Aptian planktonic foraminiferal biostratigraphy and smaller benthic foraminifera from the Párnica Formation (Choč Mts., Western Carpathians)

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Biostratigrafia planktonických foraminifer a menšie bentické foraminifery aptu párnického súvrstvia (Chočské vrchy, Západné Karpaty)

Abstract: A section through shaly marlstones, marls, layers of bioclastic limestones and Vlkolínec Breccia with carbonate paraconglomerates of Párnica Formation were recently studied near Lúčky Spa in the Hlboké Valley (Choč Mts.). Samples from the marlstones on the right side of the section showed the occurrence of well–preserved rich associations of Aptian microfauna, mainly planktonic foraminifera. Detailed sampling shows the distribution of planktonic and benthic foraminifera through the section belonging to uppermost Bedoulian – Lower Gargasian zones: Leupoldina cabri, Hedbergella luterbacheri, Globigerinelloides ferreolensis zones and to Middle Gargasian Globigerinelloides barri Zone. Composition of assemblages with different morphotypes of planktonic and benthic foraminifera casts light on changing paleoecological settings during the deposition of Párnica Formation .

Key words: Aptian, Foraminifera, Párnica Formation, Fatricum, Krížna Nappe, Zliechov Basin, Western Carpathians

1. INTRODUCTION

Sequence consisting of rather monotonous Middle Cretaceous marlstones and shales is known from the Krížna Nappe in the West Carpathians as the so called „Párnica schists" (Párnica shales) (Štúr, 1868; Hauer, 1872). Latest studies of Boorová & Filo (2013, 2014, 2016) show the formation in a new light mostly composed of shaly marlstones to marly limestones or marls with beds of bioclastic limestones. The Vlkolínec Breccia with its lower horizon of the carbonate paraconglomerate member (sensu Jablonský, 1978) is a part of the studied formation. Rich and well–preserved microfauna from pelagic deposits of the Fatric paleogeographic domain is rather scarce (Scheibnerová, 1962; Salaj & Samuel, 1966), or documented mostly from thin sections (Boorová & Potfaj, 1997; Boorová & Filo, 2013). Recent progress in studies of Lower Cretaceous planktonic foraminifera, especially with emphasis on Aptian planktonic foraminifera (Longoria, 1974; Banner & Desai, 1988; BouDagher – Fadel et al., 1997; Verga & Premoli, 2003a,b, 2005) sheds more light on their taxonomy and biostratigraphy. Planktonic foraminifera are becoming biostratigraphically important during Aptian (Caron, 1985; Robaszynski & Caron, 1995; Moullade et al., 2005).

Recent geological mapping near Lúčky village near the spa in the Hlboké Valley revealed a continuous outcrop in the Párnica Formation (49° 8.977'N, 19° 23.623'E, Fig. 1), with well-preserved microfauna suitable for up-to-date determination and biostratigraphy. Shaly marlstones, marly limestones, marls with beds of bioclastic limestones are accompanied by a thick body of breccia and paraconglomerates. This so-called

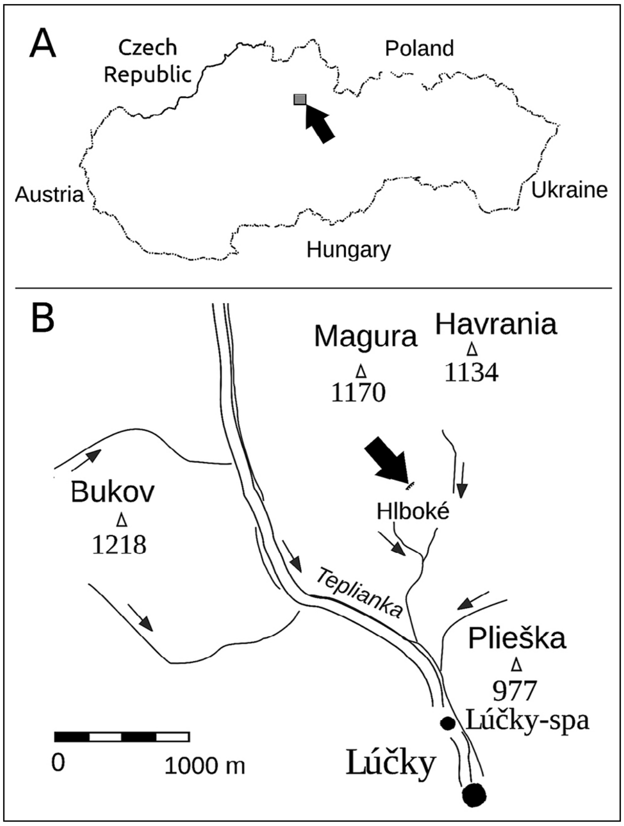

Fig. 1. Position of the studied section. A – Position of the locality in Slovakia. B – Simplified map of the territory of Lúčky Spa village in Hlboké Valley parts (location of the section indicated by arrow).

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Vlkolínec Breccia is typical for the Zliechov Basin succesions (Jablonský & Marschalko, 1992). In this paper we present a detailed micropaleontological study through the Párnica Formation (Fig. 2.1), promoting it as a local reference type section for this formation.

The foraminiferal assemblages discussed in this paper, occur after an event of major anoxia namely OAE1 which caused major biotic turnover in the microfossil record (e.g. Erbacher & Thurow, 1997; Premoli Silva et al., 1999; Erba, 2004; Patruno et al., 2015). In the Western Carpathians, such formations were studied in

