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Geology of the Pieniny Klippen Belt and the Tatra Mts, Carpathians
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Part XVIII

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The Muráň Limestone Member (Upper Hauterivian) of the Kościeliska Marl Formation, Polish Western Tatra Mts: dinocyst biostratigraphy and microfacies analysis[2]

(Figs. 1–9; Tab. 1)

Abstract. Dinocyst biostratigraphy adds new important data on the age of the Muráň Limestone Member of the Kościeliska Marl Formation in the Wściekły Żleb gully area, Polish Western Tatra Mts. Its early Late Hauterivian age is based on dinocysts indicative of the *Canningia pistica* (Capi) Interval Subzone of the *Aprobolocysta eilema* (Aie) Taxon Range Zone. This allows to correlate sedimentation of the Muráň Limestone Member with the Strážovce event recognized in the West Carpathians. As based on microfacies analysis, limestones of the Muráň Limestone Member (calcilutites and calcarenites developed as litho-bioclastic packstones and grainstones) represent distal parts of calciturbidites, which contain shallow-water bioclasts derived from a carbonate platform. The bioclasts include microproblematicum *Pieninia oblonga*, so far known from the Barremian to Eocene. Its stratigraphic range is thus extended down to the Late Hauterivian. Dinocyst age data allow to correlate the Muráň Limestone Member of the Western Tatra Mts with a lower part of the Muráň Limestone Formation in the Belanské Tatry Mts.

Key words: Dinocysts, palynofacies, carbonate microfacies, Muráň Limestone Member, Kościeliska Marl Formation, Lower Cretaceous, Tatra Mountains, Carpathians

INTRODUCTION

Lower Cretaceous (mostly Barremian–Aptian) platform carbonates in the West Carpathians are well known from the Tatric domain. They are much less common in the Fatric domain. These carbonates are comparable with the Alpine Urgonian or Schrattenkalk facies. In the Fatric domain (Krížna succession in the Tatra Mts),

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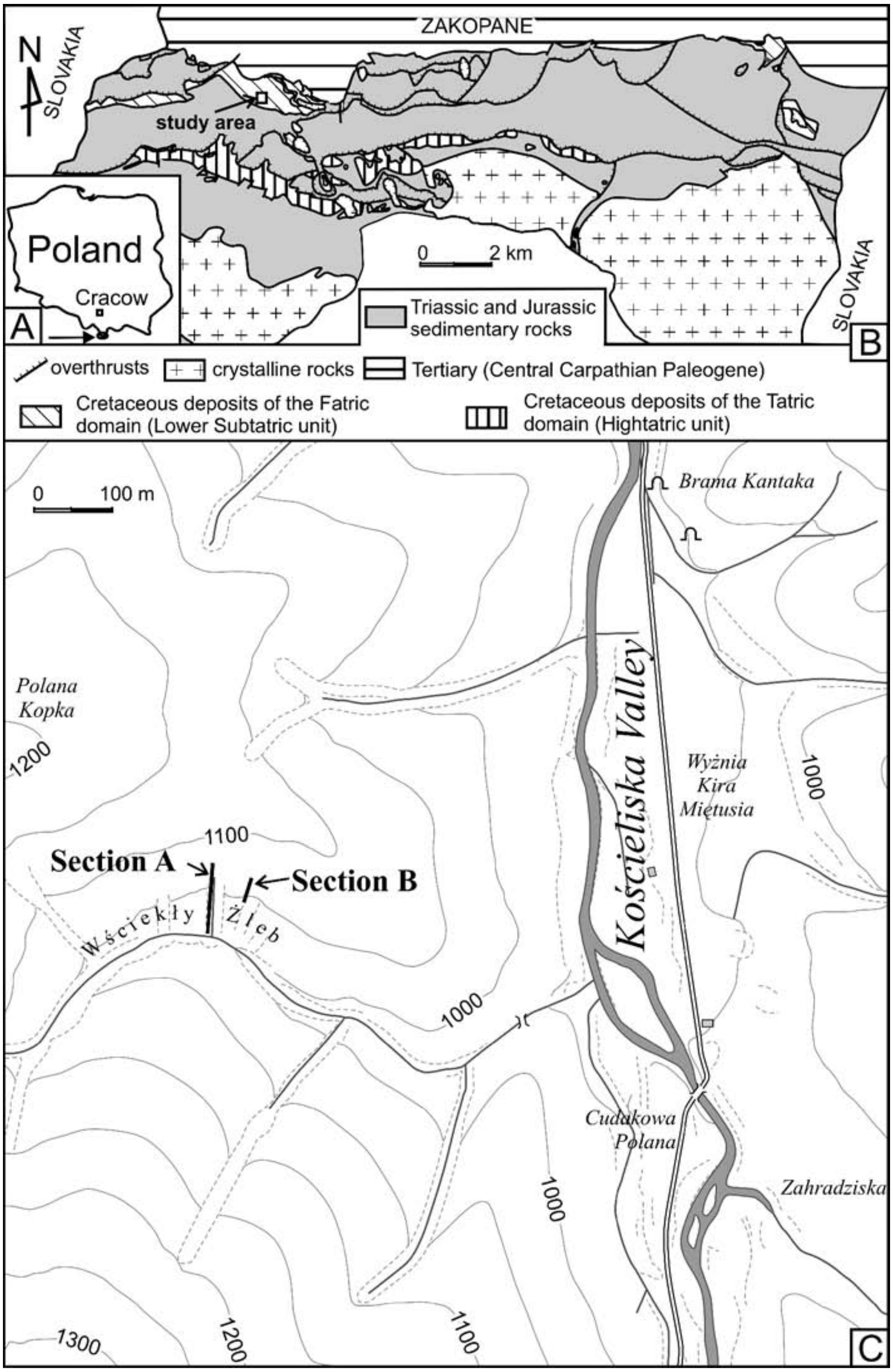

Fig. 1. Location maps (based on Guzik & Guzik, 1958; Guzik *et al.*, 1958; Bac-Moszaszwili *et al.*, 1979): **A** – position of the Tatra Mountains in South Poland; **B** – geological sketch of the Tatra Mts in Poland; **C** – location of the studied sections in the Wściekły Żleb gully, Kościeliska Valley

basinal "Neocomian marls" dominate (e.g., Vašíček *et al.*, 1994), while in the eastern part of the Tatra Mts (Belanské Tatry, Slovakia) and, locally, in the Kopy Sołtysie region (Ciemne Smreczyny) in Poland, redeposited calcarenites up to 90 m thick crop out. They have been distinguished as the Muráň Limestone Formation (Hauterivian–Barremian) – see Lefeld (1974), Michalík & Soták (1990), Vašíček *et al.* (1994). In the middle and western parts of the Tatra Mountains, calcarenites of the Muráň Limestone Formation are replaced with deposits of the Kościeliska Marl Formation. The latter formation is composed mostly of basinal marlstones, however, it contains an intercalation of calcarenites which are considered to be an equivalent of those ones from the eastern part of the Tatra Mountains (e.g., Guzik *et al.*, 1958; Guzik, 1959; Sokołowski & Kotański, 1959; Lefeld, 1974). They are distinguished as the Muráň Limestone Member, dated so far as the Lower Hauterivian. This was considered an evidence for a new bioevent in the West Carpathians – the Muráň event (Pszczółkowski, 2001, 2003a, b).

