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FACIES AND SEDIMENTARY ENVIRONMENTS OF THE UPPER SCYTHIAN–CARNIAN SUCCESSION FROM THE BELANSKÉ TATRY MTS., SLOVAKIA

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Abstract: The Triassic Fatricum basin studied in the Belanské Tatry Mts. (Slovakia) was a relatively stable and restricted platform area influenced by eustatic and climatic fluctuations. During the early Triassic the platform was influenced by continental clastic sedimentation intermittent with shallow marine transgressions when carbonate sediments formed. Common occurrence of carbonized plat debris suggests relatively humid climatic conditions dominating during this interval (Werfenian facies). Significant climate aridisation was concurrent with the beginning of the Middle Triassic transgression as indicated by evaporitic fabrics common within the entire Middle Triassic carbonate succession. The Middle Triassic has been divided into several lithofacies complexes reflecting the interplays between the eustatic and climatic fluctuations. The lower Middle Triassic complex (lower-middle Anisian?) displays dominance of calcareous sediments indicating free communication with the open ocean. The subsequent intervals are rather uniform facies assemblage composed by dolomites and evaporites formed in a restricted and stagnant basin. The basin has been strongly influenced by subtropical storms, particularly common in the late Anisian. Transgression pulse in the early Ladinian involved growth of microbial colonies building thrombolitic biostromes. Final shallowing by the end of Ladinian led to replacement of carbonate sediments by continental clastics of the Carpathian Keuper. These sediments, mostly of alluvial nature, comprise plant debris what suggests climate pluvialisation in Carnian times.

Key words: facies, paleoenvironments, late Scythian–Carnian, Belanské Tatry Mts.

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INTRODUCTION

The Triassic rocks of the Belanské Tatry Mts. (Slovakia; Fig.1), represent sediments formed within the Fatricum basin. These sediments are recently incorporated into the Krížna Nappe (Fig. 2). Triassic sedimentary facies, evolution of the basin and its controls are poorly recognized aspects of the basin history. The only exception is the Rhaetian where detailed paleontological and facies studies have been done (Gaździcki, 1974; Gaździcki *et al.*, 1979). The section of the Belanské Tatry Mts. comprises some 100 m thick profile of the late Scythian and less than 400 m thick succession of the Middle Triassic. Definite thickness of the Carnian succession is uncertain but exceeds 50 m.

Scarcity of index fossils hinders precise stratigraphic division of the succession. The only attempt of stratigraphical division was done by Kotański (1958) who divided the Middle Triassic into the Anisian stage that comprises dadocrinids and the Ladinian stage with *Encrinus* sp.

The present paper focuses on sedimentological characteristics and facies analysis of the Triassic succession from the upper Lower Triassic to lower Upper Triassic ("Carpathian Keuper"). This succession corresponds approximately to the late Scythian–Carnian interval. The inferring reconstruction of the basin evolution should give rise for future refining of chronostratigraphic resolution by means of sequence stratigraphy.

GOALS AND METHODS

A composite measured section has been done for the study area. Particular sedimentological field works (Rychliński, 2001) encompassed southern slopes of the Hlúpy (Szalony Wierch; Fig. 3) and Ždiarska Vidla Mt. (Płaczliwa Skała), belonging to the Havran unit. The sedimentological study have been supplemented by the microfacies and stable isotopes examination. The values of $\delta^{13}C$ and $\delta^{18}O$ were measured with the mass spectrometre SUMY, at the Institute of Geological Sciences, National Academy of Sciences of Belarus at Minsk. The samples were treated with 100% orthophosphoric acid, next carbon dioxide was collected in

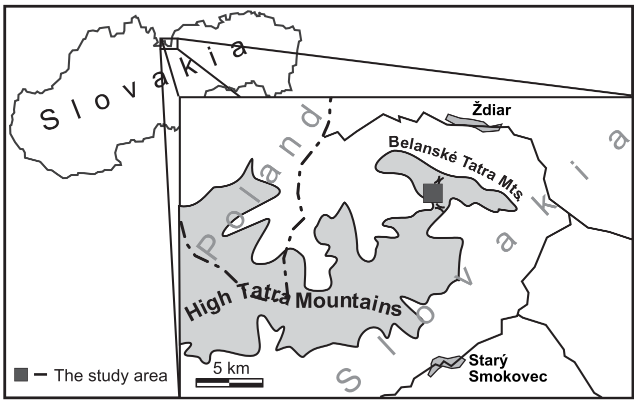

Fig. 1. The location of the studied section

a trap with liquid nitrogen and purified in vacuum. An error of measurement was about ±0.2‰. In the paper all the stable isotopes ratios in carbonate samples are presented with reference to the PDB standard.

Because of the poor knowledge about sedimentary environments of the middle Triassic from the Havran unit the main goal of our paper is reconstruction of the sedimentary environments and basin conditions as well as theirs influences on the facies development during late Scythian–Carnian times. Finally we compare the Fatricum basin with other Triassic basins from the Western Tethys domain.

GEOLOGICAL SETTING AND STRATIGRAPHICAL UNITS

Sedimentary series in the Tatra Mts. represent generally two different types of tectonic components. The first one – Wierchowa unit (so called autochthonous series) lying directly on the crystalline basement, built of Paleozoic igneous and metamorphic rocks. The second one is composed of several nappes, which represent Tethys palinspastic units (Haas *et al.*, 1995; Rakús *et al.*, 1998) and cover the autochthonous series. In the Tatra Mts. have been distinguished: the lowermost – KríŽna Nappe which represents palinspastic Fatricum unit, the middle – Choč Nappe that corresponds to the Hronicum, and the uppermost – StraŽov Nappe (as suggest Kotański, 1979) that corresponds to the Silicicum.

The described section belongs to the KríŽna Nappe. The basic geological and tectonic outline of the Belanské Tatra Mts. has been presented by Andrusov (1936, 1959) and by Sokołowski (1948). Their tectonic observations has been recently completed by Lefeld (1999). According to Lefeld (1999) the KríŽna unit in the Belanské Tatry Mts. has been divided into three tectonic units. The lower one, Subtatric partial nappe, corresponds to the Suchy Wierch unit of the Zakopane Subtatric area and is better exposed in the western part of the Belanské Tatry Mts. The middle one – the Havran partial nappe (Sokołowski, 1948) – builds the southern slopes and main ridge of the Belanské Tatry Mts., whereas the higher one – the Bujačí (Bujaczy) partial nappe – builds the northern slopes. The petrographical study of the Belanské Tatry Mts. done by Borza (1958, 1959) concerned mainly the continental clastics of the Lower and Upper Triassic and younger sediments. Some microfacies data for the Triassic carbonates of the Havran partial nappe have been discussed by Mišík (1972).

We use the stratigraphical nomenclature for Triassic of the Belanské Tatry Mts introduced by Mello and Wieczorek (1993a) and Michalík (1997a). The oldest Triassic sediments of the studied area are quartzite sandstones, which have been defined as LúŽna Formation. According to Sokołowski (1948) and Kotański (1958) it belongs to Sei-

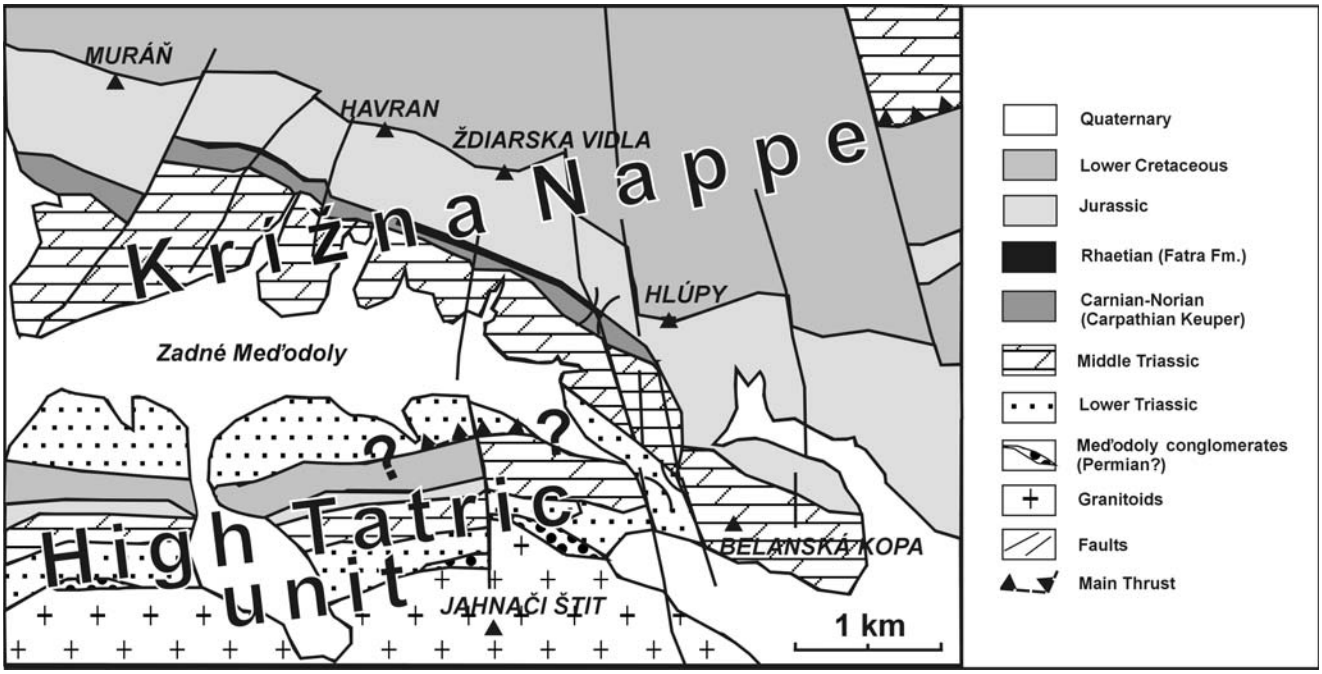

Fig. 2. Geological sketch of the study area (after Michalík *et al.*, 1997, simplified)

