Austrian Journal of Earth Sciences | Vienna | 2017 | Volume 110/1 | 21 - 35 | DOI: 10.17738/ajes.2017.0002

Turonian–Santonian sediments in the Tatricum of the Považský Inovec Mts. (Internal Western Carpathians, Slovakia)

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KEYWORDS Western Carpathians; Tatricum; Fatricum; Biostratigraphy; Foraminifera; Hubina Formation

Abstract

The first description of Upper Cretaceous ("Senonian") mass flow deposits discovered in the Striebornica section, in the central part of the Považský Inovec Mts. (Tatricum, Western Carpathians) is provided. The studied section is situated above the Poruba Formation (Albian – Lower Cenomanian) of the Tatricum tectonic unit (the Inovec succession) and below the Fatricum tectonic unit represented by the Triassic sediments. The mass flow deposits which are here classified as the Hubina Formation (new name) can be divided into three parts. The basal part is formed by calcareous pebbly mudstones and polymictic conglomerates. The middle part of the succession is composed predominantly of claystone or shale with minor sandstone interbeds. The upper part represents thickening-upward sandstone beds. The preserved post-early Turonian association of planktonic foraminifers extracted from the basal and middle part of the succession refer to a latest middle Turonian–Santonian age. The position of the Hubina Formation indicates post-Santonian emplacement of the Fatricum in the western segment of the Western Carpathians. The Hubina Formation is interpreted to be a part of the wedge-top basin overlapping the Tatricum.

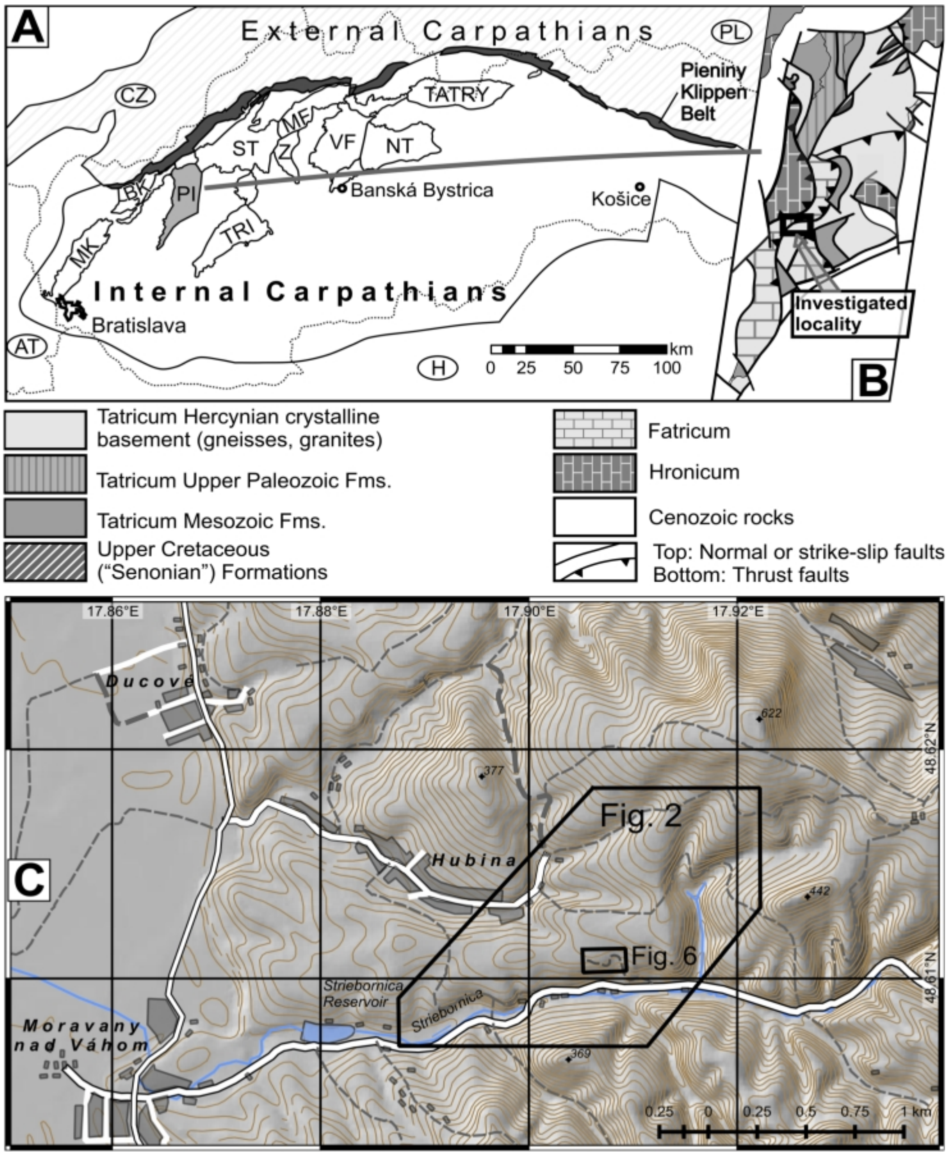
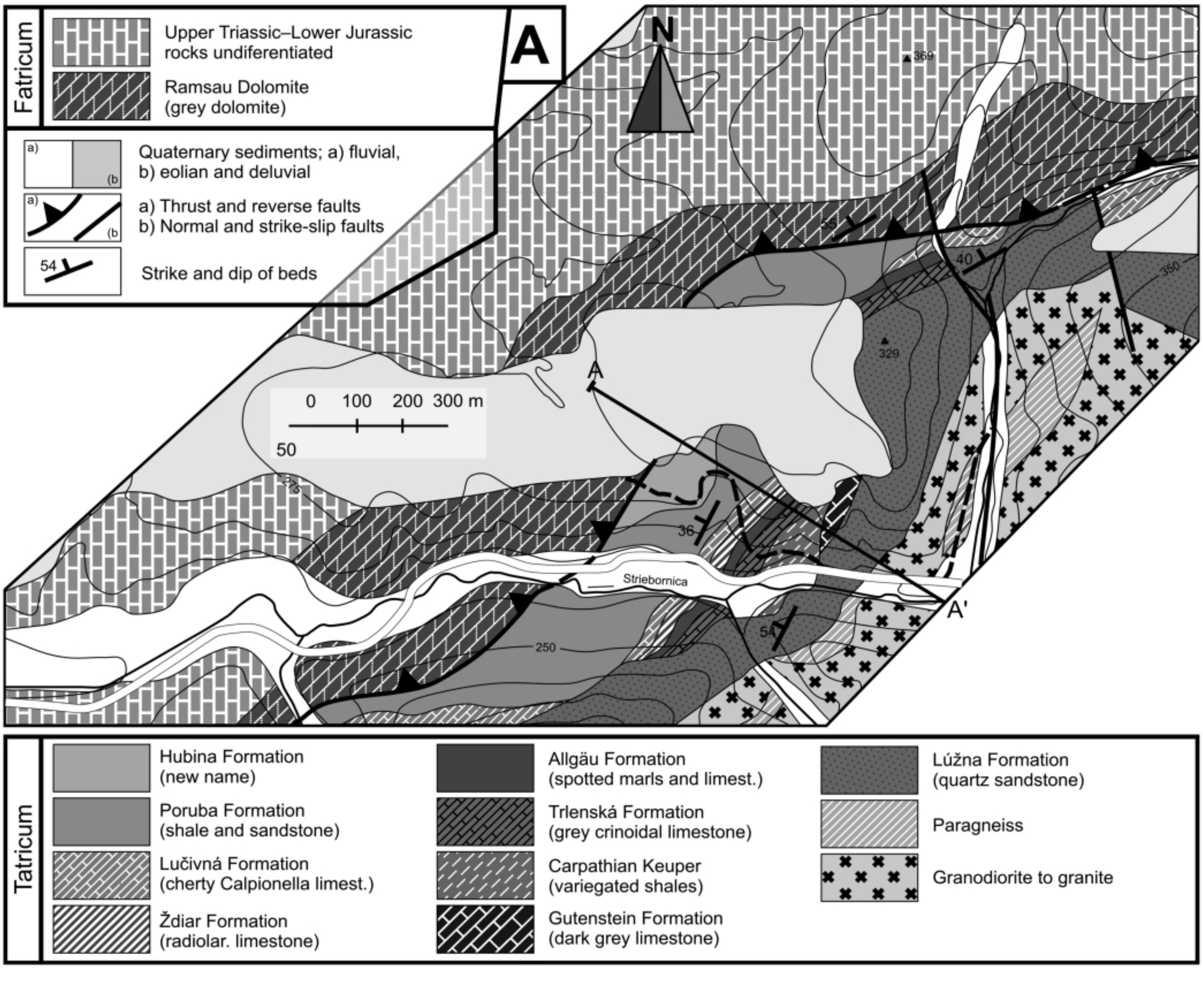


Figure 1: Study area. A: Location of the Považský Inovec Mts. (PI) in Slovakia. MK: Malé Karpaty Mts.; BR: Brezovské Karpaty Mts.; TRI: Tribeč Mts.; ST: Strážovské vrchy Mts.; MF: Malá Fatra Mts.; Z: Žiar Mts.; VF: Veľká Fatra Mts.; NT: Nízke Tatry Mts.; B: Geological map of the Považský Inovec Mts. (based on Bezák et al., 2008). Investigated locality marked by rectangle. C: Topographic map of Striebornica valley.

