Bathonian and Lower Callovian ostracods of Albstadt-Pfeffingen (Middle Jurassic, Baden-Württemberg, Germany)

Elke Beher, Erich Brand & Matthias Franz

Abstract

The study of ostracods in 13 samples from the Bathonian and Lower Callovian of Albstadt-Pfeffingen (Baden-Württemberg, southern Germany) yielded five faunal assemblages. The assemblages in the Bathonian are in general more diverse than in the Lower Callovian; at the Bathonian/Callovian boundary a significant number of last occurrences of taxa are recorded (15). In the Keppleri subzone of the Lower Callovian poor microfaunal assemblages indicate unfavourable bottom water conditions. In the upper Herveyi and the lower Koenigi zone the number of individuals and the diversity both increase again.

Keywords: Ostracods, faunal assemblages, Bathonian, Callovian.

Zusammenfassung

Die Untersuchung von 13 Proben aus dem Bathonium und Unter-Callovium von Albstadt-Pfeffingen (Baden-Württemberg, S-Deutschland) ergab fünf Faunen-Gemeinschaften. Die Assoziationen im Bathonium zeigen im Allgemeinen eine höhere Diversität als die im Callovium. An der Grenze Bathonium/Callovium wurde eine größere Anzahl von Taxa (15) letztmalig beobachtet. Stark verarmte Mikrofaunen in der Keppleri-Subzone des Unter-Callovium deuten auf ungünstige Lebensbedingungen am Meeresboden hin. In der oberen Herveyi- und der unteren Koenigi-Zone steigen die Individuenzahl und die Diversität wieder an.

Contents

1. Introduction

The Pfeffingen section in the Swabian Alb (S-Germany) is an outstanding, ammonite-rich section, which has been proposed as Callovian Global Stratotype Section and Point (GSSP). This proposal is based on the complete and continuous succession of ammonite zones and subzones of the Upper Bathonian and Lower Callovian. Strontium isotope stratigraphy, magnetostratigraphy and palynology have been carried out, but did not yield unambiguous results (Callomon & Dietl 1990, 2000, Dietl 1990). Until now, no detailed studies on the Bathonian and Lower Callovian ostracods of this section have been published.

Studies on the microfauna of the upper Middle Jurassic in southern Germany were performed by Blank (1990), Buck (1954, 1959), Buck et al. (1966), Franz et al. (2009), Liebau (1987), v. Nostitz (1949) and Ziegler (1959).

Acknowledgements

Our sincere thanks go to S. Ballent (La Plata), G. Dietl (Stuttgart), W. Ohmert (Britzingen), J. Rusbült (Schwerin) and E. Tesakova (Moscow) for numerous valuable discussions. The authors thank M. Schudack (Berlin) and U. Thewalt (Ulm) for their help with SEM photographs.

We are very grateful to A. Lord (London) and S. Ballent (La Plata) for their critical reading of the manuscript; special thanks to A. Lord for improving the English.

2. Geographical location and geological setting

The section Albstadt-Pfeffingen, located in the upper reaches of the Roschbachtal, 1 km west of the centre of Pfeffingen in the Zollernalb, Western Swabian Alb, southern Germany (Fig. 1) exposes the sedimentary sequence from the uppermost Dentalienton to the lowermost Ornatenton, representing the interval from the upper Zigzag zone of the Early Bathonian to the Koenigi zone of the Late Callovian (Fig. 2).

The upper Middle Jurassic in the Swabian Alb is a succession of mudstones (clay) with intercalations of a thin limestone bed (Fuscusbank) and two iron-oolitic horizons: the Macrocephalen-Oolith and the "Anceps-Oolith" (not exposed in the Pfeffingen section).

Since the time of Quenstedt (1858) the iron oolites have been used for the lithostratigraphical subdivision of the south German Middle Jurassic: the Macrocephalen-Oolith at the base of the Ornatenton Formation spans the interval from the Late Bathonian to the Early Callovian. To avoid any misunderstandings, we follow Callomon & Dietl (2000) and Dietl (1994); but we would rather include the "Orbis-Oolith" in the Macrocephalen-Oolith, because the oolitic facies continues without interruption across the Bathonian/Callovian boundary.

In the greater part of the Swabian Alb the Middle Bathonian is missing or only fragmentary (Dietl 2008: 14ff.); in the Upper Bathonian the Hannoveranus and Hollandi subzones are absent. Further regional gaps exist in the Callovian, but are restricted to the level of faunal horizons.

3. Description of the section Albstadt-Pfeffingen

The Pfeffingen section, which was described in detail by Callomon & Dietl (1990, 2000) and Dietl (1990, 1991, 1994), exposes the uppermost Dentalienton Formation and the Lower Ornatenton Formation. In the area of Pfeffingen

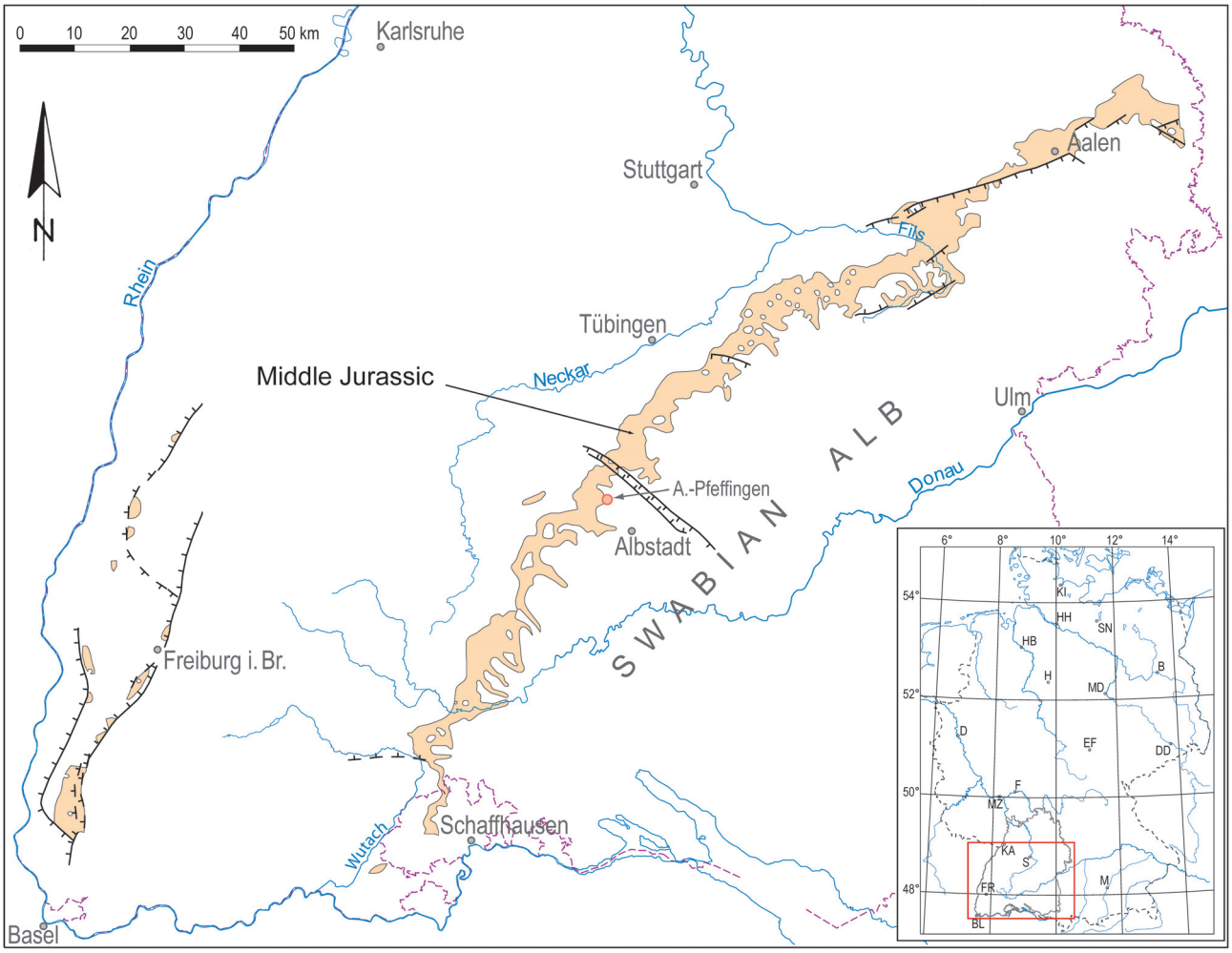


Fig. 1. Location of the section Pfeffingen.

