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The Trawne Member (Albian–Cenomanian, Pieniny Klippen Belt, Carpathians): a new insight into its foraminiferal assemblages and biostratigraphy

(Figs 1–7)

Abstract. Detailed micropalaeontological analysis of samples from the Pasieczny and Trawne stream sections has been undertaken. Twenty five species including seventeen planktonic taxa have been identified. The *Rotalipora ticinensis - Planomalina praebuxtorfi* new biozone has been proposed. In the Pasieczny Stream section, turbiditic sedimentation commenced during the Early Cenomanian (*Rotalipora appenninica* Zone). The new biozone *R. greenhornensis* has been established. The *Rotalipora reicheli - Rotalipora greenhornensis* Zone, based on coexistence of both nominal species was recognized. The studied foraminiferal associations have confirmed palaeobathymetrical associations B1-B2 (middle part of the continental slope).

Key words: Cenomanian, foraminiferids, biostratigraphy, palaeobathymetry, Pieniny Klippen Belt, Carpathians.

INTRODUCTION

The informal lithostratigraphic unit known as the "Trawne beds" was first introduced by Blaicher & Sikora (1972). Birkenmajer (1987) revised it as the Trawne Member and included this unit into the Jaworki Formation within the Branisko Nappe. Detailed micropalaeontological and biostratigraphical analyses have been undertaken by Gasiński (1981, 1983, 1984, 1988). After those years, due to changing the state of preservation of the type sections of the Trawne Member (i.e., Trawne and Pasieczny stream sections), especially after great flooding and following taxonomic and biostratigraphic changes of foraminiferal taxa, presented studies were performed.

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GEOLOGICAL SETTING

The type area of the Trawne Member is located between the Babiarzowy and the Szeligowy streams, south-west of the town of Nowy Targ. The member belongs to the Branisko Nappe (Birkenmajer, 1959, 1977, fig. 3, 1979, 1986b). The Trawne Member was once exposed in two sections: at Pasieczny Stream and at Trawne Stream (Fig 1). Nowadays, the Pasieczny Stream section (8 m thick) is the only exposed section of the Trawne Member. The Trawne Member's sediments represent a passage between pelagic and turbiditic sedimentation in this part of the Pieniny Klippen Basin. In the lowermost part of the Pasieczny Stream section, we observe a "pre-turbiditic facies" consisting of grey, bluish, and greenish spotty marly shales with sandstone intercalations. This lithology is characteristic of the Rudina Member of the Kapuśnica Formation (Birkenmajer, 1977, 1986b). The upper part of the section represents a turbiditic development, consisting of bluish, grey and greenish marly shales alternating with fine-grained turbidite sandstones from 13 cm to more than 50 cm thick (Birkenmajer, 1977, 1986b, 1987; Fig. 3).

The section exposed at Trawne Stream corresponds in the age and lithology to the Skalski Member of the Jaworki Formation (Birkenmajer, 1977). It consists of variegated and spotty marly shales 8.5 m thick (Fig. 1).

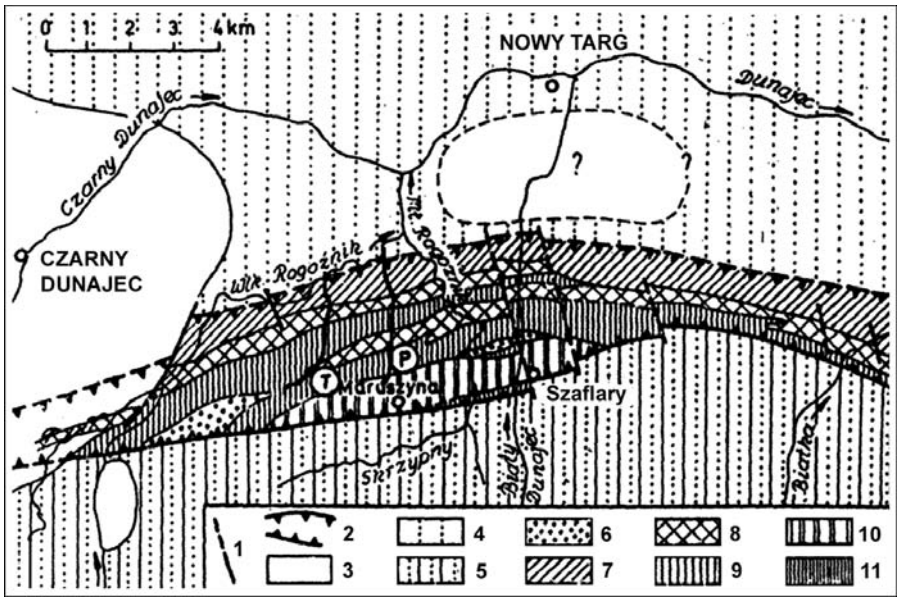

Fig. 1. Location of the main outcrops of the Trawne Member (Birkenmajer, 1986a); *1* – main transversal faults; *2* – northern and southern boundary faults of the Pieniny Klippen Belt; *3* – fresh-water Neogene cover; *4* – Magura Palaeogene; *5* – Podhale Palaeogene; *6* – Jarmuta Formation; *7* – Grajcarek Unit; *8* – Czorsztyn Unit; *9* – Branisko Nappe; *10* – Pieniny Nappe; *11* – Maruszyna Scale; P – Pasieczny Stream section; T – Trawne Stream section

METHODS

A total of 25 samples from the Pasieczny Stream (Fig. 2) and 5 samples from the Trawne Stream sections have been collected. Numbers of samples: 1–25 correspond to Pas 1/VI/03- Pas 25/VI/03 (for more details see Pióro, 2004).