1. Introduction

Exposures of Upper Cretaceous (post-Turonian or "Senonian") rock complexes in the external parts of the Internal Western Carpathians (*sensu* Hók et al., 2014) are rather scarce and spatially limited (cf. Mišík, 1978; Häusler et al., 1993; Lexa et al., 2000; Bezák et al., 2008). The largest accumulations of Upper Cretaceous sediments of the Gosau type Brezová Group occur in the Brezovské Karpaty Mts. (Samuel et al., 1980; Wagreich and Marschalko, 1995), overlying the Hronicum tectonic unit, which comprises an Oberostalpin-type thin-skinned nappe.

Different types of Upper Cretaceous deposits were described from various regions of the Považský Inovec Mts. overlying the Tatricum crystalline basement (Fig. 4). The Tatricum is a thick-skinned unit with autochthonous Mesozoic rocks attached to the pre-Alpine crystalline basement. The Fatricum is a thin-skinned nappe with the Mesozoic rocks mostly separated from its basement and overthrusted above the Tatricum (Plašienka et al., 1997; Bezák et al., 2011). Both sedimentary successions are terminated by the Poruba Formation composed of deep-marine terrigenous clastics (originally defined as "flysch"), occasionally with coarser clastic and exotic mate-



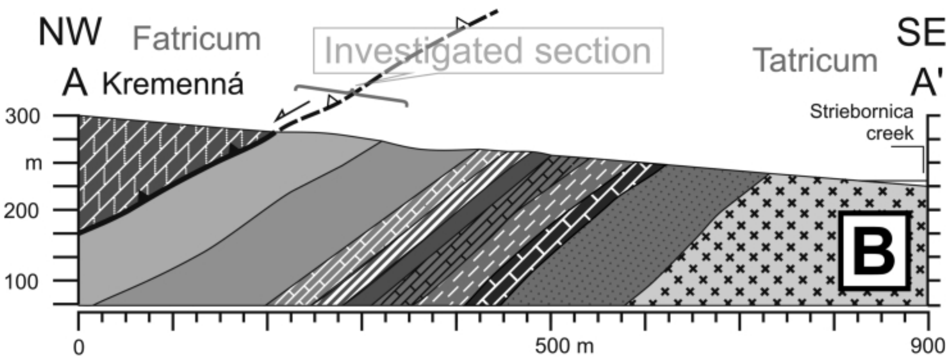


Figure 2: A: Geological map of the investigated section of the Inovec succession (based on Ivanička et al., 2007, modified). B: Geological section A – A' (for location see Fig. 2) across the investigated territory (legend in Fig 2 A). Stratigraphic affiliation of the investigated lithostratigraphic units is in Fig. 3.

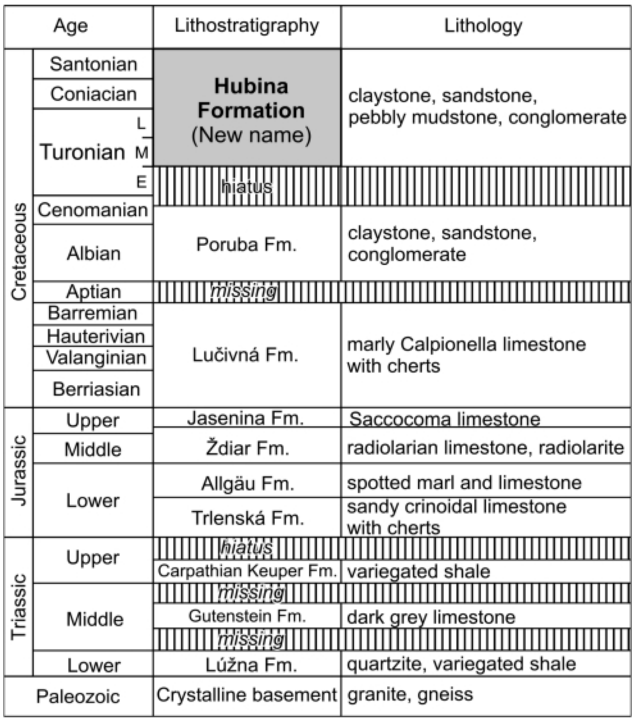


Figure 3: Lithostratigraphy of the investigated Tatricum sedimentary succession (Inovec succession; compiled and modified after Havrila in Ivanička and Kohút, 2011).

rial, mostly of Albian–Cenomanian, locally up to middle Turonian age (Jablonský, 1978, 1986, 1988; Mišík et al., 1981; Boorová and Potfaj, 1997; Plašienka, 2012). The Poruba Formation is considered to be an equivalent to the Losenstein Formation of the Eastern Alps (Jablonský, 1988; Wagreich, 2003). The deposits of the Poruba Fm. in the Tatricum are usually interpreted as the syn-orogenic sediments pre-dating emplacement of the overlying Fatricum nappe (Andrusov, 1959; Mišík et al., 1985; Plašienka, 2012; Prokešová et al., 2012). The continuous sedimentation up to the earliest middle Turonian in the Tatricum is documented only in the Veľká Fatra Mts. (Boorová and Potfaj, 1997) and Tatry Mts. (Cúlová and Andrusov, 1964). Sedimentation in the Tatricum and Fatricum was terminated at most of the currently known localities during the Albian–Turonian and occurrences of younger Upper Cretaceous sediments in these units are rare and limited only to few areas of the Považský Inovec Mts.

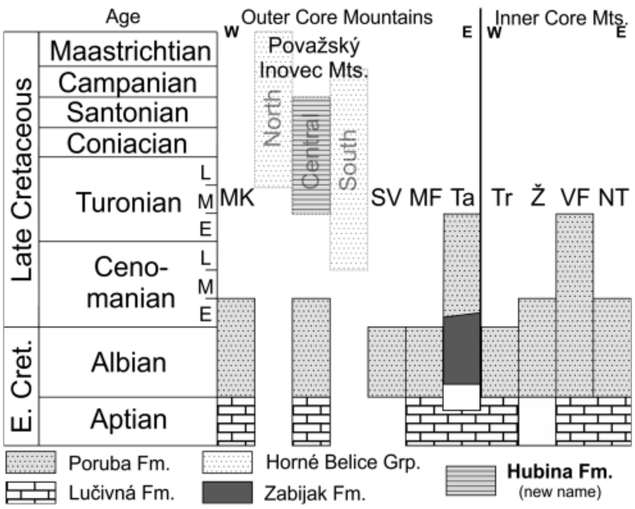


Figure 4: Distribution of the Hubina and Poruba formations and the Upper Cretaceous Horné Belice Group in the region of Core mountains (for location see Fig. 1; based on Salaj and Samuel, 1966; Ivanička et al., 1998; Ivanička and Kohút, 2011; Maheľ, 1985; Haško and Polák, 1979; Boorová and Potfaj, 1997; Polák et al., 2012; Kováčik et al., 2016; Biely et al., 1997; Krajewski, 2003). MK: Malé Karpaty Mts., SV: Strážovské vrchy Mts.; MF: Malá Fatra Mts.; Ta: Tatry Mts.; Tr: Tribeč Mts.; Ž: Žiar Mts.; VF: Veľká Fatra Mts.; NT: Nízke Tatry Mts.

The Coniacian–Maastrichtian ("Senonian") deposits of the Považský Inovec Mts. (the Belice Sucession alternatively the Horné Belice Group) are usually interpreted as syn-orogenic olistostromal mass flow deposits (Plašienka et al., 1994, Putiš et al., 2008; Ivanička and Kohút, 2011, Pelech et al., 2016). The tectonic interpretation and terminology, however, vary considerably in several points and are further described elsewhere (cf. Maheľ, 1986; Leško et al., 1988; Putiš et al., 2008; Pelech et al., 2016). In general, the Horné Belice Group is divided into two formations. The Coniacian–Santonian Rázová Formation, which is composed of grey mass flow deposits, and the overlying Campanian–Maastrichtian red mass flow deposits referred as the Hranty Formation.