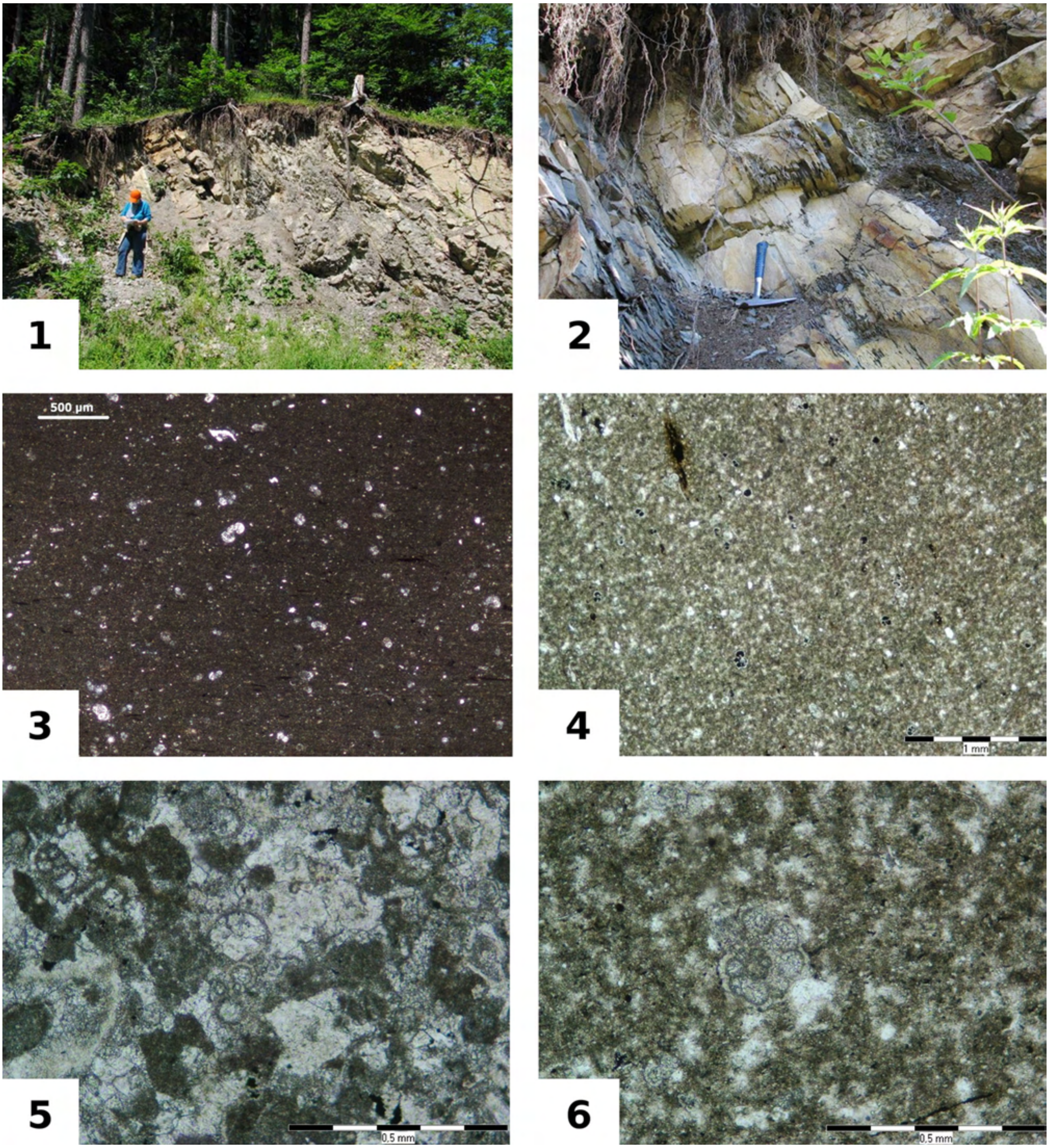

Fig. 2. Deposits of the Párnica Formation on the Lúčky – Hlboké locality.

1 – Exposed sequence of shaly marlstones, marly limestones and marls with layers of biodetritic limestones on the left side of the studied profile. Paraconglomerates and breccia are situated on the right side of the outcrop. 2 – Detail from the previous image showing shaly marlstones with characteristic cleavage. 3 – Biomicrite with planktonic foraminifera (planktonic foraminiferal mudstone), marlstone, sample L5. 4 – Intrabiopelmicrosparite/ intrabiopelmicrite with foraminifera (foraminiferal and peloidal wackestone with intraclasts), the clasts are of small size with micritic structure (mudstone), shaly marlstones, sample 7. 5 – ***Globigerinelloides ferreolensis*** **(Moullade), biodetritic limestone, sample 10vr. 6 –** ***Globigerinelloides ferreolensis*** **(Moullade), marly limestone, sample L2.**

detail by Michalík et al. (2008) from the Varín sector of Pieniny Klippen Belt (Koňhora, Brodno and Rudina formations).

Observations on living foraminifera show the relation between the test morphology and the microhabitat (e.g. Jones & Charnock, 1985; Corliss & Chen, 1988; Kaminski et al. 1995). The composition of the whole assemblage is controlled by parameters such as the flux of organic matter and oxygen concentrations in both bottom and pore waters (e.g. Jorissen et al., 1995; Kaminski et al., 1995; Van der Zwaan et al., 1999). Data from stable isotopes obtained from tests of planktonic foraminifera and comparison with living analogues also show a relation of morphology to oxygen concentrations or depth habitats in the water column (e.g. BouDagher – Fadel et al., 1997; Coxall et al., 2007; Petrizzo et al. 2008).

2. MATERIAL AND METHODS

The studied material consists of 46 samples, of which 14 samples were selected for the washing and 32 for the thin section analysis. The softer marlstone samples have been soaked in hydrogen peroxide and cleaned by detergents. Lithified samples have been treated with more corrosive methods with potassium hydroxide applied on the wet surface of the sample to obtain better results through removal of sediment from the sutures or the umbilical areas of foraminifera. Dissociated samples have been washed through 71, 125, 250 and 700 μm sieves and dried. The thin section material was selected from shaly marlstones, marly limestones and marls. Free specimens of foraminifers were studied under optical microscope (Leica S8AP0) and scanning electron microscope (SEM, JXA 840). Thin sections were studied under microscope Olympus BX51 and Jenapol, pictures were taken with Leica camera DFC290. Classification of the microfacies were used after Folk (1962) and Dunham (1962). Planktonic foraminiferal zonation is used after Caron (1985), Robaszynski & Caron (1995) and Moullade et al. (2005). Microslides with picked foraminifera are stored in the micropaleontology collections at the Department of Geology and Paleontology, Faculty of Natural Sciences, Comenius University in Bratislava. The thin sections are stored at the State Geological Institute of Dionýz Štúr in Bratislava.

3. GEOLOGICAL SETTINGS AND MICROFACIES

As shown on the section (Fig. 3), shaly marlstones and marls are prevailing over layers of bioclastic limestones. The grey or brownish, mostly laminated compact marlstones sometimes exhibit characteristic leafy cleavage (Fig. 2.2). Marlstones almost lack terrigenous admixture and are only rarely bioturbated. Darker coloured marlstones among bioclastic limestones commonly contain pyrite concretions or pyritized bioclasts (e.g. echinoid spines). Beds of bioclastic limestones are sometimes graded, with hieroglyphs on the bed planes and contain variable quantities of unsorted bioclasts. Fine grained laminated varieties may be found.

Microstructure of the marlstones and marly limestones is mostly biomicritic (Fig. 2.3), biomicrosparitic or biopelmicrosparitic (wackestone) (Figs. 2.4, 2.6). The biogenous remains are mostly represented by planktonic foraminifera completely surrounded by matrix (foraminiferal wackestones). Occasionally local accumulations of planktonic foraminifera and other biodetritus are present (foraminiferal packstones/grainstones). Scarce clasts with micritic microstructure (mudstones) and peloids have been identified. Among other microfossils occasional algae, scarce calcareous dinoflagelates, ostracods, aptychi, scarce filaments, gastropods, ?serpulids and other debris of shallow water origin are present. Bioclastic limestones in the shaly marlstones and darker marls have intrabiopelmicrosparitic or intrabiopelsparitic microtexture (grainstones or packstones – Fig. 2.5, occasionaly wackestones). Allochems are represented mostly by echinoderms, benthic foraminifera and sometimes bryozoans.

