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Planktonic gastropods (pteropods) from the Miocene of the Carpathian Foredeep and the Ždánice Unit in Moravia (Czech Republic)

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2 text-figures and 5 plates

Planktonic gastropods (pteropods)
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Contents

Planktonische Gastropoden (Pteropoden) aus dem Miozän der Karpatischen Vortiefe und der Steinitzer Einheit in Mähren (Tschechische Republik)

Zusammenfassung

Die miozänen (Eggenburgium–Badenium) Pteropoden der Karpatischen Vortiefe und der Steinitzer Einheit in Mähren (Tschechische Republik) werden systematisch bearbeitet sowie biostratigraphisch und paläobiogeographisch ausgewertet. Folgende Arten können unterschieden werden: *Limacina gramensis* (RASMUSSEN, 1968), *L. valvatina* (REUSS, 1867), *Creseis spina* (REUSS, 1867), *Clio fallauxi* (KITTL, 1886), *C. triplicata* AUDENINO, 1897, *Diacrolinia aurita* (BELLARDI, 1873), *Vaginella austriaca* (KITTL, 1886) und *Vaginella* sp. Die bisherige biostratigraphische Bedeutung einzelner Arten kann bestätigt werden, da sie in Mähren die gleiche stratigraphische Reichweite wie in anderen Gebieten der Zentralen Paratethys aufweisen. Zum ersten Mal kann das Vorkommen von *Limacina gramensis* und *Creseis spina* im Badenium von Mähren sowie der Protoconch der Art *Clio fallauxi* dokumentiert werden.

Abstract

The systematics, biostratigraphy and paleobiogeography of Miocene (Eggenburgian–Badenian) pteropods from the Carpathian Foredeep and the Ždánice Unit in Moravia (Czech Republic) are studied. The following species are identified: Limacina gramensis (RASMUSSEN, 1968), *L. valvatina* (REUSS, 1867), *Creseis spina* (REUSS, 1867), *Clio fallauxi* (KITTL, 1886), *C. triplicata* AUDENINO, 1897, *Diacrolinia aurita* (BELLARDI,

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1873), *Vaginella austriaca* (KITTL, 1886) and *Vaginella* sp. The recognised biostratigraphical value of several pteropod species may be demonstrated as they have the same stratigraphical range in Moravia as in other areas of the Central Paratethys. The occurrence of *Limacina gramensis* and *Creseis spina* in the Badenian of Moravia as well as the protoconch of the species *Clio fallauxi* could be documented for the first time.

1. Introduction

Up to now planktonic gastropods (pteropods, Thecosomata) from Moravia have been found in the Carpathian Foredeep (Southern, Middle and Northern part, including the Opava Basin), the Pouzdřany Unit, the Ždánice Unit and the Northern part of the Vienna Basin. A concise stratigraphic and tectonic synopsis of these areas is given in STEININGER et al. (1985) and ČTYROKÝ & STRÁNÍK (1995).

The paper by ČTYROKÝ et al. (1968) is the most recent in summarising the distribution of Czech pteropods. New finds of Miocene (Eggenburgian–Badenian) pteropods from the Carpathian Foredeep and the Ždánice Unit in Moravia are herein evaluated systematically, biostratigraphically and paleobiogeographically. A preliminary report of the results is given in ZORN (1998). The studied material has been donated mainly by P. ČTYROKÝ (Prague) and a further sample by F. STEININGER (Frankfurt). This material is now kept in the Geological Survey of Austria (GBA) with the reg. No. 1999/6. A part of the historical pteropod collection of E. KITTL (1886), which is housed in the Museum of Natural History (NHMW) in Vienna, is also included in this study. Some samples from the Czech localities of this collection have already been discussed in JANSSEN (1984) and JANSSEN & ZORN (1993). The Austrian material of this collection has been studied by ZORN (1991a, b).

Only a restricted amount of additional material of pteropods from Moravia is deposited in the collections of the Geological Survey of Austria. It is not included in the systematic part of this paper as it is very poorly preserved. The material dates from the time of the Austrian-Hungarian Monarchy and includes several fragments of *Vaginella* sp. from "Josephschacht bei Michalkowitz" (= Ostrava-Michálkovice) labelled as *Vaginella rzehaki* (KITTL, 1886) together with one specimen of *Vaginella austriaca* (KITTL, 1886) collected by PROCHÁZKA in the year 1891 at "Einschnitt rechts des Padochower Weges" (= Padochov).

2. History of the research on planktonic gastropods from the Neogene and Paleogene of Moravia

The earliest record of pteropods from Moravia is in a paper by SUESS (1866), where he mentioned *Vaginella depressa* DAUDIN, 1800 from the Miocene of Grußbach (= Hrušovany). But the real pioneers of the last century in pteropod research in Moravia are A. RZEHAK and E. KITTL. RZEHAK documented pteropods in several papers from the end of the last century up to the beginning of this century (RZEHAK, 1880a, b, 1881, 1883, 1886, 1895, 1897, 1902, 1913, 1915; MAKOWSKY & RZEHAK, 1884). He recorded Eocene, Oligocene and Miocene pteropods of the genera *Spirialis (= Limacina), Vaginella* and *Balantium (= Clio)* from Seelowitz (= Židlochovice), Nusslau (= Nosislav), Nikoltschitz (= Nikolčice), Rebeschowitz (= Rebesovice), Groß-Niemtschitz (Velké Němčice), Ruditz (= Rudice), Czernowitz (= Černovice near Brno), Neudorf (= Nesvačilka), Auerschitz (= Uherčice), Neuhof, Mautnitz (= Moutnice), Rosternitz near Wischau (= Rostěnice near Vyškov), Brünn (= Brno), Pratzer Berg near Brno (= Pratecký kopec near Slavkov), Satschan (= Žatčany), Skotschan (= Skočany), Schönhof, Kumrowitz (= Komárov) and Pausram (= Pouzdřany). These localities are situated in the Carpathian Foredeep (Miocene) and the Pouzdřany Unit (Eocene, Oligocene). In his 1895 paper RZEHAK named three new species from the Oligocene "Niemtschitzer Schichten" – *Spirialis fuchsi, S. turrita* and *S. haueri* – which have to be considered nomina nuda because RZEHAK gave neither descriptions nor figures.

KITTL (1886) was the first to publish a systematic monograph on the pteropods of the Austrian-Hungarian Monarchy including Miocene material from the following Moravian localities: Peterswald (= Petřvald near Ostrava), Polnisch-Ostrau (= Ostrava), Dombrau (= Doubrava near Ostrava), Poremba (= Ostrava-Poruba) in Northern Moravia and Pratzer Berg, Nusslau and Ruditz in Southern Moravia. He erected the species *Balantium fallauxi, Vaginella austriaca, V. rzehaki, V. lapugyensis* and *Hyalaea bisulcata* partly on material from these localities. Furthermore he recorded *Balantium pedemontanum* (MAYER, 1868) and *Spirialis valvatina* REUSS, 1867. This material was later reinvestigated by JANSSEN (1984) and partly revised by JANSSEN & ZORN (1993). This is especially true for the species *Clio fallauxi* KITTL, 1886 and *Vaginella rzehaki* KITTL, 1886. The greater part of KITTL'S material is still housed in the collections of the Museum of Natural History in Vienna.

KITTL (1887) mentioned several species of planktonic gastropods from the "Ostrauer Tegel" of the "Ostrau-Karwiner Steinkohlenrevier" including one questionable heteropod species (*Atlanta* ? forma indet.). This is the area between Ostrava and Karviná in Northern Moravia where many coal mines were active at that time. KITTL considered material from Polnisch-Ostrau, Peterswald, Dombrau and Orlau (= Orlová). The pteropods that he cited are *Vaginella austriaca, V. rzehaki, Balantium fallauxi* and *Hyalaea bisulcata*.

Except for RZEHAK and KITTL only V. J. PROCHÁZKA documented Moravian pteropods in the last century. He mentioned *Spirialis valvatina* from the Miocene of Mährisch-Trübau (= Moravská Třebová) (PROCHÁZKA, 1891) as well as *Vaginella depressa* and *V. austriaca* from the Miocene of the surroundings of Seelowitz (PROCHÁZKA, 1893).

Two further researchers of Oligocene pteropods were T. FUCHS and P. OPPENHEIM. FUCHS (1902) erected the species *Balantium superbum* on material from supposed "Kalkkonkretionen" of the "Niemtschitzer Schichten" (name giving locality nowadays Velké Němčice). These pteropods are deposited in the Museum of Natural History in Vienna. Unfortunately, the origin of this extraordinary material is uncertain. Even FUCHS was not sure whether it really came from Moravia or from Northern America as one label stated. In PETRASCHEK (1912) FUCHS reported on the occurrence of *Vaginella rzehaki* and *Balantium fallauxi* in a borehole from Skotschau near Teschen (= Český Těšín). OPPENHEIM (1922) found *Balantium* cf. *maximum* (LUDWIG, 1864), *Vaginella* cf. *rzehaki, Valvatina* cf. *oligocaenica* (LÖRENTHEY, 1903) and his own new species *Valvatina fuchsi* in the Oligocene "Niemtschitzer Schichten" (Neudorf, Mautnitz, Auerschitz, Pausram).

