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MICROFACIES ANALYSIS AND DEPOSITIONAL ENVIRONMENTS OF THE TITHONIAN−VALANGINIAN LIMESTONES FROM DÂMBOVICIOARA GORGES (CHEILE DÂMBOVICIOAREI), GETIC CARBONATE PLATFORM, ROMANIA

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Abstract The carbonate succession cropping out in the Dâmbovicioara Gorges (Cheile Dâmbovicioarei), eastern part of the Getic Carbonate Platform, consists of uppermost Tithonian-lowermost Valanginian limestones. Three distinct packages were distinguished: (i) reef limestones, (ii) intraclastic/bioclastic-dominated shoals and (iii) peritidal limestones. The reef limestones consisting of coral-microbial boundstones form massive structures which are typical for environments associated with the upper reef slope, near the proximal shelf margin. The bioconstruction organisms colonised the substrate while the reef framework was consolidated by microbial products and microencrusters. Microbialites formed a suitable substrate subsequently colonised by corals and sponges. The intraclastic/bioclastic-dominated shoals form the transition from reef to peritidal depositional settings. Meter- to decimeter thick beds contain rudstone, coarse bioclastic grainstone and intraclastic-bioclastic packstone facies types. The grains morphology suggests deposition under high energy conditions, in an agitated environment, with carbonate material derived either from reef or inner platform areas. These deposits have been interpreted as outer platform bioclastic shoals which were accumulating at the platform margin. Black pebbles imply subaerial exposure, development of paleosoils and their subsequent reworking. Peritidal limestones consist of centimeter-, decimeter to meter thick carbonate beds. Locally, millimeters to centimeter thick sets of laminae are present. Normal marine subtidal, restricted-subtidal, intertidal and supratidal/coastal subenvironments form the main components of the overall peritidal depositional setting. These depositional subenvironments comprise an ideal sequence which evolves from subtidal to supratidal. The facies evolution indicates a transition between these three environments. This transition can be observed at a bed or bedset scale by following the deposition of carbonate material in lagoons and ponds, beaches, tidal bars, tidal plains, swamps or lakes. The associated carbonate depositional environments point to an important progradation of the Getic Carbonate Platform during the late Tithonian-earliest Valanginian.

Keywords: microfacies, depositional environment, limestone, microfossils, Tithonian, Berriasian, Valanginian, Cheile Dâmbovicioarei, Romania.

INTRODUCTION

White massive limestones, commonly referred to as the Štramberk-type limestones, are well known from various areas of the Romanian Carpathians, stretching from the Eastern Carpathians to the Apuseni Mountains, and frequently form spectacular geological structures (e.g. Vânturariţa and Piatra Craiului Massifs from the Southern Carpathians). These deposits were previously attributed to the Kimmeridgian-Tithonian interval based on macroscopic observations and relatively scarce macrofauna. Studies in the last decades have brought new data regarding the paleontological content of the Carpathian Štramberk-type limestones, by implementing various analysis techniques (micropaleontological, microfacies and sedimentological studies). These studies have shown that the upper part of the Štramberk-type successions includes both the Berriasian and locally the lower Valanginian.

The main objective of this study is to describe the carbonate succesion from Dâmbovicioara Gorges (Cheile Dâmbovicioarei; Fig. 1) by providing new stratigraphic and sedimentological data.

GEOLOGICAL SETTING

The Mesozoic deposits of the Dâmbovicioara area belong to the eastern part of the Getic Carbonate Platform, a sedimentary cover of the Getic Nappe (the Median Dacides *sensu* Săndulescu, 1984). The sedimentary formations of the Dâmbovicioara zone include Triassic, Jurassic and Cretaceous deposits (Patrulius, 1969).

Jurassic and Cretaceous deposits are the only sediments occurring in the southern area of the Dâmbovicioara zone. The Jurassic sediments generally comprise Bajocian conglomerates and sandstones, Bathonian marls, Callovian marly-limestones and Oxfordian limestones and radiolarites. The Bathonian-Callovian interval is marked by hardgrounds and condensed levels (Lazăr et al., 2017).

Limestones overlying the radiolarites represent a general regressive succession, beginning with slope carbonate deposits, continues with platform-edge deposits, and finally sediments of inner platform and peritidal environment. The age of these successions, also known as the Štramberk-type limestones, was considered as Kimmeridgian-Tithonian (Patrulius, 1969) or Kimmeridgian-?Berriasian (Patrulius, 1976; Bucur, 1978) and was subbsequently attributed to Kimmeridgian-lower Valanginian (Patrulius in Patrulius et al., 1980; Bucur et al., 2009, Grădinaru et al., 2016). The upper part of these limestones was separated by Patrulius (1976), Patrulius et al. (1980), and Patrulius & Avram (1976) as the Cheile Dâmbovicioarei Limestone, and the Cheile Dâmbovicioarei Formation respectively.

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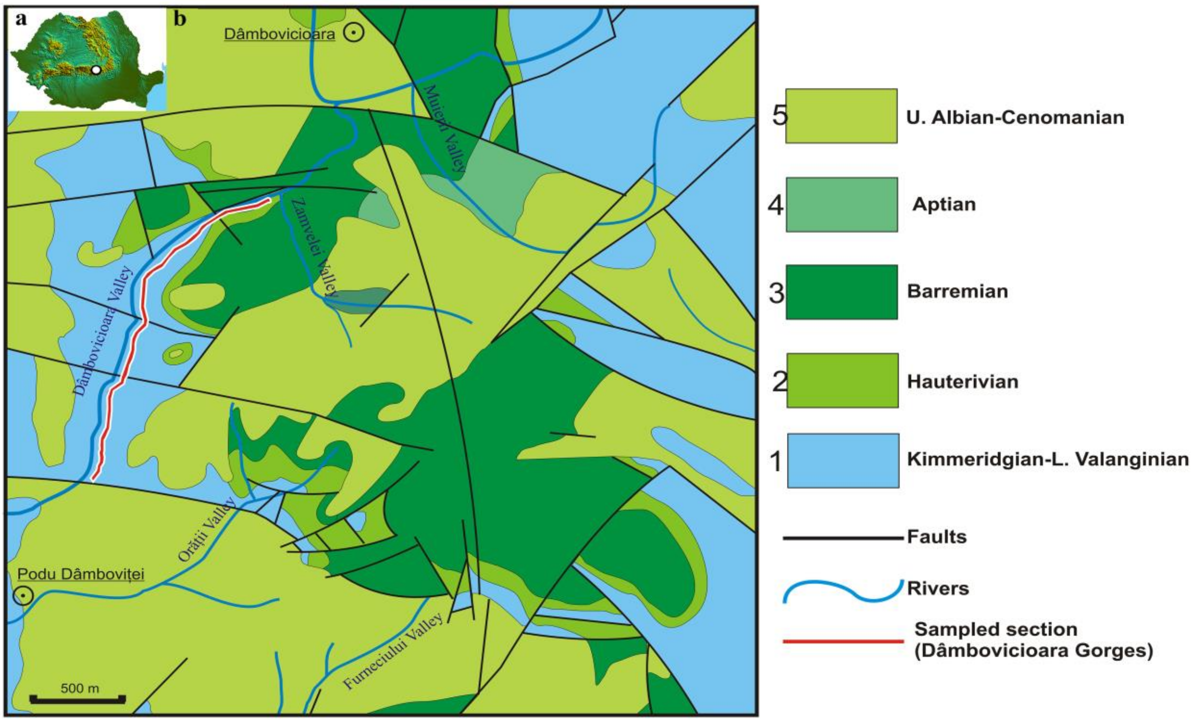

Fig. 1 Location of the Cheile Dâmbovicioarei within the Dâmbovicioara Area. **a** Location of the Dâmbovicioara zone on the Romanian map; **b** Location of the sampled profile on the geological map 1:50000 (redrawn from Dimitrescu et al., 1971 and Patrulius et al., 1971).

An intra-Valanginian unconformity exists between the Berriasian-lowermost Valanginian limestones and the upper Valanginian-lowermost Hauterivian limestones known as the Cetatea Neamţului Member of the Dâmbovicioara Formation (cf. Patrulius and Avram, 1976). A detailed study of this unconformity was recently performed by Grădinaru et al. (2016). Hauterivian marls and marly limestones of the Dealul Sasului Member are followed by Barremian-lower Aptian marls with patch-reef intercalations of the Valea Muierii Member (Dâmbovicioara Formation).

The Upper Jurassic-Lower Cretaceous deposits of the southern part of the Dâmbovicioara zone are unconformably overlain by upper Aptian and uppermost Albian-Cenomanian conglomerates.

The Cheile Dâmbovicioarei Formation

Patrulius (in Patrulius et al., 1980) defined the limestones from Cheile Dâmbovicioarei as the “Cheile Dâmbovicioarei limestone” (= Cheile Dâmbovicioarei Formation of Patrulius, 1976; and Patrulius & Avram, 1976). The type section of these carbonate deposits is located between the Podu Dâmboviţei and Dâmbovicioara localities (Fig. 1). The Cheile Dâmbovicioarei limestones are well bedded and form extensive outcrops which have a total thickness of 400 m (Patrulius et al., 1980). They consist of mudstone and wakestone with rare macro- and microfossils. Cyanobacteria (porostromatic) nodules are the most representative microfossils within the entire carbonate succession (Patrulius et al., 1980). This formation is underlain by the so called „Upper massive limestone” (described in Giuvala and Cheile Dâmboviței profiles by Patrulius et al., 1980; Cheile Dâmboviței Formation cf. Dragastan, 2010). A gradational transition exists between these formations. Following Patrulius et al. (1980) the uppermost part of the “Cheile Dâmbovicioarei limestone” (Podu Dâmboviţei, Cetatea Neamţului and Padina Braşoavei sections) contains microfossil assemblages which include *Pseudotextulariella salevensis* (Charollais, Brönnimann & Zaninetti) in association with *Trocholina alpina* (Leupold), *T. elongata* (Leupold), *Pfenderina* sp. and *Paracoskinolina* sp. According to these authors the mentioned microfossils point to Valanginian age of the uppermost part of this succession. In addition, the Jurassic-Cretaceous (Tithonian-Berriasian) boundary is placed between the „Upper massive limestone” and the “Cheile Dâmbovicioarei limestone”.

