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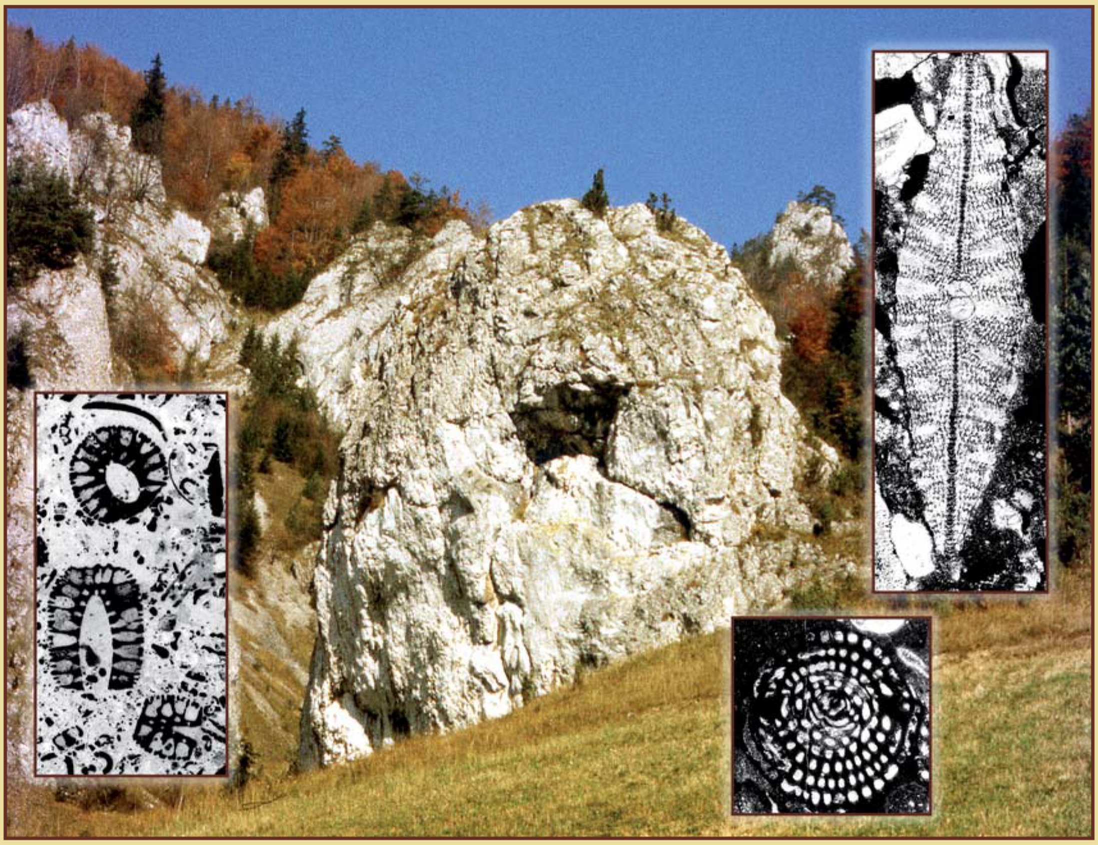

State Geological Institute of Dionýz Štúr Bratislava

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Edited by:

RNDr. Stanislav Buček, CSc.

RNDr. Eduard Köhler, DrSc.

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LIST OF ACRONYMS

CIE	Carbon Isotopic Excursion
GIDŠ	Geological Institute of Dionýz Štúr
GSSP	Global Stratotype Section and Point
GS SR	Geological Survey of the Slovak Republic
IGCP	International Geoscience Programme
K-T	K-T boundary (Cretaceous-Tertiary)
LFT	Larger Foraminifers Turnover
NLA	Northern Limestone Alps
NP	Nanoplankton
P	Planktonic foraminifers
PETM	Palaeocene-Eocene Thermal Maximum
SBZ	Shallow Benthic Zones
SGIDŠ	State Geological Institute of Dionýz Štúr

Palaeocene Reef Complex of the Western Carpathians

Stanislav Buček[1] & Eduard Köhler[2]

[1] State Geological Institute of Dionýz Štúr, Mlynská dolina 1, 817 04 Bratislava, Slovakia.
E-mail: stanislav.buček@geology.sk
[2] Astrová 52, 821 01 Bratislava

Abstract: Palaeocene reef complexes are among the rarely preserved geologic structures on Earth. In the Western Carpathians traces of one of the most northern shallow-water reef complexes have been preserved which were not previously described.

The issue of Western Carpathians reef rocks was studied by a number of publications, but their summary has been lacking; the submitted publication tries to fill the gap.

Rocks, which can be affiliated to the shallow-water Palaeocene reef complex, were found in the Western Carpathians in the areas of the Malé Karpaty Mts., Myjavská pahorkatina Upland, Middle Váh Valley, Orava, Pieniny, Slánske vrchy Mts., Ondavská vrchovina Highlands till Vihorlatské vrchy Mts. and Slovak-Ukrainian border.

Almost everywhere there has been possible to document, that their immediate original substrate were Upper Cretaceous (Campanian-Maastrichtian) orbitoid sandstones and sandy limestones, which were suitable basement for carbonate platform with shallow-water reef complexes. We have not managed to convincingly document an uninterrupted transition from Cretaceous to Tertiary in shallow-water environment, as suggested by some authors in the Myjavská pahorkatina Upland and in the Middle Váh Valley. In the Latest Maastrichtian in shallow-water environment there occurred shallowing, emergence, erosion and subsequent relocation of Cretaceous biorelics into Palaeocene carbonate rocks.

Palaeocene sedimentation began in Later Danian (SBZ 1), but the largest extent it reached in Selandian (SBZ 2) and in Early Thanetian (SBZ 3). A reef complex was formed, in which it is possible to distinguish back-reef area, reef platform and fore-reef area.

Reef complex of the Western Carpathians was of short duration. Material, which we have at disposal, proves for termination of sedimentation in Late Thanetian (SBZ 4), which documents an existence of reef complex in the Western Carpathians with a duration of only 2 – 2.5 mil. years. Its termination was connected with Late-Laramian tectonic movements. At places (in the Malé Karpaty Mts.) at the onset of Early Eocene a new transgression of sea occurred.

In back-reef environment there were identified 14 essential microfacies types, on reef platform two and in fore-reef slope environment four essential microfacies types distinguished and defined at a description of individual areas.

All the material, which has been at disposition indicates, that in the Western Carpathians during Palaeocene the conditions were unsuitable for origination of extensive reef structures, but there were only formed reef bodies of the type of isolated “patch” reefs. Despite imposing dimensions of some preserved parts of reef complex, with the exemption of sporadic fore-reef slope profiles (Myjavská pahorkatina Upland), all bodies and blocks are emplaced into younger (Eocene) sediments, which indicates vast destruction of the reef complex in Early Thanetian and at the beginning of Early Eocene – Ypresian (see also Golonka et al., 2011).

Assessment of hundreds of blocks and a direct comparison with Alpine occurrences indicates, that in Palaeocene in Alps-Carpathians space two strips of reef complex existed with different tectonic and palaeogeographic emplacement.

The Alpine stripe rimmed the Eastern Limestone Alps from the inner side. It was formed atop the nappe structures and its easternmost continuation can be observed in the same tectonic position in the Malé Karpaty Mts. (Vápenková skala at Rozbehy). This complex shows age dating Danian (SBZ 1) – Early Thanetian (SBZ 3), and has been preserved only in the form of blocks. Its most famous locality is Kambühel in Lower Austria.

The second stripe is situated at the outer (Northern) side of the Inner Western Carpathians in the vicinity of the Klippen Belt (Peri-Klippen Zone) and it can be traced from the Myjavská pahorkatina Upland till the Slovak-Ukrainian border (Beňatina). Sediments of this stripe are likely of the Danian (?SBZ 1) to Early Thanetian (SBZ 3) age. Type area is the village of Hričovské Podhradie and its close vicinity in the Middle Váh Valley at Žilina.

Study of more than 3600 thin sections, which the authors have at disposition, has shown, that already during Selandian, but mainly in Early Thanetian in the Western Carpathians an extensive recovery of organic life occurred in shallow-water environment, and some 5 mil. years after catastrophic event at the Cretaceous-Tertiary boundary, organic life was fully developed.

Key words: Western Carpathians, Palaeocene, reefs, microfacies, biostratigraphy, palaeontology, *Foraminifera*, calcareous algae, *Scleractinia*.

1. Introduction

Palaeocene (time span of 65 – 56 mil. years) represents in the history of the Earth a period, to which in the last decades an increased attention is given, which is manifested also in numerous published works.

There are several reasons of this interest. Palaeocene is a period which followed after catastrophic event extinction at the boundary Cretaceous-Tertiary. This event is ranked among “Big Five” episodes, which significantly shaped the history of the Earth. It is stated (Flügel & Kiessling, 2002), that after this event a sudden extinction occurred of 47 % of genera and 76 % of species living at that time at the Earth. Accounting for a short duration of the event, its cause is most frequently attributed to asteroid impact in the area Chicxulub in Yucatan (Alvarez et al., 1980; Kiessling & Clayes, 2001 and others). McLaren & Goodfellow (1990) state, that this event is accompanied by all consequences, which could be expected from an impact. One of the main arguments of the impact, along with negative excursion of oxygen and carbon isotopes is the iridium anomaly, at the Cretaceous-Tertiary (K-T) boundary and has been recorded in more than 60 profiles across the world.

Among the other explanations of the event the most popular is a link with volcanic activity at the end of Cretaceous (basalt volcanism in Deccan, India), but this interpretation doesn’t explain individual anomalies and on top of this it is known, that volcanic activity began 2.5 mil. years before K-T boundary. There is no reason to argue, that the volcanic activity could lead to certain change in organic world, but it was not of a global character (McLaren & Goodfellow, l.c.).

The next reason of interest in Palaeocene is Palaeocene-Early Eocene global warming (Palaeocene-Eocene Thermal Maximum – PETM). This warming led to termination of coral reefs in the area of Tethys, or their gradual shift into the higher latitudes (Scheibner et al., 2005). As emphasized by Scheibner & Speijer (2008a) recent warming of the Earth has many common features with similar episode at the boundary Palaeocene and Early Eocene. The knowledge of consequences of this warming can bring many findings and also give a momentum for recent science.

While proves for evolution of forms of life on dry land are humble for the Palaeocene period (they originate dominantly in the Western Europe areas not flooded by the sea), study of marine sediments provides wide range of data. Within the marine environment the fastest evolution occurred on shallow carbonate platforms, which rimmed continents and at places conditions for reef sedimentation were formed on them. Typical marine reefs are products of biologic processes, which originate only under favourable chemical, physical, geologic and biologic conditions. Reefs in Palaeocene document the best an intensity of recovered biologic processes.

Scheibner & Speijer (2008a, b) provide a list of 14 Palaeocene carbonate platforms in the area of Tethys. Six of them are located in Europe: Northern Limestone Alps, Western Carpathians, Northern-Adriatic Platform, Pyrenees, Italian Maiella and Greek Ionian Islands. The others are in Tunisia, Morocco, Turkey, Egypt, Libya, Oman, India, China (Tibet) and in Somalia.

The majority of referred to areas of Palaeocene platforms was given already a considerable attention and they are discussed in dozens of works (e.g. Baceta et al., 2005; Daod, 2009; Höfling et al., 1996; Hottinger & Drobne, 1998; Ogorelec et al., 2001; Pardo et al., 1999; Schlüter et al., 2008; Zachos et al., 1993; Zamagni et al., 2008). The Western Carpathians are out of this framework. Although several works were dedicated to the Palaeocene, only two of them have received international attention and are quoted in dozens of works. They are the publications of Scheibner (1968) and Samuel et al. (1972). Data from the latter work were used and quoted by the makers of today globally recognized zonation of shallow-water marine sediments – "Shallow Benthic Zones" – SBZ (Serra-Kiel et al., 1998).

In the scope of the above zonation the Palaeocene reef sedimentation was also the topic, in which Slovakia has taken part in solving international correlation programme of UNESCO no. 286 "Early Palaeogene Benthos" (since 1991 under the leadership of L. Hottinger, K. Drobne and E. Caus). In the framework of this project the authors acquainted themselves with Palaeocene profiles in Turkey, Slovenia and Spain.

Of particular importance are the Western Carpathians sites from the point of view that in addition to the Paris Basin they are the northernmost occurrences representing shallow-water reef Palaeocene carbonates at the Earth and even in the event that their location between today's 48° 30' and 49° 20' northern latitude is reduced to palaeo-latitude 43° for placement of the Western Carpathians in Palaeocene (Scheibner & Speijer, 2008a).

Because the Western Carpathians Palaeocene carbonate platforms are associated with their Upper Cretaceous substrate (Campanian-Maastrichtian mainly orbitoid layers), the paper also includes data on the immediate substrate of individual platforms in the areas of occurrence.

The Western Carpathians Palaeocene reef system is also interesting from the point of found fossils in it, which were not referred to the area except of their first occurrence. They are not only the species, but also genera, e.g. Sirel's tirelessly created foraminifers genera *Haymanella*, *Kartalina* and *Orduella* (Sirel, 1999, 2012, 2013).

Since Palaeocene reef limestones are consistent, hard rocks, most effective way of their study was the evaluation of thin section material.

Sample and thin section material was collected in the various regional projects from 1960 to 2010. Thin section material from the collections of S. Buček, J. Bystrický and E. Köhler was combined into one collection named "Palaeocene reef complex of the Western Carpathians" and is stored as material documentation in State Geological Institute of Dionýz Štúr in Bratislava. It consists of 4,171 thin sections (477 thin sections of the Late Cretaceous and 3,694 of Palaeocene and Early Eocene). Each thin section has a written documentation with description. Thin sections from earlier collecting campaigns (1960 – 1980) were re-analyzed and evaluated. For better orientation, thin sections are marked with the abbreviation Bu – S. Buček, By – J. Bystrický and Ko – E. Köhler.

In addition to the above material, thin section specimens from Austria (Kambühel and Prigglitz), Slovenia (Dolenja Vas), Spain and Turkey were used for comparison. The material was obtained by the authors in the framework of IGCP Project 286.

At space delineation of the reef complex the authors stuck to the division, defined by Henson (1950) for Cretaceous and Tertiary reef formation of the Middle East with a definition of back-reef, reef and fore-reef space.

In the Western Carpathians in Palaeocene a definition of the actual reef formation space is quite problematic, because there had not been created conditions for the emergence of large reef structures in this space and there had emerged only tinier reef bodies of the type of patch reefs.

For the attached photo-documentation the authors used their archives. They are aware that these annexes do not show the whole rich range of microfacies and biorelics of Palaeocene reef complex, but only excerpts from it. They still think that even this limited selection indicates convincingly, that under appropriate climatic warm conditions and shallow marine environment almost 5 million years after mass extinctions at the Cretaceous and Tertiary boundary there occurred a revival of the plant, as well as the animal world.

The aim of this works is to submit a comprehensive picture of origination, composition, duration and termination of the Palaeocene reef system of the Western Carpathians. Whether the authors have succeeded, the reader must judge by him/herself.

2. Chronostratigraphic and biostratigraphic division of Palaeocene

While in defining chronostratigraphic units of Late Cretaceous (Santonian to Maastrichtian) there has long been consensus (at the presence of large foraminifers a detailed division of Campanian and Maastrichtian stages is possible), definition of Palaeocene and its internal division has been for already more than a century the subject of various, often very contradictory views. The problem lies in the fact that most Palaeocene chronostratigraphic units were defined yet in the 19th century. Palaeontologically, they were based on macrofaunistic associations, types of stages were selected in a variety of marine and terrestrial environments, superposition among units was unclear and it was not known whether the individual units overlap and there are unconformities among them. These complex issues were addressed in dozens of publications, which summary was provided by Pomerol et al. (1981); Cavelier & Pomerol (1986) and in Slovak literature by Köhler & Samuel (1977) and Samuel (1988, 1989).

There is now quite a large consensus in the classification of Cretaceous/Palaeocene boundary in neritic-bathyal sediments (Cavelier & Pomerol, 1986; Molina et al., 2006). The high content of Ir, an increase in $\delta\ ^{18}O$ and drop in $\delta\ ^{13}C$ in the boundary layers are the main reasons for demarcation.

The exact time of the Cretaceous-Tertiary boundary is not entirely unequivocal, moving in the range of 65.0 to 66.7 million years (Cavelier & Pomerol, 1986), but in the majority of published schemes (Serra-Kiel et al., 1998; Scheibner & Speijer, 2008a, b) the interface is placed at 65 million years.

The upper Palaeocene boundary was recently the subject of much controversy because the original definition by Schimper (1874) is not explicit. The issue was resolved by redefinition and delineation of the Ilerdian stage (Pujalte et al., 2009a, b). Recently, the opinion prevails that Palaeocene boundary is close to 55 million years, or 55.8 ± 0.2 (Serra-Kiel et al., 1998; Scheibner & Speijer, 2008a, b, 2009), which limits the Palaeocene duration to approximately 10 million years. In favour of this boundary speak the significant events at the interface Palaeocene/Eocene as LFT (Larger Foraminifers Turnover; Pujalte et al., 2009a; Hottinger, 1998), PETM (Palaeocene-Eocene Thermal Maximum, Cabarello et al., 2006) and CIE (Carbon Isotopic Excursion; Scheibner et al., 2005).

Palaeocene internal division has undergone a long evolution. Some of the authors have used only two-stages division into Danian and Thanetian (e.g. Moussavian & Vecsei 1995; Schuster, 1996), but most authors are now inclined to a three-stages division in accordance with Global Stratigraphic Chart (1989), and Geological Timescale 2004 (Luterbacher et al., 2004). Also in this division there was a non-compliance, as some authors have used the division into stages Danian-Montian-Thanetian (in the area of Palaeocene reef facies, e.g. Tragelehn, 1996, and Samuel et al., 1972), but recently recognized division is Danian- Selandian-Thanetian. For these three stages there were defined also global boundary stratotype profiles and points (GSSP – Global Stratotype Section and Point; Molina et al., 2006; Schmitz et al., 2011), but the problem rests in the fact that these profiles are set out in neritic-bathyal sediments in which it is possible to use zoning by planktonic foraminifers (P – zone) and calcareous nanoplankton (NP – zone), but they are not suitable for shallow marine environment, SBZ – zones).

This deficiency has been resolved by Serra-Kiel et al. (1998) by establishing SBZ (Shallow Benthic Zones) based on benthic organisms for the entire Palaeocene and Eocene. This zonation has gained very quickly worldwide popularity and even despite minor corrections it is already commonly used. Less (1998) has completed this zoning on orthofragmine zoning.

Serra-Kiel et al. (l.c.) distinguish Palaeocene SBZ 1 (Danian), SBZ 2 (Selandian) and SBZ 3 – 4 (Early-Late Thanetian).

SBZ 1 biostratigraphic range is defined by *Laffitteina bibensis* MARIE and *Bangiana hanseni* DROBNE, OGORELEC et RICCAMBONI.

SBZ 2 comprises biostratigraphic range *Miscellanea globularis* RAHAGHI, *Ornatononion minutus* (RAHAGHI), *Paralockhartia eos* HOTTINGER et TAMBAREAU and *Lockhartia akbari* HOTTINGER et TAMBAREAU.

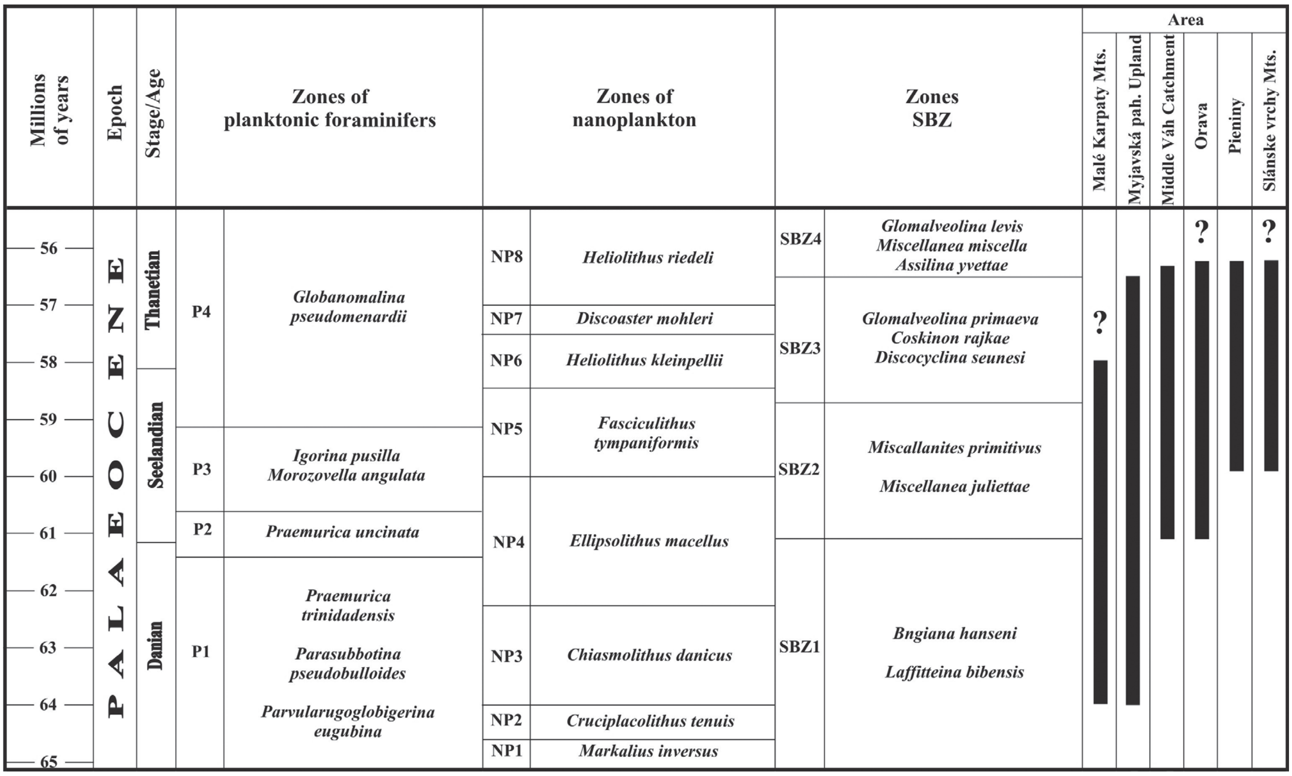
SBZ 3 includes wide association of species including *Glomalveolina primaeva* (REICHEL), *Perilocolina slovenica* DROBNE, *Coskinon rajkae* HOTTINGER et DROBNE, *Fallotella alavensis* MANGIN, *Miscellanea yvettae* LEPPIG, *Ranikothalia bermudezi* PALMER, *Operculina heberti* (MUNIER-CHALMAS) and *Discocyclina seunesi* DOUVILLÉ.

SBZ 4 stratigraphic span is defined by *Glomalveolina levis* (HOTTINGER), *Hottingerina lukasi* DROBNE, *Miscellanea meandrina* (CARTER), *Daviesina garumnensis* TAMBAREAU, *Assilina azilensis* (TAMBAREAU) and *Assilina yvettae* SCHAUB.

Comparison of individual zonings (P, NP and SBZ) and age of individual areas of the Palaeocene reef complex occurrence in the Western Carpathians is listed in the Table 1. These lists are constantly replenished and refined, (e.g. Pignatti et al., 2008); however the definition of the oldest SBZ 1 zone is still questionable, as index fossils have small geographic extent. On the Palaeocene base in shallow-water facies mostly an interruption of sedimentation occurs; its time range is uncertain. Unlike SBZ 1, index fossils of SBZ 2 and 3 are widespread in the Western Carpathians. Tragelehn (1996) at the assessing of the material from the Eastern Limestone Alps saw a great perspective in using dasycladacean algae for Palaeocene zoning, but his proposal has not been accepted (Vitale, 2008).

Because Palaeocene reef system of the Western Carpathians existed only in shallow-water environment, zoning based on planktonic foraminifera and calcareous nanoplankton is out of question (sporadic *Globigerina* forms were found in fore-reef slope sediments), therefore remains only one option to keep to SBZ zoning.

Tab. 1. Chronostratigraphic Palaeocene subdivision, zoning P, NP and SBZ (shallow-water benthic zone by Serra-Kiel et al. (1998) and age of individual areas of the Palaeocene reef complex occurrence in the Western Carpathians.



3. Occurrences of the Palaeocene reef limestones in the Western Carpathians

On Fig. 1 there are displayed 9 occurrences of the Palaeocene reef limestones in the Western Carpathians, which are described in more detail in the text below[1].

3.1. Malé Karpaty Mts.

Westernmost occurrence of bioherm Palaeocene limestones is located in Malé Karpaty mountain range at an elevation Vápenková skala, 500 m west of the village Rozbehy. This site is located less than 140 km from the famous Palaeocene Kambühel location in the Northern Limestone Alps, and when taking into account the rotation of the Malé Karpaty Mts. (Plašienka et al., 1991), original distance was even smaller.

Since Vaňová (1963) described the Early Eocene large foraminifers from basal layers of Palaeogene in abandoned quarry at Sološnica, it was assumed that Palaeogene evolution in the Malé Karpaty Mts. began with Early Eocene transgression.

The inclusion of this facies into the overall structures of the Inner Western Carpathians has been discussed by various authors. Andrusov (1965) assigned Palaeogene sediments of the Malé Karpaty Mts. in his "Súľov Group". He pointed to the presence of bioherm limestones, which he attributed Middle Eocene age. In Regional geology of Czechoslovakia (Buday et al., 1967) Palaeogene sediments of the Malé Karpaty Mts. are included in the transition zone between Peri-Klippen and Inner Carpathians facies.

In 1984, Köhler & Borza described in an abandoned quarry on the southern slope of the elevation point Vápenková skala at Rozbehy carbonate sandstones and conglomerates containing large foraminifers, Late Cretaceous in age. These authors pointed out to the existence of large blocks of bioherm limestones in Miocene conglomerate, which overlies Campanian orbitoid beds. They assigned these blocks Late Cretaceous (Campanian-Maastrichtian) age.

To their age inclusion clung also Buček & Köhler (1987), who described from the blocks of bioherm limestones dasycladacean algae *Sarosiella feremollis* Segonzac. Despite the fact that the main occurrence of this algae is in Palaeocene (Dieni et al., 1985), the authors didn't exclude Late Cretaceous age of the limestone blocks.

Overview of Palaeogene facies of the Malé Karpaty Mts. provided Gross & Köhler (1989), who – though with certain reservations – included the Palaeogene sediments of the Malé Karpaty Mts. into Borové and Huty Fms. of the Sub-Tatric Group and even despite the marked age differences to the classical definition of Sub-Tatric Group

[1]*Plašienka & Soták (2015) provided an analysis of the development of Late Cretaceous-Palaeogene synorogenic basins in Pieniny Klippen Belt and adjacent areas. They defined separate Myjava-Hričov basin, but they do not associate it with easterly continuation in the Orava region and in Pieniny.In the period of time the highest Turonian-Coniacian to Rupelian to Aquitanian they defined 7 facies phases in basins. As they state in the phase IV (Palaeocene-Early Eocene) in individual areas the reefs found occur only as replaced fragments, such as olistoliths in calcareous turbidites and as slump bodies. They didn't assess the existence of the Palaeocene reef complex in Peri-Klippen Belt of the Western Carpathians, similarly to Kováč et al. (2016), who interpreted the Palaeogene palaeogeography basin evolution of the Western Carpathians, North-Pannonian area and neighbouring spaces.*

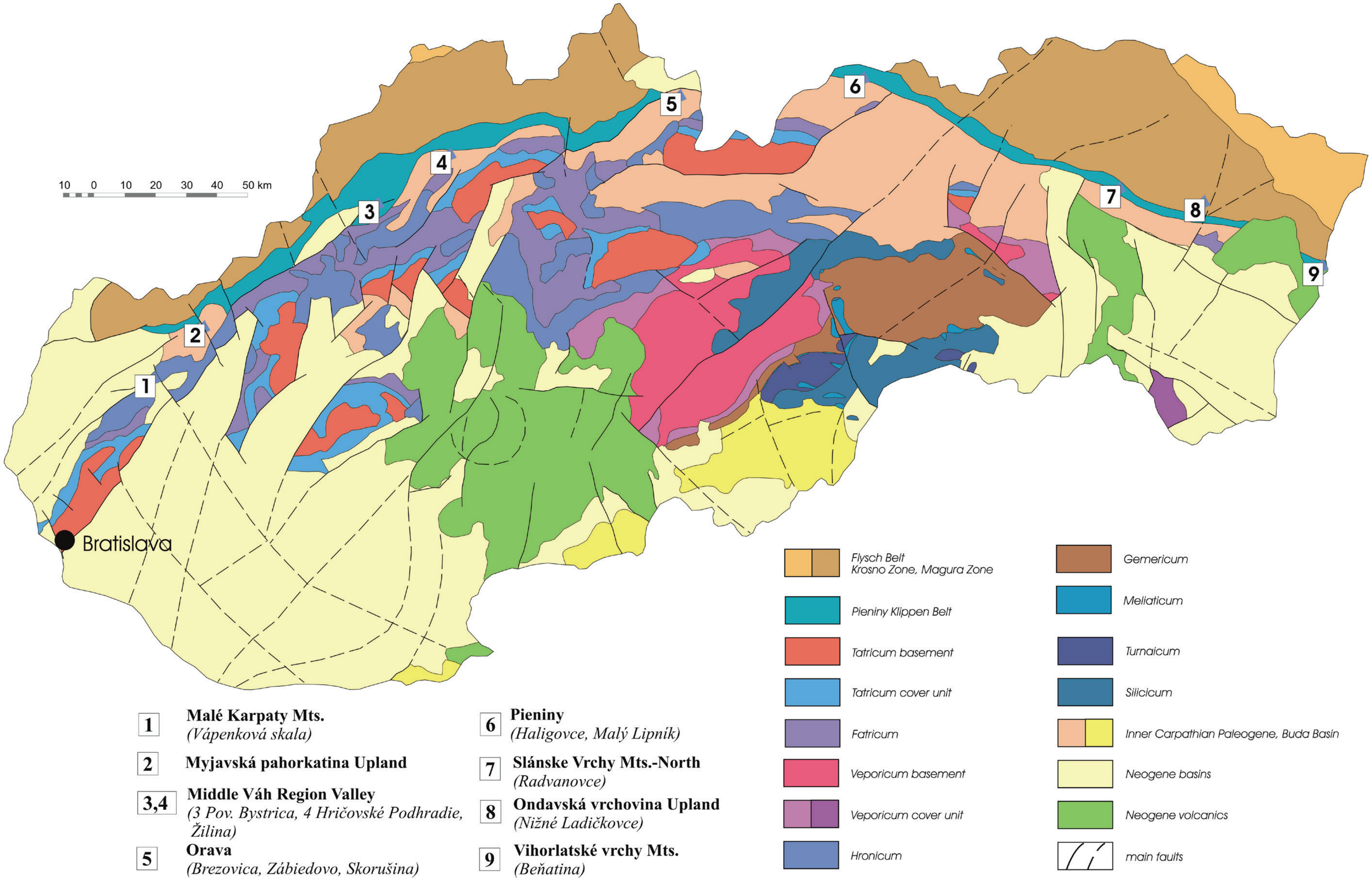


Fig. 1 Areas of described occurrences of the Palaeocene reef limestones in the Western Carpathians.

(Gross et al., 1984). They admitted the possibility that this is a transitional facies between Inner Carpathian and Peri-Klippen Palaeogene.

Plašienka et al. (1991) assumed that at Late Palaeocene to Early Eocene transgression the sea covered almost the entire territory of the today Malé Karpaty Mts. They referred to the blocks of bioherm limestones, to which they also assigned the Late Cretaceous (Santonian) age.

In an unpublished DrSc. dissertation Köhler (1995) reported that he examined 10 blocks of bioherm limestones from Vápenková skala. From their analysis he showed that they represent shallow-water biomicrites, which originated in protected environment with low water energy in the minimum depths (up to 10 m). Despite frequent disturbed debris of coral patch reefs no fragment was found to be a component of the true reef structure, and very rare occurrences of planktonic foraminifers excludes the formation of sediment in open marine environment. Köhler (l. c.) assigned the blocks to Early Palaeocene (Danian-Selandian). He recalled that after Palaeocene occurred in the area a new extensive transgression and deposition of Early Eocene lagoonal limestones. The existence of a carbonate platform in overlying Campanian orbitoid beds he limited to Danian-Selandian.

In the year 2011 in the scope of the edition of Regional geologic maps of Slovakia at scale 1 : 50 000 there was issued the Geological map of the Malé Karpaty Mts. at 1 : 50 000 (Polák et al., 2011). In the Explanatory Notes to this map (Buček in Polák et al., 2012) the facies in the area of Vápenková skala at Rozbehy was included in Myjava-Hričov Group of Palaeogene with lithostratigraphic unit "Kambühel" Limestone: organogenic reef limestones (blocks) with age-inclusion in the upper part of Danian to Thanetian. The idea that the blocks are only part of Miocene conglomerates of Eggenburgian to Karpatian age has been neglected. A thorough examination of the edge of the abandoned quarry at the site Vápenková skala showed that the blocks of bioherm limestones are mainly concentrated at the surface of Campanian sandstones, sandy limestones and conglomerates, from where a part of them was displaced into Miocene conglomerates, but a part of them remained in original position. It is a similar situation to the classic Austrian Eastern Alps Kambühel site (Tragelehn, 1996, 2000), where blocks of bioherm Palaeocene limestones are located at the surface of Late Cretaceous (Maastrichtian at this site) limestones. In Kambühel the overlaying of Miocene conglomerates didn't happen.

Debate on the inclusion of Palaeogene sediments of the Malé Karpaty Mts., which represent an onset of the Early-Eocene transgression is resolved in the Explanatory Notes to the Geological Map of the Malé Karpaty Mts. (Buček in Polák et al., 2012) by creating a new Malé Karpaty group formed by Jelenia hora, Buková and Hrabník Fms. Late Cretaceous orbitoid beds were assigned into Brezová Group (Buček in Polák et al., l.c.).

After combining thin section material by Buček and Köhler there were analyzed 73 thin sections of Late Cretaceous orbitoid beds from Vápenková skala and 130 thin sections from blocks of Palaeocene limestones.

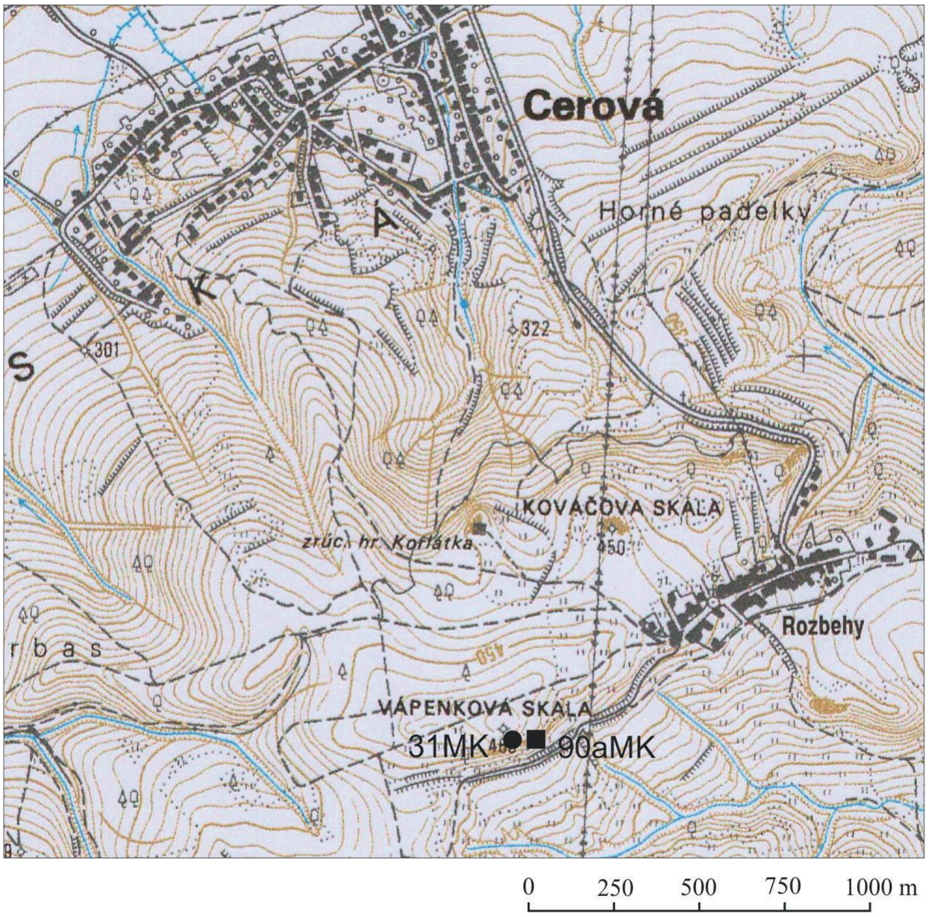


Fig. 2a. Situation map of the site Vápenková skala at Rozbehy in the Malé Karpaty Mts. at scale 1 : 25 000 (map sheet 35-313 Trstín). 90aMK = Late Cretaceous; 31MK = Palaeocene.

3.1.1. Upper Cretaceous basement of Palaeocene bioherm limestones

Although in the Malé Karpaty Mts. at different locations there were found rocks, which Late Cretaceous age cannot be excluded (e.g. blocks of organogenic limestones with rudists at Chtelnica; Buček, 1989), the only unequivocally dated occurrence is located in abandoned quarry on the southern slope of Vápenková skala (90aMK; coordinates 48°

34´07.9´´, E 17° 23´14.7´´). For accurate dating there was sampled in quarry (Fig. 2b) a 21 m long section (7 samples), but it didn't show substantial lithological or faunistic differences. The rock is medium to coarse-grained sandstone and sandy polymict limestone containing mainly variously rounded fragments of Mesozoic carbonates and sandstones and small fragments of quartz, cemented by sparite cement (Pl. I, Fig. 1).

Among biocompounds dominating are large foraminifers, Campanian in age (Pl. I, Fig. 1): *Orbitoides tissoti* Schlumberger, *Orbitoides media* d´Archiac, *Lepidorbitoides minima* Douvillé, *Pseudosiderolites vidali* (Douvillé). Besides the large foraminifers there are present tiny fragments of algae – *Sporolithon* sp. and *Polystrata alba* (Pfender) Denizot, fragments of bryozoans, bivalves, crinoids, rudists and serpulid worms. Small foraminifers are present in miliolid, agglutinated and rotaloid forms.

Rock is tidal sediment in environment with differing water energy and contribution of detritic material eroded from the mainland. Some blocks show traces of washing and sorting.

It cannot be excluded that sedimentation continued also later, but the highest layer had been removed by subsequent erosion.

3.1.2. Palaeocene limestone blocks

Blocks of Palaeocene limestones were sampled from a closest superincumbent of Cretaceous sandstones and conglomerates (site Vápenková skala, 31MK, coordinates N 48° 34´07.9´´, E 17° 23´14.7´´), as well as from the upperlying Miocene conglomerates. Size of blocks is different; in the visible ones, their diameter does not exceed 1.5 m (Figs. 2c, 2d). The blocks of Miocene conglomerates show signs of reworking, which cannot be said for those which are in direct overburden of sandstones and conglomerates and therefore their any longer transport has to be excluded.

An analysis of thin section material showed that the following microfacies types can be distinguished.

A. Corallinacean-coral packstone to rudstone

Micrite matrix with rare traces of weak washing coats frequent organic relics. Lithoclasts are missing or are very rare (fragments of carbonates up to 0.5 mm and fragments of quartz up to 0.1 mm).

The main organic component are nodules of *Elianella elegans* Pfender et Basse reaching in size up to 15 mm and showing various degree recrystallisation. Rare are nodules of *Parachaetes asvapatii* Pia. In some thin sections there are frequent (to dominant) fragments of coral patch-reefs, abundant are also solitary types and in some thin sections there are common (and dominant) fragments of coral patch reefs; abundant are also solitary types (*Dendrophyllia* sp.). Coralline algae *Sporolithon* sp., *Polystrata* sp. are present, sporadic are fragments of dasycladacean algae, bivalves, gastropods and crinoids. Among foraminifers *Haddonia praeheissigi* Samuel, Köhler et Borza, *Planorbulina cretae* (Marsson), *Sistanites* sp., *Textularia* sp. could be identified; abundant are miliolid and tiny rotaloid forms. Very rare are planktonic globigerinid forms.

Palaeo-environment of origination: sediment of this type originated in protected environment of the inner lagoon with very low water energy and with almost no contribution of detritic material with limited connections with the open sea.

Age: Upper part of SBZ 1 (Danian) – SBZ 2 (Selandian).

Fig. 2b. Site Vápenková skala, the quarry (upper part), the Malé Karpaty Mts. Polymict fine-grained and coarse-grained sandstones, conglomerates and biodetritic sandy limestone, Campanian-?Maastrichtian (limestones at Vápenková skala), Brezová Group.

Fig. 2c. Site Vápenková skala, Malé Karpaty Mts., below relay station at the edge of the asphalt road, block of Kambühel Limestone about 100 cm in diameter (flesh-tint-grey organogenic limestones), Palaeocene – upper part of Danian (SBZ 1) – Selandian (SBZ 2).

Fig. 2d. Site Vápenková skala, Malé Karpaty Mts., below relay station at the edge of the asphalt road, block of Kambühel Limestone about 100 cm in diameter (flesh-tint-grey organogenic limestones), Palaeocene – upper part of Danian (SBZ 1) – Selandian (SBZ 2). Detail: Broeckella packstone with slightly weathered dasycladacean algae (detail).

B. Elianella rudstone with Bangiana hanseni Drobne, Ogorelec et Riccamboni *(Pl. II, Fig. 1)*

Micrite matrix encases very frequent organic residues. Among lithoclasts fragments of quartz and carbonates up to 0.3 mm in size are present.

Dominant compound of thin sections are algae – nodules of *Elianella elegans* Pfender et Basse[2] reaching 12 mm, *Polystrata alba* (Pfender) Denizot indicates local growths up to 4.5 mm, very well preserved are nodules of *Sporolithon* sp., which make up also coatings on *Elianella*. Abundant are also fragments of corals (up to 13 mm), rare are fragments of bivalves, gastropods, ostracods and bryozoans. Among the foraminifers the most important are although sporadic, nevertheless present sections of Danian index fossils *Bangiana hanseni* Drobne, Ogorelec et Riccamboni (Pl. XXIV, Fig. 5). Represented are also various agglutinated forms (*Haddonia praeheissigi* Samuel, Köhler et Borza, *Textularia* sp., *Planorbulina* sp., *Sistanites* sp., *Smoutina* sp., *Mississippina* sp., miliolids and others.

[2] *In literature genus Elianella is often confused with the genus Parachaetetes. This problem was solved by Buček & Köhler (2005) stating that while genus Parachaetetes has a very regular symmetric internal structure, the genus Elianella (regardless of the cutting plane) shows very irregular internal structure.*

Palaeo-environment of origination: sediment formed in the back-reef protected environment water with low energy.

Age: SBZ 1 (Danian).

C. Packstone with Sarosiella feremollis Segonzac *(Pl. II, Fig. 4; Pl. VII, Fig. 1)*

In micrite matrix in addition to biocompounds also lithoclasts of carbonates (up to 5 mm) and quartz (up to 0.4 mm) are present. Cavities up to 0.6 mm in size are filled with sparite.

Among biocompounds dominant are sections of dasycladacean algae *Sarosiella feremollis* Segonzac, which is described from this site in more detail by Buček & Köhler (1987). Frequent are sections of crusts of coralline algae and structure-less grey crusts (?cyanobacteria), rare are *Elianella* sp., *Polystrata* sp., cyclo- and cheilostomate bryozoans, fragments of bivalves, gastropods, crinoids, corals and small rotaloid and miliolid foraminifers.

Palaeo-environment of origination: shallow-water protected environment of back-reef area out of wave action.

Age: Upper part of SBZ 1 (Danian) – SBZ 2 (Selandian).

D. Packstone with Broeckella belgica Morellet et Morellet *(Pl. II, Fig. 3)*

Flesh-tint-grey to white-grey micrite limestone almost without lithoclasts. Micrite matrix cements numerous organic remains, among which dominant are dasycladacean algae – *Broeckella belgica* Morellet et Morellet and *Neomeris* sp. (Fig. 2d.). Coralline algae form thin crusts; common are also fragments of *Polystrata* sp., *Elianella* sp., fragments of bivalves, gastropods, crinoids and corals. Small foraminifers are present in benthic forms of *Haddonia praeheissgi* Samuel, Köhler et Borza, *Miniacina* sp. and miliolid forms.

Palaeo-environment of origination: shallow-water protected environment of lagoonal area out of wave action.

Age: SBZ 2 (Selandian).

E. Packstone to grainstone with Pseudocuvillierina sireli (Inan)

Micrite cemented organic fragments of lithoclasts of carbonates and quartz are very rare. At places the rock attains a structure of the bindstone type.

Among biocompounds dominant are relics of nodules of *Elianella elegans* Pfender et Basse, frequent are also crusts and nodules of coralline algae (*Sporolithon* sp., *Polystrata alba* (Pfender) Denizot), among dasycladacean algae there are present sporadic sections of *Acicularia* sp., fragments of coral patch-reefs attain up to 15 mm dimensions, rare are fragments of bivalves, gastropods and ostracods. From the viewpoint of age dating of these microfacies important are foraminifers *Pseudocuvillierina sireli* (Inan) and *Globoflarina sphaeroidea* (Fleury). Community of foraminifers contains also *Haddonia* sp., *Placopsilina* sp., *Planorbulina cretae* (Marsson), *Sistanites* sp. and miliolids.

Palaeo-environment of origination: shallow-water, back-reef environment with low water energy and with minute contribution of detritic material.

Age: SBZ 2 (Selandian).

*F. Elianella packstone to rudstone with Miscellanites primitivus (*Rahaghi*)*

At places sandy biomicrite contains lithoclasts of quartz and carbonates. The fissures are filled-up with secondary quartz sand.

In the rock dominant are coralline algae making-up 70 % of the area of thin sections (*Sporolithon* sp., *Pseudoamphiroa propria* (Lemoine)), rare are fragments of bivalves, gastropods and bryozoans. Among foraminifers conspicuous are sections of *Miscellanites primitivus* (Rahaghi) and various tiny miliolid forms.

Palaeo-environment of origination: shallow-water, tidal, with wave action.

Age: SBZ 2 (Selandian).

G. Corallinacean-coral packstone to rudstone

In addition to micrite matrix along with biocompounds frequent are also lithoclasts of Mesozoic carbonates (up to 1.2 mm in size), rarer are fragments of quartz (up to 0.2 mm). The fissures and cavities in the rock are filled with sparite.

Coralline algae make up to 60% of the area of thin sections – dominating is the genus *Sporolithon* with up to 9 mm large nodules, rarer present are genera *Peyssonnelia*, *Elianella* and dasycladacean algae. Frequent are fragments of coral patch-reefs, which are distinctly corroded. Rarer are fragments of bivalves and gastropods, small foraminifers are present in miliolid and agglutinated forms.

Palaeo-environment of origination: shallow back-reef lagoon area with sporadic incidence of coral patch-reefs. Their breaking-up and erosion could evolve due to predators' activity.

Age: Upper part of SBZ 1 (Danian) – SBZ 2 (Selandian).

H. Corallinacean packstone-wackestone

Micrite matrix with sporadic lithoclasts of carbonates (up to 0.5 mm) and quartz (up to 0.1 mm) is cemented by up to 20 cm long variously warping crusts of coralline algae, dominantly of the genus *Sporolithon*. Complex algal structures protect the micrite matrix against washing-out in environment with energy of sea water. Rare are fragments of *Elianella* sp., *Polystrata* sp., *Pycnoporidium* sp. Rarely present is also large benthic foraminifer *Pseudocuvillierina sireli* (Inan), agglutinated tests of the type *Haddonia praeheissigi* Samuel, Köhler et Borza, *Planorbulina* sp., miliolids and rotaloids.

Palaeo-environment of origination: shallow-water, tidal with wave action.

Age: SBZ 2 (Selandian).

3.1.3. Evolution of Palaeocene carbonate platform in the Malé Karpaty Mts.

After origination of the nappe structure in the Malé Karpaty Mts., in the space of Považie and Veterlín nappes by the end of Cretaceous, in Campanian, shallow sea flooded the subsided parts. In a likely very limited space a sedimentation occurred of shallow-water sandstones with large foraminifers. There were not obtained any proves about the Maastrichtian continuation of this sedimentation, but it cannot be ruled out, because at the end of the Cretaceous interrupted sedimentation occurred, uplift and likely also intense erosion, karstifying and origination of *terra-rossa* and slope debris sedimentation (Gross & Köhler, 1989; Činčura, 1987, 1990, 1994; Činčura et al., 1991). Sedimentation was apparently interrupted during the interval at the K-T boundary (Cretaceous-Tertiary) and there is no evidence that it would be restored in Early Danian. In higher Danian (SBZ 1) very limited flooding and origination of carbonate platform likely occurred, upon which the shallow-water lagoonal sediments deposited with tiny coral-algal growths (patch-reefs). The formation of larger growths didn't occur due to unfavourable conditions. A comparable evolution was described by Vecsei & Moussavian (1997) for the Maiella platform in Italy.

Although at the site Vápenková skala there were identified only bioherm limestones of Early Palaeocene (Danian – Selandian), in the vicinity of the el. p. Vajarská at Rohožník blocks of limestones were found with *Glomalveolina primaeva* (Reichel) and at the site Ambrove vŕšky at Prievaly in carbonate sandstones there is present *Discocyclina seunesi* Douvillé (Buček in Polák et al., 2012). In Miocene conglomerate locality Kostolník at Vaďovce a carbonate cobble was found with *Glomalveolina primaeva* (Reichel), which proves for Palaeocene sedimentation to into Early Thanetian (SBZ 3), however in a limited space. After it a retreat of sea occurred, because by the beginning of the Early Eocene a new large-scale transgression occurred in the Malé Karpaty Mts. upon Mesozoic carbonates of the Považie Nappe (localities Korlátka and Jelenia hora at Plavecký Mikuláš; Buček in Polák et al., 2012, l.c.).

3.2. Myjavská pahorkatina Upland (Brezovské Karpaty Mts. included)

Dozens of reports and publications were devoted to various aspects of geological setting of the Myjavská pahorkatina Upland. Hereinafter are given only those which have directly affected the issue addressed in the present work.

Andrusov already in 1933 demonstrated Late Cretaceous age of the layers from Bradlo (at Brezová pod Bradlom) and Široké bradlo (at Priepasné) based on the presence of the species *Siderolites* (= *Pseudosiderolites*) *vidali* Douvillé.

Kühn & Andrusov (1937) described from the sites Brezová, U Kravárikov and Stará Turá species of corals, to which they attributed Santonian-Campanian age.

Andrusov (1950) in a monograph on the Carpathian Mesozoic fossils described also orbitoid foraminifers of the latest Cretaceous of the Myjavská pahorkatina Upland and he also mentioned various types of algae, among them he assigned to Senonian the Palaeocene most widespread algae in the Western Carpathians – *Elianella elegans* Pfender et Basse.

Mišík & Zelman (1959) published the first proves on the existence of coral-algal reefs in the Myjavská pahorkatina Upland. Some of the mentioned locations (vicinity of the el. p. Široké bradlo, Čirkov vrch Hill, Palčekov vrch Hill, U Kravárikov) were re-assessed and they will be listed in the hereinafter.

Salaj (1960, 1961) ranked coral-algal limestones in Danian (Early Palaeocene) and from reefs at the Jeruzalem Settlement (at the village Matejovec) he referred to the presence of an index Thanetian type – *Discocyclina seunesi* Douvillé.

Köhler (1961) from blocks at the Settlement Batíková and from Stará Turá described species *Discocyclina seunesi* Douvillé, *D. douvillei* (Schlumberger) and *Nummulites solitarius* de la Harps and reef limestones assigned into Middle Palaeocene to Early Eocene.

Salaj (1962) divided in detail the Late Cretaceous Palaeogene of the Myjavská pahorkatina Upland based on the study of profiles at Dolná and Horná Polianka at Bradlo, at the Settlement U Kravárikov and at the village Matejovec.

Köhler (1962) gave a description of Campanian and Maastrichtian large foraminifers from 6 sites in Brezovské Karpaty mountain range of the Malé Karpaty Mts.

Samuel & Salaj (1962) predicted in the area of the Brezovské Karpaty mountain range and the Myjavská pahorkatina Upland two facies – Gosau Cretaceous sediments with the overlying Palaeogene and Senonian Klippen Belt also with the overlying Palaeogene sequences and assumed that both facies gradually pass into each other. In 1963 Samuel & Salaj gave an overview of the geological setting of the Myjavská pahorkatina Upland in the Latest Cretaceous and in Palaeocene. They assigned the layers of the anticline Polianky into Danian and at places they assumed (U Kopeckých, Končiny) gradual transition from Cretaceous into Palaeogene. Flysch-like sequence with exotic conglomerates and blocks of reef limestones they assigned Middle Palaeocene to Early Eocene age.

Schaleková (1963) from reef limestones of the Brezovské Karpaty mountain range referred to presence of species belonging to the genera *Archaeolithothamnium* Rothpletz, *Lithothamnium* Philippi, *Mesophyllum* Lemoine, *Lithophyllum* Philippi, *Coralina* Linnaeus, *Jania* Lamouroux, *Acicularia* d´Archiac. Flysch-like sequence with exotic conglomerates and blocks of reef limestones she ranked to Early Palaeocene to Middle Eocene.

Among the species she described *Elianella elegans* Pfender et Basse, *Pseudolithothamnium album* Pfender and noted to the presence of dasycladacean green algae. Schaleková in 1964a published an inventory of calcareous algae from bioherm limestones the Brezovské Karpaty mountain range; she described and depicted some species.

Andrusov & Köhler (1963) defined "Myjava Facies" and contemplated on Ilerdian (Early Eocene) age of the formation with reef blocks.

In IIIrd Volume of the Geology of Czechoslovak Carpathians (Andrusov, 1965) the author describes Myjava facies of the Myjavská pahorkatina Upland and flysch sediments with bioherm limestones he ranked in the Palaeocene-Early Eocene.

Mišík (1966) handing inventory of Mesozoic and Tertiary microfacies of the Western Carpathians depicted and described on several photo-tables bioherm limestones from the Myjavská pahorkatina Upland.

Salaj & Samuel (1966) assigned into Early Palaeocene the limestones, in which large foraminifers *Operculina heberti* Munier-Chalmas, *Miscellanea* cf. *miscella* d´Archiac et Haime and *Discocyclina* aff. *seunesi* Douvillé are located.

Scheibner (1968) published a definition of by him demarcated zone Myjava-Hričov-Haligovka. From the Myjavská pahorkatina Upland he only referred to locality Lubina. According to him bioherm limestones are located in olistoliths of flysch formation of Palaeocene-Early Eocene age. The limestones originated in environment of open platform, some of them have features typical for the marginal reefs. The work by Scheibner (published in Munich) is yet frequently cited in literature on Palaeocene reefs.

Andrusov (1969) gave an overview of the findings of Palaeocene zone with bioherm limestones in the Western Carpathians. He noted that in the Myjavská pahorkatina Upland the Senonian sediments overlie transgressively Triassic basement. According to him, due to Laramian phase of folding between Cretaceous and Palaeogene, a hiatus occurred in sedimentation.

Samuel (1972) defined Váh Valley-Hanušovce sedimentation zone with different facies, among them he also mentioned Myjava facies.

Bystrický (1976) from sites Matejovec and Batíková described dasycladacean algae, species *Dactylopora* aff. *cylindracea* Lamarck, *Digitella radoičićae* Bystrický and *Broeckella belgica* Morellet et Morellet. Reef limestones of the Myjavská pahorkatina Upland he presumed to be older (Danian-?Montian) than the limestones of the Middle Váh Valley (Hričovské Podhradie).

Borza et al. (1977) gave an overview of orbitoid facies of Late Cretaceous in the Western Slovakia. From the Myjavská pahorkatina Upland and the Brezovské Karpaty mountain range they stated primary occurrences of limestones of Middle Campanian age in Jandova dolina Valley, Late Campanian are conglomerates at the sites Podlipovec, Sychrov, Široké bradlo and Bučkovci. Blocks of Campanian-Maastrichtian carbonates with large foraminifers are present also in Palaeogene conglomerates at the sites U Blatniakov and Stará Turá.

According to Marschalko (1980), in front of the central block of the Western Carpathians existed in Palaeocene to Early Eocene more than 400 km long furrow, which basement create Manín structures. Filling of the furrow includes also olistoliths of Palaeocene reefs stemming from northern-more exotic island arc.

Samuel et al. (1980) reported lithostratigraphic characteristic of Late Cretaceous and Palaeogene sediments of the Myjavská pahorkatina Upland. As Brezová Group they defined sedimentary cycle of Senonian age with Košariská, Podbradlo and Bradlo Fms. In the scope of the Bradlo Fm. (Latest Campanian-Maastrichtian) they defined limestones of Široké bradlo including orbitoid beds. As the Myjava Group they identified Palaeogene sedimentation cycle. In its framework they defined Kravárikovci Fm. (Palaeocene-Early Eocene) Priepasné Fm. (“Palaeocene”-Early Eocene), Lubina Fm. (“Middle”-Late Palaeocene-Early Eocene), Dedkov vrch Hill Fm. (Middle Palaeocene to Early Eocene) and Jablonka Fm. (Middle-Late Eocene to ?Oligocene).

Salaj & Began (1983, in Salaj, et al., 1987) provided an outline of Senonian and Palaeogene palaeogeographic facies of the Myjavská pahorkatina Upland. Based on lithofacies and stratigraphic differences they distinguished in the Late Cretaceous and Palaeogene 4 facies: Bradlo facies (south, with age range Coniacian and Early Eocene with hiatus corresponding Danian and “Montian”), Stará Turá facies (transitional in the range Palaeocene to Early Eocene), Surovín facies (northern, in the range Campanian to Late Eocene) and Rašov facies of the peripheral type at the northern edge of the Klapy sedimentary zone (Santonian-Campanian). They compared these facies with the facies in the Northern Limestone Alps and noted to significant differences.

Köhler et al. (1993) attempted to reconstruct the Palaeocene reef complex and distinguished limestones of Danian-“Montian” and limestones of Thanetian age. According to place of origination they distinguished facies of lagoonal environment, reef structures and fore-reef slope. The linking between the Myjava sedimentation area and Eastern Limestone Alps, they considered very likely. In Danian-“Montian” – they delineated biomicrites with *Elianella* (U Kravárikov, Dlhý vŕšok), biomicrites with dasycladacean algae (Jandova dolina Valley, U Kravárikov), biomicrites with corals (U Kravárikov) and biosparites (Jandova dolina Valley). In Thanetian in reef structure they defined biomicrites with massive corals (Hodulov vrch Hill and Stará Turá), biomicrites with corals and coralline algae (Stará Turá), biomicrites with corals and bryozoans (Hodulov vrch Hill, Stará Turá) and in fore-reef facies biosparites with coralline algae (Juríkovci, Tižíkovci, Hodulov vrch Hill) and biosparites with fragments of coralline algae, corals, bryozoans, bivalves and other fossils (Tižíkovci, Drahý vrch Hill). Sedimentary basin was located along the inner side of the Klippen Belt and its destruction occurred in Late Thanetian.

Köhler (1995) in an unpublished PhD. dissertation described from 23 sites in the Myjavská pahorkatina Upland 147 samples of Palaeocene age, of them 15 in situ, the rest represent redeposited blocks. The results of his analyses are a part of the submitted work.

Tragelehn (1996, 2000) at a description of the sediments of Late Cretaceous and Palaeocene on the southern edge of the Limestone Alps noted that he picked also samples from some Slovak sites. In the Myjavská pahorkatina Upland he wanted to take samples by Scheibner (1968) at the site Lubina, but whereas he failed to identify it, he selected samples from the fields at the eastern edge of the village Lubina and after their reviewing he ranked them into Later Thanetian.

Buček & Köhler (2005) at a description of algae *Elianella elegans* Pfender et Basse referred also to site Matejovec – the village and Dlhý vŕšok Hill in the Myjavská pahorkatina Upland (Buček, 2010).

In 2014 there was published Geological Map of the Biele Karpaty Mts. (southern part) and Myjavská pahorkatina Upland 1: 50 000 (Potfaj & Teťák et al.) and in 2015 Explanatory Notes to this map (Teťák & Potfaj et al.). The authors of the map assigned Palaeocene-Early Eocene sediments of the Myjavská pahorkatina Upland to Myjava-Hričov Group. They found that the Palaeogene sediments among Brezová pod Bradlom, Myjava and Lubina originally formed one space and during sedimentation they were linked to each other. In the Myjava-Hričov Group they defined:

- Kambühel Limestone: reef and bioclastic limestones (Palaeocene-Early Eocene);
- Kravárikovci Fm. (Palaeocene-Early Eocene); claystones and clays of Myjava brickworks (Late Palaeocene-Early Eocene);
- Surovín Fm. (Late Palaeocene-Early Eocene);
- Lubina Fm. (Eocene);
- Calcarenites and carbonate conglomerates at Roh and Tučkovci (?Eocene).

After combining thin section material by Buček, Köhler and Bystrický from the Myjavská pahorkatina Upland there were analysed and for the research used 357 thin sections of the Late Cretaceous and 1,641 thin sections of samples from the Palaeocene and Early Eocene.

3.2.1. Upper Cretaceous basement of Palaeogene reef complex

During the Late Cretaceous the Myjavská pahorkatina Upland area was gradually flooded by sea, in which shallow-water sediments and sediments of deeper sea deposited. Deep-water marl environment and flysch sediments were not suitable for the basement of the Palaeocene carbonate platform. However, a solid basement provided shallow-water Campanian-Maastrichtian sandstones and organodetritic limestones, designated by Potfaj & Teťák et al. (2014) as limestones of Bradlo Fm. [in the geologic map of the Myjavská pahorkatina Upland 1 : 50 000 (Began et al., 1984) they were identified as limestones of Široké bradlo]. In the Myjavská pahorkatina Upland these limestones and sandstones occur either as autochthonous (in situ), or replaced in the Eocene strata in the form of blocks.

The best-known occurrences of autochthonous Late Cretaceous limestones and sandstones of Bradlo Fm. are:

a) Vicinity of the mound of Bradlo above Brezová pod Bradlom. In the vicinity of the relay station (el. p. 538 Krátky vŕšok Hill; 1MY; coordinates N 48° 40.819´, E 17° 33.91´, Fig. 3a) there are exposed organodetritic carbonate sandstones and sandy limestones, which Campanian age is indicated by the presence of the species *Orbitoides tissoti* Schlumberger. East of the mound on the ridge continuing from the el. p. Bradlo there are sporadic exposures of biodetritic carbonate sandstones, at places rich in algae fragments and needles of sponges. The Campanian age is confirmed by the community of large foraminifers *Orbitoides tissoti* Schlumb., *O. media* (d´Archiac), *Pseudosiderolites vidali* (Douvillé) and *Lepidorbitoides minima* Douvillé.

b) Priepasné – S of Jandova dolina Settlement (6MY; coordinates N 48° 41.594´, E 17° 33.787´, Fig. 3b). In the wall of the abandoned quarry W. of Settlement Hrajnohovci (60 – 75 m x 20 – 25 m) there alternate fine-grained and coarse-grained biodetritic sandstones to sandy limestones. They contain fragments of rudists-radioliths, coralline algae and bivalves. Again, Campanian age is confirmed by large foraminifers *Orbitoides tissoti* Schlumb., *O. media* (d´Archiac) and *Pseudosiderolites vidali* (Douvillé).

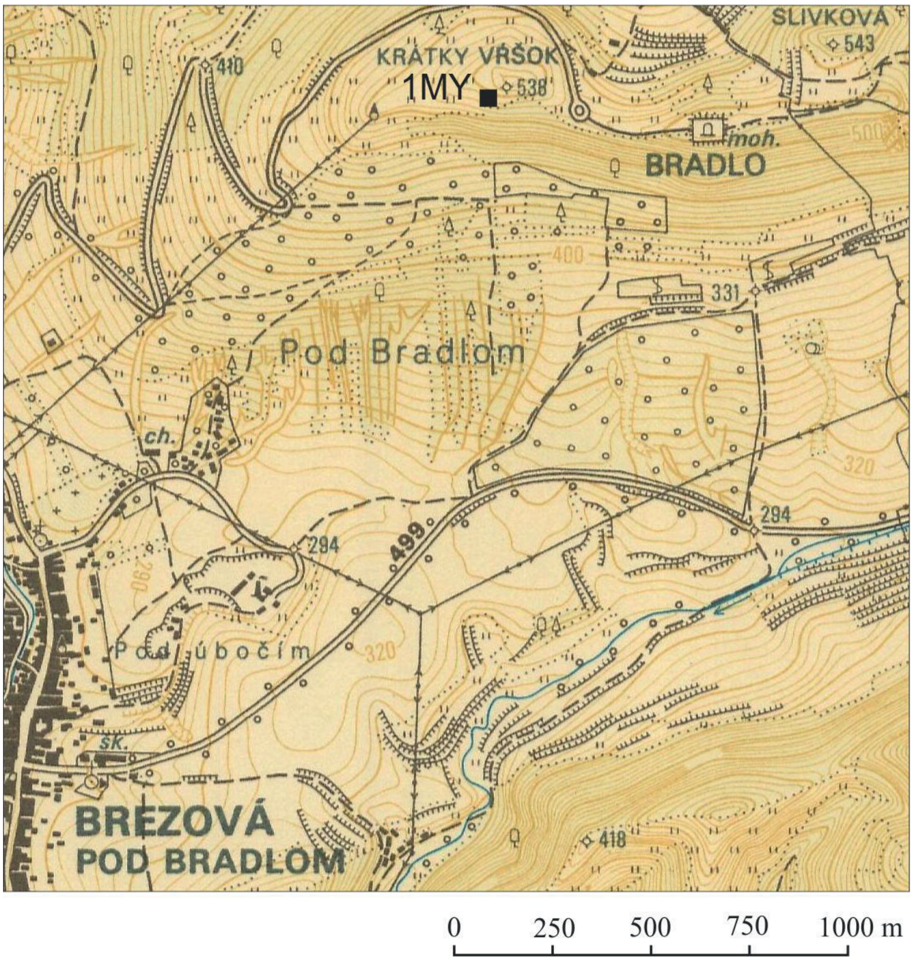


Fig. 3a. Situation map of the site Krátky vŕšok Hill (relay station) at Mound Bradlo – ▪ 1MY at scale 1 : 25 000 (map sheet 35-312 Brezová pod Bradlom).

c) At state road from Priepasné to Horné Košariská, S. of Dlhý vŕšok Settlement the site Široké bradlo is located at the road (Fig. 3b) – 9MY (el. p. 476 Zadný vŕšok Hill). Coordinates 48° 41.339´, E 17° 35.561´. It is inconspicuous site, but from times of Andrusov, in literature well-known site of sandy limestones with fragments of Mesozoic carbonates and quartz. The rock is very rich in tests of Campanian index fossil *Pseudosiderolites vidali* (Douvillé); present are also *Orbitoides tissoti* Schlumb. and *Lepidorbitoides minima* Douvillé (Pl. I, Fig. 2). Organic community replenished by fragments of coralline algae, bryozoans, rudists and other benthic foraminifers.

d) In the forest SW of the Village Matejovec in old quarry – 35MY (coordinates N 48° 42´45.2´´, E 17° 37´25.1´´, Fig. 3c) there are exposed biodetritic limestones containing frequent bioclasts, among which are in prevail fragments of rudists. Community of large foraminifers again indicates Campanian age (*Orbitoides tissoti* Schlumb., *O. media* (d´Archiac) and *Pseudosiderolites vidali* (Douvillé).

e) At Stará Turá there was found block of sandstone with *Orbitoides gensacicus praevius* Köhler, Early Maastrichtian in age (Pl. I, Fig. 4).

f) Rocks of Campanian-Maastrichtian age also occur as blocks along with blocks of bioherm Palaeocene carbonates in Early Eocene formations. For instance, at the site Kravárikovci at the Hurbanova dolina Settlement – 3MY (coordinates N 48° 42.406´, E 17° 32.135´, Fig. 3b) there was inspected a block of carbonate sandstone with *Orbitoides media* (d´Archiac) and *Pseudosiderolites vidali* (Douvillé). Between settlements Jeruzalem and Sychrov at Matejovec there were found 3 blocks of Campanian sandstones with *Orbitoides tissoti* Schlumb. and *Pseudosiderolites vidali* (Douvillé).

Block from the site Priepasné-Blatniakovci makes up quartzose sandstone extremely rich in tests of *Orbitoides apiculata plana* Köhler and *O. gensacicus praevius* Köhler, which are Early Maastrichtian in age.

During origination of Palaeocene bioherm limestones on the carbonate platform, there was also broken-up their Upper Cretaceous substrate. It is documented by redeposited tests of Cretaceous large foraminifers in blocks of Palaeocene limestones. The not insignificant scale of this process is testified by redeposited Late Cretaceous foraminifers found in 30 Palaeocene blocks at 10 sites (Ušiakovci, ridge of the Surovín Hill, Drahý vrch Hill, Hodulov vrch Hill, Tížikovia, Juríkovci, Matejovec, Stará Turá, Krásny vrch and Miškech Dedinka settlements). In majority cases Campanian species were replaced (*O. tissoti* Schlumb., *P. vidali* (Douvillé)), but in blocks from sites Hodulov vrch Hill, Juríkovci, Krásny vrch Hill, Ušiakovci and Drahý vrch Hill there are also Maastrichtian large foraminifers (*Orbitoides apiculata* Schlumb., *Siderolites calcitrapoides* Lamarck and *Hellenocyclina beotica* Reichel).

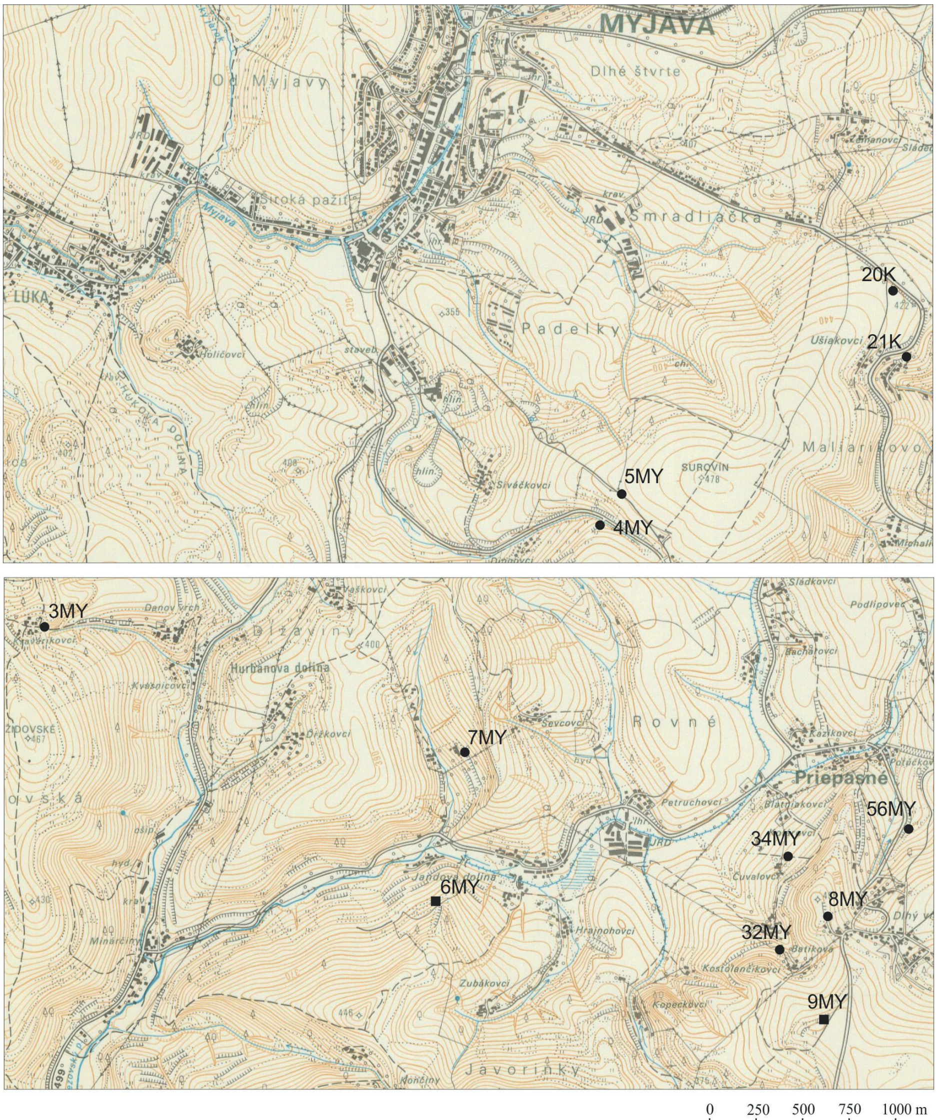


Fig. 3b. Situation map of Cretaceous (▪3MY, ▪6MY, ▪9MY) and Palaeocene (•3MY, •4MY, •5MY, •6MY, •7MY, •8MY, •32MY, •34MY, •56MY, •20K, •21K) sites in the Myjavská pahorkatina Upland at scale 1 : 25 000 (map sheet 35-134 Myjava).

Campanian and Maastrichtian large foraminifers were replaced also into the slope sediments between the carbonate platform and the open sea. At the site Dedkov vrch Hill there can be seen the alternation of biodetritic limestones to sandstones with thick claystone positions. In the sandstones, in addition to Thanetian fossils, there are also tests of *Orbitoides* sp., *Siderolites calcitrapoides* Lamarck and *Nummofallotia* sp.

In the Myjavská pahorkatina Upland unequivocal proves for the sedimentation in the Latest Maastrichtian, at the Cretaceous-Tertiary boundary and in the Earliest Palaeocene – Danian, are lacking. It was a period of regression, during which occurred significant erosion of Late Cretaceous shallow-water sediments.

3.2.2. Palaeocene bioherm limestones

Within an area of about 70 square kilometres (8.5 x 20 km) in the Myjavská pahorkatina Upland virtually everywhere crop out to the surface Early Eocene Kravárikovci or Lubina Fms.; there could be found plenty blocks of Palaeocene limestones ranging in size from 20 cm to 100 cm, but rarely there are also larger blocks; the largest in the Jandova dolina Valley has a diameter of 15 m. They are redeposited relics of Palaeocene carbonate platform, which was created upon the Upper Cretaceous substrate. Although in the literature opinions can be found about the gradual transition from the Cretaceous to Palaeocene (Samuel & Salaj, 1963), for this argument currently there are no clear and unequivocal proves (iridium anomaly, negative carbon isotopes excursion – CIE).

As previously listed, according to the explanatory notes to Geological Map of the Biele Karpaty Mts. (southern part) and Myjavská pahorkatina Upland 1 : 50 000 (Teťák & Potfaj et al., 2015), Palaeocene and Early Eocene sediments of the Myjava-Hričov Group containing rocks of the Palaeocene reef complex can be included in:

- Kravárikovci Fm.;
- Surovín Fm.;
- Lubina Fm.;
- Calcarenite and carbonate conglomerates at Roh and Tučkovci.

a) Kravárikovci Fm. (Palaeocene-Early Eocene)

This 200 – 300 m thick Fm. consists of different lithofacies. In lithofacies designated as coarse conglomerates occur polymict blocks of limestone reef complex. Material of conglomerates has varied composition of siliceous porphyry and quartz through Mesozoic limestones and dolomites till bioherm Palaeocene limestones. Salaj's (1962) opinion on Palaeocene age of conglomerates of the Kravárikovci Fm. has not been confirmed, yet.

1. Kravárikovci

It is the westernmost occurrence of Palaeocene bioherm limestones in the Myjavská pahorkatina Upland. The most famous block described by Andrusov (1965) reaching 120 cm in diameter (Fig. 3d) is located in the Hurbanova dolina Valley at the road from Settlement Danov vrch Hill to Settlement Kravárikovci (= U Kravárikov) 6 km north of Brezová pod Bradlom – 3MY (coordinates N 48° 42.406´, E 17° 32.135´, Figs. 3b, 3d), but further blocks are also in the gorge below the road and the forest north of the Settlement.

In more detail 14 blocks of Palaeocene limestones were analysed. The presence of the species *Miscellanites*

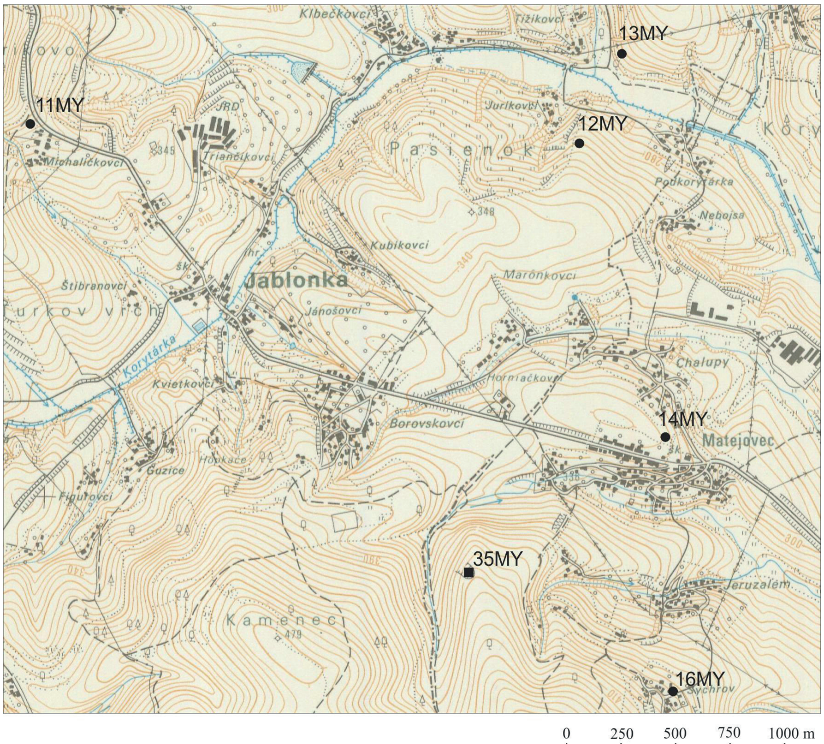


Fig. 3c. Situation map of Cretaceous (▪35MY) and Palaeocene (•11MY, •12MY, •13MY, •14MY, •16MY) sites in the Myjavská pahorkatina Upland at scale 1 : 25 000 (map sheet 35-134 Myjava).

primitivus (Rahaghi) and mass occurrence of algae *Elianella elegans* Pfender et Basse affiliates these limestones into Selandian (SBZ 2 sensu Serra-Kiel et al., 1998). It is interesting that here occur all the major facies of the reef complex (fore-reef, reef and back-reef).

2. Jandova dolina Settlement

NE of Settlement Jandova dolina at Priepasné – 7MY (coordinates 48° 42.004´, E 17° 33.961´, Fig. 3b), NE of the old school building on an area of about 200 x 200 m there are scattered large number of blocks, among them the largest block yet found in Myjavská pahorkatina Upland – 15 x 6 m reaching in size.

12 blocks were examined in more detail. According to the present bio-components they originated in the period Selandian-Early Thanetian (SBZ 2 and 3) in different environments of the reef complex. The largest block comes from fore-reef environment and its thickness (6 m) suggests that it had evolved in the highest part of moderately dipping slope.