Standard method of multiple heating and freezing with a Glauber salt has been applied. Identification of foraminiferal taxa was undertaken using the stereoscopic microscope Zeiss Stemi SV 11 and SEM (Hitachi S-4700 and Noran Vantage) in the Laboratory of Field Emission Scanning Electron Microscopy and Microanalysis at the Institute of Geological Sciences at the Jagiellonian University. Quantitative analyses were based on average of 1000 specimens of foraminiferids from each sample.

The works of Robaszynski & Caron (1979, 1995), Magniez-Jannin (1975) and Caron (1985) were used for taxonomic and biostratigraphic concepts, and the proposed biozones were correlated to the local biostratigraphic standard by Gasiński (1983, 1988).

Samples are housed at the Department of Palaeozoology of the Institute of Geological Sciences, Jagiellonian University (coll. Pas/2004).

RESULTS

Pasieczny Stream section

The analyses undertaken on the Pasieczny Stream section indicate that the *Rotalipora greenhornensis* Zone (*Rotalipora reicheli - R. greenhornensis* zone *sensu* Gasiński, 1983; Middle Cenomanian) is the last exposed biozone of the section. Following Wonders' (1975) establishment of *Planomalina praebuxtorfi* Zone and its ancestral affinity to the *Planomalina buxtorfi* zone, the *Rotalipora ticinensis - P. praebuxtorfi* Zone has been proposed as a result of more detailed subdivision of *R. ticinensis - P. buxtorfi* Zone. The new proposed biozone allows more detailed subdivision of the Cenomanian, following the rule of High Resolution Stratigraphy (HRS). Due to the absence of *Rotalipora reicheli* in the studied foraminiferal assemblages in the Pasieczny Stream section, the *Rotalipora greenhornensis* Assemblage Zone, based on the FAD of the nominal taxa has been proposed (Figs 2, 3).

Quantitative analysis of the foraminiferal assemblages of the lowermost pelagic part of the Pasieczny Stream section (up to 3.8 m thick) reveals high abundance of the planktonic taxa (about 98% of the whole assemblage), dominated by epipelagic taxa, mainly by the genera *Hedbergella* (*H. delrioensis*, *H. planispira*, *H. infracretacea*, *H. simplex*) and *Globigerinelloides* (*G. bentonensis*, *G. caseyi*). Bathypelagic forms are represented by the genera *Rotalipora* (*R. subticinensis*, *R. ticinensis*, *R. appenninica*) and *Planomalina* (*P. praebuxtorfi*, *P. buxtorfi*). A short episode of increasing numbers of bathypelagic species (mainly *P. buxtorfi*, up to 88.3% of the planktonic association) has been noted in the lower part of the *R. ticinensis - P. buxtorfi* Zone. A relatively high intraspecific variation of *P. buxtorfi* has also been observed within this zone.

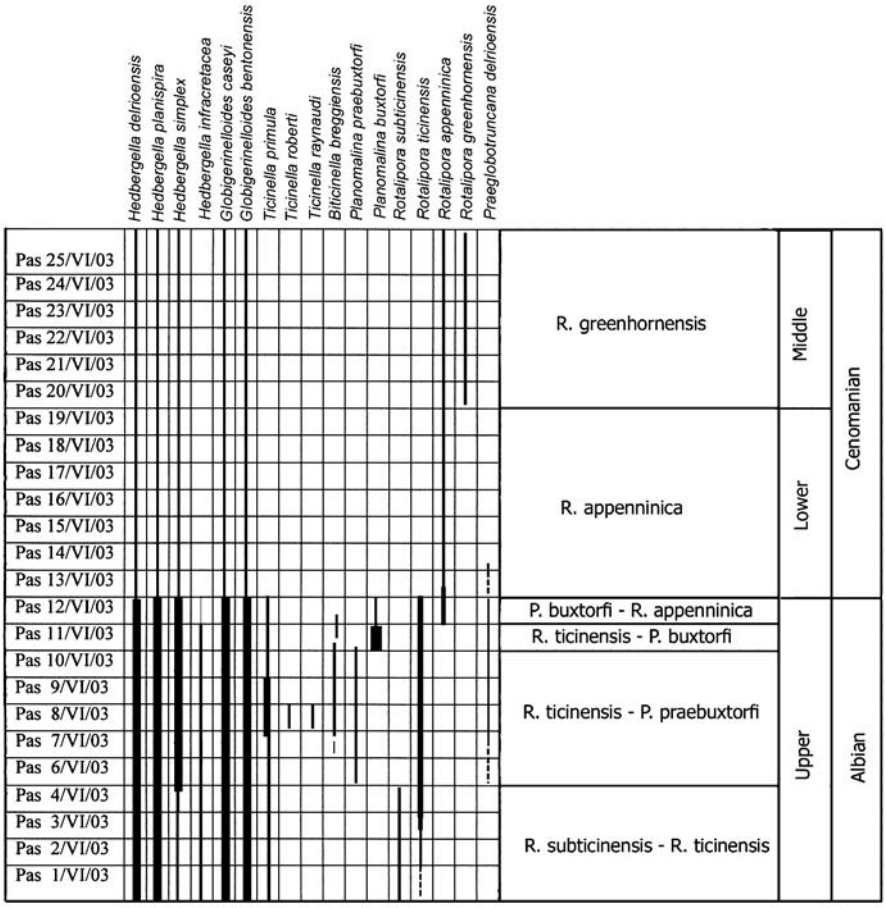

Fig. 2. Biostratigraphical zones in the Trawne Member in the Pasieczny Stream section

