Štepnická skala Klippe – unique type of the Czorsztyn Succession (Pieniny Klippen Belt, Western Carpathians)

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Štepnická skala – zvláštny vývoj čorštynskej jednotky (pieninské bradlové pásmo, Západné Karpaty)

Abstract: Štepnická skala represents a specific klippe of the Czorsztyn Succession (Pieniny Klippen Belt). The specificity of the klippe is prevalence of non-condensed micritic limestones over the condensed, *Ammonitico Rosso*-type limestones. The stratigraphic succession starts with pink to reddish crinoidal limestone (Krupianka Limestone Formation – Bajocian), which is overlain by nodular limestones of the *Ammonitico Rosso* facies (Czorsztyn Limestone Formation – Bathonian). Then follows thick Bohunice Formation (Bathonian-Lower Tithonian) which shows large lateral and vertical variability. Therefore this formation was subdivided to new-defined members: Medné Limestone Member (*Bositra* coquina – Bathonian-Callovian), micritic/crinoidal Štepnice Limestone Member (Callovian-Lower Oxfordian), micritic Babiná Limestone Member (Upper Callovian-Oxfordian), Kočkovce Limestone Member (ammonite coquina – Oxfordian) and *Saccoccoma* Streženice Limestone Member (Kimmeridgian-Lower Tithonian). In the Babiná Limestone Member, flat mound with stromatactis-like structures is visible. It was formerly interpreted as true stromatactis mud-mound but it lacks signs of microbial cementation which are typical for stromatactis mud-mounds. Bohunice Formation is overlain by Dursztyn Limestone Formation with very similar facies development (Tithonian-Berriasian).

Key words: Western Carpathians, Pieniny Klippen Belt, Czorsztyn Succession, lithostratigraphy, microfacies

1. ÚVOD

Štepnická skala is a hill with a klippe situated SSW of the town Púchov in the western Slovakia, about 500 m SE of the Štepnice Settlement (part of Streženice Village) (Fig. 1). The klippe is cut by two abandoned quarries exposing substantial part of its lithological content. The klippe belongs to the Czorsztyn Succession and is in tectonically overturned position. The Czorsztyn Succession is the shallowest unit of the Oravic Superunit which dominates the Pieniny Klippen Belt. This belt (Fig. 1A) is a narrow, tectonically complicated zone of the Western Carpathians, forming the boundary between their internides and externides. Czorsztyn Succcession is considered to be paleogeographically located on a swell or ridge which was derived from the North-European Platform and was transported far to the south during the Middle/Late Jurassic time (for reconstruction, see Aubrecht et al., 2009). The lithostratigraphic content of the Czorsztyn Succession was defined by Birkenmajer (1977), but Štepnická skala Klippe does not match this definition; it is closer to the Mestečko-type distinguished by Aubrecht (1992) (for the lithostratigraphic division of the Czorsztyn Succession – see Fig. 2). The Mestečko development is devoid of *Ammonitico Rosso* types of limestones (Czorsztyn Limestone). Instead, varieties of non-nodular micritic limestones are present (e.g. Bohunice Limestone Formation – Mišík et al., 1994). However, succession of the Štepnická skala Klippe is specific in many aspects which are not present at other localities. The locality was mentioned already by Andrusov (1945, p. 17) as the only example of the occurrence of so-called "ammonite breccia". Andrusov (l.c.) in his time knew only several boulders of this breccia because the quarries did not exist yet. This paper provides detailed description of the individual lithostratigraphic units forming the Štepnická skala Klippe and their microfacies characteristics.

2. METHODS

The lithology was studied in three sections situated in the southern, middle and northern part of the larger quarry (distance between the sections is about 30 m), as well as in the smaller quarry situated north of it. Bed thicknesses were measured and each section was sampled meter by meter. Petrographical sampling was complemented by paleontological sampling of ammonites (Schlögl, 2002) and brachiopods (M. Krobicki, AGH, Cracow and A. Tomašových SAS, Bratislava). Due to exceptional abundance of fauna, paleontological sampling and taphonomical analysis has not been finished yet. Their detailed results will be then presented later in a separate paper. Thin-sections of the petrographic samples were evaluated by microfacies analysis. Abundance

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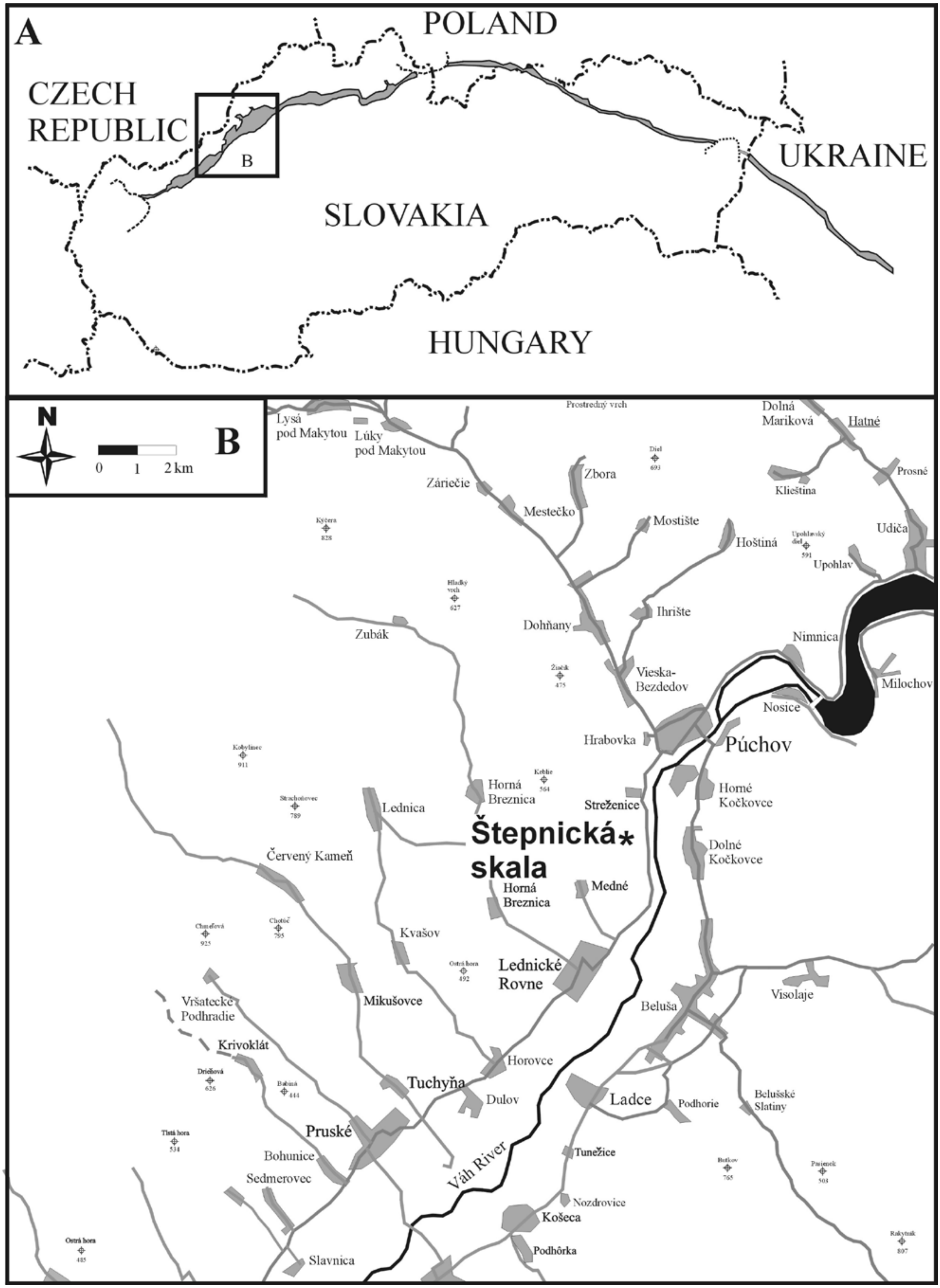
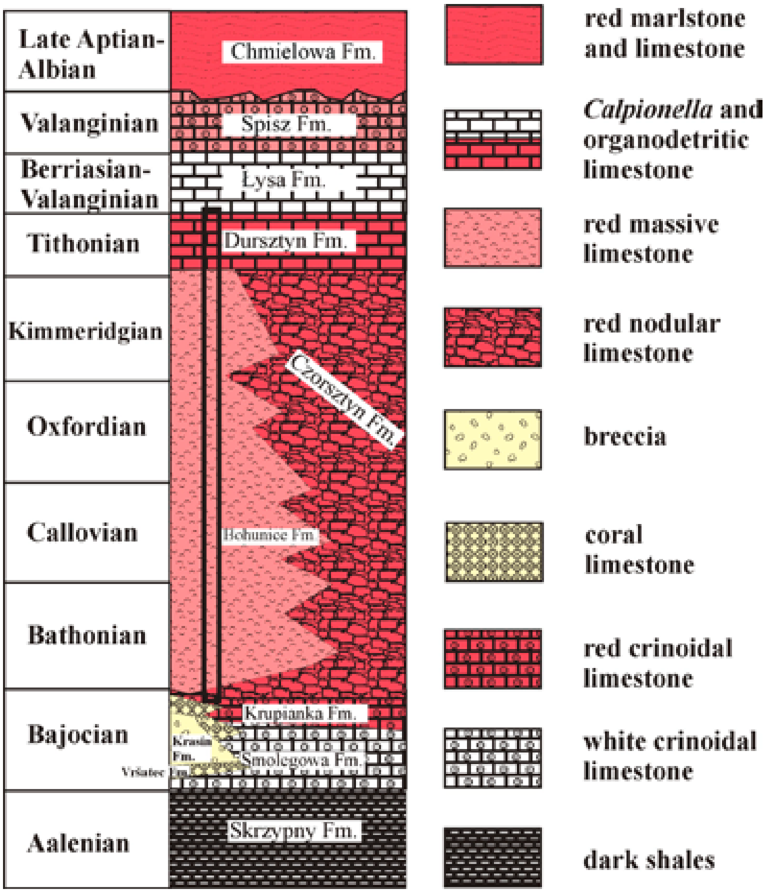


Fig. 1. Position of the examined locality. A – position of the locality within the Pieniny Klippen Belt, B – enlarged map.

Obr. 1. Pozícia skúmanej lokality. A – pozícia lokality v rámci bradlového pásma, B – zväčšená mapa.

Fig. 2. Lithostratigraphic scheme of the Czorsztyn Unit from the Aalenian to Albian. Black quadrangle marks the lithostratigraphic span of the Štepnická skala klippe.

Obr. 2. Litostratigrafická schéma čorštynskej jednotky od álenu do albu. Čierny obdĺžnik označuje litostratigrafické rozpätie bradla Štepnická skala.