3. Priepasné – Batíková

SW of Priepasné, W. of the road from Košariská to Priepasné, directly in the Settlement Batíková – 8MY (coordinates 48° 41.560´, E 17° 35.441´, Fig. 3b) and mainly in the vicinity of el. p. 453 in the direction towards Široké bradlo – 32MY (coordinates 48° 41´29.2´´, E 17° 35´15.4´´, Fig. 3b) within the area of more than 1 km² there are located large number of blocks from disintegrated Kravárikovci conglomerates. Pale-grey to pale-yellow colours signalize blocks of Palaeocene limestones. From the blocks at this site (32MY) Bystrický (1976) described dasycladacean algae *Broeckella belgica* Morellet et Morellet and Köhler (1961) Thanetian index large foraminifer *Discocyclina seunesi* Douvillé.

Fig. 3d. Site Kravárikovci, Myjavská pahorkatina Upland. Block of 120 cm diameter "Kambühel" Limestone (flesh-tint-grey organogenic limestone) Palaeocene – Selandian (SBZ 2). This site was mentioned by Andrusov (1965, p. 214, Settlement Kravárikovci).

From different places in the immediate surroundings of the village there were selected and analysed 19 blocks. The blocks represent all reef environments – back-reef lagoonal (miliolid and dasycladacean limestones), tiny reef structures (coral-algal patch-reefs) as well as assorted washed-out sandy rocks of the fore-reef slope. They fall into age range Selandian (*Miscellanites primitivus* (Rahaghi) and *Globoflarina sphaeroidea* (Fleury)) to Early Thanetian (*Discocyclina seunesi* Douvillé), i.e. into interval SBZ 2 – SBZ 3. In thin section material from this site Bystrický found *Microcodium* sp., proving for emersion phase.

4. Dlhý vŕšok

Settlement of this name is located SSE of Priepasné Village – 56MY (coordinates N 48° 41´ 50´´, E 17° 35´49.61´´, Fig. 3b). The continuation of Kravárikovci conglomerates from area Batíková is exposed here. In fields and pits at the edge of the road there are dissipated frequent blocks of Palaeocene bioherm limestones.

There were examined 13 blocks, which could be affiliated into back-reef as well as fore-reef environment. Many blocks show traces of karstifying and later filling-up of formed karst cavities with quartz sand. The age of the blocks ranks them into Selandian (*Sarosiella feremollis* Segonzac) and to Early Thanetian (*Discocyclina seunesi* Douvillé and *Miscellanea juliettae* Leppig) – into SBZ 2 – SBZ 3.

5. Priepasné – Blatniakovci

On the slope above the Settlement of this name SW of Priepasné – 34MY (coordinates N 48° 41´34.7´´, E 17° 35´14.8´´, Figs. 3b, 3e), today notably covered with scree, sporadic blocks of carbonates could be found. Besides the already mentioned Early Maastrichtian block in further 4 blocks there were identified lagoonal back-reef sediments and in one block the coral structure, Thanetian in age.

6. Matejovec

Large pit exposure in Kravárikovci Fm. at a school and in the fields around the Matejovec Village – 14MY (coordinates N 48° 43.108´, E 17° 38.280´, Fig. 3c), some 2 km SE of Jablonka, provided blocks material, in which Bystrický (1976) studied Palaeocene dasycladacean algae and from this site described also new species *Zittelina radoičicae* (Bystrický). Today this exposure is filled-in and inaccessible. However, it doesn't matter, because dozens of blocks of yellow-white Palaeocene limestones could be found in meadows and fields mainly towards the Settlement Chalupy. Blocks have various dimensions from 10 to 100 cm in diameter.

In various time periods 32 blocks from this site were collected and sampled. Among them whole range of reef environments could be found. Lagoonal environment is characterised mainly by blocks with algae *Elianella*

Fig. 3e. Site Priepasné – Blatniakovci Settlement, Myjavská pahorkatina Upland. The block of "Kambühel" Limestone with a diameter of 100 cm at the field road, Kravárikovci Fm., Palaeocene age – Thanetian (SBZ 3 – 4).

elegans PFENDER et BASSE and with dasycladacean algae. Fragments of coral patch-reefs could be components of tiny reefs. Fore-reef environment is characterised by large foraminifers, cheilostomate bryozoans and sporadic planktonic foraminifers. The contemporary destruction of Late Cretaceous sediments is indicated by replaced tests of Maastrichtian species *Siderolites calcitrapoides* LAMARCK and *Orbitoides* sp. The age of the blocks from the site Matejovec ranks them into Selandian to Early Thanetian (SBZ 2 – SBZ 3).

7. Jeruzalem and Sychrov

Small Settlement Jeruzalem is located 1 km South of Matejovec Village. From the fields between this Settlement and Settlement Sychrov blocks of bioherm limestones were collected and placed at the edge of the road, but larger blocks have remained in the fields. The largest block of 4 m diameter was exposed in the pit at the edge of the road to the Settlement Sychrov– 16MY (coordinates N 48° 42.564´, E 17° 38.296´, Fig. 3c), but the pit is recently filled with building waste.

Also from this site samples were collected in various time periods and in the course of the last 50 years thin section material has been collected from 33 blocks.

In the Settlement Sychrov there are exposed Campanian sandstones with numerous large foraminifers and therefore it is not surprise, that among blocks of Palaeocene bioherm limestones also blocks of Campanian sandstones and sandy limestones are present.

Palaeocene rocks belong into all reef environments. Back-reef lagoonal sediments with minimum contribution of terrigeneous material are in prevail. Sporadic coralline patch reefs may originate from tiny coral growths. In fore-reef sediments planktonic foraminifers from the open sea environment are not rare. Majority of blocks is Thanetian in age [with frequent *Glomalveolina primaeva* (REICHEL)], but presence of *Miscellanites primitivus* (RAHAGHI) indicates also Selandian age of some blocks.

8. Juríkovci

NE of Jablonka in the valley of the creek Korytárka in fields between settlements Juríkovci – 12MY (coordinates N 48° 43.961´, E 17° 38.280´, Fig. 3c) and Podkorytárka there are dissipated smaller blocks (up to 30 cm diameter) of flesh-tint-grey to flesh-tint-pinkish bioherm limestones. 19 blocks were evaluated.

Striking is frequent occurrence of blocks of back-reef lagoonal environment, which is represented by algal-coral biomicrites with abundant presence of coralline algae (*Elianella elegans* PFENDER et BASSE, *Polystrata alba* (PFENDER) DENIZOT, *Sporolithon* sp.), there occur also dasycladacean algae (*Sarosiella feremollis* SEGONZAC, *Broeckella* sp., *Cymopolia* sp., *Zittelina* sp.) and to 25 mm large re-worked fragments of coral patch-reefs. Blocks, in which large foraminifers *Globoflarina sphaeroidea* (FLEURY) and *Miscellanites primitivus* (RAHAGHI) are located, fall into Selandian (SBZ 2), blocks with *Miscellanea juliettae* LEPPIG into Early Thanetian (SBZ 3). Several blocks represent fore-reef slope sediments with frequent lithoclasts of variegated composition. In biocompounds there are frequent fragments of coralline algae, bryozoans; large foraminifers *Discocyclina seunesi* DOUVILLÉ and *Orbitoclypeus ramaraoi* (SAMANTA) are present, Thanetian in age. In some blocks there are present washed-in Late Cretaceous large foraminifers, such as *Siderolites calcitrapoides* LAMARCK, *Orbitoides* sp. and *Hellenocyclina beotica* REICHEL.

9. Tížikovci

NE 250 m of the Settlement Juríkovci on the ridge between settlements Tížikovci – 13MY (coordinates N 48° 44.213´, E 17° 38.186´, Fig. 3c) and Švancarova dolina in the fields large amount of up to 1 m large blocks of flesh-tint-grey, pink-yellow and red-brown limestones are located. After ploughing of the fields large accumulations of blocks can be seen at places. 17 blocks were examined.

Only 3 blocks could be affiliated into back-reef environment They are made of algal biomicrites, in one block there are also frequent fragments of massive and branched corals. Species *Miscellanites primitivus* (Rahaghi) ranks them into Selandian (SBZ 2). In blocks of fore-reef slope sediments 5 mm large clasts of back-reef biomicrites are frequent. Common are also re-worked, distinctly disturbed thalli and nodules of coralline algae; abundant are cheilostomate and cyclostomate bryozoans, tubes of worms and variegated communities of foraminifers, among which planktonic foraminifers are not lacking. Majority of blocks contains also large foraminifers *Discocyclina seunesi* Douvillé, *Operculina heberti* Munier-Chalmas, Early Thanetian in age (SBZ 3). Rare *Ranikothalia sindensis* Davies falls into Late Thanetian (SBZ 4).

10. Michaličkovci

At the road from Myjava into Jablonka 1 km NW of Jablonka at the Settlement Michaličkovci – 11MY (coordinates N 48° 44.004´, E 17° 35.859´, Fig. 3c) sporadic blocks of bioherm limestones are located. They originate from fore-reef slope environment and both examined blocks were Thanetian in age.

b) Surovín Fm.

According to Salaj et al. (1987) this is a northern facies, which succession consists of sediments of Late Cretaceous and Palaeogene age. Potfaj & Teťák et al. (2014) and Teťák & Potfaj et al. (2015) gave the name to the formation with high share of biodetritic limestones in ridge complex of Surovín – Dedkov vrch Hill. Maximum thickness of the Fm. is estimated to ?700 m and its age interval according to Teťák & Potfaj et al. (l.c.) is from Late Palaeocene till Early Eocene.

While in the above Fm. the Palaeocene layers in the original position have not been preserved, in the Surovín Fm. in the area between Myjava and Jablonka primary autochthonous occurrences were studied at 4 sites. In all cases they are deep-water sediments from the lowermost part of the slope of a carbonate platform or a basin floor.

11. Dedkov vrch

Settlement Dedkov vrch – 4MY (coordinates N 48° 43´54´´, E 17° 34´37.83´´, Fig. 3b) is located 3 km SE of Myjava and at the site a marlstone formation is exposed with sporadic thick layers of biodetritic limestones. Two examined samples of limestones show typical sediments, washed into a depression from shallower areas of the basin. They contain clasts of quartz, crystalline rocks, quartzose sandstones, Mesozoic marlstones and carbonates, but also tiny fragments of Palaeocene micritic limestones detached from carbonate platform. In organic community fragments of coralline algae are frequent. Community of large foraminifers is very variegated and contains both replaced shallow-water lagoonal species *Glomalveolina primaeva* (Reichel), as well as species bound to deeper environment, such as *Operculina azilensis* Tambareau, *Discocyclina seunesi* Douvillé, *Orbitoclypeus ramaraoi* (Samanta). Common are also redeposited tests of Late Cretaceous large foraminifers *Siderolites calcitrapoides* Lamarck, *Nummofalotella* sp. and *Orbitoides* sp. Relatively thin horizons of limestones (15 – 30 cm thick) place this rock into a deeper marine environment, maybe beyond the slope of the carbonate platform. Organic communities define Thanetian age of the Surovín Fm. (SBZ 3 – 4).

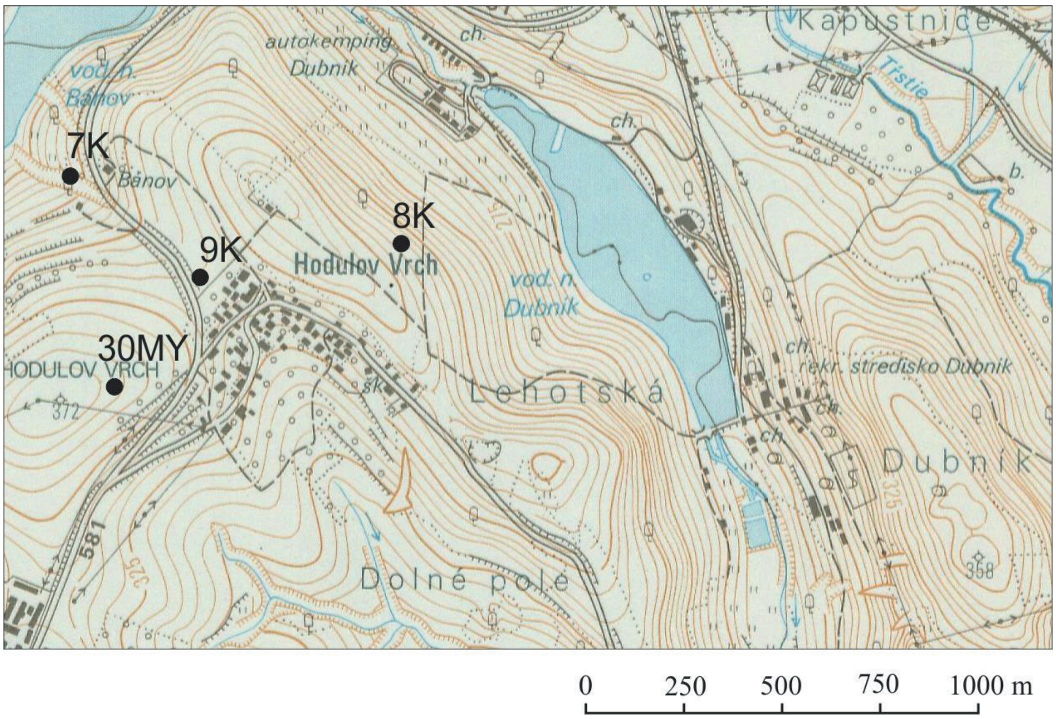


Fig. 3f. Situation map of Palaeocene sites (•30MY, •7K, •8K, •9K) of the Myjavská pahorkatina Upland at scale 1 : 25 000 (map sheet 35-143 Čachtice).

12. Surovín

Between the road from Myjava to Polianky and Surovín ridge (el. p. 478) – 5MY (coordinates N 48º 44.011´, E 17º 34. 666´, Fig. 3b) at the site a marlstone formation is exposed with sporadic up to 25 cm thick beds of detritic limestones. At various places 3 samples were collected not differing significantly from each other.

In opposite to the locality Dedkov vrch, the lithoclasts composition is more monotonous, with dominating clasts of quartz, rarer are the clasts of Mesozoic carbonates. Only in one sample there were found fragments of algal-foraminifers biomicrites of Palaeocene age washed-in from shallow-water back-reef environment. Among biocompounds fragments of coralline algae are in prevail (they make up to 50 % of the rock volume). Large foraminifers are not frequent, but presence of *Orbitoclypeus ramaraoi* (Samanta) allows no doubts on the Thanetian age. Again, redeposited Maastrichtian large foraminifers *Orbitoides media* d´Archiac and *Siderolites calcitrapoides* Lamarck are present.

13. Road Myjava – Ušiakovci

Relatively coherent profile is located above the state road from Myjava into Jablonka. It begins approx. 500 m before Settlement Ušiakovci – 20K (coordinates N 48º 44.641´, N 017º 35.858´, Fig. 3b) and terminates close before the Settlement. Although the formation is strongly weathered, it is possible to observe up to 15 cm thick layers of detritic limestones with clasts of variegated composition, among which fragments of quartz, crystalline rocks, quartzites, quartzose sandstones, dolomites and limestones, Senonian marlstones with globotruncanoids and fragments of Palaeocene biomicrites are present. Rare are grains of glauconite, aggregates of Fe oxides and pyrite.

In all samples there are present large foraminifers of Thanetian age (SBZ 3 – 4), such as *Discocyclina seunesi* Douvillé, *Orbitoclypeus ramaraoi* (Samanta) and *Operculina azilensis* Tambareau and tests replaced from shallow environment of *Glomalveolina primaeva* (Reichel) and *Coskinolina* sp. Frequent are fragments of coralline algae and cyclostomate bryozoans, which are typical for deeper marine environment. Common are also planktonic foraminifers and tests of Campanian (*Orbitoides tissoti* Schlumb.) and Maastrichtian (*Siderolites calcitrapoides* Lamarck) large foraminifers.

14. Ušiakovci

At the northern edge of the Settlement Ušiakovci – 21K (coordinates N 48° 44´24´´, E 17° 35´57.58´´, Fig. 3b) below the road there are located up to 60 cm diameter large blocks of biodetritic limestones.

Three examined blocks of them originated from fore-reef slope environment. The rocks contain large clasts of quartz, various Mesozoic carbonates, sporadically also marlstones. Notable are large fragments of massive corals; frequent are broken coralline algae. Redeposited from Senonian are *Inoceramus* plates as well as Maastrichtian large foraminifers (*Hellenocyclina beotica* Reichel, *Orbitoides media* d´Archiac). Presence of the species *Orbitoclypeus ramaraoi* (Samanta) ranks the blocks into Thanetian.

15. Exposure of rocks above the road Stará Turá – Hrašné

Above the edge of the road from Stará Turá to Hrašné, approx. 1 km N of Settlement Hodulov vrch – 7K (coordinates N 48° 45´45´´, E 17° 40´32.94´´, Fig. 3f) flysch formation with beds of biodetritic limestones is exposed. The limestones contain Thanetian large foraminifers *Discocyclina seunesi* Douvillé, *Orbitoclypeus ramaraoi* (Samanta), *Miscellanea juliettae* Leppig and from Senonian redeposited tests of large foraminifers *Orbitoides apiculata* Schlumb. and *Siderolites calcitrapoides* Lamarck. Frequent are fragments of coralline algae, bryozoans, fragments of coral patch-reefs, tubes of worms and various small foraminifers. This flysch sediment originated on marine slope and in addition to the Thanetian bioclasts of the slope environment it contains also redeposited part of reef complex washed-in by currents down the slope into open sea.

16. Water reservoir Dubník

In the slope above NW bank of the water reservoir Dubník – 8K (coordinates N 48° 45´49´´, E 17° 41´15.13´´, Fig. 3f) at Stará Turá there are exposed weathered horizons of biodetritic limestones, which besides frequent lithoclasts contain also large Thanetian foraminifers (*Glomalveolina primaeva* (Reichel), *Discocyclina seunesi* Douvillé, *Coskinolina* sp., *Daviesina* sp.) and from Late Cretaceous redeposited tests *Orbitoides media* d´Archiac. Frequent are broken nodules and thalli of coralline algae (mainly *Polystrata alba* (Pfender) Denizot), fragments of bivalves, gastropods, but also from Late Cretaceous replaced Inoceramus plates. Accounting for small thickness of biodetritic limestones layers (up to 30 cm) also this sediment has to be placed into a deeper marine fore-reef basinal environment.

c) Lubina Fm.

According to Salaj et al. (1987) Lubina Fm. (defined by Samuel et al., 1980) attains a thickness of 800 to 1000 m and it contains alternating marlstones, detritic limestones (calcarenites), coarse-grained detritic limestones (calcirudites), conglomerates and organogeneous limestones. Palaeocene-Early Eocene age of the Fm. was determined based on planktonic foraminifers and calcareous nanoplankton.

Potfaj & Teťák et al. (2014) and Teťák & Potfaj et al. (2015) defined Lubina Fm. as a flysch sequence with local occurrence of beds of conglomerates and slump bodies – olistostromes with abundant blocks of reef limestones. The formation is extended between Lubina and Stará Turá and it should be dated as Eocene.

17. Hodulov vrch

At the road from Stará Turá to Hrašné in the fields and at the edge of the forest at the Settlement Hodulov vrch – 9K as well as on the eastern slope Hodulov vrch Hill (el. p. 372) – 30MY (coordinates N 48° 45´46.7´´, E 17° 40´44.9´´, Fig. 3f) there are dissipated up to 1,5 m large blocks of Palaeocene bioherm limestones.

Samples were collected from 16 blocks. Analyses of thin sections have shown, that the rarest are blocks of

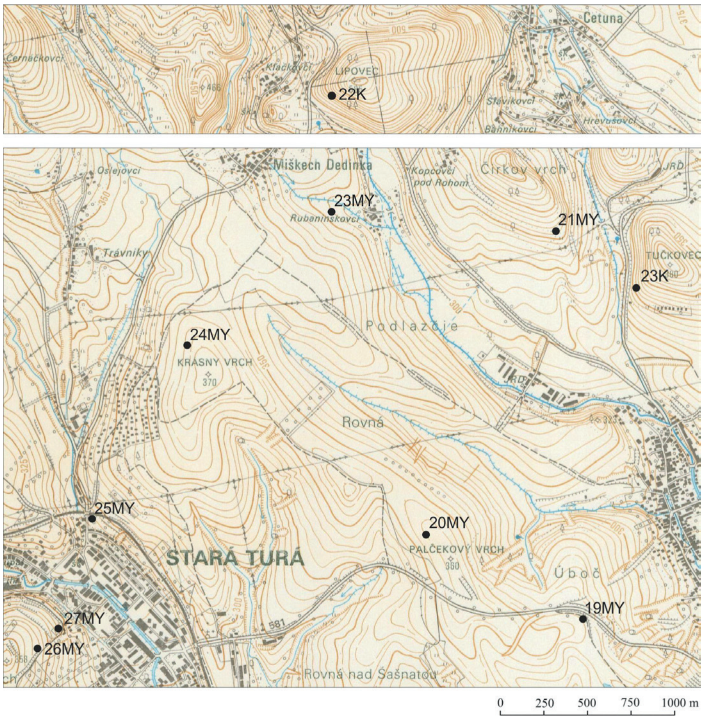


Fig. 3g. Situation map of Palaeocene sites (•19MY, •20MY, •21MY, •23MY, •24MY, •25MY, •26MY, •27MY, •23K) Myjavská pahorkatina Upland at scale 1 : 25 000 (map sheet 35-141 Stará Turá).

lagoonal biomicrites with nodules of *Elianella elegans* Pfender et Basse and numerous miliolid foraminifers. From the reef bodies originate blocks made of layered as well as branching forms of coral structures. The largest number of blocks belongs into slope of fore-reef environment. Striking is a frequent presence of lagoonal forms *Glomalveolina primaeva* (Reichel) and its minute spheroid form (up to 1 mm) was easily transported by currents into deeper environments. Characteristic Thanetian forms are *Discocyclina seunesi* Douvillé and *Operculina azilensis* Tambareau and common are also replaced Late Cretaceous sediments with large foraminifers (*Hellenocyclina beotica* Reichel), fragments of *Inoceramus* plates and planktonic foraminifers from open sea. Limestones are prevailingly Thanetian in age, but Selandian age of some algal limestones cannot be excluded.

18. Drahý vrch

At the SW edge of the town of Stará Turá the site Drahý vrch is located (el. p. 358) – 26 – 27MY (coordinates N 48° 46´40.0´´, E 17° 41´58.9´´, Fig. 3g). Around the altitudinal point, but mainly at the field road leading from the altitudinal point into Stará Turá passing a cabin settlement and abandoned cemetery there are located multiple blocks. The largest one located in the gorge N of abandoned cemetery reaches 3 m.

At various occasions samples were collected from 37 blocks. In back-reef complex a massive outburst of coralline algae and cyclostomate bryozoans was going on. Among foraminifers miliolid forms were dominating. Common are also broken fragments of coral patch-reefs. 60 – 70 % of the volume of blocks of reef structures is made of patch reefs corals. Patch reefs are frequently bored; cavities are filled with micrite or sparite. The largest number of blocks belongs into fore-reef environment, into which there were replaced also various fragments from reef and back-reef environment. Frequent presence of globigerinid foraminifers proves for open and deeper sea closeness. Intense mixing of biorelics could be a proof for very slowly subsiding ramp with strong currents from shore into open sea.

Majority of blocks is Early Thanetian in age (SBZ 3), but blocks of algal limestones with *Elianella elegans* Pfender et Basse without large foraminifers are rather of Selandian age (SBZ 2).

19. Stará Turá – viaduct

Road from Stará Turá into Miškech Dedinka on the northern edge of the town passes below a railway bridge – 25MY (coordinates N 48° 47´09.8´´, E 17° 41´19.5´´, Figs. 3g, 3h). From here till the object of brickyard (to a distance of approx. 300 m) at the road and in the slope above the road there are located blocks of pale-grey bioherm limestones reaching up to 1.5 m.

7 blocks were examined in more detail. Except of one block all the others represent slope (fore-reef) facies. Block from the back-reef environment is rich in coralline algae (nodules *Elianella elegans* Pfender et Basse are in prevail). In fore-reef sediments among lithoclasts common are also fragments of crystalline rocks, quartzose sandstones of a vague age and wide range of Mesozoic carbonates. Frequent are bryozoans, up to 2 mm long algae thalli *Distichoplax biserialis* (Dietrich) Pia. Thanetian age confirm large foraminifers (*Discocyclina seunesi* Douvillé and *Operculina azilensis* Tambareau). Communities of small foraminifers ar of very variegated composition, in which common are also planktonic forms. Substitution of biorelics with chalcedony is rarely observed.

Fig. 3h. Site Stará Turá – viaduct, Myjavská pahorkatina Upland. Block of organogenic limestone, 150 cm in diameter (grey-white organogeneous limestone) in Lubina Fm. of Palaeocene age – Selandian – Thanetian (SBZ 2 – 4).

20. Krásny vrch

1 km North of Stará Turá above the road into Miškech Dedinka in the vicinity of Krásny vrch (el. p. 370) – 24MY (coordinates N 48° 47´4.6´´, E 17° 41´42.5´´, Fig. 3g) could be found scattered blocks of bioherm Palaeocene limestones. The largest of them attains 8 x 5 m. Samples were collected from 11 blocks.

Three blocks represent sediments of back-reef protected lagoon with immense development of coralline algae (*Sporolithon* sp.) and up to 1.5 mm with large fragments of coral patch-reefs. Other blocks originated in fore-reef slope environment, which is typical of presence of large foraminifers [*Discocyclina seunesi* Douvillé and *Orbitoclypeus ramaraoi* (Samanta)]. Common are also replaced Late Cretaceous organic relics (*Siderolites calcitrapoides* Lamarck and *Hellenocyclina beotica* Reichel). Fore-reef sediments are Thanetian in age; lagoonal limestones with algae can be also of Selandian age.

21. Miškech Dedinka

In the village of Miškech Dedinka – 23MY (coordinates N 48° 48´13.8´´, E 17° 42´19.7´´, Fig. 3g) as well as in fields and meadows between the village and Settlement Rubaniskovci there are located scattered blocks of pale organogenic limestones reaching in size up to 50 cm.

10 blocks were examined, which are of similar composition as at the site Krásny vrch. Two blocks are made of biomicrites of the back-reef environment with coralline algae and fragments of coral patch-reefs. Other blocks deposited in fore-reef slope environment. Thanetian age is proven by large foraminifers *Discocyclina seunesi* Douvillé and *Orbitoclypeus ramaraoi* (Samanta). In some blocks replaced Campanian-Maastrichtian orbitoid foraminifers are also common.

22. Lubina

SW of the village Lubina above the road from Hrušové into Stará Turá an abandoned quarry– 19MY (coordinates N 48º 46´36.5´´, E 17º 44´08.8´´, Fig. 3g) enabled to observe up to 2 m large blocks of bioherm limestones, which were mentioned also by Scheibner (1968). According to him bioherms in the quarry were made of olistoliths in flysch formation. Recently the quarry is covered with scree and partially filled with illegal waste and blocks are buried. They had been searched in vain also by Tragelehn (1996) and he had to be satisfied with blocks, which he found in the fields at eastern edge of the village. According to him the blocks of pink-red limestones were found to be clastic limestones belonging into Late Thanetian. Because of their monotonous facies composition Tragelehn (l.c.) didn't use them for comparison between the Alpine (site Kambühel) and the Carpathian Palaeocene reef systems.

At abandoned quarry there is a field road to the el. p. 345 and directly in it and also on the slope above and below the road could be found blocks of bioherm limestones. 5 blocks were examined. Two of them are back-reef biomicrites rich in coralline algae, among foraminifers sessile forms are dominating. Other blocks originated from fore-reef slope environment. They contain lithoclasts of variegated composition, in biocompound a debris from coralline algae dominates (up to 50 % of the rock volume), thalli of *Distichoplax biserialis* (Dietrich) Pia reach a length of 2.7 mm. Abundant are cheilostomate bryozoans, sporadically also planktonic foraminifers are present. The composition of biocompounds in blocks proves solely Thanetian age of limestones (*Discocyclina seunesi* Douvillé).

23. Lubina – Palčekový vrch

Below the road from Lubina into Stará Turá in the vicinity of Palčekový vrch Hill (el. p. 360) and Úboč – 20MY (coordinates N 48° 46´55.3´´, E 17° 42´19.7´´, Fig. 3g) could be found up to 1 m large blocks of bioherm limestones. This locality was mentioned also by Mišík

& Zelman (1959) in their pioneer work, in which they proved, that algal-coralline limestones in the Myjavská pahorkatina Upland are not of Cretaceous age (as it had been supposed), but they are of Palaeogene, according to them, of Eocene age. From this site 7 samples of bioherm limestones were collected. Majority of blocks comes from protected back-reef environment with low water energy and almost without terrigeneous contribution. The main compound are coralline algae, abundant are fragments of corals. Other blocks are from the environment of patch-reefs, at places corals make up to 90 % of the rock volume. Although direct proves are lacking, their Thanetian age is likely.

24. Čirkov vrch

NW of Lubina Čirkov vrch Hill is located – 21MY (coordinates N 48° 47´53.6´´, E 17° 43´37.4´´, Fig. 3g); on its flanks there are dissipated sporadic blocks of limestones up to 30 cm in size. This site is also mentioned in the work by Mišík & Zelman (1959) as a proof for Palaeogene age of bioherm limestones. According to Teťák & Potfaj et al. (2015) at this site there are exposed polymict conglomeratic sandstones with share of carbonate sandstones, calcarenites and pebbles of quartzose porphyries, quartz and carbonates.

6 blocks were examined. Except one, they belong into back-reef environment in the vicinity of back-edge of the reef crest. Algal and algal-coralline biomicrites contain up to 15 mm long crusts of coralline algae and fragments of coral patch-reefs. Only one block comes from fore-reef slope environment, where common are also planktonic globigerinoid forms. Also at this site the Thanetian age of blocks seems likely, although Thanetian index forms are lacking.

d) Calcarenites and carbonate conglomerates on Roh and Tučkovec (Eocene?)

According to Salaj et al. (1987) in this space Rašov facies is developed as marginal facies of Late Cretaceous. Teťák & Potfaj et al. (2015) state, that it is a formation made of very poorly assorted conglomerates and calcarenites, relatively poorly exposed, of vague age. Examined blocks of them originated from the following sites:

25. Lipovec

Site Lipovec – 22K (coordinates N 48° 49´35´´, E 17° 42´26.37´´, Fig. 3g) is located on the western slope of the el. p. Lipovec (585) at the road from the Cetuna Village into Settlement U Škulcov (Škulcovci).

In the forest path there are located exposures of conglomerates with very variegated composition, in which common are also up to 50 cm large blocks of pale-grey Palaeocene limestones. Four examined blocks represent lagoonal back-reef limestones with large nodules of *Elianella elegans* Pfender et Basse and dasycladacean algae (*Sarosiella feremollis* Segonzac and *Broeckella belgica* Morellet et Morellet). One block is extremely rich in fragments of coral patch-reefs and comes from slope of the

Tab. 2 Distribution of examined blocks of Palaeocene bioherm limestones of the Myjavská pahorkatina Upland, from the reef complex.

Locality	Number of blocks	Environment		
		back-reef	reef crest	fore-reef
Kravárikovci	14	11	2	1
Jandova dolina	12	3	4	5
Priepasné – Batíková	19	11	5	3
Dlhý vŕšok	13	8	1	4
Priepasné – Blatniakovci	4	3	1	0
Matejovec	32	28	2	2
Jeruzalem and Sychrov	33	25	5	3
Juríkovci – Podkorytárka	19	14	0	5
Tížikovci – Podkorytárka	17	9	0	8
Jablonka – Michaličkovci	2	0	0	2
Ušiakovci	3	0	0	3
Hodulov vrch	16	5	4	7
Drahý vrch	37	19	4	14
Stará Turá – viaduct	7	4	0	3
Krásny vrch	11	3	0	8
Miškech Dedinka	10	6	0	4
Lubina	5	4	0	1
Palčekový vrch	7	1	6	0
Čirkov vrch	6	0	3	3
Lipovec	4	4	0	0
Tučkovec	1	0	0	1
Total	**272**	**158**	**37**	**77**

coralline growth. In their composition the blocks are very similar to Palaeocene bioherm limestones of the Malé Karpaty Mts. (site Vápenková skala) and they fall into Latest Danian to Selandian (SBZ 1 – 2).

26. Tučkovec

At the road from Lubina into Settlement Hrabové site Tučkovec is located (el. p. 380) – 23K (coordinates N 48° 47´45´´, E 17° 43´56.83´´, Fig. 3g). In fields and meadows on the western slope of this hill large number of blocks is located, among which common are also pale-grey blocks of Early Eocene limestones with nummulites and block of Palaeocene bioherm limestone was also found. They originated in the slope reef environment and contain replaced shallow-water *Elianella elegans* Pfender et Basse, *Glomalveolina primaeva* (Reichel) and from deeper slope biocompounds: cheilostomate bryozoans, thalli of *Distichoplax biserialis* (Dietrich) Pia. Among lithoclasts shallow-water Palaeocene limestones are also present. Species *Glomalveolina primaeva* dates the block into Early Thanetian (SBZ 3).

Since 1960 on-going research into Palaeocene bioherm limestones of the Myjavská pahorkatina Upland has allowed to collect well documented thin sections from 15 autochthonous samples (*in situ*) of layers of organogenic limestones from a deeper sea environment (bottom part of the slope till basin) and from 272 blocks. Their distribution in individual reef environments indicates Table 2. 1,511 documented thin sections from these blocks are at disposal. Thin sections from the collection of Bystrický (50 pieces), which lacked appropriate documentation, could not be assigned to individual blocks, but only to individual sites.

Study of plentiful thin section material has allowed to distinguish in bioherm limestones the following microfacies:

A. Corallinacean packstone-wackestone (bafflestone) (Pl. VIII, Fig. 4)

In the Myjavská pahorkatina Upland it belongs to the most abundant microfacies types. It represents shallow-water protected back-reef and lagoonal environment with minimum contribution of terrigeneous material (sporadic fragments of carbonates and quartz). The main compound in rocks are coralline algae – thalli of genera *Sporolithon* Heydrich, *Mesophyllum* Lemoine and *Pseudoamphiroa* Moussavian. Thalli in thin sections are up to 8 mm long, usually well preserved, but at recent situation in nomenclature and taxonomy the species determinations are very uncertain. Signs of rhodoliths are rare. In some blocks in addition to coralline algae relevant biocompounds are also thalli *Polystrata alba* (Pfender) Denizot, which are up to 20 mm long. Rarer microfacies types are bindstone and bafflestone in which coralline algae bind micrite compound. Besides algae in thin sections there are present also cyclostomate bryozoans, fragments of bivalves, crinoids, corals, small gastropods. Benthic foraminifers *Haddonia praeheissigi* Samuel, Köhler et Borza, *Textularia* sp., *Placopsilina* sp. are present with various miliolid forms.

Localities: Drahý vrch, Dlhý vŕšok, Čirkov vrch, Palčekový vrch, Hodulov vrch, Tížikovci, Jandova dolina and Priepasné – Batíková.

Palaeo-environment of origination: shallow-water back-reef protected environment.

Age: ?Latest Danian (SBZ 1) – Early Thanetian (SBZ 3).

B. Corallinacean-coral packstone to rudstone (Pl. V, Fig. 2; Pl. VIII, Figs. 1, 3)

Nodules of *Elianella elegans* Pfender et Basse are dominant compound of rocks. Nodules, reaching in size to 15 mm, occupied back-reef lagoonal area of carbonate platform, but took part in structure (formation) of coral growths.

Algae *Elianella elegans* at places makes up to 60 % of the rock volume. If it accompanies corals, they belong to the genera *Astrocoenia* and *Dendrophyllia*. Common are also fragments of coralline algae and dasycladacean algae, fragments of bivalves, rare are tiny shells of gastropods. Benthic foraminifers are represented by variegated communities of miliolids, sessile forms (*Miniacina multicamerata* Scheibner, *Planorbulina cretae* (Marsson), *Solenomeris ogormani* (Douvillé), agglutinated tests (*Textularia* sp.) and rotaloid forms.

Localities: Jeruzalem, Matejovec, Kravárikovci, Drahý vrch, Juríkovci, Tížikovia, Jandova dolina.

Palaeo-environment of origination: shallow-water lagoonal, back margin of reef platform.

Age: Selandian – Early Thanetian (SBZ 2 – 3).

C. Elianella wackestone with Globoflarina sphaeroidea (Fleury) (Pl. III, Fig. 3)

Shallow-water lagoonal sediment with low water energy and with minute terrigeneous contribution. It contains frequent nodules of *Elianella elegans* Pfender et Basse, *Polystrata alba* (Pfender) Denizot, thalli of *Sporolithon* sp. and *Pseudoamphiroa propria* Moussavian, dasycladacean algae (*Neomeris* sp., *Zittelina* sp., *Cymopolia* sp.), fragments of coral patch-reefs, spines of echinoderms, crinoids and tubes of worms. Among foraminifers *Globoflarina sphaeroidea* (Fleury) is important, *Miscellanites primitivus* (Rahaghi), *Orduella sphaerica* Sirel, *Haymanella palaeocenica* Sirel, miliolids, various agglutinated tests, *Stomatorbina* sp., *Sistanites* sp. are also not missing, and tiny indefinable benthos.

Localities: Matejovec, Jandova dolina, Jeruzalem and Priepasné – Batíková.

Age: Selandian (SBZ 2).

D. Packstone to grainstone with Pseudocuvillierina sireli (Inan)

Pseudocuvillierina sireli (Inan) is easily identifiable species in thin sections occupying shallow-water lagoonal sediments. It is accompanied by nodules of *Elianella elegans* Pfender et Basse, thalli of *Sporolithon* sp., *Polystrata alba* (Pfender) Denizot, fragments of coral patch-reefs, bivalves and gastropods. Benthic foraminifers are not rare, frequent are mainly agglutinated forms – *Haddonia praeheissigi* Samuel, Köhler et Borza and *Textularia* sp.

Localities: Priepasné – Batíková, Dlhý vŕšok and Drahý vrch.

Age: Selandian (SBZ 2).

E. Elianella packstone to rudstone with Miscellanites primitivus (Rahaghi) (Pl. III, Fig. 2)

Biomicrite originating in back-reef environment with low energy. In addition to *Miscellanites primitivus* (Rahaghi) almost spheroid form *Miscellanites globulus* (Rahaghi) is also present at places. Frequent are nodules of *Elianella elegans* Pfender et Basse, nodules and crusts of *Sporolithon* sp., *Polystrata alba* (Pfender) Denizot, at places also dasycladacean algae (*Sarosiella feremollis* Segonzac, *Broeckella* sp., *Zittelina* sp., *Acicularia* sp.) and fragments of coral patch-reefs. Among small benthic foraminifers there were identified *Miniacina multicamerata* Scheibner, *Haddonia praeheissigi* Samuel, Köhler et Borza and various miliolid and rotaloid forms.

Localities: Kravárikovci, Priepasné – Batíková, Dlhý vŕšok, Matejovec and Jeruzalem.

Age: Selandian (SBZ 2).

F. Packstone to grainstone with redeposited large foraminifers

While tiny spheroidal tests *Glomalveolina primaeva* (Reichel) are relatively frequent in slope fore-reef sediments, their living-space are shallow lagoonal protected waters, from which they are washed-away and deposited by currents in fore-reef slope sediments. In original shallow-water environment they are present along with algae (frequent are coatings, nodules and also thalli of *Sporolithon* sp.). In thin sections also dasycladacean algae (*Acicularia* sp.) could be observed, fragments of bivalves, tiny bivalves, ostracods and common are also coralline fragments (debris at the inner slope of reef platform). Among benthic foraminifers frequent are miliolid forms, sessile *Miniacina* sp., *Planorbulina* sp., agglutinated tests and rotaloids.

Localities: Jeruzalem and Sychrov, Hodulov vrch.

Age: Early Thanetian (SBZ 3).

G. Corallinacean-dasycladacean packstone to wackestone (rudstone) (Pl. III, Fig. 4; Pl. VII, Fig. 4; Pl. VIII, Fig. 2; Pl. IX, Figs. 1 – 2)

In addition to 13 mm large nodules of *Elianella elegans* Pfender et Basse important biocompound of community are dasycladacean algae – *Broeckella belgica* Morellet et Morellet, *Zittelina bystrickyi* (Dieni, Massari et Radoičić), *Cymopolia elongata* (Defrance) Munier-Chalmas, *Neomeris* (*N.*) *herouvalensis* Steinmann, *N.* (*N.*) *koradae* Dieni, Massari et Radoičić, *Uteria sarda* Dieni, Massari et Radoičić, *U.* cf. *brocchii* Morellet et Morellet, *Jodotella sloveniaensis* Deloffre et Radoičić, *Frederica coniconvexa* Dieni, Massari et Radoičić, *F. arbutiformis* Dieni, Massari et Radoičić, *Sandalia multipora* Dieni, Massari et Radoičić, *Sarosiella feremollis* Segonzac, *Terquemella macrocarpus* Morellet et Morellet, *Orioporella villatae* Segonzac, *Acicularia* sp., *Halimeda* sp. and *Rusoella radoičićae* Barattolo (Pl. III, Fig. 4, Pl. VII, Fig. 4, Pl. XVII, Figs. 1 – 9, Pl. XVIII, Figs. 1 – 2, 6 – 7, 10, Pl. XIX, Figs. 1 – 9). Frequent are fragments of coralline algae (mainly *Sporolithon* sp.), thalli of *Polystrata alba* (Pfender) Denizot, *Pycnoporidium* sp., fragments of bivalves, gastropods and corals. Small benthic foraminifers are present dominantly as miliolid forms. The absence of planktonic forms proves for isolation of this environment from open sea.

Localities: Jeruzalem and Sychrov, Juríkovci, Matejovec, Kravárikovci and Priepasné – Batíková.

Age: Selandian – Early Thanetian (SBZ 2 – 3).

H. Rudstone-framestone with Parachaetetes asvapatii Pia (Pl. IV, Fig. 3; Pl. VII, Fig. 3)

In the literature *Parachaetetes asvapatii* Pia is commonly confused with *Elianella elegans* Pfender et Basse, although both genera differ in the structure of cellular tissue. In blocks from the Myjavská pahorkatina Upland, along with multiple *Elianella elegans* there were found also sections of nodules with very regular pattern of cellular tissue, characteristic for genus *Parachaetetes* (Buček & Köhler, 2005). Nodules reach dimensions of 13 mm. Along with them there are present coralline algae, cyclostomate bryozoans, fragments of bivalves, gastropods, corals as well as miliolid and sessile foraminifers. Sediment originated in shallow-water back-reef protected environment.

Localities: Drahý vrch, Palčekový vrch and Matejovec.

Age: Selandian – Early Thanetian (SBZ 2 – 3).

I. Packstone with Sarosiella feremollis Segonzac

In the pebbles from the Myjavská pahorkatina Upland it is relatively rare type of microfacies, although dasycladacean species *Sarosiella feremollis* Segonzac is accompanied by numerous algae (*Elianella elegans* Pfender et Basse, *Polystrata alba* (Pfender) Denizot, *Sporolithon* sp., *Pseudoamphiroa* sp.), fragments of bivalves, gastropods and corals. Benthic foraminifers are present in miliolid, rotaloid and sessile forms – *Planorbulina cretae* (Marsson). The rock originated in protected shallow-water environment.

Localities: Miškech Dedinka, Matejovec and Stará Turá.

Age: Selandian (SBZ 2).

J. Coral bindstone to boundstone (Pl. IX, Fig. 2)

There are no direct proves, that in the reef complex (on reef crest) extensive reef growths (structures) of the type of the barrier reefs developed. There were rather tiny growths of the patch-reefs type, which were frequently destroyed by currents and therefore coral debris is frequent both in back-reef, as well as in fore-reef sediments.

50 to 90 % of the volume of the examined blocks is made of coral massive patch reefs and branching forms belonging to the genera *Actinacis*, *Dendrophyllia*, *Goniopora* and *Rhizangia*. Frequently they are overgrown by coralline algae even in several coatings (genus *Sporolithon*) and also by grey structureless crusts (?cyanobacteria). Almost always the coralline patch reefs are accompanied by problematic fossil *Pieninia oblonga* Borza et Mišík. Fragments of bivalves are rare. Benthic foraminifers are present mainly in sessile forms (*Planorbulina cretae* (Marsson), *Solenomeris ogormani* Douvillé, various *Miniacina* sp.). According to the age they can be affiliated to Selandian to Early Thanetian with maximum abundance in Thanetian.

Localities: Kravárikovci, Priepasné – Batíková, Jandova dolina, Palčekový vrch, Hodulov vrch and Jeruzalem.

Age: Selandian – Early Thanetian-?Late Thanetian (SBZ 2 – 3, SBZ 4?).

K. Grainstone with Discocyclina seunesi Douvillé *(Pl. VI, Fig. 4; Pl. IX, Fig. 3)*

Blocks representing sea-ward fore-reef slope sediments are not rarity in the Myjavská pahorkatina Upland. They contain up to 5 mm large clasts of Palaeocene back-reef, prevailingly lagoonal sediments, sharp-edged fragments of quartz; at places also clasts of various Mesozoic rocks are frequent. Bioclasts are very frequent, dominantly torn apart and broken coralline algae (*Sporolithon* sp., *Elianella elegans* Pfender et Basse, *Polystrata alba* (Pfender) Denizot, *Pseudoamphiroa* sp.). For fore-reef environment presence of algae *Distichoplax biserialis* (Dietrich) Pia is very typical. Common are fragments of bivalves, corals, crinoids, echinoderms as well as benthic foraminifers washed in from shallow-water environment [conspicuous are tests of *Glomalveolina primaeva* (Reichel)]. Present are organic relics of washed out Late Cretaceous beds – *Orbitoides* sp., *Siderolites* sp. and *Pseudosiderolites* sp. For fore-reef deeper environment large foraminifers are typical – *Discocyclina seunesi* Douvillé, *Orbitoclypeus ramaraoi* (Samanta), *Operculina heberti* Munier-Chalmas and *O. azilensis* Tambareau. Unless the rock doesn't contain any large foraminifers, it may be Selandian in age, but presence of the above mentioned of species foraminifers affiliates it in Thanetian.

Localities: Jandova dolina, Dlhý vŕšok, Drahý vrch, Matejovec, Stará Turá, Tížikovia, Juríkovci, Lubina, Hodulov vrch, Ušiakovci, Jablonka – Michaličkovci.

Age: Selandian – Early Thanetian-?Late Thanetian (SBZ 2 – 3, SBZ 4?).

Age of rocks containing blocks of Palaeocene bioherm limestones

Majority of examined blocks are affiliated to Kravárikovci and Lubina Fms., for which Early Eocene age was determined (Salaj et al., 1987). It is also proven by large foraminifers found in these formations, e.g. *Nummulites pernotus* Schaub at the site Hrnčiarová – Pagáčovci. From the site Lubina – motorest (Roh) comes Early Eocene community *Nummulites pernotus* Schaub, *N. exilis* Douvillé, *Assilina leymeriei* d´Archiac et Haime and *Discocyclina* cf. *archiaci* (Schlumb.) proving the Early Eocene age of the formation, which is exposed at the localities Lipovec and Tučkovec.

3.2.3. Evolution of the Palaeocene reef complex of the Myjavská pahorkatina Upland

After Cretaceous alpine folding, which had affected also area of to-date Myjavská pahorkatina Upland, this territory was again flooded by sea in Late Cretaceous. For the formation of the Palaeocene carbonate platform it was important a suitable substrate. The substrate for the carbonate platform with the reef complex provided shallow-water orbitoid limestones and sandstones, Campanian-Maastrichtian in age (Bradlo Fm.; Teťák & Potfaj et al., 2015). This inter-relationship is confirmed by the presence of redeposited tests belonging to the genera *Orbitoides*, *Siderolites*, *Pseudosiderolites*, *Hellenocyclina* in numerous Palaeocene blocks.

Although today Maastrichtian orbitoid layers are not found *in situ* in the Myjavská pahorkatina Upland, replaced organic relics and blocks prove for the fact, that sedimentation continued also in Maastrichtian. By the end of Maastrichtian occurred regression due to Laramian phase of folding.

In the literature (Salaj et al., 1987) there is mentioned a gradual transition of sedimentation from Cretaceous into Palaeocene. Such gradual transition of sedimentation into the shallow-water environment cannot be accepted, but it is possible, that the sea retreated only from shallow-water areas and in deep-marine basinal environment the sedimentation continued.

The interruption in sedimentation lasted from Late Maastrichtian into higher part of Danian. This can be deducted from the destruction of shallow-water Maastrichtian sediments of the Bradlo Fm., from the existence of the layers with *Microcodium* sp. and from missing of undoubtedly defined Early Danian shallow-water layers.

In the Later Danian at the next transgression of sea originated in the area of the Myjavská pahorkatina Upland carbonate platform, on which could be distinguished three classic parts of the reef complex: back-reef, reef and fore-reef. In the pebble material evidence has been preserved, that sedimentation was going on mainly in back-reef protected, lagoonal area, where dwelled in their living-space various organic components, dominantly coralline algae. The area of the reefs origination (reef crest) was not extensive, obviously, and the reef manifestations were bound to smaller coral and coral-algal growths. There are no proves on existence of structures of larger dimensions. Water dynamics must have been quite intensive, because reef growths corrasion occurred repeatedly. Their fragments are abundant mainly in fore-reef sediments. On the sea-ward side a slope was formed, on which deposited rocks and biocompounds washed-away from shallow back-reef part and reef crest. A slope could not be steep, otherwise layer of several metres thick biodetritic sediments could not develop; it had rather form of moderately inclined ramp. Today undamaged part of sediments with thin (15 – 30 cm thick) biodetritic beds (Dedkov vrch Hill) has to be affiliated into lowermost part of the slope or to into environment of basinal sediments.

This carbonate platform was not of long duration. While its onset is put into Latest Danian (SBZ 1), sediments of the Latest Thanetian have not been confirmed. The largest bloom of organic life on the platform was in Selandian (SBZ 2) and in Early Thanetian (SBZ 3). By the end of Thanetian new regression occurred, accompanied with corrasion and termination of the carbonate platform. Karstifying of some parts of the reef complex took part, along with intense corrosion of rocks of all its environments and disintegration into olistostromes and blocks. At new sea flooding of the area in Early Eocene these blocks were replaced into Early Eocene sediments.

Soták et al. (2011, 2013) call attention to an existence of the basin of the type Gosau in the area of Upper Nitra. In the borehole KRS-3 at the village Veľké Kršťeňany (North of Partizánske Town) in Late Palaeocene part of a sequence they state presence of layers with orthofragminids, which they attributed into horizon with *Discocyclina seunesi* belonging into SBZ 3. They also call attention to the presence of bioherm limestones clasts similar to the Kambühel type. Plašienka & Soták (2015) note, that this occurrence is located 40 km from Klippen Belt and it could be hardly correlated with Peri-Klippen facies. It is rather evidence, that not only Klippen Belt and adjacent zones were flooded by Palaeocene-Eocene Sea, but also more internal parts of the Central Western Carpathians were flooded by this sea.

3.3. The Middle Váh Valley

Between the towns of Považská Bystrica and Žilina there are located the best-known and the most frequently referred to occurrences of the Palaeocene bioherm limestones in the Western Carpathians. Their investigation progress by 1970 is recorded in detail in monograph by Samuel et al. (1972) with rich photodocumentation (180 photoplates). Late Cretaceous and Palaeogene thin section material used in this monograph is included in the collection of Köhler. For the purposes of submitted publication it was reassessed from the viewpoint of recent criteria and amended on in the last years collected new material (collections of Buček and Köhler) as well as on thin sections from the collection of Bystrický.

Palaeocene sediments of the Middle Váh Valley could be divided into two partial, 25 km from each other distant areas, which will be referred to separately. They are a) Považská Bystrica and vicinity and b) Hričovské Podhradie – Žilina.

a) Považská Bystrica and vicinity

On a relatively small area between Svätá Helena, which is today a part of the town of Považská Bystrica and Settlement Rybárikov laz there are almost 80 years referred to occurrences of bioherm limestones.

Lemoine (1933) from thin sections of D. Andrusov from Považská Bystrica described *Archaeolithothamnium mamillosum* (Gümbel) Lem., *Mesophyllum ramosum* n. sp. and *Lithothamnium* sp. and she suggested Middle- to Late Eocene age of limestones. Despite of this these limestones were for a long time assessed to be Late Cretaceous (Senonian). Kühn & Andrusov (1937) from the site Svätá Helena described corals of Santonian-Campanian age. Although Andrusov (1938) defines dasycladacean algae and coralline algae with *Distichoplax biserialis* (Dietrich) Pia from Považská Bystrica, but yet in the year 1945 he referred to the reef blocks at Považská Bystrica as Senonian. The existence of reefs he explained by a presence of warm current flowing from Gosau Sea of the Eastern Alps along southern margin of the Klippen Belt. Andrusov (1950) states presence of *Pseudolithothamnium album* (= *Polystrata alba* (Pfender) Denizot) from Makovec at Považská Bystrica. In the geologic map of the map sheet Považská Bystrica 1 : 25 000 Andrusov (1951) affiliates the reefs occurrences into Upohlava Member (hippurites, coralline and lithotamnium limestones) of Late Cretaceous age.

Schaleková (1963, 1964a) provides a list of species of coralline algae from Makovec and Svätá Helena and assigns them Palaeogene age.

Samuel & Salaj (1963) call attention to the fact, that in the vicinity of Považská Bystrica there are two types bioherm limestones – hippurites (localities Rašov and Pod Húštím) and coral-algal (Svätá Helena).

Andrusov & Köhler (1963) assigned into their "Myjava" facies also the reef blocks from Považská Bystrica and they contemplated their Ilerdian age.

Andrusov in his Geology of Czechoslovakian Carpathians III. (1965) assigned the Palaeogene sediments in the vicinity of Považská Bystrica into "Makov facies", made of conglomerates of the Súľov type, in which there are located organogeneous and organodetritic coral-lithothamnium limestones, which in some cases have to be regarded as bioherms. The formation is assigned into Ilerdian (at that time considered to be the part of the Late Palaeocene).

Samuel & Salaj (1968) assigned the reef limestones from Považská Bystrica to Middle- to Late Palaeocene.

Scheibner (1968) in his analysis of the Palaeogene reef stripe Myjava-Hričov-Haligovka mentioned also the area of Považská Bystrica. He states, that bioherms could be considered for patch-reefs, which originated in environment of open reef shallows on the northern edge of the Myjava Furrow at Klippen Belt.

Began et al. (1970) published lithological-stratigraphic description of the profile of the borehole SM-1 at the Settlement Makovec SW of Považská Bystrica. The borehole has confirmed, that the body of the Palaeocene bioherm limestone of a thickness of 3 m is located in the Quaternary scree, in which it got thanks to mass movement.

Samuel et al. (1972) in voluminous monograph on microfauna and lithostratigraphy of the Palaeogene of Middle Váh Valley gave attention also to bioherm limestones at Považská Bystrica. They noted that W of Makovec – Rybárikov is a small isolated occurrence of Montian-Thanetian sediments – conglomerates, marls and blocks of bioherm limestones. From the vicinity of Považská Bystrica (Svätá Helena, Kunovec) they vindicated Early Eocene age of rocks with blocks of bioherm limestones.

Tragelehn (1996) took samples from sites Kunovec and Svätá Helena for the in order to compare them with East-Alpine reefs facies in 1993. The samples from Kunovec he designated as bioclastite coralline floastones/rudstones (Pl. 20, Fig.6). The samples from the site Svätá Helena he assigned to microfacies 11 – bindstones and packstones with dominance of red algae (Pl. 20, Figs. 3, 4). According to Tragelehn (l.c.) the material from Svätá Helena cannot be linked directly with reefs. It represents more distal very tranquil space, in which no signs of more regular water dynamics have been recorded. According to more intense growth of tabular corals he judges, that in this environment these organisms had better conditions than in instable moving fore-reef environment. Tragelehn assigned the sample from Považská Bystrica into Late Thanetian. He remarks, that such facies types of deep fore-reef area are completely missing in Austria.

Salaj (in Elečko et al., 2004) mentioned from Kravárikovci Fm. (conglomerates and blocks of limestones), from the area of the villages Udiča and Jasenica N of Považská Bystrica, blocks of reef limestones with large foraminifers – *Operculina heberti* Munier-Chalmas, *Glomalveolina reicheli* (Mor.) and *Discocyclina seunesi* Douvillé – based on them he affiliates the formation into the Latest Palaeocene to Early Eocene. According to him the Kravárikovci Fm. transgressively overlies the Šafranica Fm. of Palaeocene age (Danian-Thanetian) dated besides *Idalina sinjarica* Grimsdale also by planktonic foraminifers. Stratigraphic hiatus between these two formations corresponds likely to the zone with *Glomalveolina levis* (Hottinger), i.e. zone SBZ 4 in Late Thanetian (Köhler & Salaj, 1997). Because species of large foraminifers *Operculina heberti* Munier-Chalmas and *Discocyclina seunesi* Douvillé belong into zone SBZ 3 (Early Thanetian), stratigraphic range of the Kravárikovci Fm. in the area of Považská Bystrica corresponds to the Hričovské Podhradie Fm. (Buček & Nagy in Mello et al., 2011) with olistoliths of "Kambühel" limestones. Because of this reason the "Makov facies" ought to be neglected and supplemented with Myjava-Hričov Group with its lithostratigraphic units.

This solution was not adopted neither by the authors of the geologic map of the Middle Váh Valley 1 : 50 000 (Mello et al., 2005) nor by the authors of the Explanatory Notes to this geologic map (Mello et al., 2011). The co-author (Salaj) of the map affiliated the Palaeocene and Early Eocene Fms. at Považská Bystrica into Kysuca unit and Hoštiná sequence of Oravicum, where he defined Šafranica Fm.: marls, calcareous sandstones, organodetritic limestones, carbonate conglomerates with beds of reefs (Palaeocene-Early Eocene) and Kravárikovci Fm.: conglomerates with pebbles and blocks of reef limestones (Early Eocene-Ilerdian). Nowadays, the SBZ 5-6 is considered as Early Eocene (Pujalte et al., 2009b).

3.3.1. Upper Cretaceous basement of Palaeocene reef system (Považská Bystrica and its vicinity)

Palaeocene carbonate platform (at least its recent rudiment form) originated on the substrate of Upper Cretaceous orbitoid Fm., which is not exposed in the area of Považská Bystrica, but redeposited tests of Late Cretaceous large foraminifers, mainly orbitoids are frequently present in the bioherm limestone blocks at the locality Rybárikov laz. Blocks of sandstones with *Orbitoides media* d´Archiac were found at the Kunovec Settlement (Pl. I, Fig. 3).

3.3.2. Palaeocene bioherm limestones

The research was focused in three areas:

1. Rybárikov laz

Small Settlement Rybárikov laz – 37SP is located 2.5 km WSW of Považská Bystrica (coordinates N 49° 06´10.0´´, E 18° 24´08.2´´, Fig. 4a) .

In fields and in the field road at the western edge of the Settlement the Šafranica Fm. of the Hoštiná Sequence of the Kysuca unit of Oravicum is exposed (Mello & Potfaj in Mello et al., 2011) with 10 – 20 cm thick beds of sandy organogenic limestones. They contain lithoclasts of variegated polymict composition (quartz, fragments of crystalline, sandstones, marlstones with globotruncans and Palaeocene biomicrites). Organic community contains mixed shallow-water and deeper-water dwelling forms. Shallow-water miliolid foraminifers and fragments of

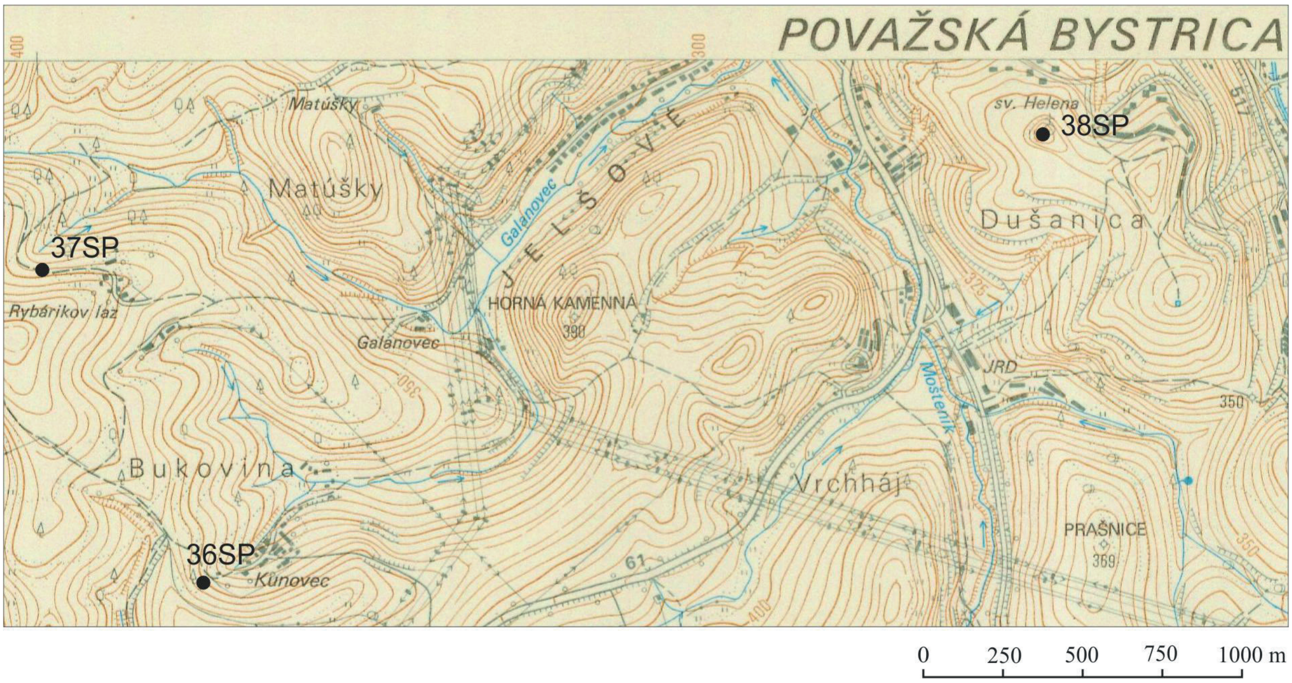


Fig. 4a. Situation map of Palaeocene sites (•36SP, •37SP, •38SP) of the Middle Váh Valley (area Považská Bystrica) at scale 1 : 25 000 (map sheet 25-443 Visolaje).

algae *Elianella elegans* Pfender et Basse are mixed with cheilostomate bryozoans. Fragments of corals are also common. Frequent presence of tests globigerinoids proves for sedimentation in open sea on the slope or its base. Frequent large foraminifers – *Glomalveolina primaeva* (Reichel), *Discocyclina seunesi* Douvillé, *Orbitoclypeus ramaraoi* (Samanta) and *Coskinolina rajkae* Hottinger et Drobne prove for the Early Thanetian (SBZ 3) age of rocks. Notable compound of the associations are redeposited tests of large Late Cretaceous foraminifers, sometimes also species definable, e.g. Maastrichtian *Orbitoides gensacicus* Leymerie and *Omphalocyclus macroporus* Leymerie. Without any doubts, during Thanetian the Senonian rocks were destructed and washed out. The weathering processes are documented also by calcite coatings of some clasts.

In fields and meadows at the Settlement Rybárikov laz there are located numerous blocks of bioherm limestones, which, because of their size (diameter up to 3 m) couldn't be a component of the Šafranica Fm., but they are rather redeposited blocks of the Kravárikovci Fm. of the same age (Early Eocene). Among them belongs also a block, in which the borehole MS-1 was drilled (Began et al., 1970). The reef block in the borehole attained a thickness of 3 m; it was overlain by 5 m of Quaternary sediments. The underlying Thanetian formation of claystones, sandy limestones, calcareous sandstones and microconglomerates in the borehole attains a thickness of 43 m.

Other blocks are typical of intergrowths of coralline algae of the type bindstone or algal-coral biomicrites of the type packstone. According to composition they belong rather into back-reef inner environment. Blocks representing the reef structure have not been found.

There were analysed 7 samples of limestones intercalated by claystones and 16 isolated blocks.

2. Kunovec

3.5 km SW of Považská Bystrica at the road from Považská Bystrica into Beluša Settlement Kunovec is located– 36SP (coordinates N 49° 06´18.6´´, E 18° 25´59.4´´, Figs. 4a, 4b). Directly at the site and its vicinity the so-called Šafranica Fm. is exposed (as mentioned above) of the age Late Palaeocene – Early Eocene, containing blocks of the Palaeocene bioherm limestones. The ploughed-up blocks are accumulated at the edges of fields; some of them are located directly in the Settlement. The largest block attains a size of 150 x 200 cm.

13 blocks were examined. They represent various environments of the reef complex.

Of the shallow-water origin are the blocks of biomicrites with nodules of *Elianella elegans* Pfender et Basse as well as with other coralline algae. Presence of *Sarosiella feremollis* Segonzac in one block documents, that the reef system originated already in Selandian (SBZ 2), but the largest range it reached in Thanetian [presence of *Glomalveolina primaeva* (Reichel)]. Some of the blocks have the structure of the type bindstone to bafflestone.

Only in one block the presence of to 20 cm large fragments of coral patch-reefs may indicate the existence of small patch-reefs.

Into fore-reef slope environment could be affiliated sandy limestones of the type grainstone to floatstone with mixing of shallow-water and fore-reef biocompounds. Large foraminifers – *Discocyclina seunesi* Douvillé, *Orbitoclypeus ramaraoi* (Samanta), *Operculina heberti* Munier-Chalmas document the Early Thanetian (SBZ 3) age of these sediments.

It is not clear, which locality the older authors designated as the Makovec – or Kunovec or Rybárikov laz site. This issue was also solved by Tragelehn (1996), who

Fig. 4b. Site Kunovec, The Middle Váh Valley, field road. Block of a 100 cm diameter of organogenic limestone in Šafranica Fm. of the Hoštiná Sequence of the Kysuca unit of Palaeocene age – Early Thanetian (SBZ 3).

states, that according to locals the Makovec designation is an old, already unused term for fields in the vicinity of Kunovec.

3. Svätá Helena

At the SW edge of Považská Bystrica a hill is located; on its summit the Church of Svätá Helena (*Saint Helene*) is built – 38SP (coordinates N 49° 06´26.9´´, E 18° 26´34.3´´, Figs. 4a, 4c). Till 1970 on its slopes the Kravárikovci Fm. was exposed (Mello et al., 2005, 2011) of Early Eocene age with up to 1 m large blocks of bioherm limestones. To-date at this locality an urban suburb is built. Blocks of bioherm limestones are dissipated as decoration at the roads and causeways, only in close vicinity of the small church several blocks are located, which have not been replaced during construction. From this site there were examined 11 blocks. Five samples from this site were analysed also by Tragelehn (1996) and he assigned them into deep fore-reef to basinal environment. We could only agree with Tragelehn (l.c.), that at this site only those blocks are present, which could be affiliated into deeper part of the fore-reef of the slope or even the more distal ones. He designated these rocks as bindstones and packstones with dominance of red algae. In some blocks also fragments of corals are frequent. Presence of *Discocyclina seunesi* Douvillé, *Orbitoclypeus ramaraoi* (Samanta), *Distichoplax biserialis* (Dietrich) Pia and replaced *Glomalveolina primaeva* (Reichel) indicates Thanetian age of these rocks.

From 3 mentioned sites 401 analysed thin sections are at disposition. These allowed to distinguish the following microfacies:

A. Corallinacean bindstone to rudstone (Pl. IX, Fig. 4)

Relevant compounds of rocks are coralline algae with up to 20 mm long thalli, nodules and also crusts belonging into genera *Sporolithon*, *Mesophyllum* and *Pseudoamphiroa*. In some of thin sections frequent are also nodules of *Elianella elegans* Pfender et Basse. Common are also thalli of *Distichoplax biserialis* (Dietrich) Pia and *Polystrata alba* (Pfender) Denizot. Crusts are sometimes combined with crusts of sessile foraminifers (*Solenomeris ogormani* Douvillé and *Miniacina* sp.) and structureless grey crusts (?cyanobacteria). At places crusts distinctly cement the sediment and form bindstone and bafflestone structures. Abundant are fragments of bivalves, small gastropods, crinoids and corals. Besides the above mentioned sessile forms the foraminifers are present also in the types of miliolids, rotaloids, *Planorbulina cretae* (Marsson) and others. The isolation from open sea is proven by complete lacking of planktonic forms. Age of rocks was defined based on single occurrence of *Discocyclina* sp. and *Glomalveolina primaeva* (Reichel). Lithoclasts in the rock are sporadic fragments of carbonates (into 1 mm) and sharp-edged quartz (up to 0.1 mm).

Localities: Rybárikov laz, Kunovec.

Age: Early Thanetian (SBZ 3).

B. Corallinacean-dasycladacean packstone with Glomalveolina primaeva (Reichel)

Unwashed sediment of the shallow-water environment contains in addition to coralline algae (*Sporolithon* sp., *Mesophyllum* sp., *Pseudoamphiroa* sp.) also dasycladacean algae (*Broeckella* sp., *Cymopolia* sp., rarely also *Sarosiella feremollis* Segonzac), frequent is also *Polystrata alba* (Pfender) Denizot, rare are fragments of lamellibranchs, gastropods, crinoids, corroded fragments of corals, miliolid and rotaloid foraminifers. Age dating is based on presence of *Glomalveolina primaeva* (Reichel), but presence of *Sarosiella feremollis* Segonzac in one block allows to define also Selandian age (SBZ 2). Contribution of detritic material is insignificant. Sporadically carbonate lithoclasts are present attaining a size of up to 0.5 mm.

Localities: Rybárikov laz, Kunovec.

Age: Early Thanetian (SBZ 3).

C. Corallinacean-coral bindstone to framestone (Pl. X, Figs. 1, 2)

Sediment originated in environment, in which small coral structures were formed, which had not been preserved in original position, but they were broken and destructed by currents. Therefore thin sections are enriched in coral fragments, but preserved structures of coral growths

Fig. 4c. Site Svätá Helena, the Middle Váh Valley. Isolated blocks of up to 150 cm diameter of organogenic limestone (grey-white organogenic limestones) in Hričovské Podhradie Fm. of Palaeocene– Early Thanetian age (SBZ 3).

are lacking. Besides corals (*Dendrophyllia* sp., *Oculina* sp.) frequent are coralline algae (*Sporolithon* sp., *Mesophyllum* sp., *Pseudoamphiroa* sp.), *Distichoplax biserialis* (Dietrich) Pia, redeposited fragments of nodules *Elianella elegans* Pfender et Basse, *Polystrata alba* (Pfender) Denizot, fragments of bivalves, gastropods and crinoids. Among foraminifers dominating are miliolid and rotaloid forms. Lithoclasts are present in the form of sporadic clasts quartz and carbonates. Sediment originated at the seaward side of rudimentary reef crust and in the highest part of the reef slope.

Localities: Rybárikov laz, Kunovec, Svätá Helena.

Age: Early Thanetian (SBZ 3).

D. Packstone to grainstone with bryozoans (Pl. VI, Fig. 1)

This sediment of fore-reef slope environment contains very frequent lithoclasts of carbonates (up to 1.5 mm) and quartz. Organic relics are frequently disturbed with traces of redeposition from shallower parts of the platform margin. Abundant are fragments of coralline algae (*Sporolithon* sp., *Mesophyllum* sp., *Pseudoamphiroa* sp.) and *Distichoplax biserialis* (Dietrich) Pia. Very frequent are cyclostomate also cheilostomate bryozoans (the last ones are documenting a deeper environment), fragments of bivalves, gastropods and coral debris. In addition to miliolid, agglutinated and rotaloid foraminifers planktonic forms are also sporadically present. Age of rocks is defined based on large foraminifers *Discocyclina seunesi* Douvillé and *Orbitoclypeus ramaraoi* (Samanta), rare is *Glomalveolina primaeva* (Reichel) replaced from shallow environment

Localities: Rybárikov laz, Svätá Helena.

Age: Early Thanetian (SBZ 3).

E. Grainstone with Discocyclina seunesi Douvillé (Pl. VI, Fig. 3)

In the Šafranica Fm. exposed in the road at the margin of the Settlement Rybárikov laz several samples were analysed from layers of biodetritic limestones. Lithoclasts are made up of carbonates fragments, sandstones and quartz of up to 0.2 – 0.3 mm size. Organic relics show traces of replacement and they are represented by fragments of coralline algae, bivalves, bryozoans, crinoids and corals (sporadically up to 8 mm large fragments). Foraminifers are present in miliolid and agglutinated forms, planktonic globigerinids are rare. Age is defined based on *Discocyclina seunesi* Douvillé and *Coskinolina rajkae* Hottinger et Drobne (Early Thanetian). An interesting feature are redeposited tests of large Maastrichtian foraminifers – *Orbitoides apiculata* Schlumberger, *O. gensacicus* Leymerie, *Lepidorbitoides* sp. proving for existence of orbitoid Late Cretaceous in this area.

Localities: Rybárikov laz.

Age: Early Thanetian (SBZ 3).

3.3.3. Age of rocks containing Palaeocene bioherm limestones

Palaeocene (prevailingly Thanetian) age of the so-called Šafranica Fm. is documented by biocompounds in biodetritic limestone layers in this formation (Rybárikov laz; microfacies C).

Early Eocene age of the Kravárikovci Fm. with blocks bioherm limestones (Svätá Helena) is debated in detail and defined in monograph by Samuel et al. (1972). This evidence is amended on sample from the site Kunovec containing large foraminifers *Nummulites pernotus* Schaub, *N. praecursor* de la Harpe, *Assilina leymeriei* (d´Archiac et Haime) and *Operculina* cf. *canalifera* Douvillé. This association affiliates the sediment into SBZ 7 – 8 (sensu Serra-Kiel et al., 1998), i.e. into Middle Ilerdian, which is in complete accord with data by Samuel et al. (l.c.).

3.3.4. Evolution of the carbonate platform

In opposite to the assertion by Tragelehn (1996), that in the vicinity of Považská Bystrica there are no actual reef rocks, the research has confirmed the existence of the carbonate platform with – although very limited – back-reef lagoonal environment, formation of small coral structures at the reef crest and also – the best preserved – fore-reef slope environment, into which assigned the samples also Tragelehn (l.c.). Interesting is preservation of 43 m thick Thanetian formation of the flysch character. Part of this Fm. is exposed at the edge of the Settlement Rybárikov laz, a part of it was encountered in the borehole SM-1 (Began et al., 1970).

After hiatus in sedimentation by the end of Maastrichtian the carbonate platform began to evolve at new sea transgression by the end of Selandian and in Thanetian. The research has not brought proves on existence of the platform at the end of Thanetian. By the end of Thanetian and probably at the beginning of Ypresian a vast destruction of the carbonate platform occurred, from which at the Settlement Rybárikov laz only fragment of fore-reef Thanetian sediments has been preserved. During the next transgression in Early Eocene the blocks of bioherm limestones were replaced into Early Eocene Kravárikovci Fm.

b) Hričovské Podhradie – Žilina

In approx. 8 km long stripe between Žilina and Hlboké n/Váhom there are located the most famous occurrences of Palaeocene bioherm limestones in the Western Carpathians, which for already a long time have attracted the attention of geologists.

Imposing limestone cliffs above Hričovské Podhradie attracted already Štúr (1860), who suggested their Cretaceous age. Hričovské Podhradie has become world-famous locality thanks to Andrusov, who in 30s of the previous century took samples from this site. He recognized, that they are enriched in algae and he sent the material to the most renowned phytopalaeontologists P. Lemoine and J. Pia.

Lemoine (1933) described from reefs at Hričovské Podhradie the community of coralline algae, which contained 11 new species already defined in the to-date literature, but depicted them only schematically. Original thin sections have to be regarded for lost and with the only exception of one occurrence (type locality of *Amphiroa propria* Lemoine) today it is hard to determine, from which site the study material came. Revision of species described by P. Lemoine is today very actual issue (Rasser & Piller, 1994; Aguirre & Braga, 1998).

No less renowned phytopalaeontologist J. Pia in the year 1934 described from Hričovské Podhradie further algae, among them also *Distichoplax biserialis* (Dietrich) Pia, which is one of the best-known Palaeocene algae.

Various algae from Hričovské Podhradie mentions also Andrusov (1938). In the year 1944 Andrusov & Kuthan published *Geological map 1 : 25,000; map sheet Žilina* and respective explanatory notes. They stated, that the coralline and algal limestones at Hričovské Podhradie were made up of 20 m long bodies. Some of them are distinctly detached from basement, but some of them seem to be connected with it by transitions. The limestones are assigned Middle Eocene – Late Lutetian age.

Köhler (1960) pointed out the existence of Maastrichtian orbitoid layers in area of Hradisko at Žilina.

Extensive list of algae from Hričovské Podhradie was provided by Schaleková (1962) in her PhD. Thesis and main results she published in the years 1963 and 1964. She assigned the limestones from Hričovské Podhradie and from Žilina – like Andrusov – Middle Eocene age.

This incorrect age was adjusted by two pairs of authors. Samuel & Salaj (1963) supported by index fossils *Discocyclina seunesi* Douvillé and *Glomalveolina* ex gr. *primaeva* (Reichel) assigned the reef blocks into Palaeocene and they didnt exclude a possibility of the reef sedimentation in Early Eocene. In the same year Andrusov & Köhler (1963) into their "Myjava facies" assigned also the formation with reef blocks from Žilina and contemplated their Ilerdian age (assigning Ilerdian into Late Palaeocene).

In voluminous monograph *Geology of Czechoslovakian Carpathians III.* Andrusov (1965) defined Hričov-Žilina Early Palaeogene zone ("facies"), of which the most notable phenomenon are lenses of bioherm limestones. The referred to formation is approx. 200 m thick. It makes up long lenticular belt tectonically wedging out within the Palaeogene Súľov Fm. and stripe of Cretaceous sediments belonging into northern-more facies of the Klippen Belt. The bioherm limestones he assigned to Palaeocene.

Mišík (1966) at a description of Mesozoic and Tertiary microfacies of the Western Carpathians didn't avoid the bioherm limestones from Hričovské Podhradie (Pl. LXXIX, Figs. 1, 2).

Köhler (1966) from the reef body at Hričovské Podhradie described index Thanetian alveolinas – *Glomalveolina primaeva primaeva* (Reichel) and *A. primaeva ludwigi* (Reichel). In addition to Thanetian, he admitted also their younger age.

Samuel et al. (1967, text Fig. 1) described profile situated in the field road NE of the Hlboké n/Váhom Village. In the profile the formation of marlstones with thin beds of sandy limestones is exposed. The profile begins in Late Campanian, it continues across the entire Maastrichtian and according to the authors it terminates in Palaeocene (in layers with *Operculina heberti* Munier-Chalmas). Among the individual parts of the profile the authors state extensive lists of large and also small foraminifers.

Samuel & Salaj (1968) assigned to the reef limestones in the area of Hričov (Dolný Hričov) – Žilina Middle- to Late Palaeocene age.

Scheibner (1968) at a description of the reef complex Myjava-Hričov-Haligovka states, that at Hričovské Podhradie the bioherm limestones make up lenses 30 – 40 thick and 10 – 200 m long, frequent are also large blocks. The age of the formation with reef limestones is Palaeocene to Early Eocene. He distinguished back-reef shallows made of miliolid limestones with small coral growths (patch-reefs), reef walls are made of coral-algal growths in form of peripheral (fringing) reefs and finally, slope breccia. Scheibner (l.c.) presumed, that accounting for their dimensions the reefs are located more-or-less at the place of their origination.

