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Original article

Mid-Cretaceous/Albian (Cretaceous) ostracod assemblages from NW Hungary reflecting deep marine, nearshore and non-marine environments☆

Diverses faunes d'ostracodes dans les dépôts marins peu profonds et non marins de l'Albiens de la Hongrie

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ABSTRACT

The Albian sediments of the Transdanubian Range in Hungary were deposited in non-marine to fully-marine environments. The studied sections revealed diverse benthic ostracod faunas with moderately-preserved specimens. Forty-six taxa are identified and *Cypridea zalanyii* n. sp. is newly described. The detailed palaeoecological study of these ostracod faunas provided an opportunity to distinguish eight assemblages. The assemblages include limnic, brackish lagoon, shallow marine, reef and low oxygenated semi-enclosed basin environments in the Northern Tethys region we investigated. This work contributes to the knowledge about Albian non-marine faunas from Europe and explores ecological requirements of brackish faunas.

RÉSUMÉ

Les sédiments albiens de Transdanubie en Hongrie représentent différents environnements aquatiques, non marins à entièrement marins. Les sections étudiées pour cet article ont produit diverses faunes d'ostracodes benthiques avec des spécimens modérément conservés. Quarante-sept taxons ont été identifiés et une nouvelle espèce a été proposée : *Cypridea zalanyii* nov. sp. L'étude paléoécologique détaillée de ces faunes d'ostracodes a permis de distinguer huit assemblages. Ces derniers représentent les environnements limniques, lagonaires saumâtres, marins peu profonds, de récif et du bassin semi-fermés pauvre en oxygène dans cette région de la Téthys septentrionale considérée ici. Ce travail complémente les connaissances actuellement limitées sur les faunes non marines d'Albien en provenance d'Europe et sur les exigences écologiques des faunes saumâtres.

1. Introduction

The Lower Cretaceous, mostly shallow marine ostracod faunas have been thoroughly studied in the Tethys region, especially in the boreal realms and in the Northern Tethys. These faunas have also been well documented from their respective occurrences in the United Kingdom, France and Germany. The ostracod assemblages of the Albian marine series are also well known. Albian ostracods from the UK were described by Kaye, 1965a) and Wilkinson (1988, 1990), which included study of biostratigraphic and palaeoecologic distributions. From France, Albian assemblages have been documented and evaluated taxonomically, biostratigraphically, palaeoecologically and palaeobiogeographically in several works (Damotte, 1971, 1979; Damotte and Grosdidier, 1963; Deroo, 1956; Oertli, 1958; Sauvagnat and Colin, 2013). From Germany, the Albian ostracod assemblages were, in most cases, looked at with reference to local

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biostratigraphy (Elstner and Kemper, 1989; Frieg and Kemper, 1989; Kemper, 1989; Mutterlose et al., 2003). Detailed taxonomic work in connection with biostratigraphic and palaeoceologic studies were published by Gründel (1966, 1967), Kemper et al. (1975), and Risch (1971). Further taxonomic, biostratigraphic, palaeoecologic and/or palaeobiogeographic works were published from (a) south west Ireland by Ainsworth (1985), Ainsworth and Horton (1986) and Hart and Crittenden (1985), from (b) Switzerland by Charollais et al., 1977 and Sauvagnat and Weidmann (2011), from (c) the Netherlands by Witte et al. (1992), from (d) Portugal by Andreu, 1981 and from (e) Spain by Andreu (1983), Swain (1993) and Schudack and Schudack (2009).

The Purbeck–Wealden non-marine faunas of the Tethys region have been widely researched (e.g. Anderson, 1985; Kilenyi and Neale, 1978), but the Albian non-marine faunas are less common. Tibert et al. (2013) studied the taxonomy, biostratigraphy and palaeoecology of a rare non-marine Albian ostracod fauna derived from a dinosaur bonebed in Spain. The taxonomy and philogeny of Early Cretaceous *Cypridea* Bosquet, 1852 and its allies were studied by Horne and Colin (2005), and the family Limnocytheridae was studied by Colin and Danielopol (1980).

Research in Hungary in the 1950s focusing on bauxite exploration provided an opportunity to study a continuous series of Cretaceous deposits in the Transdanubian Range. The ostracod faunas of the Albian strata from Hungary were studied by Zalányi (1953, 1959) from the Tés Clay Formation of the boreholes Eplény–1 and Herend–1 of the Bakony Mountains. These provided evidence for a shallow marine to freshwater depositional environment. Zalányi (1959) gave a comprehensive taxonomic description, including detailed hand drawn illustrations of the specimens, with interpretations of depositional environments of the sequence. In 1980, Colin and Danielopol revised the Subfamily Timiriaseviinae and described a new genus *Rosacythere* Colin, 1980. *Gomphocythere baconica*, described by Zalányi in 1959, was classified as belonging to this new genus. Specimens from the Albian strata of the borehole Oroszlány Ot–84 were illustrated with SEM pictures, from which one (Colin & Danielopol, 1980, pl. 7, Fig. 1) was mistakenly referred to as a holotype. Oravecz–Scheffer (in Császár, 1986) made a few fauna lists of the Albian Tés Clay Formation with a short discussion related to the biostratigraphy of the sequences. The first modern taxonomical descriptions and photos made by SEM of Cretaceous ostracods from Hungary were prepared by Monostori (2000) which were from the Albian to Cenomanian marine basin facies of the Pénzeskút Marl Formation, Bakony Mts, Transdanubian Range. The authors of the present study have examined the fauna of the Vértessomló Siltstone Formation of the Vértes foreland, Transdanubian Range. Detailed modern descriptions and palaeoecological interpretations of the marine benthic and rare pelagic ostracod assemblages were made from this semi-enclosed basin environment (Cséfán and Tóth, 2013; Cséfán and Monostori, 2014; Tóth and Cséfán, 2018). In summary, modern taxonomic work with palaeoecological interpretations of the Albian ostracod faunas from Hungary is sporadic in its nature, and only deals with the marine assemblages from the basin environment.

The main goal of this study is to provide a palaeoecological interpretation of the various freshwater to marine ostracod faunas from the Albian deposits of Hungary by obtaining modern taxonomical descriptions of the faunas. Moreover, the deposits from the aquatic environments provide an opportunity to study the palaeoecology of Albian ostracods for future ostracod studies from the Northern Tethys. Thus the analyses presented here should help to create a model of the changes of ostracod assemblages in different aquatic environments during the Albian, and illustrate how the Albian ostracod fauna adapts to the oscillating salinity and oxygen levels.

The ostracod fauna studied here were collected from a continuous sequence of Albian deposits from four boreholes in the Transdandubian Range: namely, Tés Tt–27, Mór Mt–7, Bokod O–1828 and Vértessomló Vst–2 (Fig. 1). The intervals include fluvial to marine marly clay deposits of Tés Clay, the transitional, carbonate to siliciclastic deposits of the reef carbonate Környe Limestone and Tés Clay, and the siltstones of Vértessomló Siltstone. The interpretation is consistent with those of Monostori (2000) concerning Pénzeskút Marl, and Vértessomló Siltstone from boreholes Vst–8 and Agt–2. Details about the latter were published by Cséfán and Tóth (2013), who interpreted that they were deposited in basin environments.

2. Geological settings

The studied sections are located in the Transdanubian Range, Hungary (Fig. 1). The sediments were deposited during the Albian and are considered as a heteropic facies (Figs. 2 and 3). Boreholes Tt–27 (in the Bakony Mts) and Mt–7 (in the Vértes foreland) penetrated the Albian Tés Clay, which was deposited in a fluvial-paludal, shallow brackish, marine, and lagoonal depositional environment (Császár, 1998). In the Vértes foreland, the Albian sediments are mostly fluvial (alluvial and delta), whereas in the Bakony Mountains lacustrine, paludal, marine lagoon and brackish sediments are more common. Based mainly on sporomorphs, the age of the sections is Middle Albian (Császár, 1986).

In borehole Tt–27, which is the stratotype section of the Tés Clay, the section is underlain by the Triassic platform carbonate of Dachstein Limestone, and overlain by the Albian Urgon-type Zirc Limestone (Fig. 4). The section consists of alternating variegated and grey marl, marly clay, silt, clay and calcareous clay layers where occasionally *Ostrea* shards are present. Császár (1986) had earlier described nine cyclothems in the section, which starts with bauxite (Alsópere Bauxite) and ends with a transition to the overlying Zirc Limestone, as indicated by rudist shards (Császár, 1986). In borehole Mt–7 the Tés Clay is underlain by the crinoidal Tata Limestone and consists mainly of variegated clays, the latter being interrupted by thin layers of sandstone marls and limestones (Fig. 4). The sediments of borehole O–1828 are transitional between the Tés Clay and the Környe Limestone (Fig. 5). The latter belongs to the Urgon facies and was deposited in a reef environment during the Albian (Görög, 1995; Császár, 2002). The sequence starts with the thick-bedded Kecskéd Member of Környe Limestone, transitioning up from the crinoidal Tata Limestone. It is overlain by the nodular Kocs Member of the Környe Limestone. The latter is overlain by the first sequence of the transitional deposits of the Tés and Környe Formation. It consists of grey and variegated clays, siltstones, marls, limestones and, at the top, sandstones. After another sequence of Környe Limestone, the second sequence of the Tés–Környe Formation is present. It is slightly different with respect to the first sequence due to the higher amount of sandstone intercalations (some are cross-stratified) and contains more rudist shells. The transition to the clay and siltstone-dominated Tés Clay occurs at around 326 m. The sediments of borehole Vst–2 were deposited in a basin environment and belong to the Vértessomló Siltstone Formation (Fig. 5). The borehole is situated in the Vértes foreland, close to borehole Vst–8 (which was studied by Cséfán and Tóth, 2013). The studied section consists mainly of marl and silt, with two layers of *Orbitolina*-bearing limestone; it is very likely that this is related to the intercalating allodapic limestone bed of borehole Vst–8 described by Császár (2002). The sequence starts with a silty marl as a transition from the underlying Tata Limestone. There are two layers of micro-crystalized limestone alternating with the marl layers. These marl layers are overlain by the two aforementioned layers of *Orbitolina*-bearing limestone, with an intervening

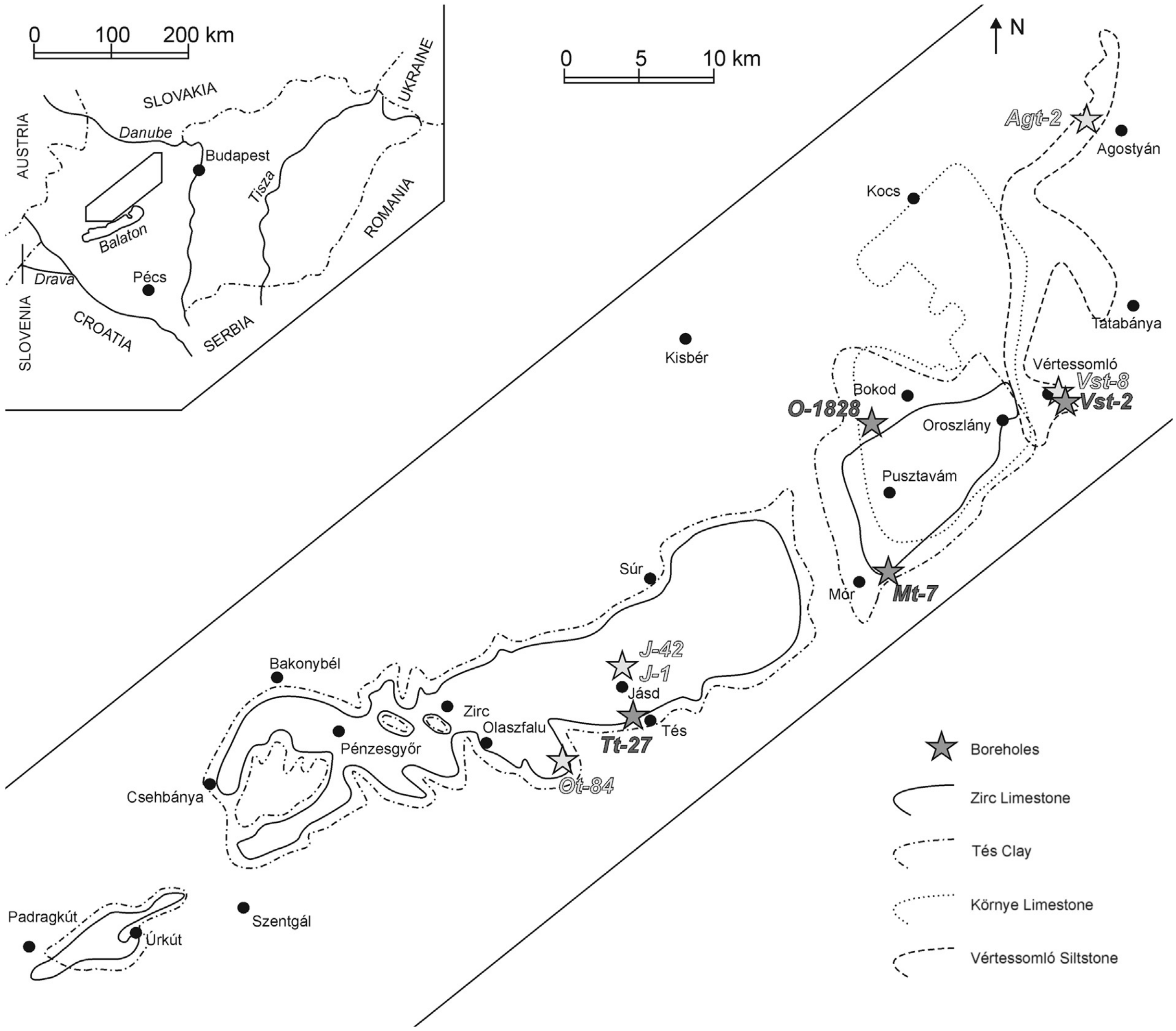

Fig. 1. Geological map of the Transdanubian Range, Hungary with the location of the Albian deposits and the studied boreholes (modified after Császár, 2002).

Carte géologique de Transdanubie, Hongrie avec la position des dépôts albiens et des forages étudiés (modifié d'après Császár, 2002).

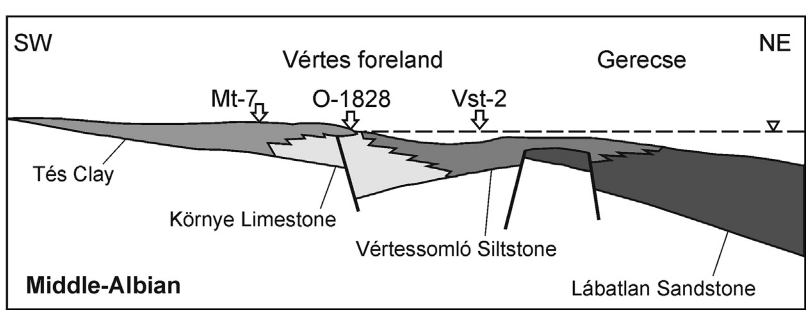

Fig. 2. Cross section model of the sedimentary environments of the Gerecse Mountains and Vértes Foreland with the position of the studied boreholes (modified after Császár, 2002).

Section géologique des milieux sédimentaires des monts de Gerecse et l'avant-pays du Vértes avec la position des forages étudiés (modifié d'après Császár, 2002).

calcareous marl layer. The sequence ends with marl and is overlain by Eocene sediments. The age of the studied section is Early to Middle Albian, based mainly on foraminiferal and dinocyst studies (Bodrogi, 1992; Leereveld, 1992; Görög, 1993, 1996; Császár, 2002). The detailed geological settings of the Albian ostracod faunas from Hungary — which the authors referred for comparison — can be found in the papers of Monostori (2000), Cséfán and Tóth (2013) and Cséfán and Monostori (2014).