During the structural investigation in the central segment of the Považský Inovec Mts. (Fig. 1 B), previously unknown sedimentary rocks were found overlying the Poruba Fm. The wider area is built by complexes of the Tatricum crystalline basement and an autochthonous sedimentary succession (the Inovec succession sensu Ivanička and Kohút, 2011) (Figs. 2 and 3). The crystalline basement is composed of granite rocks and gneisses. The Tatricum sedimentary succession contains Mesozoic complexes of Early Triassic to Cretaceous age (Ivanička and Kohút, 2011; Fig. 3). The uppermost part of the Inovec succession is built by the Lučivná and Poruba formations. The youngest documented age of the Poruba Fm. in the Považský Inovec Mts. is Albian–Early Cenomanian (Salaj and Samuel, 1966; Jablonský, 1986, 1988). These formations previously considered as the youngest ones, are overlain by even younger, newly discovered sedimentary rocks which are the main object of this study.

2. Study area and methods

The study area is situated in the southwestern part of the central segment of the Považský Inovec Mts., in the Striebornica Valley east of the Moravany nad Váhom, Piešťany district, Slovakia, on the northern slope of the valley. The best outcrops are found in the forest road cut (48° 36.714′ N 17° 54.462′ E; Figs. 1, 2 and 6). The locality was investigated by sedimentological and detailed biostratigraphic methods. A total of 20 samples have been processed for microbiostratigraphic analysis. Foraminifera were extracted from fractions of larger than 0.2 mm whereas below this size, microfossils were very poorly recognized as a consequence of bad preservation. Both SEM images and studies in immersion oil were carried out on the foraminifera specimen in order to see both surface and inner diagnostic features (chamber shape and arrangement, sutures). Additionally, 26 rock thin sections have been studied (Fig. 6).

3. Results

3.1 Lithostratigraphy, petrography and sedimentology

The lowermost part of the Striebornica section is exposed in outcrop 1 (Figs. 5, 6) and is composed of several bodies of 1–4.5m thick ochraceous to yellow-grey matrix-supported conglomerates and pebbly mudstones to pebbly sandstones (facies A1.3 and A1.4 sensu Pickering et al., 1986; Fig. 7A–C) and up to 1m thick clast-supported conglomerates with sandy matrix (Fig. 7D). These conglomerates and pebbly mudstones are polymictic. The clasts of the pebbly mudstones and conglomerates vary between small pebbles and boulders (0.5–30 cm), and consist of quartz sandstones, dolomites and micritic, crinoidal and oolitic limestones, radiolarites, as well as sandstone and crystalline basement rocks (granite and gneiss). The quartz sandstones and carbonates are most abundant. The pebble and cobble size clasts are usually rounded to well rounded, medium to coarse-grained. The pebbly mudstone beds are characterized by a strong variability in clast size. Grading is poorly defined and numerous "floating" lager size clasts are observed. Pebbles are often imbricated (Fig. 7C). The pebbly sandstones to mudstones form moderately lithified massive beds with indistinctive bedding planes especially in the basal part of the studied section (Fig. 5).

The fine to medium-grained matrix of the pebbly mudstone/-sandstone beds is composed of grey to ochraceous siliciclastic

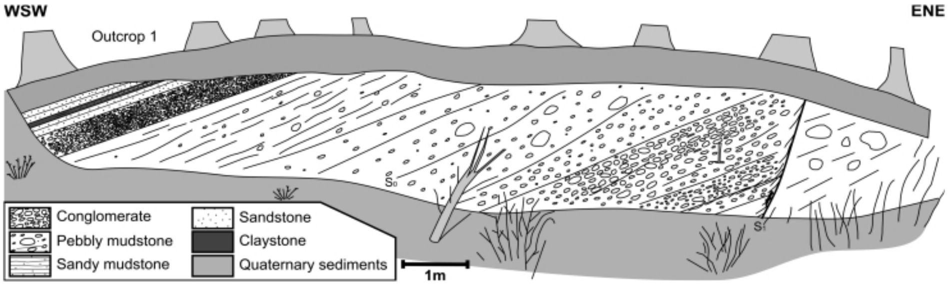


Figure 5: Sedimentological sketch of outcrop 1 showing the basal part of the Hubina Formation, composed of conglomerate and pebbly sandstone-mudstone. Sedimentary log shown in Fig. 6 and position within the formation see Fig. 3. Sedimentary bedding S0 = 245/27°. Normal fault plane in the right S1 = 252/54 °.

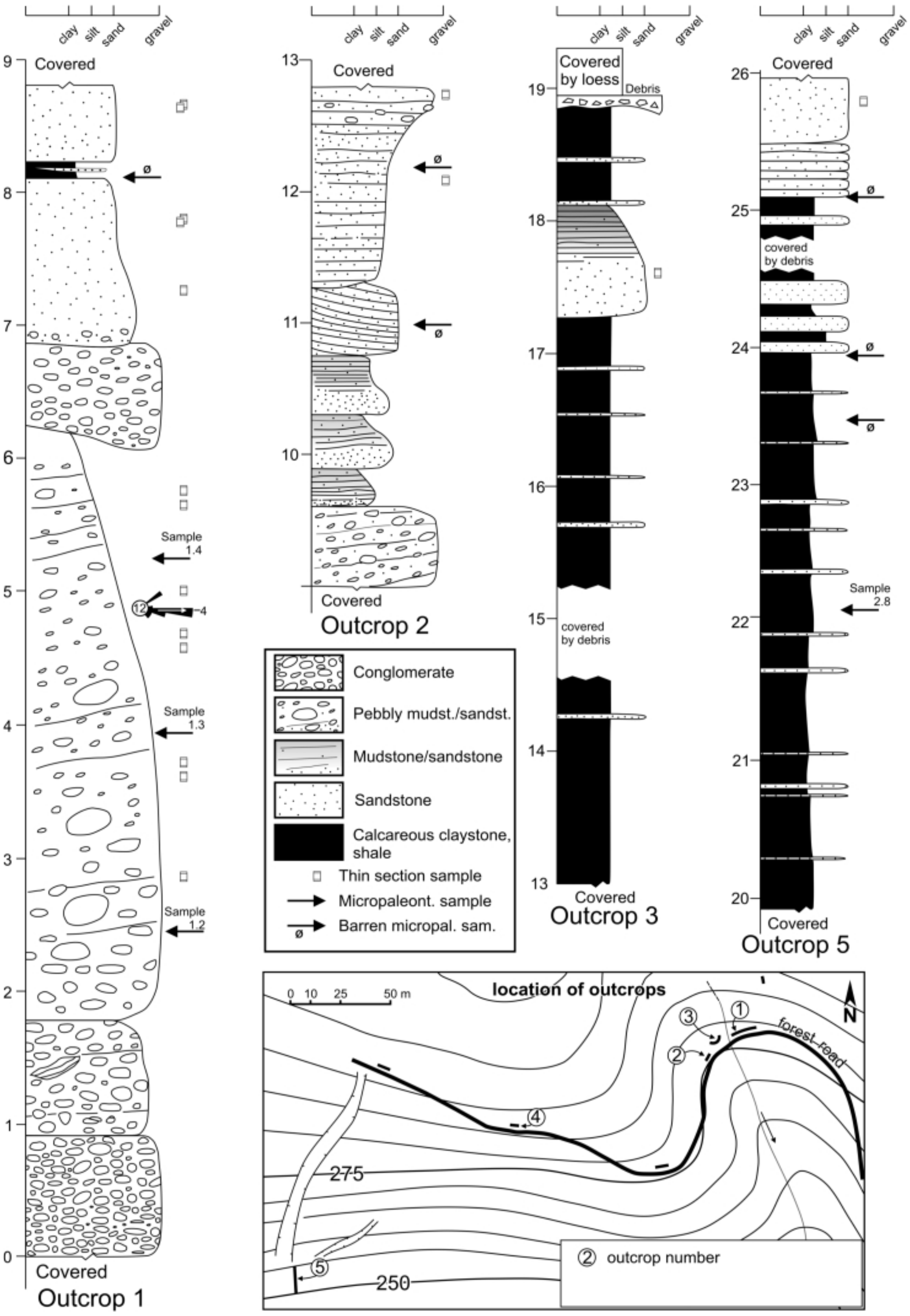


Figure 6: Schematic sedimentary logs showing outcrops 1–3 and 5, and location of all studied outcrops in the road cut and stratigraphic relations. Rose diagram in the Outcrop 1 showing paleocurrent direction inferred from the pebble imbrication (number of measurements in circle). Location of the map see Fig. 1C.

material (Fig. 7 B) with large amounts of mica flakes. Siliciclastic material in the matrix has varying roundness; however, most of the grains are angular, and rarely almost idiomorphic quartz grains were observed, indicating relatively short transport of material. Mix of well rounded coarse clastic and angular finer grained material may be reported.