the 10 cm thick Fuscusbank is overlain by 10–40 cm blue-grey mudstone, followed by 15 cm of an iron-oolitic marly limestone with a 5–8 cm thick layer of limestone nodules at its base. These nodules show *Lithophaga*-type bivalve borings on all sides and especially their lower surfaces are covered by serpulids (Fig. 2). The *Lithophaga* borings are filled with iron-oolitic sediment, which is often observed as the initial stage of iron-oolites in the Swabian Alb (see Franz 1986). This nodule layer and the overlaying 1.5 m thick alternation of iron-oolitic marls and limestones represent the "Orbis-Oolith" and the Macrocephalen-Oolith, which is overlain by 30–50 cm of grey mudstones of the Ornatenton.

The Dentalienton with the Fuscusbank in its upper part belongs to the Zigzag zone of the Lower Bathonian (Dietl 2007). According to Callomon & Dietl (1990, 2000) and Dietl (1994) the "Orbis-Oolith" represents the uppermost Zigzag zone, the ? *suspensum* horizon of the Progracilis zone of the Middle Bathonian and the Orbis zone of the Upper Bathonian. The Macrocephalen-Oolith sensu Dietl (1994) comprises the Discus zone of the Upper Bathonian and the Herveyi zone of the Lower Callovian. The Bathonian/Callovian boundary is between the beds 6a and 6b (Callomon & Dietl 2000). The boundary to the Koenigi zone is at the base of a small nodule layer ("toricelli-Knollen") on top of the section. The lowermost Ornatenton as exposed in this section belongs to the Gowerianus subzone of the Koenigi zone.

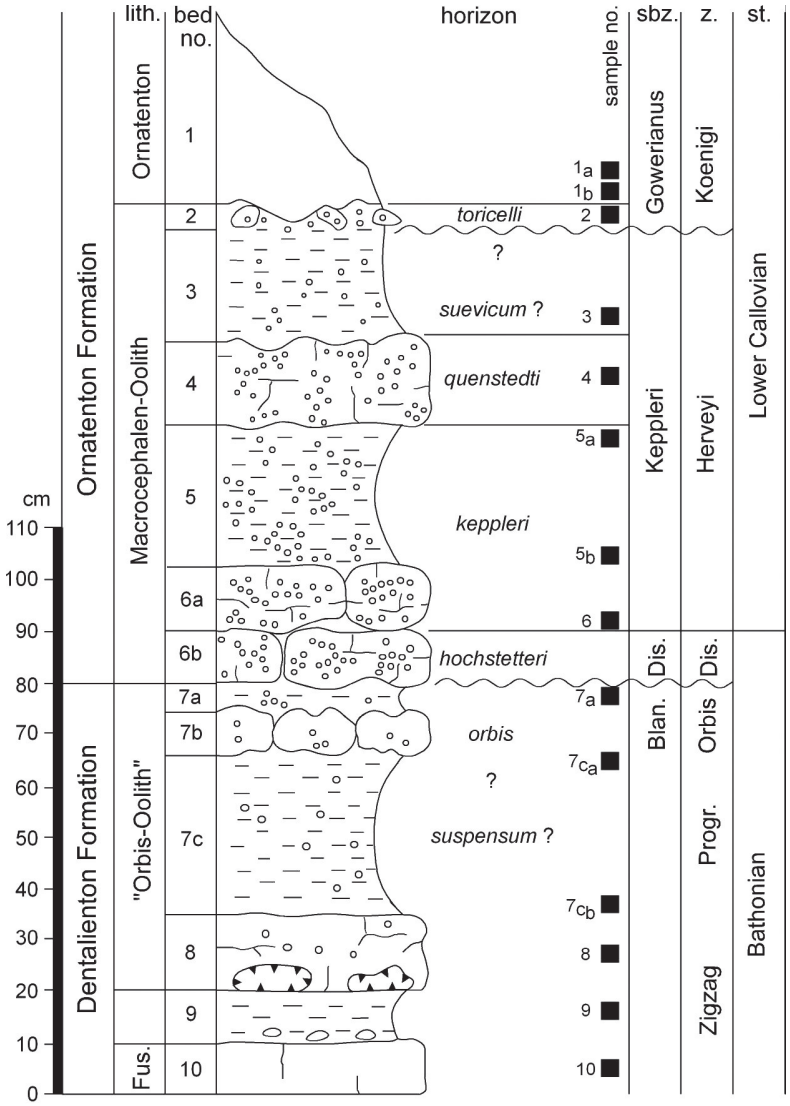


Fig. 2. Lithology of the section Pfeffingen, after Callomon & Dietl (2000), slightly modified. – Blan. = Blanazense, Dis. = Discus, Fus. = Fuscusbank, Progr. = Progracilis.