3. Material and methods

Overall, 269 samples from various Albian sediments of the Transdanubian Range were examined: 44 from borehole Tt–27 in the Bakony Mts, 72 from borehole Mt–7, 120 from borehole O–1828, and 33 from borehole Vst–2 in the Vértes foreland. The carbonate skeletal microfauna was mostly processed with hydrogen-peroxide from silts, silty and argillaceous marls, and

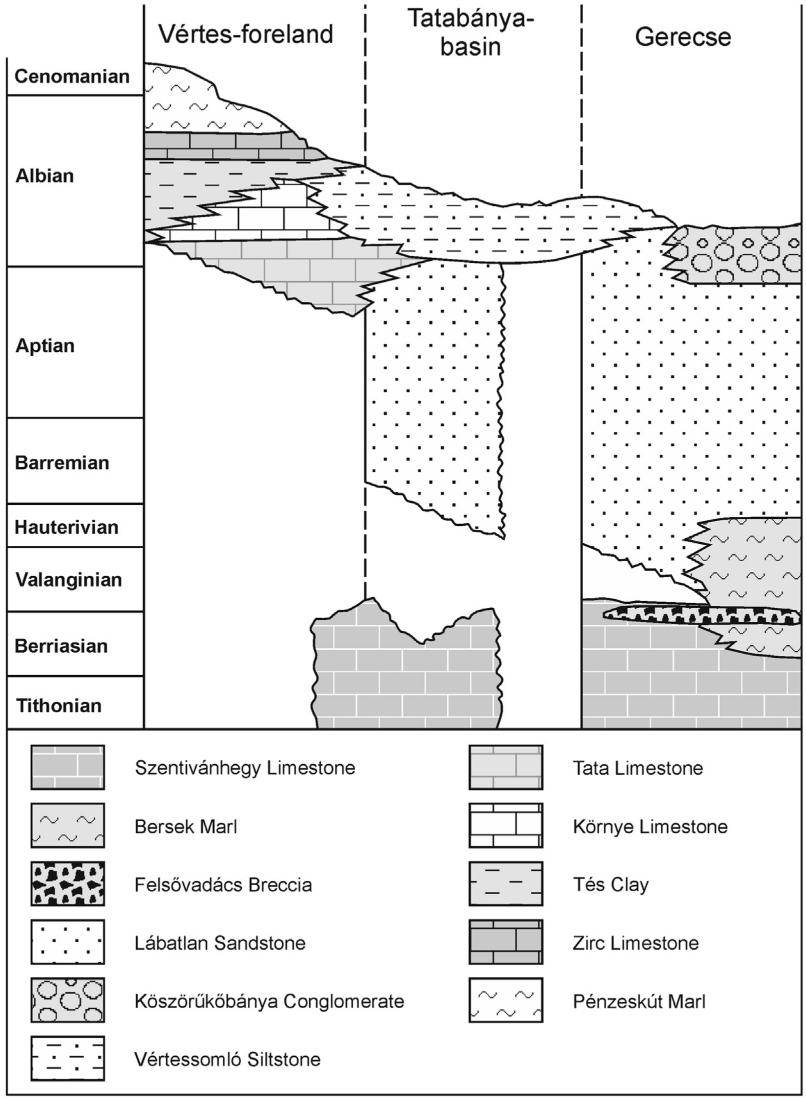

Fig. 3. Stratigraphic relations of the Cretaceous formations in the Vértes foreland and the Gerecse Mountains (Császár, 2002).
Relations des formations crétacées de l'avant-pays du Vértes et des monts Gerecse (Császár, 2002).

infrequently from marly limestones, and limestones. In the case of the more calcareous samples cold acetolysis was used, following a protocol originally worked out by Lethiers and Crasquin–Soleau (1988). The scanning electron microscope images were made at the Department of Petrology and Geochemistry, Eötvös Loránd University, and at the Botanical Department of the Hungarian Natural History Museum in Budapest.

The ecological limits of the Cretaceous ostracods are based on recent analogies with genera that are still living; in the case of the extinct forms, the co-occurring faunal elements, sediment type, and previous ostracod studies were referred to.

4. Systematic palaeontology

The classification of the ostracods used in this study is the same as that followed Horne et al. (2002) and Hartmann and Puri (1974). The specimens are deposited in the Department of Paleontology of Eötvös University, Budapest. Number of specimens (valves/carapaces) of the described taxa can be found in Table 1. Abbreviations: LV: left valve, RV: right valve, L: length, H: height.

Class Ostracoda Latreille, 1802
Subclass Podocopa G. W. Müller, 1894
Order Platycopida Sars, 1866
Suborder Platycopina Sars, 1866
Family Cytherellidae Sars, 1866
Genus ***Cytherella*** Jones, 1849

Cytherella* gr. *ovata (Roemer, 1841)
Fig. 6a

1841. *Cytherina ovata* n. sp.–Roemer, p. 104, pl. 16, figs. 21. a–b.

2014. *Cytherella* gr. *ovata* (Roemer, 1841)–Cséfán and Monostori pp. 82–83, pl. 1, figs. 1–4. (cum syn.)

Dimensions: L: 462–913 μm, H: 263–571 μm, L/H: 1.59–1.76

Remarks: The original description of the holotype of this variable species is not detailed enough and the type material of the species is lost. Due to the great intraspecific variabilities of the shape and the size and the smooth valve surface without characters, identification of extinct species belonging to the genus *Cytherella* is difficult. However, there are specimens almost identical to the specimens described by Herrig (1966) from the

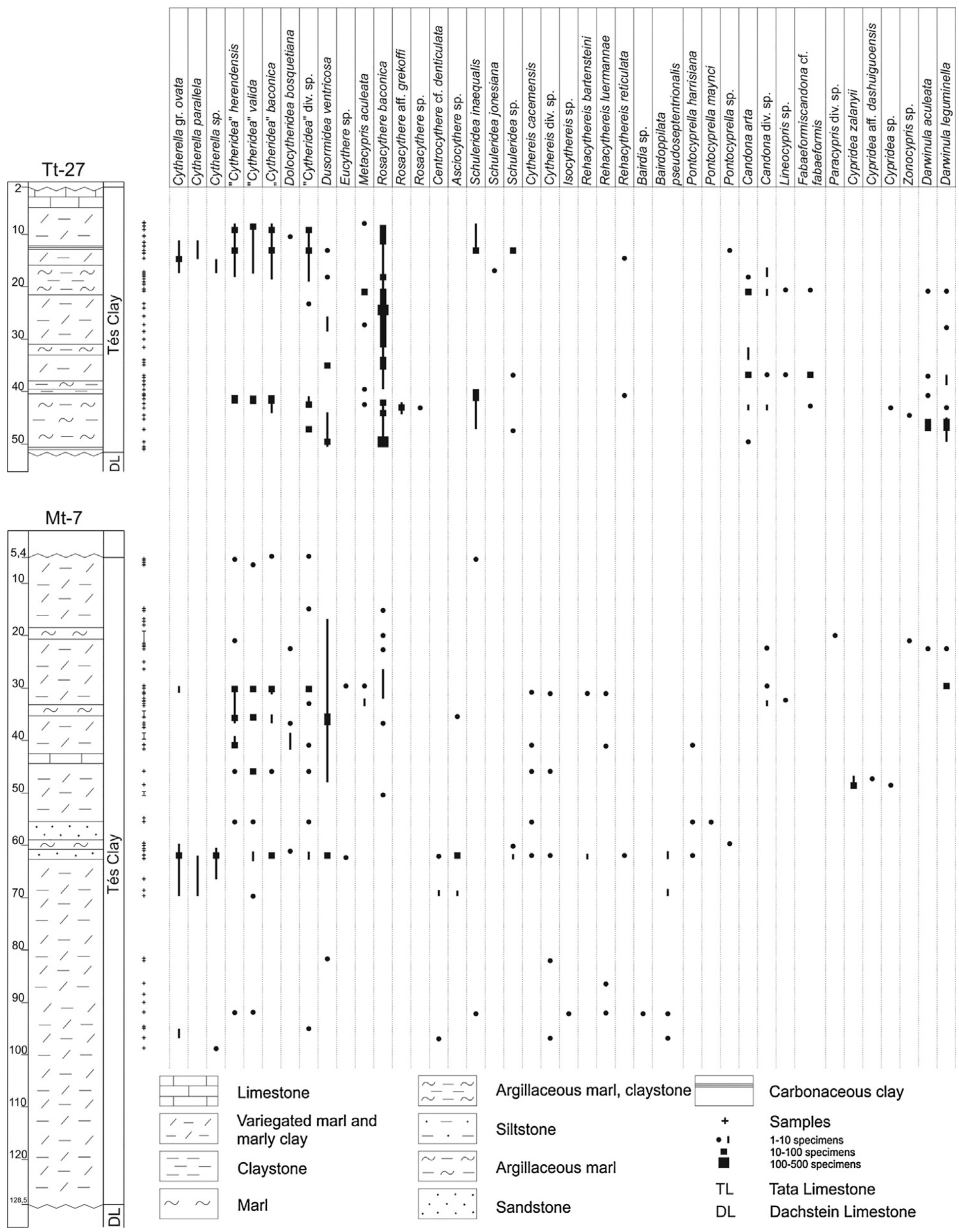

Fig. 4. Lithologic columns of boreholes Tt–27 and Mt–7 with the location of the samples and the distribution of ostracod taxa (modify after Császár, 1986 and Fülöp, 1967).
Colonnes lithologiques des forages Tt-27 et Mt-7 avec la position des échantillons et la distribution des taxons d'ostracodes (modifié d'après Császár, 1986 et Fülöp, 1967).

Lower Maastrichtian of Germany. Herrig's forms could be used as reference specimens for this species.

Occurrences and stratigraphic ranges: UK: Aptian to Turonian (Kaye, 1965b; Neale, 1978, Jarvis et al., 1988), Ireland: Aptian to Maastrichtian (Keen and Siddiqui, 1971; Ainsworth, 1985), France: Aptian to Campanian (Deroo, 1956; Oertli, 1958; Damotte, 1971; Damotte and Freytet, 1974; Damotte, 1979; Babinot et al., 1985; Babinot and Grosheny, 1993; Andreu and Bilotte, 2006; Babinot et al., 2007), Netherlands: Cenomanian (Witte et al., 1992), Switzerland: Albian (Charollais et al., 1977), Germany: Albian to Maastrichtian (Roemer, 1841; Gründel, 1966; Herrig, 1966), Hungary: Albian to Cenomanian (Zalányi, 1959; Monostori, 2000; Cséfán and Monostori, 2014; this paper), Spain: Albian to Turonian (Breman, 1976; Swain, 1978; Schudack and Schudack, 2009), Algeria: Cenomanian (Majoran, 1990), Egypt: Cenomanian to Maastrichtian (Morsi, 2000; El–Nady, 2002; El–Nady et al., 2008), Israel: Cenomanian to Turonian (Rosenfeld and Raab, 1974), Iran: Turonian to Santonian (Allameh et al., 2010), India: Albian (Jain, 1976).

Cytherella parallela (Reuss, 1845)

Fig. 6b

1845. *Cytherina parallela* n. sp.–Reuss, p. 16, pl. 5, fig. 33.

2014. *Cytherella parallela* (Reuss, 1845)–Cséfán and Monostori, p. 83, pl. 1, figs. 5–6. (cum syn.)

Dimensions: L: 668–743 μm, H: 294–357 μm, L/H: 2–2.26

Remarks: Great intraspecific variability is characteristic of the species. The studied specimens show the most similarity to the specimens described by Oertli (1958), Breman (1976), Babinot et al. (1985, 2007), Babinot and Grosheny (1993), Monostori (2000) and Andreu and Bilotte (2006).

Occurrences and stratigraphic ranges: UK: Albian (Damotte, 1971), France: Aptian to Turonian (Oertli, 1958; Damotte, 1971; Damotte, 1979; Babinot et al., 1985; Babinot and Grosheny, 1993;

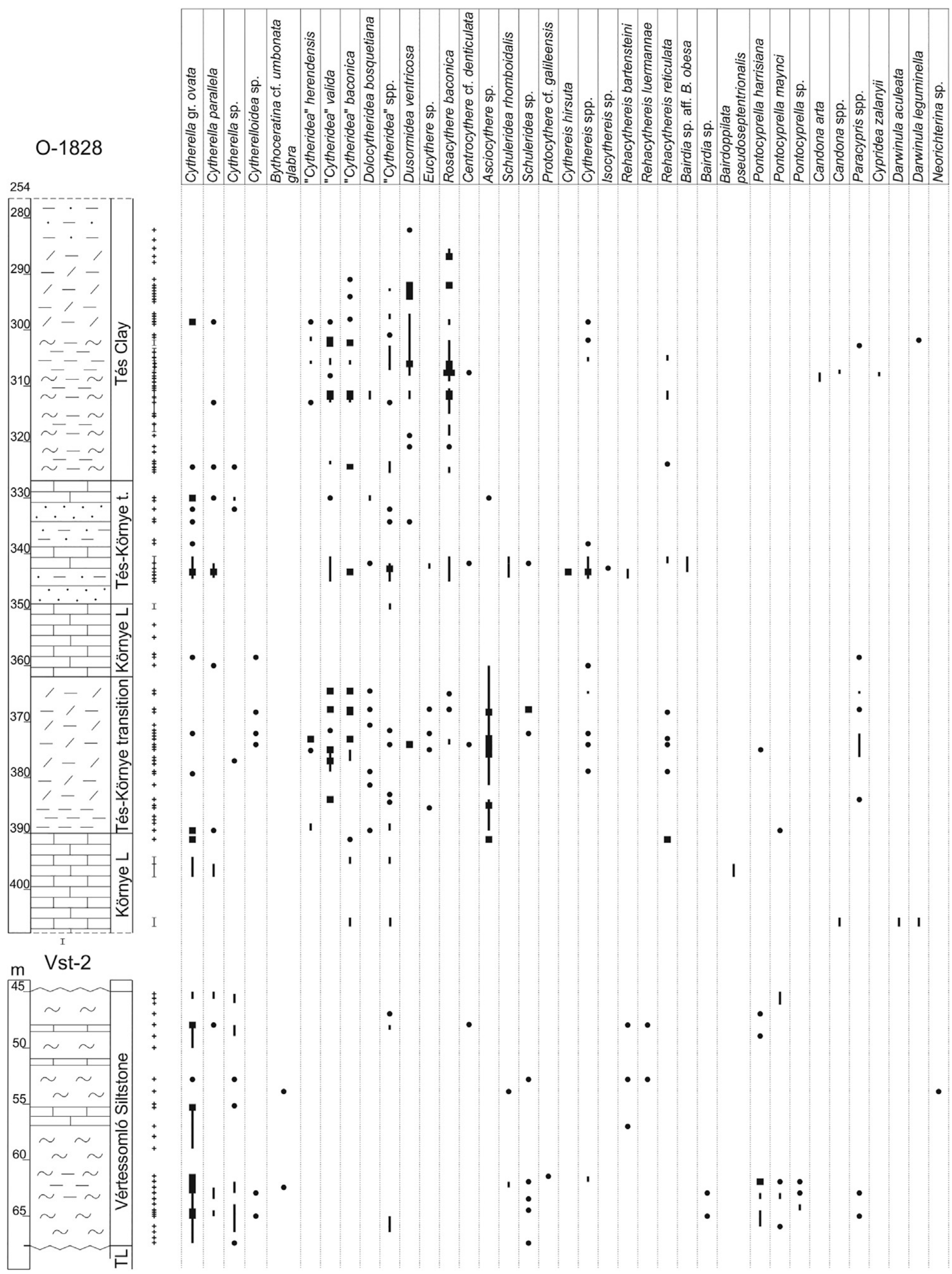

Fig. 5. Lithologic columns of boreholes O–1828 and Vst–2 with the location of the samples and the distribution of ostracod taxa (after Császár et al., 1968 and Császár, 2002). *Colonnes lithologiques des forages O-1828 et Vst-2 avec la position des échantillons et la distribution des taxons d'ostracodes (modifié d'après Császár et al., 1968 et Fülöp, 1967).*

Andreu and Bilotte, 2006), Switzerland: Albian (Charollais et al., 1977), Germany: Cenomanian (Damotte, 1971), Hungary: Albian to Cenomanian (Monostori, 2000; Cséfán and Monostori, 2014; this paper), Egypt: Cenomanian to Coniacian (Ismail and Soliman, 1997; El–Nady, 2002), Israel: Cenomanian to Turonian (Rosenfeld and Raab, 1974), India: Albian (Jain, 1976).

Genus ***Cytherelloidea*** Alexander, 1929

***Cytherelloidea* sp.**
Fig. 6c
Dimensions: L: 538–545 μm, H: 270–326 μm, L/H: 1.8–2
Remarks: The studied carapaces are poorly-preserved, corroded and compressed along the margins. The characteristic ornamentation on the valve surface cannot be observed.

Occurrences and stratigraphic ranges: Hungary: Albian (this paper).

Order Podocopida Sars, 1866
Suborder Cytherocopina Gründel, 1967
Family ***Bythocytheridae*** Sars, 1866
Genus *Bythoceratina* Hornibrook, 1952

Bythoceratinacf.umbonata glabra Weaver, 1982
Fig. 6d
1982. *Bythoceratina* (*Bythoceratina*) *umbonata glabra* subsp. nov.–Weaver, p. 40, pl. 6, figs. 17–19.
Dimensions: L: 602–634 μm, H: 247–254 μm, L/H: 2.4–2.5
Remarks: The outline and carapace ornamentation of the poorly preserved specimens resemble that of B. umbonata glabra

Table 1
Number of specimens of the ostracod taxa from the studied sections.
Nombre des spécimens des taxons d'ostracodes des sections étudiées.