Andrusov (1969) judged that at Hričovské Podhradie there are present lenticular bioherms transiting into surrounding calcareous sandstones. These bodies he presumed to represent true non-stratified bioherms, making-up morphologically conspicuous structures. Andrusov (l.c.) defined the Palaeocene Myjava-Hričov Furrow, dividing the ramp of the Klippen Belt from uplifted region of the Western Carpathians.

According to Čorbová (1969) planimetric analyses have shown, that in the reef limestones at Hričovské Podhradie the most frequent are algae (23.92 %), corals (19.66 %) and foraminifers (9.95 %).

Up to now the most detailed description of the reef bodies between Žilina and Hlboké n/Váhom is provided in the monograph by Samuel et al. (1972). The authors described in detail the most famous reef bodies at Žilina and Hričovské Podhradie, they created lists of fossils determined by them and depicted them on numerous photoplates. From Hričovské Podhradie they described 8 reef blocks and from Žilina 3 occurrences of reef limestones. One of the most important findings is the fact, that all reef bodies are detached from original basement and none of the blocks – despite their dimensions – is located in the autochthonous place of its origination. The reefs are Montian (today Selandian) – Thanetian in age, buried (replaced) dominantly in sediments of Ilerdian (Early Eocene) age.

Samuel (1972, 1973) defined Hričov-Žilina facies within Považie (Váh Valley)-Hanušovce sedimentary zone.

Bystrický (1976) at a description Palaeocene dasycladacean algae utilised also material from Hričovské Podhradie.

Köhler (1995) assessed 29 samples from this area. In opposite to Scheibner (l.c.) he doubted about the existence of large reef cliffs. He pointed out, that Thanetian blocks were replaced into Early Eocene rocks already in lithified form, after their diagenesis.

Tragelehn (1996) describes in more detail two localities from Hričovské Podhradie. As HP I he designated samples from distinct stony bench („Large Reef" in Samuel et al., 1972) east above the village. He stated, that it is not a true reef body, but rather a large lithified block of coarse-detritic limestones of dorsal fore-reef or of open environment and pointed out, that the placement of the block is alltochthonous, because it overlies siliciclastic sediments (conglomerates and sandstones) of Ilerdian. As much more interesting Tragelehn assesses the occurrence SW of the village. Lagoonal sediments of the Later Thanetian as well as limestones with reef debris he designated as the sample HP II. Into his list of Palaeocene microfacies from Hričovské Podhradie he assigned coral-algal rudstone and coral-Parachaetetes-bafflestones and float/rudstones. He assigned the rocks into Later Thanetian and pointed out, that in Alpine reef complex the rocks of this age are missing.

Buček (1998) mentions from Hričovské Podhradie the community of dasycladacean algae: *Zittelina bystrickyi* (Dieni, Massari et Radoičić), *Orioporella villatae* Segonzac, *Neomeris* sp., *Cymopolia* sp. and *Acicularia* sp.

In the year 2005 The Geological Map of the Middle Váh Valley 1 : 50 000 was published and in year 2011 The Explanatory notes to it (Mello et al., 2005, 2011). Within the collective of authors Buček & Nagy defined the Myjava-Hričov Group with the following lithostratigraphic units:

– Hričovské Podhradie Fm. – Palaeocene – Early Eocene;
– Jablonové Fm. – Palaeocene – Early Eocene;
– Súľov Fm. – Early to Middle Eocene;
– Domaniža Fm. – Middle Eocene.

Into Hričovské Podhradie Fm. (sensu Andrusov, 1965) with age range Palaeocene-Early Eocene they assigned also olistoliths of reef limestones.

3.3.5. Upper Cretaceous basement of the Palaeocene reef system (Hričovské Podhradie – Žilina)

While in some other territories some doubts could be expressed, whether the substrate of the Palaeocene carbonate platform provided only orbitoid layers of the Latest Cretaceous, two localities rimming from South and from North the Palaeocene-Early Eocene Hričovské Podhradie Fm. allow no doubts, that they are located directly on the basement of this facies.

a) The profile at Hlboké n/Váhom

The profile in detail described Samuel et al. (1967, Text-Fig. 1). It is located in the field road NE of the village approx. 500 m SW of the el. p. 551. Individual parts of the profile are documented by communities of planktonic foraminifers (in marlstones) and of large foraminifers (in the layers of biodetritic limestones). The profile begins in the Latest Campanian. Early and Middle Maastrichtian is typical of community *Globotruncana falsostuarti* Sigal, *G. elevata stuartiformis* Dalbiez (= *Globotruncanita stuartiformis*) and particularly abundant ?*Globotruncanella. havanensis* Voorwijk. Large foraminifers are represented by species *Orbitoides apiculata plana* Köhler, *O. apiculata apiculata* Schlumberger, *O. gensacicus praevius* Köhler, *Lepidorbitoides minor* Leymerie and *Siderolites calcitrapoides* Lamarck. Late Maastrichtian is represented by presence of *Orbitoides apiculata apiculata* Schlumb., *O. gensacicus gensacicus* Leym., *Lepidorbitoides socialis* (Leymerie) and *Siderolites calcitrapoides* Lam. Small foraminifers are represented by species *Abanthomphalus mayaroensis* (Bolli), *Globotruncana stuarti* (Lapparent), *Racemiguembelina varians* (Rhezak) and *Gublerina glaessneri* Brönnimann.

The profile according to the authors continues without change in facies and tectonic style into Palaeocene, which is made of sequence of organogenic limestones and calcareous organogenic sandstones. They contain only rare small foraminifers *Globigerina pseudobulloides* Plummer (= *Parasubbotina pseudobulloides*), *Gl. compressa* Plummer (= *Globanomalina compressa* and *Gl. triloculinoides* Plummer (= *Subbotina triloculinoides*), large foraminifers are represented by tests of *Operculina heberti* Munier-Chalmas and *Discocyclina* sp.

According to than-knowledge it could represent an uninterrupted transition from Cretaceous into Tertiary. Today we know, that *Operculina heberti* M.-Ch. doesn't occur in Danian and it appeared later (according to zonation by Serra-Kiel et al., 1998 in SBZ 3, i.e. in Early Thanetian and the same is valid for the first appearance of the genus *Discocyclina*). Therefore we have to assume, that between the Latest Maastrichtian and Thanetian there is a hiatus equalling to interval Danian-Selandian.

b) Na Skale – west of Žilina

On the flanks of the el. p. Hradisko, 400 m NE of el. p. 441 Na skale (map sheet 26-313 Žilina) west of Žilina in small exposures in nameless creek the Hradisko Fm. is cropping out (Mello et al., 2011) with share of sandy limestones to conglomerates of Maastrichtian age, from which Köhler (1960) states the orbitoid species: *Orbitoides apiculata* Schlumb., *O. media* (d´Archiac), *O. gensacicus* (Leymerie), *Lepidorbitoides socialis* (Douvillé) and *Siderolites calcitrapoides* Lamarck. Planktonic foraminifers represent *Abathomphalus mayaroensis* zone (Salaj et al., 1978). The top part of this Fm. is of regressive character – crushed organic relics document high energy of the environment.

Because in the immediate superincumbent of the Maastrichtian layers claystones are present, which represent Early Danian *Globigerina taurica-daubjergensis* zone (Salaj et al., l.c.), the considerations about gradual uninterrupted transition from Cretaceous into Tertiary at this site seemed to be justified. In this term the profile was presented also the participants of the excursion to the 18th European micropalaeontological colloquium (see Excursion Guide, Samuel & Gašpariková, 1983). The participants in the excursion took samples, but as stated by Hansen et al. (1990) the transition was documented neither by palaeomagnetic methods nor by the existence of iridium anomaly and certain hiatus has to be assumed here. To this corresponds also the uppermost part of the Maastrichtian Fm. of very shallow environment with high energy and signs of regression.

Also these two examples have clearly proven that the Late Cretaceous orbitoid layers in this area provided the substrate to the Palaeocene carbonate platform.

3.3.6. Palaeocene bioherm limestones

From Ostrý vrch (el. p. 548) above the village Hlboké n/Váhom till Žilina there are dissipated dozens of small and large blocks of the Palaeocene bioherm limestones. Their occurrences were divided into the following sites (Mello et al., 2005):

1. Hričovské Podhradie – Ostrý vrch

From the el. p. 548 Ostrý vrch – 41SP (coordinates N 49° 13´08.7´´, E 18° 36´53.1´´, Fig. 5a) above the village Hlboké n/Váhom till the first houses in the Hričovské Podhradie Village in addition to the stony cliff "Hričovská ihla – Hričov Needle" (site 2 in Samuel et al., 1972) passes the field road exposing the higher Early Eocene part of the Hričovské Podhradie Fm. In the flysch Fm. with sporadic beds of sandstones there are located large number of blocks Mesozoic and Palaeocene limestones. Signs of karstifying document emergence of the sediment, boring of their surfaces on shallow-water environment, into which they were replaced. The blocks are located directly in the field road, but also on both its sides, mainly in the vicinity of the el. p. 548 above "Hričov needle".

8 blocks were examined. Only the southernmost block at Ostrý vrch Hill represents fore-reef sediment with clasts of sandstones, quartz and Palaeocene biomicrites. Its Thanetian age is evidenced by the presence of *Discocyclina seunesi* Douv., *Orbitoclypeus ramaraoi* (Samanta) and *Operculina heberti* Munier-Chalmas. Other blocks originated from back-reef lagoonal to reef environment The original micrite matrix is frequently recrystallised. One block containing up to 10 mm large fragments of coral patch-reefs could come also from small coral growth (patch-reef), other originated in shallow lagoonal environment and in their composition participate mainly coralline algae, fragments of corals. Among foraminifers miliolid forms are dominating. The sporadical presence of *Discocyclina seunesi* Douv. and *Orbitoclypeus ramaraoi* (Samanta) indicates possibility of link of this environment with open sea. Interesting is the presence of large foraminifers *Miscellanea juliettae* Leppig (Early Thanetian – SBZ 3) in some blocks, because this species is extraordinary rare across the entire Palaeocene of the Western Carpathians.

2. Hričovské Podhradie – Hričovská ihla (Hričov Needle)

The protected Nature Monument "Hričov Needle" – 42SP (coordinates N 49° 13´13.7´´, E 18° 36´51.4´´, Figs. 5a, 5b) (= site 2 in Samuel et al., 1972) is visible to a large distance from the Váh River Valley. It is located in the slope 500 m west of the village Hričovské Podhradie. It is a 12 m high stony tower made of biomicrite of the type packstone, at places distinctly recrystallised. Clastic admixture is limited to tiny fragments of quartz and carbonates. In organic community dominating are coralline algae, a quite common fossil is *Peyssonnelia antiqua* Johnson. In community of foraminifers the most frequent are miliolid and sessile forms (*Solenomeris ogormani* (Douvillé), *Planorbulina cretae* (Marsson) and *Miniacina* sp.). Presence of large foraminifers *Discocyclina seunesi* Douv., *Orbitoclypeus ramaraoi* (Samanta) and *Operculina* cf. *heberti* Munier-Chalmas puts origin of this sediment into deeper parts of the carbonate platform. It originated during Early Thanetian (SBZ 3).

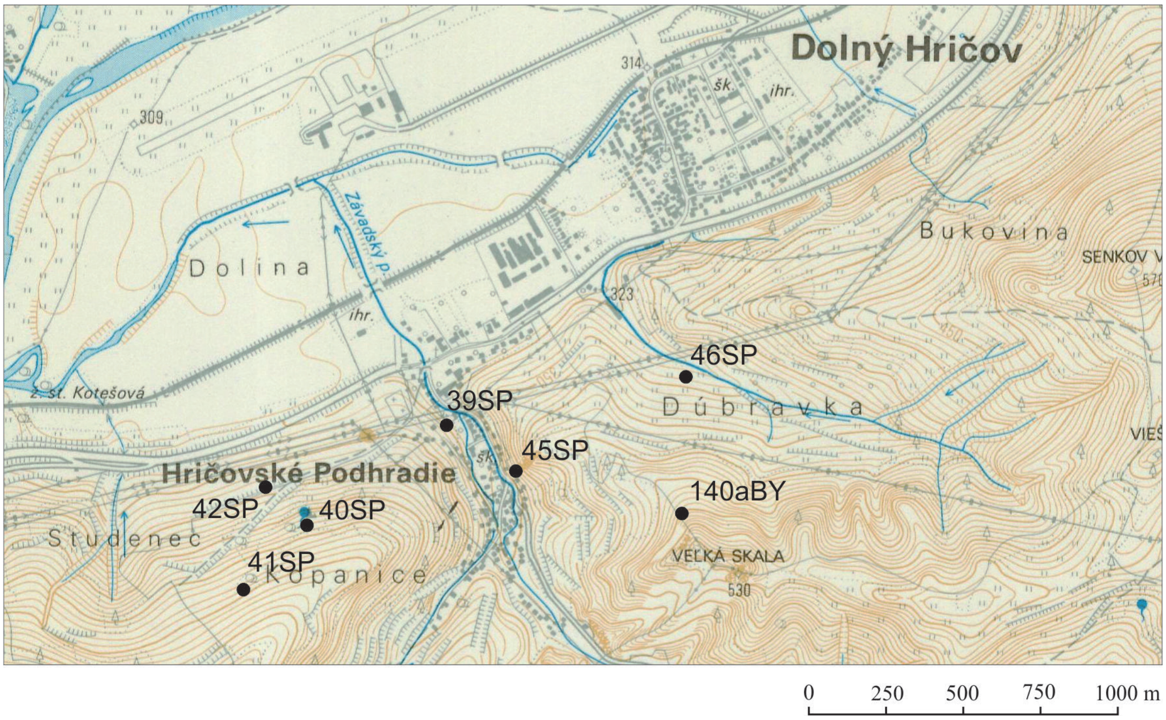


Fig. 5a. Situation map of Palaeocene sites (•39SP, •40SP, •41SP, •42SP, •45SP, •46SP, •140aBY) of the Middle Váh Valley (area Hričovské Podhradie – Žilina) at scale 1 : 25 000 (map sheet 25-424 Bytča).

A bit smaller block of approx. 2 m diameter is located in the slope below "Hričov Needle" and the road from Dolný Hričov to Bytča. It is of different composition as the previous block. Lagoonal shallow-water environment is evidenced by up to 7 mm large nodules of *Elianella elegans* Pfender et Basse, quiet protected environment is evidenced also by frequent growths around bioclasts, mainly corals, coralline algae. The absence of index fossils has not allowed to determine the age of this block precisely, but large similarity with the rocks of the following locality places it into Thanetian.

3. Hričovské Podhradie – abandoned quarry

It is one of the most attractive Palaeocene sites of the Western Carpathians, also included among selected excursion localities of the Middle Váh Valley (Buček in Mello et al., 2011).

The quarry is located on the western edge of the Hričovské Podhradie Village – 39SP (coordinates N 49° 13´22.404´´, E 18° 37´11.352´´, Figs. 5a, 5c-d). It was operated in 30s and 40s of the previous century (Andrusov, 1965), but up to now the profile of the reef body (more than 100 m in diameter) is well exposed.

Fig. 5b. Site Hričovské Podhradie – Hričov Needle, The Middle Váh Valley. 12 m high exposed block of organodetritic limestone (pale-yellow of organogeneous limestone with frequent large foraminifers and coralline algae) in Hričovské Podhradie Fm. of Palaeocene age – Early Thanetian (SBZ 3).

Fig. 5c. Site Hričovské Podhradie – the quarry, The Middle Váh Valley. Abandoned quarry exposing the reef olistolith more than 100 m diameter in the slope on the western edge of the village. Organogenic limestone in the Hričovské Podhradie Fm. of Palaeocene age – Early Thanetian (SBZ 3).

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The old abandoned quarry has attracted the attention already for many years. Bystrický (1976) described from here dasycladacean algae *Dactylopora* aff. *cylindracea* Lamarck and *Dactylopora deloffri* Bystrický. Köhler (1966) from this site described large foraminifers *Alveolina* (*Glomalveolina*) *primaeva primaeva* Reichel and *A*. (*G*.) *primaeva ludwigi* Reichel. Čorbová (1969) studied lithology of this body and distinguished 4 environments: a) fore-reef detritic facies, b) bottom of the reef with its sediments, c) wall and core of the reef and d) lagoonal facies.

Samuel et al. (1972) state that the body is made of very tectonically disturbed limestones with numerous tectonic breccias and secondary calcite. Organic relics make up to 40 % of rocks.

Köhler (1995) has pointed out, that while the northern and central part of the quarry exposes rocks of lagoonal environment with abundant thalli, nodules and crusts of coralline algae, frequent dasycladacean algae, fragments of branching and massive corals, miliolid foraminifers and Thanetian index fossil *Glomalveolina primaeva* Reichel, at the southern edge of the quarry the presence of *Discocyclina seunesi* Douv. and *Distichoplax biserialis* (Dietrich) Pia proves for a deeper environment (could represent a channel in reef platform or onset of its slope). He pointed out, that the block isn't at its original place, but is encompassed by Early Eocene rocks.

Tragelehn (1996) chose this locality to compare it with Alpine reef material. He assigned the limestones into coral-algal rudstone and coral-*Parachaetetes* bafflestone and float/rudstone. He depicted them in Pl. 20, Figs. 1, 2.

To-date the collections of S. Buček, E. Köhler and J. Bystrický from this quarry contain more than 200 examined thin sections.

Buček (in Mello et al., 2011, p. 306) in excursion description of this site in the right side of the quarry describes pinkish to red-brown and yellow-grey organogeneous limestones made of association of corals (*Actinacis cognata* Oppeheim), calcareous algae (*Elianella* sp., *Polystrata alba* (Pfender) Denizot, *Parachaetetes asvapatii* Pia), fragments of coralline algae and dasycladacean algae (*Cymopolia* sp., ?*Dissocladella* sp.), of various sessile forms of foraminifers, gastropods, bivalves and tubes of worms. The foraminifers are present mainly in miliolid forms, present is also *Glomalveolina primaeva* (Reichel), and *Miscellanea* sp. The environment is lagoonal (back-reef).

Fig. 5d. Site Hričovské Podhradie – the quarry, The Middle Váh Valley. Exposures of organogenic limestone in Hričovské Podhradie Fm. of Palaeocene age – Early Thanetian (SBZ 3).

Yellow-grey organogeneous and organodetritic limestones in left part of the quarry are composed mainly of corals (*Dendrophyllia* cf. *cantalabrum* Hennig, *Actinacis* sp.), algae (*Parachaetetes asvapatii* Pia, *Elianella elegans* Pfender et Basse, *Pycnoporidium* sp.), coralline algae (*Sporolithon* sp., *Pycnoporidium* sp.) and of Dasycladales species (*Cymopolia zitteli* L. et J. Morellet, *C. elongata* (Defrance) Munier-Chalmas, *Cymopolia* sp., *Neomeris koradae* Dieni, Mass. et Rad., *N*. cf. *grandis* Dieni, Mass. et Rad., *Uteria* cf. *brocchii* L. et J. Morellet, *U*. sp., *Rostroporella oviformis* Segonzac, ?*Sarfatiella* sp., *Frederica arbutiformis* Dieni, Mass. et Rad., *Sandalia multipora* Dieni, Mass. et Rad., *Trinocladus* sp., *Terqemella* sp., *Acicularia* sp., *Rusoella radoičicae* Barattolo, *Dactylopora bystrickyi* Dieni, Mass. et Rad. Large foraminifers are represented by species *Discocyclina seunesi* Douv., *Miscellanea* sp., *Alveolina* (*Gl*.) *primaeva* Reichel, *Idalina sinjarica* Grimsdale and various small foraminifers (*Triloculina* sp.), fragments of bivalves and gastropods. Samples with *Discocyclina seunesi* may belong into a deeper environment (fore-reef or a channel).

Several metres north of the quarry, behind its margin towards the houses there is located a limestone body made of breccia, in which fragments of biomicrites are cemented by sparite. The fragments originated from back-reef shallow-water environment with thalli and nodules of coralline algae, cyclostomatous bryozoans and miliolids. Fragments of coral patch-reefs make up separate clasts. Presence of *Orbitoclypeus ramaraoi* (Samanta) indicates Early Thanetian age (SBZ 3) of this sediment of the sea slope.

4. Hričovské Podhradie – blocks of bioherm limestones above abandoned quarry

In the slope above abandoned quarry in Hričovské Podhradie (between quarry and “Hričov Needle”) there are located several larger blocks of bioherm limestones. Of them the largest one (20 x 50m) is located in the slope above the field road – 40SP (coordinates N 49° 13´14.2´´, E 18° 37´00.5´´, Figs. 5a, c). According to the information by Andrusov from this body comes type material of some algae, which described Lemoine (1933) and likely from this body, and maybe also from the quarry, Pia (1934) described dasycladacean algae. It ought to be type locality of the described species *Lithothamnium andrusovi* Lem., *L. contraversum* Lem., *Mesophyllum varians* Lem., *M. ramosum* Lem., *M. heteroctidium* Lem., *Lithophyllum carpathicum* Lem., *Amphiroa propria* Lem., *Corallina abundans* Lem. Pia (1934) approx. from this site described *Dissocladella* spec. indet., *Acicularia* spec. indet., *Gyrogonites* spec. indet., and *Distichoplax biserialis* (Dietrich) Pia. The rock is micrite limestone – packstone with minute clastic admixture of quartz and carbonates. The relevant part of the rocks is made up of coralline algae, fragments of corals overgrown by algae and sessile foraminifers. Among the foraminifers frequent are miliolid forms (also *Miliolina andrusovi* Samuel, Borza et Köhler), among the agglutinated forms *Haddonia praeheissigi* Samuel, Borza et Köhler. Present are also large foraminifers *Discocyclina seunesi* Douv. and *Orbitoclypeus ramaraoi* (Samanta). The block originated in a bit deeper environment of back-reef (in channel fore-deep) or in the upper parts of fore-reef slope during Thanetian.

Fig. 5e. Site Hričovské Podhradie – large reef, the Middle Váh Valley. The largest Palaeocene reef olistolith in the Western Carpathians (220 x 50 m). organogenic limestone in Hričovské Podhradie Fm. of Palaeocene age – Early Thanetian (SBZ 3).

5. “Large Reef” above Hričovské Podhradie

Above the houses in Hričovské Podhradie, NE of the village up to now the largest body of Palaeocene limestones in the Western Carpathians is exposed, reaching a length of approx. 200 m and thickness of several dozens of metres – 45SP (coordinates N 49° 13´21.9´´, E 18° 27´27.4´´, Figs. 5a, 5e). Andrusov & Kuthan (1944) assumed that the body passes gradually into surrounding sandstones, but Samuel et al. (1972) doubted this opinion. Further research has shown, that this block is also redeposited into upper part of the Hričovské Podhradie Fm. Early Eocene in age (Mello et al., 2011) and it doesn’t prove for a gradual transition into surrounding rocks.

In the literature is a tradition (Scheibner, 1968; Samuel et al., l.c.), that it is the true reef body, but its composition contradicts the definitions of the reef structures. Already Tragelehn (1996) pointed out, that it is the fore-reef talus part. The rock is biosparite with rare lithoclasts. The main organic compound are coralline algae, which make up 2/3 of the rock volume (mainly *Sporolithon* sp.), frequent are thalli of *Polystrata alba* (Pfender) Denizot. Bryozoans are represented mainly by cheilostomate forms. Among foraminifers sessile forms are dominating, mainly *Planorbulina cretae* (Marsson). Sporadically there are present also globigerinoid planktonic forms. Frequent large foraminifers [*Discocyclina seunesi* Douv. and *Orbitoclypeus ramaraoi* (Samanta)] place this block into Early Thanetian (SBZ 3).

6. Hričovské Podhradie – blocks of bioherm limestones among “Large Reef” and el. p. 530 Veľká skala (el. p. 532 Komíny in Samuel et al., 1972)

From “Large Reef” south-eastwards – 140aBy (coordinates N 49° 13´12´´, E 18° 37´50.1´´, Fig. 5a) is well exposed Early Eocene (Middle Ilerdian-Cuisian) Ovčiarsko Mb. (conglomerate flysch) of the Hričovské Podhradie Fm. (Mello et al., 2005, 2011). In them there is located larger number of blocks attaining from 20 up to 150 cm in size. In more detail 4 blocks were examined. They represent biomicrites to biosparites of brecciated character at places. In two blocks is present community *Daviesina garumniensis* Tambareau, *Orbitoclypeus ramaraoi* (Samanta), *Discocyclina seunesi* Douv. and *Miscellanea* sp., but the most abundant biocompounds are coralline algae, rare fragments of coral patch-reefs. The sediment contains mixed shallow-water forms (*Daviesina garumniensis* Tamb. and rotaloid forms) with forms from a deeper environment. The further two blocks already unequivocally belong into talus of fore-reef environment. In addition to orthofragminid foraminifers, they contain also *Operculina heberti* Munier-Chalmas and globigerinids, but the main organic compound here are the coralline algae. All 4 blocks are Thanetian in age.

7. Hričovské Podhradie – "Vlčia jama" (Wolf Pit)

ENE of the Hričovské Podhradie Village towards the Ovčiarsko Village there is located a valley of nameless creek (cadastre part Dúbravka) – 46SP (coordinates N 49° 13´23.7´´, E 18° 38´08.3´´, Fig. 5a) (older designation Vlčia jama in Samuel et al., 1972). In the slope above the field road (north of the el. p. 530 Veľká Skala) there is scattered large number of blocks of Palaeocene bioherm limestones falling-out from the upper part of the Hričovské Podhradie Fm. of Early Eocene age (Mello et al., 2005, 2011).

From this site 7 blocks were examined. The rocks are biosparites to brecciated limestones. The most frequent fossils are coralline algae, cyclo- and cheilostomate bryozoans and variegated communities of foraminifers. Brecciated limestones are composed of fragments of algal and coral biomicrites. In two blocks substitution of biorelics, but also micrite, by chalcedony, is notable. Some of the blocks were exposed to karstifying and the cavities are filled with sandy material. All blocks from this site are Thanetian in age, which is proven by the presence of large foraminifers *Discocyclina seunesi* Douv. and *Operculina heberti* Munier-Chalmas. They originated in talus of fore-reef environment. Abundant fragments of coral biomicrites in breccias documents that also here the coralline structures were formed, but shortly after their origination they were destructed. They likely didn't mature into stage of diagenesis, which should increase the resistance of structures against the waves action.

8. Ovčiarsko

At the field road from the Ovčiarsko Village – 1K (coordinates N 49° 13´16´´, E 18° 40´47.18´´, Fig. 5f) into Žilina (700 – 750 m SW. from the el. p. 638 Malé hradisko (Veľké hradisko) in Mello et al., 2005, or Hradisko in Samuel et al., 1972) there are located several blocks of pale-grey bioherm limestones positioned in the upper part of the Hričovské Podhradie Fm. (in conglomerates of the flysch of the Ovčiarsko Mb.), Early Eocene in age.

3 blocks were examined. The largest of them with a diameter of 2 m Samuel et al. (1972) assigned to Cretaceous, because it contains *Cadosina undulosa* Borza, *C. spinosa* Borza, but also *Pithonella ovalis* (Kaufmann), *Calcisphaerula* cf. *innominata* Bonet and *Bonetocardiela* cf. *cardiiformis* (Ayla-Castanares, Seiglie). This age dating was not correct, because in the block type Selandian fossils (SBZ 2) – *Pseudocuvillierina sireli* (Inan) and *Sarosiella feremollis* Segonzac were identified and in addition to them frequent coralline algae, nodules of *Elianella elegans* Pfender et Basse, fragments of coral patch-reefs, cyclostomate bryozoans and miliolid foraminifers. Sediment originated in protected back-reef environment and it is up to now the only block in the area of Hričovské Podhradie – Žilina, which is not Thanetian, but Selandian in age and it is evidenced, that in this area the reef system started to evolve already in Selandian.

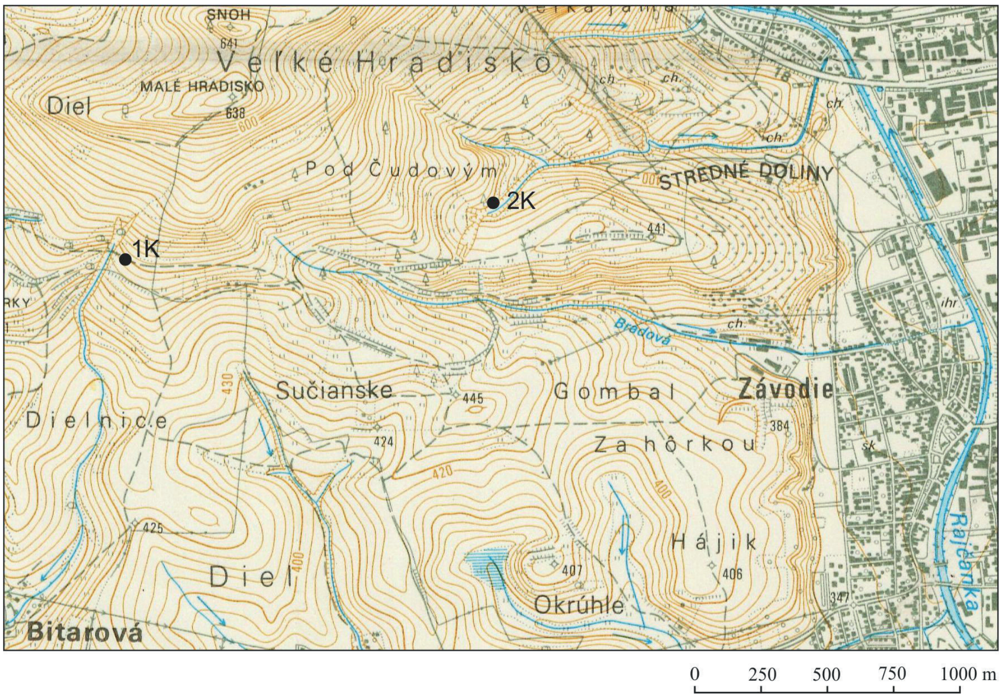

Fig. 5f. Situation map of Palaeocene sites (•1K, •2K) of the Middle Váh Valley (area Hričovské Podhradie – Žilina) at scale 1 : 25 000 (map sheet 26-313 Žilina).

9. Hradisko

Geologic profiles between Žilina and el. p. 638 Malé Hradisko (Veľké Hradisko in Mello et al., 2005) – 2K (coordinates N 49° 13´23´´, E 18° 41´55.91´´, Fig. 5f) were objects of various publications. In detail they were processed in Excursion Guide to the 18th European micropalaeontologic colloquium (Samuel & Gašpariková, 1993).

Blocks of grey-white to grey bioherm limestones 10 to 50 cm in size are the most frequently found in the vicinity of el. p. 450 (1 km SE of Veľké Hradisko). 6 blocks were examined. Only 1 block of biomicrite nature (packstone) could be affiliated into back-reef lagoonal environment. It contains frequent coralline algae (excellent-preserved thalli of *Polystrata alba* (Pfender) Denizot, cyclostomate bryozoans, fragments of corals and frequent foraminifers, among them also *Daviesina* sp. and *Miscellanea* sp. The block is Thanetian in age similarly to other blocks, which originated in slope of the fore-reef environment and they contain large foraminifers *Discocyclina seunesi* Douv. and *Orbitoclypeus ramaraoi* (Samanta) and redeposited *Coskinolina* sp. Common are also coralline algae, bryozoans, fragments of corals, bivalves, tubes of worms. In addition to lithoclasts the grains of glauconite are not rare.

From the area of Hričovské Podhradie – Žilina in collections of Buček, Köhler and Bystrický there are stored 971 examined thin sections.

This rich thin section material has allowed to distinguish the following microfacies types in Palaeocene bioherm limestones:

A. Corallinacean-dasycladacean packstone with Glomalveolina primaeva (Reichel) (Pl. IV, Fig. 4)

Shallow-water lagoonal sediment is exposed dominantly in abandoned quarry on the western end of the village Hričovské Podhradie. Limestones with micrite are penetrated by numerous fissures 0.3 – 1.5 mm wide and with sparite. Among biocompounds dominating are coralline algae (*Sporolithon* Heydrich, *Pseudoamphiroa* Moussavian, *Polystrata* Denizot, *Elianella* Pfender et Basse, *Distichoplax biserialis* (Dietrich) Pia). Very frequent are sections of spheroidal tests *Glomalveolina primaeva* (Reichel). This Thanetian index fossil (SBZ 3 – 4) from Hričovské Podhradie described in detail Köhler (1966). Common are also tests of *Miscellanea* sp., fragments of bivalves and gastropods, tiny fragments of corals. Among benthic foraminifers dominating are miliolids, agglutinated tests of textularia type and tiny rotaloid forms.

Site: Hričovské Podhradie – abandoned quarry

Age: Early Thanetian (SBZ 3)

B. Corallinacean-dasycladacean packstone to wackestone

In shallow-water lagoonal environment originated also horizons with frequent dasycladacean algae (Buček, 1998) and namely the species *Zittelina bystrickyi* (Dieni, Massari et Radoičić), *Orioporella villatae* Segonzac, *Neomeris* sp., *Cymopiolia* sp. and *Acicularia* sp.

Biomicrite matrix is frequently secondary broken and later again cemented by sparite, whereas the fissures are up to 3 mm wide (the destruction occurred after cementation of original biomicrite). In addition to dasycladacean algae dominating are also further algae belonging to the genera *Sporolithon* Heydrich, *Polystrata* Denizot, *Elianella* Pfender et Basse, *Distichoplax* Pia. Present are also tiny fragments of corals, fragments of bivalves, gastropods and ostracods. Among the foraminifers there are frequent sections of *Solenomeris ogormani* (Douvillé), *Sistanites* sp., *Textularia* sp., miliolid and rotaloid forms.

Site: Hričovské Podhradie – abandoned quarry

Age: Early Thanetian (SBZ 3)

C. Corallinacean-coral bindstone to boundstone (Pl. V, Fig. 4)

Although thin sections are frequently enriched in fragments of colony or solitary corals, true coralline or coral-algal growths (structures) have not been preserved. Large amount of fragments proves for existence of coral bodies of smaller dimensions, which were frequently broken by currents and waves action after their origination.

The essential construction biocompounds in this environment were corals belonging to *Gonipora* sp. as well as algae of genera *Sporolithon* Heydrich, *Pseudoamphiroa* Moussavian, *Polystrata* Denizot, *Distichoplax* Pia. Common are also dasycladacean algae (much rarer than in previous microfacies), fragments of bivalves, gastropods and crinoids. Among foraminifers present are *Solenomeris ogormani* (Douvillé), frequently in crusts with algae (*Haddonia praeheissigi* Samuel, Borza et Köhler, sessile *Planorbulina cretae* (Marsson), rotaloids of the type *Smoutina* sp., miliolid and other rarer forms.

Site: Hričovské Podhradie – abandoned quarry, block at “Hričov Needle”

Age: Early Thanetian (SBZ 3)

D. Corallinacean-coral rudstone to framestone (Pl. II, Fig. 2; Pl. X, Figs. 3, 4)

Type locality of *Pseudoamphiroa* (the *Amphiroa,* originally) *propria* (Lemoine 1933) is block of bioherm limestone in the slope above the abandoned quarry in Hričovské Podhradie. Accounting for large number of nodules of *Pseudoamphiroa* Moussavian in thin sections this type is defined as a particular microfacies (Buček & Köhler, in press).

The micrite matrix contains sporadic fragments of carbonates (up to 0.5 mm) and fragments of quartz up to 0.2 mm. Up to 2 mm wide fissures are filled with sparite. Among the biocompounds in thin sections dominating are excellent preserved thalli and nodules of *Pseudoamphiroa propria* (Lemoine), up to 30 mm large fragments of corals of the genus *Orbignygyra* sp.; the association is amended on further algae of genera *Sporolithon* Heydrich, *Elianella* Pfender et Basse, *Polystrata* Denizot, rare are fragments of bivalves, gastropods, bryozoans and tubes of serpulid worms. The age dating allows the presence of (although very rare) *Glomalveolina primaeva* (Reichel), *Discocyclina seunesi* Douvillé, abundant are agglutinated foraminifers *Placopsilina* sp. *Haddonia praeheissigi* Samuel, Borza et Köhler, sessile *Solenomeris ogormani* (Douvillé), *Planorbulina cretae* (Marsson), very rare are tests of globigerinid foraminifers. The sediment originated at the back side part of the reef crest.

Site: Hričovské Podhradie – block of the Palaeocene limestone in the slope west of the village

Age: Early Thanetian (SBZ 3)

E. Grainstone to rudstone with Miscellanea juliettae LEPPIG *(Pl. V, Fig. 1)*

Representatives of genera *Miscellanea* and *Daviesina* are rare in the described rocks, but the presence of very frequent tests of *Miscellanea juliettae* LEPPIG in blocks above the "Hričov Needle" west of Hričovské Podhradie enables definition of independent microfacies type.

The rock is flesh-tint-grey organogeneous limestone. In the micrite matrix there are present carbonate clasts reaching in size up to 2 mm. Up to 6 mm wide fissures are filled with sparite. Dominant microfossil in the community is *Miscellanea juliettae* LEPPIG, sporadically associated with *Glomalveolina primaeva* (REICHEL), *Daviesina* sp. and *Operculina* sp. Common are coralline algae of genera *Sporolithon* HEYDRICH, *Elianella* PFENDER et BASSE, *Polystrata* DENIZOT. In thin sections there are also fragments of bivalves, coral patch-reefs, crinoids and foraminifers (benthic, miliolid and rotaloid forms).

Site: Hričovské Podhradie – blocks above the "Hričov Needle"

Age: Early Thanetian (SBZ 3)

F. Packstone to grainstone with bryozoans (Pl. XI, Fig. 1)

Fore-reef talus sediment containing frequent bryozoans (mainly deeper dwelling cheilostomate forms), discocyclinas and operculinas contains also frequent organic relics washed-in from the carbonate platform. The organic debris is very heterogeneous and mixed-up. The most frequent are fragments of algae (*Sporolithon* HEYDRICH, *Elianella* PFENDER et BASSE, *Polystrata* DENIZOT, *Distichoplax* PIA), fragments of bivalves and coral debris. Relatively frequent are large foraminifers dwelling in deeper slope of neritic environment than *Discocyclina seunesi* DOUVILLÉ, *Orbitoclypeus ramaraoi* (SAMANTA) and *Operculina heberti* MUNIER-CHALMAS. Rare are from shallower environment replaced tests of *Daviesina* sp., *Miscellanea* sp. and small benthic foraminifers. Quite striking is lacking of planktonic foraminifers.

Site: Hričovské Podhradie – the "Hričov Needle", Large Reef

Age: Early Thanetian (SBZ 3)

*G. Packstone to grainstone with Pseudocuvillierina sireli (*INAN*) (Pl. III, Fig. 1)*

The only block at Ovčiarsko by its composition and age differs from all blocks of the bioherm limestones between Hričovské Podhradie and Žilina. Original biomicrite of the type packstone is notably recrystallised and micrite matrix is substituted by sparite. Lithoclasts are almost lacking. Organic composition is very heterogeneous; frequent are coralline algae, but dasycladacean algae *Sarosiella feremollis* SEGONZAC is also present. Frequent are fragments of coral patch-reefs, bivalves; among foraminifers dominating are frequent and relatively well preserved tests of *Pseudocuvillierina sireli* (INAN), very frequent are also various miliolid forms. The rock originated in protected lagoonal environment almost without contribution of terrigeneous material.

Site: Ovčiarsko

Age: Selandian (SBZ 2)

3.3.7. Age of sediments containing blocks of the Palaeocene bioherm limestones

Samuel et al. (1972) gave a great attention to rocks, in which the reef bodies are present in the form of separated blocks and olistoliths. Although had not looked likely, their research has shown, that also the largest bodies are replaced into younger sediments. Samuel et al. (l.c.) provide also lists of fossils (mainly of large foraminifers), for which the Early Eocene (mainly Ypresian) age has been proven.

Also the recent research has confirmed Early Eocene age of the higher parts of the Hričovské Podhradie Fm. We can offer the examples of the flysch Hričovské Podhradie Fm. in the slope above the "Hričov Needle" (site 1). Here, the horizons of non-assorted polymict sandstones with up to 4 mm large lithoclasts contain numerous large foraminifers, among them *Nummulites pernotus* SCHAUB, *N. praecursor* DE LA HARPE, *N. exilis* DOUVILLÉ, *Assilina leymeriei* D´ARCHIAC et HAIME, *Ass. pustulosa* DONCIEUX, *Operculina canalifera* D´ARCHIAC, *O. semiinvoluta* NEMKOV et BARKHATOVA, *Discocyclina archiaci* (SCHLUMBERGER). These fossils date the sandstones into the Middle Ilerdian (SBZ 7 – 8).

The next locality is the valley of unnamed creek in the area Dúbravka ("Vlčia jama – Wolf Pit" – site 7) east of Hričovské Podhradie. The Hričovské Podhradie Fm. contains numerous smaller blocks of bioherm limestones. Fine- to medium-grained sandstones with clasts reaching in size 0.2 – 1.0 mm contain weakly rounded clasts of carbonates, sandstones and quartz. Frequent large foraminifers show traces of damage and grinding of tests. Community of large foraminifers is represented by *Nummulites pernotus* SCHAUB, *N. exilis* DOUVILLÉ, *N. praecursor* DE LA HARPE, *N. robustiformis* SCHAUB, *Assilina pustulosa* DONCIEUX, *Operculina canalifera* D´ARCHIAC, *O. semiinvoluta* NEMKOV et BARKHATOVA and *Discocyclina archiaci* (SCHLUMBERGER) and also this upper part of the Hričovské Podhradie Fm. is placed into the zone SBZ 7 – 8 (Middle Ilerdian).

3.3.8. Evolution of the carbonate platform

Occurrences of the Late Cretaceous orbitoid layers in the basement of the Palaeogene sediments again provide the evidence, that the carbonate platform was formed upon this substrate. But in opposite to other areas, where during Palaeocene corrasion of the substrate and frequent resedimenation of Late Cretaceous biocompounds into Palaeocene sediments occurred, here the sedimentation at the beginning of Palaeocene (already in Danian, cf. Samuel & Gašpariková, 1993) conserved this substrate.

Although in previous works (Samuel et al., 1972; Mello et al., 2011) only Early Thanetian (SBZ 3) age of the reef system duration was assumed, the Selandian block at Ovčiarsko (site 8) indicates, that at least rudimentary this system originated already in Selandian, but fully developed in Early Thanetian. From examined blocks 28 % could be affiliated into lagoonal back-reef environment and 72 % into fore-reef slope environment. No one of blocks can be assigned as a component of the reef structure, but large amount of fragments of coral patch-reefs in thin sections indicates, that in some form the reef crest could exist here and tiny coralline and coral-algal growths (patch-reefs) could develop on it. This could be in accord with the opinion by Tragelehn (1996), that in Hričovské Podhradie could be found only fore-reef slope facies, but immense thickness of these fore-reef sediments (Hričovské Podhradie – "Large Reef", site 5) is really striking.

In Late Thanetian (SBZ 4) occurred, similarly to other sites of the Peri-Klippen Belt, intense tectonic movements (after-events of the Laramian phase of folding), during which the carbonate platform was completely uncovered and corroded. The recovered sedimentation in the Early Ypresian – Ilerdian (Samuel et al., 1972) was of flysch character, which proves for a deeper sedimentary environment, into which disrupted parts of the carbonate platform had slumped.

3.4. Orava

Orbitoid facies of the Late Cretaceous in the area Orava is already in known. Andrusov (1950) states that in Podhale flysch south of Tvrdošín and Trstená there are present blocks containing large foraminifers of *Pseudosiderolites vidali* (Douvillé) and *Orbitoides media* (d´Archiac).

Till the year 1968 the occurrence of the Palaeocene rocks from Orava was not documented. For a long time it had been supposed, that a large part of the Orava area is covered by the sediments of the Inner Carpathian Palaeogene, which sedimentation began in Middle Eocene. Orava is a classical territory, in which there was delineated and defined Sub-Tatric Group (Gross et al., 1984) with basal Borové and overlying Huty, Zuberec and Biely Potok formations (stratigraphic range Middle Eocene to Oligocene).

To the existence of sediments, older than the sediments of the Sub-Tatric Group, pointed out Mišík et al. (1968), who from the site Brezovica stated presence of blocks of Campanian limestones of bioherm character containing *Orbitoides media media* (d´Archiac), *O. media megaloformis* Papp et Küpper and *Pseudosiderolites vidali* (Douvillé). Even more frequent at this site are blocks of Palaeogene bioherm limestones, in which the most abundant compounds are coralline algae and at places also dasycladacean algae, sessile foraminifers, corals and bryozoans. Mišík et al (l.c.) pointed out, that in opposite to other known sites of the Palaeocene bioherm limestones in these are lacking some typical fossils as *Distichoplax biserialis* (Dietrich) Pia and *Globochaete* sp. The authors assumed that the relevant contributor of the material was cordillera from wider area of the Klippen Belt related to the south-eastern margin of its recent boundary.

Bystrický (1976) described from the site Brezovica dasycladacean algae of Palaeocene age *Dactylopora gušići* Bystrický, *Broeckella belgica* Morellet et Morellet and he mentions also presence of genera *Cymopolia* Lamouroux, *Karreria* Munier-Chalmas, *Dactylopora* Lamarck, *Digitella* Morellet et Morellet, *Neomeris* Lamouroux, *Dissocladella* Pia, *Indopolia* Pia, *Acicularia* d´Archiac and *Terquemella* Munier-Chalmas, which in the scope of the study of representatives of the genus *Triploporella* in the Western Carpathians were supplemented by Soták et al. (1988) on occurrences of the species *Triploporella apenninica* Baretti.

Gross et al. (1993) state, that blocks of Palaeocene rocks are located in thick layers of paraconglomerates in the Biely Potok Fm. of the Sub-Tatric Group, of the age Late Eocene to Oligocene. These conglomerates are sediments of submarine slumps and are typical of their large heterogeneity of rock lithotypes, well rounding, and high share of Palaeogene intraclasts and at places large dominance of sandy component in the blocks.

Köhler et al. (1993) judged, that Palaeocene reef limestones from Orava show many similar features to the limestones of the Myjavská pahorkatina Upland and therefore they placed them into single Myjava sedimentary basin.

In detail this issue was analysed by Köhler & Gross (1994), who described blocks from three sites: Brezovica, Zábiedovo and Skorušina. The blocks are located in the bottom part of the Biely Potok Fm. The authors stated, that "Peri-Klippen Belt" in Orava represents a complex and variegated facies unit. The oldest rocks, which could be affiliated to it, are Late Cretaceous – Senonian in age. In Palaeocene a considerable differentiation of sedimentary spaces in the basin had occurred. A platform developed with all elements of the reef complex – back-reef also fore-reef environment as well as coral-algal structures. The complex reef system couldn't evolve in small area, which is proven by tiny fragments of Palaeocene rocks scattered in the Eocene rocks of the Sub-Tatric Group covering large area of Orava. In Thanetian Late-Laramian movements occurred during which the Upper Cretaceous substrate of the platform was corroded, but the platform itself extinct in Early Eocene – Ilerdian during pronounced deepening of the sedimentary space. The process of destruction of the carbonate platform and the reef complex atop it had attained the greatest intensity in younger Eocene and by the beginning of Oligocene, when the rocks of the "Peri-Klippen" Zone had got into unbalanced position due to vertical movements and they had undergone disintegration and redeposition in the form of blocks placed into the Biely Potok Fm. of the Sub-Tatric Group.

3.4.1. Upper Cretaceous basement of the Palaeocene reef system

Proves of the Late Cretaceous rocks occurrence in orbitoid facies in Orava could be divided into three groups: occurrences in situ; replaced occurrences in blocks; replaced Late Cretaceous fossils in Palaeocene bioherm limestones (will be referred to at the description of the Palaeocene microfacies).

Occurrences in situ:

Salaj & Köhler (2001) delineated in Senonian in Orava the facies of the Lučivný vrch Hill and they described in it two profiles:

The profile Homôlka N of Kňažia Village between el. p. Homôlka (740 m) and Opálený (755 m) is made of sandstone complex containing large foraminifers, Campanian in age: *Praesiderolites dordoniensis* Wannier, *Pseudosiderolites vidali* (Douvillé) and „*Operculina*" sp. as well as community of foraminifers with *Globotruncana arca* (Cushman), *Globotruncanita elevata stuartiformis* (Dalbiez) and others.

The second profile is located in the vicinity of the el. p. Lučivný vrch Hill (840 m), 1.3 km N of the Podbiel Village. Also in this profile there are sandstones Campanian in age and they contain community *Praesiderolites dordoniensis* Wannier, *Pseudosiderolites vidali* (Douvillé) and numerous small foraminifers as *Globotruncana arca* (Cushman), *G.* cf. *bulloides* Vogler and others.

On the southern slopes of the el. p. Lučivný vrch Hill there are blocks of sandstones, originally making up the highest part of the formation under study. The blocks contain *Orbitoides tissoti* Schlumberger, *Lepidorbitoides* sp., *Helicorbitoides* sp. and the authors assigned them into interface between the Early and Late Campanian.

Late Maastrichtian orbitoid layers described Salaj & Samuel (1963) in the road-cut at the Krivá Village, where in the sandstones *Orbitoides gensacicus* (Leymerie), *O. apiculata* Schlumberger, *O. apiculata grünbachensis* Papp, *O. apiculata plana* Köhler and *Siderolites calcitrapoides* Lamarck are present.

Allochthonous occurrences in blocks:

They were mentioned already by Andrusov (1950). Blocks of Campanian from Brezovica and from creek Zábidovčík described Mišík et al. (1968). Borza et al. (1977) from Brezovica state blocks of sandstones with *Orbitoides media media* (d´Archiac), *O. megaloformis* Papp et Küpper, *O. apiculata plana* Köhler, *Lepidorbitoides minor* (Schlumberger), *Hellenocyclina beotica* Reichel and *Omphalocyclus macroporus* Lamarck, which they assigned into Early Maastrichtian.

Köhler & Gross (1994) also analysed several blocks from the site of Brezovica and they describe carbonate sandstones and sandy limestones with *Pseudosiderolites vidali* (Douvillé), bioherm micrite limestones with *Orbitoides media* (d´Archiac), *Pseudosiderolites vidali* (Douvillé) and *Lepidorbitoides* sp. and sandstones and sandy limestones with fragments of *Inoceramus* plates (Late Campanian to Maastrichtian).

From the sites Zábidovčík and Skorušina (at Zábiedovo) the above mentioned authors state polymict sandstones to sandy limestones with tests of *Orbitoides apiculata plana* Köhler, *O. gensacicus praevius* Köhler, *Siderolites calcitrapoides* Lamarck, *Lepidosiderolites socialis* (Leymerie) and *Nummofallotia cretacea* (Schlumberger). These blocks are Late Maastrichtian in age.

3.4.2. Palaeocene bioherm limestones

Analysed material comes from three sites and was collected in various time periods.

1. Brezovica – Water reservoir

Paraconglomerate body in the Biely Potok Fm. of the Sub-Tatric Group was exposed in the gullies above southern edge of the village at the water reservoir – 17 O (coordinates N 49° 20.239´, E 19° 39.216´, Fig. 6a) (Köhler & Gross, 1994). The gullies exposure is very variable, it depends on the season, intensity of rainfall and also from anthropogenic activities, such as earth-works, which deleted the majority of gullies (Fig. 6b).

The Palaeocene age could be assigned to 32 examined pebbles, which dimensions range from 5 into 40 cm in diameter.

14 blocks could be affiliated into back-reef lagoonal environment. Large nodules of *Elianella elegans* Pfender et Basse call the attention to the shallow-water lagoonal environment, in some pebbles also dasycladacean algae are very frequent (some of them described Bystrický, 1976), Common are also fragments of corals, bivalves, gastropods, fragments of crinoids and numerous foraminifers. Several blocks are lacking of any index fossils and their Danian-Selandian age (SBZ 1 – 2) cannot be excluded. In some blocks there are present the Selandian index fossils – *Globoflarina* sp., *Pseudocuvillierina sireli* (Inan) and mainly *Miscellanites primitivus* (Rahaghi). There were determined also *Haymanella palaeocenica* Sirel, *Haddonia praeheissigi* Samuel, Köhler et Borza, *Placopsilina* sp., *Stomatorbina* sp., *Miniacina* sp. and others. We have to note, that Bystrický (l.c.) was in favour of Danian-Montian (= Selandian) age of limestones with dasycladacean algae from Brezovica.

Large part of two blocks of coralline biomicrites was made up (to 90 % of the area) of coral patch reefs of the genus *Actinacis*. They could be considered as elements of coral structures on the reef crest.

16 blocks belong into fore-reef talus facies. They are made of variegated palette of rocks from biodetritic limestones up to sandstones. Lithoclasts are represented by fragments of quartz, quartzites and fragments of various carbonates. Among the bioclasts the most common are fragments of coralline algae and *Distichoplax biserialis* (Dietrich) Pia, quite frequent are cheilostomate bryozoans, redeposited fragments of corals, bivalves, gastropods, crinoids and various foraminifers. Some of the blocks don't contain any index fossils and their Danian-Selandian age cannot be excluded. In other pebbles with *Miscellanites primitivus* (Rahaghi) – Selandian (SBZ 2) are located, but there are present also blocks of unequivocally Thanetian age with *Discocyclina seunesi* Douvillé, *Coskinolina* sp., *Operculina heberti* Munier-Chalmas. In these rocks very frequent are also replaced Late Cretaceous fossils, such as *Orbitoides media* (d´Archiac), *Lepidorbitoides minor* Schlumberger, *Siderolites calcitrapoides* Lamarck, *Hellenocyclina beotica* Reichel, which originated from the disturbed Maastrichtian layers.

2. Zábiedovo –Zábidovčík Creek

Locality is mentioned already in Mišík et al. (1968) and Köhler & Gross (1994). The conglomerate body above right bank of the Zábidovčík Creek 1.2 km south of the Zábiedovo Village – 18 O (coordinates N 49° 18.488´, E 19° 36.669´, Fig. 6c) contains blocks of variegated composition, among them dominating are blocks of pale-grey Palaeocene limestones reaching max. 50 cm in diameter. The exposure of rocks was in the last the years covered

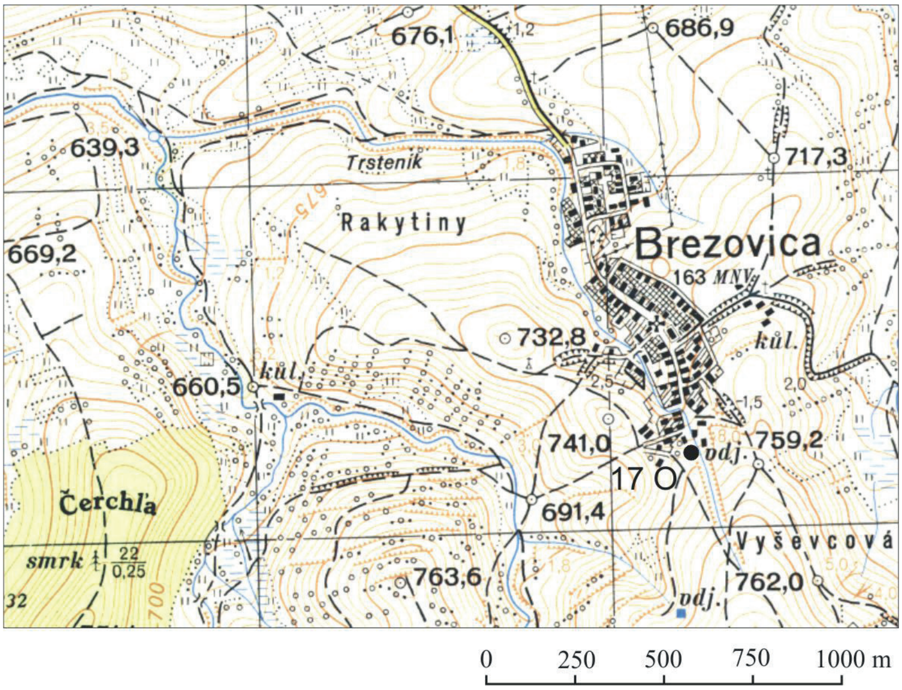

Fig. 6a. Situation map of locality Brezovica – •17 O in Orava at scale 1 : 25 000 (map sheet M-34-88-C-d Liesek).

Fig. 6b. Site Brezovica Water reservoir, Orava. Horizons of up to 10 m thick paraconglomerates in the bottom part of the Biely Potok Fm. of the Sub-Tatric Group. The Paraconglomerates they contain pebbles of Late Cretaceous and Palaeocene organogenic limestone (Selandian – Early-?Late Thanetian, SBZ 2 — SBZ 3 — ?4).

with scree and for assessment the material from older samplings was used.

13 blocks were examined. Two blocks are of the lagoonal origin containing large nodules of *Elianella elegans* Pfender et Basse, in variegated association of foraminifers miliolid forms are in prevail, rare are sections of *Miscellanites primitivus* (Rahaghi). Further three blocks also originated from back-reef environment, where huge evolution of coralline algae occurred and at places also of cyclostomate bryozoans. Clastic admixture is insignificant. In one block, besides coralline algae, frequent are also dasycladacean algae. One block contains large fragments of coral patch-reefs and comes from vicinity of coral growths.

Other blocks represent slope environment. Frequent presence of Senonian large foraminifers indicates underlying Cretaceous sediments. Tests of *Orbitoides media* d´Archiac, *O.* cf. *apiculata* Schlumberger, *Hellenocyclina beotica* Reichel and *Siderolites calcitrapoides* Lamarck are also present. Much rarer are tests of Palaeocene large foraminifers – *Discocyclina seunesi* Douvillé and *Miscellanites* sp. Among biocompounds frequent are fragments of thalli and nodules of coralline algae. Lithoclasts are of variegated composition, they are represented mainly by fragments of Mesozoic carbonates and fragments of quartz.

While the slope fore-reef sediments are Thanetian in age (SBZ 3), lagoonal sediments have wider age interval – Selandian-Early Thanetian (SBZ 2 – 3).

3. Skorušina

The site is located ESE of Zábiedovo in the forest road cut 3 km west of summit of the el. p. Skorušina and 500 m SSE of the el. p. 1,033.3 (Köhler & Gross, 1994) – 1K (coordinates N 49° 17´32´´, E 19° 39´1.59´´, Fig. 6d). Weakly exposed paraconglomerate body provided several blocks of Late Cretaceous orbitoid limestones and sandstones, but also two blocks of Palaeocene age.

One block originated in lagoonal back-reef environment. In the rock dominating are large nodules of *Elianella elegans* Pfender et Basse, among foraminifers is present variegated association of miliolid forms. The block is Selandian in age (SBZ 2). The second block is biosparite with frequent lithoclasts; it originated on the slope of the fore-reef environment. Among organic compounds in the rock coralline algae are dominating. For age dating is important the presence of *Discocyclina seunesi* Douvillé (Early Thanetian – SBZ 3). Common are also replaced tests of Maastrichtian species *Siderolites calcitrapoides* Lamarck, *Hellenocyclina beotica* Reichel and *Lepidorbitoides* sp.

It was already mentioned, that the Palaeocene carbonate platform at the territory of Orava had notably larger extent. While larger blocks are only in paraconglomerates of the Biely Potok Fm. (Late Eocene – Oligocene), numerous fragments of algal and algal-foraminifers micritic limestones were found in sandstone layers of the Huty and Zuberec Fms. of the Sub-Tatric Group (Köhler & Gross, 1994). Basinal claystones with Palaeocene microfacies in blocks at the Kňažia Village were mentioned by Matějka & Hanzlíková (1962).

From the Late Cretaceous and Palaeocene layers of Orava 408 examined thin sections are at disposition (collections by Buček, Köhler and Bystrický).

In the blocks of the Palaeocene bioherm limestones it was possible to distinguish the following microfacies types:

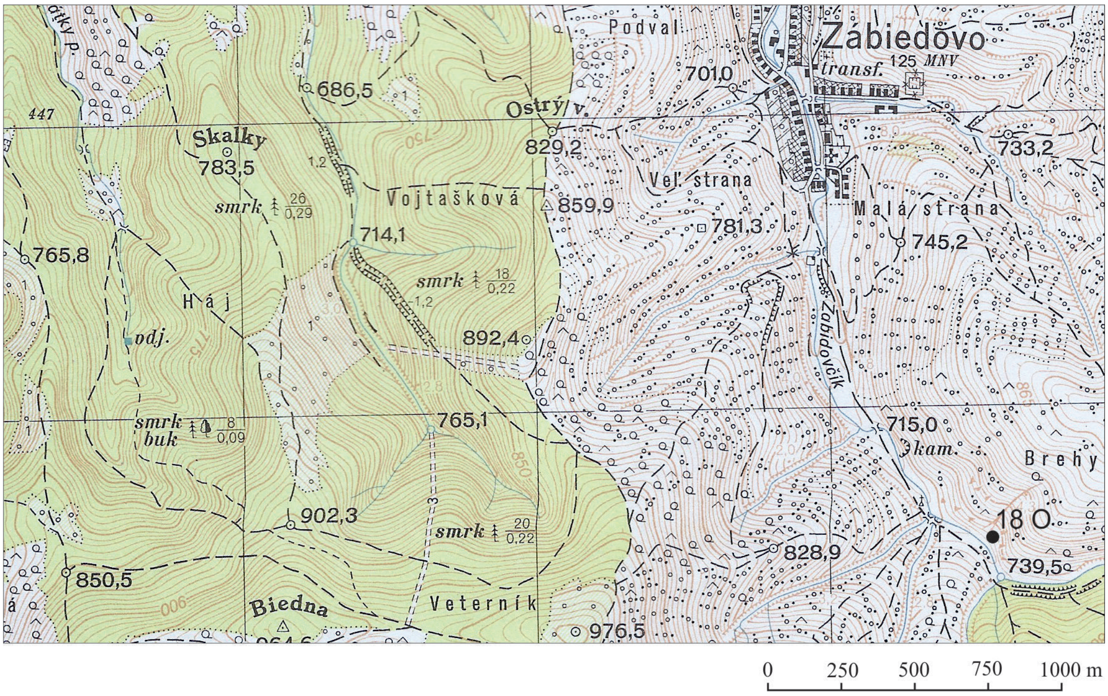

Fig. 6c. Situation map of locality Zábiedovo – •18O in Orava at scale 1 : 25 000 (map sheet M-34-100-A-a Nižná).

A. Corallinacean packstone-wackestone

The rock is biomicrite with very rare lithoclasts of carbonates and quartz reaching in size up to 0.7 mm. Dominant organic compound are up to 10 mm large and well preserved nodules of *Elianella elegans* Pfender et Basse; common are also fragments of coralline algae belonging to the genus *Sporolithon* and sections of *Polystrata alba* (Pfender) Denizot. Among dasycladacean algae there are present only sporadic sections of *Acicularia* sp. Rare are fragments of bivalves, gastropods, corals, ostracods; among foraminifers mainly miliolid forms are present, rare are rotaloid forms, agglutinated tests of the type *Haddonia* sp. and sessile miniacinas. The sediment originated in back-reef lagoonal environment without contribution of terrigeneous material from the shore with minimal water energy. While index fossils are lacking, for its precise age dating, at the absence of large foraminifers, Middle Palaeocene – Selandian age (SBZ 2) has to be considered as the most probable.

Localities: Brezovica, Zábiedovo, Skorušina.

Age: Selandian (SBZ 2).

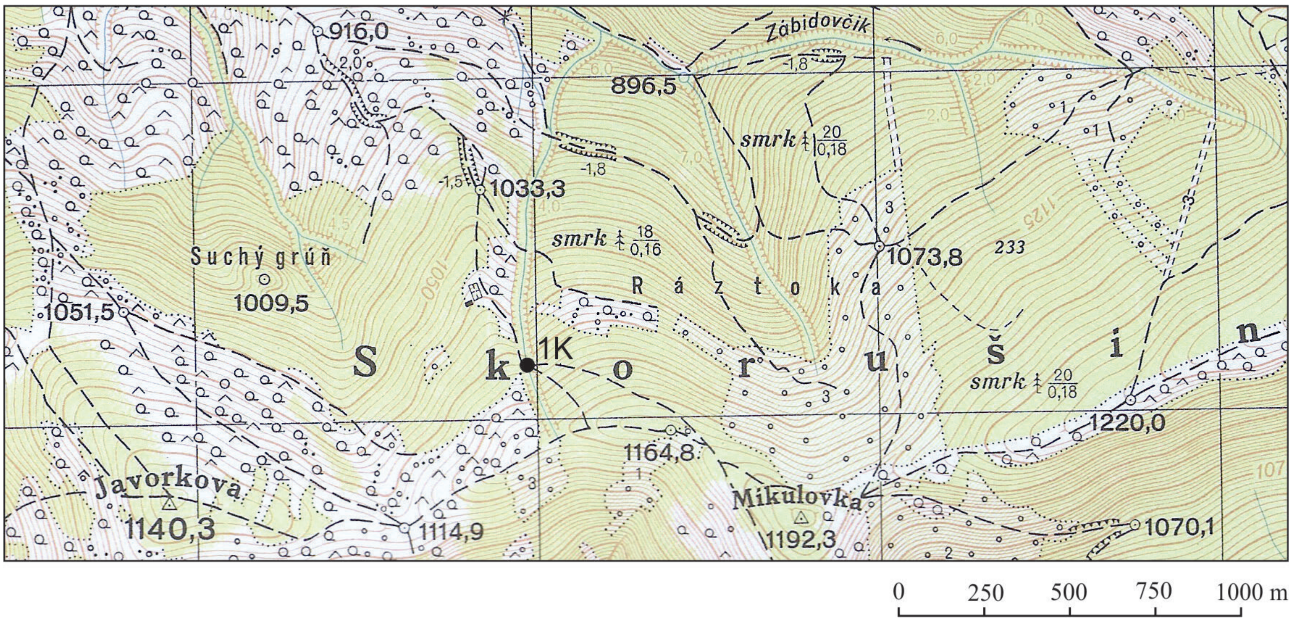

Fig. 6d. Situation map of locality Skorušina – •1K in Orava at scale 1 : 25 000 (map sheet M-34-100-A-b).

B. *Corallinacean-dasycladacean packstone to wackestone (Pl. XI, Figs. 2, 3, Pl. XVIII, Figs. 3 – 5, 8 – 9)*

Biomicrite contains only rare lithoclasts (fragments of carbonates and quartz reaching in size up to 0.5 mm). Besides very frequent nodules of *Elianella elegans* Pfender et Basse (reaching in size up to 5 mm) and dissipated fragments of coralline algae attention attract frequent dasycladacean algae. Bystrický (1976) gave them attention; from the site Brezovica he described species *Dactylopora gušići* Bystrický and *Broeckella belgica* Morellet et Morellet. Common are also genera *Zittelina*, *Neomeris* and *Acicularia*. Organic composition is enriched in fragments of bivalves, crinoids, echinoderms. Among foraminifers miliolid forms are dominating and agglutinated tests of the type *Haddonia praeheissigi* Samuel, Köhler et Borza. Presence of *Haymanella palaeocenica* Sirel, *Miscellanites primitivus* (Rahaghi) and *Broeckella belgica* Morellet et Morellet confirms Selandian age of this shallow-water lagoonal sediment originating in environment with very low water energy.

Localities: Brezovica, Zábiedovo

Age: Selandian (SBZ 2).

C. *Polystrata packstone to rudstone*

Biomicrite almost without lithoclasts with dominance algae of *Polystrata alba* (Pfender) Denizot making up complex structures of thalli. Crusts and nodules of *Sporolithon* sp. are not frequent, nodules of *Elianella elegans* Pfender et Basse show traces of recrystallisation. Common are sections of bivalves, gastropods and echinoderms. Among foraminifers miliolid forms are again dominant, present are also sessile forms of *Planorbulina cretae* (Marsson) and tiny agglutinated tests. Similarly to the two previous types striking is minimal presence and even lacking of bryozoans. Shallow-water lagoonal sediment didn't provide index fossils for age dating, but the most probable is its Selandian (SBZ 2) age.

Localities: Brezovica

Age: ?Selandian (SBZ 2).

D. *Packstone to grainstone with Pseudocuvillierina sireli (Inan)*

Rocks are relatively heterogeneous, from biomicrites almost without lithoclasts up to biosparites, where the sparite matrix cements large fragments of biomicrites. Relevant compounds of the rocks are coralline algae, crusts and thalli of *Solenomeris* sp. Frequent are also nodules of *Elianella elegans* Pfender et Basse, *Polystrata alba* (Pfender) Denizot, rarer are nodules of *Parachaetetes asvapatii* Pia, present are also *Acicularia* sp., fragments of bivalves, gastropods, corals, echinoderms and crinoids. Besides miliolid and agglutinated foraminifers the important compound of the community are Selandian index fossils (SBZ 2) *Pseudocuvillierina sireli* (Inan), *Miscellanites primitivus* (Rahaghi), *Globoflarina* sp. Sediment originated in shallow-water environment without terrigeneous contribution from the shore, in environment protected against destruction by currents.

Localities: Brezovica

Age: Selandian (SBZ 2).

E. *Corallinacean-coral bindstone to boundstone (Pl. V, Fig. 3)*

Micrite matrix contains sporadic fragments of carbonates and tiny grains of quartz, among bioclasts dominating are large fragments of coral patch-reefs (*Actinancis* sp., *Goniopora* sp.), but in none of the thin section cemented growths were observed. Coralline fragments use to be overgrown by crusts of coralline algae (*Sporolithon* sp.), rare are fragments of bivalves and of various crust foraminifers. The rocks originated from intense corroded environment of the reef crest, where the evolving tiny growths were broken into coral-algal debris by currents.

Localities: Brezovica, Zábiedovo

Age: Selandian-Early Thanetian (SBZ 2 – 3).

F. Packstone to grainstone with bryozoans

Frequent lithoclasts are sharp-edged fragments of quartz, but also up to 6 mm large fragments of Palaeocene biomicrites. Organic relics show traces of redeposition and damage. Besides fragments of coralline algae the important compound are cheilostomate bryozoans indicating deeper environment of the rocks origination. Large fragments of coral colonies also occur, spines of echinoderms, fragments of bivalves and fragments of tubes of serpulid worms. Frequent are redeposited tests of miliolid and agglutinated foraminifers, but common are also planktonic globigerinoid foraminifers proving for contact with open sea. Sediment originated in upper part of the fore-reef slope and contains replaced autochthonous (bryozoans), as well as allochthonous organic material. Lacking index fossils of Late Palaeocene affiliates the rock into Middle Palaeocene – Selandian (SBZ 2).

Localities: Brezovica, Zábiedovo

Age: Selandian (SBZ 2).

G. Packstone to grainstone with Miscellanites primitivus (Rahaghi) (Pl. VI, Fig. 2)

Relevant compound of the rocks are lithoclasts of Mesozoic carbonates, quartzose sandstones and quartz reaching in size up to 2 mm. Rare are clasts of Palaeocene biomicrites. Common are rounded clasts of thalli and crusts of coralline algae, fragments of *Polystrata alba* (Pfender) Denizot, bryozoans, bivalves, crinoids, but relatively frequent are redeposited tests of large foraminifers – from shallow-water environment *Miscellanites primitivus* (Rahaghi), *Pseudocuvillierina sireli* (Inan), but also Late Cretaceous forms coming from orbitoid layers in the basement of the Palaeocene carbonate platform *Orbitoides apiculata* Schlumberger, *O. gensanicus* (Leymerie), *Siderolites calcitrapoides* Lamarck, *Hellenocyclina beotica* Reichel, *Lepidorbitoides* sp. Maastrichtian in age, but in some blocks there is located also Campanian form *Pseudosiderolites vidali* (Douvillé). The sediment originated on the fore-reef slope environment during Middle Palaeocene – Selandian (SBZ 2) and it evidences, that already in this period an intense destruction of the pre-Palaeogene substrate occurred.

Localities: Brezovica, Zábiedovo

Age: Selandian (SBZ 2).

H. Grainstone with Discocyclina seunesi Douvillé

Dominant compound of the rocks are clasts of Mesozoic carbonates, Palaeocene biomicrites, quartzose sandstones and quartz, mostly up to 2 – 3 mm large, but common are also 10 mm large fragments. Cement is sparite. Frequent disturbed fragments of algae are represented by genera *Sporolithon* Heydrich, *Elianella* Pfender et Basse, rare is *Pseudoamphiroa* Moussavian. Common are cyclo- and cheilostomate bryozoans, spines of echinoderms, fragments of bivalves, crinoids, relatively rare are fragments of corals. Among benthic foraminifers there are present rotaloid, miliolid and agglutinated forms. Link with open sea is indicated by presence of planktonic foraminifers. Thanetian age is evidenced by the presence of *Discocyclina seunesi* Douvillé, *Operculina heberti* Munier-Chalmas, present is also from Selandian layers redeposited *Globoflarina* sp. From Late Cretaceous redeposited are Maastrichtian forms of *Orbitoides* sp., *Siderolites calcitrapoides* Lamarck, *Hellenocyclina beotica* Reichel and *Lepidorbitoides* sp. The sediment originated in fore-reef slope environment during Late Palaeocene – Thanetian (SBZ 3 –?4).

Localities: Brezovica, Zábiedovo, Skorušina

Age: Thanetian (SBZ 3 –?4).

3.4.3. Evolution of the carbonate platform

Occurrence of orbitoid foraminifers in the fore-reef slope sediments at the sites Brezovica and Zábiedovo evidences a close relationship of the carbonate platform with its Upper Cretaceous substrate. While layers of Campanian age have been preserved at the place of their origination (Homôlka, Lučivný vrch), Maastrichtian layers were disintegrated and have been preserved only in the form of blocks (Brezovica, Zábiedovo).

The carbonate platform itself obviously had to be of great extent, but only tiny fragments of its back-reef of lagoonal part, of the reef crest and mainly of fore-reef sediments containing redeposited organic relics have been preserved. Analysis of blocks doesn’t allow for precise determination of the beginning of the reef complex sedimentation on the platform. For sure, it existed in the Middle Palaeocene – Selandian (SBZ 2), but due to a lack of index fossils the highest Danian age (SBZ 1) cannot be excluded, as well. It reached the maximum extent in Selandian and in Thanetian (SBZ 2 – 3 –?4).

Köhler & Gross (1994) assumed that the termination of the reef system didn’t occur in Palaeocene, but by the beginning of Early Eocene – in Ilerdian. They found the support from analyses of some blocks at the sites Brezovica and Zábiedovo. These blocks of carbonate coarse-grained sandstones contain in addition to the Palaeocene redeposited fossils of the carbonate platform also Early Eocene (Ilerdian) fossils – *Discocyclina archiaci* (Schlumberger) and *Nummulites* sp.

Although these findings provided the evidence, that in the Orava space by the end of Palaeocene full emergence didn’t occur and the sedimentation continued in deeper basinal environment also in Early Eocene, but they have not brought the prove for the continuous sedimentation on the carbonate platform also in Early Eocene. It has been only proven, that in Early Eocene the destruction of the carbonate platform took place. All the facts document, that in the Orava space by the end of Palaeocene the conditions for evolution of the reef complex had terminated.

It is interesting, that in continuation of this stripe at the territory of the Polish Republic the shallow-water Palaeocene sediments have not been identified. Referred to are only deep-water sediments with planktonic communities of foraminifers (Alexandrowicz & Birkenmajer, 1978).

3.5. Pieniny

In the Pieniny section of the Klippen Belt Horwitz & Rabowski (1929) delineated Jarmuta Mb., which they assigned to Palaeogene, but Bieda (1935) in the samples from Jarmuta defined Maastrichtian large foraminifers

Orbitoides media d´Archiac and *Lepidorbitoides socialis* Leymerie, which allowed to define Late Cretaceous age of the Jarmuta Mb. Only 5 km from Jarmuta at the Slovak side of Pieniny described Köhler & Buček (2000) in the Jarmuta Mb. Maastrichtian age based on presence of *Orbitoides apiculata* Schlumberger, *Lepidorbitoides socialis* Leymerie, *Siderolites calcitrapoides* Lamarck and *Nummofallotia cretacea* Schlumberger from the el. p. 844 above Settlement Jezovka north of Haligovce.

Existence of the Palaeocene sediments in Pieniny has been known since the year 1959, when Hanzlíková (manuscript report) referred to, that in the formation of variegated marlstones and claystones with beds of sandy limestones she found Early Palaeocene microfauna with *Globigerina daujergensis* Plummer and higher also Late Palaeocene microfauna with *Globigerina triloculinoides* Plummer and *Globorotalia arca* Cushman et Renz. Matějka (1961) defined in Pieniny Haligovce facies and he distinguished in it southern (marlstone) and northern (conglomerate) stripes. The determinations by Hanzlíková were related to the southern stripe, from the northern stripe large foraminifers of Eocene age were defined by Bieda (1930).

Scheibner at geologic mapping in year 1960 identified at the southern slope of the Klippe Haligovka a block with dimensions of 10 x 8 x 10 m made of grey algal-coral limestones. The block is located only 45 m from the outcrops of Mesozoic rocks of the Klippe Haligovka.

According to Scheibner (1968) the block represents a lens of the northern stripe of Matějka, which is in tectonic contact with the Klippe Haligovka.

From the material provided by Scheibner Schaleková (1962) described coralline algae *Archaeolithothamnium proprium* (Lemoine), *Lithothamnium* cf. *contraversum* Lem. and *Jania* cf. *nummulitica* Lem.

Scheibner (1968) from a block above Settlement Paluby described three new foraminifer species: *Bullopora multicamerata* Scheibner, *Planorbulina uva* Scheibner and *Miniacina multiformis* Scheibner. In this frequently quoted work Scheibner (l.c.) defined the zone Myjava-Hričov-Haligovka in the Palaeogene reef complex.

Tiny olistolith with blocks of Palaeocene bioherm limestones at eastern edge of the village Červený Kláštor referred to by Scheibner (l.c.) couldn't be found later, it is likely buried below deluvial sediments.

Presence of reef blocks allowed Birkenmajer (1985) to express an opinion, that Haligovce sedimentary space was in close relationship with Myjava Basin.

Nemčok & Kullmanová (1988) pointed out to the presence of limestones of reef origin at the village Veľký Lipník not far from Haligovce in the Excursion Guide to the national palaeontologic conference in Ružbašská Míľava. They assumed, that they are "perimeter reefs" or isolated reef nests in shallow open environment separated from each other by channels, through which clastic material from source area was brought into sedimentary environment.

Potfaj & Rakús (in Janočko et al., 2000a,b) defined in the scope of the Klippen Belt Palaeogene two lithostratigraphic units, namely conglomerates and "nummulite" dark to black limestones (Aksamitka, Jezovka) with *Alveolina* (*Glomalveolina*) *primaeva* Reichel, *Fallotella alavensis* Mangin, *Ethelia alba* (Pfender), *Pycnoporidium levantinum* Johnson, *Parachaetetes* sp. and miliolid foraminifers of Palaeocene age. The second lithostratigraphic unit is claystone-sandstone Žilina Fm. of Early to Middle Eocene age with blocks of organogenic and biodetritic limestones, Palaeocene in age. According to the above mentioned authors the limestone blocks are equivalents of the reef limestones in Žilina Fm. in the Váh Valley (Samuel et al., 1972), or are equivalents of the Hričov-Žilina Fm. by Andrusov (1965).

The locality Veľký Lipník described in detail Köhler & Buček (2005). They concluded, that this reef complex originated upon muddy substrate in Early Thanetian (SBZ 3). After stabilisation of the sediment by crustal algae and sessile foraminifers originated a space-limited reef structure with skeletal growths up to 10 m large and smaller back-reef and fore-reef environment. Primary constructors of the reef complex were red algae and corals. Sedimentation in outer part of the shelf was going on in prevailingly protected environment. Bioerosion was the main reason for destruction of the reef structures. Reef complex existed for a very short time span (less than 1 MA) during Early Thanetian.