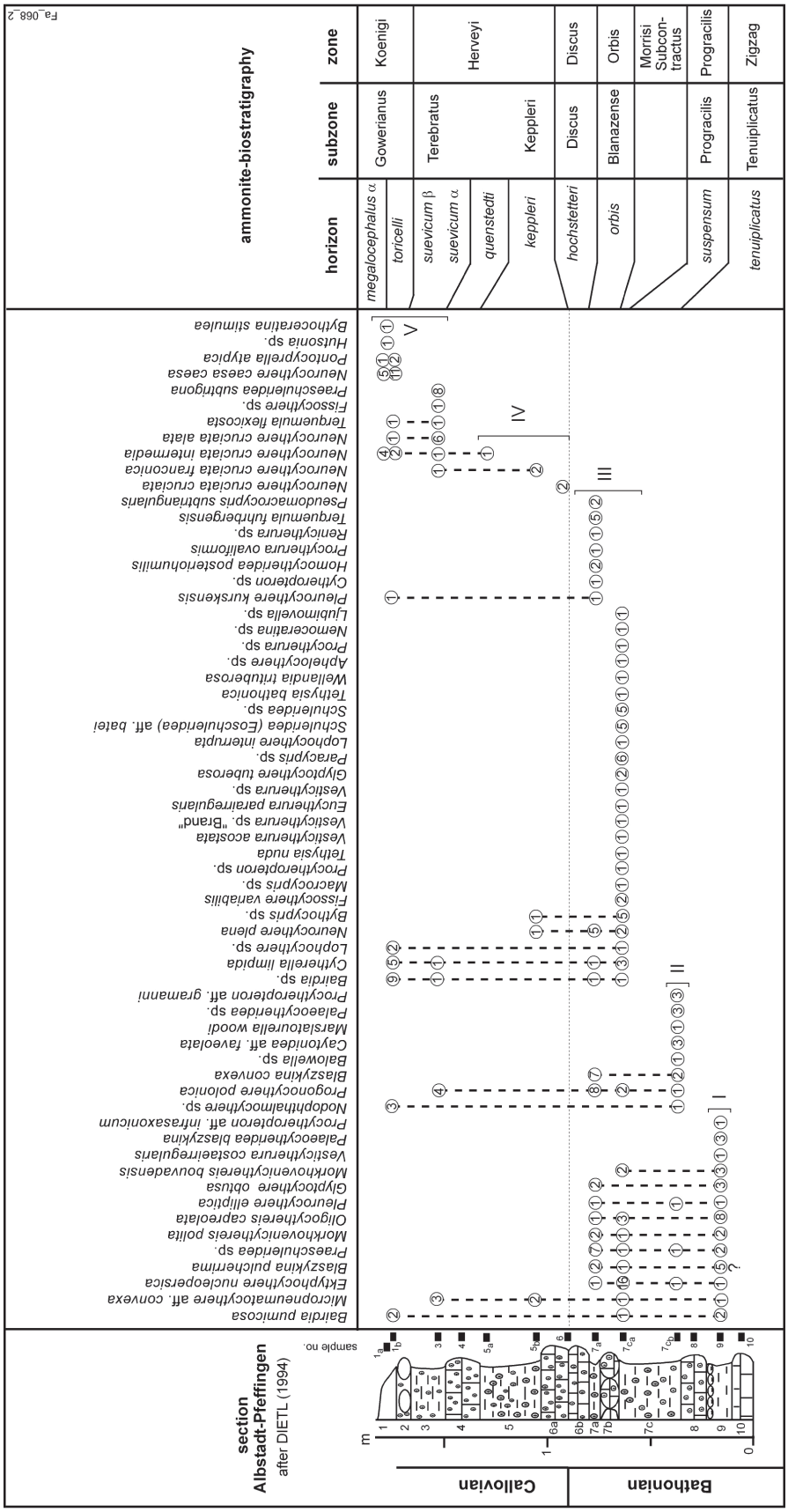


Fig. 3. Distribution of ostracods in the section Pfeffingen.

4. Material

During the annual meeting of the German Subcommission on Jurassic stratigraphy in 1991 we collected 11 (E. Brand) resp. 13 (M. Franz) samples for the study of the ostracod fauna from the Pfeffingen section. Initially we worked on the microfauna independently of each other. The relatively modest fossil content of some samples led us to the decision to study the ostracods of this section together.

The sampling was based on the ammonite faunal horizons or subzones (Callomon & Dietl 1990, Dietl 1990, 1991) and with regard to the changes of the lithologies. Thicker units were sampled twice (at the base and near the top).

From each sample 0.5–1 kg were dried, treated with hydrogen peroxide (H_2O_2) and subsequently washed on a 0.1 mm sieve. The picking of the residues and the study of the microfauna – foraminifera were also selected, but not studied in detail – was carried out under the binocular microscope and under the SEM, respectively.

The slides are stored in the collection of the Landesamt für Geologie, Rohstoffe und Bergbau in the Regierungs-Präsidium Freiburg, the specimens figured in Pl. 1 and 2 are stored under no. Em 361–Em 387.

5. Vertical distribution of the ostracods

From 10 samples, a total of 260 specimens have been obtained, corresponding to 4 suborders, 14 families and 40 genera. Samples no. 4, 8 and 10 yielded no ostracods. The stratigraphically important species are represented in Pls. 1 and 2. 63 taxa were distinguished, but some badly or fragmentarily preserved specimens as well as some juvenile individuals remain identified only on a generic level. The composition of the ostracod assemblages and the number of individuals found is shown in Fig. 2.

Based on the distribution of ostracod species five different assemblages were established, reflecting the major stratigraphic units of the section:

I – the Lower Bathonian (Zigzag zone)
II – the Middle Bathonian belonging to the Progracilis zone
III – the Upper Bathonian of the Orbis zone (the Discus zone was not sampled)
IV – the Lower Callovian belonging to the Herveyi zone, *keppleri* horizon
V – the Lower Callovian belonging to the Herveyi zone, *suevicum* horizon and the Koenigi zone.

5.1. Zigzag zone (assemblage I)

Samples no. 9, 10. – From two samples that were taken in the Zigzag zone (Tenuiplicatus subzone), only sample no. 9 yielded Ostracoda: 33 specimens representing 13 species. The majority of specimens correspond to the families Trachyleberididae (13) and Progonocytheridae (9). The majority of species persist through the Middle and Upper Bathonian. The assemblage is characterized by the occurrence of *Oligocythereis capreolata* Sheppard in Brand, *Morkhovenicythereis bouvadensis* (Dépêche), *M. polita* Brand, *Blaszykina pulcherrima* (Brand), *Glyptocythere obtusa* Lutze and *Palaeocytheridea blaszykina* Franz et al. According to Franz et al. (2009) *Oligocythereis capreolata* is the index species of the Capreolata subzone of the Pleurocythere connexa ostracod zone.

5.2. Progracilis zone (assemblage II)

Sample no. 7c (bottom). – The fauna from the *suspensum* horizon of the Progracilis zone is composed by 11 species from 11 genera (a total of 18 specimens), with a dominance of the family Progonocytheridae (seven specimens). Seven species are represented by only one individual, eight species appeared for the first time in this sample: *Progonocythere polonica* Błaszyk, *Blaszykina convexa* (Błaszyk), *Procytheropteron* aff. *gramanni* Brand, *Caytonidea* aff. *faveolata* Bate, *Marslatourella woodi* Sheppard, *Palaeocytheridea* sp., *Nodophthalmocythere* sp. and *Balowella* sp. However, the number of samples in this part of the section and the size of this particular sample are too small to interpret these "first appearances" stratigraphically.

5.3. Orbis zone (assemblage III)

Samples no. 7a, 7c (top). – The assemblage of the Upper Bathonian Orbis zone (two samples) is significantly different from those of the Lower and Middle Bathonian. The number of individuals increases to 74 resp. 51, corresponding to 42 (33/19) species, the highest number in the whole section. The majority of specimens correspond to the families Progonocytheridae (11/30), Protocytheridae (16/3), Cytheruridae (9/3) and Schulerideidae (11/7).

The Upper Bathonian is characterized by the first appearance of several new species, e. g. *Neurocythere plena* (Triebel), *Cytherella limpida* Błaszyk, *Procytherura ovaliformis* Brand, *Eucytherura parairregularis* (Brand) and *Pleurocythere kurskensis* Tesakova. According to Franz et al. (2009) *Neurocythere plena* is the index species of the N. plena ostracod zone. 25 species were found only in the Orbis zone, 17 of which are represented by a single specimen (see above). Nine further species of the genera *Blaszykina*, *Glyptocythere*, *Morkhovenicythereis* and *Oligocythereis* have their last occurrences in the Upper Bathonian.

5.4. Herveyi zone, *keppleri* horizon (assemblage IV)

Samples no. 5 (bottom and top), 6. – From the three samples a total of only 13 specimens was obtained, not allowing us to interpret the assemblage in detail.

In this assemblage only six taxa were identified, out of which one was already present in the Lower Bathonian and two in the Upper Bathonian. The most significant genus is *Neurocythere* (five specimens), represented by three subspecies of *N. cruciata*. *Neurocythere cruciata cruciata* (Triebel), which according to Buck et al. (1966: 43) characterizes the Bathonian/Callovian boundary, appears in a thin marly layer immediately above the Bathonian/Callovian boundary at the base of the *keppleri* horizon, but is very scarce. Franz et al. (2009) recently defined a Neurocythere cruciata ostracod zone for the basal Callovian.

5.5. Herveyi zone, *suevicum* horizon and Koenigi zone (assemblage V)

Samples no. 1 (bottom and top), 3. – One sample from the *suevicum* horizon and only two samples from the Koenigi zone were studied, because the exposed thickness of the latter is only 30–50 cm. The three samples together yielded 77 specimens (26, 38 and 13). The fauna of the uppermost sample may be reduced by weathering. The assemblage as a whole is also dominated by the family Progonocytheridae represented by 44 specimens, 31 of which belong to the genus *Neurocythere*. The Bairdiidae play a subdominant role, represented by 11 specimens.

Micropneumatocythere aff. *convexa* Bate and *Progonocythere polonica* have their last occurrences in the suevicum horizon. *Neurocythere caesa caesa* (Triebel), *Bythoceratina stimulea* (Schwager), *Hutsonia* sp. and *Pontocyprella atypica* (Kaye) appear for the first time in the Koenigi zone.

