic *Cytherella*, while the subdominants are: *Cytherelloidea* (shallow warmer waters indicator) and deep-water *Paracypris*, with scarce *Pontocyprella*, *Bythoceratina*, *Neocythere* and *Cythereis*. The Protocytheridae, typical of all members below and above, are completely missing. This indicates some minor improvement of living conditions (increase in the taxonomic diversity, presence of *Cytherelloidea*): either decreasing depth, or restoration of previously existing near-bottom water temperatures, or both.

The argillaceous deposits of Member 26 were formed in an environment similar to the depositional environment of members 20–22. However, the taxonomic and quantitative composition of the ostracod assemblage becomes even more significant. Many new species occur. Specimens of genera *Costacythere* and *Reticythere* are predominant; *Cytherella*, *Cytherelloidea*, *Paracypris* are subdominant; there are numerous specimens of *Bairdia*, *Pontocyprella*, *Bythoceratina*, *Neocythere*, *Cythereis*. In addition, a small number of the representatives of genus *Pterygocythere* Hill, 1954 also occur. Their distinctive ornamentation such as spines and ventrolateral alae are typical for the silty substrate inhabitants of shallow water environments with good aeration and weak near-bottom hydrodynamics (Andreev *et al.*, 1999; Tesakova, 2010). In all likelihood the living conditions became more favorable; possibly the basin depth decreased. The increased abundance of the brackish/fresh water genus *Cypridea* can be an additional argument in favor of the closeness of the shoreline (Morkhoven, 1963; Andreev *et al.*, 1999; Horne, 2009; Tesakova, 2010, and others).

Any changes of the living environment will lead to restructuring of the entire ostracod assemblage. Figures 2 and 3 show the predominant and subdominant genera of ostracods, with short descriptions of the assemblage structure and relative basin depth (shallower–deeper). The comparison of the species diversity and numbers of ostracods curves demonstrates that the species diversity increases with the numbers. Higher in the upper part of the section the taxonomic diversity gradually increases, while the shells become lighter, and the thin-walled forms are better preserved, which, apparently, reflects more favourable conditions for ostracods and for the deposition of fine-grained facies in the sedimentary basin. The most interesting fact is that in the lower part of the section (Member 5) the specimens of genera *Costacythere* and *Schuleridea* have heavy shells, while in the upper part (members 20–26) they have thin-walled shells, and genus *Schuleridea* loses its predominant position.

CONCLUSIONS

The palaeoecological analysis of ostracods from the Berriasian deposits of central Crimea demonstrates that the assemblages developed in the more or less favorable environments of a warm shallow basin, with temporary cooling of the near-bottom waters (members 23 and 24). Limited diversity of the species, abundance of certain specimens, large and heavy shells of ostracods are typical of the shallowest parts of a basin with active hydrodynamic environments (Member 5). The highest taxonomic diversity of the ostracod associations was encountered in the fairly shallow and calm environments with low sorting of substrate and weak near-bottom hydrodynamics (Member 26). When the conditions became unfavourable (probably due to increased depth and cooling of the near-bottom water) the community structure simplified (members 23–24).

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PLATE

PLATE 1

Berriasian ostracods of central Crimea

Fig. 1. *Cytherella krimensis* Neale, 1966; no. 138/13244, sample 39-2-1, left valve, lateral view; Balki, Occitanica Zone

Fig. 2. *Cytherella fragilis* Neale, 1962; no. 139/13244, sample 25-9-1, left valve, lateral view; Balki, Boissieri Zone, Euthymi Subzone

Fig. 3. *Cytherelloidea flexuosa* Neale, 1966; no. 140/13244, sample 25-3-1, left valve, lateral view; Balki, Boissieri Zone, Euthymi Subzone

Fig. 4. *Cytherelloidea flexuosa* Neale, 1966; no. 155/13244, right valve, lateral view; Balki, Boissieri Zone, Euthymi Subzone

Fig. 5. *Paracypris* sp.; no. 141/13244, sample 29-1-3, carapace, right lateral view; Novoklenovo, Sary-Su river, Occitanica Zone, Tauricum Subzone

