Stratigraphy of the Middle Jurassic Sengenthal Formation of Polsingen-Ursheim (Nördlinger Ries, Bavaria, Southern Germany)

Authors: Dietze, Volker, Franz, Matthias, Kutz, Michael, and Waltschew, Anton

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Volker Dietze, Matthias Franz, Michael Kutz & Anton Waltschew

Abstract

We here present a synopsis of the litho- and biostratigraphy of the Middle Jurassic Sengenthal Formation (Lower Bajocian, Discites Zone to Lower Oxfordian, Cordatum Zone) in the section Polsingen-Ursheim (Nördlinger Ries, Bavaria). The ammonite biostratigraphy, based on bed-by-bed collections from three excavation pits, is correlated with the microfauna (ostracods, foraminifera) from the nearby drillcore VB Polsingen-Ursheim. Our results are compared with literature data from other regions. The distribution of ostracods confirms the zonation for the Middle Jurassic of Southern Germany (Franz et al. 2014a; Ohmert 2004) when correlated with the ammonite biostratigraphy of the Nördlingen Ries area (Dietze & Dietl 2006; Dietze et al. 2002, 2007). This positive correlation could be underlined by the presence of seven biostratigraphically valuable species of foraminifera. The synoptical analysis of the three fossil groups leads to a more detailed subdivision of the Sengenthal Formation and to a more precise correlation.

Keywords: Lithostratigraphy, biostratigraphy, ammonites, ostracods, foraminifera, Sengenthal Formation, Middle Jurassic.

1. Introduction

The Sengenthal Formation (Zeiss 1977; Franz et al. 2014b) has been studied in detail several times during the last decade especially in respect to its ammonite fauna (Arp 2001; Callomon et al. 1987; Dietze & Dietl 2006; Dietze et al. 2002, 2007). Data concerning the microfauna have been published by Ziegler (1959), Munk (1978, 1993) and Franz et al. (2014a).

In the present paper the biostratigraphical subdivision of the Sengenthal Formation by ammonites, ostracods and foraminifera is described synoptically for the first time.

In 2012 we could study the Sengenthal Formation in Ursheim (northeastern part of the Ries impact crater) in a completely cored drill section. In the years 2010 to 2013 the first author investigated the greatest part of the formation exposed in three excavation pits.

Abbreviations: BAB = Bundesautobahn (Highway), GK = Geologische Karte (geological map), TK = Topographische Karte (topographical map), SEM = scanning electron microscope, VB = Versuchsbohrung (test boring).

Acknowledgements

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2. Location and geological overview

Polsingen-Ursheim is a small village close to the northeastern margin of the Ries impact crater (TK and GK 25 of Bavaria, map sheet 7030 Wolferstadt; Fig. 1). The geology to the west of Ursheim is composed of sediments of the Tertiary Ries Crater Lake, to the north neighboured by a mosaic of allochthonous and parautochthonous megablocks from the Eisensandstein, Sengenthal, Dietfurt and Arzberg formations. In the eastern part of the village, outside of the crater, the bedrocks are built by Upper Jurassic limestones and marlstones (Dietfurt and Arzberg formations), partially overlain by allochthonous blocks of the Middle and Upper Jurassic up to several hundred square meters of size.

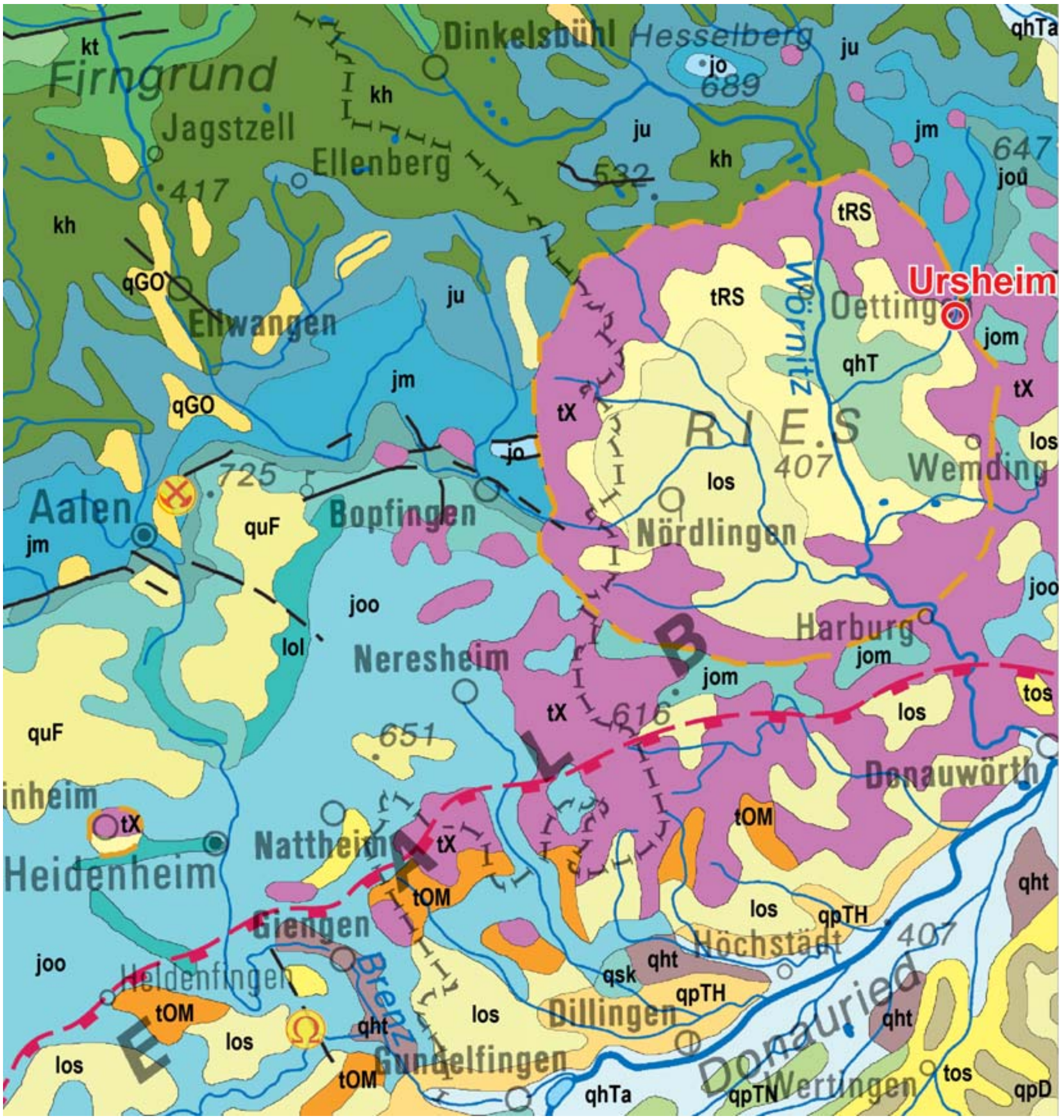

Fig. 1. Geological map, showing the location of Polsingen-Ursheim in the northeastern part of the Ries crater (detail from LGRB 2011, slightly modified; symbols according to 'Symbolschlüssel Geologie Baden-Württemberg'). Legend: qhTa, Holocene floodplain deposits; qht, Holocene bog; qsk, Holocene tufa; qhT, Holocene river deposits; quF, flint-bearing silty loam; los, loess sediment; lol, loess loam; qpTN, low-lying terrace deposits; qpTH, high-lying terrace deposits; qGO, Quaternary Goldshöfe Sand; qpD, cover gravel; tRS, Ries Crater Lake Formation; tX, Impakt Formation; tOS, Upper Freshwater Molasse; tOM, Upper Marine Molasse; jo, Upper Jurassic (undivided); joo, upper Upper Jurassic; jom, middle Upper Jurassic; jou, lower Upper Jurassic; jm, Middle Jurassic; ju, Lower Jurassic; kh, Upper Middle and Upper Keuper; kt, Lower Middle Keuper.

2. Stratigraphy of the Sengenthal Formation

2.1. Lithostratigraphy

The Sengenthal Formation consists of calcarenites and sandy mudstones in its lower part (Weiße-Laber Subformation), followed by a several meters thick alternation of iron oolitic marlstones and limestones (Berching Subformation). These are overlain by dark mudstones of the Winnberg Subformation, with a layer of sandy, glauconitic marlstone (Sachsendorf horizon) on top (Franz et al. 2014b).

In the following we use the traditional names for the members 'Wedelsandstein', 'Humphriesi-Oolith', 'Bifurcaten-Oolith', 'Parkinsonien-Oolith', 'Varians-Oolith', 'Macrocephalen-Oolith' and 'Ornatenton' (see Dietze et al. 2007: 107). These informal names are helpful for a pragmatic subdivision, but are also used for synchronous beds in other formations of the Braunjura Group (Middle Jurassic).

2.2. Core drilling

The test boring VB Ursheim has been brought down in 2012 in order to improve the public drinking water supply. It was located about 1 km southeast to the village (r 44 06 858, h 54 22 628). The 127 m deep boring sunk through the following set of strata:

0–1.10 m Quaternary and Tertiary sediments (impact ejection)
– 9.00 m Karstic deposits
– 73.55 m Dietfurt Formation (Upper Jurassic)
– 127.00 m Braunjura
– 86.20 m Sengenthal Formation (jmS)
– 76.40 m Sachsendorf horizon (‘Glaukonitsandmergel’)
– 76.80 m Winnberg Subformation (‘Ornatenton’)
– 82.85 m Berching Subformation (‘Humphriesi-Oolith’–‘Macrocephalen-Oolith’)
– 86.20 m Weiße-Laber Subformation (‘Wedelsandstein’)
– 121.07 m Eisensandstein Formation (jmES)
– 90.20 m Disciteston
– 127.00 m Opalinuston Formation (jmOPT)

2.3. Excavation pits in 2010/2011 and 2013

In the years 2010/2011 and 2013 three big fermenters for the production of biogas were constructed in the northern part of Ursheim (Fig. 2). The section in Fig. 3 could be composed from three parts that were exposed in these excavation pits. The basal part of the section could be reconstructed on the base of a number of photographs, kindly provided by the foundation expert. These pictures showed clearly, that the sequence of strata may vary substantially within a short distance. The different detail sections overlap one another so that the complete section could be reconstructed reliably.

The pits are situated in an isolated block in the transitional zone of the crater margin to the undisturbed Jurassic bedrocks of the southwestern Franconian Alb. In the third excavation pit (2013) the strata suddenly bent steeply downwards in a southward direction (towards the crater) and disappeared under the pit bottom.

In the following the section of the Sengenthal Formation is described top down; the strata have been numbered in the opposite direction:

Berching Subformation

Above the ‘Varians-Oolith’, the topmost part of the insitu sequence, there were yellow-beige oolitic rock fragments with big, dark brown ooids and rare fragments of *Macrocephalites macrocephalus*, which could be assigned to the ‚Macrocephalen-Oolith’ [bed 11].

Fig. 2. Photograph of the section Polsingen-Ursheim, exposed in excavation pits at the northern outskirts of the village, Lower Bajocian to Lower Callovian. Numbers = bed numbers (see text).

'Varians-Oolith' (in-situ bedded: 0.4–0.45 m; only the lower part of this bed was preserved [bed 10]):

- 0.3 m Fe-oolitic marly limestone [bed 10b], varying in colours from carmine to brown and grey blue. Numerous Fe-ooids are arranged in clouds, brachiopods are frequent. The ammonites are often covered by a yellow-beige stromatolite-like crust. From the bed we got: *Oraniceras wuerttembergicum*, *O. gyrumbilicum*; from its bottom: *Procerites laeviplex* (Pl. 8, Figs. 3, 4), *Oraniceras wuerttembergicum* (Pl. 8, Figs. 1, 2) und *O. gyrumbilicum* (Pl. 8, Figs. 4, 5).
- 0.1–0.13 m Fe-oolitic clay marl [bed 10a]; no ammonites found.

'Parkinsonien-Oolith' (about 0.9 m [bed 9]):

Strongly weathered, predominantly red series of Fe-oolitic marly limestones, towards its base decreasing carbonaceous.

- 0.2 m Fe-oolitic marly limestone [bed 9d] with very rare brachiopods. From here we got one badly preserved fragment of *Parkinsonia* [„*Gonolkites*"] *convergens* (not figured).
- Fe-oolitic bedding joint.
- About 0.15 m red Fe-oolitic marly limestone [bed 9c]; *Parkinsonia* sp.
- 0.2–0.3 m carmine, Fe-oolitic limestone with densely packed ooids [bed 9b], splitting up to irregular small layers (0.03–0.1 m thick). These yielded: *Parkinsonia pseudoparkinsoni* (Pl. 6, Figs. 3, 6) and *P. clapense* (Pl. 7, Figs. 2, 3). A *Strigoceras truellei* (Pl. 7, Fig. 1), found by the late G. Schairer during the fieldwork for his diploma thesis in Ursheim, also comes from this part of the section, according to attached rock particles.
- About 0.3 m reddish-beige, strongly Fe-oolitic, crumbly marly limestone [bed 9a]. From the top of this bed we got: *Parkinsonia rarecostata* (Pl. 6, Figs. 1, 2) and *Garantiana ipfensis* (Pl. 6, Figs. 4, 5). From the lower part: *Garantiana wetzeli* (Pl. 5, Figs. 11, 12); from the basis *Prorsisphinctes pseudomartinsi* (Pl. 5, Fig. 10).

'Bifurcaten-Oolith' (0.6–0.7 m [bed 8])

- 0.05–0.1 m light beige, Fe-oolitic clay marl [bed 8c] with big belemnites, brachiopods and *Garantiana subgaranti* (Pl. 5, Figs. 8, 9) and *G.* aff. *platyrryma* (Pl. 5, Figs. 5–7).
- 0.05–0.1 m thick layer of flat nodules of Fe-oolitic, light beige, marly limestone [bed 8b]: *Garantiana suevica* (Pl. 5, Figs. 3, 4).
- 0.4–0.5 m Fe-oolitic, yellow-beige marl with two to three layers of about 0.05 m thick flat layers of marly limestone [bed 8a]. According to the attached rock the *Caumontisphinctes rota* (Pl. 5, Figs. 1–2), which was found in the excavated material, comes from this part of the section.

'Humphriesi-Oolith' (2.5–2.6 m [bed 7])

Intercalation of Fe-oolitic, hard marly limestone beds (mostly 0.1–0.2 m thick) and as a rule a little thinner clay marl layers. The thicknesses of the layers in this sequence vary laterally within short distances. The three lowermost, fine Fe-oolitic marly limestone beds [beds 7a–c] are blue grey when unweathered; the upper marly limestone beds are predominantly brown/beige and also fine Fe-oolitic:

- A very fossiliferous, 0.25 m thick layer of weakly cemented, predominantly brown clay marl (with numerous bivalves, brachiopods and belemnites), with densely packed, small Fe-ooids, about 1–1.1 m above the top of this sequence [between beds 7e and 7f], yielded several specimens of *Itinsaites* (Pl. 3, Figs. 3, 4, 9, 10). We found only fragments and an inner whorl of the macroconch genus *Stephanoceras*, undeterminable to the species level (Pl. 3, Figs. 5, 6).
- The exact position of the bed with a monospecific accumulation of the brachiopod *Loboidothyris perovalis* (Pl. 4) could not be identified during the description of the section. In the excavated material – the layers partially were still linked together – this bed was found close to the above mentioned marls. This is why we assume that the brachiopod bed was situated close to the bed with *Itinsaites* [presumably beds 7d–f].
- The exact position of the chondroceratids (Pl. 3, Figs. 11–16) could not be located during the description of the section. These small ammonites were frequently found in an easily recognizable bed, but also firmly attached to the hardground on top of the bed. According to the rock composition, this layer should be two or three beds below the *Itinsaites* bed [bed 7c or 7d].

Weiße-Laber Subformation

'Wedelsandstein' [beds 4–6]:

- [bed 6] In the wall of the fermenter built in 2013 the Fe-oolitic facies was underlain by 0.45 m grey blue clay [bed 6c], the uppermost 0.1 m passing over in a brownish grey. Here and there in the section these characteristic dark grey blue clays begin already higher in the section, replacing the brown-beige, Fe-oolitic marl layers between the marly limestone beds. Beneath it lies a fine Fe-oolitic marly limestone bed (0.1 m), breaking characteristically smooth [bed 6b]. The fresh bed is grey, brown when weathered. Several fragmentary preserved *Dorsetensia* (*D. subtecta*: Pl. 3, Figs. 7, 8) may come from bed 6b according to the attached rock fragments. In SW Germany *Dorsetensia* normally appears in somewhat older beds than *Chondroceras*.

Downwards follow grey blue clays again (about 0.4 m [bed 6a]). The photographs from the year 2010 show that bed 6 first wedges out in the upper part (bed 6c), some meters further also in the lower part (bed 6a). Finally it was replaced completely by brown marls.