From the immediate closeness of the Klippen Belt in Pieniny Leszczyński et al. (2012) from deep-marine flysch sediments states rhodoliths and clasts of Late Palaeocene age; their biocompounds content is very similar to the Palaeocene reef complex in Pieniny section. According to the authors the material belongs into Outer Western Carpathians and comes from shelf of the Silesian Ridge, which rimmed Silesian Basin from the South.

3.5.1. Upper Cretaceous basement of the Palaeocene reef system

Similarly to in all up to now mentioned territories also in the study area of Pieniny there are present Late Cretaceous layers with orbitoids (Jarmuta Mb.). Köhler & Buček (2000) described them from artificial exposure above the Jezovka Settlement north of Haligovce. In the area of Veľký Lipník the orbitoid layers have not been found and in the basement of the reef complex variegated marls and marlstones of the Púchov Fm. are located of the age Cenomanian-Turonian-?Santonian-Maastrichtian (Potfaj & Rakús in Janočko et al., 2000b).

While in the up to now described western-more territories of the Western Carpathians the link of the layers orbitoid with the reefs complex is undoubted (frequent are washed-out Campanian and Maastrichtian large foraminifers in the fore-reef slope sediments), in Pieniny a direct relationship between the substrate of the orbitoid layers and the reef complex has not been confirmed (it could be caused by the fact, that blocks of the fore-reef slope sediments are extraordinary rare).

3.5.2. Palaeocene bioherm limestones

As it was already referred to in the review of research up to now, from the Slovak part of Pieniny to-date two localities of the Palaeocene reef limestones are known: Haligovce – Paluby and Veľký Lipník. According to Potfaj & Rakús (in Janočko et al., 2000a) the blocks of Kambühel Limestone, Thanetian in age, are present in Žilina Fm. in Palaeogene of the Klippen Belt.

1. Haligovce – Paluby

Already from a distance well visible body of the reef limestone above the Paluby Settlement at Haligovce with dimensions of 10 x 8 x 10 m – 42 P (coordinates 49° 22´48´´, E 20° 26´54.22´´, Figs. 7a, 7b) was studied in detail on 14 point samples. The rock is biomicrite (packstone to bindstone) with a very small share of clastic admixture. The rock has characteristic signs of reef structures with large primary cavities filled up with micrite matrix or crystallic sparite. The essential structure compounds are coralline patch reefs (*Actinacis* sp., *Dendrophyllia* sp.) and coralline algae (*Sporolithon* sp.), which form complex crusts and which lithified the structures. In some samples there are present also large nodules of *Elianella elegans* Pfender et Basse, striking is frequent presence of algae *Distichoplax biserialis* (Dietrich) Pia, which is rather characteristic for slope fore-reef sediments, but dasycladacean algae abundant almost in all samples, in opposite, are typical for shallow-water lagoonal and back-reef environment The community of sessile foraminifers forming crusts along with coralline algae is also variegated. It is dominated by *Miniacina multicamerata* (Scheibner), *Planorbulina uva* Scheibner and *Miniacina multiformis* Scheibner. Some interconnection with open sea is documented by occasional presence of planktonic foraminifers. Large foraminifers are extraordinary rare and are represented by *Orbitoclypeus ramaraoi* (Samanta), *Daviesina* sp. and *Miscellanites* cf. *primitivus* (Rahaghi). They put the age of the reef into Early Thanetian (SBZ 3), but they don't exclude the beginning of sedimentation already in the Latest Selandian (upper part of SBZ 2).

Despite the thoroughful sampling of the contact with substrate the biosparites referred to by Scheibner (1968) have not been identified. Probably, he studied a small separate block, which has already decomposed.

2. Veľký Lipník

The site is located north of the village of Veľký Lipník below el. p. 739.3, underneath the road from Veľký Lipník to Lesnica – 43 P (coordinates N 49° 22´43´´, E 20° 29´46.19´´, Figs. 7a, 7c).

The stripe of disintegrated blocks reaches a length of into 200 m and width of 30 m. Individual blocks attain dimensions from 50 cm up to 10 m. Below the bottom-most blocks there are exposures of reddish marlstones of likely Late Cretaceous age. The locality described in detail Köhler & Buček (2005). 20 samples were examined. All of them represent biomicrites with primary cavities filled up with sparite. Common are dispersed tiny clasts of quartz in matrix. According to organic composition the blocks could be affiliated into reef structures, into adjacent back-reef lagoonal environment and with some restriction also into the uppermost part of the fore-reef slope.

In the back-reef lagoonal environment dominating are packstones, wackestones and bindstones with up to 12 mm large nodules of *Elianella elegans* Pfender et Basse, frequent are cyclostomate bryozoans and tiny fragments of coral patch-reefs. Among the foraminifers miliolid forms are not rare, lagenides, sessile *Planorbulina cretacea* (Marsson) and *Planorbulina uva* Scheibner as well as sessile agglutinated tests. Coral-algal growths have the structure of boundstones and bindstones. Among the co-

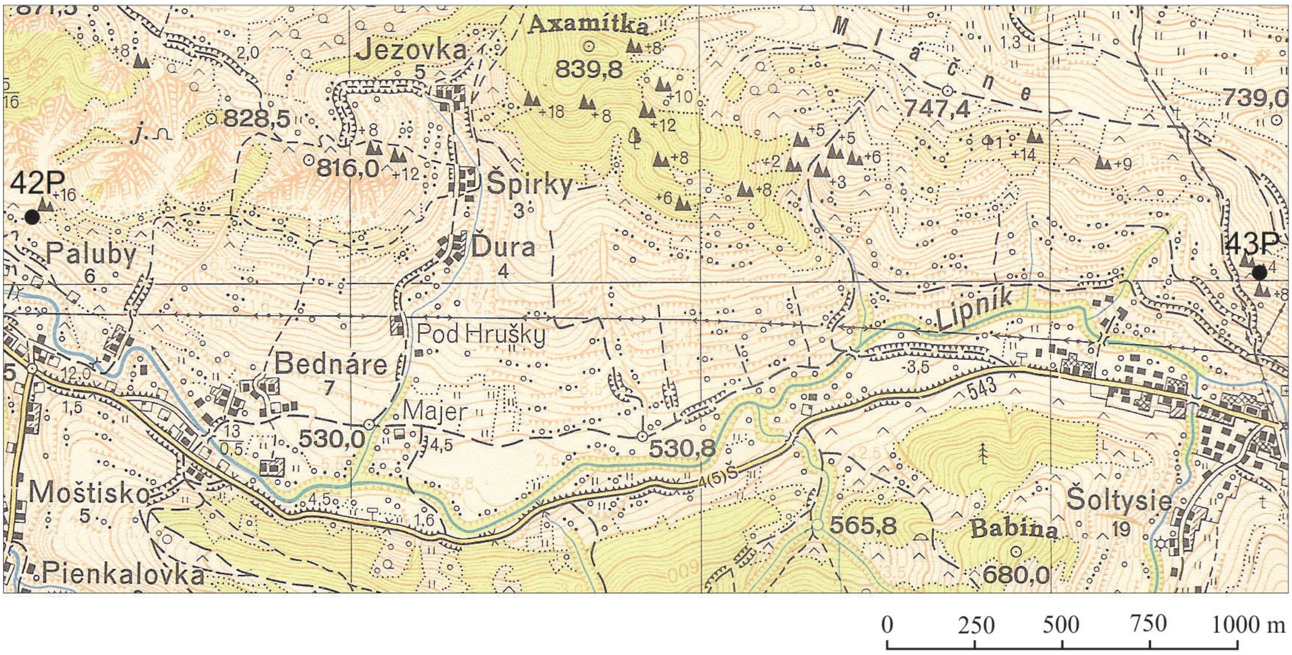

Fig. 7a. Situation map of the site Haligovce – Paluby – •42P in Pieniny at scale 1 : 25 000 (map sheet M-34-89-D-d Haligovce).

Fig. 7b. Site Haligovce – Paluby, Pieniny. Olistolith (10 x 10 m) of organogenic limestone of Palaeocene age (upper part of Selandian – Early Thanetian (SBZ 2 – SBZ 3).

rals the genera *Actinacis* are present dominantly. Large colonies are overgrown by coralline algae (*Sporolithon* sp.), sessile foraminifers (*Planorbulina* sp. and *Solenomeris* sp.) and also rare bryozoans. The accompanying form of coral patch-reefs *Pieninia oblonga* Borza et Mišík is not missing, as well. Typical fore-reef slope facies are not present, but some packstones and wackestones could be affiliated into the highest slope environment. In addition to carbonate matrix they contain also silty components at places. Organic relics are mixed – very frequent are fragments of coralline algae (*Sporolithon* sp.), *Elianella elegans* Pfender et Basse, tiny debris from coral colonies, *Distichoplax biserialis* (Dietrich) Pia. Variegated composition have foraminifers associations – miliolids, rotaloids, agglutinated tests and tiny benthos.

Reliable age dating of the blocks from Veľký Lipník enables sporadic presence of large foraminifers – *Glomalveolina primaeva* (Reichel) and *Discocyclina seunesi* Douvillé – the Early Thanetian index fossils.

Some of the blocks, after their deposition, had to be exposed to weathering and karstifying, which is evidenced by cavities filled-up with sandy material with dominance of quartz grains.

From both sites 193 thin sections were examined and documented from the collections of S. Buček and E. Köhler. There were distinguished the following lithofacies types:

A. Corallinacean-miniacina bindstone (Pl. IV, Fig. 2)

This microfacies type frequently contains intraclasts of carbonates (up to 1.5 mm) and tiny sharp-edged fragments of quartz (up to 0.2 mm). The fissures and cavities are filled with sparite, sporadically also with sandy fill, which is of post Palaeocene age and filled-up cavities in the reef body, which was exposed to subaeric weathering processes. Coralline algae are present by several genera (*Sporolithon* Heydrich, *Mesophyllum* Lemoine, *Pseudoamphiroa* Moussavian, *Jania* Lamouroux and *Elianella* Pfender et Basse). At

Fig. 7c. Site Veľký Lipník, Spišská Magura Mts. North of the village Veľký Lipník below the road from Veľký Lipník to Lesnica there are located in the slope in a line of length of approx. 200 m and width of up to 30 m blocks of white-grey reef organogenic limestone of Palaeocene age (Early Thanetian, SBZ 3) in Žilina Fm. of Early-Middle Eocene age.

places they form complex crusts, which along with sessile foraminifers are the essential construction biocompounds of the rocks. Common are also fragments of bivalves, gastropods, brachiopods and tiny fragments of corals. Among foraminifers dominating are sessile forms in crusts with algae: *Solenomeris ogormani* Douvillé, *Miniacina multicamerata* (Scheibner), *M. multiformis* Scheibner, *Planorbulina uva* Scheibner, *P. cretae* (Marsson) and large agglutinated forms of *Haddonia praeheissigi* Samuel, Köhler et Borza. *Orbitoclypeus ramaraoi* (Samanta) affiliates the sediment into Early Thanetian (SBZ 3); rare presence of *Miscellanites* cf. *primitivus* (Rahaghi) allows also the upper part of Selandian (upper part of SBZ 2). The sediment originated in back-reef lagoonal protected environment.

Site: Haligovce – Paluby

Age: upper part of Selandian – Early Thanetian (SBZ 2 – SBZ 3).

B. Corallinacean-coral bindstone to boundstone (Pl. XI, Fig. 4, Pl. XXXI, Fig. 4, Pl. XXXII, Fig. 3)

The main construction compounds of the rocks are coralline algae and fragments of coral colonies encompassed in micrite matrix. Intraclasts of carbonates and fragments of quartz have only minor participation in the rocks composition. The coralline algae frequently have a form of crusts and they overgrow colonies of corals and lithify the original growths. They belong to the genera *Sporolithon* Heydrich, *Mesophyllum* Lemoine, at places there are present also nodules of *Elianella elegans* Pfender et Basse and in some samples important biocompound are also thalli of *Polystrata alba* (Pfender) Denizot. Pale crusts without traces of structures can be of cyanobacterian origin. The corals colonies make up to 50 % of the area of thin sections (prevailingly genus *Actinacis*). With corals occurrences small bodies of *Pieninia oblonga* Borza et Mišík (Pl. XXXIII, Figs. 3 – 4) are also connected. Rarer are fragments of bivalves and gastropods. Foraminifers are present with species *Solenomeris ogormani* Douvillé, *Miniacina multiformis* Scheibner, *Haddonia praeheissigi* Samuel, Köhler et Borza, *Placopsilina* sp. Rare are miliolid forms and tiny benthos. The affiliation into Early Thanetian (SBZ 3) enables rare occurrence of *Discocyclina seunesi* Douvillé. The sediment originated on the reef crest with algal-coral growths, which were of short duration and due to action of currents, waves and bioerosion they disintegrated into variously large fragments.

Localities: Haligovce – Paluby, Veľký Lipník

Age: Early Thanetian (SBZ 3).

C. Corallinacean packstone-wackestone

Unwashed micrite contains very rare clasts of carbonates (up to 1 mm) and quartz (up to 0.1 mm). Sparite fills up cavities in the rock and at places it substitutes also organic relics and original micrite. Coralline algae make up the relevant part of the rock. They are represented by dominant genera *Sporolithon* Heydrich, *Mesophyllum* Lemoine and *Elianella* Pfender et Basse. In some samples they form crusts; in the others they are present only in the form of disintegrated thalli. Sporadically present are fragments of bivalves, ostracods and cyclostomate bryozoans. Frequent are also sessile foraminifers – *Planorbulina cretae* (Marsson), *Solenomeris ogormani* Douvillé, *Miniacina multiformis* Scheibner, very frequent are also miliolid forms. Fragments of coral colonies are rare. The age determining index foraminifers are lacking, but there are no doubts, that this sediment originated in the protected back-reef environment in the time span of the Latest Selandian – Early Thanetian.

Site: Veľký Lipník

Age: Latest Selandian – Early Thanetian (top of SBZ 2 – SBZ 3).

3.5.3. Evolution of the carbonate platform

The placement of the reef block at the site Haligovce – Paluby is undoubtedly of tectonic nature and it doesn't provide any information on the existence of the carbonate platform, on which the reef system had evolved. The presence of Late Cretaceous of the orbitoid layers in close vicinity (Köhler & Buček, 2000) suggests that also here it could exist the space-limited carbonate platform.

Between the sites Haligovce – Paluby and Veľký Lipník there is only 4 km distance and between the both sites could be found sporadic small fragments of the bioherm limestones (Potfaj & Rakús in Janočko et al., 2000a), which also proves for an existence of coherent platform and formation of back-reef, reef and fore-reef environments.

This assumption is questioned by the situation in Veľký Lipník, where reef bodies overlie variegated marls and marlstones of Late Cretaceous-?Early Palaeocene age. Köhler & Buček (2005) contemplated about the possibility, that blocks are autochthonous and after the formation of the crusts of coralline algae and sessile foraminifers there were limited conditions for reef growths. After reaching certain weight they collapsed and sunken into the shale substrate. But at least another explanation is at hand, that blocks are not present at the place of their origination, but during Late Laramian movements they slumped due to gravity action into claystone substrate.

The reef complex had a very short duration of 1 to 1.5 mil. years with time range the Latest Selandian – Early Thanetian (SBZ 2 – SBZ 3).

In the superincumbent of the reef blocks in Veľký Lipník there are located horizons of fine-grained sandstones, which contain (Köhler & Buček, 2005) *Operculina azilensis* Tambareau, *Assilina yvettae* Schaub, *Nummulites* sp. and *Discocyclina* sp. and they are dated into the Earliest Early Eocene (Ilerdian). The authors deducted, that the reef complex termination had occurred during Thanetian.

3.6. Slánske vrchy Mts. – North

To the existence of reef coral limestones in Proč Fm. pointed out Leško & Samuel (1965, 1968). According to the authors in the upper part of the Proč Fm. coralline limestones make up a constant stratigraphic niveau, with conspicuous morphology protruding above the surface.

They point out in particular (Leško & Samuel, 1968, p. 49), that in the area of Radvanovce NW of Hanušovce nad Topľou atop the Campanian-Maastrichtian layers reef coralline limestones within the flysch layers are located. The affiliation of these limestones into Palaeocene the authors supported by the findings of *Discocyclina seunesi* Douvillé. They compare the limestones with the reef limestones of the analogical age from the Myjavská pahorkatina Upland, the vicinity of Považská Bystrica and Žilina. In their superincumbent in fine-grained conglomerates to sandy limestones there is present association of large foraminifers of Early Eocene age (Bieda, 1960).

Mišík (1966) at a description of microfacies of the Mesozoic and Tertiary limestones of the Western Carpathians in Pl. LXXXI, Fig. 2 depicted coral patch reef from the site Radvanovce belonging to the genus *Elasmocoenia* Edwards et Haime.

In Explanatory Notes to the Geological Map of the Northern Part of the Slánske vrchy Mts. and Košická kotlina Basin 1 : 50 000 (Kaličiak et al., 1991) the blocks of reefs of algal-coralline origin are referred to from Middle Eocene Fm. of carbonate sandstones and conglomerates in the area Radvanovce (Molnár in Kaličiak et al., l.c., p. 39).

3.6.1. Upper Cretaceous basement of the Palaeocene reef system

From the vicinity of Radvanovce state Leško & Samuel (1968) occurrences of flysch (Jarmuta) layers of Campanian-Maastrichtian age, dated based on planktonic foraminifers. They didn't refer to the existence of the orbitoid shallow-water layers, which could provide substrate of the carbonate platform. These authors even assumed gradual transition of the flysch Late Cretaceous layers up to the flysch layers of Palaeocene to Early Eocene in the area of Radvanovce.

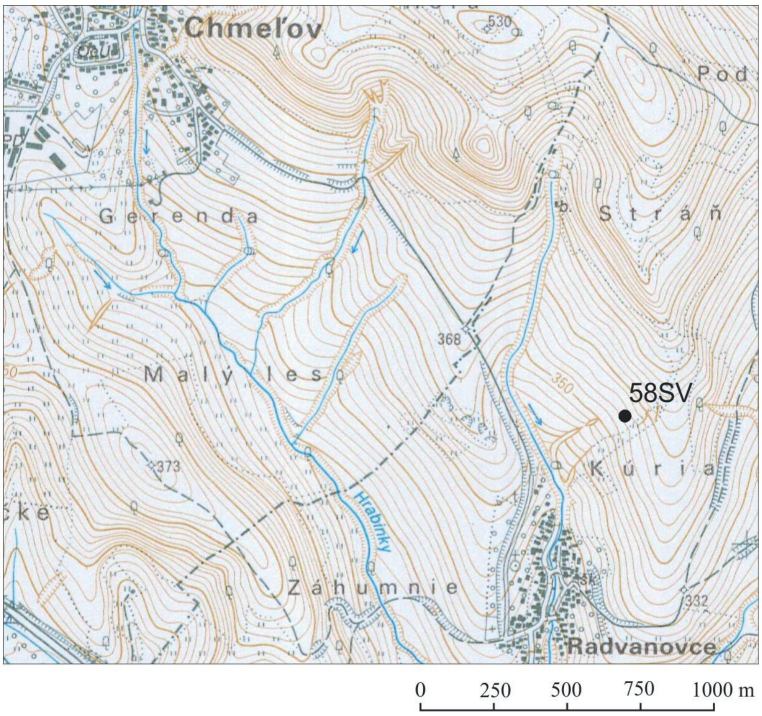

Fig. 8a. Situation map of the locality Radvanovce – •58SV in the Slánske vrchy Mts. at scale 1 : 25 000 (map sheet 28-333 Chmeľov).

To-date they are not at disposition any reliable data on the existence of Late Cretaceous solid substrate of the Palaeocene platform.

3.6.2. Palaeocene bioherm limestones

In the area of interest the bioherm limestones, which could be affiliated to the Palaeocene reef system of the Western Carpathians, were found only at single site – Radvanovce.

North-west of Hanušovce nad Topľou and north of the Radvanovce Village in the cadastre part Kúria, between the village and el. p. 448 – 58 SV (coordinates N 49° 3´17.9´´, E 21° 27´47.16´´, Fig. 8a) in layers of conglomerates of the Proč Fm. of the Strihov partial nappe (Potfaj in Bezák et al., 2004), or Krynica unit (Žec et al., 2006, 2011), there are located up to 50 cm large blocks of bioherm algal-coral limestones.

12 blocks were examined and 61 thin sections were documented (collections of S. Buček and E. Köhler).

Into the back-reef lagoonal environment belong 4 blocks. In the composition of rocks coralline algae are dominating, mainly *Elianella elegans* Pfender et Basse, fragments of coral colonies, tubes of serpulid worms and dominantly large miliolid foraminifers (*Idalina sinjarica* (Grimsdale), *I. causae* Sirel). In one block the present *Miscellanites primitivus* (Rahaghi) indicates Selandian age (SBZ 2).

The most frequently the blocks belong to the reef platform with growths of coral-algal limestones (6 blocks). The major part of the rocks make up coralline colonies of *Dendrophyllia* sp., *Actinacis* sp. and *Goniopora* sp., frequently cemented by crusts of coralline algae (mainly *Sporolithon* sp.), *Elianella elegans* Pfender et Basse is also present, the companion of coral colonies *Pieninia oblonga* Borza et Mišík, rare are fragments of bivalves and gastropods. Among foraminifers sessile forms are in prevail, dominantly *Planorbulina cretae* (Marsson) and *Placopsilina* sp. The rock doesn't contain index fossils allowing for their age dating.

Only two blocks could be affiliated into the fore-reef slope environment. They are biosparites of the type grainstone containing frequent large foraminifers – *Glomalveolina primaeva* (Reichel), *Discocyclina seunesi* Douvillé, *Operculina heberti* Munier-Chalmas, *Daviesina* sp. and *Miscellanites* sp. Frequent are also fragments of various coralline algae, thalli of *Distichoplax biserialis* (Dietrich) Pia and variegated communities of foraminifers partially redeposited from the back-reef environment (large miliolids). Large foraminifers Early Thanetian in age (SBZ 3) in the fore-reef slope sediments expand the age range of the reef complex from Selandian to Early Thanetian (SBZ 2 – SBZ 3).

There were distinguished the following lithofacies types:

A. Corallinacean-coral packstone to rudstone (Pl. IV, Fig. 1)

Micrite matrix contains intraclasts of carbonates reaching in size up to 1 mm. Among biocompounds dominating are coralline algae (dominantly genus *Sporolithon* Heydrich) and up to 6 mm large nodules of *Elianella elegans* Pfender et Basse. Less frequent are sections of dasycladacean algae, fragments of bryozoans, bivalves, ostracods and spines of echinoderms. In the foraminifera community large miliolid forms are in prevail (already mentioned *Idalina sinjarica* (Grimsdale) and *I. causae* Sirel), which are typical forms of the back-reef lagoonal environment. Among the agglutinated tests *Haddonia praeheissigi* Samuel, Köhler et Borza is frequently present. *Miscellanites primitivus* (Rahaghi) identified in one block gives the Selandian (SBZ 2) age, but lacking index fossils in the other blocks do not exclude the Thanetian age blocks.

Site: Radvanovce

Age: Selandian – Early Thanetian (SBZ 2 – SBZ 3).

B. Coral-Corallinacean bindstone to boundstone

In the micrite matrix dominating are coralline colonies belonging to the genera *Actinacis* d´Orbigny, *Goniopora* de Blainville, *Dendrophyllia* de Blainville and *Rhizangia* Milne Edwards et Haime. They used to be cemented by crusts of coralline algae (genus *Sporolithon* Heydrich) and sessile foraminifers *Planorbulina cretae* (Marsson). The coralline colonies are up to 25 mm large with traces of bioturbations. Secondary components are nodular coralline algae (*Elianella elegans* Pfender et Basse), fragments of cyclostomatous bryozoans, bivalves, gastropods and spines of echinoderms. They are relics of coral-algal growths on the reef crest, which remained at the level of patch-reefs and didn't create larger structures. They don't contain index forms allowing for their age dating, which could be derived only indirectly.

Site: Radvanovce

Age: Selandian – Early Thanetian (SBZ 2 – SBZ 3).

C. Grainstone with Discocyclina seunesi Douvillé

In the sparite matrix very frequent are clasts of quartz up to 0.6 mm in size as well as clasts of quartzose sandstones and lagoonal biomicrites. Very common are fragments of coralline algae, *Distichoplax biserialis* (Dietrich) Pia, fragments of bivalves, ostracods, segments of crinoids and tubes of worms. Very rare are fragments of coral colonies. Community of foraminifers is mixed and is made up of miliolids, rotaloid and agglutinated forms and tiny benthos. Thanetian index foraminifers are also present – *Discocyclina seunesi* Douvillé, *Operculina heberti* Munier-Chalmas, from lagoonal environment replaced *Glomalveolina primaeva* (Reichel) and odd *Daviesina* sp. and *Miscellanea* sp. The sediment deposited in the fore-reef environment in upper part of the slope.

Site: Radvanovce

Age: Early Thanetian (SBZ 3).

3.6.3. Age of rocks containing blocks of the Palaeocene bioherm limestones

Among the sites, from which Bieda (1960) determined large foraminifers in Peri-Klippen Belt at the Eastern Slovakia is also the site Radvanovce. From samples of coarse- and fine-grained sandstones, which provided B. Leško, he determined species *Nummulites planulatus* Lamarck, *N. exilis* Douvillé, *N. globulus* Leymerie, *N. rotularius* Deshayes, *Assilina douvillei* Abrard et Favre and *Operculina couizaensis* Doncieux. This community confirms Early Eocene Middle Ilerdian (SBZ 7 – SBZ 8) age of the formation in which also the blocks of the Palaeocene bioherm limestones are located.

3.6.4. Evolution of the Palaeocene reef system

Based on the single locality it is not possible to get an image of the extent of the Palaeocene reef complex. Study of blocks enables to determine the age interval to Selandian to Early Thanetian (SBZ 2 – SBZ 3) and according to the blocks composition also to assume, that in the complex there were developed all three main environments: back-reef, reef and fore-reef. However, the extent of this complex remains vague.

3.7. Ondavská vrchovina Mts. and Vihorlatské vrchy Mts. (SW and E of the el. p. 621 Paprtný)

Although the existence of blocks of various rocks in the Proč Fm. of Eastern Slovakia was known already in works by Leško & Samuel (1968), their detail study was carried out by Mišík et al. (1991a). They studied thoroughly 328 blocks rocks from 8 sites falling within the range Late Triassic to Early Eocene.

Blocks of Campanian and Maastrichtian limestones were identified at the sites Proč, Beňatina, Inovce and Mošurov. 13 blocks of Palaeocene bioherm limestones came from sites Proč, Prosačov, Ladičkovce and Beňatina. They state, that the most frequently they are typical bioliths, then biosparrudites, intrabiosparrudites and biomicrites. Based on mainly foraminifers species in blocks Mišík et al. (1991a) favoured the Ilerdian age of blocks and as an evidence they referred to the presence of *Discocyclina seunesi* Douvillé in the block from Nižné Ladičkovce (Thanetian index fossil – SBZ 3 – SBZ 4).

The source area of clasts they assigned to Neo-Pieniny Cordillera, which was elongated along the inner (southern) margin of the Klippen Belt and was a component of a stripe, which started in the easternmost part of the Eastern Limestone Alps (Kambühel) and continued through the entire Western Carpathians up to Eastern Carpathians.

Mišík et al. (1991b) described also other occurrences of blocks of Palaeocene limestones, namely from the Strihov Fm., which is situated at the outer (Northern) side of the Klippen Belt. The Strihov Fm. reaching thickness of 1,700 to 2,300 m is dated into Early and Middle Eocene (Mišík et al., 1991b; Buček & Žecová in Žec et al., 2005) and it involves also up to 3 m thick horizons of conglomerates with small (up to 10 cm large) blocks, among which common are also Palaeocene rocks. Mišík et al. (l.c.) analysed 13 blocks from sites Mičakovce, Jasenové, Udavské, Malý Lipník, Majdán and Starina. In organic compound calcareous algae *Elianella elegans* Pfender et Basse, *Polystrata alba* (Pfender) Denizot are dominating, bryozoans, fragments of echinoderms and small benthic foraminifers. Blocks of miliolid limestones from lagoonal (back-reef) area and blocks of algal-coral limestones from back-reef area were distinguished.

Mišík et al. (1991b) interpreted the presence of Palaeocene limestones in the Strihov Fm. by the existence of two, although parallel, but from each other independent reef stripes – one contributed the material to the Strihov Fm., another to the Proč Fm. Based on the presence of *Miscellanea miscella* Pfender and algae *Broeckella belgica* Morellet et Morellet Mišík et al. (l.c.) assigned limestones to Danian and Montian (according to to-date criteria to Selandian and Early Thanetian – SBZ 2 and SBZ 3).

In Explanatory Notes to the Geological Map of the Vihorlatské and Humenské vrchy Mts. 1 : 50 000 (Žec et al., 1997a, b) the blocks of "Kambühel" Limestone are referred to in the Strihov Fm. (Early Eocene – Middle Eocene) as well as in Beňatina sequence of the Klippen Belt in Súľov Conglomerate (Early Eocene? – Middle (?) Eocene). The Súľov Conglomerate in the area between Beňatina and Podhoroď overlies transgressively the Cretaceous conglomerates of the Jarmuta Mb. The Proč Mb. affiliates Potfaj (in Žec et al., l.c.) up to Magura Palaeogene p. l. and not to the Klippen Belt.

3.7.1. Upper Cretaceous basement of the Palaeocene reef system

Mišík et al. (1991a) from the site Beňatina describe a block of coarse-grained biosparite containing *Pseudosiderolites vidali* Douvillé, which evidences for Campanian age of the block.

From the site Mošurov they describe coarse-grained biomicrite with *Siderolites calcitrapoides* Lamarck, *Orbitoides media* (d´Archiac), *O. apiculata* Schlumberger and *Lepidorbitoides campaniensis* Gorsel, which prove for Maastrichtian age of the block.

Presence of these blocks documents, that in the Klippen Belt area also in the easternmost part of Slovakia originated Late Cretaceous orbitoid layers, which could provide substrate for the carbonate platform, but direct evidence for this linkage is missing.

3.7.2. Palaeocene bioherm limestones

The authors had an opportunity to be familiar with the part of the thin section material, which was used by Mišík et al. (1991a, b) in their analyses. They utilised also thin section material of Potfaj (referred to in Žec et al., 1977b) and material from own collections. In more detail they studied two areas:

1. Nižné Ladičkovce

Approx. 2 km SE of the village Nižné Ladičkovce – 59 OV (coordinates 49° 0´37.4´´, E 21° 55´32.79´´, Fig. 8b) in the field road crossing the left tributary of the creek Ľubiška, 625 m NW of the el. p. Veľká Hora (274 m) the conglomerate layer is exposed in the Proč Fm. Three blocks were affiliated to Palaeocene. 18 thin sections of them were studied.

One block represents biomicrite of the type packstone with dispersed clasts of quartz, quartzites and crystalline carbonates. At places the original mud micrite recrystallised into sparite. In thin sections there are frequent fragments of coralline algae, bryozoans, of coral colonies and bivalves. Among foraminifers miliolid forms are in prevail proving for shallow-water back-reef environment. The index forms enabling age dating are lacking, but Selandian-Thanetian age is the most probable.

Two blocks could be affiliated up to fore-reef slope environment. Biosparites of the type grainstone contain up to 5.5 mm large clasts of carbonate rocks. Organic relics are broken, common are also fragments of *Elianella elegans* Pfender et Basse, cheilostomate bryozoans, rare are fragments of corals and crinoids. Community of foraminifers is very mixed; it contains also planktonic globigerinid forms. Neither in this community there are index forms and its Selandian-Thanetian age has to be assumed.

2. Beňatina

At the edge of the road from Beňatina Village– 57 VV (coordinates N 48° 48´ 32´´, E 22° 18´53.78´´, Fig. 8c) to Inovce, E and SW of the el. p. 621 Paprtný vrch Hill there are exposed conglomerate bodies with plenty of weathered-out blocks. Diameter of blocks is up to 25 cm, sporadically up to 1 m. Majority of white-grey to reddish bioherm limestones is not of Palaeocene age, but they represent Cretaceous (Barremian-Aptian) orbitoline limestones in "Urgon Facies". Blocks of algal- coral Palaeocene limestones are much rarer (Potfaj in Žec et al., 1997b). Part of the examined blocks comes from material of Potfaj (57P), who their collected them between Beňatina and southern edge of the village Podhoroď (between elevation points Veľký and Malý Osojik). The exposures were originally affiliated to the Proč Mb. of the Klippen Belt (Mišík et al., 1991a), but Potfaj (in Žec et al., l.c.) assigned them to the Súľov Mb.

In more detail there were examined 22 thin sections from 7 blocks. Three blocks represent back-reef lagoonal facies. They are biomicrites of the type packstone to bindstone with very frequent various branching and crust coralline algae; very frequent is *Polystrata alba* (Pfender) Denizot. Fragments of coral colonies used to be overgrown by algae. Among foraminifers dominating are miliolid, rotaloid and agglutinated forms. Age is in the range Selandian – Early Thanetian (BZ 2 – SBZ 3). *Sarosiella feremollis* Segonzac identified in one block indicates Selandian (SBZ 2) age.

Two blocks represent coral-algal boundstones with coral colonies of the genus *Actinacis* (d´Orbigny) overgrown by coralline algae, mainly of the genera *Sporolithon* Heydrich. They represent fragments of coral-algal growths of the patch-reefs type. Other organic compounds are present in secondary proportion (bryozoans, bivalves, tubes of worms, sessile foraminifers). Fragments are of Selandian-Early Thanetian age (SBZ 2 – SBZ 3).

Two blocks originated in fore-reef slope environment. Packstones to grainstones contain clasts of sandstones, quartz and carbonates, common are also clasts of shallow-water Palaeocene biomicrites. In addition to fragments of coralline algae, thalli of *Distichoplax biserialis* (Dietrich) Pia, fragments of bivalves, gastropods, corals,

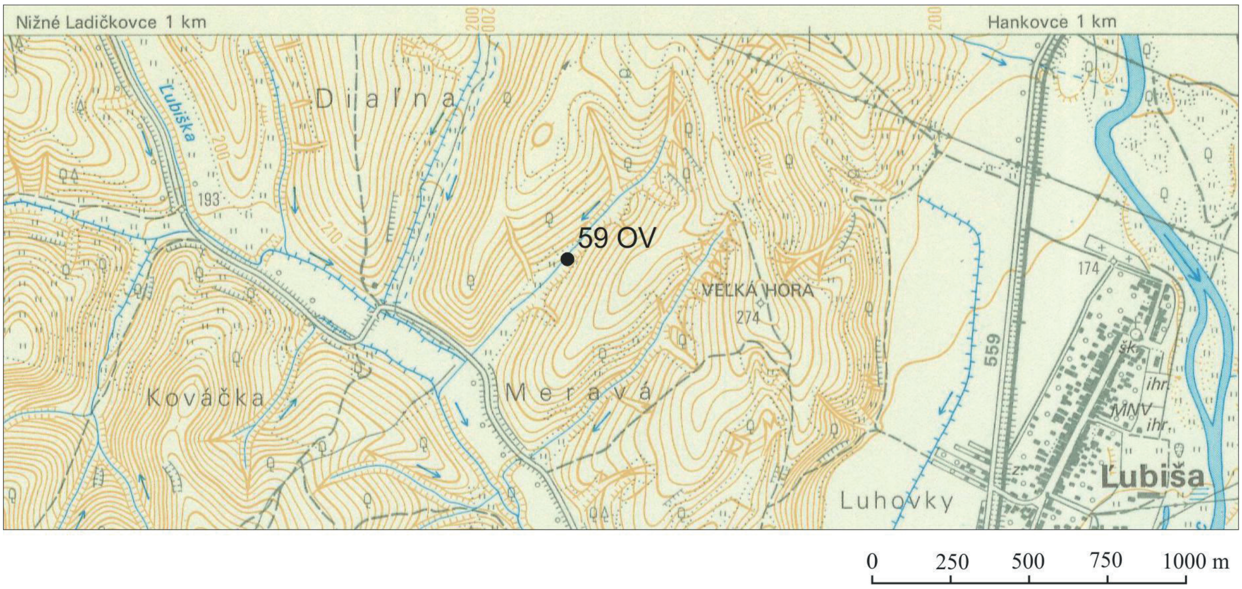

Fig. 8b. Situation map of the locality Nižné Ladičkovce – •59OV in the Ondavská vrchovina Mts. at scale 1 : 25 000 (map sheet 38-122 Humenné).

crinoids and not-rare small foraminifers (including for the first time from the Western Carpathians described genus *Elazigina* SIREL). Present are also index foraminifers *Discocyclina seunesi* DOUVILLÉ, *Orbitoclypeus ramaraoi* (SAMANTA) and *Operculina heberti* MUNIER-CHALMAS, which determine the rock age to Early Thanetian (SBZ 3).

In 60 examined thin sections there was possible to distinguish the following microfacies types:

A. Corallinacean packstone-wackestone

In the micrite matrix the lithoclasts are present in the form of fragments of quartz, quartzites and crystalline carbonates. At places the recrystallisation of the original matrix occurred. The main organic compounds of the rocks are coralline algae in the form of thalli, nodules and crusts, at places cementing the rock. Bryozoans are present in cyclostomate forms, rare are bivalves and gastropods, very rare are dasycladacean algae. Besides frequent miliolid forms among foraminifers present are sessile *Planorbulina cretae* (MARSSON), *Haddonia praeheissigi* SAMUEL, KÖHLER et BORZA and tiny rotaloid forms. The rock originated in back-reef lagoonal shallow-water environment.

Site: Nižné Ladičkovce, Beňatina

Age: Selandian – Early Thanetian (SBZ 2 – SBZ 3).

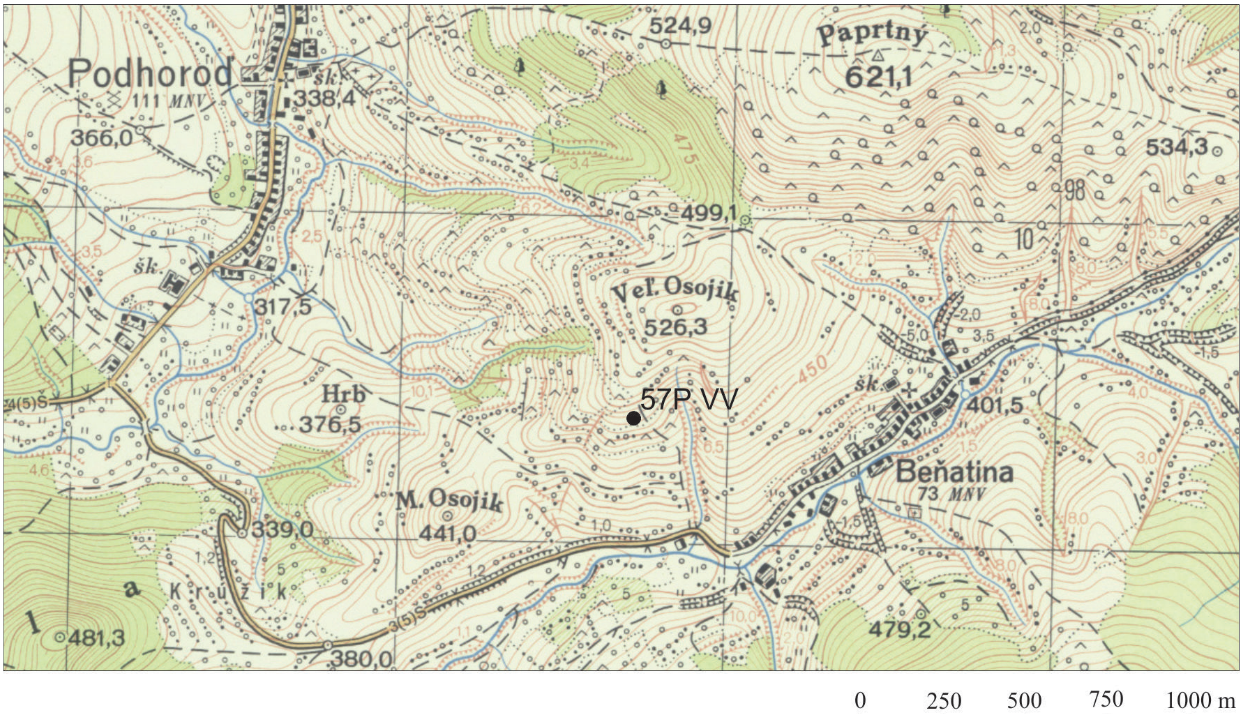

Fig. 8c. Situation map of the locality Beňatina – •57 VV in Vihorlatské vrchy Mts. at scale 1 : 25 000 (map sheet M-34-117-D-a Podhoroď).

B. Packstone with Sarosiella feremollis Segonzac

Micrite matrix is intense recrystallised, the rock was exposed to subaeric weathering and fissures developed, which were later filled-up with sandy material. Dominant fossil is dasycladacean algae *Sarosiella feremollis* Segonzac, frequent are also coralline algae (*Sporolithon* Heydrich, *Mesophyllum* Lemoine, *Lithothamnion* Heydrich), common are also nodules of *Elianella elegans* Pfender et Basse. Rare are bryozoans, fragments of bivalves and corals; frequent are miliolid, agglutinated and rotaloid foraminifers. The rock originated in shallow-water lagoonal environment.

Site: Beňatina

Age: Selandian (SBZ 2).

C. Corallinacean – coral bindstone to boundstone

The micrite matrix encompasses intraclasts of carbonates reaching up to 1 mm in size. In organic compound dominating are up to 25 mm large colonies of corals, dominantly of the genus *Actinacis* (d´Orbigny). Frequent are traces of bioturbation by endobionts. Corals are overgrown by coralline algae, dominantly of the genera *Sporolithon* Heydrich. Common are also nodules of *Elianella elegans* Pfender et Basse, less frequent are dasycladacean algae, fragments of bryozoans, bivalves, serpulids, ostracods and spines of echinoderms. Among sessile foraminifers the most common are *Planorbulina cretae* (Marsson), *Placopsilina* sp., common are also miliolid forms. Sediment evolved on the reef crest, where coral-algal growths originated.

Site: Beňatina

Age: Selandian – Early Thanetian (SBZ 2 – SBZ 3).

D. Corallinacean packstone to rudstone

Biomicrite to biosparite with numerous clasts of quartz, carbonates (with replaced fragments of back-reef biomicrites). Organic relics are frequently disturbed and broken. Dominant organic compound are coralline algae of genera *Sporolithon* Heydrich, *Mesophyllum* Lemoine, *Jania* Lamouroux. Common are also sections of *Polystrata alba* (Pfender) Denizot, *Elianella elegans* Pfender et Basse, frequent are thalli *Distichoplax biserialis* (Dietrich) Pia. Bivalves, gastropods and corals are present in the form of small fragments. In addition to miliolid and agglutinated forms there are present also large foraminifers *Discocyclina seunesi* Douvillé, *Orbitoclypeus ramaraoi* (Samanta) and *Operculina heberti* Munier-Chalmas. The talus sediment originated during Early Thanetian (SBZ 3).

Site: Nižné Ladičkovce, Beňatina

Age: Early Thanetian (SBZ 3).

3.7.3. Age of sediments containing blocks of the Palaeocene bioherm limestones

Palaeogene formations of the Klippen Belt of the Eastern Slovakia were attributed by Leško (1960) into the series "Beňatina Flysch", which he separated from Magura Flysch Group accounting for its genetic-tectonic peculiarity and facial-stratigraphical uniqueness. As the lowermost member of this flysch he defined the Proč. Mb. with range from Late Palaeocene up to Early Eocene.

From the site SW of Veľký Osojik (526 m) Leško & Samuel (1968) and Samuel & Salaj (1968) referred to community with dominating *Globigerina* aff. *linaperta* Finlay, which place the rock into Late Palaeocene. From the same area (and maybe the same site) Potfaj (in Žec et al., 1997b) refers to community of calcareous nanoplankton with *Toweius eminens* (Bramlette et Sullivan), *Discoaster* cf. *barbadiensis* Tan, *D. multiradiatus* Bramlette et Riedel. The community gives in addition to Palaeocene redeposition the age Early Eocene – ?Middle Eocene. Žecová (in Žec et al., 2005) from the layers of variegated claystones of the Proč Fm. described community of calcareous nanoplankton belonging to Late Palaeocene to Early Eocene.

From the above data it follows, that the Proč Fm. (sensu Potfaj in Žec et al., 1997b the Súľov Conglomerate), containing blocks of Palaeocene bioherm limestones, is most probably of Early Eocene age.

3.7.4. Evolution of the carbonate platform

The collected, and in literature referred to material from the Palaeocene blocks allows for deciphering of the history of the carbonate platform in rough outline only. The substrate of the platform is not unequivocally documented, but the blocks of Late Cretaceous of the orbitoid layers in the vicinity of Beňatina indicate, that these layers (designated as Jarmuta Mb.) provided the solid substrate, on which by the beginning of Palaeocene the carbonate platform evolved. Typical rocks of the Palaeocene reef system are documented in temporal range Selandian – Early Thanetian (SBZ 2 – SBZ 3). In the blocks all three reef systems environments have been preserved – blocks of lagoonal back-reef shallow-water part, the most frequently blocks with algal-coral growths of the central part of the reef and quite rare blocks of the fore-reef slope environment.

The time of the reef system termination is not clear, because Mišík et al. (1991a) from the Proč Fm. at Inovce describe two blocks of bioherm limestones up to 1 m in size and they assume, that they represent continuation of the reefs formation from Palaeocene. In organic composition of blocks coralline algae are in prevail, frequent are also foraminifers and among them also *Alveolina* sp., *Nummulites aquitanicus* (Benoist) and *Discocyclina scalaris* (Schlumberger). Two possible explanations are at hand: either the blocks confirm the opinion of Mišík et al. (l.c.), that reef sedimentation at the inner edge of the Klippen Belt in the Eastern Slovakia terminated in Early Eocene, or the blocks belong into new Early Eocene cycle, which was defined e.g. in the Malé Karpaty Mts. (Buček in Polák et al., 2012).

3.8. Continuation of the Palaeocene reef complex in the Eastern Carpathians

Although in palaeogeographic sketches of the Alpine-Carpathian Palaeocene the reef stripe doesn't continue up to the Eastern Carpathians (cf. Kázmer et al., 2003), this boundary is questionable. The continuation of the Proč Fm. at the territory of Ukraine is the Vulchovčik Fm. with age range Palaeocene – Early Eocene. In its scope

Gofštejn & Dabagjan (1967) delineated 10 – 50 m thick conglomerates of Lužanka. Černov (1973) examined the localities of Lužanka and Bolšoj Ugolok. According to him 75.5 % blocks represents sedimentary rocks, the rest are magmatic and metamorphosed rocks. The sedimentary rocks have age range from Late Triassic up to Palaeocene; of the Palaeocene (Danian) age are the blocks of sandstones. According to Černov (l.c.) the material comes from so-called North-Pieniny Cordillera, which coincides with the Western Carpathians Neo-Pieniny Cordillera.

Although in the available literature the data on the occurrence of the Palaeocene bioherm limestones in the Ukraine Vulchovčik Fm. are missing, their presence within this Fm. cannot be excluded.

3.9. Microfacies of the Palaeocene reef complex of the Western Carpathians

At a description of individual areas there are provided characteristic microfacies for the given area. Their overview is in Table 3.

Tab. 3 Representation of microfacies types of the Palaeocene reef complex of the Western Carpathians in individual territories of their occurrence with their affiliation into shallow-water benthic zones (SBZ) according to Serra-Kiel et al. (1998).

	Malé Karpaty Mts.	Myjavská pahorkatina Upland	The Middle Váh Valley – Považská Bystrica	The Middle Váh Valley – Hričovské Podhradie – Žilina	Orava	Pieniny	Slánske vrchy Mts. -North	Ondavská vrchovina Upland and Vihorlatské vrchy Mts.	SBZ
Back-reef lagoonal microfacies									
Elianella rudstone with *Bangiana hanseni*	B								1
Corallinacean-coral packstone to rudstone	A, G	B					A		1 – 3
Packstone with *Broeckella belgica*	D								2
Packstone with *Sarosiella feremollis*	C	I						B	2
Packstone to grainstone with *Pseudocuvillierina sireli*	E	D		G	D				2
Elianella packstone to rudstone with *Miscellanites primitivus*	F	E							2
Elianella wackestone with *Globoflarina sphaeroide*a		C		B	B				2 – 3
Corallinacean packstone/wackestone	H	A			A	C		A	2 – 3
Polystrata packstone to rudstone					C				2 – 3
Corallinacean-miniacine bindstone						A			2 – 3
Rudstone/framestone with *Parachaetetes asvapatii*		H							2 – 3
Corallinacean-dasycladacean packstone with *Glomalveolina primaeva*			B	A					3
Grainstone to rudstone with *Miscellanea juliettae*				E					3
Reef structure									
Corallinacean-coral bindstone/framestone to boundstone			C	C, D	E	B	B	C	2 – 3 –?4
Coral bindstone to boundstone		J							2 – 3
Fore-reef slope sediments									
Packstone to grainstone with bryozoans			D	F	F				2 – 3
Packstone to grainstone with redeposited large foraminifers		F			G				2 – 3
Corallinacean bindstone to rudstone			A					D	3
Grainstone with *Discocyclina seunesi*		K	E		H		C		3

More detailed data on individual microfacies types are referred to in description of microfacies of individual areas of their occurrence in the Western Carpathians.

4. Comparison of the Palaeocene bioherm facies of the Western Carpathians and Northern Limestone Alps and their linkage

Existence of bioherm limestones of vague age both in the Western Carpathians as well as in the Northern Limestone Alps has been known already for a long time. Occurrence of "Lithothamnia" blocks from the area of Liesenhütte is already referred to in Felix (1914), later Spengler (1914) and Kühn (1930), but their age was vague for a long time. The limestone bodies at Hričovské Podhradie (Western Carpathians, the Middle Váh Valley) attracted the attention of Andrusov, who launched their systematic research. He stimulated Lemoine (1933) and Pia (1934) in their description of algae from these limestones, which at that time had been assessed Middle Eocene.

Further intense research into bioherm limestones occurred in the second half of the previous century. In Alps Plöchinger (1967) pointed out the existence of shallow-water limestones at Kambühel at Ternitz and in olistostromes in the area of Prigglitz. In the Western Carpathians Mišík & Zelman (1959) pointed out, that blocks of bioherm limestones are present not only in the Middle Váh Valley, but also in the Myjavská pahorkatina Upland. The age of these limestones specified Salaj (1960) to Palaeocene (Danian) and Köhler (1961) to Palaeocene to Early Eocene.

Tollmann (1976) stated, that " .. at the southern slopes of the Limestone Alps are located within the other areas of the Limestone Alps unknown, but from the Central Western Carpathians described unique facies of Danian-Palaeocene(?) coral reefs in the form of Kambühel Limestone (nov. nom.)". This sentence introduced widely adopted term Kambühelkalk into the geological literature. Tollmann (l.c.) at the same time stated, that at the site Kambühel this limestone overlies Gosau orbitoidal sandstone without stratigraphic link. This work initiated series of the reef limestones studies at the southern flanks of the Northern Limestone Alps, which culminated by the monograph by Tragelehn (1996).

Moussavian (1984) introduced term "Alp-Carpathian Reef Stripe", which has been adopted till today (e.g. Kázmer et al., 2003). According to Moussavian in Palaeocene an extensive space of the reef facies had evolved, which continued from the Northern Limestone Alps up to Western Carpathians. The sedimentation began mostly in the upper part of Danian and persisted up to beginning of Ypresian. The reef stripe of the southern edge of the Northern Limestone Alps (NLA) was not formed by large barrier reefs, but mostly only by small growths with dominance of red coralline algae and corals in morphologically strongly differentiated environment. Moussavian (1993) recognized the linkage of the occurrences in Alps with Myjava-Hričov-Haligovka zone sensu Scheibner (1968). Like the other authors, also Moussavian (l.c.) presumed blocks in Kambühel to be allochthonous, replaced up to NLA from the south.

At the recent status of findings the idea of the united Alp-Western Carpathians reef stripe is not unequivocal. As stated hereinafter, one stripe really rested upon the Austro-Alpine nappes south of the NLA flanks and in the same tectonic position it continued up to the area of the Malé Karpaty Mts., but the second stripe (the younger one) bordered the Western Carpathians from the counter – northern side in completely different tectonic and palaeogeographic position and its interconnection with the southern stripe (cf. Wagreich & Marschalko, 1995) across the basement of the Vienna Basin, is questionable (Fig. 9).

Southern Inner Stripe

According to recent knowledge at the southern slope of NLA at the territory of Austria there are known at least 6 sites, in which blocks of Palaeocene bioherm limestones are located in olistoliths of Late Palaeocene to Early Eocene age and one site (Kambühel), where blocks do not create a component of olistoliths (Tragelehn, 1996).

Up to now the westernmost occurrence from the territory of Austria describe Schlagintweit et al. (2003). In the area of Zwieselalm the limestone blocks in olistolith contain fauna and flora of Thanetian age. At this site, it is located also layer of calcarenite limestones overlying Selandian marls (Middle Palaeocene) age. The authors are of the opinion, that also the blocks of calcarenites are allochthonous and they assume their redeposition from the edge of the platform adjacent basin.

Further to the west of NLA there are blocks of bioherm Palaeocene limestones referred to Eocene and Oligocene conglomerates from the valley of the Inn River (Hagn, 1971; Moussavian, 1984) as well as from molasse conglomerates of the Allgau area (Hagn, 1989).

Towards the exposure in Zwieselalm there is located famous site Mooshuben, which in more detail was described by Lein (1982) and Tragelehn (1996). Substrate of the orbitoid layers of the Latest Cretaceous provided Dachstein Limestone of Triassic nappe. At the sites in this area (Tragelehn, l.c.) olistoliths are referred to containing bioherm limestones of Danian-Thanetian age. Majority of blocks comes from the back-reef shallow-water environment. Lein (1982) presumed that blocks were replaced from shallow-water platform located out of NLA.

From the site Worschach described Janoschek (1968) blocks of pale Palaeocene limestones from olistoliths in Early Eocene marls.

At the site Ochsenboden (2 km NW of the village Niederalpl) the nappe Gutenstein Limestones are transgressively overlain by Maastrichtian orbitoid limestones. Olistoliths of the type Mooshuben are exposed only at small area and they contain blocks of bioherm limestones.

On the western slope of the Kleiner Ebenstein in the Hochschwach Massif Tragelehn (1996) refers to other small isolated occurrence of olistolith of the type Mooshuben with blocks of bioherm limestones.

Locality Prigglitz is mentioned already by Plöchinger (1967), but in more detail it was described by Tragelehn (1996). At three places – recently buried by scree – there were found olistoliths with blocks of prevailingly back-

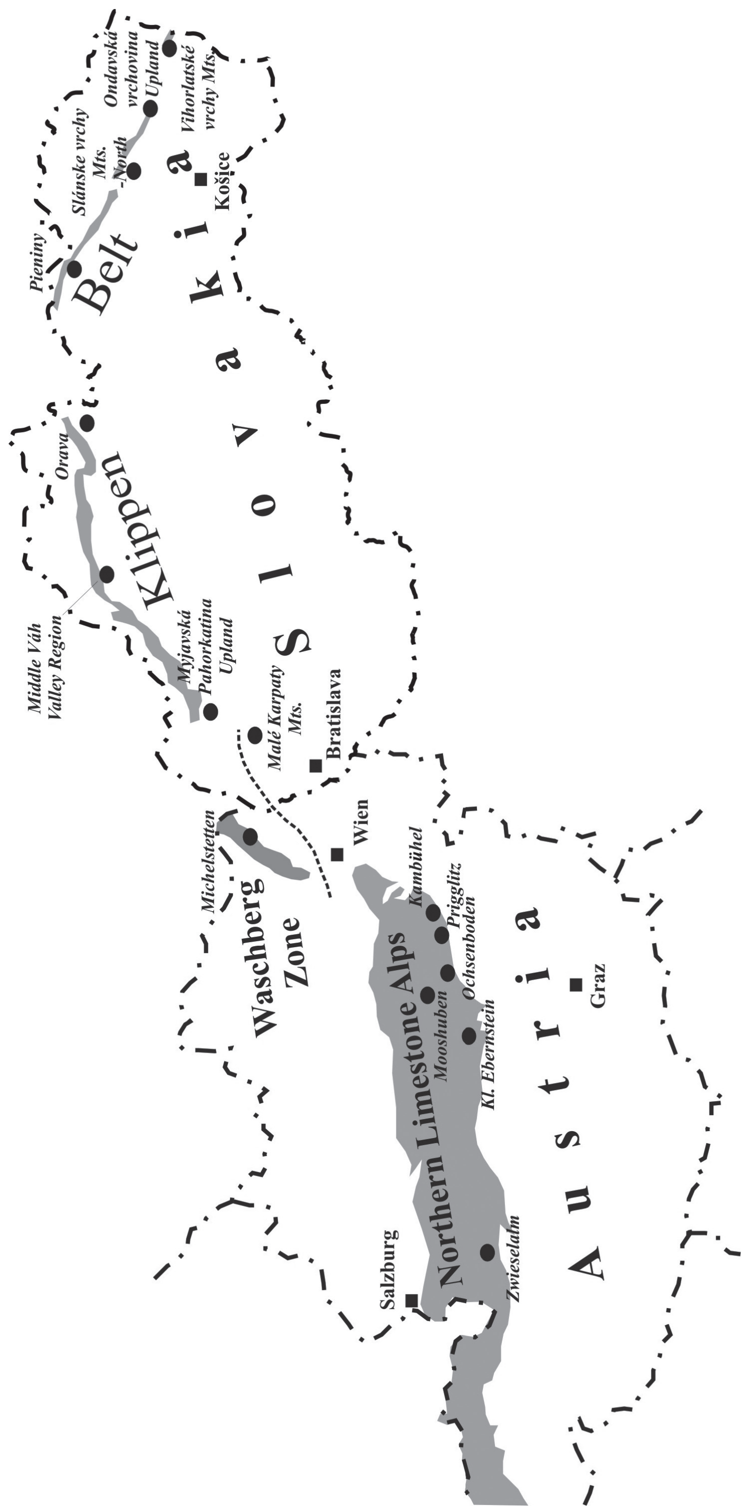

Fig. 9. The placement of examined sites of Palaeocene bioherm limestones in the Western Carpathians and location of Palaeocene sites in Northern Limestone Alps (according to H. Tragelehn, 1996, Fig. 2, modified according to S. Buček & E. Köhler) – boundary among northern and southern stripes.

reef shallow-water Palaeocene limestones. It is interesting, that here the substrate are not Late Cretaceous orbitoid layers, but the Palaeocene marly limestones and marls of a deeper hemipelagic environment.

The most famous, and the most questioned occurrence of the Palaeocene bioherm limestones is the site Kambühel, only 180 m high wooded hill 2 km north of the town Terlitz. The locality was for the first time pointed out by Plöchinger (1967) and Tollmann (1976, 1995) introduced widely adopted term "Kambühelkalk". At the area of 1.5 km^2 there are exposed Late Cretaceous layers and Palaeocene blocks. The substrate is made of Lunz Mb. of Triassic.

In the steep southern slope of the site Kambühel there are exposed Maastrichtian orbitoid sandstones; Tragelehn (1996) assumes in the marginal uppermost part the existence of the Cretaceous-Tertiary boundary, but he doesn't offer convincing evidence (iridium layer, excursions of carbon and oxygen isotopes). Palaeocene blocks are distributed at the upper plain of the orbitoid sandstone surface without any traces of original deposition, which already in the publication of Lein (1982) raises the question of their autochthonous position; this is amplified also by their facies and age heterogeneity. They differ roughly in red algal-bryozoans' limestones of Early Danian age (up to now they have no representatives in the Western Carpathians) and white algal limestones of Late Danian. Tragelehn (l.c.) defined in Kambühel 5 horizons. 1 – the Latest Maastrichtian to Earliest Danian, 2 – Middle Danian, 3 – Later Danian, 4 – Montian, 5 – Early Thanetian (and he added to them also horizons 6 – Later Thanetian and 7 – bottom part of Early Eocene, which is known only from material, which he collected in Slovakia). In the area of Kambühel he defined the Kambühel Fm. with two members: the lower St. Lorenz and the higher Ragglitz. In Late Cretaceous he defined 11 microfacies types and in Palaeocene 17 (some of them are known only from Slovakia).

The authors of this publication paid a visit to the localities Prigglitz and Kambühel, in order to compare them with the occurrences in the Western Carpathians. They concluded that the southern Alpine stripe has direct continuation in the Western Carpathians only in the Malé Karpaty Mts., where the locality Vápenková skala at the village Rozbehy could be directly compared with the Kambühel site (although it is significantly smaller), similarly to the referred to Alpine occurrences in the Malé Karpaty Mts. The occurrences are located atop nappe structures (Triassic Wetterstein and Reifling limestones of the Považie nappe of Hronicum; Geological map of the Malé Karpaty Mts. 1 : 50 000, Polák et al., 2011). Transgressive layer of orbitoid sandstones, Campanian in age, is buried below Miocene conglomerates in which up to 1 m large blocks of Palaeocene bioherm limestones occur. At thoroughful examination of the site it is clear, that blocks of Palaeocene limestones are not only replaced in conglomerates, but they create also interface of the orbitoid sandstone with conglomerates, so they are in the same position as at the site Kambühel. Lack of the Maastrichtian layers could be explained by emergence and erosion after Campanian. The reef complex originated in Later Danian (analogy to the red limestones from Kambühel was not identified here). It is up to now the northernmost occurrence of the stripe, which overlaid the southern nappe units of the Limestone Alps and also the next evidence of the link of the Malé Karpaty Mts. with the Alpine units, as it was already suggested by Maheľ (1987). The to-date position of the localities is obscured by assumed post-Palaeogene rotation of the Malé Karpaty Mts. (Plašienka et al., 1991).

Northern Outer Stripe

It borders from the northern side the Western Carpathians from the space of the Myjavská pahorkatina Upland till the Slovak-Ukrainian border. It makes up a component of the Klippen Belt sensu Maheľ (1980) in Peri-Klippen Belt, but at places (Pieniny – Haligovce) the reef carbonates are present directly on klippes. This northern (Western Carpathians, Peri-Klippen) stripe is located in completely different palaeogeographic and tectonic position than the southern (Alpine) stripe situated at the inner (southern) side of NLA (Fig. 9).

The interconnection of these two stripes has raised questions. Several authors (e.g. Wagreich & Marschalko, 1995) assumed interconnection of the Alpine Gosau facies with the Western Carpathians Peri-Klippen facies below fill of the Vienna Basin. Occurrence of Palaeocene reef facies of the Alpine type (Kambühel s.s.) in the Malé Karpaty Mts. (Vápenková skala) has confirmed this interconnection. The issue of the link of the Palaeocene reef complex in the Malé Karpaty Mts. with its continuation from Myjavská pahorkatina Upland eastwards has not been clarified, where it has to be considered also the post-Palaeogene rotation of the Malé Karpaty Mts. affecting the original position of the Palaeocene reef complex.

The complete independence of the Alpine and Western Carpathians Palaeocene reef complexes is improbable, although we could only hardly imagine the northern Peri-Klippen Belt as a coherent carbonate platform. More probable is, that in this space originated smaller basins with carbonate platforms, which were of short duration.

There remains a theoretical possibility of link of northern NLA rim with Waschberg Zone, which contains also Palaeocene sediments (Seifert et al., 1978). Blocks of Palaeocene bioherm carbonates from the site Michelstetten (Upper Austria) described Lobitzer (1978). Algal-bryozoan carbonates with sporadic tests of *Discocyclina* sp. have the same structure and biocompounds as the fore-reef slope sediments of Late Palaeocene age in the Western Carpathians and also Tollmann (1972) points out, that the Waschberg Zone from the facies viewpoint indicates strong dominance of the Carpathian influence above the Alpine one. From the northern side of NLA, from the Weitenau area described Krische et al. (2012) from Late Palaeocene Zwieselalm formation sandstones rich in bioclasts containing Thanetian fossils *Parachaetetes asvapatii* Pia (= *Elianella elegans* Pfender et Basse), *Distichoplax biserialis* (Dietrich) Pia and *Pseudocuvillierina sireli* (Inan), which notably remind of the communities of the northern Peri-Klippen Belt of the Western Carpathians, but direct proves about the link of these two stripes bordering NLA from north and the Western Carpathians to-date are not known.

Term Kambühel Limestone could be in the Western Carpathians used in two ways. As the Kambühel Limestone s.s. it is fully substantiated that is related to the Palaeocene bioherm limestones of the Malé Karpaty Mts. (Vápenková skala), because they are a component of the same Palaeocene reef stripe with similar age dating and microfacies types as in the southern stripe in NLA in Austria.

In the northern Peri-Klippen Belt of the Western Carpathians from the Myjavská pahorkatina Upland till Slovak-Ukrainian border this term has a broader sense than Kambühel Limestone s.l. and it relates to the Palaeocene bioherm limestones involving wide range of environments and microfacies types.

In recently issued geological maps 1 : 50 000 (e.g. Geological Map of the Middle Váh Valley; Mello et al., 2005 or Geological Map of the Biele Karpaty Mts. (southern part) and the Myjavská pahorkatina Upland; Potfaj & Teťák, 2014) this term has a broader meaning than Kambühel Limestone s.l.

4.1. Comparison with other Palaeocene reef systems in Europe (Western Tethys)

Already in previous chapter it was stated, that the reef stripe bordering NLA and the Western Carpathians has further westward continuation. Vecsei & Moussavian (1997) nota bene, attribute to it also margin of the carbonate platform Maiella in Italy, occurrences in Slovenia, Croatia.

First age-dated note on the existence of Palaeocene blocks in Bavarian Alps provided Hagn & Ott (1975), who from Miocene Waschberg gravels in sub-Alpine molasse north of Salzburg described Thanetian block with *Miscellanea miscella* (d´Archiac et Haime) and *Elianella elegans* Pfender et Basse. They assumed that such block could come only from reef stripe at the southern edge of the Alps. Hagn (1972) describes also further blocks from the sub-Alpine molasse from gravels on Blauen Wand (South of Traunstein). The blocks contained *Discocyclina seunesi* Douvillé, *Planorbulina cretae* (Marsson), corals, bryozoans and red algae. In this work Hagn already pointed out, that the Palaeocene bioherm limestones from the foreland of Alps are very similar to the Palaeocene rocks of the Western Carpathians. Hagn & Moussavian (1980) described further Thanetian blocks from sub-Alpine molasse from the site Chiemgau.

The broadest study elaborated Moussavian (1984), who analysed blocks present in Angerberg layers, which are the youngest member of Tertiary in the Inn Valley and are relic of extensive talus fan. Moussavian (l.c.) gave a particular attention to blocks of Thanetian age and distinguished and described in detail limestones of the reef core, lagoonal detritic limestones and detritic limestones of the fore-reef or outer shelf. In Fig. 3 in text he provided model of the most important Thanetian organisms' distribution in fore-reef, reef and back-reef environments. He highlighted important role of algae *Elianella elegans* Pfender et Basse in structure of limestones of the reef belt.

Hagn (1989) from Oligocene conglomerates in Ällgau analysed blocks from 21 sites. He states, that abundant are blocks of Middle Palaeocene reef limestones with dominant occurrence of algae *Elianella elegans* Pfender et Basse, and that the blocks of coarse-clastic varieties with material from corroded reef structures are more common than the reef blocks.

Comparison between the blocks descriptions and list of their fauna (Hagn & Moussavian,1980) with fauna in the northern Peri-Klippen Belt of the Western Carpathians let us no doubts about close relation between sedimentary spaces, which was already several times pointed out by the above authors.

Relatively detailed information on Palaeocene reef sediments from central Italy (carbonate platform Maiella) provided Moussavian & Vecsei (1995) and Vecsei & Moussavian (1997). Reef bodies are redeposited within younger sediments (according to the above authors they were replaced due to gravity action down the sea slope to deeper environment). The authors distinguished two stages in facies of the reef system in Maiella: Danian-Early Thanetian and Late Thanetian. In the first stage the limestones are typical by presence of genera *Koskinobulimina* sp., *Acervulina* sp. and plentiful associations of red and green algae, in the younger association dominate *Cribrobulimina carniolica* Hottinger et Drobne, *Fallotella alavensis* Mangin, *Miscellanea* sp. and *Ranikothalia sindensis* (Davies). In the overview table (Moussavian & Vecsei, 1995, p. 220) algae, foraminifers and corals from Palaeocene limestones are summarised. Many members of the communities are identical with those from the Western Carpathians, similar is also replacement of blocks into younger sediments and frequent presence of replaced Senonian large foraminifers (mainly orbitoids), which is common phenomenon in the fore-reef sediments of the Western Carpathians.

From the territory of Slovenia the Palaeocene reef systems are not referred to explicitly, but existence of patch reefs in Palaeocene successions is frequently mentioned. At a description of corals from the site Dolenja Vas Turnšek (in Drobne et al., 1988) at an account of 9 species states, that reef colonies were small and were made of only patch reefs. Turnšek & Drobne (1998) from the northern part of the Adriatic carbonate platform (Slovenia and part of Italy) provide list of 7 occurrences of Palaeocene corals (Padriciano, Hrpelje, Golež, Sopada, Dolenja Vas and Breg). Zamagni et al. (2006) state from profiles Čebulovica and Kozina coralline reef facies 60 and 14 m thick. Zamagni (2009) reminds, that in Palaeocene in Slovenia large barrier reef bodies were not formed, but only smaller patch reefs, namely during Middle and Late Palaeocene, which is in full accord with situation in the Western Carpathians.

Babić et al. (1976) described Palaeocene reef rocks from area Banija in Central Croatia. The referred to coralline structures show the attributes of reef bodies. The reef body is exposed in a width of 15 – 20 m and is 6 – 12 m high. The account of fossils and attached depictions show many forms known from the Western Carpathians [e.g. *Elianella elegans* Pfender et Basse, *Pycnoporidium levantinum* Johnson, *Planorbulina cretae* (Marsson)]. The authors quoted the monograph by Samuel et al. (1972) and called attention to this conspicuous coincidence. Gušič & Babić (1973) mentioned Palaeocene limestones of the reef type also from Mt. Medvenica in Northern Croatia.

In similar latitude as the Alps-Western Carpathians occurrences of bioherm limestones is located reef complex Vigny in Paris Basin. The complex is exposed in a length of 1 km, width of 500 m and height of 20 m in several quarries. The reef complex consists of two reef episodes (Danian and Selandian). The account of identified fossils is presented in work by Bignot (1972). This author states, that along with fragments of corals, bivalves and gastropods, tests of bryozoans, brachiopods, tubes of worms, fragments of crabs and fish teeth in the rocks composition participate 10 species of red algae, 1 species of dasycladacean algae and 75 species of foraminifers (15 of them replaced from Campanian sediments) are involved. The reef bodies originated in a depth of up to 30 m in warm water, enriched in oxygen with normal salinity. The reef is resting upon solid substrate.

The body reef in Vigny could be compared with the reef body in Haligovce-Paluby (Pieniny; Janočko et al., 2000a,b), which is however a bit younger (Thanetian). Majority of components making-up the reef complex Vigny was identified at the genus level also in the Western Carpathians.

Large reef bodies of Palaeocene age are known only from the western part of the Iberian Basin in the northern Spain (Baceta et al., 2005). Here, the Palaeocene shallow-water sediments are 300 – 500 m thick, stripe is 50 km wide and has a length of several 100 km. In temporal range Palaeocene-Early Ilerdian there were distinguished 6 deposition sequences as well as 5 phases of reef growth. The cores of reefs are coral-algal or algal-coralline. In the stripe it is possible to distinguish fore-reef, reef and back-reef sediments. The Danian reefs are 7 – 80 m thick and 50 – 300 m wide; they are made of corals, algae and foraminifers, frequent is bioerosion. The Thanetian reefs (the authors divide Palaeocene only to Danian and Thanetian) are 15 – 35 m thick and reach dimensions of 200 to 600 m. The Danian reefs were lenticular and dome shaped, the Thanetian tabular. The authors assume, that the recovery of the reef systems at the K-T boundary lasted only 3 – 4 mil. years.

From the southern Pyrenees Pajaud & Plaziat (1972) mentioned white reef limestones with algae and corals and Plaziat & Mangin (1969) lagoonal limestones with *Alveolina* (*G.*) *primaeva* Reichel, *Fallotella alavensis* Mangin. Presence of *Discocyclina seunesi* Douvillé and *Operculina heberti* Munier-Chalmas affiliates this complex into Thanetian. Similar rocks are known also from carbonate Gallinera and Navarri formations (Barnolas et al., 1990). Serra-Kiel et al. (in Barnolas et al., 1990) mentioned in the Middle and Late Thanetian of Southern Pyrenees area with crusts of red algae and reef structures.

In northern (French) Pyrenees significant sea dynamics made impossible growth of reef structures. Signs of reef sedimentation in Small Pyrenees were recorded by Lepicard (1985).

From Eastern Sardinia Dieni et al. (1985) described rich communities of dasycladacean algae, which were found in blocks of continental conglomerates. The authors state, that these communities are characterised by back-reef environment. Many species of the described dasycladacean algae are known also in the Western Carpathians.

At the territory of Greece Gavrovo-Tripolitza platform (Fleury, 1980; Deloffre et al., 1991) provided conditions mainly for development of shallow-water back-reef sediments with dasycladacean algae (majority of species is described also from the Western Carpathians). In Late Palaeocene layers there are present genera *Fallotella*, *Miscellanea* and *Ranikothalia* which place the sediments into Thanetian.

This review doesn't include the Early Palaeocene Bryozoan reefs in Denmark (Fakse) and Southern Sweden, because they are not shallow-water sediments, but originated in depths of 100 – 300 m (Bernecker & Weidlich, 1990; Bignot, 1992), while a depth of typical shallow-water reef systems in Palaeocene didn't exceed 100 m (Bignot, 1992 refers to the depth of up to 30 m).

From the review it follows, that a conspicuous similarity and even conformity exist among the Palaeocene rocks of the Western Carpathians and Alpine area in broader understanding (till Maiella platform). In the majority of the described areas only smaller reef structures of the patch reefs type developed, typical barrier reefs are known only from Pyrenees area.

Bryan (1991), who studied Palaeocene reef carbonates of Southern Alabama (USA) deduced, that after collapse at the Cretaceous-Tertiary boundary within the further 8 to 12 mil. years originated only tiny reefs with low diversity of the communities. The recent research notably reduces this period, which is documented in barrier reefs in Pyrenees (Baceta et al., 2005).

5. Important compounds of fauna and flora of the Palaeocene reef limestones

Reef complexes represent of all taxonomic levels extraordinary diverse systems. Under favourable environmental and ecologic conditions and at sufficient temporal interval for unbroken development they form complex systems, in which participate numerous different taxons, and also extraordinary is variability of taxons.

At considerable similarity with recent reefs, the fossil reefs show many specifics yet, as a consequence of either different composition of fauna and flora or also the fact, that in geological record there have been preserved only calcified or silicified relics of flora and fauna, and data on the compound, which has not left any traces, are lacking.

The most data could be retrieved on the constructors of the reef bodies, relatively many data at hand are about dwellers of protected lagoons and back-reef platforms, problems raise at the assessment of the communities in fore-reef slope environments, where selection and mixing of the communities from various environments took place. We cannot omit the fact, that the data on animals with mobile way of life are questionable and more-or-less incidental.

Although the role of organisms, which took part in the destruction of the reef systems had to be considerable, in the fossil record it is difficult to distinguish a destruction of organic origin (besides boring activity) from mechanical disruption by currents and waves.

Certainly interesting relationships among organisms, their commensals and parasites, quality and quantity of food, the impact of light on the composition of organic life, relationships of competition for space are only rarely documented specific dates. Significant share in this vague picture had also diagenesis, dissolution, recrystallization and a range of various physical and chemical processes.

Anyone who examines fossil reef complexes must be aware, that the integrity of his findings cannot be compared with knowledge, which is obtained at study of recent reef complexes.

In order to apprehend Palaeocene composition of the communities in the greatest possible extent, it was not possible to focus in the description of the individual taxons at the species or subspecies levels. Unless this was feasible, the authors tried to assess the participation of individual genera of life in the reef complex and only appoint or briefly define taxa (species, subspecies), which presence was clearly determined. Detailed study of individual groups should expand the work excessively and its completion would be delayed up to the future.

We have already mentioned several times, that solid limestones were evaluated, in which a quite complete form is research into thin section material. However, there are organic groups, which determination in thin sections to-date is not quite developed. It is, for instance, the case of Palaeocene bryozoans (identification based on external signs of zoaria), the same could be said for the bivalves, molluscs and other groups. Here, the authors had to be content with very rough division. Even this area experiences in the last years a substantial progress, just to mention a series of new foraminiferal genera, described by Sirel (1981, 1988, 1997, 1998, 1999, 2009, 2012, 2013) from Palaeogene in Turkey and it occurs also in material from the Western Carpathians.

The authors have tried to display all major compounds of fauna and flora in photographic plates. The forms, which were found only in 1 – 2 sections and their participation in ecosystems have to be regarded as almost zero are not displayed. In order to provide the reader the easiest comparison, there were only used 5x, 10x, 30x, 50x and 80x magnifications.

On photographs are not displayed image repetitions, which are depicted on 180 photoplates in monograph by Samuel et al. (1972). New thin section material from the Middle Váh Valley completed them very successfully.

At the processing of data the authors also used thin sections from samples obtained at workshops of IGCP Project 286, mainly from Slovenia, Turkey and Spain, but this material is not photographically documented in the submitted work.

5.1. Calcareous red algae (Rhodophyta)

Calcareous red algae overcome the best a biological collapse at the Cretaceous and Tertiary boundary and by the beginning of Palaeocene they had virtually no competitor in the battle for the emptied space. In the Latest Danian and by the beginning of Selandian the corals started successful launch in the battle for space. In Early Palaeocene rocks the coralline algae make up 40 to 80 % by volume. From the viewpoint of stratigraphy their significance is not particularly acclaimed, but as a component of fossil ecosystems in Palaeocene they occupy a prominent place.

The most important families were *Solenoporaceae*, *Squamariaceae*, *Corallinaceanae*, *Melobesioideae* and *Corallinoideae*.

Family ***Solenoporaceae*** Pia, 1927

This family comprises only extinct genera known from Cambrian (*Xolenopora*) up to Neogene (*Neosolenopora*). They form mostly regular or irregular nodules, less frequently thin crusts (Wray, 1977). Structure of cellular tissue is relatively simple, tightly arranged filaments are divided into cells by horizontal septs. Reproductive organs of Solenoporaceae are not unequivocally defined. Pia (1927) suggested that they were external and non-calcified.

From the Palaeocene sediments of the Western Carpathians there are referred to two genera: *Elianella* and *Parachaetetes*.

Genus *Elianella* Pfender et Basse, 1947 (Pl. XII, Figs. 1 – 3)

In addition to genus *Sporolithon* it is the most common genus of red algae in the Palaeocene reef complex of the Western Carpathians. It is relevant compound of several microfacies and in thin sections it is easily identifiable.

In palaeontological literature a debate is going on a systematic classification of the genus *Elianella*. While some authors advocate the existence of this genus (Hagn & Ott, 1975; Poignant, 1989; Buček & Köhler, 2005), others (Elliott, 1955, 1964; Segonzac, 1962) consider it to be a synonym of the well-known genus *Parachaetetes*. The differences ought to be in tissue structure: in *Elianella* horizontal septs are irregular, incoherent; cells in one row have different height, while in the genus *Parachaetetes* horizontal septs are coherent, straight or slightly bent and cells of one row are of the same height. This criterion was questioned by Moussavian (1989), who identified both types of arrangement in the same nodule and distinguishing of both genera he presumed unsubstantiated.