4. PLANKTONIC FORAMINIFERA AND PLANKTONIC FORAMINIFERAL BIOSTRATIGRAPHY

Studies on distribution of planktonic foraminifera allowed to recognize four zones: Leupoldina cabri, Hedbergella luterbacheri, Globigerinelloides ferreolensis and Globigerinelloides barri zones (Fig. 3). Most of the species of planktonic foraminifera are morphotypes with globular chambers, some of them have elongated or ovoid chambers. Morphotypes with tubulospines and ampullae as pseudoschackoinids and leupoldinids, or morphotypes with elongated chambers are rather scarce. The association is generally represented by hedbergellids and globigerinelloidids.

The oldest assemblages above the breccia member belong to the L. cabri Zone. Occurrence of the species with ampullae and tubulospines such as *Leupoldina pustulans* (Bolli, 1957), *Leupoldina cabri* Sigal, 1952, *Leupoldina reicheli* (Bolli, 1957), *Pseudoschackoina saundersi* (Bolli, 1959), *Pseudoschackoina* aff. *saundersi* (Bolli, 1959) (Figs. 4.1-4.7), or smaller planktonic foraminifera with elongated chambers such as *Globigerinelloides sigali* Longoria, 1974 (Fig. 4.8) and *Hedbergella kuhryi* Longoria, 1974 (Fig. 4.9) are occasional. Species that are found through the whole section are represented by globular – chambered small hedbergellids such as *Hedbergella mitra* (Banner & Desai, 1988) (Figs. 8.5-8.6), *H. aptiana* Bartenstein, 1965 (Fig. 7.5), *H. praetrocoidea* Kretchmar & Gorbachik, 1986 (in Gorbatchik, 1986) (Figs. 8.1-8.2), *H. occulta* Longoria, 1974 (Fig. 7.6), *H. infracretacea* Glaessner, 1937 (Figs. 7.1-7.2) and smaller globigerinelloidids such as *Globigerinelloides aptiensis* Longoria, 1974 (Fig. 5.7), *G. duboisi* (Chevalier, 1961) (Figs. 5.1-5.2) and *G. maridalensis* Bolli, 1959 (Fig. 5.3). *Globigerinelloides paragottisi* Verga & Premoli Silva, 2005 (Fig. 5.4) or *G. blowi* (Bolli, 1959) occur occasionally (Figs. 5.5-5.6).

After the last occurrence (LO) of *Leupoldina* spp. the first occurrence (FO) of occasional *Hedbergella luterbacheri* Longoria, 1974 (Figs. 8.3-8.4) was recognized. Marked decrease in abundance of small globigerinelloidids is observed while the smaller hedbergellids are more frequent and are characteristic for this and the later zones as well. The only representant of the larger globigerinelloidids is *Globigerinelloides aptiensis* Longoria, 1974

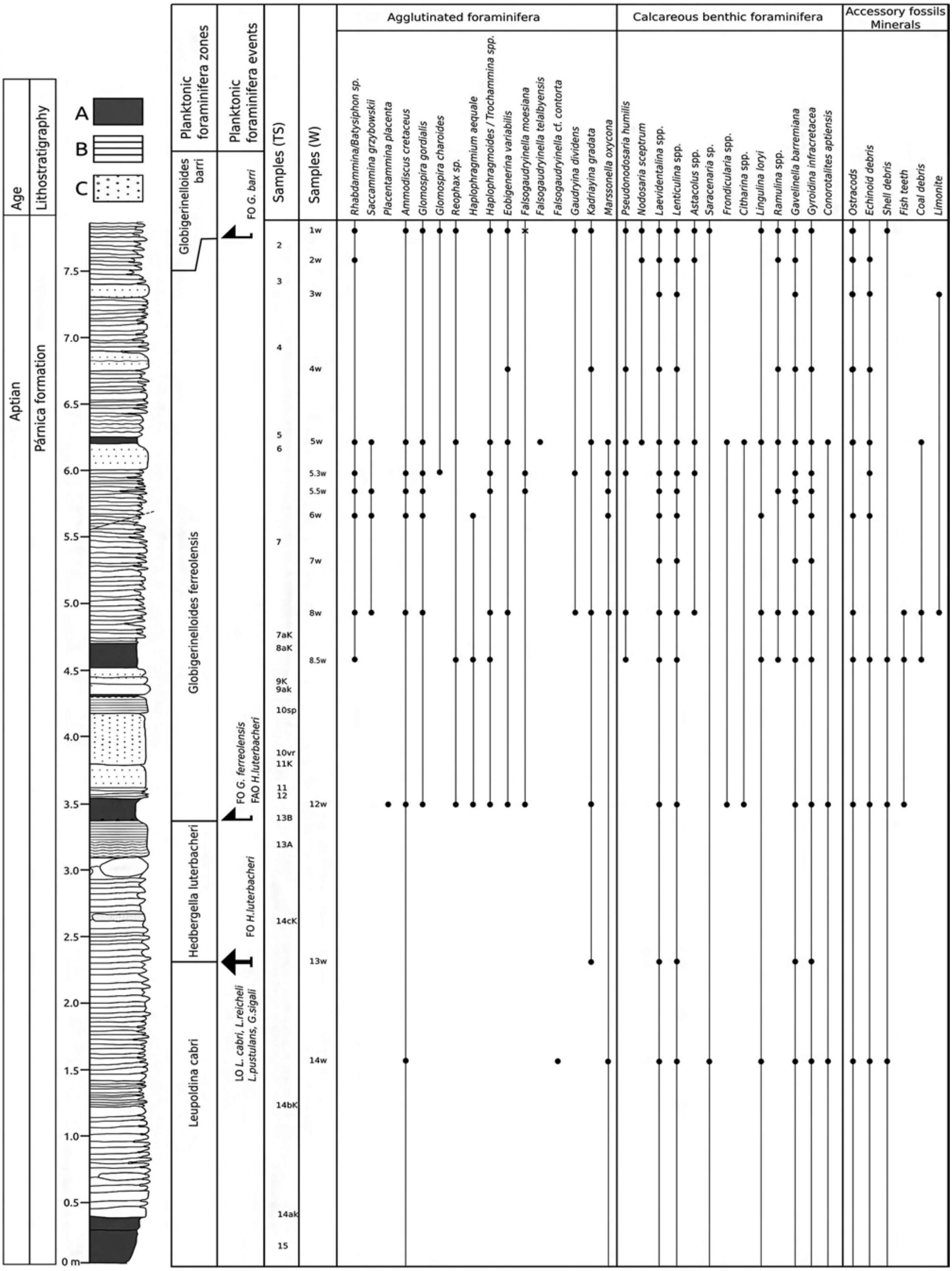

Fig. 3. Lithologic – biostratigraphic profile on the left side of the outcrop, with planktonic foraminiferal zonation, events and distribution of small benthic foraminifera studied in detached material. Lithology: A – Dark marls; B – Shaly marlstones, marly limestones; C – Biodetritic limestones; X – questionable occurrence; W – washed samples; TS – thin section samples.