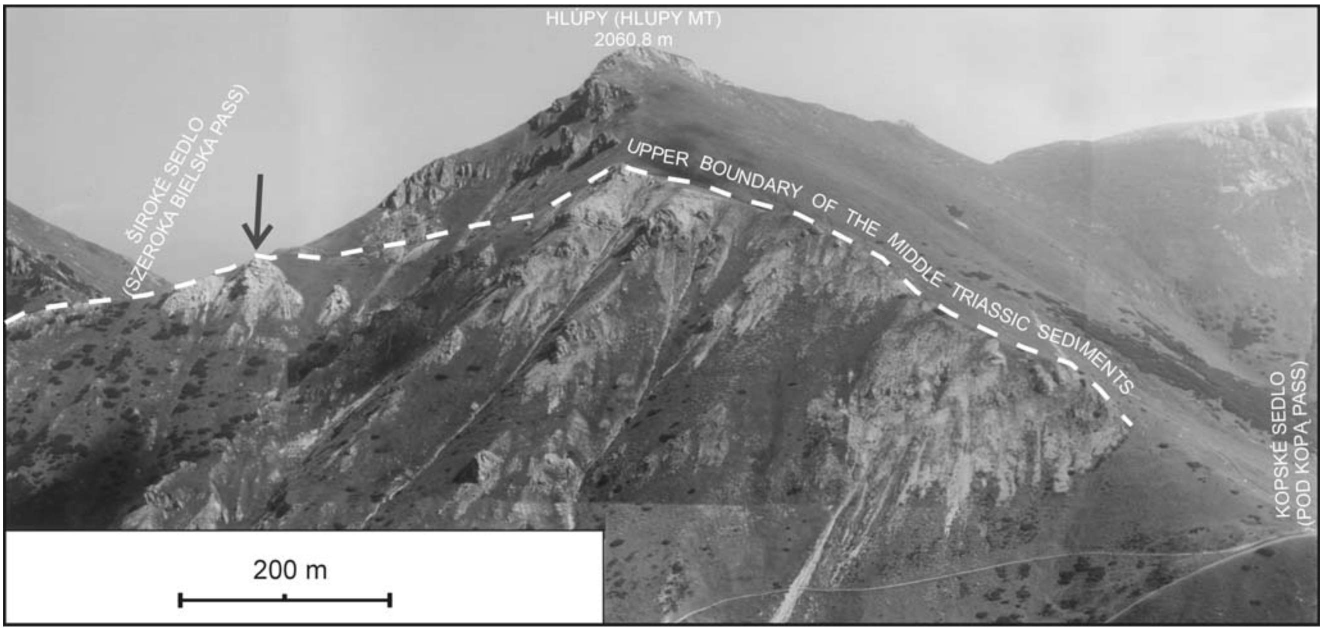

Fig. 3. View of the Middle Triassic section of the Hlúpy Mt. Arrow indicates karst site presented in Fig. 12A, B

sian of the Havran Unit, but it may be a part of the lowermost tectonical units as proposed by Lefeld (1999). However the latter suggested also, that within the Havran – Jahnači (Jagnięcy) elevation only the Havran unit is more or less preserved (cf. Fig. 2). The overlying mixed clastic-carbonates sediments with rauhwackes belong to Šuňava Formation. In the Polish Tatra Mts. the rauhwacke carbonates have been described as informal Myophoria beds (Kotański, 1963). The Middle Triassic carbonates have been divided into Gutenstein Formation (including dolomites and limestones of Anisian age) and Ramsau Formation that includes light grey dolomites of the Upper Anisian–Ladinian (and Carnian?) age (Plašienka *et al.*, 1997). The Upper Triassic of the study area called Carpathian Keuper (Carnian and Norian) is dominated by shales and sandstones with intercalations of dolomites. The uppermost Triassic (Fatra Formation – Michalík & Jendrejáková, 1978) is built mainly of limestones with benthic fauna (Gaździcki, 1971, 1974).

DESCRIPTION OF THE SECTION

Lower Triassic

The studied section begins with yellow cavernous dolomites (rauhwackes) directly covered by greenish quartzite sandstones. The sandstones are replaced by variegated mudstones and yellow dolomitic marls rich in carbonized organic matter (Fig. 4C). The next sequence begins again with cross-stratified, fluvial sandstones with variegated mudstones (Fig. 4A) that are followed by dark-coloured bituminous limestones and dolomites (Fig. 4B). Clasts of these limestones and dolomites along with flakes of mudstones occur within the overlying, poorly outcropped cavernous horizon (Fig. 4D).

The subsequent sediments are fine-grained dolomites and limestones, comprising sulphate pseudomorphs. Upsection the pseudomorphs disappear and the carbonates become coarser-grained. Kotański (1958) called these sediments as "Myophoria beds" and ascribed them to the Campilian, that is to the late Scythian. Thickness of the Lower Triassic series reaches ca. 80 m.

Middle Triassic

Scarcity of fossils, in particular the index ones, makes the stratigraphic resolution of the Middle Triassic very vague. The only fossils of stratigraphic significance are rare crinoids reported by Kotański (1958). Considering however modern taxonomy of crinoids, this determination seems to be uncertain. The above discussed, recently introduced formal units (Mello & Wieczorek, 1993a; Michalík, 1997a) are lacking precisely defined boundaries. Therefore we have tentatively divided the Middle Triassic succession into sedimentary complexes after their outstanding sedimentary features, which reflect most pronounced changes in sedimentary environments during the Middle Triassic. The supposed age is ascribed after the mentioned crinoids and by way of comparing of the section with other, better resolved Triassic sections of the Fatricum basin.

Limestone Complex (Lower Anisian)

The dolomitic "Myophoria beds" grade into dololutites pierced by internal breccias. The following deposits are calcarenites intercalated with grey bioturbated calcilutites ("Wursterkalke", "vermicular limestones"). The calcarenites that display thinning and fining upward trend are replaced by light coloured dolomites including sulphate pseudomorphs (Fig. 5B–D). After the evaporitic episode the calcareous deposition reestablished. The limestones show deformations evidently related to contemporaneous tectonic activity: synsedimentary faults (up to several centimetres; Fig. 6C) and slumps (Rychliński, 2004). The calcarenites comprise bivalve and gastropod shell debris (Fig. 7A–D)