Despite this negative assessment the genus *Elianella* has not been abandoned in the literature and mainly in the Pyrenees area it is still used (Baceta et al., 2005). Buček & Köhler (2005) after inspection of more than 700 nodules from the Palaeocene of the Western Carpathians are in favour of the opinion, that there are two genera *Elianella* and *Parachaetetes* and they provided their thorough description and depictions.

Genus *Elianella* is characteristic algae of the back-reef lagoonal environment with low water energy, it is present also in reef structures, but in fore-reef slope sediments only broken redeposited fragments are present.

Palaeocene specimens from the Western Carpathians could be affiliated to the species *Elianella elegans* Pfender et Basse, originally described from the island of Madagascar. Nodules reach dimensions up to 25 mm and are of very variegated external morphology, the most typical are cauliflower-shaped and lobe-shaped forms. The internal structure is simple: tissue is made up of vertical tightly arranged filaments, divided into cells by transversal (horizontal) very irregularly arranged and incoherent septs. Diameter of filaments is 0.03 – 0.06 mm, height of cells 0.02 – 0.06 mm. In tangential sections the filaments have circular to polygonal shape.

The first occurrences of the genus *Elianella* are referred to from Early Albian in Urgon Facies in Eastern Alps (Schlagintweit, 1991). From the Western Carpathians Andrusov (1950) defined it from Senonian.

Species *Elianella elegans* Pfender et Basse in the Palaeocene reef complex of the Western Carpathians occurred for the first time in Danian, maximum development it reached in Selandian, in Thanetian it retreated and it is not known, whether it could lasted up to Early Eocene.

From the Palaeocene of the Western Carpathians this species was mentioned also by Schaleková (1964a) and Scheibner (1968), but without description and depictions.

Elianella elegans Pfender et Basse is known in Palaeocene of the Western Carpathians at numerous sites from the Malé Karpaty Mts. through the Myjavská pahorkatina Upland, the Middle Váh Valley up to Pieniny area. In more detail the data provided Buček & Köhler (2005).

Genus *Parachaetetes* Deninger, 1906 (Pl. XII, Fig. 4)

In Palaeocene it is represented by species *Parachaetetes asvapatii* Pia (Stockar, 2000; Aguirre & Barattolo, 2001), originally described in publication Pia (in Rao & Pia, 1936) from Palaeocene Niniyur layers in India. According to original description the nodules attain up to 70 mm dimensions. In original description regularity of internal arrangement is emphasized.

This is typical also for sporadic exemplars found in Palaeocene of the Western Carpathians (Buček & Köhler, 2005). Nodules in the Western Carpathians attain only 26 mm in size, tissue is very regularly arranged and cells in rows are of the same height. Filaments have diameter 0.04 – 0.06 mm, height of cells rows is 0.03 to 0.15 mm. Species is much rarer than *Elianella elegans* Pfender et Basse and was found in three territories – in the Malé Karpaty Mts. (Vápenková skala), Myjavská pahorkatina Upland (Matejovec, Dlhý vŕšok) and in area of Slánske vrchy Mts.-North (Radvanovce), always in sediments of protected back-reef environment. Its age range is from Danian up to Thanetian, but from the territory of Poland Bucur et al. (2005) state *Parachaetetes* cf. *asvapatii* Pia from limestones of Late Jurassic.

Family *Squamariaceae* = *Peyssonneliaceae* Denizot, 1968

They are prevailingly crust algae made of tightly arranged cellular filaments with division into basal layer (hypothallium) and from it stemming vertical or bent rows of cells (perithallium). Reproductive organs have not been unequivocally identified in fossil forms; in recent species they are placed at the external surface of algae.

Squamariaceae are referred to from Late Carboniferous and they live also in to-date seas (Wray, 1977). They dwell in shallow waters (up to 50 m depth) in tropic and subtropic environments, but some of their calcified forms are known also from subarctic waters.

Fossil genera *Polystrata*, *Peyssonnelia* and *Pycnoporidium* are present also in Palaeocene sediments of the Western Carpathians.

Genus *Polystrata* Heydrich, 1905 (family *Peyssonneliaceae* Denizot, 1968) (Pl. XIII, Figs. 1 – 6)

Species *Polystrata alba* (Pfender) Denizot belongs among common algae in Palaeocene sediments of the Western Carpathians.

In the literature this genus is referred to under various genus names, such as *Polystrata* Heydrich, 1905, *Ethelia* Weber van Bosse, 1913 (only for recent forms) and *Pseudolithothamnium* Pfender, 1936 (for fossil forms). Recently in literature genus name *Polystrata* has been adopted (Stockar, 2001).

Species *Polystrata alba* (Pfender) Denizot in Carpathian Palaeogene is typical of great variability of growth forms from simple thalli through crusts up to very complex overlying crusts. Thalli have length of 0.5 to 5 mm, thickness up to 0.5 mm. In sections basal part (hypothallium) is usually preserved, perithallium is developed rudimentary or it is missing.

For a long time a function of cavities is debated, which are located in hypothallium and attain diameter of 0.03 – 0.08 mm. Andrusov (1938) presumed them for cavities after sporangia and this opinion confirmed Aguire & Braga (1999).

Massieux & Denizot (1964) state for this genus stratigraphic interval from Late Barremian-Early Aptian up to Eocene (and with uncertainty up to Oligocene).

In Palaeocene of the Western Carpathians the species is present in whole scale of environments from shallow-water through reef structures up to fore-reef slope environment, but the largest boom was in shallow-water lagoonal environment during Thanetian. In thin sections the majority sections of this algae were identified at the sites from the Myjavská pahorkatina Upland (Jeruzalem, Drahý vrch, Tížikovia), in the Middle Váh Valley (from Hričovské Podhradie) and from blocks in Orava (Zábiedovo), in Pieniny (Haligovce) and Slánske vrchy Mts. (Radvanovce). Thalli preservation is excellent including cavities in hypothallium. Recrystallised and disturbed thalli occur only in fore-reef sediments.

Species designated as *Pseudolithothamnium album* Pfender from Slovak Carpathians were described already in Andrusov (1938, 1950) from Cretaceous sediments, but among sites he referred to also Palaeocene occurrences in the Myjavská pahorkatina Upland (e.g. Krávarikovci). The species was mentioned, but not depicted by Schaleková (1964a) under name *Ethelia alba* (Pfender). From the Middle Váh Valley it was depicted by Samuel et al. (1972).

Genus *Peyssonnelia* Decaisne, 1841 (family *Peyssonneliaceae* Denizot, 1968) (Pl. XII, Figs. 5 – 6)

This genus dwells also in to-date seas and study of recent forms enables to better understand structure of fossil algae and environment, in which they had lived.

Up to year 1988 from Palaeocene was known only one species of these algae, namely *Peyssonnelia antiqua* Johnson. The species was defined by Johnson in year 1964 based on study of exemplars from Palaeocene limestones in Iraq. According to this author the crusts consist of thin basal hypothallium, perithallium and thin epidermal layer. In detail this species was studied by Denizot & Massieux (1965) and they compared it with recent forms. These authors pointed out, that genus *Karpathia* with species *K. sphaerocellulsa* defined by Maslov in year 1962 may be identical with *Peyssonnelia*.

In year 1988 Moussavian published revision of the genus *Peyssonnelia* and from Palaeocene in addition to *P. antiqua* he described 3 new species: *P. praeantillea* (with type locality Kambühel in Austria), *P. taeniiformis* (from Thanetian limestone in olistolith at Wörschach) and *P. bistrata* (from block in Angenberg Oligocene layers in the Northern Tirol). These 4 species according to Moussavian (1988) differ in hypothallium and perithallium thicknesses.

Investigation of the Carpathian material indicates that it contains dominantly species *Peyssonnelia antiqua* Johnson, but some of the sections show similarity with *P. taeniiformis* Moussavian. Exemplars from Palaeocene rocks of the Western Carpathians make up coherent crusts up to 5 mm in length and thickness of 0.3 mm. Cells of hypothallium have diameter 0.030 – 0.045 mm, cells of perithallium are smaller – 0.012 – 0.020 mm.

Species *Peyssonnelia antiqua* is the most common in fore-reef slope sediments, which is in accord with data from recent occurrences. Denizot & Massieux (1965) refer to its occurrences from depth of 0 to 50 m, according to Bosence (1985) genus *Peyssonnelia* is located in structures made of coralline algae in the Mediterranean Sea.

Genus *Peyssonnelia* in the Western Carpathians is present almost exclusively in Thanetian sediments in the Myjavská pahorkatina Upland (Hodulov vrch, Drahý vrch, Krásny vrch and Tížikovia), in the Middle Váh Valley (Rybárikov laz and Hričovské Podhradie) and in Orava (Zábiedovo). From the Middle Váh Valley species *Peyssonnelia antiqua* Johnson was depicted, but not described by Samuel et al. (1972).

Genus *Pycnoporidium* Yabe et Toyama, 1928 (*Solenoporaceae*) (Pl. XIV, Figs. 5 – 6)

This in literature rarely referred to and described genus is neither frequent in the Western Carpathians. From Palaeocene is known only species *Pycnoporidium levantinum* Johnson, 1964 from northern Iraq. According to Johnson *P. levantinum* makes up mass of freely deposited bent filaments. Sections of filaments are polygonal to rounded and in thin sections easily distinguishable. Horizontal septs in filaments are irregularly arranged.

Exemplars from Palaeocene of the Western Carpathians have in sections reticular appearance (Pl. XIV, Figs. 5 – 6). They attain diameter of 6.5 mm, reticule meshes have diameter 0.06 to 0.15 mm, septs are separated from each other by 0.25 – 0.35 mm. Occurrence of the species seems to be limited to protected lagoonal back-reef environment in the whole temporal range of Palaeocene. In the Western Carpathians they are located in the Malé Karpaty Mts. (Vápenková skala), in the Myjavská pahorkatina Upland (Kravárikovci, Dlhý vŕšok, Jeruzalem) and in the Middle Váh Valley (Hričovské Podhradie). They are also described from Croatian Palaeocene (Babić et al., 1976) as well as from Slovenian profile Dolenja Vas (Drobne et al., 1988).

Family *Corallinaceanae* Lamouroux, 1812

It is the largest family of calcareous red algae, typical of great variability of growth forms. Thanks to calcification numerous genera of this family have been preserved also in fossil record.

Calcified cellular tissue is one of the most important diagnostic signs of these algae and individual genera are characterised by arrangement and dimensions of cells and reproductive organs. These are internal and are present in cellular tissue. They form either large conceptacles or complex aggregates of simple sporangium (Wray, 1977). Cellular tissue is composed of central hypothallium and peripheral perithallium. Cells of epithallium making up a thin surface layer have been rarely preserved in fossil state.

The first Corallinaceanae emerged in Jurassic, but maximum development they reached in Tertiary. Today living representatives of this family dwell from tropic to polar seas in depths of up to 250 m. The essential factors at distribution of individual genera are temperature and intensity of light (Adey & Macintyre, 1973). Some of the genera are limited only to tropic and subtropic waters (*Sporolithon*), other dwell also in colder environment (*Lithothamnion*, *Mesophyllum*). Despite considerable depth distribution majority of genera has limited depth interval. Only some of the species are capable to adjust themselves to the changes in salinity and dwell also in brackish environment. *Corallinaceanae* are the important component of reef structures, crust forms are the most important lithifying and cementing biocompounds of reef structures. The uppermost part of recent reef structures – reef crests – are made almost exclusively of red algae.

The issue of classification and terminology of Corallinaceanae has not been solved yet. There were elaborated various classifications (e.g. Adey & Johansen, 1972; Poignant, 1979a, b), but application of electron raster microscope at understanding the structures of recent algae on one side immensely broaden knowledge on tissues composition and expanded range of diagnostic signs, on the other side it deepened troubles at comparison among recent and fossil representatives, because many signs cannot be found on fossil forms (Bosence, 1991; Woelkerling, 1988). Revisions of recent taxons being carried out recently (Woelkerling, l.c.) have been consequently reflected also in revision of fossil taxons.

Genus *Sporolithon* Heydrich, 1897 (family *Sporolithaceae* Verheij, 1993) (Pl. XIV, Figs. 1 – 4)

Up to issuing of work Moussavian & Kuss (1990) for this genus name *Archaeolithothamnium* Rothpletz, 1891 was used. The authors vindicated priority of the name *Sporolithon* above *Archaeolithothamnium*, because this genus was not validated in publication.

This genus has the most primitive internal structure within the family. The genus is known from Late Jurassic (Japan) and lives up to now. During Cretaceous its boom started and in Palaeocene it was already the most important among genera in algal communities. Since Miocene its importance is fading out (Johnson, 1963).

Genus *Sporolithon* is typical of great variability of growth forms from thin crusts to rounded nodules, but common are also various branching forms. Hypothallium use to be relatively thin, perithallium tissue is commonly thick, made of regular rows of cells. The most characteristic sign of the genus are its reproductive organs – numerous simple sporangia are arranged in rows or lenses in perithallium tissue (Pl. XIV, Figs. 1 – 4).

Recent representatives of the genus dwell in depths of up to 60 m in warm tropic and subtropic seas, in majority they make up crusts on solid substrate, but they grow also on unlithified floor. Ghose (1977) refers to presence of this genus in algal crests of reefs.

From Palaeocene and Eocene there are described more than 40 species, which brief account also with characteristics provided Johnson (1963). From Palaeocene of Hričovské Podhradie described Lemoine (1933) species *Archaeolithothamnium mamillosum* (GÜMBEL) LEM. and *Arch. nummuliticum* (GÜMBEL) ROTHPLETZ. Segonzac (1962) described from Palaeocene of Pyrenees *Arch. aschersoni* (SCHWAGER), *Arch. lugeoni* PFENDER, *Arch. liberum* LEM. Johnson (1964) described from Palaeocene rocks of Iraq *Arch. batalleri* LEM., *Arch. oulianovi* PFENDER, *Arch. nummulitica* (GÜMB.), *Arch. aschersoni* (SCHWAGER), *Arch. parisiense* (GÜMBEL) LEM. and *Arch. perplexus* JOHNSON. Schaleková (1964a) from Palaeocene of the Western Carpathians described *Arch. lugeoni* PFENDER, *Arch. gunteri* JOHNSON et FERRIS, *Arch. ?proprium* (LEM.), *Arch. nummuliticum* (GÜMBEL) ROTHPLETZ and *Arch.* cf. *oulianovi* PFENDER. Poignant & Chaffaut (1970) from Corsica announced *Arch. aschersoni* (SCHWAGER), *Arch. gunteri* JOHNSON et FERRIS and *Arch. nongsteinensis* SRIPADA RAO. Bignot (1992) in reef Palaeocene limestones of the Paris Basin identified *Arch. parisiense* (GÜMBEL), Moussavian & Vecsei (1995) from Central Italy mention *Sporolithon* cf. *parisiense* (LEM.), *Sp.* aff. *oulianovi* (PFENDER) and *Sp.* aff. *lugeoni* (PFENDER).

In thin sections from Palaeocene of the Western Carpathians are the representatives of the genus *Sporolithon* very common and are present in all environments, mainly in back-reef protected environment and in reef structures, in fore-reef environment they used to be replaced. They occur in the entire temporal range of Palaeocene.

Genus *Sporolithon* is located in all referred to occurrences, but the most common is in the Malé Karpaty Mts. (Vápenková skala), in the Myjavská pahorkatina Upland (Kravárikovci, Hodulov vrch, Drahý vrch, Stará Turá, Miškech Dedinka, Tížikovia), in the Middle Váh Valley in Hričovské Podhradie, but also in Orava (Brezovica, Zábiedovo) than also in Pieniny (Haligovce, Veľký Lipník). They are present in various forms, e.g. with pattern of sporangia in rows, in lenses or completely irregularly, dimensions and forms of sporangia are also various (from 0.04 up to 0.08 mm). Revision of plentiful material from Palaeocene of the Western Carpathians is very desirable.

Genus *Lithothamnion* HEYDRICH, 1897 nom. cons. (Family *Hapalidiaceae*, GRAY, 1864) (Pl. XV, Fig. 2)

Genus excels in great variability of growth forms from thin coatings till large masses made of overlying branches. Hypothallium is made of reticulate structure relatively long cells; tissue of perithallium is made up of vertical rows of cells smaller than cells of hypothallium. Tiny cells of epithallium don't use to be calcified and their presence in fossil forms cannot be confirmed. Reproductive organs are conceptacles on the external surface of algae (Pl. XV, Fig. 2).

Genus emerged during Cretaceous and lasted up to recent times. From Palaeocene 10 species are known (in recent seas there are identified 10 species of this genus). The genus has large extent till cold polar seas.

As stated by Johnson (1962) in non-oriented sections taxons of this genus could be easily confused with crusts of *Sporolithon* (with similar tissue pattern) and *Mesophyllum* (similar conceptacles). These problems are raised also at study of thin sections from Palaeocene of the Western Carpathians; at the same time 3 species have their type localities in Slovakia, because Lemoine (1933) from Hričovské Podhradie described at that time new species *Lithothamnium andrusovi* LEM., *Lt. abrardi* LEM. and *Lt. controversum* LEM. differing in dimensions of cellular pattern. Segonzac (1962) from Pyrenees reported presence of the species *Lithothamnium cantabricum* LEM., Schaleková (1964a) identified from Palaeocene limestones in Slovakia *Lt. andrusovi* LEM. and *Lt. controversum* LEM., further species are known from Palaeocene of Corsica (Poignant & Chaffaut, 1970) and of the Paris Basin (Bignot, 1992).

Samuel et al. (1972) depicted *Lithothamnium controversum* LEM. from Palaeocene in Hričovské Podhradie.

Although a confusion with genera *Sporolithon* and *Mesophyllum* cannot be excluded, seemingly this genus is not rare in the Carpathian Palaeocene. Its main occurrence is in Thanetian limestones, in Danian and Selandian it was rarer. It is present at the sites in the Malé Karpaty Mts. (Vápenková skala), in the Myjavská pahorkatina Upland (Stará Turá, Drahý vrch), in the Middle Váh Valley (Hričovské Podhradie, Hradisko) and in Pieniny (Haligovce, Veľký Lipník). Also for this genus the revision of material from the Western Carpathians is needed, mainly revision of description of species, which was elaborated by Lemoine from the material from Hričovské Podhradie.

Genus *Lithophyllum* PHILIPPI, 1837 (*Corallinaceanae*) (Pl. XV, Fig. 3)

Tissue of genus is made of filaments dissected into cells. Hypothallium use to be basal or coaxial. Tissue of perithallium is made of vertical threads, septs divided into cells. Usually, the transition zone between hypothallium and perithallium is obscure. (Johnson & Adey 1965) suggested that thickness of perithallium depends upon the age of algae, nutrition availability and other local influences. Reproductive organs are conceptacles, which have large diameter and tendency to flatten upwards. It is the only genus, in which amidst conceptacle is only one porus, but if the conceptacles structure is not evident, confusion with other genera (*Mesophyllum*) is easy.

Genus originated in Early Cretaceous, from Palaeocene 11 species are known, in recent seas live 180 species (Johnson & Adey 1965). Genus is very adaptive and it is present in seas from tropics up to polar areas in depths max. up to 80 m.

Almost half of known Palaeocene species described Lemoine (1933) from Hričovské Podhradie, namely *Lithophyllum carpathicum* Lem., *Lp. continuum* Lem., *Lp. mengaudi* var. *carpathica* Lem., *Lp. dubium* Lem. and *Lp. densum* Lem. and she attributed to the already previously described *Lp. quadrangulum* Lem. Segonzac (1962) in Palaeocene of Pyrenees identified *Lithophyllum densum* Lem., *Lp. dubium* Lem. Schaleková (1964a) described from Hričovské Podhradie and the Myjavská pahorkatina Upland *Lithophyllum quadrangulum* Lem., *Lp. mengaudi* var. *carpathica* Lem. and depicted also *Lp. carpathica* Lem. Samuel et al. (1972) depicted from Hričovské Podhradie *Lithophyllum quadrangulum* Lem. and *Lp. mengaudi* var. *carpathica* Lem.

According to data from literature (Johnson & Adey, 1965; Ghose, 1977) *Lithophyllum* belongs among the most adaptive genera of crust algae. It is present from tropics till polar waters in depths up to 80 m. The genus is known from reef crests of recent Pacific reefs.

More frequent occurrence of these algae was recorded at the sites in Hričovské Podhradie and Rybárikov laz (the Middle Váh Valley), sporadically it is present in the Myjavská pahorkatina Upland (Kravárikovci, Matejovec, Hodulov vrch, Lubina) and at the sites in Pieniny (Veľký Lipník) in limestones of Thanetian age (Pl. XV, Fig. 3). Its occurrence in Early Palaeocene is controversial.

Genus *Mesophyllum* Lemoine, 1928 (family *Hapalidiaceae*, Gray, 1864) (Pl. XV, Fig. 1)

Non-oriented sections of this species are easily to be confused with genera *Lithothamnion* and *Lithophyllum*. Cells of hypothallium and perithallium are arranged in regular rows, sometimes rows of higher and lower cells alternate. Conceptacles are similar to those in *Lithophyllum*, but in their roof more pores are present.

Genus *Mesophyllum* emerged in Palaeocene (Wray, 1977), but lasted up to now.

Lemoine (1933) described from Hričovské Podhradie 4 species, namely *Mesophyllum tropicale* Lem., *Mp. varians* Lem., *Mp. heteroclitum* Lem. and *Mp. ramosum* Lem, but Schaleková (1964a) at new inspection of the material from Hričovské Podhradie found only two species, namely *Mp. tropicale* Lem. and *Mp. ramosum* Lem. Poignant & Chaffaut (1970) identified in Palaeocene rocks of Corsica *Mesophyllum pfenderae* Lem. and *Mp. schencki* Howe. Segonzac (1962) in Thanetian of Pyrenees determined *Mesophyllum pfenderae* Lem. and *Mp. sierrae blancae* (Howe), *Mp. camarasae* Lem. and *Mp. royoi* (Miranda) var. *tenuis* Miranda, from Montian limestones in Vigny (Paris Basin) Bignot (1992) refers to only *Mesophyllum lignyense* (Lem.).

Material from the Western Carpathians is not so well-preserved, that it would be possible to count the number of pores in roofs of conceptacles, which is the main nomenclature sign of the genus. Uncertain exemplars were found at the sites of the Middle Váh Valley – Hričovské Podhradie and Hradisko (Pl. XV, Fig. 1).

While the thin sections, which had at disposition Lemoine, are assessed for lost today, it would be desirable collection of topotype material from Hričovské Podhradie with new modern description of species, which defined Lemoine.

Genus *Pseudoamphiroa* Moussavian, 1989 (*Corallinaceanae*) (Pl. XVI, Figs. 1 – 2)

In Palaeocene limestones of Slovakia relatively frequently algae is present with very characteristic tissue pattern. It was described by Lemoine (1933) from material from Hričovské Podhradie as a new species *Amphiroa propria* Lem., but already in at the description she noted, that it had signs different from the genus *Amphiroa*. Doubts on the legitimacy of the genus classification motivated Schaleková (1964a) to affiliate the species to the genus *Archaeolithothamnium*, which was not a fortunate solution, because structure of both genera is very diverse. Objections against this affiliation into the genus *Amphiroa* rested also in the fact, that *A. propria* Lem. has sporangia, while the genus *Amphiroa* conceptacles.

These issues have been solved by Moussavian (1989), who defined new genus *Pseudoamphiroa* with type species *Amphiroa propria* Lemoine. According to him the species is commonly present also in Palaeocene of the Eastern Alps.

Pseudoamphiroa propria (Lem.) creates 1 – 2 mm large nodules, which in section show characteristic bent rows of cells with height 0.10 – 0.30 mm. Thallus is non-geniculate. The sporangia are irregularly arranged, their diameter doesn't exceed 0.05 – 0.07 mm, and commonly 2 – 3 sporangia create an aggregate. Schaleková refers to (1964a) that Maslov was of opinion, that they are not sporangies, but species of spherical parasites, but this opinion has not been accepted.

The species in the Western Carpathians were present during the entire Palaeocene mainly in protected back-reef zone (Pl. XVI, Figs. 1 – 2). It is known from the Malé Karpaty Mts. (Vápenková skala), Myjavská pahorkatina Upland (Stará Turá), the Middle Váh Valley (Hričovské Podhradie) and from Pieniny (Veľký Lipník). The species was depicted also from Hričovské Podhradie by Samuel et al. (1972).

As the authors know the accurate localisation of samples, from which Lemoine (1933) described *A. propria* Lem., but original thin sections have to be regarded for lost, at the site Hričovské Podhradie new samples were collected and they prepare issuance of a revision of this species (Buček & Köhler, in press).

Genus *Corallina* Linnaeus, 1758 (*Corallinaceanae*) (Pl. XV, Fig. 4)

Fragments of thalli, which could be affiliated to this genus are not frequent in thin sections and were known only from the vicinity of classical locality Hričovské Podhradie, where Lemoine (1933) described new species *Corallina abundans*. In major cases only tissue of central hypothallium is preserved, thin perithallium is usually missing. Cells are arranged in rows 0.04 to 0.075 mm high. Restriction of rows doesn't use to be sharp, individual cells can be arranged in various planes, which was already pointed out by the author of the species. Conceptacles have not been preserved in fossils (Pl. XV, Fig. 4).

Thalli grew prevailingly in back-reef protected environments and seem to be limited to Thanetian sediments. In slope sediments thalli were redeposited.

Lemoine (1933) reminded that she knew the species *C. abundans* also from Eocene of Persia, Priabonian SE of France and even from Oligocene of Mesopotamia. From Hričovské Podhradie described and depicted the species also Schaleková (1964a), and Samuel et al. (1972) only depicted it.

Genus *Jania* Lamouroux, 1812 (*Corallinaceanae*) (Pl. XV, Fig. 5)

Algae of this genus are characteristic by thalli, in which cells of hypothallium are high and narrow, perithallium is developed only rudimentary. Rows of hypothallium cells are not sharply restricted.

From Palaeocene 2 species are known, namely *Jania nummulitica* Lemoine and *J. mengaudi* Lemoine. Both species from Hričovské Podhradie described Lemoine (1933) and Schaleková (1964a), *J. nummulitica* Lem. depicted Samuel et al. (1972).

Segonzac (1962) described the species *Jania nummulitica* Lem. from Pyrenees. Recently these algae live in depths up to 30 m and they dwell dominantly internal margins of reef platforms and shallow back-reef environment (Ghose, 1977). In similar conditions they had lived also in Palaeocene.

Genus *Jania* with a small number of exemplars was identified mainly in Thanetian limestones of back-reef protected environment in the Middle Váh Valley (Hričovské Podhradie) and in the Slánske vrchy Mts., Radvanovce (Pl. XV, Fig. 5).

Algae of uncertain position

Genus *Distichoplax* Pia, 1934 (*Corallinaceanae*) (Pl. XVI, Figs. 3 – 5)

Pia (1934) in detail described from Palaeocene reef limestones in Hričovské Podhradie till then little known genus, to which he gave also new genus name. According to section planes Pia distinguished sections, in which cells on both sides make with axis an angle of approx. 100° and the sections, which cells are perpendicular to the central axis. Pia suggested, that species *D. biserialis* (Dietrich) Pia emerged in the Later Eocene, which corresponded to then-opinion on the age of limestones from Hričovské Podhradie.

In literature only species *Distichoplax biserialis* (Dietrich) Pia is described. Poignant & Chaffaut (1970) pointed out, that this species is extremely frequent in Palaeocene limestones of Corsica. On its immense extent proves also, that Keij (1964) counted 33 to 80 fragments of thalli per 1 cm² in limestones from Borneo. Andrusov (1938) reported the presence of the species in Cretaceous sediments, but he was irritated by false Palaeocene affiliation of the locality Kravárikovci (Myjavská pahorkatina) into Senonian.

Debate on affiliation of *Distichoplax* developed Lemoine (1960), who doubted its affiliation to algae and proposed the genus to be affiliated to animal tribe Helichordata, class *Pterobranchia*, but this extreme opinion has not been accepted. Majority of authors refer to the genus without closer systematic affiliation.

Sections of *Distichoplax biserialis* (Dietrich) Pia are not rare in Palaeocene rocks of the Western Carpathians. Thalli reach a length of up to 2.7 mm with constant diameter of 0.09 – 0.10 mm. Pattern of cells corresponds to the one, described by Pia (1934), sometimes also larger accumulation of thalli could be seen (Pl. XVI, Figs. 3 – 5).

The species is present dominantly in fore-reef slope environment. Rarer occurrence in back-reef environments and in reef structures could evidence an existence of deeper channels, which dissected the platform and separated individual structures from each other. It is in accord with opinion, expressed by Ghose (1977), according to whom the genus *Distichoplax* is typical form of reef channels.

Frequent occurrence of *D. biserialis* (Dietrich) Pia was recorded in blocks from the Myjavská pahorkatina Upland (Kravárikovci, Jandova dolina, Dlhý vŕšok, Drahý vrch, Stará Turá and Lubina), of the Middle Váh Valley (Hričovské Podhradie), Orava (Brezovica), Pieniny (Haligovce, Veľký Lipník) and from Slánske vrchy Mts. (Radvanovce). Samuel et al. (1972) provided several depictions of the species in monograph on the Middle Váh Valley.

The species emerged in the upper part of Early Palaeocene (by the end of Selandian), but the largest boom it reached in Thanetian. It didn't extinct by the end of Palaeocene, as it had been previously assumed, but lasted up to Middle Eocene as shown by Schaleková (1964b). Despite this, it belongs among most typical fossils of Palaeocene.

Grey crusts of vague affiliation (Pl. IX, Fig. 4)

In several thin sections with crust algae among individual crusts there are present pale-grey crusts, which do not show any structure signs. It could be assumed, that these crusts excreted organisms, which have not been preserved (e.g. various bacteria). Inorganic origin of these crusts could be excluded, because they copy undulated surface of algal crusts on which they rest and are repeatedly overgrown by algal crusts.

More frequent occurrence of these crusts was recorded in environment of reef structures or in their neighbourhood in the Myjavská pahorkatina Upland (e.g. Jandova dolina) and in Slánske vrchy Mts. (Radvanovce), in sediments of Thanetian age.

5.2. Calcareous green algae (*Chlorophyta*, *Dasycladales*)

This large group comprises algae dwelling not only in marine, but also in fresh-water and dry land environment. Thanks to green pigment their living forms are green-coloured, but after apobiosis this colour is quickly lost.

Calcareous green algae are divided into three families. The first two (*Codiaceae* and *Dasycladaceae*) comprise exclusively marine algae, the last one (*Charophyceae*) comprises forms, which didn't live in marine environment.

In marine green algae frequently calcification of thalli occurs, which is condition for their preservation in fossil state.

Dasycladales

Recently there live approx. eight genera of this family, but described were up to 100 fossil genera. All genera represent tropic or subtropic marine plants, which were attached to substrate and grew upwards. For their thalli is characteristic radial symmetry along central axis. Important diagnostic signs provide branches, which are arranged in verticils.

Classification of Dasycladales was introduced by Pia (1920) and with various amendments it has been preserved up to now. It is based on overall form of thalli, their dimensions, type, on form and pattern of branches, shape of central part of thalli and on appearance and placement of reproductive organs. Pia introduced also certain symbols (e.g. D – outer diameter, d – diameter of axial thalli, etc.), which are used at a description up to now. Valet (1969) introduced classification of recent Dasycladales on notably different principles. An attempt to unify palaeontologic and botanic criteria in classification proposed Bassoulet et al. (1975). According to them the essential characteristics of genera should be: pattern of primary branching, shape of a plant, shape and ordering of branches and reproduction organs.

Dasycladales have existed since Early Cambrian. Recent forms prefer tropic and subtropic marine waters, only a few species are capable to proliferate in a bit colder waters. Although they live up to depths of 30 m, they enjoy shallow waters maximum 5 m deep. To their growth they need normal salinity of waters; they dwell on sandy and muddy floor. They prefer environment with low water energy.

Ghose (1977) refers to, that already since Permian is evident linkage of dasycladacean algae with environments of reef complexes. Their skeletons (whole or broken) significantly participate in composition of sediments of back-reef environment in the vicinity of reef structures. From the above it follows, that presence of dasycladacean algae indicates very shallow protected environment of lagoons with warm water.

Already in the introduction it was mentioned, that Palaeocene dasycladacean algae of the Western Carpathians are systematically dealt with Dr. S. Buček. In this work only brief review of up to now identified genera is presented (Pls. XVII – XIX). Systematic inspection of the material of dasycladacean algae will be dealt in separate work.

Genus *Broeckella* Morellet et Morellet, 1922 (Pl. II, Fig. 3, Pl. XI, Fig. 2, Pl. XVII, Figs. 1 – 3)

Species *Broeckella belgica* Morellet et Morellet from Palaeocene limestones of the Western Carpathians described Bystrický (1976). The author referred to the typical localities of Matejovec and Široké bradlo Klippe (Myjavská pahorkatina Upland) and pebbles from Brezovica (Orava). Based on the fact, that this species was described from Belgian Montian, Bystrický (l.c.) suggested its pre-Thanetian age also in the Western Carpathians.

Exemplars belonging to the species *B. belgica* are easily identifiable in thin sections thanks to their barrel-shaped sections. They attain average dimensions of 1 – 3 mm, rare up to 4 mm. Their thorough description was elaborated by Bystrický (l. c.).

Sections of this species were found in the Malé Karpaty Mts. (Vápenková skala), in the Myjavská pahorkatina Upland (Jandova dolina, Matejovec and Jeruzalem; Pl. XVII, Figs. 1 – 3) and in Orava (Brezovica). It could be agreed, that this species is of pre-Thanetian age, occupying the layers of Later Danian (= Montian) at various sites from Cuba till Iran (in Belgium, France, Croatia, Slovenia, Sardinia, Greece, but also in Cuba, in Iran and Iraq (cf. Deloffre & Granier, 1992).

Genus *Cymopolia* Lamouroux, 1816 (Pl. X, Fig. 3, Pl. XVII, Fig. 9, Pl. XVIII, Fig. 1)

This genus differs from other of dasycladacean species by segmenting of thalli and existence of numerous secondary branches. There are known 30 fossil species and only two recent ones: *Cymopolia barbata* and *C. van Bosseae*. Recent species can be easily distinguished from each other by thalli diameters and presence of or lacking of thallus axes. Fossil species are defined based on shape of primary branches, forms of fertile ampullae, forms of distal rims of secondary branches and number of secondary branches per one primary branch. Assessed are also dimensions of thalli, branches and fertile ampullae as well as number of verticils per segment. Diameter of thalli doesn't exceed 1.5 – 1.8 mm.

Individual segments are frequently broken and species determination asks for considerable caution (Génot, 1987).

The best-known species is *Cymopolia elongata* (Defrance), but its stratigraphic significance is small, because it is present from Palaeocene up to Miocene. It seems that also Slovak exemplars belong prevailingly to this species. They occur almost exclusively at Thanetian sites (Jeruzalem in the Myjavská pahorkatina Upland, Pl. XVIII, Fig. 1). Genus *Cymopolia* lived in very shallow-water lagoonal conditions.

Genus *Cymopolia* is known from numerous Palaeocene sites across Europe. It is depicted by e.g. Dieni et al. (1985) from Sardinia, Drobne et al. (1988) from Slovenia, Deloffre et al. (1991) from Greece.

Genus *Montiella* Morellet et Morellet, 1922

From the reason, that original diagnosis of this genus was not unequivocal, Génot (1987) suggested a modified diagnosis, according to which genus *Montiella* has primitive (non-segmented) thallus and branchings of the primary and of the secondary orders. Each primary branch has atop one fertile case, branching of the secondary order is sterile. In some sections the genus is hardly distinguishable from very similar genus *Neomeris*.

From Palaeocene there are known two species, namely *Montiella munieri* Morellet et Morellet (type species of the genus) from Belgian Mons and *M. macropora* Morellet et Morellet from Thanetian of the Paris Basin. Both species described Génot (1987) in detail, but despite this, reports on them in literature are very rare.

Occurrence of this genus in Palaeocene of the Western Carpathians is a welcome opportunity to update data on it. Very nice and well-preserved exemplars reaching in size to 2.5 mm dwelled in Thanetian shallow back-reef to lagoonal environment. Most famous locality in the Western Carpathians is Jeruzalem in the Myjavská pahorkatina Upland.

Genus *Neomeris* Lamouroux, 1816 (Pl. III, Fig. 4, Pl. XI, Fig. 3, Pl. XVII, Figs. 4 – 6, 8, 10, Pl. XVIII, Figs. 2 – 5, 8 – 9)

Species of the genus *Neomeris* are according to relative arrangement of secondary branches and according to fertile cases on primary branches divided into three subgenera: *Neomeris*, *Larvaria* and *Drimella*, from Palaeocene there are known only the first two. Recently 7 species of this genus live, but number of fossil species is notably higher. Génot (1987) names 24 species from Palaeogene. Large variability in calcification of branches makes almost impossible their application for classification of species. More suitable criteria are morphologic characteristics of branches and reproductive organs.

From Belgian Mons species *Neomeris montensis* Morellet et Morellet is described, from Thanetian of the Paris Basin *Neomeris craniphora* (Morellet et Morellet) (cf. Génot, l. c.) is referred to. The genus is very frequent in Palaeocene of Sardinia. From here Dieni et al. (1985) described 10 various species, three of them have got new species names.

It is obvious, that in Palaeocene of the Western Carpathians this genus has considerable extent, because it is known from the Myjavská pahorkatina Upland (site Jeruzalem, Pl. XVII, Figs. 4 – 5) and from Pieniny (Veľký Lipník). It dwelled in back-reef to lagoonal environment, prevailingly in Thanetian.

Genus *Zittelina* Munier-Chalmas, 1877 (Pl. VII, Fig. 4, Pl. IX, Figs. 1 – 2, Pl. XIX, Figs. 1 – 9)

According to Génot (1987) genus *Zittelina* comprises set of species, which have single row of branches, along which fertile cases originate.

The genus had the largest extent in Eocene, from Palaeocene there are known species *Zittelina jacquei* (Deloffre) from Danian of the Western Aquitania, *Z. radoičićae* (Bystrický) from Palaeocene of the Western Carpathians (Pl. XIX, Fig. 1 – 2), *Z. bystrickyi* (Dieni, Massari et Radoičić) from Palaeocene of Sardinia and Western Carpathians (Pl. XIX, Figs. 3 – 9). The last species was reclassified from the genus *Dactylopora* into the genus *Zittelina* by Barattolo (1985).

Species *Z. radoičićae* yet under genus designation *Digitella* described Bystrický (1976) from the site Matejovec in the Myjavská pahorkatina Upland. In this region it is present also at other sites, e.g. at the site Batíková (Pl. XIX, Figs. 1 – 2). It dwelled in shallow lagoonal waters in the Latest Danian (= Montian) and in Thanetian.

Genus *Sarosiella* Segonzac, 1972 (Pl. II, Fig. 4, Pl. VII, Fig. 1)

Sections of thalli of this dasycladacean algae were known in the Western Carpathians already prior to Segonzac (1972) introduced genus *Sarosiella*. They were depicted by Samuel et al. (1972) from the site Ovčiarsko in the Middle Váh Valley and classified as *Neomeris* cf. *cretacea* Elliott.

According to Segonzac (l. c.) the genus comprises the only species *Sarosiella feremollis* Segonzac, found by author in limestones of "Sparnacian" in Pyrenees, Haute-Garonne, Ariége and Aude. Dieni et al. (1985) found the species in Palaeocene pebbles (Danian-Montian) of limestones in the Eastern Sardinia. These authors expressed suspicion, that the genus is younger synonym of the genus *Trinocladus*. The species *S. feremollis* from the Western Carpathians described in detail Buček & Köhler (1987). They were in favour of Campanian-Maastrichtian age of rocks with *Sarosiella*, but they didn't exclude Danian-Montian age.

Recent research has shown, that *S. feremollis* is rarely present in facies, representing environment of lagoons and reef platforms. The species was found in the Malé Karpaty Mts. (Vápenková skala), in the Myjavská pahorkatina Upland (Drahý vrch, Dlhý vŕšok, Hodulov vrch, Lipovec) and in the Middle Váh Valley (Hričovské Podhradie – "Vlčia jama", Ovčiarsko). The accompanying association of fauna and flora has documented Early Palaeocene (Danian-Selandian), and not the Senonian age of this species in the Western Carpathians. It is in full accord with data by Dieni et al. (1985). The only up to now unrevised data on Campanian-Maastrichtian age of *S. feremollis* comes from Beckmann & Beckmann (1966), who depicted the genus under name *Trinocladus* (?) sp. indet. from Late Cretaceous of Cuba. This data asks for verification. It is obvious, that in European Tethys region is the genus *Sarosiella* excellent indicator for affiliation of limestones into Palaeocene.

As a thorough description of this species was provided by Buček & Köhler (1987), it is not necessary to repeat it. We present only measured values of dimensions (explanation of acronyms is in Deloffre & Génot /1982/) of the exemplars from the Western Carpathians: L (mm) max. 3.85, D = 0.64 – 2.21, d = 0.138 – 0.236, w = 7 – 9, h = 0.037 – 0.102, l = 0.119 – 0.192, w' = 2, p' = 0.027 – 0.038, l" = 0.027 – 0.044, p" = 0.019 – 0.030. Based on the above measurings the exemplars from the Western Carpathians correspond referred to specimens from France (Segonzac, 1972) and from Sardinia (Dieni et al., 1985), but they have greater variability of dimensions, which in some cases may be caused by various level of recrystallisation of measured individuals.

Genus *Acicularia* d´Archiac, 1843

Acicularia belongs among algae, which thalli have not been preserved in fossil state and only their fertile cases are known. This deficiency is compensated by the fact, that complete recent exemplars of the genus *Acetabularia* are known, which have similar fertile cases (if not identical).

To distinguish among individual species of *Acicularia* we have only restricted number of signs at disposition: overall form of cases, form of their distal rim, arrangement of cases, form and appearance of lateral zones of cases, form and position of cysts, as well as presence of cavities in axial parts of cases.

Already the first glance on existing depicted exemplars of the genus *Acicularia* indicates that they include diverse forms, differing not only in dimensions, but also in internal arrangement. It is possible, and very probable, that part of sections belongs to the other genera, namely the genus *Terquemella* Morellet et Morellet, *Frederica* Barta-Calmus and they could be also *Sandalia* Dieni, Massari et Radoičić. As emphasized by Génot (1987), distinguishing between genera *Acicularia* and *Terquemella* in thin sections is very troublesome. Confusing is criterion, according to which one has circular section and the other oval. As genus *Frederica* are designated large fertile ampullae with cavities arranged very regularly on periphery. Genus *Sandalia* has carrot-shape, compact case and large number of pores in tight rows. From the genus *Acicularia* it differs by shape, position and maybe by larger number of pores as well as by their arrangement in rows.

In Palaeocene limestones of the Western Carpathians sections of this type are very frequent; locally accumulation of fertile cases occurs in the rock. They are common in rocks of lagoonal or protected back-reef environment in the Myjavská pahorkatina Upland (e.g. Jeruzalem and Hodulov vrch), in the Middle Váh Valley (Hričovské Podhradie), in Orava (Brezovica) and in Pieniny (Veľký Lipník). In addition to genus *Acicularia*, some of sections could be affiliated to other genera, e.g. (Pl. XVIII, Fig. 7) to the genus *Sandalia*.

Various sections of *Acicularia* sp. from Palaeocene sites depicted Samuel et al. (1972) in Pl. CXXV, Figs. 1 – 7, Pl. CXXVI, Figs. 1 – 3, Pl. CXXVII, Figs. 1 – 9 and Pl. CXXVIII, Figs. 1 – 7.

Tragelehn (1996) refers to the following species of dasycladacean algae from the Western Carpathians: *Acicularia* cf. *cornigera*, *A*. cf. *eocaena* – Hričovské Podhradie-the quarry; *Acicularia* sp. 5 (= *A*. sp. 4 in Samuel et al., 1972, Pl. 128, Fig. 7); *Orioporella malaviae* – Hričovské Podhradie-the quarry; *Sandalia multipora* – Hričovské Podhradie-the quarry; *Cymopolia inflataramosa* – Hričovské Podhradie-the quarry and Svätá Helena; *Cymopolia paronai* – Hričovské Podhradie-the quarry; *Cymopolia zitteli* – Hričovské Podhradie-the quarry; *Dactylopora deloffrei* – Hričovské Podhradie-the quarry; *Frederica coniconvexa* (= *Acicularia* sp. 3 in Samuel et al.,1972, Pl. 128, Fig. 4); *Neomeris plagnensis* – Hričovské Podhradie-the quarry; *Neomeris* (*L.*) *grandis* – Hričovské Podhradie-the quarry; *Rusoella* sp. 1, 2 – Hričovské Podhradie-the quarry.

5.3. Large benthic foraminifers

Under this term in literature very heterogeneous group is reported of various foraminifers taxons characteristic by tests, which diameter exceeds 0.5 mm. This group has dominant status in shallow-water sediments of Palaeogene. Short duration of taxons and their placement in coherent phylogenetic order has led to creation of Shallow Benthic Zones (SBZ) with division of the entire Palaeocene and Eocene into 20 biozones based on large foraminifers (Serra-Kiel et al., 1998). This SBZ biozonation (originally suggested for Tethys) quickly emerged in dozens of publications and at present it has world-wide application.

Family *Alveolinidae* Ehrenberg, 1839

Genus *Globoflarina* Rahaghi, 1983 (Pl. XXI, Figs. 6 – 7)

In year 1982 described Fleury from Palaeocene in Greece a small form, which he designated as *Cyclorbiculina*? *sphaeroidea* n. sp. Rahaghi (1983) introduced new genus *Globoflarina* and in detail described and depicted species *Globoflarina sphaeroidea* (Fleury) from Late Palaeocene of Iran. Thoroughly emended description of the genus and of the species provided Sirel (1998, 2013) and he stated that this species is located in Late-Danian-Early Selandian limestones in the western Turkey.

In Palaeocene reef complex of the Western Carpathians this species is relatively rare and it is located in shallow-water (back-reef) sediments of Selandian (Middle Palaeocene) age in the Myjavská pahorkatina Upland (Jeruzalem, Hodulov vrch, Matejovec) and in the Middle Váh Valley (Hričovské Podhradie). Spheroidal central parts of tests have diameter 0.6 – 0.7 mm, protoconch has diameter 0.07 – 0.09 mm. These values are lower than those stated by Rahaghi (l.c.) and Sirel (2013) and it is possible, that this is a more primitive facies form (Pl. XXI, Figs. 6 – 7).

Genus *Glomalveolina* Reichel, 1937 (Pl. XXI, Figs. 1 – 5)

One of the most important index fossils of Early Palaeocene is *Glomalveolina primaeva* (Reichel), which is also index fossil of SBZ 3 (Early Thanetian sensu Serra-Kiel et al., 1998). Tests of this spheroidal form are known already for decades from abandoned quarry at the eastern edge of the Hričovské Podhradie in the Middle Váh Valley. They were described in detail by Köhler (1966) and description and depictions are presented also in monograph by Samuel et al. (1972).

In further years at thoroughful study of Palaeocene carbonates of the Western Carpathians the tests of this species were found also in limestone blocks of the Myjavská pahorkatina Upland (Hodulov vrch, Jeruzalem, Dlhý vŕšok, Drahý vrch), in the Middle Váh Valley (besides Hričovské Podhradie also Rybárikov laz) as well as in Pieniny (Veľký Lipník) and in Slánske vrchy Mts. (Radvanovce).

Spheroidal tests have diameter 0.6 to 1.1 mm, the most frequently 0.8 – 1.0 mm. Protoconch has dimensions 0.05 – 0.10 mm, it is followed by two irregularly convoluted whorls, further whorls are convoluted in one plane. Tests have 6 to 9 whorls.

In year 1966 Köhler distinguished in the quarry in Hričovské Podhradie typical form of *Glomalveolina primaeva primaeva* Reichel and its smaller variety *Glomalveolina primaeva ludwigi* Reichel, thus following Hottinger (1960). This distinguishing has not been adopted in literature and recently only name *Glomalveolina primaeva* is used (see e.g. Sirel, 1998). The exemption is publication by DiCarlo et al. (2010), where both subspecies are referred to.

By the end of Thanetian in phylogenetic order *Glomalveolina primaeva* (Reichel) is substituted by species *Glomalveolina levis* Hottinger. This species was not identified in the studied material, which is one of proves on termination of Palaeocene reef systems in the Western Carpathians before the end of Thanetian.

Sporadically tests of this species could be found also in fore-reef sediments. Spheroidal shape obviously enabled easy shift of tests by currents and waves from the shore towards basin. We could assume, that the carbonate platform was very narrow, which allowed for transport from shallow-water environment. The narrow platform had not provided conditions for growth of large reef structures.

Species *Glomalveolina primaeva* (Reichel) is known from numerous Thanetian sites of the Western Tethys (Pyrenees, Italy, Sicily, Slovenia).

Family *Asterocyclinidae* Brönnimann, 1951

Genus *Orbitoclypeus* Silvestri, 1907 (Pl. XX, Figs. 5 – 8)

This originally less used genus name revived Less (1987), which assigned into it whole rank of species.

Originally Less (1987) suggested, that the oldest species of this genus is *Orbitoclypeus seunesi* (Douvillé), but later he reclassified this species into genus *Discocyclina* (Less et al., 2007) and so the initial species of the genus became *Orbitoclypeus ramaraoi* (Samanta), originally described from Late Palaeocene-Early Eocene Pondichery formation in Southern India (Samanta, 1967). Less (1987) according to dimensions of embryon divided species into 4 subspecies (evolution stages): *Orbitoclypeus ramaraoi ramaraoi*, *O. ramaraoi neumannae*, *O. ramaraoi suvlukayensis*, *O. ramaraoi crimensis*.

Originally Less (l.c.) referred to the species as Ilerdian-Cuisian (and separately refers to localities Myjava and Hričovské Podhradie from the Western Carpathians as Early Ilerdian), but in suggestion of zonation of Mediterranean Late Palaeocene and Eocene *Orthophragminae* he reclassified *Orbitoclypeus ramaraoi* as subspecies into *Orbitoclypeus schopeni* with time range only in Thanetian (O.1 – 2).

In monograph on the Middle Váh Valley Samuel et al. (1972) described this species and depicted it under name *Discocyclina douvillei* (Schlumberger).

The authors stick to the original concept and consider *Orbitoclypeus ramaraoi* (Samanta) to be the oldest species of phylogenetic branch *Orbitoclypeus* with restriction to Thanetian.

In Palaeocene reef complex of the Western Carpathians this species is present exclusively in fore-reef slope sediments and was identified in 33 blocks of Thanetian age. Prevailingly coarse-lenticular tests have diameter 0.8 – 2.6 mm and thickness 0.6 – 1.3 mm. Embryonal apparatus is eulepidine with transition to nephrolepidine arrangement. Protoconch has diameter 0.08 – 0.11 mm, diameter of first two 2 embryonal chambers is 0.15 to 0.22 mm. Equatorial layer is very thin, diameter of pillars is 0.06 to 0.11 mm.

The species is relatively frequently present in blocks from the Myjavská pahorkatina Upland (Priepasné-Batíková, Stará Turá), it is not rare in the Middle Váh Valley (Hričovské Podhradie). It was found also in limestones of the Humenské vrchy Mts. and Vihorlat (Beňatina).

Family *Coskinolinidae* Moullade, 1965

Genus *Coskinon* Hottinger et Drobne, 1980 (Pl. XXI, Figs. 8 – 9)

In monograph by Samuel et al. (1972) from the Middle Váh Valley is presented depiction of cone-shaped forms with designation *Dictyoconus alavensis* (Mangin). When in year 1980 Hottinger & Drobne introduced new species *Coskinolina* (*Coskinon*) *rajkae* into its taxonomy they placed also depiction of *Dictyoconus alavensis* (Mangin) from the monograph by Samuel et al. (l.c.). At type locality Golež in Slovenia the species occurs in layers with *Glomalveolina primaeva* (Reichel), i.e. in Thanetian.

Carpathian tests are cone-shaped, up to 1.4 mm high and 0.6 – 1.2 mm in diameter. Protoconch is placed in apex and is rarely encountered in sections and has diameter 0.08 – 0.15 mm. It is followed by chambers arranged in low trochospiral.

Regarding a relative scarcity of sections it cannot be excluded, that a part of tests belongs to the species *Fallotella alavensis* Mangin, with which the described form is frequently present.

In the Western Carpathians the species *Coskinon rajkae* Hottinger et Drobne is present in Thanetian shallow-water lagoonal sediments of the Myjavská pahorkatina Upland (Dedkov vrch), in the Middle Váh Valley (Rybárikov laz, Hričovské Podhradie) and in Orava (Brezovica).

Family *Discocyclinidae* Vaughan et Cole, 1940

Genus *Discocyclina* Gümbel, 1868 (Pl. XX, Figs. 1 – 4)

In Palaeocene only species *Discocyclina seunesi* Douvillé is present, which is the index fossil of the zone SBZ 3 (Early Thanetian sensu Serra-Kiel et al., 1998). *Discocyclina seunesi* is present very frequently in Thanetian fore-reef slope sediments. Provided it is present in back-reef platforms, it probably dwelled in deeper channel spaces.

Less (1987) originally assigned this species to the genus *Orbitoclypeus* as an initial member of the phylogenetic lineage, but study material from Bulgaria (Less et al., 2007) convinced him that the species belongs to the genus *Discocyclina*. Less et al. (l.c.) in the scope of the species distinguished 3 evolutionary stages – subspecies: *Discocyclina seunesi seunesi*, *D. seunesi beloslavensis*, *D. seunesi karabaekensis* with gradually enlarging embryonal apparatus.

In the Western Carpathians the sections of *Discocyclina seunesi* Douvillé were determined in thin sections from 34 limestone blocks mainly in the Myjavská pahorkatina Upland (Priepasné-Batíková, Hodulov vrch, Stará Turá), in the Middle Váh Valley (Rybárikov laz, Hričovské Podhradie, Vlčia jama, Hradisko). Depictions of this species in monograph by Samuel et al. (1972) were adopted also by the authors of SBZ zonation (Serra-Kiel et al., l.c.) and they pointed out to them in appendix at page 245.

Tests of *Discocyclina seunesi* Douvillé in the Western Carpathians are flat-lenticular with moderate central elevation. Tests have diameter 1.6 – 5.0 mm and attain thickness of 0.4 – 1.0 mm in the centre. Embryonic apparatus is of the eulepidine to trybliolepidine type, protoconch diameter is 0.10 – 0.15 mm (occasionally up to 0.20 mm), diameter of the first two embryonal chambers is 0.16 to 0.28 mm. The equatorial layer is distinctly thickening towards the perimeter; diameter of pillars is 0.05 to 0.08 mm. These parameters affiliate the referred to forms to the subspecies *Discocyclina seunesi seunesi* sensu Less et al. (2007).

Family *Miscellaneidae* Pfender, 1935

Genus *Miscellanea* Pfender, 1935 (Pl. XXIV, Figs. 1 – 4)

Rare tests of this genus could be affiliated to the species *Miscellanea juliettae* Leppig.

Lenticular to moderately angular tests have diameter of 0.6 to 1.5 mm and thickness of 0.5 – 0.7 mm. Diameter of protoconch ranges within 0.08 to 0.19 mm (according to section plane). Leppig (1988a, b) divided this species into two subspecies *Miscellanea juliettae pfenderae* n. ssp. and *M. juliettae villatae* n. ssp., but the Carpathian material doesn't allow for such division.

According to Leppig (l.c.) in Spain both subspecies are present in association with *Discocyclina seunesi* and *Operculina* sp. immediately below layers containing *Alveolina* (*G.*) *primaeva* and *Fallotella* (*F.*) *alavensis*, i.e. in Thanetian.

From the Western Carpathians the species was recorded in blocks in the Myjavská pahorkatina Upland (Hodulov vrch, Stará Turá, Dlhý vŕšok), in the Middle Váh Valley (Rybárikov laz and Hričovské Podhradie) in Thanetian sediments.

Samuel et al. (1972) depicted and described *Miscellanea* cf. *miscella* (d´Archiac et Haime) with age range Campanian-Maastrichtian-?Palaeocene, but according to depictions they were dominantly specimens of *Miscellanites primitivus* (Rahaghi).

Genus *Miscellanites* Hottinger, 2009 (Pl. XXIII, Figs. 1 – 5)

In the year 2009 Hottinger split from the original genus *Miscellanea* a new subfamily *Miscellanitinae* and assigned to it new genus *Miscellanites*. In the same year Sirel (2009) defined for species *Miscellanea primitiva* Rahaghi a new genus *Akbarina* with type species *Akbarina primitiva* (Rahaghi). This way the original species *Miscellanea primitiva* Rahaghi ended up in two new genera. Sirel (2015) refers to, that neither *Akbarina primitiva* (Rahaghi), nor *Miscellanites primitivus* (Rahaghi) belong to the genus *Miscellanites*, because they differ from type species *Miscellanites iranicus* (Rahaghi) of this genus. This issue has remained open, but the authors are in favour of the concept of Hottinger (2009).

Miscellanites primitivus (Rahaghi) is very frequent species in Palaeocene of the Western Carpathians. Its tests have diameter of 0.7 – 1.2 mm and thickness of 0.4 – 0.8 mm. Protoconch has diameter of 0.06 – 0.12 mm (Pl. XXIII, Figs. 1 – 4). As referred to by Sirel (2009) this species is very similar to commonly present *Pseudocuvillierina sireli* (Inan) with thin wall, indistinct pores and lacking of lateral channel.

We could agree with Sirel (l.c.), that it is Palaeocene – Selandian form, which in decreasing abundance passes also into Early Thanetian. It is present in the Malé Karpaty Mts. (Vápenková skala), in the Myjavská pahorkatina Upland (Kravárikovci, Jandova dolina, Drahý vrch, Matejovec), in the Middle Váh Valley (Hričovské Podhradie, Hradisko, Ovčiarsko), Orava (Zábiedovo), Pieniny (Haligovce) and in Slánske vrchy Mts. (Radvanovce).

Very rare are also tiny almost spheroidal forms, which could be affiliated to *Miscellanites globularis* (Rahaghi). They attain diameter of 0.6 to 1.1 mm, rare specimens of protoconch have diameter of up to 0.10 mm. They were found in the Myjavská pahorkatina Upland (Jeruzalem, Matejovec) as well as in the Middle Váh Valley (Hričovské Podhradie) in Selandian and Early Thanetian sediments (Pl. XXIII, Fig. 5).

Genus *Ornatononion* Hottinger, 2009 (Pl. XXIII, Fig. 6)

In the Myjavská pahorkatina Upland at the sites Kravárikovci, Dlhý vŕšok and Jeruzalem there were found tiny tests of only 0.5 – 0.8 mm diameter and thickness of 0.3 – 0.4 mm, rarely sampled protoconch attains diameter of 0.045 – 0.6 mm. In their structure they are similar to representatives of the genus *Ornatononion* Hottinger, 2009, but a small number of sections doesn't allow for more detail determination.

Genus *Pseudocuvillierina* Sirel, 1998 (Pl. XXII, Figs. 1 – 6)

In the year 1988 Inan described from central Anatolia (Turkey) new species *Cuvillierina sireli* occupying the Thanetian Tecer Fm. Sirel (1998) for this form created and defined a new genus *Pseudocuvillierina* with the single-known species *P. sireli* (Inan), also from Thanetian limestones of Turkey (the profile Çaldağ; Sirel, 2012, 2015). Hottinger (2014) suggested to re-affiliate *Pseudocuvillierina* to the genus *Cuvillierina*, but the authors are in favour of the Sirel (1998) concept.

The tests of this type in Palaeocene of the Western Carpathians are present in the Middle Váh Valley (Ovčiarsko) and in Orava (Zábiedovo, Brezovica). The tests reach dimensions of 0.8 to 1.6 mm and thickness of 0.6 to 0.8 mm, protoconch has diameter of 0.045 – 0.06 mm, rare to 0.08 mm. In sections pillars in central part of tests are conspicuous (Pl. XXII, Figs. 1 – 6).

The form from the Western Carpathians has notably smaller protoconch as referred to by Sirel (0.13 mm) and it is not present in Thanetian, but in Selandian. Accounting for tiny dimensions of tests and protoconch it is likely a predecessor of typical *Pseudocuvillierina sireli* (Inan).

Genus *Bolkarina* Sirel, 1981

Very rarely in thin sections could be found sections of tabular disc-shaped tests reaching in diameter up to 3.2 mm and thickness of 0.4 mm. Because no equatorial section is at disposition, the species affiliation has remained problematic. The tests were found in Thanetian limestone blocks in the Myjavská pahorkatina Upland (Dlhý vŕšok) and in the Middle Váh Valley (Rybárikov laz, Hričovské Podhradie, Vlčia jama).

Family *Nummulitidae* de Blainville, 1827
Genus *Assilina* d´Orbigny, 1839

Only in the Myjavská pahorkatina Upland (Drahý vrch, Juríkovci, Tížikovci) there are rare tests with distinctly evolute tightly coiled spiral of chambers, which could be affiliated to the species *Assilina yvettae* Schaub, 1981.

Tests are lenticular with a diameter of 1.04 – 2.0 mm and thickness of 0.4 – 0.7 mm, protoconch reaches a diameter of 0.11 to 0.19 mm. Sirel (1998) refers to a bit higher values of dimensions of tests and also protoconch. Tests were found in limestones of Thanetian age. Their very rare occurrence doesn't allow for more detail investigation of internal signs.

Genus *Operculina* d´Orbigny, 1826 (Pl. XXV, Figs. 1 – 4, 6)

Tests of this genus rarely occur in fore-reef slope sediments of Thanetian age.

Examined material enables to distinguish two species: *Operculina heberti* (Munier-Chalmas) has flat-lenticular tests of megalospheric generations reaching in size 2.0 – 3.5 mm and thickness of 0.6 – 0.8 mm, diameters of protoconch are quite variable (according to cutting plane) between 0.14 to 0.25 mm. Microspheric generation is very rare and tests attain diameter of 5.3 to 6.5 mm (Pl. XXV, Figs. 1 – 3).

Operculina azilensis Tambareau has a bit closer coiling. Diameter of tests is 1.5 to 1.7 mm, thickness 0.4 to 0.7 mm, protoconch has diameter of 0.09 – 0.14 mm (Pl. XXV, Fig. 4).

Operculina heberti (Munier-Chalmas) was found in fore-reef sediments of the Myjavská pahorkatina Upland (Matejovec, Juríkovci, Krásny vrch) and in the Middle Váh Valley (Rybárikov laz, Hričovské Podhradie, Vlčia jama), rarely it is present also in Slánske vrchy Mts. (Radvanovce). *Operculina azilensis* Tambareau is present in the Myjavská pahorkatina Upland (Stará Turá, Hodulov vrch, Tížikovci) and in the Middle Váh Valley (Rybárikov laz, Hričovské Podhradie).

Genus *Ranikothalia* Caudri, 1944 (Pl. XXV, Fig. 5)

In thin sections the sections very rarely occur, which could be affiliated to this genus. Tests are flat-lenticular with diameter of 1.6 – 4.0 mm, thickness of 0.4 – 0.7 mm and very conspicuous pillars. Very rarely protoconch are found with diameter of 0.18 – 0.36 mm (according to cutting plane). According to these parameters these tests are the closest to the species *Ranikothalia sindensis* (Davies). They were identified in Thanetian fore-reef sediments of the Myjavská pahorkatina Upland (Drahý vrch, Tížikovci, Stará Turá) and in the Middle Váh Valley (Rybárikov laz).

Family *Rotaliidae* Ehrenberg, 1839
Genus *Daviesina* Smout, *1954* (Pl. XXIII, Figs. 7 – 8)

At some sites in limestones sections of tests are present, which systematic affiliation is very questionable. Moussavian (1984) assigned very similar exemplars to the genus *Ranikothalia*, but conspicuous asymmetry of tests evolved due to uneven development of pillars in central part of tests rather corresponds to the definition of the genus *Daviesina* by Smout (1954). Caus et al. (1980) at revision of the genus *Daviesina* assigned to it the tests with operculina coiling, but depicted also distinctly asymmetric tests, similar to those, which are present in the Western Carpathians.

Tests of *Daviesina* sp. in materials from the Western Carpathians attain diameter of 0.9 to 1.3 mm and thickness in the centre 0.5 – 1.0 mm. Protoconch has diameter of 0.07 – 0.11 mm. In central part of the tests there are groups of conspicuous pillars, which are strongly developed at one side. According to structure the tests are the closest to the species *Daviesina garumnensis* Tambareau from Late Thanetian.

The referred to tests were found in shallow-water back-reef, but also slope fore-reef sediments in the Myjavská pahorkatina Upland (Kravárikovci, Jandova dolina, Dlhý vŕšok, Hodulov vrch, Tížikovci), in the Middle Váh Valley (Svätá Helena, Hričovské Podhradie, Hradisko) than also in Slánske vrchy (Radvanovce) in sediments of Thanetian age.

5.4. Small benthic foraminifers

In addition to algae the small foraminifers are the most abundant organic compound of the Palaeocene reef complex of the Western Carpathians. To these groups belong dozens of genera and hundreds of species. Their more detail description in the scope of this study is not possible and therefore the attention is focused mainly in those compounds, which are in Palaeocene reef system represented by large number of exemplars, including those which up to now have not been known from northern Tethys.

The authors are aware of the fact, that they cannot cover the issues of all benthic small foraminifers at least at genera level. Their processing in more detail could be handled by several monographic works, whereas an extensive thin section material is at disposition.

Family *Placopsilinidae* Rhumbler, 1913

On various substrates, but mainly on algae crusts and in cavities of organic structures originate regular or completely irregular structures with agglutinated walls up to 0.20 mm thick. At places these organisms significantly participated in sediment cementation.

Bignot (1992) from reefs in Vigny (Paris Basin) described new species *Acruliamina robusta* Bignot and into its synonymics he assigned also forms, which Samuel et al. (1972) depicted from the Middle Váh Valley under genus names *Placopsilina*, *Coscinophragma* and *Haddonia*. The authors stick to the genus name *Placopsilina* d´Orbigny. Representatives of this genus lived in Thanetian in all environments of the reef complex, the most frequently at the sites Kravárikovci, Matejovec, Jeruzalem, Lubina, Hodulov vrch (Myjavská pahorkatina Upland), Hričovské Podhradie and Hradisko (the Middle Váh Valley), Haligovce and Veľký Lipník (Pieniny). Genus *Placopsilina* is present from Mesozoic up to recent and has large geographic extent.

Family *Elphidiidae* Galloway, 1933 (Pl. XXIV, Fig. 5)

Drobne et al. (2007) published description of the new genus *Bangiana* with type species *Bangiana hanseni*. This very tiny form reaching dimensions 0.44 mm is originally described from the site Dolenja Vas in Slovenia and was defined as Danian type fossil (SBZ 1).

In one sample from the site Vápenková skala (Malé Karpaty Mts.) sections were identified in thin sections, which could be associated with this species, although no single section is in ideal central position (Pl. XXIV, Fig. 5). It is the only direct proof of Danian age (SBZ 1) of the bioherm limestones of the Palaeocene reef complex in the Western Carpathians.

Family *Haddoniidae* Saidova, 1981 (Pl. XXVIII, Figs. 4 – 5)

Agglutinated tests of the genus *Haddonia* Chapman belong among very frequent fossils in Palaeocene rocks, mainly in the Middle Váh Valley (vicinity of Považská Bystrica, Hričovské Podhradie and Hradisko). As the type species *Haddonia heissigi* Hagn is present since Eocene, Samuel et al. (1972) created for the form from the Latest Cretaceous to Palaeocene new species *Haddonia praeheissigi* Samuel, Köhler et Borza. This striking agglutinated form has irregular tests with walls 0.15 to 0.20 mm thick. It is interesting, that the walls are made of dominantly quartz fragments, even in such a case, when in the encompassing rock fragments of quartz are almost missing (Pl. XXVIII, Figs. 4 – 5). Species from Palaeocene island Zakynthos (Greece) describe DiCarlo et al. (2010).

Family *Textulariidae* Ehrenberg, 1838 (Pl. XXVIII, Figs. 2 – 3)

Tiny conical tests sporadically occur in rocks originating in shallow-water back-reef environment, but also in fore-reef rocks of slope. They could be affiliated most likely to the genera *Textularia* Defrance and *Valvulina* d´Orbigny. They occur in the entire temporal range of Palaeocene.

Family *Miliolidae* Ehrenberg, 1839 (Pl. XXVII, Figs. 1 – 7)

In shallow-water back-reef environments miliolid foraminifers belong among the most frequent foraminifers. Roughly they could be divided into three groups: tiny thick-wall forms, thin-wall forms and large forms with characteristic structure (*Idalina*).

There is almost no locality, in which tiny thick-wall forms are missing. They belong most likely to the genera *Quinqueloculina* d´Orbigny and *Triloculina* Reuss. Samuel et al. (1977) described for pentagonal section in thin sections easily recognizable species *Miliola*? *andrusovi* Samuel, Köhler et Borza (= *Idalina sinjarica*) occupying in Thanetian mainly protected back-reef environments (Hričovské Podhradie, Moštenec; Pl. XXVII, Fig. 4).

Up to now thin-wall miliolid forms impose large problems from the viewpoint of taxonomic affiliation and the authors mostly avoid affiliation into certain genera (Sirel, 1998). Some of the sections could be affiliated to the genus *Nurdanella* Sirel. Miliolid structure has also genus *Kartalina* Sirel occupying in Selandian and Thanetian Turkey. Exemplars, which could be affiliated to this genus sporadically occur also in the Western Carpathians (the Middle Váh Valley).

In thin sections genus *Idalina* Grimsdale is easily distinguishable. Thanks to excellent description by Drobne (1974) species *Idalina sinjarica* Grimsdale could be identified also in material from the Western Carpathians, mainly at the sites Vápenková skala (Malé Karpaty Mts.), Hričovské Podhradie and Hradisko (the Middle Váh Valley). According to Drobne (l.c.) this species has interval Late Palaeocene to Ilerdian. Sirel (1998) defined species *Idalina causae* Sirel with thicker walls and smaller test than *I. sinjarica*. Also this form could be identified in thin sections from Slánske vrchy Mts. (Radvanovce).

Schlagintweit (2005) described and depicted from Palaeocene blocks from Mooshuben and Klein Ebenstein (Alpine south Palaeocene reef stripe) cryptobiotic form occurring in cavities formed by boring of thalli algae. Schlagintweit assigned this form to suborder *Miliolina* Delage et Herouard, but avoid the genus and species affiliation. Tragelehn (1996) termed this form as "in cavities dwelling foraminifer gen. et sp. indet." This form is present also in bored cavities of the algae *Elianella elegans* Pfender et Basse in the Myjavská pahorkatina Upland (Matejovec) – Pl. XXVII, Fig. 5.

Very rarely sections of tests are present, which could be affiliated to the genus *Kartalina*, which defined Sirel (2012) for forms occurring in Late Palaeocene (Pl. XXVII, Fig. 7).

Family *Rotaliidae* Ehrenberg, 1839 (Pl. XXIX, Figs. 1, 3 – 4, 6)

Into this family could be affiliated plenty of forms typical of rotaloid structure of tests.

Genus *Smoutina* Drooger, as described by Sirel (1998), is very common dweller of shallow-water environment. Its lenticular tests attain diameter 0.6 – 1.0 mm, thickness 0.4 – 0.7 mm, protoconch has diameter 0.06 – 0.08 mm. The tests are frequent in Palaeocene sediments of the Myjavská pahorkatina Upland (Stará Turá, Drahý vrch, Jeruzalem, Hodulov vrch) and of the Middle Váh Valley (Moštenec, Hričovské Podhradie) – Pl. XXIX, Fig. 4.

Genus *Sistanites* Rahaghi has very characteristic and easily distinguishable section. In the Western Carpathians it has very tiny dimensions (0.5 – 0.7 mm), protoconch attains 0.035 – 0.05 mm. Species *Sistanites iranica* Rahaghi was originally described from Late Palaeocene of Iran, Sirel (2009) depicted it from Selandian of Turkey. Rare exemplars of this species were found in Selandian (Malé Karpaty Mts. – Vápenková skala) to Early Thanetian (Middle Váh Valley – Vlčia jama) sediments – Pl. XXIX, Fig. 3.

Hottinger (2014) in his posthumously issued publication provided extensive revision of Palaeogene rotaloid foraminifers from western and central Neo-Tethys. Several times he mentioned also depictions in monograph by Samuel et al. (1972). Hottinger in this publication defined new genus *Plumokathina* and as *P. lenticula* n. sp. in synonymics of the species assigned also the form, which Samuel et al. (l.c.) described and depicted under species name *Rotalia hensoni* Smout. They create mostly tiny forms with diameter of 0.7 to 1.5 mm and thickness of 0.4 to 0.8 mm, They occur in Palaeocene sediments of the Myjavská pahorkatina Upland (Lubina, U Ušiakov, Priepasné-Batíkovia), of the Middle Váh Valley (Kunovec, Hričovské Podhradie) and Slánske vrchy Mts. (Radvanovce) – Pl. XXIX, Figs. 1, 6.

As *Paralockhartia eos* n. sp. he assigned in synonymics also *Rotalia* sp. 4 from monograph by Samuel et al. (l.c.).

Questionable is systematic affiliation of tests assigned to the genus *Kathina*. This genus created Smout (1954) from Middle East. In Palaeocene of the Western Carpathians lenticular tests of the genus attain diameter of 0.8 to 1.1 mm and thickness of 0.6 to 0.8 mm. Rarely visible initial chamber has diameter 0.06 – 0.08 mm. Genus is present mainly in fore-reef slope sediments of the Myjavská pahorkatina Upland (Dedkov vrch, Stará Turá), in the Middle Váh Valley (Svätá Helena and Hričovské Podhradie), uncertain exemplars are located in Pieniny (Veľký Lipník).

Typical Palaeocene genera *Lockhartia* Davies and *Laffitteina* Marie have not been identified yet in the Palaeocene rocks of the Western Carpathians.

Family *Mississippinidae* Saidova, 1981 (Pl. XXIX, Figs. 2, 5)

Tiny, merely reaching in section diameter 1 mm, very characteristic angular form use to be designated in literature as *Stomatorbina* (previously *Mississippina*) *binkhorsti* (Reuss). It is present in lagoonal back-reef as well as in slope fore-reef sediments, but always in very small number of exemplars. It was identified in thin sections from the Myjavská pahorkatina Upland (Kravárikovci, U Ušiakov), from the Middle Váh Valley (Hričovské Podhradie, Vlčia jama) and from Orava (Brezovica) in blocks of Thanetian age.

Family *Lituolidae* de Blainville, 1827

Genus *Haymanella* Sirel, 1999 (Pl. XXIV, Fig. 6)

Flat elongated tests of small dimensions (up to 1.8 mm) occur relatively rarely in back-reef lagoonal sediments of the Myjavská pahorkatina Upland (Stará Turá) and of the Middle Váh Valley (Hričovské Podhradie). By their dimensions and shape they are close to *Haymanella palaeocenica* Sirel, but a small number of sections doesn't allow for definition in more detail.

Family *Orduellinidae* Sirel, 1999

Genus *Orduella* Sirel, 1999 (Pl. XXIV, Fig. 7)

Family and genus defined by Sirel (1999) according to material from Turkey are typical of spheroidal appearance and multiple spirals in early stage. Its type species is *Orduella sphaerica* Sirel occurring in Thanetian. Tiny tests with typical section attain diameter up to 2.1 mm (4.2 mm in B-forms?). Very rare exemplars were found in the Myjavská pahorkatina Upland (Matejovec) and in the Middle Váh Valley (Svätá Helena, Kunovec, Hričovské Podhradie, Vlčia jama) in shallow-water sediments of Thanetian age.

Family *Vaginulinidae* Reuss, 1860

Genus *Lenticulina* Lamarck belongs among genera, which representatives relatively frequently occur in Thanetian fore-reef slope sediments. Despite fairly large tests they do not play important role in communities. They were found in the Myjavská pahorkatina Upland (Kravárikovci, Jandova dolina, Priepasné – Batíková, Stará Turá) and in the Middle Váh Valley (Hričovské Podhradie).

Family *Planorbulinidae* Schwager, 1877 (Pl. XXX, Figs. 5 – 6)

Genus *Planorbulina* d´Orbigny belongs among the most frequent sessile foraminifers occurring in majority of examined blocks in shallow-water lagoonal back-reef sediments across the entire Palaeocene.

The tests are either attached to solid substrate (on fragments of corals and on algae) or are detached from it. The shape of tests was related to the substrate morphology.

In palaeontologic literature the opinion has been adopted, that all Palaeocene exemplars could be affiliated to the species *Planorbulina cretae* (Marsson). The exception was Scheibner (1968), who for species from Pieniny (Haligovce) gave new name *Planorbulina uva* Scheibner, but this taxon has not been adopted. Exemplars usually attain diameter up to 1.5 mm, but diameter up to 3 mm is not exceptional. Rarely initial chamber could be distinguished with diameter of 0.06 – 0.10 mm.

Exemplars of *Planorbulina cretae* (Marsson) were found everywhere in the Western Carpathians Palaeocene reef stripe from the Malé Karpaty Mts. (Vápenková skala) till Pieniny (Haligovce).

Family *Acervulinidae* Schultze, 1854 (Pl. XXX, Fig. 4)

Similarly to genus *Planorbulina*, sessile genus *Solenomeris* Douvillé is present in majority of examined blocks in shallow-water lagoonal back-reef sediments across the entire Palaeocene.

This long-known genus was originally considered to be alga (Elliott, 1964; Wray, 1977), later this problematics was handled in detail by Perrin (1987, 1992, 1994, 2009), Moussavian (1989) and Moussavian & Höfling (1993) and the genus was assigned to foraminifers. Perrin (1987, 1992) is in favour of keeping the original genus name *Solenomeris*, other authors (Moussavian, 1989) assign it to the genus *Acervulina* Schultze.

From Palaeocene the only species *Solenomeris ogormani* Douvillé is described. According to Moussavian & Höfling (1993) the species occupied warm tropic seas in depths from 20 to 120 m. In addition to crusts attached to solid substrate, the genus created also macroids, when at slow rotation by currents or waves (in more detail see Hottinger, 1993) it coated a core (fragment of coralline alga). Rate of sedimentation had to be low, to avoid burial of macroid prior to its maturity.

Crusts of *Solenomeris ogormani* Douvillé were observed in thin sections from the Myjavská pahorkatina Upland (Kravárikovci, Jandova dolina, Jeruzalem, Dlhý vŕšok, Hodulov vrch, Tížikovci), from the Middle Váh Valley (Rybárikov laz, Hričovské Podhradie) and from Pieniny (Haligovce, Veľký Lipník). Besides type locality in the southern France this species is referred to from numerous sites from Iraq till Germany (Perrin, 1992).

Scheibner (1968) designated this form from block in Haligovce as *Gypsina ogormani* (Douvillé), but Samuel et al. (1972) depicted it incorrectly under the name *Miniacina multicamerata* (Scheibner).

Family *Homotrematidae* Cushman, 1927 (*Miniacinidae* Thalmann, 1938) (Pl. XXX, Figs. 1 – 3)

Scheibner (1968) described under the names *Bullopora multicamerata* n. sp. and *Miniacina multiformis* n. sp. forms from the site Haligovce in Pieniny. In literature there were adopted the names *Miniacina multicamerata* (Scheibner) and *Miniacina multiformis* Scheibner. Crusts to branching tests are made of thin layers. Crusts may attain to 4 mm length and thickness of 1.5 mm.

Despite tiny dimensions exemplars are quite frequent and easily distinguishable in sediments of back-reef shallow-water environment in the Middle Váh Valley (Kunovec, Hričovské Podhradie) and in Pieniny (Haligovce and Veľký Lipník).