Dinocyst analysis of the Muráň Limestone Member in the Wściekły Żleb gully in the Dolina Kościeliska valley, Western Tatra Mountains, Poland (Fig. 1) brings new data on its age (cf. Gedl *et al.*, 2003, 2004). Moreover, microfacies of this unit was also analysed. The studied thin sections and slides are housed in the Institute of Geological Sciences, Jagiellonian University, Cracow.

GEOLOGICAL SETTING

The Kościeliska Marl Formation (Berriassian–Aptian) – Lefeld (1985), is the youngest lithostratigraphic unit of the Krížna Succession in the Western Tatra Mountains where it attains 88–114 m (Pszczółkowski, 2003b). Lithological differences within the Kościeliska Marl Formation allow to distinguish formal lithostratigraphic units of lower rank. The Pod Furkaską Member (25–26 m thick marlstones interbedded with biomicrites and marly limestones; late-mid Berriasian–lowest Valanginian) occurs at the base of the formation above the Osnica Formation. It is overlain by the Kryta Member (15–25 m thick marlstones interbedded with sandstones and limestones; middle part of Lower Valanginian) (see – Świerczewska & Pszczółkowski, 1997). There comes the Wściekły Żleb Member (34–70 m thick marlstones interbedded with limestones; Lower Valanginian–lowermost Hauterivian) overlain by the Muráň Limestone Member (biocalcarenites interbedded with marlstones and calcilutites; Lower Hauterivian; Pszczółkowski, 2001). The reader should note that the Muráň Limestone Formation of Lefeld (1985) and the Muráň Limestone Member of Pszczółkowski (2001) are treated as separate units of a higher rank.

Calcarenites of the Muráň Limestone Member in the Wściekły Żleb gully form a row of low klippes and cliffs. These calcarenites are shown in the geological map 1: 10, 000 (Guzik *et al.*, 1958) as discontinuous bands parallel to the boundaries of the unit. Deposits of the Kościeliska Marl Formation form here an upper part of a monoclinal thrust sheet known as the Bobrowiec Unit. According to Guzik (1961), the limestones of the Muráň-type in the Wściekły Żleb gully form probably a false

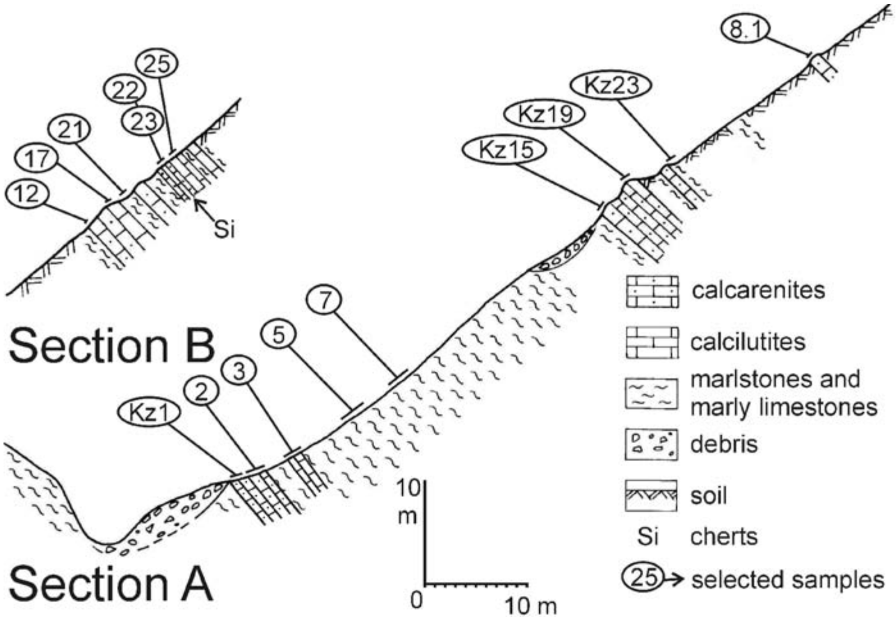

Fig. 2. Location of samples in the studied sections A, B, Wściekły Żleb gully, Kościeliska Valley, Tatra Mts

anticline. Based on ammonite faunas, the age of rocks included now to the Kościeliska Marl Formation was determined as Berriasian, Valanginian, Hauterivian and Barremian stages (Vigiliev, 1914; Lefeld, 1974). Valanginian to early Aptian, and, possibly Aptian/Albian nannoplankton has been found (Kędzierski & Uchman, 1997, 2004).

The Muráň Limestone Member was investigated in two sections (Fig. 2 A, B) about 50 m apart (Figs 2, 3) on northern slopes of the Wściekły Żleb gully (Fig. 2).

Section A embraces upper part of the Wściekły Żleb Member *sensu* Pszczółkowski (2003a, fig. 2B): mainly grey, bioturbated marlstones and marly limestones. Calcarenites (samples Kz1, 2) and sandy calcilutits (sample 3) were recognized in thin sections in the lower part of section A. According to Pszczółkowski (2003a, fig. 2B), upper boundary of the Wściekły Żleb Member is located higher up, at the base of a thick calcarenite bed which forms a klippe. However, the occurrence of calcarenites already in the lower part of section A, makes it possible to lower this boundary down to their base. In upper part of section A, there occurs a thick calcarenite bed (4.0–4.5 m thick), which can be traced in the field to the main calcarenites of **Section B**. Above the main calcarenite, 2 or 3 thinner (less than 1 m thick) calcarenite beds appear overlain by poorly exposed marlstones (forested slope). According to Pszczółkowski (2003a), the Muráň Limestone Member in the Wściekły Żleb gully is 40–45 m thick. Our measurements from the first to the last calcarenite bed in section A corrected this value to 68 m.