	Tt-27		Mt-7		O-1828		Vst-2	
Cytherella gr. *ovata*	21	2	50	78	135	60	169	25
Cytherella parallela	5	2	2	10	21	26	15	2
Cytherella sp.	0	9	0	26	0	17	45	0
Cytherelloidea sp.					0	5	2	0
Bythoceratina cf. *umbonata glabra*							2	0
"Cytheridea" herendensis	84	23	103	47	29	12		
"Cytheridea" valida	129	74	24	82	90	172	0	1
"Cytheridea" baconica	86	81	30	34	172	209		
Dolocytheridea bosquetiana	0	1	1	17	2	27		
"Cytheridea" spp.	81	34	12	36	68	49	2	4
Dusormidea ventricosa	67	22	108	82	134	95		
Eucythere sp.			0	5	0	17		
Metacypris aculeata	8	61	3	4				
Rosacythere baconica	1274	729	2	11	125	509		
Rosacythere aff. *grekoffi*	162	42						
Rosacythere sp.	0	12	1	0				
Centrocythere cf. *denticulata*			0	4	1	1	1	0
Asciocythere sp.			4	16	116	209		
Schuleridea inaequalis	47	144	5	5	2	2		
Schuleridea sp.	11	5	1	6	5	24	6	4
Protocythere cf. *galileensis*							0	1
Cythereis cacemensis			2	6				
Cythereis hirsuta					4	12		
Cythereis spp.			0	12	12	13	0	2
Isocythereis sp.			0	2	0	1		
Rehacythereis bartensteini			0	10	2	8	1	2
Rehacythereis luermannae			0	5	0	2	1	1
Rehacythereis reticulata	4	4	0	1	38	13		
Bairdia sp. aff. *B. obesa*							1	1
Bairdia sp.			0	1			2	1
Bairdoppilata pseudoseptentrionalis			0	11	7	9		
Pontocyprella harrisiana	0	2	3	3	0	1	30	4
Pontocyprella maynci			3	0	0	1	16	5
Pontocyprella sp.			0	2			9	1
Candona arta	17	26			1	8		
Candona spp.	4	14	3	4	0	2		
Lineocypris sp.	1	3	0	2				
Candona sp.	4	14	3	4	0	2		
Fabaeformiscandona cf. *fabaeformis*	20	1						
Paracypris spp.			1	1	1	29	2	0
Cypridea zalanyii			0	16	0	4		
Cypridea aff. *dashuiguoensis*	1	0	0	2				
Cypridea sp.			0	1	0	3		
Zonocypris sp.	0	1	0	1	0	1		
Darwinula aculeata	86	9	0	1	0	1		
Darwinula leguminella	28	21	0	14	0	8		
Neorichterina sp.							0	1

described by Weaver (1982). The characteristic ornamentation cannot be observed in detail due to the preservation.

Occurrences and stratigraphic ranges: Hungary: Albian (this paper).

Family Cytherideidae Sars, 1925

Genus "***Cytheridea***" Bosquet, 1852

"***Cytheridea***"*herendensis* Zalányi, 1959

Figs. 6e–g

1959. *Cytheridea herendensis* n. sp.–Zalányi, pp. 458–460, text–fig. 29.

Dimensions: L: 684–813.7 µm, H: 337–437.9 µm, L/H: 1.8–2

Remarks: The studied specimens bear a fragile, indented rim and a small posteroventral depression which is characteristic of the species. The "*Cytheridea*" species described by Zalányi can be assigned to the genus with a small uncertainty due to the preservation of the carapaces.

Occurrences and stratigraphic ranges: Hungary: Albian (Zalányi, 1959; this paper).

"***Cytheridea***" *valida* Zalányi, 1959

Fig. 6h

1959. *Cytheridea valida* n. sp.–Zalányi, pp. 478–481, text–figs. 39–40.

Dimensions: L: 644–683.2 µm, H: 330–353 µm, L/H: 1.82–2

Occurrences and stratigraphic ranges: Hungary: Albian (Zalányi, 1959; this paper).

"***Cytheridea***" *baconica* Zalányi, 1959

Fig. 6i

1959. *Cytheridea* (*Haplocytheridea*) *baconica* n. sp.–Zalányi, pp. 462–465, text–figs. 31–32.

Dimensions: L: 530–713 µm, H: 278–443 µm, L/H: 1.69–1.93

Remarks: The studied specimens bear a tiny depression around the arched margin similarly to the holotype described by Zalányi, 1959.

Occurrences and stratigraphic ranges: Hungary: Albian (Zalányi, 1959; this paper).

"***Cytheridea***" **spp.**

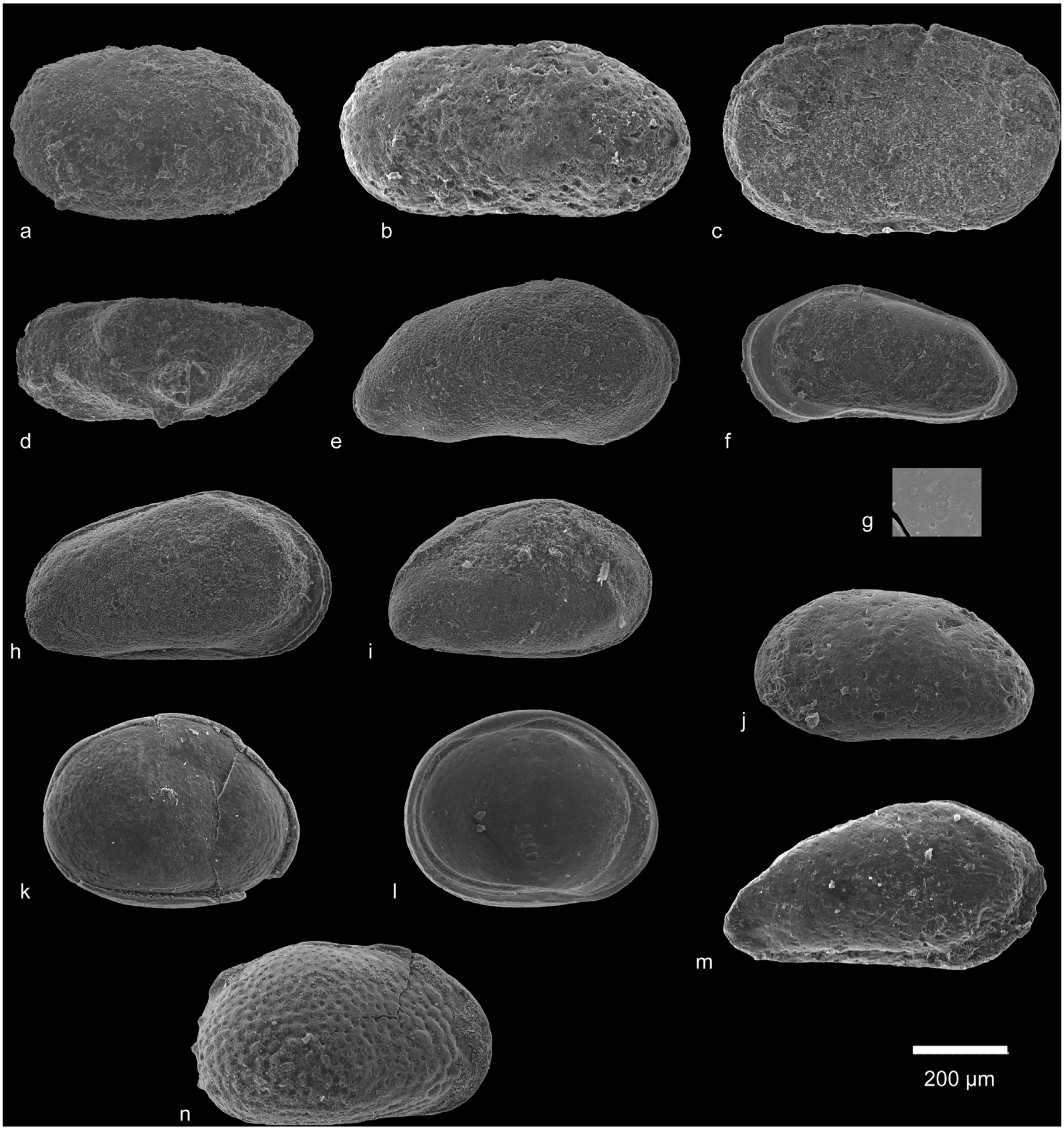

Fig. 6. a. *Cytherella* gr. *ovata* (Roemer, 1841). EMNH.2018.1.4.4. C in right view: borehole Vst–2, 84 m. b. *Cytherella parallela* (Reuss, 1845). EMNH.2018.2.6.3. LV in lateral view: borehole O–1828, 329.8–330.3 m. c. *Cytherelloidea* sp. EMNH.2018.2.6.6. C in left view: borehole O–1828, 372 m. d. *Bythoceratina* cf. *umbonata glabra* Weaver, 1982. EMNH.2018.1.2.4. LV in lateral view: borehole Vst–2, 54 m. e. "*Cytheridea" herendensis* Zalányi, 1959. EMNH.2018.1.12.10. RV in lateral view: borehole Mt–7, 30 m. f. "*Cytheridea" herendensis* Zalányi, 1959. EMNH.2018.1.8.2. RV inner view: borehole Mt–7, 30 m. g. "*Cytheridea" herendensis* Zalányi, 1959. EMNH.2018.1.11.12. RV inner view: borehole Mt–7, 30 m. h. "*Cytheridea" valida* Zalányi, 1959. EMNH.2018.1.6.9. C in right view: borehole Mt–7, 46 m. i. "*Cytheridea" baconica* Zalányi, 1959. EMNH.2018.1.12.7. C in right view: borehole Mt–7, 29.5 m. j. *Dolocytheridea bosquetiana* (Jones & Hinde, 1890). EMNH.2018.1.10.4. LV in lateral view: borehole Mt–7, 37 m. k. *Dusormidea ventricosa* Zalányi, 1959. EMNH.2018.1.10.11. C in right view: borehole Mt–7, 35.5 m. l. *Dusormidea ventricosa* Zalányi, 1959. EMNH.2018.1.9.9. LV inner view: borehole Mt–7, 35.5 m. m. *Eucythere* sp. EMNH.2018.2.6.5. C in right view: O–1828, 368 m. n. *Metacypris aculeata* Zalányi, 1959. EMNH.2018.1.14.5. RV in lateral view: borehole Mt–7, 32 m.

a. Cytherella *gr.* ovata *(Roemer, 1841). EMNH.2018.1.4.4. C en vue droite : forage Vst–2, 84 m. b.* Cytherella parallela *(Reuss, 1845). EMNH.2018.2.6.3. VG en vue latérale : forage O–1828, 329.8–330.3 m. c.* Cytherelloidea *sp. EMNH.2018.2.6.6. C en vue gauche : forage O–1828, 372 m. d.* Bythoceratina *cf.* umbonata glabra *Weaver, 1982. EMNH.2018.1.2.4. VG en vue latérale : forage Vst–2, 54 m. e.* "Cytheridea" herendensis *Zalányi, 1959. EMNH.2018.1.12.10. VD en vue latérale : forage Mt–7, 30 m. f.* "Cytheridea" herendensis *Zalányi, 1959. EMNH.2018.1.8.2. Vue interne de la VD : forage Mt–7, 30 m. g.* "Cytheridea" herendensis *Zalányi, 1959. EMNH.2018.1.11.12. Vue interne de la VD : forage Mt–7, 30 m. h.* "Cytheridea" valida *Zalányi, 1959. EMNH.2018.1.6.9. C en vue droite : forage Mt–7, 46 m. i.* "Cytheridea" baconica *Zalányi, 1959. EMNH.2018.1.12.7. C en vue droite : forage Mt–7, 29.5 m. j.* Dolocytheridea bosquetiana *(Jones & Hinde, 1890). EMNH.2018.1.10.4. VG en vue latérale : forage Mt–7, 37 m. k.* Dusormidea ventricosa *Zalányi, 1959. EMNH.2018.1.10.11. C en vue droite : forage Mt–7, 35.5 m. l.* Dusormidea ventricosa *Zalányi, 1959. EMNH.2018.1.9.9. Vue interne de la VG : forage Mt–7, 35.5 m. m.* Eucythere *sp. EMNH.2018.2.6.5. C en vue droite : forage O–1828, 368 m. n.* Metacypris aculeata *Zalányi, 1959. EMNH.2018.1.14.5. VD en vue latérale : forage Mt–7, 32 m.*

Remarks: *Cytheridea* with poor preservation, thus cannot be assigned to species with certainty.

Genus ***Dolocytheridea*** Triebel, 1938

Dolocytheridea bosquetiana (Jones and Hinde, 1890)
Fig. 6j
1938. *Cytheridea* (*Dolocytheridea*) *bosquetiana* (Jones et Hinde)–Triebel, pp. 498–500, pl. 5, figs. 80–83., pl. 6. fig. 91.
1956. *Dolocytheridea bosquetiana* (Jones and Hinde, 1890)–Mertens, pp. 196–197, pl. 10, figs. 45–47.
1958. *Dolocytheridea bosquetiana* (Jones and Hinde, 1890)–Oertli, pl. 4, figs. 85–86.
1959. *Cytheridea* (*Dolocytheridea*) *bosquetiana* (Jones et Hinde)–Zalányi, pp. 470–472, text–fig. 35.
1962. *Dolocytheridea bosquetiana* (Jones and Hinde, 1890)–Ellermann, p. 401, text–figs. 14–15.
1963a. *Dolocytheridea* cf. *bosquetiana* (Jones and Hinde, 1890)–Kaye, pp. 33–34, pl. 3, figs. 15–16.
1964. *Dolocytheridea bosquetiana* (Jones and Hinde, 1890)–Kaye, pp. 46–47, pl. 1, figs. 18–20.
1966. *Dolocytheridea bosquetiana* (Jones and Hinde, 1890)–Gründel, p. 18, pl. 2, fig. 14.
1971. *Dolocytheridea bosquetiana* (Jones and Hinde, 1890)–Damotte, p. 110, pl. 7, fig. 16.
1971. *Dolocytheridea* (*Puracytheridea*) *bosquetiana* (Jones and Hinde, 1890)–Gründel, pp. 36–37, text–fig. 9. pl. 4, figs. 7–11.
1971. *Dolocytheridea bosquetiana* (Jones and Hinde)–Bertram and Kemper, pl. 2, figs. 7–8.
1978. *Dolocytheridea bosquetiana*–Wiel, pl. 2, fig. 14.
1979. *Dolocytheridea* (*Puracytheridea*) *bosquetiana* (Jones and Hinde, 1890)–Damotte, p. 291, pl. 6/4, fig. 34.
1982. *Dolocytheridea* (*Puracytheridea*) *bosquetiana* (Jones and Hinde, 1890)–Weaver, p. 33, pl. 5, figs. 6–9.
1992. *Dolocytheridea bosquetiana* (Jones and Hinde, 1890)–Witte et al., p. 53, pl. 3, fig. 1.
2007. *Dolocytheridea* (*Puracytheridea*) aff. *bosquetiana* (Jones and Hinde, 1890)–Babinot et al., pl. 3, fig. 6.
Dimensions: L: 566–595 μm, H: 305–310 μm, L/H: 1.85–1.92
Occurrences and stratigraphic ranges: UK: Albian to Cenomanian (Kaye, 1963a, 1964; Weaver, 1982; Babinot et al., 2007), France: Aptian to Albian (Damotte, 1971, 1979; Wiel et al., 1978), Netherlands: Lower Cenomanian (Witte et al., 1992), Germany: Albian to Lower Cenomanian (Triebel, 1938; Mertens, 1956; Oertli, 1958; Ellermann, 1962; Gründel, 1966, 1971; Bertram and Kemper, 1971), Hungary: Albian (Zalányi, 1959; this paper).

Genus ***Dusormidea*** Zalányi, 1959

Dusormidea ventricosa Zalányi, 1959
Figs. 6k–l
1959. *Dusormidea ventricosa* n. sp.–Zalányi, p. 499–500, text–figs. 52–53. pl. 2, fig. 2; pl. 3. fig. 2.
Dimensions: L: 505–712,4 μm, H: 368–565 μm, L/H: 1.1–1.36
Remarks: Some specimens have a faint reticulation which is more distinct near the edges. Zalányi (1959) had described eight species of his new genus. Further researches revealed that most of the studied specimens are transitional forms, thus they are considered as intraspecies variations herein.
Occurrences and stratigraphic ranges: Hungary: Albian (Zalányi, 1959; this paper).

Family Eucytheridae Puri, 1954
Genus ***Eucythere*** Brady, 1868

Eucytheresp.
Fig. 6m
Dimensions: L: 656–677 μm, H: 334–350 μm, L/H: 1.93–1.96
Remarks: Specimens are poorly preserved, outline is almost triangular with a broadly rounded anterior margin and a pointed posterior margin.