- Bed 5 begins with a 0.3 m thick extremely hard, reddish Fe-oolitic limestone bed [bed 5c], present all over the exposed wall. Beneath the following, about 0.1 m thick marl layer [bed 5b] lies another hard, 0.1–0.2 m thick, brown to red Fe-oolitic limestone bed [bed 5a], which is also present throughout.
- Bed 4 consists of 0.4–0.6 m thick brownish marly limestones with intercalation of single, not constantly present hard beds. The specimens of *Pseudoshirbuirnia stephani* (Pl. 1, Figs. 1, 3), which were found in the excavated material, presumably come from one of these beds according to the rock composition. The specimen of *Sonninia* aff. *strigoceroides* (Pl. 3, Figs. 1, 2), when compared with its occurrences in other localities, must come from younger beds than *Ps. stephani*. Therefore, *S.* aff. *strigoceroides*, which was embedded in a beige, marly matrix, most presumably comes from the upper part of bed 4; however, bed 5b cannot be ruled out.
- Bed 3: The thickest hard limestone bed in the whole pit (0.45–0.7 m) varies from brown to red [bed 3b]. It is

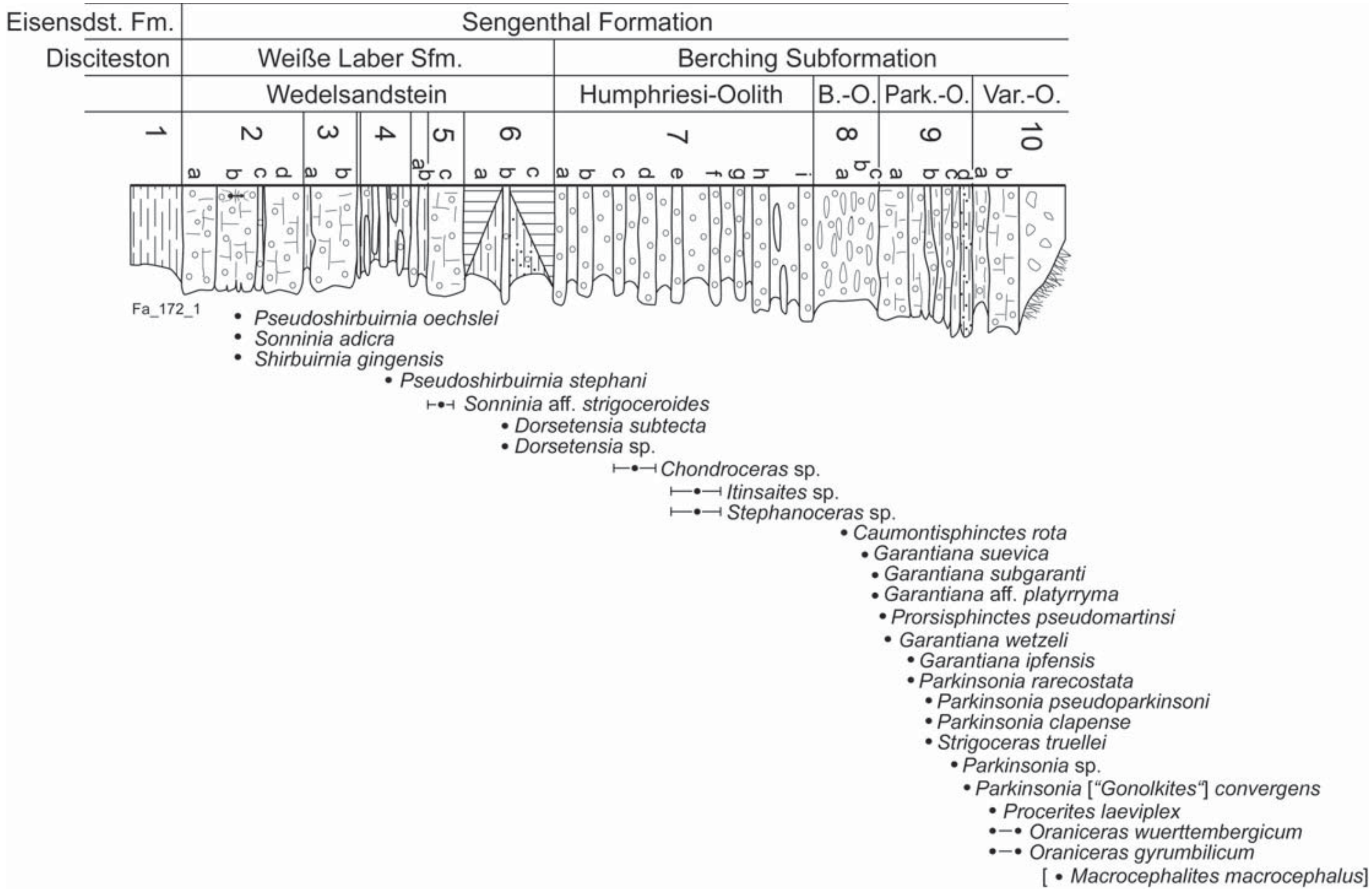

Fig. 3. Section Polsingen-Ursheim (compiled from the excavation pits), showing the vertical distribution of ammonites. Eisensdst. = Eisensandstein, B. O. = Bifurcaten-Oolith, Park.-O. = Parkinsonien-Oolith, Var.-O. = Varians-Oolith; *Macrocephalites microcephalus* was found in the overburden.

underlain by mostly reddish, here and there dark grey marls (ca. 0.1 m) [bed 3a].

– Bed 2: It is underlain by a bright red, Fe-oolitic sequence of beds (about 1.2 m), the uppermost part of which (0.3–0.5 m [bed 2c]) as well as its base (ca. 0.3 m [bed 2a]) are developed as massive limestone beds. The middle part (0.4–0.6 m [bed 2b]) has a higher clay content and is less hard, with a 0.1 m thick hard bed intercalated in its upper part. The following ammonites were found in bed 2 from the excavated material: *Pseudoshirbuirnia oechslei* (Pl. 1, Figs. 2, 4), *Sonninia adicra* (Pl. 2, Figs. 1, 2) and a big *Shirbuirnia gingensis* (Pl. 2, Figs. 3, 4).

'Disciteston'

Bed 1: at the base up to 0.5 m of a grey-black, obviously clayey layer were exposed. No fossils could be assigned to this clay.

3. Palaeontology

3.1. Material and methods

As far as possible the ammonites were collected bed-by-bed. Specimens from the excavated material have been used for stratigraphical interpretation only when attached rock allowed it undoubtedly.

The originals illustrated on Pls. 1–13 are stored in the collection of the 'Landesamt für Geologie, Rohstoffe und Bergbau in the Regierungspräsidium Freiburg, Albertstr. 5, 79104 Freiburg im Breisgau, Germany', except for the *Strigoceras truellei* (Pl. 7, Fig. 1), which is stored in the 'Bayerische Staatssammlung für Paläontologie und Geologie, Richard-Wagner-Str. 10, 80333 München, Germany'.

For the investigation of the microfauna we took 40 samples (two or three samples per meter) from the drill core VB Ursheim from 73.00 m (Middle Oxfordian) down to 90.50 m (Upper Aalenian). From each sample 0.5 kg was dried, disaggregated with hydrogen peroxide (H_2O_2) and subsequently washed through a 0.1 mm sieve. After drying the residues were divided into three fractions: >0.315 mm, 0.315–0.20 mm and 0.2–0.15 mm. The picking of the residues and the study of the microfauna was carried out using a binocular microscope. In the iron oolitic facies the number of microfossils in a given volume of rock is more or less 'diluted' by the ooid content. In order to obtain representative results, we looked through the whole residue, except for the finest fraction (0.15–0.20 mm), from which we investigated three selection trays. For the photographs of the ostracods and foraminifera we used the SEM.

The slides are stored in the collection of the Landesamt für Geologie, Rohstoffe und Bergbau in the Regierungspräsidium Freiburg, the figured specimens are stored under nos. Em 711–Em 791.

The 40 samples yielded a total of 1461 ostracods, with a maximum of 122 resp. 115 specimens per sample in the clays of the Weiße-Laber Subformation ('Wedelsandstein'). For semi-quantitative analysis of the composition of the ostracod fauna single valves were counted as 0.5, resulting in a total of 1130 individuals. The number of foraminifera amounts to >3500; small (juvenile) specimens have not been picked quantitatively.

All over the studied section the ostracods are partly badly and/or fragmentary preserved or partly covered by remnants of rock. For this reason we were not able to figure all the index and the accompanying species, even though they could be reliably determined.

3.2. Short remarks on the ammonite faunas

Family Sonniniidae Buckman, 1892

Surprisingly the section yielded some sonniniids. Until now only few specimens of sonniniids had been found in the vicinity of Westhausen (BAB 7; Dietze et al. 2005), from the Ries area and the neighbouring Franconian Alb.

– Genus *Pseudoshirbuirnia* Dietze, Callomon, Schweigert & Chandler, 2005

The very rare species *Pseudoshirbuirnia oechslei* Dietze et al., 2005 (Pl. 1, Figs. 2, 4) was until now only recorded from the Middle Swabian Alb, the Wutach area and Alsace (Dietze et al. 2005, 2012). The fragmentary specimen figured in this paper is the first record of this species in the Ries area and the (southwestern) Franconian Alb. The same can be said for *Pseudoshirbuirnia stephani* (Buckman, 1883), which we figure in a typical specimen (Pl. 1, Figs. 1, 3). *Ps. stephani* is showing a rounded ventral side, a rounded umbilical edge and a highly oval cross section. In contrast the whorl section of the species *Ps. oechslei* is fastigate, its umbilical angle is sharp as well as its venter. Moreover, the latter species appears in little older strata.

– Genus *Shirbuirnia* Buckman, 1910

A big, badly preserved specimen (Pl. 2, Figs. 3–4) can be assigned to *Shirbuirnia gingensis* (Waagen, 1867). Dietze et al. (2005) published similar ammonites from the eastern Swabian Alb as *Sh. gingensis* α-form. *S. gingensis* sensu Dietze et al. (2005) with its very complex suture line bears close, but unexplained relationships to the genus *Fissilobiceras* Buckman, 1919.

– Genus *Sonninia* Bayle, 1879

A small ammonite bearing long spines on the inner whorls adjacent to the umbilical wall (Pl. 2, Figs. 1–2) belongs to the very variable group of *Sonninia adicra* (Waagen, 1867) [*S. adicra* var. *berckhemeri* ex Dorn sp., see Dietze et al. 2005: fig. 5]. A slightly corroded internal mold, found loose in the excavated material (Pl. 3, Figs. 1–2) can be assigned to *S.* aff. *strigoceroides* Dorn, 1935. In grazing light a faint row of papillae can be recognized in the outer third of the whorl flank. Dorn (1935) published a greater number of morphologically similar specimens from the northern Franconian Alb under different names.

– Genus *Dorsetensia* Buckman, 1892

In addition to the figured specimen (Pl. 3, Figs. 7, 8) two further whorl fragments of the easily recognizable species *Dorsetensia subtecta* Buckman, 1892 were found.

Family Sphaeroceratidae Buckman, 1920

– Genus *Chondroceras* Mascke, 1907

The species *Chondroceras polypleurum* Westermann, 1956 (Pl. 3, Figs. 11, 12), *C. gerzense* Westermann, 1956 (Pl. 3, Figs. 15–16) und *C. multicostatum* Westermann, 1956 (Pl. 3, Figs. 13, 14) could be proven. Numerous specimens collected bed-by-bed from the *gervillii/cycloides* horizon of the western Swabian Alb have been described by Dietze et al. (2015). For a detailed discussion of the genus *Chondroceras* see Westermann (1956).

Family Stephanoceratidae Neumayr, 1875

Subfamily Stephanoceratinae Neumayr, 1875

– Genera *Stephanoceras* Waagen, 1869 and *Itinsaites* McLearn, 1927

Only a few fragments and a nucleus of a macroconch of *Stephanoceras* (= *Stephanoceras* sp.; Pl. 3, Figs. 5–6), not identifiable to the species level, were found, together with several specimens of the genus *Itinsaites*, the microconch counterpart of the genus *Stephanoceras* (Ohmert et al. 1995). The two figured specimens are assigned to *Itinsaites quenstedti* Roché, 1939 (Pl. 3, Figs. 3, 4, 9, 10). The identification of the numerous, partly very similar and even synonymous morphospecies (Westermann 1954) is as difficult as for the genus *Chondroceras*.

Subfamily Garantianinae Wetzel, 1937

– Genus *Garantiana* Mascke, 1907

The morphospecies *Garantiana suevica* Wetzel, 1911 (Pl. 5, Figs. 3, 4), *G. subgaranti* Wetzel, 1911 (Pl. 5, Figs. 8–9) and *G.* aff. *platyrryma* (Buckman, 1921) (Pl. 5, Figs. 5–7) are closely related and represent only morphological variants of the genus *Garantiana* within a short time span (Dietze et al. 2000). *Garantiana wetzeli* Trauth, 1923 (Pl. 5, Figs. 11, 12) is a morphological and stratigraphical transient form from the *G. subgaranti* Wetzel/*G. garantiana* (d'Orbigny) group to *G. ipfensis* Dietze et al., 2002 (Pl. 6, Figs. 4, 5). Following Dietze et al. (2007) we refuse the use of the genus *Paragarantiana* Gauthier, 2003 for *Garantiana longidoides* (Gauthier et al., 2000) and closely related forms. The morphological differences are insufficient for the erection of a separate genus *Paragarantiana*.

Family Parkinsoniidae Buckman, 1920

– Genus *Parkinsonia* Bayle, 1878

In addition to some fragments of older parkinsoniids a well preserved, only slightly compressed *Parkinsonia rarecostata* (Buckman, 1881) (Pl. 6, Figs. 1, 2) from the Acris Zone was recovered. In comparison to the *P. arietis/acris/rarecostata group* the finely ribbed and involute *P. clapense* Maubeuge, 1951 (Pl. 7, Figs. 2, 3) and the also finely ribbed *P. pseudoparkinsoni* Wetzel, 1911 (Pl. 6, Figs. 3, 6) are younger species in the family tree of the parkinsoniids that ranges up to the Bathonian.

– Genus *Caumontisphinctes* Buckman, 1920

The different species of this genus are difficult to distinguish and interconnected by numerous transitions (Dietl 1980). Our specimen can be assigned to the morphospecies *Caumontisphinctes rota* (Bentz, 1924) according to Bentz (1924, pl. 8, figs. 2a–b).

Family Perisphinctidae Steinmann, 1890

– Genus *Prorsisphinctes* Buckman, 1924

Despite its fragmentary preservation the big *Prorsisphinctes pseudomartinsi* (Siemiradzki, 1899) is distinctive (Dietze et al. 2002).

– Genus *Procerites* Buckman, 1898

The complete internal mold of a phragmocone of a *Procerites laeviplex* (Quenstedt, 1887) still exhibits the beginning of the body chamber.

Family Strigoceratidae Buckman, 1924

– Genus *Strigoceras* Buckman, 1924

The specimen of *Strigoceras truellei* (d'Orbigny, 1845) shows the distinctive inflated whorl section and the three deeply countersunk spiral furrows (Schweigert et al. 2007).

3.3. Ostracods

The obtained 1461 ostracods represent 177 species, belonging to 60 genera, not taking into account the indeterminable specimens. For the following coarse description of the faunal assemblages it should be kept in mind that the number of specimens is very low in the upper Bajocian, upper Bathonian and Lower Callovian.

In the Upper Aalenian (in the lower half of the 'Disciteston') only 10 specimens were found, representing the species *Merocythere ovalis* Plumhoff, 1963, *Camptocythere* cf. *lincolnensis* Bate, 1963, *Procytheridea* cf. *teteimene* Dilger, 1963, and *Cytheropterina* sp. The scarcity of ostracods does not allow any further interpretation. Moreover, the description of the Aalenian fauna is beyond the scope of this paper.

The Lower Bajocian assemblages as a whole (702 specimens) are dominated by the genus *Praeschuleridea* Bate, 1963, accompanied by the genera *Kinkelinella* Martin, 1960, *Progonocythere* Sylvester-Bradley, 1948, *Eocytheridea* Bate, 1963, *Dolocythere* Mertens, 1956, and the family Cytherellidae Sars, 1866.

In the following we list the taxa found in this part of the section in order of frequency [number of specimens in brackets]:

Discites Zone (4 samples):

Praeschuleridea ventriosa Plumhoff, 1963 [77], *Praesch.* sp. (smooth) [19], *Praesch.* sp. (punctate) [2], *Kinkelinella* sp. [16], *K.* (*Ektyphocythere*) cf. *levata* Ohmert, 2004 [11], *K.* sp. B Ohmert, 2004 [2], *K.* sp. A Ohmert, 2004 [1], *Eocytheridea* aff. *carinata* Bate, 1964 [6], *Progonocythere* sp. [4], *Acrocythere* sp. [3], *Dolocythere maculosa* Bate, 1963 [3], *D. tuberculata* Luppold, 2012 [1], *D.* sp. [1], *Cytheropterina* sp., [2], cf. *Aphelocythere* ? *pygmaea* Plumhoff, 1963 [2], *Monoceratina* cf. *ungulina* Triebel & Bartenstein, 1938 [2], *Merocythere* sp. [2], single findings of: *Procytheridea* cf. *teteimene* Dilger, 1963, *Cytheropteron* sp., ? *Paracypris* sp. D Oertli, 1963, *Asciocythere* sp., *Procytheropteron* sp., *Schuleridea* sp., *Caytonidea* sp., *Fuhrbergiella* sp.; additionally 37 Gen. et sp. indet.

Ovale–Laeviuscula zones (7 samples)

Praeschuleridea sp. (smooth) [107], *Praesch.* sp. (punctate) [102], *Praesch. ventriosa* Plumhoff, 1963 [1], *Praesch. decorata* Bate, 1968 [1], *Dolocythere tuberculata* Luppold, 2012 [30], *Pleurocythere* cf. *laticosta* Braun, 1958 [15], *Pleurocythere laticosta* Braun, 1958 [5], *Fuhrbergiella* (*Praef.*) *horrida bicostata* Brand & Malz, 1962 [14], *Procytheridea* cf. *teteimene* Dilger, 1963 [11], *Eocytheridea* cf. *lacunosa* Bate, 1963 [10], *Eocyth.* aff. *carinata* Bate, 1964 [1], *Eocyth.* ? *acuta* Bate, 1964 [1], *Eocyth.* cf. *erugata* Bate, 1964 [1], *Praeschuleridea ornata* Bate, 1963 [10], *Praesch.* sp. [3], *Cytherella ascia incurvata* Braun, 1958 [10], *Progonocythere* cf. *triangulata* Braun, 1958 [9], *Prog.* sp. [4], *Prog.* cf. *ampla* (Terquem, 1885) [4], *Homocytheridea* aff. *cylindrica* Bate, 1963 [9], *Cytheropterina cribra* (Fischer, 1962) [7], *Cyth.* cf. *bicuneata* (Braun) in Dilger, 1963 [1], *Cytherella* sp. [5], C. *callosa ampla* Braun, 1958 [4], *Kinkelinella* sp., [4], *K.* (*Ekt.*) *triangula* (Brand, 1961) [4], *K.* cf. *malzi* (Dépèche, 1973) [3], ? *Procytheropteron trematon* Dilger, 1963 [4], *Paracypris bajociana* Bate, 1963 (3), ? *Systenocythere* cf. *exilofasciata* Bate, 1963 (3), *Syst.* sp. [1], *Cytherelloidea cadomensis* Bizon, 1960 [2], single findings of: *Clithrocytheridea vallata* Braun, 1958, *Eucytherura* sp., *Fuhrbergiella* (*Praef.*) *favosa* Plumhoff, 1963, *Isobythocypris* sp., *Oculocytheropteron* sp., *Polycope* sp., *Procytherura* cf. *reticulata* Brand, 1990, *Renicytherura* sp., *Schuleridea* sp., *Southcavea* sp., additionally 26 Gen. et sp. indet.

