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# North-Tethyan Tithonian chitinoidellids from exotic limestone pebbles in the Silesian Nappe (Polish Outer Carpathians)

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**Abstract:** A small group of Tithonian planktonic ciliates, little-known in the area of the Polish Outer Carpathians, has been recorded in exotic limestones from the western part of the Silesian Nappe. Eleven species of the family Chitinoidellidae Trejo, 1975, belonging to the genera *Chitinoidella*, *Daciella*, *Dobeniella*, *Longicollaria* and *Popiella* are described here. The majority of studied samples have been assigned to the Boneti Subzone of the *Chitinoidella* Zone. Exotics with chitinoidellids represent environments which can be interpreted as platform margin reefs, slope of platform and inner platform.

**Key words:** Tithonian, Outer Carpathians, biostratigraphy, microfacial analysis, exotic limestones, chitinoidellids.

## Introduction

The beginning of the development of a deep-water basin in the southern part of the European shelf took place during the latest Jurassic (e.g. Birkenmajer 1986; Săndulescu 1988). In this Skole-Subsilesian-Silesian Basin, bounded by the Silesian Ridge on the south, sediments represented by the contemporary Outer Carpathian series were deposited. Carbonate platforms were developed along the southern margin of the European Platform and around the Silesian Ridge, during the latest Jurassic–earliest Cretaceous (e.g. Krobicki et al. 2004). The remnants of these platforms occur in the Outer Carpathians only in the form of klippen, boulders, and pebbles, as a result of the fragmentation of the European Platform in this area (e.g. Golonka et al. 2003). The preservation of deposits filling the axial parts of the Carpathian basins is associated with the subduction of the ridge and basin slopes (e.g. Książkiewicz 1962; Cieszkowski et al. 2005).

The redeposited exotic rocks are located among the turbiditic deposits of younger age. With regard to their similarity to the limestones occurring in the form of several klippen in the vicinity of Štramberk (Moravia, Czech Republic) (see e.g. Houša 1975; Eliáš & Eliášová 1984; Houša 1990), they are traditionally called "the Štramberk-type limestones".

Investigation of exotics provides information about deposits from the Carpathian basin margins and slopes of the ridges, which enables us to reconstruct the paleogeography and geological history of areas that are not preserved.

This paper deals with a small group of Tithonian planktonic ciliates (Protozoa), belonging to the family Chitinoidellidae Trejo, 1975. Chitinoidellids precede calpionellids — ciliates with a hyaline lorica — in the fossil record. Their wall was previously considered to be chitinous (Doben 1962), then microgranular calcitic (Borza 1966, 1969; Remane 1969), which was confirmed by studies of the ultrastructure of the wall using the SEM method (Reháková & Michalík 1992, 1993). Chitinoidellids are widespread within the Tethyan Realm and have stratigraphic significance. The *Chitinoidella* Zone constitutes the lowest part of the calpionellid zonation.

## Previous studies and distribution of Chitinoidellidae

Chitinoidellids are known from Tithonian deposits of the Western Carpathians (Borza 1965, 1966, 1969, 1984; Reháková 1995, 2002; Reháková & Michalík 1997; Houša et al. 1999a,b; Michalík et al. 2009; Grabowski et al. 2010b), southern Moravia (Řehánek 1986, 1987a,b), Ukrainian Pieniny Klippen Belt (Reháková et al. 2011), Germany (Doben 1963), Northern Calcareous Alps (Reháková et al. 1996), Gresten Klippenbelt (Reháková et al. 2009; Lukeneder et al. 2010), Transdanubian Mountains (Grabowski et al. 2010a), Southern Carpathians (Pop 1997, 1998a,b), Western Balkanides and Fore-Balkan (Bakalova 1977; Lakova 1993; Ivanova 1997; Lakova et al. 1999), Venetian Alps (Grandesso 1977), Dolomites (Grün & Blau 1997), Apennines (Řehánek & Cecca 1993; Houša et al. 2004), SE France (Cecca et al. 1989), western Sicily (Andreini et al. 2007), Mallorca (Olóriz et al. 1995), Spanish Betic Cordilliera (Enay & Geyssant 1975; Andreini et al. 2009; Pruner et al. 2010). These microfossils were also described from Tunisia (Boughdiri et al. 2006, 2009; Abdesselam-Mahdaoui et al. 2010; Sallouhi et al. 2011), Morocco (Benzaggagh & Atrops 1995; Benzaggagh et al. 2010), Turkey (Altiner & Özkan 1991; Akyazi & Tunç 1998), NW Iran (Benzaggagh et al. 2012), Cuba (Furrazola-Bermúdez 1965; Pszczółkowski & Myczyński 2010; López-Martínez et al. 2013), Mexico (Trejo 1975; Adatte et al. 1996).

The *Chitinoidella* Zone was also distinguished in the Štramberk Limestone (Houša 1990; Houša & Řehánek 1993) that are traditionally considered as representing a similar type of sedimentation as the latest Jurassic–earliest Cretaceous exotic limestones occurring in the Outer Carpathians.

In the Polish Outer Carpathians occurrence of chitinoidellids, as well as latest Jurassic and earliest Creataceous calpionellids is infrequent. A sedimentological record of this period is known only from the area of the Silesian Basin. Moreover, the turbiditic type of sedimentation hinders planktonic ciliates occurrence and preservation. Chitinoidellids were described only from the Cieszyn Beds of the Silesian Nappe. Nowak (1968, 1976) reported presence of *Chitinoidella* sp. from "under-calpionellids limestone" and *Chitinoidella boneti* Doben from the exotic level below the Cieszyn Limestone (Nowak 1968). Olszewska (2005) and Olszewska et al. (2008) described and illustrated *Ch. boneti* Doben from the Lower Cieszyn Shales.