The benthic associations are dominated by calcareous benthic taxa such as: *Gavelinella*, *Lenticulina*, *Astacolus*, *Gyroidinoides*, *Pleurostomella* (*P. reussi*), *Tristix* (*T. excavata*). Agglutinated taxa comprise mainly: *Tritaxia* (*T. gaultina*), *Dorothia* (*D. oxycona*, *D. gradata*), *Ammodiscus*, *Glomospira* (mainly *G. charoides*). Miliolids (mainly *Quinqueloculina*) are sporadically noted.

The predominance of agglutinated taxa was observed within the samples collected from the upper part of the Trawne Member, characterized by a turbiditic sequence. Among agglutinated taxa, the suspension feeding morphogroup; tubular forms such as *Rhabdammina* and *Dendrophyra* prevailed. It should be mentioned that Turonian microfauna has been noted among these assemblages (contamination?).

Within the studied samples, agglutinated forms prevail (about 60–80% of the whole foraminiferal assemblage). Among scarce planktonic taxa, *Hedbergella* (*H. delrioensis*, *H. simplex*, *H. planispira*), *Globigerinelloides* (*G. caseyi*, *G. bentonensis*), and *Rotalipora* (*R. appenninica*, *R. greenhornensis*) have been identified.

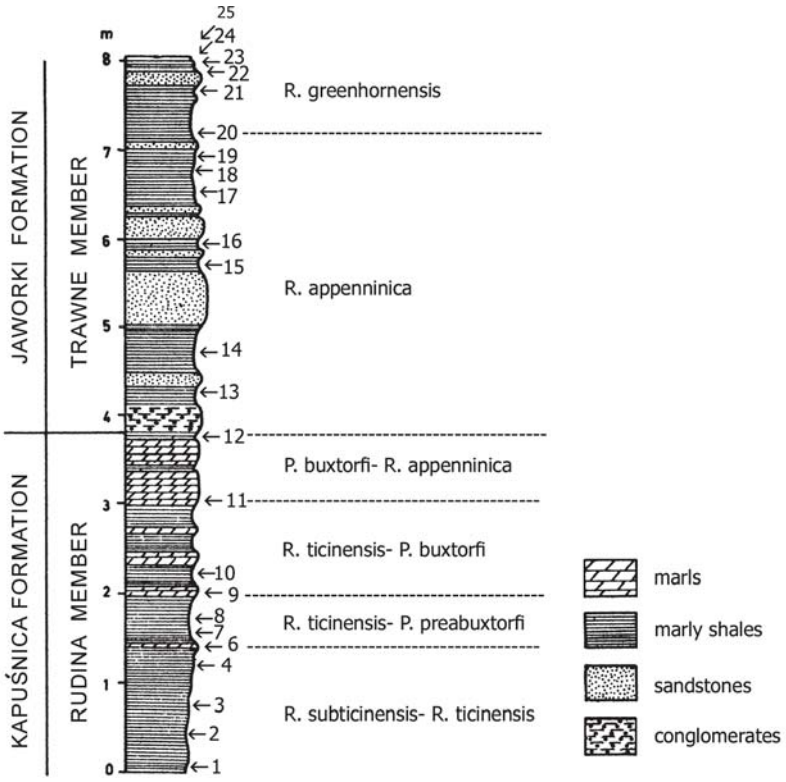

Fig. 3. Lithologic column of the Trawne Member at Pasieczny Stream (after Birkenmajer *et al.*, 1986; lithostratigraphic units after Birkenmajer, 1987) with location of samples. Recognized and established local biozones (this paper)

Trawne Stream section

Quantitative analysis of foraminiferal assemblages from the Trawne Stream section showed similarities to assemblages from the pelagic part of the Pasieczny Stream section. The assemblages are here dominated by epipelagic taxa (about 98%), mainly: *Hedbergella* (*H. delrioensis*, *H. planispira*, *H. simplex*), *Globigerinelloides* (*G. caseyi*, *G. bentonensis*), *Schackoina* and *Heterohelix*. Bathypelagic forms are represented by *Rotalipora* (*R. appenninica, R. reicheli, R. greenhornensis, R. montsalvensis*) and relatively numerous *Praeglobotruncana delrioensis.* The identified benthic taxa are mainly composed of calcareous forms such as the genera *Gavelinella*, *Lenticulina*, *Gyroidinoides*, *Osangularia* and *Tristix* (*T. excavata*). Less numerous agglutinated forms are dominated by *Tritaxia* and *Glomospira*. A characteristic coexistence of *R. reicheli* and *R. greenhornensis*, and the absence of *R. cushmani*, indicates an earlier appearance of *R. greenhornensis* in this region, compared with the standard Cretaceous Planktonic Foraminiferal zonations of Robaszynski & Caron (1979), Caron (1985) and Sliter (1989). In previously pub-