Family Limnocytheridae Klie, 1938
Subfamily Timiriaseviinae Mandelstam, 1960
Genus ***Metacypris*** Brady and Robertson, 1870

Metacypris aculeata Zalányi, 1959
Fig. 6n
1959. *Metacypris aculeata* n. sp.–Zalányi, p. 436–439, text–figs. 18–19.
Dimensions: L: 576–719.7 μm, H: 383–441.9 μm, L/H: 1.45–1.63
Occurrences and stratigraphic ranges: Hungary: Albian (Zalányi, 1959; this paper).

Genus ***Rosacythere*** Colin, 1980

Rosacythere baconica (Zalányi, 1959)
Figs. 7 a–c
1959. *Gomphocythere baconica* n. sp.–Zalányi, pp. 443–454, text figs. 21, 21/a, 22, 23, 24, 25, 26; pl. 4. fig. 1; pl. 5. figs. 1–12; pl. 6. figs. 1–12.
1980. *Rosacythere baconica* (Zalanyi)–Colin and Danielopol, pl. 7, figs. 1–11.
Dimensions: L: 510–1301 μm, H: 316.2–909.6 μm, L/H: 1.43–1.65
Remarks: Sexual dimorphism is distinct: brood–pouch on female specimens is present.
Occurrences and stratigraphic ranges: Hungary: Albian (Zalányi, 1959; Colin and Danielopol, 1980).

Rosacythereaff.grekoffi (Colin, 1974)
Fig. 7d
1974. *Theriosynoecum grekoffi* n. sp.–Colin, pp. 185–187, pl. 1, figs. 4–7.
Dimensions: L: 605–678.5 μm, H: 405–464.9 μm, L/H: 1.42–1.58
Remarks: The studied specimens are very similar to the examples of *R. baconica* but with a tubercle near the posterodorsal margin. It is possibly an ecophenotypic variation of *R. baconica*, since the development of the tubercles are variable, and it coexists with the non-tubercled version. The original *Rosacythere grekoffi* was collected from the Cenomanian of France (Colin and Danielopol, 1980).
Occurrences and stratigraphic ranges: Hungary: Albian (this paper).

Family Neocytheridae Wilkinson, 1988
Genus ***Centrocythere*** Mertens, 1956

Centrocytherecf.denticulata Mertens, 1956
Fig. 7e
1956. *Centrocythere denticulata* n. sp.–Mertens, pp. 204–205, pl. 11, figs. 66–71; pl. 14. figs. 97–99.
Dimensions: L: 483–502 μm, H: 318–330 μm, L/H: 1.51–1.52

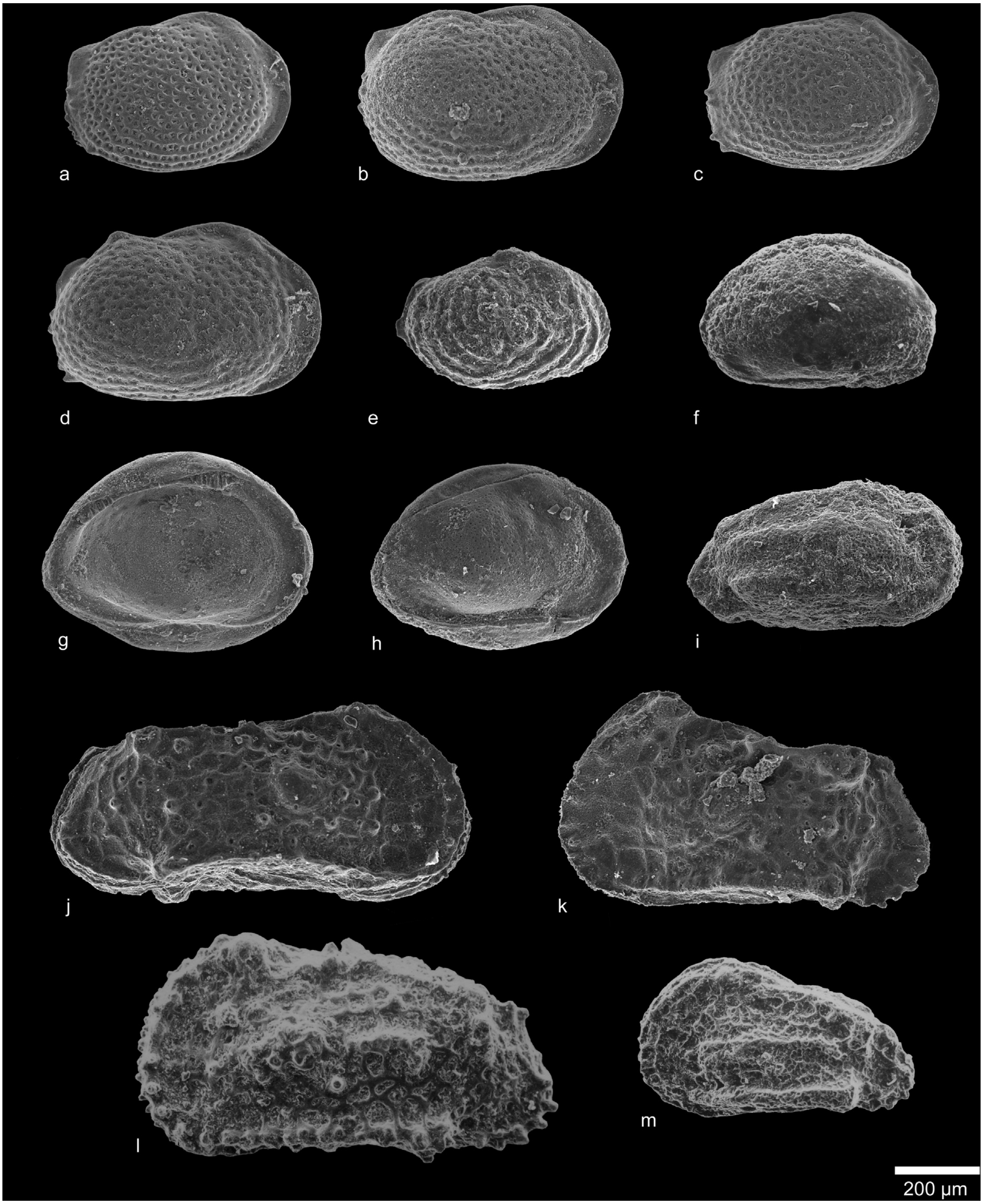

Fig. 7. a. *Rosacythere baconica* (Zalányi, 1959). EMNH.2018.1.14.1. RV in lateral view: borehole Tt–27, 13 m. b. *Rosacythere baconica* (Zalányi, 1959). EMNH.2018.1.14.2. RV in lateral view: borehole Tt–27, 13 m. c. *Rosacythere baconica* (Zalányi, 1959). EMNH.2018.1.15.3. RV in lateral view: borehole Tt–27, 13 m. d. *Rosacythere* aff. *grekoffi* (Colin, 1974). EMNH.2018.1.15.4. RV in lateral view: borehole Tt–27, 43 m. e. *Centrocythere* cf. *denticulata* Mertens, 1956. EMNH.2018.1.4.1. RV in lateral view: borehole Vst–5, 73.35–74 m. f. *Asciocythere* sp. EMNH.4.7.5. C in right view: borehole O–1828, 391 m. g. *Schuleridea inaequalis* (Zalányi, 1959). EMNH.2018.1.5.6. LV inner view: borehole Mt–7, 63 m. h. *Schuleridea inaequalis* (Zalányi, 1959). EMNH.2018.1.5.3. C in right view: borehole Mt–7, 63 m. i. *Protocythere* cf. *galileensis* Rosenfeld & Raab, 1984. EMNH.2018.1.2.3. C in right view: borehole Vst–2, 61.5 m. j. *Cythereis cacemensis* Andreu, 1981. EMNH.2018.1.10.10. C in right view: borehole Mt–7, 41 m. k. *Cythereis cacemensis* Andreu, 1981. EMNH.2018.1.9.4. C in left view: borehole Mt–7, 30.5 m. l. *Cythereis hirsuta* Damotte & Grosdidier, 1963. EMNH.2018.4.8.5. LV in lateral view: borehole O–1828, 343–344 m. m. *Isocythereis* sp. EMNH.2018.4.8.11. LV in lateral view: borehole O–1828, 343–344 m.

a. Rosacythere baconica *(Zalányi, 1959). EMNH.2018.1.14.1. VD en vue latérale : forage Tt–27, 13 m. b.* Rosacythere baconica *(Zalányi, 1959). EMNH.2018.1.14.2. VD en vue latérale : forage Tt–27, 13 m. c.* Rosacythere baconica *(Zalányi, 1959). EMNH.2018.1.15.3. VD en vue latérale : forage Tt–27, 13 m. d.* Rosacythere *aff.* grekoffi *(Colin, 1974). EMNH.2018.1.15.4. VD en vue latérale : forage Tt–27, 43 m. e.* Centrocythere *cf.* denticulata *Mertens, 1956. EMNH.2018.1.4.1. VD en vue latérale : forage Vst–5, 73.35–74 m. f.* Asciocythere *sp. EMNH.4.7.5. C en vue droite : forage O–1828, 391 m. g.* Schuleridea inaequalis *(Zalányi, 1959). EMNH.2018.1.5.6. Vue interne de la VG : forage Mt–7, 63 m. h.* Schuleridea inaequalis *(Zalányi, 1959). EMNH.2018.1.5.3. C en vue droite : forage Mt–7, 63 m. i.* Protocythere *cf.* galileensis *Rosenfeld & Raab, 1984. EMNH.2018.1.2.3. C en vue droite : forage Vst–2,* Remarks: *Centrocythere* with spines and concentric ridges. Despite of the moderate preservation, the outline and ornamentation allowed the classification on species level.

Occurrences and stratigraphic ranges: UK: Albian (Kaye, 1963b, 1964; Neale, 1978), France: Albian (Damotte, 1971, 1979; Wiel et al., 1978; Babinot et al., 1985), Switzerland: Albian (Charollais et al., 1977), Germany: Albian (Mertens, 1956; Ellermann, 1962; Gründel, 1966; Keller et al., 1989), Hungary: Albian (this paper), Spain: Upper Albian to Cenomanian (Colin et al., 1982), Tunisia: Albian (Zghal et al., 1996), Israel: Albian to Cenomanian (Rosenfeld and Raab, 1984).

Family Schulerideidae Mandelstam, 1959
Genus ***Asciocythere*** Swain, 1952

***Asciocythere*sp.**
Fig. 7f
Dimensions: L: 487.9–636.8 μm, H: 319.3–387.8 μm, L/H: 1.41–1.8
Remarks: The studied specimens differ from that of *A. albae albae* Damotte, 1973 in a more symmetric carapace in lateral view and from *A. polita* Damotte, 1962 in a less distinguished sexual dimorphism and in a more evenly rounded dorsal margin. In some cases, distinguishing LV and RV was problematic due to the poor preservation.
Occurrences and stratigraphic ranges: Hungary: Albian (this paper).

Genus *Schuleridea* Swartz and Swain, 1946

Schuleridea inaequalis (Zalányi, 1959)
Figs. 7g–h
1959. *Cythereis inaequalis* n. sp.–Zalányi, pp. 377–378; 515–518, text–figs. 59–60.
Dimensions: L: 605–700.9 μm, H: 466–476 μm, L/H: 1.32–1.5
Occurrences and stratigraphic ranges: Hungary: Albian (Zalányi, 1959; this paper).

Family Protocytheridae Ljubimova, 1956
Genus **Protocythere** Triebel, 1938

Protocythere*cf.*galileensis Rosenfeld and Raab, 1984
Fig. 7i
1984. *Protocythere galileensis* n. sp.–Rosenfeld & Raab, pp. 101–102, pl. 4, figs 4—6.
Dimensions: L: 655 μm, H: 340 μm, L/H: 1.92
Remarks: The genus is represented by a single poorly preserved carapace.
Occurrences and stratigraphic ranges: Hungary: Albian (Cséfán and Monostori, 2014; this paper).

Family Trachyleberididae Sylvester–Bradley, 1948
Genus ***Cythereis*** Jones, 1849

Cythereis cacemensis Andreu, 1981
Fig. 7j–k
1981. *Cythereis cacemensis cacemensis* n. sp.–Andreu, pp. 130–131, pl. 4, figs. 1–3.
Dimensions: L: 877–1072.9 μm, H: 450–553 μm, L/H: 1.7–2.1
Remarks: Strength of ornamentation on the valve surface varies on different specimens.
Occurrences and stratigraphic ranges: Portugal: Albian (Andreu, 1981).

Cythereis hirsuta Damotte and Grosdidier, 1963
Fig. 7l
1963. *Cythereis hirsuta* n. sp.–Damotte and Grosdidier, p. 56–57, pl. 2, fig. 5.
1964. *Cythereis hirsuta* Damotte and Grosdidier, 1963–Gründel, pl. 1, figs. 6–7.
1965. *Cythereis hirsuta* Damotte and Grosdidier, 1963–Herrig, pl. 3, fig. 4.
1966. *Cythereis hirsuta* Damotte and Grosdidier, 1963–Gründel, p. 35, pl. 6, figs. 16, 20.
1966. *Cythereis hirsuta* Damotte and Grosdidier, 1963–Herrig, pl. 23, fig. 6.
1971. *Cythereis hirsuta* Damotte and Grosdidier, 1963–Damotte, p. 65, pl. 2, fig. 11.
1977. *Cythereis hirsuta* Damotte and Grosdidier, 1963–Charollais et al. pl. 2, fig. 11.
1977. *Cythereis* (*Cythereis*) *hirsuta* Damotte and Grosdidier, 1963–Damotte, pl. 1, fig. 2.
1978. *Cythereis* (*Cythereis*) *hirsuta* Damotte and Grosdidier, 1963–Wiel, pl. 3, figs. 5–15.
1979. *Cythereis hirsuta* Damotte and Grosdidier, 1963–Damotte, p. 281, pl. 6/1, fig. 10.
1982. *Cythereis hirsuta* Damotte and Grosdidier, 1963–Weaver, pp. 64–65, pl. 12, figs. 7–11, 14.
1985. *Cythereis* (*Cythereis*) *hirsuta* Damotte and Grosdidier, 1963–Babinot et al., pl. 51, figs. 12–14.
1989. *Cythereis hirsuta* Damotte and Grosdidier–Frieg and Kemper, pl. 4, figs. 1–2.
1992. *Cythereis hirsuta* Damotte and Grosdidier, 1963–Witte et al., pp. 68–70, pl. 6, fig. 13.
Dimensions: L: 925–1052 μm, H: 517–556.6 μm, L/H: 1.67–1.9
Occurrences and stratigraphic ranges: UK: Cenomanian (Weaver, 1982), France: Albian to Cenomanian (Damotte and Grosdidier, 1963; Damotte, 1971, 1977, 1979; Wiel, 1978; Babinot et al., 1985), Netherlands: Lower Cenomanian (Witte et al., 1992), Switzerland: Albian (Charollais et al., 1977), Germany: Albian to Maastrichtian (Gründel, 1964, 1966; Herrig, 1965, 1966; Frieg and Kemper, 1989).
***Cythereis*spp.**
Remarks: *Cythereis* with poor preservation, thus cannot be assigned to species with certainty.

Genus ***Isocythereis*** Triebel, 1940

***Isocythereis*sp.**
Fig. 7m
Dimensions: L: 618.2–649 μm, H: 369–375 μm, L/H: 1.65–1.75
Remarks: Poorly preserved specimens of *Isocythereis* with characteristic reticulated valve surface. Eye tubercle is present.

61.5 m. j. *Cythereis cacemensis* Andreu, 1981. EMNH.2018.1.10.10. C en vue droite : forage Mt–7, 41 m. k. *Cythereis cacemensis* Andreu, 1981. EMNH.2018.1.9.4. C en vue gauche : forage Mt–7, 30.5 m. l. *Cythereis hirsuta* Damotte & Grosdidier, 1963. EMNH.2018.4.8.5. VG en vue latérale : forage O–1828, 343–344 m. m. *Isocythereis* sp. EMNH.2018.4.8.11. VG en vue latérale : forage O–1828, 343–344 m.

Occurrences and stratigraphic ranges: Hungary: Albian (this paper).

Genus ***Rehacythereis*** Gründel, 1973

Rehacythereis bartensteini (Oertli, 1958)

Fig. 8a

1958. *Cythereis bartensteini* n. sp.–Oertli, pp. 1513–1514, pl. 8, figs 171–179, pl. 9, figs 197–198.

2014. *Rehacythereis bartensteini* (Oertli, 1958)–Cséfán and Monostori, p. 85, pl. 2, figs. 1–3. (cum syn.)