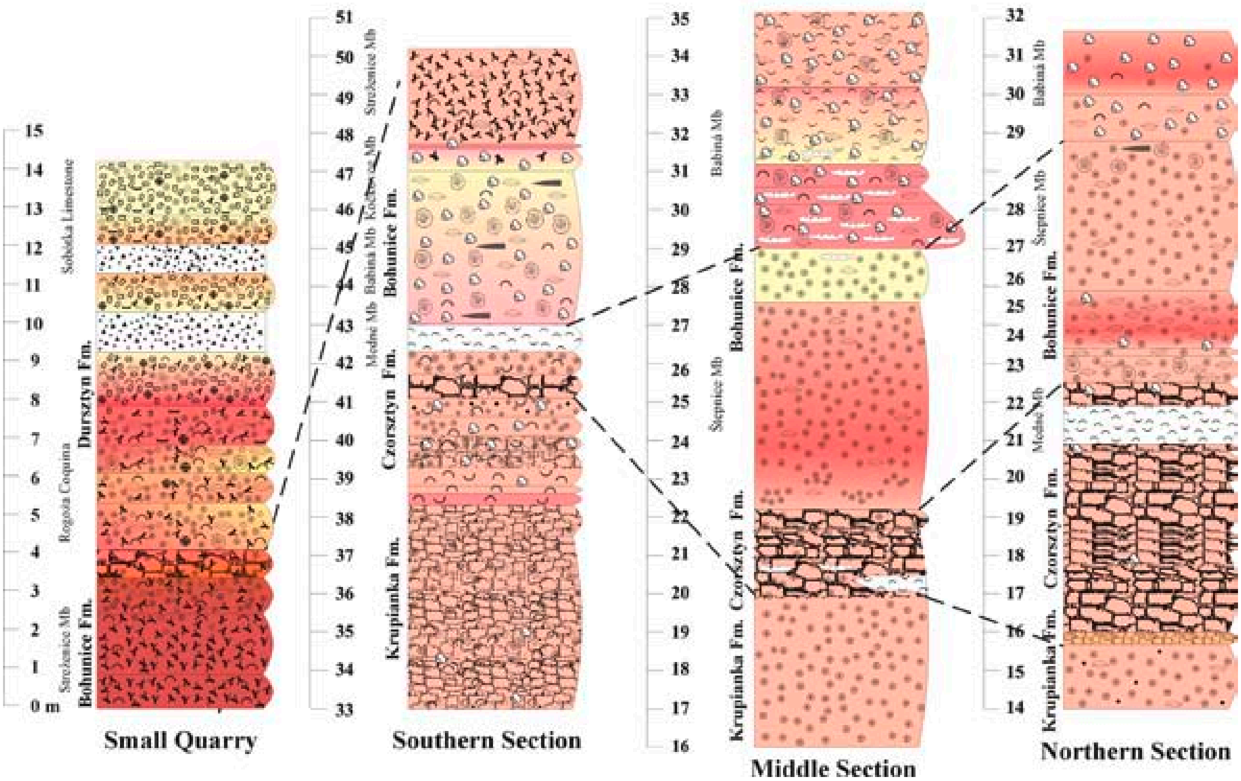


Fig. 3. Lithological sections of the examined locality, showing facies variability of the klippe.

Obr. 3. Litologické profily na skúmanej lokalite poukazujúce na laterálnu variabilitu bradla.

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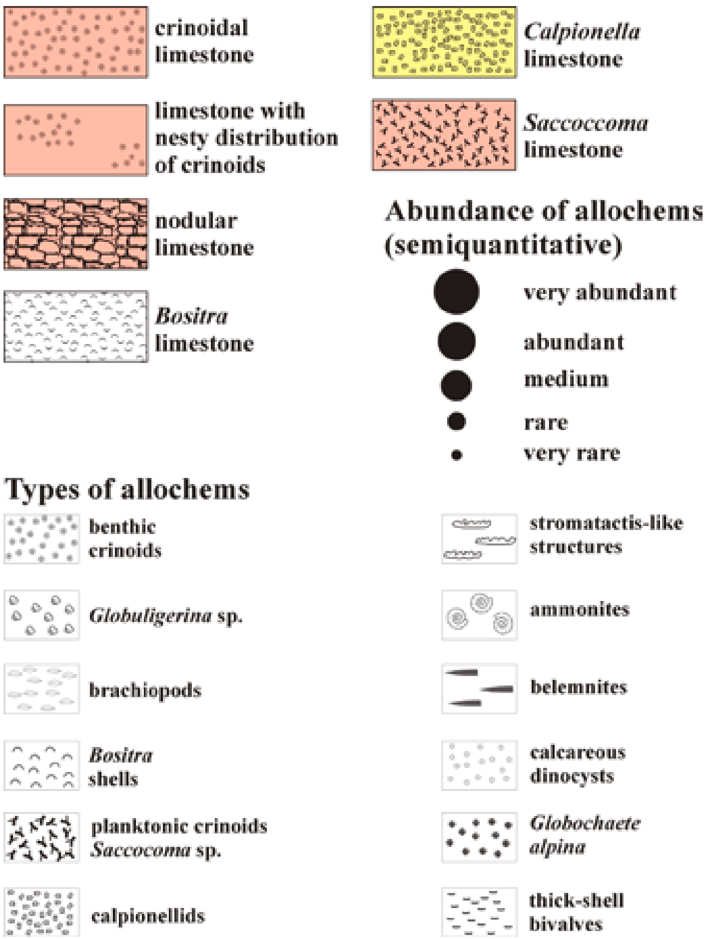

Fig. 3a – continuation: Explanations to figures 3-5.

Obr. 3a – pokračovanie: Vysvetlivky k obr. 3-5.

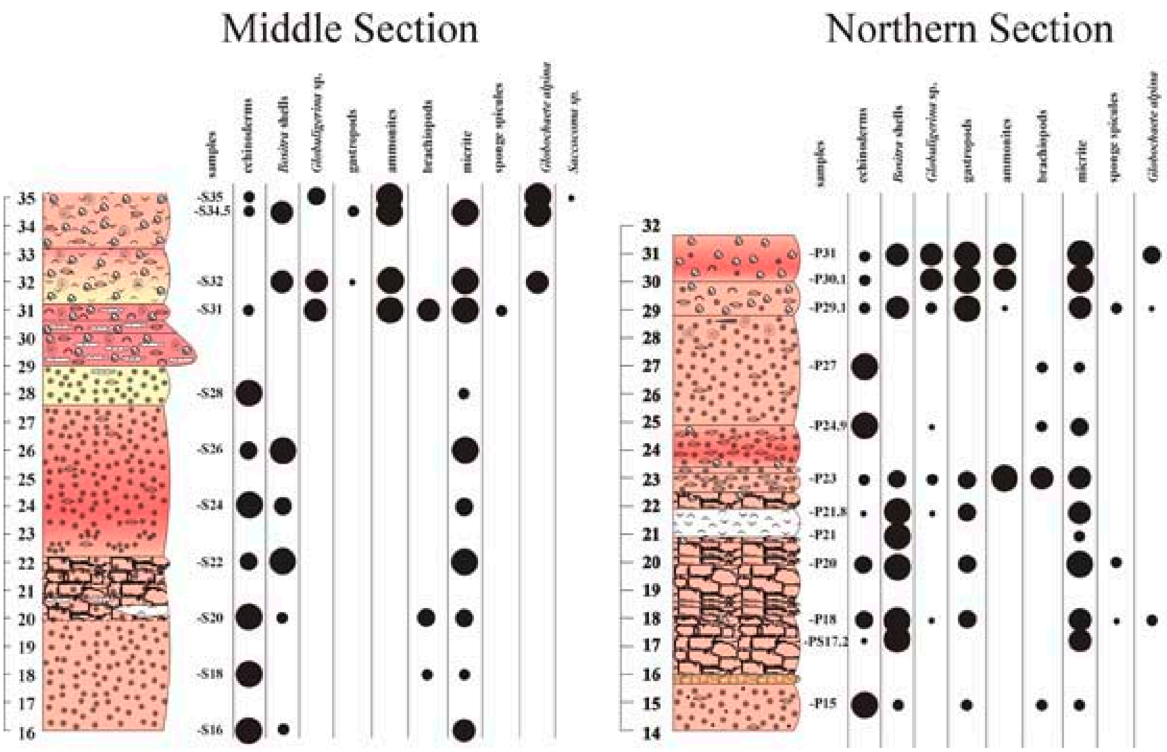

Fig. 4. Distribution of the limestone components in the northern and middle sections.

Obr. 4. Distribúcia komponentov vo vápencoch severného a stredného profilu.

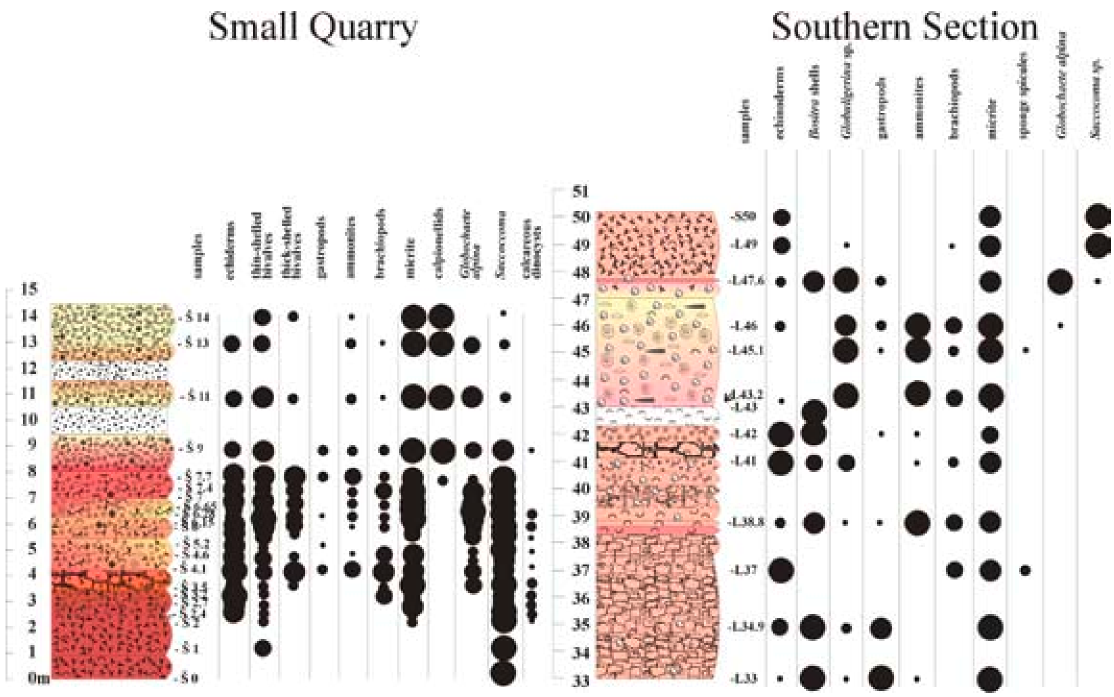

Fig. 5. Distribution of the limestone components in the southern section and small quarry.
Obr. 5. Distribúcia komponentov vo vápencoch južného profilu a malého lomu.

of allochems was evaluated semiquantitatively and plotted along the lithological logs (Figs. 3-5). Petrological analysis was complemented by SEM study of some samples from stromatactis-like structures and their host rocks. They were also analysed for O and C stable isotopes. Selected bulk samples and several generations of cavity fillings were analysed by standard methods of Craig (1957) at the Belarusian Academy of Science, Minsk, Belarus (spectrometer SUMY).

3. LITHOLOGICAL DESCRIPTION OF THE KLIPPE

Composition of the individual sections shows considerable lateral variability of the facies. The larger quarry (N 49°5'45.1'', E 18°17'55.6'', Fig. 7A) cuts limestones with stratigraphic range from Bajocian to Kimmeridgian; the smaller quarry (N 49°5'52.7'', E 18°17'52.0'', Fig. 7B) starts in the Kimmeridgian and ends in the Upper Tithonian-Lower Berriasian limestones. The stratigraphical base of the klippe is represented by Krupianka Limestone Formation (pink crinoidal limestones), which are partly nodular in the southern section. Bajocian age is inferred for this formation on the basis of previous research of Krobicki & Wierzbowski (2004). It is not possible to estimate their thickness as there is no visible contact with the older, Aalenian shales (Skrzypny Shale Formation).