Microfossils present in pebbly mudstones are poorly recognizable and very poorly preserved due to deformation (often

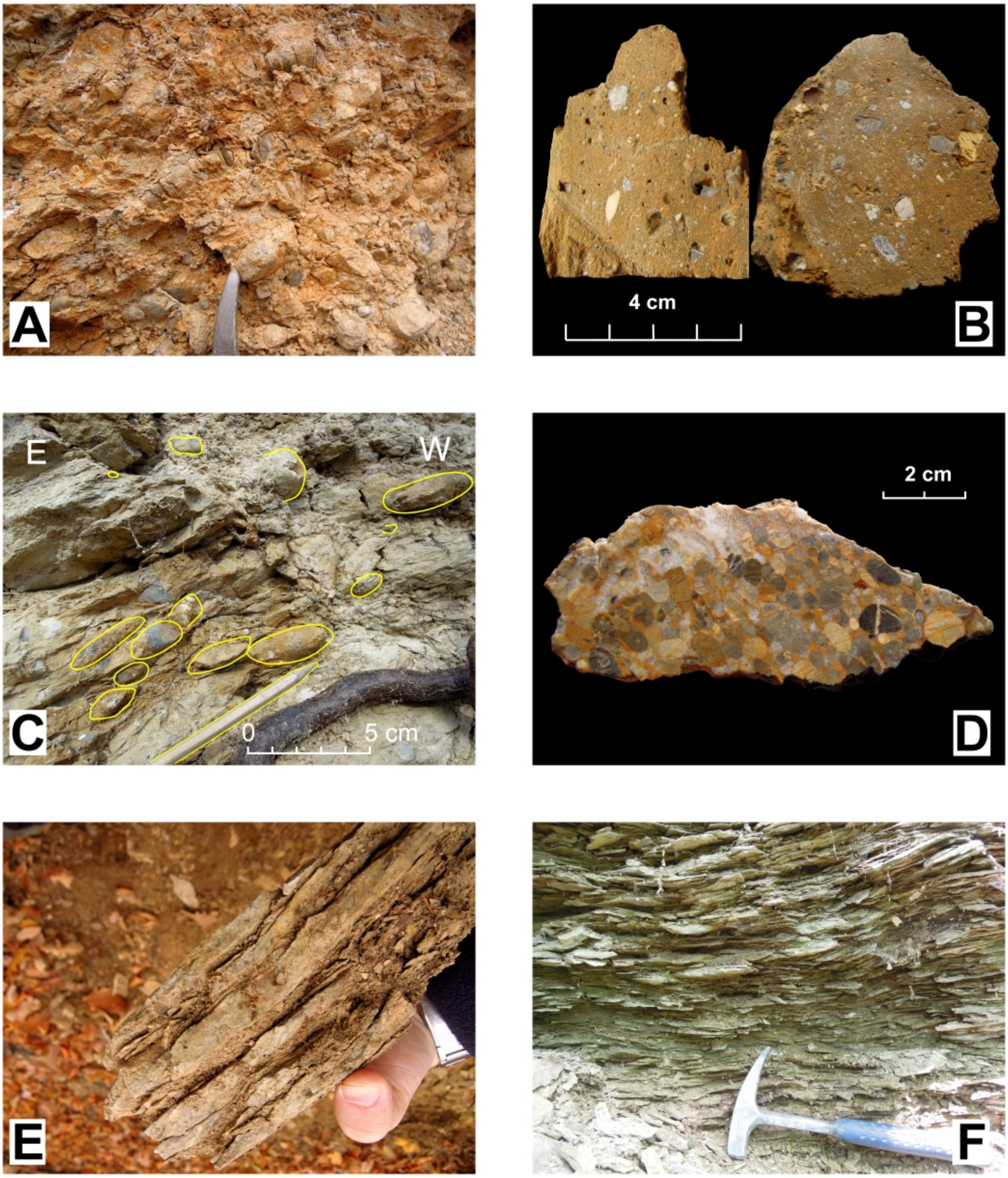


Figure 7: A: Ochraceous pebbly mudstone-sandstone with fractured pebbles in the outcrop 1. Pick head of hammer as scale. B: Detailed view on fresh surface of pebbly mudstone sample. C: Fresh surface of clast supported conglomerate sample showing different limestone and quartz sandstone clasts. D: Imbrication of the pebbles in the pebbly sandstone layer. Pencil for scale. E: Detailed view on thin-bedded sandstone-claystone couplets at outcrop 5. F: Characteristic lithology of claystones and shales at outcrop 5 with more or less developed cleavage.

dorsoventrally flattened, stretched from the original circular to elliptical shape, Fig. 10). Better recognizable microfossils are found in the fraction above 200 μm, where they are quite common. No microfossils with biostratigraphic value were observed in the thin sections.

Overall geometry and composition suggests that the pebbly

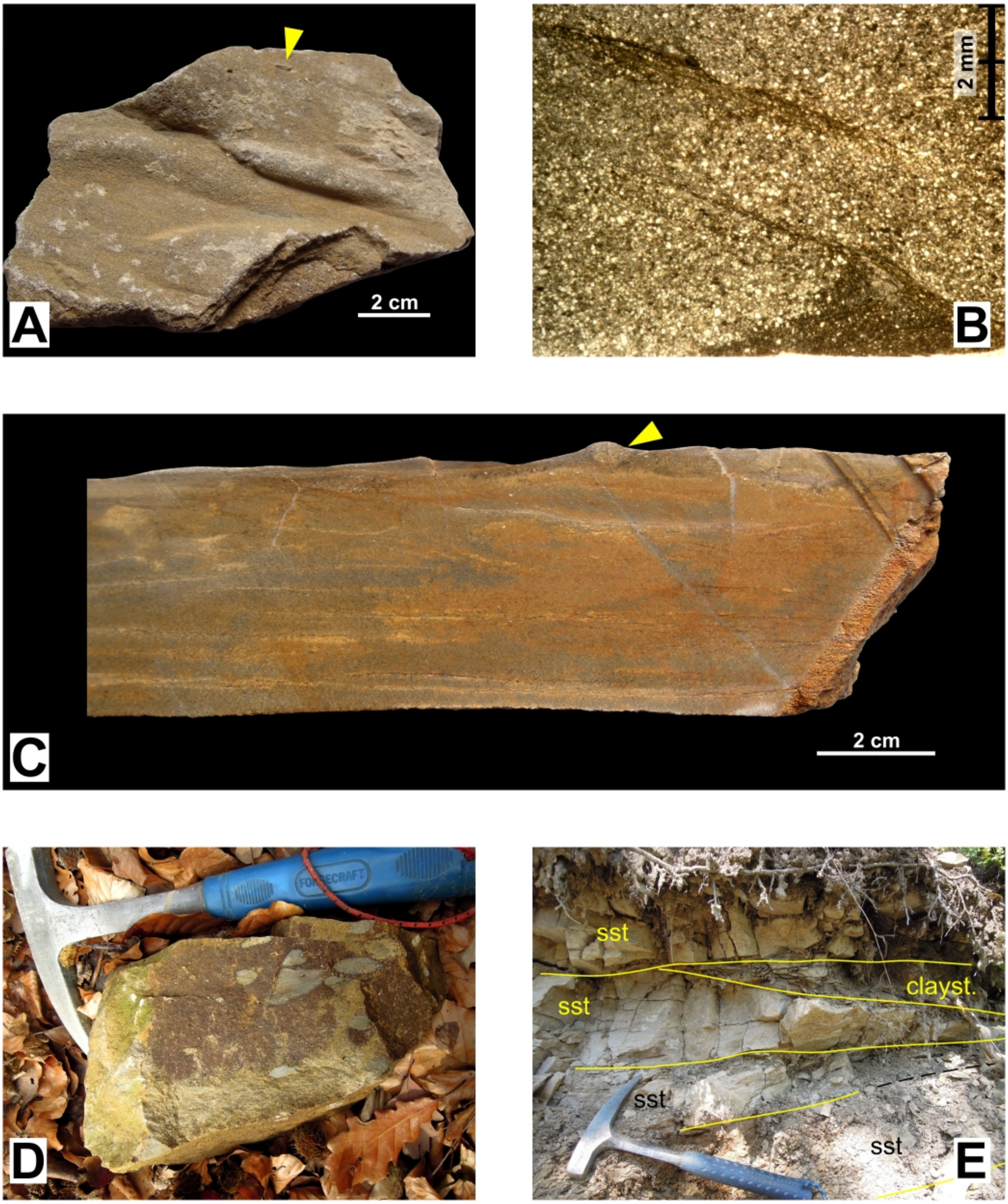


Figure 8: A: Elongate slightly asymmetrical flute cast on the lower bedding plane of a sandstone bed. Small plant remains marked by yellow triangle. B: Cleavage developed in the basal part of a sandstone bed from outcrop 5. C: Thin bed of sandstone with bioturbation (coarser sand, marked by yellow triangle) and claystone at the top. Sedimentary structures partially disrupted. D: Grey claystone rip-up clasts in sandstone from top of the outcrop 1. E: Interbedded lenses of sandstones (sst) and claystones at outcrop 4.