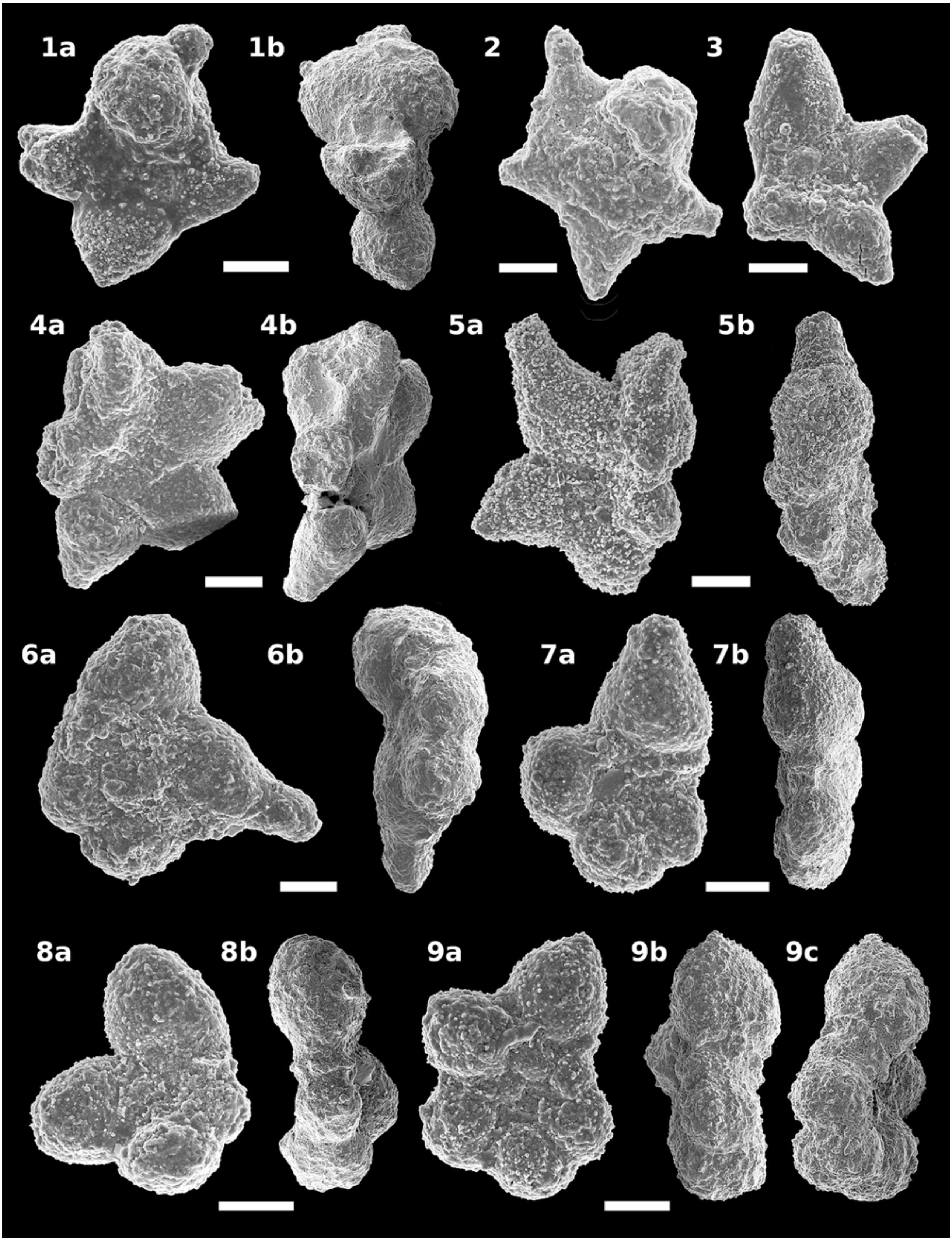

Fig. 4. 1. *Leupoldina cabri* **(Sigal), 1a – dorsal view, 1b – peripheral view. 2, 4.** *Leupoldina pustulans* **Bolli, 2, 4a – dorsal view, 4b – peripheral view. 3.** *Leupoldina reicheli* **Bolli, dorsal view. 5.–6.** *Pseudoschackoina saundersi* **(Bolli), 5a, 6a – dorsal view, 5b, 6b – peripheral view. 7.** *Pseudoschackoina* **aff.** *saundersi* **(Bolli), 7a – dorsal view, 7b – peripheral view. 8.** *Globigerinelloides sigali* **Longoria, 8a – dorsal view, 8b – peripheral view. 9.** *Hedbergella kuhryi* **Longoria, 9a – dorsal view, 9b – peripheral view, 9c – umbilical view. Sample L14, Leupoldina cabri Zone. Scale bar 50 µm.**