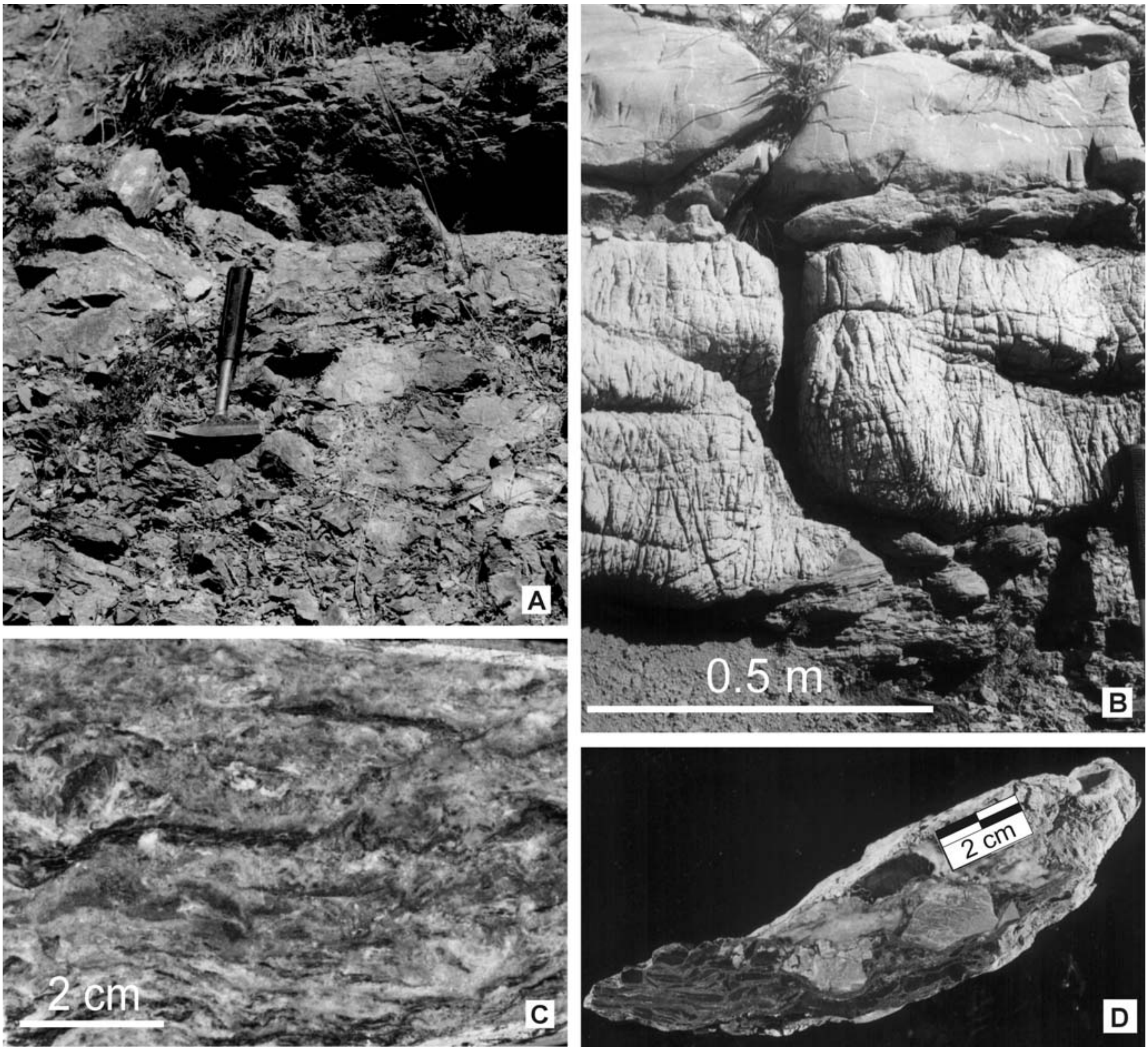

Fig. 4. Lower Triassic sediments. **A** – Red sandstones and brecciated variegated mudstones of the Upper Scythian; **B** – Limestones and dolomites of the uppermost Scythian ("Myophoria beds"); **C** – Yellow bituminous-rich limestones, Upper Scythian; **D** – Intraformational limestone breccia, Upper Scythian

and display flat and cross stratification (Fig. 8A, B). In the upper part of the sequence one may observe cherts that fill the bioturbations (Fig. 5A). According to dadocrinid remnants found in these sediments Kotański (1958) has dated them as lower Anisian. Thickness of the Lower Anisian succession reaches 80 m.

Tempestite Complex (Upper Anisian ?)

This interval is dominated by grey dolarenites alternated with dark dololutites. Most of the coarser grained beds display features of storm reworking (e.g., hummocky cross stratification (HCS), intraclasts, erosional scours). The dolarenites display also synsedimentary cracks that are healed with fine-grained sediments (Fig. 6A, B, D). The dololutitic beds comprise sulphate pseudomorphs and solution breccias.

Part of the section is poorly outcropped however one may observe that proportion of the sulphate-bearing dolomites increases upsection, and these dolomites are accompanied by thin intercalations of dolomitic shales. Thickness of the interval is ca. 140 m.

Microbialite Complex (Lower Ladinian ?)

The exact position of the boundary between the Anisian and Ladinian is uncertain and we assume it just below the onset of the obviously shallower facies assemblage evidenced by stromatolites, desiccation cracks and substantial contribution of dolomitic shales, as in other Fatric sections (see e.g., Szulc *et al.*, 2004). The Lower Ladinian complex begins with light-coloured thin to medium bedded dololutites overlain by darker dolomites including sulphate pseudomorphs and interlayered with bioclastic tempestites (Fig.

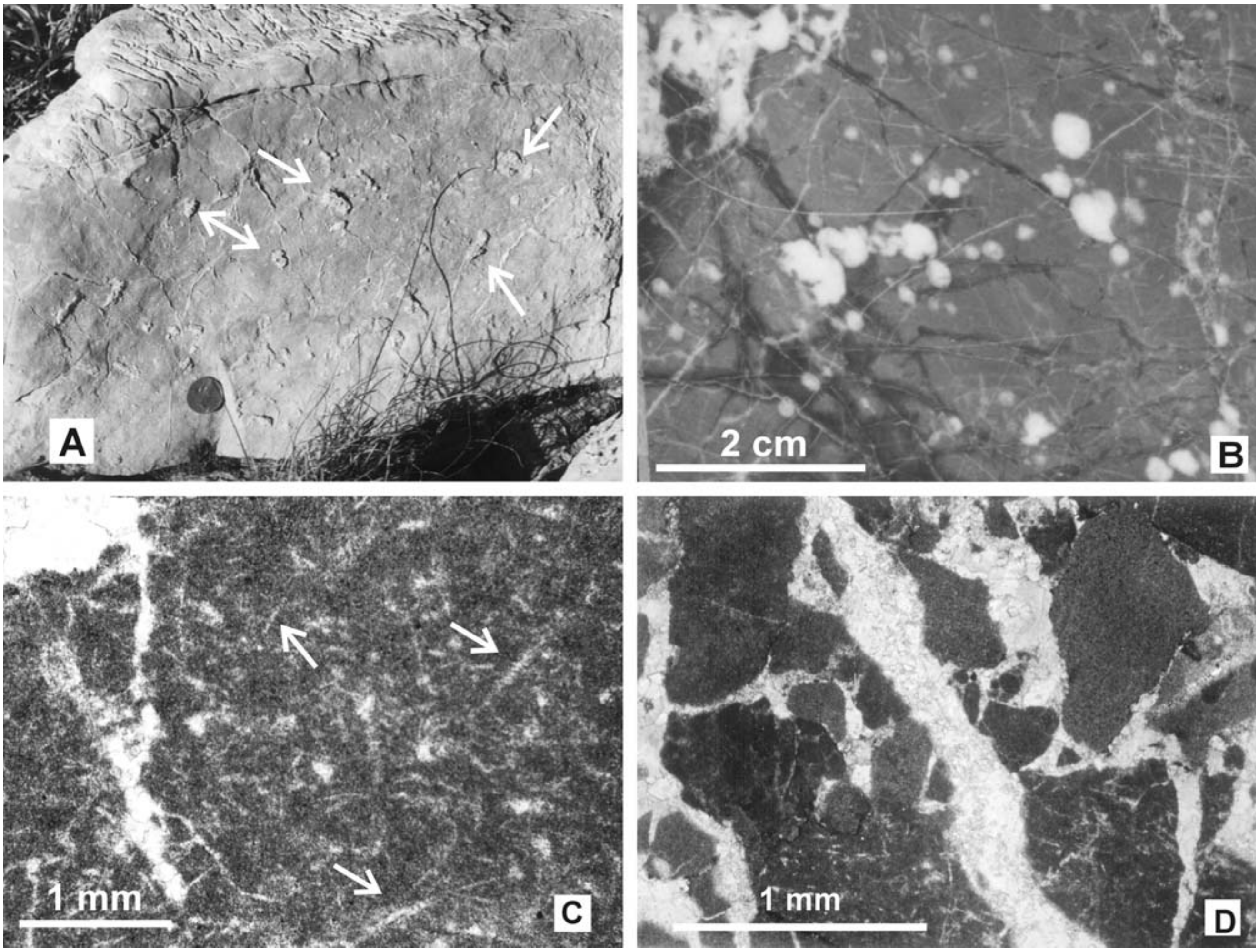

Fig. 5. Evaporites and postevaporitic collapse breccia fabrics. **A** – Calcilutites with cherts (arrows) that follow bioturbations. Limestone Complex, Lower Anisian, coin 10 mm across; **B** – Cracked dololutites with sulphate pseudomorphs, Limestone Complex, Lower Anisian; **C** – Halite pseudomorphs ("hoppers" – arrows) in dolomicrite, Microbialite Complex, Lower Ladinian; **D** – Dark grey dolosiltites with collapse breccias, Limestone Complex, Lower Anisian

7F). They grade to the first tepee complex (Fig. 9A, B) and then into an assemblage of shales and dolomite beds that may reach up to 2 m in thickness. Thin dolomite beds comprise microbial mats with small spongean colonies (Fig. 10A–C). Such a sponge-microbial assemblages have been found so far in other parts of the Western Tethys domain (Szulc, 1997) and they are believed to represent a lilliputian metazoan-bacterial buildups, enabling survive and recovery of the regular sponge buildups after P/T crisis (Szulc, 2003).

The upper part of the Lower Ladinian series is built by 7 m – thick complex of medium bedded thrombolitic dolomites comprising pelecypods and encrusting foraminiferas (Fig. 10D). The thrombolitic layers are intermittently degraded by storm events (Fig. 8E). The Lower Ladinian succession is 90 m thick.

Tepee Complex (Upper Ladinian)

The lower part of the Upper Ladinian series is composed of three shallowing upward sequences composed of thick-bedded, sulphate-bearing dolomites that grade into thin bedded dolomites with tepee structures and shales (Figs 7E, G, H, 8C, D). This cyclic sequence is succeeded by stromatolitic complex (Fig. 11A, B). The uppermost part of the Ladinian succession is composed by brecciated dololutites rich in silicified sulphate pseudomorphs. The top of the Ladinian dolomites is featured by common pedogenic fabrics and paleokarst phenomena (Fig. 12A–F; Rychliński & Jaglarz, 2004). Total thickness of the Upper Ladinian succession is 60 m.

Upper Triassic

The karstified top surface of the Ladinian series dolomites is covered by the Upper Triassic yellowish mudstones that penetrate also the karstic cavities (Fig. 12B). Upsection the mudstones are interlayered with coarse-grained sandstones and conglomerates and their color changes to reddish. The upper part of the Carpathian Keuper is dominated by dolomitic mudstones that gave way to normal marine, fossil rich limestones of the Rhaetian. Thickness of the Upper Triassic succession exceeds 50 m.