CARBONATE FACIES AND MICROFACIES

The uppermost Tithonian-lowermost Valanginian succession from the Cheile Dâmbovicioarei is predominantly represented by peritidal limestones. Approximately 70 m thick reef limestones form the lower part of the succession that pass gradually into 50 m thick black pebbles-bearing intraclastic/bioclastic-dominated shoals which are well exposed near the road crossing the Dâmbovicioara Gorges. The contact with the peritidal limestones is located approximately 175 meters, upstream from the gorge entrance. In terms of lithological units, the Cheile Dâmbovicioarei section consists of three distinct packages: 1) reefal limestones; 2) intraclastic/bioclastic-dominated shoals and 3) peritidal limestones.

A. Reefal limestones

Coral-microbial and sponge-microbial boundstones are the main component of the massive limestones well outcropped near the Podul Dâmboviţei locality, in the prox-

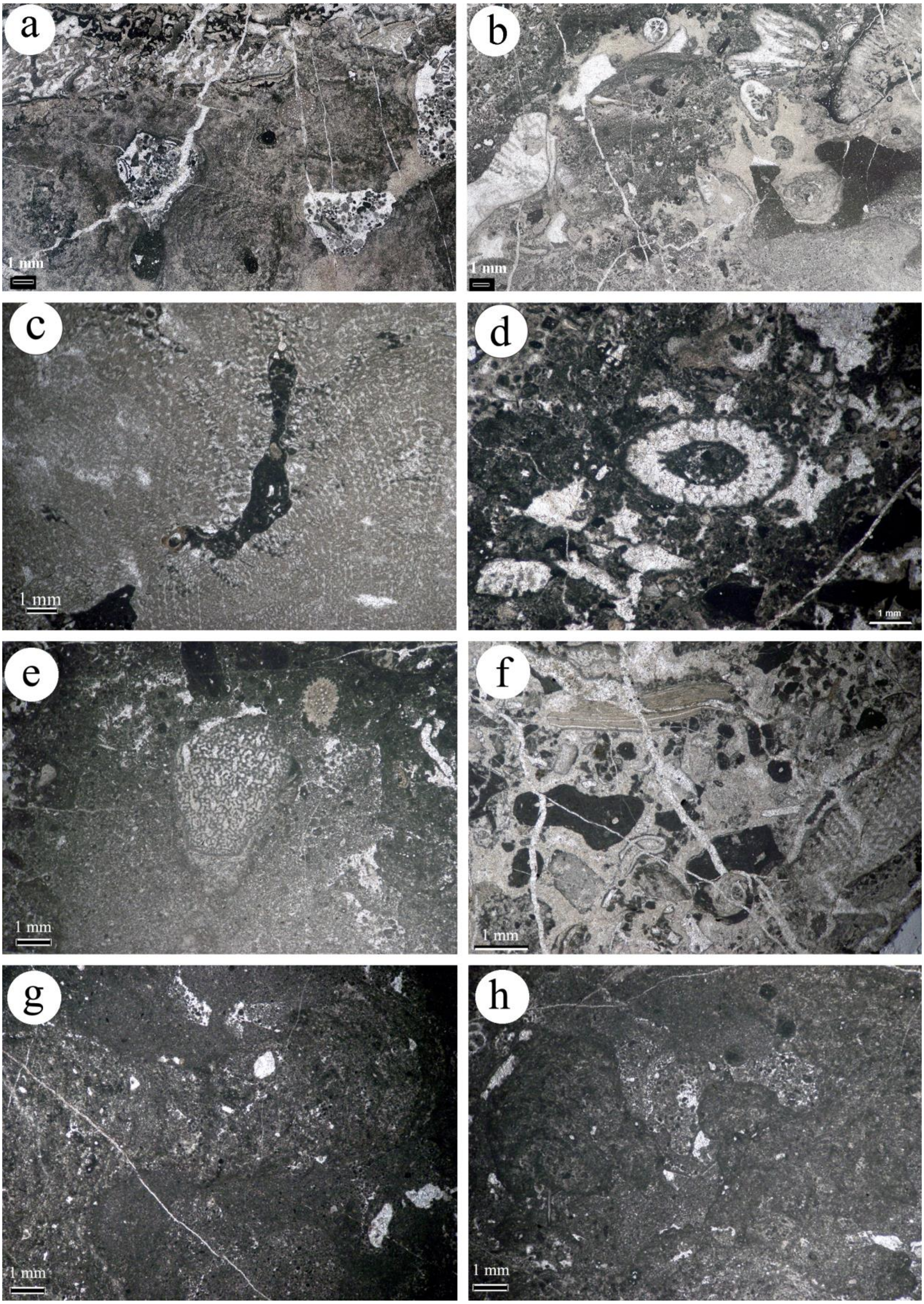

Fig. 2 Reefal facies. **a-c** Coral-microbial boundstone; coral colonies are heavily encrusted by problematic microorganisms (a) or bordered by syndepositional, radiaxial-fibrous cements (b). **d-h** Bioclastic packstone (d, e, g-h) and bioclastic grainstone (f) internal sediment with dasycladalean algae [*Steinmanniporella kapelensis* (Sokač & Nikler)] (d), sponges (e), mollusks, corals, *Crescentiella* (f), microstalactitic (g) and microthrombolitic (h) microbial crusts.

imity of the Dâmbovicioara Gorges entrance. Stratigraphically these limestones belong to the uppermost parts of the „Upper massive limestone” (Patrulius et al., 1980) or Cheile Dâmboviței Formation (cf. Dragastan, 2010).

Coral-microbial boundstones with abundant microbial crusts and problematic microorganisms is the main type facies (Fig. 2 a-c; e; g-h). Macroscopic components include branching and lamellar corals which are intensely encrusted by problematic microorganism and syndepositional radiaxial-fibrous cements (Fig. 2 b). Other biotic components include sponges (Fig. 2 e), peloidal microstromatolitic crusts (Fig. 2 g), microthrombolites (Fig. 2 h), and problematic microorganisms [*Crescentiella morronensis* (Crescenti), *Radiomura cautica* (Senowbari-Daryan & Schäffer, *Koskinobullina socialis* (Cherchi & Schroeder), *Lithocodium aggregatum* (Elliott)]. The internal sediment is composed of peloidal-bioclastic packstone (Fig. 2 e) and bioclastic grainstone (Fig. 2 f) with dasycladalean algae [*Steinmanniporella kapelensis* (Sokač & Nikler)] (Fig. 2d), *Rivularia*-type cyanobacteria (Fig. 2 b), foraminifera, echinoderm plates, crabs, mollusks, bryozoans (Fig. 2 e) and worm tubes.

Interpretation

Coral, coral-sponge and coral-microbial boundstones are typical for environments associated with the upper reef slope, near the proximal shelf crest (Mullins et al., 1984; McIlreath & James, 1984; Grammer et al., 1991; Ginsburg et al., 1991). Corals and sponges were colonising the substrate while the reef framework was consolidated by microbial crusts and microencrusters (Riding, 1991; 2000; Schmid, 1996; Shapiro, 2000). Microbial deposits formed the ideal substrate for the subsequent colonisation by corals and sponges.

B. Intraclastic/bioclastic-dominated shoals

These limestones form the transition from reef to peritidal depositional settings. They represent the boundary between the „Upper massive limestone” (Patrulius et al., 1980 or Cheile Dâmboviței Formation cf. Dragastan, 2010) and the Cheile Dâmbovicioarei Formation. Meter- to decimeter thick beds contains alternating packages of calcirudites, coarse bioclastic grainstone and intraclastic bioclastic packstone facies types (Fig. 3). Well rounded to subrounded clasts are common (Fig. 3). Carbonate material was sourced from various depositional settings such as reefs (coral fragments, sponge fragments, microbial crusts or microproblematic organisms) or inner platform areas. The former are indicated by the abundance of oncoid-bearing intraclasts, bioclastic mudstone-wackestone fragments and micritised intraclasts. Other components consist of normal and incipient ooids, vadoids (Fig. 3 g-h), oncoids and peloids. Bioclasts were identified both in the intraclasts and in the matrix sediment. They cover a large spectrum which ranges from large benthic foraminifera (Fig. 3 a, c, d) to coral fragments (Fig. 3 b, d, e), *Rivularia*-type cyanobacteria (including *Diversocallis* sp.) (Fig. 3 c), bivalve and echinoderm fragments, dasycladalean algae [*Clypeina sulcata* (Alth)] (Fig. 3 a) and gastropods (Fig. 3 f).

The most characteristic feature is the presence of abundant intraclasts and blackened bioclasts (black pebbles) (Fig. 3 a, c, d, f, h). These clasts are hosted within carbonate beds which mark the boundary between the granular and peritidal limestones (Fig. 4). Siltic to arenitic-sized blackened bioclasts are randomly distributed within the rock mass.