Calcareous deposits of the Pieniny Klippen Belt and the Tatra Mountains provide better opportunities for research. Chitinoidellids from the Pieniny Klippen Belt were reported by Nowak (1976, 1978, 1980), Pszczółkowski & Myczyński (2004), Reháková & Wierzbowski (2005). Pszczółkowski (1996), Grabowski & Pszczółkowski (2006a,b), Jach et al. (2012) described these microfossils from the Tatra Mountains.

## Material and methods

Chitinoidellid fauna was found in 19 thin sections prepared from exotic pebbles collected from 9 localities (Fig. 1) situated in the western part of the Silesian Nappe (ages for 3–9 after Oszczypko et al. 2006):

1) Żegocina (11 km north from Limanowa), abandoned quarry — Grodziszcze Formation; Late Barremian (Malik & Olszewska 1984).

2) Żywiec, outcrop upon the Soła River, below the mouth of the Koszarawa River — deposits of the Grodziszcze Formation within olistostrome; Valanginian–Early Hauterivian (Cieszkowski et al. 2009).

3) Krzyworzeka (near Dobczyce), tributary of the Krzyworzeka River — Lower Istebna Beds; Campanian–Maastrichtian.

4) Biskupice (5 km southeast from Wieliczka), streams and outcrops on Bukowiec Hill — Grodziszcze Formation; Hauterivian–Barremian.

5) Gródek upon Dunajec, outcrop by the Rożnów Lake — Ciężkowice Sandstone; Eocene.

6) Sygneczów (near Wieliczka), abandoned quarry — Grodziszcze Formation; Hauterivian–Barremian.

7) Podole-Górowa (12 km west from Ciężkowice), tributary of the Paleśnianka stream — Ciężkowice Sandstone; Eocene.

8) Tarnawa (5 km south from Łapanów), tributary of the Tarnawka stream — Upper Istebna Beds; Paleocene.

9) Zarzyce Wielkie (4 km northeast from Kalwaria Zebrzydowska), outcrop in a landslide niche — Lower Istebna Beds; Campanian–Maastrichtian.

The micropaleontological studies of thin sections were carried out under Nikon's Eclipse LV100 POL polarizing microscope, and the microfacial studies under Nikon's SMZ1000 stereomicroscope. Diversified amount of well preserved and determinable (in more or less axial sections) chitinoidellids was found in particular thin sections, most often several or ten-odd specimens.

## Microfacies description and environmental remarks

The studied exotics constitute remnants of the Late Jurassic–Early Cretaceous carbonate platforms which were devel-

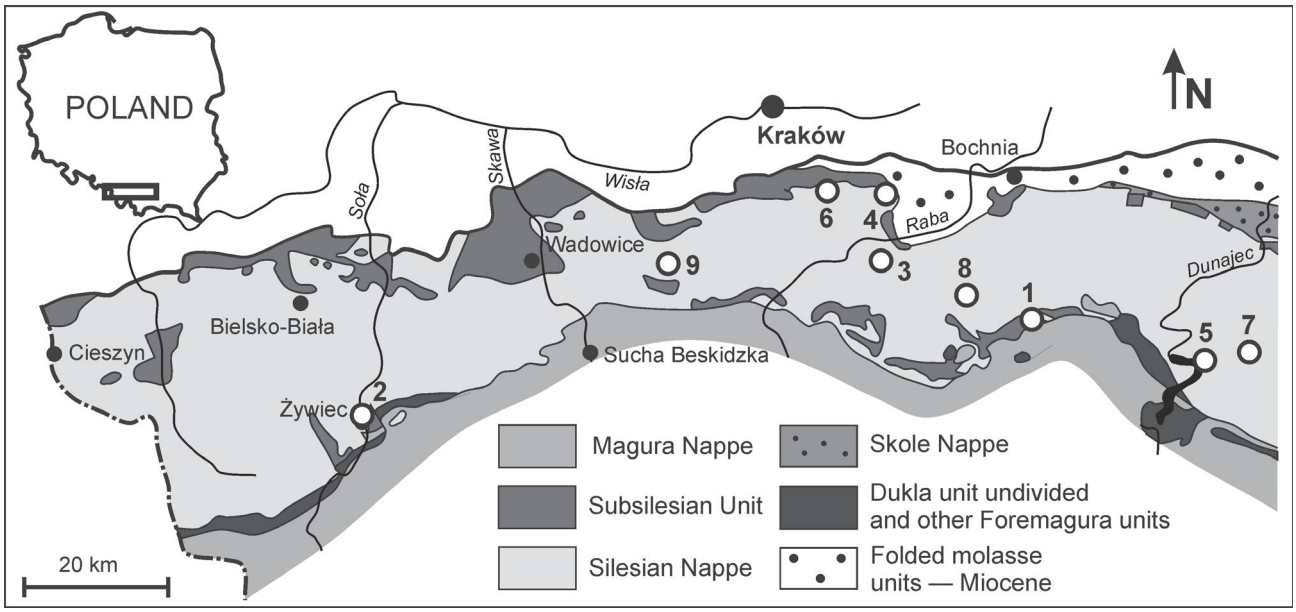


**Fig. 1.** The position of localities with analysed exotics on the geological map of the southwest part of the Polish Outer Carpathians (map after Lexa et al. 2000, simplified). **1** — Żegocina, **2** — Żywiec, **3** — Krzyworzeka, **4** — Biskupice, **5** — Gródek upon Dunajec, **6** — Sygneczów, **7** — Podole-Górowa, **8** — Tarnawa, **9** — Zarzyce Wielkie.

oped along the southern margin of the European Platform and around the Silesian Ridge (e.g. Krobicki et al. 2004). Detailed reconstruction of these platforms is problematic and difficult due to fragmentation and transportation of deposits. According to Hoffman & Kołodziej (2008), high-energy debris reefs occurred on the margin of these platforms, while the inner platform was a depositional setting where coral-microbial patch reefs were developed together with bioclastic limestones with foraminifera and algae and peloidal-bioclastic limestones.