Sauzei Zone (1 sample):
Palaeocytheridea blaszykina Franz et al., 2009 [14], *Rutlandella* sp. [10], *R. transversiplicata* Bate & Coleman, 1975 [1], *Systenocythere perforata* (Braun, 1958) [10], *Fuhrbergiella* (*Praef.*) *sauzei* Brand & Malz, 1962 [8], *Procytherura* cf. *reticulata* Brand, 1990 [3], *Proc.* cf. *celtica* Ainsworth, 1986 [2], *Proc.* cf. *jordani* Brand, 1990 [1], *Praeschuleridea plana* (Braun, 1958) [3], *Praesch.* sp. (smooth) [1], single findings of: *Eocytheridea* sp., *Macrocypris* sp., *Paracypris bajociana* Bate, 1963, *Parac.* sp., ? *Plumhoffia* sp., additionally 9 Gen et. sp. indet.

Humphriesianum Zone (4 samples):
Tethysia bathonica Sheppard in Brand, 1990 [25], ? *Bythocypris* sp. [9], *Pleurocythere* cf. *regularis* Triebel, 1951 [8], *Bythocypris* sp. [6], *Fuhrbergiella* (*Fuhrb.*) *transversiplicata transversiplicata* Brand & Malz, 1962 [5], *Isobythocypris* sp. [3], *Procytheropteron trematon* Dilger, 1963 [3], *Palaeocytheridea blaszykina* Franz et al., 2009 [3], *Patellacythere paravulsa tenuis* Brand, 1990 [3], *Paracypris* sp. [2], *Fuhrbergiella* (*Praef.*) *horrida horrida* Brand & Malz, 1962 [2], *Glyptocythere regulariformis* Brand & Malz, 1962 [2], ? *Monoceratina* sp. [2], *Pontocyprella* sp. [2], *Procytherura* sp.1 [2], single findings of *Eucytherura* sp., *Procytherura* sp. 2 and ? *Pseudomacrocypris* sp.; additionally 15 Gen et sp. indet.

In the Upper Bajocian (44 specimens) the genera *Pleurocythere* Triebel, 1951 and to a lesser extent *Praeschuleridea* Bate, 1963 are dominant.

Niortense–Parkinsoni zones (2 samples):
Pleurocythere regularis Triebel, 1951 [15], *Praeschuleridea* sp. [6], *Tethysia bathonica* Sheppard in Brand, 1990 [4], *Wellandia* sp. [4], *Homocytheridea posteriohumilis* (Blaszyk, 1967) [3], *Homocytheridea triangulata* Brand, 1990 [3], *Cytheropteron* ? *infrasaxonicum* Brand, 1990 [2], ? *Ektyphocythere* sp., single findings of *Polycope* sp., *Patellacythere paravulsa tenuis* Brand, 1990, ? *Aphelocythere* sp., *Fuhrbergiella* (*Fuhrb.*) *projecta* Brand & Malz, 1962, *Fuhrbergiella* (*Fuhrb.*) *transversiplicata minuta* Brand & Malz, 1962, *Southcavea* cf. *concentrica* Permyakova, 1973, *Procytherura sp.*, *Blaszykina pulcherrima* Brand, 1990, *Procytheropteron* sp., ? *Procytherura* sp., additionally 4 Gen et sp. indet.

The Lower Bathonian ostracod assemblage (169) is characterized by the presence of the genera *Glyptocythere* Brand & Malz, 1962, *Pleurocythere* Triebel, 1951 and *Cytheropteron* Sars, 1866, whereas in the Upper Bathonian (22 specimens) the genus *Praeschuleridea* Bate, 1963 is dominant again.

Zigzag Zone (6 samples):
Procytheropteron aff. *gramanni* Brand, 1990 [17], *Glyptocythere tuberosa* Brand & Malz, 1962 [16], *Gl. obtusa* Lutze, 1966 [8], *Gl. comes* Brand & Malz, 1966 [3], *Gl. similis* Brand & Malz, 1966 [3], *Gl.* cf. *tuberosa* Brand & Malz, 1962 [1], *Gl. polita* Bate, 1965 [1], *Gl. reticulata* Brand & Malz, 1966 [1], *Gl.* sp. [1], *Pleurocythere connexa* Triebel, 1951 [13], *Pl. favosa* Triebel, 1951 [5], *Pl. impar* Triebel, 1951 [4], *Pl. richteri* Triebel, 1951 [2], *Pl.* sp. [1], *Fuhrbergiella* (*Fuhrb.*) *transversiplicata minuta* Brand & Malz, 1962 [9], *F.* (*F.*) *gigantea gigantea* Brand & Malz, 1962 [3], *F.* sp. [1], *Palaeocytheridea carinilia* (Sylvester-Bradley, 1948) [7], *Palaeocyth.* aff. *blaszykina* Franz et al. 2009 [3], *Morkhovenicythereis polita* Brand, 1990 [6], *Eucytherura rectodorsalis* Blaszyk, 1967 [6], *Tethysia bathonica* Sheppard in Brand, 1990 [4], *Cytheropteron tenuis* Blaszyk, 1967 [4], *C. spinosum* Lyubimova, 1955 [1], *Wellandia trituberosa* Brand, 1990 [4], *Polycope* sp. [3], *Isobythocypris* sp. [3], *Oligocythereis capreolata* Sheppard in Brand, 1990 [3], *Blaszykina convexa* (Blaszyk, 1967) [3], *Bl. pulcherrima* Brand, 1990 [2], *Renicytherura* cf. *parairregularis* Brand, 1990 [2], *R. angulocostata* (Knitter, 1983) [2], *R.* sp. [1], *Procytherura* sp. [2], *Pr. ovaliformis* Brand, 1990 [1], *Tropacythere verrucosa* (Blaszyk, 1967) [2], *Paracypris bajociana* Bate, 1963 [2], *P.* sp. [1], single findings of *Praeschuleridea* sp., ? *Infracytheropteron* sp., *Fissocythere* sp. *Bythoceratina scrobiculata* (Triebel & Bartenstein, 1938), *B. separata* Brand, 1990, *Pontocyprella subaureola* Sheppard in Brand, 1990, *Cytherella limpida* Blaszyk, 1967, *Patellacythere paravulsa paravulsa* Brand, 1990; additionally 10 Gen et sp. indet.

Orbis Zone (1 sample):
Praeschuleridea subtrigona Jones & Sherborn, 1888 [6], *Procytheropteron* aff. *gramanni* Brand, 1990 [2], *Palaeocytheridea carinilia* (Sylvester-Bradley, 1948) [2], *Neurocythere plena* (Triebel, 1951) [2], single findings of *Procytherura* sp. 5, *Renicytherura* cf. *parairregularis* Brand, 1990, *V. acostata* Tesakova, 2002, *Blaszykina convexa* (Blaszyk, 1967), *Bythocypris* sp., *Aphelocythere* aff. *hamata* Plumhoff, 1963, *Pleurocythere kurskensis* Tesakova, 2009, and *Wellandia mesojurassica* Brand, 1990; additionally 2 Gen et sp. indet.

The Lower Callovian ostracod fauna (27 specimens) is dominated by the genera *Neurocythere* Whatley, 1970 and *Tethysia* Donze, 1975, followed in the Middle and Upper Callovian (96 specimens) by an assemblage with the dominant genera *Neurocythere* Whatley, 1970, *Patellacythere* Gründel & Kozur, 1971 and *Bythoceratina* Hornibrook, 1952, *Vesticytherura* Gründel, 1964, and *Polycope* Sars, 1866.

Herveyi Zone (1 sample):
Tethysia bathonica Sheppard in Brand, 1990 [7], *Neurocythere cruciata cruciata* (Triebel, 1951) [6], *N. cruciata alata* (Whatley, 1970) [3], *Micropneumatocythere brendae* Sheppard, 1978 [3], *Bythocypris* sp. [2], ? single findings of ? *Monoceratina* sp., *Renicytherura angulocostata* (Knitter, 1983), *R.* sp., *Cytheropteron spinosum* Lyubimova, 1955, *Procytheropteron* aff. *gramanni* Brand, 1990; additionally 1 Gen. et sp. indet.

Koenigi–Calloviense zones (3 samples):
Neurocythere cruciata intermedia (Lutze, 1960) [17], *Patellacythere paravulsa paravulsa* Brand, 1990 [17], *Polycope* sp. [11], *Bythoceratina* cf. *stimulea* (Schwager, 1866) [8], *B. scrobiculata* (Triebel & Bartenstein, 1938) [4], *B. separata* Brand, 1990 [1], *Bairdia* sp. [6], *Vesticytherura* sp. [6], *V.* sp. 1 [5], *Bythocypris* sp. [5], *Macrocypris* sp. [4], *Eucytherura bicostata* Ballent [2], single findings of *Cytheropteron spinosum* Lyubimova, 1955, *Procytherura* sp. and *Cytherella fullonica* Jones & Sherborn, 1888; additionally 5 Gen. et sp. indet.

In the very poor microfaunas of the Lower to Middle Oxfordian (56 specimens) the dominant genera are *Vesticytherura* Gründel, 1964, *Polycope* Sars, 1866, *Platylophocythere* OERTLI, 1960, and *Bythoceratina* HORNIBROOK, 1952.

Cordatum – ? Plicatilis zones (7 samples):

Polycope sp. [11], *Vesticytherura* sp. [11], *V.* sp.1 [7], *V. acostata* TESAKOVA, 2002 [2], *Platylophocythere hessi* OERTLI, 1960 [6], *Bythoceratina stimulea* (SCHWAGER, 1866) [4], *B. scrobiculata* (TRIEBEL & BARTENSTEIN, 1938) [1], *Neurocythere cruciata intermedia* (LUTZE, 1960) [2], *N. dulcis* (LYUBIMOVA, 1955) [1], single findings of *Patellacythere paravulsa paravulsa* BRAND, 1990, *Pontocyprella* sp., *Praeschuleridea decorata* BATE, 1968; additionally 7 Gen. et sp. indet.

3.4. Foraminifera

Most of the 40 samples contained a rich benthonic foraminiferal fauna (Table 1) except for the three lowermost samples, which yielded some crinoid remains only. The spectrum of the foraminifera is dominated by calcareous forms, mainly Nodosariids. Agglutinated and miliolid taxa appear only in the upper half of the section studied.

The major part of the nodosariid taxa belong to the subfamily Lenticulininae CHAPMAN, PARR & COLLINS, 1934, comprising the genera *Marginulina* D'ORBIGNY, 1826, *Lenticulina* LAMARCK, 1804, *Astacolus* DE MONTFORT, 1808, *Planularia* DEFRANCE, 1826, *Palmula* LEA, 1833, *Vaginulina* D'ORBIGNY, 1826, *Saracenaria* DEFRANCE in DE BLAINVILLE, 1824, and *Citharina* D'ORBIGNY in LA SAGRA. 1839. The remaining are mostly representatives of the genera *Nodosaria* LAMARCK, 1812 and *Dentalina* RISSO, 1826.

Taxonomical remarks on some foraminifera:

– *Planularia eugenii* (TERQUEM, 1863). It is questionable whether this Early Jurassic species is identical with the closely related *Planularia semiinvoluta* (TERQUEM, 1869) and *Planularia subinvoluta* (TERQUEM, 1869), described from Upper Bajocian sediments of Fontoy. For reasons of conventional taxonomy and comparability with the literature this name was maintained. *Astacolus pseudoradiata* FRENTZEN, 1941 might be identical as well.

– *Astacolus volubilis* DAIN, 1958. There is a close morphological relationship between this species and *Subhercynella parkinsoniana* BARTENSTEIN & LUPPOLD, 2005 from the uppermost Bajocian of NW Germany. Differences concern the umbilical region and the sutures, but further comparative investigations are indicated. Stratigraphical distribution: Bajocian and Bathonian of Germany and Poland (BIELECKA & STYK 1969; MUNK 1978; BLANK 1990).

– *Subhercynella arachne* (KOPIK, 1969). Middle Jurassic foraminifera formerly referred to *Cristellaria tricarinella* REUSS, 1863 from the Cretaceous or *Cristellaria polymorpha* TERQUEM, 1870 from the Bajocian were revised by KOPIK (1969) as *Lenticulina (Astacolus) polymorpha arachne* n. ssp. BARTENSTEIN & LUPPOLD (2005) pointed out, that this morphotype differs essentially from other Middle Jurassic lenticulinids, and therefore should be treated as a distinct species rather than a subspecies of *Lenticulina polymorpha*. They referred it to the genus *Subhercynella* BARTENSTEIN, 2000.

– *Lenticulina helios* (TERQUEM, 1870). Starting in the Toarcian, the genus *Lenticulina* LAMARCK, 1804 tends to produce morphotypes with a prominent umbilicus and radial ribs. Such specimens have been commonly referred to *Lenticulina subalata* (REUSS, 1854) from the Cretaceous, whereas TERQUEM (1870) described a very similar species from the Middle Jurassic. *Lenticulina helios* is most common between 86.45 m and 88.00 m in the section studied.

3.5. Further microfossil groups

Other components of the microfauna besides ostracods and foraminifera are echinoderm remains (crinoids, ophiurids, echinids, asterozoans and holothurians), bryozoa, gastropods, belemnite tentacle hooks and fish teeth.

The two samples between 88.95 m and 89.50 m contained exclusively skeletal remains of the crinoid species *Chariocrinus wuerttembergicus* (OPPEL, 1856). Except for this two samples the section below 79.70 m was void of echinoderm remains. Gastropods are more abundant in the lower half of the sampled section. Fish teeth are present in most samples but more common above 77.00 m. Bryozoa were found between 77.33 m and 79.70 m only.

3.6. Remarks on the associated fauna

In the drill core the number of macrofaunal elements is to low for any kind of interpretation. In the excavation pits our primary focus was on ammonites, notes on the associated fauna are restricted to peculiar occurrences. Besides nectonic species (ammonites, belemnites) the iron oolites are often characterized by endo- and epibiontic faunas, rich in species and specimens (FRANZ 1986; KÄSTLE 1990).

In the lowest part of the 'Humphriesi-Oolith' a hardground is developed, which is often the case in midjurassic iron oolites (FRANZ 1986). The rich fauna in the bed with *Chondroceras* in Ursheim is a colluviation of bivalves (*Actinostreon marshi* [SOWERBY, 1814], '*Ostrea*' *eduliformis* SCHLOTHEIM, 1820, *Pseudolimea* sp., *Gresslya abducta* [PHILLIPS, 1829], *Pholadomya*), brachiopods (*Loboidothyris*), and belemnites (*Megateuthis*, *Hibolithes*). The chaoticly embedded and partly fragmented shells are densely overgrown by serpulids. In the 'Varians-Oolith' ammonite shells and other hard substrates are encrusted by stromatolites. All these observations indicate a shallow, high energy environment with repeated events of reworking. A few bigger bone fragments – presumably from marine reptiles – have been found in the 'Parkinsonien-Oolith'.

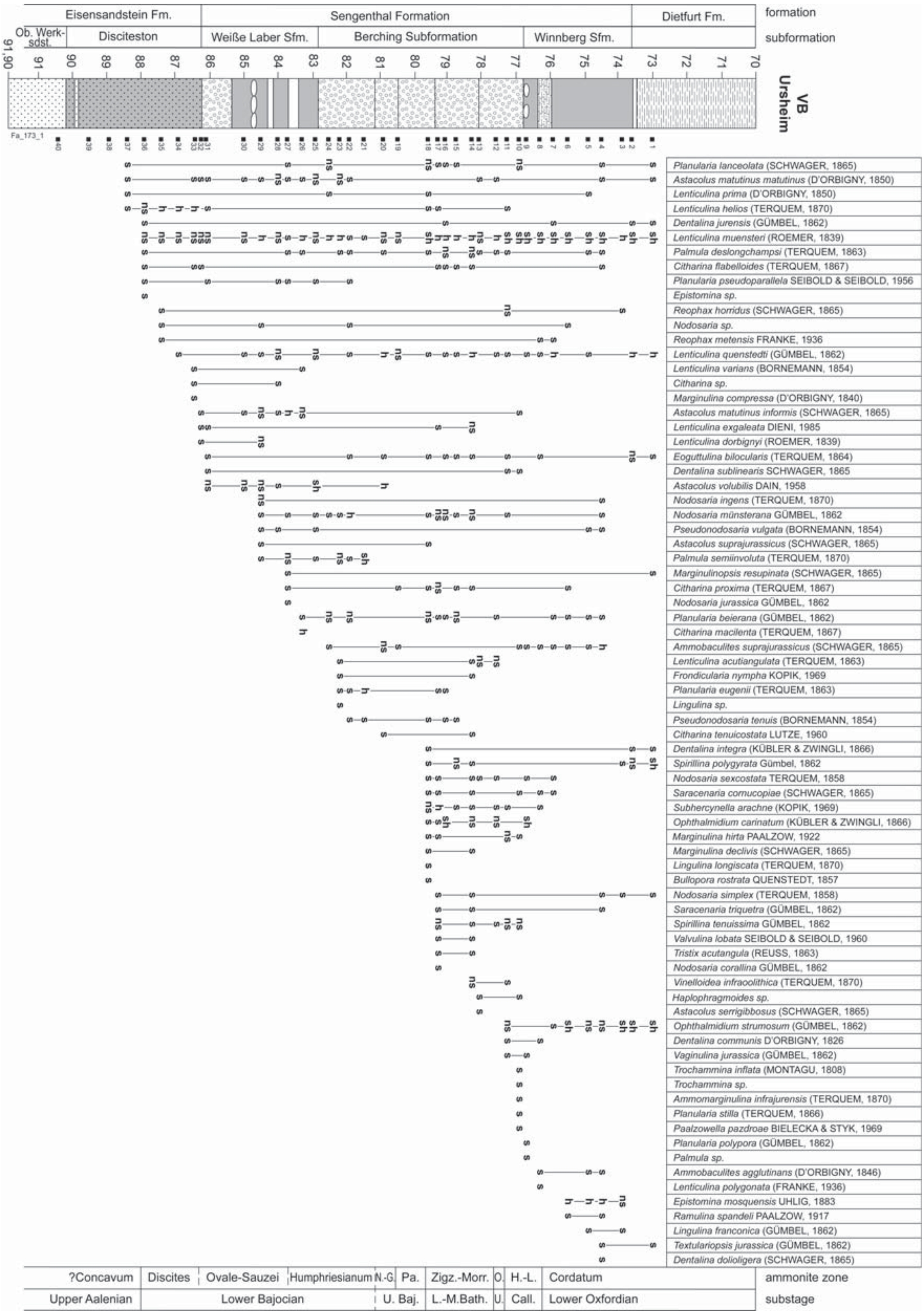

Table 1. Distribution of the foraminifera in the drillcore VB Ursheim. For abbreviations see Fig. 4; s = selten (rare, 1–3 specimens), ns = nicht selten (not rare, 4–10 specimens), h = häufig (frequent, 11–20 specimens), sh = sehr häufig (very frequent, >20 specimens). N.-G. = Niortense – Garantiana, Pa = Parkinsoni, Zigz.-Morr. = Zigzag – Morrisi, O = Orbis, H.-L. = Herveyi – Lamberti.