Family *Gavelinellidae* Hofker, 1956

Genus *Valvulineria* Hofker, 1956 (Pl. XXVI, Figs. 1, 3)

Originally, tests assigned to the genus *Anomalina* d´Orbigny with anomalinid structure are relatively frequent in Palaeocene rocks across the entire Palaeocene. Sirel (2015) depicted them from Selandian in Turkey under the name *Valvulineria* aff. *patalaensis* Haque. In thin sections they are easily determinable according to characteristic sections. The genus was identified in thin sections from the Malé Karpaty Mts. (Vápenková skala), Myjavská pahorkatina Upland (Jandova dolina, Jeruzalem, Hodulov vrch, Dlhý vŕšok, Tížikovci), the Middle Váh Valley (Svätá Helena, Hričovské Podhradie), Orava (Brezovica), Pieniny (Haligovce) and from Slánske vrchy Mts. (Radvanovce).

Planktonic foraminifers

In protected shallow-water back-reef environment and in the zone of patch-reefs formation planktonic foraminifers are very rare. Sporadic tests determined in thin sections document the fact, that carbonate platforms were narrow and furrowed by channels, into which also planktonic organisms from open sea could be carried mainly during tide and storms (e.g. at the site Kunovec in the Middle Váh Valley).

More frequent occurrence of the tests of planktonic foraminifers was identified in fore-reef slope sediments connected with open sea. The representatives of genera *Eoglobigerina* and *Globoconusa* in temporal range Danian – Early Thanetian are present at the sites in the Malé Karpaty Mts. (Vápenková skala), Myjavská pahorkatina Upland (Dlhý vŕšok, Hodulov vrch, Stará Turá, Lubina and Tížikovci) and in the Middle Váh Valley (Kunovec and Hričovské Podhradie), almost always in fore-reef slope sediments. More frequently genera *Subbotina* and *Acarinina* are present; they are located sporadically also in reef structures (Pieniny – Haligovce), but the most frequently in fore-reef sediments of the Middle Váh Valley (Hričovské Podhradie and Ovčiarsko), always in sediments of Thanetian age (Pl. XXVI, Figs. 4 – 8).

We have to note, that Tragelehn (1996) at study of the reef complex of Eastern Alps identified more frequently planktonic foraminifers namely in solid bioherm limestones. He divided them into planktonic foraminifers of Danian P1a *Parvularuglobigerina eugubina* zone and of P1b/c *pseudobulloides* (*trinidanensis* zone), Montian (= Selandian) P1c/P2 *trinidadensis*-*uncinata* zone (besides the others also pink reef limestones of the site Kambühel) and Thanetian (Early – P3a/b and Late P3b/4). Without more detail taxonomic affiliation he depicted them in Figs. 11 to 16. It is interesting, that in Fig. 16 he displays sections of Late Thanetian planktonic foraminifers from the Slovak sites and in the text he refers to, that they originated from fore-reef sediments of Slovakia without indication of localisation and taxonomic affiliation of sections.

Planktonic foraminifers of Palaeocene basinal sediments, mainly of the Myjavská pahorkatina Upland and of the Middle Váh Valley were in focus of numerous research works (Samuel & Salaj, 1963, 1968; Samuel et al., 1972, 1980; Salaj et al., 1978). The acquired results – mainly the age affiliation of sediments – are in full accord with data gained from the Palaeocene reef system.

Incertae sedis

Genus *Pieninia* Borza et Mišík, 1976 (Pl. XXXIII, Figs. 3 – 4)

Genus *Pieninia* with type species *Pieninia oblonga* was introduced in year 1976 by Borza & Mišík. They stated that tiny isolated bodies belonging to this genus are present in reef and back-reef facies, exclusively in shallow-water sediments. They assigned the genus to algae of the family Codiaceae. Among sites they stated also Hričovské Podhradie (the Middle Váh Valley).

Later the authors of this publications provided Mišík thin section material from further sites, where species *Pieninia oblonga* doesn't form tiny bodies, but it is located inside the corals body structures. Mišík in year 1998 issued a new publication, in which he stated, that in the meantime the bodies of *Pieninia oblonga* were found in sediments from Barremian up to Late Eocene in many countries (Italy, Hungary, Croatia, Spain, Austria), but the authors, who described them, didn't find accord in their systematic assignment. Mišík himself asked several European specialists to provide opinion, where this genus ought to be affiliated, but he received very contradictive replies. In his publication Mišík (1998) refers to as type localities of *P. oblonga* in Palaeocene Veľký Lipník (Pieniny), Makovec (the Middle Váh Valley), Drahý vrch and Dúbrava at Stará Turá (Myjavská pahorkatina Upland). Unless the tiny bodies are present within coral body structures, he affiliates them to sponge *Karatosa*. He didn't find a satisfactory explanation whether the bodies are endoparasites or components of the skeletons.

Tiny bodies of *Pieninia oblonga* Borza et Mišík have a spherical to spindle-shaped 0.15 to 0.25 mm form and length of up to 0.45 mm. In the centre the central channel could be recognized. They are easily distinguishable in crossed nicols. Besides frequent free exemplars they are also present in skeletons of corals and sponges. It cannot be excluded, that there is no relationship symbiosis between host and guest, it is possible, that *Pieninia* is endoparasite and bored into the skeletons. After apobiosis of host structures the *Pieninia* tiny bodies fall out and get into the sediment.

Mišík (1998) expressed the hope that such material will be found, which will clearly resolve the systematic inclusion of *Pieninia* and way of life of this genus.

In the Palaeocene complex of the Western Carpathians *Pieninia oblonga* BORZA et MIŠÍK is common fossil in the back-reef and reef environments in blocks from the Myjavská pahorkatina Upland (besides the above mentioned Stará Turá also in Miškech Dedinka and Kravárikovci) of the Middle Váh Valley (Rybárikov Laz, Hričovské Podhradie) and Pieniny (Veľký Lipník), and seems to be limited to Selandian-Early Thanetian (SBZ 2 – SBZ 3).

5.5. *Metazoa* (multicellular animals)

Besides corals and bryozoans their significance at building Palaeocene shallow-water communities is relatively small. It is probably also the result of the fact that biological collapse at the Cretaceous-Tertiary boundary affected them more distinctly than in unicellular foraminifers and algae.

Phylum *Coelenterata*
Class *Hydrozoa*

In some of thin sections colony forms were found, which – although not with certainty – could be attributed to the hydrozoans. They created irregular calcareous structures. Numerous cavities are filled with micrite matrix. Often inside the calcified structures there are located tiny bodies of vague affiliation designated as *Pieninia oblonga* BORZA et MIŠÍK. Fragments (likely coming from small reef structures) were found in Pieniny (Veľký Lipník) and in the Myjavská pahorkatina Upland (Miškech Dedinka).

Class *Anthozoa*

Order Scleractinia (= Hexacorallia) (Pl. V, Figs. 3 – 4, Pl. VII, Fig. 4, Pl. VIII, Figs. 1 – 2, Pl. IX, Fig. 2, Pl. X, Figs. 1 – 4, Pl. XI, Fig. 4, Pl. XXXI, Figs. 1 – 4, Pl. XXXII, Figs. 1 – 6, Pl. XXXIII, Figs. 1 – 2)

Corals were in the whole history of the Earth the most successful builders of reef structures. Scleractinia appeared during the Triassic and by the end of Cretaceous they reached the largest development and diversity (Wells, 1956). Event at the Cretaceous and Tertiary boundary (K-T) affected them very significantly. By the beginning of the Palaeocene their number of genera decreased by approximately one third and those, who survived were so decimated, that they were not capable to build structures and by the beginning of Danian they created only simple structures. From literature there are not known convincing proves of coral structures from the beginning of the Palaeocene. A new expansion of their building activity occurred in Later Danian, 2 – 3 million years after the events at the K-T boundary. Currently they are the most important builders of reef structures, including the Great Barrier Reef, the largest reef complex on the Earth. They live up to depths of 100 m (maximum development they have to depths of up to 30 m) in waters with a temperature of 25 – 29 °C and with the normal salinity. It can be assumed, that similar requirements for environment they had also in Palaeocene.

There are not many works, which would deal with Palaeocene corals, namely Scleractinia. We should mention the works by Floris (1972), Kuzmicheva (1975), Turnšek (in Drobne et al., 1988), Turnšek & Drobne, 1998), Schuster (1996) and mainly monograph by Baron-Szabo (2006, 2008).

It is interesting, that the issue of Palaeocene corals from the Western Carpathians was paid attention already prior to the issuance of the above mentioned works. In year 1937 Kühn & Andrusov published description of corals of supposedly Cretaceous age and among them from the site of Svätá Helena at Považská Bystrica there was mentioned species *Agathelia asperella* Reuss and from the Myjavská pahorkatina Upland from the site Kravárikovci species *Epiphaxum murchisoni* (Reuss), *Stylosmilia* (?) *carpathica* nov. spec., *Actinacis* cf. *porosa* Oppenheim, *A. remeši* Felix and from the site Stará Turá *Agathelia asperella* Reuss, *Leptoria konincki* E.H. form *typica* and *Actinacis remeši* Felix.

Scheibner (1968) published on p. 89 a table, in which in addition to other fossils there is also a list of corals known from Palaeogene limestones in Slovakia. The list comprises *Epiphaxum* sp., *E.* cf. *murchisoni* (Reuss), *Plytremacis* sp., *P. partschi* Reuss, *Astreopora* sp., *Actinacis cymatocysta* Felix, *A. remeši* Felix, *A.* cf. *porosa* Oppenheim, *A.* sp., *Stylosmilia* sp., *S.* (?) *cyroathica* Kühn, *Agathelia asperella* Reuss and *Leptoria konincki* (E. et H.). These species are reported from sites Haligovka (Pieniny), Považská Bystrica and Hričovské Podhradie (the Middle Váh Valley) and Lubina (Myjavská pahorkatina Upland) without depictions and description in more details.

Samuel et al. (1972) depicted several Palaeocene corals structures. It could be noted that Baron-Szabo (2006) stated their determination "solitary coral" (Pl. 155, Fig. 3) from the site Hradisko to genus *Heterocoenia* Milne Edwards et Haime.

The diversity of Palaeocene corals in the Alps-Carpathian space was not minute; it is indicated by the fact that Baron-Szabo (l.c.) assigned into the genera *Stylocoenia* Milne Edwards et Haime, *Acropora* Oken, *Astreopora* Blianville, *Paraplacocoenia* Beauvais, *Calamophylliopsis* Alloiteau, *Haimesastrea* Vaugham, *Pachygyra* Milne Edwards et Haime and *Heterocoenia* Milne Edwards et Haime the hexacorals depicted in monograph by Tragelehn

(1996; Pls. 60 – 62). Among the images there are also two ones from the Slovak sites. On Pl. 60, Fig. 2, the morphotype 4 from Hričovské Podhradie Baron-Szabo (2006) assigned to *Pachygyra* Milne Edwards et Haime and on Pl. 61, Fig. 2 the morphotype 8 from the site Kunovec Baron-Szabo (l.c.) assigned to genus *Paraplacocoenia* M. Beauvais.

In the Palaeocene sediments of the Western Carpathians they are present as genera building solid structures, as well as various branching forms.

Mainly genera *Actinacis* d´Orbigny and *Stylocoenia* Milne Edwards et Haime were capable to build up solid structures. Structures of smaller one meter dimensions had large cavities filled up with marine micrite and biorelics. Initial diagenesis had not been quite intense to allow coalescence of structures into resistant bodies; rather it appears that structures were exposed to intense bioerosion and mechanical damage by waves and currents. These destructive elements acquired superiority above building and coralline structures and soon after their origination they crumbled to gravel and tiny debris. Only bodies cemented by coralline algae could maintain the size reaching up to 10 m (Haligovce in Pieniny). Larger and smaller fragments of coral structures are dissipated in blocks from Myjavská pahorkatina Upland (Kravárikovci, Jandova dolina, Dlhý vŕšok, Matejovec, Jeruzalem, Hodulov vrch, Stará Turá, Krásny vrch, Miškech Dedinka, Juríkovci), from the Middle Váh Valley (Svätá Helena, Hričovské Podhradie), Orava (Brezovica, Zábiedovo) and Pieniny (Haligovce and Veľký Lipník) – Pl. XXXII, Figs. 1 – 2.

Branching corals are present dominantly by genera *Dendrophyllia* Blainville, *Rhizangia* Milne Edwards et Haime and *Orbignygyra* Alloiteau. They occur dominantly on the front side of the reef structures. They are known from the Myjavská pahorkatina Upland (Jeruzalem, Hodulov vrch, Lubina), the Middle Váh Valley (Rybárikov laz, Kunovec) and from Slánske vrchy Mts. (Radvanovce) – Pl. XXXII, Figs. 4 – 6, Pl. XXXIII, Figs. 1, 2.

In Pieniny we have found a share of the genus *Litharaea* (*L.* sp.); in its structure *Pieninia oblonga* Borza et Mišík is present – Pl. XXXIII, Figs. 3 – 4.

Reef structures made of corals in Palaeocene of the Western Carpathians are dated from Selandian up to Thanetian. They occur also in Danian layers (Vápenková skala in the Malé Karpaty Mts.), but don't form accumulations. Their maximum development in Thanetian was interrupted by Late Thanetian regression and with associated termination of carbonate platforms and reef structures.

Phylum *Porifera*

Although in some of thin sections the sections were found, which could be affiliated to sponges, available literature on the Palaeocene doesn't provide options of their comparison and taxonomic affiliation.

Phylum *Annelida*

Class *Polychaeta* (Pl. XXXIV, Figs. 4 – 5, Pl. XXXV, Fig. 5)

Mainly in fore-reef slope sediments could be occasionally found typical bilayer circular sections of tubes of worms, which could be affiliated to the genus *Ditrupa,* with some reservation.

Occurrences are quite rare in the Myjavská pahorkatina Upland (Kravárikovci, Jandova dolina, Hodulov vrch, Drahý vrch, Krásny vrch, Lubina, Matejovec, Tížikovci), in the Middle Váh Valley (Rybárikov laz, Hričovské Podhradie), in Slánske vrchy Mts. (Radvanovce). In Palaeocene genus *Ditrupa* didn't reach such extent as in Eocene to Miocene. At places also more complex structures of mutually connected pipes could be found. To-date their taxonomic classification is not possible.

Phylum *Bryozoa*

Class *Gymnolaemata* (Pl. XXXV, Figs. 1 – 4, 6)

Bryozoans in Palaeocene seas created colonies of different forms and significance. At the present state of their taxonomic elaboration the study of thin section material doesn't provide opportunities for their determination. Mostly, division into two large groups is possible: *Cyclostomata* represent irregular forms without central axis and *Cheilostomata*, which have polygonal section with a central axis and a solid calcified wall. *Cyclostomata* dwelled in shallow lagoonal waters, *Cheilostomata* are characteristic for deeper fore-reef environment. Interesting are relationships of bryozoans with coralline algae. There were recorded cases where bryozoans overgrew thalli of coralline algae forming a macroid, but also completely opposite situation where sponge was coated by crusts of coralline algae.

In Palaeocene the largest interest provoked bryozoans making up reefs in Denmark and in the southern Sweden, with highly diversified communities of cheilostomate bryozoans. In detail they were dealt with Thomsen (1977, 1983), who divided bryozoans in reefs into two groups: erected (20 species) and crustal (51 species). Bernecker & Weidlich (1990) and Bignot (1992) based on plentiful evidence concluded that reefs in Fakse (Denmark) originated in depths of 100 to 300 m.

In Palaeocene limestones of the Western Carpathians the bryozoans are common compound of the communities. *Cyclostomata* are present mainly in their protected back-reef environments, while *Cheilostomata* in sediments of fore-reef slopes. The most frequent occurrences of mostly excellent-preserved zoaria of cyclostomatous forms are at the sites Vápenková skala (Malé Karpaty Mts.), Kravárikovci, Jandova dolina, Priepasné-Batíková, Dlhý vŕšok, Matejovec, Jeruzalem, Hodulov vrch, Drahý vrch, Krásny vrch, Stará Turá, Miškech Dedinka (Myjavská pahorkatina Upland), Rybárikov laz, Kunovec, Hričovské Podhradie, Ovčiarsko (the Middle Váh Valley), Zábiedovo (Orava), Haligovce and Veľký Lipník (Pieniny). *Cheilostomata* forms are frequent at the sites Jandova dolina, Drahý vrch, Tížikovci (Myjavská pahorkatina Upland), Rybárikov laz, Kunovec and Hradisko (the Middle Váh Valley). They are present from Early up to Late Palaeocene.

Numerous photographs of bryozoans are presented in monograph by Samuel et al. (1972; Pls. 110 – 114).

Phylum *Mollusca*

Class *Bivalvia* (Pl. XXXVI, Figs. 4 – 5)

Fragments of bivalves occur very frequently in thin sections. Usually they are tiny fragments, larger parts of preserved shells are great rarities. Since they are located in hard rocks, their isolation and accurate (at least gender) determination, isn't possible (perhaps with the exception of *Ostrea* sp.).

Class *Gastropoda* (Pl. XXXVI, Figs. 1 – 3)

Tiny shells (of height 2 – 3 mm) are not rare in thin sections, but cuts don't allow their assignment on the genus level. More frequent occurrence was recorded at the sites Vápenková skala (Malé Karpaty Mts.), Kravárikovci, Jeruzalem, Jandova dolina (Myjavská pahorkatina Upland), Haligovce and Veľký Lipník (Pieniny). Gastropods lived in protected back-reef environments, but also in cavities of reef structures.

Phylum *Arthropoda*

Class *Ostracoda* (Pl. XXXIV, Figs. 6 – 7)

Completely unbroken tests of ostracods are rare in thin sections, much more often their fragments could be found. They occur prevailingly in the back-reef environment, in the fore-reef slopes they are already crushed. Their distribution during the entire Palaeocene was quite uneven. The most complete shells were found at the sites Hodulov vrch and Miškech Dedinka (Myjavská pahorkatina Upland), Hričovské Podhradie (the Middle Váh Valley) and Veľký Lipník (Pieniny). To-date, the genus or species identification of non-isolated tests in thin sections isn't possible.

Phylum *Echinodermata*

Class *Crinoidea* (Pl. XXXIV, Fig. 3)

Scattered crinoids segments and the fragments of articulate bryozoans are not rarity in Palaeocene rocks, but their importance at building of reef communities is negligible. In thin sections usually fragments of central part of crinoids (stalks) or calyx plates could be found. Complete sections with conservation of peripheral part are rare. Fragments of crinoids were found at the sites Vápenková skala (Malé Karpaty Mts.), Jandova dolina, Dlhý vŕšok, Matejovec, Hodulov vrch, Stará Turá, Krásny vrch, Lubina and Tížikovci (Myjavská pahorkatina Upland) and Zábiedovo (Orava).

Class *Echinoidea* (Pl. XXXIV, Fig. 1)

Similarly to articles of crinoids, echinoderms spines are also dissipated in Palaeocene rocks of various reef environments. The best preserved cells were found in thin sections from the sites Vápenková skala (Malé Karpaty), Jandova dolina, Dlhý vŕšok, Stará Turá, Lubina and Lipovec (Myjavská pahorkatina Upland), Hradisko (the Middle Váh Valley), Zábiedovo (Orava), Haligovce (Pieniny) and Radvanovce (Slánske vrchy Mts.). Methodology for echinoderms taxons determining according to their spines is not elaborated, although it is obvious that they differ from each other in the dimensions and the arrangement of building elements.

Vertebrata (Pl. XXXIV, Fig. 2)

The only trace of the existence of vertebrates in Palaeocene reef complexes are rare sections of fish teeth, e.g. at the site Jeruzalem in the Myjavská pahorkatina Upland.

6. Conclusions

More than 50 years lasting research of various parts of the Palaeocene reef complex of the Western Carpathians and its comparison with Palaeocene reef stripe of the Northern Limestone Alps (NLA) has shown that in area of the today's Western Carpathians existed two Palaeocene reef stripes with completely different palaeogeographic and tectonic emplacement.

The stripe, which lined NLA from the southern inner side has relatively simple structure: by the end of Cretaceous upon the Mesozoic carbonate nappe structures shallows were formed and on them horizons of shallow-water orbitoid sandstones, Campanian-Maastrichtian in age, directly on the surface of sandstones (Kambühel) were deposited, or in the form of blocks in the Early Eocene sediments of the Gosau Group fragments of the Palaeocene reef facies have been preserved. This typical Alpine evolution continued also to the Malé Karpaty Mts. (SW Slovakia), where site Vápenková skala at the village Rozbehy has all the attributes of the southern Alpine Palaeocene stripe: upon the Mesozoic nappe structure there are located layers of orbitoid sandstones and on their surface (and partially replaced into the overlying Miocene conglomerates) are located blocks of bioherm Palaeocene limestones of similar composition than in the NLA. To-date situation at the locality at the NW edge of the Malé Karpaty Mts. (Pezinské Malé Karpaty Mts.) doesn't match the situation of the site in Palaeocene at the post-Palaeogene rotation of the Malé Karpaty Mts. Similarity between Alpine Kambühel locality and the site Vápenková skala is one of the arguments, that at the beginning of the Cainozoic the Malé Karpaty Mts. were still a component of the East-Alpine system. Age range of the southern Alpine stripe is Danian-Early Thanetian (SBZ 1 – SBZ 3 sensu Serra-Kiel et al., 1998).

While the first stripe is the relevant part of the NLA space, the second stripe lines the Western Carpathians from the northern outer side. It is located in the so-called Peri-Klippen Belt space in-between the internal Western Carpathians and the Klippen Belt. Discontinuous intermittent stripe can be observed from the west through Myjavská pahorkatina Upland, the Middle Váh Valley, Orava, Spišská Magura (Pieniny), Slánske vrchy Mts., Ondavská vrchovina Highlands up to Vihorlatské vrchy Mts. on the Slovak-Ukrainian border. Its assumed continuation to Ukraine has not been the subject of presented research. With the exception of Pieniny, where the Palaeocene block Haligovce – Paluby overlies directly the Klippen Belt rocks, the stripe lines the Klippen Belt at its inner side.

Direct proves of the link of the Palaeocene southern reef complex (Alpine) and Northern (Western Carpathians, Peri-Klippen) stripe are lacking to-date and it could be considered with various alternatives.

Originally assumed interconnection of the Vienna Basin fill (cf. Wagreich & Marschalko, 1995) was confirmed by the identification of the Palaeocene reef facies of the Alpine type in the Malé Karpaty Mts. (Vápenková skala). Questionable remains the interconnection among the Palaeocene reef complexes of the Malé Karpaty Mts. and in the Myjavská pahorkatina Upland commencing Peri-Klippen Belt, where it is necessary to consider also the post-Palaeogene rotation of the Malé Karpaty Mts. Improbable is the independence of both stripes, although it is difficult to imagine the northern stripe as a basin with continuous carbonate platform. In complex tectonic conditions originated rather smaller basins with carbonate platforms, which had short time duration. Another option is interconnection of the Northern Western Carpathians stripe with the Waschberg zone, which rims NLA from the North. From this zone blocks of bioherm Palaeocene limestones were described (site Michelstetten; Lobitzer, 1978), microfacies resembling Palaeocene limestones of the northern reef complex of the Western Carpathians, but further proves of the link are not available.

Palaeocene age interval of the reef carbonates of the Western Carpathians is from Later Danian (SBZ 1) till Early Thanetian (SBZ 3), at places even up to the end of the Late Thanetian (SBZ 4), i.e. duration of 2 to 2.5 million years.

It is likely that Late-Laramian movements at the end of Thanetian caused the emergence and termination of the Palaeocene reef complex.

Thorough research into more than 3,600 thin sections of the Palaeocene bioherm limestones of the Western Carpathians has allowed distinguishing reef complex in the back-reef lagoonal shallow-water area, reef core and gradually deepening fore-reef slope area with characteristic microfacies types. Due to a large variety of mainly back-reef shallow-water microfacies the authors faced a difficult role to narrow their number in order to characterise essential types: 14 microfacies types of back-reef environment, 2 microfacies of reef core and 4 fore-reef slope microfacies types, each with designated time range.

Although some of the reef structures attain imposing dimensions (e.g. "Large Reef" above Hričovské Podhradie), they aren't true reef structures, but the relics of fore-reef and back-reef sediments. True reef structures made of corals and coralline algae achieve small dimensions of "patch-reefs" and shortly after their origination the currents, waves and bioerosion had broken them and they had become a component of algal-coral debris.

It is notable, that the substrate of the Palaeocene reef complex in both stripes with some small exceptions (e.g. Veľký Lipník in Pieniny) provided sandstones and sandy limestones of the Latest Cretaceous of the orbitoid shallow-water facies. Provided the Latest Cretaceous sediments were in different facies (e.g. rudists limestones in the Middle Váh Valley), these do not show any link with Palaeocene shallow-water facies.

Although in the past attempts were made mainly in the Myjavská pahorkatina Upland and in the Middle Váh Valley to find smooth transitions from Cretaceous to Palaeocene, they didn't succeed in the shallow-water environments (Hansen et al., 1990). According to today's criteria palaeontologic proves from shallow-water sediments are not sufficient and proves of iridium anomaly and/or carbon isotopes excursions and oxygen are required. More likely option is the hiatus in the top part of Maastrichtian up to Middle to Late Danian. Similar hiatus begins also in Late Thanetian and it continues up to Early Eocene. The exception are the Malé Karpaty Mts., where in Early Eocene (Gross & Köhler, 1989; Buček in Polák et al., 2011, 2012) a new transgression occurred with deposition of limestones, at places of reef character, and maybe also the area of Eastern Slovakia. The largest boom in carbonate platforms (probably also due to climatic changes – warming) ruled by the end of Selandian and in Early Thanetian.

For reef limestones environment large variety of their organic composition is characteristic feature. In literature aggregated data on the organic world are rare (e.g. Tragelehn, 1996), the authors have usually chosen a specific organic group to which they paid special attention. The authors of this monograph wanted to avoid this bias and therefore they sought to draw attention to the all important compounds of fauna and flora of the Palaeocene reef environment. It was not in their capacity to submit a comprehensive list of taxons of fauna and flora, they rather have tried to draw attention to the most important compounds as well as to their – still underestimated – biostratigraphic importance (e.g. in foraminifers genera *Globoflarina* (Fleury), *Pseudocuvillierina* Sirel, in algal genera *Distichoplax* Pia, *Broeckella belgica* Morellet et Morellet and *Sarosiella* Segonzac). They also wanted to draw attention on some organisms, which have been unknown up to now from the northern Tethys (e.g. foraminifers genera *Haymanella* Sirel, *Orduella* Sirel and *Sistanites* Rahaghi).

At comparison of the Western Carpathians with other areas of Tethys significant similarity among facies and platform termination with the Italian Maiella area is obvious (Moussavian & Vecsei, 1995 Vecsei & Moussavian, 1997), with the facies of Pyrenees (Baceta et al., 2005), with Slovenia (Drobne et al., 1988; Zamagni, 2009) and with Turkey (Sirel, 1998, 2009, 2015).

The most typical Palaeocene reef complex of the Western Carpathians is developed in the Middle Váh Valley in the village of Hričovské Podhradie and in its close vicinity. Accessibility, variability of facies and diverse range of biorelics attract anyone who deals with the Palaeocene reef facies.

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Explanations to photoplates I-XXXVI

Plate I

Microfacies of orbitoid beds of Campanian-Maastrichtian age underlying Palaeocene reef complex

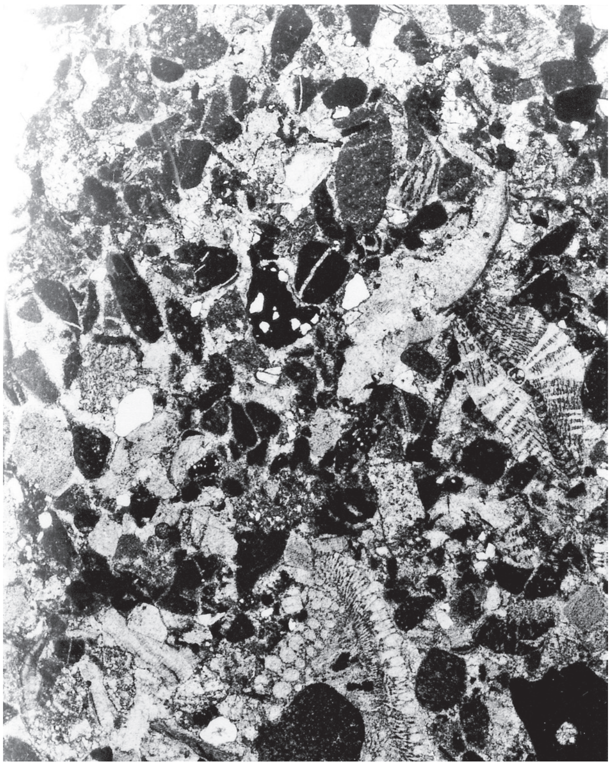
Fig. 1. Polymict coarse-grained sandstone with tests of *Orbitoides tissoti* Schlumberger (to the right). Malé Karpaty Mts., Vápenková skala, thin section 1940/06 Bu, Campanian, magnif. 10x.

Fig. 2. Grainstone with tests of *Pseudosiderolites vidali* (Douvillé) (in the centre). Myjavská pahorkatina Upland, Dlhý vŕšok (= Široké bradlo), thin section 2259/08 Bu, Campanian, magnif. 10x.

Fig. 3. Polymict sandstone with tests of *Orbitoides media* d´Archiac. Middle Váh Valley, Kunovec, SW of el. p. 380, thin section 2 Ko, Campanian, magnif. 10x.

Fig. 4. Polymict sandstone with tests of *Orbitoides gensacicus praevius* Köhler (below). Myjavská pahorkatina Upland, Stará Turá – viaduct, thin section 32 Ko, Maastrichtian, magnif. 10x.

I



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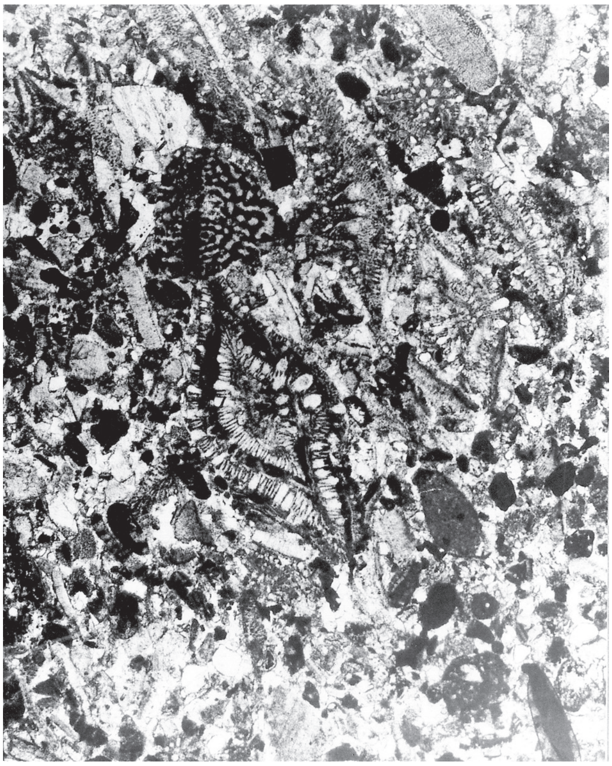

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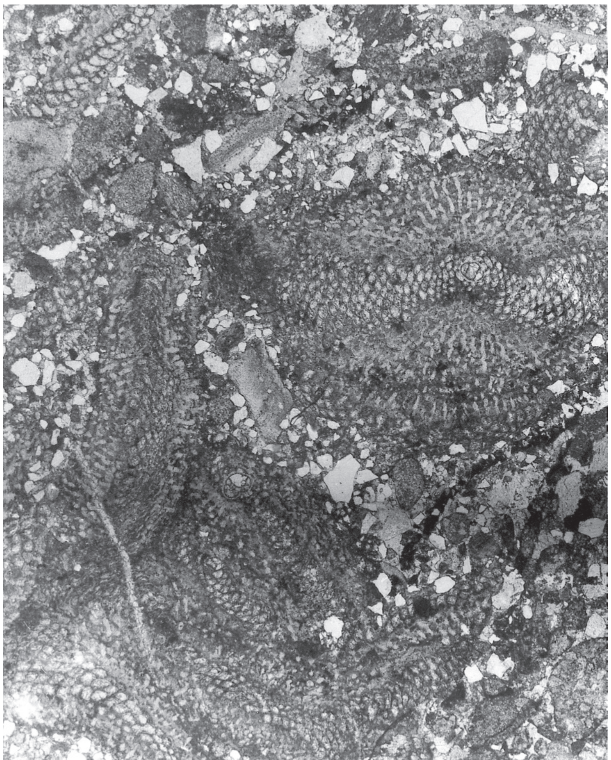

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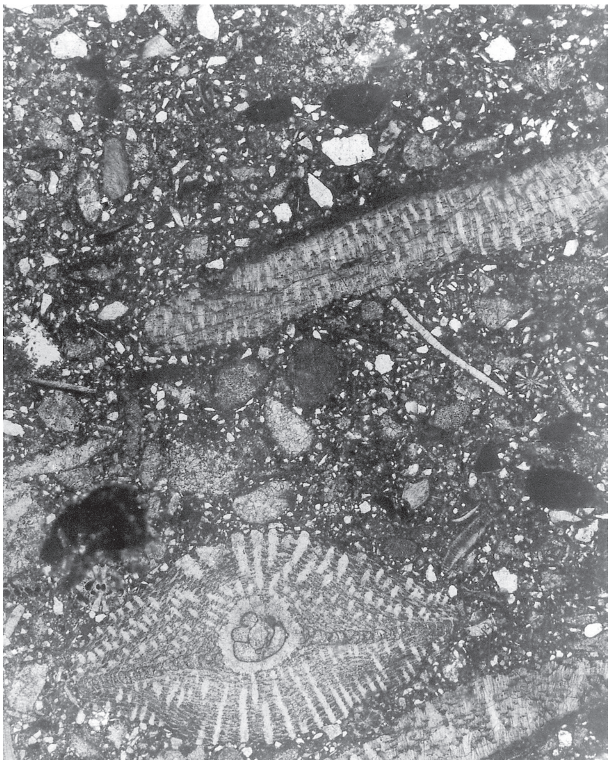

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Plate II

Back-reef lagoonal microfacies of the Palaeocene reef complex of the Western Carpathians

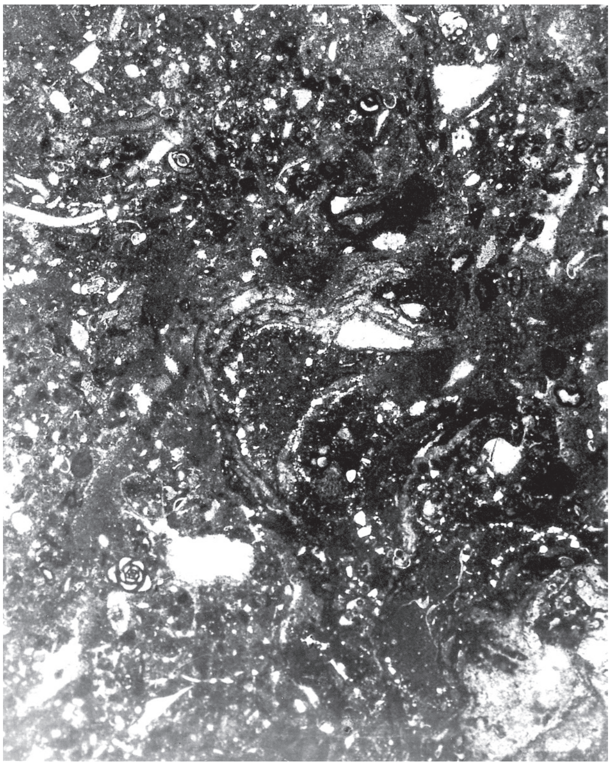
Fig. 1. *Elianella* rudstone with *Bangiana hanseni* Drobne, Ogorelec et Ricamboni. Malé Karpaty Mts., Vápenková skala, block 10, thin section 6 Ko, Danian (SBZ 1), magnif. 10x.

Fig. 2. Corallinacean-coral rudstone to framestone. Middle Váh Valley, Hričovské Podhradie – wall, thin section 9 Ko, Early Thanetian (SBZ 3), magnif. 10x.

Fig. 3. Dasycladacean packstone with sections of *Broeckella belgica* Morellet et Morellet. Malé Karpaty Mts., Vápenková skala, thin section 1949/06 Bu, Selandian (SBZ 2), magnif. 10x.

Fig. 4. Packstone with sections of *Sarosiella feremollis* Segonzac. Malé Karpaty Mts., Vápenková skala, thin section 1269/89 Bu, Selandian (SBZ 2), magnif. 10x.

II



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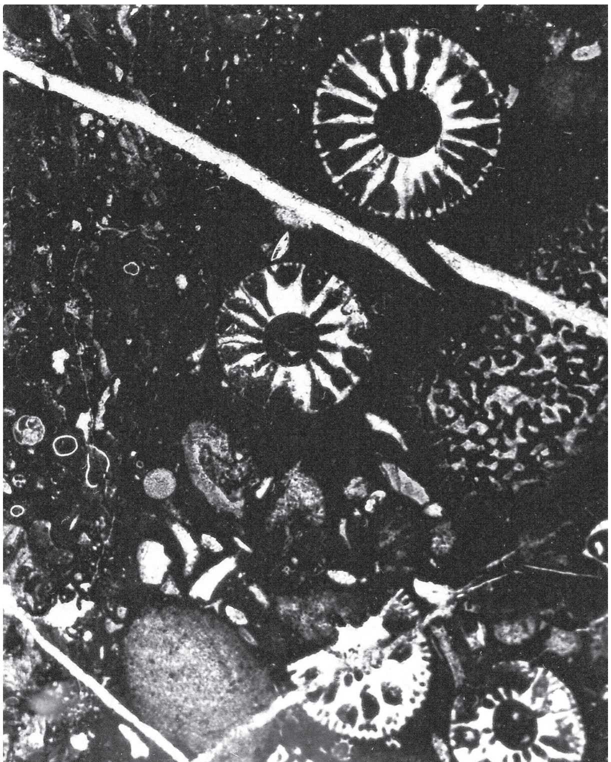

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Plate III

Back-reef lagoonal microfacies of the Palaeocene reef complex of the Western Carpathians

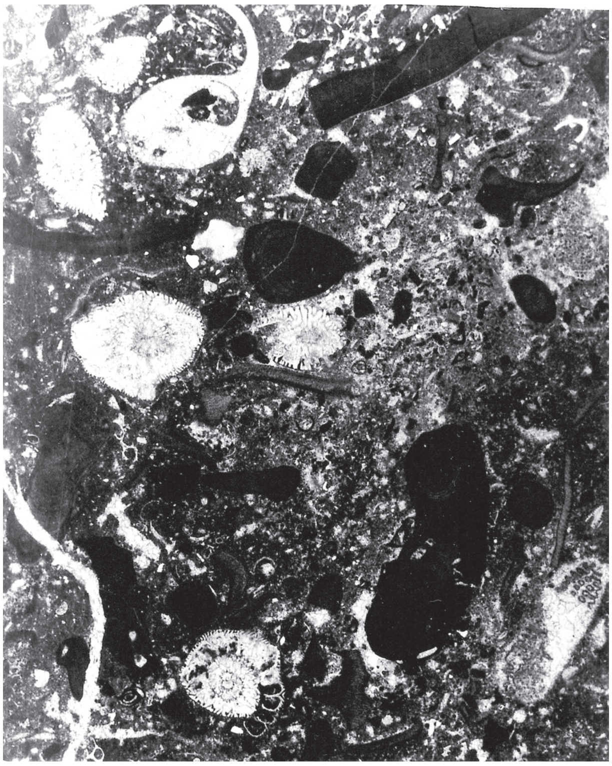
Fig. 1. Packstone with sections of *Pseudocuvillierina sireli* (Inan). Middle Váh Valley, Ovčiarsko – reef 1, thin section 14 Ko, Selandian (SBZ 2), magnif. 10x.

Fig. 2. Packstone with *Miscellanites primitivus* (Rahaghi) and *Pseudocuvillierina sireli* (Inan). Myjavská pahorkatina Upland, Priepasné, thin section 1437/89 Bu, Selandian (SBZ 2), magnif. 10x.

Fig. 3. Wackestone with *Globoflarina sphaeroides* (Fleury). Myjavská pahorkatina Upland, Hodulov vrch, block 7, thin section 1 Ko, Selandian (SBZ 2), magnif. 10x.

Fig. 4. Corallinacean packstone with sections of dasycladacean algae (*Neomeris* sp.). Myjavská pahorkatina Upland, Jeruzalem, thin section 1367/89 Bu, Selandian-Early Thanetian (SBZ 2 – 3), magnif. 10x.

III



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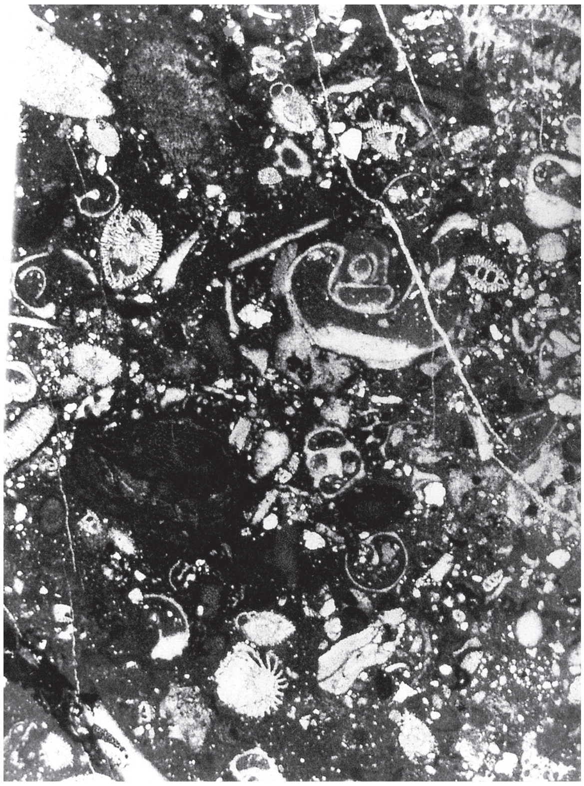

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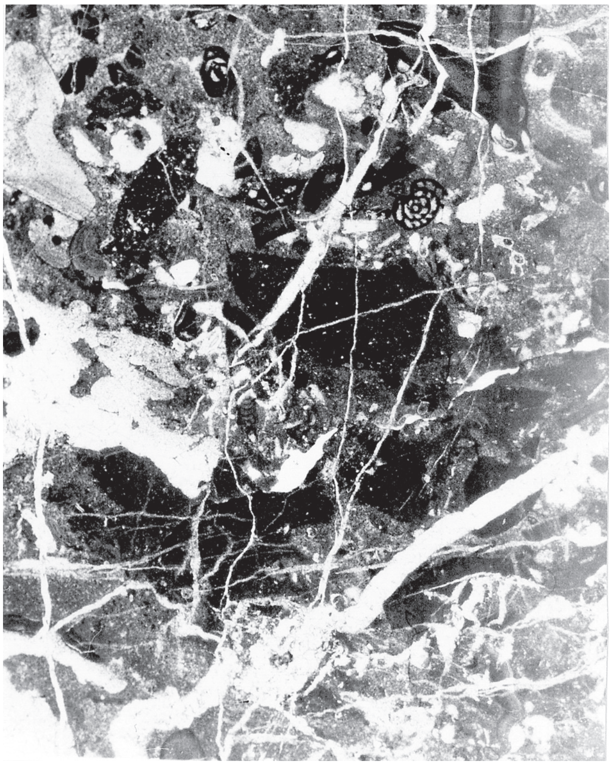

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Plate IV

Back-reef lagoonal microfacies of the Palaeocene reef complex of the Western Carpathians

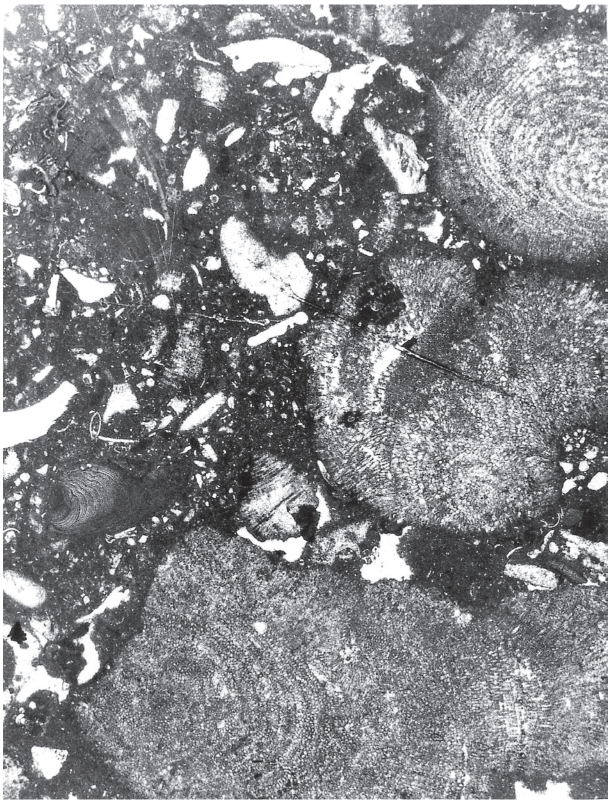
Fig. 1. *Elianella* packstone to rudstone with numerous sections of *Elianella elegans* Pfender et Basse. Slánske vrchy Mts., Radvanovce, block 1, thin section 10 Ko, Early – ?Late Thanetian (SBZ 3 – ?SBZ 4), magnif. 10x.

Fig. 2. Corallinacean-*Miniacina* packstone to bindstone with section of *Miniacina multicamerata* (Scheibner). Pieniny, Haligovce – Paluby, thin section 1834/90 Bu, Early Thanetian (SBZ 3), magnif. 10x.

Fig. 3. Rudstone with large nodule of *Parachaetetes asvapatii* Pia. Myjavská pahorkatina Upland, Matejovec, thin section 1242/89 Bu, Selandian (SBZ 2), magnif. 10x.

Fig. 4. Corallinacean-dasycladacean packstone with *Glomalveolina primaeva* (Reichel). Middle Váh Valley, Hričovské Podhradie – quarry, thin section 4 Ko, Early Thanetian (SBZ 3), magnif. 10x.

IV



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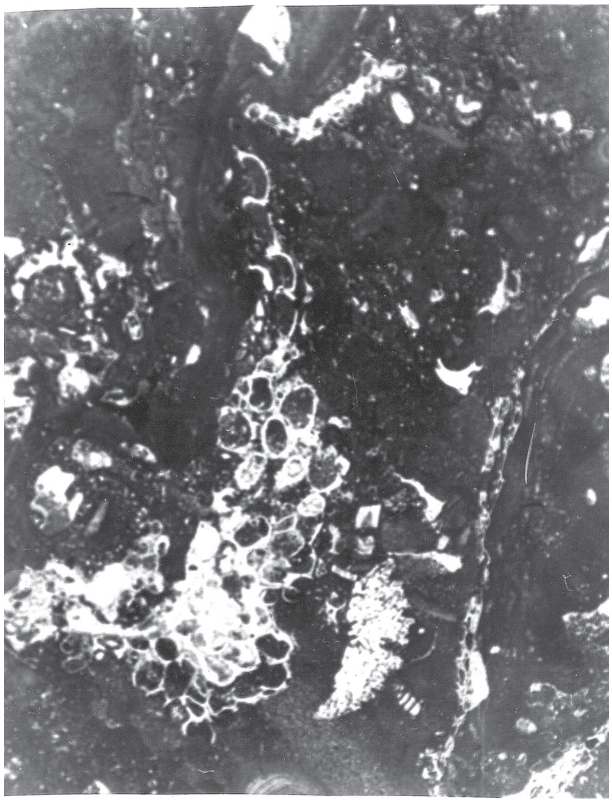

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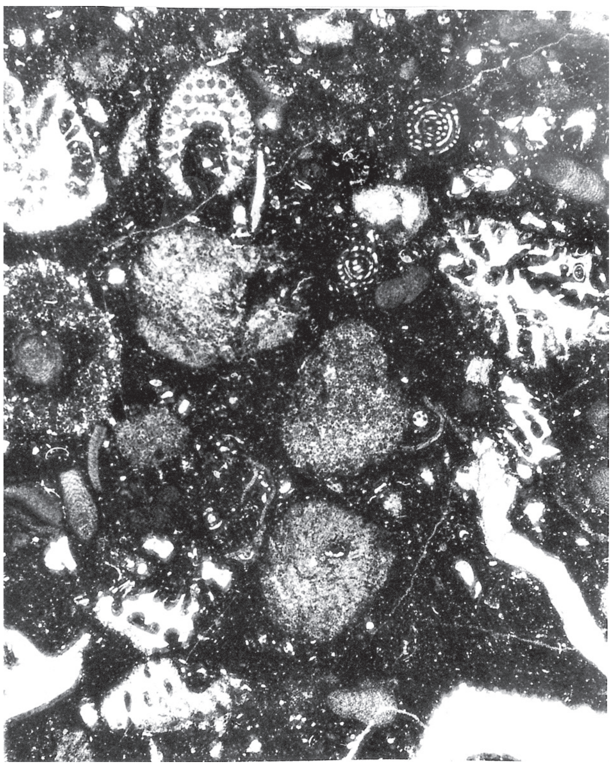

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Plate V

Back-reef lagoonal microfacies of the Palaeocene reef complex of the Western Carpathians

Fig. 1. *Miscellanea* grainstone to rudstone with sections of *Miscellanea juliettae* Leppig. Middle Váh Valley, Hričovské Podhradie – Ostrý vrch, thin section 1613/90 Bu, Early Thanetian (SBZ 3), magnif. 10x.

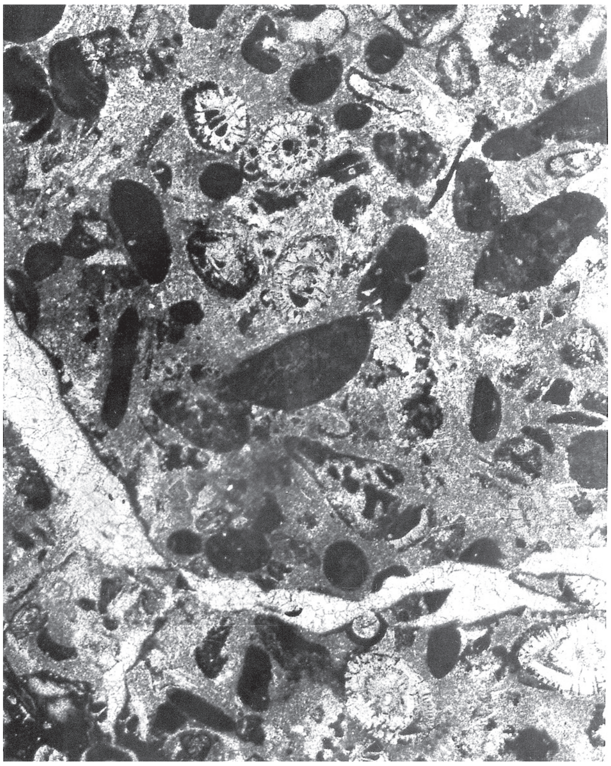
Microfacies of reef structures of the Palaeocene reef complex of the Western Carpathians

Fig. 2. Wackestone with sections of coral *Astrocoenia* sp. Myjavská pahorkatina Upland, Matejovec – field, thin section 1398/89 Bu, Selandian (SBZ 2), magnif. 10x.

Fig. 3. Coral boundstone with sections of coralites *Actinacis* sp. Orava, Brezovica – water reservoir, thin section 798/91 Bu, Early Thanetian (SBZ 3), magnif. 10x.

Fig. 4. Coral bindstone with sections of coralites *Actinacis* sp. Middle Váh Valley, Hričovské Podhradie – quarry, thin section 2435/97 Bu, Early Thanetian (SBZ 3), magnif. 10x.

V



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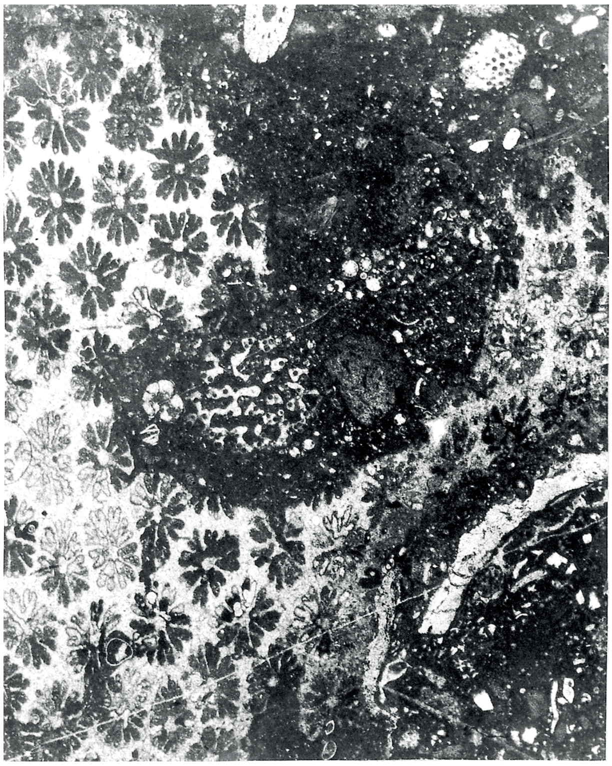

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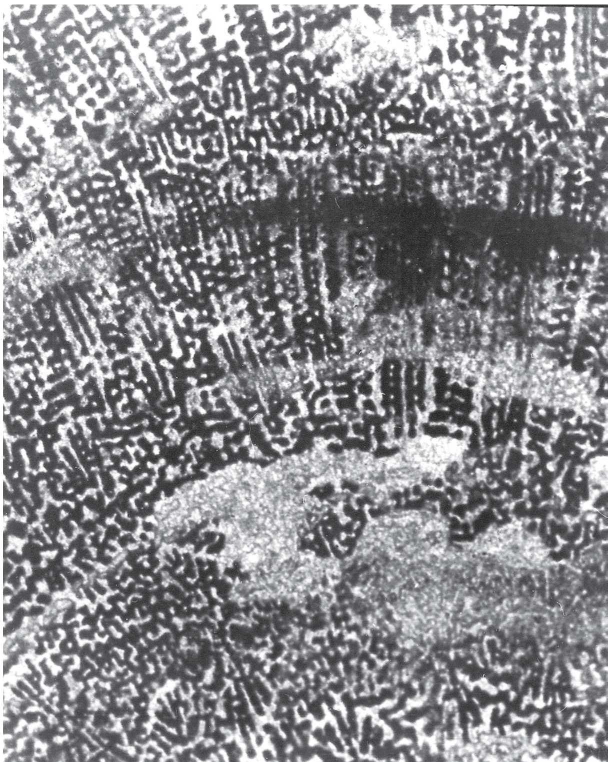

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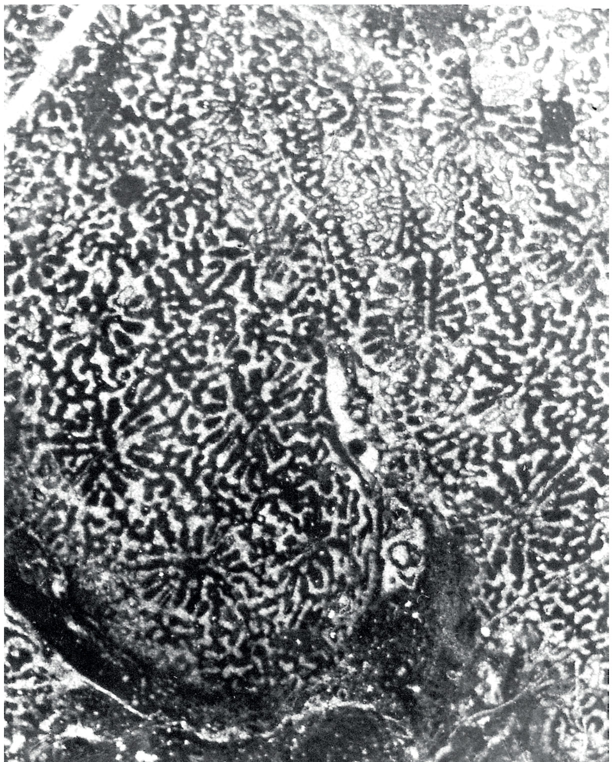

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Plate VI

Microfacies of fore-reef slope sediments of the Palaeocene reef complex of the Western Carpathians

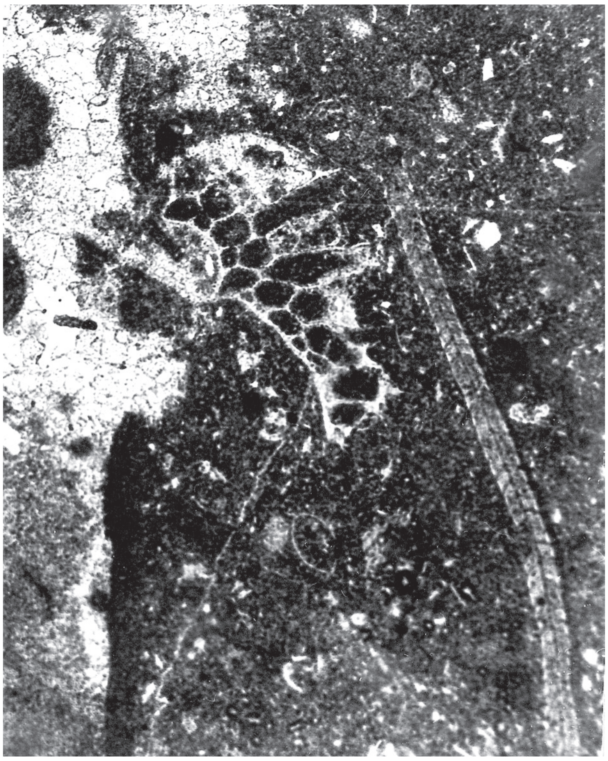
Fig. 1. Packstone with section of cyclostomate bryozoan and alga *Distichoplax biserialis* (Dietrich) Pia. Middle Váh Valley, Rybárikov laz – field, thin section 2021/92 Bu, Early Thanetian (SBZ 3), magnif. 10x.

Fig. 2. Grainstone with redeposited large foraminifers with section of *Orbitoides apiculata* Schlumberger (to the right below). Orava, Brezovica – water reservoir, thin section 2212/08 Bu, Selandian-Early Thanetian (SBZ 2 – SBZ 3), magnif. 10x.

Fig. 3. Packstone to floatstone with section of *Orbitoclypeus ramaraoi* (Samanta). Middle Váh Valley, Rybárikov laz – field, thin section 2023/92 Bu, Early Thanetian (SBZ 3), magnif. 10x.

Fig. 4. Packstone to grainstone with sections of *Discocyclina seunesi* Douvillé and *Orbitoclypeus ramaraoi* (Samanta). Myjavská pahorkatina Upland, Juríkovci, thin section 2209/08 Bu, Early Thanetian (SBZ 3), magnif. 10x.

VI



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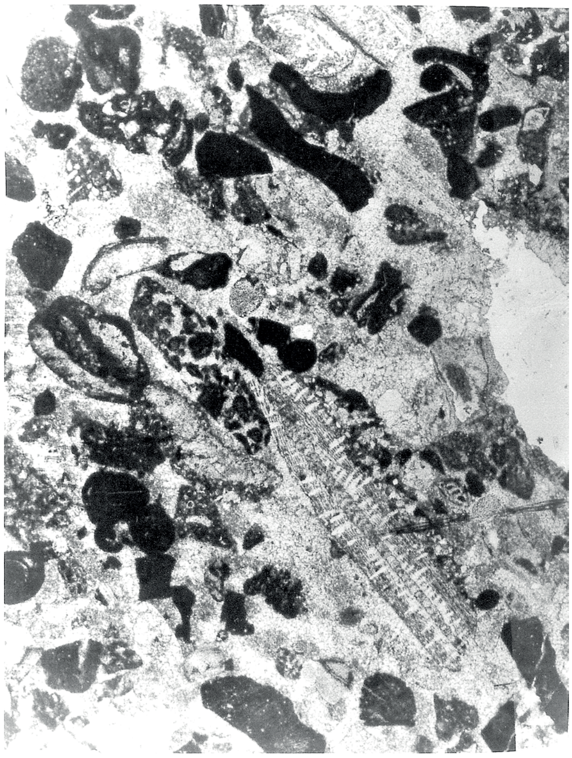

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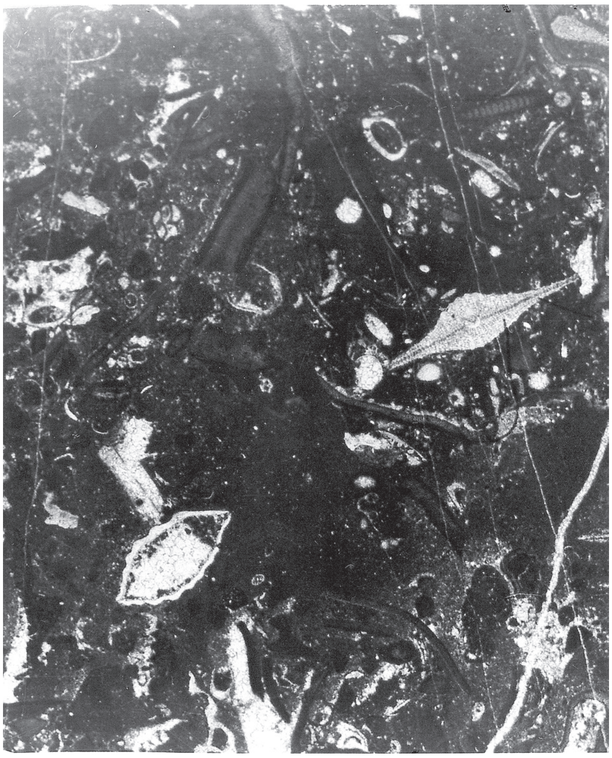

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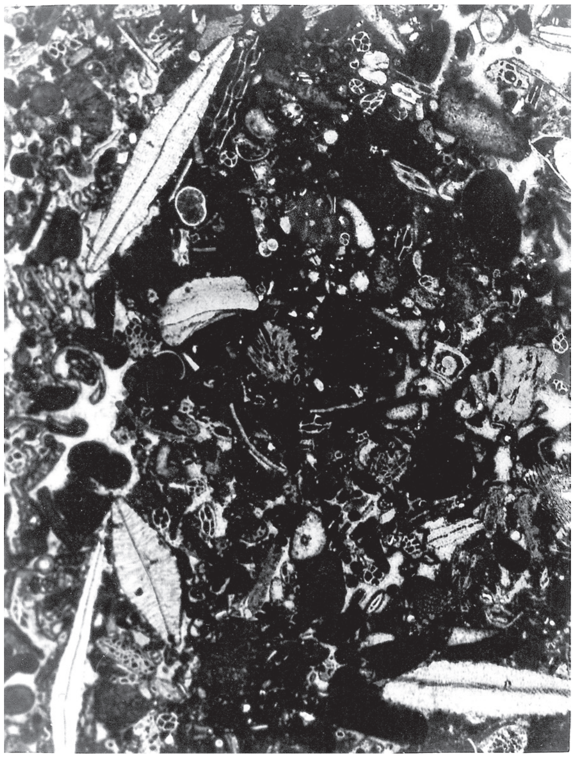

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Plate VII

Microfacies of the Palaeocene reef complex of the Western Carpathians (negative prints of thin sections)

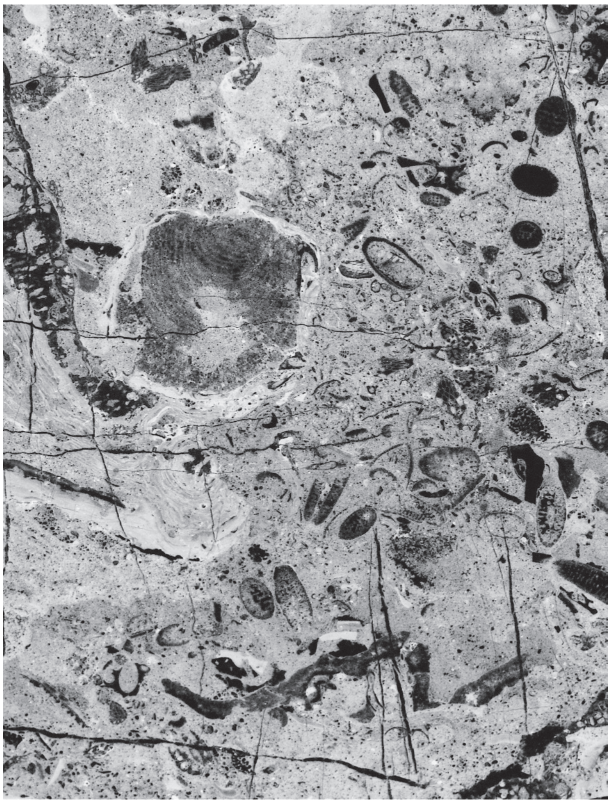
Fig. 1. Packstone with *Sarosiella feremollis* Segonzac. Malé Karpaty Mts., Vápenková skala, thin section 1225/89 Bu, back-reef lagoonal environment, Selandian (SBZ 2), magnif. 5x.

Fig. 2. *Elianella* rudstone with section of nodule *Elianella elegans* Pfender et Basse. Myjavská pahorkatina Upland, Priepasné-Batíková, thin section 1445/90 Bu, back-reef lagoonal environment, Early Thanetian (SBZ 3), magnif. 5x.

Fig. 3. *Parachaetetes* rudstone to framestone with section of nodule *Parachaetetes asvapatii* Pia. Myjavská pahorkatina Upland, Matejovec, thin section 1242/89 Bu, back-reef lagoonal environment, Selandian (SBZ 2), magnif. 5x.

Fig. 4. *Elianella* rudstone with dominant nodule of *Elianella elegans* Pfender et Basse, fragments of dasycladacean algae (*Zittelina* sp., *Cymopolia* sp.) and corals (*Rhizangia* sp.). Myjavská pahorkatina Upland, Matejovec, thin section 1258/89 Bu, back-reef lagoonal environment, Selandian-Early Thanetian (SBZ 2 – SBZ 3), magnif. 5x.

VII



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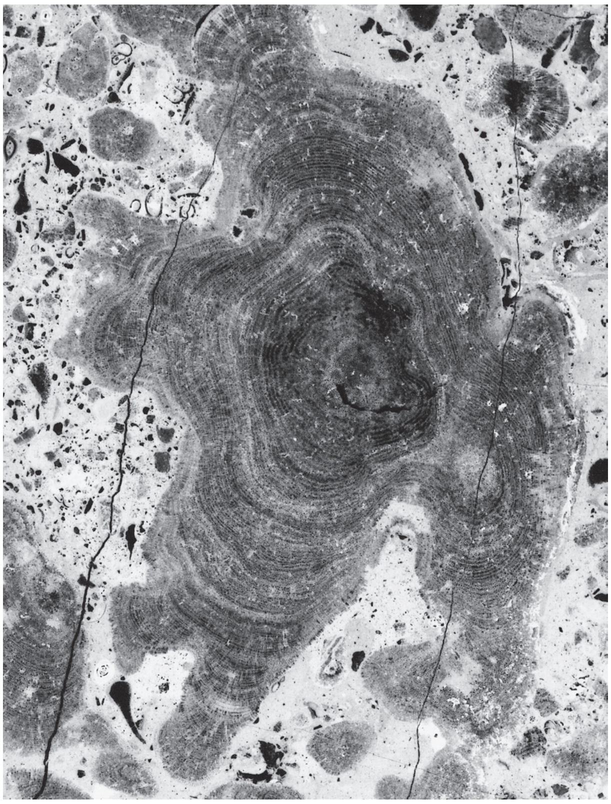

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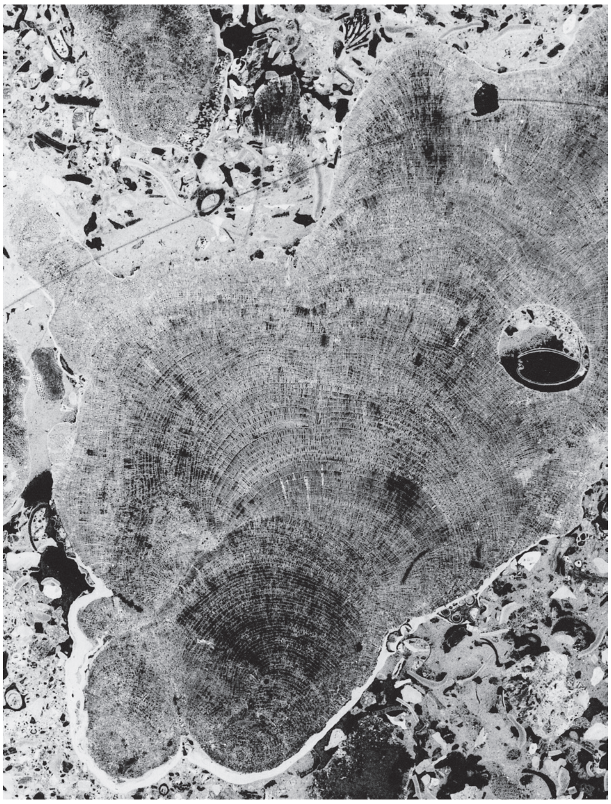

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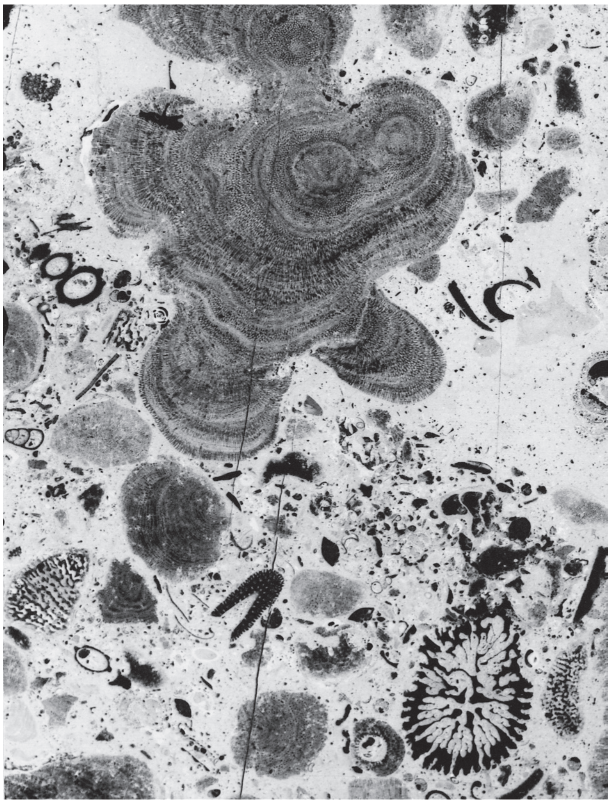

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Plate VIII

Microfacies of the Palaeocene reef complex of the Western Carpathians (negative prints of thin sections)

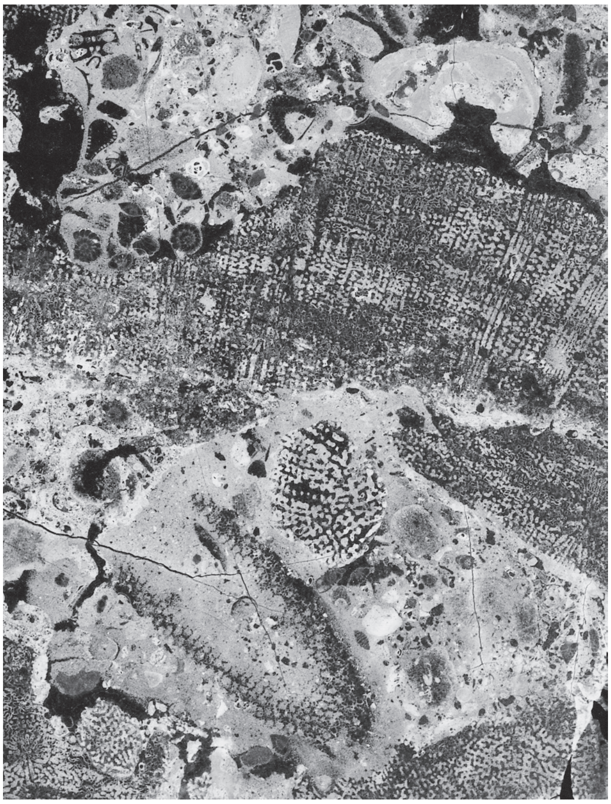
Fig. 1. Coral rudstone with dominance of *Actinacis* sp., rarer are fragments of coralline and dasycladacean algae. Myjavská pahorkatina Upland, Matejovec, thin section 270/84 Bu, rim of reef structure, Selandian-Early Thanetian (SBZ 2 – SBZ 3), magnif. 5x.

Fig. 2. *Elianella*-dasycladacean rudstone with sections of *Elianella elegans* PFENDER et BASSE, dasycladacean algae (*Uteria* sp.), gastropod and coral *Actinacis* sp. Myjavská pahorkatina Upland, Matejovec, thin section 1429/89 Bu, back-reef lagoonal environment, Selandian-Early Thanetian (SBZ 2 – SBZ 3), magnif. 5x.

Fig. 3. Coral framestone with dominance of *Dendrophyllia* sp., sporadic fragments of coralline algae. Myjavská pahorkatina Upland, Juríkovci, thin section 1680/89 Bu, back-reef lagoonal environment, Selandian-Early Thanetian (SBZ 2 – SBZ 3), magnif. 5x.

Fig. 4. Corallinacean bafflestone with variegated composition of organic relics – coralline algae, dasycladacean algae and corals. Myjavská pahorkatina Upland, Tížikovci, thin section 1491/90 Bu, back-reef lagoonal environment, Selandian-Early Thanetian (SBZ 2 – SBZ 3), magnif. 5x.

VIII



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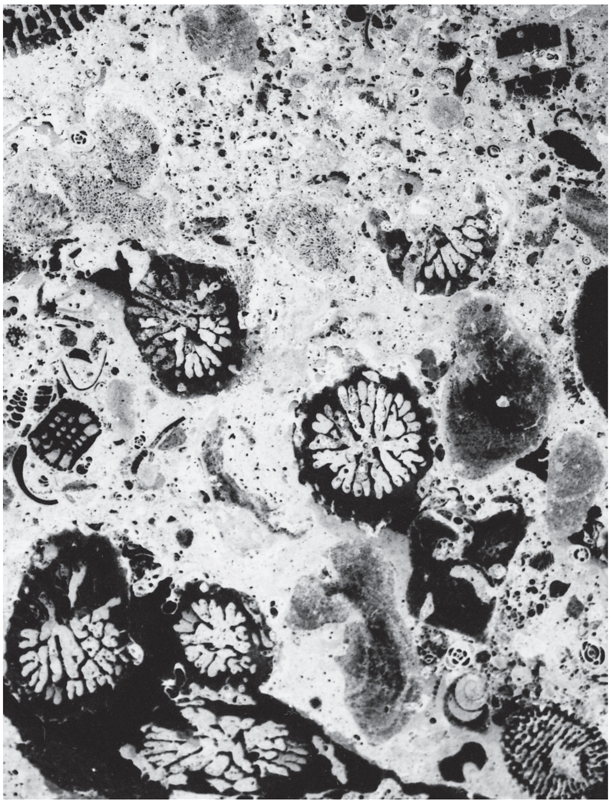

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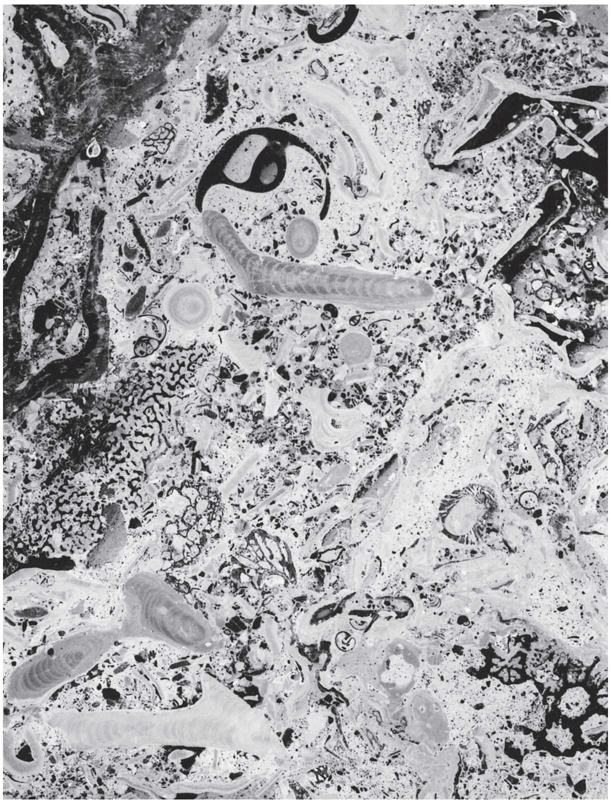

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Plate IX

Microfacies of the Palaeocene reef complex of the Western Carpathians (negative prints of thin sections)

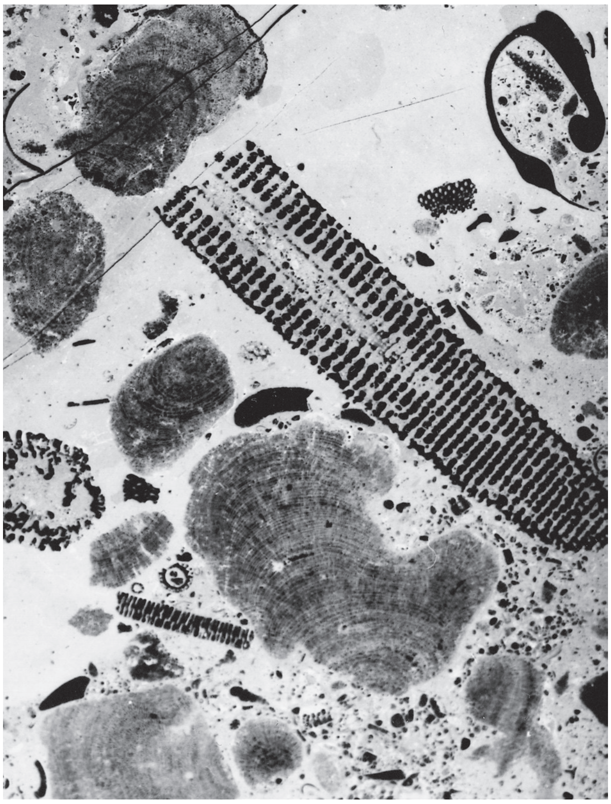
Fig. 1. *Elianella*-dasycladacean packstone with sections of coralline alga *Elianella elegans* Pfender et Basse and dasycladacean alga *Zittelina* sp. Myjavská pahorkatina Upland, Juríkovci, thin section 1679/90 Bu, back-reef lagoonal environment, Selandian-Early Thanetian (SBZ 2 – SBZ 3), magnif. 5x.

Fig. 2. Coral bindstone with section of coral *Actinacis* sp. and dasycladacean alga *Zittelina* sp. Myjavská pahorkatina Upland, Juríkovci, thin section 1464/90 Bu, rim of reef structure, Selandian (SBZ 2), magnif. 5x.

Fig. 3. Grainstone, mostly clasts made of fragments of coralline algae, mainly *Sporolithon* sp. and clasts of micrite carbonates. Myjavská pahorkatina Upland, Stará Turá- reef, thin section 2071/89 Bu, fore-reef slope environment, Early Thanetian (SBZ 3), magnif. 5x.