MICROFACIES

Limestones of the Muráň Limestone Member in the Wściekły Żleb gully section belong to calcarenites (grain-packstones) and calcilutites (calcimudstones, wacke-

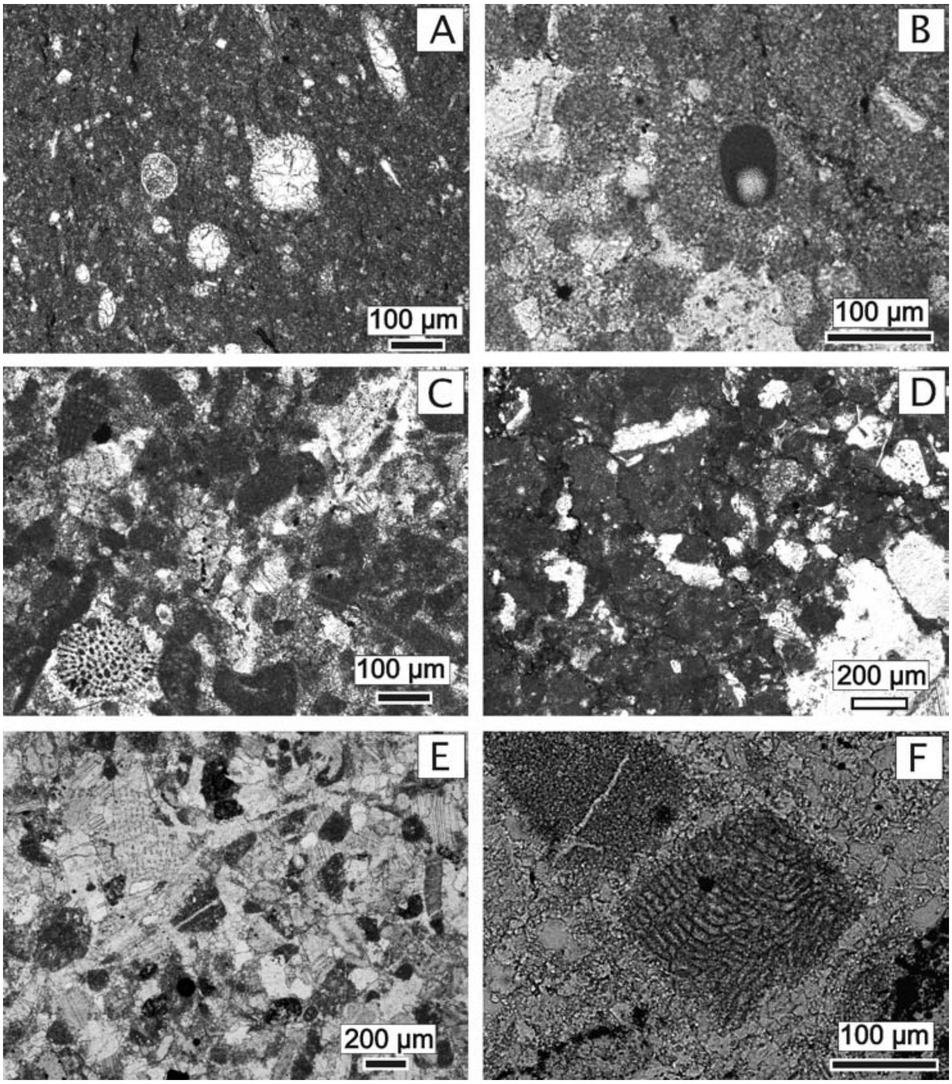

Fig. 3. Microfacies from the Wściekły Żleb gully. **A** – radiolarian wackestone (sample 21); **B** – bioclastic wackestone with calcareous dinocyst *Cadosina semiradiata* (sample 3); **C** – litho-bioclastic grain- and packstone (samples 12); **D** – litho-bioclastic packstone with fitted fabric (sample 2); **E** – echinoderm-lithoclastic grainstone with quartz (Kz1); **F** – algal(?) fragment from the echinoderm-lithoclastic grainstone (sample Kz1)

stones). Their bioclasts are represented mainly by echinoderm skeletal elements. Other fragments of macrofauna are small, micritized, difficult to identify. Microproblematicum *Pieninia oblonga* Borza & Mišík, 1976 (see Mišík, 1998) occurs in samples 2, 12, 23 and Kz 17 (Fig. 4 A–B). Benthic foraminifera tests were also recognized. According to Pszczółkowski (2003b), foraminifera from the Muráň Limestone Member are represented mainly by Miliolidae, Textulariidae, Nodosariidae

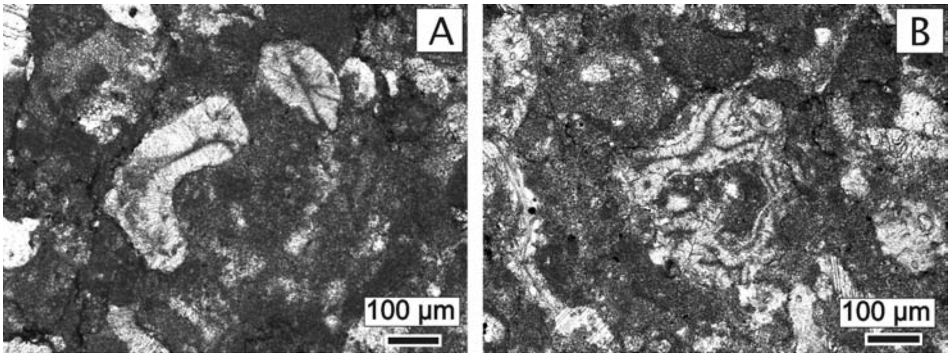

Fig. 4. **A, B** – Microproblematicum *Pieninia oblonga* Borza & Mišik, 1976; sample 2

and *Spirillina* sp. Out of four species of calcareous dinocysts recognized by Pszczółkowski (2003b), two of them, *Stomiosphaera echinata* Nowak, 1968 and *Cadosina semiradiata* Wanner, 1940 (Fig. 3B), were identified in thin sections studied. Small fragments of benthic algae were mentioned by Pszczółkowski (2003a). Micritic grains, interpreted here as lithoclasts and strongly micritized bioclasts, are characteristic components of the analysed limestones.

Microfacies description

Calcimudstone (sample 5). Allochems in this microfacies are rare (below 10%) and difficult to identify.

Radiolarian wackestone (sample 21; Fig. 3A). Bioclasts include radiolarian tests replaced by calcite, uncommon calcareous dinocysts, benthic foraminifera tests, small fragments of echinoderms, bivalve shells and ostracod tests.

Litho-bioclastic grainstone and packstone (samples 12, 22, 8.1; Fig. 3C). This microfacies is composed of micritic grains interpreted as lithoclasts (sharp-bordered ones, in particular) strongly micritized bioclasts and skeletal elements. It consists mainly of echinoderm elements (commonly bored). Other bioclasts include bivalve shell and bryozoan (very rare) fragments, ostracod and benthic foraminifera tests, calcareous dinocysts and microproblematicum *Pieninia oblonga* (Fig. 4). Glauconite grains occur in low quantities. Fine lamination was well visible in sample 22.