6. Biostratigraphical remarks

The distribution and the relative abundance of the ostracods allow us to distinguish the following four groups of ostracods:

The first group is composed of species which are represented by a greater number of specimens and that are restricted to the Bathonian: Trachyleberididae like *Morkhovenicythereis bouvadensis*, *M. polita*, *Oligocythereis capreolata*, some Progonocytheridae like *Blaszykina convexa*, *Bl. pulcherrima*, the representatives of the genus *Glyptocythere* and some Schulerideidae, e. g. *Schuleridea (Eoschuleridea)* aff. *batei* Dépèche.

The second group includes the majority of the Cytheruridae, which are also restricted to the Bathonian, but almost all were found only as single specimens. The majority of species appear in the Orbis zone, where the highest number of species in the whole section was identified (42).

The genus *Neurocythere* with *N. plena* and the subspecies of *N. cruciata* forms the third group. *N. plena* appears for the first time in the Orbis zone, *N. cruciata* (and its subspecies) appears in the Herveyi zone and then is the dominant species throughout the Lower Callovian as exposed in Pfeffingen.

The fourth group includes species with a wide vertical range with a variable, mostly small number of specimens throughout the section.

In general the ostracod zonation shows a lower stratigraphical resolution than the ammonite zonation (see e. g. Bate 2009, Brand & Mönnig 2009, Bodergat 1997, Franz et al. 2009, Wilkinson & Whatley 2009). In Pfeffingen the most prominent boundary is at the transition Upper Bathonian/Lower Callovian. Twenty two species have their last occurrences in the Orbis zone – not including taxa, which are represented by single specimens. *Neurocythere cruciata cruciata*, *N. cruciata franconica* (Triebel), *Praeschuleridea subtrigona* (Jones & Sherborn) and *Terquemula flexicosta* (Triebel) have their first occurrences in the Herveyi zone.

7. Conclusions

The ostracod assemblages of the Bathonian and Lower Callovian in the section Albstadt-Pfeffingen are fully marine, but in general are made up of a small number of specimens. The scarcity of specimens in the samples might be due to unfavourable bottom water conditions, but this needs further studies.

Specimens of the family Progonocytheridae dominate all the studied samples. However, in the Bathonian they are accompanied by the subdominant families Cytheruridae, Trachyleberididae, Schulerideidae and, less important, Protocytheridae, all of which show a remarkable decrease at the Bathonian/Callovian boundary.

The ostracod zonation as established by Franz et al. (2009) – Connexa zone, Capreolata subzone, Plena zone and Cruciata zone – is recognizable in the Bathonian and the Callovian of Pfeffingen.

The highest number of last occurrences is concentrated in the Upper Bathonian. This probably represents a significant faunal turnover, which requires confirmation through the study of ostracod assemblages from the same time interval in other areas.

8. References

Bate, R. H. (2009): Middle Jurassic (Aalenian – Bathonian). – In: Whittaker, J. E. & Hart, M. B. (eds.): Ostracods in British Stratigraphy. – The Micropalaeontological Society, Special Publications: 199–223; London (Geological Society Publishing House).

BLANK, H. (1990): Die kalkschaligen benthonischen Foraminiferen des Ober-Bajocium bis Unter-Callovium der südwestlichen Schwäbischen Alb, Baden-Württemberg. – Tübinger Mikropaläontologische Mitteilungen, **8**: 1–213.

BODERGAT, A. M. (1997): Les ostracodes marins du Jurassique Europeen – utilisation stratigraphique. – In: Groupe Française d'étude du Jurassique (1997): Biostratigraphie du Jurassique Ouest-Européen et Méditerranéen. – Bulletin du centre des recherches Elf Exploration-Production, Mémoires, **17**: 197–223.

BRAND, E. & MÖNNIG, E. (2009): Litho- und Biostratigraphie des Mittel-Jura (Dogger) in Bohrungen Norddeutschlands. – Schriftenreihe der Deutschen Gesellschaft für Geowissenschaften, **54**: 5–73.

BUCK, E. (1954): Stratigraphisch wichtige Ostracoden aus dem Lias u. Dogger von SW-Deutschland. – Freiburg i. Br. (unpublished table).

BUCK, E. (1959): Wichtige Ostrakoden aus dem Callovien u. Oxfordien von Kandern (Südbaden). – Freiburg i. Br. (unpublished table).

BUCK, E., HAHN, W. & SCHÄDEL, K. (1966): Zur Stratigraphie des Bajociums und Bathoniums (Dogger delta – epsilon) der Schwäbischen Alb. – Jahreshefte des Geologischen Landesamtes Baden-Württemberg, **8**: 23–46.

CALLOMON, J. H. & DIETL, G. (1990): Proposed definition of the Callovian Stage. Field Symposium in Swabia, Stuttgart/Albstadt (16–21 September, 1990). – ISJS, Callovian Working Group, MS: XI + 20 pp.; (unpublished).

CALLOMON, J. H. & DIETL, G. (2000): On the proposed Basal Boundary Stratotype (GSSP) of the Middle Jurassic Callovian Stage. – GeoResearch Forum, **6**: 41–54.

DIETL, G. (1990): *Procerites progracilis* COX & ARKELL und andere Ammoniten aus dem basalen Mittel-Bathonium (Mittl. Jura) der Zollernalb, Schwäb. Alb, SW-Deutschland. – Jahresberichte und Mitteilungen des Oberrheinischen Geologischen Vereins, Neue Folge, **72**: 329–340.

DIETL, G. (1991): DUGW-Subkommission für Jura-Stratigraphie, Jahrestagung 1991, Albstadt, Zollernalbkreis, Exkursionsführer. 41 pp.; Stuttgart (unpublished).

DIETL, G. (1994): Der *hochstetteri*-Horizont – ein Ammonitenfaunen-Horizont (Discus-Zone, Ober-Bathonium, Dogger) aus dem Schwäbischen Jura. – Stuttgarter Beiträge zur Naturkunde, Serie B, **202**: 1–39.

DIETL, G. (2007): Die Dentalienton-Formation (bt) des Schwäbischen Juras – Beschreibung und Gliederung. – Jahreshefte der Gesellschaft für Naturkunde in Württemberg, **163**: 5–20.

DIETL, G. (2008): Die Variansmergel-Formation (btV) des Schwäbischen Juras – Beschreibung und Gliederung. – Jahreshefte der Gesellschaft für Naturkunde in Württemberg, **163**: 5–19.

FRANZ, M. (1986): Ökologie und Fazies der Oolithhorizonte im Bajocium Südwestdeutschlands. – Dissertation Universität Heidelberg, 313 pp.; Heidelberg.

FRANZ, M., TESAKOVA, E. & BEHER, E. (2009): Documentation and revision of the index ostracods from the Lower and Middle Jurassic in SW Germany according to BUCK (1954). – Palaeodiversity, **2**: 119–167.

HORNE, D. J., COHEN, A. & MARTENS, K. (2000): Taxonomy, Morphology and Biology of Quaternary and Living Ostracoda. – In: HOLMES, J. A. & CHIVAS, A. R. (eds.): The Ostracoda – Applications in Quaternary Research. – Geophysical Monograph, **131**: 5–36.

LIEBAU, A. (1987): Skulptur-Beziehungen jurassischer Progonocytheridae (Ostracoden). – Neues Jahrbuch für Geologie und Paläontologie, Abhandlungen, **176** (1): 15–47.

NOSTITZ, S. VON (1949): Die Foraminiferen und Ostrakoden des Callovien und Oxfordien im Rheintal Oberbadens (zugleich ein Beitrag zur Stratigraphie dieser Stufen). – Thesis Universität Freiburg, 114 pp.; Freiburg i. Br. (unpublished).