Since the records of PROCHÁZKA it took almost half a century until VAŠÍČEK (1949) continued the description of pteropods from the Middle Miocene. He erected two new species, *Clio vrazi* and *Spirialis holubi,* which he found at Úsobrno. The figured specimens obviously belong to other

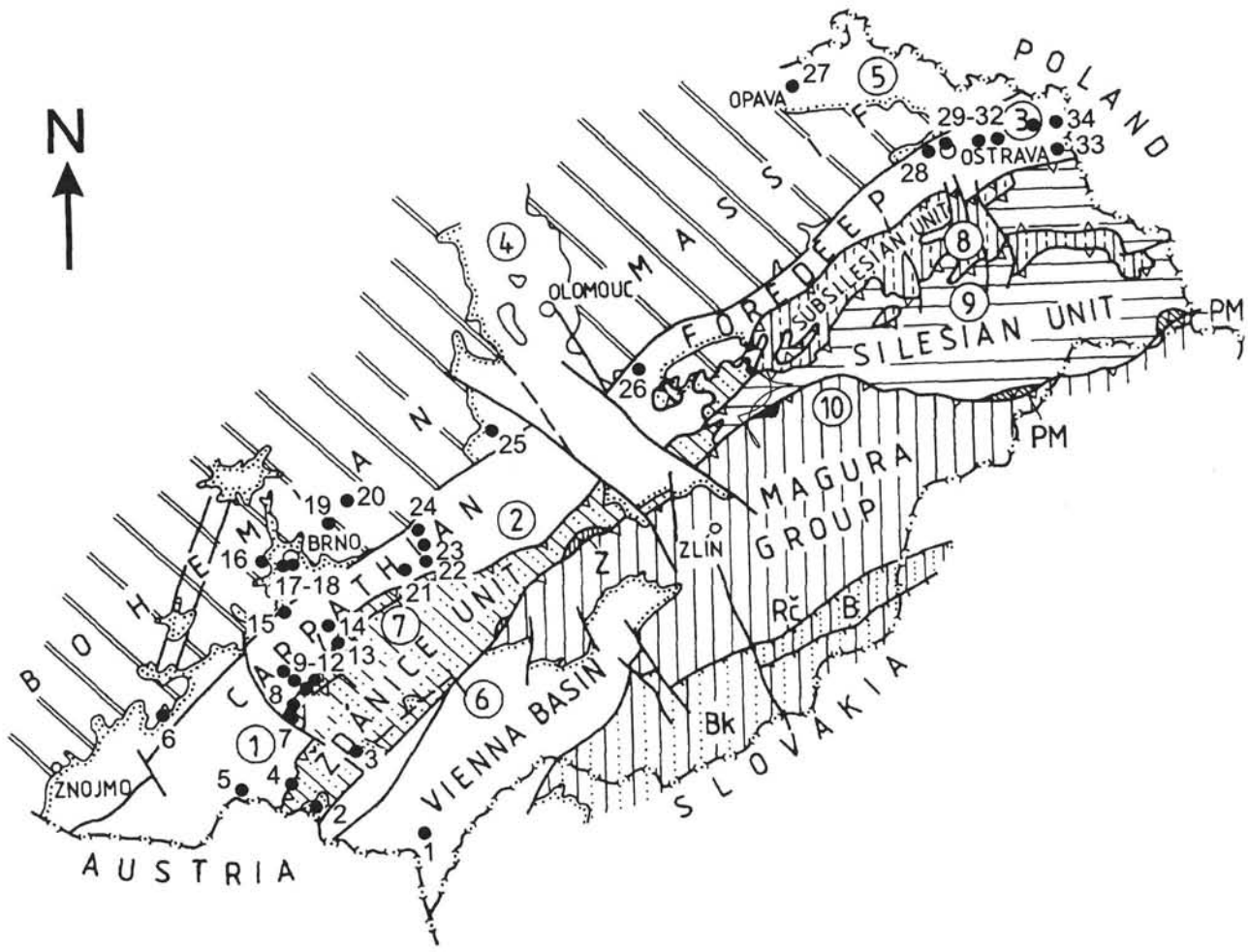
species. *Clio vrazi* represents the protoconch of *Vaginella austriaca* and *Spirialis holubi* probably is a junior synonym of *Limacina valvatina*. One year later SCHÜTZNEROVÁ-HAVELKOVÁ (1950) mentioned *Vaginella* from the Oligocene of Němčice.

From the early sixties onward, P. ČTYROKÝ published several papers which include remarks on pteropods. He documented *Vaginella* ? sp. juv. from the Karpatian of the borehole Stefanov-18 in Western Slovakia (ČTYROKÝ, 1962), *Valvatina fuchsi* from the Eocene of Moutnice (ČTYROKÝ, 1966) and *Clio triplicata* AUDENINO, 1897 from the Early Miocene of the Vienna Basin (borehole Morava-1) (ČTYROKÝ, 1968). In 1968 ČTYROKÝ gave a summary about the state of research on pteropods in the Central Paratethys together with A. PAPP and F. STEININGER (ČTYROKÝ et al., 1968). At that time they recorded *Clio triplicata* (Early Miocene), *Spiratella valvatina, S. andrussowi andrussowi* KITTL, 1886 and *S. cf. koeneni* (KITTL, 1886) (all Late Badenian) for the Moravian area. *Spiratella valvatina* and *S. koeneni* are also mentioned in CICHA (1978). Later ČTYROKÝ found *Vaginella* in the Karpatian of the surroundings of Mikulov (ČTYROKÝ, 1987) and *Clio triplicata* and *Vaginella* sp. in the Eggenburgian NW of Valtice (ČTYROKÝ, 1991, 1993). *Vaginella* from the Karpatian of the Carpathian Foredeep was also found by STRÁNÍK et al. (1991) SE of Brno.

During the last decade J. KRHOVSKÝ investigated a horizon with *Spiratella (= Limacina)* at the Kiscellian localities of the Ždánice and Pouzdřany Unit: Pouzdřany (JURÁŠOVÁ et al., 1991) and Velké Němčice (KRHOVSKÝ, 1993a; KRHOVSKÝ et al., 1992). He discussed the biostratigraphy of this horizon in further papers (KRHOVSKÝ, 1993b; KRHOVSKÝ & KUČERA, 1994).

3. Localities

The geographical positions of the localities mentioned in this paper are shown in text-figure 1. The historical localities Neuhof and Schönhof could not be located as they are very common names. The other localities are included in the "Orts-Lexikon" (RUDOLPH, year unknown). The localities and samples from which the pteropods have been examined by the author are listed below with their stratigraphical position and their species content. All pteropods have been found in pelitic sediments, in light greyish Foraminifera marls of the



Text-Fig. 1.
Schematic subdivision of the Western Carpathians in the territory of the Czech Republic with the geographical position of the localities mentioned in this paper (modified after ČTYROKÝ & STRÁNÍK, 1995). 1: Morava-1, 2: Valtice, 3: Zaječí, 4: Mikulov, 5: Nový Přerov-1, 6: Miroslav, 7: Pouzdřany, 8: Uherčice, 9: Židlochovice, 10: Nosislav, 11: Velké Němčice, 12: Nikolčice, 13: Moutnice, 14: Žatčany, 15: Rebešovice, 16: Padochov, 17: Komárov, 18: Černovice, 19: Rudice, 20: Úsobrno, 21: Slavkov, 22: Dražovice, 23: Rostěnice, 24: Tučapy, 25: Moravská Třebová, 26: Nové Dvory, 27: Opava (boreholes in the Opava Basin not indicated separately), 28: Ostrava-Poruba, 29: Ostrava-Michálkovice, 30: Petřvald, 31: Orlová, 32: Doubrava, 33: Český Těšín, 34: Karviná.

Eggenburgian and greyish to bluish clay marls of the Karpatian and Badenian.

3.1. Ždánice Unit

NNW Valtice (locality 305 in Čtyroký, 1991, 1993), Eggenburgian, Šakvice Formation: *Clio triplicata* Audenino, 1897, *Vaginella* sp.

Zaječí, railway cutting NE of the town along the road from Vel. Pavlovice to Zaječí, Eggenburgian, Šakvice Formation, NN2-NN3 (det. R. Braunstein, 1990): *Clio triplicata* Audenino, 1897, *Vaginella* sp.