In some beds brachiopods are notably frequent, e.g. in Ursheim in the 'Varians-Oolith', in the 'Bifurcaten-Oolith' and in the 'Humphriesi-Oolith'. The first author of this paper found a greater piece of such a brachiopod bed in the excavated material in Ursheim, which, according to its lithology, comes from the level with frequent *Itinsaites*. The sample (Pl. 4) exhibits 45 specimens of 40–45 mm long *Loboidothyris perovalis* (Sowerby, 1825) in an area of 30 x 20 cm; the bed thickness is only 6 cm.

Repeatedly in the geological record the fauna of single beds is monospecific or at least by far dominated by one species. Franz (1982, 1986) described examples from Middle Jurassic iron oolites with terebratulid and rhynchonellid brachiopods, bivalves (*Catinula* sp., *Gryphaea calceolaeformis* Schäfle, 1929), and serpulids. In most cases these layers reflect local or regional short-time specific living conditions. Some may also indicate the domination of pioneer species after the breakdown of the previously existing benthic fauna, presumably caused by storm or other catastrophic events.

3.7. Ecology of foraminifera and other microfauna

The mixed benthic foraminiferal fauna and the accompanying microfaunal elements in most samples are typical for shallow marine environments of normal salinity.

An important feature is the low species diversity and the absence of agglutinated and miliolid foraminifera as well as of the genus *Spirillina* in the samples below 81.50 m. The foraminiferal fauna in the lower part of the section is dominated by genera of the subfamily Lenticulininae. In these samples gastropods are more abundant. This might indicate rather shallow marine or regressive conditions, which corresponds to the lithofacies of oolitic marls and limestone beds between 79 m and 86 m in the section.

The samples between 76.93 m and 79.70 m contain a diverse foraminiferal fauna with a higher amount of agglutinated and miliolid taxa, in addition *Spirillina* and *Epistomina*, more echinoderms and bryozoans. This might suggest somewhat deeper and warmer conditions. Rotaliids (*Epistomina*) correlate with a lower Calcium carbonate content of the sediment (Seibold & Seibold 1960) and are more abundant in the Oxfordian of France, Switzerland and South Germany than in Boreal European regions (Groiss 1970).

4. Biostratigraphy

4.1. Ammonites

The Middle Jurassic strata exposed during the construction of the biogas plant range from the Lower Bajocian to Lower Callovian. An overview of the Bajocian in SW Germany is given in Dietze et al. (2011).

B a j o c i a n

L o w e r B a j o c i a n

– Discites Zone: The oldest Bajocian ammonite zone could not be proven reliably. Sonniniids with a wide umbilicus and spines on the inner whorls as the figured *Sonninia adicra* (Waagen, 1867) (Pl. 6, Figs. 1, 2) appear in South Germany from the Discites Zone up to the Laeviuscula Zone (Dietze et al. 2005). Sonniniids from the Discites Zone usually show a more subquadrate whorl section.

– Ovale Zone: This zone was only recorded by *Pseudoshirbuirnia oechslei* Dietze et al., 2005. At least a part of bed 2 belongs to the *oechslei* horizon, characterizing the younger part of the Ovale Zone, which was previously described from the Eastern Swabian Alb and the Wutach area (Dietze et al. 2005, 2012).

– Laeviuscula Zone: The Trigonalis Subzone is proven by specimens of *Shirbuirnia gingensis* (Waagen, 1867) and *Pseudoshirbuirnia stephani* (Buckman, 1883). The big *Sh. gingensis* comes from bed 2. Hence bed 2 belongs at least partly to the Trigonalis Subzone, which is represented in the eastern Swabian Alb by the *adicra* α and *adicra* β horizons (with *Sh. gingensis* and *S. adicra*; Dietze et al. 2005). *Ps. stephani* is eponymous and characteristic for the *stephani* horizon. The brownish calcareous marl layer, which yielded this species and which presumably comes from bed 4, belongs to this youngest faunal horizon of the Trigonalis Subzone.

The single specimen of a *Sonninia* aff. *strigoceroides* Dorn, 1935 does not allow us to assign it to the Laeviuscula Subzone or to the Sauzei Zone. Very similar sonniniids with an extremely narrow whorl section, a high keel and more or less distinctly visible lateral papillae appear in the transient region of both these zones (Dorn 1935: specimens from Oberleinleiter; Chandler et al. 2006, pl. 9, figs. 1a–b, pl. 10, figs. 1a, 2b); Dietze et al. 2009, pl. 1, figs. 1, 2).

– Sauzei Zone: As mentioned above, this zone might be present in Polsingen-Ursheim but could not be proven positively.

– Humphriesianum Zone: *Dorsetensia subtecta* Buckman, 1892 appears in the Pinguis Subzone as well as in the Romani Subzone (Dietze et al. 2011, 2013). Bed 6b, where our specimen supposedly came from, can be assigned to one of these subzones. The bed with *Chondroceras polypleurum* Westermann, 1956, *C. gerzense* Westermann, 1956 and *C. multicostatum* Westermann, 1956 (bed 7c or 7d) can be dated clearly to the base of the Humphriesianum Subzone (Dietze et al. 2013, 2015). The *gervillii/cycloides* horizon, characterized amongst others by the frequency of mostly small *Chondroceras* is now traceable in South Germany from the Upper Rhine

Graben to the northwestern Ries area. The marl layer with stephanoceratids and frequent *Itinsaites* between beds 7e and 7f belongs also to the Humphriesianum Subzone, but is slightly younger than the *gervillii/cycloides* horizon.

Upper Bajocian

– Niortense Zone: The Polygyralis Subzone could be proven by a loose specimen of *Caumontisphinctes rota* (Bentz, 1924) according to Dietl (1980). According to the adherent rock fragments this specimen comes from the middle or lower part of the 'Bifurcaten-Oolith'.

– Garantiana Zone: Dietze et al. (2002) stated by means of several *Garantiana spp.* collected bed-by-bed, that the genus *Garantiana* is highly variable within a faunal horizon and that the several morphospecies of the genus can appear in several successive faunal horizons. Therefore, the specimens of *Garantiana suevica* Wetzel, 1911 and *G. subgaranti* Wetzel, 1911 only prove, that the upper part of the 'Bifurcaten-Oolith' can be dated in the Garantiana Subzone. The specimens of *Prorsisphinctes pseudomartinsi* (Siemiradzki, 1899) and *G. wetzeli* Trauth, 1923 indicate that the basal part of the 'Parkinsonien-Oolith' belongs to the Tetragona Subzone.

– Parkinsoni Zone: *Garantiana ipfensis* Dietze et al., 2002 and *Parkinsonia rarecostata* Buckman, 1881 are diagnostic ammonites of the Acris Subzone (Dietze 2000, Dietze et al. 2002). The Truellei Subzone is proven by its index species *Strigoceras truellei* (d'Orbigny, 1845) (Pl. 7, Fig. 1), *Parkinsonia pseudoparkinsoni* Wetzel, 1911 (Pl. 6, Figs. 3, 6) and *P. clapense* Maubeuge, 1951 (Pl. 7, Figs. 2–3) (Dietze & Dietl 2006). We were not successful to verify the Bomfordi Subzone, probably present below the Convergens Subzone in the upper third of the 'Parkinsonien-Oolith' (Dietze & Dietl 2006).

Bathonian

Lower Bathonian

– Zigzag Zone: The unfigured fragment of a *Parkinsonia* ["*Gonolkites*"] *convergens* (Buckman, 1925) indicates – as in the nearby Ipf area (Dietze & Dietl 2006) – that the uppermost bed of the 'Parkinsonien-Oolith' belongs to the Convergens Subzone of the Lower Bathonian. Hence, the lithostratigraphical and biostratigraphical boundaries do not coincide. The Macrescens Subzone is proven by specimens of *Oraniceras wuerttembergicum* (Oppel, 1857), *O. gyrumbilicum* (Quenstedt, 1886) and *Procerites laeviplex* (Quenstedt, 1887) in the composite beds of the 'Varians-Oolith' (Dietze & Dietl 2006).

Callovian

Lower Callovian

Fragments of *Macrocephalites macrocephalus* (Schlotheim, 1813) in the weathered residuals of the 'Macrocephalen-Oolith' in the overburden indicate the early Koenigi Zone (Callomon et al. 1992).

4.2. Ostracods

About one third of the 177 ostracod species recorded in the Ursheim section (se Pls. 9–12) are stratigraphically useful. Their vertical distribution is shown in Table 2. Most of the index species according to Ohmert (2004) and Franz et al. (2014a) could be proven, except for those of the "Plana" and Primitiva ostracod zones.

Upper Aalenian – Lower Bajocian

– Pusilla ostracod Zone. The ostracod fauna of the uppermost Aalenian is very poor (total of 10 individuals in 3 samples). *Camptocythere pusilla* Triebel, 1950, index species of the Pusilla ostracod zone (Ohmert 2004) could not be found here nor in the lowermost Bajocian, the basal boundary of which is indicated by the first appearance of *Kinkelinella* (*Ekt.*) cf. *levata* Ohmert, 2004, ranging from 88.00 m to 86.45 m. The index species of the Levata ostracod Subzone is accompanied by *Praeschuleridea ventriosa ventriosa* Plumhoff, 1963 (unfigured), which persists a little higher up (86.0 m), and *Dolocythere maculosa* Bate, 1963 (unfigured), occurring in sample 87.50 m only.

– Triangula ostracod Zone. The ostracod fauna of the Weiße-Laber Subformation is characterized by *Dolocythere tuberculata* Luppold, 2012, the zonal index species *Kinkelinella* (*Ekt.*) *triangula* (Brand, 1961) and the subzonal index species *Progonocythere triangulata* Braun, 1958 and *Fuhrbergiella* (*Praef.*) *horrida bicostata* Brand & Malz, 1962. *Pr. triangulata* ranges from 86.25 to 85.05 m and *F.* (*Praef.*) *horrida bicostata* ranges from 84.60 to 83.70 m. The index species are accompanied by *Pleurocythere laticosta* Braun, 1958 (unfigured), *Praeschuleridea ornata* Bate, 1963, *Cytherella callosa ampla* Braun, 1958 (unfigured), and *Cytherelloidea cadomensis* Bizon, 1960. In the upper part of the Weiße-Laber Subformation, persisting up to the 'Humphriesianum-Oolith', we found several specimens of a transitional form of *Pleurocythere laticosta* Braun, 1958 to *Pl. regularis* Triebel, 1951. In our opinion this transitional form is closer to the latter species which lead us to the determination as *Pleurocythere* cf. *regularis* (Pl. 10, Fig. a).

– Sauzei ostracod Zone. *Fuhrbergiella* (*Praef.*) *sauzei* Brand & Malz, 1962 occurred only in sample 82.95–83.00 m, together with moderately preserved ? *Clithrocytheridea* aff. *plana* (Braun, 1958) (unfigured). We assigned this sample to the Sauzei Zone, because the identification of *C. plana* is somewhat doubtful. These two species are accompanied by *Pleurocythere* cf. *regularis*, *Palaeocytheridea blaszykina* Franz et al., 2009 and single representatives of several species of the small genera *Procytherura, Plumhoffia* and *Rutlandella.*

– ? Plana/Primitiva Ostracod zones. Neither index species could be proven. The overlying part of the section is characterized by the co-occurrence of *Tethysia*

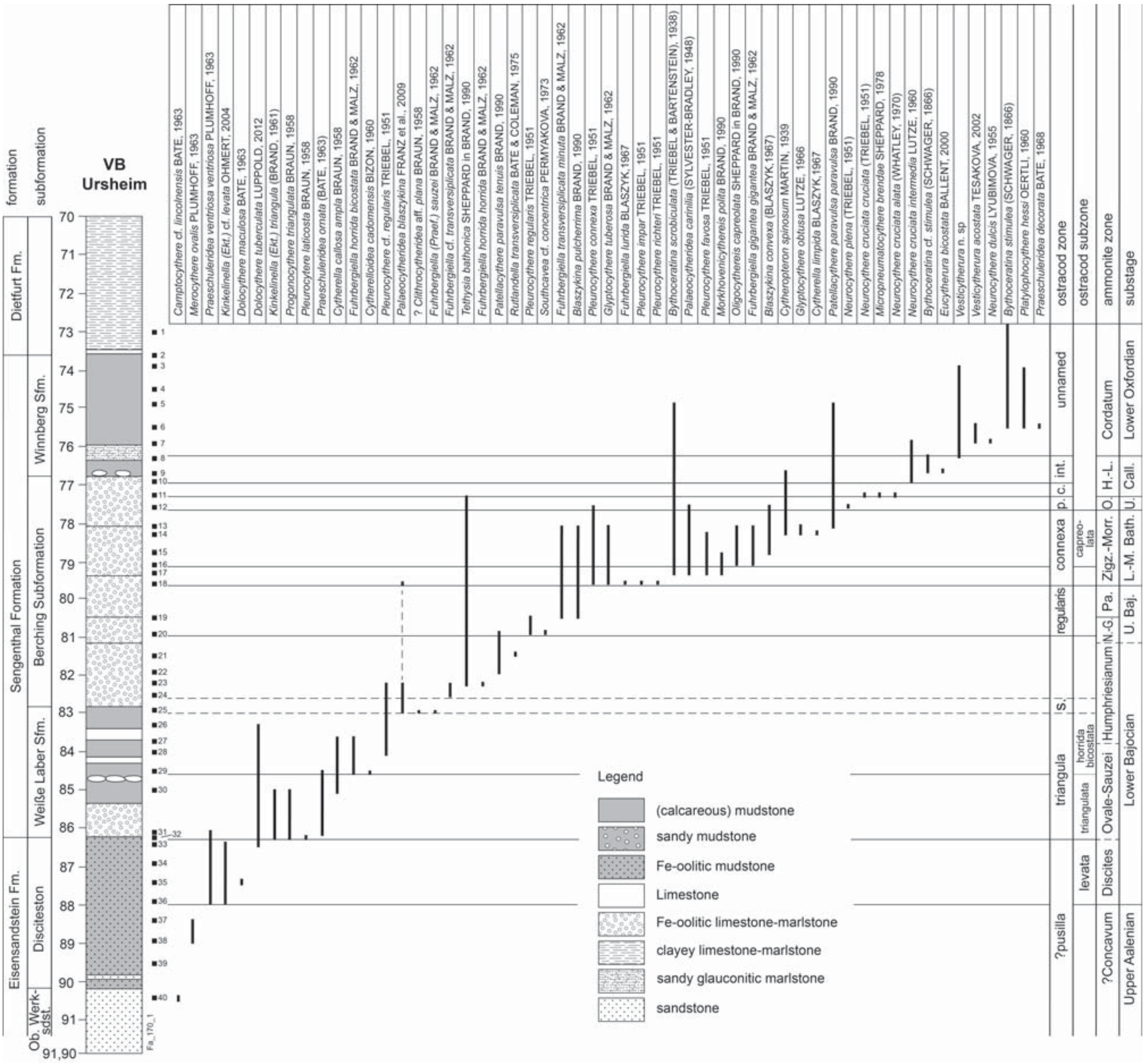

Table 2. Vertical distribution of biostratigraphically valuable ostracods in the drillcore VB Ursheim.
s. = sauzei, p. = plena, c. = cruciata; for further abbreviations see Fig. 4.

bathonica Sheppard in Brand, 1990, *Pleurocythere* cf. *regularis* Triebel, 1951, *Palaeocytheridea blaszykina* Franz et al., 2009, *Fuhrbergiella* (*Fuhrb.*) *cf. transversiplicata* Brand & Malz, 1962, *Fuhrbergiella* (*Praef.*) *horrida horrida* Brand & Malz, 1962, *Patellacythere paravulsa tenuis* Brand, 1990 (unfigured) and *Rutlandella transversiplicata* Bate & Coleman, 1975.

Lower – Upper Bajocian

– Regularis Ostracod Zone. Besides the index species *Pleurocythere regularis* Triebel, 1951, which first appears in sample 80.90–80.95 m, the most significant species are *Fuhrbergiella* (*Fuhrb.*) *transversiplicata minuta* Brand & Malz, 1962, *Blaszykina pulcherrima* Brand, 1990 and *Tethysia bathonica* Sheppard in Brand, 1990.

Lower Bathonian

– Connexa Ostracod Zone. The lower Bathonian ostracod assemblage is characterized by the index species *Pleurocythere connexa* Triebel, 1951 and other species of this genus, *Pl. favosa* Triebel, 1951 (unfigured), *Pl. impar* Triebel, 1951 (unfigured), *Pl. richteri* Triebel, 1951. Accompanying elements are several species of *Glyptocythere* as *Gl. tuberosa* Brand & Malz, 1962 (unfigured) and *Gl. obtusa* Lutze, 1966 and *Procytheropteron* aff. *gramanni* Brand, 1990. The first appearance of *Oligocythereis capreolata* Sheppard in Brand, 1990 in sample 79.06–79.14 m defines the base of the Capreolata Subzone.

Upper Bathonian

– Plena Ostracod Zone. Only sample 77.65–77.70 m can be assigned to this zone, indicated by the appearance of *Neurocythere plena* (Triebel, 1951) (unfigured). *Pleurocythere connexa* Triebel, 1951, *Palaeocytheridea carinilia* Franz et al., 2009 and *Blaszykina convexa* (Blaszyk, 1967) (unfigured) have their last occurrences here.

Lower – Middle Callovian

– Cruciata Ostracod Zone. At the base of the Callovian *Neurocythere cruciata cruciata* (Triebel, 1951) and *N. cruciata alata* (Whatley, 1970) (unfigured) appear, together with *Micropneumatocythere brendae* Sheppard, 1978. *Tethysia bathonica* Sheppard in Brand, 1990 is still frequent and has its last occurrence here.