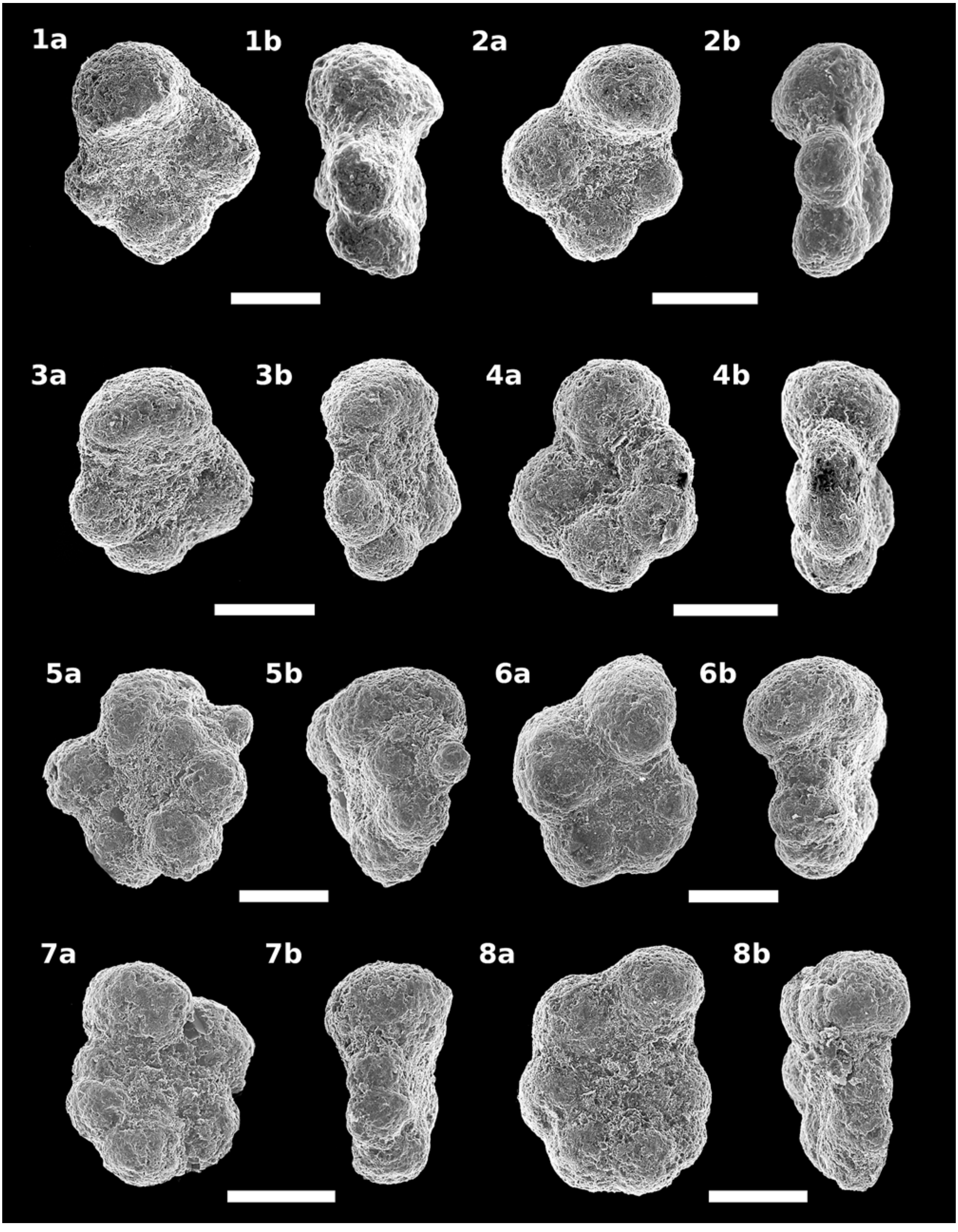

Fig. 5. 1-2. *Globigerinelloides duboisi* **Chevalier. 1a - dorsal view, 1b - peripheral view, sample L1; 2a - dorsal view, 2b - peripheral view, sample L8. 3.** *Globigerinelloides maridalensis* **(Bolli), 3a - dorsal view, 3b - peripheral view, sample L1. 4.** *Globigerinelloides paragottisi* **Verga & Premoli Silva, 4a - dorsal view, 4b - peripheral view, sample L8. 5-6.** *Globigerinelloides blowi* **(Bolli), 5a - dorsal view, 5b - peripheral view, sample L5; 6a - dorsal view, 6b - peripheral view, sample L1. 8-9.** *Globigerinelloides aptiensis* **Longoria, 8a - dorsal view, 8b - peripheral view, sample L8; 9a - dorsal view, 9b - peripheral view, sample L5. 1, 3, 6 - Globigerinelloides barri Zone; 2, 4, 5, 7, 8 - Globigerinelloides ferreolensis Zone. Scale bar 100 µm.**

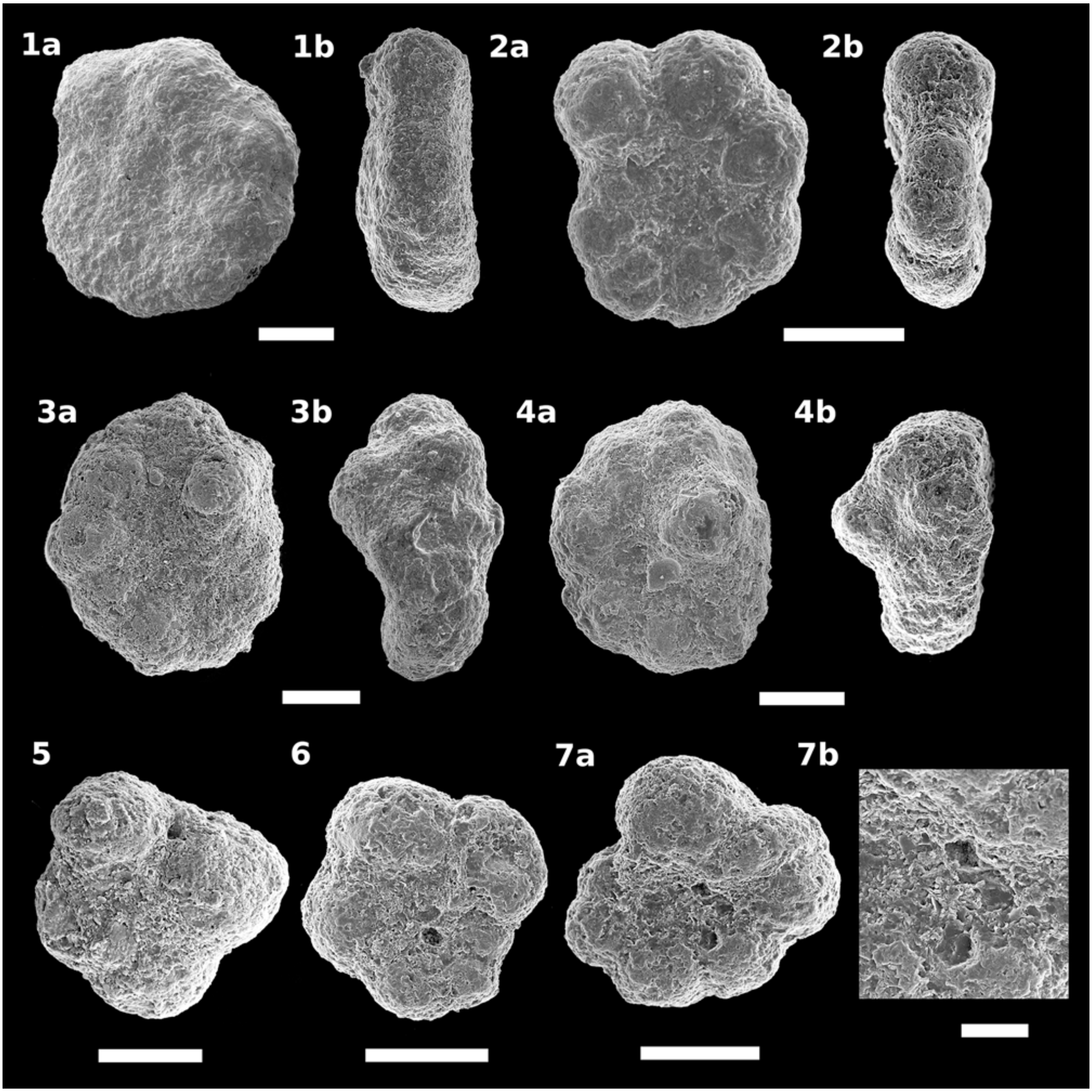

Fig. 6. 1-2. *Globigerinelloides ferreolensis* **(Moullade), 1a - dorsal view, 1b - peripheral view, sample L2; 2a - dorsal view, 2b - peripheral view, sample L1. 3-4.** *Globigerinelloides barri* **(Bolli, Loeblich & Tappan), 3a, 4a - dorsal view, 3b, 4b - peripheral view, sample L1. 5-7. Representants of the genus** *Globigerinelloides* **with growth deformations. 5.** *Globigerinelloides* **sp. 1, dorsal view, sample L8. 6.** *Globigerinelloides* **sp. 2, dorsal view, sample L5. 7.** *Globigerinelloides* **sp. 3, 7a - dorsal view, 7b - detail of the umbilicus with bioerosion marks, sample L5. 1, 5-7. Globigerinelloides ferreolensis Zone; 2-4. Globigerinelloides barri Zone. Scale bar 100 µm.**

