FACIES ASSOCIATIONS AND MICROFOSSILS FROM THE MIDDLE-UPPER TRIASSIC LIMESTONES OF THE TRANSILVANIAN NAPPES (PERȘANI MOUNTAINS, EASTERN CARPATHIANS, ROMANIA)

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Abstract Triassic limestones that belong to the Transilvanian Nappe system, form extensive outcrops in the central part of the Perșani Mountains, near Racoș locality, on the southern and northern sides of the Olt Gorges. Triassic carbonate olistoliths were sampled in four distinct locations belonging to the Transilvanian Nappe: the Old Racoș Quarry, Olt Gorges, Tipia Racoșului Hill and Tipia Ormenișului Hill. The identified facies types include brecciated limestones with encrusting organisms and cyanobacteria, packstone-grainstone with sponges and encrusting organisms, boundstone with grainstone internal sediment, peloidal wackestone-packstone, peloidal packstone-grainstone, intraclastic grainstone-rudstone. Such microfacies characterize reefal bioconstructions or fore-reef domains located in the vicinity of shelf crest areas. They share common features with similar Wetterstein facies carbonates from Italy, Austria or Hungary. The micropaleontological assemblage indicates the Anisian-Ladinian to Carnian ages for the studied limestones, the present study bringing new data concerning the age of these carbonates. In addition, the presence of some foraminifera and dasycladalean algae are mentioned for the first time in this area.

Keywords: Reefs, Wetterstein facies, Anisian-Ladinian-Carnian, olistoliths, corals, sponges, fore-reef.

INTRODUCTION

Middle Triassic facies and microfossil associations were studied by numerous authors in many regions of the Tethyan Realm [Gaetani et al., 1981; Buser et al., 1982; Senowbari-Daryan et al. (1993, 2009, 2011, 2015); Flügel et al. 1994; Bucur et al. (1994, 1997); Sanchez-Beristain & Reitner (2016, 2018, 2019)]. During Middle-Upper Triassic (Anisian to Carnian) shallow-water reefal carbonates were accumulating on a large scale in various locations. Such carbonate deposits were mentioned from Hungary (Balogh & Kovacs, 1976; Senowbari-Daryan et al., 2011; Velledits et al., 2011; Horvath & Hips, 2015), Italy (Senowbari-Daryan et al., 1993) or Romania (Popa & Dragastan, 1973; Istocescu & Dragastan, 1978; Dragastan et al., 1982; Mantea, 1985; Bucur et al., 1994, 1997; Popescu, 2001; Popescu & Popescu, 2004). The main purpose of this study is to describe the microfacies and microfossil associations from the Middle-Upper Triassic carbonate olistoliths located in the Transilvanian Nappes of the Perșani Mountains, Racoș area.

GEOLOGICAL FRAMEWORK AND LOCATION OF STUDIED SECTIONS

The Perșani Mountains are characterized by a very complicated geological structure. Their geological and structural framework consists of two sets of units: the Bucovinian and Transilvanian Nappes (Patrulius et al., 1966; Săndulescu, 1984). Three major units define the Transilvanian Nappe system which overthrusts the Bucovinian Nappe. These units are represented by the Hăghimaș, Perșani and Olt Nappes (Patrulius et al., 1966). They represent fragments originating from different areas of the

Transilvanian oceanic realm (Săndulescu, 1984). Elements belonging to the Transilvanian units were subsequently deposited as olistoliths in various parts of the Eastern Carpathians (Ilie, 1954; Patrulius et al., 1966; Săndulescu 1984). In the Olt Gorges, the lowermost part of the Bucovinian Nappe consists of Tithonian-Hauterivian pelagic rocks (Carhaga Formation) covered by flysch and wildflysch type deposits (Patrulius et al., 1966) (Fig. 1a-d). The latter contain clays interbedded with coarse sandstones and fine quartzitic sandstones (Popescu et al., 1976). Patrulius et al. (1966) assigned them to the Barremian-Aptian (Bedoulian) interval. The Wildflysch Formation incorporates Lower Triassic (Campilian) to Hauterivian carbonate and siliciclastic olistoliths in association with Ladinian mafic rocks (Patrulius et al., 1966). All these olistoliths are derived from the Olt and Perșani Nappes or the Carhaga Formation (Fig. 1a-b, d). The post-tectonic cover contains upper Aptian polymictic conglomerates and Aptian (Vraconian)-lower Albian (Turonian) calcarenites and sandy limestones (Popescu et al., 1976).