3.2. Carpathian Foredeep

borehole Dražovice HJ-302 (268m), Early Badenian: *Clio fallauxi* (Kittl, 1886)

borehole Nosislav-3 (106.3m, 152.7m), Late Karpatian: *Vaginella austriaca* Kittl, 1886

borehole HJ-309 Nové Dvory (142.5m, 144.5m, 147.5m), 2700m SW Lipník nad Bečvou, Early Badenian: *Vaginella austriaca* Kittl, 1886, *Limacina* sp. indet.

borehole Nový Přerov-1 (801.5m, 802.3m, 802.7m), Karpatian: *Vaginella austriaca* Kittl, 1886, *Limacina* sp. indet.

borehole HJ-303 Tučapy NE Brno (323.5m, 344.2m, 345.5m, 348.3m, 348.8m, 349.2m, 349.3m, 349.5m, 350m), Early Badenian: *Vaginella austriaca* Kittl, 1886

borehole M-20 Trnove Pole at Miroslav, S Brno (30m), Early Karpatian: *Limacina valvatina* (Reuss, 1867)

3.3. Opava Basin

Boreholes in the surroundings of Opava, Late Badenian:

Zábřeh OMc-1 (9.6–9.7m, 18.7–18.8m): *Limacina valvatina* (Reuss, 1867)

Krestit OMc-1d (53.7–53.8m): *Limacina valvatina* (Reuss, 1867)

Zábřeh OMc-2 (32.5–32.6m, 38.5–38.6m): *Limacina valvatina* (Reuss, 1867)

Zábřeh OMc-3 (30.25–30.35m): *Limacina valvatina* (Reuss, 1867), *Limacina gramensis* (Rasmussen, 1968)

OMc-3d (90.2–90.3m): *Limacina valvatina* (Reuss, 1867), *Creseis spina* (Reuss, 1867)

OMc-4d (63.5–63.6m): *Limacina valvatina* (Reuss, 1867), *Limacina gramensis* (Rasmussen, 1968)

Kravaře OMc-7 (18.3–18.4m): *Limacina valvatina* (Reuss, 1867)

Zábřeh OMc-8 (30.2–30.3m, 35.4–35.5m): *Limacina valvatina* (Reuss, 1867), *Limacina gramensis* (Rasmussen, 1968)

Kravaře OMc-13 (20.4–20.5m): *Limacina valvatina* (Reuss, 1867)

Kravaře OMc-14 (29.5–29.6m): *Limacina valvatina* (Reuss, 1867)

Pištr OŠ-49 (60.4–60.45m): *Limacina valvatina* (Reuss, 1867)

OV-5a (144m, 194.3–194.4m, 198.2–198.3m, 200.5–200.7m, 210.5–210.6m): *Limacina valvatina* (Reuss, 1867)

Š-1 (36.0–37.0m): *Limacina valvatina* (Reuss, 1867)

4. Systematical part

The critical signs of synonymy in this chapter are adopted from Richter (1943). For most species only those synonymies referring to Czech and/or Paratethys material are given. It is indicated where the reader will find more complete synonymy lists. The explanations of the abbreviations of the different collections are in the introduction.

Classis Gastropoda Cuvier, 1795
Subclassis Heterobranchia Gray, 1840
Cohors Pentaganglionata Haszprunar, 1985
Superordo Tectibranchia Cuvier, 1817
Ordo Thecosomata Blainville, 1824
Subordo Euthecosomata Meisenheimer, 1905

Familia Limacinidae Gray, 1847

Genus: *Limacina* Bosc, 1817
Type species: *Limacina helicina* (Phipps, 1774)

Limacina gramensis (Rasmussen, 1968)

(Pl. 1, figs. 1–3, 5)

The following synonymy list concentrates on Paratethys material (excl. Krach, 1981) and additional synonymies which are not included in Janssen & Zorn (1993):

* 1968 *Spiratella gramensis* nov. sp. – Rasmussen, p. 244, pl. 27, figs. 4–7.
. 1968 *Spiratella* cf. *koeneni* (Kittl) – Čtyroký et al., p. 132, pl. 4, fig. 13.
. *1980* *Spiratella gramensis* Rasmussen – Hinsch, p. 40, tab. 2.
v. 1984 *Spirialis stenogyra* (Philippi, 1844) – Janssen, p. 71, pl. 3, figs. 1–2.
. *1986* *Spiratella gramensis* Rasmussen – Hinsch, p. 358.
. *1989* *Spiratella gramensis* – Hinsch, tab. 7.

Plate 1

Fig. 1–3: *Limacina gramensis* (Rasmussen, 1968), borehole Zábřeh OMc-4d, 63.5–63.6m, Late Badenian, fig. 1: x 40, fig. 2–3: x 50.
Fig. 4: *Limacina valvatina* (Reuss, 1867), borehole Zábřeh OMc-4d, 63.5–63.6m, Late Badenian, x 40.
Fig. 5: *Limacina gramensis* (Rasmussen, 1968), borehole Zábřeh OMc-8, 35.4–35.5m, Late Badenian, x 60.
Fig. 6–7: *Limacina valvatina* (Reuss, 1867), Děvínská Nová Ves (Slovakia), Late Badenian, x 50.
Fig. 8–10: *Limacina valvatina* (Reuss, 1867), OV-5a, 200.5–200.7m, Late Badenian, fig. 8: x 55, fig. 9: x 50, fig. 10: x 40.

v. 1993 *Limacina gramensis* (RASMUSSEN, 1968) – JANSSEN & ZORN, p. 175, pl. 3, fig. 13; pl. 4, figs. 1–9; pl. 5, figs. 1–3. (cum syn.)
. 1996 *Limacina gramensis* (RASMUSSEN, 1968) – URBANIAK & JAKUBOWSKI, p. 719, pl. 123, fig. 13; pl. 124, fig. 5a (copied from KRACH, 1981).

Material studied: Zábřeh OMc-3 (30.25–30.35m), OMc-4d (63.5–63.6m), OMc-8 (30.2–30.3m, 35.4–35.5m), Late Badenian.

Diagnosis: Sinistral shell with a high spire, height/width-ratio varying between 110–150. The umbilicus is narrow. The relatively high whorls increase slowly in width, up to five whorls are developed. The tangents of the spire are straight.

Remarks: As in the Polish specimens of the Carpathian Foredeep, which have been examined by JANSSEN & ZORN (1993) *Limacina valvatina* and *L. gramensis* can only be separated by artificial boundaries, that is especially the height/width-ratio of 110.

Distribution: In the Central Paratethys *Limacina gramensis* is stratigraphically restricted to the Late Badenian. It is known from the Carpathian Foredeep of Southern Poland, Rumania, the Ukraine (JANSSEN & ZORN, 1993) and Moravia. In NW-Europe it is recorded from the lower part of Pteropod Zone 20 in the Langenfeldian (JANSSEN & KING, 1988) which correlates with the Late Badenian. Therefore this species is to be considered an index fossil.

Limacina valvatina (REUSS, 1867)
(Pl. 1, figs. 4, 6–10)

*v 1867 *Sp. valvatina* RSS. – REUSS, p. 146, pl. 6, fig. 11.
v. 1886a *Spirialis valvatina* REUSS. – KITTL, p. 69, pl. 2, fig. 38.
1891 *Spirialis valvatina* – PROCHÁZKA, p. 106.
. 1949 *Spirialis holubi*, n. sp. – VAŠÍČEK, p. 32, pl. 1, figs. 1a–d.
v. 1968 *Spiratella valvatina* (REUSS) – ČTYROKÝ et al., p. 131–132, pl. 4, fig.10a–b.
v. 1984 *Limacina valvatina* (REUSS, 1867) – JANSSEN, p. 381, pl. 20, figs. 1a–b, 2a–b.
v. 1991b *Limacina valvatina* (REUSS, 1867) – ZORN, p. 97, pl. 1, figs. 1–6; pl. 10, figs. 1–2; pl. 11, figs. 4–5.
v. 1993 *Limacina valvatina* (REUSS, 1867) – JANSSEN & ZORN, p. 179, pl. 1, figs. 4–11, pl. 2, figs. 1–11, pl. 3, figs. 1–12. (cum syn.)
. 1995 *Limacina valvatina* (REUSS) – NIKOLOV, p. 71, figs. 3.1–3.2.

Material studied: Borehole M-20 Trnove Pole (30m), Early Karpatian. Zábřeh OMc-1 (9.6–9.7m, 18.7–18.8m), Krestit OMc-1d (53.7–53.8m), Zábřeh OMc-2 (32.5–32.6m, 38.5–38.6m), Zábřeh OMc-3 (30.25–30.35m), OMc-4d (63.5–63.6m), Kravaře OMc-7 (18.3–18.4m), Zábřeh OMc-8 (30.2–30.3m, 35.4–35.5m), Kravaře OMc-13 (20.4–20.5m), Kravaře OMc-14 (29.5–29.6m), Pištr OŠ-49 (60.4–60.45m), OV-5a (144m, 194.3–194.4m, 198.2–198.3m, 200.5–200.7m, 210.5–210.6m), S-1 (36.0–37.0m), Late Badenian.