The studied exotic limestones with chitinoidellids represent environments that can be interpreted as platform margin reefs, slope of platform and inner platform. Several main types of microfacies with chitinoidellids can be distinguished (Fig. 2):

**MF1: Peloidal bindstone and peloidal-ooidal bindstone often grading into peloidal-bioclastic grainstone or bioclastic wackstone.**

These limestones consist mostly of peloids, sometimes also microbial and in situ-formed ooids. Fossils occur mostly in wackstone and grainstone parts: crinoid plates, sponge spicules, ostracods, gastropods, calcareous sponges, fragments of bivalve shells, fragments of green algae (Dasycladaceae), serpulid worm tubes including *Carpathiella* sp., planktonic green algae *Globochaete alpina* Lombard, benthic foraminifera: *Ammobaculites* sp., *Crescentiella morronensis* (Crescenti), *Haghimashella arcuata* (Haeusler), *Lenticulina* sp., *Neotrocholina* sp., *Nubecularia* sp., *Spirillina* sp., *Textularia* sp., miliolid foraminifera and single calcareous dinoflagellates.

**MF2: Coated-bioclastic packstone-grainstone.**

Most bioclasts are micritized or have micrite envelopes. Other constituents are peloids, ooids and small oncoids. Recognized fossils: echinoid spines, crinoid plates, ostracods, calcareous sponges, fragments of bivalve shells, *Globochaete alpina*, benthic foraminifera: *Crescentiella morronensis*, *Globospirillina* sp., *Neotrocholina* sp., *Spirillina* sp., *Uvigerinammina uvigeriniformis* (Seibold & Seibold), miliolid foraminifera (including *Istriloculina* sp.), and calcareous dinoflagellates.

**MF3: Coral-microbial boundstone.**

Fossils: corals, bivalve shells, polychaetes *Terebella lapilloides* Münster, serpulid worm tubes, "Tubiphytes"-type structures, microorganisms *incertae sedis Koskinobulina*