The Wildflysch Formation incorporates four major types of olistoliths (Patrulius, 1996; Patrulius et al., 1996). They include: 1) olistoliths derived from the Perșani Nappe; 2) olistoliths derived from the Olt Nappe; 3) olistoliths and blocks derived from the Transilvanian Zimbru Series (Norian-Rhaetian limestones); 4) olistoliths and rocks derived from the Carhaga Formation (Tithonian-Hauterivian) (Fig. 1 b). The Upper Jurassic Merești olistoliths are included in the lowermost part of the Aptian post-tectonic cover (Fig. 1 b).

The Olt Nappe is exposed on large surfaces in the northern part of the Perșani Mountains (Fig. 1 d). Some of the most important exposures are located in the Meghieș area, Hăghimaș Valley, Olt Gorges (Pietrele lui Murgoci, Tipia

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Fig. 1 a Geological map of the studied area and location of studied sections [(A-Olt Gorges section and the Old Racos Quarry; B-Tipia Racosului section; C-Tipia Ormenișului section) (redrawn from Popescu et al., 1976)]; **b** Olistoliths from the Perșani Mountains and their relationship with other sedimentary units (redrawn from Patrușiu et al., 1996) (not at scale); **c** Carbonate successions of the Triassic deposits from the olistoliths belonging to the Perșani and Olt nappes (Hăghimaș, Surmanu and Pietrele lui Murgoci sections) (redrawn from Patrușiu et al., 1996); **d** Distribution of the olistoliths on the territory of the central and northern Perșani Mountains (redrawn from Patrușiu et al., 1996).

Ormenișului) or Surmanu Hill (Patrușiu et al., 1996) (Fig. 1c-d).

An ideal vertical succession through the Olt Nappe (based on olistolith rocks) comprises the following units: limestones and thin-bedded clays (Campilian-lower Anisian), meter thick-bedded limestones (lower Anisian), an ophiolitic complex covered by bostonitic porphyres and andesites (lower Anisian-lower Ladinian), Hallstatt type limestones and massive reefal carbonates (lower Carnian-upper Norian) (Fig. 1 c) in association with lower Jurassic Adneth type limestones (Fig. 1 a) (Patrușiu et al., 1996). The carbonate succession from the Olt Gorges is divided in two main categories. The first one includes packages of thin Hallstatt type limestones and massive Norian carbonates which cover Ladinian mafic rocks. They form large outcrops on the Tipia Ormenișului Hill, approximately 1.5 km south-east from Olt Gorges. Their Norian age is indicated by Patrușiu et al. (1996) based on an assemblage of poorly preserved ammonites (*Cladiscites* sp., *Arcestes* sp.) from thin beds of Hallstatt type limestones underlying massive reefal limestones. The second category consists of interbeddings of Hallstatt type limestones and coarse carbonates. It forms a well-exposed outcrop in the Pietrele lui Murgoci area, at the confluence between the Olt River and Tipia valley (Fig. 1c).

The carbonate succession from the Perșani Nappe forms extensive outcrops in various locations such as Colții Nadașului, Rica Hill or Hăghimașului Hill. These carbo-

nates consist of decimeter- to meter thick stratified limestones and dolomites covered by Steinalm type limestones with abundant foraminifera and dasycladalean algae (Fig. 1c).