Diagnosis: Sinistral shell with a low to medium high spire, height/width-ratio below 110. The umbilicus is narrow (pl. 1, fig. 9). The whorls are less high than in *Limacina gramensis* and increase slowly in width, up to four whorls are developed. The tangents of the spire are straight.

Remarks: To show *Limacina valvatina* in better preservation a specimen from Děvínska Nová Ves near Bratislava (Slovakia, Vienna Basin) is illustrated on plate 1 (figs. 6–7).

Distribution: Late Oligocene to Late Miocene in NW-Europe (JANSSEN & KING, 1988), Late Oligocene to Middle Miocene (Badenian) in the Paratethys (ZORN, 1991a, b). *Limacina* cf. *valvatina* occurs in the Late Aquitanian–Early Burdigalian of Italy (JANSSEN, 1995).

Familia Cavoliniidae FISCHER, 1883
Subfamilia Creseiinae RAMPAL, 1973

Genus *Creseis* RANG, 1828
Type species: *Creseis virgula* (RANG, 1828)

Creseis spina (REUSS, 1867)
(Pl. 2, figs. 1–2)

*v 1867 *Cleodora (Creseis) spina* RSS. – REUSS, p. 145, pl. 6, fig. 9.
v. 1886a *Creseis* (?) *spina* (REUSS). – KITTL, p. 51.
1980 *Cleodora spina* Reuss – MOISESCU & POPESCU, p. 217, pls. 1, 2.
v. 1981 *Vaginella lapugyensis* KITTL, 1886 – KRACH, p. 123, pl. 1, fig. 14; pl. 6, figs. 9, 10.
v. 1984 *Cleodora (Creseis) spina* REUSS, 1867 – JANSSEN, p. 66, pl. 1, figs. 1a, b, 2a, b.
v. 1991a *Creseis spina* (REUSS, 1867) – ZORN, p. 23, pl. 3, figs. 1–3, 5–11.
v. 1991b *Creseis spina* (REUSS, 1867) – ZORN, p. 110, pl. 5, figs. 1–6, 13–14; pl. 12, fig. 2.
v. 1993 *Creseis spina* (REUSS, 1867) – JANSSEN & ZORN, p. 190, figs. 2–4, pl. 7, figs. 2–4. (cum syn.)
v. 1994 *Creseis spina* (REUSS, 1867) – BOHN-HAVAS & ZORN, p. 76–77, figs. 2–4, pl. 2, fig. 9.
. 1995 *Creseis olteanui* STANCU – NIKOLOV, p. 72, fig. 3.6.
non 1995 *Creseis spina* (REUSS) – NIKOLOV, p. 72, fig. 3.5.

Material studied: Zábřeh OMc-3d (90.2–90.3m), 8 fragments, Late Badenian.

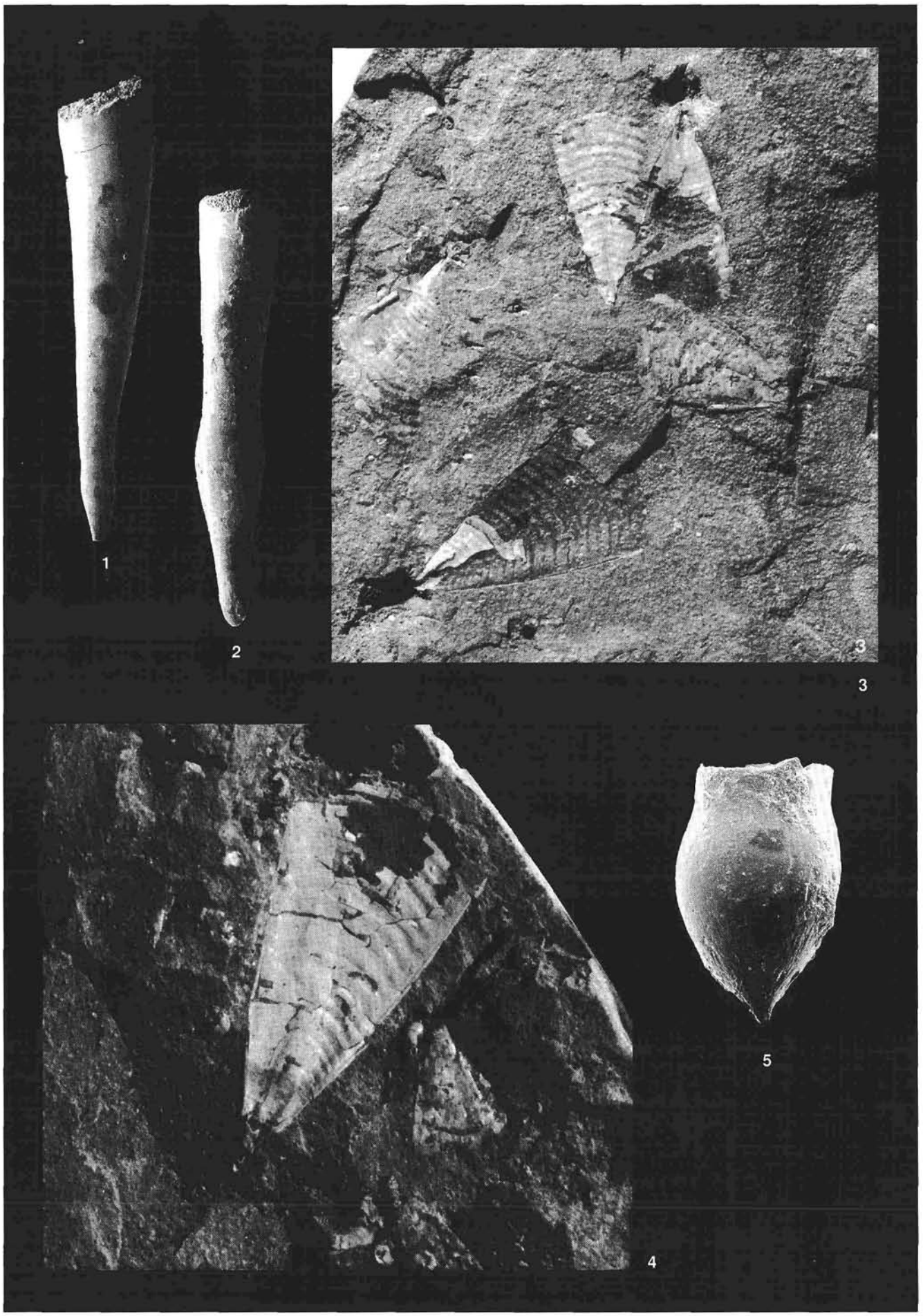
Diagnosis: Slender and conical shell with a smooth surface. Protoconch bulbous in its younger part and elongated with rounded tip in its older part.

Remarks: In the material at hand no complete specimen is present. Only protoconchs (pl. 2 fig. 2) and fragments of the teleoconch are preserved. The most complete specimen is illustrated on plate 2 (fig. 1). No differences with regard to characteristic specimens have been found.

Distribution: In the Central Paratethys *Creseis spina* is restricted to the Badenian, being distributed in the Early Badenian of Bulgaria (NIKOLOV, 1995), in the Early and Middle Badenian of Poland (JANSSEN & ZORN, 1993), in the Middle Badenian of Rumania (MOISESCU & PROTESCU, 1980), in the Middle and Late Badenian of Austria (ZORN,

Plate 2

Fig. 1–2: *Creseis spina* (REUSS, 1867), borehole Zábřeh OMc-3d, 90.2–90.3m, Late Badenian, fig. 1: x 40, fig. 2: x 90.
Fig. 3–5: *Clio fallauxi* (KITTL, 1886), borehole HJ-302, Dražovice, 268m, Early Badenian, Lagenid Zone, fig. 3: x 4, fig. 4: x 6,5, fig. 5: protoconch, x 120.



1991a, b; BOHN-HAVAS & ZORN, 1994) and in the Late Badenian of Slovakia and Moravia. Only questionable specimens from the Middle Miocene of Italy have been recorded (JANSSEN & ZORN, 1993).