Stratigraphically younger is Czorsztyn Limestone Formation (red nodular limestone – *Ammonitico Rosso*-type, Fig. 7C) with large lateral variability expressed by variable thickness. It is 5 m thick in the northern section, 2 m thick in the middle section and only 0.5 m thick in the southern section. However, this attenuated part does not correspond completely to the stratigraphic span of the limestones in the first two sections. There is probably a lateral replacement of the crinoidal and nodular limestone facies by *Bositra* coquina (see below). Stratigraphic base of the Czorsztyn Limestone Formation (about 20.4 m level in the mid-

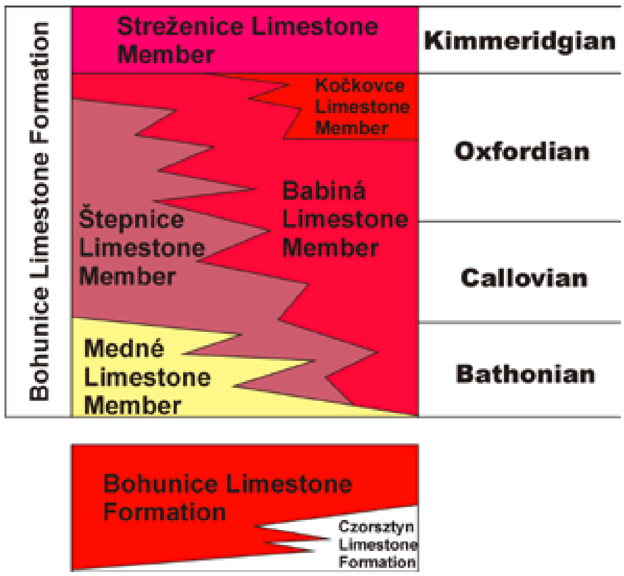

Fig. 6. Subdivision of the Bohunice Limestone Formation and the mutual relationship of its members (top) and the relationship of the Bohunice and Czorsztyn limestone formations at Štepnická skala Klippe (bottom).
Obr. 6. Členenie bohunického súvrstvia a vzájomné vzťahy jeho členov (hore) a vzájomný vzťah bohunického a čorštynského súvrstvia v bradle Štepnická skala (dole).

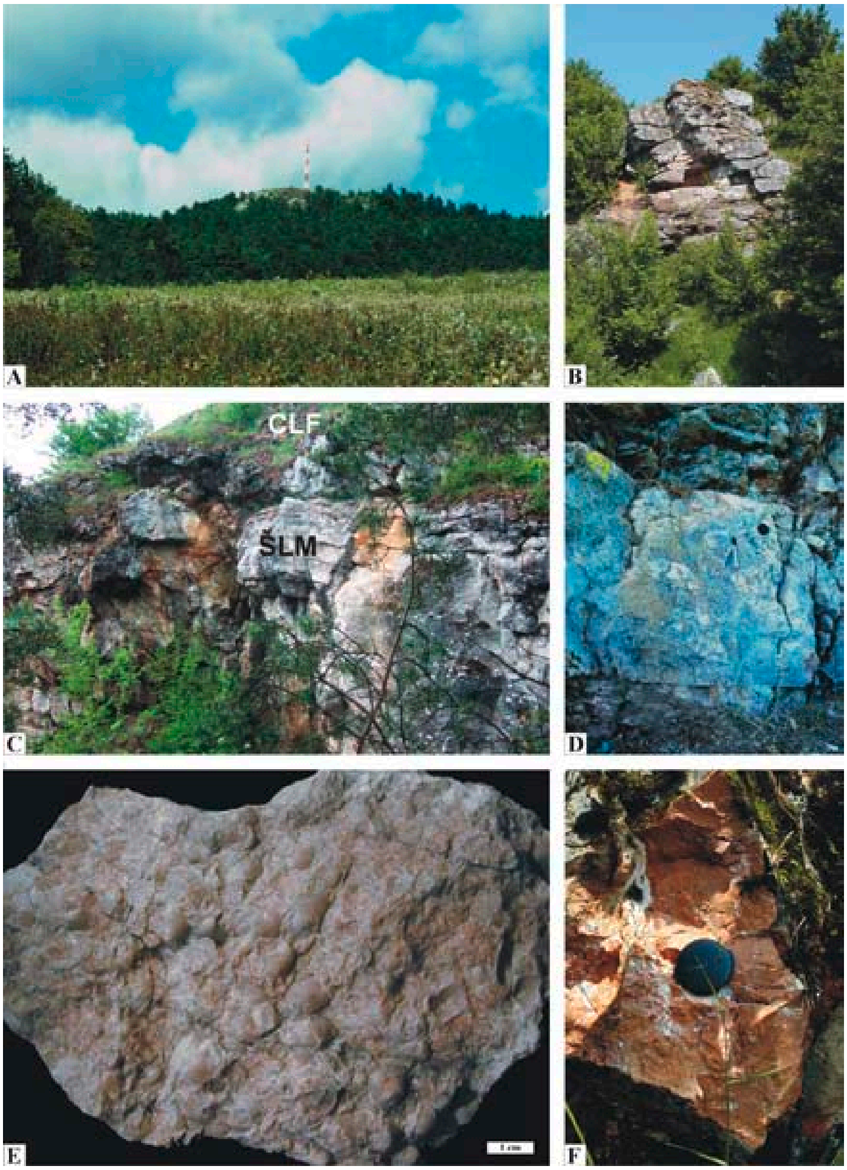

Fig. 7. Field photos of the quarries and some of the individual lithostratigraphic units. A – Main quarry – view from the road between Streženice and Lednické Rovne. B – View on the small quarry. C – View on the main quarry (Middle Section). Czorsztyn Limestone Formation (CLF) is visible in the upper part of the section; the main wall of the quarry is formed by the Štepnice Limestone Member (ŠLM). D – Layer of *Bositra* coquina (Medné Member of the Bohunice Limestone Formation) in the northern section. E – Closer view on *Bositra* coquina. F – Red micritic limestone (Babiná Member of the Bohunice Limestone Formation).

Obr. 7. Terénne fotografie lomov a niektorých litostratigrafických jednotiek. A – Hlavný lom – pohľad z cesty medzi Streženicami a Lednickými Rovňami. B – Pohľad na malý lom. C – Pohľad na hlavný lom (stredný profil). Na vrchu profilu vidno čorštynský vápenec (CLF); hlavná stena lomu je tvorená štepnickým vápencom (ŠLM). D – Vrstva bositrovej lumachely (medňanský vápenec – člen bohunického súvrstvia) v severnom profile. E – Bližší pohľad na bositrovú lumachelu. F – Červený kalový vápenec (babinský vápenec – člen bohunického súvrstvia).

dle section) yielded rich ammonite fauna, indicating the lowermost Bathonian. The most abundant is *Nannolytoceras tripartitum* (Raspail) (up to 90 %), then *Phylloceras* sp., *Calliphylloceras disputabile* (Zittel) and mainly *Morphoceras multiforme* Arkell, indicating Zigzag Zone, Macrescens Subzone (Schlögl, 2002; Schlögl et al., 2005).

The condensed Czorsztyn Limestone Formation is stratigraphically overlain by uncondensed limestone facies which can be connected under the formal name Bohunice Formation. This formation is variable, consisting of several members which are here formally distinguished for the first time (Fig. 6). They differ by their deposition environments and prevailing fossil components. In the northern section, about 1 m thick layer of white, *Bositra* limestone (*Bositra* coquina) occurs above the nodular limestone (Fig. 7D,E). It consists exclusively of thin shells of *Bositra buchi* (formerly known as *Posidonia alpina*). However, this layer is not continuous as it partly wedges out in the middle section. We suggest a new name for this member: Medné Limestone Member. Its probable age is Bathonian as it occurs within, or just above the Czorsztyn Limestone and can eventually reach Callovian. The name is derived from the nearby village Medné.

Still younger is red, massive micritic limestone with numerous crinoids. The crinoids are unevenly distributed, mostly forming nests in the micritic limestone but locally they pass to crinoidal packstone. This formation then consists of two mixed end-members – pink to red micritic limestone, with crinoidal limestone. It is obvious that the crinoidal limestone is not identical to that of the Krupianka Limestone Formation defined by Birkenmajer (1977). This limestone is somewhat younger than the *Bositra* coquina and also lacks formal name. Its bottom part may be of the Bathonian age and the top part reaches Lower Oxfordian, as indicated by the onset of the *Globuligerina* microfacies. Therefore we suggest a new formal name Štepnice Limestone Member (Fig. 7C, the name is derived from the nearby Štepnice Settlement). It differs from the Bajocian Smolegowa

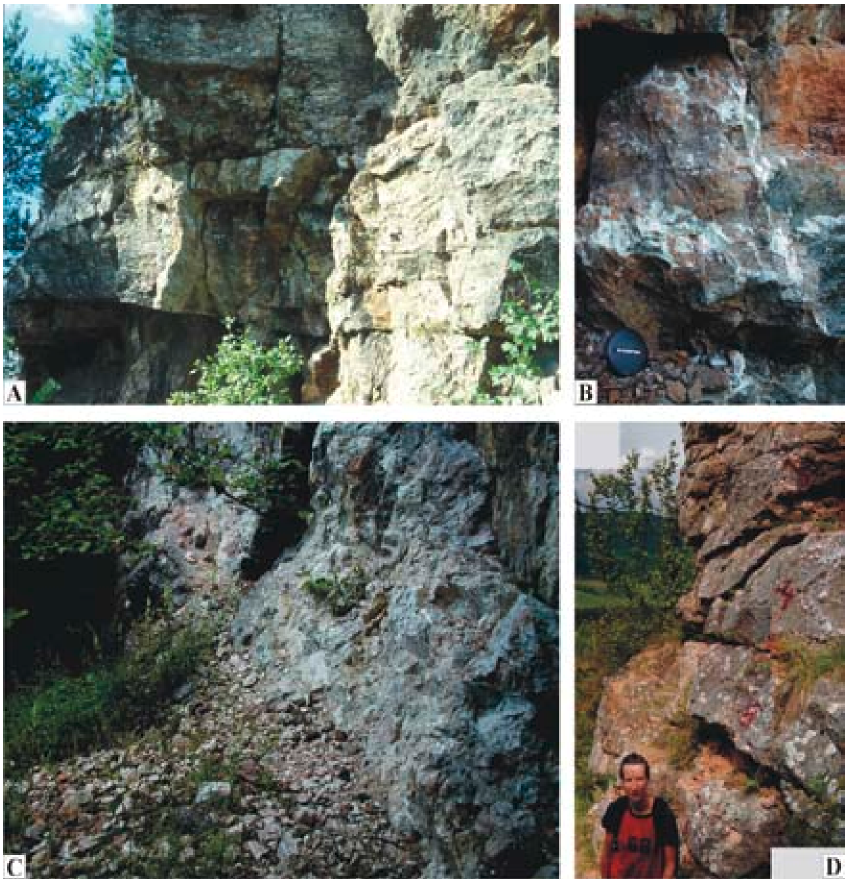

Fig. 8. Field photos of some lithostratigraphic units. A – Pinching-out beds of the flat mound-shaped body in the Babiná Member of the Bohunice Limestone Formation (middle section). B – Stromatactis-like structures in the mud-mound. C – Ammonite coquina (Kočkovce Member of the Bohunice Limestone Formation) with *Saccocoma* limestone (Streženice Member) below (tectonically overturned) in the southern section. D – Upper part of the small quarry formed by Streženice Member, passing downward (at the number 4 painted on the outcrop) to the Dursztyn Limestone Formation.

Obr. 8. Terénne fotografie niektorých litostratigrafických jednotiek. A – Vykliňujúce vrstvy plochej mikritickej kopy v rámci babinského vápenca bohunického súvrstvia (stredný profil). B – Štruktúry podobné štruktúram typu stromatactis v mikritickej kope. C – Amonitová lumachela (kočkovský vápenec bohunického súvrstvia) so sakokomovým vápencom (streženický vápenec) v podloží (v prevrátenom slede, južný profil). D – Vrchná časť malého lomu tvorená streženickým vápencom, ktorý nižšie (pri čísle 4 na odkryve) prechádza do durštynského súvrstvia.

and Krupianka limestones by much higher content of micrite admixture and by larger crinoidal ossicles. On the other hand it differs from the typical red micritic Bohunice Limestone (here named as Babiná Limestone Member – see below) defined by Mišík et al. (1994) by having rich crinoidal detritus. The limestone is rich in brachiopods and locally brachiopod-ammonite coquinas are present (mainly in the northern section, in 22.5-23.5 m levels).