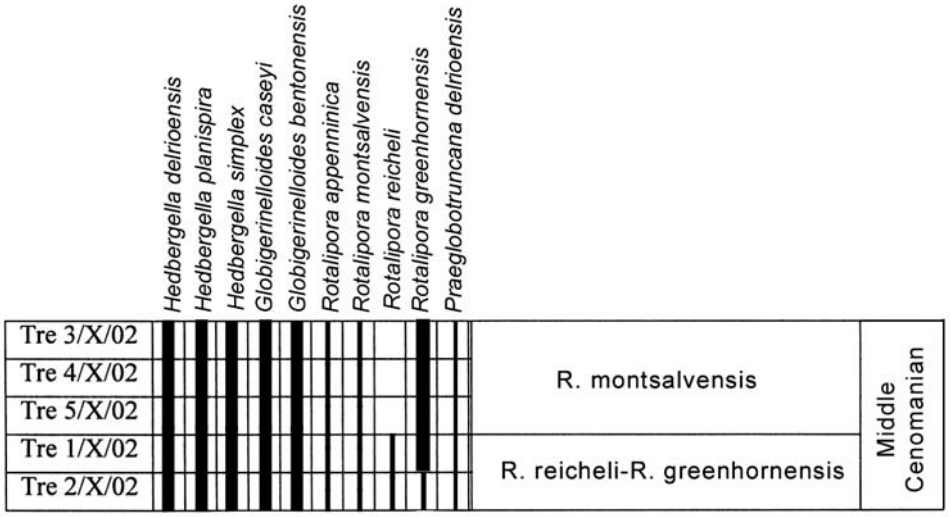

Fig. 4. Biostratigraphical zones in the Trawne Stream section

lished schemes, the FAD of *R. greenhornensis* coincides with the FAD of *R. cushmani* and Last Appearance Datum (LAD) of *R. Reicheli*.

Recognized and proposed biozones (Fig. 4)

***Rotalipora reicheli - Rotalipora greenhornensis* local PCRZ (*sensu* Gasiński, 1988)**

Lower boundary: FAD of *R. reicheli* and FAD of *R. greenhornensis*
Upper boundary: LAD of *R. reicheli*.

Foraminiferal assemblages of this zone contain co-existing *R. reicheli* and *R. greenhornensis* in the lower part of the section (first meter). Numerous epipelagic taxa: *H. delrioensis*, *H. planispira*, *G. bentonensis*, *G. caseyi*, *Heterohelix* sp., *Schackoina* sp. and bathypeagic *R. reicheli*, *R. greenhornensis*, *R. montsalviensis*, *P. delrioensis* prevail. *Gavelinella* and *Gyroidinoides* are the main elements of the calcareous benthos, scarce agglutinated taxa are represented by the genus *Glomospira*.

***Rotalipora montsalvensis* local PRZ (new proposed biozone)**

Lower boundary: LAD of *R. reicheli*
Upper boundary: FAD of *R. cushmani* (not identified in the studied section).

In comparison to the previous zone, *Schackoina* and *Heterohelix* became more numerous among epipelagic associations. *R. greenhornensis*, *R. appenninica*, *R. montsalvensis* and *P. delrioensis* constitute bathypelagic group. Benthic taxa such as: *Gavelinella*, *Lenticulina*, *Osangularia*, *Gyroidinoides*, *Tristix* (*T. excavate*), miliolids, moreover *Glomospira*, *Ammodiscus* and *Tritaxia* are more numerous than in the previous biozone. Ostracods and fish teeth have also been found.