which in some cases appears similar to specimen described by Verga & Premoli Silva (2003a) as trans. *ferreolensis* (Fig. 5.8). According to Moullade et al. (2005) FO of the species *Hedbergella luterbacheri* (Figs. 8.3-8.4) predates the FO of *Globigerinelloides ferreolensis* (Moullade, 1961) (Figs. 6.1-6.2).

The increase in abundance of *Hedbergella luterbacheri* and the FO of *Globigerinelloides ferreolensis* occurr in a narrow interval within the noticeably darker marls (Fig. 3.A). This part of the planktonic assemblage is represented by hedbergellids such as *Hedbergella mitra* (Figs. 8.5-8.6), *H. aptiana* (Fig. 7.5), *H. infracretacea* (Figs. 7.1-7.2), *H. occulta* (Fig. 7.6), *H. praetrocoidea* (Figs. 8.1-8.2), *H. gorbachikae* Longoria, 1974 (Figs. 7.3-7.4) and *H.* cf. *ruka* (Banner, Copestake & White, 1993). *Pseudoloeblichella convexa* (Longoria, 1974) or *Pseudoschackoina saundersi* are very rare. Occurrence of smaller globigerinelloidids in these last two zones is rather scarce except for the presence of *Globigerinelloides maridalensis* (Fig. 5.3) which is still common with consistent occurrence along the section. At the top of the profile the FO of *Globigerinelloides barri* (Bolli, Loeblich & Tappan, 1957) is noted within this assemblage (Figs. 6.3-6.4).

Sometimes, growth deformations and bioerosion marks are present among planktonic foraminifera (Figs. 6.5-6.7, 7.7). The

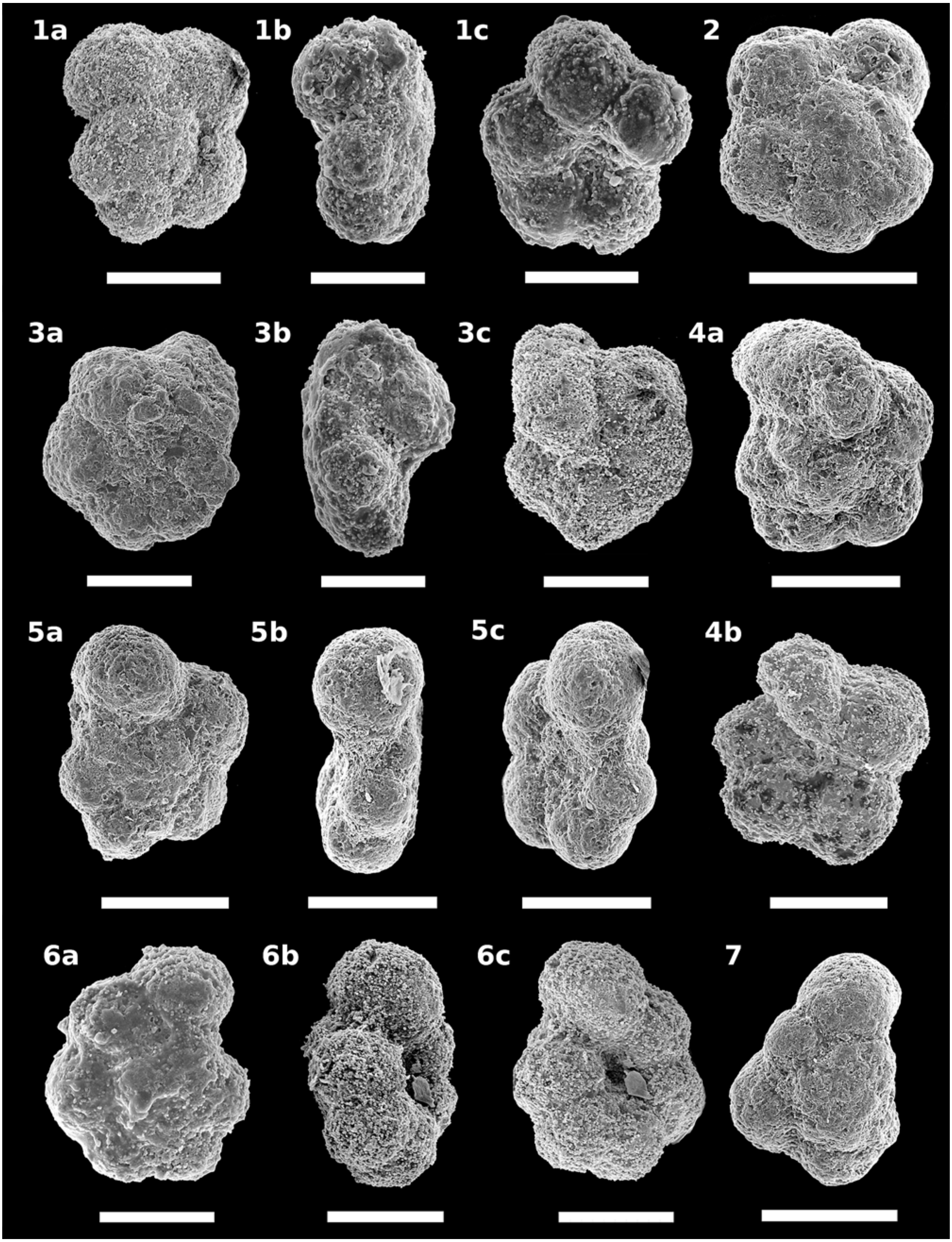

Fig. 7. 1-2. ***Hedbergella infracretacea*** **(Glaessner), 1a, 2 - dorsal view, 1b - peripheral view, 1c - umbilical view, 1a,b - sample L4, 1c-2 - sample L8. 3-4.** ***Hedbergella gorbachikae*** **Longoria, 3a, 4a - dorsal view, 3b - peripheral view, 3c, 4b - umbilical view, 3 - sample L5, 4 - sample L8. 5.** ***Hedbergella aptiana*** **Bartenstein, 5a - dorsal view, 5b - peripheral view, 5c - umbilical view, sample L8. 6.** ***Hedbergella occulta*** **Longoria, 6a - dorsal view, 6b - peripheral view, 6c - umbilical view, sample L8. 7.** ***Hedbergella*** **sp. with growth deformations, sample L5, Globigerinelloides ferreolensis Zone. Scale bar 100 µm.**