Another facies, partly alternating with the Štepnice Limestone Member but reaching Upper Oxfordian is pink to beige micritic limestone (Fig. 7F) with ammonites, brachiopods, bivalves and belemnites. This limestone can be identified as typical Bohunice Limestone of Mišík et al. (1994). In this new subdivision we suggest a new formal name for this limestone: Babiná Limestone Member (the name is derived from Babiná Hill at which the Bohunice Formations was first described and where the alternation with the Štepnice Limestone Member is well visible). It is about 4 m thick in the southern section. The observable thickness in the middle section is 6 m and in the northern section about 3.5 m. However, there are no younger strata present in these two sections and the overall thickness cannot be estimated. The situation is complicated by some occurrences of red micritic limestones with ammonite fauna of Callovian age in the lower parts of the Bohunice Limestone Formation which were interpreted as filling of neptunian sills (Schlögl et al., 2009). In the middle section, two beds are present, pinching out laterally in 10 m distance (Fig. 8A). These beds contain stromatactis-like structures (Fig. 8B) which infer that the beds may represent a small, flat stromatactis mud-mound (Aubrecht et al., 2002a). The beds yielded fragments of *Sowerbyceras* sp. which has, however, wider stratigraphic span and does not enable dating. The age of this member can be estimated to be Upper Callovian-Oxfordian.

Still higher (best visible in southern section), the Babiná Member passes into typical ammonite coquina (Fig. 8C) which resembles Rogożnik Coquina Member but is of Oxfordian age. The coquina yielded ammonite fauna indicating Middle and Upper Oxfordian (Aubrecht & Schlögl, 2004). The Middle Oxfordian is indicated by *Adabofoloceras* sp., *Phylloceras* sp., *Holcophylloceras* sp., *Protetragonites* sp., *Trimarginites* sp., *Neoprionoceras* cf. *lautlingense* (Rollier), *Proscaphites anar* (Oppel), *Perisphinctes (Arisphinctes)* aff. *plicatilis* (Sowerby), *Gregoryceras (G.)* cf. *riazi* (De Grossouvre), *Euaspidoceras* cf. *oegir* (Oppel) and *Mirosphinctes* sp. Upper Oxfordian was dated by the ammonites *Adabofoloceras* sp., *Phylloceras* sp., *Holcophylloceras* sp., *Sowerbyceras tortisulcatum* (d´Orbigny), *Protetragonites* sp., *Glochiceras (Coryceras) modestiforme* (Oppel), *Taramelliceras (Strebliticeras) externnodosum* (Dorn), *Euaspidoceras* sp. (cf. *E. radisense* (d´Orbigny)), *Mirosphinctes* sp., *Epipeltoceras bimammatum* (Oppel), *Aspidoceras* cf. *binodum* Fontannes. For this member we suggest a new name Kočkovce Limestone Member (after Horné and Dolné Kočkovce villages situated opposite to Štepnická skala across the Váh River).

In the southern section, Kočkovce Limestone Member is stratigraphically overlain by thick-bedded, brownish to reddish-brown *Saccocoma* limestone (Fig. 8C,D) which is the youngest lithostratigraphic unit exposed in the larger quarry but continues in the smaller quarry where it forms the stratigraphic base. Macroscopically it resembles crinoidal limestone but the ossicles are smaller and the sediment is much finer (about 1-2 mm in average). Locally, the limestone is more micritic, with brachiopods and bivalves. The limestone lacks formal name. Therefore, a new name – Streženice Limestone Member is suggested (after Streženice Village). The overall thickness cannot be calculated as it occurs in two separate sections with unknown overlap. In the smaller quarry, its preserved thickness does not reach over 3.5 m. The age of the formation, inferred from the prevailing *Saccocoma* microfacies is Kimmeridgian to Lower Tithonian.

The Bohunice Formation is stratigraphically overlain by the limestones which can be grouped to Dursztyn Limestone Formation (Fig. 8D), which is very similar to the Bohunice Formation in its facies development. It starts with reddish nodular limestone (Lower Tithonian – indicated by microfauna) with irregularly distributed crinoidal ossicles. The nodules are 3-5 cm in diameter, consist of micrite and are arranged parallel to the bedding. Higher up this limestone passes to slightly brecciated, pink, red to beige crinoidal-micritic limestone resembling Rogoża Coquina Member (Birkenmajer, 1977), with visible cross-sections of juvenile ammonites, bivalves and brachiopods.

The succession then continues by Rogoża Coquina Member, formed by massive, reddish, crinoidal-micritic packstone to wackestone (in the upper part) with nest-like distribution of crinoids (partly resembling Štepnice Limestone Member) evidencing large bioturbation. More micritic parts are stylolitized. These limestones take less than 2m as the succession is interrupted by about 3 m of debris and soil cover. The succession then continues by massive, beige wackestones to packstones of the Sobótka Limestone Member (Birkenmajer, 1977), which represent the youngest exposed lithostratigraphic unit of the klippe.

4. PETROGRAPHIC AND MICROFACIES DESCRIPTION OF THE INDIVIDUAL LITHOSTRATIGRAPHIC UNITS.

Krupianka Limestone Formation

The limestone represents crinoidal biosparite to biomicrite (grainstone to packstone), locally also pelmicrite. The micrite locally represents filling of voids originated by bioturbation. The sediment is well to poorly sorted. Along with crinoidal ossicles, the limestone contains rich sandy quartz admixture, clasts of dolomites and dedolomites, fragments of bivalve shells (locally oysters and *Bositra* shells), brachiopods, some foraminifers *Lenticulina* sp., nodosariid foraminifers, agglutinated sessile nubecularid foraminifers, agglutinated foraminifers *Ophthalmidium* sp., gastropods, echinoid spines and serpulid worm tubes.

Czorsztyn Limestone Formation

The limestone represents biomicrite – wackestone to packstone (Fig. 9A), frequently with nest-like distribution of allochems which indicates considerable bioturbation. Among some allochems, relic micrite-free voids occur, filled with pure calcite spar. The sediment contains intraclasts of similar limestones which can be distinguished by their contrastingly different contents of allochems. Some intraclasts are coated by Fe-Mn oxides. *Bositra* ("filamentous") microfacies prevails all over the limestone. Along with *Bositra* shells, crinoid ossicles, ostracods, agglutinated foraminifers *Dorothia* (*Marssonella*), calcareous foraminifers *Lenticulina* sp., and nodosariid foraminifers are also common. Planispiral ammodiscid foraminifers, nubecularid foraminifers, agglutinated foraminifers *Ophthalmidium* sp., calcified radiolarians, *Globochaete alpina*, echinoid spines, serpulid worm tubes, ghosts after sponge spicules, ghosts after aragonite bivalve shells, tiny gastropods and tiny half-moon shaped *Schizosphaerella* are rarely present, too. Very rarely, tiny representatives of *Globuligerina* sp. are present. In some thin-sections "microforaminifers" were found. They represent ferroan coatings (impregnated organic coatings) of the juvenile chambers of foraminiferal tests which were preserved after their dissolution (Mišík & Soták, 1998). One fragment of fine-laminated Fe-Mn stromatolite was observed, too. Some allochems are strongly bored by various organisms. In one case, a neptunian "microdyke" was observed, filled with micrite containing *Bositra* shells with transition to sterile micrite free of allochems. The rock is penetrated by stylolites which represent late-diagenetic phenomena.

Bohunice Limestone Formation

Medné Limestone Member (*Bositra* coquina)

It represents a pure *Bositra* biosparite with well-sorted, mostly shells equally oriented by bottom currents (Fig. 9B). Only locally some geopetal micritic filling was preserved under the shells. Other allochems are rare, e.g. agglutinated foraminifers and ostracods. One fragment of reptile bone was found, too.

Štepnice Limestone Member (micritic/crinoidal limestone)

It represents crinoidal-*Bositra* biomicrite, locally biosparite (Fig. 9C), with various levels of sorting. In biosparites, pure, euhedral syntaxial overgrowths are developed on the crinoid ossicles. Unlike the Krupianka Limestone Formation, size of the ossicles is variable, including very large plates and sometimes connected basals of crinoidal calices. The rock commonly contains dolomitic lithoclasts, quartz sandy admixture, fragments of bivalve and brachiopod shells (including ghosts after aragonite shells), foraminifers *Lenticulina* sp., agglutinated foraminifers *Ophthalmidium* sp., rare foraminifers *Dorothia* (*Marssonella*) sp., nubecularid foraminifers, nodosariid foraminifers, echinoid spines, serpulid worm tubes, gastropods, intraclasts with *Bositra* microfacies and rare belemnite rostra, bryozoan fragments and