MATERIALS AND METHODS

Three sections were studied: (A-C in Fig. 1a; Fig. 2a-e): Olt Gorges, Tipia Racosului Hill, Tipia Ormenișului Hill. The Olt Gorges section is divided in two important sectors: The Old Racos Quarry and the right side of the Olt Gorges (Fig. 2a-c). The first sector is located approximately 200 meters east from the actual Racos Quarry, in the Surmanul Hill (Fig. 2c). Patrușiu et al. (1996) described from this location a detailed section of the Triassic succession. The authors indicate its Norian age based on some bivalve fragments (*Monotis haueri* Kittl). The second segment of the Olt Gorges section is perpendicular on the Olt river flow-path being located at approximately 100 meters east from the old Racos Quarry (Fig. 2c). The starting point is represented by a ravine/stream. Altered mafic rocks belonging to the Olt Nappe form the bedrock of this small creek. The final point of this section is located approximately 200 meters towards NE (Fig. 2c).

Tipia Racosului section follows the carbonate olistolith from the Tipia Racosului hill. It is located approximately two kilometres NE from the Racos locality and one

Fig. 2 Outcrop images and location of the studied olistoliths [a, b: outcrops - of the Old Racoș Quarry; c location of the studied olistoliths and position of the most important topographic elements (A-Old Racoș Quarry and Olt Gorges section, samples 1-31 and 32-100; B-Tipia Racoșului section, samples 101-171; C-Tipia Ormenișului section, samples 172-220); d General view over the Tipia Racoșului Hill (black rectangle); e General view of the Olt Gorges and Tipia Ormenișului Hill (black rectangle).

kilometre north from the ending point of the Olt Gorges section (Fig. 2c-d).

Tipia Ormenișului section is located one kilometre NE from the confluence between Tipia valley and the Olt river. Patrușiu et al. (1996) mention its Upper Triassic age and indicate its stratigraphic position within the Olt Nappe. The studied section follows a predominantly SW-NE direction, from the Tipia Valley towards the topmost part of the hill (Fig. 2e).

Two hundred twenty samples were collected from various outcrops associated with carbonate olistoliths belonging to the studied sections. Sampling was performed at 2-3 meters resolution. Two hundred thirty thin sections were analysed for their microfacies and micropaleontological associations. Carbonate rock classification follows Dunham (1962) and Embry & Klovan (1971).

MICROFACIES

Four major microfacies associations (MFA1-MFA4) define the studied sections.

Microfacies association 1 (MFA1)

This facies association occurs in all the studied sections and dominates the facies spectrum of the Tipia Racoșului section. The most important microfacies types are represented by boundstone with grainstone-type internal sediment, boundstone with recrystallized peloidal wackestone-packstone internal sediment, coral-microbial boundstone, sponge bearing boundstone (Fig. 3a-b). Corals are encrusted by unidentified encrusting organisms and *Tubiphytes* sp. Some corals present micritised septa. The internal sediment contains encrusting organisms, worm tubes, large calcareous sponges, gastropods, bivalves, echinoderm plates, foraminifera and millimetre-sized angular intraclasts. The major components are embedded in fibrous radial cement.

Interpretation

These bioconstructions were accumulated in a high energy shelf crest depositional setting. The abundance of encrusting organisms indicates the presence of a rigid, wave resistant shelf margin. The presence of grainstone-type internal sediment confirms high-energy conditions where the waves were washing the muddy sediment deposited inside the bioconstructions. Although rare, the wackestone type internal sediment characterizes deeper water bioconstructions defined by low-energy conditions.

Microfacies association 2 (MFA2)

This facies association comprises the following microfacies: brecciated limestones, intraclastic rudstone, peloidal bioclastic grainstone-rudstone, bioclastic rudstone (Fig. 3c-d). It is very frequent in the Tipia Ormenișului and Tipia Racoșului sections.

Bioclasts consist of coral fragments, encrusting organisms, frequent echinoderm plates, cyanobacteria nodules, bivalves, agglutinated foraminifera and calcareous sponges. Corals are encrusted by microbial structures. Fragments of microbial crusts, thrombotic structures and worm tubes are common. Microbial crusts contain alternating laminae of spar and microspar or elongated filamentous structures. Voids are filled by abundant fibrous cement. Millimetre-to centimetre-sized angular intraclasts are present. They contain micrite and may trap peloids or other bioclasts.