Litho-bioclastic packstone with fitted fabric (sample 2; Fig. 3D). Components of this microfacies are similar to the previous one, but lithoclasts and echinoderm bioclasts are larger and show fitted fabric underlined by reddish-stained microstylolites. Sample 16 is represented by breccia composed of limestone clasts similar to the microfacies from sample 2 (this breccia is probably of a tectonic, and not a sedimentary origin).

Bioclastic wackestone (samples 3, 17, Kz 19; Fig. 3B). This microfacies is composed of similar bioclasts as in the microfacies described above, however, they

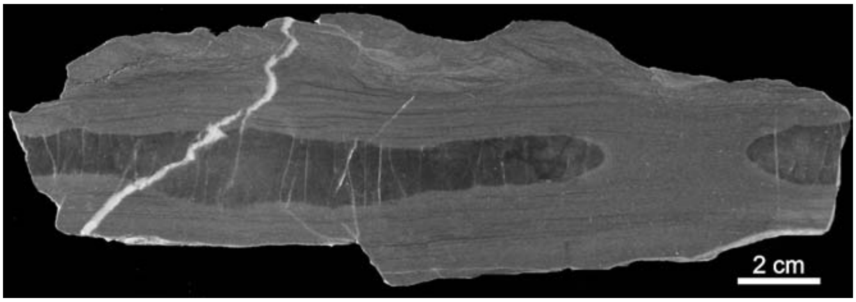

Fig. 5. Bio-lithoclastic packstone with chert (sample 23)

are smaller and less frequent. Peloids and small lithoclasts may be also present, however they are difficult to identify in micritic matrix.

Echinoderm-lithoclastic grainstone with quartz (samples Kz 1, Kz 15; Fig. 3E). Echinoderm skeletal elements and micritic grains are the main components. They are accompanied by quartz grains, small bivalve shell fragments and rare, small benthic foraminifera tests, calcareous dinocysts and fragments of benthic algae.

Bio-lithoclastic packstone with cherts (sample 23; Fig. 5). Radiolarian tests replaced by calcite are characteristic, although dispersed, component of this microfacies. Other bioclasts are similar to those described in other microfacies. Micritic grains are possibly formed mainly by small lithoclasts.

PALYNOFACIES

Five samples (Nos 3, 7, 21, 25, Kz23) were processed for palynological analysis: dissolving in 38% HCl and, then, in 40% HF, heavy liquid separation with $ZnCl_2$, sieving with a 15 μm sieve, and centrifuging to concentrate the residuum. Two gelatine-glycerine slides for each sample were studied under transfluent light microscope.

Palynofacies components were diversified into several groups (cf. Tyson, 1995; Batten, 1996): black woody particles; brown woody particles; sporomorphs; dinocysts; foraminifera test linnings; and amorphous organic matter (Figs 6–9).

Samples 3, 7, 21 and **25** contain similar palynofacies assemblages, characterised by the presence of moderately well preserved dinocysts, which predominate over land-derived sporomorphs (Fig. 6, C). Foraminifera organic test linings are present (Fig. 6, E). Brown and black woody particles are represented by relatively large fragments (Fig. 6, F); they occur in similar percentages. Amorphous organic matter constitutes a few percentage of the remaining palynoclast. Dinocyst assemblages differ in particular samples. Sample 3 is characterised by frequent occurrence of the *Chlamydophorella*/*Gardodinium* group; this group belongs to outer neritic group of Leereveld (1995). In sample 7 (Fig. 6, A), frequency of chorate cysts, such as *Cymososphaeridium* and *Callaiosphaeridium*, increases; their may suggest an environment closer inshore. *Cymososphaeridium* sp. is the most common dinocyst in sample 21, where amount of woody particles increases significantly. Sample 25 (Fig. 6, B) contains much less land-derived material; dinocyst are generally poorly preserved there; this may suggest a longer transport, possibly a deeper environment.

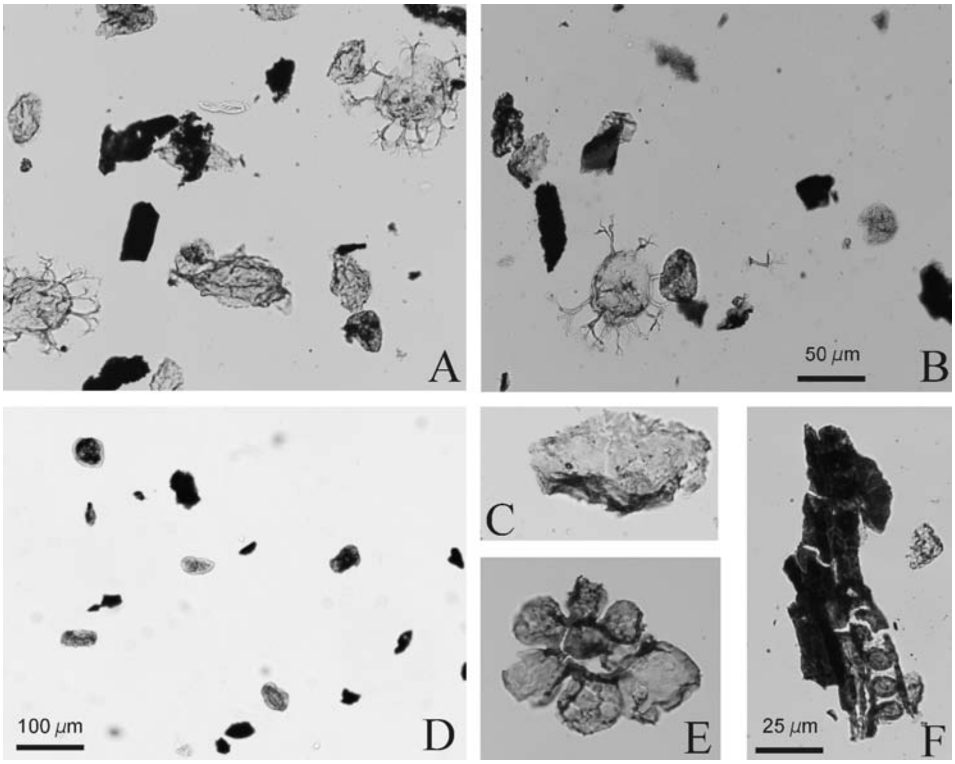

Fig. 6. Palynofacies from the studied deposits: **A** – sample 7; **B** – sample 25, scale refers to A and B pictures); **C**, **E**, **F** – selected palynomorphs from the studied sections (scale bar at F refer to C, E and F): C – sporomorph, E – foraminifera test lining, F – fitoclast; D – sample Kz21

Sample Kz23 contains a different palynofacies assemblage (Fig. 6, D), in which palynomorphs are less common. Palynoclasts are represented by equidimensional, small, rounded particles. Dinocysts are uncommon, represented mostly by the genera *Dingodinium* and *Cerbia*. These taxa belong to the outer-neritic group; *Dingodinium* prefers even a deeper environment than *Chlamydophorella* (Leereveld, 1995). A transgressive trend is recognizable upwards the section A (from samples 3 to Kz23), as well as in section B (samples 21 to 25).