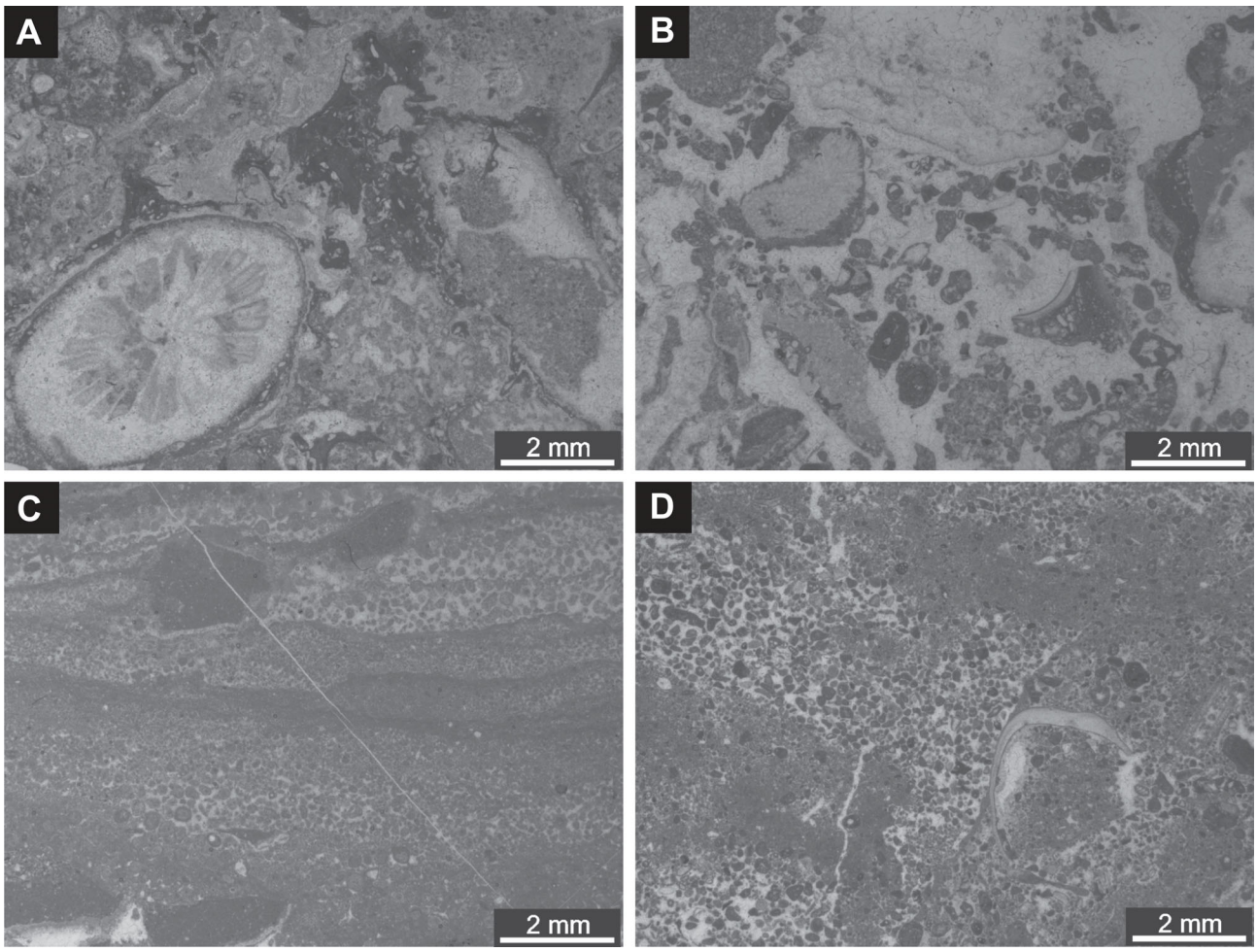


**Fig. 2.** Microfacies of the studied exotic limestones with chitinoidellids. **A** — microbial-coral boundstone (Gródek upon Dunajec, thin section S19/41); **B** — intraclastic-bioclastic grainstone-rudstone with peri-reefal components (Gródek upon Dunajec, thin section S19/3); **C** — peloid-alooidal bindstone (Żegocina; thin section S6/9); **D** — coated-bioclastic packstone/grainstone (Tarnawa, thin section S23/3).

*socialis* Cherchi & Schröder, foraminifera: *Crescentiella morronensis*, encrusting foraminifera and single agglutinated foraminifera.

**MF4: Sponge-microbial and microbial boundstone.**

Fossils: calcareous sponges, ostracods, oysters, gastropods, crinoid plates, fragments of bivalve shells, "Tubiphyte"-type structures, *Globochaete alpina*, *Terebella lapilloides*, serpulid worm tubes (including *Carpathiella* sp. and *Mercierella dacica* Dragastan), benthic foraminifera: *Crescentiella morronensis*, *Neotrocholina* sp., *Patellina* sp., *Protopeneroplis* sp., *Spirillina* sp., miliolid foraminifera (including *Rumanoloculina multicostata* Neagu), encrusting foraminifera and calcareous dinoflagellates.

**MF5: Intraclastic or intraclastic-bioclastic rudstone and coarse grainstone with peri-reefal components.**

Fossils: calcareous sponges, corals, crinoid plates, echinoid spines, fragments of brachiopod and bivalve shells, gastropods, ostracods, calcimicrobes, serpulid worm tubes (including *Carpathiella triangulata* Mišík, Soták & Ziegler, *Carpathiella* sp. and *Mercierella dacica*), *Terebella lapilloides*, pelagic crinoids *Saccocoma* sp., *Globochaete alpina*, microfossils *incertae sedis Lithocodium aggregatum* Elliott and *Koskinobulina socialis*, foraminifera: *Andersenolina* sp., *Crescentiella morronensis*, *Lenticulina* sp., *Mohlerina basiliensis* (Mohler), *Neotrocholina* sp., *Nubecularia* sp., *Protopeneroplis ultragranulata* (Gorbatchik), *Protopeneroplis* sp., *Spirillina* sp., *Trocholina odukpaniensis* Dessauvagie, *Uvigerinammina uvigeriniformis*, miliolid foraminifera and calcareous dinoflagellates.

**MF6: Peri-reefal grainstone with bioclasts, peloids and intraclasts.**

Fossils: calcareous sponges, fragments of bivalve shells, gastropods, echinoid spines, crinoid plates, ostracods, *Globochaete alpina*, *Koskinobulina socialis*, *Mercierella dacica*, *Saccocoma* sp., *Terebella lapilloides*, foraminifera: *Andersenolina alpina* (Leupold), *Crescentiella morronensis*, *Nubecularia* sp., *Patellina* sp., *Protopeneroplis striata* Weynschenk, *Spirillina* sp., *Uvigerinammina uvigeriniformis*, miliolid foraminifera and calcareous dinoflagellates.

## Systematic paleontology

Family: Chitinoidellidae Trejo, 1975
Genus: *Chitinoidella* Doben, 1963
*Chitinoidella boneti* Doben, 1963

Fig. 3A–C

1963 *Chitinoidella boneti* n.sp. — Doben, pl. 6, figs. 1–5
1965 *Tintinnopsella carpathica* (Murgeanu & Filipescu) — Furrazola Bermúdez, pl. 4, fig. 2
1969 *Chitinoidella boneti* Doben — Borza, pl. LXVII, figs. 3–16; pl. LXVIII, figs. 1–7, 9–13
1975 *Tintinnopsella carpathica* (Murgeanu & Filipescu) — Trejo, pl. XII, fig. 34
1980 *Chitinoidella boneti* Doben — Nowak, pl. LXXXIX, fig. 3
1995 *Chitinoidella boneti* Doben — Reháková, pl. I, figs. 6–7
1996 *Chitinoidella boneti* Doben — Pszczółkowski, figs. 13.1–2
2002 *Chitinoidella boneti* Doben — Reháková, figs. 2.1–4
2005 *Chitinoidella boneti* Doben — Olszewska, pl. 1, figs. 1–2
2006a *Chitinoidella boneti* Doben — Grabowski & Pszczółkowski, fig. 4C
2006b *Chitinoidella boneti* Doben — Grabowski & Pszczółkowski, figs. 7A,B
2008 *Chitinoidella boneti* Doben — Olszewska et al., fig. 6A
2011 *Chitinoidella boneti* Doben — Sallouhi et al., pl. 1, fig. 24
2013 *Chitinoidella boneti* Doben — Lakova & Petrova, pl. 1, figs. 17–18, pl. 5, figs. 21–23

**Material:** Żegocina (S6/9), Żywiec (S7/1), Krzyworzeka (S10B/4), Biskupice (S16/5), Gródek upon Dunajec (S19/3, S19/24, S19/31, S19/40), Sygneczów (S20/1), Podole-Górowa (S22/7, S22/10, S22/16), Tarnawa (S23/3, S23/5).

**Dimensions:** 48–62 μm in length and 36–45 μm in width, length/width ratio 1.2–1.5.

**Description:** Bell-shaped lorica with a large oral opening, outwardly deflected collar and usually short caudal appendage at the aboral pole.