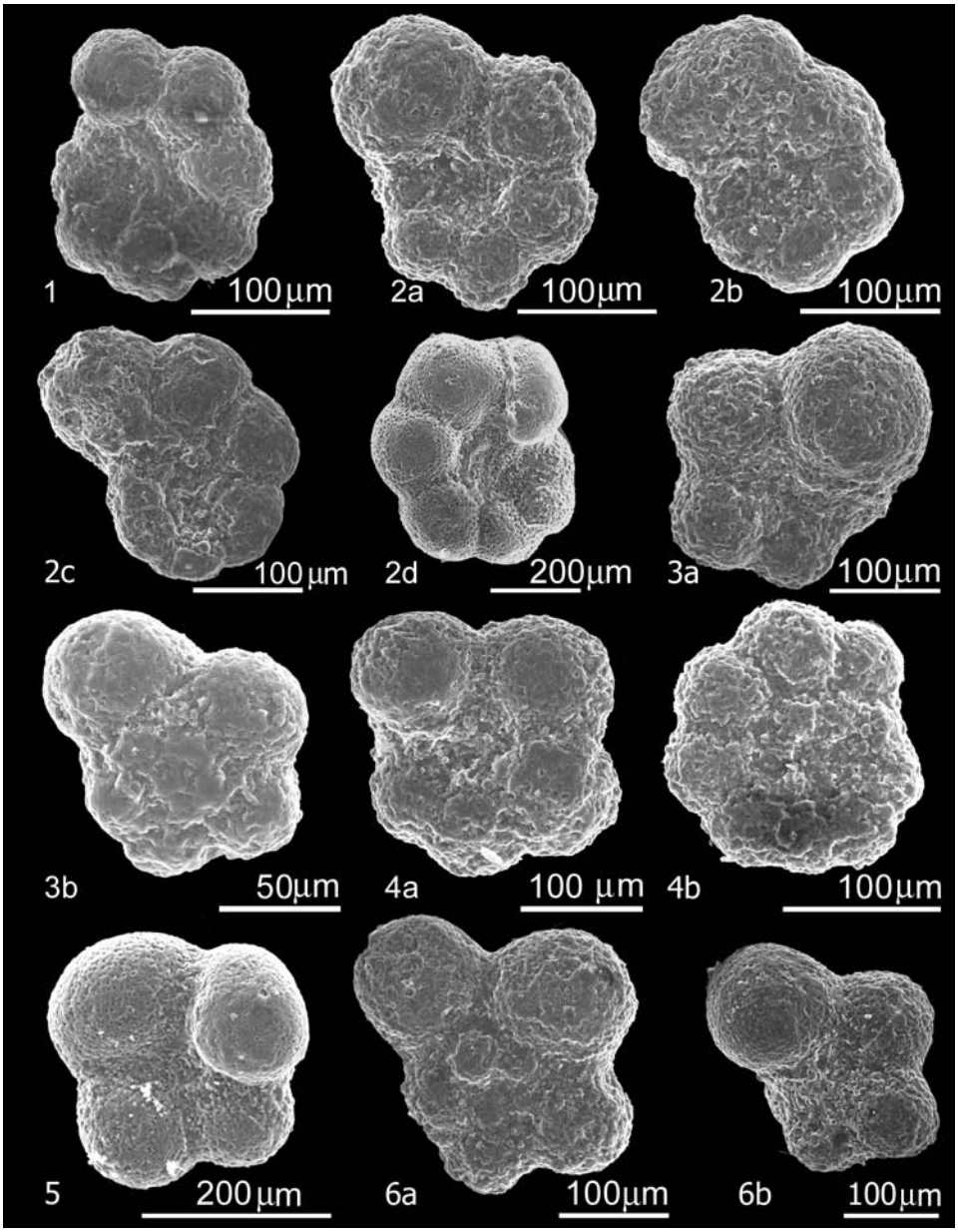

Fig. 5. Planktonic foraminiferids from the Trawne Member. **1** – Gl*obigerinelloides caseyi* (Bolli, Loeblich & Tappan), Pas 7; **2a–d** – *Globigerinelloides bentonensis* (Morrow), Pas 6; **3a, b** – *Hedbergella delrioensis* (Carsey), Pas 2; **4a, b** – *Hedbergella planispira* (Tappan), Pas 8; ***5*** – *Hedbergella infracretacea* (Glaessner) Pas 8; ***6a, b*** – *Hedbergella simplex* (Morrow), Pas 9