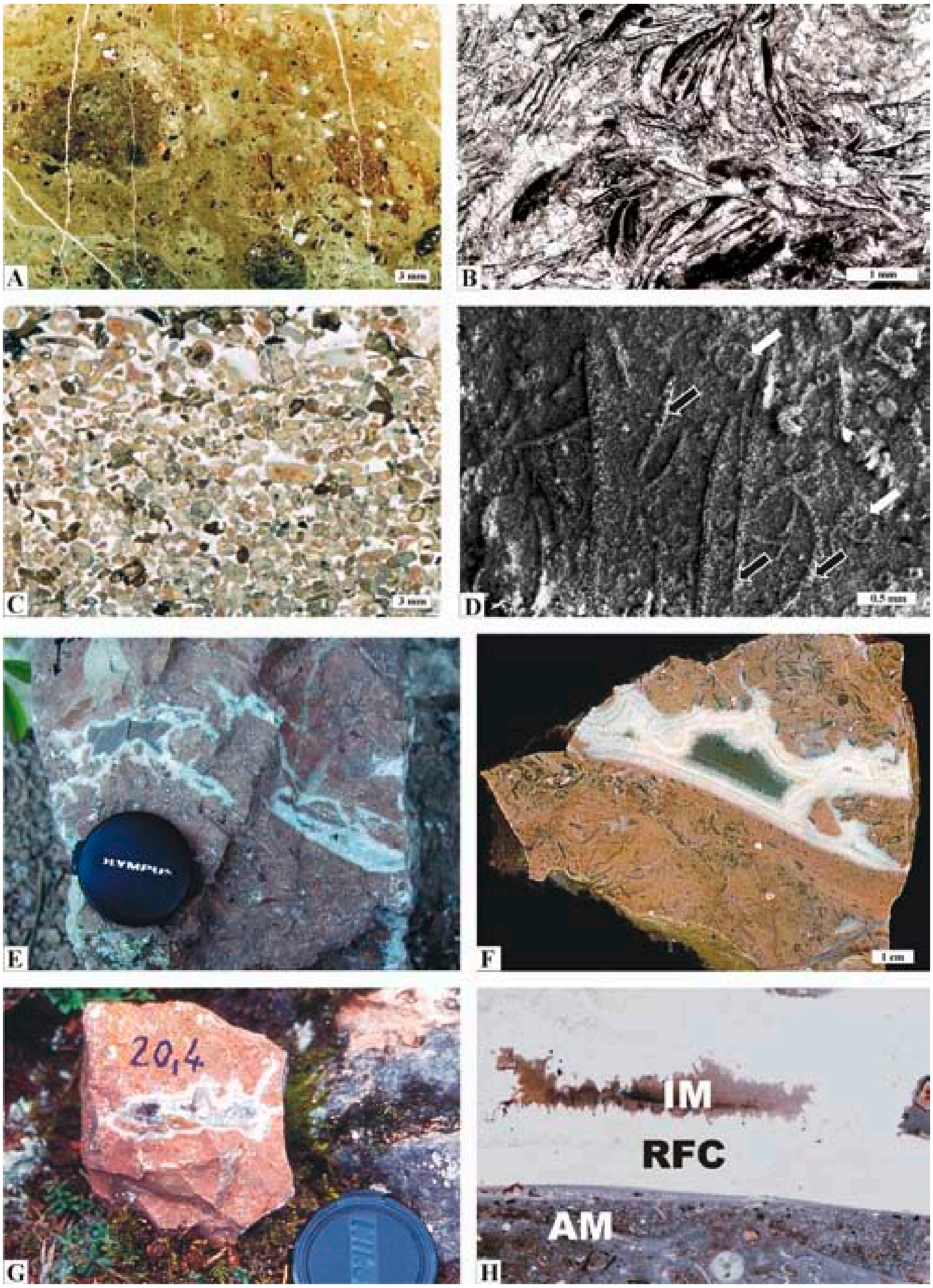

Fig. 9. A - Microphoto of the Czorsztyn Limestone (Ammonitico Rosso). The nodules represent packstone intraclasts in the wackestone matrix. Sample from the middle section, 22 m level. B – Microphoto of the *Bositra* coquina (Medné Limestone) – well-sorted biosparite with parallel-oriented shells. Sample from the middle section, 21 m level. C – Microphoto of the Štepnice Limestone – crinoidal biosparite with variable size of the ossicles. Sample from the northern section, 27 m level. D – Babiná Limestone with cross-sections of *Bositra* buchi (black arrows), crinoids and planktonic foraminifers *Globuligerina* sp. (white arrows). SEM photo, etched polished slab. E-F – Various stromatactis-like structures in the Babiná Limestone. Middle section, 30 m level. Multigeneration radiaxial calcite cement and dark internal micrite are visible. G – Similar structure from the Czorsztyn Limestone. Middle section, 20.4 m level. H – Thin-section of the void from the Fig. 8F. It shows original autochthonous micrite (AM), radiaxial fibrous calcite (RFC) and final, sterile internal micrite (IM).

Obr. 9. A - Mikrofoto z čorštynského hľuznatého vápenca. Hľuzy predstavujú packstonové intraklasty vo wackestonovej matrix. Vzorka zo stredného profilu, z metráže 22 m. B – Mikrofoto z bositrovej lumachely (medňanský vápenec) – dobre vytriedený biosparit s orientovanými schránkami. Vzorka zo severného profilu, z metráže 21 m. C – Mikrofoto zo štepnického vápenca – krinoidový biosparit s rôznou veľkosťou alochémov. Vzorka zo severného profilu, z metráže 27 m. D – Babinský vápenec s prierezmi lastúrnikov *Bositra* buchi (čierne šípky), krinoidmi a planktonickou foraminiferou *Globuligerina* sp. (biele šípky). Fotografia z elektrónového mikroskopu. Naleptaný nábrus. E-F – Rôzne štruktúry podobné štruktúram typu stromatactis v babinských vápencoch v strednom profile (metráž cca 30 m). Vidno viacgeneračný radiaxiálny kalcitový tmel a tmavý interný mikrit. G – Podobná štruktúra z čorštynského hľuznatého vápenca. Stredný profil, metráž 20.4 m. H – Výbrus z dutiny zobrazenej na Obr. 8F. Vidno pôvodný autochtónny mikrit (AM), radiaxiálny fíbrózny kalcit (RFC) a záverečný sterilný interný mikrit (IM).

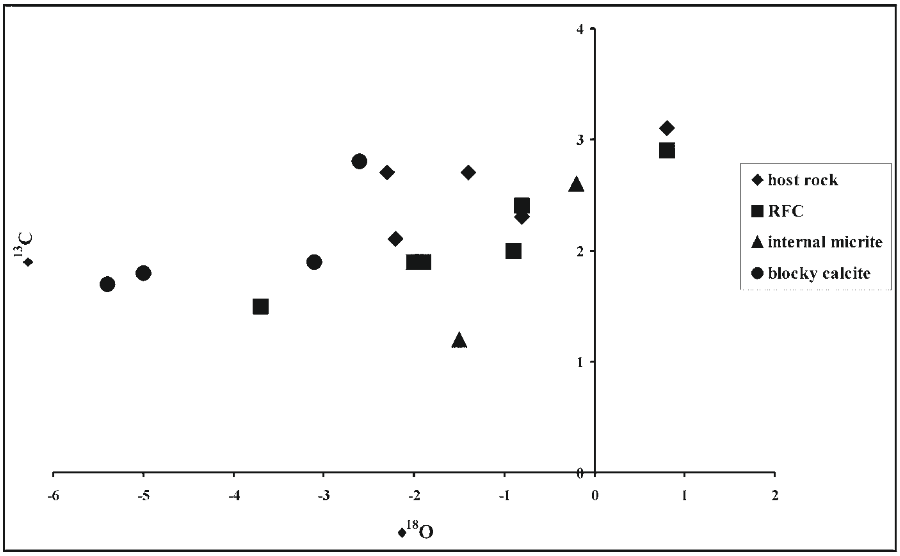

Fig. 10. Ratio of carbon and oxygen stable isotopes in the individual components of the stromatactis-like structures in the Babiná Limestone

Obr. 10. Pomer stabilných izotopov uhlíka a kyslíka v jednotlivých komponentoch štruktúr typu stromatactis v babinskom vápenci.

rare planktonic foraminifers *Globuligerina* sp. Very rare clasts of sandstone with opaque matrix and glauconite grains were found, too. Some allochems bear signs of boring; the crinoidal ossicles are often strongly corroded. Common are Fe-Mn coatings (locally even stromatolitic) around and impregnations inside the allochems. Very common are seams and microstylolites evidencing pressure dissolution. This is the youngest diagenetic phenomenon as the microstylolites cut also the syntaxial calcitic rims in the sparitic parts. In the places of local accumulations of brachiopods, coquina bodies were formed, representing biomicrites – wacketones, often with geopetal fillings of the remaining pores. The limestone is also cut by neptunian microdykes with crinoidal or *Bositra* microfacies.

Babiná Limestone Member (micritic limestone)

It represents biomicrite – wackestone to packstone, with various mixed *Bositra* and *Globuligerina* microfacies (Fig. 9D). Locally also gastropod and *Globochaete* microfacies are present. The micrite is often bioturbated. According to the correlations between the microfacies changes and the ammonite biostratigraphy presented by Wierzbowski et al. (1999), the change from the *Bositra* to *Globuligerina* microfacies in the Pieniny Klippen Belt occurred in the lowermost Oxfordian. There is no sharp boundary between these microfacies in the Babiná Limestone Member; the transition is gradual. Along with *Bositra* shells and tests of the planktonic foraminifers *Globuligerina* sp., the microfacies commonly contain tiny gastropods, problematic algae *Globochaete alpina*, ammonites shells, echinoderm ossicles, ostracods, ghosts after aragonite bivalve shells, brachiopods, "microforaminifers", nodosariid foraminifers, foraminifers *Lenticulina* sp., *Dorothia* sp., various planispiral forms, ostracods, echinoid spines and ghosts after sponge spicules. Rarely also aptychi, rhyncholites and quartz grains can be found. The allochems are commonly impregnated by opaque Fe-Mn oxides or rarely coated by thin Fe-Mn stromatolites. The coquinas often exhibit geopetal micritic fillings, passing to pelmicrites in the final stages of filling.

Stromatactis-like structures (Fig. 9E,F) occur solely in the middle section, mainly in the flat mud-mound (29-31 m levels) and in the beds directly overlying and underlying it. Rare stromatactis-like structures can be observed already in the Czorsztyn Limestone Formation (*Ammonitico Rosso*), in 20.4 m level (Fig. 9G). The stromatactis-like structures are commonly more than 10 cm long and more than 2 cm high. They have flat bottom and uneven, digitate roofs which fits to the definition of stromatactis introduced by Bathurst (1982). Except of them, also uneven voids and obvious shelter porosity under the ammonite and bivalve shells are present. The void filling is multigenerational (Fig. 9H). The first phase of filling is usually internal sediment which is similar to the ambient matrix, but laminated and with different amount of allochems. The micritic filling commonly grades to pelmicrite. The internal surfaces of the voids are sometimes coated with thin stromatolites (cryptic stromatolites most likely of bacterial origin). The following filling generation, taking most of the space is radiaxial fibrous calcite (RFC). It is typically blade-shaped in sub-parallel sections, with densely packed inclusions, with typical convex-up deformation of twinning lamellae. The RFC is always centripetal, normal to the substrate (Fig. 11C,D, even if enclosing allochems or matrix islets (so called "floating allochems" – see discussions in Aubrecht et al., 2002 and Aubrecht et al. 2009a). At Štepnická skala, the RFC commonly encloses allochems representing ghosts after aragonite bivalves and ammonites. These were first coated by black Fe-Mn coatings and dissolved; the originated space was sometimes geopetally filled with micrite and microsparite (Fig. 11A,B). RFC cementation post-dated after all these phases. This indicates that in the time of coating, dissolution and filling the surrounding environment of the allochems was neither RFC, nor microbial organic matter, but most likely micrite. Centers of

Tab. 1. Carbon and oxygen stable isotope data from the individual components of the stromatactis-like structures in the Babiná Limestone
Tab. 1. Namerané hodnoty stabilných izotopov uhlíka a kyslíka z jednotlivých komponentoch štruktúr typu stromatactis v babinskom vápenci.

sample	$\delta^{13}C$ (PDB)	$\delta^{18}O$ (PDB)	lithology
Šs-5	3.1	0.8	red micrite (host rock)
Šs-1	2.3	-0.8	red micrite (host rock)
Šs-10	2.7	-1.4	red micrite (host rock)
Šs-13	2.1	-2.2	red micrite (host rock)
Šs-8	2.7	-2.3	red micrite (host rock)
Šs-16	1.9	-2	radiaxial fibrous calcite
Šs-17	1.9	-1.9	radiaxial fibrous calcite
Šs-3	2.4	-0.8	radiaxial fibrous calcite
Šs-12	2	-0.9	radiaxial fibrous calcite
Šs-14	2.9	0.8	radiaxial fibrous calcite
Šs-15	1.5	-3.7	radiaxial fibrous calcite
Šs-11	2.6	-0.2	dark internal micrite
Šs-2	1.2	-1.5	dark internal micrite
Šs-6	2.8	-2.6	blocky calcite (latest filling)
Šs-4	1.8	-5	blocky calcite (latest filling)
Šs-7	1.7	-5.4	blocky calcite (latest filling)
Šs-9	1.9	-3.1	blocky calcite (latest filling)

the voids are usually filled with clear blocky calcite (Fig. 11E), crystal silt or internal micritic sediment. Some voids even remained unfilled. Carbon and oxygen isotope data (Tab. 1, Fig. 10) show that most of the components, i.e. micritic matrix, radiaxial fibrous calcite and internal micritic filling of the voids show isotope vales close to the average limestones precipitated from the Jurassic marine water ($\delta^{18}O$ = approx. –1.4‰ PDB, $\delta^{13}C$ = approx. 3.0‰ PDB – see Lohmann, 1988). Only the blocky calcite representing the latest voids filling has oxygen isotopes slightly shifted to the negative values. There is no visible shift in carbon values which are typical for fresh-water influenced cementation. The results may be then interpreted as thermal influence in the time of the blocky calcite cementation, i.e. the blocky calcite represent later, burial diagenetic cement.

The unusual diagenetic succession observed on the "floating allochems", together with the fact that the surrounding matrix is not typical for stromatactis mud-mounds (representing pure uniform micrite, no polymuds, full of micropeloidal automicrite of microbial origin) shows that the flat mound with the voids does not necessarily represent true stromatactis mud-mound. Therefore, it was not involved into the inventory of the stromatactis mud-mounds found in the Czorsztyn Succession by Aubrecht et al. (2009a).