Interpretation

Clast morphology suggests deposition under high energy conditions with carbonate material being sourced either from reef settings or from inner platform areas. These deposits have been interpreted as outer platform bioclastic shoals which were accumulating at the platform margin. The limestones have accumutated over upper slope reefs environment due to the decrease of eustatic level or the accommodation space and the bioclastic shoals have migrated to the edge of the platform. They represent the transition between the upper slope facies to the shalower facies in the marginal zone of the platform. The tidal currents control the morphology and distribution of the recent bioclastic banks from the shelf margins. Such structures reflect the orientation and topographic complexity of the platform margins (Davies, 1970; Enos, 1977; Halley et al., 1983) and these sediments may border lagoons or shallow subtidal areas (e.g., Bahamas and Florida) (Tucker & Wright, 1990). Subsequent reworking of paleosoils is indicated by the presence of black pebbles, thus highlighting the importance of these intraclasts (Francis, 1986; Strasser & Davaud, 1983; Shinn & Lidz, 1988; Vera & Cisneros, 1993). Black pebbles are frequently associated with intertidal, supratidal, brackish and lacustrine evironments (Strasser & Davaud, 1983; Vera & Cisneros, 1993; Săsăran, 2006). Blackened bioclasts and intraclasts could be sourced from pedogenetically altered subtidal, intertidal or supratidal depositional settings (Strasser, 1984; Shinn & Lidz, 1988).

The intraclastic/bioclastic – dominated shoals and the peritidal limestones are separated by a sharp limit (Fig. 4). Subaerial exposure is evident at the topmost part of the intraclastic/bioclastic limestone (described above) (Fig. 5). This process is indicated by the presence of meniscus and microstalactitic cements in association with matrix dissolution features (Fig. 5 c, d), micritised carbonate clasts, vadoids and blackened intraclasts (Fig. 5). These sediments were affected by vadose and meteoric fresh-water phreatic diagenesis (Fig. 5a-d). Grains and cavities are bordered by meniscus, microstalactitic and fine crystalline equigranular cements. Moreover, cavities are filled with vadose silt which contains large crystals of equigranular calcite (Fig. 5 c, d).

Meniscus and microstalactitic carbonate cements were previously described from vadose and meteoric phreatic diagenetic environments (Longman, 1980; Harris et al., 1985). These types of cements are associated with vadose diagenetic environments. By contrast, equigranular cements are the main product of fresh-water diagenesis.

C. Peritidal limestones

This pile of carbonate rocks is the most representative lithological unit from the entire succession, reaching a total thickness of 400 m (Patrulius et al., 1980). Well bedded (Fig. 6), centimeters to decimeter thick carbonate beds form the most significant macroscopic feature of this unit. The peritidal succession overlying the bioclastic shoals consists of centimeter/decimetre to meter thick

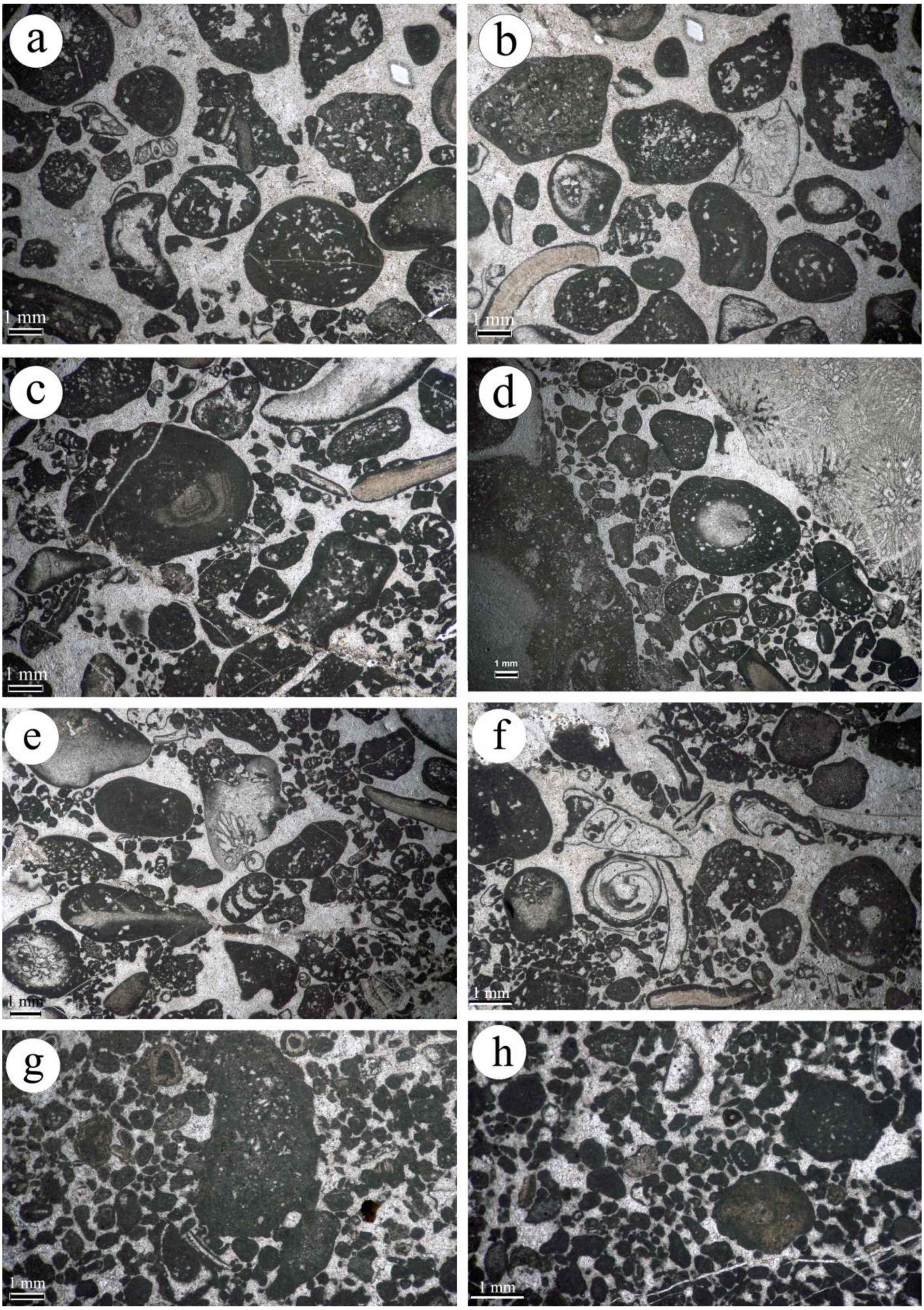

Fig. 3 Intraclastic/bioclastic-dominated shoals. **a-f** Coarse intraclastic-bioclastic grainstone and rudstone containing intraclasts, oncoids, peloids, normal and incipient ooids. **g-h** Intraclastic-bioclastic grainstone and rudstone with vadoids. Bioclasts are represented by large benthic foraminifera (a, c-d), coral fragments (b, d-e), rivulariacean-type cyanobacteria (e.g. *Diversocalis* sp.) (c), bivlave fragments, echinoderm fragments, dasycladalean algae [*Clypeina sulcata* (Alth)] (a) and gastropods (f); intraclasts and blackened bioclasts (black pebbles) (a, c, d, f, h).

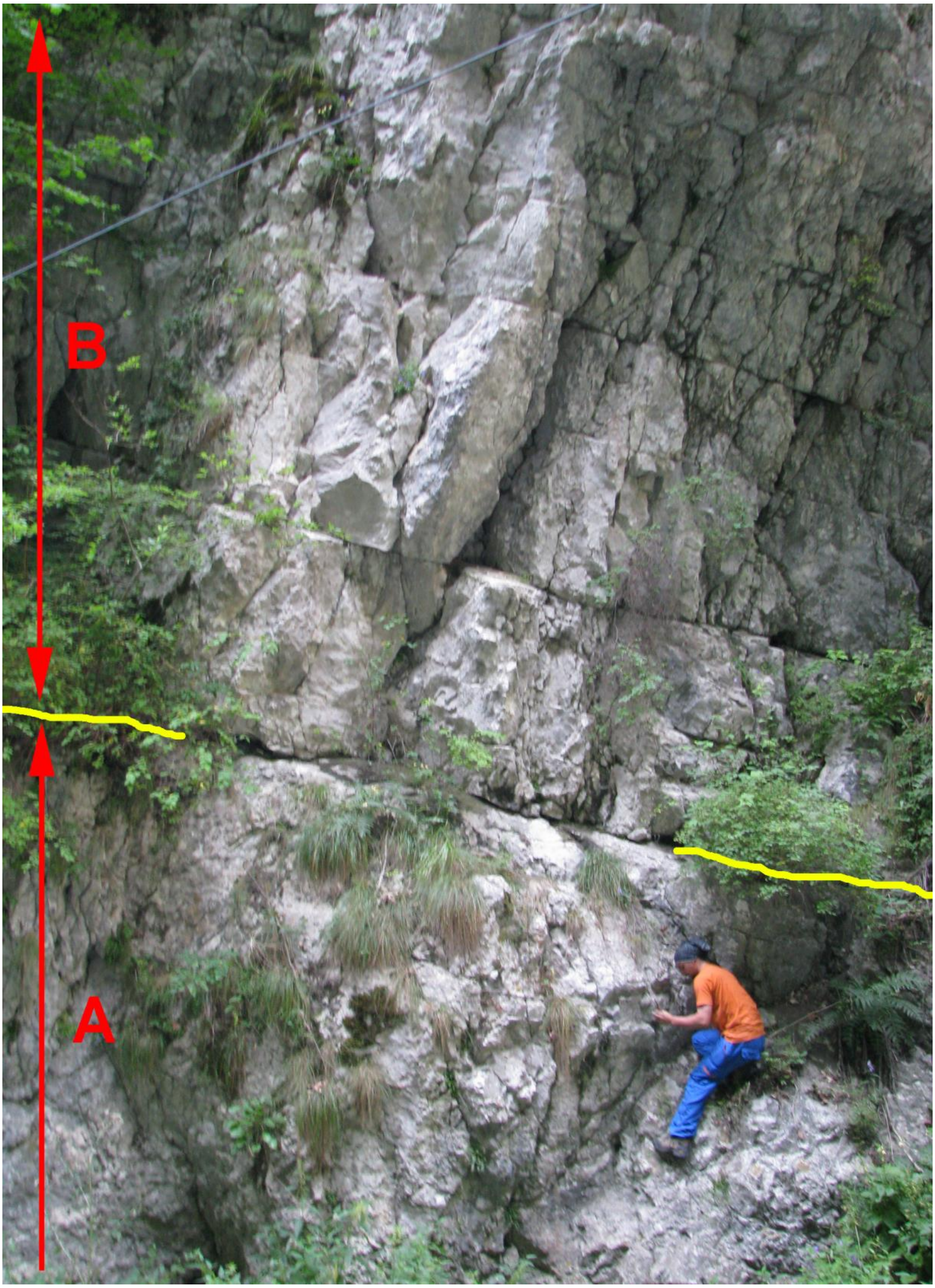

Fig. 4 Contact between the intraclastic/bioclastic-dominated shoals (A) and peritidal limestones (B) in the Dâmbovicioara Gorges.