Dimensions: L: 705–1077 μm, H: 352–617.7 μm, L/H: 1.62–2

Remarks: Sexual dimorphism is present: males are more elongated.

Occurrences and stratigraphic ranges. France: Aptian to Albian (Oertli, 1958; Babinot et al., 1985, 2007), Germany: Albian (Risch, 1971), Morocco: Albian (Andreu et al., 1993), Hungary: Lower to Middle Albian (Cséfán and Monostori, 2014; this paper).

Rehacythereis luermannae (Triebel, 1940)

Fig. 8b

1940. *Cythereis lürmannae* n. sp.–Triebel, pp. 201–204, pl. 6, figs 63–66.

2014. *Rehacythereis luermannae* (Triebel, 1940)–Cséfán and Monostori, p. 85, pl. 2, figs. 4–6. (cu. syn.)

Dimensions: L: 680–900 μm, H: 380–450 μm, L/H: 1.72–2

Occurrences and stratigraphic ranges. UK: Albian to Cenomanian (Damotte, 1971, 1979; Gründel, 1966; Weaver, 1982), France: Albian to Cenomanian (Babinot et al., 1985; Damotte, 1971, 1977, 1979; Gründel, 1966), Netherlands: Albian to Cenomanian (Herngreen et al., 1996; Witte et al., 1992), Switzerland: Cenomanian (Sauvagnat and Weidmann, 2011), Germany: Albian to Cenomanian (Bertram and Kemper, 1971; Damotte, 1971, 1979; Frieg and Kemper, 1989; Gründel, 1966; Weaver, 1982), Poland: Albian to Cenomanian (Gründel, 1966), Canada: Albian (Witte et al., 1992), Hungary: Lower Albian (Cséfán and Monostori, 2014; this paper).

Rehacythereis reticulata (Jones and Hinde, 1890)

Fig. 8c

1890. *Cythereis ornatissima reticulata* n. sp.–Jones and Hinde, p. 24, pl. 1, figs. 67–68, 77; pl. 4. figs. 9–12.

1940. *Cythereis reticulata* Jones and Hinde–Triebel, pp. 192–195, pl. 5, figs. 51–56.

1956. *Cythereis reticulata* Jones and Hinde–Deroo, p. 1518, pl. 5, figs. 68–82.

1963. *Cythereis reticulata* Jones and Hinde, 1890–Damotte and Grosdidier, pl. 2, fig. 6.

1964. *Cythereis reticulata* Jones and Hinde, 1890–Kaye, pp. 67–68, pl. 8, figs. 16–19.

1965. *Cythereis reticulata reticulata* Jones and Hinde, 1890–Herrig, text fig. 4c. pl. 3, fig. 3.

1966. *Cythereis reticulata reticulata* Jones and Hinde, 1890–Gründel, pp. 36–37, pl. 7, figs. 1–2.

1966. *Cythereis reticulata reticulata* Jones and Hinde, 1890–Herrig, pl. 23, figs. 4–5.

1971. *Cythereis reticulata* (Jones and Hinde, 1890)–Damotte, pp. 64–65, pl. 2, fig. 10.

1971. *Cythereis reticulata* Jones and Hinde, 1890–Risch, pp. 60–61, pl. 7, figs. 13–14.

1972. *Cythereis reticulata* Jones and Hinde, 1890–Donze and Porthault, pp. 367–368, pl. 3, figs. 11–14.

1977. *Cythereis* (*Rehacythereis*?) *reticulata* Jones and Hinde–Damotte, pl. 1, fig. 3.

1977. *Rehacythereis reticulata* (Jones and Hinde, 1890)–Charollais et al., pl. 2, fig. 10.

1978. *Rehacythereis reticulata* (Jones and Hinde)–Neale, pl. 12, figs. 1–2.

1978. *Cythereis* (*Cythereis*) *reticulata*–Wiel, pl. 4, figs. 1–13.

1979. *Cythereis reticulata* (Jones and Hinde, 1890)–Damotte, p. 282, pl. 6/2, fig. 13.

1985. *Cythereis* (*Rehacythereis*) *reticulata* (Jones and Hinde, 1890)–Babinot et al., pl. 52, figs. 4–6.

1985. *Rehacythereis* aff. *reticulata* (Jones and Hinde, 1890)–Babinot et al., pl. 62, fig. 6.

1992. *Cythereis reticulata* Jones and Hinde, 1890–Witte et al., pp. 70–71, pl. 6, fig. 7.

Dimensions: L: 825.7–933.5 μm, H: 473–545.2 μm, L/H: 1.51–1.85

Occurrences and stratigraphic ranges: UK: Albian to Cenomanian (Jones and Hinde, 1890; Kaye, 1964; Herrig, 1965; Neale, 1978), France: Albian to Cenomanian (Deroo, 1956; Damotte and Grosdidier, 1963; Damotte, 1971, 1977, 1979; Donze and Porthault, 1972; Wiel, 1978; Babinot et al., 1985), Netherlands: Lower to Middle Cenomanian (Witte et al., 1992), Switzerland: Albian (Charollais et al., 1977), Germany: Albian (Triebel, 1940; Gründel, 1966; Risch, 1971).

Suborder Bairdiocopina Gründel, 1967

Superfamily Bairdioidea Sars, 1888

Family Bairdiidae Sars, 1888

Genus ***Bairdia*** McCoy, 1844

Bairdia*sp. aff.*B. obesa Margerie, 1967

Fig. 8e

1967. *Bairdia obesa* n. sp.–Margerie, pp. 22–23, pl. 1. figs. 19, 22; pl. 3, fig. 20.

Dimensions: L: 671 μm, H: 357 μm, L/H: 1.88

Remarks: The outline of the poorly preserved specimen suggests an affinity with the species *B. obesa* described by Margerie (1967).

Occurrences and stratigraphic ranges: Hungary: Albian (this paper).

Genus ***Bairdioppilata*** Coryell, Sample and Jennings, 1935

Bairdoppilata pseudoseptentrionalis Mertens, 1956

Fig. 8f

1956. *Bairdoppilata pseudoseptentrionalis* n. sp.–Mertens, pp. 182–184, pl. 8. figs. 7–10; pl. 13, figs. 89–90.

1965a. *Bairdia pseudoseptentrionalis* (Mertens, 1956)–Kaye, pp. 223–224, pl. 2, figs. 1., 3–6.

1966. *Bairdia pseudoseptentrionalis* (Mertens, 1956)–Gründel, p. 15. pl. 1, fig. 18.

1971. *Bairdia pseudoseptentrionalis* (Mertens, 1956)–Damotte, pp. 58–59, pl. 1, fig. 15.

1971. *Bairdia pseudoseptentrionalis* (Mertens, 1956)–Keen and Siddiqui, p. 63, pl. 1, fig. 2.

1978. *Bairdia pseudoseptentrionalis* (Mertens, 1956)–Wiel, pl. 1, fig. 6.

1979. *Bairdia pseudoseptentrionalis* (Mertens, 1956)–Damotte, p. 279, pl. 6/1, fig. 6.

1982. *Bairdoppilata pseudoseptentrionalis* Mertens, 1956–Weaver, pp. 24–25, pl. 4, figs. 1–3.

1985. *Bairdoppilata pseudoseptentrionalis* Mertens, 1956–Ainsworth, p. 30, fig. 10/8.

1985. *Bairdia pseudoseptentrionalis* (Mertens, 1956)–Babinot et al., pl. 51, fig. 1.

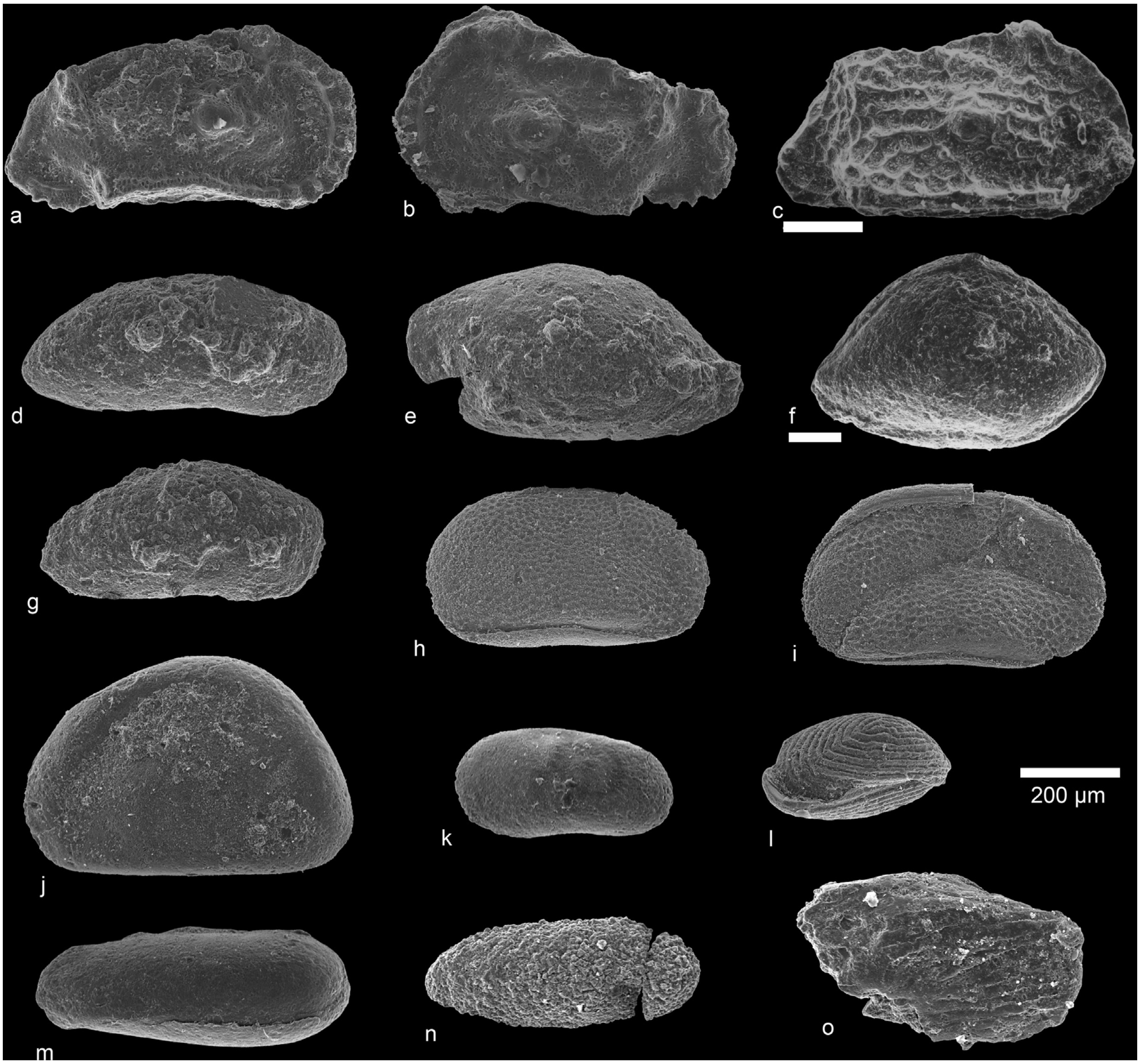

Fig. 8. Scale applies to all specimens but c) and f) with own scale bars (all bars represent 200 µm). a. *Rehacythereis bartensteini* (Oertli, 1958). EMNH.2018.1.2.7. RV in lateral view: borehole Vst–2, 48 m. b. *Rehacythereis luermannae* (Triebel, 1940). EMNH.2018.1.2.6. LV in lateral view: borehole Vst–2, 48 m. c. *Rehacythereis reticulata* (Jones & Hinde, 1890). EMNH.2018.4.6.16. RV in lateral view: borehole O–1828, 391 m. d. *Pontocyprella harrisiana* (Jones, 1849). EMNH.2018.1.3.2. RV in lateral view: borehole Vst–2, 63 m. e. *Bairdia* sp. aff. *B. obesa* Margerie, 1967. EMNH.2018.1.3.6. LV in lateral view: borehole Vst–2, 63 m. f. *Bairdoppilata pseudoseptentrionalis* Mertens, 1956. EMNH.2018.1.7.16. C in right view: borehole O–1828, 343–344 m. g. *Pontocyprella maynci* Oertli, 1958. EMNH.2018.1.3.9. RV in lateral view: borehole Vst–2, 63.5 m. h. *Candona arta* Zalányi, 1959. EMNH.2018.1.15.1. C in right view: borehole Tt–27, 20.9 m. i. *Candona arta* Zalányi, 1959. EMNH.2018.1.15.2. C in right view: borehole Tt–27, 43 m. j. *Lineocypris* sp. EMNH.2018.1.14.9. C in left view: borehole Mt–7, 32 m. k. *Fabaeformiscandona* cf. *fabaeformis* (Fischer, 1851). EMNH.2018.2.7.7. C in right view: borehole Tt–27: 37 m. l. *Zonocypris* sp. EMNH.2018.1.11.4. C in ventral view: borehole Mt–7, 23 m. m. *Darwinula leguminella* (Forbes, 1855). EMNH.2018.1.12.12. C in left view: borehole Mt–7, 30 m. n. *Darwinula aculeata* Zalányi, 1959. EMNH.2018.2.7.3. LV in lateral view: borehole Tt–27, 47.5 m. o. *Neorichterina* sp. EMNH.2018.2.7.2. C in lateral view (?): borehole Vst–2, 54 m.

a. Rehacythereis bartensteini *(Oertli, 1958). EMNH.2018.1.2.7. VD en vue latérale : forage Vst–2, 48 m. b.* Rehacythereis luermannae *(Triebel, 1940). EMNH.2018.1.2.6. VG en vue latérale : forage Vst–2, 48 m. c.* Rehacythereis reticulata *(Jones & Hinde, 1890). EMNH.2018.4.6.16. VD en vue latérale : forage O–1828, 391 m. d.* Pontocyprella harrisiana *(Jones, 1849). EMNH.2018.1.3.2. VD en vue latérale : forage Vst–2, 63 m. e.* Bairdia *sp. aff.* B. obesa *Margerie, 1967. EMNH.2018.1.3.6. VG en vue latérale : forage Vst–2, 63 m. f.* Bairdoppilata pseudoseptentrionalis *Mertens, 1956. EMNH.2018.1.7.16. C in right view : borehole O–1828, 343–344 m. g.* Pontocyprella maynci *Oertli, 1958. EMNH.2018.1.3.9. VD en vue latérale : forage Vst–2, 63.5 m. h.* Candona arta *Zalányi, 1959. EMNH.2018.1.15.1. C en vue droite : forage borehole Tt–27, 20.9 m. i.* Candona arta *Zalányi, 1959. EMNH.2018.1.15.2. C en vue droite : forage Tt–27, 43 m. j.* Lineocypris *sp. EMNH.2018.1.14.9. C en vue gauche : forage Mt–7, 32 m. k.* Fabaeformiscandona *cf.* fabaeformis *(Fischer, 1851). EMNH.2018.2.7.7. C en vue gauche : forage Tt–27 : 37 m. l.* Zonocypris *sp. EMNH.2018.1.11.4. C en vue ventrale : forage Mt–7, 23 m. m.* Darwinula leguminella *(Forbes, 1855). EMNH.2018.1.12.12. C en vue gauche : forage Mt–7, 30 m. n.* Darwinula aculeata *Zalányi, 1959. EMNH.2018.2.7.3. VG en vue latérale : forage Tt–27, 47.5 m. o.* Neorichterina *sp. EMNH.2018.2.7.2. C en vue latérale (?) : forage Vst–2, 54 m.*

1988. *Bairdoppilata pseudoseptentrionalis* Mertens–Jarvis et al., fig. 15/j.

1992. *Bairdoppilata pseudoseptentrionalis* Mertens, 1956–Witte et al., p. 48, pl. 2, fig. 1.

2000. *Bairdia pseudoseptentrionalis* (Mertens, 1956) s. l.–Monostori, p. 9, pl. 2, figs. 6–8., pl. 3. fig. 1.

2006. *Bairdoppilata* aff. *pseudoseptentrionalis* Mertens, 1956–Andreu and Bilotte, pl. 1, figs. 15–17.

2009. Bairdoppilata pseudoseptentrionalis Mertens–Vaziri, fig. 7/a.

Dimensions: L: 1230–1406.7 µm, H: 821.6–1000 µm, L/H: 1.4–1.53

Remarks: Specimens differ from the holotype in a less pointed posteroventral caudal process.