Kočkovce Limestone Member (ammonite coquina)

Microfacies characteristics of the Kočkovce Limestone Member are similar as those of the previous member, with the exception that it is strongly dominated by ammonite shells (Fig. 11F). This ammonite coquina in fact represents the "ammonite breccia" described by Andrusov (1945).

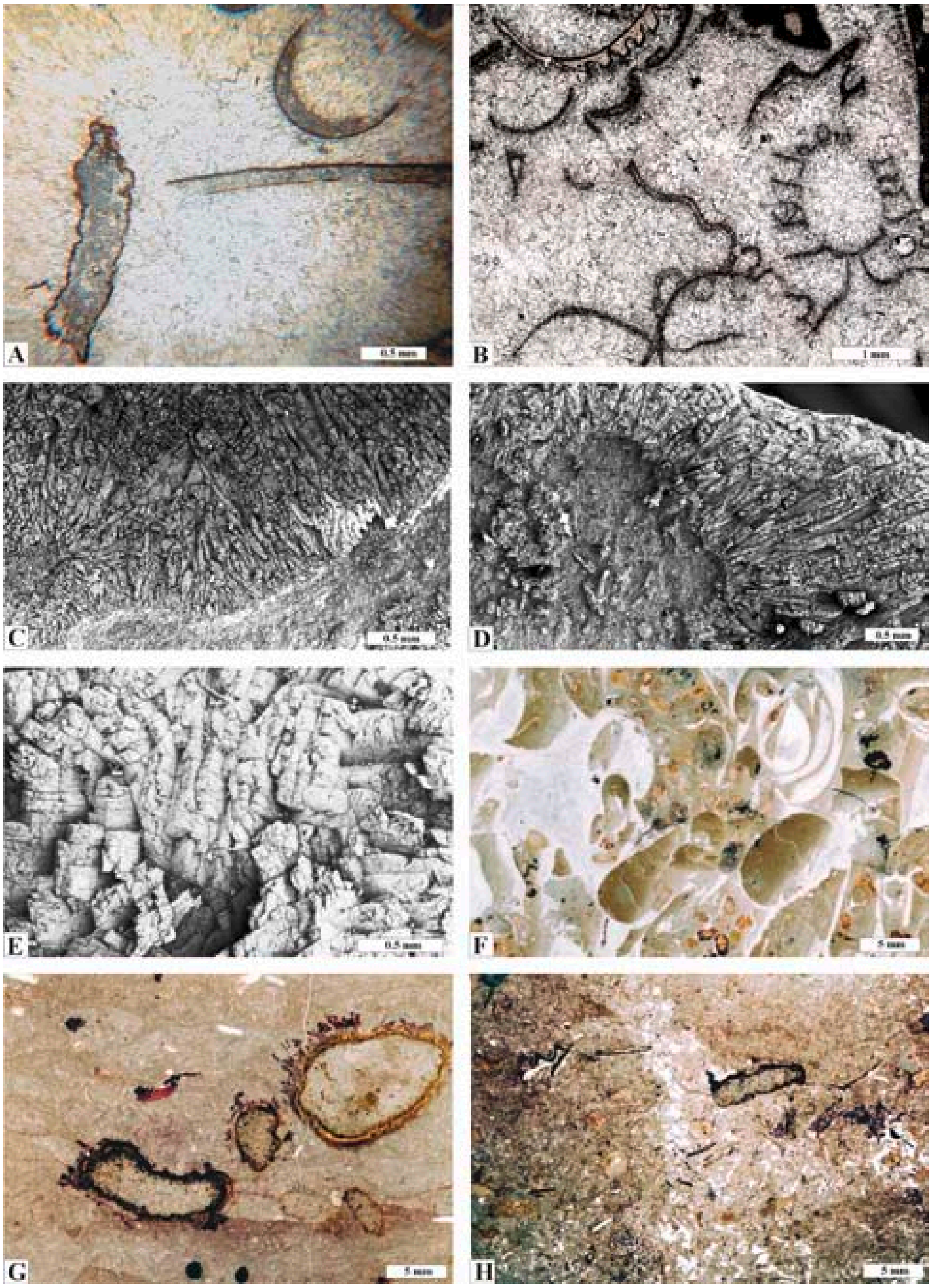

Fig. 11. A – Ghosts of former shells of ammonites and bivalves in the stromatactis-like structure. They were coated by Mn-oxides, dissolved and filled with micrite. Then they were surrounded by radiaxial fibrous calcite (RFC). It indicates that in the time of dissolution, the shells were surrounded by micrite. Middle section, 30.5 m level. B – Similarly as in the previous figure. C – Etched polished slab of the stromatactis-like structure. Perpendicular orientation of the RFC crystals grown on the micritic matrix is visible. D – Similarly as in the previous figure. E – Etched polished slab of the stromatactis-like structure. Blocky calcite, filling the centre of the void is visible. Middle section, 29.5 m level. F – Microphoto from the ammonite coquina (Kočkovce Limestone). Northern section, 23 m level. G – Thin section of the sample taken from the southern section (47.5 m level). The initial Fe-Mn oncoids were formed around clasts with *Saccocoma* microfacies. However, the surrounding matrix is still formed by *Globuligerina* microfacies. H – Thin-section from sample taken from the southern section (50 m level). The limestone is formed by *Saccocoma* microfacies (Streženice Limestone).

Obr. 11. A - Fantómy bývalých schránok amonitov a lastúrnikov v štruktúre typu stromatactis. Boli povlečené Mn oxidmi, vylúhované a vyplnené mikritom. Až potom boli obkolesené radiaxiálnm fibróznym kalcitom (RFC). To naznačuje, že v čase vylúhovávania schránok ich okolie bolo tvorené mikritom. Stredný profil, metráž 30.5 m. B – Podobne ako predchádzajúci obrázok. C – Naleptaný nábrus zo štruktúry typu stromatactis. Vidno kolmú orientáciu kryštálov RFC na mikritickej matrix. D – Podobne ako predchádzajúci obrázok. E – Naleptaný nábrus štruktúry typu stromatactis. Vidno blokový kalcit vypĺňajúci stred dutiny. Stredný profil, metráž 29.5 m. F – Mikrofoto z amonitovej lumachely (kočkovský vápenec). Vzorka zo severného profilu, z metráže 23 m. G – Výbrus zo vzorky z južného profilu (metráž 47.5 m). Iniciálne Fe-Mn onkoidy sú tvorené okolo klastov so sakokómovou mikrofáciou, zatiaľ čo matrix obsahuje ešte globuligerínovú mikrofáciu. H – Výbrus zo vzorky z južného profilu (metráž 50 m). Vápenec obsahuje sakokómovú mikrofáciu (streženický vápenec).

Streženice Limestone Member (*Saccocoma* limestone)

The *Saccocoma* microfacies appears first in limestone clasts in the topmost part of the underlying Bohunice Limestone which is still formed by *Globuligerina* microfacies (Fig. 11G). Saccocoma microfacies appears suddenly in the following bed (Fig. 11H, 12A). The limestone represents biomicrite (wackestones to packstones) sometimes with unevenly distributed biosparite, with *Saccocoma* and *Saccocoma-Bositra* microfacies, containing also frequent bivalves and ossicles of benthic crinoids. In places, aptychi, ostracods, benthic foraminifers, echinoid spines, gastropods, juvenile ammonites and brachiopod shells occur, too. The bivalve shells were originally mostly aragonitic, later corroded

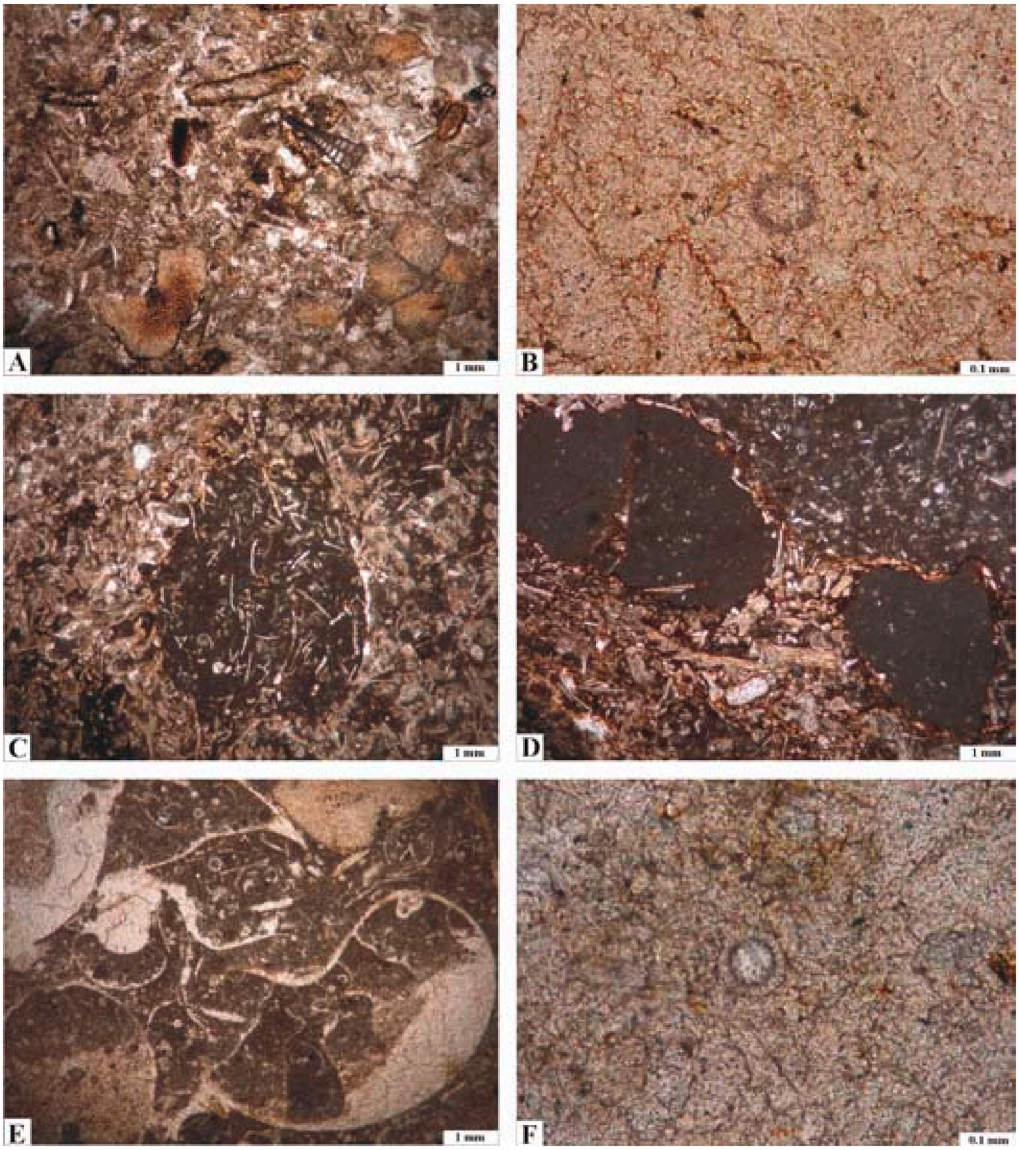

Fig. 12. A – Streženice Limestone, packstone with *Saccocoma* ossicles, benthic crinoid ossicles, thin *Bositra* shells, brachiopods, bivalves and foraminifer *Textularia* sp., Kimmeridgian-higher Lower Tithonian (small quarry, 2.75m level). B – *Cadosina parvula* (Nagy), Streženice Limestone, Kimmeridgian- higher Lower Tithonian (small quarry, 3.2m level). C – Rogoża Coquina, *Bositra-Saccocoma* intraclasts in the *Saccocoma* matrix, Lower-Middle Tithonian (small quarry, 6m level). D – Rogoża Coquina, micritic mudstones with radiolarians in the *Saccocoma* matrix, Lower-Middle Tithonian (small quarry, 6.15m level), E – Rogoża Coquina, gastropods and ammonites with polarity structures, locally forming coquina, Lower-Middle Tithonian (small quarry, 4.1m level), F – *Shizosphaerella minutissima* (Colom), Rogoża Coquina, Lower-Middle Tithonian (small quarry, 6.28m level).