Interpretation

The presence of angular intraclasts, poor sorting and the frequent occurrence of coral fragments and other reefal bioclasts suggest that carbonate sediments were transported on a short distance, from topographically elevated shelf crest areas. These sediments were reworked on a fore-reef slope from adjacent reefal settings. Abundant echinoderm ossicles characterize such normal marine depositional environments. Intense microbial activity led to the formation of thrombotic structures (Pleș et al. 2013). Although

Fig. 3 **a** Boundstone with peloidal packstone-grainstone internal sediment. Corals are encrusted by *Tubiphytes* sp. (yellow arrows); **b** Sponge bioconstruction with *Solenolmia manon manon*. The internal sediment contains encrusting organisms (*Tubiphytes* sp.-red arrow, *Ladinella porata*-yellow arrow); **c** Brecciated intraclastic peloidal rudstone with encrusting organism (*Tubiphytes* sp.-yellow arrow); **d** Bioclastic grainstone with encrusting organisms; **e** Dolomitized wackestone-packstone. It contains abundant cyanobacteria nodules (*Rivularia* sp.-yellow arrow), bivalves and gastropods. Euhedral dolomite crystals are present within the micritic sediment; **f** Dolomitized wackestone-packstone with cyanobacteria nodules and black pebble type intraclasts; **g** Fenestral wackestone-packstone with cyanobacteria (*Rivularia* sp.), fragments of “*Solenopora*” sp. and bivalves. Millimetre sized fenestral structures (white arrows) contain vadose silt and geopetal sediment. Meniscus micrite is present between peloids and other intraclasts; **h** Fenestral wackestone with black pebbles (yellow arrows). It contains rare bivalves and cyanobacteria nodules. The fenestral structures contain vadose silt and geopetal sediment. a: sample 80, Olt Gorges section; b: sample 77, Olt Gorges section; c: sample 55, Olt Gorges section; d: sample 30, Old Racș Quarry; e, f: sample 173, Tipia Ormenișului section; g: sample 174, Tipia Ormenișului section; h: sample 175, Tipia Ormenișului section. Scale bar: 1 mm.

Aitken (1967) considered that thrombolites form under subtidal conditions, more recent studies (Kennard, 1981; Feldmann and McKenzie, 1998) suggest that such microbial accumulations prefer low salinity, high energy settings.

Microfacies association 3 (MFA3)

This association contains two main microfacies types: peloidal bioclastic grainstone and packstone-grainstone. It is very frequent in the Olt Gorges section.

Bioclasts are represented by encrusting organisms (*Tubiphytes* sp.), calcareous sponges, echinoderm plates, rare coral fragments, gastropods, bivalves, foraminifera. Encrusting organisms and up to one millimetre-sized peloids dominate the grain spectrum. However, the occurrence of MFA3 is less common within the studied sections.

Interpretation

The presence of encrusting organisms and rare coral fragments indicate transport from a reefal area. However, the abundance of micritic sediment and well-rounded peloids may suggest a longer period of transport, on a distal shelf slope.

Microfacies association 4 (MFA4)

Wackestone-packstone with cyanobacteria nodules and black pebbles - and dolomitised wackestone-packstone (Fig. 3e-h) define this facies association which forms the basal part of the Tipia Ormenişului section. Bioclasts are represented by bivalves, gastropods, cyanobacteria nodules, ellianellacean algae. Micritic intraclasts are pigmented by organic matter. Other pigmented clasts include *Rivularia* type nodules and various bioclasts (bivalves, gastropods). In addition, the matrix contains abundant iron oxides and vadose silt. Meniscus micrite is well developed between some intraclasts. Dolomitisation is frequent. Euhedral dolomite crystals can replace the micritic sediment of these limestones. Only some blackened cyanobacteria keep their original structure. Sponges, cyanobacteria and gastropods can be recognised in the non-dolomitised facies types. Rare fenestral structures are filled with vadose silt and geopetal sediment.