– Intermedia Ostracod Zone. Besides the index species *Neurocythere cruciata intermedia* (Lutze, 1960) the most significant ostracods in this assemblage are *Patellacythere paravulsa paravulsa* Brand, 1990, *Bythoceratina stimulea* (Schwager, 1866) (unfigured), vesticytherurids and polycopids.

Upper Callovian – Middle Oxfordian

– Unnamed "Zone". In this part of the section, comprising the upper part of the Sachsendorf horizon (the former 'Glaukonitsandmergel') and the upward following claystones, *Platylophocythere hessi* Oertli, 1960 appears new, *Bythoceratina stimulea* (Schwager, 1866) still persists, again accompanied by vesticytherurids and polycopids.

4.3. Foraminifera

Most foraminiferal taxa encountered in the Ursheim section (see Pl. 13) have long ranges within the Jurassic. Only few species have a certain stratigraphical value. *Astacolus volubilis* Dain, 1958 ranges from the Bajocian to the Lower Bathonian of Germany and Poland (Bielecka & Styk 1969, 1981; Munk 1978), *Palmula semiinvoluta* (Terquem, 1870) occurs in the Upper Bajocian and Bathonian of Southwest Germany (Blank 1990). S*ubhercynella arachne* (Kopik, 1969) ranges from the Bathonian to the Oxfordian. *Lingulina franconica* (Gümbel, 1862) and *Epistomina mosquensis* Uhlig, 1883 are mostly restricted to the Callovian and Oxfordian (Brand & Fahrion 1962; Klingler et al. 1962). *Ophthalmidium strumosum* (Gümbel, 1862) is a characteristic species of the Callovian to Kimmeridgian of Europe (Munk 1978; Shipp 1989).

In the Ursheim section *Astacolus volubilis* Dain, 1958 was present from 86.20 m to 80.90 m, *Palmula semiinvoluta* (Terquem, 1870) extended between 81.50 m and 84.60 m. S*ubhercynella arachne* (Kopik, 1969) was found in most samples between 76.33 m and 79.70 m. *Ophthalmidium strumosum* (Gümbel, 1862) has a first occurrence at 77.40 m and extends to the top of the section. *Epistomina mosquensis* Uhlig, 1883 was frequent in all samples between 73.95 m and 75.50 m, whereas *Lingulina franconica* (Gümbel, 1862) was observed in two samples only (at 74.50–74.55 m and at 75.50–75.55 m).

The following species are also characteristic for the Bajocian to Oxfordian in Western Europe: *Ammobaculites suprajurassicus* (Schwager, 1865), *Tristix acutangula* (Reuss, 1863), *Lingulina longiscata* (Terquem, 1870), *Planularia beierana* (Gümbel, 1862), *Planularia lanceolata* (Schwager, 1865), *Planularia pseudoparallela* Seibold & Seibold, 1956, *Citharina proxima* (Terquem, 1867), *Marginulina hirta* Paalzow, 1922, *Lenticulina quenstedti* (Gümbel, 1862), *Saracenaria cornucopiae* (Schwager, 1865), *Saracenaria triquetra* (Gümbel, 1862), *Spirillina polygyrata* Gümbel, 1862, and *Spirillina tenuissima* Gümbel, 1862.

4.4. Biostratigraphical correlation

The combination of biostratigraphy by macro- and microfauna allows us to define previously unknown zonal boundaries or to state some boundaries more precisely in the section studied (see Fig. 4):

The base of the Discites Zone could be defined in the middle of the 'Disciteston' only by the first appearance of *Kinkelinella* (*Ekt.*) cf. *levata*.

The Ovale Zone and the lower Laeviuscula Zone are proven by *Pseudoshirbuirnia oechslei*, *Shirbuirnia gingensis* and *Pseudoshirbuirnia stephani* on the one hand and the first occurrences of *Kinkelinella* (*Ekt.*) *triangula* and *Progonocythere triangulata*, which all appear in the peculiar red bed 2. In sample 86.12–86.14 m (~ bed 2a) *Astacolus volubilis* also appears first.

Fuhrbergiella (*Praef.*) *horrida bicostata* is characteristic for the upper Laeviuscula Zone (samples 84.55–84.60 to 83.70–83.75 m), presumably corresponding to beds 3–5. *Palmula semiinvoluta*, which ranges from sample 81.50–81.55 m to 84.55–84.60 m (= bed 5 to the middle of bed 7), has its first occurrence here.

The Sauzei Zone could not be proven by ammonites. *Fuhrbergiella* (*Praef.*) *sauzei*, index ostracod of the Sauzei Ostracod Zone, according to Ohmert (2004) corresponding to the upper part of the Sauzei Ammonite Zone and the lowermost Humphriesianum Zone, could be found only in one sample (82.95–83.00 m). The Pinguis Subzone is proven by *Dorsetensia subtecta* in bed 6b, which seemingly is situated a little deeper in the section. As a consequence, the base of the Sauzei Ostracod Zone might be situated a little deeper or we must assume a hiatus.

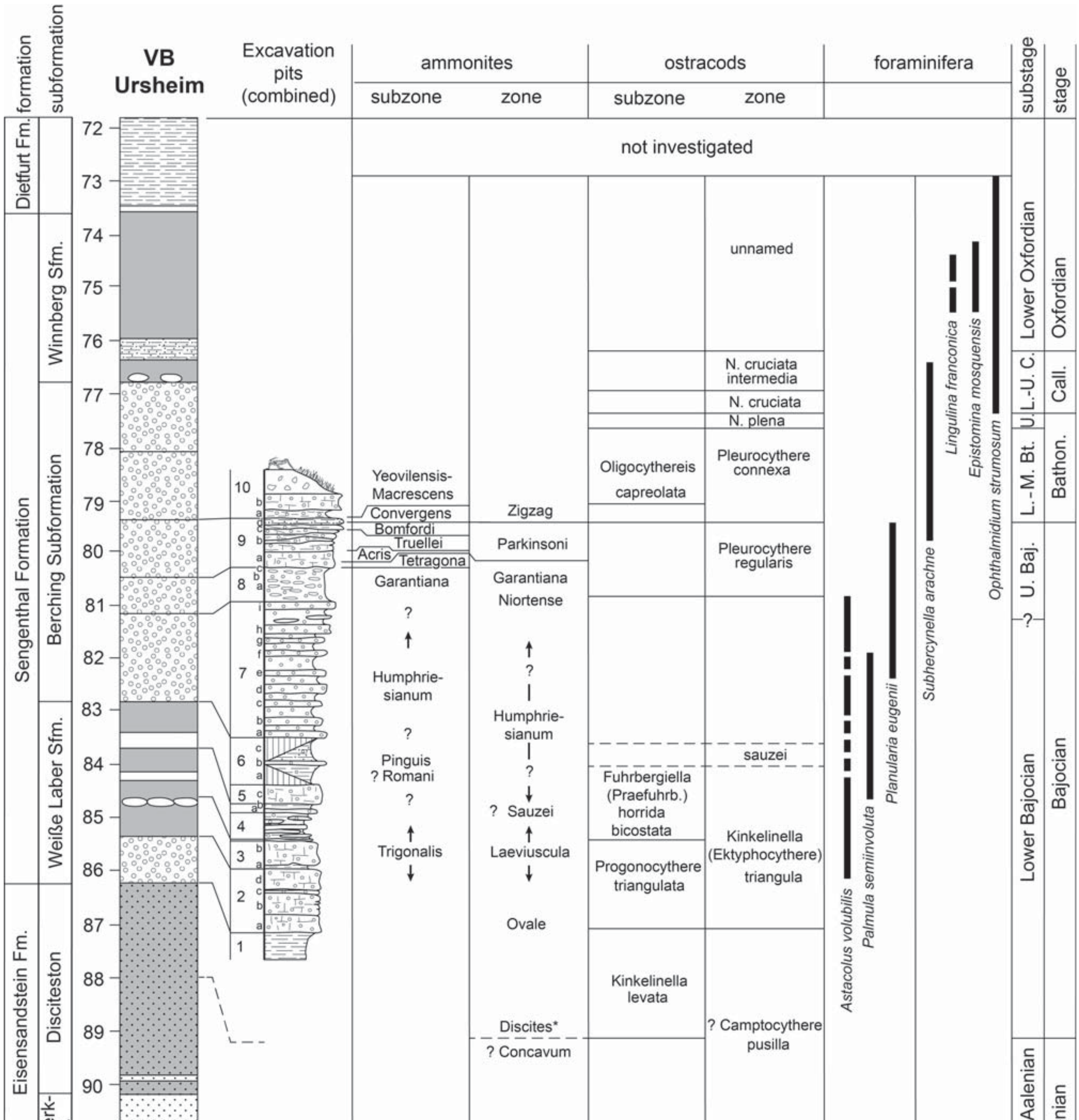

Fig. 4. Synopsis of the lithostratigraphy of core drilling VB Polsingen-Ursheim, the excavation pits in Polsingen-Ursheim (compiled) and the ammonite, ostracod and foraminifera chronostratigraphy (* the Discites Zone is only proven by ostracods). Abbreviations: Ob. Werksdst. = Oberer Werksandstein, N. = Neurocythere, U. Baj = Upper Bajocian, L. – M. Bt. = Lower – Middle Bathonian, U = Upper Bathonian, L. – U. C. = Lower – Upper Callovian, Call. = Callovian.

Beds 7a–7i represent the Humphriesianum Zone, proven by the genera *Chondroceras*, *Itinsaites* and *Stephanoceras*, though not collected bed-by-bed. The index ostracods *Schuleridea* "*plana*" and *Fuhrbergiella* (*Fuhrb.*) *primitiva* could not be found in the corresponding part of the drillcore. The assemblage instead is characterized by *Fuhrbergiella* (*Praef.*) *horrida horrida*, *Procytheropteron trematon* – according to Brand & Malz (1962) and Braun (1958) typical ostracods of the Humphriesianum Zone – and *Pleurocythere* cf. *regularis.* In sample 82.20–82.25 m *Planularia eugenii,* which is closely related to *Planularia pseudoradiata*, appears.

The Niortense to Parkinsoni zones (beds 8 and 9) are well documented by ammonites of the genera *Caumontisphinctes*, *Garantiana*, *Parkinsonia*, *Strigoceras*, which correlate well with the occurrence of *Pleurocythere regularis* together with *Fuhrbergiella* (*Fuhrb.*) *projecta* and *Fuhrbergiella* (*Fuhrb.*) *transversiplicata transversiplicata* in samples 80.55–80.60 to 80.90–80.95 m.

In sample 79.62–79.70 m (= bed 9d) *Pleurocythere connexa*, the index species of the Connexa Ostracod Zone, appears together with *Subhercynella arachne*. According to Franz et al. (2014a) *Pl. connexa* ranges from the base to the top of the Bathonian. The highly diverse ostracod fauna comprises, among others, the typical Bathonian species *Blaszykina convexa*, *Fissocythere* sp., *Fuhrbergiella* (*F.*) *gigantea gigantea*, *F.* (*F.*) *transversiplicata minuta*, *Glyptocythere tuberosa*, *Gl. similis*, *Gl. comes*, *Pleurocythere favosa*, *Pl. impar*, *Pl. richteri*, and *Morkhovenicythereis polita*.

The first appearance of *Oligocythereis capreolata* defines the base of the Capreolata Subzone, which corresponds to the Macrescens through the Tenuiplicatus subzones, thus confirming the results of Dietze & Dietl (2006) and Dietze et al. (2007).

The upward following part of the section was eroded in the excavation pits, so we can correlate it only on the base of ostracods and foraminifers from the drillcore.

Together with *Neurocythere plena,* the index ostracod of the Plena Ostracod Zone, *Pleurocythere kurskensis* and *Praeschuleridea subtrigona* appear in sample 77.65–77.70 m. *Subhercynella arachne* is still present.

While *Subhercynella arachne* still persists in sample 77.33–77.40 m, *Neurocythere cruciata cruciata* and *N. cruciata alata* appear, accompanied by *Micropneumatocythere brendae*.

The assemblage with *Neurocythere cruciata intermedia*, *Bythoceratina stimulea* and *Eucytherura bicostata* ranges from 76.33 m to 77.0 m. At this level *Subhercynella arachne* has its last occurrence.

The yet unnamed ostracod zone above the Sachsendorf horizon (73.00–75.95 m), presumably belonging to the Transversarium Zone, is characterized by the co-occurrence of *Platylophocythere hessi*, *Neurocythere dulcis* and *Bythoceratina stimulea*, partly accompanied by *Lingulina franconica* (74.5–75.55 m) and *Epistomina mosquensis* (73.95–75.55 m).

5. Correlation with neighbouring areas

5.1. Lithostratigraphy and ammonites in the Sengenthal Formation

Zöllner (1946) described a section Hechlingen-Kapellenberg (ca. 1 km north of the Ursheim section) from the 'Braunjura β' [= Eisensandstein Formation] to the uppermost 'Braunjura γ' [= Wedelsandstein Formation]. Concerning lithology and thickness of the strata this section differs remarkably from the Ursheim section, so that a correlation is virtually impossible. Some 5–6 m thick yellow to yellowish-grey sandstones with single thin clay-layers of the upper 'Braunjura β' are overlain by 0.1 m calcareous sandstone, named 'Grenzbank β/γ' [boundary bed] by Zöllner (1946). Above follow 0.4 m clayey sands, overlain by a 0.15 m thick red calcareous marlbed with red clay marl lenses. Section-up follow ca. 2 m thick green, weathered yellow "clays" with concretions and "rattle stones", in their lower fourth with a horizontally consistent "red layer". The red beds may partly correlate to our characteristic red bed 2. The following 0.8 m thick alternation of dark clays, marls, calcareous sandstones and sands may eventually correspond in part with our beds 3 and 4. The top of the 'Braunjura γ' is built by 0.6 m thick yellowish-brown, calcareous sandstones with small ooids. These beds may partly correlate to our beds 4 and 5.

Some 600 m east of Hechlingen Schairer (1973) described a section from the 'Braunjura β' to the 'Weißjura α' – figured in Gall et al. (1977) and Schmidt-Kaler (1991). Hence, his observations are questionable concerning the partly abnormally small thicknesses as well as the bed sequence and its fossil content. Eventually the strata were strongly weathered and/or slidden; otherwise his descriptions of the Sengenthal Formation are difficult to interprete, especially because the succession of ammonites is confusing, namely the occurrence of *Garantiana* and *Caumontisphinctes* (Garantiana and Niortense zones) above fragments of parkinsoniids (Parkinsoni Zone) and directly below stephanoceratids (Humphriesianum Zone).

In the explanations of the geological map of Bavaria, sheet no. 6930 Heidenheim (Schmidt-Kaler, 1970) a section at the eastern outskirts of Heidenheim am Hahnenkamm, nearly 10 km north of Ursheim, first published by Wagner (1963), is reproduced. Therein, the calcareous marl (0.3 m) between the 'Varians-Oolith' and the 'Parkinsonien-Oolith' as well as the 'Parkinsonien-Oolith' (1.1 m) are slightly thicker, the 'Bifurcaten-Oolith' (1.25 m) notably thicker as the corresponding beds 10a–8 in Ursheim. Near

Heidenheim, below the 'Bifurcaten-Oolith' follow several meters thick "Oolithkalke" [calcareous iron oolites], which at least partly can be correlated with bed 7 in Ursheim. The correlation of deeper parts of the section is difficult due to the short descriptions by SCHMIDT-KALER (1970).

From a location near Erlbach (sheet Öttingen), at the northern Ries margin, GERSTLAUER (1940) described the lower "Sowerbyi-Schichten" [= Wedelsandstein Formation] as similar to the Eisensandstein Formation. This corresponds well to the lithology of bed 2 in Ursheim. Above follow blueish-grey limestones with *Sonninia crassispinata* BUCKMAN, 1892 and *Dorsetensia liostraca* BUCKMAN, 1892 (Ursheim: beds 3–5), overlain by blue clays void of fossils (Ursheim: bed 6). The "Wedelsandstein- und Coronaten-Kalke" ['Humphriesi-Oolith'] near Erlbach, Niederhofen and Hausen are very rich in fossils like the approximately correlatable bed 7 in Ursheim. In addition to several *Stephanoceras* spp. GERSTLAUER (1940) mentioned a *Witchellia* sp. [= ?*Dorsetensia* sp.] and numerous belemnites, bivalves, gastropods, etc. The 'Bifurcaten-Oolith' was not exposed in the area of map sheet Öttingen. The 'Parkinsonien-Oolith', 'Varians-Oolith' and 'Macrocephalen-Oolith' near Erlbach and in its vicinity are similarly developed as in Ursheim (beds 9–11). The Sengenthal Formation as a whole in the region northwest of Öttingen corresponds largely with the one in Polsingen-Ursheim.

In the area of map sheet Wemding, situated southwest of Ursheim at the Ries margin, WEBER (1941) could not describe a complete section. Due to the Ries impact there are only small blocks with Middle Jurasssic sediments exposed. But he found out that on the southwestern slope of the Wart as well as east and north of Wemding – in contrast to the Ries foreland (BENTZ 1924) –, the red "Pectinidenbank" (Ursheim: bed 2) and the overlaying, irregularly composed, 0.4–0.65 m thick "Sowerbyibank" (Ursheim: beds 3–4) are amalgamated to a calcareous sandstone. WEBER recovered in his so-called "Sowerbyibank" a fragment of a *S. gingensis* (WAAGEN, 1867) and a cast similar to "*S. sowerbyi*", and slightly higher up in the section a *Witchellia* cf. *laeviuscula* (SOWERBY, 1824) [= ? *Dorsetensia* sp.], determined after DORN (1935). Unfortunately he could not describe the section. From the Wart WEBER (1964) described directly above the "Sowerbyi-Sandkalksteinbank" fossil-rich, hard, strongly oolitic limestones, corresponding with the lower 'Braunjura δ' of the Bopfingen area, with a fragment of a *Stephanoceras* (Ursheim: lower part of bed 6). Along the old road Wemding–Wolferstadt he observed "higher strata of the Braunjura δ of the Bopfingen area" (Ursheim: upper part of bed 6), 0.6 m thick "Coronaten-Schichten" with *Teloceras blagdeni* (SOWERBY, 1818). He could neither prove the 'Bifurcaten-Oolith', 'Parkinsonien-Oolith', 'Varians-Oolith', and 'Macrocephalen-Oolith' (Ursheim: beds 9–11), which were recorded only as rubblestones.