Obr. 12. A - Streženický vápenec, packston so sakokómami, bentickými krinoidmi, bositrami, brachiopódmi, lastúrnikmi a foraminiferou *Textularia* sp., kimeridž-vyšší spodný titón (malý lom, metráž 2.75m). B – *Cadosina parvul*a (Nagy), streženický vápenec, kimeridž-vyšší spodný titón (malý lom, metráž 3.2m). C – Rogožská lumachela, bositrovo-sakokómové intraklasty v sakokómovej matrix, spodný-stredný titón (malý lom, metráž 6m). D – Rogožská lumachela, mikritové mudstony s rádioláriami v sakokómovej matrix, spodný-stredný titón (malý lom, metráž 6.15m), E – Rogožská lumachela, gastropódy a amonity so štruktúrami polarity, lokálne tvoriace lumachelu, spodný-stredný titón (malý lom, metráž 4.1m), F – *Shizosphaerella minutissima* (Colom), rogožská lumachela, spodný-stredný titón (malý lom, metráž 6.28m).

to completely dissolved. The originated voids were filled with secondary fine-grained sparite. The limestone locally contains intraclasts of the underlying limestones with *Globuligerina* microfacies. The allochems are often strongly corroded, bored and commonly coated with Fe-Mn oxides. The sediment is bioturbated which is evidenced by the presence of fucoids. The limestone contains calcareous dinoflagellate cysts *Shizosphaerella minutissima* (Colom), *Colomisphaera carpathica* (Borza), rarely *Cadosina parvulla* (Nagy) (Fig. 12B), *Colomisphaera pulla* (Borza) and mostly *Parastomiosphaera malmica* (Borza), indicating the Malmica Zone (Kimmeridgian-Lower Tithonian). This member was previously mentioned in the literature under the name *Saccocoma* limestone from Žiačik and Pod Mokrou Skalou localities (Tomašových & Schlögl, 2008).

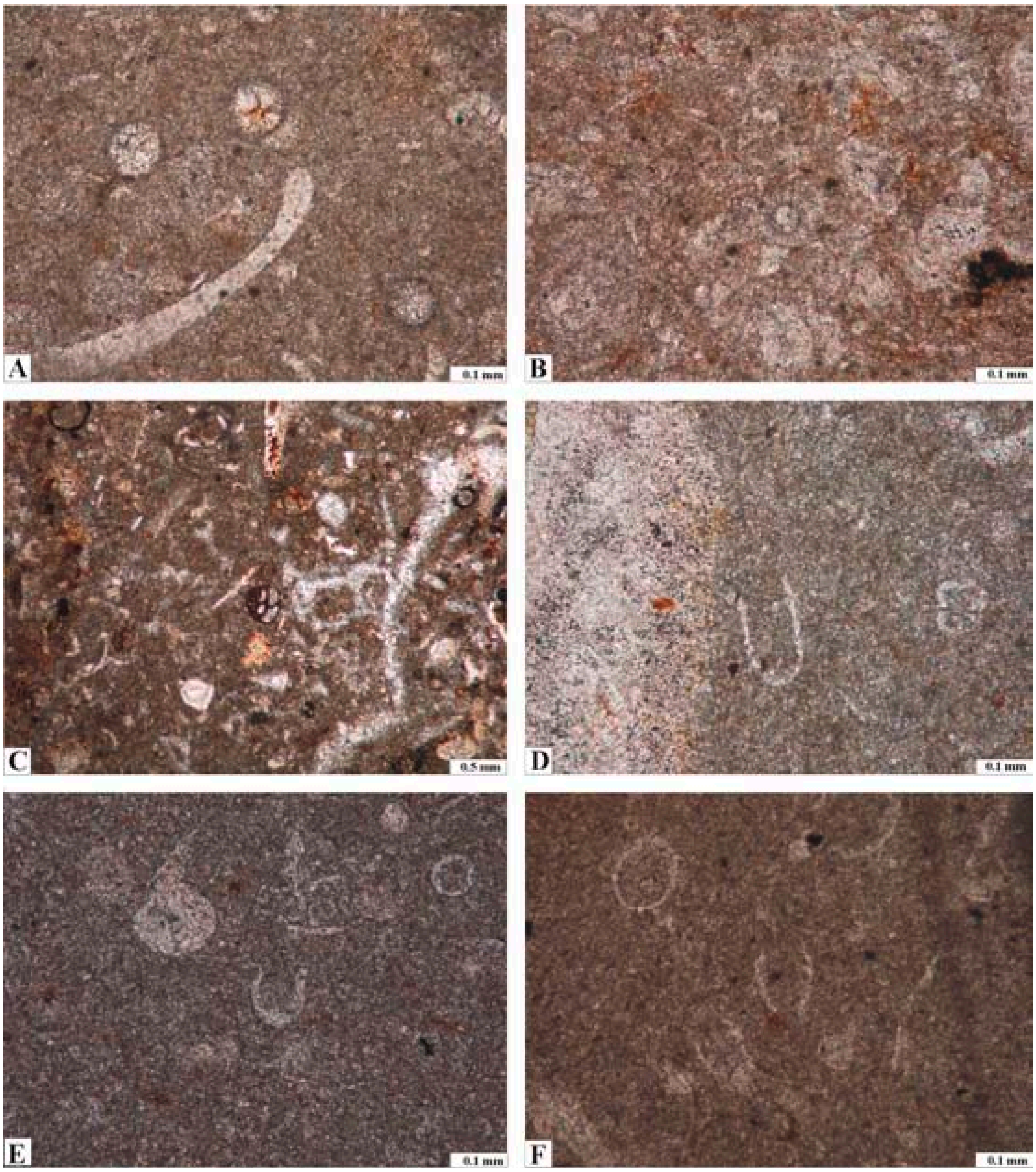

Fig. 13. A - *Cadosina semiradiata semiradiata* (Wanner), Rogoża Coquina, Lower-Middle Tithonian (small quarry, 6.28m level). B – *Colomisphaera carpathica* (Borza), Rogoża Coquina, Lower-Middle Tithonian (small quarry, 6.63m level). C – "Microforaminifera", Rogoża Coquina, Upper Tithonian (small quarry, 7.4 level). D – *Crassicollaria intermedia* (Durand Delga), Rogoża Coquina, Upper Tithonian (small quarry, 7.4 level). E – *Crassicollaria brevis* (Remane), Sobótka Limestone, Upper Tithonian-Lower Berriasian (small quarry, 13m level). F – *Tintinnopsella doliformis* (Borza), Sobótka Limestone, Upper Tithonian-Lower Berriasian (small quarry, 13m level).

Obr. 13. A - *Cadosina semiradiata semiradiata* (Wanner), rogožská lumachela, spodný-stredný titón (malý lom, metráž 6.28m). B – *Colomisphaera carpathica* (Borza), rogožská lumachela, spodný-stredný titón (malý lom, metráž 6.63m). C -„Mikroforaminifera", rogožská lumachela, vrchný titón (malý lom, metráž 7.4m). D – *Crassicollaria intermedia* (Durand Delga), rogožská lumachela, vrchný titón (malý lom, metráž 7.4m). E – *Crassicollaria brevis* (Remane), sobótsky vápenec, vrchný titón-spodný berias (malý lom, metráž 13m). F – *Tintinnopsella doliformis* (Borza), sobótsky vápenec, vrchný titón-spodný berias (malý lom, metráž 13m).

Dursztyn Limestone Formation

Red nodular and brecciated limestone

Thickness of these laterally substituting, but similar types of limestones is 3.5 m. They have no formal name and their attribution to the Dursztyn Limestone Formation is based solely according to its age. Lower part of the formation is formed by *Saccocoma*-crinoidal microfacies (wackestones to packstones), with abundant brachiopods, thin-shell bivalves, some ammonites and gastropods. *Parastomiosphaera malmica* (Borza) indicating Lower Tithonian is still present. Towards the top, *Saccocoma* is still dominant, but problematic algae *Globochaete alpina* become also more abundant (sometimes arranged in chains), together with calcified radiolarians. The limestone consists of intraclasts, some of them representing bivalve-*Saccocoma* wackestones but mudstones with calcified radiolarians are present, too. The intraclasts are rounded and mineralized. There are numerous punctate brachiopods, aptychi (*Laevaptychus* sp.), gastropods, bivalves with thicker shells, locally forming coquinas. Ammonites are also present (rarely also etched phylloceratid ammonites); forming even packstone in one thin layer. The limestone also contains benthic foraminifers *Ophthalmidium* sp., *Textularia* sp. and *Dorothia* sp. and locally also serpulid worm tubes. The allochems are bored and coated with Fe-Mn oxides. Rare quartz grains are also present. In the lower part of the formation, calcareous dinocysts *Colomisphaera pulla* (Borza), *Shizosphaerella minutissima* (Colom) (Fig. 12F) and *Colomisphaera carpathica* (Borza) (Fig. 13B) are present. In the upper parts, *Cadosina semiradiata fusca* (Wanner) and *Cadosina semiradiata semiradiata* (Wanner) (Fig. 13A), indicating Semiradiata Zone (Middle Tithonian), become more frequent. Both types of limestones contain veins filled with blocky calcite and the limestones are stylolitized.

Rogoża Coquina Member

In the lower part of the limestone, planktonic crinoids *Saccocoma* are still dominant (Fig. 12C,D), together with ossicles of benthic crinoids. Numerous are thick-shelled bivalves, aptychi, ammonites (Fig. 12E), punctate brachiopods, ophiurian ossicles, "microforaminifers" (Fig. 13C) and gastropods with preserved geopetal filings. The first calpionellids start to appear, represented by *Crassicollaria intermedia* (Durand Delga) (Fig. 13D) and rarely *Tintinnopsella remanei* (Borza) indicating Upper Tithonian (Crassicollaria Zone, Intermedia Subzone).

Sobótka Limestone Member

The limestone is formed of *Calpionella*, *Saccocoma*-bivalve and radiolarian-*Globochaete* microfacies. Higher up, the amount of *Saccocoma* ossicles decreases; still present are juvenile ammonites and agglutinated foraminifers. Lower part of the limestone can be dated to Crassicollaria Zone (Parvula/Brevis Subzone), which is indicated by presence of *Crassicollaria parvula* (Remane), *Crassicollaria massutiniana* (Colom), *Crassicollaria brevis* (Remane) (Fig. 13E), *Calpionella grandalpina* (Nagy) and appearance of *Calpionella alpina* (Lorenz) and *Tintinnopsella doliformis* (Borza) (Fig. 13F). Beige limestones pass higher to slightly brecciated pink *Calpionella* limestone with dominant presence of *Crassicollaria brevis* (Remane). The mentioned calpionellid microfauna indicates Upper Tithonian to Lower Berriasian age.

5. DISCUSSION

Štepnická skala belongs to the klippen of the Czorsztyn Succession which are characterized by facies which are less condensed than its classical development in the Pieniny Mts. which was taken by Birkenmajer (1977) as the standard for this unit. These less condensed developments are concentrated mainly in the western segments of the Pieniny Klippen Belt and document lateral facies variability of this unit (Aubrecht et al., 1997). Bohunice Limestone Formation was distinguished by Mišík et al. (1994) as non-nodular analog of the Czorsztyn Limestone Formation with the same stratigraphic time span. At Štepnická skala Klippe, these two formations are superposed and even laterally replaced (Fig. 6). So far known Bohunice Limestone Formation was here subdivided to new distinguished Medné, Štepnice, Babiná, Kočkovce and Streženice limestone members.