**Remarks:** *Ch. boneti* occurs commonly in almost all samples.

**Distribution:** Boneti Subzone.

*Chitinoidella carthagensis* Sallouhi, Boughdiri & Cordey, 2011
Fig. 3D,E

2011 *Chitinoidella carthagensis* n.sp. — Sallouhi et al., pl. 1, figs. 26–29

**Material:** Żywiec (S7/1).

**Dimensions:** 53–56 μm in length and 38–39 μm in width (length/width ratio 1.4–1.5).

**Description:** Elongated bell-shaped lorica with a large oral opening, outwardly deflected collar and conical aboral pole with a small caudal appendage. Bowl is polygonal in shape and the maximum width can be measured just below the collar, where a short angular shoulder-like feature occurs.

**Distribution:** Boneti Subzone.

*Chitinoidella elongata* Pop, 1997
Fig. 3F–H

1969 *Chitinoidella boneti* Doben — Borza, pl. LXVIII, fig. 8
1997 *Chitinoidella elongata* n.sp. — Pop, fig. 2, photos 3–4
2002 *Chitinoidella elongata* Pop — Reháková, figs. 2.5–8
2006a *Chitinoidella elongata* Pop — Grabowski & Pszczółkowski, fig. 4D
2013 *Chitinoidella elongata* Pop — Lakova & Petrova, pl. 1, figs. 20–21, pl. 5, figs. 24–25

**Material:** Krzyworzeka (S10B/2), Biskupice (S16/5), Gródek upon Dunajec (S19/31), Tarnawa (S23/3), Zarzyce Wielkie (S26/7).

**Dimensions:** 60–84 μm in length and 30–38 μm in width, length/width ratio 1.7–2.3.

**Description:** Cylindrical lorica with an outwardly deflected, often large collar and conical aboral pole with a distinct caudal appendage. The maximum width can be measured in the lower part of the bowl.