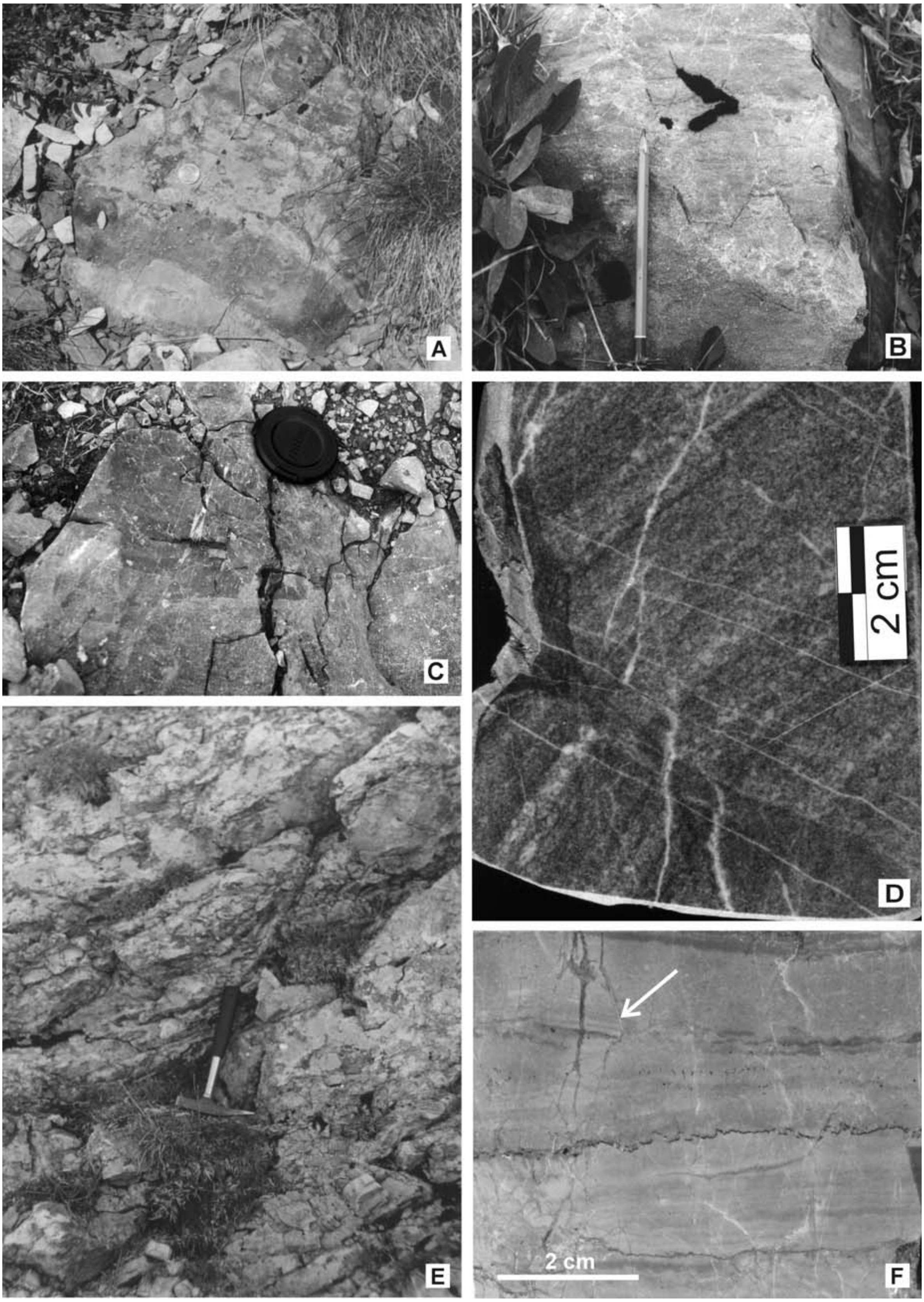

Fig. 6. Synsedimentary faults related to Triassic tectonic activity in the Fatricum basin. **A**, **B** – Tempestite Complex, Upper Anisian, coin in A 10 mm across; **C** – Limestone Complex, Lower Anisian, (camera cap for scale); **D** – Tempestite Complex, Upper Anisian, note the rotation of dolarenitic blocks; **E** – Microbialite Complex, Lower Ladinian; **F** – small scale faults (arrow) in dololutites, Tepee Complex, Upper Ladinian

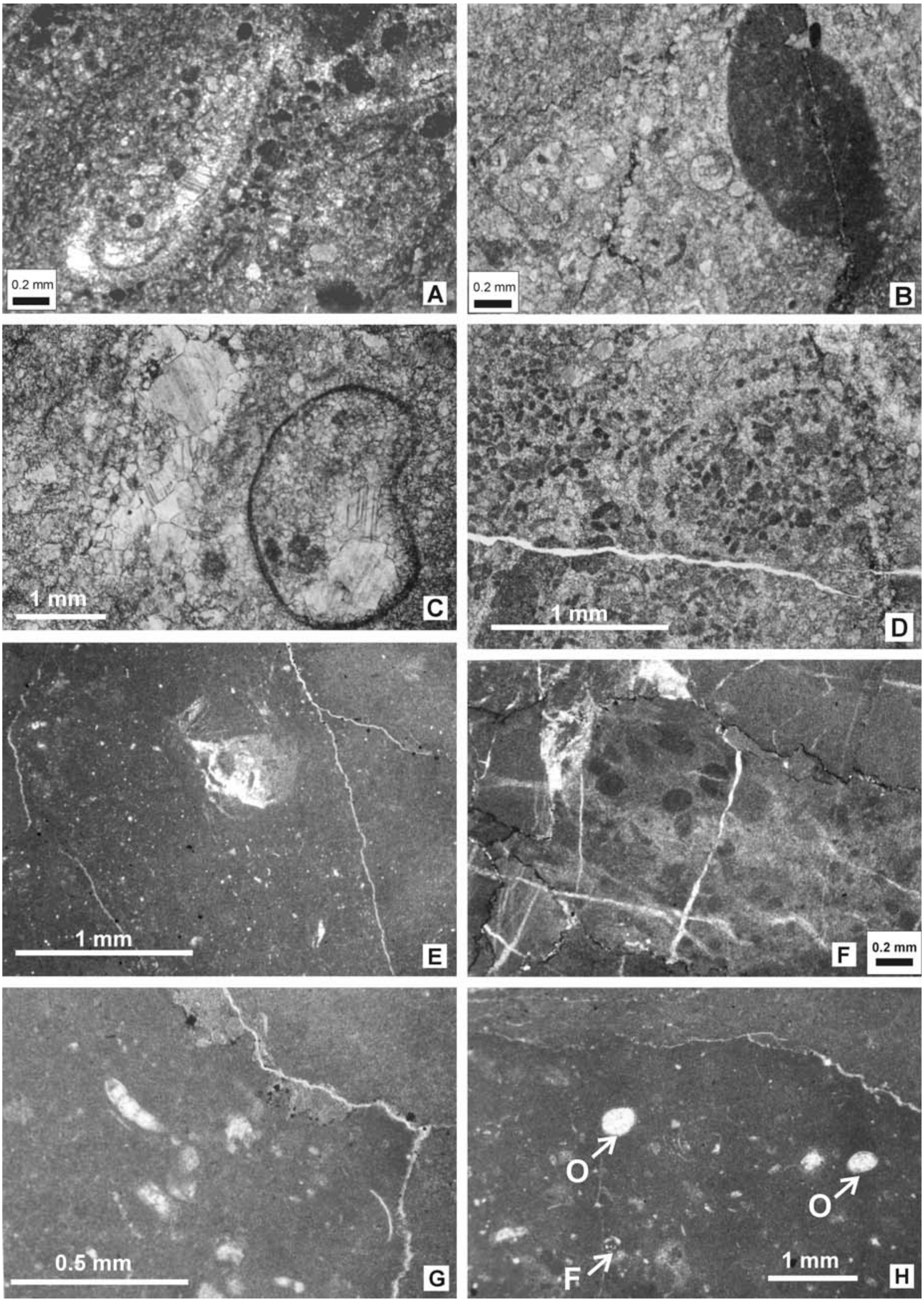

Fig. 7. Chosen microfacies aspects of the Middle Triassic carbonates. **A** – Biopelsparitic limestones with pelecypod dissolved shell, Limestone Complex, Lower Anisian; **B** – Biosparitic limestones with pelecypod and gastropod shells, Limestone Complex, Lower Anisian; **C** – Biopelsparitic limestones with ostracod shell, Limestone Complex, Lower Anisian; **D** – Pelsparitic limestones, Limestone Complex, Lower Anisian; **E** – Bioturbated dolomictrite, Tepee Complex, Upper Ladinian; **F** – Dolomicrite with fecal pellets of crabs, Microbialite Complex, Lower Ladinian; **G** – Dolomicrite with foraminifera and thin shelled pelecypods, Tepee Complex, Upper Ladinian; **H** – Dolomicrite with ostracods (O) and foraminifera (F), Tepee Complex, Upper Ladinian