Interpretation

Such sedimentological features indicate carbonate deposition in low energy, internal platform areas. The presence of fenestral structures and *Rivularia* type cyanobacteria indicates a restricted environment (possibly intertidal ponds). Subaerial exposure is suggested by the existence of vadose silt, meniscus micrite and black pebble type intraclasts (Strasser & Davaud, 1983; Strasser, 1984).

BIOSTRATIGRAPHY

The micropaleontological association consists of foraminifera [*Earlandia* sp., *Endoteba* sp., *Endotebanella* sp., *Endotriadella wirzi* (Koehn-Zaninetti, 1969), *Endotriadella* sp., *Glomospirella* sp., *Meandrospira dinarica* Kochansky-Devide & Pantić, 1966, *Ophthalmidium* sp., *Paleolituonella* sp., *Reophax* sp., *Turriglomina mesotriasica* (Koehn-Zaninetti, 1969) and *Turriglomina* sp., duostominid foraminifera] (Fig. 4a-l), microproblematic organisms [*Bacinella ordinata* Pantić, 1972, *Baccanella*

floriformis Pantić, 1971, *Ladinella porata* Ott, 1968, *Perturbatacrusta leini* Schlagintweit & Gawlick, 2011, *Plexoramea cerebriformis* Mello, 1977, *Radiomura cautica* Senowbari-Daryan & Schaffer, 1979, *Tubiphytes* sp.] (Fig. 5a-j), calcareous sponges [*Celyphia zoldana* Ott, Pisa & Farabegoli, 1980, *Colospongia catenulata catenulata* Ott, 1967, *Solenolmia manon manon* (Münster, 1841)] (Fig. 6a-d).

Meandrospira dinarica is known mainly from the Anisian deposits (Premoli Silva, 1971; Zaninetti et al., 1972; Bucur et al., 1994; Kobayashi, 2008; Okay et al., 2014; Lehrmann et al., 2015).

The first occurrence of *Endotriadella wirzi* is at the Olenekian-Anisian boundary (Zaninetti, 1976; Dağ, 1980). However, it is frequently described from Anisian carbonate deposits (Dağ, 1978; Salaj et al., 1983; Oravec-Scheffer, 1987; Rettori, 1995).

Turriglomina mesotriasica is mentioned mainly from upper Anisian-Ladinian deposits (Bucur et al., 1997; Rychlinski et al., 2013) and it has a biostratigraphic distribution which characterizes the lower Anisian-Carnian interval (Rettori, 1995; Nittel, 2006).

Radiomura cautica has a larger stratigraphic distribution within the Anisian-upper Aptian interval (Pleş et al., 2017). However, it was frequently described from Triassic (Senowbari-Daryan, 1984; Velledits et al., 2011) or Upper Jurassic (Pleş et al., 2015) deposits.

Perturbatacrusta leini is an encrusting organism which is well known from shallow-water, Kimmeridgian-Berriasian deposits (Schlagintweit & Gawlick, 2011; Pleş et al., 2013). This paper probably represents the first mentioning of this microfossil from the Triassic deposits.

Baccanella floriformis was described by Pantić (1971) from the Ladinian carbonates. It is frequently associated with *Plexoramea cerebriformis* and *Ladinella porata* in Ladinian limestones (Balogh & Kovacs, 1976; Senowbari-Daryan et al., 1993; Popescu, 1998; Gale et al., 2018).

Solenolmia manon manon is a calcareous sponge which was frequently mentioned from the Ladinian deposits. It was assigned to the Ladinian-lower Carnian interval by Balogh and Kovacs (1976). Other authors described this species from the Anisian-Carnian deposits of the Tethyan Realm (Senowbari-Daryan & Garcia Bellido, 2002; Senowbari-Daryan et al., 2011).

Ott et al. (1980) described *Celyphia zoldana* from the Anisian limestones. Its occurrence was also reported from the Anisian by Senowbari-Daryan et al. (1993, 2011) and Emmerich et al. (2005).

Colospongia catenulata catenulata was mentioned for the first time from the Ladinian-Carnian carbonates by Balogh & Kovacs (1976). This calcareous sponge is also known from other localities of the Tethyan Realm, especially from the Ladinian-Carnian deposits (Senowbari-Daryan et al., 2011).