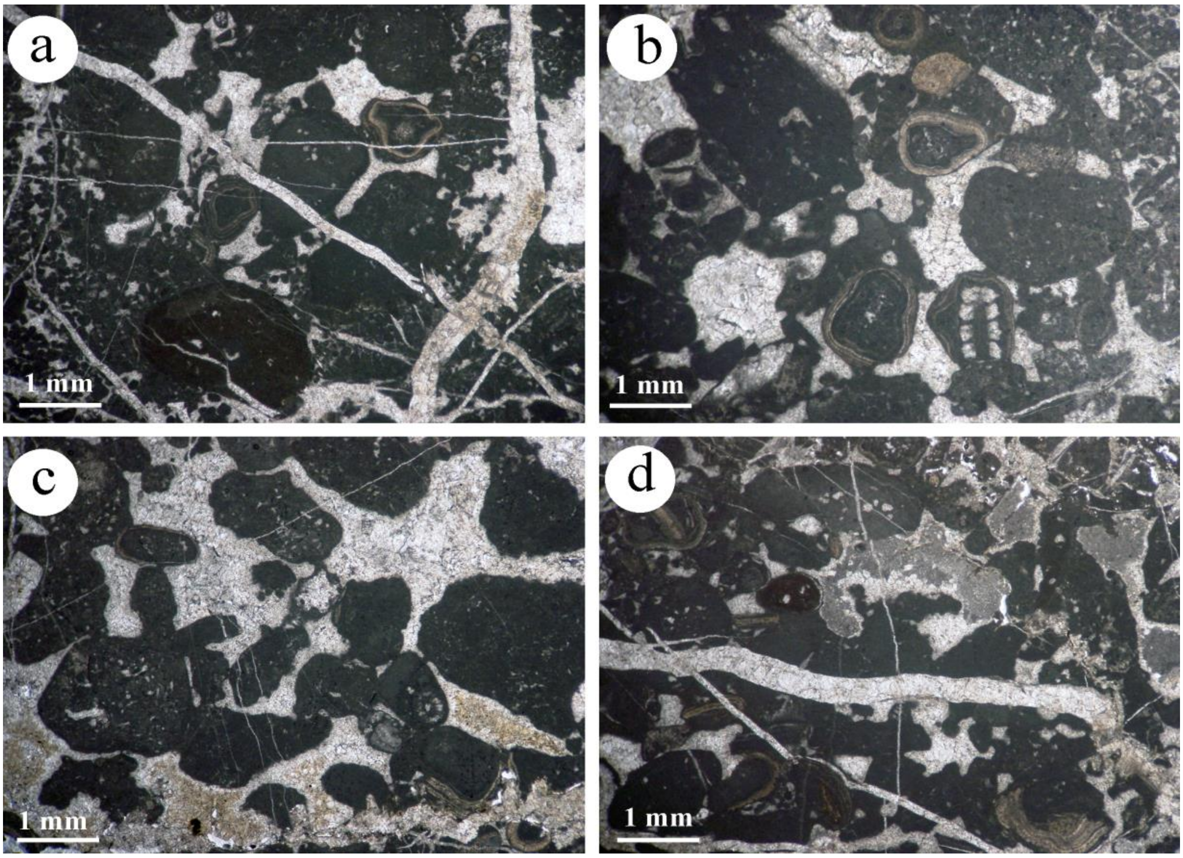

Fig. 5 Pedogenetically altered granular limestones. **a, b** Peloidal-bioclastic grainstone bearing vadoids and black pebbles, micritised intraclasts and meniscus cements. **c-d** Dissolution features associated with microstalactitic and equigranular cements which are developed arround cavities and grains; cavities are filled with vadose silt in association with large crystals of equigranular calcite.

carbonate beds (Fig. 7 a,b). In some cases, milimeter to centimeter thick laminae and sets of laminae with distinct granulometry are present (Fig. 7 c). Another feature is represented by fenestral structures, parallel with the bedding planes (Fig. 7 c).

Interpretation

Recent peritidal limestones were thoroughly studied by various authors (Lucia 1972; Ginsburg 1975; Shinn 1983; Tucker & Wright 1990, Pratt et al., 1992). Three distinct bathymetric zones (subtidal, intertidal, supratidal) were defined within the peritidal depositional setting, by taking into account the existing tidal processes (Shinn 1983, Tucker & Wright 1990, Pratt et al., 1992).

Normal marine subtidal, restricted subtidal, intertidal and supratidal/coastal subenvironments form the main components of the overall peritidal depositional setting. These depositional subenvironments comprise bed scale ideal sequences which evolve from subtidal to supratidal units. Generally, the carbonate succession from the Cheile Dâmbovicioarei Formation consists of incomplete sequences. Bed scale facies evolution indicates a transition between subtidal, intertidal and supratidal environments. One may follow this transition at the bed or bedset scale by highlighting the deposition of carbonate material in lagoons and ponds, beaches, tidal bars, tidal plains, swamps, lakes or algal-microbial mats. Cycle scale depositional environment changes are controlled by various factors such as morphology, hydrodynamics, nutrient levels and physical/bio-physical changes (Shinn 1983, Tucker & Wright 1990, Pratt et al., 1992).

C1. Normal marine subtidal carbonates

These limestones form the lowermost part of the peritidal carbonate beds. They consist of intensely bioturbated peloidal-bioclastic micrites (Fig. 8). The microfossil assemblage comprises dasycladalean algae [*Seliporella neocomiensis* (Radoičić)] (Fig. 8), echinoderm fragments, bivalves, gastropods, miliolids and rivulariacean-type cyanobacteria. Other components include oncoids, peloids and intraclasts embedded in a micritic matrix. The most representative facies is wackestone/packstone with dasycladalean algae and foraminifera (Fig. 8)

Interpretation

The microfacies characteristics point to a shallow, low energy, normal marine environment. Marine subtidal conditions are indicated by the distribution of various carbonate components (bioclasts, peloids, oncoids, intraclasts) in a dominant micritic matrix (Ginsburg, 1975; Shinn, 1983a; Hardie & Shinn, 1986; Tucker & Wright, 1990; Pratt et al., 1992).

C2. Marine, restricted subtidal carbonates

These deposits form the most representative component of the entire Cheile Dâmbovicioarei succession. In this case, centimeters to meter thick limestones have a lateral extent of ten to hundreds of meters. They are frequently

Fig. 6 Peritidal limestones from the Dâmbovicioara Gorges.

interbedded with marine subtidal and supratidal facies types. A gradual transition exists between the marine subtidal and restricted facies. As a consequence, it is difficult to establish the exact limit between these units. Facies components include mudstone with cyanobacteria, oncoidic bioclastic wackestone with cyanobacteria, fenestral peloidal bioclastic packstone with cyanobacteria (Fig. 9). Microfossils show low diversity values with cyanobacteria being dominant (Fig. 9). Other fossils are represented by rare foraminifera, ostracods, gastropods, thin shell bivalves and microproblematic organisms [bacinellid structures, *Lithocodium aggregatum* (Elliott) and *Taumathoporella parvovesiculifera* (Raineri)]. Intraclasts and bioclasts lack any microstructure since they are strongly micritised.

Interpretation

The entire microfossil assemblage characterizes a restricted subtidal subenvironment. Shallow marine subtidal conditions are present mainly in the lower part of the peritidal beds. Cyanobacteria and ostracods colonized the sediment in restricted conditions which favored bioclast micritisation and low biotic diversity. Such restricted settings may be associated with intertidal ponds or internal platform lagoons. Environmental conditions vary significantly within intertidal ponds with marked transitions from initial normal marine conditions to processes associated with restricted settings or even subaerial exposure (Tucker & Wright, 1990; Shinn, 1983a; Ginsburg, 1975; Pratt et al., 1992).