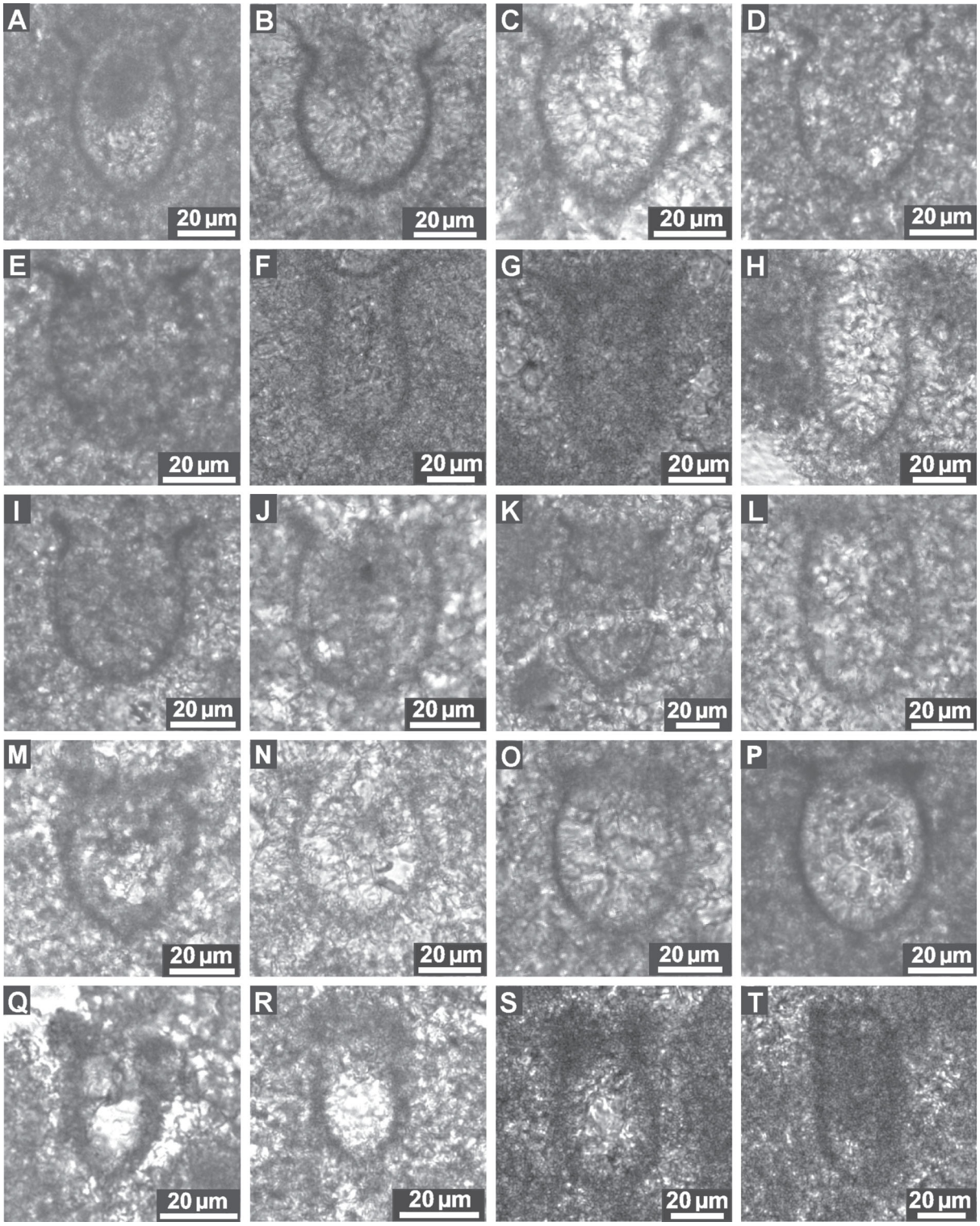


**Fig. 3.** Chitinoidellids. **A–C** — *Chitinoidella boneti* Doben. A — Krzyworzeka, thin section S10B/4. B — Biskupice, thin section S16/5. C — Podole-Górowa, thin section S22/10; **D, E —** *Chitinoidella carthagensis* Sallouhi, Boughdiri & Cordey. Żywiec, thin section S7/1; **F–H** — *Chitinoidella elongata* Pop. F, G — Zarzyce Wielkie, thin section S26/7. H — Tarnawa, thin section S23/5; **I, J** — *Chitinoidella hegarati* Sallouhi, Boughdiri & Cordey. I — Żywiec, thin section S7/1. J — Podole-Górowa, thin section S22/10; **K, L —** *Chitinoidella popi* Sallouhi, Boughdiri & Cordey. K — Żywiec, thin section S7/1. L — Tarnawa, thin section S23/9; **M, N** — *Dobeniella tithonica* (Borza). M — Podole Górowa, thin section S22/10. N — Podole-Górowa, thin section S22/7; **O, P** — *Dobeniella cubensis* (Furrazola-Bermúdez). O — Gródek upon Dunajec, thin section S19/40. P — Żywiec, thin section S7/1; **Q** — *Daciella danubica* Pop. Gródek upon Dunajec, thin section S19/34; **R** — *Longicollaria dobeni* (Borza); Gródek upon Dunajec, thin section S19/34; **S** — *Longicollaria insueta* (Řehánek). Zarzyce Wielkie, thin section S26/7; **T** — *Popiella oblongata* Reháková. Zarzyce Wielkie, thin section S26/7.

**Remarks:** The found specimens have relatively small dimensions.

**Distribution:** Boneti Subzone.

*Chitinoidella hegarati* Sallouhi, Boughdiri & Cordey, 2011
Fig. 3I,J

1995 *Chitinoidella bermudezi* (Furrazola-Bermúdez) — Benzaggagh & Atrops, fig. 4.7
1997 *Chitinoidella* sp. 1 — Grün & Blau, pl. 1, fig. 7
2007 *Chitinoidella boneti* Doben — Andreini et al., pl. I, figs. 3–4
2011 *Chitinoidella hegarati* n.sp. — Sallouhi et al., pl. 1, figs. 25, 30–31
2013 *Chitinoidella hegarati* Sallouhi, Boughdiri & Cordey — Lakova & Petrova, pl. 1, fig. 19

**Material:** Żegocina (S6/9), Żywiec (S7/1), Gródek upon Dunajec (S19/3), Podole Górowa (S22/10).

**Dimensions:** 50–54 μm in length and 37–42 μm in width, length/width ratio 1.2–1.4.

**Description:** Spheroid to slightly elongated lorica, fairly isometric bell-shaped to polygonal in shape bowl with parallel to fairly rounded lateral edges, small preoral construction and the maximum width in the middle part of the lorica. A shoulder-like structure conducts to the oral part with relatively short collar. Conical aboral pole has rather poorly marked caudal appendage.

**Remarks:** *Ch. hegarati* can be distinguished from *Ch. boneti* by its more polygonal shape and distinct preoral constriction.

**Distribution:** Boneti Subzone.

*Chitinoidella popi* Sallouhi, Boughdiri & Cordey, 2011
Fig. 3K,L

2011 *Chitinoidella popi* n.sp. — Sallouhi et al., pl. 1, figs. 32–33

**Material:** Żywiec (S7/1), Gródek upon Dunajec (S19/40), Tarnawa (S23/9).

**Dimensions:** 60–70 μm in length and 37–44 μm in width, length/width ratio 1.6.

**Description:** Elongated bell-shaped lorica with a small preoral constriction, large preoral opening and maximum width located in the middle part of the lorica. Conical aboral pole has a well-marked caudal appendage. Outwardly deflected collar is lense-like in section.

**Remarks:** *Ch. popi* is a homeomorph of the calpionellid species *Tintinnopsella carpathica* (Murgeanu & Filipescu), so it differs from *Ch. elongata*, which resembles rather *Tintinnopsella longa* (Colom).

**Distribution:** Boneti Subzone.

Genus *Daciella* Pop, 1998
*Daciella danubica* Pop, 1998
Fig. 3Q

1969 *Chitinoidella* sp. — Borza, pl. LXIII, fig. 4
1998b *Daciella danubica* n.sp. — Pop, fig. 2, photos 14–18
2002 *Daciella danubica* Pop — Reháková, figs. 2.17–20
2011 *Daciella danubica* Pop — Sallouhi et al., pl. 1, fig. 17
2013 *Daciella danubica* Pop — Lakova & Petrova, pl. 1, figs. 1–5, pl. 5, figs. 9–13

**Material:** Gródek upon Dunajec (S19/34).

**Dimensions:** 39 μm in length and 24 μm in width, length/width ratio 1.6.

**Description:** Conical to ovoid lorica. Sharp aboral pole ends with a caudal appendage. Large oral opening has characteristic thickening and a short cylindrical collar.