For the correlation of the strata at the Hesselberg (northwest of the Ries) and at the Ipf (western Ries margin) we can refer to GALL et al. (1977) and SCHMIDT-KALER (1991), where the Hechlingen section by SCHAIRER (1963) is correlated with the Ipf and Hesselberg sections.

5.2. Ostracoda (Sengenthal Formation)

The microfauna (mainly foraminifera) of 31 cores from Middle Jurassic strata in Northern Bavaria were studied by ZIEGLER (1959). Concerning the Sengenthal Formation ('Braunjura γ'–'Braunjura ζ') he found no index ostracods in the Lower Bajocian. According to ZIEGLER (1959) *Pleurocythere regularis* TRIEBEL, 1951 is indicative for the Niortense to Parkinsoni zones, *Pl. connexa* TRIEBEL, 1951 is the index species of the Bathonian, *Lophocythere* (= *Neurocythere*) *plena* (TRIEBEL, 1951) of the Aspidoides-Schichten (= Orbis Zone). The Lower and Middle Callovian is characterized by *Neurocythere cruciata cruciata* (TRIEBEL, 1951) and *N. cruc. franconica* (TRIEBEL, 1951).

FRANZ et al. (2014a) published the Bathonian and Lower Callovian ostracod fauna of the Röttingen section. There, the Bathonian ostracod fauna was very poor; this is why the index species for the Bathonian could not be proven. The Callovian could be documented by several specimens of subspecies of *Neurocythere cruciata* (TRIEBEL, 1951) besides *Micropneumatocythere brendae* SHEPPARD, 1978, *Vesticytherura acostata* TESAKOVA, 2002, and others.

5.3. Foraminifera (Western Europe)

In NW Germany BARTENSTEIN & BRAND (1937) for the first time investigated extensively the foraminiferal fauna of the Middle and Upper Jurassic. LUTZE (1960) described Callovian and Oxfordian microfaunas (foraminifera and ostracoda), BRAND (1990) the foraminifera and ostracoda from an Upper Bathonian section near Hildesheim, NW Germany.

Stratigraphical investigations from South Germany were contributed by FRENTZEN (1941: Lower, Middle and Upper Jurassic of the Blumberg area, SW Germany), SEIBOLD & SEIBOLD (1953, 1960: Upper Jurassic of S Germany), ZIEGLER (1959: Middle Jurassic of Northern Bavaria), GROISS (1970: Oxfordian of the Franconian Alb), MUNK (1978, 1993: Bajocian to Oxfordian of the Franconian Alb), RIEGRAF (1988; Callovian foraminifera from SW Germany), and BLANK (1990: Bajocian to Callovian of the Swabian Alb).

In 1962, as a result of a consensus of German micropalaeontologists, commented range charts of stratigraphically important microfossils were published (BRAND

& FAHRION 1962; KLINGLER et al. 1962). Important index foraminifera of the Middle Jurassic of Northwest Germany are *Frondicularia nodosaria* [= *longiscata*] TERQUEM, 1870 for the Upper Bajocian, *Lenticulina tricarinella* (REUSS, 1863) for the Bathonian to Oxfordian, *Frondicularia franconica* GÜMBEL, 1862 and *Epistomina mosquensis* UHLIG, 1883 for the Callovian to Oxfordian.

From Great Britain essential stratigraphical investigations based on foraminifera include CIFELLI (1959: Bathonian of England), COLEMAN (1982: Middle Jurassic of England), GORDON (1967, 1970: Middle Jurassic of England and Scotland), BARNARD et al. (1981; Callovian to Oxfordian of England).

MORRIS & COLEMAN (1989) compiled range charts of stratigraphically important British Middle Jurassic foraminiferal species from the literature. Relevant species in common with those of the Ursheim section are *Lingulina longiscata* (TERQUEM, 1870), *Lenticulina quenstedti* (GÜMBEL, 1862) and *Lenticulina exgaleata* DIENI, 1985 in the Bajocian and Bathonian. More restricted Bathonian markers are *Lenticulina tricarinella* (REUSS, 1863) [syn. S*ubhercynella arachne* (KOPIK, 1969)], *Planularia eugenii* (TERQUEM, 1863), *Nodosaria ingens* (TERQUEM, 1870) and some others. In the Callovian appear *Frondicularia franconica* GÜMBEL, 1862 and *Saracenaria oxfordiana* TAPPAN, 1958 [syn. *Saracenaria triquetra* GÜMBEL, 1862]. According to SHIPP (1989) the Oxfordian and Kimmeridgian is characterized by *Citharina serratocostata* (GÜMBEL, 1862), *Epistomina mosquensis* UHLIG, 1883, *Epistomina parastelligera* (HOFKER, 1954), *Epistomina ornata* (ROEMER, 1841), *Frondicularia nikitini* UHLIG, 1883, *Lenticulina subalata* (REUSS, 1854) [syn. *Lenticulina helios* (TERQUEM, 1870)], *Tristix triangularis* BARNARD, 1953 [syn. *Tristix acutangula* (REUSS, 1863)], *Planularia beierana* (GÜMBEL, 1862), and *Ophthalmidium strumosum* (GÜMBEL, 1862).

There are only few biostratigraphical data on Middle Jurassic foraminifera from France (BIZON 1958; GARROT et al. 1958; WERNLI 1971). WERNLI (1971) listed *Ammobaculites coprolithiformis* (SCHWAGER, 1867), *Lingulina nodosaria* (TERQUEM, 1870) [related to *Lingulina longiscata* (TERQUEM, 1870)], *Planularia eugenii* (TERQUEM, 1863), *Lenticulina quenstedti* (GÜMBEL, 1862), *Lenticulina subalata* (REUSS, 1854) [syn. *Lenticulina helios* (TERQUEM, 1870)] and *Vaginulina clathrata* (TERQUEM, 1863) [related to *Citharina proxima* (TERQUEM, 1867)] from the Bajocian to Oxfordian, *Lenticulina tricarinella* (REUSS, 1863), *Marginulina glabra* D'ORBIGNY, 1826 [syn. *Marginulina hirta* PAALZOW, 1922], *Saracenaria cornucopiae* (SCHWAGER, 1865), *Vaginulina macilenta* (TERQUEM, 1867) in the Bathonian to Oxfordian, and *Epistomina mosquensis* UHLIG, 1883 in the Oxfordian.

The Bathonian foraminifera from the Mecsek Mountains (South Hungary) studied by GÖRÖG (1995) possess several characteristic species in common with the Ursheim section and other West European localities, but there are more Tethyan elements and similarities to the Bathonian fauna of Portugal or Sicily.

When compared to foraminiferal faunas from the Bathonian and Callovian of Poland there are many similarities, suggesting a communication of the German and Polish basins, with a higher faunal exchange during the Callovian (BIELECKA & STYK 1969, 1981).

6. Conclusions

The major part of the Sengenthal Formation was exposed in three excavation pits in the years 2011–2013 in Ursheim-Polsingen. The upper part of the formation, i.e., a part of the Bathonian and the Callovian, was missing by local erosion. At the same time, the drillcore VB Ursheim-Polsingen, below 73 m of Upper Jurassic sediments sunk through the complete Sengenthal Formation in a thickness of 13 m.

The ammonite collections from the excavation pits documented the Lower Bajocian Ovale, Laeviuscula and Humphriesianum Zones, the Upper Bajocian Niortense, Garantiana and Parkinsoni zones and the Lower Bathonian Zigzag Zone. The ostracod fauna from the drillcore, the relative richness of which may be due to its deep position below the reach of weathering, has proven the Kinkelinella levata Subzone of the Pusilla Zone, the Kinkelinella triangula Zone (with the Progonocythere triangulata and the Fuhrbergiella (Praef.) horrida bicostata subzones), the Fuhrbergiella (Praef.) sauzei Zone and the Pleurocythere regularis Zone in the Bajocian. In the Bathonian the Pleurocythere connexa and the Neurocythere plena zones could be documented. In the Callovian the Neurocythere cruciata cruciata and the N. cruciata intermedia zones could be proven.

From the surprisingly great number of species of foraminifera only seven seem to have a biostratigraphical value: *Astacolus volubilis*, *Palmula semiinvoluta*, *Planularia eugenii*, *Subhercynella arachne*, *Lingulina franconica*, *Epistomina mosquensis*, and *Ophthalmidium strumosum*.

Our results confirm the correlation of the well-established ammonite biostratigraphy of the Sengenthal Formation (DIETZE & DIETL 2006, DIETZE et al. 2007) with the ostracod zonations published by ZIEGLER (1959), OHMERT (2004) and FRANZ et al. (2014).

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Addresses of the authors:

VOLKER DIETZE, Meraner Straße 41, 86720 Nördlingen, Germany.

DR. MATTHIAS FRANZ, Regierungspräsidium Freiburg, Abt. 9, Landesamt für Geologie, Rohstoffe und Bergbau (LGRB), Sautierstr. 36, 79104 Freiburg i. Br., Germany.

MICHAEL KUTZ, 8 rue haute, 67390 Mackenheim, France.

ANTON WALTSCHEW, Steinplattenweg 55a, 90491 Nürnberg.

E-mails: dietze.v@t-online.de; Matthias.Franz@rpf.bwl.de; michael.kutz@orange.fr; anton.waltschew@googlemail.com

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Plate 1

All ammonites: Lower Bajocian; Polsingen-Ursheim.
1, 3. *Pseudoshirbuirnia stephani* (BUCKMAN, 1883); presumably bed 4; *stephani* horizon, Trigonalis Subzone, Laeviuscula Zone; E 821.
2, 4. *Pseudoshirbuirnia oechslei* DIETZE et al., 2005; bed 2, *oechslei* horizon, Ovale Zone; E 822.
Scale bar = 0.1 m.


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Plate 2

All ammonites: bed 2; Lower Bajocian; Polsingen-Ursheim.
(1, 2) *Sonninia adicra* (Waagen, 1867); Trigonalis Subzone, Laeviuscula Zone; E 823.
(3, 4) *Shirbuirnia gingensis* (Waagen, 1867); Trigonalis Subzone, Laeviuscula Zone; E 824.
Figs. 1–2 in natural size; Figs. 3–4: scale bar = 0.1 m. Beginning of the body chamber is indicated by an asterisk.


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Plate 3

All ammonites: Lower Bajocian; Polsingen-Ursheim.
(1, 2) *Sonninia aff. strigoceroides* DORN, 1935; from the excavated material, according to state of preservation from bed 4; Laeviuscula – Sauzei Zone; E 825.
(3, 4, 9, 10) *Itinsaites quenstedti* ROCHÉ, 1939*;* marl layer between beds 7e and 7f, Humphriesianum Subzone, Humphriesianum Zone; **3–4** E 826; **9–10** E 827.
(5, 6) *Stephanoceras* sp.*;* marl layer between beds 7e and 7f, Humphriesianum Subzone, Humphriesianum Zone; E 828.
(7, 8) *Dorsetensia subtecta* BUCKMAN, 1892; from the excavated material; according to state of preservation presumably from bed 6b; Pinguis or Romani Subzone (Humphriesianum Zone); E 829.
(11, 12) *Chondroceras polypleurum* WESTERMANN, 1956*;* from the excavated material; according to state of preservation from bed 7c or 7d; *gervillii/cycloides* horizon, Humphriesianum Subzone, Humphriesianum Zone; E 830.
(13, 14) *C. multicostatum* WESTERMANN, 1956*;* from the excavated material; according to state of preservation from bed 7c or 7d; *gervillii/cycloides* horizon, Humphriesianum Subzone, Humphriesianum Zone; E 831.
(15, 16) *C. gerzense* WESTERMANN, 1956*;* from the excavated material; according to state of preservation from bed 7c or 7d; *gervillii/cycloides* horizon, Humphriesianum Subzone, Humphriesianum Zone; E 832.
All specimens in natural size. Beginning of the body chamber is indicated by an asterisk.


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Plate 4

Loboidothyris perovalis (Sowerby, 1825); from the excavated material, very presumably from beds 7d–7f; Humphriesianum Subzone, Humphriesianum Zone; Polsingen-Ursheim; E 833. Natural size.

Plate 5

All ammonites: Upper Bajocian; Polsingen-Ursheim.

(1, 2) *Caumontisphinctes rota* (Bentz, 1924); from the excavated material; according to attached rock fragments presumably from the lower half of the 'Bifurcaten-Oolith'; [bed 8a] ?Polygyralis Subzone, Niortense Zone; E 834.

(3, 4) *Garantiana suevica* Wetzel, 1911; uppermost marl layer in the 'Bifurcaten-Oolith' [bed 8c], Garantiana Subzone, Garantiana Zone; E 835.

(5–7) *Garantiana* aff. *platyrryma* (Buckman, 1921); uppermost marl layer in the 'Bifurcaten-Oolith' [bed 8c], Garantiana Subzone, Garantiana Zone; E 836.

(8, 9) *Garantiana subgaranti* Wetzel, 1911; uppermost marl layer in the 'Bifurcaten-Oolith' [bed 8c], Garantiana Subzone, Garantiana Zone; E 837.

(10) *Prorsisphinctes pseudomartinsi* (Siemiradzki, 1899); lower surface of the 'Parkinsonien-Oolith' [base of bed 9a], Tetragona Subzone, Garantiana Zone; E 838.

(11, 12) *Garantiana wetzeli* Trauth, 1923; lowermost bed of the 'Parkinsonien-Oolith' [bed 9a], Tetragona Subzone, Garantiana Zone; E 839.

Figs. 1–9, 11–12 in natural size; Fig. 10: scale bar = 0.1 m. Beginning of the body chamber is indicated by an asterisk.

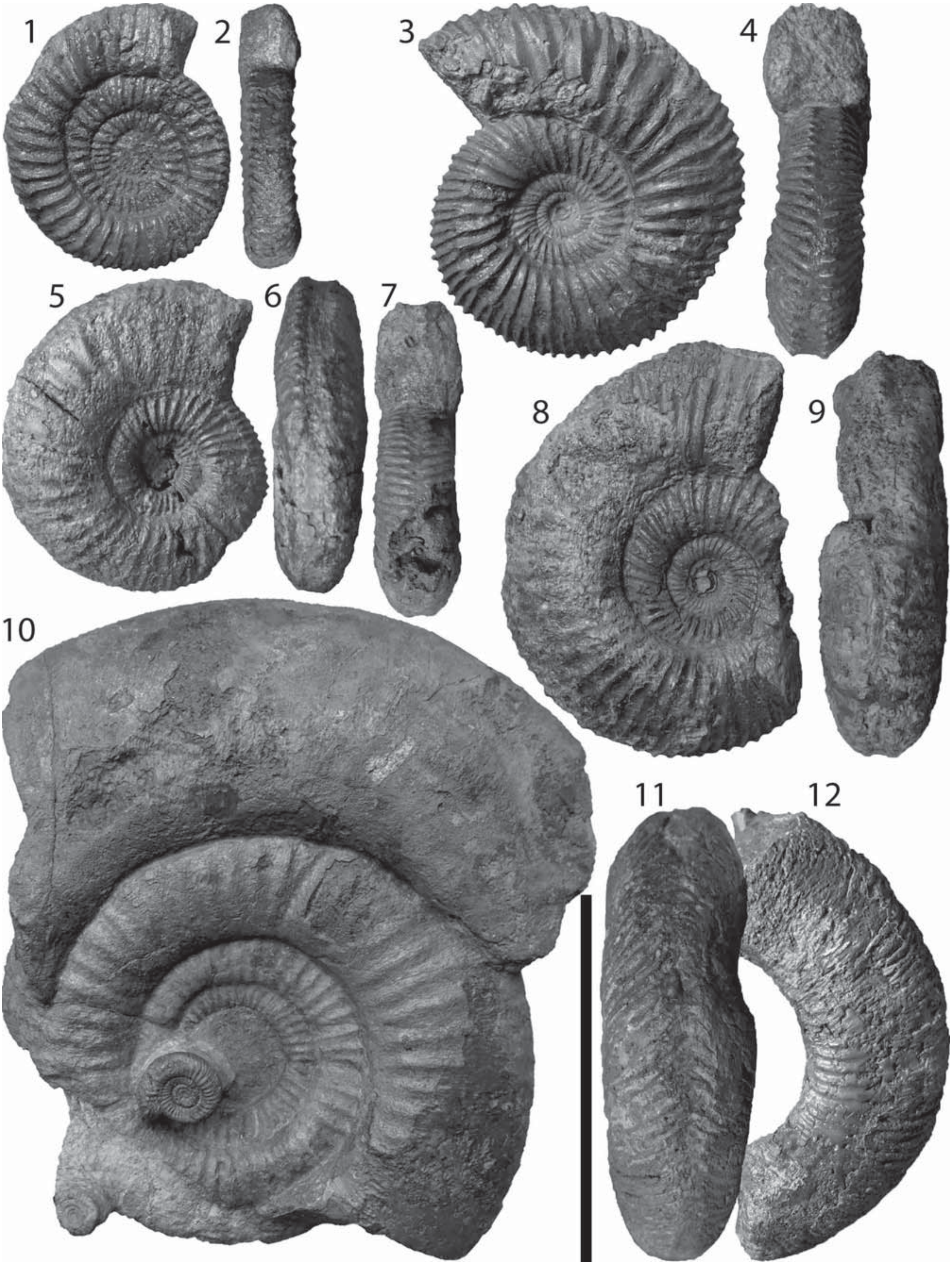
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Plate 6

All ammonites: 'Parkinsonien-Oolith', Parkinsoni Zone, Upper Bajocian; Polsingen-Ursheim.
(1, 2) *Parkinsonia rarecostata* (BUCKMAN, 1881); 0.2–0.3 m above the base of the 'Parkinsonien-Oolith' [top of bed 9a]; Acris Subzone; E 840.
(3, 6) *Parkinsonia pseudoparkinsoni* WETZEL, 1911; middle part of the 'Parkinsonien-Oolith'; Truellei Subzone [bed 9b]; E 841.
(4, 5) *Garantiana ipfensis* DIETZE et al., 2002; 0.2–0.3 m above the base of the 'Parkinsonien-Oolith' [top of bed 9a]; Acris Subzone; E 842.
All specimens in natural size. Beginning of the body chamber is indicated by an asterisk.