Fig. 4. Algal bindstone cemented by coralline algae (mainly *Sporolithon* sp.), crusts of vague origin (?cyanobacteria) and sessile foraminifer (*Solenomeris* sp.). Middle Váh Valley, Rybárikov laz, thin section 2016/92 Bu, back-reef environment, Early Thanetian (SBZ 3), magnif. 5x.

IX



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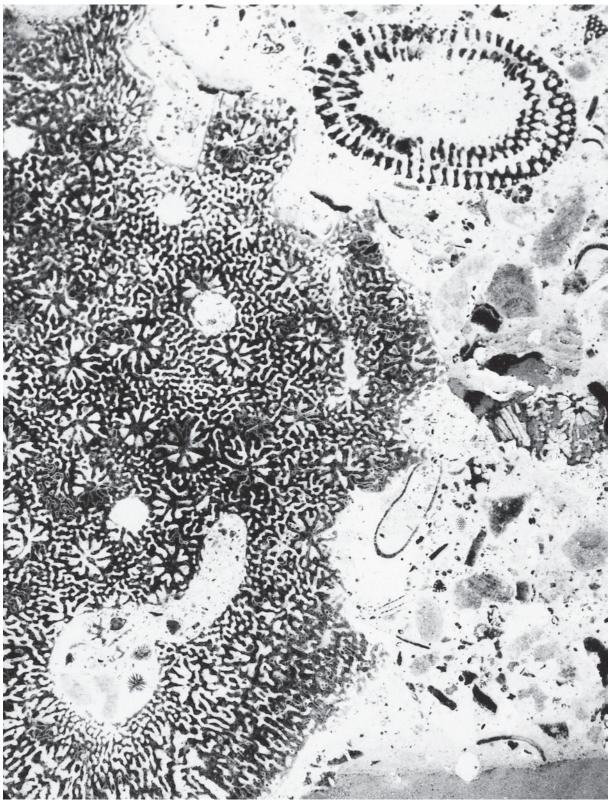

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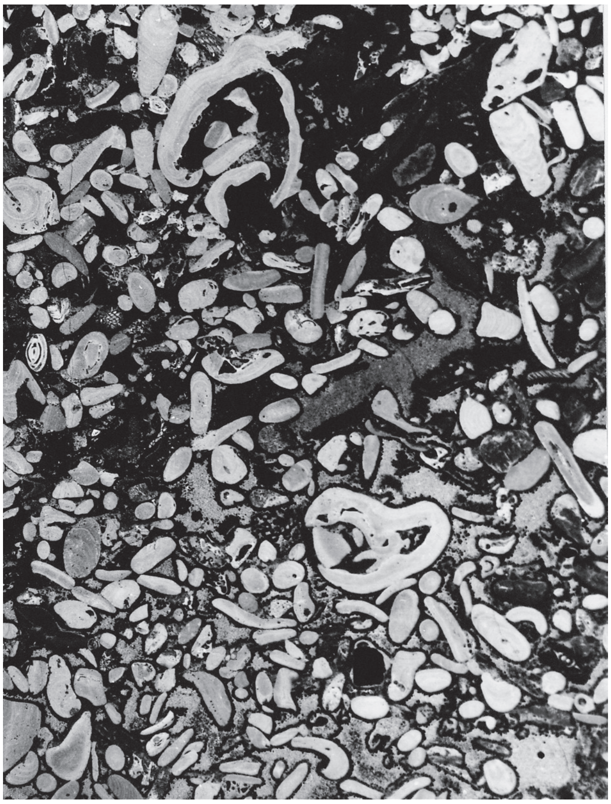

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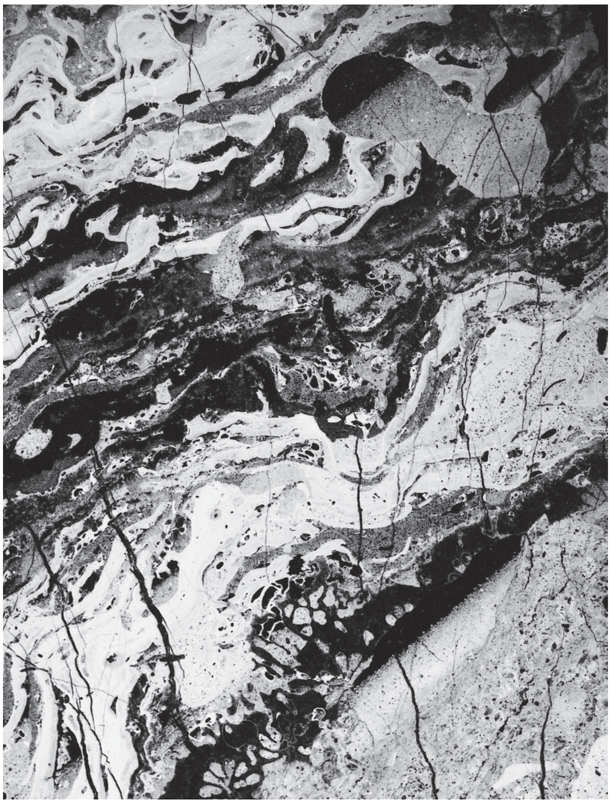

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Plate X

Microfacies of the Palaeocene reef complex of the Western Carpathians (negative prints of thin sections)

Fig. 1. Coral-algal bindstone. Main compound are tufts of *Actinacis* sp. and fragments of coralline algae – *Polystrata alba* (Pfender) Denizot, *Elianella elegans* Pfender et Basse. Middle Váh Valley, Rybárikov laz, thin section 2009/92 Bu, back-reef environment, Early Thanetian (SBZ 3), magnif. 5x.

Fig. 2. Coral framestone. Dominating are sections of corals (*Rhizangia* sp.), dasycladacean algae and miliolid foraminifers. Middle Váh Valley, Kunovec, thin section 1988/91 Bu, back-reef environment, Early Thanetian (SBZ 3), magnif. 5x.

Fig. 3. Coral rudstone to framestone. Section of coral *Orbignygyra* sp., dasycladacean alga *Cymopolia* sp. dominates, Middle Váh Valley, Hričovské Podhradie – quarry, thin section 1800/90 Bu, back-reef lagoonal environment, Early Thanetian (SBZ 3), magnif. 5x.

Fig. 4. Coral rudstone with fragments of coral *Rhizangia* sp. and clasts of micrite carbonates. Middle Váh Valley, Hričovské Podhradie – quarry, thin section 1571/90 Bu, back-reef lagoonal environment, Early Thanetian (SBZ 3), magnif. 5x.

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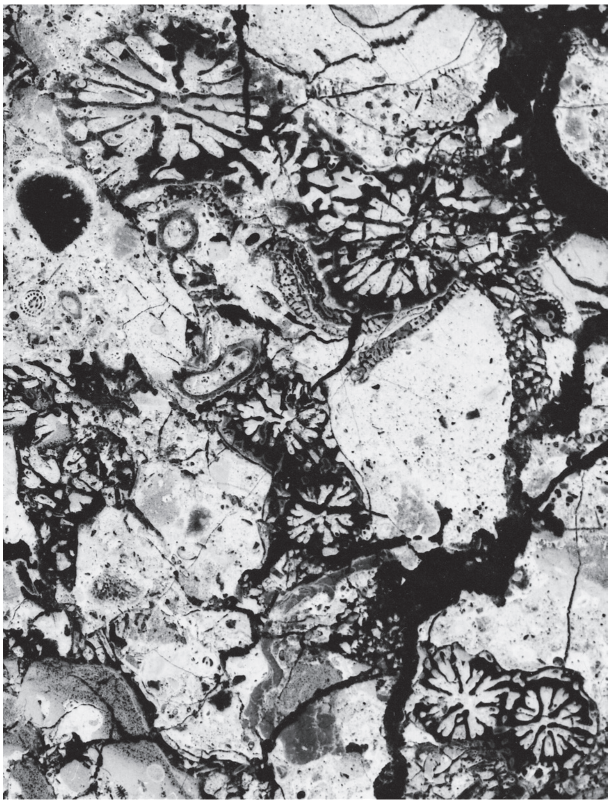

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Plate XI

Microfacies of the Palaeocene reef complex of the Western Carpathians (negative prints of thin sections)

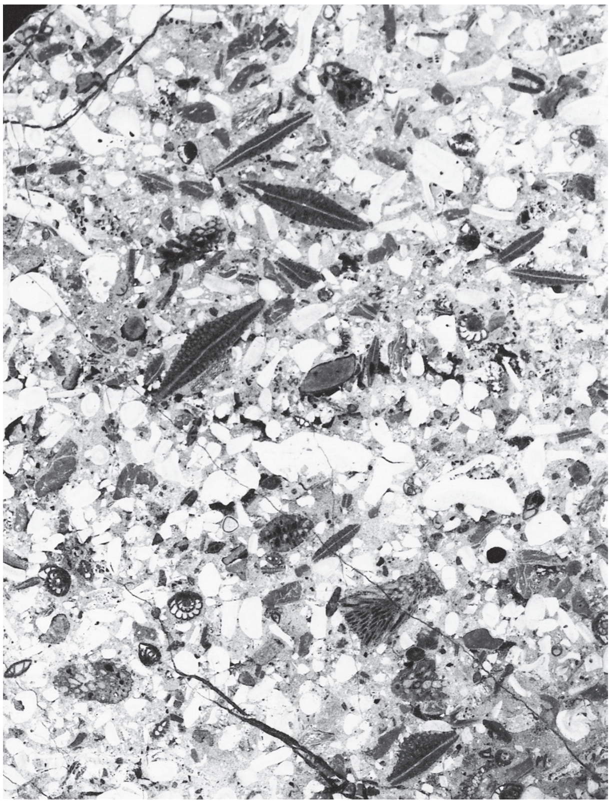
Fig. 1. Packstone with sections of *Discocyclina seunesi* Douvillé, *Miscellanea* sp., bryozoans and fragments of coralline algae. Middle Váh Valley, Hričovské Podhradie – needle, thin section 1755/90 Bu, fore-reef slope environment, Early Thanetian (SBZ 3), magnif. 5x.

Fig. 2. Dasycladacean grainstone with sections of dasycladacean alga *Broeckella belgica* Morellet et Morellet. Orava, Brezovica, thin section 1275/89 Bu, back-reef environment, Selandian-Early Thanetian (SBZ 2- SBZ 3), magnif. 5x.

Fig. 3. Dasycladacean grainstone with sections of *Neomeris* (*L.*) *koradae* Dieni, Massari et Radoičić, coral *Dendrophyllia* sp. and fragments of bivalves. Orava, Brezovica, thin section 1455/90 Bu, back-reef lagoonal environment, Selandian-Early Thanetian (SBZ 2- SBZ 3), magnif. 5x.

Fig. 4. Coral-algal bindstone with dominance of coral (*Actinacis* sp.) and coralline alga (*Sporolithon* sp.). Pieniny, Veľký Lipník, thin section 1871/91 Bu, back-reef environment, Early Thanetian (SBZ 3), magnif. 5x.

XI



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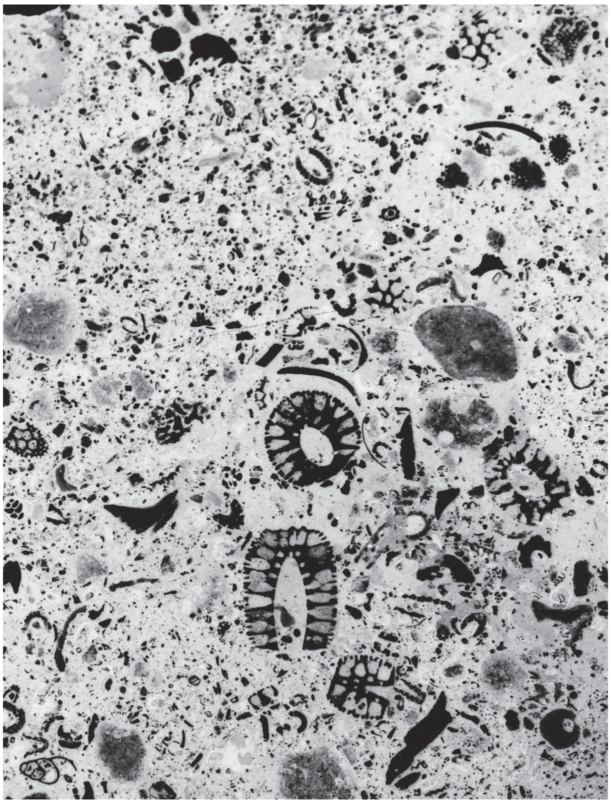

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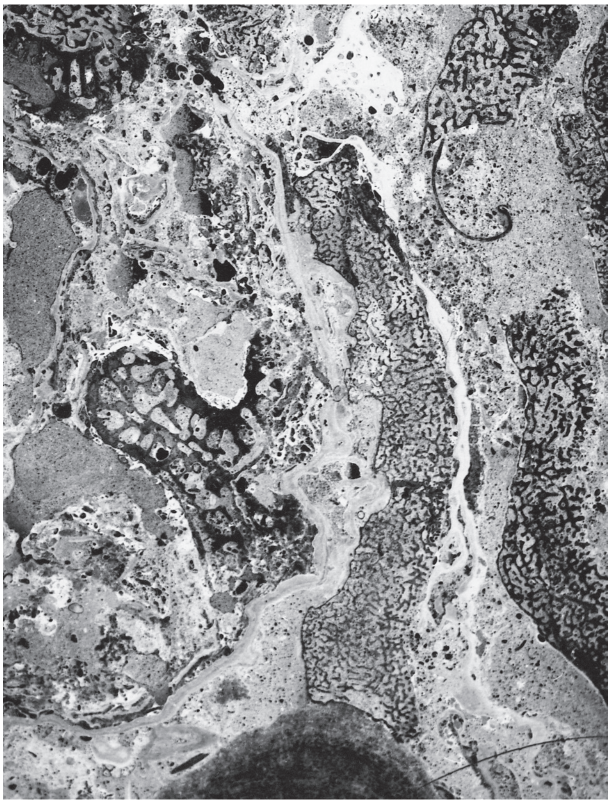

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Plate XII

Red algae in the Palaeocene reef complex of the Western Carpathians

Fig. 1. *Elianella elegans* Pfender et Basse, section of the whole nodule. Orava, Zábiedovo, block 11, thin section 1 Ko, back-reef environment, Selandian-Early Thanetian (SBZ 2 – SBZ 3), magnif. 10x.

Fig. 2. *Elianella elegans* Pfender et Basse, sections of nodules. Myjavská pahorkatina Upland, Kravárikovci, block 1, thin section 4 Ko, back-reef environment, Selandian (SBZ 2), magnif. 10x.

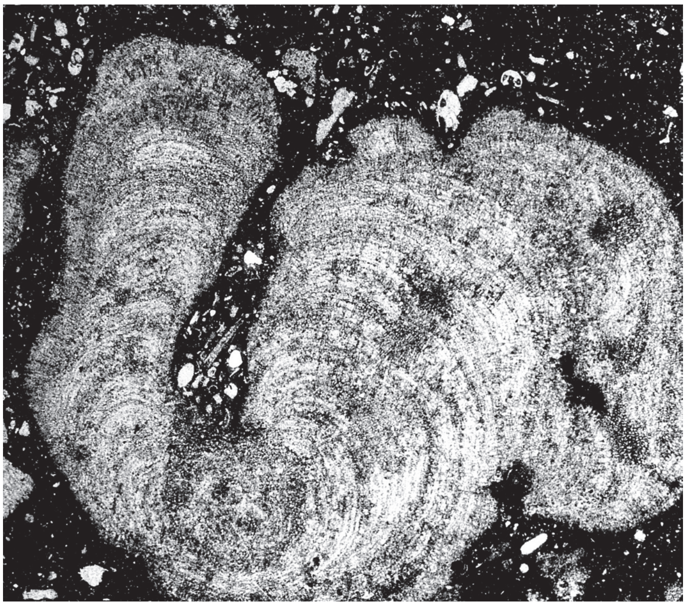
Fig. 3. *Elianella elegans* Pfender et Basse, section through tube-like filaments with irregularly arranged domed cross-partitions. Myjavská pahorkatina Upland, Jandova dolina, block 1, thin section 6 Ko, lagoonal environment, Selandian (SBZ 2), magnif. 50x.

Fig. 4. *Parachaetetes asvapatii* Pia, section through tube-like filaments with regularly arranged rows of cells. Slánske vrchy Mts., Radvanovce, block 2, thin section 6 Ko, back-reef environment, Selandian-Early Thanetian (SBZ 2 – SBZ 3), magnif. 50x.

Fig. 5. *Peyssonnelia* cf. *antiqua* Johnson, section through thalli. Myjavská pahorkatina Upland, Dlhý vŕšok, block 8, thin section 4 Ko, fore-reef environment, Early Thanetian (SBZ 3), magnif. 80x.

Fig. 6. *Peyssonnelia* cf. *antiqua* Johnson, section through thalli. Pieniny, Haligovce – Paluby, sample 1, thin section 1 Ko, reef structure, Early Thanetian (SBZ 3), magnif. 80x.

XII



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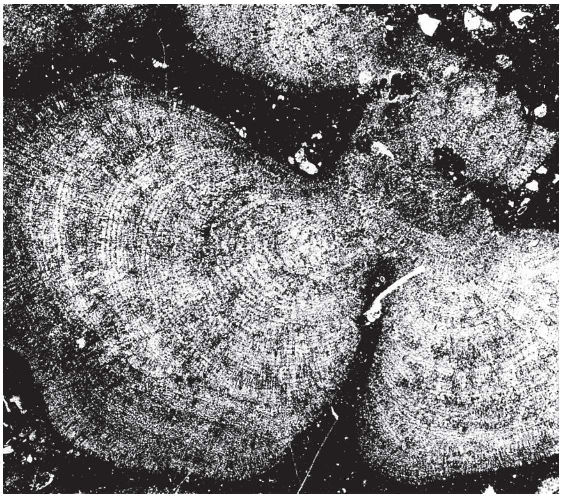

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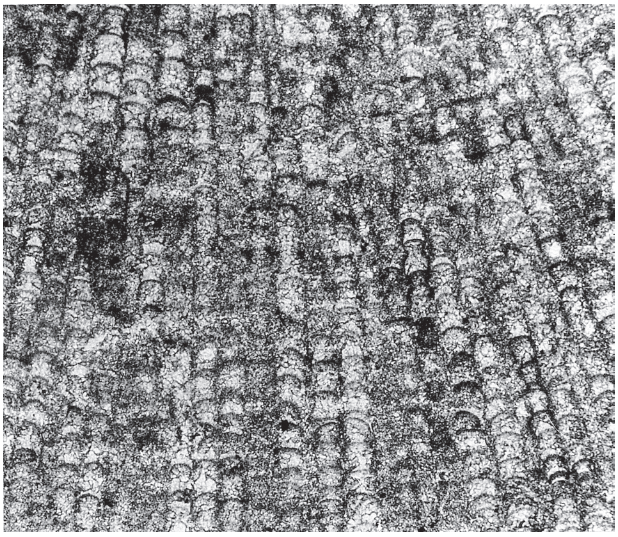

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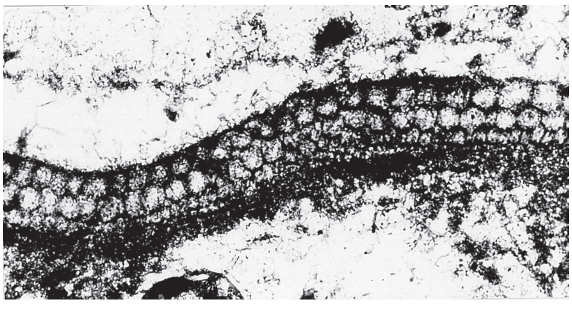

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Plate XIII

Red algae in the Palaeocene reef complex of the Western Carpathians

Fig. 1. *Polystrata alba* (Pfender) Denizot, longitudinal cross-section through thalli. Myjavská pahorkatina Upland, Jandova dolina, block 1, thin section 4 Ko, lagoonal environment, Selandian (SBZ 2), magnif. 80x.

Fig. 2. *Polystrata alba* (Pfender) Denizot, longitudinal cross-section through thalli with cavities in the central part. Myjavská pahorkatina Upland, Tížikovci – Podkorytárka, block 3, thin section 6 Ko, fore-reef environment, Early Thanetian (SBZ 3), magnif. 80x.

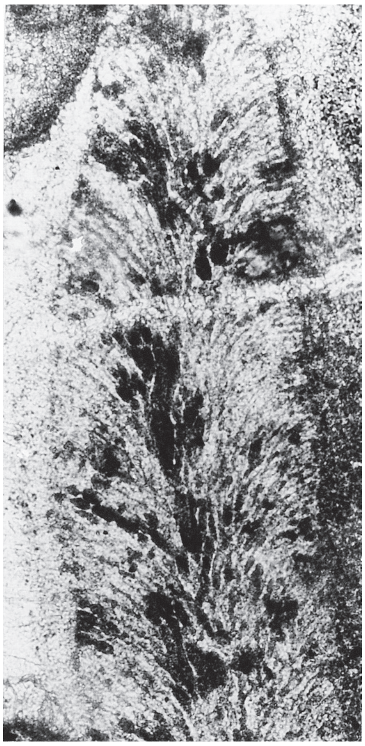
Fig. 3. *Polystrata alba* (Pfender) Denizot, crust form. Middle Váh Valley, Hričovské Podhradie, block 8, thin section 1 Ko, back-reef environment, Early Thanetian (SBZ 3), magnif. 80x.

Fig. 4. *Polystrata alba* (Pfender) Denizot, cross-section of crusts with several layers. Myjavská pahorkatina Upland, Jandova dolina, block 4, thin section 5 Ko, fore-reef environment, Early Thanetian (SBZ 3), magnif. 80x.

Fig. 5. *Polystrata alba* (Pfender) Denizot, complex crust in oblique cross-section. Orava, Zábiedovo, block 9, thin section 1 Ko, lagoonal environment, Selandian-Early Thanetian (SBZ 2 – SBZ 3), magnif. 80x.

Fig. 6. *Polystrata alba* (Pfender) Denizot, part of complex crust. Middle Váh Valley, Hričovské Podhradie, block 5, thin section 5 Ko, fore-reef environment, Early Thanetian (SBZ 3), magnif. 80x.

XIII



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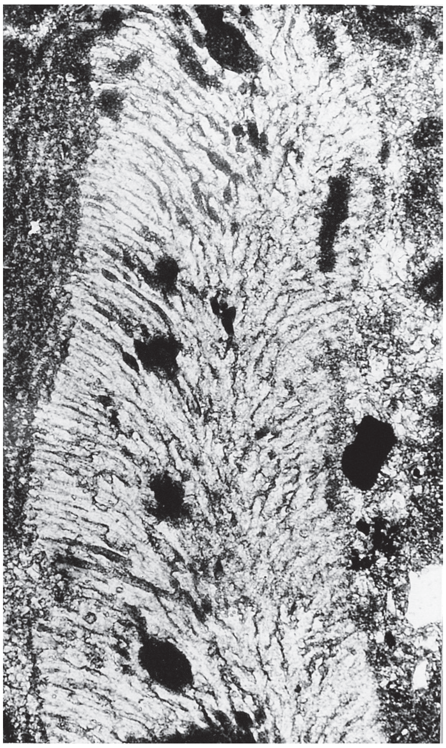

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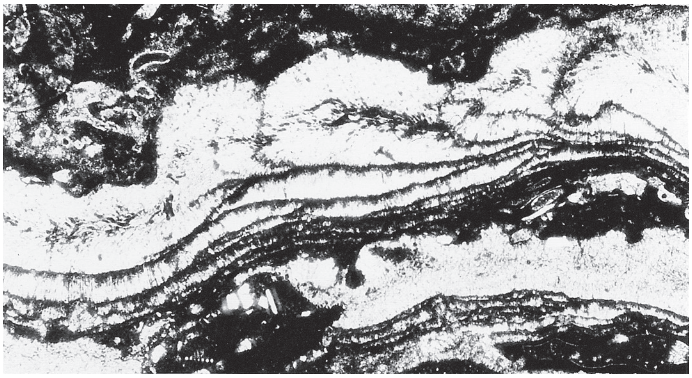

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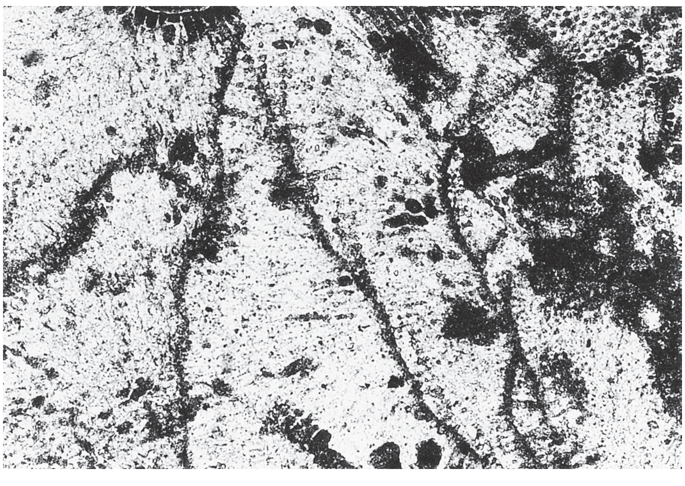

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Plate XIV

Red algae in the Palaeocene reef complex of the Western Carpathians

Fig. 1. *Sporolithon* sp., crust form. Visible arrangement of sporangia. Malé Karpaty Mts., Vápenková skala, block 1, thin section 4 Ko, back-reef environment, Selandian (SBZ 2), magnif. 80x.

Fig. 2. *Sporolithon* sp. with irregular arrangement of sporangia. Pieniny, Haligovce – Paluby, sample 9, thin section 3 Ko, reef structure, Early Thanetian (SBZ 3), magnif. 80x.

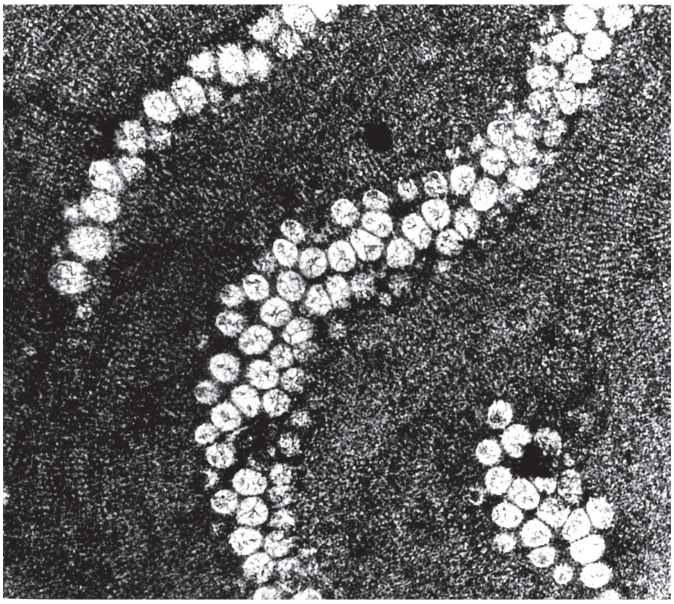
Fig. 3. *Sporolithon* sp., form with regular rows of sporangia. Middle Váh Valley, Hričovské Podhradie, block 5, thin section 6 Ko, fore-reef environment, Early Thanetian (SBZ 3), magnif. 80x.

Fig. 4. *Sporolithon* sp., crust form with clusters of sporangia. Pieniny, Veľký Lipník, sample 12, thin section 3 Ko, reef structure, Early Thanetian (SBZ 3), magnif. 80x.

Fig. 5. *Pycnoporidium* cf. *levantinum* Johnson, section through nodule. Myjavská pahorkatina Upland, Dlhý vŕšok, block 8, thin section 4 Ko, fore-reef environment, Early Thanetian (SBZ 3), magnif. 80x.

Fig. 6. *Pycnoporidium* cf. *levantinum* Johnson, tangential cross-section arrangement of cells. Myjavská pahorkatina Upland, Dlhý vŕšok, block 8, thin section 4 Ko, fore-reef environment, Early Thanetian (SBZ 3), magnif. 80x.

XIV



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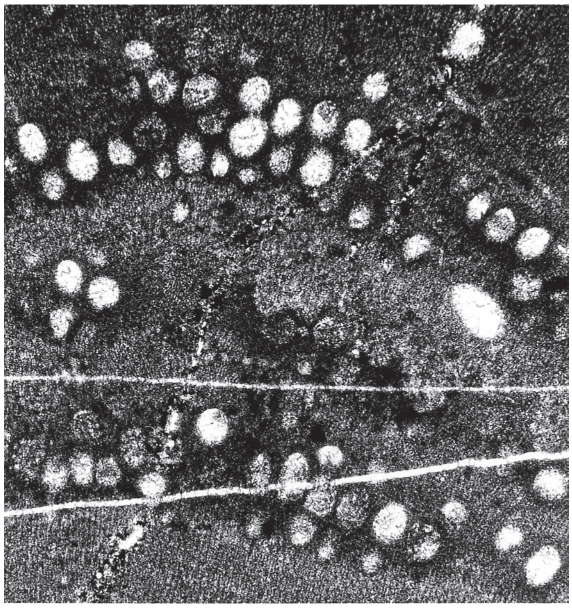

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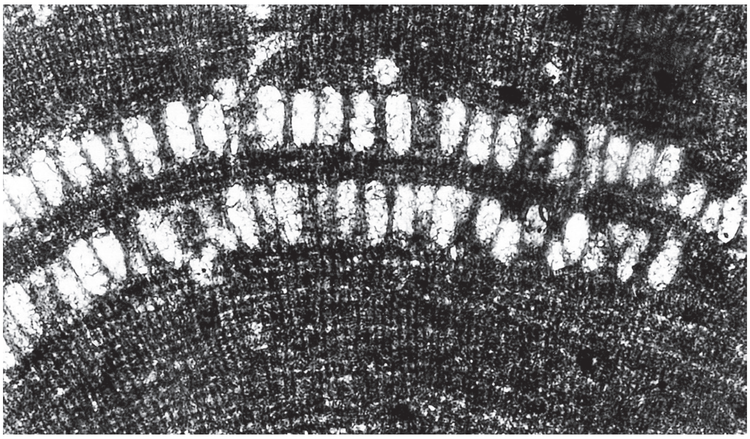

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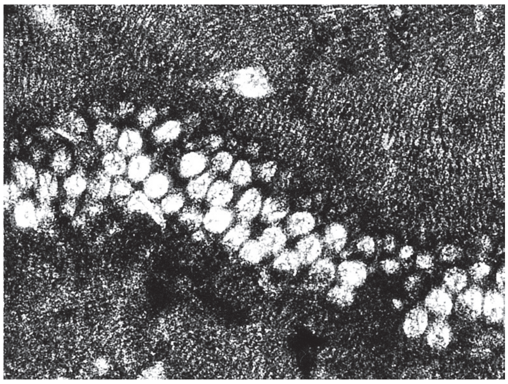

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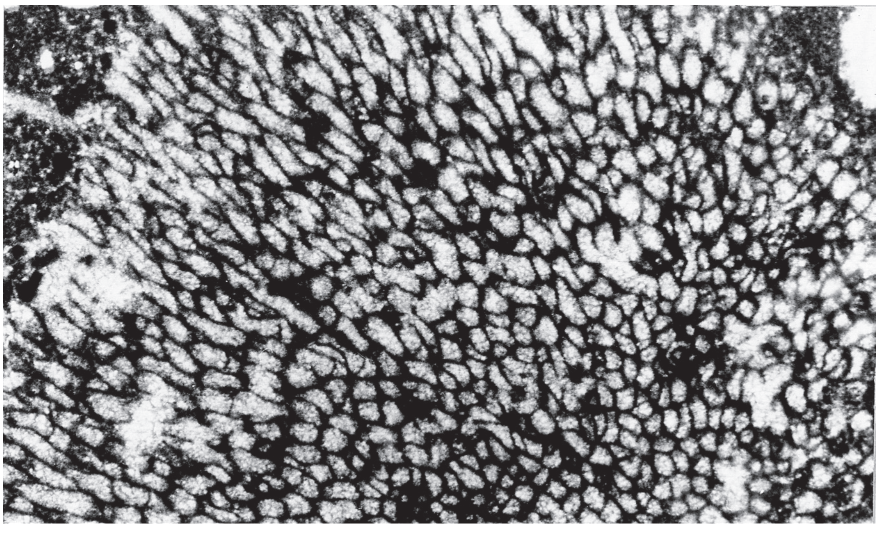

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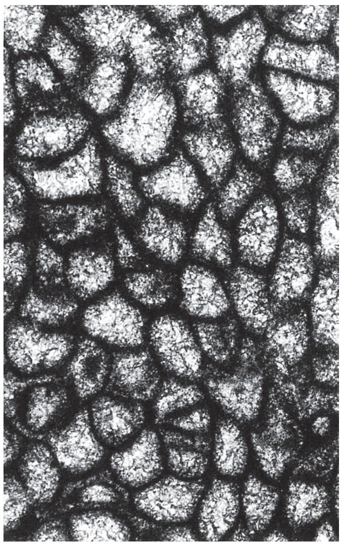

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Plate XV

Red algae in the Palaeocene reef complex of the Western Carpathians

Fig. 1. *Mesophyllum* sp., cross-section through part of nodule with conceptacles. Orava, Zábiedovo, block 2, thin section 1 Ko, rim of reef structure, Early Thanetian (SBZ 3), magnif. 80x.

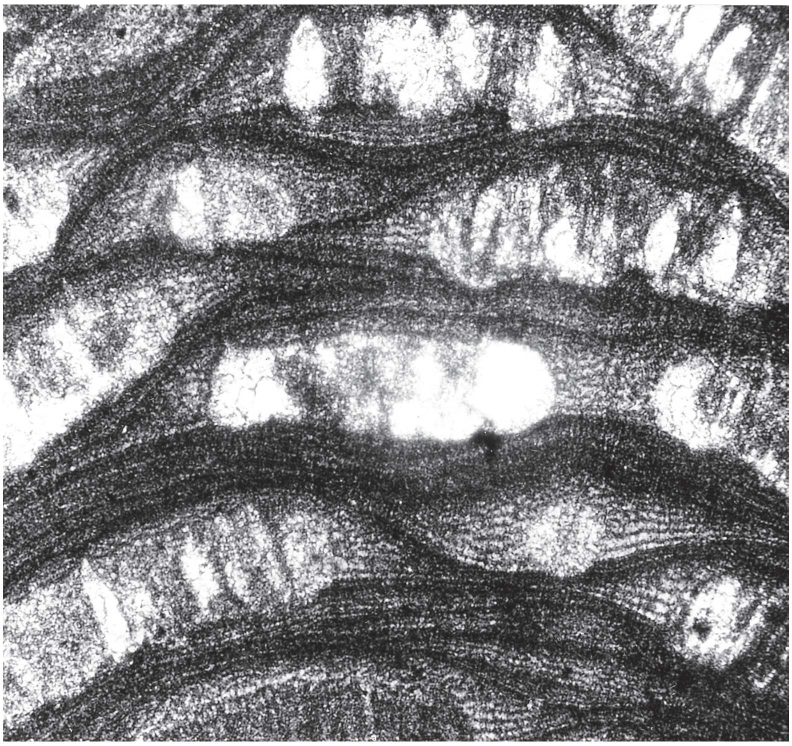
Fig. 2. *Lithothamnion* sp. with conceptacles. Middle Váh Valley, Hradisko, block 1, thin section 1 Ko, Selandian- Early Thanetian (SBZ 2 – SBZ 3), magnif. 80x.

Fig. 3. *Lithophyllum* sp., longitudinal cross-section. Myjavská pahorkatina Upland, Dedkov vrch, sample 2, thin section 9 Ko, fore-reef slope environment, Early Thanetian (SBZ 3), magnif. 80x.

Fig. 4. *Corallina* sp., longitudinal cross-section. Middle Váh Valley, Hričovské Podhradie, block 6, thin section 2 Ko, fore-reef slope environment, Early Thanetian (SBZ 3), magnif. 80x.

Fig. 5. *Jania* sp., longitudinal cross-section through thalli. Middle Váh Valley, Hričovské Podhradie, block 3, thin section 19 Ko, back-reef lagoonal environment, Early Thanetian (SBZ 3), magnif. 80x.

XV



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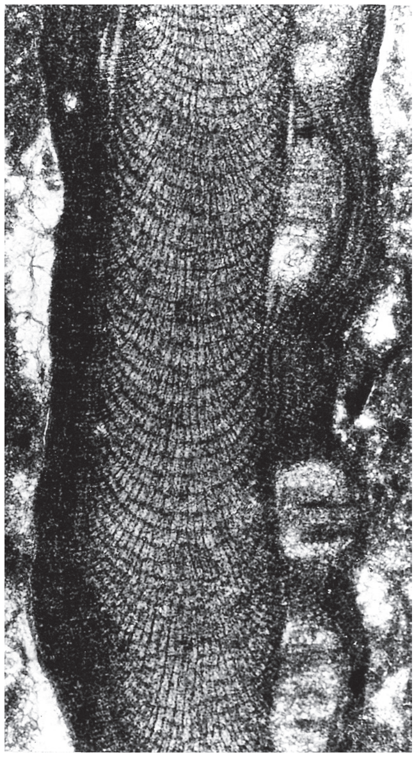

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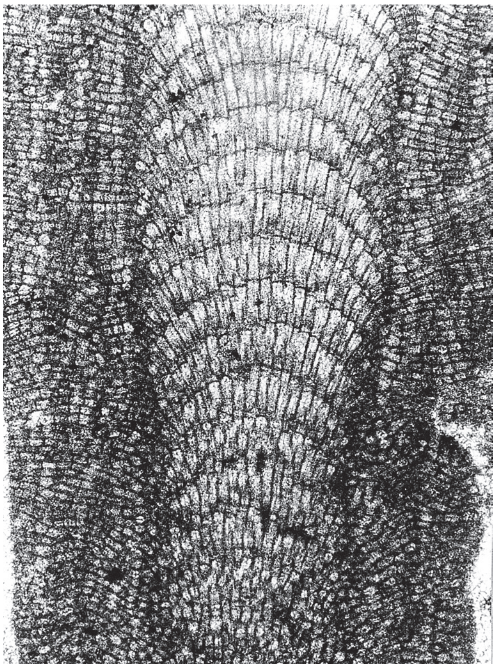

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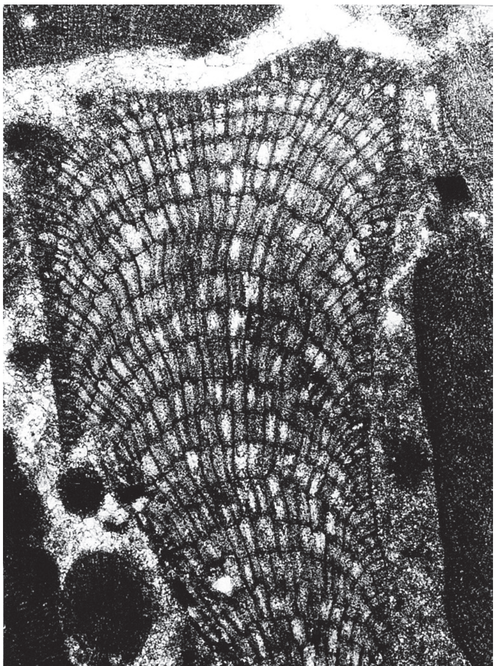

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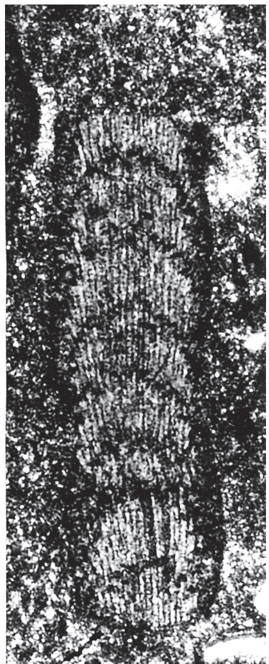

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Plate XVI

Red algae in the Palaeocene reef complex of the Western Carpathians

Fig. 1. *Pseudoamphiroa propria* (Lemoine), section through part of nodule with sporangia. Pieniny, Veľký Lipník, sample 2, thin section 1 Ko, back-reef environment, Early Thanetian (SBZ 3), magnif. 80x.

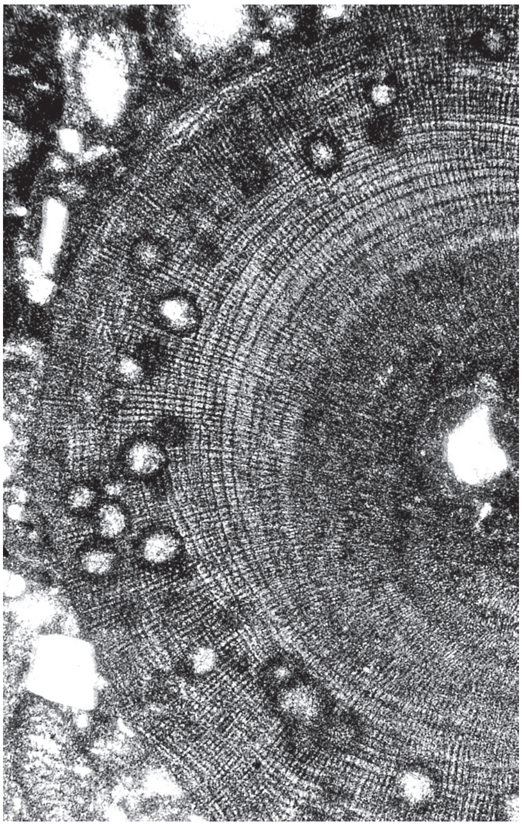
Fig. 2. *Pseudoamphiroa propria* (Lemoine), section through nodule with sporangia. Myjavská pahorkatina Upland, Stará Turá – cemetery, block 2, thin section 6 Ko, fore-reef environment, Early Thanetian (SBZ 3), magnif. 80x.

Fig. 3. *Distichoplax biserialis* (Dietrich) Pia, thalli in various cutting planes. Myjavská pahorkatina Upland, Lubina, block 1, thin section 3 Ko, fore-reef environment, Early Thanetian (SBZ 3), magnif. 80x.

Fig. 4. *Distichoplax biserialis* (Dietrich) Pia, longitudinal cross-section through thallus. Myjavská pahorkatina Upland, Lubina, block 1, thin section 3 Ko, fore-reef environment, Early Thanetian (SBZ 3), magnif. 80x.

Fig. 5. *Distichoplax biserialis* (Dietrich) Pia, longitudinal cross-section in different plane as in Fig. 4. Myjavská pahorkatina Upland, Dlhý vŕšok, block 8, thin section 2 Ko, fore-reef environment, Early Thanetian (SBZ 3), magnif. 80x.

XVI



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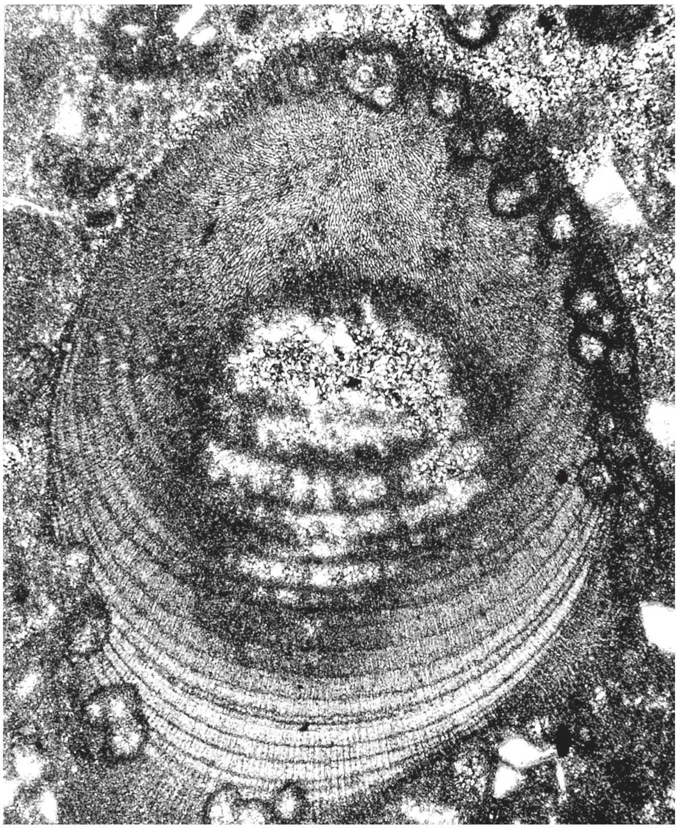

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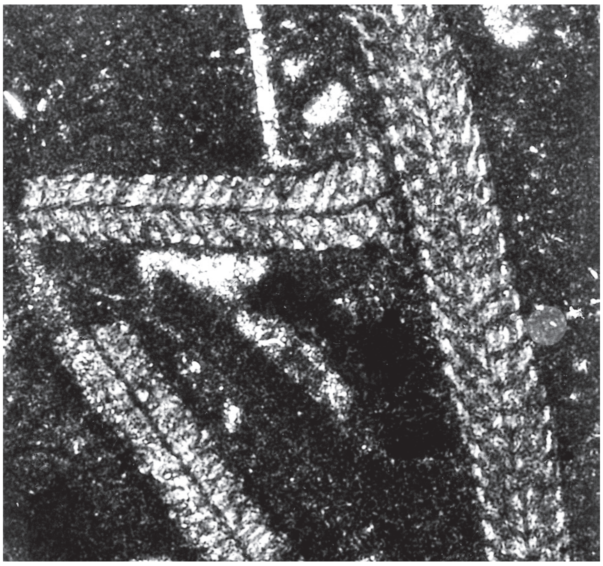

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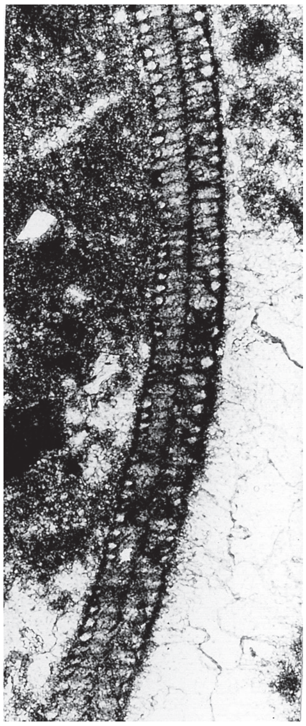

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Plate XVII

Green algae (Dasycladales) in the Palaeocene reef complex (back-reef lagoonal environment) of the Western Carpathians

Fig. 1. *Broeckella belgica* MORELLET et MORELLET. Myjavská pahorkatina Upland, Matejovec, thin section 1334/89 Bu, Early Thanetian (SBZ 3), magn. 23x.

Fig. 2. *Broeckella belgica* MORELLET et MORELLET. Myjavská pahorkatina Upland, Matejovec, thin section 1334/89 Bu, Early Thanetian (SBZ 3), magn. 25x.

Fig. 3. *Broeckella belgica* MORELLET et MORELLET. Myjavská pahorkatina Upland, Jeruzalem, thin section 1337/89 Bu, Early Thanetian (SBZ 3), magn. 12x.

Fig. 4. *Neomeris* sp. Myjavská pahorkatina Upland, Jeruzalem, thin section 1339/89 Bu, Early Thanetian (SBZ 3), magn. 8x.

Fig. 5. *Neomeris* sp. Myjavská pahorkatina Upland, Jeruzalem, thin section 1339/89 Bu, Early Thanetian (SBZ 3), magn. 16x.

Fig. 6. *Neomeris* sp. Myjavská pahorkatina Upland, Jeruzalem, thin section 1337/89 Bu, Early Thanetian (SBZ 3), magn. 12x.

Fig. 7. *Clypeina* sp. Myjavská pahorkatina Upland, Matejovec, thin section 1335/89 Bu, Early Thanetian (SBZ 3), magn. 24x.

Fig. 8. *Neomeris* sp. Myjavská pahorkatina Upland, Jeruzalem, thin section 1338/89 Bu, Early Thanetian (SBZ 3), magn. 10x.

Fig. 9. *Cymopolia* sp. Myjavská pahorkatina Upland, Matejovec, thin section 1335/89 Bu, Early Thanetian (SBZ 3), magn. 24x.

Fig. 10. *Neomeris* sp. Myjavská pahorkatina Upland, Jeruzalem, thin section 1337/89 Bu, Early Thanetian (SBZ 3), magn. 5x.

XVII

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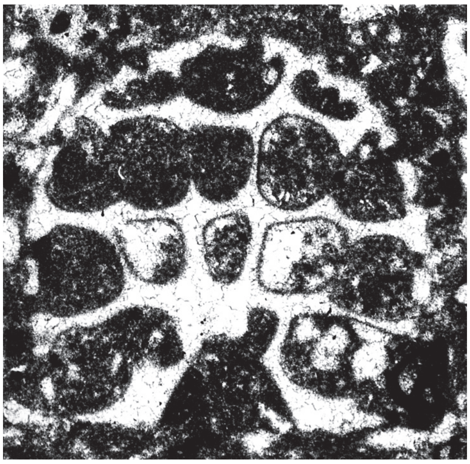

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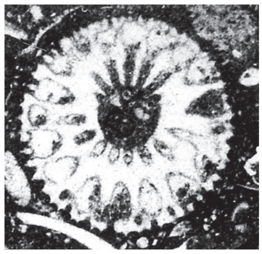

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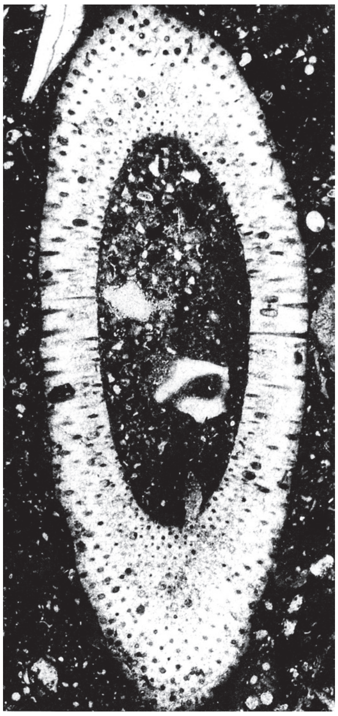

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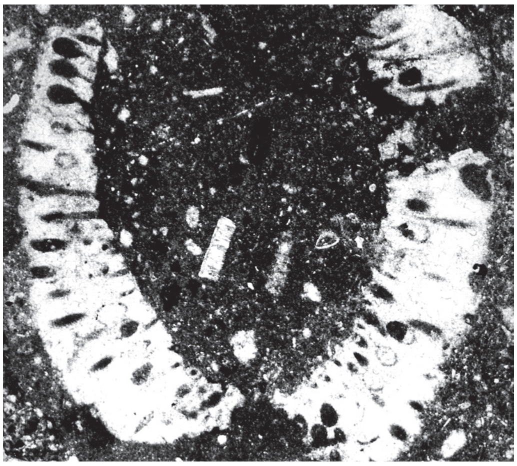

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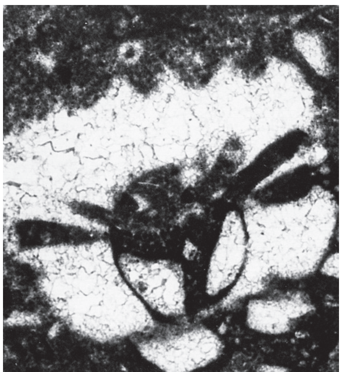

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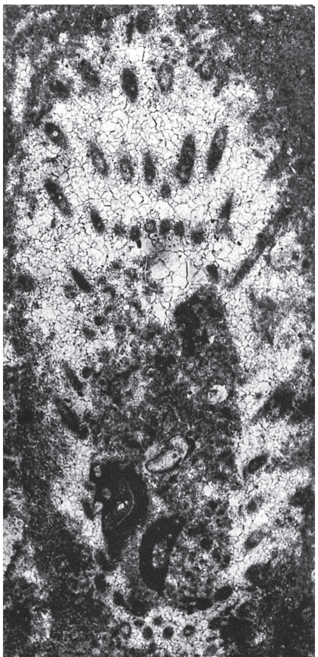

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Plate XVIII

Green algae (Dasycladales) in the Palaeocene reef complex (back-reef lagoonal environment) of the Western Carpathians

Fig. 1. *Cymopolia* sp. Myjavská pahorkatina Upland, Jeruzalem, thin section 1337/89 Bu, Early Thanetian (SBZ 3), magn. 27x.

Fig. 2. *Neomeris* sp. Myjavská pahorkatina Upland, Matejovec, thin section 1334/89 Bu, Early Thanetian (SBZ 3), magn. 25x.

Fig. 3. *Neomeris* (*Larvaria*) *koradae* Dieni, Massari et Radoičić. Orava, Brezovica, thin section 1470/90 Bu, Early Thanetian (SBZ 3), magn. 10x.

Fig. 4. *Neomeris* (*Larvaria*) *koradae* Dieni, Massari et Radoičić. Orava, Brezovica, thin section 1499/90 Bu, Early Thanetian (SBZ 3), magn. 10x.

Fig. 5. *Neomeris* (*Larvaria*) *koradae* Dieni, Massari et Radoičić. Orava, Brezovica, thin section 1498/90 Bu, Early Thanetian (SBZ 3), magn. 10x.

Fig. 6. *Microsporangiella*? sp. Myjavská pahorkatina Upland, Jeruzalem, thin section 1339/89 Bu, Early Thanetian (SBZ 3), magn. 42x.

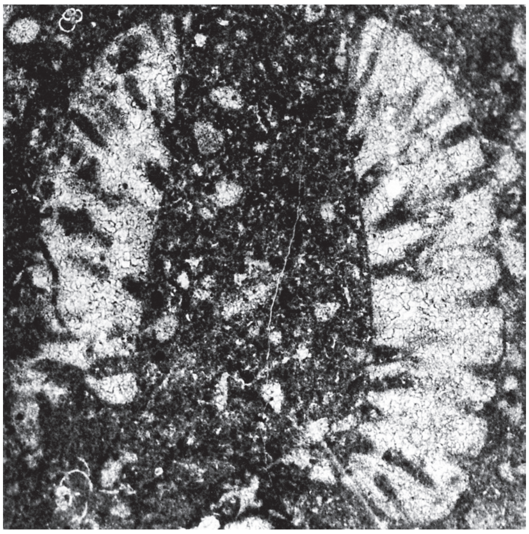
Fig. 7. *Sandalia multipora* Dieni, Massari et Radoičić. Myjavská pahorkatina Upland, Jeruzalem, thin section 1337/89 Bu, Early Thanetian (SBZ 3), magn. 27x.

Fig. 8. *Neomeris* (*Larvaria*) *koradae* Dieni, Massari et Radoičić. Orava, Brezovica, thin section 1454/90 Bu, Early Thanetian (SBZ 3), magn. 10x.

Fig. 9. *Neomeris* (*Larvaria*) *koradae* Dieni, Massari et Radoičić. Orava, Brezovica, thin section 1469/90 Bu, Early Thanetian (SBZ 3), magn. 10x.

Fig. 10. *Uglasiella*? sp. Myjavská pahorkatina Upland, Jeruzalem, thin section 1339/89 Bu, Early Thanetian (SBZ 3), magn. 36x.

XVIII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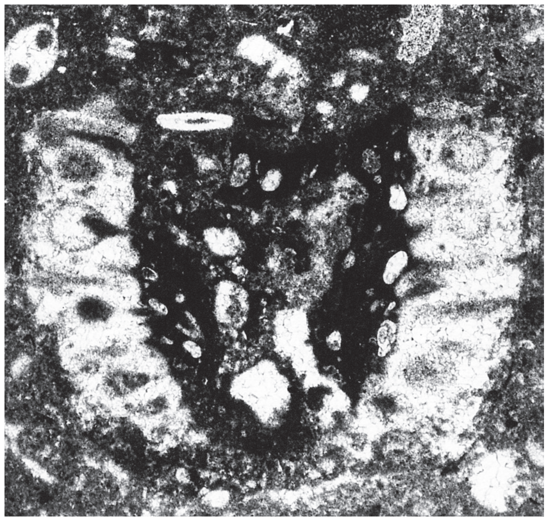
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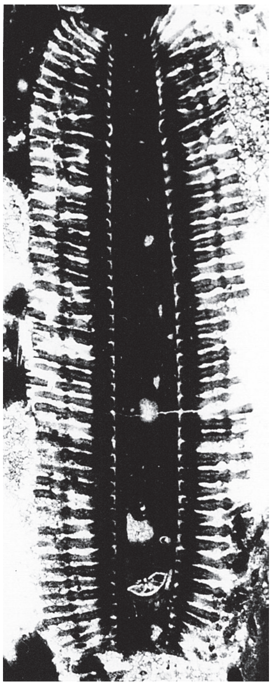
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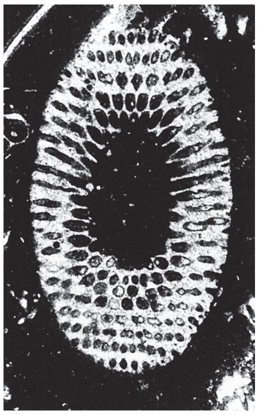
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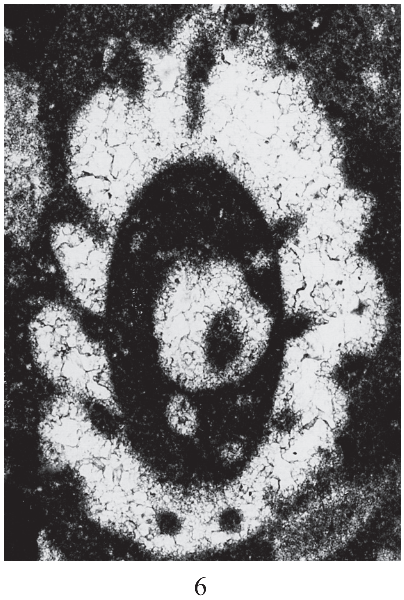
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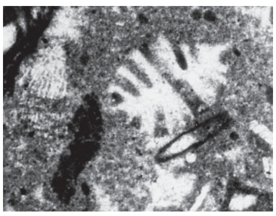
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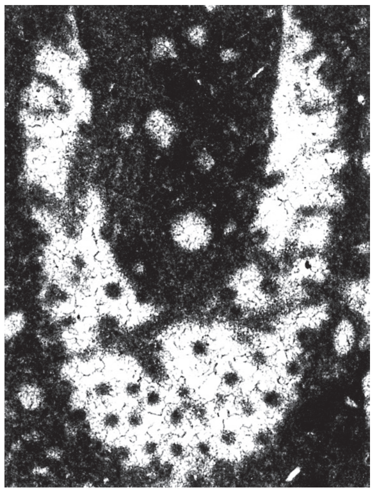
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Plate XIX

Green algae (Dasycladales) in the Palaeocene reef complex (back-reef lagoonal environment) of the Western Carpathians

Fig. 1. *Zittelina radoičićae* (Bystrický), oblique cross-section. Myjavská pahorkatina Upland, Jeruzalem, thin section 1247/89 Bu, Early Thanetian (SBZ 3), magnif. 15x.

Fig. 2. *Zittelina radoičićae* (Bystrický), slightly oblique-transversal cross-section. Myjavská pahorkatina Upland, Jeruzalem, thin section 1365/89 Bu, Early Thanetian (SBZ 3), magnif. 15x.

Fig. 3. *Zittelina bystrickyi* (Dieni, Massari et Radoičić), oblique cross-section. Myjavská pahorkatina Upland, Juríkovci, thin section 1452/90 Bu, Early Thanetian (SBZ 3), magnif. 10x.

Fig. 4. *Zittelina radoičićae* (Bystrický), axial cross-section. Myjavská pahorkatina Upland, Jeruzalem, thin section 1563/90 Bu, Early Thanetian (SBZ 3), magnif. 14,5x.

Fig. 5. *Zittelina radoičićae* (Bystrický), oblique-tangential cross-section. Myjavská pahorkatina Upland, Jeruzalem, thin section 1314/89 Bu, Early Thanetian (SBZ 3), magnif. 14,5x.

Fig. 6. *Zittelina radoičićae* (Bystrický), subaxial cross-section. Myjavská pahorkatina Upland, Matejovec, thin section 1526/90 Bu, Early Thanetian (SBZ 3), magnif. 14,5x.

Fig. 7. *Zittelina radoičićae* (Bystrický), axial cross-section. Myjavská pahorkatina Upland, Matejovec, thin section 1416/89 Bu, Early Thanetian (SBZ 3), magnif. 10x.

Fig. 8. *Zittelina radoičićae* (Bystrický), axial cross-section. Myjavská pahorkatina Upland, Jeruzalem, thin section 1322/89 Bu, Early Thanetian (SBZ 3), magnif. 14,5x.

Fig. 9. *Zittelina radoičićae* (Bystrický), axial cross-section. Myjavská pahorkatina Upland, Matejovec, thin section 1427/89 Bu, Early Thanetian (SBZ 3), magnif. 14,5x.

XIX

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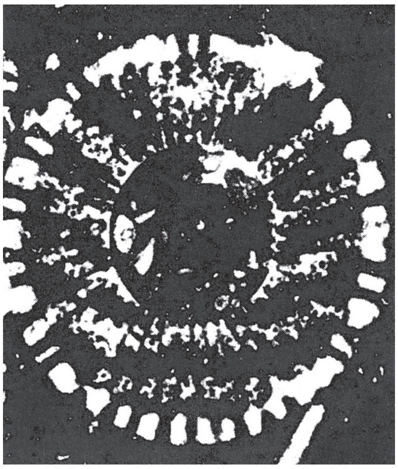

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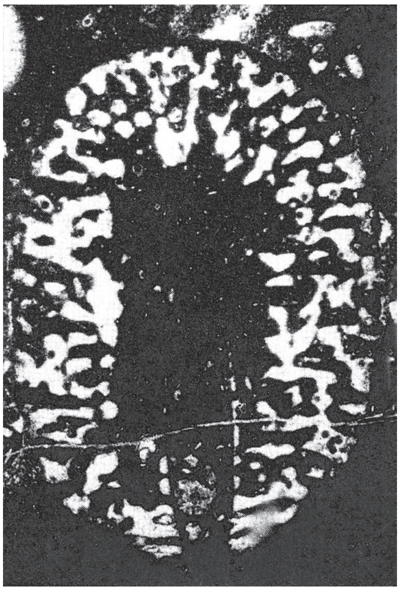

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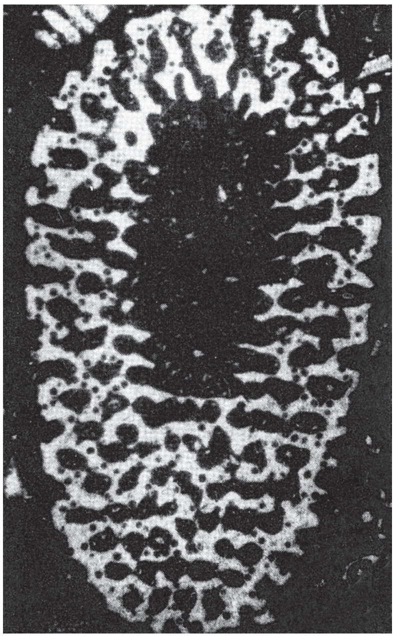

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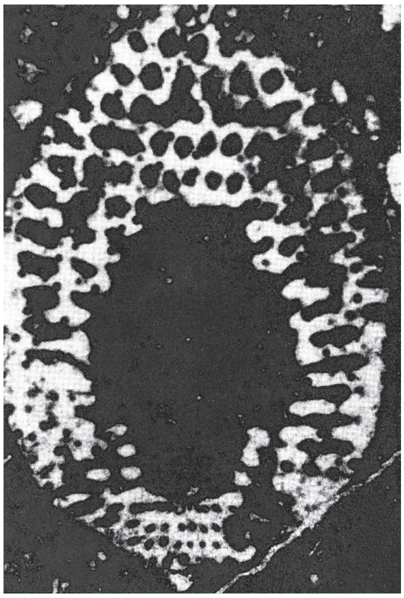

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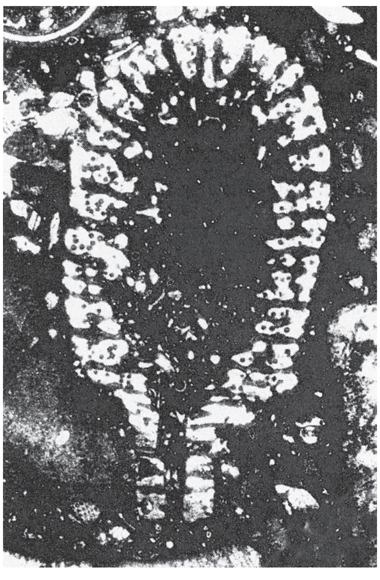

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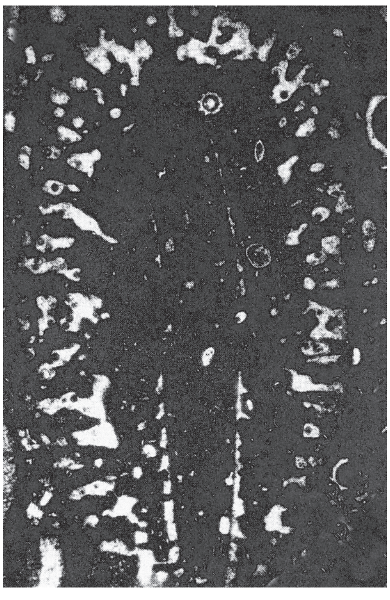

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Tab. XX

Large benthic foraminifers in the Palaeocene reef complex of the Western Carpathians

Fig. 1. *Discocyclina seunesi* Douvillé, oblique equatorial cross-section through the test. Middle Váh Valley, Svätá Helena, block 7, thin section 4 Ko, fore-reef slope environment, Early Thanetian (SBZ 3), magnif. 30x.

Fig. 2. *Discocyclina seunesi* Douvillé, transversal cross-section through the test. Myjavská pahorkatina Upland, Juríkovci, block 1, thin section 4 Ko, fore-reef slope environment, Early Thanetian (SBZ 3), magnif. 30x.

Fig. 3. *Discocyclina seunesi* Douvillé, transversal cross-section through the test. Myjavská pahorkatina Upland, Hodulov vrch, block 12, thin section 1 Ko, fore-reef slope environment, Early Thanetian (SBZ 3), magnif. 30x.

Fig. 4. *Discocyclina seunesi* Douvillé, transversal cross-section through the test. Middle Váh Valley, Svätá Helena, block 7, thin section 3 Ko, fore-reef slope environment, Early Thanetian (SBZ 3), magnif. 30x.

Fig. 5. *Orbitoclypeus ramaraoi* (Samanta), equatorial cross-section through the test. Middle Váh Valley, Hričovské Podhradie, block 10, thin section 1 Ko, fore-reef slope environment, Early Thanetian (SBZ 3), magnif. 30x.

Fig. 6. *Orbitoclypeus ramaraoi* (Samanta), equatorial and transversal cross-sections through the test. Middle Váh Valley, Rybárikov laz, sample 7, thin section 12 Ko, fore-reef slope environment, Early Thanetian (SBZ 3), magnif. 30x.

Fig. 7. *Orbitoclypeus ramaraoi* (Samanta), transversal cross-section through the test. Middle Váh Valley, Hričovské Podhradie, block 10, thin section 1 Ko, fore-reef slope environment, Early Thanetian (SBZ 3), magnif. 30x.

Fig. 8. *Orbitoclypeus ramaraoi* (Samanta), transversal cross-section through the test. Myjavská pahorkatina Upland, Tížikovci, block 7, thin section 7 Ko, fore-reef slope environment, Early Thanetian (SBZ 3), magnif. 30x.

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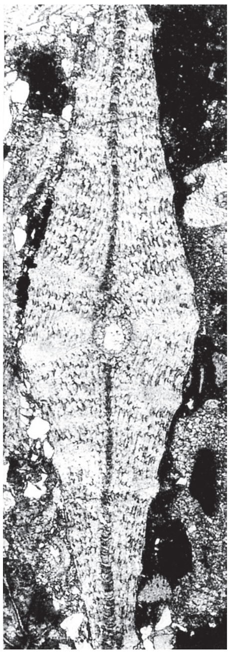

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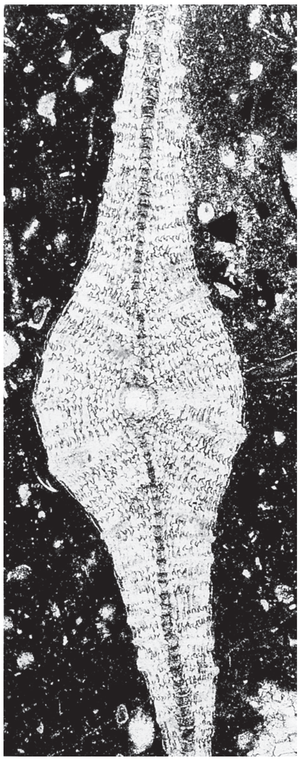

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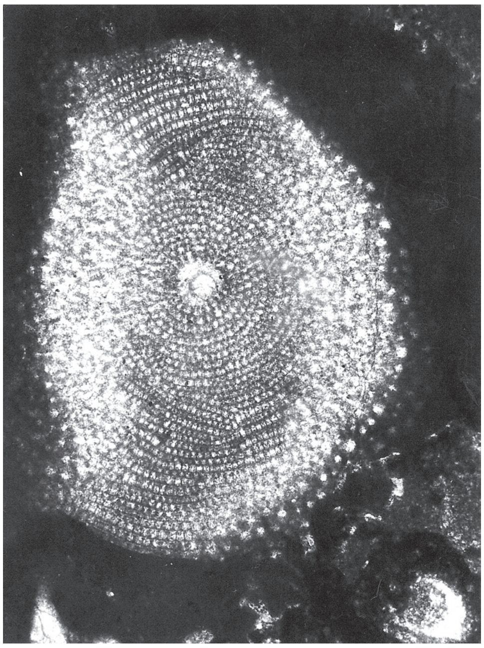

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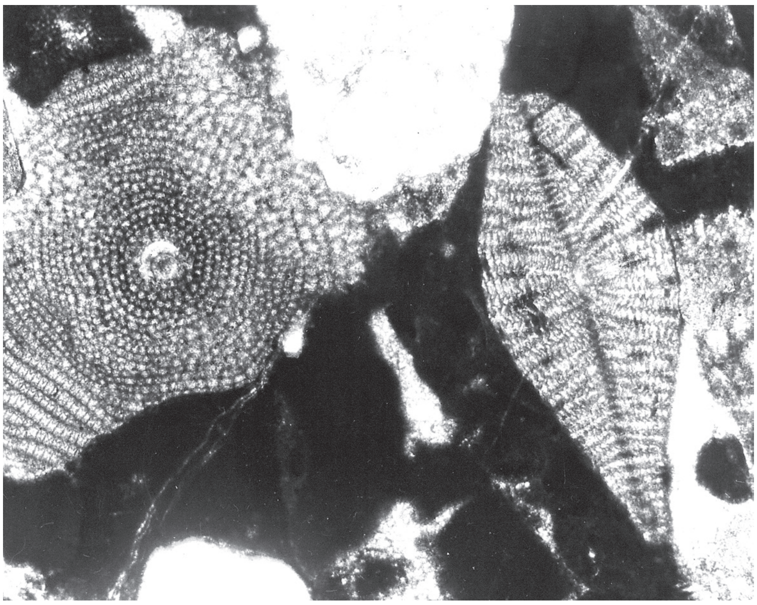

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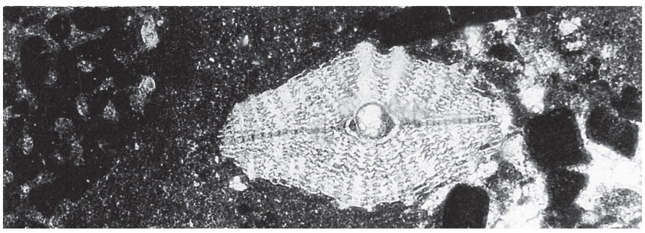

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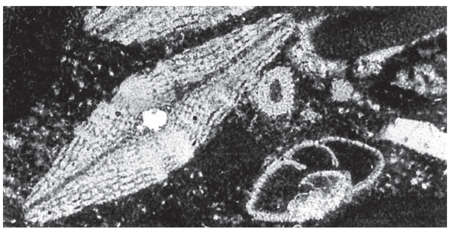

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Plate XXI

Large benthic foraminifers in the Palaeocene reef complex of the Western Carpathians

Fig. 1. *Glomalveolina primaeva* (Reichel), to the left dasycladacean alga *Cymopolia* sp. Myjavská pahorkatina Upland, Dlhý vŕšok, block 8, thin section 1 Ko, channel of reef flat, Early Thanetian (SBZ 3), magnif. 30x.

Fig. 2. *Glomalveolina primaeva* (Reichel), equatorial cross-section. Middle Váh Valley, Rybárikov laz, sample 4, thin section 7 Ko, back-reef environment, Early Thanetian (SBZ 3), magnif. 30x.

Fig. 3. *Glomalveolina primaeva* (Reichel) in oblique cross-section. Myjavská pahorkatina Upland, Hodulov vrch, block 12, thin section 5 Ko, back-reef environment, Early Thanetian (SBZ 3), magnif. 30x.

Fig. 4. *Glomalveolina primaeva* (Reichel) in oblique cross-section. Middle Váh Valley, Rybárikov laz, sample 4, thin section 17 Ko, back-reef environment, Early Thanetian (SBZ 3), magnif. 30x.

Fig. 5. *Glomalveolina primaeva* (Reichel) in oblique cross-section. Middle Váh Valley, Hričovské Podhradie, sample 8, thin section 53 Ko, back-reef environment, Early Thanetian (SBZ 3), magnif. 30x.

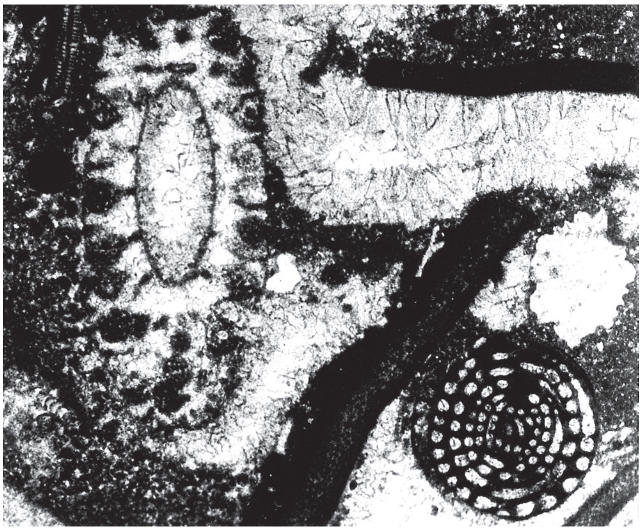
Fig. 6. *Globoflarina sphaeroidea* (Fleury), equatorial cross-section. Myjavská pahorkatina Upland, Matejovec, thin section 1535/90 Bu, lagoonal environment, Selandian (SBZ 2), magnif. 30x.

Fig. 7. *Globoflarina sphaeroidea* (Fleury) in transversal cross-section. Myjavská pahorkatina Upland, Jeruzalem, block 1, thin section 2 Ko, lagoonal environment, Early Thanetian (SBZ 3), magnif. 30x.

Fig. 8. *Coskinon rajkae* Hottinger et Drobne, below *Glomalveolina primaeva* (Reichel). Middle Váh Valley, Rybárikov laz, sample 4, thin section 1 Ko, fore-reef slope environment, Early Thanetian (SBZ 3), magnif. 30x.

Fig. 9. *Coskinon rajkae* Hottinger et Drobne, transversal cross-section. Middle Váh Valley, Rybárikov laz, sample 4, thin section 16 Ko, fore-reef slope environment, Early Thanetian (SBZ 3), magnif. 30x.

XXI



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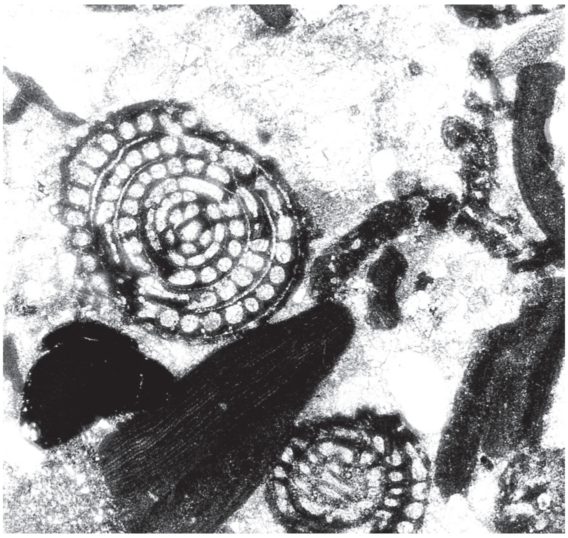

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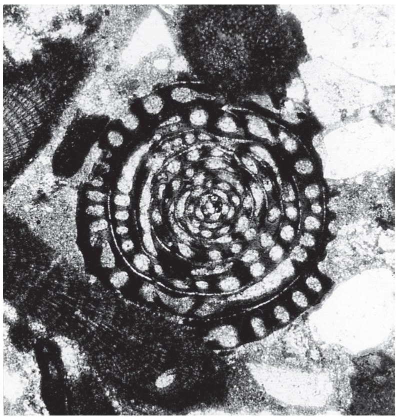

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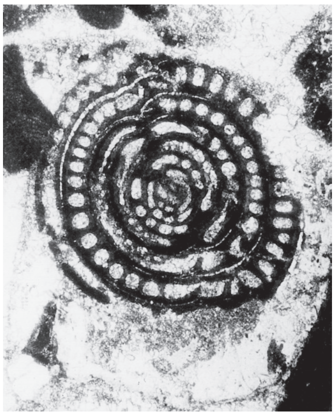

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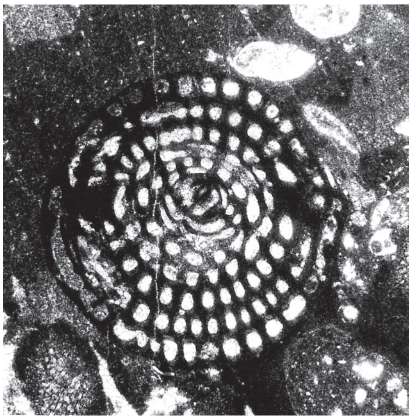

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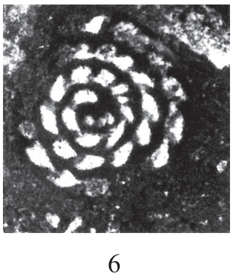

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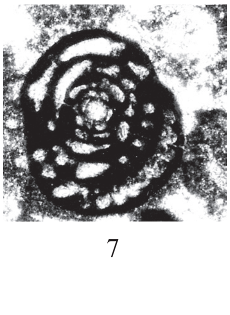

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Plate XXII

Large benthic foraminifers in the Palaeocene reef complex of the Western Carpathians

Fig. 1. *Pseudocuvillierina sireli* (Inan) in transversal cross-sections. Middle Váh Valley, Ovčiarsko, block 1, thin section 5 Ko, back-reef lagoonal environment, Selandian (SBZ 2), magnif. 30x.

Fig. 2. *Pseudocuvillierina sireli* (Inan), oblique cross-section. Middle Váh Valley, Ovčiarsko, block 1, thin section 21 Ko, back-reef lagoonal environment, Selandian (SBZ 2), magnif. 30x.

Fig. 3. *Pseudocuvillierina sireli* (Inan), transversal cross-section. Middle Váh Valley, Ovčiarsko, block 1, thin section 17 Ko, back-reef lagoonal environment, Selandian (SBZ 2), magnif. 30x.