Subfamilia Clioinae JANSSEN, 1990

Genus *Clio* LINNÉ, 1767
Type species: *Clio pyramidata* LINNÉ, 1767

Clio fallauxi (KITTL, 1886)
(Pl. 2, figs. 3–5)

*v	1886a	*Balantium Fallauxi* n. f. – KITTL, p. 62, pl. 2, figs. 23–26.
v.	1886a	*Balantium pedemontanum* (C. MAYER) – KITTL, p. 64, pl. 2, fig. 28 (partim, non fig. 33 = *Clio pedemontana*).
.	*1887*	*Balantium Fallauxi* KITTL – KITTL, pp. 222, 223, 227, 228.
	1912	*Balantium Fallauxi* KITTL – PETRASCHEK, p. 87.
?	1974	*Clio fallauxi* (KITTL, 1886) – STANCU, p. 186, pl. 1, figs. 8–10.
	1980	*Clio fallauxi* (KITTL) – MOISESCU & POPESCU, pp. 215, 219, pls. 1, 2.
v.	1981	*Clio fallauxi* (KITTL) 1886 – KRACH, p. 123, pl. 1, figs. 2–8, 11, 12.
v.	1984	*Balantium fallauxi* KITTL, 1886 – JANSSEN, p. 65, pl. 5, figs. 1–3.
v.	1993	*Clio fallauxi* (KITTL, 1886) – JANSSEN & ZORN, p. 195, pl. 8, figs. 1–9, pl. 9, figs. 1–3. (cum syn.)
v.	1994	*Clio fallauxi* KITTL, 1886 – BOHN-HAVAS & ZORN, p. 78, figs. 3–4, pl. 3, fig. 7.
.	1995	*Clio* cf. *fallauxi* KITTL, 1886 – NIKOLOV, p. 72, p. 73, fig. 7.

Material studied: Type material housed in the NHMW: Paralectotypes: Dombrau (= Doubrava), "Eleonorenschacht": 3 specimens, acquired 1884, reg. no. 1993/15/1–3. Polnisch-Ostrau (= Ostrava): 2 specimens, reg. no. 1888.I.5; 2 specimens, reg. no. 1888.I.70. Pratzer Berg (= Pratecký kopec): 1 specimen, reg. no. 1993/16.
Material stored in the GBA: Borehole Dražovice (268m): more than 30 specimens on both sides of a core slab, reg. no. 1999/6.

Diagnosis: Triangular shell with transverse ribs and secondary transverse riblets. Lateral margins slightly convex to almost straight. Protoconch bulbous with a sharply pointed tip.

Remarks: The type material of *Clio fallauxi* was already discussed in JANSSEN (1984) and JANSSEN & ZORN (1993). The first paper gives illustrations of the material from Polnisch-Ostrau and the second one from Dombrau. The material from Peterswald remains unavailable.

For the first time a protoconch of *Clio fallauxi* could be found (pl. 2, fig. 5). The protoconch of *Clio* sp. 2 figured in ZORN (1991a: pl. 5, fig. 2) from the Lagenid Zone of Vöslau in Lower Austria is very similar to the protoconch of *Clio fallauxi*. As it is not completely preserved the identity remains uncertain.

The apical angle was stated to be one of the most important characters to differentiate between the related species *Clio pedemontana* (MAYER, 1868) and *C. fallauxi* when the transverse ribs are flattened out or when the secondary riblets are missing (JANSSEN & ZORN, 1993). The specimens from Dražovice show the fine riblets but the apical angle reminds of the species *C. pedemontana*. As the variability of *C. fallauxi* may not be fully known because of the poor material documented up to now, and as the fine riblets are preserved in the Dražovice material these specimens are considered to belong to *C. fallauxi*.

Distribution: *Clio fallauxi* is restricted to the Early Badenian of the Central Paratethys. It is known from the Carpathian Foredeep of Moravia (KITTL, 1886; this paper) and Poland (KRACH, 1981; JANSSEN & ZORN, 1993), from Sopron in Hungary (BOHN-HAVAS & ZORN, 1994), from Bulgaria (NIKOLOV, 1995) and from Rumania (STANCU, 1974; MOISESCU & POPESCU, 1980).

Clio triplicata AUDENINO, 1897
(Pl. 3, figs. 1–2)

*v	1897	*Clio triplicata* n. sp. – AUDENINO, p. 106, pl. 5, figs. 4a–e.
v.	1968	*Clio* cf. *triplicata* AUDENINO, 1897 – ČTYROKÝ, p. 95, figs. 1, 2; pl. 1, figs. 1–6.
v.	1968	*Clio* cf. *triplicata* AUDENINO – ČTYROKÝ et al., p. 133, pl. 4, fig. 14.
v.	*1973*	*Clio* cf. *triplicata* AUDENINO, 1896 – STEININGER, p. 450.
v.	1991a	*Clio triplicata* AUDENINO, 1896 – ZORN, p. 24, pl. 3, figs. 14–15.
v.	1991b	*Clio triplicata* AUDENINO, 1896 – ZORN, p. 112, pl. 8, figs. 7–9; pl. 13, figs. 3–8.
v.	*1991*	*Clio triplicata* (AUDENINO) – ČTYROKÝ, p. 36.
v.	*1993*	*Clio triplicata* (AUDENINO) – ČTYROKÝ, p. 19.
v.	1995	*Clio triplicata* AUDENINO, 1897 – JANSSEN, p. 93, pl. 8, figs. 1–6. (cum syn.)
v.	*1998*	*Clio triplicata* AUDENINO, 1897 – ZORN, p. 658.

Material studied: Valtice: leg. ČTYROKÝ (1993: No. 305), 8 specimens; Zaječí: leg. STEININGER, 4 specimens, Eggenburgian, Šakvice Formation.

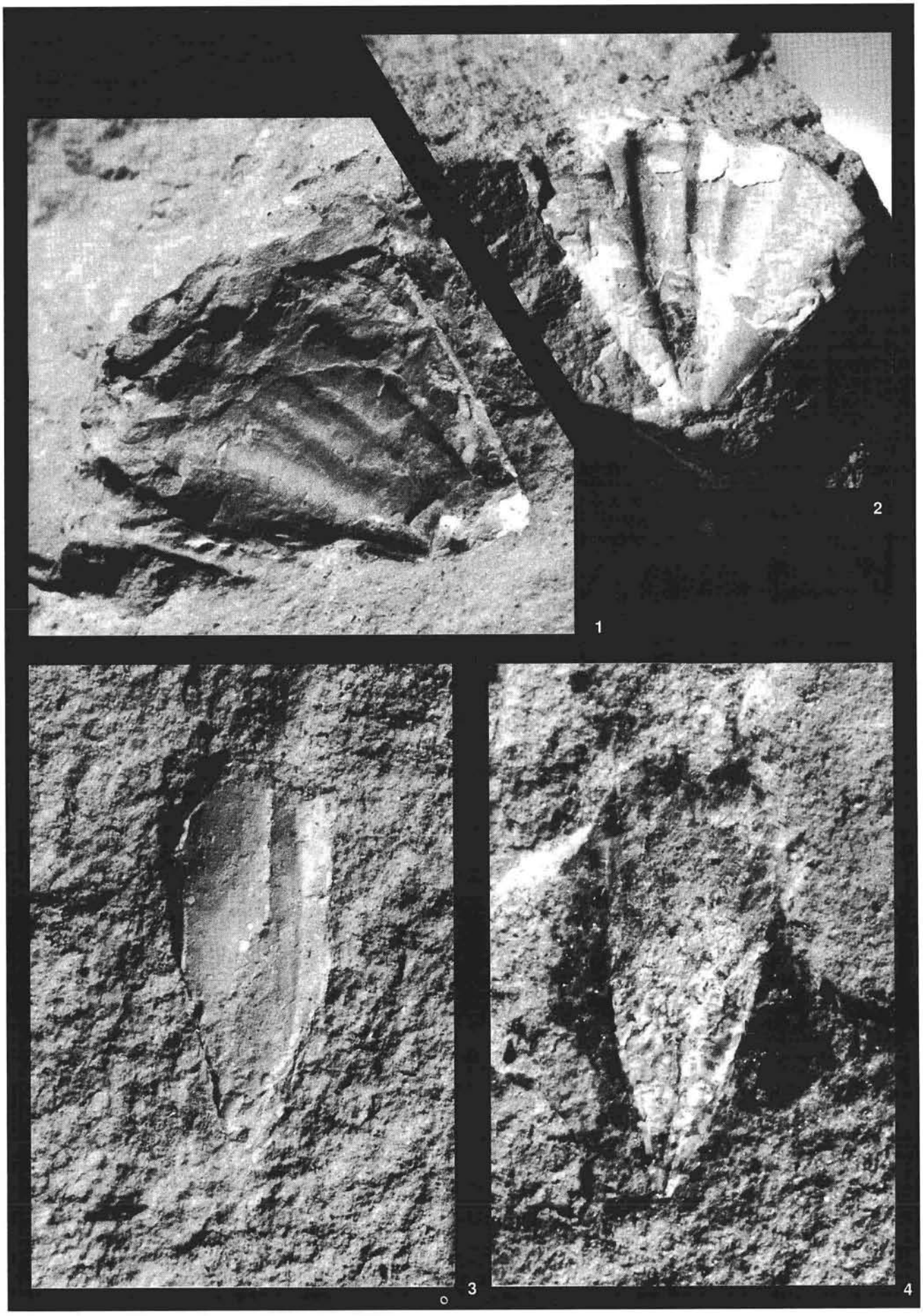
Diagnosis: Triangular shell. Dorsal side with three radial ribs which evolve from a single rib in the older shell part. Ventral side with a single radial rib.