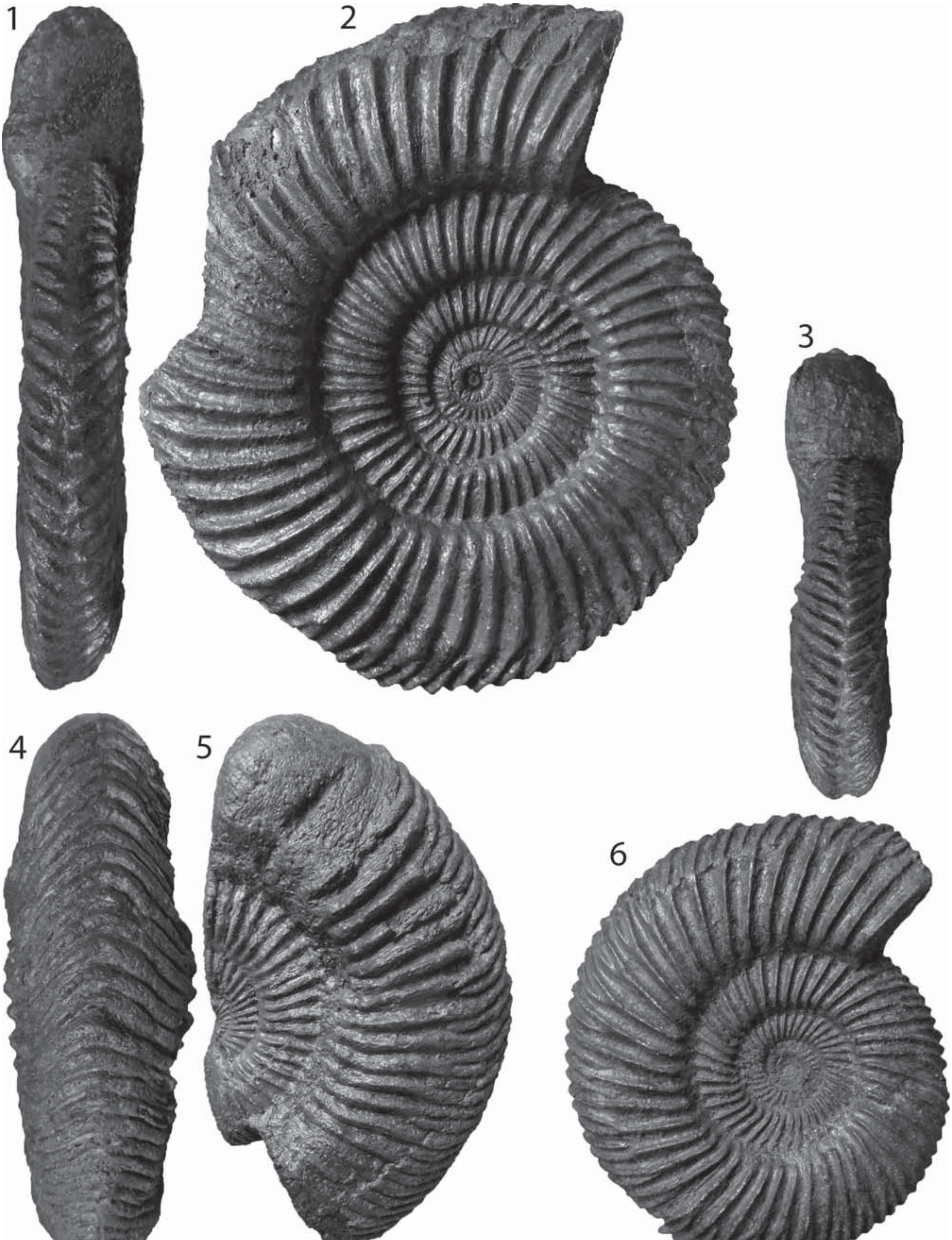
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Plate 7

All ammonites: 'Parkinsonien-Oolith'; Truellei Subzone, Parkinsoni Zone, Upper Bajocian; Polsingen-Ursheim.
(1) *Strigoceras truellei* (d'Orbigny, 1845); leg. Schairer†, exact bed unknown, according to attached rock fragments from the middle part of the 'Parkinsonien-Oolith' [bed 9b]; coll. no. SNSB-BSPG 1963 XXVII 88.
(2, 3) *Parkinsonia clapense* Maubeuge, 1951; middle part of the 'Parkinsonien-Oolith' [bed 9b]; E 843.
Figs. 1–3: Scale bar = 0.1 m. Beginning of the body chamber is indicated by an asterisk.


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Plate 8

All ammonites: 'Varians-Oolith' [bed 10]; Zigzag Zone, Lower Bathonian; Polsingen-Ursheim.
(1, 2) *Oraniceras wuerttembergicum* (Oppel, 1857); base of bed 10b, Macrescens Subzone; E 844.
(3, 6) *Procerites laeviplex* (Quenstedt, 1887); bed 10b; Macrescens Subzone; E 845.
(4, 5) *Oraniceras gyrumbilicum* (Quenstedt, 1886); base of bed 10b; Macrescens Subzone; E 846.
Figs. 1, 2 in natural size; Figs. 3–6: scale bar = 0.1 m. Beginning of the body chamber is indicated by an asterisk.


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Plate 9

All ostracods: Lower Bajocian; VB 1 Polsingen-Ursheim.
(a) *Kinkelinella* cf. *levata* Ohmert, 2004; LV, 87.95–88.00 m; Discites Zone; Em 711.
(b) *Acrocythere* sp.; RV, 87.95–88.00 m; Discites Zone; Em 712.
(c) *Kinkelinella* sp.; carapace, right view, 87.95–88.00 m; Discites Zone; Em 713.
(d) *Praeschuleridea ornata* (Bate, 1963); carapace, right view, 86.45–86.50 m; Discites Zone; Em 714.
(e) *Caytonidea* sp.; carapace, right view, 86.45–86.50 m; Discites Zone; Em 715.
(f) *Cytheropterina cribra* (Fischer, 1962); LV, 86.20–86.25 m; Laeviuscula Zone; Em 716.
(g) *Praeschuleridea* aff. *decorata* Bate, 1968; carapace, left view, 86.10–86.14 m; Laeviuscula Zone; Em 717.
(h) *Pleurocythere laticosta* Braun, 1958; carapace, left view, 86.10–86.14 m; Laeviuscula Zone; Em 718.
(i) *Kinkelinella malzi* (Dépêche, 1973); RV; 85.05–85.10 m; Laeviuscula Zone; Em 719.
(j) *Progonocythere* cf. *triangulata* Braun, 1958; carapace, left view, 85.05–85.10 m; Laeviuscula Zone; Em 720.
(k) *Procytheropteron trematon* Dilger, 1963; carapace, right view, 84.55–84.60 m; Laeviuscula Zone; Em 721.
(l) *Cytherelloidea cadomensis* Bizon, 1960; carapace, right view, 84.55–84.60 m; Laeviuscula Zone; Em 722.
(m) *Fuhrbergiella (Praefuhrbergiella) horrida bicostata* Brand & Malz, 1962; carapace, right view, 84.55–84.60 m; Laeviuscula Zone; Em 723.
(n) *Fuhrbergiella (Praefuhrbergiella) horrida bicostata* Brand & Malz, 1962; carapace, right view, 84.05–84.10 m; Laeviuscula Zone; Em 724.
(o) *Dolocythere tuberculata* Luppold, 2012; carapace, left view, 84.05–84.10 m; Laeviuscula Zone; Em 725.

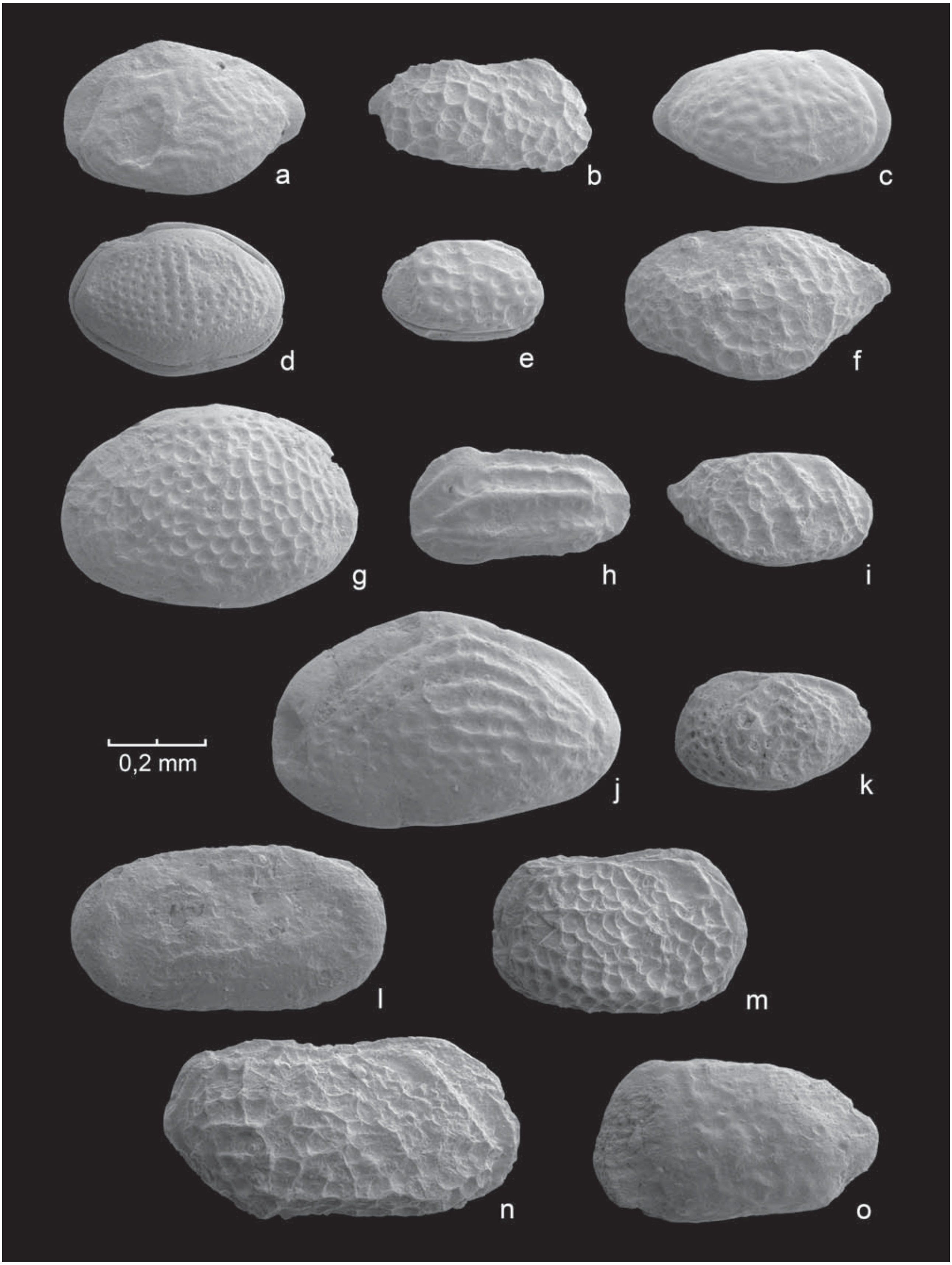
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Plate 10

All ostracods: Lower Bajocian; VB 1 Polsingen-Ursheim.
(a) *Pleurocythere cf. regularis* Triebel, 1951; carapace, right view; 83.70–83.75 m; Laeviuscula Zone; Em 726.
(b) *Cytheropterina cribra* (Fischer, 1962); carapace, left view; 83.35–83.40 m; Laeviuscula Zone; Em 727.
(c) *Palaeocytheridea blaszykina* Franz et al., 2009; carapace, left view, 82.95–83.00 m; Sauzei Zone; Em 728.
(d) *Rutlandella* sp.; carapace, right view, 82.95–83.00 m; Sauzei Zone; Em 729.
(e) *Systenocythere perforata* (Braun, 1958); carapace, right view, 82.95–83.00 m; Sauzei Zone; Em 730.
(f) *Fuhrbergiella* (*Praefuhrbergiella*) *sauzei* Brand & Malz, 1962; carapace, left view; 82.95–83.00 m; Sauzei Zone; Em 731.
(g) *Fuhrbergiella* cf. *transversiplicata* Brand & Malz, 1962; carapace, right view, 82.55–82.60 m; Humphriesianum Subzone, Humphriesianum Zone; Em 732.
(h) *Palaeocytheridea blaszykina* Franz et al., 2009; carapace, right view, 82.20–82.25 m; Humphriesianum Subzone, Humphriesianum Zone; Em 733.
(i) *Kinkelinella* cf. *malzi* (Dépêche, 1973); carapace, right view; 82.20–82.25 m; Humphriesianum Subzone, Humphriesianum Zone; Em 734.
(j) *Fuhrbergiella* (*Praefuhrbergiella*) *horrida* cf. *horrida* Brand & Malz, 1962; carapace, left view, 82.20–82.25 m; Humphriesianum Subzone, Humphriesianum Zone; Em 735.
(k) *Homocytheridea* aff. *cylindrica* Bate, 1963; carapace, right view, 81.95–82.00 m; Humphriesianum Zone; Em 736.
(l) *Rutlandella transversiplicata* Bate & Coleman, 1975; carapace, right view, 81.50–81.55 m; Humphriesianum Zone; Em 737.
(m) *Bythocypris* sp.; carapace, left view, 81.50–81.55 m; Humphriesianum Zone; Em 738.
(n) *Procytherura* sp.; carapace, right view, 81.50–81.55 m; Humphriesianum Zone; Em 739.
(o) *Renicytherura* cf. *parairregularis* Brand, 1990; carapace, left view, 81.50–81.55 m; Humphriesianum Zone; Em 740.

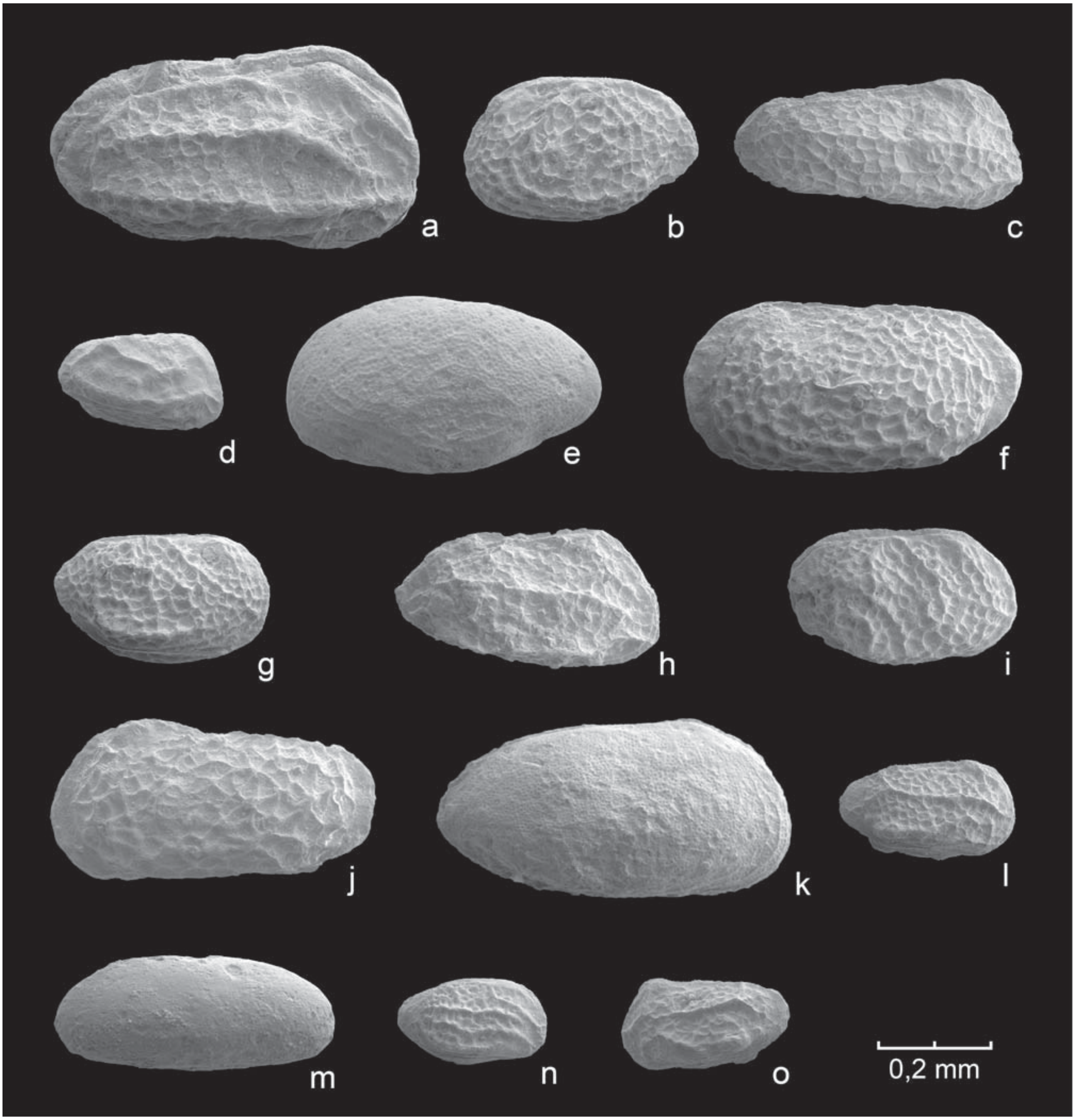
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Plate 11

Ostracods: Upper Bajocian–Lower (?Middle) Bathonian; VB 1 Polsingen-Ursheim.
(a) *Tethysia bathonica* Sheppard in Brand, 1990; carapace, left view; 80.90–80.95 m; Niortense Zone; Em 741.
(b) *Procytherura* sp.; carapace, left view; 80.90–80.95 m; Niortense Zone; Em 742.
(c) *Procytheropteron* ? *infrasaxonicum* Brand, 1990; carapace, left view, 80.90–80.95 m; Niortense Zone; Em 743.
(d) *Pleurocythere regularis* Triebel, 1951; RV, 80.55–80.60 m; Garantiana Zone; Em 744.
(e) *Pleurocythere richteri* triebel, 1951; carapace, right view, 79.62–79.70 m; Convergens Subzone, Zigzag Zone; Em 745.
(f) *Fuhrbergiella* (*Praef.*) *lurida* Blaszyk, 1967; carapace, right view; 79.62–79.70 m; Convergens Subzone, Zigzag Zone; Em 746.
(g) *Pleurocythere connexa* Triebel, 1951; carapace, right view, 79.32–79.41 m; Macrescens–Yeovilensis subzones, Zigzag Zone; Em 747.
(h) *Morkhovenicythereis polita* Brand, 1990; carapace, left view, 79.32–79.41 m; Macrescens–Yeovilensis Subzone, Zigzag Zone; Em 748.
(i, j) *Procytheropteron* sp.; I, RV, male; j, LV, female; 79.06–79.14 m; Macrescens–Yeovilensis subzones, Zigzag Zone; Em 749.
(k) *Pleurocythere connexa* Triebel, 1990; RV, 79.06–79.14 m; Macrescens–Yeovilensis subzones, Zigzag Zone; Em 750.
(l) *Oligocythereis capreolata* Sheppard in Brand, 1990*;* RV, 78.82–78.88 m; ? Zigzag Zone; Em 751.
(m) *Glyptocythere obtusa* Lutze, 1966; carapace, right view, 78.32–78.34 m; ? Zigzag Zone; Em 752.
(n) *Palaeocytheridea carinilia* (Sylvester-Bradley, 1948); LV, 78.32–78.34 m; ? Zigzag Zone; Em 753.
(o) *Procytheropteron* aff. *gramanni* Brand, 1990; RV, 78.10–78.16 m; ? Zigzag Zone; Em 754.
(p) *Glyptocythere reticulata* (Bate, 1963); RV, 78.10–78.16 m; ? Zigzag Zone; Em 755.