Cymososphaeridium sp. A

(sample 25; Fig. 7, A–F)

Remarks: *Cymososphaeridium* sp. A differs from all previously described species of the genus. *Cymososphaeridium* sp. A is much larger than *Cymososphaeridium validum* and differs from that species, as well as from *Cymososphaeridium* sp. 1 of Davey (1982), in having broad and flared process terminations. Surface of the cyst body is ornamented by tubercles. Central body is not sphaerical, but elongated, its antapical region developes into two small, blunt protrusions.

This species is similar to *Cymososphaeridium benmorense* Schöler and Wilson (1998) in having broad and flaring process terminations, but differs in possessing much broader postcingular processes with proximal initial branching in them.

Only one specimen has been found, so creation of a new species was postponed until discovering of more specimens.

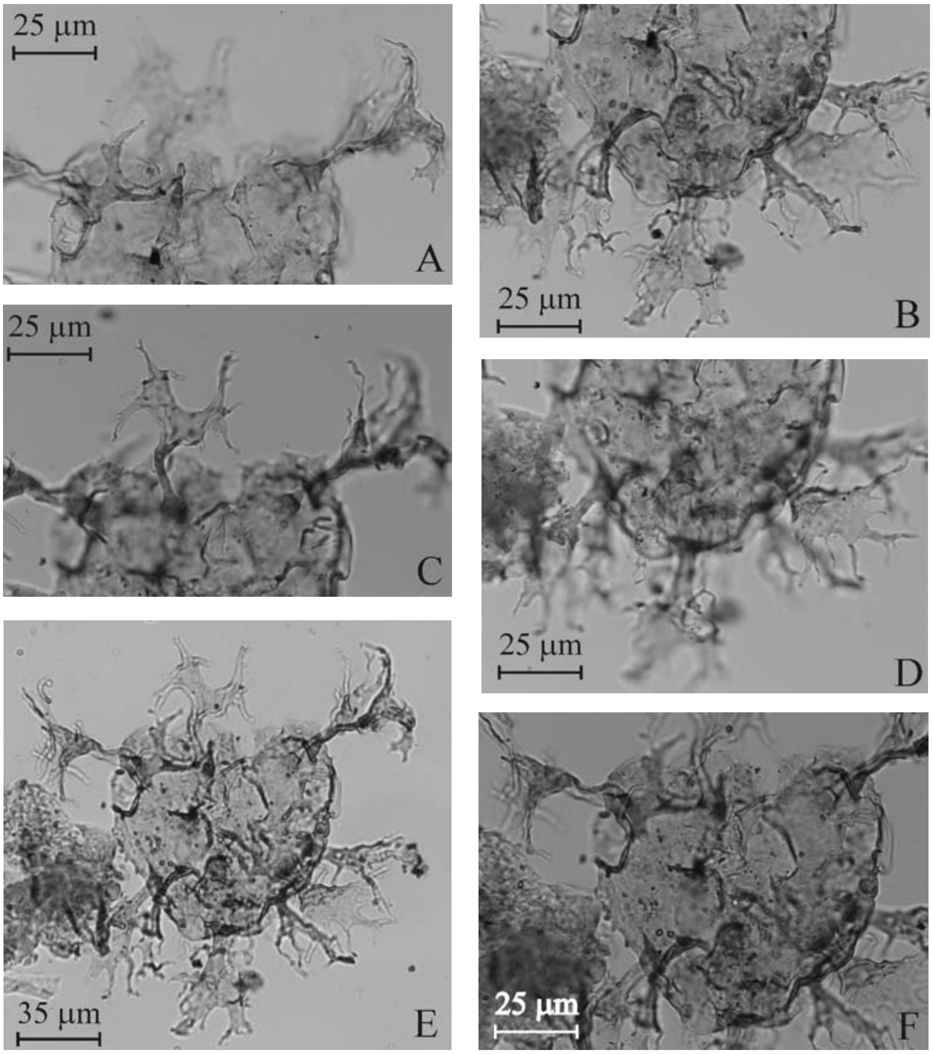

Fig. 7. Dinocyst species *Cymososphaeridium* sp. A (Wściekły Żleb, sample 25): **A**, **C** – precingular area; **B**, **D** – postcingular and antapical area; **E** – the whole cyst, operculum detached (objective of 40x); **F** – central body, at the left side of the cyst tubercules well visible

Gardodinium cf. *ordinale*

(sample 21; Fig. 9, B, C)

Remarks: This species differs from *G. ordinale* Davey (1974) in having rounded apical horn of outer wall, which is neither tapering nor truncated distally. Paratabulation is well defined by ridges of connected short processes. Intratabular areas are almost devoid of processes, but irregularily arranged tubercules are present. The overall shape is rather angular, in contrast to *G. ordinale* which possesses a non-angular shape.

AGE

Dinocyst assemblages in the studied samples (Tab. 1) are characteristic of the latest Early to Late Hauterivian. The last occurrences (LOs) of *Cymososphaeridium validum* (Fig. 8, I), *Lithodinia pertusa* (Fig. 8, D, E, K) and *Bourkidinium granulatum* in uppermost Hauterivian is a worldwide known event (Heilmann-Clausen, 1987; Leereveld, 1995, 1997; Toricelli *in* Erba *et al.*, 1999; Toricelli, 2000). Co-occurrence of these species with *Lithodinia stoveri* (Fig. 9, H) and *Callaiosphaeridium trycherium* (Fig. 8, A; Fig. 9, J) suggests that the age of the studied samples is not older than the late Early Hauterivian (see Heilmann-Clausen, 1987; Leereveld, 1995). The occurrence of *Subtilisphaera terrula* (Fig. 9, D, G) in sample 21 points to the early Late Hauterivian (Leereveld, 1995). Other species, such as *Kleithriasphaeridium corrugatum*, *Pseudoceratium pelliferum*, *Phoberocysta neocomica, Dingodinium coerviculum* and *Achomosphaera neptunii*, commonly occurs in deposits of the same age (Heilmann-Clausen, 1987; Leereveld, 1995; Torricelli *in* Erba *et al.*, 1999; Torricelli, 2000), however, their ranges are not limited to the Hauterivian, but are typical of the Early Cretaceous as a whole. It is worth to mention the occurrence of *Cerbia* cf. *tabulata* – *sensu* Leereveld (1995) and *Pseudoceratium retusum* "anaphrissum shaped" – *sensu* Leereveld (1995) – Fig. 9, F. These species differ from *Cerbia tabulata* and *Pseudoceratium anaphrissum* in some morphological aspects, presumably being transitional forms to the youngest (Barremian) species. This is an additional argument for the Late Hauterivian age of our dinocyst assemblage.