QUENSTEDT, F. A. (1858): Der Jura. 842 pp.; Tübingen (Laupp).

WILKINSON, I. P. & WHATLEY, R. C. (2009): Upper Jurassic (Callovian – Portlandian). – In: WHITTAKER, J. E. & HART, M. B. (eds.): Ostracods in British Stratigraphy. – The Micropalaeontological Society, Special Publications: 241–287; London (Geological Society Publishing House).

ZIEGLER, J. H. (1959): Mikropaläontologische Untersuchungen zur Stratigraphie des Braunjura in Nordbayern. – Geologica Bavarica, **40**: 9–128.

Addresses of the authors:

Dr. ELKE BEHER, Göbelstr. 2, 68775 Ketsch, Germany
E-mail: ebeher@gmx.de

Dr. ERICH BRAND, Wilhelmshöher Weg 49, 34128 Kassel, Germany

Dr. MATTHIAS FRANZ, Regierungspräsidium Freiburg, Abt. 9: Landesamt für Geologie, Rohstoffe und Bergbau, Ref. 92;
Albertstr. 5, 79104 Freiburg i. Br., Germany
E-mail: Matthias.Franz@rpf.bwl.de

Manuscript received: 7 July 2010, accepted: 28 August 2010.

Appendix. Taxonomic list of the ostracod taxa identified in the Bathonian – Lower Callovian from the section Pfeffingen-Albstadt (Western Swabian Alb, S Germany), following the suprageneric classification proposed by Horne et al. (2000). Species are referred with their author and year of publication. The identified taxa are:

Superclass Crustacea Pennant, 1777
Class Ostracoda Latreille, 1806
Subclass Podocopa Müller, 1894
Order Platycopida Sars, 1866
Suborder Platycopina Sars, 1866
Superfamily Cytherelloidea Sars, 1866
Family Cytherellidae Sars, 1866
Genus *Cytherella* Jones, 1849

Cytherella limpida Błaszyk, 1967

M a t e r i a l : 4 carapaces, 4 right valves, 2 left valves.
L a y e r s : no. 1 (bottom), 3, 7a, 7c (top).
D i s t r i b u t i o n : Orbis zone – Koenigi zone.

Order Podocopida Müller, 1894
Suborder Bairdiocopina Sars, 1866
Superfamily Bairdioidea Sars, 1866
Family Bairdiidae Sars, 1888
Genus *Bairdia* Mc Coy, 1844

Bairdia pumicosa Sheppard in Franz et al., 2009

M a t e r i a l : 5 carapaces.
L a y e r s : no. 1 (bottom), 7c (top), 9.
D i s t r i b u t i o n : Zigzag – Koenigi zone.

Bairdia sp.

M a t e r i a l : 8 carapaces, 1 right valve, 2 left valves.
L a y e r s : no. 1 (bottom), 7a, 7c (top).
D i s t r i b u t i o n : Orbis – Koenigi zone.

Family Bythocyprididae Maddox, 1969
Genus *Bythocypris* Brady, 1880

Bythocypris sp.

M a t e r i a l : 4 carapaces, 1 right valve, 1 left valve.
L a y e r s : no. 5 (bottom), 7c (top).
D i s t r i b u t i o n : Orbis – Herveyi zone.

Suborder Cypridocopina Jones, 1901
Superfamily Macrocypridoidea Müller, 1912
Family Macrocyprididae Müller, 1912
Genus *Macrocypris* Brady, 1868

Macrocypris sp.

M a t e r i a l : 1 carapace.
L a y e r : no. 7c (top).
D i s t r i b u t i o n : Orbis zone.

Genus *Pseudomacrocypris* Michelsen, 1975

Pseudomacrocypris subtriangularis Michelsen, 1975

M a t e r i a l : 2 carapaces.
L a y e r : no. 7a.
D i s t r i b u t i o n : Orbis zone.

Superfamily Pontocypridoidea Müller, 1894
Family Pontocyprididae Müller, 1894
Genus *Pontocyprella* Ljubimova, 1955

Pontocyprella atypica (Kaye, 1965)

M a t e r i a l : 2 carapaces, 1 right valve.
L a y e r : no. 1 (bottom and top).
D i s t r i b u t i o n : Koenigi zone.

Superfamily Cypridoidea Baird, 1845
Family Paracyprididae Sars, 1923
Genus *Paracypris* Sars, 1866

Paracypris sp.

M a t e r i a l : 6 carapaces.
L a y e r : no. 7c (top).
D i s t r i b u t i o n : Orbis zone.

Suborder Cytherocopina Baird, 1850
Superfamily Cytheroidea Baird, 1850
Family Bythocytheridae Sars, 1926
Genus *Bythoceratina* Hornibrook, 1952

Bythoceratina stimulea (Schwager, 1866)
Pl. 2, Fig. 8

M a t e r i a l : 1 carapace.
L a y e r : no. 1 (top).
D i s t r i b u t i o n : Koenigi zone.

Genus *Nemoceratina* Gründel & Kozur, 1971

Nemoceratina sp.

M a t e r i a l : 1 right valve.
L a y e r : no. 7c (top).
D i s t r i b u t i o n : Orbis zone.

Genus *Ljubimovella* Brand & Malz, 1961

Ljubimovella sp.

M a t e r i a l : 1 carapace.
L a y e r : no. 7c (top).
D i s t r i b u t i o n : Orbis zone.

Family Protocytheridae Ljubimova, 1956
Genus *Pleurocythere* Triebel, 1951

Pleurocythere elliptica Błaszyk, 1967

M a t e r i a l : 2 right valves, 1 left valve.
L a y e r s : no. 7a, 7c (bottom), 9.
D i s t r i b u t i o n : Zigzag – Orbis zone.

Pleurocythere kurskensis Tesakova, 2009
Pl. 2, Figs. 4, 11

M a t e r i a l : 1 carapace, 1 left valve.
L a y e r s : no. 1 (bottom), 7a.
D i s t r i b u t i o n : Orbis – Koenigi zone.

Genus *Palaeocytheridea* Mandelstam, 1947

Palaeocytheridea blaszykina Franz et al., 2009
Pl. 1, Fig. 7

M a t e r i a l : 2 right valves, 1 left valve.
L a y e r : no. 9.
D i s t r i b u t i o n : Zigzag zone.

Palaeocytheridea sp.
Pl. 1, Fig. 4

M a t e r i a l : 2 carapaces, 1 right valve.
L a y e r : no. 7c (bottom).
D i s t r i b u t i o n : ? Orbis zone.

Genus *Ektyphocythere* Bate, 1963

Ektyphocythere nucleopersica Błaszyk, 1967
Pl. 2, Fig. 2

M a t e r i a l : 8 right valves, 11 left valves.
L a y e r s : no. 7a, 7c (top and bottom), 9.
D i s t r i b u t i o n : Zigzag – Orbis zone.

Ektyphocythere sp. ?

M a t e r i a l : 1 right valve.
L a y e r : no. 7a.
D i s t r i b u t i o n : Orbis zone.

Family Progonocytheridae Sylvester-Bradley, 1948
Genus *Neurocythere* Whatley, 1970

Neurocythere caesa caesa (Triebel, 1951)
Pl. 2, Fig. 12

M a t e r i a l : 7 carapaces, 3 right valves, 6 left valves.
L a y e r : no. 1 (bottom and top).
D i s t r i b u t i o n : Koenigi zone.

Neurocythere cruciata intermedia (Lutze, 1960)
Pl. 2, Fig. 9

M a t e r i a l : 4 carapaces, 1 right valve, 3 left valves.
L a y e r s : no. 1 (bottom and top), 3, 5 (top).
D i s t r i b u t i o n : Herveyi – Koenigi zone.

Neurocythere cruciata alata (Whatley, 1970)
Pl. 2, Fig. 5

M a t e r i a l : 5 right valves, 2 left valves.
L a y e r s : no. 1 (bottom), 3.
D i s t r i b u t i o n : Herveyi – Koenigi zone.