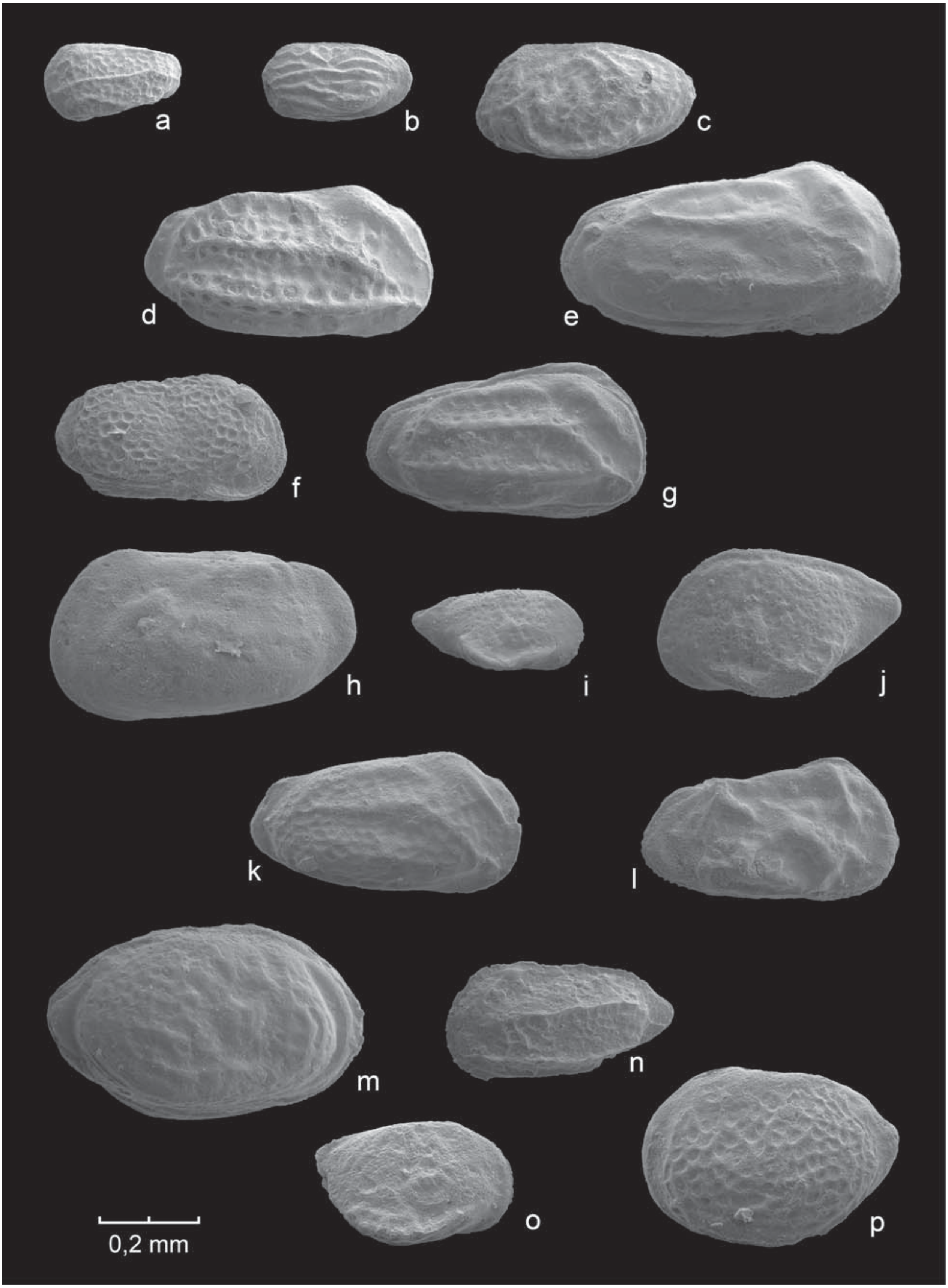
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Plate 12

Ostracods: Upper Bathonian–? Middle Oxfordian; VB 1 Polsingen-Ursheim.
(a) *Procytherura* sp.; carapace, LV; 77.65–77.70 m; Orbis Zone; Em 756.
(b) ? *Morkhovenicythereis* sp.; RV; 77.65–77.70 m; Orbis Zone; Em 757.
(c) *Pleurocythere kurskensis* Tesakova, 2009; RV, 77.65–77.70 m; Orbis Zone; Em 758.
(d) *Micropneumatocythere brendae* Sheppard, 1978; RV, 77.33–77.40 m; Herveyi Zone; Em 759.
(e) *Neurocythere cruciata cruciata* triebel, 1951; LV, 76.93–77.00 m; Koenigi Zone; Em 760.
(f) *Eucytherura bicostata* Ballent, 2000; carapace, right view; 76.70–76.75 m; Koenigi Zone; Em 761.
(g) *Cytherella fullonica* Jones & Sherborn, 1888; RV, 76.33–76.35 m; Calloviense Zone; Em 762.
(h) *Patellacythere paravulsa paravulsa* Brand, 1990; carapace, right view, 76.33–76.35 m; Calloviense Zone; Em 763.
(i) *Vesticytherura* sp. 1; G, left view; 75.90–75.95 m; ? Transversarium Zone; Em 764.
(j) *Neurocythere dulcis* (Lyubimova, 1955); carapace, left view; 75.90–75.95 m; Cordatum – ?Plicatilis zones; Em 765.
(k) *Neurocythere cruciata.intermedia* (Lutze, 1960); RV, 75.90–75.95 m; Cordatum – ? Pliactilis zones; Em 766.
(l) *Praeschuleridea decorata* Bate, 1968; RV, 75.50–75.55 m; Cordatum – ? Plicatilis zones; Em 767.
(m) *Vesticytherura acostata* Tesakova, 2002; carapace, left view, 75.50–75.55 m; Cordatum – ? Pliactilis zones; Em 768.
(n) *Platylophocythere hessi* Oertli, 1960; LV, 74.50–74.55 m; Cordatum – ? Plicatilis zones; Em 769.
(o) *Pontocyprella* sp.; carapace, left view, 73.00–73.05 m; ? Transversarium Zone; Em 770.

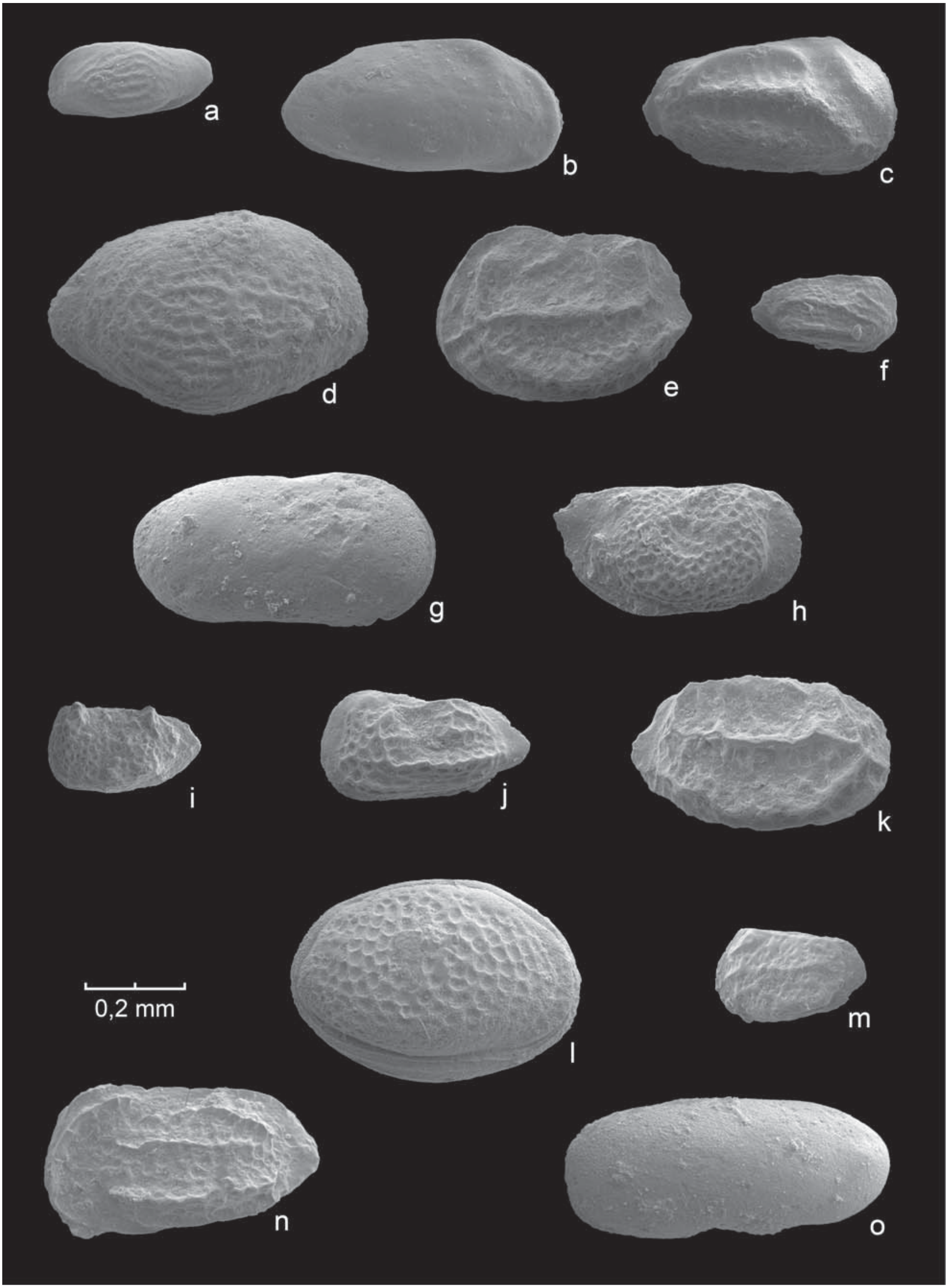
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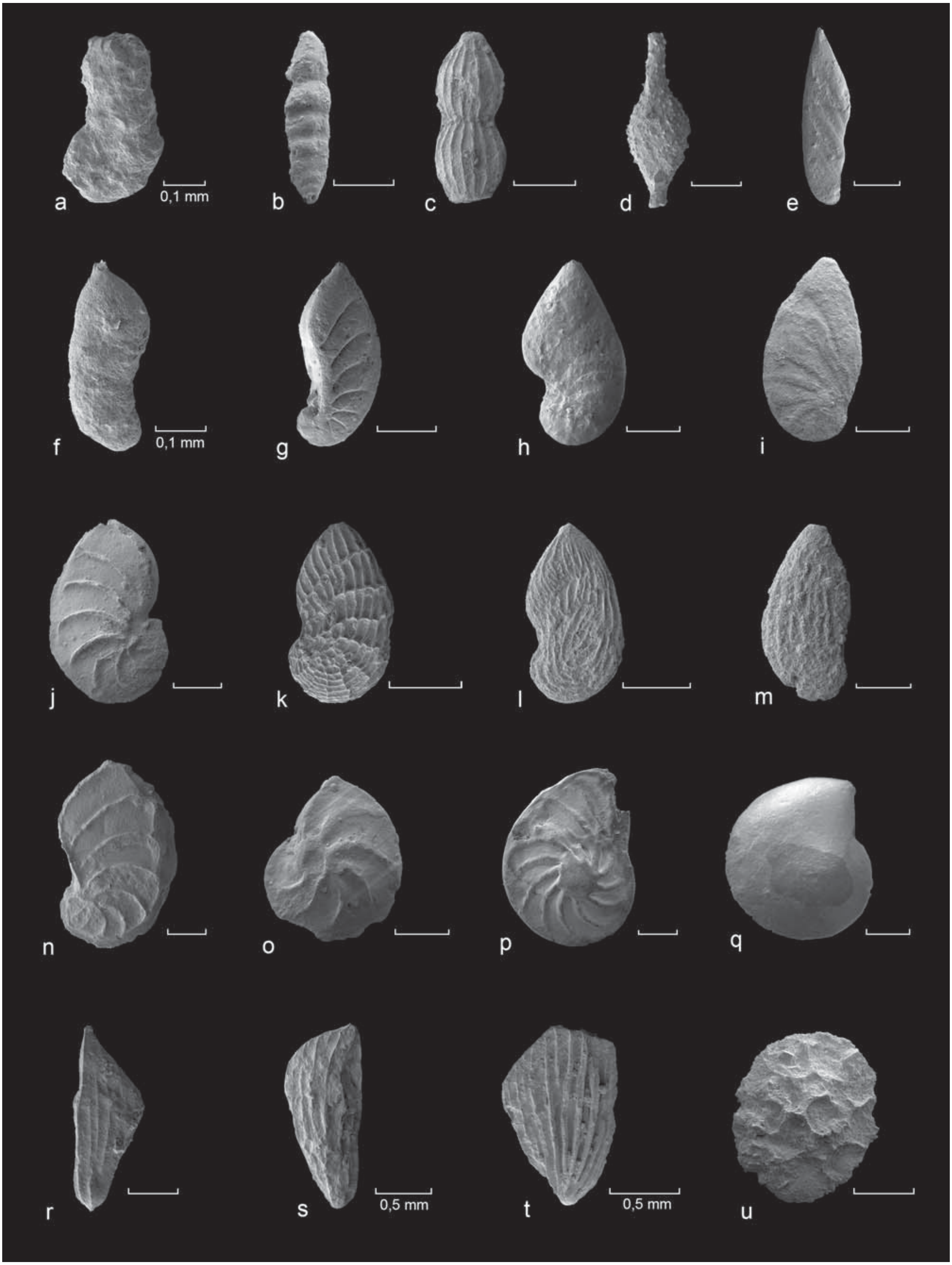
Plate 13

Foraminifera: Lower Bajocian Discites–? Middle Oxfordian, VB 1 Polsingen-Ursheim.
(a) *Ammobaculites suprajurassicus* (Schwager, 1865); 74.50–74.55 m; Cordatum – ? Plicatilis zones; Em 771.
(b) *Lingulina franconica* (Gümbel, 1862); 75.50–75.55 m; Cordatum – ? Plicatilis zones; Em 772.
(c) *Nodosaria münsterana* Gümbel, 1862; 81.95–82.00 m; Humphriesianum Zone; Em 773.
(d) *Ramulina spandeli* Paalzow, 1917; 74.50–74.55 m; Cordatum – ? Plicatilis zones; Em 774.
(e) *Vaginulina jurassica (*Gümbel, 1862); 77.33–77.40 m; Herveyi Zone; Em 775.
(f) *Marginulina hirta* Paalzow, 1922; 76.93–77.00 m; Koenigi Zone; Em 776.
(g) *Saracenaria triquetra* (Gümbel, 1862); 74.50–74.55 m; Cordatum – ? Plicatilis zones; Em 777.
(h) *Astacolus matutinus informis* (Schwager, 1865); 83.35–83.40 m; Laeviuscula Zone; Em 778.
(i) *Planularia beierana* (Gümbel, 1862); 81.95–82.00 m; Humphriesianum Zone; Em 779.
(j) *Astacolus volubilis* Dain, 1958; 85.05–85.10 m; Laeviuscula Zone; Em 780.
(k) *Lenticulina dorbignyi* (Roemer, 1839); 84.55–84.60 m; Laeviuscula Zone; Em 781.
(l) *Palmula semiinvoluta* (Terquem, 1870); 81.50–81.55 m; Humphriesianum Zone; Em 782.
(m) *Planularia eugenii* (Terquem, 1863); 81.50 81.55 m; Humphriesianum Zone; Em 783.
(n) *Subhercynella arachne* (Kopik, 1969); 79.62–79.70 m; Convergens Subzone, Zigzag Zone; Em 784.
(o) *Lenticulina quenstedti* (Gümbel, 1862); 79.62–79.70 m; Convergens Subzone, Zigzag Zone; Em 785.
(p) *Lenticulina helios* (Terquem, 1870); 86.95–87.00 m; Discites Zone; Em 786.
(q) *Lenticulina muensteri* (Roemer, 1839); 75.90–75.95 m; Cordatum – ? Plicatilis zones; Em 787.
(r) *Citharina flabelloides* (Terquem, 1867); 74.50–74.55 m; Cordatum – ? Plicatilis zones; Em 788.
(s) *Citharina macilenta* (Terquem, 1867); 83.35–83.40 m; Laeviuscula Zone; Em 789.
(t) *Citharina proxima* (Terquem, 1867); 79.32–79.41 m; Macrescens–Yeovilensis subzones, Zigzag Zone; Em 790.
(u) *Epistomina mosquensis* Uhlig, 1883; 74.50–74.55 m; Cordatum – ? Plicatilis zones; Em 791.
Unless stated otherwise the scale bar equals 0.2 mm.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