Data on the first and the last occurrences of dinocyst taxa (Leereveld, 1995) derive from the Río Argos section (SE Spain), which was chosen as the reference section for stratigraphy of the pelagic Tethyan Cretaceous deposits (Hoedemaeker *et al.*, 1993; Hoedemaeker & Leereveld, 1995). Biozones of dinoflagellate cysts from the Río Argos section are calibrated against the standard amonite zonation for the Tethyan Early Cretaceous. Comparing the studied material with the Tethyan dinocyst zones, and taking into account that *Aprobolocysta eilema* is not present in the studied dinocyst assemblages, we could attribute our dinocyst assemblage to the *Lithodinia stoveri* (Lst) Interval Zone (upper Early Hauterivian–lower Late Hauterivian) rather than the *Aprobolocysta eilema* (Aie) Taxon Range Zone (Upper Hauterivian). However, one poorly preserved specimen of *Subtilisphaera terrula* was found in sample 21. This species is considered to be an additional criterion for determining the base of the *Aprobolocysta eilema* (Aie) Taxon Range Zone (Leereveld, 1995). Co-occurrence to *Lithodinia pertusa* suggests a lower part of this zone – the *Canningia pistica* (Capi) Interval Subzone (Upper Hauterivian), correlated with the ammonite zone Ligatus (early Late Hauterivian; Leereveld, 1995). Thus, an early Lower Hauterivian age is accepted for the Muráň Limestone Member.

Table 1

Distribution of dinocysts in samples from the Muráň Limestone Member, Western Tatra Mts

Taxon / Litostratigraphy samples	Kościeliska Marls Formation Muráň Limestone Mmber				
	s. 3	s. 7	Kz23	s. 21	s. 25
Achomosphaera neptunii	+		+		
Aprobolocysta sp.				+	+
Apteodinium sp.	+				
Batiacasphaera sp.				+	+
Bourkidinium granulatum					+
Callaiosphaeridium asymmetricum		+		+	
Callaiosphaeridium trycherium		+			+
Cerbia cf. *tabulata* sensu Leereveld, 1995			+		+
Chlamydophorella sp.	+				+
Chytroeisphaeridia chytroeides				+	
Chytroeisphaeridia scabrata				+	
Circulodinium distinctum				+	
Circulodinium sp.				+	+
Cometodinium habibii	+			+	
Coronifera sp.	+				
Cribroperidinium sp.				+	+
Cymososphaeridium validum	+	+		+	+
Cymososphaeridium sp. A					+
Dapsilidinium laminaspinosum					+
Dingodinium albertii		+	+		+
Dingodinium coerviculum		+		+	
Discorsia nannus				+	
Endoscrinium campanula	+				
Exochosphaeridium phragmites	+				
Gardodinium cf. *ordinale*				+	
Gardodinium sp.	+			+	+
Gonyaulacysta sp.	+				
Hapsocysta peridictya		+		+	+
Histiocysta outanensis				+	
Kiokansium unituberculatum					+
Kleithriasphaeridium corrugatum	+				
Kleithriasphaeridium eoinodes					+
Kleithriasphaeridium sp.					+
Lithodinia pertusa		+	+	+	
Lithodinia stoveri	+				

Table 1 contineud

Distribution of dinocysts in samples from the Muráň Limestone Member, Western Tatra Mts

Litostratigraphy samples / Taxon	Kościeliska Marls Formation Muráň Limestone Mmber				
	s. 3	s. 7	Kz23	s. 21	s. 25
Muderonia neocomica		+		+	+
Muderongia sp.		+		+	+
Occisucysta tentoria					+
Oligosphaeridium asterigerum					+
Oligosphaeridium diluculum				+	
Oligosphaeridium poculum		+			
Oligosphaeridium sp.	+				
Pseudoceratium pelliferum	+				
Pseudoceratium retusum					+
Sentusidinium sp.	+	+			+
Spiniferites sp.	+	+	+	+	+
Subtilisphaea terrula				+	
Systematophora sylibum	+				
Tanyosphaeridium boletus					+
Tanyosphaeridium magneticum	+			+	
Thaleisphaera sp.				+	
Wallodinium krutzschii				+	+

DISCUSSION

Reháková (2000) recognized five bioevents in the West Carpathians, from Tithonian to earliest Cretaceous (Berriasian–Hauterivian), on the basis of calcareous dinnoflagellate and calpionellid assemblages: the Hloboč, Zliechov, Nozdrovice, Oravice and Strážovce events; they have been correlated with the eustatic sea-level changes.

Pszczółkowski (2001, 2003a, b) attributed the Muráň Limestone Member to the calpionellid Tintinnopsella Zone (Middle-Late Valanginian–Hauterivian). He specified its age as the Lower Hauterivian on the basis of correlation of isotope signature excursion ($\delta^{13}C$) from an upper part of the Wściekły Żleb Member in the Dolina Kryta valley (Western Tatra Mountains), with dated excursion of this type in southern France. Pszczółkowski (2003b) considered the redeposited calcarenites as an important event, did not correlating with any events of Reháková (2000): therefore, he proposed the Muráň event as a new one. However, the Upper Hauterivian age of the discussed calcarenites of the Muráň Limestone Member in the Wściekły Żleb gully (Gedl *et al.*, 2003, 2004, and the present paper) suggests that