Occurrences and stratigraphic ranges: UK: Albian to Turonian (Keen and Siddiqui, 1971; Weaver, 1982; Jarvis et al., 1988; Vaziri, 2009), Ireland: Upper Albian (Ainsworth, 1985), France: Albian to Cenomanian (Babinot et al., 1985; Damotte, 1971, 1979; Wiel et al., 1978), Cenomanian to Turonian (Andreu and Bilotte, 2006), Netherlands: Upper Albian to Middle Cenomanian (Witte et al., 1992), Germany: Albian (Mertens, 1956; Gründel, 1966), Hungary: Albian to Cenomanian (Monostori, 2000; this paper).

Family Bythocyprididae Maddocks, 1979
Genus ***Pontocyprella*** Mandelstam, 1958

Pontocyprella harrisiana (Jones, 1849)
Fig. 8d

1849. *Cythere* (*Bairdia*) *harrisiana* n. sp.–Jones p. 25–26, pl. 6, fig. 17a–f.

2014. *Pontocyprella harrisiana* (Jones, 1849)–Cséfán and Monostori, p. 86, pl. 2, fig. 8. (cum syn.)

Dimensions: L: 590–1170 μm, H: 268–770 μm, L/H: 1.7–2.44

Occurrences and stratigraphic ranges: UK: Albian to Turonian (Jones, 1849; Gründel, 1966; Neale, 1973; Weaver, 1982; Slipper, 1997; Vaziri, 2009), France: Barremian to Aptian (Babinot et al., 2007; Babinot and Colin, 2011), Netherlands: Cenomanian (Witte et al., 1992), Germany: Albian to Cenomanian (Gründel, 1966; Weaver, 1982), Poland: Albian to Cenomanian (Gründel, 1966), Hungary: Albian to Cenomanian (Monostori, 2000; Cséfán and Monostori, 2014; this paper), Morocco: Valanginian (Babinot and Colin, 2011), Iran: Albian to Cenomanian (Vaziri et al., 2007).

Pontocyprella maynci Oertli, 1958
Fig. 8g

1958. *Pontocyprella maynci* n. sp.–Oertli, pp. 1504–1505, pl. 2, figs. 46–54; pl. 3. figs. 55–60.

1966. *Pontocyprella maynci* Oertli, 1958–Gründel, pp. 16–17, pl. 2, fig. 4.

1985. *Pontocyprella maynci* Oertli, 1958–Babinot et al., pl. 48, fig. 4.

2007. *Pontocyprella maynci* Oertli, 1958–Babinot et al. p. 47, pl. 3, figs. 13–17.

Dimensions: L: 572–669.3 μm, H: 268–292.3 μm, L/H: 2.1–2.29

Occurrences and stratigraphic ranges: France: Aptian to Albian (Oertli, 1958; Babinot et al., 1985, 2007), Germany: Upper Aptian to Lower Albian (Gründel, 1966).

Suborder Cypridocopina Jones, 1901
Superfamily Cypridoidea Baird, 1845
Family Candonidae Kaufmann, 1900
Subfamily Candoninae Kaufmann, 1900
Genus ***Candona*** Baird, 1845
Candona arta Zalányi, 1959
Fig. 8h–i

1959. *Candona arta* n. sp.–Zalányi, pp. 412–413, fig. 6.

Dimensions: L: 575–641.5 μm, H: 324–375.6 μm, L/H: 1.65–1.87

Remarks: The carapace surface of the studied specimens is densely reticulated. This ornamentation is very characteristic of the species.

Occurrences and stratigraphic ranges: Hungary: Albian (Zalányi, 1959; this paper).

***Candona*spp.**

Remarks: ***Candona*** with poor preservation, thus cannot be assigned to species with certainty.

Genus ***Lineocypris*** Zalányi, 1929

***Lineocypris*sp.**
Fig. 8j

Dimensions: L: 659–678 μm, H: 439–450 μm, L/H: 1.5

Remarks: The scarcity of the specimens allows to identify the form only on generic level.

Occurrences and stratigraphic ranges: Hungary: Albian (this paper).

Genus ***Fabaeformiscandona*** Krstić, 1972

Fabaeformiscandona*cf.*fabaeformis (Fischer, 1851)
Fig. 8k

1978. *Candona* cf. *fabaeformis* (Fischer, 1851)–Szczechura, p. 86, fig. 7/S, T, U., pl. 19, figs. 7–10.

Dimensions: L: 422–436 μm, H: 198–208 μm, L/H: 2–2.1

Remarks: The studied specimens are very similar in their outline to the recent *Fabaeformiscandona fabaeformis* (Fischer, 1851) and the forms described by Szczechura (1978, pl. 19. figs. 7–10) from the Upper Cretaceous of Mongolia.

Subfamily Paracypridinae Sars, 1923
Genus ***Paracypris*** Sars, 1866

***Paracypris*spp.**

Remarks: *Paracypris* with poor preservation, thus cannot be assigned to species with certainty.

Family Cyprideidae Martin, 1940
Genus *Cypridea* Bosquet, 1852
Cypridea zalanyii n. sp.
Figs. 9a–d

Derivation of name: In honour of Béla Zalányi, one of the most significant ostracodologists of Hungary from the first half of the 1900s.

Holotype: Carapace, Eötvös Museum of Natural History, EMNH.2018.1.10.7. Fig. 9d. Borehole Mt–7, 50–50.5 m

Paratype. Carapace, Eötvös Museum of Natural History, EMNH.2018.1.6.3. Fig. 9b. Borehole Mt–7, 48 m.

Type locality: Borehole Mt–7, Vértes foreland, Hungary

Stratigraphic horizon: Albian, depth 50–50.5 m

Material: Borehole O–1828: 4 carapaces; borehole Mt–7: 16 carapaces.

Dimensions: L: 896–1020 μm, H: 562–620 μm, L/H: 1.59–1.65

Diagnosis: A species of *Cypridea* with an almost rectangular carapace and small rostrum.

Description: Carapace robust, semi–rectangular in lateral view. Anterior margin rounded, but the anterodorsal part truncated. Dorsal margin straight and sloping towards the posterior. Posterior margin truncated. A minute rostrum visible along the anteroventral margin that is more distinct on the right valves. The alveolus very weak and only visible on the right valves. LV overlaps RV. Maximum height at 1/3 length. Surface smooth.

Remarks: Similar to *Cypridea* (*Cypridea*) *globra* described by Hou from China (see Ye and Li, 1988) but has a more distinct rostrum. Also shows similarity in shape to *Mongolocypris kohi* described by Choi and Huh (2016) from the Albian of South Korea but has a more rectangular outline. The studied specimens fit into the genus *Cypridea* Bosquet, 1852 based on its descriptions supplemented by Sylvester–Bradley (1949) and Szczechura (1978), although the latter one is mainly focused on the interior of the carapaces, which is cannot be observed on the studied specimens. Differs from

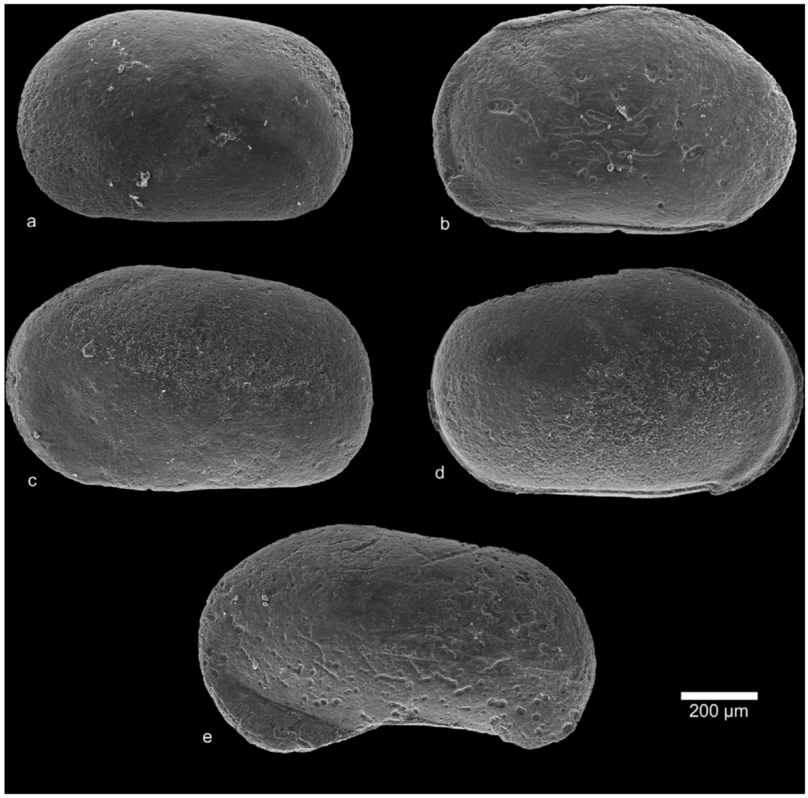

Fig. 9. a. *Cypridea zalanyii* n. sp. EMNH.2018.1.10.5. C in left view: borehole Mt–7, 50–50.5 m. b. *Cypridea zalanyii* n. sp. Paratype, EMNH.2018.1.6.3. C in right view: borehole Mt–7, 48 m. c. *Cypridea zalanyii* n. sp. EMNH.2018.1.10.8. C in left view: borehole Mt–7, 50–50.5 m. d. *Cypridea zalanyii* n. sp. Holotype, EMNH.2018.1.10.7. C in right view: borehole Mt–7, 50–50.5 m. e. *Cypridea* aff. *dashuiguoensis* van Itterbeeck et al., 2004. EMNH.2018.1.6.2. C in left view: borehole Mt–7, 48 m.
a. Cypridea zalanyii *nov. sp. EMNH.2018.1.10.5. C en vue gauche : forage Mt–7, 50–50.5 m. b.* Cypridea zalanyii *nov. sp. Paratype, EMNH.2018.1.6.3. C en vue droite : forage Mt–7, 48 m. c.* Cypridea zalanyii *nov. sp. EMNH.2018.1.10.8. C en vue gauche : forage Mt–7, 50–50.5 m. d.* Cypridea zalanyii *nov. sp. Holotype, EMNH.2018.1.10.7. C en vue droite : forage Mt–7, 50–50.5 m. e.* Cypridea *aff.* dashuiguoensis *van Itterbeeck et al., 2004. EMNH.2018.1.6.2. C en vue gauche : forage Mt–7, 48 m.*

Cypridea isasae (Kneupper–Haack, 1966) from the Hauterivian to Early Barremian of Spain (see Schudack and Schudack, 2009) in a less narrowly shaped posterior half, and in ornamentation: *C. isasae* has a pitted surface, while the newly described species' surface is smooth.

Occurrences and stratigraphic ranges: Hungary: Albian (this paper).

Cypridea aff. *dashuiguoensis* van Itterbeeck et al., 2004
Fig. 9e

2004. *Cypridea dashuiguoensis* n. sp.–Van Itterbeeck, Markevich & Horne, pp. 398–399, figs. 3U–W.

Dimensions: L: 1023–1051 µm, H: 580–603 µm, L/H: 1.74–1.76

Remarks: Very similar in outline to *Cypridea dashuiguoensis* described by van Itterbeeck et al. (2004) from the sediments of the Dashuiguo Formation (Barremian) of the Dashuiguo section, Inner Mongolia, P.R. China, which is anterodorsally depressed, while the studied specimen is anteroventrally depressed.

Occurrences and stratigraphic ranges: Hungary: Albian (this paper).

Family Cyprididae Baird, 1845
Subfamily Cypridopsinae Kaufmann, 1900
Genus *Zonocypris* Müller, 1898

Zonocypris sp.
Fig. 8l

Dimensions: L: 359–370 µm, H: 204–218 µm, L/H: 1.7–1.76

Remarks: The studied specimens have slightly deformed and damaged carapaces. Carapace ornamented with concentric ridges and thin grooves.

Occurrences and stratigraphic ranges: Hungary: Albian (this paper).

Suborder Darwinulocopina Sohn, 1988
Superfamily Darwinuloidea Brady and Norman, 1889
Family Darwinulidae Brady and Robertson, 1885
Genus *Darwinula* Brady and Robertson in Jones, 1885

Darwinula aculeata Zalányi, 1959
Fig. 8n

1959. *Darwinula aculeata* n. sp.–Zalányi, p. 428, text fig. 14.

Dimensions: L: 400–562 µm, H: 185–221 µm, L/H: 2.16–2.54

Occurrences and stratigraphic ranges: Hungary: Albian (Zalányi, 1959; this paper).

Darwinula leguminella (Forbes, 1855)
Fig. 8m

1885. *Darwinula leguminella* (Forbes)–Jones, pp. 346–347, pl. 8, figs. 30–31.

1940. *Darwinula leguminella* (Forbes)–Martin, pp. 317–318, pl. 4, figs. 58–61.

1959. *Darwinula leguminella* (Forbes)–Zalányi, pp. 425–428, text figs. 12, 12/a, 13.

1963. *Darwinula leguminella* (Forbes, 1855)–Christensen, pp. 21–23, pl. 2, figs. 2.

1963. *Darwinula leguminella* (Forbes, 1855)–Oertli, p. 20, pl. 6, fig. 40.

1966. *Darwinula leguminella* (Forbes, 1855)–Barker, p. 472, pl. 7, fig. 9.

1968. *Darwinula leguminella* (Forbes, 1855)–Kilenyi and Allen, pp. 144–145, pl. 29, fig. 8.

1978. *Darwinula leguminella* (Forbes, 1855)–Kilenyi and Neale, pl. 6, figs. 12, 14.

1985. *Darwinula leguminella* (Forbes, 1855)–Anderson, p. 34, pl. 11, fig. 8.

1985. *Darwinula leguminella* (Forbes)–Shou, pl. 1. figs. 14–15.

1985. *Darwinula leguminella* (Forbes, 1855)–Colin and Oertli, pl. 40, fig. 1.

1986. *Darwinula leguminella* (Forbes)–Zhang and Wu, pl. 3. figs. 6–7.

1993. *Darwinula leguminella* (Forbes)–Xu, pl. 2. figs. 11–13.

2012. *Darwinula leguminella* (Forbes, 1855)–Zhang and Lin, pl. 3, figs. 15–20.

2013. *Darwinula leguminella* (Forbes, 1855)–Zhang and Lin, pl. 1, figs. 25–31.

Dimensions: L: 638–705 μm, H: 241–705 μm, L/H: 2.3–2.64

Occurrences and stratigraphic ranges: UK: Berriasian (Barker, 1966), Valanginian to Barremian (Jones, 1885; Kilenyi and Allen, 1968; Kilenyi and Neale, 1978), Berriasian to Barremian (Anderson, 1985), France: Berriasian (Oertli, 1963; Colin and Oertli, 1985), Denmark: Berriasian to Barremian (Christensen, 1963), Germany: Berriasian to Barremian (Martin, 1940), Hungary: Albian (Zalányi, 1959; this paper), China: Early Cretaceous (Shou, 1985; Zhang and Wu, 1986), Albian to Cenomanian (Zhang and Lin, 2012, 2013), Cretaceous (Xu, 1993).

Subclass Myodocopa Sars, 1866
Order Entomozocopida Gründel, 1969
Suborder Entomozocopina Gründel, 1969
Family Entomozoidae Přibyl, 1950
Genus *Neorichterina* Tóth and Cséfán, 2018

Neorichterina sp.

Fig. 8o

Dimensions: L: 579 μm, H: 340 μm, L/H: 1.7

Remarks: Carapace deformed and broken. Surface ornamented with elongated ribs which are wider than the intervening grooves. The ornamentation is the same as that of *Neorichterina striata* Tóth and Cséfán, 2018.

Occurrences and stratigraphic ranges: Hungary: Albian (Tóth and Cséfán, 2018; this paper).

5. Results and discussion

5.1. Characteristics and palaeoecological interpretation of the ostracod faunas of the studied Albian non-marine to fully-marine successions

The Lower Cretaceous (Albian) sediments of the Transdanubian Range yielded a diverse ostracod fauna originating from freshwater lacustrine environments to the fully-marine basin environments of the Northern Tethys. The preservation potential of the studied specimens is moderate given that most of the valves and carapaces are recrystallized and filled with sediment. The proportion of carapaces constitutes around 35% of all specimens from the boreholes Tt–27 and Vst–2, and 60% from boreholes Mt–7 and O–1828.

The ostracod fauna of the Tés Clay from borehole Tt–27 consists of 28 taxa belonging to 14 genera of 10 families. The sequence of borehole Tt–27 yielded a total of 3500 specimens (and this does not included highly corroded, broken specimens which could only be classified into Ostracoda indet.). In total, 65% of the ostracods belong to the limnocytherid genus *Rosacythere*. The second most frequent genus was the “*Cytheridea*” with 17%, followed by the other forms all below 10% (Fig. 10).