Neurocythere cruciata franconica (Triebel, 1951)

M a t e r i a l : 1 carapace, 1 right valve, 1 left valve.
L a y e r s : no. 3, 5 (bottom).
D i s t r i b u t i o n : Herveyi zone.

Neurocythere cruciata cruciata (Triebel, 1951)
Pl. 2, Fig. 6

M a t e r i a l : 2 carapaces.
L a y e r : no. 6.
D i s t r i b u t i o n : Herveyi zone.

Neurocythere plena (Triebel, 1951)
Pl. 2, Fig. 1

M a t e r i a l : 2 carapaces, 2 right valves, 4 left valves.
L a y e r s : no. 5 (top), 7a, 7c (top).
D i s t r i b u t i o n : Orbis – Herveyi zone.

Genus *Lophocythere* Sylvester-Bradley, 1948

Lophocythere interrupta Triebel, 1951

M a t e r i a l : 1 left valve.
L a y e r : no. 7c (top).
D i s t r i b u t i o n : Orbis zone.

Lophocythere sp.

M a t e r i a l : 2 right valves.
L a y e r : no. 1 (bottom).
D i s t r i b u t i o n : Orbis – Koenigi zone.

Genus *Nodophthalmocythere* Hiltermann, 1958

Nodophthalmocythere sp.

M a t e r i a l : 3 right valves, 1 left valve.
L a y e r s : no. 1 (bottom), 7c (bottom).
D i s t r i b u t i o n : Progracilis – Koenigi zone.

Genus *Terquemula* Błaszyk & Malz, 1965

Terquemula flexicosta (Triebel, 1951)
Pl. 2, Fig. 7

M a t e r i a l : 1 right valve, 1 left valve.
L a y e r s : no. 1 (bottom), 3.
D i s t r i b u t i o n : Herveyi – Koenigi zone.

Terquemula fuhrbergensis (Triebel, 1951)

M a t e r i a l : 2 carapaces, 2 right valves, 1 left valve.
L a y e r : no. 7a.
D i s t r i b u t i o n : Orbis zone.

Genus *Fissocythere* Malz, 1959

Fissocythere variabilis Malz, 1959
Pl. 2, Fig. 14

M a t e r i a l : 2 carapaces.
L a y e r : no. 7c (top).
D i s t r i b u t i o n : Orbis zone.

Fissocythere sp.

M a t e r i a l : 1 left valve.
L a y e r : no. 3.
D i s t r i b u t i o n : Herveyi zone.

Genus *Micropneumatocythere* Bate, 1963

Micropneumatocythere aff. *convexa* Bate, 1963
Pl. 2, Fig. 10

M a t e r i a l : 5 left valves, 2 right valves.
L a y e r s : no. 3, 5 (bottom), 7c (top), 9.
D i s t r i b u t i o n : Zigzag – Herveyi zone.

Genus *Progonocythere* Sylvester-Bradley, 1948

Progonocythere polonica Błaszyk, 1959
Pl. 1, Fig. 8

M a t e r i a l : 4 carapaces, 5 right valves, 6 left valves.
L a y e r s : no. 3, 7a, 7c (top and bottom).
D i s t r i b u t i o n : ? Orbis – Herveyi zone.

Genus *Blaszykina* Brand, 1990

Blaszykina convexa (Błaszyk, 1967)
Pl. 1, Fig. 13

M a t e r i a l : 1 carapace, 8 left valves.
L a y e r s : no. 7a, 7c (bottom).
D i s t r i b u t i o n : ? Orbis – Orbis zone.

Blaszykina pulcherrima (Brand, 1990)
Pl. 1, Fig. 6

M a t e r i a l : 1 carapace, 1 right valve, 6 left valves.
L a y e r s : no. 7a, 7c (top), 9.
D i s t r i b u t i o n : Zigzag – Orbis zone.

Genus *Caytonidea* Bate, 1956

Caytonidea aff. *faveolata* Bate, 1965
Pl. 1, Fig. 9

M a t e r i a l : 2 right valves, 1 left valve.
L a y e r : no. 7c (bottom).
D i s t r i b u t i o n : ? Orbis zone.

Genus *Glyptocythere* Brand & Malz, 1962

Glyptocythere obtusa Lutze, 1960
Pl. 1, Fig. 3

M a t e r i a l : 3 carapaces, 1 right valve, 1 left valve.
L a y e r s : no. 7a, 9.
D i s t r i b u t i o n : Zigzag – Orbis zone.

Glyptocythere tuberosa Błaszyk, 1967

M a t e r i a l : 2 left valves.
L a y e r : no. 7c (top).
D i s t r i b u t i o n : Orbis zone.

Family Cytheridae Baird, 1850
Genus *Marslatourella* Malz, 1959

Marslatourella woodi Sheppard, 1981
Pl. 1, Fig. 11

M a t e r i a l : 1 carapace.
L a y e r : no. 7c (bottom).
D i s t r i b u t i o n : ? Orbis zone.

Family Cytherideidae Sars, 1925
Genus *Aphelocythere* Triebel & Klingler, 1959

Aphelocythere sp.

M a t e r i a l : 1 carapace.
L a y e r : no. 7c (top).
D i s t r i b u t i o n : Orbis zone.

Genus *Homocytheridea* Bate, 1963

Homocytheridea posteriohumilis (Błaszyk, 1967)
Pl. 2, Fig. 13

M a t e r i a l : 2 carapaces.
L a y e r : no. 7a.
D i s t r i b u t i o n : Orbis zone.

Family Schulerideidae Mandelstam, 1959
Genus *Praeschuleridea* Bate, 1963

Praeschuleridea subtrigona (Jones & Sherborn, 1888)

M a t e r i a l : 5 right valves, 3 left valves.
L a y e r : no. 3.
D i s t r i b u t i o n : Herveyi zone.

Praeschuleridea sp.

M a t e r i a l : 5 carapaces, 1 right valve, 5 left valves.
L a y e r s : no. 7a, 7c (top and bottom), 9.
D i s t r i b u t i o n : Zigzag – Orbis zone.

Genus *Schuleridea* Swarts & Swain, 1946

Schuleridea (Eoschuleridea) aff. *batei* Dépêche, 1969

M a t e r i a l : 5 right valves.
L a y e r : no. 7c (top).
D i s t r i b u t i o n : Orbis zone.

Schuleridea sp.

M a t e r i a l : 4 carapaces, 1 left valve.
L a y e r : no. 7c (top).
D i s t r i b u t i o n : Orbis zone.

Family Cytheruridae Müller, 1894
Genus *Balowella* Wienholz, 1967

Balowella sp.

M a t e r i a l : 1 carapace.
L a y e r : no. 7c (bottom).
D i s t r i b u t i o n : ? Orbis zone.

Genus *Eucytherura* Müller, 1894

Eucytherura parairregularis (Brand, 1990)
Pl. 2, Fig. 3

M a t e r i a l : 1 carapace.
L a y e r : no. 7c (top).
D i s t r i b u t i o n : Orbis zone.

Genus *Hutsonia* Swain, 1946

Hutsonia sp.

M a t e r i a l : 1 left valve.
L a y e r : no. 1 (top).
D i s t r i b u t i o n : Koenigi zone.

Genus *Procytherura* WHATLEY, 1970

Procytherura ovaliformis BRAND, 1990

M a t e r i a l : 1 carapace.
L a y e r : no. 7a.
D i s t r i b u t i o n : Orbis zone.

Procytherura sp.

M a t e r i a l : 1 carapace.
L a y e r : no. 7c (top).
D i s t r i b u t i o n : Orbis zone.

Genus *Procytheropteron* LJUBIMOVA, 1955

Procytheropteron aff. *gramanni* BRAND, 1990
Pl. 1, Fig. 12

M a t e r i a l : 2 right valves, 1 left valve.
L a y e r : no. 7c (bottom).
D i s t r i b u t i o n : ? Orbis zone.