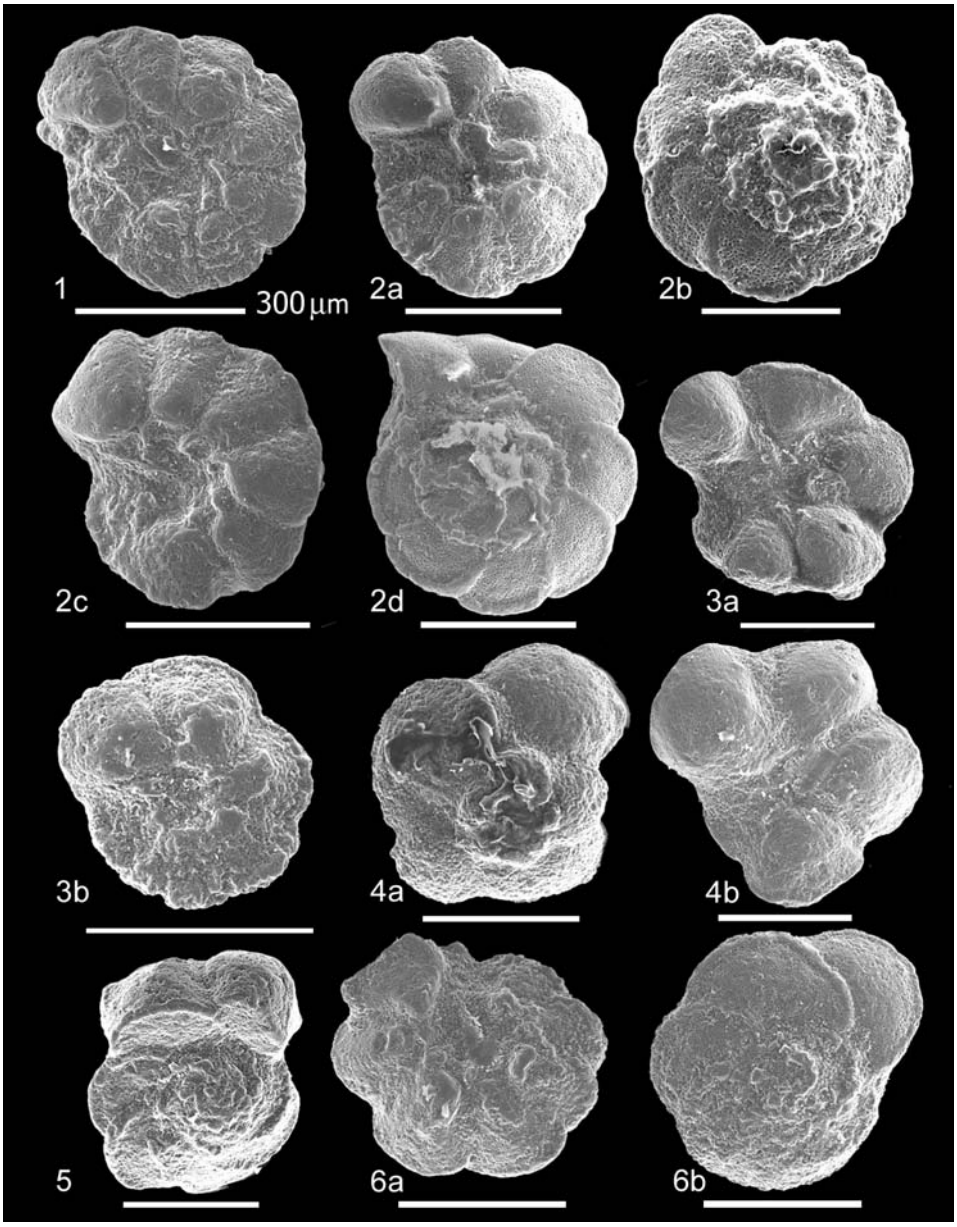

Fig. 6. Planktonic foraminiferids from the Trawne Member. **1** – *Rotalipora subticinensis* (Gandolfi), Pas 2; **2a–d** – *Rotalipora ticinensis* (Gandolfi), Pas 10; **3a, b** – *Rotalipora appenninica* (Renz), Pas 12; **4a, b** – *Rotalipora montsalvensis* (Mornod), Tre 2; **5** – *Rotalipora reicheli* (Mornod) Tre 5; **6a, b** – *Rotalipora greenhornensis* (Morrow) Tre 5; all scale bars = 300 µm

Palaeoecology

The Pasieczny Stream section can be divided into two stratigraphic units, based on its lithology and foraminiferal assemblages. Samples collected from the lower, pelagic part of the section (Rudina Member *sensu* Birkenmajer, 1987) are enriched in planktonic taxa (Figs 5, 6) such as: *H. delrioensis*, *H. planispira*, *H. simplex*, *G. caseyi*, *G. bentonensis*, *R. subticinensis*, *R. ticinensis*, *P. buxtorfi*, *P. praebuxtorfi*, *R. appenninica*. Benthic associations (comprising only 2% of the whole assemblage) are dominated by calcareous genera: *Lenticulina*, *Pleurostomella*, *Gavelinella*, *Gyroidinoides*. *Tritaxia*, *Dorothia*, *Glomospira* and *Ammodiscus* are represent agglutinated foraminiferids. Quantitative and qualitative analyses of the assemblages have allowed to distinguish the B1 bathymetric association which corresponds to the middle part of the continental slope (Gasiński, 1991; Birkenmajer & Gasiński, 1992).

Foraminiferal assemblages of the upper, turbiditic sequence of the studied section are characterized by an increasing number of agglutinated forms, especially the tubular suspension feeding morphogroup (up to 80% of the whole asssemblage). Such changes of foraminiferal association are due to turbiditic current activity and an induced increasing supply of organic matter to the basin floor. Such associations can be correlated with the B2 association of middle slope affected by turbiditic current activity (cf. Gasiński, 1991; Birkenmajer & Gasiński, 1992). The samples collected from the Cenomanian part of the Trawne Stream section (*R. greenhornensis* Zone) are dominated by *H. delrioensis*, *H. planispira*, *H. simplex*, *G. bentonensis*, *G. caseyi*, *R. reicheli*, *R. greenhornensis*, *R. appenninica*, *R. montsalvensis*, *Heterohelix* sp., *Schackoina* sp., *Gavelinella*, *Lenticulina*, *Gyroidinoides*, *Osangularia*, *Tristix*, *Tritaxia* and *Glomospira*. They are also affiliated to B1 association, of Gasiński (1991).

The studied foraminiferal assemblages are dominated by planktonic species of the genera: *Hedbergella*, *Globigerinelloides*, *Planomalina*, *Rotalipora* and, less frequent, *Praeglobotruncana* (*P. delrioensis*), *Ticinella*, *Biticinella* (*B. breggiensis*). In the Trawne Stream section, *Heterohelix* and *Schackoina* appear.

Hedbergella and *Heterohelix* are characteristic genera of colder, high latitude areas (Sliter, 1972), however as opportunistic taxa they extend into the equatorial zone (Haig, 1972). As epipelagic genera, they occupied surface waters above shallow and deep-water areas, their abundance increasing into the open marine realm (Sliter, 1972). Keeled, bathypelagic *Rotalipora* and *Planomalina* are typical genera of low latitudes, and indicate continental slope palaeodepth (Haig, 1972). *Ticinella* characterises the low latitude environments. *Planomalina* is less temperature-tolerant genus (Haig, 1972).

Intraspecific variation of *Planomalina buxtorfi*

Two main different morphological trends (morphotypes) have been observed among *Planomalina buxtorfi* (Fig. 7: *2a–h*). The first one comprises highly involuted forms having small apertural face. These forms are more robust and massive.