DISCUSSIONS

The studied Triassic carbonates characterize a shallow-water, high-energy environment. The identified facies associations define a shelf margin area with associated coral-sponge bioconstructions encrusted by microproblematic organisms. Rudstone facies types were accumulated on a fore-reef slope, in the proximity of a reefal crest. Angular

Fig. 4 Foraminifera from the Triassic limestones of the studied area. **a** *Endotriadella wirzi* Koehn-Zaninetti; **b** *Meandrosira dinarica* Kochansky-Devidé & Pantić; **c** Duostominid foraminifera; **d** *Turritellina mesotriasica* Koehn-Zaninetti; **e** *Endoteba* sp.; **f** *Endotriada* sp.; **g, i** *Paleolituonella* sp.; **h, l** *Ophtalmidium* sp.; **j** Nodosariid foraminifera; **k** *Earlandia* sp. a: sample 20, Old Racoș Quarry; b: sample 19B, Old Racoș Quarry; c: sample 9, Old Racoș Quarry; d: sample 219, Tipia Ormenișului section; e: sample 40, Olt Gorges section; f: sample 44, Olt Gorges section; g, h: sample 183, Tipia Ormenișului section; i: sample 52, Olt Gorges section; j: sample 39, Olt Gorges section; k: sample 19c, Old Racoș Quarry; l: sample 118, Tipia Racoșului section. Scale bar: 0.25 mm.

clasts were subjected to short periods of transport. The presence of coral and sponge fragments in association with encrusting organisms points to a reefal origin of these bioclasts. Microproblematic encrusting organisms are well known for their role in stabilising reefal bioconstructions (Reitner, 2013). *Baccanella floriformis* prefers high-energy shallow conditions (Martini et al., 2004; Sanchez-Beristain, 2010; Sanchez-Beristain & Reitner, 2018). This microproblematic organism is frequently associated with bioconstructions or rudstone deposits. In addition, *Ladinella porata* prefers well lit shallow-water settings (Sanchez-Beristain & Reitner, 2012, 2016, 2018, 2019). The packstone-grainstone and grainstone facies are defined by increasing proportions of *Tubiphytes* sp., commonly associated with depositional environment deepening (Aurell & Badenas, 2004).

The inner platform facies (black pebble-bearing wackestone) were accumulating in restricted intertidal ponds. This fact is confirmed by the presence of *Rivularia* type cyanobacteria and fenestral structures (Lucia, 1972). Subaerial exposure is indicated by the presence of blackened bioclasts and vadose silt in association with meniscus micrite (Strasser & Hillgärtner, 1998). Dolomitisation may occur simultaneously with carbonate subaerial exposure in an intertidal-supratidal depositional setting. Such processes were described by different authors [Assereto & Kendall (1971), Jadoul et al. (1992)] from the Ladinian carbonate deposits of the Italian Alps.

The sedimentological features share common characteristics with the Wetterstein-type facies. Similar limestones were described by several authors from Hungary (Balogh & Kovacs, 1976; Senowbari-Daryan et al., 2011; Velledits et al., 2011; Horvath & Hips, 2015), Italy (Senowbari-

Fig. 5 Microproblematic organisms from the Triassic limestones of the studied area. **a** *Bacinella ordinata* Pantić. **b** *Tubiphytes* sp. **c** *Plexoramea cerebriformis* Mello. **d** *Perturbatacrusta leini* Schlagintweit & Gawlick. **e** *Radiomura cautica* Senowbari-Daryan & Scheffer. **f** *Taumatoporella parvovesiculifera* (Raineri). **g** *Ladinella porata* Ott. **h** *Baccanella floriformis* Pantić. **i** *Rivularia* sp. **j** “*Solenopora*” sp. a: sample 52, Olt Gorges section; b: sample 90, Olt Gorges section; c: sample 38, Olt Gorges section; d: sample 74, Olt Gorges section; e: sample 143, Tipia Racoșului section; f: sample 39, Olt Gorges section; g: sample 47, Olt Gorges section; h: sample 75, Olt Gorges section. Scale bar: a-c, e-h: 0.25 mm; d, i-j: 0.5 mm.