Procytheropteron aff. *infrasaxonicum* BRAND, 1990

M a t e r i a l : 1 right valve.
L a y e r : no. 9.
D i s t r i b u t i o n : Zigzag zone.

Procytheropteron sp.
Pl. 1, Fig. 10

M a t e r i a l : 1 left valve.
L a y e r : no. 7c (top).
D i s t r i b u t i o n : Orbis zone.

Genus *Renicytherura* GRÜNDEL, 1981

Renicytherura sp.

M a t e r i a l : 1 carapace.
L a y e r : no. 7a.
D i s t r i b u t i o n : Orbis zone.

Genus *Tethysia* DONZE, 1975

Tethysia bathonica SHEPPARD in BRAND, 1990

M a t e r i a l : 1 carapace.
L a y e r : no. 7c (top).
D i s t r i b u t i o n : Orbis zone.

Tethysia nuda BRAND, 1990

M a t e r i a l : 1 carapace.
L a y e r : no. 7c (top).
D i s t r i b u t i o n : Orbis zone.

Genus *Vesticytherura* GRÜNDEL, 1964

Vesticytherura acostata TESAKOVA, 2002

M a t e r i a l : 1 carapace.
L a y e r : no. 7c (top).
D i s t r i b u t i o n : Orbis zone.

Vesticytherura costaeirregularis (WHATLEY, 1970)

M a t e r i a l : 1 right valve.
L a y e r : no. 9.
D i s t r i b u t i o n : Zigzag zone.

Vesticytherura sp. "BRAND, 1990"

M a t e r i a l : 1 carapace.
L a y e r : no. 7c (top).
D i s t r i b u t i o n : Orbis zone.

Vesticytherura sp.

M a t e r i a l : 1 carapace.
L a y e r : no. 7c (top).
D i s t r i b u t i o n : Orbis zone.

Genus *Wellandia* BATE & COLEMAN, 1975

Wellandia trituberosa BRAND, 1990

M a t e r i a l : 1 carapace.
L a y e r : no. 7c (top).
D i s t r i b u t i o n : Orbis zone.

Family Trachyleberididae SYLVESTER-BRADLEY, 1948
Genus *Oligocythereis* SYLVESTER-BRADLEY, 1948

Oligocythereis capreolata SHEPPARD in BRAND, 1990
Pl. 1, Fig. 1

M a t e r i a l : 5 carapaces, 4 right valves, 3 left valves.
L a y e r s : no. 7a, 7c (top), 9.
D i s t r i b u t i o n : Zigzag – Orbis zone.

Genus *Morkhovenicythereis* GRÜNDEL, 1975

Morkhovenicythereis bouvadensis (DÉPÊCHE, 1969)
Pl. 1, Fig. 2

M a t e r i a l : 4 carapaces, 1 left valve.
L a y e r s : no. 7c (top), 9.
D i s t r i b u t i o n : Zigzag – Orbis zone.

Morkhovenicythereis polita BRAND, 1990
Pl. 1, Fig. 5

M a t e r i a l : 2 carapaces, 3 left valves.
L a y e r s : no. 7a, 7c (top), 9.
D i s t r i b u t i o n : Zigzag – Orbis zone.

Plate 1

Ostracods from the Zigzag and Progracilis zones (assemblages I + II), section Albstadt-Pfeffingen.

Fig. 1. *Oligocythereis capreolata* Sheppard in Brand, 1990; Em 361, carapace, right lateral view; sample no. 9, Zigzag zone.
Fig. 2. *Morkhovenicythereis bouvadensis* (Dépêche, 1969); Em 362, carapace, left lateral view; sample no. 9, Zigzag zone.
Fig. 3. *Glyptocythere obtusa* Lutze, 1960; Em 363, carapax, right lateral view; sample no. 9, Zigzag zone.
Fig. 4. *Palaeocytheridea* sp.; Em 364, right valve, external view; sample no. 9, Zigzag zone.
Fig. 5. *Morkhovenicythereis polita* Brand, 1990; Em 365, carapace, right lateral view; sample no. $7c_b$, Progracilis zone.
Fig. 6. *Blaszykina pulcherrima* (Brand, 1990); Em 366, right valve, external view; sample no. $7c_b$, Progracilis zone.
Fig. 7. *Palaeocytheridea blaszykina* Franz et al., 2009; Em 367, right valve, external view; sample no. 9, Zigzag zone.
Fig. 8. *Progonocythere polonica* (Blaszyk, 1959); Em 368, right valve, external view; sample no. $7c_b$, Progracilis zone.
Fig. 9. *Caytonidea* aff. *faveolata* Bate, 1965; Em 369, right valve, external view; sample no. $7c_b$, Progracilis zone.
Fig. 10. *Procytheropteron* sp.; Em 370, left valve, external view; sample no. $7c_a$, ? Orbis-zone.
Fig. 11. *Marslatourella woodi* Sheppard, 1981; Em 371, carapace, left lateral view; sample no. $7c_b$, Progracilis zone.
Fig. 12. *Procytheropteron* aff. *gramanni* Brand, 1990; Em 372, left valve, external view; sample no. $7c_b$, Progracilis zone.
Fig. 13. *Blaszykina convexa* (Blaszyk, 1967); Em 373, left valve, external view; sample no. $7c_b$, Progracilis zone.

Length of scale bar = 0.1 mm.