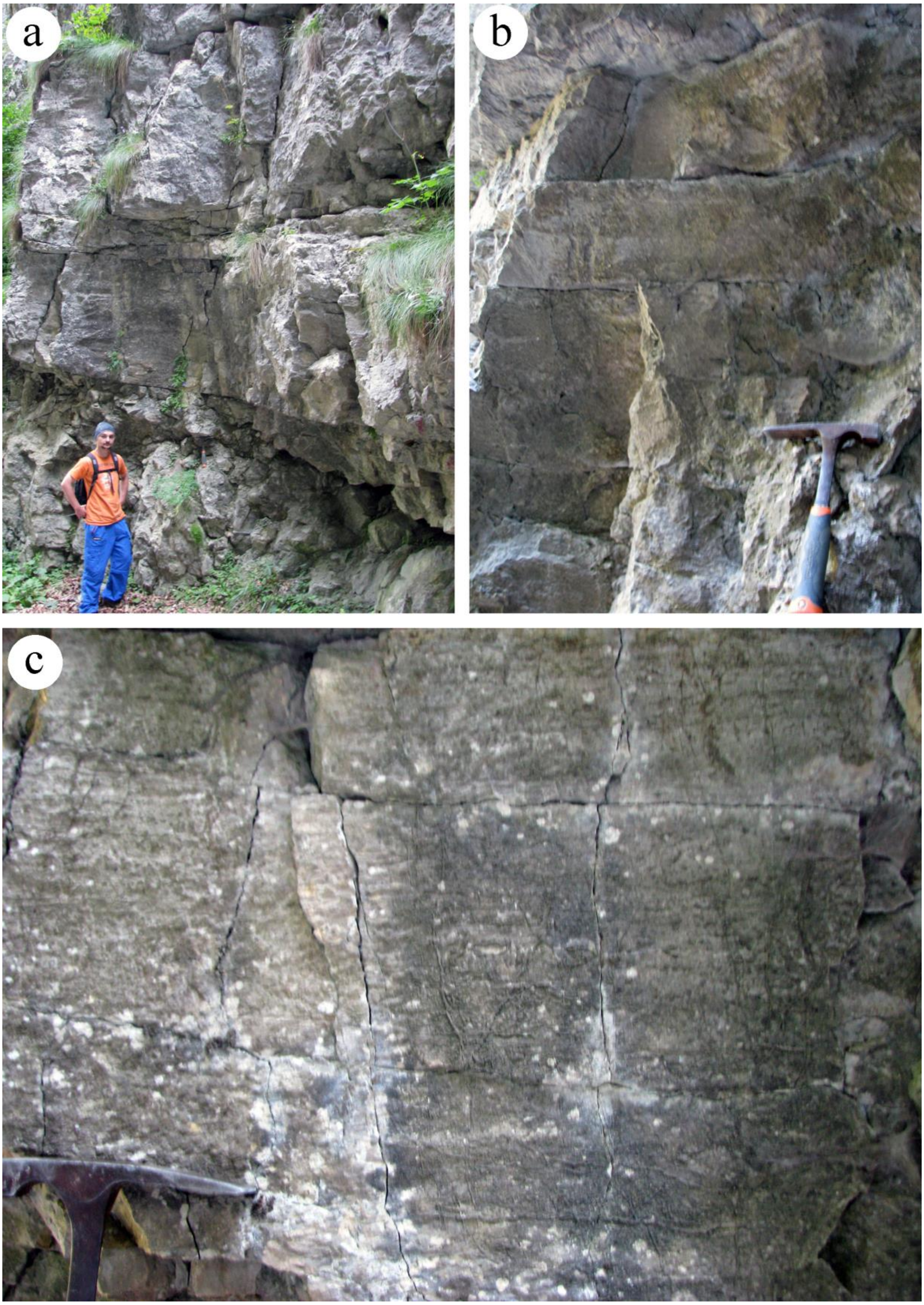

Fig. 7 a, b Well bedded, decimetre- to meter-thick limestones from the peritidal succession of the Cheile Dâmbovicioarei; **c** fenestral structures and millimeter to centimeter-thick sets of laminae are present.

C3. Intertidal carbonates

The following microfacies types were identified within these limestones: peloidal oncoidal grainstone, fine laminated peloidal grainstone (Fig. 10 a), fenestral peloidal-bioclastic grainstone (Fig. 10 b) and fenestral peloidal-bioclastic intraclastic packstone. These facies occupy the middle-upper part of the peritidal carbonate beds forming interbedded structures between the lower micritic subtidal units and the upper laminitic supratidal limestones.

These limestones contain well sorted components which consist of siltic-arenitic intraclasts, bioclasts, peloids, ooids and vadoids. Other features include the presence of scarce fauna and flora, micritized bioclasts and various sedimentary structures such as fenestral structures, erosional surfaces, millimeter-scale firmgrounds and alternation of millimeter-scale oblique lamination. Voids are geopetally filled with cement, and/or internal sediment. Facies associations form intercalated centimeter-decimeter to meter thick banks across the entire outcrop surface.

Ripple laminations can be observed within well-sorted deposits (Fig. 10 a). Intraclasts represent non-fossiliferous mudstone and marine-fauna rich wackestone (Fig. 10 b). Flat, elongated intraclasts may be associated with rounded, subangular components. The biotic spectrum includes ostracods, thin-shelled gastropods, miliolids and cyanobacteria. Micritic meniscus type cement (Fig. 10 b) is binding the main components. Irregular, flat to rounded millimeter sized fenestral structures are common (Fig. 10 b).

Millimeter scale discontinuity surfaces (firmgrounds) occur (Fig. 11). Primary structures are covered by an intensely micritised grains which fills the lower part of the discontinuity surfaces (Fig. 11). However, the micropaleontological assemblage of the latest deposits shows high diversity values if compared with the intertidal limestones. Micritic envelopes are formed by cyanobacteria around various bioclasts.

Interpretation

The intertidal depositional environment is characterized by the abundance of intraclasts and peloids. High energy conditions are indicated by wave and current ripples. Fenestral structures are typical for intertidal environments (Shinn, 1968; Lucia, 1972; Shinn, 1983a; 1983b; Tucker & Wright, 1990). Fenestral structures are associated with gas escape features resulting from organic matter decomposition. Other hypothesis links them with sediment contraction and dehydration processes (Shinn, 1968). In some cases, fenestral structures present traces of meteoric water influence (vadose silt or microstalactitic cement) (Fig. 10 b). Some bioclastic banks contain dissolution structures and reprecipitation features generated by meteoric water influence (Fig. 11). Confusion with upper subtidal carbonates is possible.

C4. Supratidal limestones

Supratidal limestones form the top of each peritidal carbonate bed. The centimeter to decimeter thick carbonate beds have variable lateral extension in terms of facies distribution. Facies diagnostic tools include the identification of algal-microbial mats, non-fossiliferous laminated mudstone and fenestral muds with desiccation cracks. Algal-microbial mats can be composed of very fine, micritic laminae (occasionally of cyanobacterial origin) (Fig. 12). They separate thicker sets of laminae which were produced by calcified cyanobacteria skeletons (Fig. 12 a, b). Agglutinated sediment is present within cyanobacteria rich laminae. It consists of fine peloids and ostracods (Fig. 12 b).

Fig. 12 c, d illustrates another example of algal microbial mats. Microlamination is created by cyanobacteria in association with small sized, irregular shaped fenestral structures. The preservation potential of small sized fenestral structures is induced by the irregular growth of cyanobacteria (Monty, 1976; Playford & Cockbain, 1976). Rivulariacean-type cyanobacteria are also present (Fig. 12 c). Generally algal-microbial mats are associated with laminae or thin beds composed of ostracod-bearing mudstone and cyanobacteria nodules. Horizontal lamination is created by interbedded, small scale levels of algal-microbial mats and ostracod-bearing mudstones. Millimeter to centimeter-thick mudstone layers are interbedded between algal-microbial mats. Bioclasts are represented by ostracods and millimeter-submillimeter sized cyanobacteria nodules.

Non-fossiliferous laminated mudstone and fenestral muds with desiccation cracks (Fig. 13 a) are present within this depositional subenvironment.

Horizontal or wavy lamination is common for the non-fossiliferous mudstone facies. The laminated sediment is generally fine-grained and micritic with coarser, siltic intercalations. Fenestral muds are present in the upper part of the peritidal beds. These deposits are intensely fractured and their upper part contains desiccation cracks (Fig. 13 a, b, c). The resulting carbonate breccia is composed of elongated-tabular intraclasts which contain the same facies associations as the original carbonate rock (Fig. 13 a). Desiccation generated horizontal, vertical and oblique cracks (Fig. 13 a). These sedimentary structures are filled with cement, vadose silt or a combination of these two components.

Interpretation

Supratidal carbonates can be strongly affected by pedogenetical alteration (Fig. 13 b, c). Such processes include the development of a distinct diagenetic overprint (microstalactitic and meniscus cements) together with the formation of other components (micritic carbonate clasts, pisoids, vadoids, horizontal, vertical and oblique cracks, vadose silt filling voids and fractures) (Fig. 13 b, c). Subsequent lithification of the supratidal sediments leads to the formation of calcretes (Tucker and Wright, 1990).