Fig. 6 Sponges from the Triassic limestones of the studied area. **a,b** *Solenolmia manon manon* (Münster). **c** *Celyphia zoldana* Ott, Pisa & Farabegoli. **d** *Colospongia catenulata catenulata* Ott. a: sample 13, Olt Gorges section; b: sample 77, Olt Gorges section; c-sample 103, Tipia Racoșului section; d: sample 195, Tipia Ormenișului section. Scale bar: 1 mm.

Daryan et al., 1993) and Romania (Dragastan & Grădinaru, 1975; Bucur et al., 1994).

Patrulus et al. (1996) described three types of Upper Triassic carbonate successions from the Olt Gorges: (1) a Carnian-Norian (Tipia Ormenișului) massive, coral-sponge bioconstructions overlying Hallstatt-type limestones of reduced thickness; (2) Norian coral bioconstructions covering mafic and ultramafic rocks (Surmanul), and (3) Carnian-Norian alternances of Hallstatt-type limestones and coarse carbonates (Pietrele lui Murgoci). Some of the identified microfossils (e.g. *Turrioglomina*

mesotriasica) indicate a Ladinian-Carnian age for the carbonate succession from the Tipia Ormenișului Hill. Such microfossils are associated with Ladinian-Carnian microproblematic organisms (e.g. *Baccanella floriformis*, *Ladinella porata*) or sponges (e.g. *Colospongia catenulata*). The underlying Hallstatt-type limestones were biostratigraphically assigned by Patrulus et al. (1996) to the Carnian-Norian interval based on some poorly preserved ammonites (*Arcestes* sp.). However, the biostratigraphic range of the microfossils from the overlying limestones is limited to the Carnian. Thus, the age of the massive reefal

succession from the Tipia Ormenișului hill could be restricted to this interval.

The Norian age of the Surmanul olistolith is indicated by a rich association consisting of brachiopods and bivalve fragments (*Monotis haueri*) (Patrulius et al., 1996). However, Anisian foraminifera (e.g. *Meandrospira dinarica*, *Endotriadella wirzi*) and Ladinian microproblematica (e.g. *Ladinella porata*, *Plexoramea cerebriformis*) are present in the Old Racoș Quarry sector (200 m to the east, samples 1-31) and the Olt Gorges. Thus, some of the Carnian-Norian limestones mapped by Popescu et al. (1976) could be older, probably Anisian-Ladinian or Carnian. The Anisian facies types (Old Racoș Quarry) are strikingly similar with the Steinalm-type facies described by Patrulius et al. (1996) from the Perșani Nappe olistoliths (Rica and Hăghimașului Hill). The latter contain the same type of microfossils as those presented in this study (e.g. *Meandrospira dinarica*, *Glomospirella* sp., *Endotriadella wirzi*). As a consequence, some of the carbonate olistoliths presented in this paper could form an integrating part of the Perșani Nappe and not the Olt Nappe as indicated by former studies performed in the area.

CONCLUSIONS

Microfacies analysis was performed on carbonate samples belonging to the Triassic succession of the different Transilvanian Nappes that are present in the Perșani Mountains. This analysis indicates the presence of shallow-water high-energy reefal bioconstructions where corals and sponges were thriving in optimal environmental conditions. Encrusting organisms played a key role in building such reefal frameworks. Numerous bioclasts and angular/subangular intraclasts were transported on a fore-reef slope from shelf margin areas. Bioclasts are represented mainly by corals, sponges and encrusting organisms. The micropaleontological associations indicate Anisian-Ladinian and Carnian ages for the studied carbonate deposits. Previous studies indicated an Upper Triassic (Carnian-Norian) age for these limestones. The Anisian-Ladinian age of some of the studied olistolith suggests that they could belong to the Perșani Nappe and not to the Olt Nappe as considered before.

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