The changes in the benthic assemblages more or less mirrors the alternation of cyclothemes suggested by Császár (1986); this is based on the lithological attributes and reflects the lacustrine to lagoonal depositional environment of the Tés Clay. The first cyclothem in borehole Tt-27 was the terrestrial Alsópere Bauxite. The fauna of the second cyclothem (with a depth interval between 51.3 m and 44 m, Fig. 4) is dominated by specimens of the limnocytherid *Rosacythere* and the also freshwater form, *Darwinula*; the latter co-occurred with specimens of *Dusormidea*, euryhaline *Cytheridea*, and the limnobrackish *Candona.* This assemblage indicates the strong influence of freshwater in a lagoonal environment, since the specimens mentioned are solely non-marine; this is consistent with the scenario of the assemblage being overlain by bauxite. The existence of a brackish lagoon environment is supported by the presence of the euryhaline green algae *Munieria* (Császár and Bodrogi, 1985). The third cyclothem (with a depth interval between 44 m to 33 m, Fig. 4) has the most varied fauna. The genus *Rosacythere* is present in great abundance at the start of the cyclothem and is accompanied by a few specimens of *Candona*. In the younger strata intercalated by *Ostrea* lumachelles, the genus “*Cytheridea*” and the appearance of shallow marine *Schuleridea* indicates a changing environment from freshwater to a brackish lagoonal environment. However, it is disrupted by the reappearance of the genera *Candona* and *Darwinula*, followed by *Dusormidea* and *Rosacythere*; this reappearance indicates the renewal of freshwater influence in the area. This trend continues in the fourth cyclothem (with a depth interval between 33 m to 21.7 m, Fig. 4) which — apart from a few specimens of the genera *Candona* and *Dusormidea* — is represented by *Rosacythere* in high numbers. In the fifth cyclotheme (with a depth interval between 21.7 m to 19.8 m, Fig. 4), the specimen number suddenly declines, and the marine influence is renewed again with the appearance of the genus “*Cytheridea*”. The first samples from the sixth cyclothem (with a depth interval between 19.8 m to 16.7 m, Fig. 4.) contain non-marine forms such as *Candona* and *Darwinula*, which occur with carbonized plant remains. In the younger strata, the genus “*Cytheridea*” occurs in great abundance; furthermore, the first appearance of the marine *Cytherella* genus is within the sixth cyclothem, indicating an even stronger marine influence. This is supported by the presence of *Ostrea* shards in the termination of the cyclothem and by the occurrence of echinoderms and foraminifers along with the genus *Cytherella* (Császár, 1986). This fluctuation of salinity in the depositional environment can also be traced through the seventh (with a depth interval between 16.7 m to 13.9 m) and eighth (with a depth interval between 13.9 m to 12.7 m) cyclothems (Fig. 4). The fauna of the ninth cyclotheme (with a depth interval between 12.7 m to 5.6 m, Fig. 4) mainly consists of specimens of the genera “*Cytheridea*”, *Rosacythere* and a few specimens of marine *Schuleridea* and the limnocytherid *Metacypris*. This indicates a brackish lagoonal environment with freshwater influence. In conclusion, the studied stratotype section was deposited in an unstable, shallow marine, presumably lagoon environment with well-ventilated bottom waters and fluctuating salinity (the latter point indicating freshwater to fully-marine conditions). It is important to take careful notice *Chara* gyrogonites; this could only be found in samples of freshwater ostracods.

The Tés Clay is also represented in borehole Mt–7. The studied fauna contained the highest proportion of the genus “*Cytheridea*” (45%), the common genera *Cytherella* (19%), and *Dusormidea* (23%); the percentages refer to the proportion of ostracods out of the 920 specimens (Fig. 10). The fauna occurring at a depth interval between 99 m to 5.6 m indicates a dominantly marine depositional environment. This represents the most diverse fauna of those studied, with 37 taxa, 21 genera and 13 families. The sequence starts with the dominance of marine faunal elements consisting of *Cytherella*, ornamented cytherids, trachyleberids and schulerideid

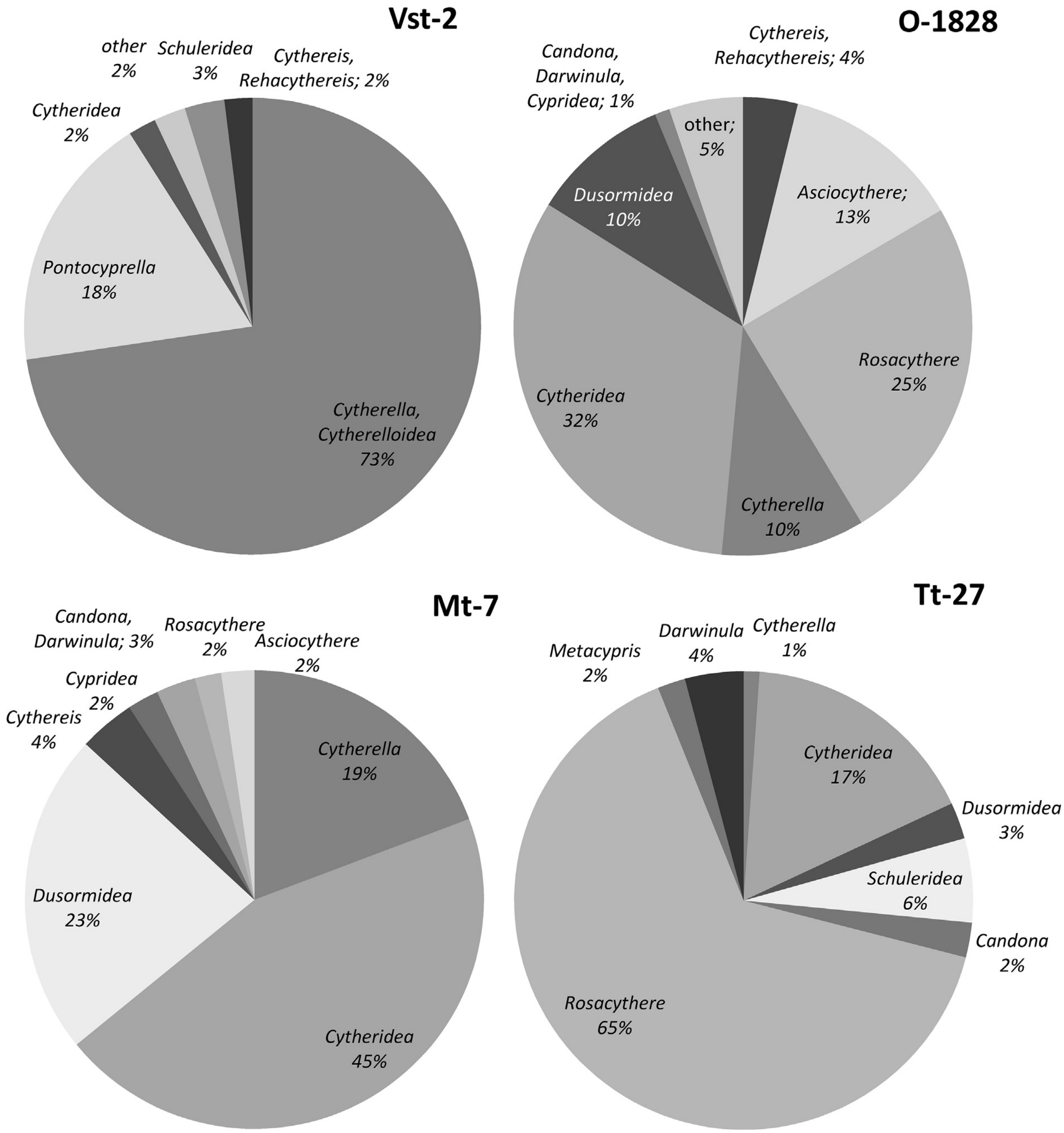

Fig. 10. Percentage distribution of ostracod genera in the studied boreholes.
Répartition en pourcentage des genres d'ostracodes dans les forages étudiés.

Asciocythere; even so, the brackish and non-marine forms such as "*Cytheridea*", *Dusormidea* and *Rosacythere*, also appear periodically. The reign of the *Cytherella* and other marine genera is interrupted by a *Rosacythere*–*Cypridea*–*Dusormidea* assemblage between 50.5 m to 48 m suggesting a strong freshwater influence (Fig. 4). The younger strata of the studied section are characterized by a "*Cytheridea*"- and *Dusormidea*-dominated assemblages, with the sporadic occurrence of specimens of non-marine to fully-marine taxa, such as *Candona, Darwinula, Rosacythere, Asciocythere, Cythereis, Rehacythereis* and *Cytherella*.

The studied series of borehole Mt–7 was deposited in a shallow marine to brackish, well-ventilated environment; the latter was more stable than in the area of borehole Tt–27. The fauna of the oldest strata indicates a normal marine environment which became an unstable environment with more or less fluctuating salinity; this environment was then interrupted by a strong freshwater influence. The upper part of the sequence was deposited in a more stable brackish environment.

The studied section of borehole O–1828 (with a depth between 405 m to 282 m, Fig. 5) represents the interfingering strata of the urgon-type Környe Limestone and the nearshore Tés Clay; it yielded a diverse fauna consisting of 33 taxa, 20 genera and 13 families. The fauna is dominated by the genera "*Cytheridea*" (32%) and *Rosacythere* (25%); other forms are around 10% (*Dusormidea*, *Asciocythere* and *Cytherella*) (Fig. 10). From 2570 specimens, altogether 10% was represented by the remaining genera. A few corroded specimens of shallow marine forms such as *Cytherella*, *Asciocythere*, *Cythereis*, *Rehacythereis*, "*Cytheridea*" and *Bairdia* were found in the studied samples of the Környe Limestone (depth intervals between 405 m to 391 m and 360 m to 353 m, Fig. 5). In the lowest sample, reworked non-marine and brackish forms — i.e. "*Cytheridea*", *Candona* and *Darwinula* — are also present. The lower part of the Tés–Környe transition sequence (at depths between 389.5 m and 364.5 m, Fig. 5) is dominated by "*Cytheridea*" and *Asciocythere*; there is also the sporadic presence of other normal marine forms (*Cytherelloidea, Cytherella, Rehacythereis, Pontocyprella, Paracypris, Bairdia* and *Centrocythere*) and non-marine and brackish elements (*Candona, Darwinula, Rosacythere* and *Dusormidea*). The fauna suggests strong fluctuation of the salinity from fresh water to normal marine conditions. The upper part of the Tés–Környe transition sequence (depths between 349 m and 329.8 m, Fig. 5) did not yield as many specimens as the lower sequence, and the composition of the fauna is slightly different as well. *Asciocythere* is represented by only two specimens from one sample, and the *Asciocythere*–"*Cytheridea*" assemblage is replaced by a *Cytherella*–"*Cytheridea*" assemblage. The latter also demonstrates the sporadic occurrence of specimens ranging from freshwater to marine forms (*Candona, Rosacythere, Dusormidea, Schuleridea, Bairdia, Cythereis* and *Rehacythereis*).

The section of the Tés Clay between 324.5 m to 282 m is characterized by a *Rosacythere*–*Dusormidea*–"*Cytheridea*" assemblage (Fig. 5). This suggests a non-marine to brackish depositional environment. The sequence yielded sporadic occurrences of *Cypridea, Zonocypris, Candona, Darwinula, Cytherella, Paracypris* and *Rehacythereis*. Even though these taxa are represented by only a very few specimens, their appearance still suggests a slight fluctuation of salinity.

In conclusion, the sediments of the Tés–Környe transition sequence were deposited in a shallow marine environment, near the carbonate platform. However, there is clear evidence of a slight freshwater influence: an influence that became even stronger through time; this interpretation is supported by the presence of chara gyrogonites. The environment evolved into a brackish to freshwater unstable lagoon with salinity fluctuation; the latter is indicated by the mainly brackish ostracod assemblage and the sporadic appearance of some variable marine and freshwater taxa.

The boreholes Vst–2, Vst–8 and Agt–2 in the Vértes foreland penetrate the basin facies of the Albian Vértessomló Siltstone. The ostracods of the sequences from borehole Vst–8 and Agt–2 were studied earlier by Cséfán and Monostori (2014) and Cséfán and Tóth (2013), who interpreted that the studied series were deposited in a semi-enclosed, upper bathyal fully-marine basin. The basin had low oxygenated conditions in its bottom water which is based on the high proportion of the platycopid *Cytherella*, especially in the deeper part of the basin. Császár and Árgyelán (1994) assumed a strong terrigenous input from an E–NE direction, which may account for the low oxygen levels. The deposition of the Albian series of the Vst–8 borehole was closer to the carbonate platform (Környe Limestone) as indicated by the presence of ostracods with well-developed eye spots and strongly ornamented carapaces. The sequence of borehole Agt–2 was deposited further away from the platform where the paleo-oxygen level and the amount of light was more reduced. The evidence for this is based on the "platycopid signal" and the presence of ostracods with weaker or absent eye spots. The latter is measured by the proportion of platycopids per sample, thus high proportion of the cytherellids could indicate low oxygenated bottom water conditions (e.g. Boomer and Whatley, 1992; Whatley et al., 1994).

The ostracod fauna of the Albian strata in borehole Vst–2 is very similar to that of borehole Vst–8. From the 20 taxa, 13 genera and 11 families, the reigning genus is platycopid *Cytherella*; the latter is in all but four samples. From a total of 570 specimens, 72% of these were represented by the genus *Cytherella*, the only other notable common genus was *Pontocyprella* with 18% (Fig. 5). The measurement of palaeo-oxygen levels from the "platycopid signal" was not possible due to the low specimen numbers in most of the samples. The genus *Pontocyprella* was common in the samples and this suggests a bathyal environment (Babinot and Colin, 1983). The trachyleberid *Rehacythereis* and *Cythereis* are essentially bound to the more calcareous layers. The preservation of their carapaces is similar to the examples in borehole Vst–8, with a less developed reticulation and presence of eye tubercles. The genus *Schuleridea* was identified from seven samples throughout the section, and the genus "*Cytheridea*" from the upper and lower parts of the sequence. The sequence yielded very few specimens of other normal marine forms (*Bythoceratina*, *Centrocythere*, *Protocythere, Bairdia* and *Paracypris*). The low number of these marine forms — which prefer well-ventilated conditions — could also be an indication of a low oxygenated environment. This assumption is supported by the unique preservation of the weakly-calcified carapace of the rare myodocopid *Neorichterina*. In conclusion, the sediments of borehole Vst–2 were deposited in a marine, shallow bathyal environment with low oxygenated bottom waters.

The closing sequence of the Albian in this area is the Pénzeskút Marl, the ostracod fauna of which was studied by Monostori (2000) from boreholes Jásd–1, Jásd–42 in Bakony Mts, and Ot–84 in the Vértes foreland. The depositional environment of the Albian part of the Pénzeskút Marl was an outer shelf with low oxygenated bottom water conditions. This is evidenced by the high proportion of the cytherellids and is similar to the case of the studied basin environment. The total 1040 studied specimens of borehole Jásd–42 is dominated by the abundant *Cytherella* genus, which represents 62% of that total. The genus *Schuleridea* represents 15% of the specimens and the less frequent trachyleberid genera *Rehacythereis* and *Cythereis* 12% (Monostori, 2000).

This Upper Albian marine fauna is very similar to the Lower to Middle Albian ostracod assemblages from the Vértessomló Siltstone, represented here by borehole Vst–2. However, the proportion of the bathyal *Pontocyprella* is lower than in the Vértessomló Siltstone and the composition of the ornamented cytherid and trachyleberid taxa is slightly different. The great abundance of *Rehacythereis glabrella* and *R. reticulata* and the presence of the genera *Veeniacythereis* and *Cornicythereis* are characteristic features for the fauna of the Pénzeskút Marl. In contrast to this, the species *Rehacythereis bartensteini* and *R. luermannae* are the dominant cytherid taxa in the Vértessomló Siltstone. This observation can be explained by the respectively different depositional ages of the studied sediments in this region.

In conclusion, the Albian series of borehole Tt–27 (Tés Clay) yielded the highest proportion of non-marine limnocytherids, while the section of borehole Mt–7 (Tés Clay) included the highest percentage of the brackish elements (mainly cytherideids). The fauna of borehole O–1828 (Tés–Környe transition, Környe Limestone and Tés Clay) was the most variable because of the interfingering of the different facies: from the marine platform to the brackish lagoon environments with freshwater inputs. Those fully-marine strata of the Albian which were studied occurred in boreholes Vst–2, Vst–8 and Agt–2 (Vértessomló Siltstone); as well as, Jásd–42 (Pénzeskút Marl) yielded a platycopid–dominated shallow bathyal association.

5.2. Albian freshwater to fully-marine ostracod assemblages and endemic forms

The Albian deposits of Transdanubian Range in Hungary contain a highly variable and rich ostracod fauna. The studied area can be presumed to have been a semi-confined basin of the Northern Tethys. Different environments of this sedimentary basin are represented, non-marine, brackish lagoon to fully-marine basin environments. The ostracod faunas studied here reflected this variability and made it possible to distinguish the different ostracod associations of different Albian environments within a single basin.