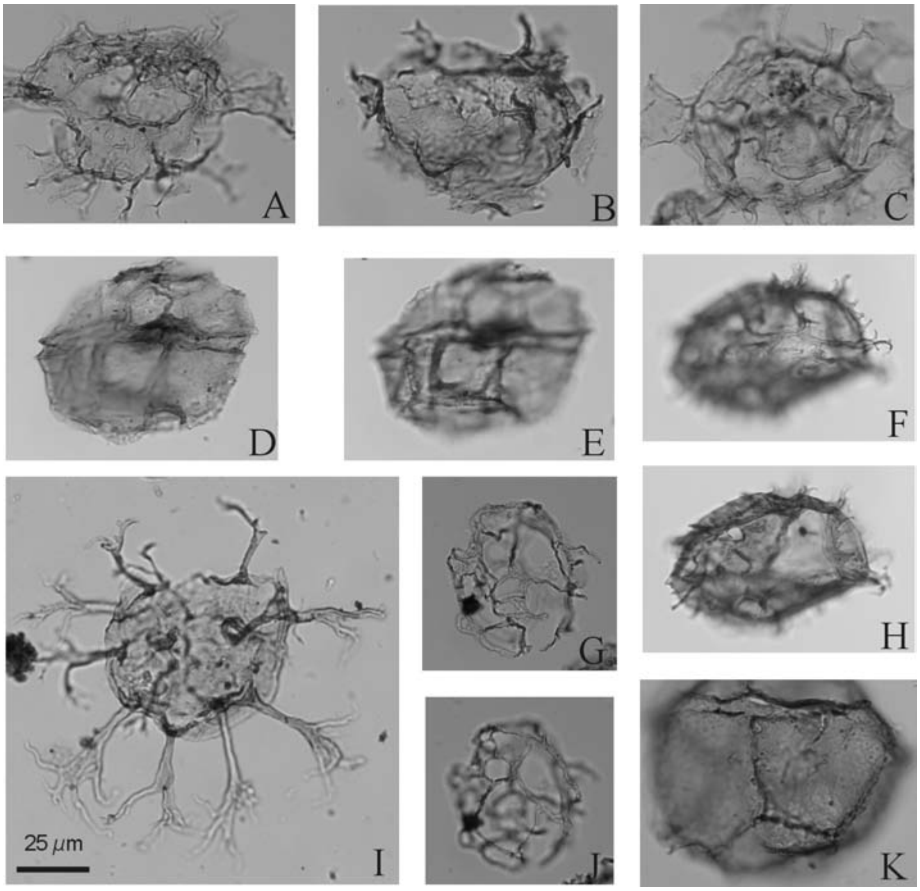

Fig. 8. Dinocysts from the Muráň Limestone Member, Western Tatra Mts: **A** – *Callaiosphaeridium trycherium* (sample 7); **B** – *Oligosphaeridium poculum* (sample 7); **C** – *Callaiosphaeridium asymmetricum* (sample 7); **D**, **E** – *Lithodinia pertusa* (Kz23); **F**, **H** – *Spiniferites* sp. (sample Kz23); **G**, **J** – *Hapsocysta peridictya* (sample 21); **I** – *Cymososphaeridium validum* (sample 25); **K** – *Lithodinia pertusa* (sample 7). Scale bar in picture I refers to all pictures

their deposition correlates with the Late Hauterivian Strážovce event (see Reháková, 2000). Such interpretation was not excluded by Pszczółkowski (2003b).

The Strážovce event is characterized by the maximum diversity of calcareous dinocysts correlated with "the transgressive phase recorded by the second-order eustatic curve", which influenced turbiditic sedimentation in the region (Reháková, 2000, p. 238). A huge Strážovce turbidite complex (Borza *et al.*, 1980) was deposited in the Zliechov Basin of the Fatric domain at that time (Reháková, 2000). The Strážovce event is recognizable also outside the Krížna basin (see Vašiček *et al.*, 1994; Pszczółkowski, 2003a). A maximum redeposition from carbonate platforms is being expected during high, stable sea-level rise when overproduction of carbonates on carbonate platforms is exported outside to the basin (Emery & Myers, 1996,

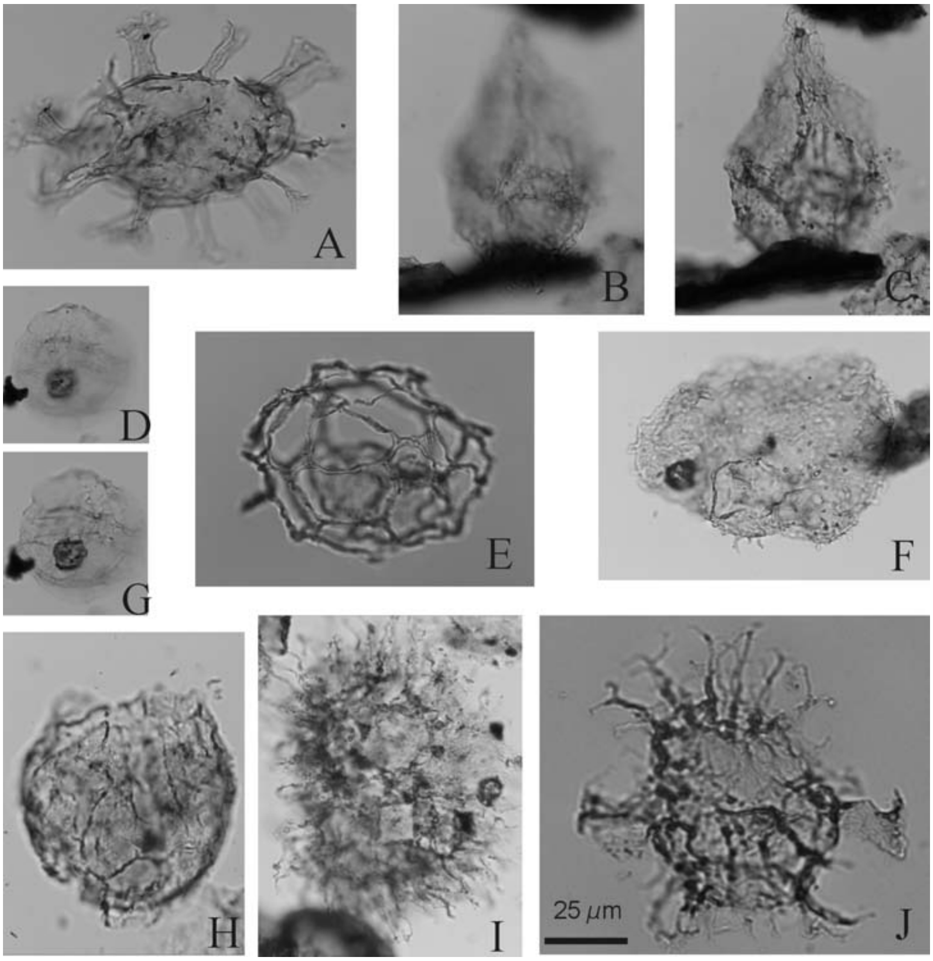

Fig. 9. Dinocysts from the Muráň Limestone Member, Western Tatra Mts: **A** – *Kleithriasphaeridium eoinodes* (sample 25); **B**, **C** – *Gardodinium* cf. *ordinale* (sample 21); **D**, **G** – *Subtilisphaera terrula* (sample 21); **E** – *Hapsocysta peridictya* (sample 25); **F** – *Pseudoceratium retusum* "*anaphrissum*"-type shape (sample 25); **H** – *Lithodinia stoverii* (sample 21); **I** – *Cometodinium habibii* (sample 21); **J** – *Callaiosphaeridium trycherium* (sample 25). Scale bar in picture J refer to all pictures

p. 214). This puts a question mark on the correlation of this event with eustatic sea-level curve (see also Pszczółkowski, 2003b, p. 991).