The disappearance of the marginal keel on the last chambers was observed. Other forms show a tendency to more evolute structure of the ultimate whorl of the test. These forms are huge, evolute, more flattened on both sides. Forms which possess the last part of the ultimate whorl almost completely erected/having tendency to uncoiling are also observed. It could be stressed that the above mentioned tendencies

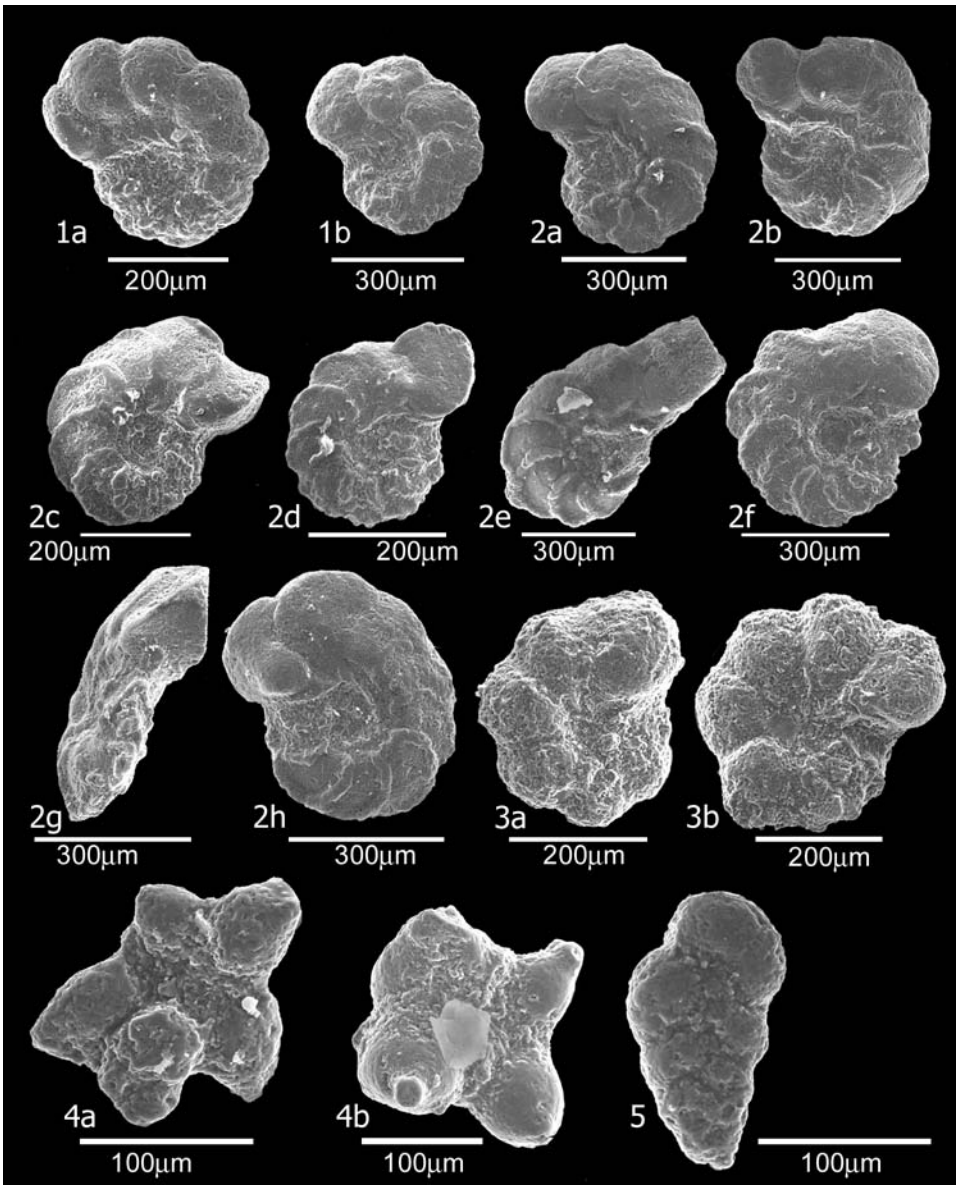

Fig. 7. Planktonic foraminiferids from the Trawne Member. **1** – *Planomalina praebuxtorfi* Wonders, Pas 9; **2a–h** – *Planomalina buxtorfi* (Gandolfi), Pas 11; **3a, b** – *Ticinella primula* Luterbacher, Pas 8; **4a, b** – *Schackoina* sp., Tre 5; **5** – *Heterohelix* sp., Tre 4

are observed within all ontogenetic stages, including juvenile stages of both "morphotypes".

CONCLUSIONS

1. New local biozones have been proposed, i.e., (a) *Rotalipora ticinensis - Planomalina praebuxtorfi* local CRZ and *Rotalipora greenhornensis* local AZ in Pasieczny Stream section; (b) *Rotalipora reicheli - Rotalipora greenhornensis* local PCRZ and *Rotalipora montsalvensis* local PRZ in Trawne Stream section.

2. The sediments of the Trawne Member provide evidence of the earliest stage of turbiditic sedimentation in the Branisko Succession during the Early Cenomanian (*R. appenninica* Zone). Deposited on middle part of continental slope, the sediments were influenced by turbiditic current activity. In the adjacent area of the Branisko Succession, during the Early Cenomanian, pelagic sedimentation was only slightly influenced by turbidities (thin bedded muddy sandstones).

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REFERENCES

Birkenmajer, K., 1959. Geological cross-section through Poland (in Polish). Wydawnictwa Geologiczne. Warszawa: 1–20.

Birkenmajer, K., 1977. Jurassic and Cretaceous lithostratigraphic units of the Pieniny Klippen Belt, (Carpathians) in Poland. *Studia Geologica Polonica*, 9: 7–376.