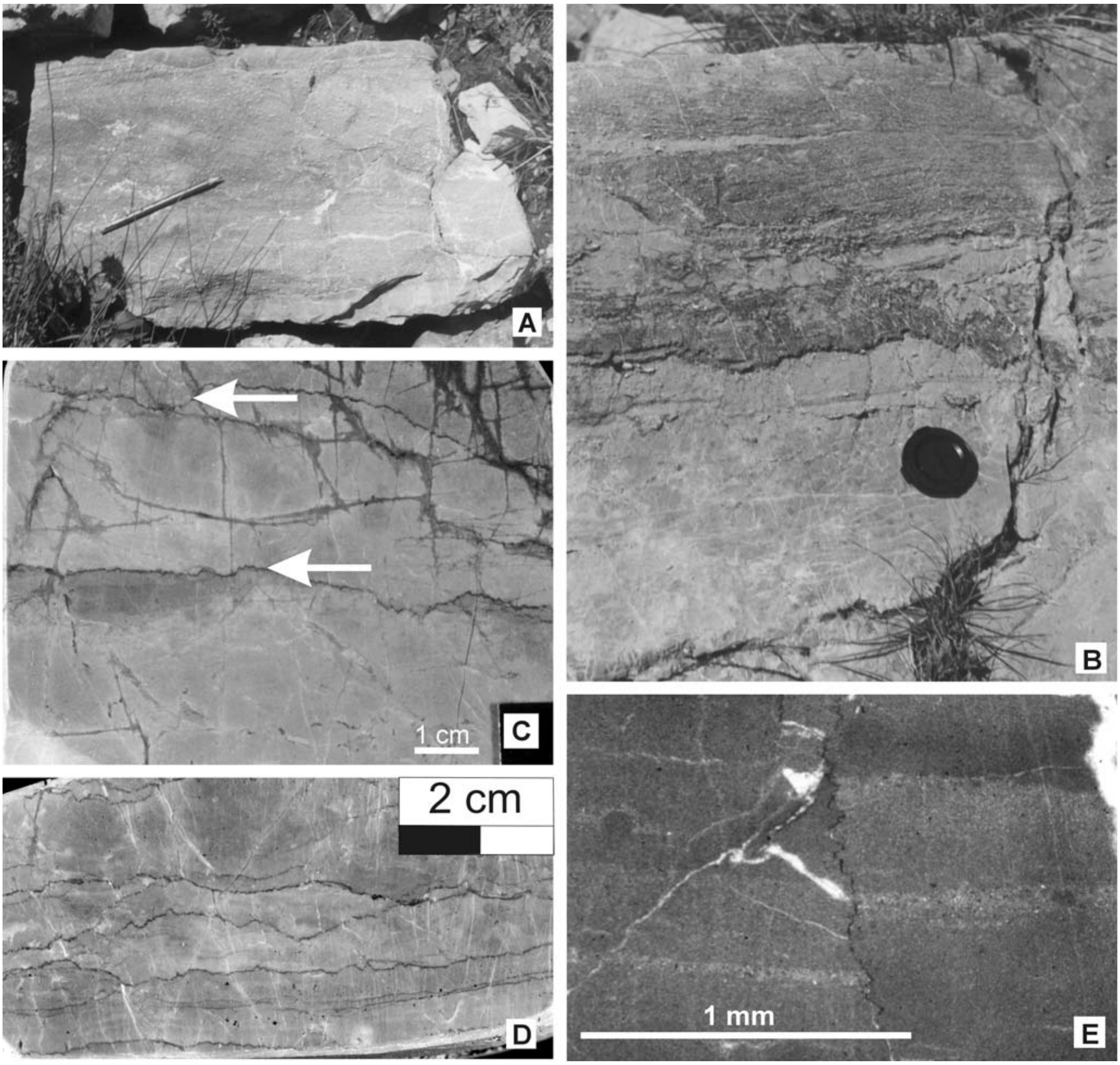

Fig. 8. Chosen sedimentary structures typical for the Middle Triassic carbonates of the Belanské Tatry Mts. **A** – HCS calcarenites with intraclasts (pencil 15 cm long), Tempestite Complex, Upper Anisian; **B** – Vermicular limestones covered by tempestitic, partly amalgamated calcarenites (camera cap for scale), Tempestite Complex, Upper Anisian; **C** – Dololutites with small scale tempestite deposits marked by stylolites (arrows), Tepee Complex, Upper Ladinian; **D** – Stylolitised hummocky cross stratified dololutites, Tepee Complex, Upper Ladinian; **E** – Microtempestites in dolomicrite, Microbialite Complex, Lower Ladinian

INTERPRETATION

The Lower Triassic section is composed of three upward-deepening cycles. Two of them started with fluvial sandstones, the third one begun with rauhwackes. We interpret these cycles as result of eustatic 3rd order fluctuations. Considering significant proportion of carbonized plant debris both in fluvial clastics and in marine carbonates (cf. Fig. 4C), one may assume a relatively humid palaeoclimate during this time. Nonetheless, the presence of evaporitic fabrics in the succession indicates general subtropical paleoposition of the Fatricum basin in early Triassic times. It is worthy to note a very fast progress of the second transgression as one may infer from the direct replacement of the fluvial sandstones by marine limestones.

The Lower Anisian succession consists of two upward-shallowing cycles. The limestones formed in shallow but normal marine waters as indicated by fauna remnants (Fig. 7A–C) and common bioturbations (Fig. 5A). Episodic storm events ameliorated oxic conditions in the basin. The thin-bedded dark coloured dolomites, overlying the limestones, mark the periods of stagnation and shallowing of the basin up to the phase when the evaporated brine was concentrated enough to involve early diagenetic dolomitisation of the ambient limestones.

The Upper Anisian carbonate sedimentation progressed under stabilized shallow water conditions. Periods of restricted circulation are recorded by dololutite packages with sulphate pseudomorphs. Growing contribution of the evaporitic facies and appearance of shale intercalations indicate gradual shallowing of the basin by the end of Anisian.

A very pronounced contribution of sedimentary fabrics related to storm activity indicates that during this time the basin was situated within the pathway of the subtropical cyclones.

Next transgressive pulse opens the Ladinian succession that starts with bioclastic coarse grained carbonates, displaying still features of storm activity. This transgression halted soon as indicated by tepee complex overlying the high energy deposits. After the emersion, that resulted in origin of tepee structures (Fig. 9), the next ingression led to origin of thrombolitic fabrics forming biostromal horizons (cf. Fig. 10D).

The Upper Ladinian succession is composed of cyclically-arranged extremely shallow-water facies ranging from evaporite-rich dolomite to supralittoral deposits with tepee and pedogenic fabrics. The final emersion is recorded by a pronounced karst surface (Fig. 12) featuring the top of the Ladinian dolomites.

The Upper Triassic succession is dominated by continental variegated mudstones and sandstones formed upon peneplanized mudflat-sandflat area (Rychliński & Szulc, 2004). The final Triassic transgression began with dolomites and climaxed with open marine, bioclastic limestones of the Rhaetian.

GEOCHEMICAL INDICATORS OF THE BASIN EVOLUTION

Stable isotopes signals of $\delta^{13}C$ and $\delta^{18}O$ values measured from the uppermost Scythian to Ladinian, enabled a more refined reconstruction of basin evolution in terms of the complex interplays of marine *vs*. meteoric water influx and the evaporation effect. Therefore it is necessary to refer and interpret the stable isotopes to the general paleoenvironmental context.

Considering the studied profile one may find that the incursions of normal marine water as evidenced by the onset of calcareous deposition and the appearance of benthic fauna are coincidental with negative shifts of $\delta^{13}C$ values (cf. samples 17, 21, 25; Fig. 13). By way of contrast the positive excursions of $\delta^{13}C$ values are linked to evaporite-rich dolomites. This indicates the evaporation as a main factor controlling isotopes fractionation within the Fatricum basin in Triassic times. The situation changed only during late Ladinian (Tepee Complex, samples 8, 4 to 1) when the subaerially-exposed marine carbonate sediments underwent pronounced influence of the early meteoric diagenesis apparently recorded in negative shift of both isotopes. The $\delta^{18}O$ trend in the Ladinian goes in hand with growing contribution of evaporite pseudomorphs (cf. Fig. 5C).

COMPARISON OF THE FATRICUM BASIN WITH OTHER TETHYAN TRIASSIC BASINS

During the Early Triassic and early Middle Triassic Fatricum basin was a part of the large carbonate ramp, situated on the southern shelf of the Palaeo-Europe (Fig. 14; Michalík, 1993, 1994; Rüffer & Zühlke, 1995). The ramp became a carbonate platform during the Ladinian. Therefore there are some similarities between the Fatricum and other Tethys carbonate platforms.