The presence of *Pieninia oblonga*, micritized and bored bioclasts, and small algal bioclasts, indicates redeposition from a shallow-water environment. *Pieninia oblonga*, previously considered to represent an alga, sclerites of Gorgoniaceae or, more recently, as skeletal parts or endoparasites of Keratosa sponges (Mišík, 1998), occurred in shallow-water limestones of the Barremian–Eocene age.

Most of the bioclasts are small and strongly micritized, what makes their identification difficult. This feature is typical of shallow waters, or for distal gravity flow deposits (cf. Lukeneder & Schlagintweit, 2005). Material from shallow water platform is here mixed with pelagic elements, such as calcareous dinocysts.

Calcarenite intercalations in the Kościeliska Marl Formation were interpreted by Lefeld (1974, p. 318) as "detrital limestone turbidites" or "allodapic limestones" (Lefeld, 1985). Hauterivian calcarenites of the Strážov Member of the Mráznica Formation (West Carpathians, Slovakia), and the Schrambach Formation (Northern Calcareous Alps), were also interpreted as calciturbidites (e.g., Vašiček *et al.*, 1994; Lukeneder & Schlagintweit, 2005). On the contrary, in the studied sections, sedimentological features attributable to mass flow transportation are almost absent. Graded bedding is only locally observed. The main calcarenite bed (samples Kz15, Kz19, 12, 17) shows vertical grain-size changes which had probably resulted from amalgamation of a few depositional events. The surrounding marlstones belong to basinal facies (Passendorfer, 1961) as is confirmed by ichnofabric analysis (Kędzierski & Uchman, 1997; Uchman, 1997).

Deposition of the Muráň Limestone Member of the West Tatra Mts correlated with the lower part (late Hauterivian–Barremian) of the Muráň Limestone Formation in the Belanské Tatry Mts. Cherts in the Wściekly Żleb gully (section B, Fig. 2; see also Guzik, 1961), probably also cherts mentioned by Guzik & Guzik (1958) and Guzik *et al.* (1958), from the discussed calcarenites of the Bobrowiec Unit, may correlate with abundance of cherts in the lower part of the Muráň Limestone Formation (Michalík & Soták, 1990).

CONCLUSIONS

1. The Muráň Limestone Member in the West Tatra Mts contains calcarenites composed of shallow water bioclasts exported from a carbonate platform, then redeposited in a basin where marly sedimentation prevailed.

2. The Muráň Limestone Member of this area is dated at the early Late Hauterivian *Aprobolocysta eilema* (Aie) Taxon Range Zone, *Canningia pistica* (Capi) Interval Subzone of Leereveld (1995).

3. Taking the above into account, the Muráň Limestone Member in the West Tatra Mts (including horizons with cherts) is considered an equivalent of the lower part of the Muráň Formation in the Belanské Tatry Mountains. It deposition was related to the Strážovce event.

4. Stratigrafic range of microproblematicum *Pieninia oblonga* (formerly, Barremian–Eocene) is extended down to the Late Hauterivian.

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APPENDIX

Alphabetic list of dinocyst taxa from the Wściekły Żleb gully sections A and B, West Tatra Mts (for taxonomic citation see Williams *et al.*, 1998):

Achomosphaera neptunii (Eisenack, 1958a) Davey et Williams, 1966a
Aprobolocysta sp.
Apteodinium sp.
Batiacasphaera sp.
Bourkidinium granulatum Morgan, 1975, emend Nøhr-Hansen, 1993
Callaiosphaeridium asymmetricum (Deflandre et Courteville, 1939) Davey et Williams 1966; **Fig. 8, C**
Callaiosphaeridium trycherium Duxbury, 1980; **Fig. 8, A; Fig. 9, J**
Cerbia cf. *tabulata* sensu Leereveld, 1995
Chlamydophorella sp.
Chytroeisphaeridia chytroeides (Sarjeant, 1962) Downie et Sarjeant, 1965
Chytroeisphaeridia scabrata Pocock, 1972
Circulodinium distinctum (Deflandre et Cookson, 1955) Jansonius, 1986
Circulodinium sp.
Cometodinium habibii Monteil, 1991; **Fig. 9, I**
Coronifera sp.
Cribroperidinium sp.
Cymososphaeridium validum Davey, 1982; **Fig. 8, I**
*Cymososphaeridium*sp. A; **Fig. 7, A–F**
Dapsilidinium laminaspinosum (Davey et Williams, 1966) Lentin et Williams, 1981
Dingodinium albertii Sarjeant, 1966
Dingodinium coerviculum Cookson et Eisenack, 1958, emend. Khowaja-Atteequzzaman *et al.*, 1990
Discorsia nannus (Davey, 1974) Duxbury, 1977; emend. Khowaja-Ateequzzaman *et al.*, 1985
Endoscrinium campanula (Gocht, 1959) Vozzhennikova, 1967
Exochosphaeridium phragmites Davey *et al.*, 1966
Gardodinium cf. *ordinale*; **Fig. 9, B, C**
Gardodinium sp.
Gonyaulacysta sp.
Hapsocysta peridictya (Eisenack et Cookson, 1960) Davey, 1979b; **Fig. 8, G, J; Fig. 9, E**
Histiocysta outanensis Below, 1981
Kiokansium unituberculatum (Tasch, in Tasch *et al.*, 1964) Stover et Evitt, 1978
Kleithriasphaeridium corrugatum Davey, 1974
Kleithriasphaeridium eoinodes (Eisenack, 1958) Davey,1974; emend. Sarjeant, 1985; **Fig. 9, A**
Kleithriasphaeridium sp.
Lithodinia pertusa Duxbury, 1977; **Fig. 8, D, E, K**
Lithodinia stoveri (Millioud, 1969) Gocht, 1976; **Fig. 9, H**
Muderongia neocomica (Gocht, 1957) Lentin et Williams, 1993
Muderongia sp.
Occisucysta tentoria Duxbury, 1977, emend. Jan du Chêne *et al.*, 1986b
Oligosphaeridium asterigerum (Gocht, 1959) Davey et Williams, 1969
Oligosphaeridium diluculum Davey, 1982
Oligosphaeridium poculum Jain, 1977; **Fig. 8, B**
Oligosphaeridium sp.
Pseudoceratium pelliferum Gocht, 1957, emend. Dörhöfer et Davies, 1980
Pseudoceratium retusum “anaphrissum shaped”, cf. Leereveld, 1995; **Fig. 9, F**
Sentusidinium sp.
Spiniferites sp.; **Fig. 8, F, H**

Subtilisphaea terrula (Davey, 1974) Lentin et Williams, 1976; emend. Harding, 1986; **Fig. 9, D, G**
Systematophora sylibum Davey, 1979
Tanyosphaeridium boletus Davey, 1974
Tanyosphaeridium magneticum Davies, 1983
Thaleisphaera sp.
Wallodinium krutzschii (Alberti, 1961) Habib, 1972 emend. Poulsen 1996

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