The original wackestones of Bohunice Limestone Formation show large variability, leading to completely different end-members, such as the Štepnice Limestone Member (in the places of larger accumulation of crinoids). On the other hand, the *Bositra* coquina (Medné Limestone Member) evidently originated where the sedimentary environment was exposed to bottom currents and instead of normally present *Bositra* packstones to wackestones (e.g. in the Czorsztyn Limestone Formation or Štepnice Limestone Member) the sediment turned to *Bositra* grainstone. It is evidenced by lateral uneven thickness and even discontinuity of the coquina bed and by its occurrence both, in the Czorsztyn and Bohunice limestone formations. Other explanation would be temporary prolific bottom environment resulting in dominance of adult specimens and lack of juvenile stages of *Bositra*. That means that the dominance of larger shells might have been primary, not influenced by winnowing of smaller shells. The Kočkovce Limestone Member ("ammonite breccia" of Andrusov, 1945) is also just a local variety of the Bohunice Limestone Formation which originated at places with high abundance of ammonite shells. Lithotypes of the Štepnice, Babiná and Kočkovce members in the same stratigraphic succession can be also recognized at the type locality of the Bohunice Formation in the quarry at Babiná Hill near Bohunice which proves reasonability of this subdivision. Unlike the classical development with nodular *Ammonitico Rosso* facies, there is no facies contrast between the Bohunice Formation and the overlying Dursztyn Formation. Their sedimentary conditions were obviously very similar.

Although the members like Štepnice and Streženice members was first described from this klippe, Tomašových & Schlögl, 2008 distinguished *Saccocoma* limestones in some other sections, too. It is just a question of recognition as both facies resemble Bajocian crinoidal limestones (Smolegowa and Krupianka limestone formations). Therefore, in poorly outcropped areas (without microfacies analysis) the Štepnice and Streženice members might be misinterpreted as some of the varieties of the Bajocian crinoidal limestones.

The flat mound with stromatactis-like structures exposed in the middle section in the Babiná Limestone Member is problematic. It differs from true stromatactis mud-mounds by having pure micritic matrix. Most of the stromatactis mud-mounds have typical polymud fabric (Lees & Miller, 1995) containing lot of dispersed non-sorted allochems of various size (with polymodal size-distribution – so called polydisperse sediments sensu Hladil, 2005). The main feature, however is the typical micropeloidal ("clotted") matrix which is believed to be of microbial origin (see e.g. Chafetz, 1986). It is so called automicrite that dominates the polymud fabric. Latest research showed that the microbial micropeloids may came from sponges (Aubrecht et al., 2009a). Sponges contain symbiontic microbes which contribute to their metabolic processes (Reitner et al., 2001; Lee et al., 2001). These microbes are believed to play an important role also in post-mortem decay and early calcification of sponge tissues. Therefore, micropeloidal fabrics of the host rocks in stromatactis mud-mounds are attributed to the "inoculation" by these microbes. Lack of the micropeloidal fabric shows that microbial processes were not involved in the formation of this mound and the mound, together with the voids might originate by other, yet unknown processes.

5. CONCLUSIONS

1. Štepnická skala Klippe represents a special development of the Czorsztyn Succession (Pieniny Klippen Belt) with less condensed Middle to Upper Jurassic facies. Bajocian crinoidal limestone (Krupianka Limestone Formation) is stratigraphically overlain by thin Czorsztyn Limestone Formation (uppermost Bajocian-Bathonian) and then by thick packet of Bohunice Limestone Formation (Bathonian-Lower Tithonian), followed by similar limestones of Dursztyn Limestone Formation (Tithonian-Berriasian).

2. The Bohunice Formation was subdivided to new members: Medné Limestone Member (*Bositra* coquina – Bathonian-?Callovian), micritic/crinoidal Štepnice Limestone Member (?Bathonian-Lower Oxfordian), micritic Babiná Limestone Member (?Bathonian-Oxfordian), Kočkovce Limestone Member (ammonite coquina – Oxfordian) and *Saccocoma* Streženice Limestone Member (Kimmeridgian-Lower Tithonian).

3. Flat mound-shaped body in the Babiná Limestone Member, bearing stromatactis-like structures is problematic. It lacks microfacies features (e.g. microbial cements) which typically occur in all stromatactis-mud-mounds.

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Resumé: Bradlo Štepnická skala je zvláštnym vývojom čorštynskej jednotky bradlového pásma. Nachádza sa na vrchu JJZ od Púchova, asi 500 m JV od osady Štepnice (časť obce Streženice). Sukcesiu bradla vidno v prevrátenom slede v dvoch opustených lomoch. Vo väčšom z nich (N 49°5'45.1'', E 18°17'55.6'') vidno vápence v stratigrafickom rozsahu bajok až kimeridž. Nakoľko fácie vykazujú značnú laterálnu variabilitu, urobili sa tri paralelné profily – severný, stredný a južný. Sukcesia pokračuje v menšom lome (N 49°5'52.3'', E 18°17'51.7''), kde vidno vápence kimeridžu až beriasu. Vývoj čorštynskej jednotky na Štepnickej skale je blízky vývoju Mestečka, opísaného Aubrechtom (1992), čiže namiesto hľuznatých čorštynských vápencov v ňom prevládajú nekondenzované fácie zastúpené bohunickým súvrstvím definovaným Mišíkom et al. (1994). Lokalitu spomína už Andrusov (1945) ako jediný výskyt tzv. amonitovej brekcie. V čase jeho výskumov však ešte spomínané odkryvy neejstvovali a jeho nálezy pochádzajú z izolovaných balvanov.

Vrstevný sled začína ružovými až červenkastými krupianskými krinoidovými vápencami veku bajok. Ide o krinoidové biosparity až biomikrity (grainstony až packstony). Nie je možné stanoviť ich hrúbku, nakoľko v bradle nie je zachytený ich styk s podložnými álenskými bridlicami (szkrzypnianske súvrstvie). V ich stratigrafickom nadloží vystupujú červené čorštynské hľuznaté vápence, ktoré majú v severnom profile hrúbku okolo 6 m, zatiaľ čo v strednom profile sa stenčujú na 2 m. V južnom profile dosahujú mocnosť približne 4 m. Z bazálnej časti vrstvy hľuznatého vápenca pochádza pomerne početná amonitová makrofauna, dobre indikujúca najspodnejší bat. Vápence predstavujú biomikrit (wackeston až packston) s prevládajúcou bositrovou mikrofáciou (v minulosti označovaná ako „vláknová“). Ziedkavo sa vyskytujú aj planktonické foraminifery *Globuligerina* sp. V stratigrafickom slede ďalej nasleduje najhrubšie súvrstvie v bradle – bohunické súvrstvie (bat až spodný titón). Toto súvrstvie má značnú vertikálnu aj laterálnu variabilitu, pričom jednotlivé členy možno na tejto lokalite pomerne dobre odčleniť. Preto v ňom boli formálne vyčlenené nové litostratigrafické jednotky na úrovni členov. Najspodnejší je medňanský vápenec (pomenovaný podľa neďalekej obce Medné), ktorý predstavuje 1 m hrubú polohu bieleho bositrového vápenca (bositrová lumachela), zloženého takmer výlučne zo schránok lastúrnikov *Bositra buchi* (býv. *Posidonia alpina*). V stratigrafickom nadloží sa vyskytuje červený kalový vápenec so značným zastúpením krinoidov. Krinoidy sú zastúpené veľmi nerovnomerne, vytvárajú hniezda v kalovom vápenci. V tomto člene sa teda prelínajú litológie dvoch koncových členov – ružového až červeného kalového vápenca a krinoidového vápenca. Jeho vek je kelovej-spodný oxford. tento člen bol nazvaný ako štepnický vápenec (nazvaný podľa osady Štepnice). Vápenec je bohatý aj na brachiopódy a miestami sa obsahuje aj brachiopódové lumachely. Prevláda krinoidovo-vláknová mikrofácia, pričom v stratigraficky vyššej časti pribúdajú foraminifery *Globuligerina* sp. Čiastočne laterálne sa s ním zamieňa o čosi mladší člen – babinský vápenec (podľa vrchu Babiná pri Bohuniciach). Ide o červený mikritický vápenec, ktorý bol v minulosti vyčlenený ako typický pre celé bohunické súvrstvie (Mišík et al., 1994). Ide prevažne o wackeston, s bositrami a prevládajúcou globuligerínovou mikrofáciou indikujúcou oxfordský vek. V rámci babinského vápenca vystupuje plochý kopovitý útvar so štruktúrami typu stromatactis. Od typických stromatactisových mikritických kôp (“stromatactis mud-mounds”) sa líši tým, že jej matrix je čisto mikritická, bez akýchkoľvek známok mikrobiálnej cementácie. Vyššie leží amonitová lumachela s množstvom amonitov indikujúcich stredný až vrchný oxford. Ide o amonitovú brekciu opísanú Andrusovom (1945). Tento člen bol nazvaný kočkovský vápenec (podľa obcí Horné a Dolné Kočkovce oproti lokalite na druhej strane Váhu). Stratigraficky vyššie leží najmladší novo vyčlenený člen bohunického súvrstvia – streženický vápenec (nazvaný podľa obce Streženice). Ide o sakokomový packston makroskopicky pripomínajúci dogerský krinoidový vápenec, avšak jemnozrnnejší. Jeho vek je kimeridž-spodný titón (zóna malmica), čo indikujú vápnité dinocysty *Shizosphaerella minutissima* (Colom), *Colomisphaera carpathica* (Borza), zriedkavá *Cadosina parvulla* (Nagy), *Colomisphaera pulla* (Borza) a najmä *Parastomiosphaera malmica* (Borza). Tento člen je najmladšiou jednotkou vystupujúcou vo väčšom lome. Jej vrstevný sled pokračuje v menšom lome, kde zasa tvorí stratigrafickú bázu. Nad bohunickým súvrstvím leží faciálne veľmi podobné durštynské súvrstvie tvorené naspodu polohou hľuznato-brekciovitého vápenca, ktorý predstavuje sakokómovo-krinoidový wackeston a obsahuje faunu vápnitých dinocýst v spodnej časti so stále prítomnou *Parastomiosphaera malmica* (Borza), ďalej *Colomisphaera pulla* (Borza), *Shizosphaerella minutissima*

(Colom) a *Colomisphaera carpathica* (Borza) poukazujúce na spodný titón. Vo vyššej časti už vystupujú *Cadosina semiradiata fusca* (Wanner) a *Cadosina semiradiata semiradiata* (Wanner) poukazujúce na zónu semiradiata (stredný titón). Vápenec vyššie prechádza do rogožskej lumachely, ktorá ešte stále obsahuje rozptýlené sakokómy, množstvo schránok lastúrnikov, brachiopódov a amonitov. Kalpionelidy *Crassicollaria intermedia* (Durand Delga) a zriedkavá *Tintinnopsella remanei* (Borza) indikujú vrchnotitónsky vek (zóna crassicollaria, podzóna intermedia). Navrchu leží svetlý sobótsky vápenec (vrchný titón až spodný berias). Vápenec je tvorený kalpionelovou a sakokómovo-bositrovou mikrofáciou, zriedkavo aj globochétovou mikrofáciou. Spodnú časť možno ešte datovať do zóny crassicollaria (podzóna parvula/brevis), ako to naznačuje prítomnosť *Crassicollaria parvula* (Remane), *Crassicollaria massutiniana* (Colom), *Crassicollaria brevis* (Remane), *Calpionella grandalpina* (Nagy) a objavenie sa *Calpionella alpina* (Lorenz) a *Tintinnopsella doliformis* (Borza). Vyššie, v brekciovitejšej časti už vystupuje *Crassicollaria brevis* (Remane).