The Lower Triassic succession of the Fatricum basin displays a very close similarity to the eastern part of the

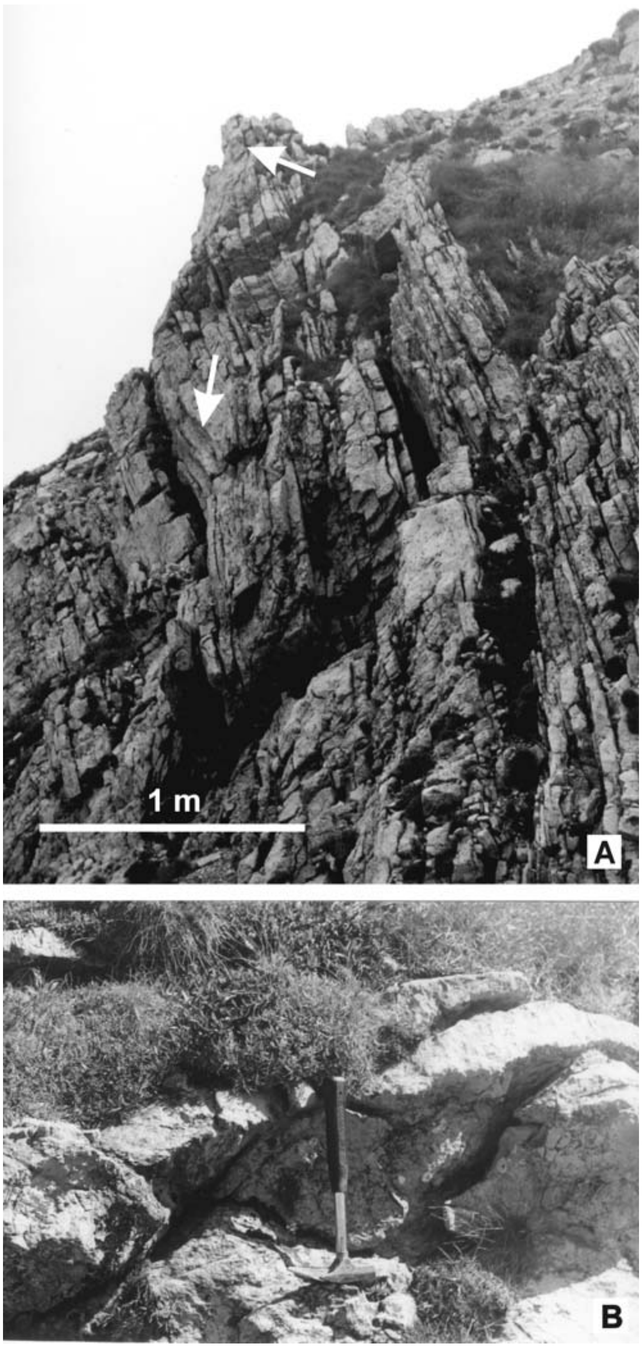

Fig. 9. **A**, **B** – Tepee deformations (arrows) from the Lower Ladinian

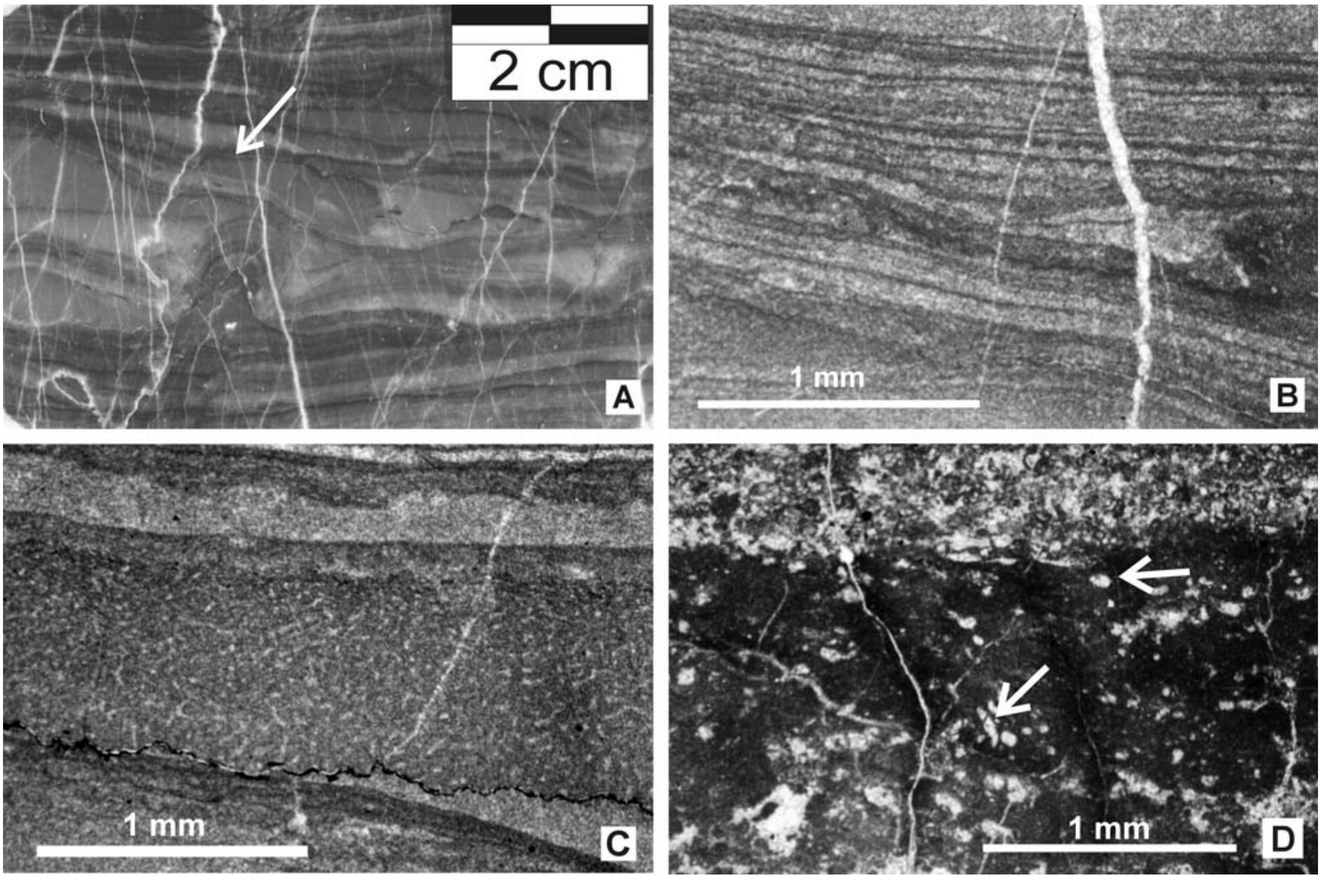

Fig. 10. Microbial and sponge fabrics (Microbialite Complex, Lower Ladinian). **A** – Sponge-microbial colony (arrow) within microbially laminated sediments; **B** – Microbial microfabrics, detail from A; **C** – Sponge microfabrics, detail from A; **D** – Thrombolitic structures with encrusting foraminifera (arrows)

Northern Calcareous Alps (NCA) where the mixed continental clastic and shallow marine carbonate facies with evaporites built the Werfen Formation (Mostler & Rossner, 1984; Krainer, 1987). However, the equivalent of the Fatricum basin differs from its alpine counterparts with extreme paucity of fossils. The only genus *Costatoria costata* and *Gervillea* sp. have been found by Limanowski (1901) in the Suchy Wierch unit of the Polish Tatra Mts., what makes this stage of Fatricum history similar to the Tatricum one, where the Lower Triassic is built by alternated mudstones and dololutites (Jaglarz & Szulc, 2003).

The postevaporitic vuggy dolomites (rauhwackes) at the Scythian/Anisian boundary are typical also for other sections of the Fatricum basin (Kotański, 1963; Szulc *et al.*, 2004) and they are common also in the Tatricum and the alpine Triassic (Reichenhaller Formation) from the NCA (Spötl, 1988).

The Lower Anisian limestones intensively affected by infauna activity ("vermicular limestones") and by storm events are typical for the whole Fatricum basin. It has been lately described from the Vysoká Nappe from Malé Karpaty Mts. as the Geldek Member (Michalík, 1997b). Both are equivalents of the Gutenstein Fm. from NCA.

With the early Anisian, the similar development of the Fatricum and the NCA basins finished. The Fatricum basin stayed very shallow, restricted platform with monotonous carbonates sedimentation interrupted only by the storms episodes, whereas the NCA basin started to disintegrate and apart the shallow water facies (Wetterstein Formation, Steinalm Formation), deep water facies appeared (e.g., Reifling Formation, Partnach Formation). The Middle Triassic from the Fatricum differs also from other Western Carpathian Units. In the Hronicum from the Nízke Tatry Mts, within Anisian sequence occur calcareous megabreccia (Farkašovo Formation; Michalík, 1979; Kochanová & Michalík, 1986), which clearly records synsedimentary tectonic activity. During Anisian time some tensional basins formed at the carbonate platform in the Hronicum basin (Fig. 14; Michalík, 1993), and they were filled by deep water sediments. Hronicum Unit differs from the Fatricum also with common occurrence of fossils (cf. Mello & Wieczorek, 1993b), that indicates better environmental condition (oxygen regime, contact with fresh marine water etc.). The intense rifting affecting the NCA basins is only slightly recorded in the Fatricum basin in form of seismically-induced deformations, such as slumps from the Nízke Tatra Mts. (Mišík, 1972), or tsunamites from Vysoká Formation in the Malé Karpaty Mts. (Michalík, 1997b). This opposite tendency continued up to the late Triassic when the global transgression encompassed finally also the Fatricum basin.

DEPOSITIONAL SEQUENCES OF THE LATE SCYTHIAN–LADINIAN (CARNIAN?) OF THE FATRICUM BASIN

The application of the sequence stratigraphy procedure is difficult since the primary prerequisite of the method that is the sequence boundaries are vague and hardly to point out. Nevertheless, one may find at least four distinct transgressive events that could be interpreted as maximum flooding zones (mfz – see Fig. 13). The first three are visible in the Anisian succession where they are marked by limestone intervals with benthic fauna. The last one in Ladinian is again marked by appearance of the benthic pelecypods and foraminifera. The third Anisian mfz could be related to the Pelsonian trangressive event of a global scale (cf. Rüffer & Zühlke, 1995). Also the Ladinian mfz may be related to global Fassanian transgression. The depositional sequences are quite clear in the Lower Triassic succession where they are well defined by the erosional sequence boundaries (see also above). To define the other depositional sequences, in particular in the Middle Triassic, one needs more detailed studies on the lower-order cyclicity (5^{th} and 4^{th} order), that should give way for deciphering the 3^{rd} – order sequences.