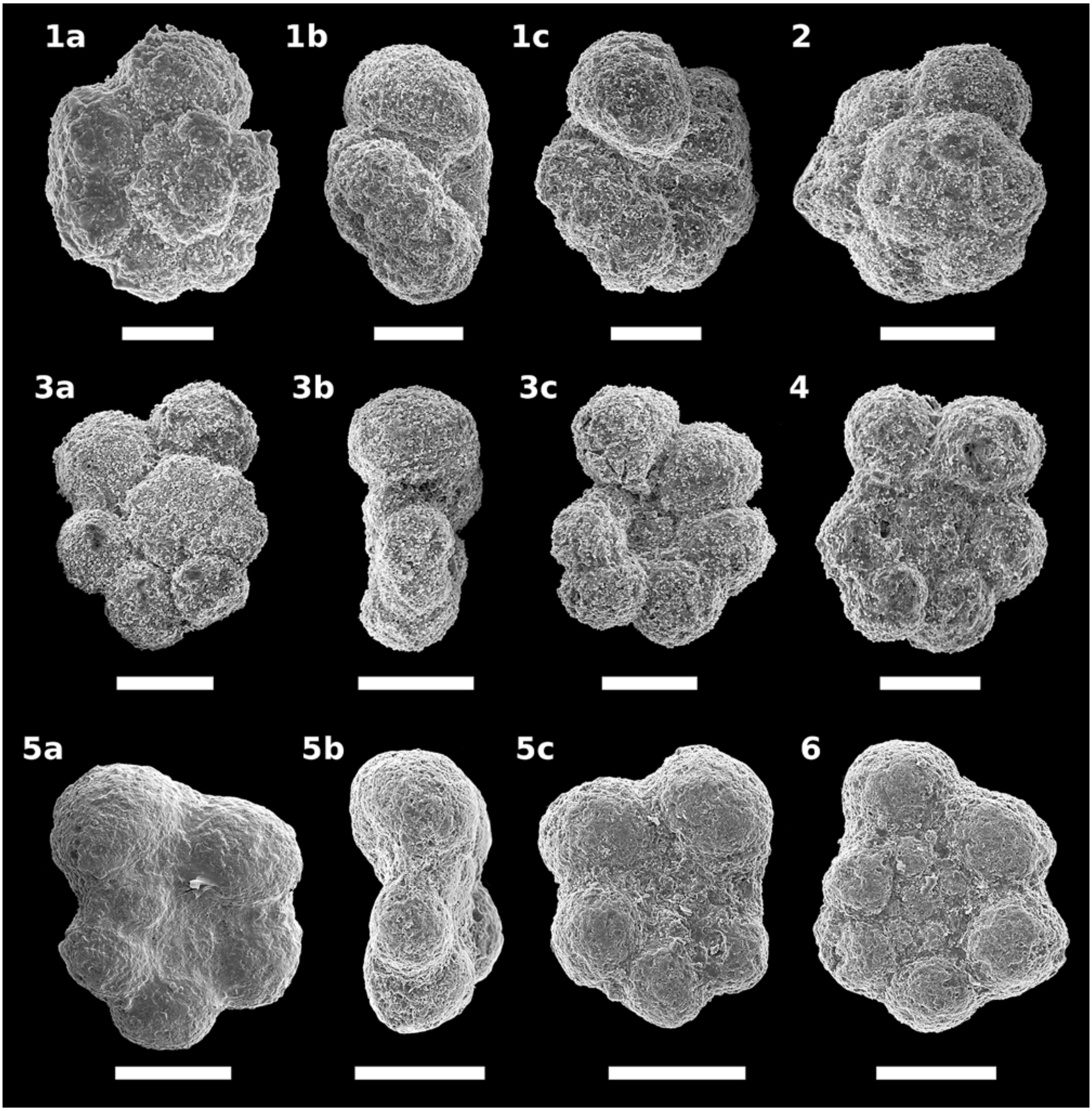

Fig. 8. 1-2. ***Hedbergella praetrocoidea*** **Kretchmar & Gorbachik, 1a, 2 - dorsal view, 1b - peripheral view, 1c - umbilical view, sample L12. 3-4.** ***Hedbergella luterbacheri*** **Longoria, 3a, 4 - dorsal view, 3b - peripheral view, 3c - umbilical view, sample L12. 5-6.** ***Hedbergella mitra*** **(Banner & Desai), 5 - dorsal view, 6a,c - peripheral view, 6b - umbilical view, sample L8, Globigerinelloides ferreolensis Zone. Scale bar 100 µm.**

nature of these bioerosional marks can be observed as common microborings in the umbilical area (Fig. 6.7b) and less common on the sutures, penultimate or ultimate chambers (Fig. 6.5). This feature was commonly observed in the higher part of the section (Fig. 2; samples L8w – L5w), within the G. ferreolensis Zone. The effect by this predatory or parasitic organism of uncertain origin might have resulted in the lack of cytoplasm, therefore some of the chambers of the meantime attacked specimen have much smaller volume and are often deformed. Abnormal small chambers rarely occur on various parts of the foraminiferal test (Fig. 7.7). Most of the affected specimens belong to *Globigerinelloides* (Figs. 6.5–6.7), less to *Hedbergella* (Fig. 7.7).

5. SMALLER BENTHIC FORAMINIFERA FROM MARLS AND SHALY MARLSTONES

Studied samples commonly showed occurrences of smaller benthic foraminifera both agglutinated and calcareous (Fig. 3). Most of the species of agglutinated foraminifera start to occur along the first abundant occurrence (FAO) of *Hedbergella* *luterbacheri* at the base of G. ferreolensis Zone. Below this base only *Marssonella oxycona* (Reuss, 1860) and *Kadriayina gradata* (Berthelin, 1880) occasionally occur. Scarce *Falsogaudryinella* cf. *contorta* (Herm, 1965) and *Ammodiscus cretaceus* (Reuss, 1845) were also noted. Above this interval, diversity of agglutinated foraminifera increases and the group is represented mostly by *Glomospira gordialis* Jones & Parker, 1860, *Ammodiscus cretaceus*, *Kadriayina gradata*, mostly deformed specimens of *Haplophragmoides* spp. or *Trochammina* spp., *Reophax sp.*, *Bimonilina entis* Mjatliuk, 1988 (in Mjatliuk & Vassilenko, 1988), tubular morphotypes such as *Rhabdammina* sp. or *Bathysiphon* sp., and scarce *Falsogaudryinella moesiana* (Neagu, 1965). The first four mentioned taxa are more abundant towards the top of the section. Some of the larger and coarse-grained agglutinated foraminifera like *Saccammina grzybowskii* (Schubert, 1902) and *Haplophragmium aequale* (Roemer, 1841) were noted only in the lower part of G. ferreolensis Zone, where *Marssonella oxycona* also occurs. Species such as *Placentammina placenta* (Grzybowski, 1898), *Falsogaudryinella tealbyensis* (Bartenstein, 1956) and *Falsogaudryinella* cf. *contorta* (Herm, 1965) were observed as a single occurrences only.