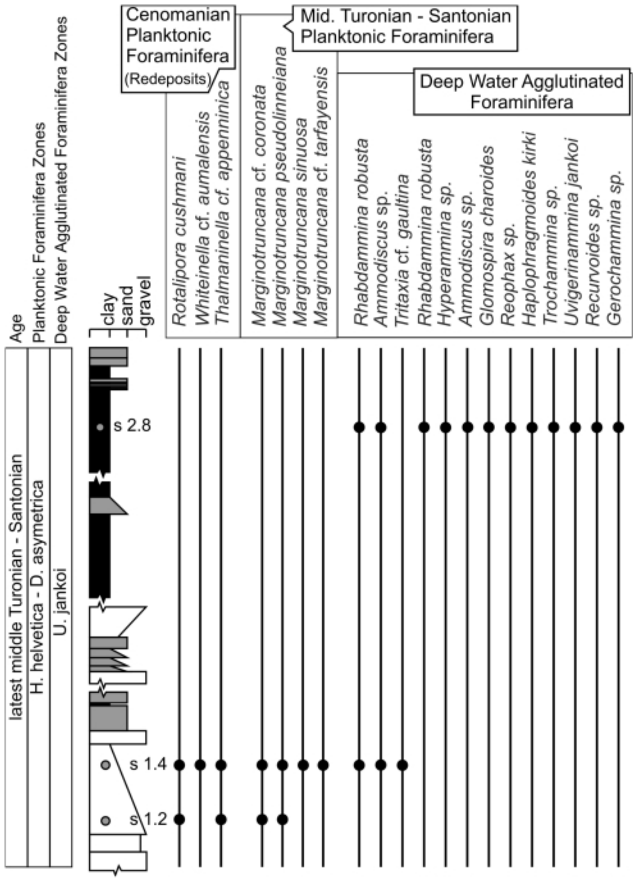


Figure 9: Distribution of microfossils in samples across the section (detailed location of samples on Fig. 8). Ranges of planktonic foraminifera according to Caron (1985) and Premoli Silva and Verga (2004). Zones of planktonic foraminifera according to Hardenbol et al. (1998). Zones of agglutinated foraminifera according to Kuhnt (1990) and Bąk (2000).

mudstone/sandstone beds (at outcrops 1 and 2; Figs. 5–6, 7A–C) were deposited by frictional freezing and could be considered as debrites originating in a submarine channel infill in the middle to upper part of submarine fan. Accompanying normally graded sandstone-mudstone couplets in the outcrop 2 could represent turbidites which may evolve from the more dilute upper part of the debris flow (Lowe, 1982; Talling et al., 2012).

Another type of mass-flow deposits is represented by thin to medium beds of grey calcareous sandstone (facies B1 sensu Pickering et al., 1986, Figs. 8C–E). This facies is alternating with debrites in the lower part of the section (Figs. 5, 6) or with grey-green claystone and shale in the upper part. Medium bedded sandstones are 10 to 30 cm thick, coarse or more often medium to fine-grained and show no or only slight grading. Bioturbation was locally observed in the upper parts of sandstone beds (Fig. 8C). Several sandstone bodies show lateral pinch-outs in outcrop scale (Fig. 8E) and sharp basal contact with underlying beds.

The composition of sandstones varies between lithic arenite and lithic arkose. Psammitic grains are represented mainly by quartz, feldspars are relatively rare. Lithoclasts of sedimentary rocks include carbonates, mainly dolomites and quartz sandstones. Less abundant lithoclasts are represented by gneisses, basic volcanic rocks and plant remains. Claystone rip-up clasts were observed (Fig. 8D). Medium to thick-bedded sandstones on the outcrops 1–6 could be interpreted as thickening-upward sandy turbidites of the middle submarine fan environment (Mutti and Normark, 1987; Einsele, 1992) alternatively as sandy debrites (according to Shanmugam and Moiola, 1995, and Shanmugam, 1996). It cannot be excluded that former mass flow deposits were later reworked by bottom currents.

Locally thin beds of fine-grained sandstone or less frequently thin-bedded sand-clay couplets were found (outcrop 5, facies C2 sensu Pickering et al., 1986). Internal sedimentary textures are often disrupted, however, several beds show normal grading and often small groove marks at their base (Fig. 8A), wavy lamination and very rarely ripples in the upper part (Fig. 7 E). Such sediments, found in outcrops 3 and 5, could be interpreted as low concentration turbidity currents deposited in a middle to outer submarine fan environment (Pickering et al., 1986, Mutti and Normark, 1987; Einsele, 1992; Stow et al., 1996) or thin-bedded overbank deposits (Mutti, 1977; Mutti and Normark, 1987). Further unequivocal identification was not possible due to lack of larger outcrops and considerable tectonic overprint especially in fine-grained sediments.

Grey-green calcareous and non-calcareous claystones or shales with small amount of silt admixture and sand laminae represent mostly hemipelagic sediments (facies G2 and E2, locally D2 sensu Pickering et al., 1986; Fig. 7 F). Their co-occurrence with sporadic thin sandstone beds and locally also thick sandstone beds reflects influence by mass flow deposits and/or bottom currents. The claystones are present in different stratigraphic horizons of the section. They are rare at the base, but became dominant in the central part of the section and were not observed in the upper part (Fig. 6 and 13).

3.2 Biostratigraphy

The microfossil distribution in the studied section is concentrated mainly in the pebbly mudstone layers at the base of the formation in outcrop 1 (Figs. 5, 6, 9). The sample 1.2 represents mixed assemblages of latest middle Turonian–Santonian age with reworked late Albian–Cenomanian specimen. The redeposited microfauna is represented by poorly preserved foraminifers belonging to the genus *Whiteinella*, *Rotalipora* and *Thalmanninella* (forms similar to *Rotalipora cushmani* (Morrow) (Fig. 10, 7a–7c), *Thalmanninella* cf. *appenninica* (Renz) Fig. 10, 8a–8c), *Whiteinella* cf. *aumalensis* (Sigal) (Fig. 10, 6a–6c) while the stratigraphically younger specimen in the same sample are represented by poorly preserved *Marginotruncana* spp. In the stratigraphically upper sample 1.4 from the same debris flow layer, besides reworked Upper Albian–Cenomanian (*T.* cf. *appenninica* and *Rotalipora* spp)., most of the planktonic foraminifera are identified as *Marginotruncana pseudolinneiana* Pessagno (Fig. 10, 4a–4c), *Marginotruncana coronata* (Bolli) indicating a stratigraphic range from the middle Turonian to earliest Campanian (Fig. 10, 1a–1c,