Remarks: Most of the specimens show the typical features of *Clio triplicata*. Only few specimens have a somewhat wider apical angle up to 70° such as the two illustrated specimens (pl. 3, figs. 1–2). JANSSEN (1995) stated an apical angle of 50° for the type material. The three ribs of the dorsal side are similar in width. Typically the inner one is wider. Despite these differences the specimens at hand are assigned to *Clio triplicata*.

In ZORN (1991a, b) an occurrence of *Clio triplicata* at Ottnang-Schanze (Upper Austria), the stratotype of the Ottnangian stage, was established (see also *Clio* cf. *triplicata* in ČTYROKÝ, 1968, ČTYROKÝ et al., 1968 and

Plate 3

Fig. 1–2: *Clio triplicata* AUDENINO, 1897, Zaječí, Eggenburgian, Šakvice Formation, x 10.
Fig. 3: *Vaginella* sp., Zaječí, km 100.4, Eggenburgian, Šakvice Formation, x 10.
Fig. 4: *Vaginella* sp., Valtice 305, Eggenburgian, Šakvice Formation, x 10.



STEININGER, 1973). Because the material comes from an old collection and no other finds from the Ottnangian are known, the foraminifera association of the relevant sample has recently been studied by Ch. RUPP (Geological Survey of Austria). The fauna can be assigned to the Eggenburgian/Ottnangian. The relative abundant occurrence of *Uvigerina posthantkeni* PAPP is more characteristic for the Eggenburgian. This species has never been recorded for Ottnang-Schanze, neither in literature nor in recent investigations by Ch. RUPP. It therefore cannot be excluded that the sample was incorrectly labelled.

There remains no certain indication for an occurrence of *Clio triplicata* in the Ottnangian, because also the finds in the Lužice Formation from the borehole Morava-1 (ČTYROKÝ, 1968) perhaps belong to the lower part of the Lužice Formation which corresponds with the Eggenburgian (pers. comm. P. ČTYROKÝ).

Distribution: *Clio triplicata* is known in Italy from the Late Oligocene to the Langhian (Middle Miocene) (see synonymy list in JANSSEN, 1995). In the Central Paratethys this species is restricted to the Eggenburgian, documented from the Molasse Zone in Upper Austria (ZORN, 1991a, b) and from the Ždánice Unit and the Vienna Basin in Moravia (ČTYROKÝ, 1968a, 1991, 1993; ČTYROKÝ et al., 1968).

Subfamilia Cavoliniinae VAN DER SPOEL, 1967

Genus *Diacrolinia* JANSSEN, 1995
Type species: *Diacrolinia aurita* (BELLARDI, 1873)

Diacrolinia aurita (BELLARDI, 1873)
(Pl. 5, figs. 3–4)

*v	1873	*Hyalaea aurita*, BON. – BELLARDI, p. 26, pl. 3, fig. 6.
v.	1886a	*Hyalaea bisulcata* n. f. – KITTL, pp. 65, 72, pl. 2, figs. 29–32.
	1886b	*Hyalaea bisulcata* KITTL – KITTL, p. 20.
v.	*1887*	*Hyalaea bisulcata* KITTL – KITTL, pp. 222, 228.
v.	1984	*Hyalaea bisulcata* KITTL, 1886 – JANSSEN, pp. 65, 68, pl. 5, figs. 4–5.
v.	*1993*	*Cavolinia bisulcata* (KITTL, 1886) – BOHN-HAVAS & ZORN, pp. 62ff., figs. 2–3.
v.	1994	*Cavolinia bisulcata* (KITTL, 1886) – BOHN-HAVAS & ZORN, p. 76–78, figs. 3–4, pl. 3, figs. 1–2.
v.	1995	*Diacrolinia aurita* (BELLARDI, 1873) – JANSSEN, p. 111, pl. 9, figs. 6–8 (cum syn.).

Material studied: Type material of *Hyalaea bisulcata:* Lectotype and one paralectotype (Museum of Natural History Vienna, reg. No. 1888.I.6), Polnisch-Ostrau (Josefschacht), Early Badenian.

Diagnosis: Shell cavoliniform. Dorsal side flat with three radial ribs, the middle one being much wider than the lateral ones. Ventral side convex with two radial furrows giving the shell a trilobate impression. Posterior margin straight.

Remarks: JANSSEN (1984) was the first to reinvestigate the type material of *Hyalaea bisulcata* (KITTL, 1886) and later (JANSSEN, 1995) found out that together with several other taxa it is a junior synonym of *Diacrolinia aurita* (BELLARDI, 1873).

Distribution: In the Central Paratethys this species is restricted to the Early Badenian, known from the surroundings of Ostrava in Northern Moravia (KITTL, 1886) and from different parts of Northern Hungary (BOHN-HAVAS & ZORN, 1994). It is stratigraphically more widespread in the Mediterranean area (Sardinia, Italy, Malta, Turkey), where it occurs from the Early Miocene to the Serravallian (see synonymy list in JANSSEN, 1995). The type sample is from the Langhian (JANSSEN, 1995). Outside Europe it is known from the Early Miocene of Trinidad (RUTSCH, 1934: sub *Cavolinia audeninoi trinitatis*) and from the Miocene of Japan (sub *Cavolinia raritatis* NOMURA & ZINBO, 1935).

Genus *Vaginella* DAUDIN, 1800
Type species: *Vaginella depressa* DAUDIN, 1800

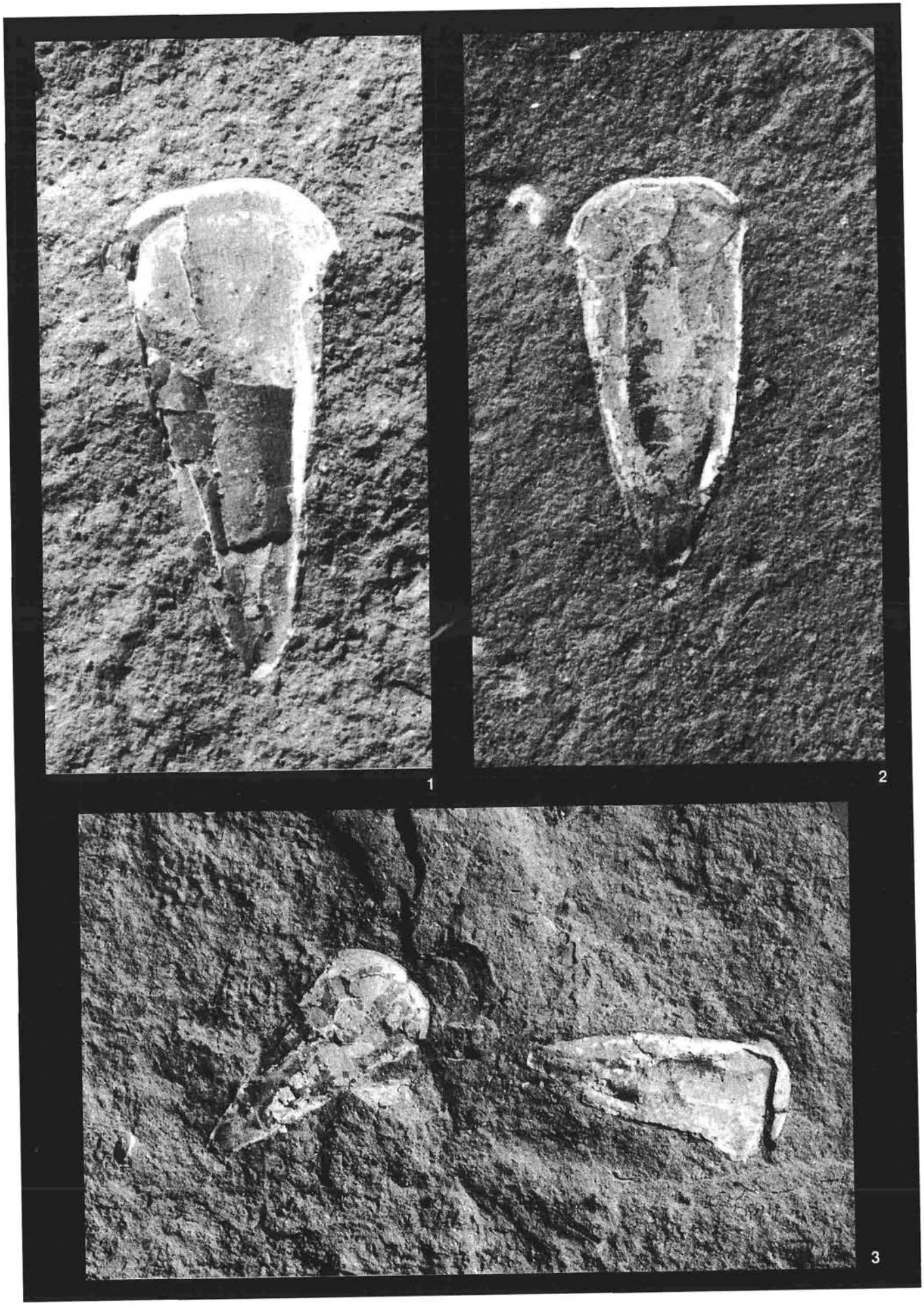
Vaginella austriaca (KITTL, 1886)
(Pl. 4, figs. 1–3; pl. 5, figs. 1–2)