In the lower part of the section corresponding to H. luterbacheri and L. cabri zones (below the FAO of Hedbergella luterbacheri event), calcareous benthic foraminifera are dominant over the agglutinated ones. The most frequent taxa along the whole profile are *Gavelinella barremiana* Bettenstaedt, 1952, *Gyroidina infracretacea* Morozova, 1948, *Lenticulina* spp., *Lingulina loryi* Berthelin, 1880, and *Laevidentalina* spp. Excluding the smooth walled *Lenticulina* spp. whereas other spiral lagenids as *Astacolus* spp., *Saracenaria* sp., *Frondicularia* spp. and *Citharina* spp. are scattered and scarce. *Conorotalites aptiensis* (Bettenstaedt, 1952) occurs discontinuously, but is more frequent towards the lower part of the section, and with the highest occurrence in the G. ferreolensis Zone. Only low magnitude changes in diversity among calcareous benthic foraminifera were noted above the FAO of Hedbergella luterbacheri event. In the lower part, mostly lagenids such as *Pseudonodosaria humilis* (Roemer, 1841), *Ramulina* spp., *Astacolus* spp. occur, while *Nodosaria sceptrum* Reuss, 1863 occurs only in the uppermost part of the G. ferreolensis Zone.

6. DISCUSSION

Although standard zonation of Caron (1985) and Robaszinsky & Caron (1995) is widely accepted, the planktonic foraminiferal events are similar to the zonation proposed by Moullade et al. (2005) from the Gargasian stratotype section of La Bédoule from SE France which allows a more precise biostratigraphic assignement of the studied deposits. The original zones – L. cabri and G. ferreolensis zones, are complemented by newer proposed zones of lowermost Gargasian – H. luterbacheri and Middle Gargasian G. barri zones.

Synchronous Western Carpathian formations bear records of anoxia (e.g. Michalík 1994; Michalík et al. 2008), but the common benthic foraminifera, occasional bioturbation and dominance of planktonic foraminifera of globular – chambered morphotypes do not support such paleoecological interpretation of the studied section. As illustrated by various authors (e.g. Premoli Silva et al., 1999; Patruno et al. 2015), black shales of the OAE1 appear at the base of L. cabri Zone, therefore the lowermost part of our section is most likely represented only by later part of this zone. According to BouDagher – Fadel et al. (1997) and Coxall et al. (2007), an increase in planktonic foraminifera with elongated chambers suggests an expansion of OMZ. This increased occurrence of the planktonic foraminifers such as pseudoschackoinids, leupoldinids or small globigerinelloidids is observed in the lowermost part of the section. Lower oxygen concentration at the bottom and pore waters is also indicated by presence of the agglutinated foraminifera represented mostly by infauna, and low abundance or locally even absence of epifauna. Such assemblages are most frequent in environments close to or even in anoxic zones (e.g. Jorissen et al., 1995; Kaminski et al., 1995). This is also affirmed by the calcareous benthic foraminifera where species with morphology of the test that matches epifaunal mode of life such as *Gavelinella barremiana* and *Conorotalites aptiensis* are less frequent. Among all benthic foraminifera, the *Lenticulina* spp. is the most dominant and this dominance is attributed to suboxic facies (e.g. Rückheim et al., 2006). This feature is also similar to the later development of the foraminiferal assemblages in upper part of the L. cabri Zone above the Selli Level in the upper part Gorgo a Cerbara section from Umbria-Marche Basin, Italy (Patruno et al., 2015). The FAO of *Hedbergella luterbacheri* occurs within the markedly darker marl horizont (Fig. 3), alltogether with other abundant globular – chambered morphotypes of planktonic foraminifera (mostly hedbergellids and less globigerinelloidids). The environmental preferences of these taxa oppose those with elongated chambers preferring lower oxygen settings (BouDagher– Fadel et al., 1997; Coxall et al., 2007). This indicates a fallback of the oxygen minimum zone (OMZ) in the water column in the Zliechov Basin settings during the H. luterbacheri and younger zones. Coccioni et al. (1992) suggested more oligothrophic conditions for globigerinelloidids than hedbergellids and stable isotope studies on planispiral morphotypes such as larger many-chambered globigerinelloidids from the Albian suggest a habitat in the deeper parts of the mixed layer (Petrizzo et al., 2008). The small few–chambered globigerinelloidids might have shared the same habitat with hedbergellids and their decrease might reflect such onset of the eutrophic settings during the G. ferreolensis Zone. This euthrophy is also reflected by the increase in abundance of both planktonic foraminifera with globular chambers and epifaunal morphotypes of benthic foraminifera. Among agglutinated foraminifera, active and passive deposit feeders (*Ammodiscus* spp., *Glomospira* spp., *Trochammina* spp.) and suspension feeders (tubular agglutinated foraminifera) start to occur.

7. CONCLUSIONS

Here presented biostratigraphical study of the section enabled a more detailed stratigraphic subdivision of the Párnica Formation. Standard foraminiferal zones – L. cabri and G. ferreolensis zones of Caron (1985) and Robaszinsky & Caron

(1995) and the zones proposed by Moullade et al. (2005) were identified.

Planktonic and benthic foraminiferal assemblages reflect dysoxic to anoxic conditions in the lower part of the section (L. cabri/H. luterbacheri zones). Planktonic foraminifera are represented by smaller hedbergellids and globigerinelloidids with elongated chambers (*Hedbergella kuhryi, Globigerinelloides sigali*), ampullae or tubulospines (*Leupoldina* spp., *Pseudoschackoina saundersi*). Benthic assemblages are represented mostly by infaunal agglutinated foraminifera and low diversity calcareous benthic foraminifera. Increase of oxygen content in the higher part of the section is suggested by the higher diversity of smaller benthic foraminifera and an increase in larger planktonic foraminifera with globular chambers in the G. ferreolensis and G. barri zones (*Hedbergella luterbacheri*, *Hedbergella praetrocoidea*, *Globigerinelloides aptiensis* and *Globigerinelloides ferreolensis*). Almost all the studied samples yielded rich assemblages of planktonic foraminifera with dominant globular–chambered morphotypes (*Globigerinelloides* spp., *Hedbergella* spp.). Occasional growth deformations were observed among the planktonic foraminifera caused by microborings in the umbilical area, sutures or the last chambers.

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