**Remarks:** One specimen was found.

**Distribution:** Dobeni Subzone.

Genus *Dobeniella* Pop, 1997
*Dobeniella cubensis* (Furrazola-Bermúdez, 1965)
Fig. 3O,P

1965 *Tintinnopsella cubensis* n.sp. — Furrazola-Bermúdez, pl. 1, figs. 1a–c; p. 32, pl. 2, figs. 1–5; p. 38, pl. 5, fig. 1
1966 *Chitinoidella cubensis* (Furrazola-Bermúdez) — Borza, pl. X, fig. 10
1969 *Chitinoidella cubensis* (Furrazola-Bermúdez) — Borza, pl. LXVIII, figs. 14–16
1995 *Chitinoidella cubensis* (Furrazola-Bermúdez) — Reháková, pl. I, fig. 10
1996 *Chitinoidella cubensis* (Furrazola-Bermúdez) — Pszczółkowski, fig. 13.3
1997 *Dobeniella cubensis* (Furrazola-Bermúdez) — Pop, fig. 2, photos 5–6
1998a *Dobeniella cubensis* (Furrazola-Bermúdez) — Pop, pl. I, figs. 27–29
2002 *Dobeniella cubensis* (Furrazola-Bermúdez) — Reháková, figs. 3.4–6
2011 *Dobeniella cubensis* (Furrazola-Bermúdez) — Sallouhi et al., pl. 1, figs. 7–10
2013 *Dobeniella cubensis* (Furrazola-Bermúdez) — Lakova & Petrova, pl. 5, figs. 29–32

**Material:** Żywiec (S7/1), Gródek upon Dunajec (S19/40).

**Dimensions:** 52 and 53 μm in length and 42 and 40 μm in width, length/width ratio 1.3 and 1.2.

**Description:** Bell-shaped, ovoid to elongated lorica with a large preoral opening and conical aboral pole ended with caudal appendage. Collar consisting of a short, outwardly deflected outer ring and rounded inner ring, at least partially closing the oral zone.

**Remarks:** Two specimens were found.

**Distribution:** Boneti Subzone.

*Dobeniella tithonica* (Borza, 1969)
Fig. 3M,N

1969 *Chitinoidella tithonica* n.sp. — Borza, pl. LXVII, figs. 1–2
1993 *Chitinoidella tithonica* Borza — Lakova, pl. I, fig. 3
1995 *Chitinoidella tithonica* Borza — Reháková, pl. I , fig. 5
1997 *Dobeniella tithonica* (Borza) — Pop, fig. 2, photos 9
2002 *Dobeniella tithonica* (Borza) — Reháková, fig. 3.10–12
2011 *Dobeniella tithonica* (Borza) — Sallouhi et al., pl. 1, figs. 3–6

**Material:** Podole-Górowa (S22/7, S22/10), Tarnawa (S23/5).

**Dimensions:** 50–55 μm in length and 39–43 μm in width, length/width ratio 1.2–1.3.

**Description:** Bell-shaped lorica with a caudal appendage or pointed aboral part and a distinct, sharp preoral constric-

tion. The collar consists of two rings: the inner is shorter and lens-like in section, whereas the outer is outwardly deflected.

**Remarks:** Three specimens were found.

**Distribution:** Boneti Subzone.

Genus *Longicollaria* Pop, 1997
*Longicollaria dobeni* (Borza, 1966)
Fig. 3R

1966 *Chitinoidella dobeni* n.sp. — Borza, pl. XIX, figs. 1–12
1993 *Chitinoidella dobeni* Borza — Lakova, pl. I, figs. 5–6
1995 *Chitinoidella dobeni* Borza — Reháková, pl. I, figs. 1–2
1997 *Longicollaria dobeni* (Borza) — Pop, figs. 2, photos 12–13
2002 *Longicollaria dobeni* (Borza) — Reháková, figs. 4.1–3
2011 *Longicollaria dobeni* (Borza) — Sallouhi et al., pl. 1, figs. 1–2
2012 *Longicollaria dobeni* (Borza) — Jach et al., fig. 12I
2013 *Longicollaria dobeni* (Borza) — Lakova & Petrova, pl. 1, figs. 11–12, pl. 5, figs. 17–20

**Material:** Gródek upon Dunajec (S19/34).

**Dimensions:** 39 μm in length and 19 μm in width, length/width ratio 2.0.

**Description:** Ovoid lorica with a conical aboral pole terminating in a sharp caudal appendage, a slight preoral constriction and a long cylindrical collar which thickens distally.

**Remarks:** One specimen was found.

**Distribution:** Dobeni Subzone.

*Longicollaria insueta* (Řehánek, 1986)
Fig. 3S

1986 *Chitinoidella insueta* n.sp. — Řehánek, pl. I, figs. 1–4
1993 *Chitinoidella insueta* Řehánek — Lakova, pl. 1, fig. 1
1995 *Chitinoidella insueta* Řehánek — Reháková, pl. I, fig. 8
1997 *Cylindrella insueta* (Řehánek) — Pop, fig. 2, photos 16
1998a *Aninella insueta* (Řehánek) — Pop, pl. I, fig. 21
2002 *Longicollaria insueta* (Řehánek) — Reháková, figs. 4.7–9
2013 *Longicollaria insueta* (Řehánek) — Lakova & Petrova, pl. 5, fig. 26

**Material:** Gródek upon Dunajec (S19/3), Zarzyce Wielkie (S26/7).

**Dimensions:** 66 and 69 μm in length and 36 and 40 μm in width, length/width ratio 1.7 and 1.8.

**Description:** Elongated, vase-like lorica with a rounded aboral pole. Collar is cylindrical or tubular, with walls thickening upward. The collar is longer than the bowl.

**Remarks:** Two specimens were found.

**Distribution:** Boneti Subzone.

Genus: *Popiella* Reháková, 2002
*Popiella oblongata* Reháková, 2002
Fig. 3T

1998b *Daciella svinitensis* — Pop, fig. 2, photo 19
2002 *Popiella oblongata* n.sp. — Reháková, fig. 4.10–12
2011 *Popiella oblongata* Reháková — Sallouhi et al., pl. 1, fig. 22

**Material:** Zarzyce Wielkie (S26/7).

**Dimensions:** 77 μm in length and 32 μm in width, length/width ratio 2.4.

**Description:** Elongated cylindrical lorica with a rounded aboral pole, straight and parallel walls and without a collar.