*v	1886	*Vaginella austriaca* n. f. – KITTL, p. 54, pl. 2, figs. 8–12.
v.	1886	*Vaginella Rzehaki* n. f. – KITTL, p. 56, pl. 2, figs. 13–16.
v?	1886	*Vaginella Lapugyensis* n. f. – KITTL, p. 52. (partim, not the material from Lapugy, figs. 4–5 = *Vaginella lapugyensis*)
	1887	*Vaginella austriaca* KITTL – KITTL, pp. 222, 227, 228.
.	1949	*Clio vrázi*, n. sp. – VAŠÍČEK, p. 35, textfig. 1, pl. 1, figs. 2a, b, 3.
v.	1968	*Vaginella austriaca* KITTL – ČTYROKÝ & al., p. 133, pl. 4, figs. 3–8 [non fig. 9].
.	1974	*Vaginella austriaca* KITTL, 1886 – STANCU, p. 188, pl. 2, figs. 1a, b, 2, 5, 6; pl. 3, figs. 1a, b, 2–9.
v.	1981	*Vaginella austriaca* KITTL 1886 – KRACH, p. 124–125, pl. 1, figs. 15–18, 20; pl. 2, figs. 1–3, 21–24; pl. 4, fig. 2.
v.	1984	*Vaginella austriaca* KITTL, 1886 – JANSSEN, p. 73–75, pl. 4, figs. 1–8.
v?	1984	*Vaginella lapugyensis* KITTL, 1886 – JANSSEN, p. 76, pl. 3, figs. 9–10. (partim, non figs. 6–8 = *Vaginella lapugyensis*)
v.	1991a	*Vaginella austriaca* KITTL, 1886 – ZORN, p. 25, pl. 3, fig. 4; pl. 4, figs. 1–3.
v.	1991b	*Vaginella austriaca* KITTL, 1886 – ZORN, p. 120, pl. 6, figs. 1–6; pl. 7, figs. 1–9; pl. 12, figs. 4, 5; pl. 14, figs. 1–8; pl. 16, figs. 1–4.
v.	1993	*Vaginella austriaca* KITTL, 1886 – JANSSEN & ZORN, p. 203, pl. 6, figs. 8–15; pl. 10, figs. 1–5; pl. 11, figs. 1–6. (cum syn.)
v.	1994	*Vaginella austriaca* KITTL, 1886 – BOHN-HAVAS & ZORN, p. 76ff., pl. 2, figs. 2–8; pl. 3, figs. 3–5.
.	1995	*Vaginella austriaca* KITTL, 1886 – NIKOLOV, p. 72, fig. 3.8.
.	1995	*Vaginella austriaca* KITTL, 1886 – JANSSEN, p. 139, pl. 11, figs. 7–10. (cum syn.)

Material studied: borehole Nosislav-3 (106.3m, 152.7m), Late Karpatian: 14 specimens; borehole Nový Přerov-1 (801.5m, 802.3m, 802.7m), Karpatian: several specimens, only 3 of these are well preserved; borehole HJ-309 Nové

Plate 4

Fig. 1–3: *Vaginella austriaca* KITTL, 1886, borehole HJ-303 Tučapy, Early Badenian, figs. 1–2: 349.3m, x 10, fig. 3: 348.3m, x 6.



Dvory (142.5m, 144.5m, 147.5m), Early Badenian: many specimens; borehole Tučapy (323.5m, 344.2m, 345.5m, 348.3m, 348.8m, 349.2m, 349.3m, 349.5m, 350m), Early Badenian: many specimens. KITTL collection (NHMW), Paralectotypes: 4 specimens from Ruditz (reg. no. 1862.XXIX.97), 6 specimens from Dombrau, 11 specimens from Polnisch-Ostrau, around 19 specimens from Nusslau.

Diagnosis: Lance-shaped shell, dorsoventrally flattened, with smooth surface and weak preapertural constriction.

Remarks: KITTL's (1886) specimens of *Vaginella lapugyensis* KITTL, 1886 from Nusslau probably belong to *V. austriaca*. JANSSEN (1984) could not identify these specimens because of their bad state of preservation, but also the specimens of *Vaginella austriaca* from Nusslau are in that state of preservation. For the synonymy of *Vaginella austriaca* and *V. rzehaki* the reader is referred to JANSSEN & ZORN (1993).

Distribution: Karpatian to Badenian in the Central Paratethys (Austria, Poland, Moravia, Hungary, Rumania, Bulgaria) (for details see distribution of this species in ZORN, 1991a and following literature), Burdigalian–Langhian (Aquitanian ?, Serravallian ?) in the Mediterranean area (JANSSEN, 1995), Hemmoorian to Reinbekian in NW-Europe (JANSSEN & KING, 1988).

Vaginella sp.

(Pl. 3, figs. 3–4)

v. *1991* *Vaginella* sp. – ČTYROKÝ, p. 36.
v. *1993* *Vaginella* sp. – ČTYROKÝ, p. 19.

Material studied: Valtice: leg. ČTYROKÝ (1993: No. 305), 5 specimens; Zaječí, km 100.4, leg. ZORN, 8 specimens, leg. ČTYROKÝ, 2 specimens.

Remarks: *Vaginella* is often associated with *Clio triplicata* in Eggenburgian pelitic sediments of the Central Paratethys but is always low in number and comparatively badly preserved. This is especially true for Upper Austria (Haller Schlier) where *Vaginella depressa* DAUDIN, 1800 has been documented (ZORN, 1991a, b). In Moravia *Vaginella* is preserved even more poorly. Some of the specimens at hand seem to be more slender than *V. depressa*. Because of the bad state of preservation they can only be named *Vaginella* sp.

5. Conclusions on the stratigraphical distribution of pteropods and paleobiogeographical notes

In this chapter a short description of the stratigraphical distribution of pteropods in the Moravian Miocene is given. Text-figure 2 shows a summary of the results. Further occurrences in the Paratethys and other European bioprovinces are briefly mentioned.

The Eggenburgian pteropods which are presented in this paper originate from the Šakvice Marls of Zaječí and Valtice. These strata are sediments of the Vienna Basin which are tectonically incorporated to the Ždánice Unit in Southern Moravia. The presence of *Clio triplicata* AUDENINO, 1897, which is the most typical pteropod in the Eggenburgian of the Central Paratethys and probably restricted to this stage, and *Vaginella* sp. could be established. It is one of the northernmost occurrences of *Clio triplicata*, which is common in the Hall Schlier of the Molasse Zone in Upper Austria (ZORN, 1991a, b) and is also known from the Lužice Formation in the Vienna Basin. In the Mediterranean area its stratigraphical range is from Early to Middle Miocene (Langhian). This species obviously reached the Paratethys with the Eggenburgian transgression.