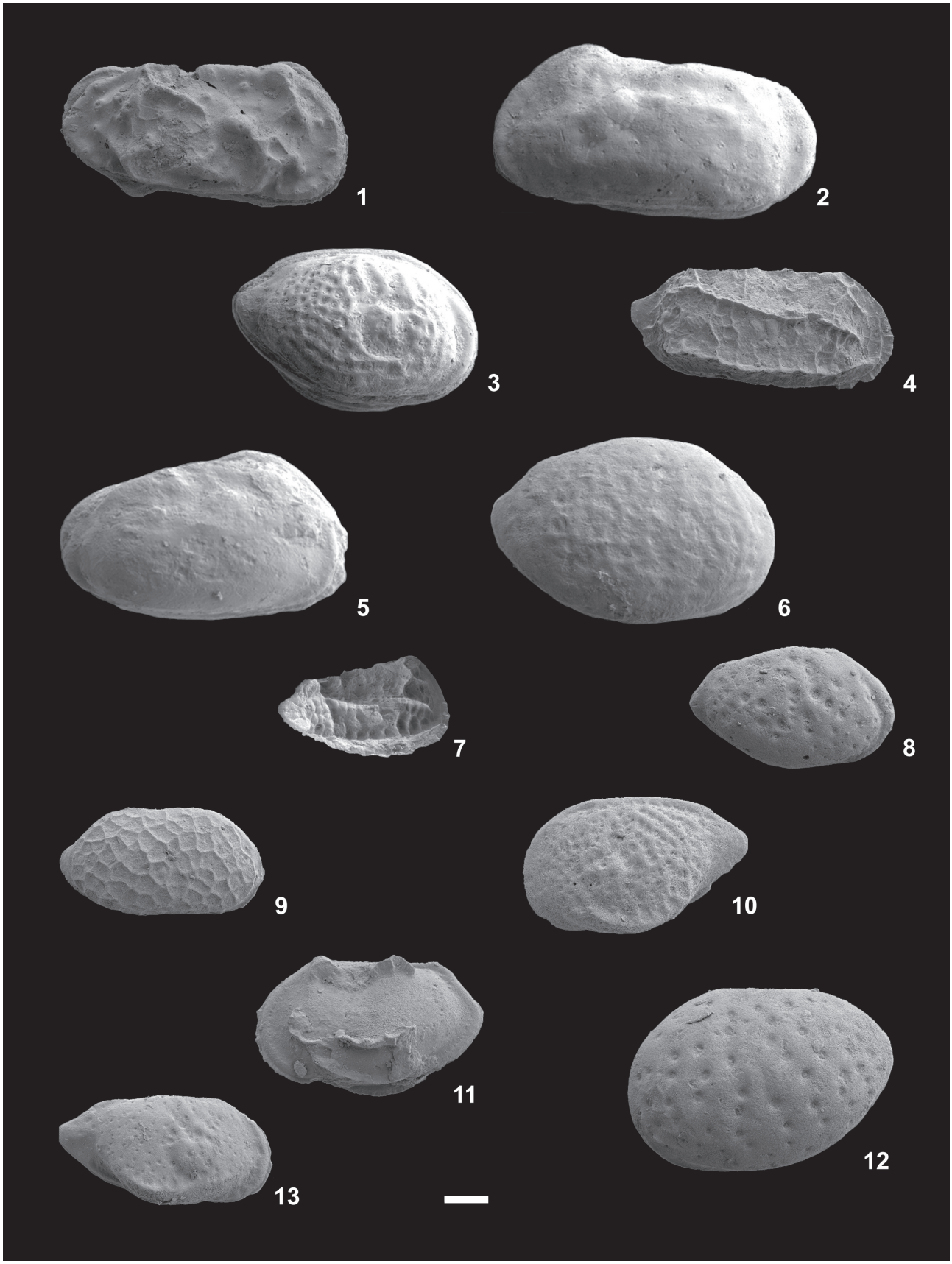

1
2
3
4
5
6
7
8
9
10
11
12
13

Plate 2

Ostracods from the Orbis, Herveyi and Koenigi zones (assemblages III – V), section Albstadt-Pfeffingen.

Fig. 1. *Neurocythere plena* (Triebel, 1951); Em 374, left valve, external view; sample no. 7a, Orbis zone.

Fig. 2. *Ektyphocythere nucleopersica* Blaszyk, 1967; Em 375, right valve, external view; sample no. 7a, Orbis zone.

Fig. 3. *Eucytherura parairregularis* (Brand, 1990); Em 376, carapace, left lateral view; sample no. $7c_a$, ? Orbis zone.

Fig. 4. *Pleurocythere kurskensis* Tesakova, 2009; Em 377, carapace, right lateral view; sample no. 7a, Orbis zone.

Fig. 5. *Neurocythere cruciata alata* (Whatley, 1970); Em 378, carapace, right lateral view; sample no. 3, Herveyi zone, *suevicum* horizon.

Fig. 6. *Neurocythere cruciata cruciata* (Triebel, 1951); Em 379, carapace, left lateral view; sample no. 6, Herveyi zone, *keppleri* horizon.

Fig. 7. *Terquemula flexicosta* (Triebel, 1951); Em 380, left valve, external view; sample no. 1b, Koenigi zone.

Fig. 8. *Bythoceratina stimulea* (Schwager, 1866); Em 381, carapace, left lateral view; sample no. 1a, Koenigi zone.

Fig. 9. *Neurocythere cruciata intermedia* (Lutze, 1960); Em 382, right valve, external view; sample no. 3, Herveyi zone, *suevicum* horizon.

Fig. 10. *Micropneumatocythere* aff. *convexa* Bate, 1963; Em 383, left valve, external view; sample no. 3, Herveyi zone, *suevicum* horizon.

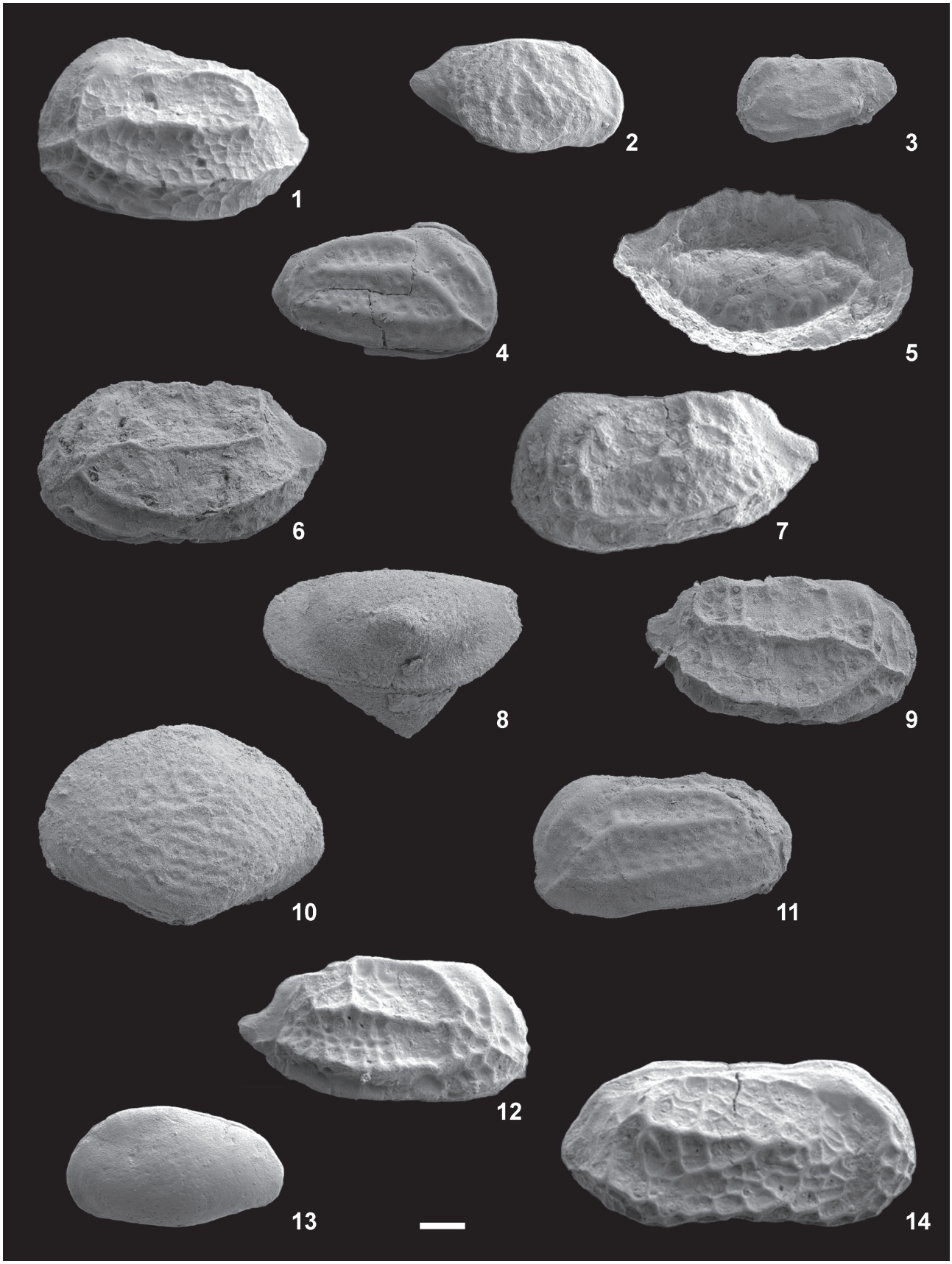
Fig. 11. *Pleurocythere kurskensis* Tesakova, 2009; Em 384, left valve, external view; sample no. 1b, Koenigi zone.

Fig. 12. *Neurocythere caesa caesa* (Triebel, 1951); Em 385, right valve, external view; sample no. 1b, Koenigi zone.

Fig. 13. *Homocytheridea posteriohumilis* (Blaszyk, 1967); Em 386, carapace, left lateral view; sample no. 7a, Orbis zone.

Fig. 14. *Fissocythere variabilis* Malz, 1959; Em 387, carapace, right lateral view; sample no. $7c_a$, ? Orbis zone.

Length of scale bar = 0.1 mm.


1
2
3
4
5
6
7
8
9
10
11
12
13
14