Recent algal-microbial mats are mainly composed of filamentous cyanobacteria in association with other microbes (Pratt, 1979; Tucker & Wright, 1990). Tidal flat sediments are washed away before they are agglutinated by cyanobacteria filaments (Pratt, 1979; Tucker & Wright, 1990). Such algal-microbial mats are common for the supratidal environment with their upper limit being controlled by desiccation processes (Tucker & Wright, 1990). Their association with ostracod-bearing mudstones indicates deposition under restricted conditions in supratidal swamps (Shinn & Lloyd, 1969). Non-fossiliferous fenestral limestones are typical for the upper intertidal-supratidal depositional environments (Shinn,

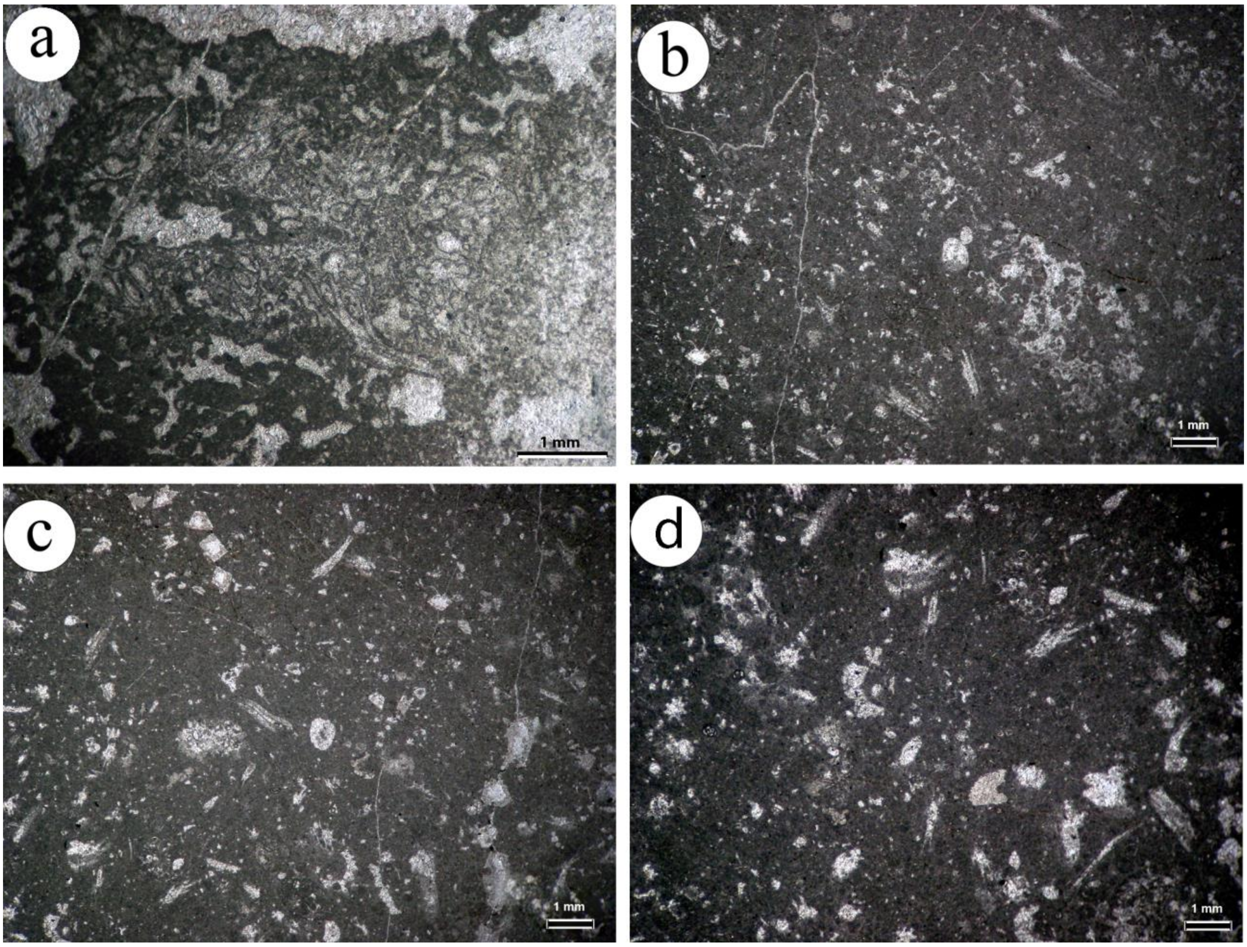

Fig. 8 a-d Normal marine subtidal limestones. Bioturbated bioclastic packstone with dasycladalean algae [*Selliporella neocomiensis* (Radoičić), *Terquemella* sp.]; miliolids, ostracods and bivalve fragments.

1968; Lucia, 1972; Shinn, 1983a; 1983b; Tucker & Wright, 1990). Desiccation processes can be associated with supratidal flats and upper intertidal areas (Shinn, 1983a; Hardie & Shinn, 1986; Tucker & Wright, 1990).

The supratidal deposits (Fig. 14) contain millimeter-centimeter-scale cycles. Spring tides, storms and phreatic level oscillations were responsible for the formation of tidal flat depositional micro-cycles. Such an example can be observed in Fig. 14. In this case, bioclastic micrites or desiccated non-fossiliferous mudstones [Fig. 14 (1)] are interbedded with storm deposits [Fig. 14 (2)] and pond type facies (ostracod bearing mudstone) [Fig. 14 (3). Continentally driven storm deposition is indicated by the presence of fine grained material within bioclastic or non-fossiliferous micrites (Pratt et al., 1992).

Another example of micro-cycles is indicated by the presence of alternating algal-microbial mudstones and cyanobacteria nodules. The algal-microbial mats contain disarticulated ostracods and fine peloidal sediments agglutinated by cyanobacteria. These data suggests high energy sedimentation within shallow swamp areas (Fig. 12 a, b). Filamentous cyanobacteria can form fenestral structures in shallow, low energy swamps by developing irregular growth features (Fig. 12 c, d). Algal-microbial mat development may be hampered by sea level growth or increasing turbidity. Such sea level growth is indicated by the presence of interbedded ostracod-bearing mudstones. In these situations the sediment is derived mainly from suspension since current wave sedimentary structures are missing.

D. The upper part of the limestone succession

The uppermost part of the Cheile Dâmbovicioarei Formation is well exposed in the Padina Braşoavei area. The section is located in the northen part of the Padina Braşoavei (Urdăriţa Horst area), approximately 2 km east of the Dâmbovicioara Gorges. In terms of age constraints, Patrulius [in Patrulius et al. (1980] identified a foraminiferal association considered to characterize the Valanginian. Moreover, the same authors described a Berriasian-Valanginian discontinuity from this section (Fig. 15). These limestones form a 10 m thick succession which is located in the vicinity of the Braşov-Câmpulung Muscel national road (Fig. 15).

Patrulius et al. (1980) described the following succession, from the base to the top:

1) 2-2.5 m of limestones with vague bedding surfaces marked by microfacies boundaries and stylolites;
2) 10 cm of breccia with green-greyish clay rich matrix and grey micritic elements. It contains rare foraminifera (*Pseudotextulariella salevensis* Charollais, Brönimann & Zaninetti and *Pfenderina* sp.);
3) One limestone bed composed of bioclastic packstone;
4) 10 cm of grey micritic limestone with centimeter size clasts of black limestone; it contains ostracods and rare foraminifera (including lituolids and miliolids);

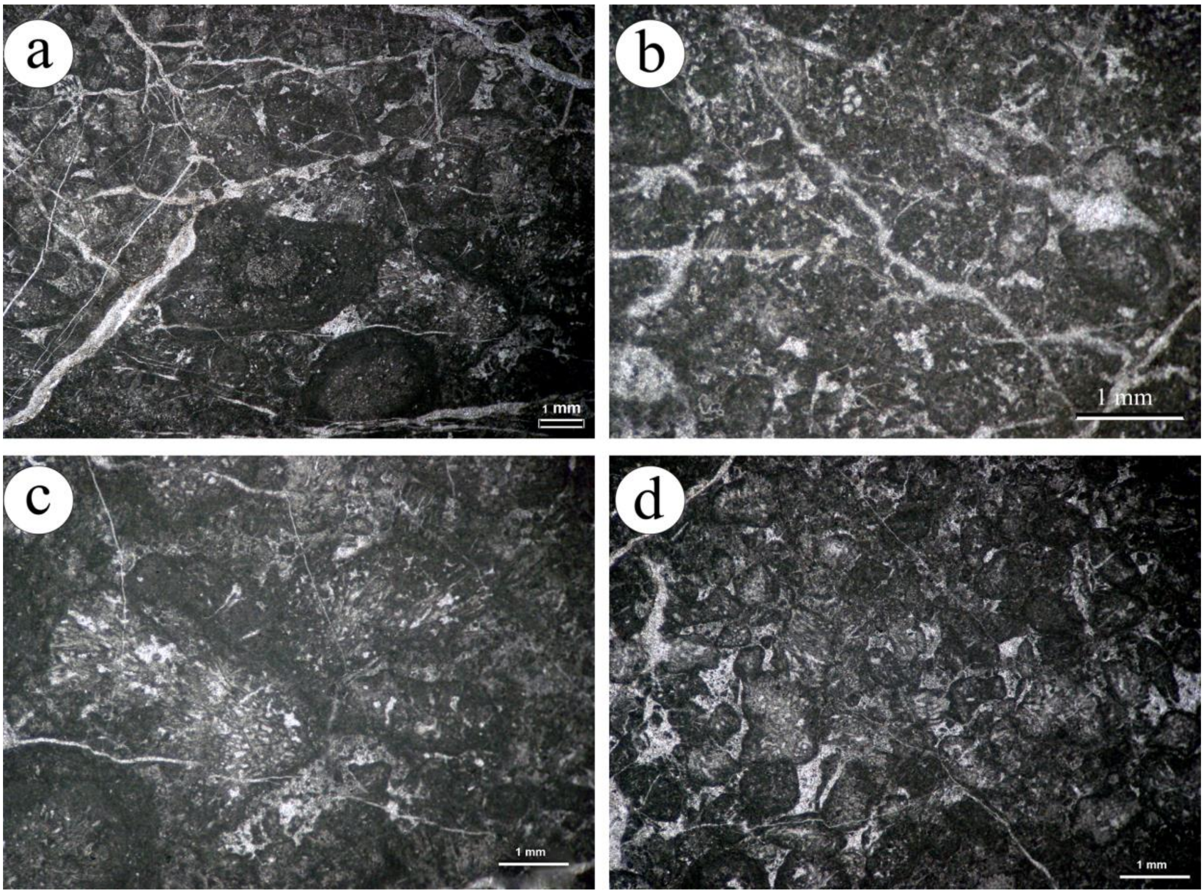

Fig. 9 Restricted marine subtidal limestones. **a-d** Oncoidal-bioclastic packstone with cyanobacteria nodules.