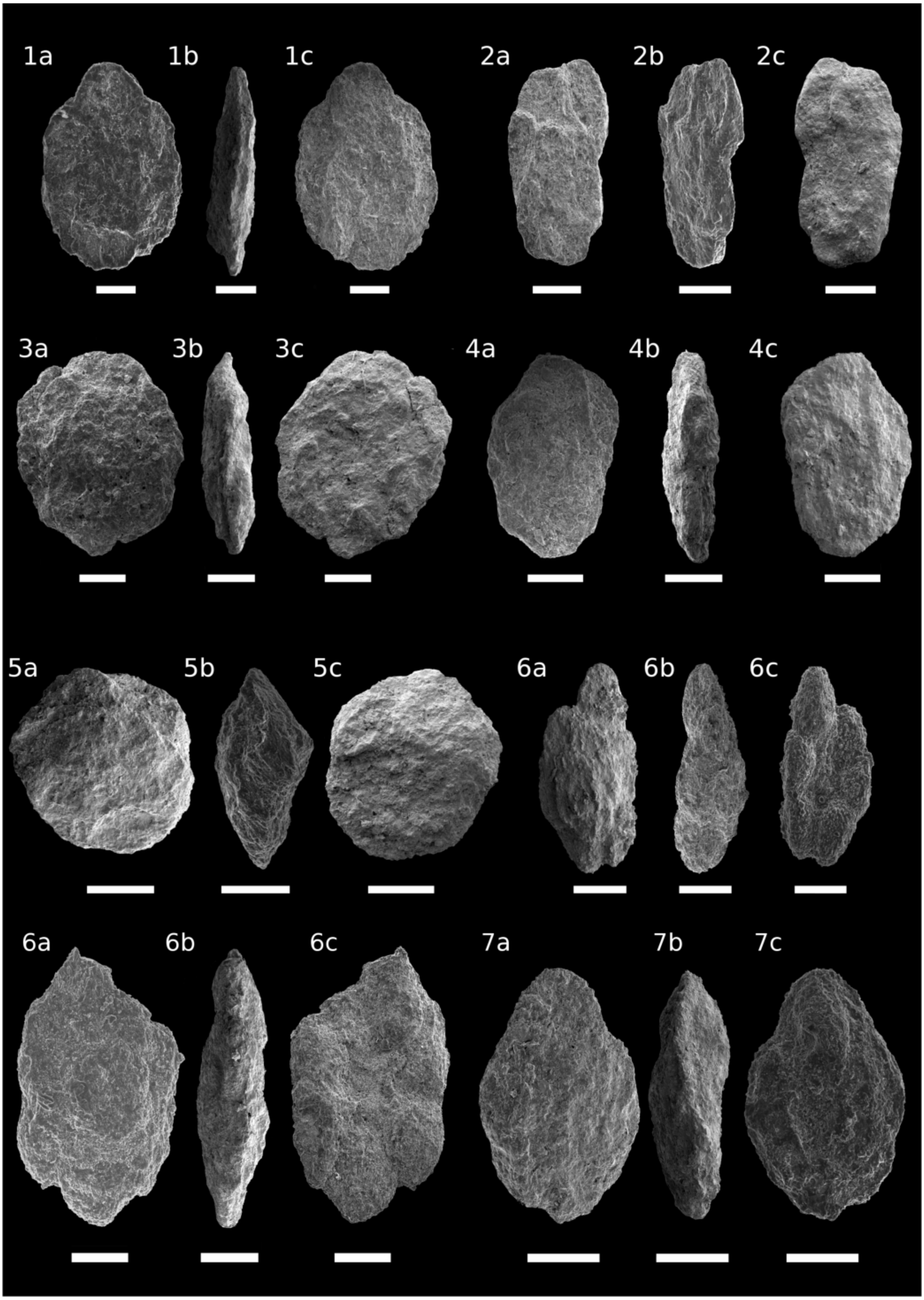

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Figure 10: Planktonic foraminifera. 1a-1c: *Marginotruncana coronata* (Bolli), 2a-2c: *Marginotruncana sinuosa* Porthault, 3a-3c: *Marginotruncana* cf. *coronata* (Bolli), 4a-4c: *Marginotruncana pseudolinneiana* Pessagno, 5a-5c: *Marginotruncana* cf. *sigali* (Reichel), 6a-6c: *Whiteinella* cf. *aumalensis* (Sigal), 7a – 7c: *Rotalipora cushmani* (Morrow), 8a – 8c: *Rotalipora* cf. *appenninica* (Renz), a – dorsal views, b – peripheral views, c – umbilical views, 1-7 sample 1.4, 8 sample 1.2 scale bar – 200µm.

3a–3c; Caron, 1985, Premoli Silva and Verga, 2004). Some of the taxa are assigned to *Marginotruncana sinuosa* (Porthault) (Fig. 10, 2a–2c), Marginotruncana cf. *tarfayensis* (Lehmann)

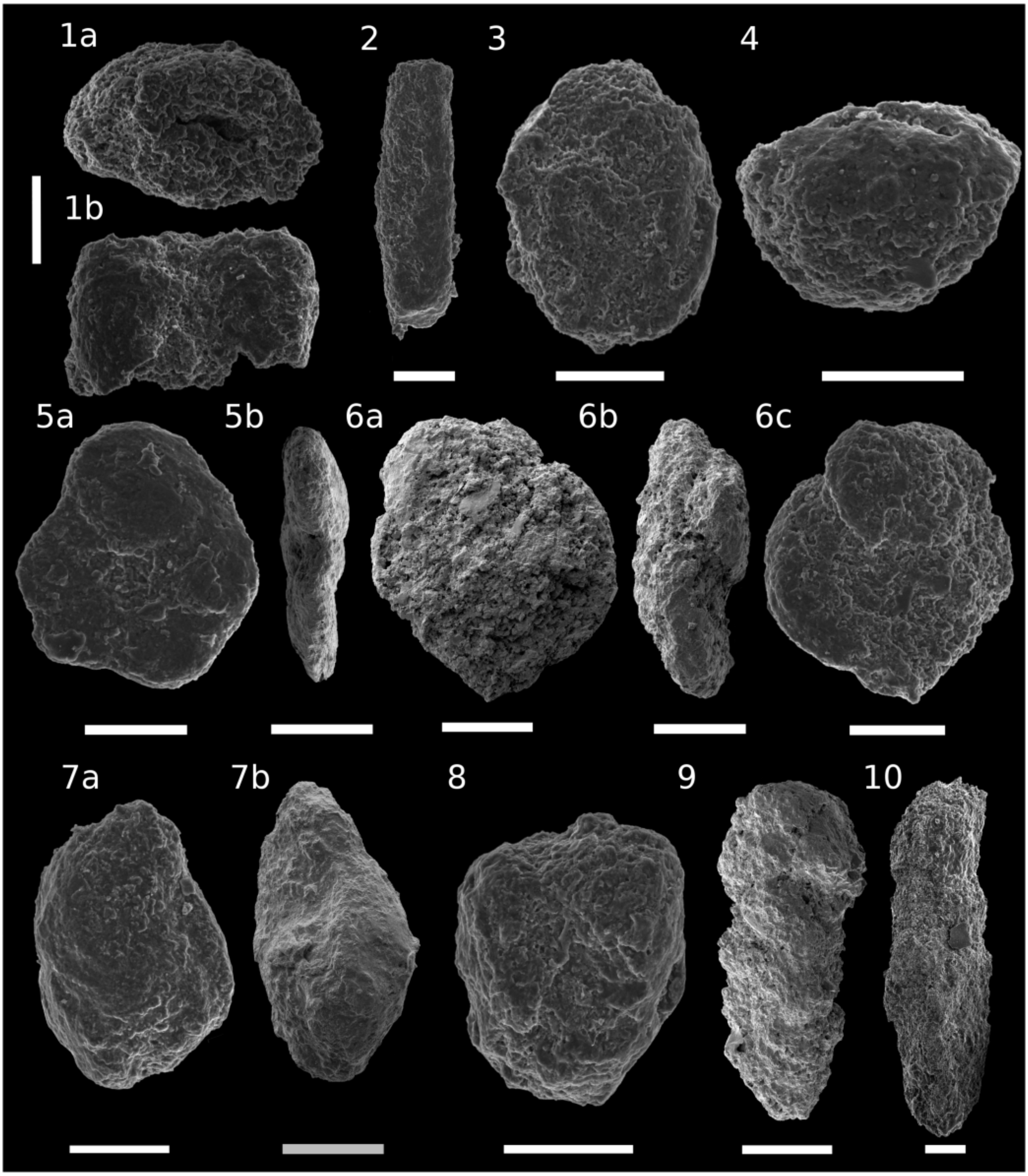

Figure 11: Agglutinated foraminifera. 1a, 1b: *Rhabdammina robusta* (Grzybowski); 2: *Batysiphon* sp.; 3: *Ammodiscus* sp.; 4: *Glomospira charoides* (Jones and Parker); 5a, 5b: *Haplophragmoides kirki* (Wickenden), 5a – dorsal, 5b peripheral view; 6a – 6c: *Trochammina* sp., 6a – dorsal, 6b – peripheral, 6c – umbilical, 7a, 7b: *Uvigerinammina jankoi* Majzon, 8: ?*Recurvoides* sp.; 9: *Gerochammina* sp.; 10: *Tritaxia* cf. *gaultina* (Morozova). 1-9 sample 2.8, 10 sample 1.2 Scale bar 100µm.

and *Marginotruncana* cf. *sigali* (Reichel) (Fig 10, 5a-5c). Marginotruncanids represent more than 95% of the assemblage. Additional agglutinated foraminifera such as *Rhabdammina robusta* (Grzybowski), *Ammodiscus* sp. or *Tritaxia* cf. *gaultina* (Morozova) were noted.