Fig. 6. *Cypridea funduklensis* Tesakova, 1996; no. 192/13220, sample 29-1-2, left valve, lateral view, Novoklenovo, Sary-Su river, Occitanica Zone, Tauricum Subzone

Fig. 7. *Eucytherura* sp.; no. 142/13244, sample 29-1-1, left valve, lateral view; Novoklenovo, Sary-Su river, Occitanica Zone, Tauricum Subzone

Fig. 8. *Eucytherura* sp.; no. 143/13244, sample 29-1-3, carapace, right lateral view; Novoklenovo, Sary-Su river, Occitanica Zone, Tauricum Subzone

Fig. 9. *Costacythere foveata* Tesakova et Rachenskaya, 1996; no. 145/13244, sample 41-5-1, left valve, lateral view; Balki, Occitanica Zone

Fig. 10. *Costacythere foveata* Tesakova et Rachenskaya, 1996; no. 146/13244, sample 41-5-1, carapace, dorsal view; Balki, Occitanica Zone

Fig. 11. *Costacythere foveata* Tesakova et Rachenskaya, 1996; no. 147/13244, sample 34-1-1, left valve, lateral view; Novoklenovo, Boissieri Zone

Fig. 12. *Costacythere drushchitzi* (Neale, 1966); no. 148/13244, sample 31-2-1, left valve, lateral view; Mezhgorie, Burulcha river, Boissieri Zone

Fig. 13. *Costacythere drushchitzi* (Neale, 1966); no. 149/13244, sample 35-2-1, right valve, lateral view; Novoklenovo, Boissieri Zone

Fig. 14. *Costacythere* sp.; no. 150/13244, sample 34-1-1, right valve, lateral view; Novoklenovo, Boisseieri Zone

Fig. 15. *Costacythere khiamii* Tesakova et Rachenskaya, 1996; no. 151/13244, sample 39-2-1, male left valve, lateral view; Balki, Occitanica Zone

Fig. 16. *Reticythere* aff. *marfenini* (Tesakova et Rachenskaya, 1996); no. 156/13244, sample 25-3-1, right valve, lateral view; Balki, Boissieri Zone, Euthymi Subzone

Fig. 17. *Reticythere marfenini* (Tesakova et Rachenskaya, 1996); no. 152/13244, sample 25-3-1, male right valve, lateral view; Balki, Boissieri Zone, Euthymi Subzone

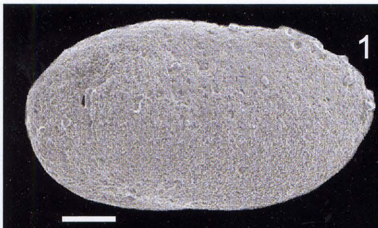
Fig. 18. *Reticythere marfenini* (Tesakova et Rachenskaya, 1996); no. 153/13244, sample 25-2-1, female carapace, left lateral view; Balki, Boissieri zone, Euthymi Subzone

Fig. 19. *Cythereis* sp.; no. 243/13220, sample 29-1-2, right valve, lateral view; Novoklenovo, Occitanica Zone, Tauricum Subzone

Fig. 20. *Schuleridea* ex gr. *juddi* Neale, 1962; no. 154/13244, sample 41-3-2, right valve, lateral view; Balki, Occitanica Zone