Tentatively for the Fatricum of the Havran unit some of the tepee horizons, pedogenic and karstic phenomenon or evaporites solution phenomena (solution breccias, rauhwackes) common in the Middle Triassic, seem to be good candidates for the sequence boundaries.

The 3^{rd} – order depositional sequence framework for the Triassic in NCA is not definite, since some synsedimentary movements have been observed there (Satterley, 1996). Nevertheless the role of local controls, including tectonics, was subdued as indicated by good correlation of the Alpine framework with its counterparts from the other Triassic basins (Rüffer & Zühlke, 1995). So we assume too the eustatic fluctuations as the main factor controlling the facies changes in the Triassic Fatricum basin. Some short-lived changes may be however resulted from local tectonic causes.

CONCLUSIONS AND FINAL REMARKS

During the Triassic, the Fatricum basin was an extensive flat platform area influenced by eustatic and climatic fluctuations. The role of synsedimentary tectonics was subdued.

The Lower Triassic is characterised by mixed continental-shallow marine sedimentation. During the regressive periods the basin was dominated by sandy and silty sedimentation proceeding over a sandflat-mudflat area. During the transgressive phases a shallow, restricted basin formed as indicated by bituminous rich marls and calcilutitic sedi-

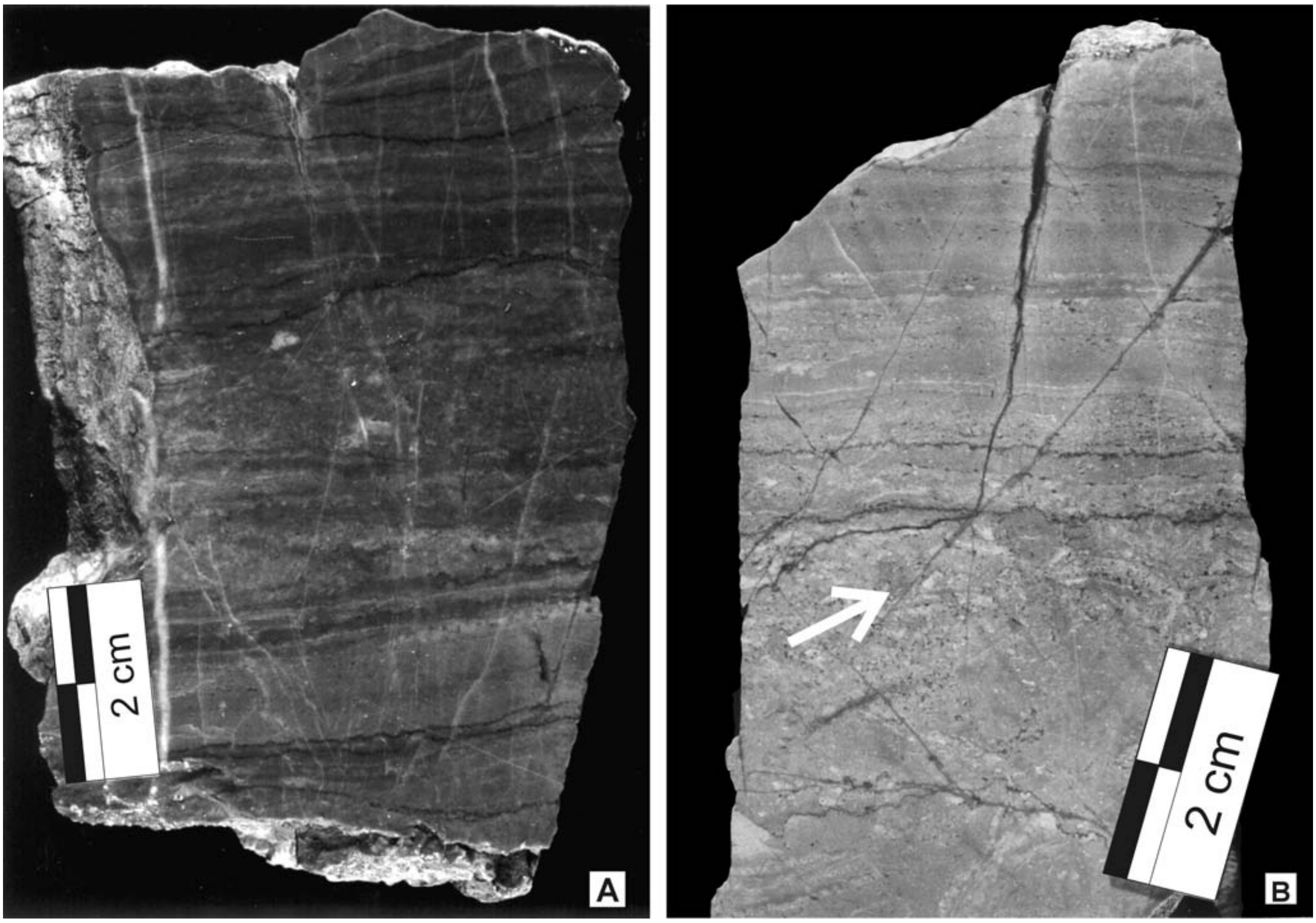

Fig. 11. Intertidal deposits. **A** – Microbial mat-tempestite sets, Tepee Complex, Upper Ladinian; **B** – Microbial mat covering the intraclastic level (arrow), Tepee Complex, Upper Ladinian

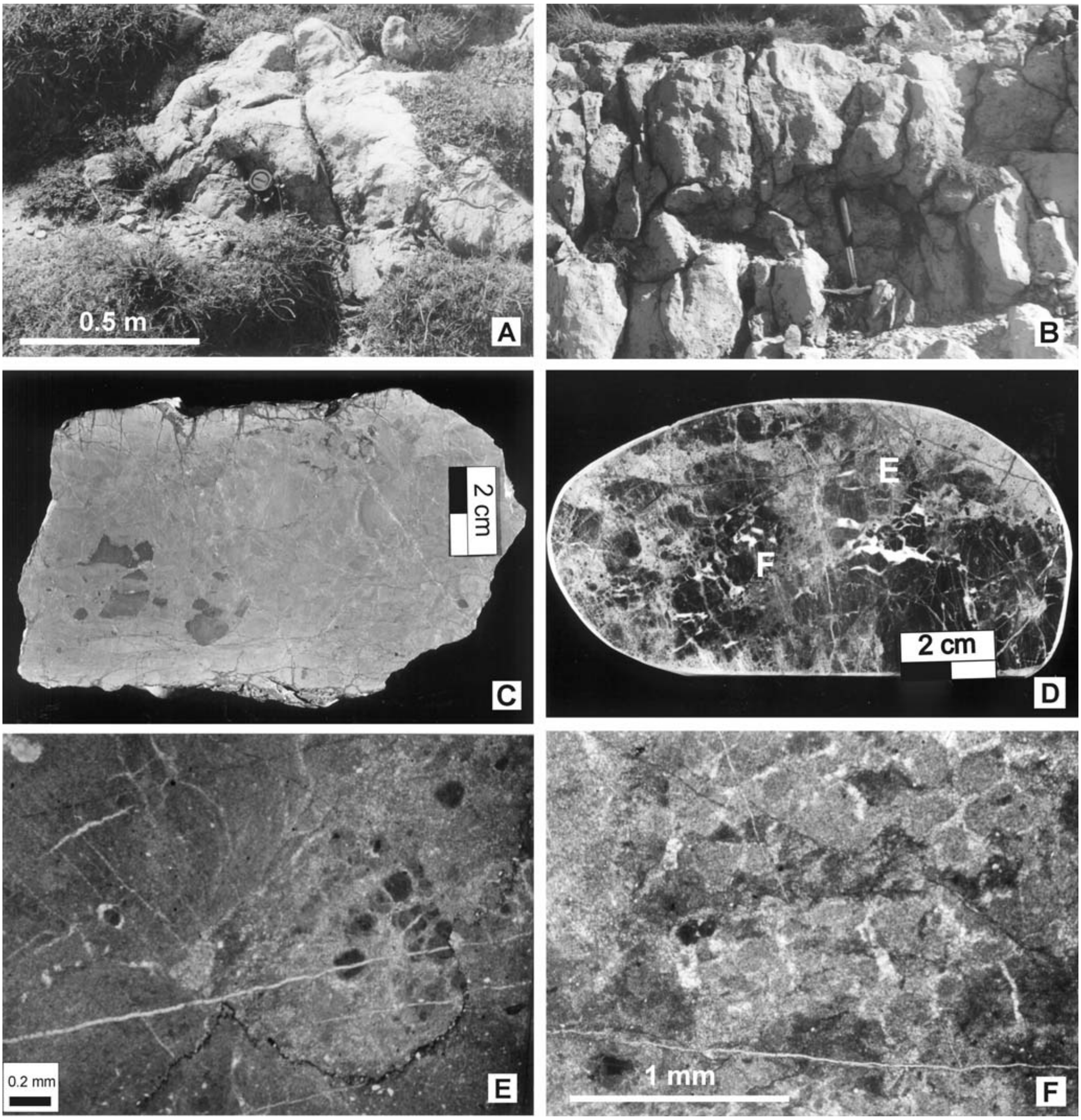

Fig. 12. Palaeokarst features of the Upper Ladinian (Tepee Complex). **A**, **B** – Karstified top of the Ladinian dolomites; **C** – Initial pedogenic structure ("black pebbles") in dololutites; **D** – Karst breccia from the topmost part of the Ladinian, the letters indicate location of thin sections from E and F; **E** – Detail from D, note the dark initial pedogenic structure; **F** – Microbreccias in krastified dolomites, detail from D

ments. Common occurrence of carbonized plat debris suggests relatively humid climatic conditions.