A single sample (2.8) further up-section, from outcrop 5 below a road cut, yielded an impoverished assemblage of deep water agglutinated foraminifera (DWAF) including taxa such as *Rhabdammina robusta* (Grzybowski), *Hyperammina* sp., *Ammodiscus* sp., *Glomospira charoides* (Jones and Parker), *Reophax* sp., *Haplophragmoides kirki* Wickenden, *Trochammina* sp., *Uvigerinammina jankoi* Majzlon, *Recurvoides* sp. and *Gerochammina* sp. (Fig. 11, 1–10). The age of this sample confirms the Uvigerinammina jankoi deep water agglutinated foraminifera zone (Turonian–Santonian, Fig. 11, 7a, 7b).

One specimen of the conodont *Neogondolella aldae* Kozur, Krainer and Mostler, of the latest Anisian–earliest Ladinian age (Kozur et al., 1994, Chen et al., 2015), was extracted from pelagic carbonate clasts of the pebbly mudstones (sample 1.3; Fig. 12A–D). Most probably it represents material derivated from the overlying Hronicum nappe as Triassic pelagic carbonates are very rare in the Tatricum and Fatricum (Mišík and Marschalko, 1988; Gawlick et al., 2002).

4. Lithostratigraphic definition of the Hubina Formation (New name)

The studied rock sequence in the Striebornica section in the outcrops 1 to 5 is herein defined as the Hubina Formation (New name). The reasons for applying a new lithostratigraphic term are differences in the lithological composition, especially the occurrence of conglomerates and pebbly mudstones, the peculiar position above the typical Poruba Formation, a hiatus at the base, and the younger stratigraphic age relative to established formations.

Origin of name: The Hubina Formation (new name; Slovak: hubinské súvrstvie) is named after the village Hubina, Piešťany District, Slovakia, nearby the stratotype locality (Fig. 1).

Type section: Forest road cut and nearby slopes in the northern flank of the Striebornica Valley (east of the Moravany nad Váhom), municipality Hubina, Považský Inovec Mts., Slovakia (Figs. 1C, 2, 6). Coordinates: 48° 36.714′ N 17° 54.462′ E.

Distribution: The formation is known from the Tatricum sedimentary sequence (Inovec succession) in the central Považský Inovec Mts. of the Internal Western Carpathians in Slovakia (Figs. 1–3). Occurrences outside the Považský Inovec Mts. are not known.

Lithology: Variable lithologies ranging from ochraceous pebbly mudstones, pebbly sandstones and conglomerates to grey-green sandstones, claystones or shales. Very characteristic and distinct massive ochraceous pebbly mudstone to pebbly sandstone (Fig. 7A–C) with occasional conglomerate (Fig. 7D) and sandstone beds occur in the basal part of the section (Figs. 5–6). Light grey-green shaly claystone and marlstone, sometimes with thin sandstone interbeds, are dominant in the middle part of the section (Fig. 7E–F). The upper part is characterized by generally coarsening upward character with higher abundance of medium and thick beds of grey calcareous sandstones (Fig. 8A, C, E), claystones are present only in a small amount.

Thickness: 30–100 m. Minimum 30 m visible on 6 outcrops, during the years 2014 – 2016. Maximum assumed thickness based on map extent of the Hubina Formation, and deduced from dimensions of the sedimentary body between the overthrust of the Fatricum and top of the underlying Poruba Fm. (Tatricum).

Boundaries: The direct contact with the Poruba Fm. is not exposed. The *lower boundary* is a sharp change from grey-green shale and marlstones of the Poruba Fm. to the brown-grey to ochraceous conglomerates and pebbly mudstones of the Hubina Formation. A lower degree of lithification in com-

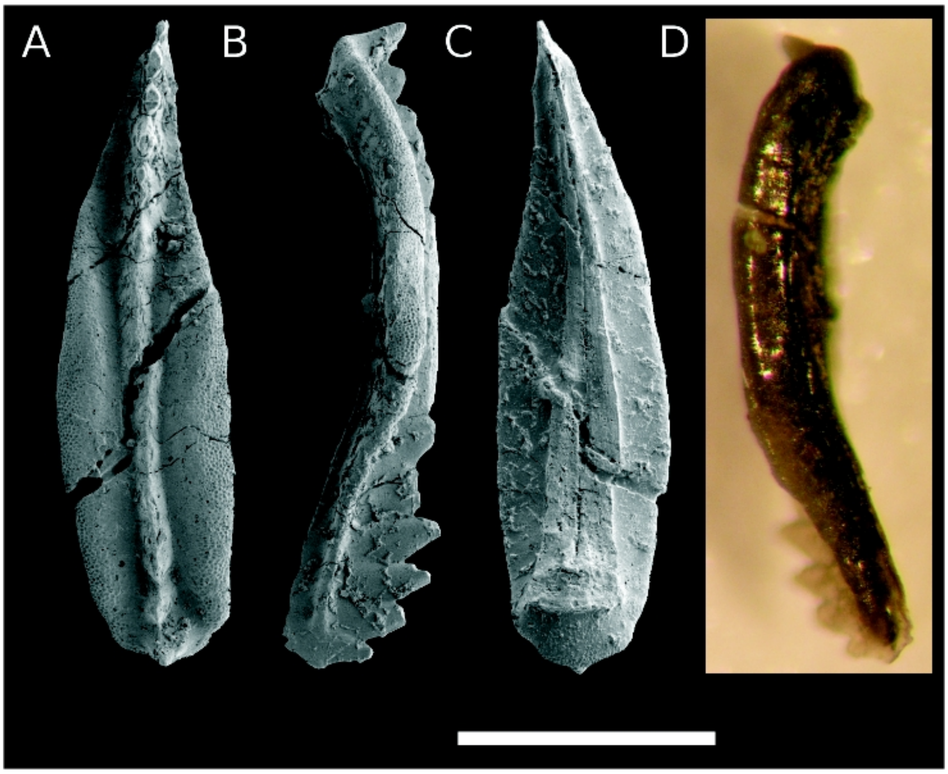

Figure 12: Conodont. A – D: *Neogondolella aldae* Kozur, Krainer and Mostler, A – upper view, B – lateral view, C – lower view, D – colour image illustrating the alteration coloration of the conodont, corresponding to CAI 2.0–2.5 according to Königshof (2003). Sample 1.3 Scale bar 500 µm.

parison with the Poruba Fm. is evident. The *upper boundary* is tectonic, the thrust fault of the Fatric unit is obvious. The basal part of the Fatricum nappe is marked by a sharp change in lithology where the Middle Triassic dolomite (Ramsau Fm.,) is known at the type locality. The Hubina Formation in the Striebornica section is partially covered by Quaternary loess which discordantly overlies various stratigraphic units of the Fatricum and Tatricum in the region (Fig. 2).

Geological age: middle Turonian–Santonian (for detail see section 3.2 and 5.1, Fig. 9).

Dating method: Paleontological investigation based on microfossil (foraminifera) content.

Equivalents and correlations: There are no direct equivalents. Stratigraphic analogues in the Brezová Group (Gosau facies; Samuel et al. 1980; Wagreich and Marschalko, 1995) represent mostly shallow water littoral sediments.

Another stratigraphic analogue is represented by the Coniacian–Santonian Rázová Fm. of the Horné Belice Group (see Plašienka et al., 1994; Pelech et al., 2016) which occurs in the northern and southern Považský Inovec Mts. The Rázová Fm. is, however, situated directly above the crystalline basement and the coarser clastics (Čierny vrch Conglomerate Member) are not comparable.

5. Discussion

5.1 Stratigraphic age of the Hubina Formation

The youngest documented biostratigraphic zone in the whole Poruba Formation stems from the top of the Balcová section in the Veľká Fatra Mts., represented by the early to middle Turonian Helvetoglobotruncana helvetica planktonic foraminiferal zone (Boorová and Potfaj ,1997). This biozone was documented also by Cúlová and Andrusov (1964) in the Tichá dolina Valley, in the Tatry Mts (Fig. 4). In the Polish part of the Tatry Mts. only late Cenomanian ages were confirmed (Bąk and Bąk, 2013). All these occurrences indicate that the youngest rocks found in the footwall of Fatricum are middle Turonian or older.