Scale bar 100 μm

PLATE 1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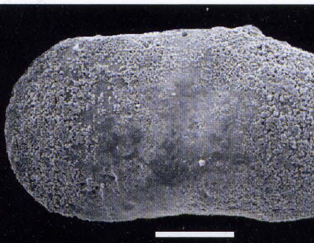
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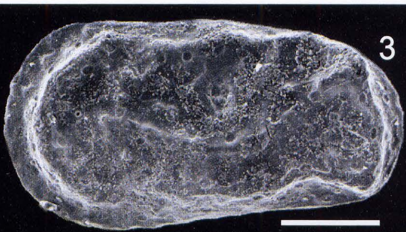
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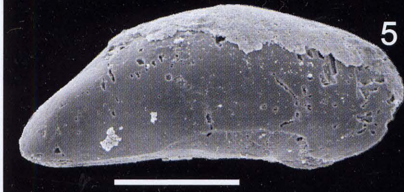
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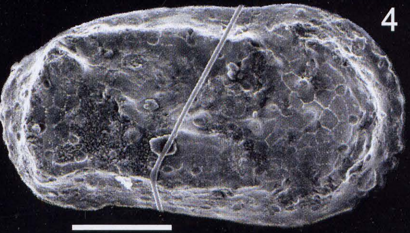
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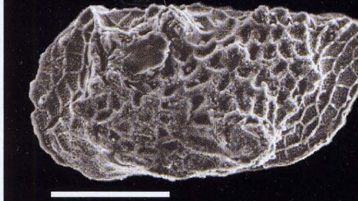
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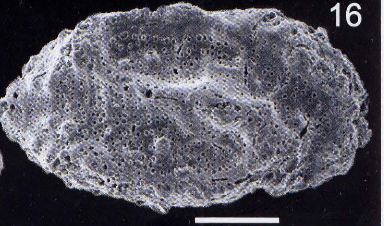
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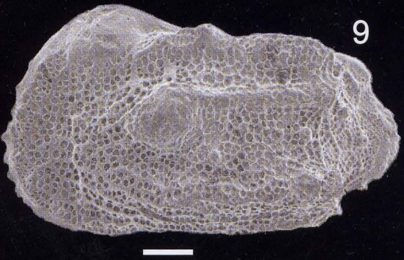
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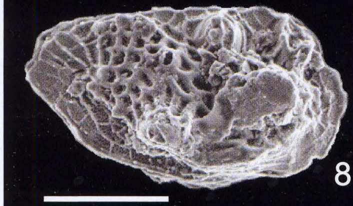
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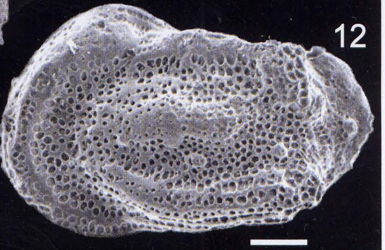
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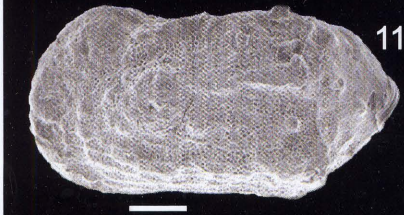
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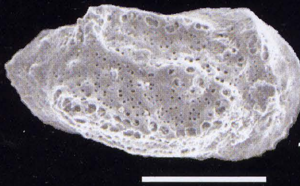
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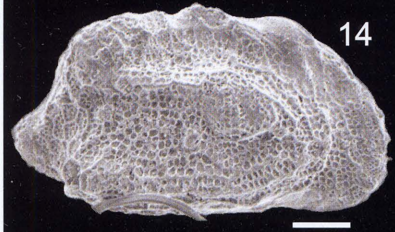
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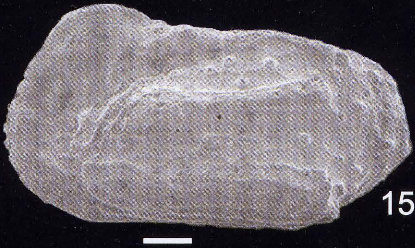
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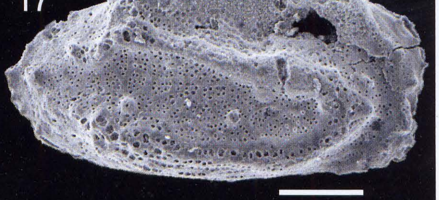
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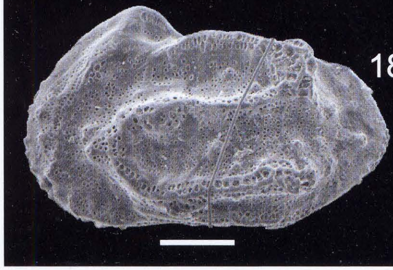
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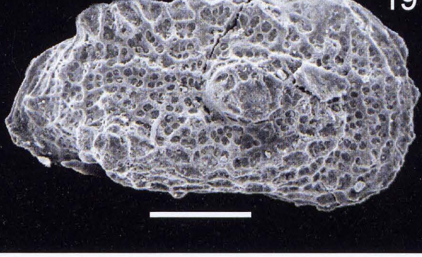
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