Birkenmajer, K., 1979. *Geological field guide-book to the Pieniny Klippen Belt* (in Polish). Wydawnictwa Geologiczne, Warszawa: 1–236.

Birkenmajer, K., 1986. Stages of structural evolution of the Pieniny Klippen Belt, Carpathians. *Studia Geologica Polonica*, 88: 7–32.

Birkenmajer, K., 1986b. Excursion A: 5. Pasieczny Stream, 5A: Rogoźnik-Pasieczny Stream (in Polish). *In*: K. Birkenmajer, K. & Poprawa, D. (eds), *Przewodnik 57 Zjazdu Polskiego Towarzystwa Geologicznego Pieniński pas skałkowy*, 18-20.IX.1986, Kraków.

Birkenmajer, K., 1987. The Trawne Member (Upper Albian–Upper Cenomanian) – a flysch development in the Branisko Nappe, Pieniny Klippen Belt, Carpathians. *Studia Geologica Polonica*, 91: 29–42.

Birkenmajer, K., Gasiński, M. A., Krawczyk, A. J., Obermajer, M. & Słomka, T., 1986. Excursion A: 5. Pasieczny Stream (in Polish). *In*: Birkenmajer, K. & Poprawa, D. (eds), *Przewodnik 57 Zjazdu Polskiego Towarzystwa Geologicznego Pieniński pas skałkowy*, 18-20.IX.1986, Kraków.

Birkenmajer, K., & Gasiński, M. A., 1992. Albian and Cenomanian palaeobathymetry in the Pieniny Klippen Belt Basin, Polish Carpathians. *Cretaceous Research*, 13: 479–485.

Blaicher, J. & Sikora, W., 1972. New Albian Flysch Facies in the Polish part of the Pieniny Klippen Belt (in Polish). *Kwartalnik Geologiczny*, 16 (4): 1067–1068. Warszawa.

Caron, M., 1985. Cretaceous planktic Foraminifera. *In*: Bolli, H. M., Saunders, J. B. & Perch- Nielsen, K. (eds), *Plankton stratigraphy*. Cambridge University Press, Cambridge: 17–86.

Gasiński, M. A., 1981. The stratigraphy of Trawne beds in the profile of Potok Szeligowy based on

microfauna. The Pieniny Klippen Belt, Polish Carpathians. *Biuletyn Instytutu Geologicznego*, 331: 165–172. Warszawa.

Gasiński, M. A., 1983. Albian and Cenomanian planktic Foraminiferida from the Trawne beds (Pieniny Klippen Belt, Polish Carpathians). *Cretaceous Research*, 4: 221–249.

Gasiński, M. A., 1984. Selected benthic Foraminiferida from the so-called Trawne beds (Pieniny Klippen Belt, Polish Carpathians). *Studia Geologica Polonica*, 83: 51–65.

Gasiński, M. A., 1988. Foraminiferal biostratigraphy of the Albian and Cenomanian sediments in the Polish part of the Pieniny Klippen Belt, Carpathian Mountains. *Cretaceous Research*, 9: 217–247.

Gasiński, M. A., 1991. Albian and Cenomanian Palaeobathymetry of the Pieniny Klippen Belt (Polish Carpathians) based on Foraminifers. *Bulletin of Polish Academy of Sciences, Earth Sciences*, 39: 1–11.

Haig, D. W., 1979. Global distribution patterns for Mid-Cretaceous foraminiferids. *Journal of Foraminiferal Research*, 9: 29–40.

Krawczyk, A. J. & T. Słomka, T., 1986. Excursion A: 5. Pasieczny Stream, 5 D: Sedimentologic characteristics of the Trawne Member (in Polish). *In*: Birkenmajer, K. & D. Poprawa, D. (eds), *Przewodnik 57 Zjazdu Polskiego Towarzystwa Geologicznego Pieniński pas skałkowy*, 18–20. IX. 1986. Kraków.

Magniez-Jannin, F. 1975. *Les foraminiféres de l'Albien de l'Aube: paléontologie, stratigraphie, écologie*. Cahiers de Paléontologie, Paris: 1–360.

Pióro, K., 2004. *Biostratigraphy of the Trawne Member sediments (Pieniny Klippen Belt)* (in Polish). Unpublished M. Sc. Thesis, Institute of Geological Sciences, Jagiellonian University, Kraków: 1–55.

Robaszynski, F. & Caron, M. (Coordinators), 1979. Atlas de Foraminifères planctoniqes du Crétacé moyen (mer Boréal et Tethys), I et II. *Cahiers de Paléontologie*, I: 1–185; II: 1–181.

Robaszynski, F., & Caron, M., 1995. Foraminiferes planctoniques du Crétacé: commentaire de la zonation Europe-Méditerranée. *Bulletin de la Societe Géologique de France*, 6: 681–692.

Sliter, W. V., 1972. Upper Cretaceous planktonic foraminiferal zoogeography and ecology. *Palaeogeography, Palaeoclimatology, Palaeoecology*, 12:15–31.

Sliter, W. V., 1989. Biostratigraphic zonation for Cretaceous planktonic foraminifera examined in thin section. *Journal of Foraminiferal Research*, 19: 1–19.

Wonders, A. A. H., 1975. Cretaceous planktonic foraminifera of the *Planomalina buxtorfi* group from El Burrueco, Spain. *Koninklijke Nederlandse Akademie van Wetenschappen*, B (78): 83–93.