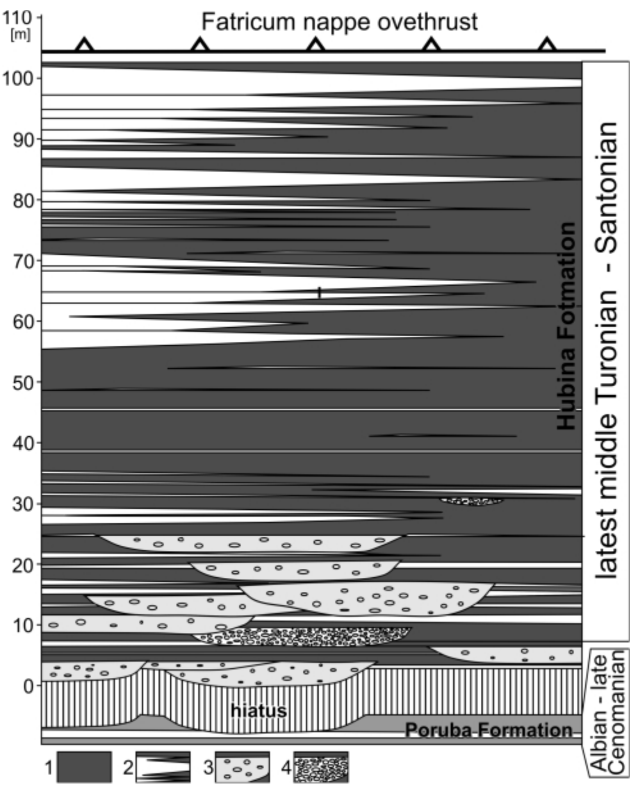

Figure 13: Schematic litho- and chronostratigraphic column of the investigated Hubina Formation, with marked approximate position of outcrops in the section. 1: Claystone or shale alternating with thin beds of sandstone; 2: Sandstone; 3: Pebbly mudstone; 4: Conglomerate.

Mass flow sediments with conglomerates located between the alternating shales and sandstones which are reported also from the northern block of the Považský Inovec Mts. (Kullmanová and Gašparíková, 1982), later designated as the Rázová Formation and Čierny vrch Conglomerate Member (Plašienka et al., 1994) are Coniacian–Santonian, based on planktonic foraminifera.

Despite the poor preservation of the microfauna from the studied Striebornica section, most of the planktonic foraminifers are represented by *Marginotruncana pseudolinneiana* Pessagno (Fig. 10, 4a–c) and *Marginotruncana coronata* (Bolli) (Fig. 10 1a–c, 3a–c) indicating a post-early Turonian age. The oldest possible age includes the upper part of Helvetoglobotruncana helvetica planktonic foraminiferal zone (Caron, 1985; Premoli Silva and Verga, 2004), although the marker species was not identified. Marginotruncanids widely appear in the middle Turonian and almost completely disappear at the Santonian–Campanian boundary (Gale et al., 2008). Species such as the *Marginotruncana sinuosa* (Porthault) and *Marginotruncana tarfayensis* (Lehmann) appear according to some authors later in the late Turonian in the M. sinuosa planktonic foraminiferal zone (Caron, 1985; Premoli Silva and Verga, 2004) or even in the Coniacian (Ion et al., 2004; Grosheny and Malarte, 2002).

Species such as *Rotalipora cushmani* Morrow, *Thalmanninella appenninica* (Renz) (Fig. 10, 7a–c, 8a–c), and *Whiteinella* cf. *aumalensis* (Sigal) (Fig. 10, 6a – 6c) are clearly redeposited. Taking into account the fact that foraminifera have been found only in the basal part of the sequence in one of the debris flow beds (outcrop 1) and in the claystones of the middle part of the formation (outcrop 5), it cannot be fully excluded that the overall age of the formation represents a narrower interval. However, there is no reliable evidence from the microfauna that would point to more precise or younger age. However, a significantly younger Cenozoic age can be excluded based on the typical lithology, the deep-water character of the sediments and the overall tectonic position below the Fatricum nappe which generally overthrusts the lower units during the Cretaceous.

A reconstruction of the depositional environment of the Hubina Fm. based on current knowledge is incomplete and only very general. The model of possible depositional environment can rely on a few facts. At first the presence of planktonic foraminifera suggests an open marine environment (e.g., Falzoni et al., 2013) and bathyal to abyssal depths based on the deep-water agglutinated foraminifera occurrence (e.g., Kaminski et al., 1999). Other factors include the nature of mass flow deposits which are usually considered as basin slope sediments deposited in the wide area between submarine channels and the middle to outer part of the submarine fans (Einsele, 1992).

6.2 Timing of the emplacement of the Fatricum

The existing models for the evolution of the Western Carpathians thin-skinned nappes consider the emplacement of the Fatricum nappe to occur before the "Senonian", thus before the Coniacian (e.g. Andrusov et al., 1973; Mišík et al. 1985; Mišík, 1997; Plašienka et al., 1997; Plašienka, 1999, 2012; Bezák et al., 2011; Prokešová et al., 2012). The emplacement was gradual and lasted since the Albian near the root parts of the Fatricum nappe (Nemčok and Kantor, 1989) till the earliest middle Turonian in the Tatry Mts. (Cúlová and Andrusov, 1964) and the Veľká Fatra Mts. (Boorová and Potfaj, 1997).

The occurrence of the Turonian–Santonian rocks below the Fatricum overthrust and above the Tatricum sedimentary succession in the Považský Inovec Mts. is unique within the framework of Internal Western Carpathians. It points to fact that the emplacement of the Fatricum nappe system occurred in the area of the present Považský Inovec Mts. after Santonian times, thus later than in other regions of the Western Carpathians. Such an assumption is in agreement with results of investigation of the borehole SBM-1 Soblahov situated at the western margin of the Strážovské vrchy Mts. (Maheľ, 1985). The borehole SBM-1 shows that in the footwall of the Mesozoic rocks correlated with the Fatricum, rock complexes correlated with the Upper Cretaceous Horné Belice Group were found in depths between 516 and 1801 m (Maheľ, 1985). This fact documents a gradually younger age of the syn-orogenic sediments to the foreland and dates gradual emplacement of the middle group of nappes (sensu Hók et al. 2014) that took a longer time period than it was previously assumed (cf. Andrusov et al., 1973; Plašienka, 1999, 2012; Prokešová et al., 2012). Such an interpretation is partly consistent with the older hypothesis (Kysela, 1988, and Havrila, 2011).

The deformation and emplacement of the Fatricum nappe was generally north- or northwest vergent (in present-day coordinates; Prokešová, 1994; Kováč and Bendík, 2002) but varies along the strike due to the arcuate shape of the Western Carpathian chain and post-emplacement Cenozoic rotations (cf. Túnyi and Márton, 1996).

7. Conclusion

The studied Striebornica section represents the upper part of the Tatricum sedimentary succession. It overlies the turbiditic sequence of the Albian–lower Cenomanian Poruba Formation and lies in the footwall of the middle Triassic complexes of the Fatricum nappe in the Považský Inovec Mts. The newly found grey sandstones and claystones with ochraceous pebbly sandstone-mudstone bodies, interpreted as mass flow and hemipelagic deposits, are herein formally attributed as the Hubina Formation (new name). The age of the studied sediments according to foraminifera extracted from the investigated section represents the latest middle Turonian–Santonian.

The new results disrupt the yet persistent view of the "pre-Senonian" age of the Fatricum nappe emplacement (Andrusov et al., 1973; Prokešová et al., 2012; Plašienka, 2012), which is probably valid only for southern (or more internal) areas of the Internal Western Carpathians.

Acknowledgements

The work was financially supported by the Slovak Research and Development Agency under the contracts Nos. APVV-0212-12 "Transfer"; APPV-0099-11 "Danube" and APVV-0315-12 "Tracktec" and Scientific Grant Agency under contract Nos. VEGA 2/0094/14. We are particularly grateful to E. Setoyama, E. Halásová, M. Havrila, J. Jablonský, A. Lukeneder, Y. Chen, I. Kostič, J. Madzin and S. Burmann for their help. The original manuscript was substantially improved thanks to constructive comments of D. Boorová, K. Bąk, M. Potfaj, H.J. Gawlick and two anonymous reviewers.

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Received: 17 May 2016
Accepted: 4 May 2017

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