**Remarks:** One specimen was found.

**Distribution:** Boneti Subzone.

## Biostratigraphy

The *Chitinoidella* Zone was introduced by Enay & Geyssant (1975) in the Spanish Betic Cordilliera. Grandesso (1977) defined this zone in the Venetian Alps. The first occurrence (FO) of microgranular chitinoidellids defines the lower boundary of the zone, whereas the upper boundary coincides with the lower boundary of the *Praetintinnopsella* Zone and the first occurrence of *Praetintinopsella andrusovi* Borza. Calpionellid zonation for the Western Carpathians (Borza 1984; Reháková 1995; Reháková & Michalík 1997) situated the Chitinoidella Zone in the middle Tithonian — a chronostratigraphic unit no longer existing in the standard Jurassic Time Scale based on ammonites (Ogg & Hinnov 2012). Actually the Dobeni Subzone belongs to the latest Early Tithonian, whereas the Boneti Subzone is in the earliest Late Tithonian (e.g. Boughdiri et al. 2006; Lakova & Petrova 2013) (Fig. 4).

The *Chitinoidella* Zone is divided into two interval subzones: Dobeni Subzone and Boneti Subzone (Grandesso 1977; Borza 1984). After the systematic revision of chitinoidellids (Reháková 1995, 2002; Pop 1997), the latter author defined their lower boundaries at the FO of *Longicollaria dobeni* (Borza) for the Dobeni Subzone, and at the FO of *Chitinoidella boneti* Doben for the Boneti Subzone.

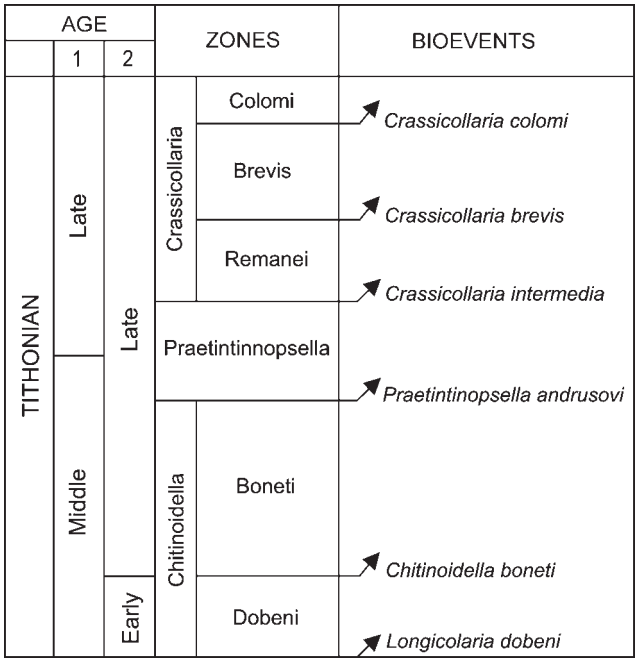


**Fig. 4.** Tithonian calpionellid zonation for the Western Carpathians according to Reháková & Michalík 1997; age: 1 — Reháková & Michalík 1997; 2 — Lakova & Petrova 2013.

Almost all studied samples belong to the Boneti Subzone. *Chitinoidella boneti* Doben is a predominant species, *Ch. elongata* Pop occurs rather frequently. In addition such species as *Ch. carthagensis* Sallouhi, Boughdiri & Cordey, *Ch. hegarati* Sallouhi, Boughdiri & Cordey, *Ch. popi* Sallouhi, Boughdiri & Cordey, *Dobeniella cubensis* (Furrazola-Bermúdez), *Dobeniella tithonica* (Borza), *Longicollaria insueta* (Řehánek) and *Popiella oblongata* Reháková are present. These chitinoidellids are accompanied by calcareous dinoflagellates: *Schizosphaerella minutissima* (Colom), *Colomisphaera carpathica* (Borza), *Colomisphaera pulla* (Borza), *Cadosina semiradiata fusca* (Wanner), *Cadosina semiradiata semiradiata* Wanner, *Colomisphaera cieszynica* Nowak, *Cadosina semiradiata olzae* (Nowak).

Only one sample contains single chitinoidellids indicating the Dobeni Subzone: *Longicollaria dobeni* (Borza) and *Daciella danubica* Pop. In this sample the following calcareous dinoflagellates were also observed: *Schizosphaerella minutissima* (Colom), *Colomisphaera carpathica* (Borza), *Parastomiosphaera malmica* (Borza), *Cadosina semiradiata olzae* (Nowak), *Colomisphaera cieszynica* Nowak.

## Conclusions

- Study of exotics from 9 localities provided information about the composition, paleoenvironments and stratigraphy of the sequences of not preserved areas of the Carpathian basin margins and slopes of the elevated ridges;
- Chinoidellids, rare in the Outer Carpathians, were described from the Cieszyn Beds (Silesian Unit), which represent deeper, turbiditic sedimentation. These exotics are richer in chitinoidellid fauna in comparison to the deposits of the Cieszyn Beds;
- Pebbles of limestones belonging to the *Chitinoidella* Zone, occur relatively rarely compared to exotics of Early Tithonian age or representing younger calpionellid zones;
- New rarely reported species were identified (*Chitinoidella carthagensis* and *Ch. popi)* in the examined samples among the chitinoidellid association. They were only recently described from Tunisia (Sallouhi et al. 2011), and have not been reported from other areas so far;
- Tintinnid limestones are typical for the latest Jurassic–earliest Cretaceous pelagic deposits, whereas the studied exotic limestones with chitinoidellids represent shallower environments. This may explain the occurrence of relatively small numbers of specimens in most of the samples.

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