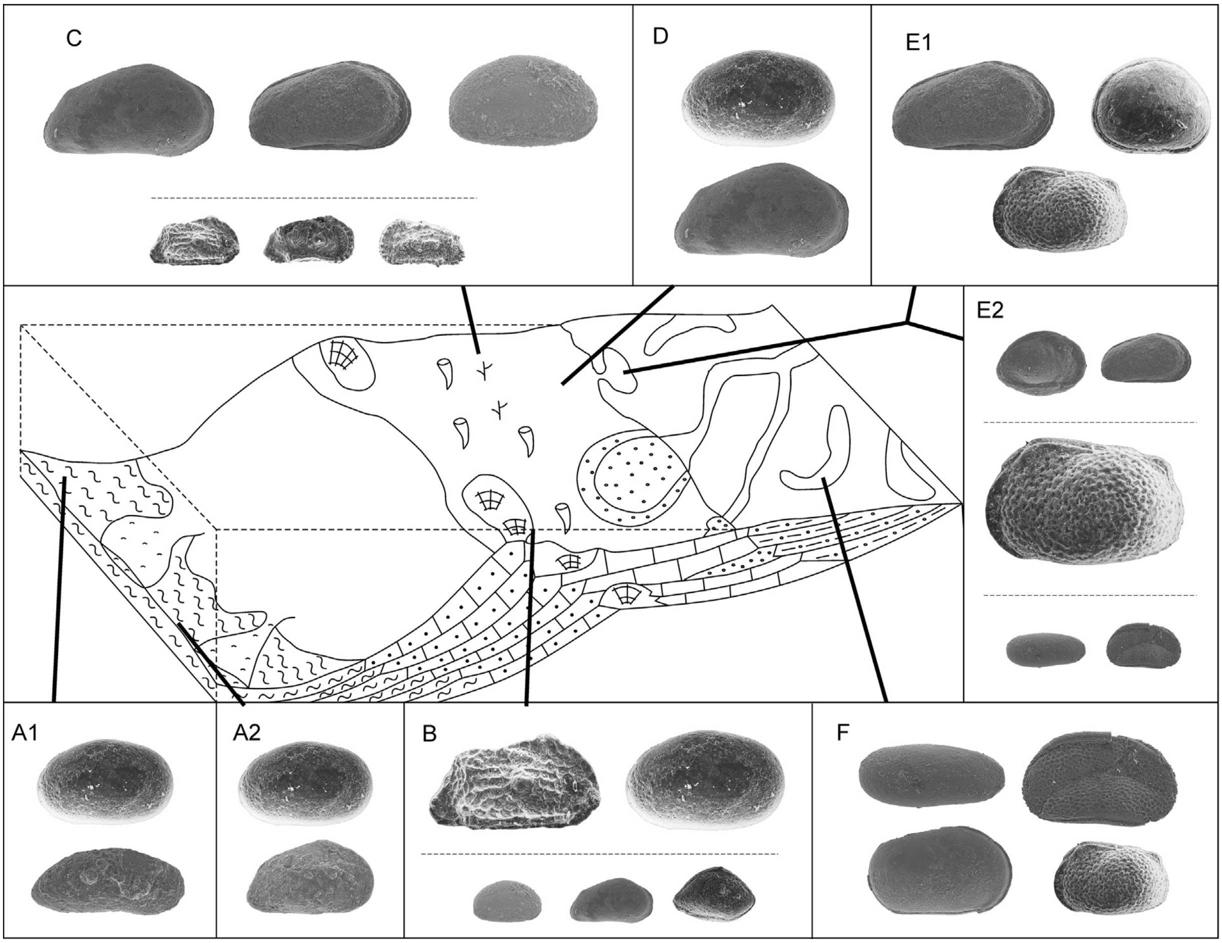

Fig. 11. Palaeoecologic model of the studied Lower Cretaceous sedimentary basin (after Császár, 2002) with the respective ostracod assemblages. The specimens are scaled according to their abundance. A: Fully-marine, shallow bathyal, slightly dysoxic basin environment. A1: *Cytherella-Pontocyprella* assemblage. A2: *Cytherella–Schuleridea* assemblage. B: Fully-marine, well-ventilated reef environment: *Rehacythereis reticulata–Cytherella ovata* assemblage. C: Transition between B and D: *Asciocythere–"Cytheridea"* assemblage (and accompanying *Rehacythereis reticulata, R. bartensteini* and *Cythereis hirsuta*). D–F: Unstable, well-ventilated, near shore shallow marine to brackish lagoon environments. D: Shallow-marine: *Cytherella ovata–"Cytheridea" baconica* assemblage. E: Brackish lagoon. E1: "*Cytheridea*" *valida–Rosacythere baconica-Dusormidea ventricosa* assemblage. E2: *Rosacythere baconica*-dominated assemblage (*Schuleridea inaequalis, "Cytheridea" valida–Darwinula leguminella, Candona arta*). F: Non-marine environment: *Candona arta–Darwinula leguminella* assemblage (*Cypridea zalanyii, Rosacythere baconica*).

Modèle paléoécologique du bassin sédimentaire du Crétacé inférieur étudiés (d'après Császár, 2002) avec les assemblages d'ostracodes respectifs. Les spécimens sont mis à l'échelle en fonction de leur abondance. A : environnement de bassin avec milieux bathyal peu profond, entièrement marin et légèrement dysoxique. A1 : assemblage Cytherella-Pontocyprella*. A2 : assemblage* Cytherella–Schuleridea*. B : Environnement récifal entièrement marin et bien ventilé : assemblage* Rehacythereis reticulata–Cytherella ovata*. C : Transition entre B et D : assemblage* Asciocythere–"Cytheridea" *(et taxons d'accompagnement :* Rehacythereis reticulata, R. bartensteini *et* Cythereis hirsuta*). D–F : Environnements instables marins peu profonds à lagonaires saumâtres, bien ventillés. D : le milieu marin peu profond : assemblage* Cytherella ovata–"Cytheridea" baconica*. E : la lagune saumâtre. E1 : assemblage* "Cytheridea" valida–Rosacythere baconica-Dusormidea ventricosa*. E2 : assemblage dominé par les specimens de* Rosacythere baconica *(*Schuleridea inaequalis, "Cytheridea" valida–Darwinula leguminella, Candona arta*). F : environnement non-marin : assemblage* Candona arta–Darwinula leguminella *(*Cypridea zalanyii, Rosacythere baconica*).*

In the studied area, the fully-marine, upper bathyal, slightly dysoxic basin environment is represented by the Lower to Middle Albian Vértessomló Siltstone and Upper Albian part of the Pénzeskút Marl. The Lower to Middle Albian series are characterized by the *Cytherella–Pontocyprella* assemblage with an association of abundant *Cytherella ovata* and the common *Pontocyprella harrisiana* and *P. maynci* (Fig. 11A1). These forms are present along with the occasional *Rehacythereis bartensteini*, *R. luermannae*, *Schuleridea jonesiana* and "*Cytheridea*" sp. The Upper Albian sequences of Pénzeskút Marl yielded a slightly different bathyal ostracod assemblage in contrast to the above-mentioned Lower to Middle Albian Vértessomló Siltstone.

A *Cytherella–Schuleridea* assemblage is characteristic of this basin environment with some occasional trachyleberid taxa, such as *Cythereis* cf. *lerata* Gründel, 1966, *Rehacythereis glabrella* (Triebel, 1940) s.l., and *Rehacythereis reticulata* (Monostori, 2000, Fig. 11A2).

The fully-marine, well-ventilated reef environment represented by the Környe Limestone is characterized by a *Rehacythereis reticulata–Cytherella ovata* assemblage (Fig. 11B). Other, frequent ostracods of this assemblage are *Asciocythere* sp., *Bairdia* sp. and "*Cytheridea*" *baconica*. The fauna of the Tés–Környe transitional sequences, deposited in nearshore shallow marine environments, are represented by an *Asciocythere–"Cytheridea"* assemblage, with the occasional trachyleberid taxa: *Rehacythereis reticulata, R. bartensteini* and *Cythereis hirsuta* (Fig. 11C). The unstable, well-ventilated, near shore shallow marine to brackish lagoon environment is represented by the depositional environments of the Tés Clay. The shallow marine deposits yielded a *Cytherella ovata–"Cytheridea" baconica* assemblage with the occasional presence of *Cythereis cacemensis* (Fig. 11D). The ostracod fauna of the brackish lagoon is represented by a "*Cytheridea*" *valida–Rosacythere baconica–Dusormidea ventricosa* assemblage (Fig. 11E1) and a *Rosacythere baconica*-dominated assemblage

(Fig. 11E2). In the case of more marine conditions the latter association is characterized by the presence of *"Cytheridea" baconica, "Cytheridea" valida*, and *Schuleridea inaequalis*, while with a stronger freshwater input the presence of *Darwinula leguminella, Candona arta* is evident. The non-marine environment is represented by a *Candona arta–Darwinula leguminella* assemblage, where *Rosacythere baconica* is also frequent, and there is the rare but noteworthy appearance of the genus *Cypridea* (Fig. 11F).

The studied bathyal, to shallow marine fauna (with reference to the Northern Tethys and boreal realm) shows the greatest similarity to the European faunas, based on previously-mentioned studies (e.g. Babinot et al., 1985); this includes the common genera *Bairdia*, *Cytherella*, *Centrocythere*, *Schuleridea*, *Cythereis*, *Rehacythereis*, and *Pontocyprella*. The studied marine assemblages of the Transdanubian Range are very similar to the fauna from France, as described by Damotte and Grosdidier (1963). The latter includes abundant *Schuleridea jonesiana* and *Cytherella ovata*, frequent *Protocythere*, and *Cythereis reticulata*. *Cytherella*-dominated Albian assemblages also occur in France described by Oertli (1958), in Spain described by Schudack and Schudack (2009), and in Switzerland described by Charollais et al. (1977) and by Sauvagnat and Weidmann (2011).

Based on the composition of the ostracod community a high degree of endemism can be traced in the brackish lagoon and freshwater environments. Most of the studied Cytherideidae from this area were described by Zalányi in 1959. Ten of the studied taxa are endemic at the species level and one at the generic level (*Dusormidea*); these constitute 64% of the studied specimens. The forms regarded as endemic include the euryhaline taxa "*Cytheridea*" *herendensis*, "*Cytheridea*" *valida*, *"Cytheridea" baconica*, and *Dusormidea ventricosa*, and also the freshwater forms *Metacypris aculeata*, *Rosacythere baconica*, *Candona arta*, *Lineocypris* sp., *Cypridea zalanyii* and *Darwinula aculeata.* In conclusion, the Albian ostracod faunas in Hungary show a high level of endemism in the brackish to freshwater environments, while the marine faunas do not, despite the semi-enclosed basin environment they were living in. As is the case with other European assemblages, the non-marine faunas usually show a higher degree of endemism than the marine ones (e.g. Tibert et al., 2013); however, endemism is not rare among the shallow marine lagoon faunas.

Based on previous studies, the palaeoecological needs of the most important, above-mentioned endemic forms are discussed below. The Cretaceous representatives of the genus *Cytheridea* were probably euryhaline forms, living in shallow marine to brackish lagoon environments (Nogueira et al., 2011 and references therein). The ostracods belonging to the genus *Dusormidea* probably had ecological needs similar to those of other Cytherideidae, but in some cases they dominate the samples and can appear in rock-forming quantities as well. In most cases *Dusormidea* appear in samples along with the limnobrackish *Rosacythere* and euryhaline "*Cytheridea*". This could suggest that the ostracod *Dusormidea* was a brackish to limnobrackish, "opportunist" form, inhabiting the stress environments and proliferating when other forms disappeared from the habitat. According to Remane (see Hinz–Schallreuter and Schallreuter, 1999) who based his studies on recent analogies, there is a minimum number of taxa at salinities of c. 5‰ in brackish environments. It is possible that the appearance of the monospecific *Dusormidea* assemblages in large quantities is connected with a stress environment characterized by similar salinity conditions.

Cretaceous limnocytherids and darwinulids are non-marine forms which are similar to the recent representatives (e.g. Whatley, 1990); according to Colin and Danielopol (1980) and Cabral and Colin (1998) the limnocytherid *Rosacythere* was also living in shallow, permanent limnic to oligohaline waters. In the studied section, it is a dominant form in brackish lagoon environments (*Rosacythere* dominated assemblage, Fig. 11E2) and this might indicate that this Albian species of *Rosacythere* is also a euryhaline form which tolerated a slight increase in salinity. The *Rosacythere* aff. *grekoffi* — with a tubercle — seems to be an ecophenotypic form of *Rosacythere baconica*. This phenomenon might be a result of the fluctuation of salinity. The tubercled form dominates in the lagoonal environment under strong freshwater influence, but coexists with the non-tubercled *R. baconica* in brackish conditions. A similar phenomenon can be observed in the case of the recent euryhaline *Cyprideis torosa* (Jones, 1850). The carapace of its ecophenotypes goes through morphological changes with the varying salinity levels (Kilenyi, 1972, Keyser and Aladin, 2004).

The Albian cyprideids were also limnic forms (e.g. Sylvester–Bradley, 1949). The Chinese, Korean and Mongolian non-marine faunas are worthy of mention, since the Hungarian Cyprideidae show more resemblance to the Lower Cretaceous Chinese ones (e.g. Ye and Li, 1988), the Upper Cretaceous Mongolian forms (e.g. Szczechura, 1978) and the South Korean Upper Aptian? to Albian forms (e.g. Choi and Huh, 2016) than towards the Lower Cretaceous forms of Europe. The common features are usually a more developed rostrum, ornamentation, and more asymmetrical carapaces (e.g. Kilenyi and Neale, 1978 and Anderson, 1985). The group was common in the Northern Tethys and boreal realms in the lower Cretaceous until the Aptian marine transgressions, but was unchanged in China and Mongolia (Whatley, 1990). Despite the similar carapace morphology, it cannot be stated that these forms belong to the same species, given their relative palaeobiogeographical positions.

6. Conclusions

Diverse, moderately-preserved Albian ostracod faunas were studied from mostly fine-grained sediments of the Vértes Foreland (boreholes Vst–2, O–1828 and Mt–7) and Bakony Mts (borehole Tt–27) in the Transdanubian Range of Hungary. The composition of the fauna consists of freshwater, brackish and fully-marine forms of 46 taxa (including one new non-marine species), belonging to 27 genera, and 16 families of the orders Platycopida, Podocopida and Entomozocopida, respectively. They were recovered from non-marine, brackish lagoon, shallow marine, reef and fully-marine basin environments; this made it possible to study the faunas of different aquatic habitats during the Albian. From the coast towards the basin, based on their ostracod faunas, the studied sequences from boreholes Tt–27 and Mt–7 (Tés Clay) were deposited in an unstable, shallow marine, presumably lagoonal environment; the latter had well-ventilated bottom waters and fluctuating salinity conditions caused by periodic freshwater inputs. The more variable sequence of borehole O–1828 (Környe Limestone, Tés–Környe transition and Tés Clay) was deposited in a shallow marine to brackish depositional environment, with an increasing freshwater influence. Certain strata deposited under brackish conditions yielded numerous examples of the endemic *Dusormidea* and *Rosacythere baconica*. These taxa were most likely euryhaline opportunist forms, and probable indicators of the environment with c. 5‰ salinities. Moreover, the freshwater input enabled the research to broaden the knowledge about the rare Albian non-marine ostracod faunas.

The Early Albian basin environment was represented by the sequence (Vértessomló Siltstone) of borehole Vst–2, completed by the series of the previously published details about the fauna of boreholes Agt–2 and Vst–8. The platycopid-dominated ostracod fauna suggests a shallow bathyal environment with low oxygenated bottom water. The dysoxic condition can be explained by the terrigenous input from an E–NE direction. The studied ostracod communities of the Upper Albian Pénzeskút Marl (Jásd–1, Jásd–42 and Ot–84) also indicate a dysoxic outer shelf environment.

Based on the palaeoecological interpretations of the studied Albian ostracod fauna eight characteristic ostracod assemblages were distinguished, namely *Cytherella–Pontocyprella* and *Cytherella–Schuleridea* (marine dysoxic basin), *Rehacythereis reticulata–Cytherella ovata* (well-ventilated reef), *Asciocythere–"Cytheridea"* and *Cytherella ovata–"Cytheridea" baconica* (shallow marine), "*Cytheridea*" *valida–Rosacythere baconica–Dusormidea ventricosa* and *Rosacythere baconica*–dominated (brackish lagoon), as well as, *Candona arta–Darwinula leguminella* (non-marine) assemblages.

Disclosure of interest

The authors declare that they have no competing interest.

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