Fig. 4. *Pseudocuvillierina sireli* (Inan), equatorial cross-section. Middle Váh Valley, Ovčiarsko, block 1, thin section 23 Ko, back-reef lagoonal environment, Selandian (SBZ 2), magnif. 30x.

Fig. 5. *Pseudocuvillierina sireli* (Inan), equatorial cross-section. Middle Váh Valley, Ovčiarsko, block 1, thin section 1 Ko, back-reef lagoonal environment, Selandian (SBZ 2), magnif. 30x.

Fig. 6. *Pseudocuvillierina sireli* (Inan), transversal and oblique cross-sections. Middle Váh Valley, Ovčiarsko, block 1, thin section 10 Ko, back-reef lagoonal environment, Selandian (SBZ 2), magnif. 30x.

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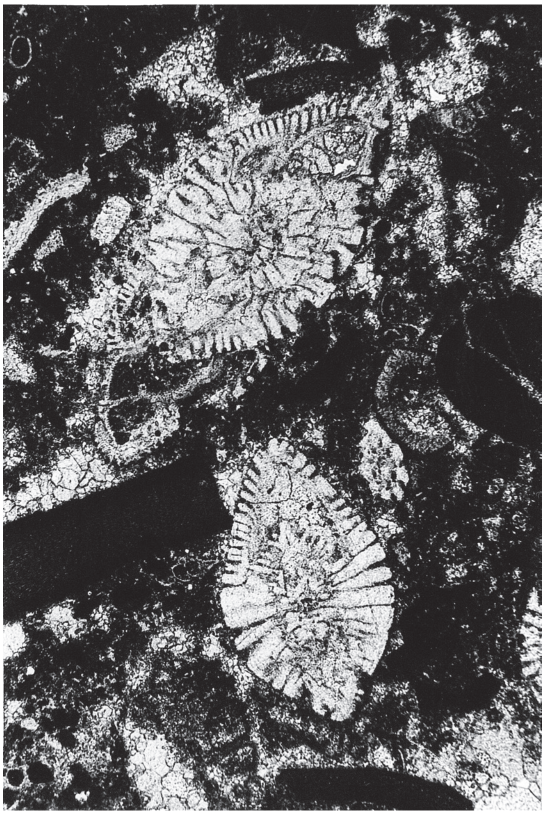

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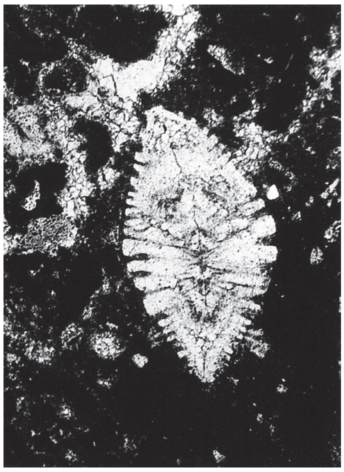

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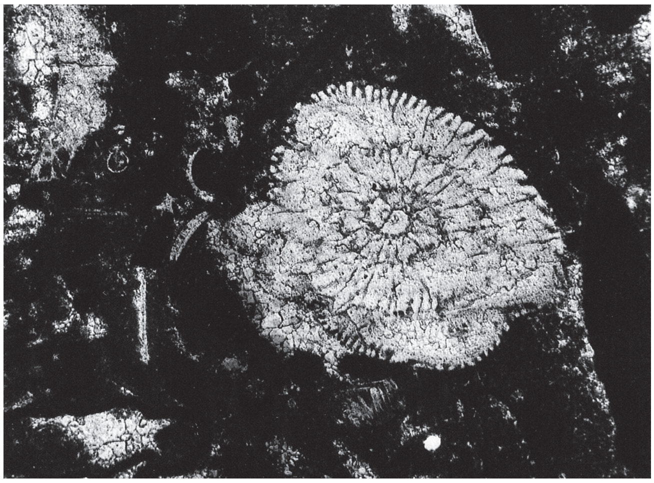

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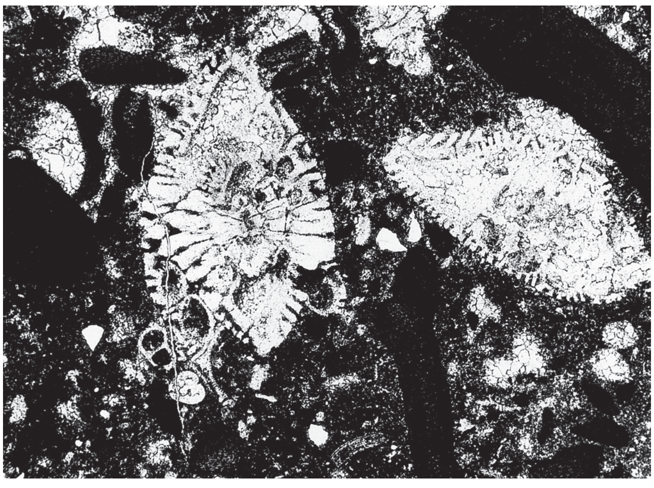

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Plate XXIII

Large benthic foraminifers in the Palaeocene reef complex of the Western Carpathians

Fig. 1. *Miscellanites primitivus* (Rahaghi), oblique sections. Orava, Brezovica, block 19, thin section 1 Ko, back-reef environment, Selandian (SBZ 2), magnif. 30x.

Fig. 2. *Miscellanites primitivus* (Rahaghi), transversal section. Orava, Brezovica, block 19, thin section 2 Ko, back-reef environment, Selandian (SBZ 2), magnif. 30x.

Fig. 3. *Miscellanites primitivus* (Rahaghi). Myjavská pahorkatina Upland, Dlhý vŕšok, block 3, thin section 1 Ko, back-reef environment, Selandian (SBZ 2), magnif. 30x.

Fig. 4. *Miscellanites primitivus* (Rahaghi). Orava, Zábiedovo, block 1, thin section 3 Ko, back-reef environment, Selandian (SBZ 2), magnif. 30x.

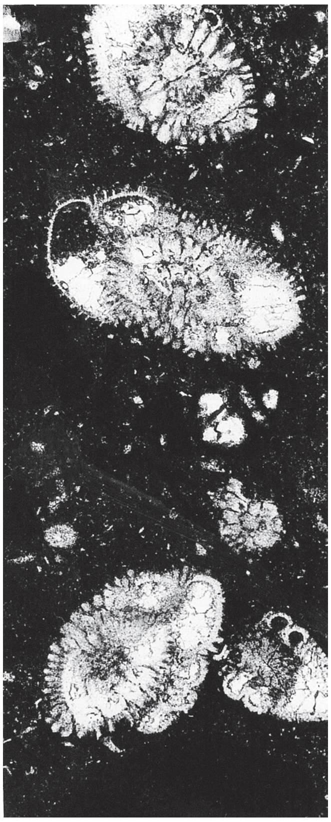
Fig. 5. *Miscellanites globularis* (Rahaghi), oblique section. Middle Váh Valley, Hričovské Podhradie, block 4, thin section 3 Ko, back-reef environment, Early Thanetian (SBZ 3), magnif. 30x.

Fig. 6. *Ornatonion* sp. oblique section. Myjavská pahorkatina Upland, Jeruzalem, block 2, thin section 4 Ko, back-reef environment, Selandian (SBZ 2), magnif. 30x.

Fig. 7. *Daviesina* sp. Myjavská pahorkatina Upland, Tížikovci, block 5, thin section 6 Ko, fore-reef slope environment, Early Thanetian (SBZ 3), magnif. 30x.

Fig. 8. *Daviesina* sp. equatorial section. Middle Váh Valley, Hričovské Podhradie, block 4, thin section 5 Ko, fore-reef slope environment, Early Thanetian (SBZ 3), magnif. 30x.

XXIII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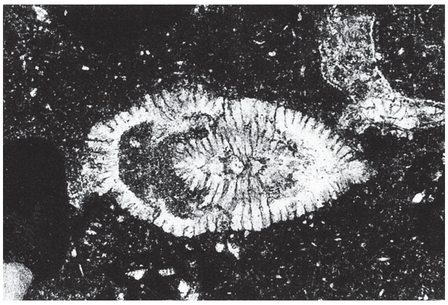
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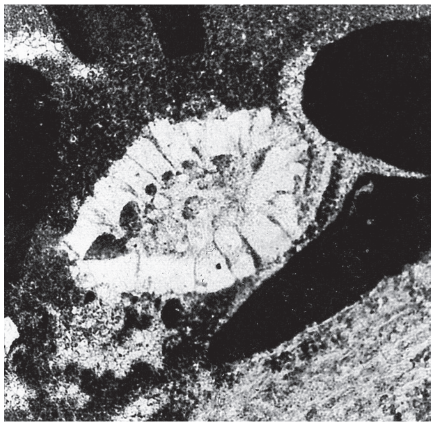
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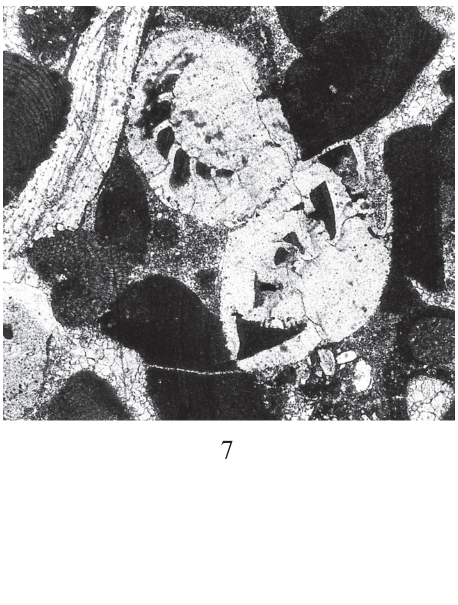
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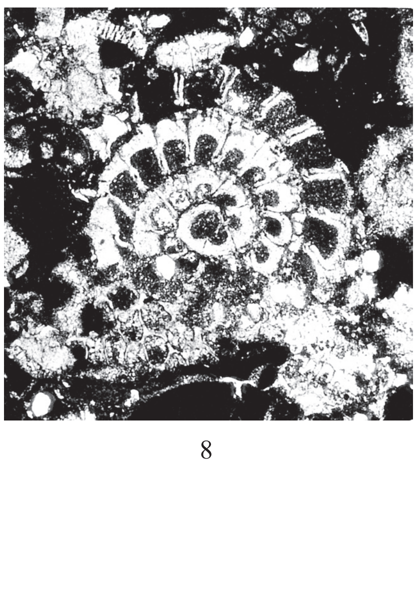
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Plate XXIV

Large benthic foraminifers in the Palaeocene reef complex of the Western Carpathians

Fig. 1. *Miscellanea juliettae* Leppig, transversal and equatorial sections. Middle Váh Valley, Hričovské Podhradie, block 3, thin section 1 Ko, back-reef environment, Early Thanetian (SBZ 3), magnif. 30x.

Fig. 2. *Miscellanea juliettae* Leppig. Myjavská pahorkatina Upland, Tížikovci, block 6, thin section 5 Ko, fore-reef environment, Early Thanetian (SBZ 3), magnif. 30x.

Fig. 3. *Miscellanea juliettae* Leppig. Middle Váh Valley, Hričovské Podhradie, block 2, thin section 6 Ko, fore-reef slope environment, Early Thanetian (SBZ 3), magnif. 30x.

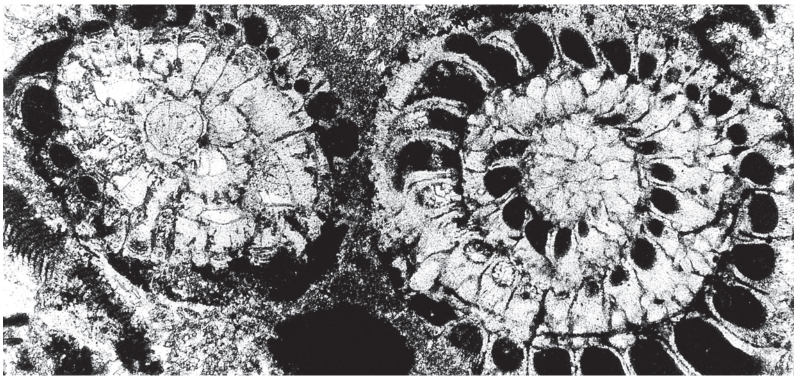
Fig. 4. *Miscellanea juliettae* Leppig. Middle Váh Valley, Hričovské Podhradie, block 2, thin section 3 Ko, fore-reef slope environment, Early Thanetian (SBZ 3), magnif. 30x.

Fig. 5. *Bangiana hanseni* Drobne, Ogorelec et Ricamboni, oblique section. Malé Karpaty Mts., Vápenková skala, block 10, thin section 3 Ko, back-reef environment, Danian (SBZ 1), magnif. 80x.

Fig. 6. *Haymanella paleocenica* Sirel. Myjavská pahorkatina Upland, Matejovec, thin section 1400/89 Bu, back-reef environment, Selandian (SBZ 2), magnif. 30x.

Fig. 7. *Orduella sphaerica* Sirel, equatorial section. Myjavská pahorkatina Upland, Matejovec, thin section 1417/89 Bu, back-reef environment, Selandian (SBZ 2), magnif. 30x.

XXIV



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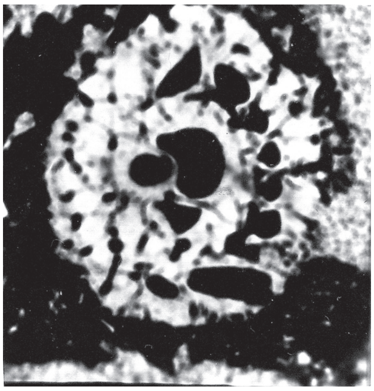

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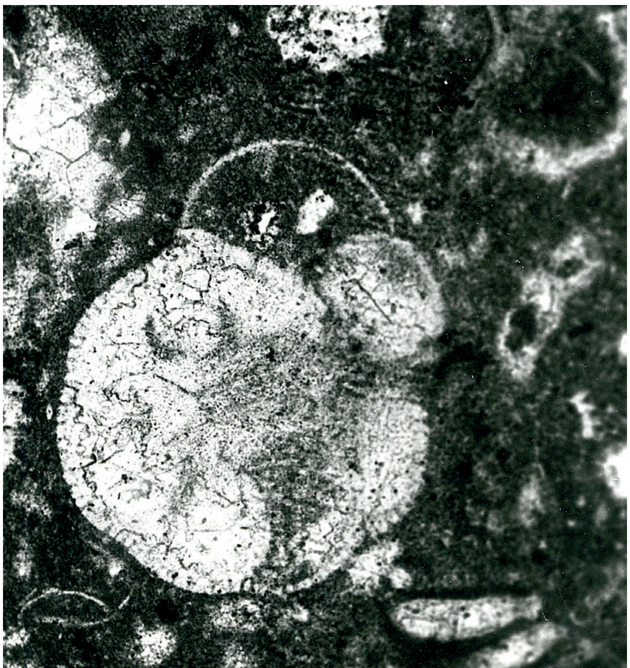

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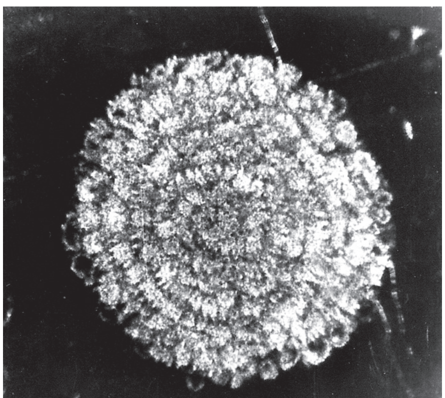

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Plate XXV

Large benthic foraminifers in the Palaeocene reef complex of the Western Carpathians

Fig. 1. *Operculina* cf. *heberti* Munier-Chalmas in oblique cross-section. Myjavská pahorkatina Upland, Tížikovci, block 6, thin section 4 Ko, fore-reef slope environment, Early Thanetian (SBZ 3), magnif. 30x.

Fig. 2. *Operculina* cf. *heberti* Munier-Chalmas in transversal cross-section. Middle Váh Valley, Hričovské Podhradie, block 4, thin section 1 Ko, fore-reef slope environment, Early Thanetian (SBZ 3), magnif. 30x.

Fig. 3. *Operculina* cf. *heberti* Munier-Chalmas in transversal cross-section. Myjavská pahorkatina Upland, Tížikovci, block 3, thin section 2 Ko, fore-reef slope environment, Early Thanetian (SBZ 3), magnif. 30x.

Fig. 4. *Operculina* cf. *azilensis* Tambareau, rim of the test in transversal cross-section. Middle Váh Valley, Kunovec, block 5, thin section 5 Ko, fore-reef slope environment, Early Thanetian (SBZ 3), magnif. 30x.

Fig. 5. ?*Ranikothalia* sp. Middle Váh Valley, Rybárikov laz, block 5, thin section 9 Ko, fore-reef slope environment, Early Thanetian (SBZ 3), magnif. 30x.

Fig. 6. *Operculina* sp. in transversal cross-section. Slánske vrchy Mts., Radvanovce, block 1, thin section 9 Ko, fore-reef slope environment, Early Thanetian (SBZ 3), magnif. 30x.

XXV


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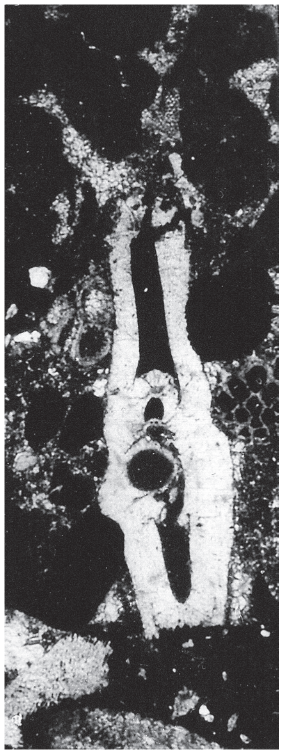
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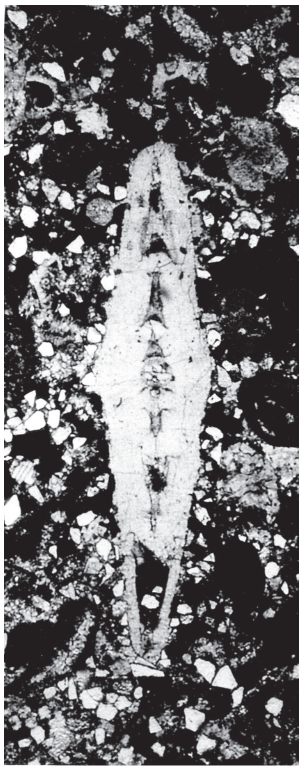
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Plate XXVI

Benthic and planktonic foraminifers in the Palaeocene reef complex of the Western Carpathians

Fig. 1. *Valvulineria* sp. Middle Váh Valley, Hričovské Podhradie, block 3, thin section 23 Ko, fore-reef environment, Early Thanetian (SBZ 3), magnif. 80x.

Fig. 2. *Cibicides* sp. Myjavská pahorkatina Upland, Dlhý vŕšok, block 9, thin section 5 Ko, back-reef environment, Early Thanetian (SBZ 3), magnif. 80x.

Fig. 3. *Valvulineria* sp. Myjavská pahorkatina Upland, Tížikovci, block 11, thin section 4 Ko, fore-reef environment, Early Thanetian (SBZ 3), magnif. 80x.

Fig. 4. *Subbotina velascoensis* Cushman. Middle Váh Valley, Hričovské Podhradie, block 10, thin section 24 Ko, fore-reef environment, Early Thanetian (SBZ 3), magnif. 80x.

Fig. 5. *Subbotina triloculinoides* (Plummer) and *Globoconusa* sp. Middle Váh Valley, Hradisko, block 2, thin section 3 Ko, fore-reef environment, Early Thanetian (SBZ 3), magnif. 80x.

Fig. 6. *Eoglobigerina* sp. Middle Váh Valley, Kunovec, block 10, thin section 22 Ko, fore-reef environment, Early Thanetian (SBZ 3), magnif. 80x.

Fig. 7. *Acarinina* sp. Middle Váh Valley, Hričovské Podhradie, block 10, thin section 23 Ko, fore-reef environment, Early Thanetian (SBZ 3), magnif. 80x.

Fig. 8. *Acarinina* sp. Middle Váh Valley, Rybárikov laz, block 8, thin section 24 Ko, fore-reef environment, Early Thanetian (SBZ 3), magnif. 80x.

XXVI

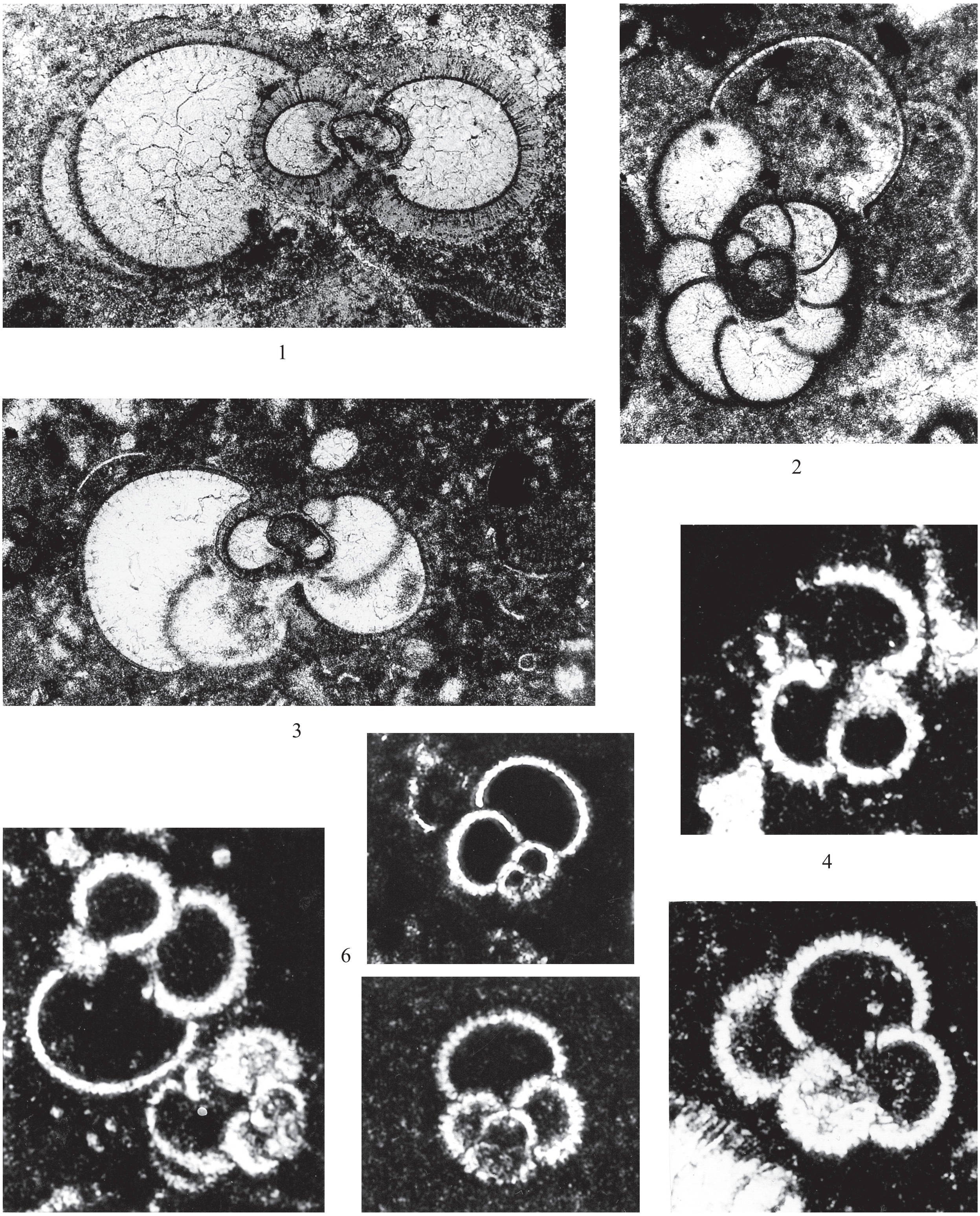


Plate XXVII

Benthic foraminifers in the Palaeocene reef complex of the Western Carpathians

Fig. 1. *Pseudoglandulina* sp. Middle Váh Valley, Hričovské Podhradie, block 1, thin section 14 Ko, fore-reef slope environment, Early Thanetian (SBZ 3), magnif. 80x.

Fig. 2. *Idalina* sp. in oblique cross-section. Malé Karpaty Mts., Vápenková skala, block 5, thin section 3 Ko, back-reef environment, Selandian (SBZ 2), magnif. 80x.

Fig. 3. *Idalina sinjarica* Grimsdale. Malé Karpaty Mts., Vápenková skala, block 3, thin section 1 Ko, back-reef environment, Selandian (SBZ 2), magnif. 80x.

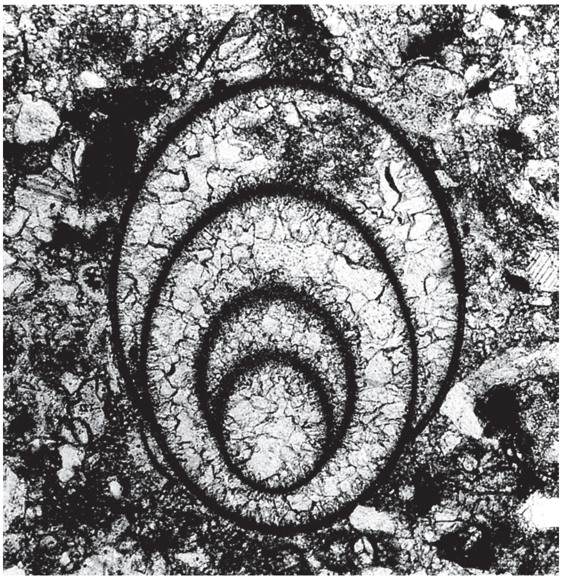
Fig. 4. *Idalina andrusovi* (Samuel, Köhler et Borza). Myjavská pahorkatina Upland, Miškech Dedinka, block 5, thin section 5 Ko, back-reef environment, Early Thanetian (SBZ 3), magnif. 80x.

Fig. 5. *Miliola* sp. in nodule of *Elianella elegans* PFENDER et BASSE. Malé Karpaty Mts., Vápenková skala, block 3, thin section 2 Ko, back-reef environment, Selandian (SBZ 2), magnif. 80x.

Fig. 6. *Idalina sinjarica* Grimsdale. Middle Váh Valley, Hradisko, block 2, thin section 14 Ko, fore-reef environment, Early Thanetian (SBZ 3), magnif. 80x.

Fig. 7. *Kartalina* sp. Middle Váh Valley, NE of Ostrý vrch Hill, block 1, thin section 10 Ko, back-reef environment, Early Thanetian (SBZ 3), magnif. 80x.

XXVII



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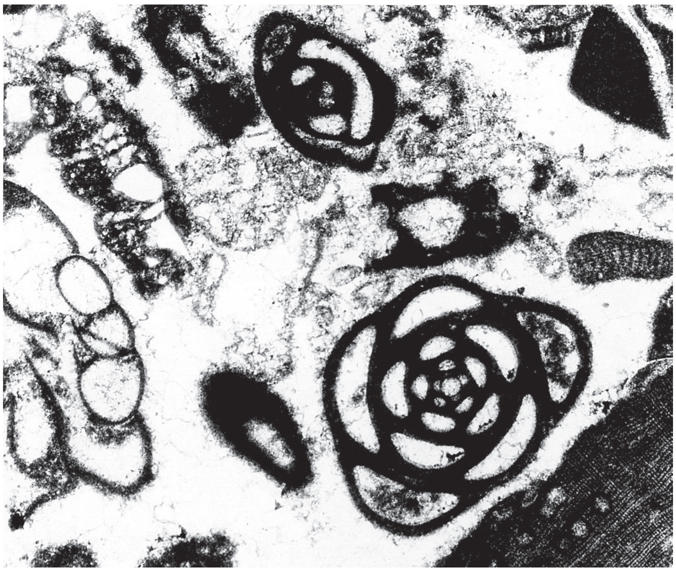

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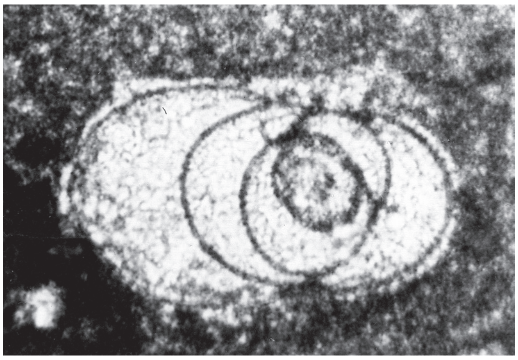

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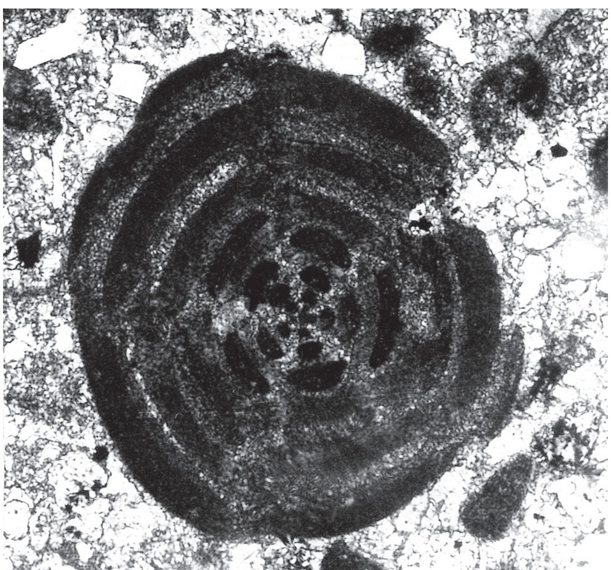

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Plate XXVIII

Benthic foraminifers in the Palaeocene reef complex of the Western Carpathians

Fig. 1. *Scandonea* sp. Middle Váh Valley, Hričovské Podhradie, block 4, thin section 15 Ko, fore-reef slope environment, Early Thanetian (SBZ 3), magnif. 80x.

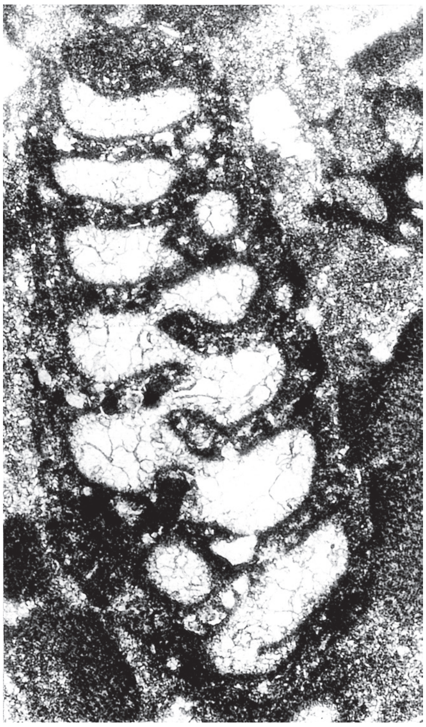
Fig. 2. *Valvulina* sp. Myjavská pahorkatina Upland, Kravárikovci, block 5, thin section 1 Ko, fore-reef slope environment, Selandian- Early Thanetian (SBZ 2 – SBZ 3), magnif. 80x.

Fig. 3. *Valvulina* sp. Myjavská pahorkatina Upland, Jeruzalem, block 5, thin section 4 Ko, back-reef environment, Early Thanetian (SBZ 3), magnif. 80x.

Fig. 4. *Haddonia praeheissigi* Samuel, Köhler et Borza, section of the part of test. Pieniny, Veľký Lipník, block 10, thin section 1 Ko, back-reef environment, Early Thanetian (SBZ 3), magnif. 30x.

Fig. 5. *Haddonia praeheissigi* Samuel, Köhler et Borza. Pieniny, Veľký Lipník, block 1, thin section 1 Ko, back-reef environment, Early Thanetian (SBZ 3), magnif. 30x.

XXVIII



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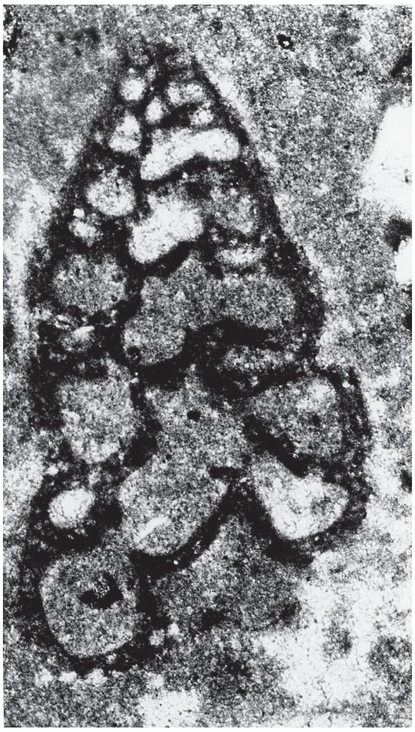

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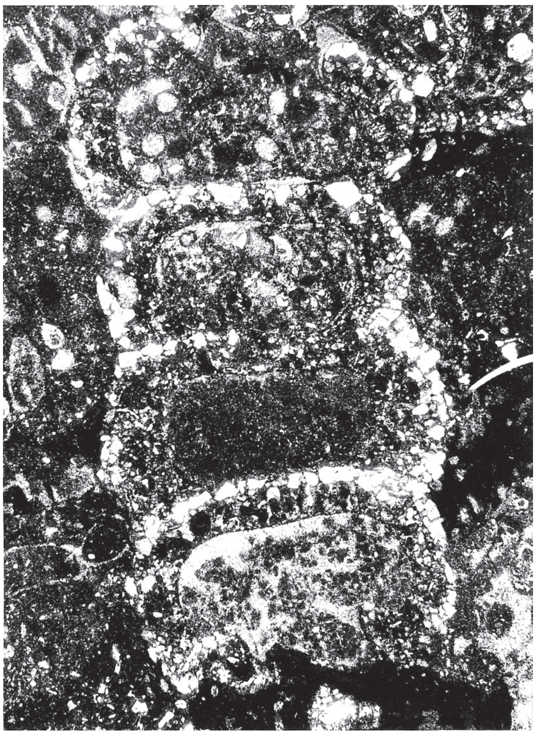

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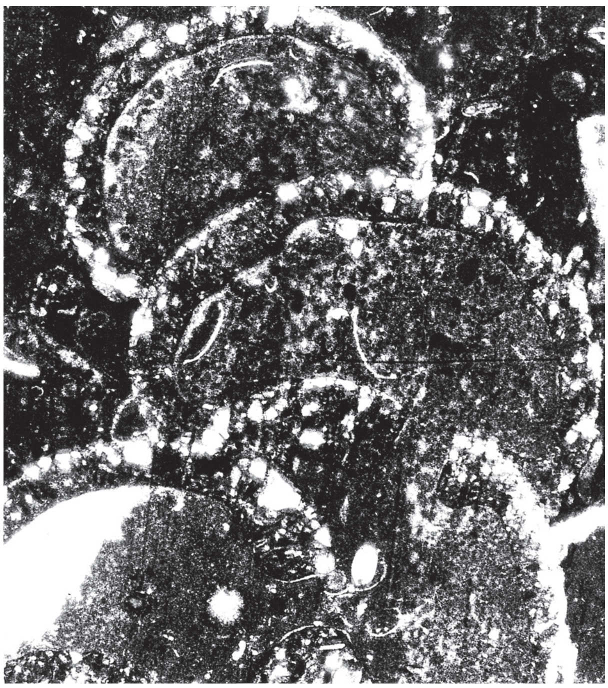

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Plate XXIX

Benthic foraminifers in the Palaeocene reef complex of the Western Carpathians

Fig. 1. *Plumokathina* sp. Myjavská pahorkatina Upland, Dedkov vrch, sample 1, thin section 6 Ko, fore-reef environment, Early Thanetian (SBZ 3), magnif. 80x.

Fig. 2. *Stomatorbina* (*Mississippina*) *binkhorsti* (Reuss). Middle Váh Valley, Svätá Helena, block 7, thin section 14 Ko, fore-reef environment, Early Thanetian (SBZ 3), magnif. 80x.

Fig. 3. *Sistanites iranicus* Rahaghi. Myjavska pahorkatina, Jablonka, sample 5, thin section 9 Ko, fore-reef environment, Early Thanetian (SBZ 3), magnif. 80x.

Fig. 4. *Smoutina* sp. Pieniny, Veľký Lipník, block 1, thin section 1 Ko, back-reef environment, Early Thanetian (SBZ 3), magnif. 30x.

Fig. 5. *Stomatorbina* (*Mississippina*) *binkhorsti* (Reuss). Middle Váh Valley, Hričovské Podhradie, block 2, thin section 19 Ko, fore-reef environment, Early Thanetian (SBZ 3), magnif. 80x.

Fig. 6. *Plumokathina* sp. Myjavská pahorkatina Upland, Tížikovci, block 3, thin section 5 Ko, fore-reef environment, Early Thanetian (SBZ 3), magnif. 30x.

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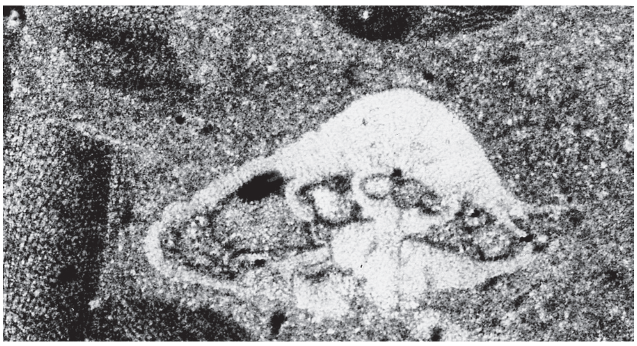

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Plate XXX

Sessile benthic foraminifers of the Palaeocene reef complex of the Western Carpathians

Fig. 1. *Miniacina multiformis* Scheibner. Pieniny, Veľký Lipník, block 8, thin section 1 Ko, reef structure, Early Thanetian (SBZ 3), magnif. 30x.

Fig. 2. *Miniacina multiformis* Scheibner. Pieniny, Haligovce – Paluby, sample 3, thin section 5 Ko, reef structure, Early Thanetian (SBZ 3), magnif. 30x.

Fig. 3. *Miniacina multiformis* Scheibner Myjavská pahorkatina Upland, Juríkovci, block 2, thin section 5 Ko, fore-reef slope environment, Early Thanetian (SBZ 3), magnif. 30x.

Fig. 4. Macroid made of overgrowing form *Solenomeris ogormani* Douvillé on the core with coralinne alga. Middle Váh Valley, Rybárikov laz, sample 2, thin section 1 Ko., fore-reef slope environment, Early Thanetian (SBZ 3), magnif. 30x.

Fig. 5. *Planorbulina cretae* (Marsson). Myjavská pahorkatina Upland, Jandova dolina, block 3, thin section 1 Ko, fore-reef slope environment, Selandian (SBZ 2), magnif. 30x.

Fig. 6. *Planorbulina cretae* (Marsson). Myjavská pahorkatina Upland, Jandova dolina, block 3, thin section 5 Ko, fore-reef slope environment, Selandian (SBZ 2), magnif. 30x.

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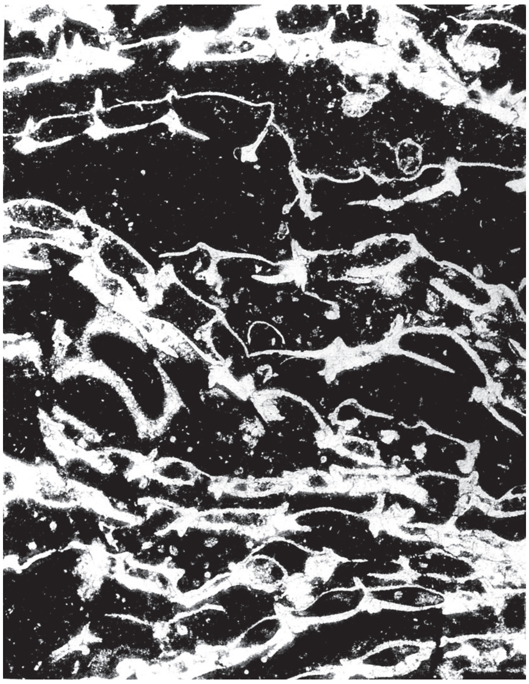

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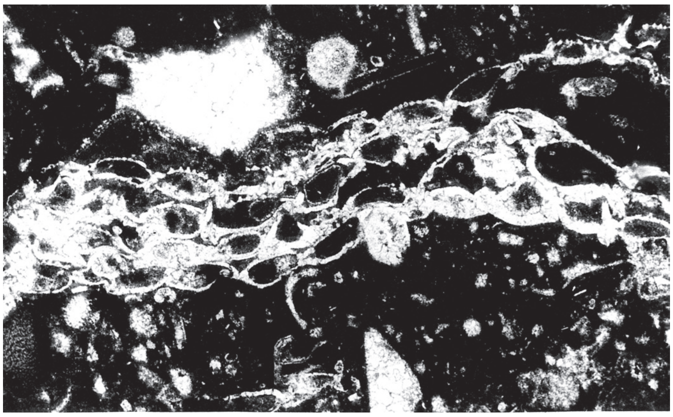

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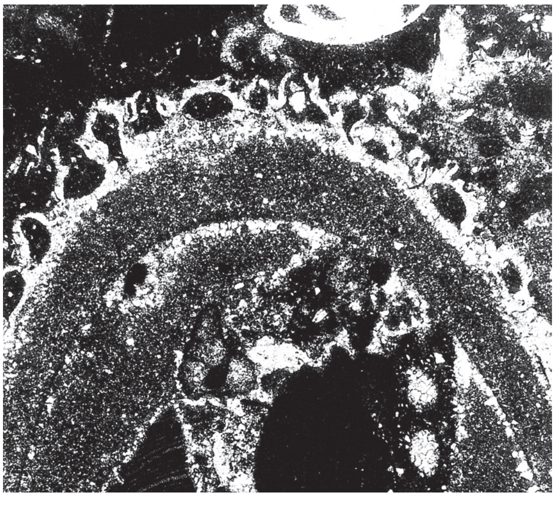

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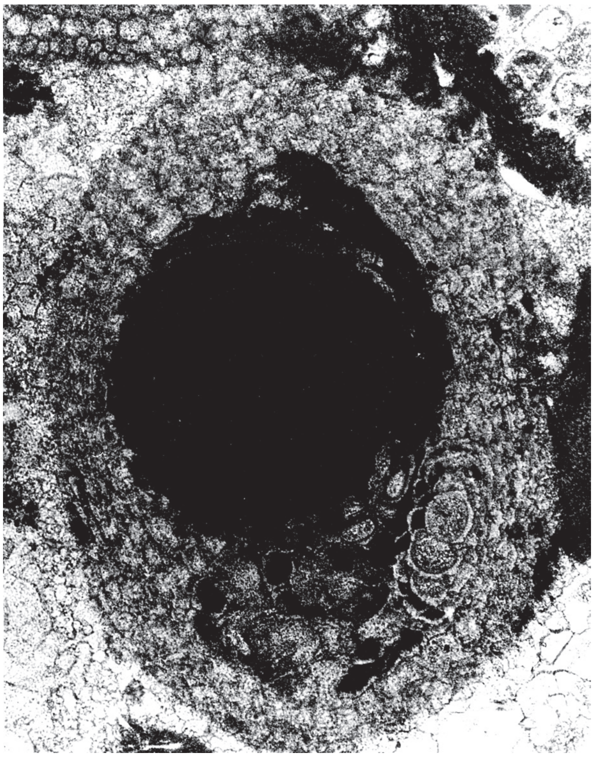

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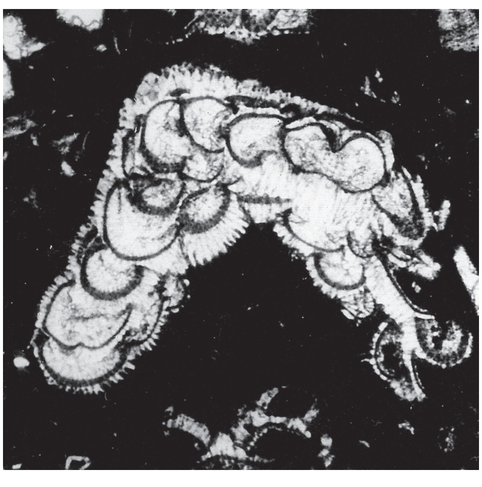

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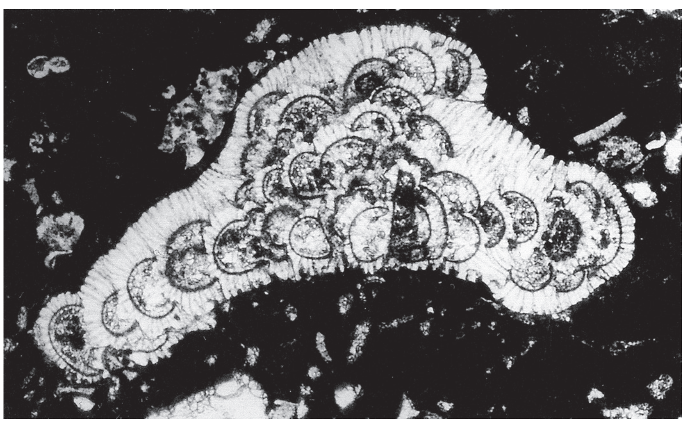

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Plate XXXI

Corals of the Palaeocene reef complex of the Western Carpathians

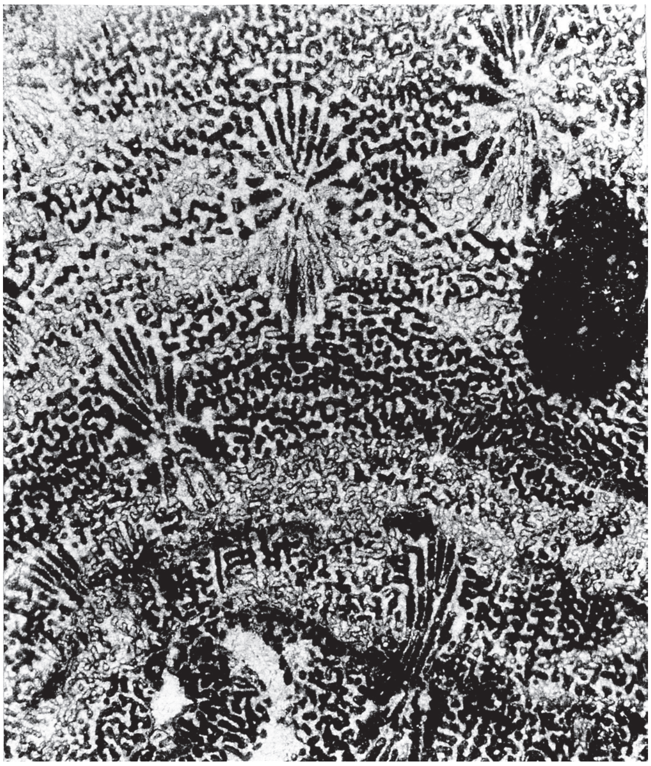
Fig. 1. *Actinacis* sp. forming structure. Myjavská pahorkatina Upland, Dlhý vŕšok, block11, thin section 4 Ko, fragment of reef structure (not *in situ*), Early Thanetian (SBZ 3), magnif. 10x.

Fig. 2. *Actinacis* sp., by bioerosion disrupted reef structure. Myjavská pahorkatina Upland, Jeruzalem, block 9, thin section 6 Ko, rim of reef structure, Early Thanetian (SBZ 3), magnif. 10x.

Fig. 3. *Actinacis* sp., structure of coralites. Malé Karpaty Mts., Vápenková skala, block 7, thin section 5 Ko, reef structure, Selandian (SBZ 2), magnif. 10x.

Fig. 4. *Litharaea* sp. Pieniny, Veľký Lipník, block 10, thin section 3 Ko, reef structure, Early Thanetian (SBZ 3), magnif. 10x.

XXXI



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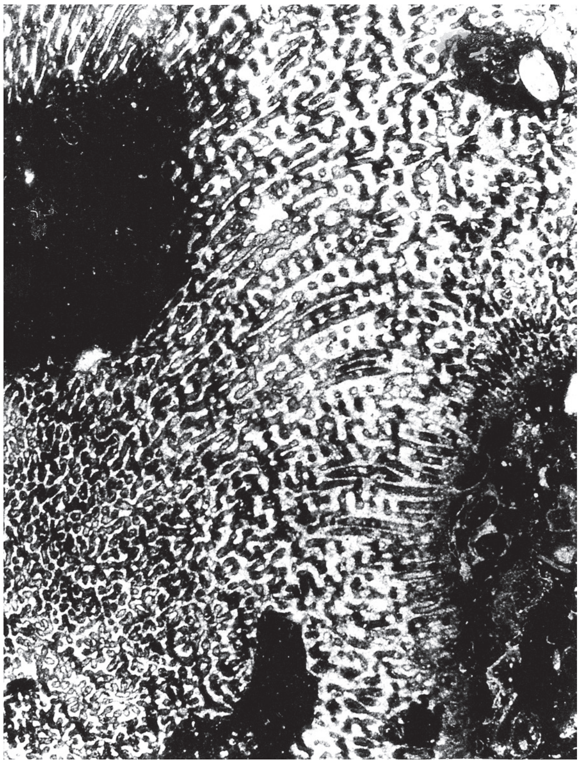

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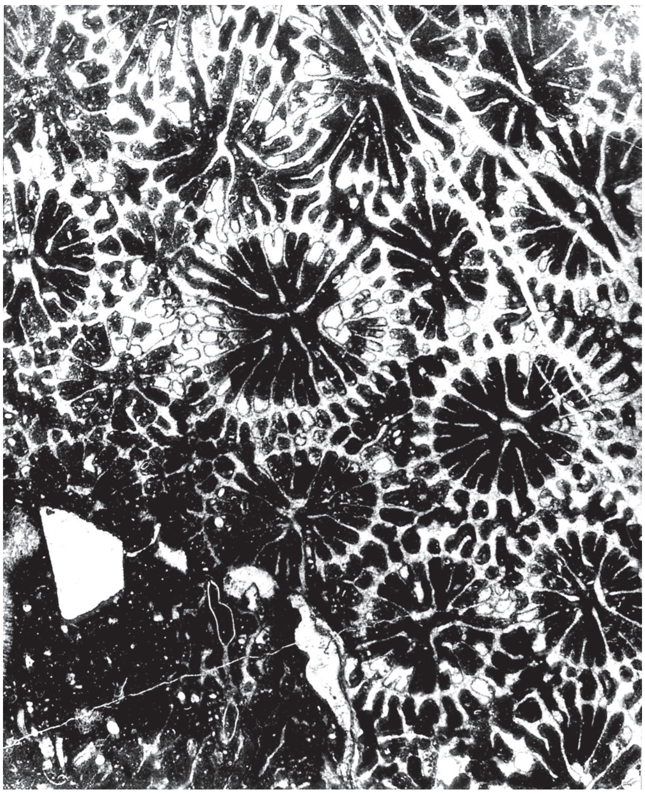

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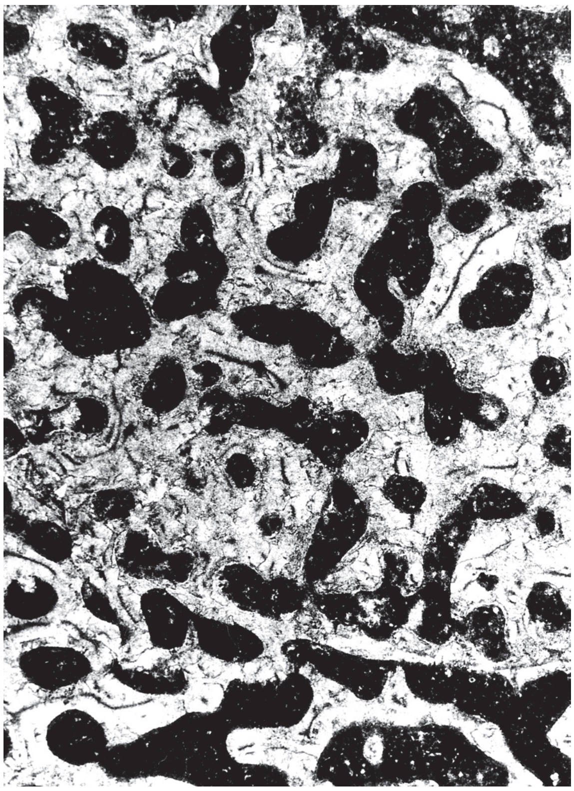

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Plate XXXII

Corals of the Palaeocene reef complex of the Western Carpathians

Fig. 1. *Actinacis* sp., by bioerosion disrupted structure. Myjavská pahorkatina Upland, Juríkovci, block 3, thin section 3 Ko, rim of reef structure, Early Thanetian (SBZ 3), magnif. 10x.

Fig. 2. *Actinacis* sp., structure of coralites. Middle Váh Valley, Hričovské Podhradie, block 8, thin section 9, reef structure, Early Thanetian (SBZ 3), magnif. 30x.

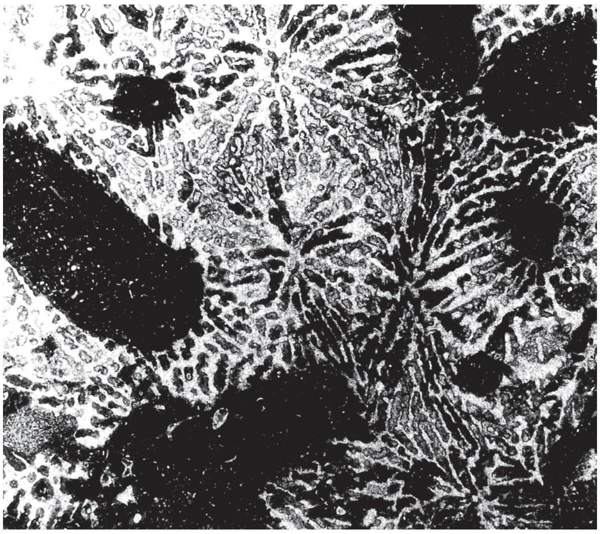
Fig. 3. *Stylocoenia* sp. Pieniny, Veľký Lipník, block 2, thin section 2 Ko, reef structure, Early Thanetian (SBZ 3), magnif. 30x.

Fig. 4. *Rhizangia* sp. Myjavská pahorkatina Upland, Hodulov vrch, block 2, thin section 1 Ko, rim of reef structure, Early Thanetian (SBZ 3), magnif. 30x.

Fig. 5. *Dendrophyllia* sp. Myjavská pahorkatina Upland, Lubina, block 5, thin section 4 Ko, fragment in fore-reef slope environment, Early Thanetian (SBZ 3), magnif. 30x.

Fig. 6. *Dendrophyllia* sp. Myjavská pahorkatina Upland, Ušiakovci, block 2, thin section 1 Ko, fragment in fore-reef slope environment, Early Thanetian (SBZ 3), magnif. 30x.

XXXII



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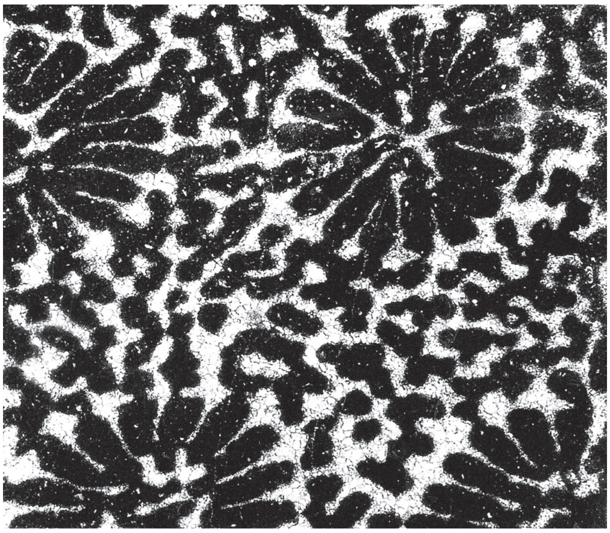

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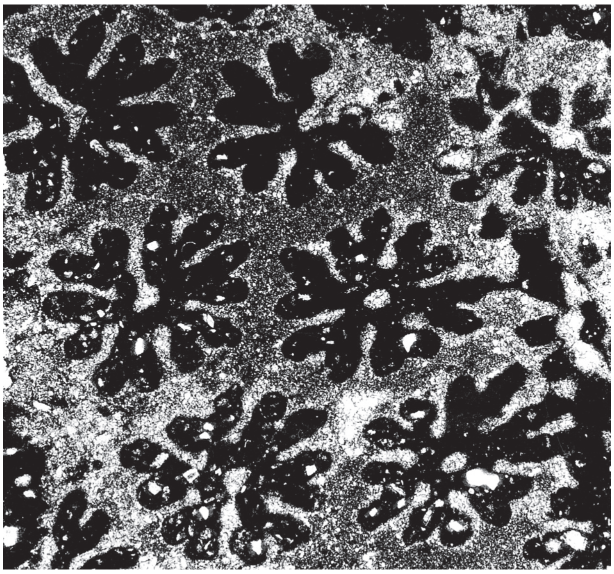

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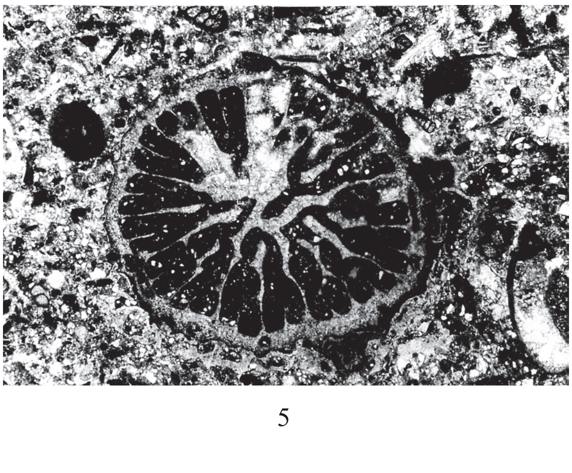

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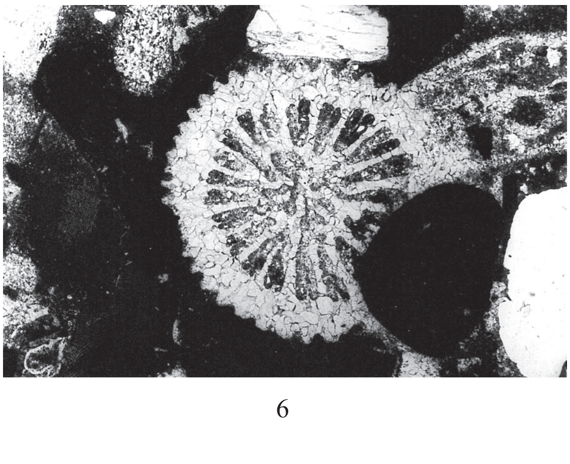

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Plate XXXIII

Corals of the Palaeocene reef complex of the Western Carpathians

Fig. 1. *Dendrophyllia* sp. Myjavská pahorkatina Upland, Hodulov vrch, block 2, thin section 2 Ko, reef structure, Early Thanetian (SBZ 3), magnif. 30x.

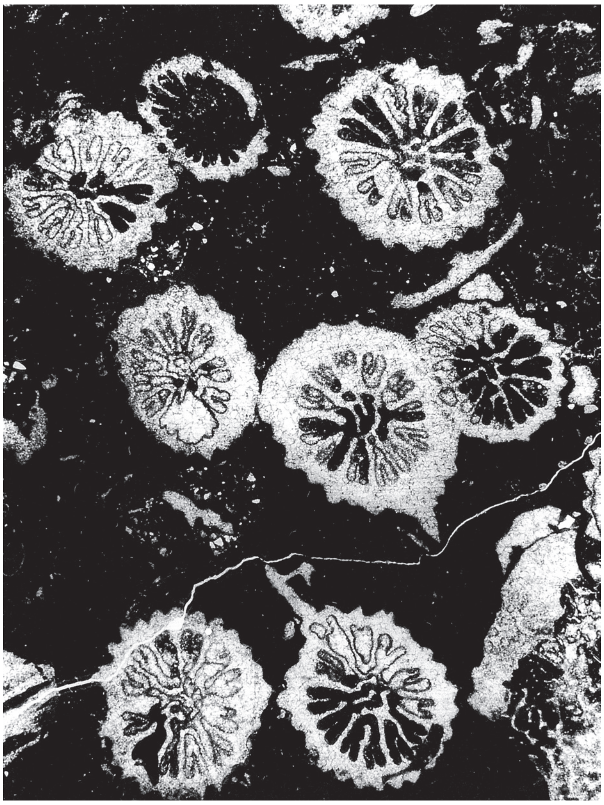
Fig. 2. *Dendrophyllia* sp. Myjavská pahorkatina Upland, Hodulov vrch, block 3, thin section 1 Ko, disrupted reef structure, Early Thanetian (SBZ 3), magnif. 30x.

Incertae sedis

Fig. 3. *Pieninia oblonga* Borza et Mišík in structure of *Litharaea* sp. Pieniny, Veľký Lipník, block 10, thin section 6 Ko, reef structure, Early Thanetian (SBZ 3), magnif. 30x.

Fig. 4. *Pieninia oblonga* Borza et Mišík in structure of *Litharaea* sp. Pieniny, Veľký Lipník, block 10, thin section 7 Ko, reef structure, Early Thanetian (SBZ 3), magnif. 30x.

XXXIII



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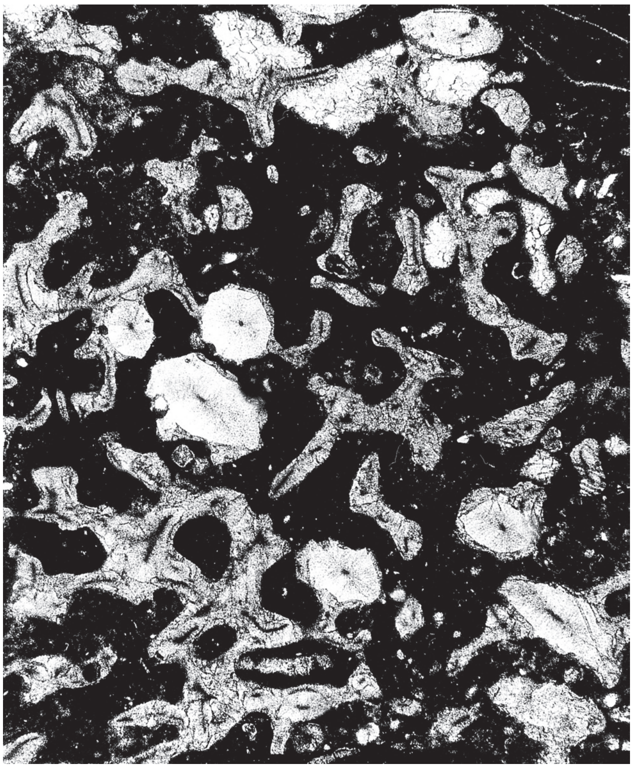

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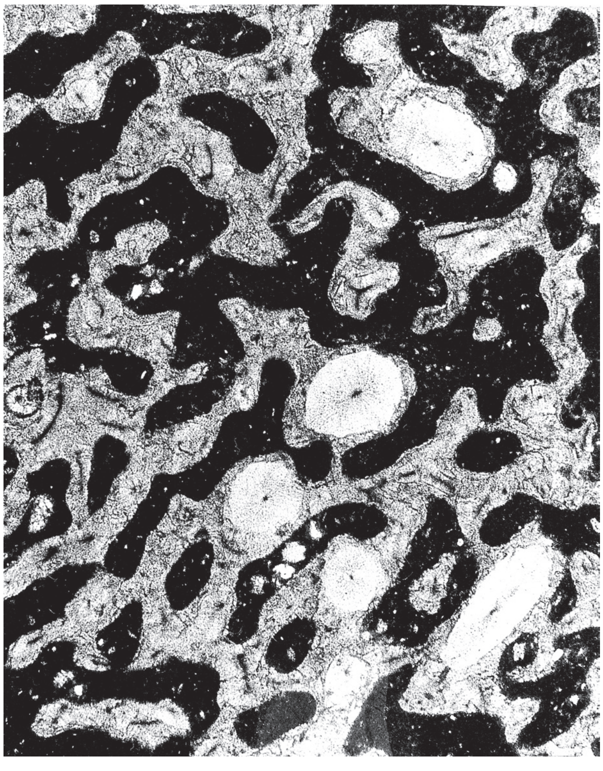

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Plate XXXIV

Macrofauna of the Palaeocene reef complex of the Western Carpathians

Fig. 1. Spike of echinoderm between branched zoarium of cyclostomate bryozoan. Middle Váh Valley, Hričovské Podhradie, block 6, thin section 1 Ko, fore-reef slope environment, Early Thanetian (SBZ 3), magnif. 30x.

Fig. 2. Section through fish tooth. Myjavská pahorkatina Upland, Jeruzalem, block 1, thin section 3 Ko, back-reef lagoonal environment, Early Thanetian (SBZ 3), magnif. 30x.

Fig. 3. Cross-section through crinoid segment. Myjavská pahorkatina Upland, Stará Turá, block 4, thin section 3 Ko, fore-reef slope environment, Early Thanetian (SBZ 3), magnif. 30x.

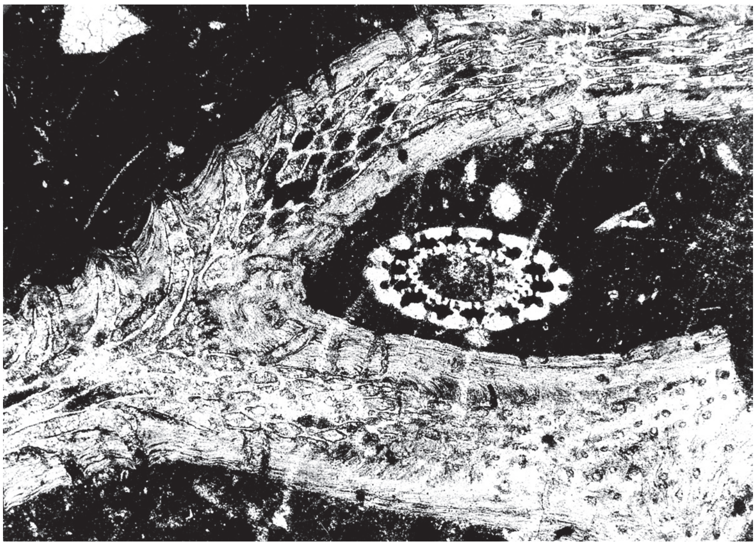
Fig. 4. Section through tube of worm *Ditrupa* sp. Slánske vrchy Mts., Radvanovce, block 1, thin section 7 Ko, fore-reef slope environment, Early Thanetian (SBZ 3), magnif. 30x.

Fig. 5. Section through tube-like test of worm *Ditrupa* sp. Myjavská pahorkatina Upland, Tížikovci, block 6, thin section 8 Ko, fore-reef slope environment, Early Thanetian (SBZ 3), magnif. 30x.

Fig. 6. Section through both shells of ostracod. Myjavská pahorkatina Upland, Hodulov vrch, block 8, thin section 2 Ko, back-reef lagoonal environment, Early Thanetian (SBZ 3), magnif. 30x.

Fig. 7. Section through both shells of ostracod. Myjavská pahorkatina Upland, Miškech Dedinka, block 5, thin section 1 Ko, back-reef lagoonal environment, Early Thanetian (SBZ 3), magnif. 30x.

XXXIV



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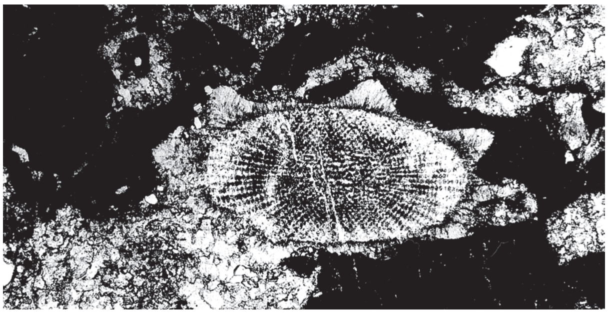

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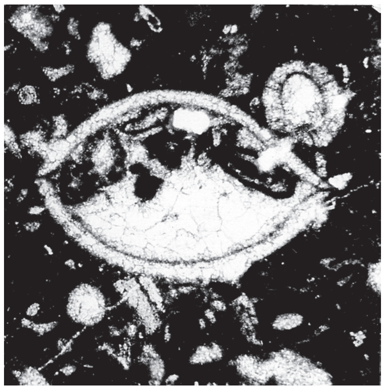

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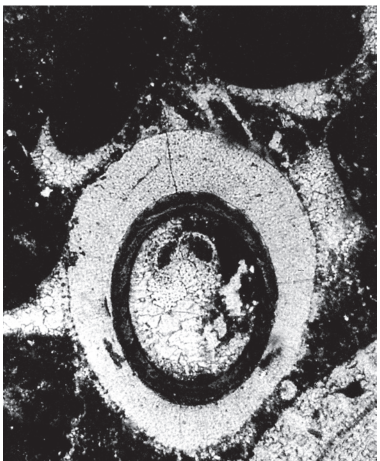

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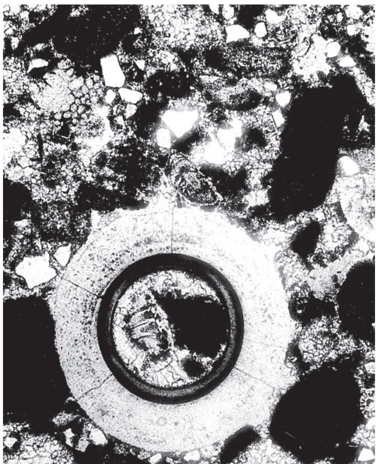

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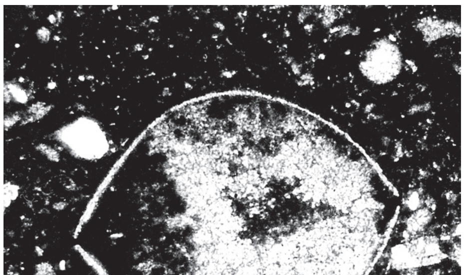

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Plate XXXV

Macrofauna of the Palaeocene reef complex of the Western Carpathians

Fig. 1. Sections through cyclostomate bryozoan. Middle Váh Valley, Kunovec, block 2, thin section 6 Ko, fore-reef slope environment, Early Thanetian (SBZ 3), magnif. 30x.

Fig. 2. Section through cheilostomate bryozoan. Middle Váh Valley, Hričovské Podhradie, block 10, thin section 17 Ko, fore-reef slope environment, Early Thanetian (SBZ 3), magnif. 30x.

Fig. 3. Section through cheilostomate bryozoan. Myjavská pahorkatina Upland, Jeruzalem, block 13, thin section 3 Ko, fore-reef slope environment, Early Thanetian (SBZ 3), magnif. 30x.

Fig. 4. Section through cheilostomate bryozoan. Myjavská pahorkatina Upland, Matejovec, block 4, thin section 1 Ko, fore-reef slope environment, Early Thanetian (SBZ 3), magnif. 30x.

Fig. 5. Connected tubes of serpulid worms. Myjavská pahorkatina Upland, Jablonka, sample 8, thin section 6 Ko, fore-reef slope environment, Early Thanetian (SBZ 3), magnif. 30x.

Fig. 6. Cheilostomate bryozoan overgrowing coralinne alga. Myjavská pahorkatina Upland, Dlhý vŕšok, block 4, thin section 3 Ko, fore-reef slope environment, Early Thanetian (SBZ 3), magnif. 30x.

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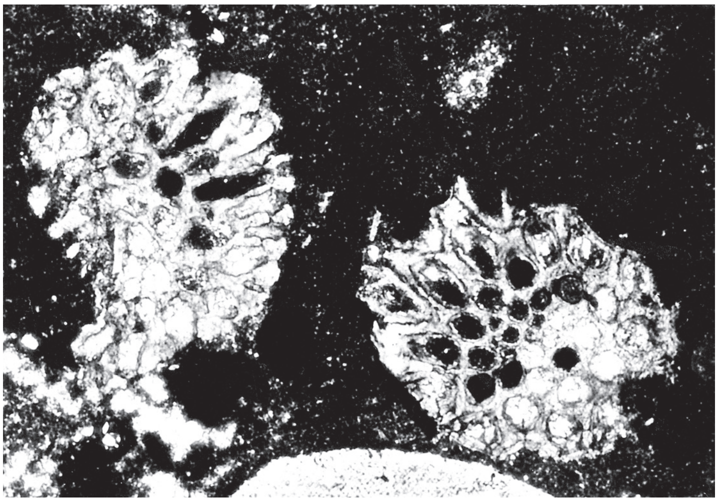

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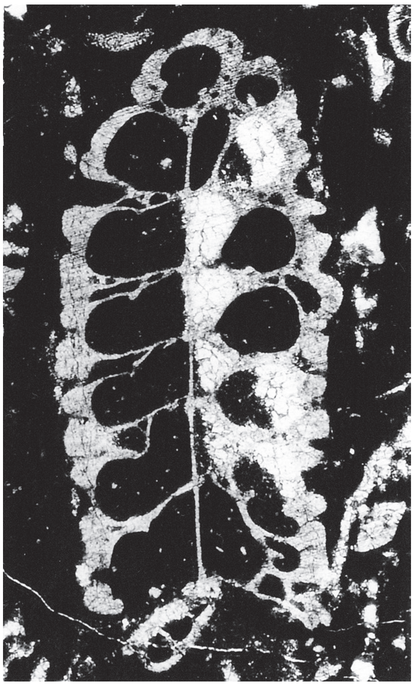

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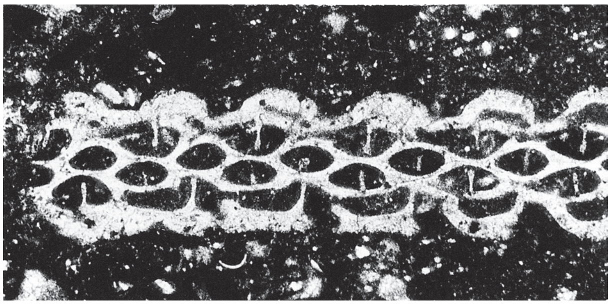

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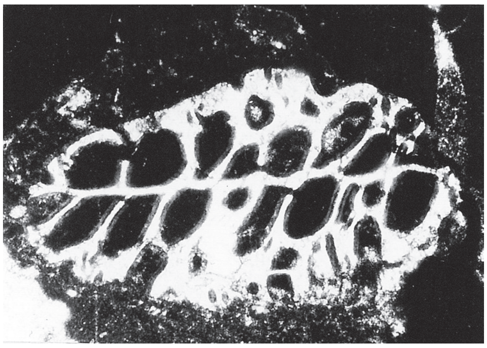

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Plate XXXVI

Macrofauna of the Palaeocene reef complex of the Western Carpathians

Fig. 1. Cross-sections through tiny gastropods. Pieniny, Veľký Lipník, block 5, thin section 5 Ko, back-reef lagoonal environment, Early Thanetian (SBZ 3), magnif. 30x.

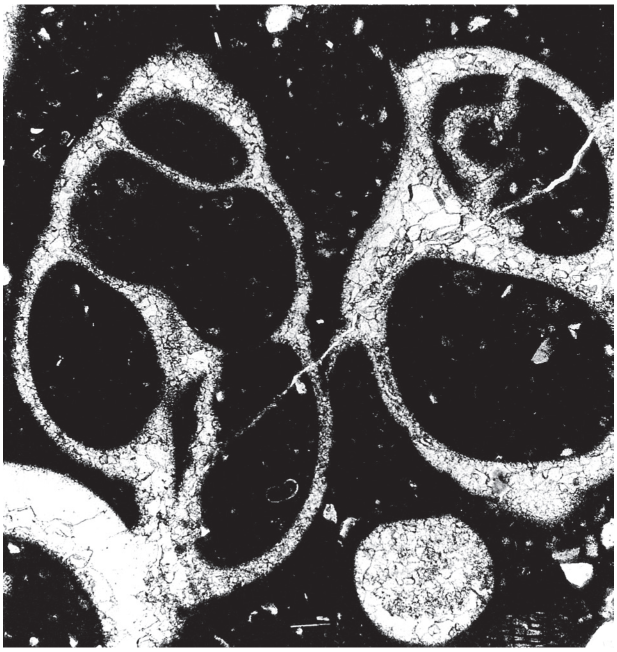
Fig. 2. Longitudinal cross-section through a gastropod shell. Myjavská pahorkatina Upland, Jeruzalem, block 3, thin section 3 Ko, back-reef lagoonal environment, Early Thanetian (SBZ 3), magnif. 30x.

Fig. 3. Longitudinal cross-section through a gastropod shell. Myjavská pahorkatina Upland, Miškech Dedinka, block 3, thin section 2 Ko, back-reef lagoonal environment, Early Thanetian (SBZ 3), magnif. 30x.

Fig. 4. Section through a shell of bivalve with traces of a hinge. Myjavská pahorkatina Upland, Matejovec, block 4, thin section 1 Ko, fore-reef slope environment, Early Thanetian (SBZ 3), magnif. 30x.

Fig. 5. Fragment of a shell of bivalve. Myjavská pahorkatina Upland, Stará Turá, block 2, thin section 1 Ko, fore-reef slope environment, Early Thanetian (SBZ 3), magnif. 30x.

XXXVI



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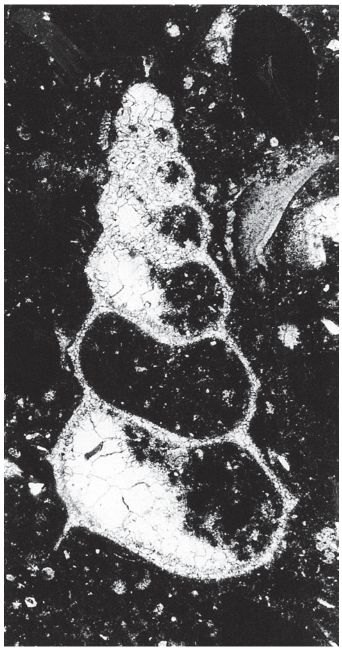

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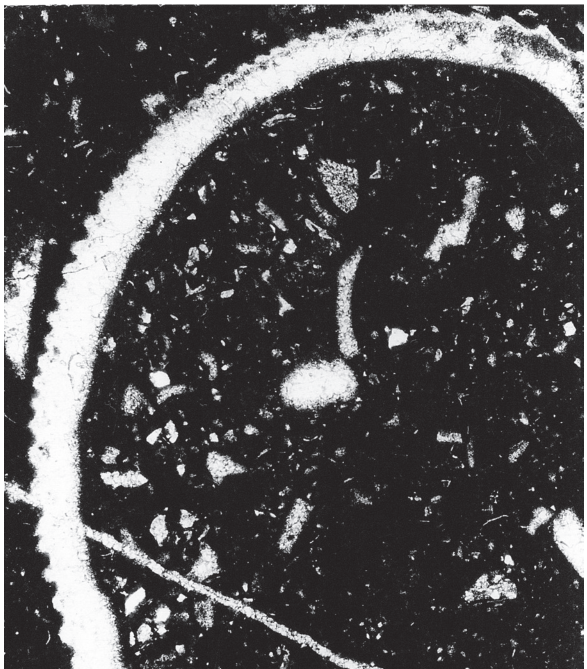

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