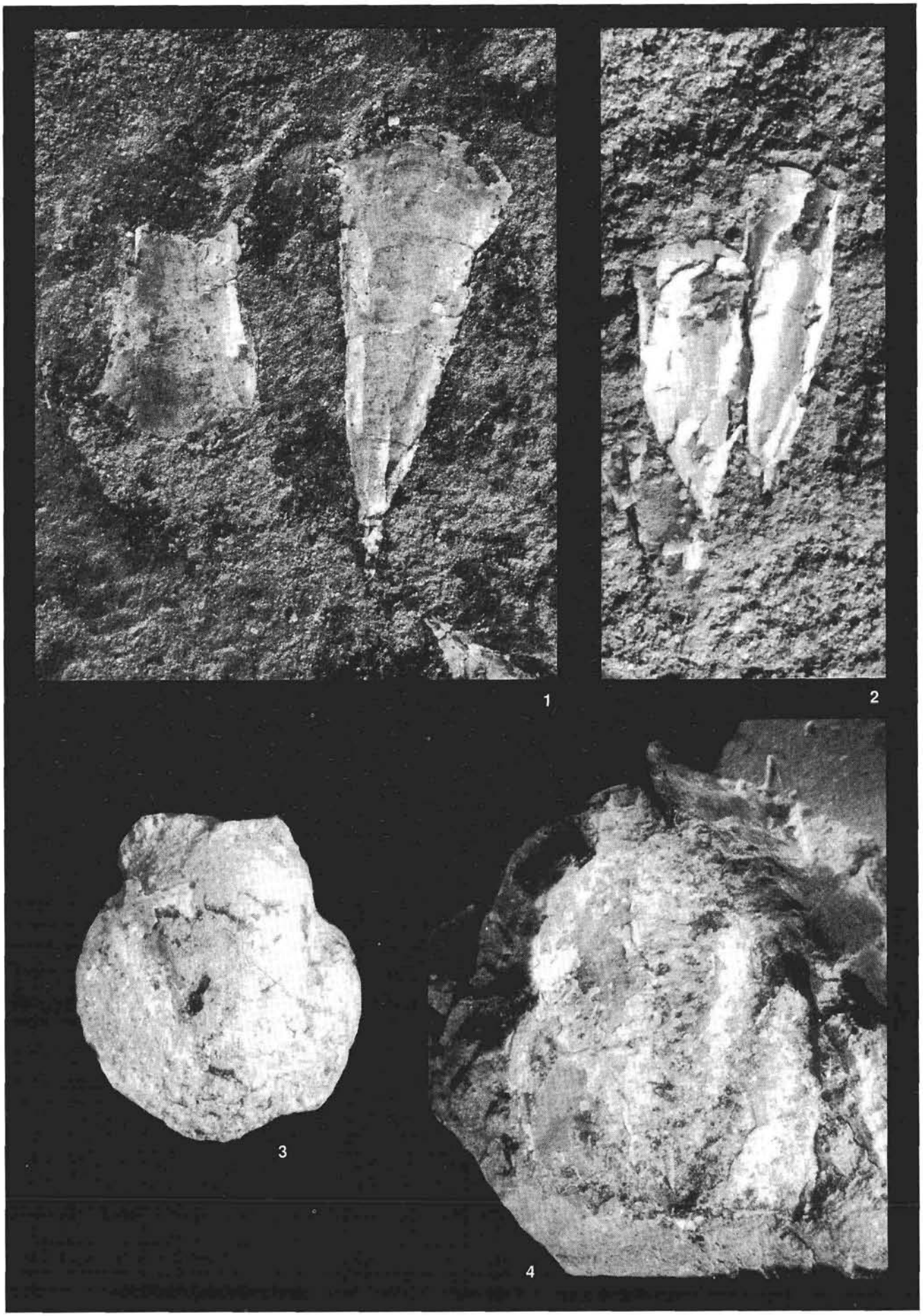
The next younger occurrence of pteropods in Moravia is that of *Vaginella austriaca* (KITTL, 1886) in the Karpatian of the Carpathian Foredeep, documented in the boreholes Nový Přerov-1 and Nosislav-3. The former borehole also yielded *Limacina* sp. indet. In other parts of the Central Paratethys *Vaginella austriaca* is also the most typical representative of pteropods during the Karpatian. The oldest specimens known come from the Burdigalian in the Mediterranean where this species reached the Langhian and probably the Serravallian. Perhaps *V. austriaca* invaded the Paratethys during the Karpatian transgression coming from the Mediterranean via the Slovenian trench. But there are so many finds of to date unidentified *Vaginella* in older sediments that it cannot be excluded that they partly belong to this species. The borehole M-20 Trnove Pole yielded *Limacina valvatina* (REUSS, 1867) in Karpatian sediments.

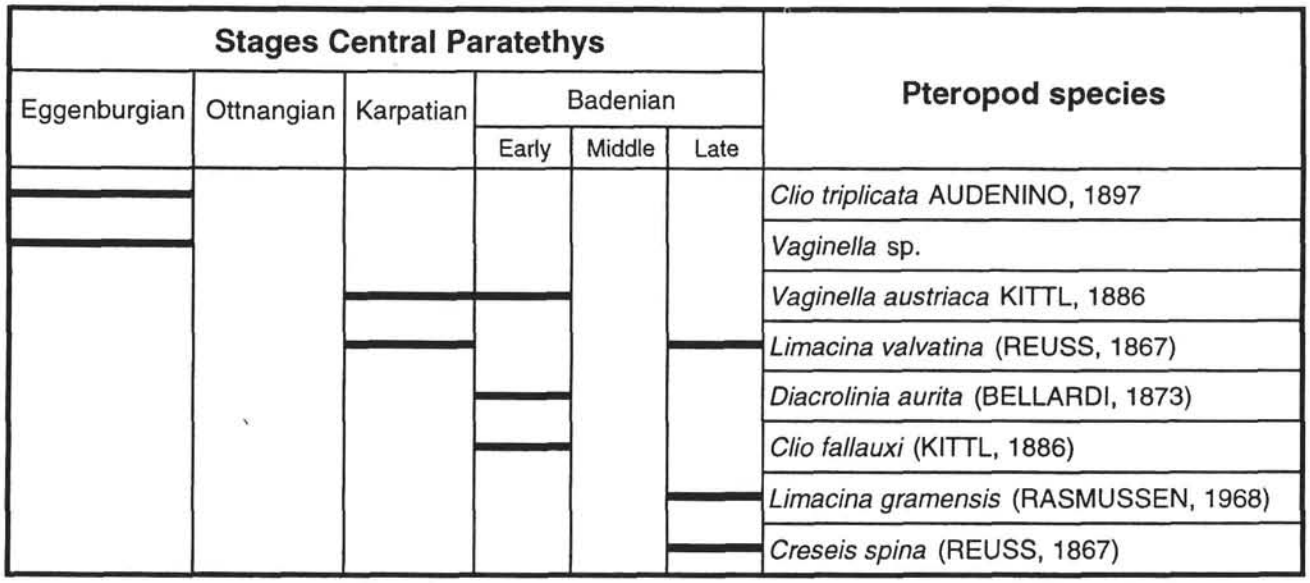
In the Early Badenian of the Carpathian Foredeep *Vaginella austriaca* (KITTL, 1886), *Clio fallauxi* (KITTL, 1886) and *Diacrolinia aurita* (BELLARDI, 1873) have been found. The boreholes HJ-303 (Tučapy), HJ-309 (Nové Dvory) and Dražovice, as well as the material from KITTL's localities of the surroundings of Ostrava and Karviná have been studied. *Clio fallauxi* and *Diacrolinia aurita* are stratigraphically restricted to the Early Badenian within the Central Paratethys and therefore are index fossils. *Clio fallauxi* has never been found outside the Paratethys and seems to be endemic. Probably it evolved from *C. pedemontana* which has also been found in the Early Badenian of the Central Paratethys. This species occurs in the Mediterranean from the Late Oligocene to the Middle Miocene. *Diacrolinia aurita* is most characteristic for the Langhian in the Mediterranean area but also occurring in the Burdigalian and Serravallian.

The pteropod assemblage from the Late Badenian deposits of the Carpathian Foredeep originates from boreholes in Northern Moravia (surroundings of Opava, Opava Basin). They yielded *Limacina valvatina* (REUSS, 1867), *L. gramensis* (RASMUSSEN, 1968) and *Creseis spina* (REUSS, 1867). Within the Paratethys realm *Limacina gramensis* is restricted to the Late Badenian of the Carpathian Foredeep, known from W to E from Northern Moravia, Southern Poland, the Ukraine and Rumania (JANSSEN & ZORN, 1993). Otherwise it is known from coeval deposits of the Langenfeldian in the North Sea Basin. Therefore this species is an index fossil. The occurrence of *Creseis spina* during the Late Badenian in Northern Moravia concurs with that of the Austrian deposits, whereas in other parts of the Central Paratethys it occurs in

Plate 5

Fig. 1: *Vaginella austriaca* KITTL, 1886, borehole Nový Přerov-1, 802.7m, Karpatian, x 10.
Fig. 2: *Vaginella austriaca* KITTL, 1886, borehole Nosislav-3, 152.7m, Late Karpatian, x 10.
Fig. 3–4: *Diacrolinia aurita* (BELLARDI, 1893), lectotype of *Hyalaea bisulcata* KITTL, 1886 (NHMW, reg. No. 1888.I.6), Polnisch-Ostrau (Josefschacht), Early Badenian, fig. 3: ventral side, x 7,7, fig. 4: external mould of the dorsal side, x 7.





Text-Fig. 2.
Stratigraphical distribution of Miocene pteropods in Moravia.

the Middle and/or Early Badenian. Besides *Vaginella austriaca, Limacina valvatina* is the most characteristic pteropod species of the Badenian. It is recorded stratigraphically from the Egerian (questionable finds), Karpatian and Badenian and is known geographically from the Molasse Zone of Lower Austria in the West to the Crimea Peninsula in the East. Like *Limacina gramensis* it is known outside the Paratethys only from the North Sea Basin. There it occurs from the Chattian to the Langenfeldian. The find of *Limacina* cf. *valvatina* in the Late Aquitanian/Early Burdigalian from Val Ceppi in Italy (JANSSEN, 1995) up to now is the only connecting find between the distribution of this species in the North Sea Basin and in the Paratethys.

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