The climate became hot and arid as one may infer from evaporitic fabrics featuring the Scythian/Anisian boundary.

Similar arid climate characterised also the early Anisian, however due to prominent recurring sea level rises the evaporitic regime has been attenuated.

The succession from the Lower Anisian onwards displays uniform sedimentary facies development what suggests that the subsidence kept pace with eustatic fluctuations. The dolomitic and evaporitic sedimentation prevailed. The stagnant and restricted basin has been occasionally agitated by subtropical storms, particularly common in the late Anisian.

Slight ingression in early Ladinian involved growth of microbial colonies forming a complex of thrombolitic biostromes.

Continual shallowing in late Ladinian led to emersion of the Fatricum platform and to replacement of carbonate sediments by continental clastics of the Carpathian Keuper.

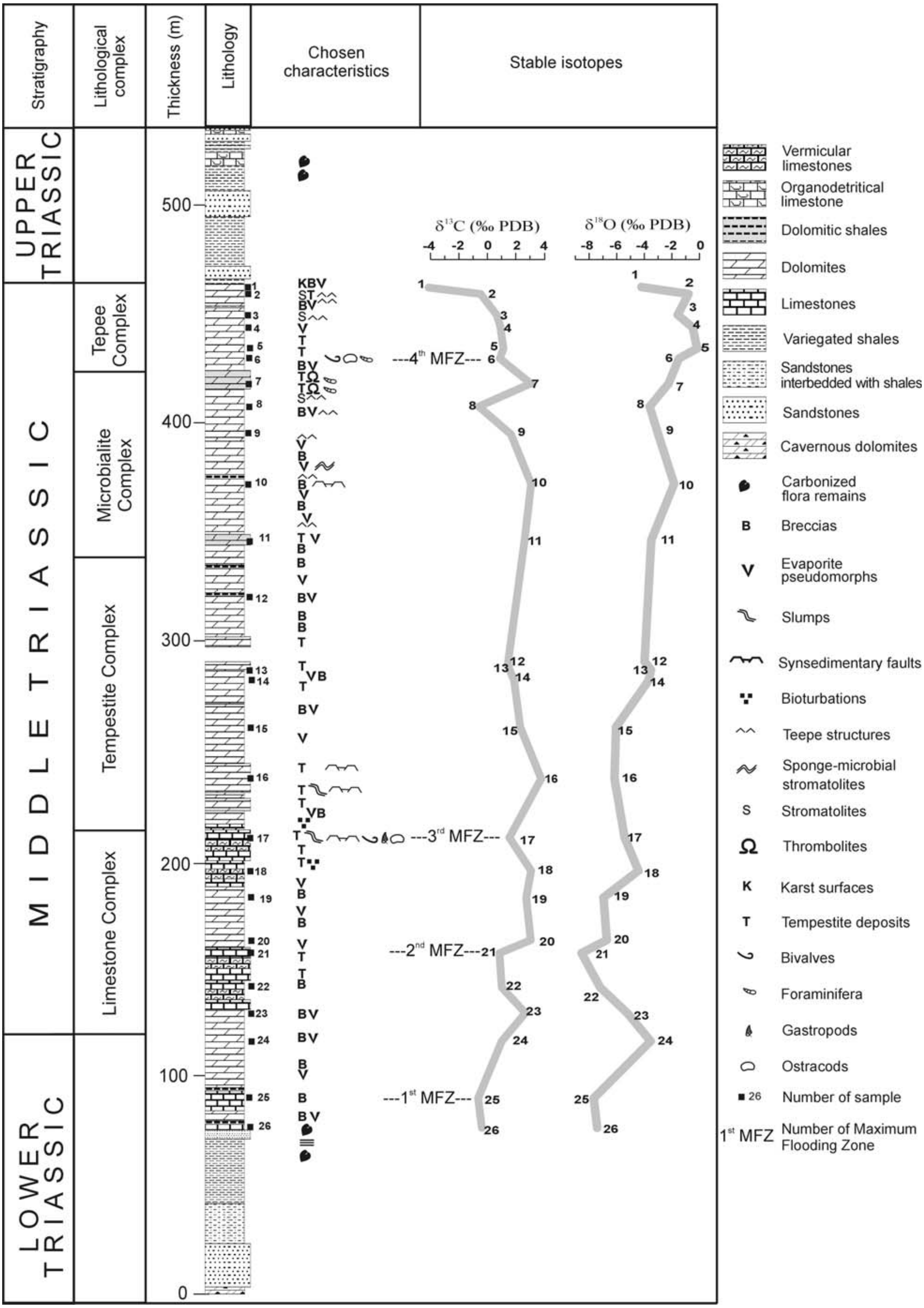

Fig. 13. Synthetic section, lithological complexes and stable isotopes curves of the lower-upper Triassic succession of the Fatricum from the Belanské Tatry Mts.

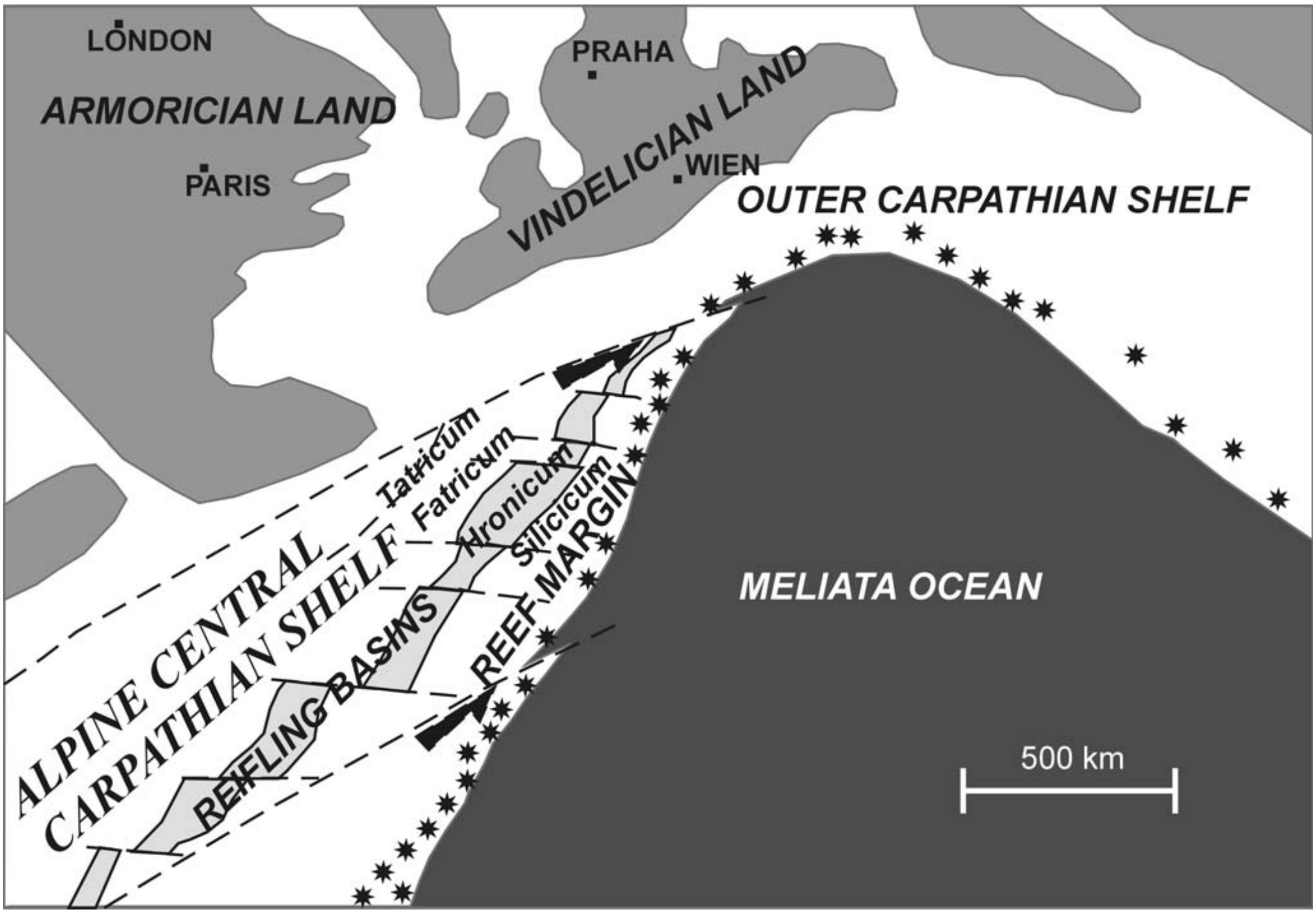

Fig. 14. Palaeogeographical sketch of the southern Palaeo-European shelf during the Ladinian (after Michalík, 1993)

Since these sediments are mostly alluvial and they comprise plant debris (in the upper interval), a significant climate pluvialisation is suggested.

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