5) Interbedded layers of micrites and fenestral packstones with peloids, porostromatic nodules, rare foraminifera (miliolids and *Pseudotextulariella salevensis* Charollais, Brönimann & Zaninetti) and nerineids. The breccia overlaying the discontinuity contains voids and cavities filled with orange calcisiltites (Patrulius et al., 1980).

Well-bedded limestones form the entire carbonate succession from the Padina Brasoavei area (Fig. 15, 16 a, b). Fenestral structures are present both in the lower (Fig. 16 c) and upper part of the succession (Fig. 16 d). Patrulius et al. (1980) described two distinct breccia levels from this section. The authors of the present study identified the same carbonate layers which are described further in detail.

Alternating levels of peloidal oncoidic-bioclastic grainstone, peloidal fenestral grainstone/packstone and fenestral intraclastic grainstone form the lower and upper part of this section. These limestones contain mainly rivulariacean-type cyanobacteria, rare benthic foraminifera (miliolids) and ostracods. Sedimentary structures include firmgrounds, fenestral pores and angular to subrounded fragments of non-fossiliferous peloidal mudstones.

Centimeter-thick brecciated levels (Fig. 16 a, indicated by yellow and red arrows) may show variable lateral extension (Fig. 16 e). There is a strinking microfacies similarity between the breccia clasts and the underlying limestones. This feature indicates an *in situ* brecciation (Fig. 17). The lowermost boundary of these limestones is marked by a transitional passage towards the non-altered bedrock. The angular to subrounded breccia clasts are frequently embedded in a greenish-grey marl (Fig. 16 e) which fills embedded in a greenish-grey marl (Fig. 16 e) which fills the vertical and oblique fractures from the underlaying carbonate bed. The fauna and flora occur within breccia clasts. It consists of foraminifera (Fig. 17 d), ostracods and cyanobacteria (Fig. 17 a-d). Micritisation and dissolution are common within these subaerially exposed limestones. The newly formed cavities contain vadose silt and continental terrigenous material (clay minerals and silt size quartz fragments) (Fig. 17 e).

Interpretation

Three distinct stages were responsible for the formation of these deposits. Firstly, the initial sediments were accumulated in ponds and supratidal swamps. In a second stage, these sediments were subaerially exposed. Finally, pedogenetical alteration occurred. Pedogenetical alteration lead to the formation of specific textures and structures which include brecciated features or vertical and horizontal circumgranular cracks (Fig. 17 e-f). Such processes affected the pre-existing rock on a variable scale. Pedogenetic processes acted as the main trigger for the formation of these brecciated features with structures and textures resembling palustrine limestones. These type of limestones have been described from continental as well as marginal marine successions (Freytet, 1973; 1984; Platt, 1989; Fernandez & Melendez, 1991; Platt & Wright, 1991; Platt, 1992; Platt & Wright, 1992; Wright & Platt, 1995; Wright et al., 1997; Armenteros et al., 1997; Armenteros & Daley, 1998; Dunagan & Driese, 1999; Tandon & Andrews, 2001; Freytet & Verrecchia, 2002; Alonso-Zarza & Wright, 2010). Is is frequently

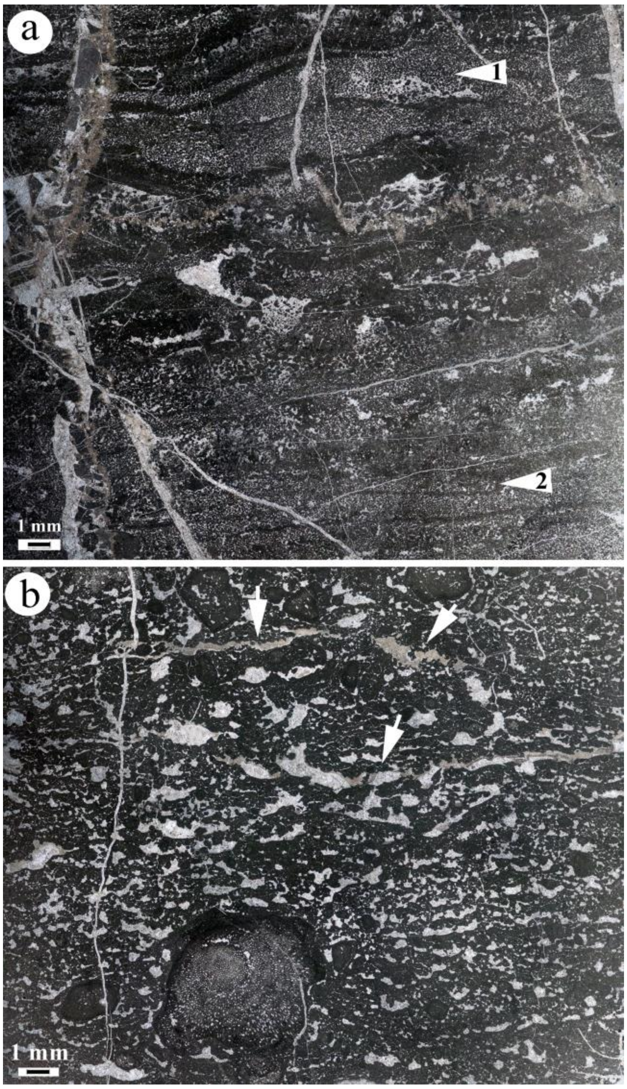

Fig. 10 Intertidal limestones. **a** Fine laminated peloidal grainstone; well-sorted limestones with frequent ripples (1) and horizontal or small-scale oblique laminations (2). **b** Subaerially exposed fenestral peloidal-bioclastic grainstone with vadose microstalactitic cement (arrowed).

difficult to identify this environment because pedogenetic changes of the marginal lacustrine limestones are simmilar with changes identified within the facies of the peritidal environment (Wright & Platt, 1995).

Age constraints

The lower part of the succession from Cheile Dâmbovicioarei, dominated by bioconstructions, contains corals and diverse microencrusters including *Psudorothpletzella* sp. and frequent *Crescentiella morronensis* (Crescenti). The rudstones and grainstones following the bioconstructions contain foraminifera (*Coscinoconus alpinus* Leupold and *Bramkampella arabica* Redmond) (Fig. 18 a) and calcareous algae (*Clypeina sulcata* (Alth)) suggesting a late Tithonian age.

The passage to fenestral micrites makes the beginning of the Cheile Dâmbovicioarei Formation. Within the more than 350 m limestone succession of this formation, a relatively rich assemblage of calcareous algae and foraminifera was identified. Among algae, the following species have been identified: *Selliporella neocomiensis* (Radoičić) (Fig.18 b), *Pseudocymopolia jurassica* (Dragastan) (Fig. 18 c), *Salpingoporella praturloni* (Dragastan) (Fig. 18 d), *Salpingoporella* cf. *circassa* Farinacci & Radoičić, *Salpingoporella* sp., ?*Neomeris* sp., *Humiella* sp., *Pseudotrinocladus piae* (Dragastan), ?*Permocalculus* sp. and *Thaumatoporella parvovesiculifera* (Raineri) (Fig. 18 q). The foraminiferal assemblage consists of *Earlandia*? *conradi* Arnaud-Vanneau, *Pseudocyclammina* sp., *Everticyclammina* div. sp., *Haplophragmoides joukowskyi* Charollais, Brönnimann & Zaninetti (Fig. 18 e,f), *Montsalevia salevensis* (Charollais, Brönnimann & Zaninetti) (Fig. 18 g), *Protopeneroplis ultragranulata* (Gorbatchik) (Fig. 18p), *Pfenderina neocomiensis* (Pfender), *Pseudotextulariella courtionensis* Brönnimann (Fig. 18 i), *Scythiolina* div. sp. (Fig. 18 h), *Vercorsella* sp., *Freixielina planispiralis* Ramalho, *Siphovalvulina variabilis* Septfontaine, *Kamiskia* sp., *Ammobaculites* sp., *Nautiloculina* sp., *Gaudryina* sp., *Troglotella incrustans* Wernli & Fookes, *Danubiella gracilima* Neagu (Fig. 18 m), *Meandrospira* sp., *Spiroloculina* sp. and diverse other

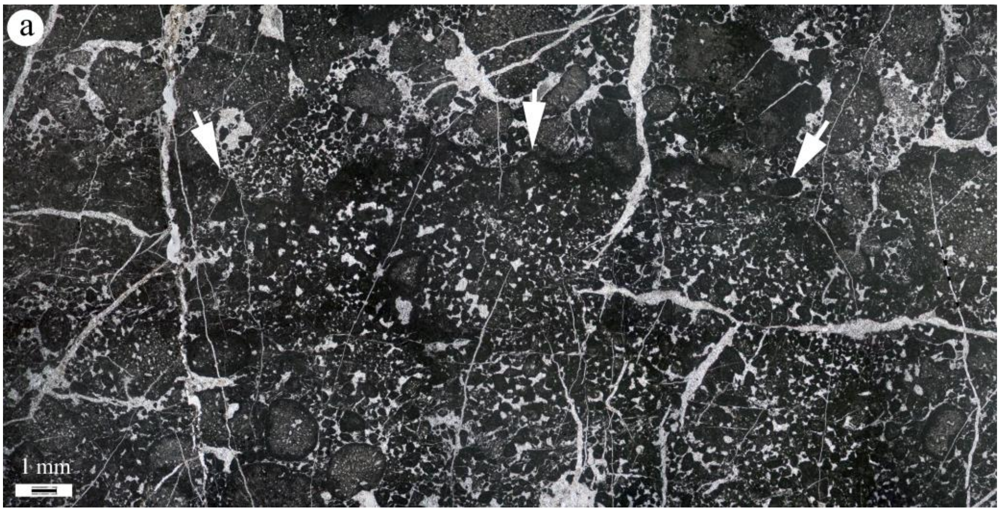

Fig. 11 a Intertidal carbonates (micro-cycles delimitated by firmground type surfaces) (thin section in panorama). Fenestral peloidal-oncoidic grainstone; Millimeter-scale firmgrounds are composed of micritic laminae (arrowed).

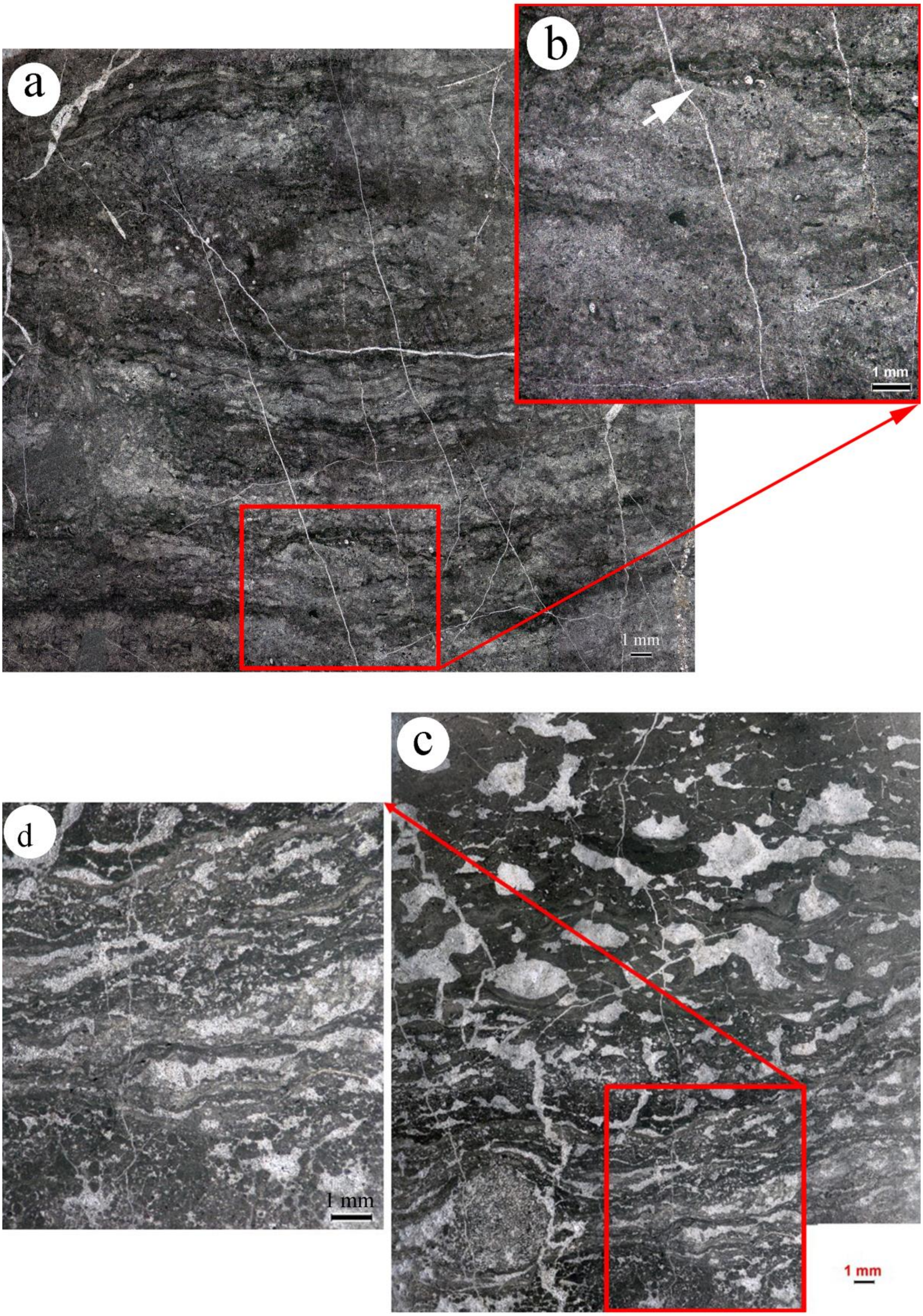

Fig. 12 Supratidal limestones. **a** Algal-microbial mats; they contain alternations of calcified cyanobacteria and very fine micritic lamine. **b** Detail from the image a; the cyanobacteria laminae with agglutinated fine peloids and ostracods (indicated by arrows). **c, d** Fenestral algal/cyanobacterial bindstone; micro-lamination is formed by calcified cyanobacteria filaments; the lower part is composed of rivulariacean-type cyanobacteria; detail at left;

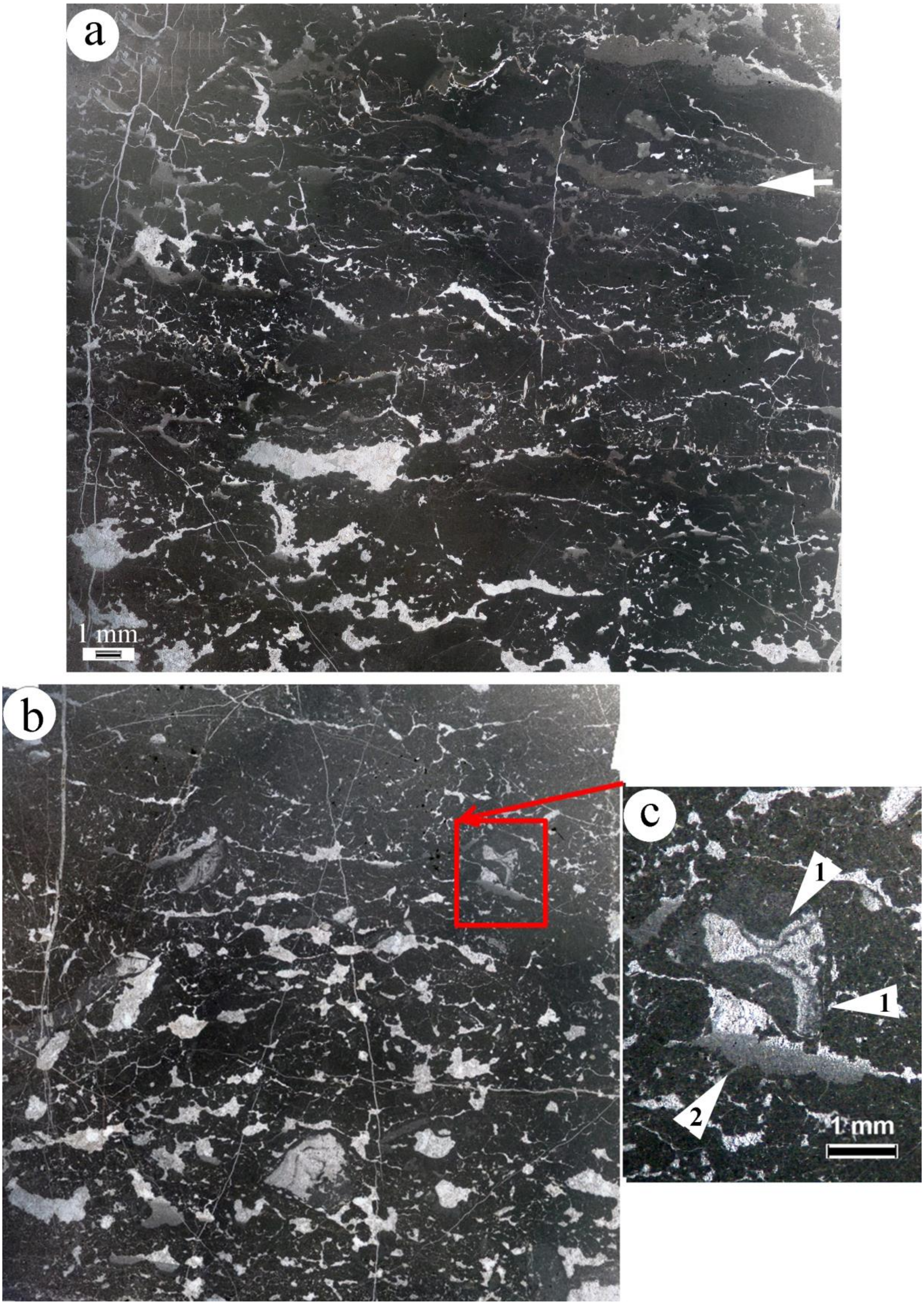

Fig. 13 Supratidal limestones. **a** Fenestral muds with horizontal, vertical and oblique desiccation cracks. The horizontal cracks are parallel with the lamination while the upper part of the cracks is filled with vadose silt (arrow). **b, c** Pedogenetically modified supratidal limestones. Fractured fenestral mudstone (b, c); it contains horizontal, oblique and vertical cracks; c, detail of b; cavities are filled by micro-stalactitic and meniscus cements which from vadoid crusts (arrows 1); the lower part of the cavities contains vadose silt (arrow 2).

Fig. 14 Micro-cycles within supratidal carbonates. Alternations of fractured fenestral non-fossiliferous mudstone and ostracod-bearing mudstone; horizontal, oblique and vertical cracks are present within the non-fossiliferous levels (1); fractured cavities contain vadose silt; storm deposits (2) and pond type facies (ostracod-bearing mudstone) (3).

miliolids, *Neotrocholina* sp., *Coscinoconus cherchiae* (Arnaud-Vanneau, Boiseeau & Darsac) (Fig. 18 j), *Coscinoconus* cf. *campanellus* (Arnaud-Vanneau, Boiseeau & Darsac) (Fig. 18 l), *Coscinoconus* cf. *perconigi* (Neagu) (Fig. 18 k), *Paracoskinolina*? *jourdanensis* (Fooury & Moullade) (Fig. 18 n, o), *Paracoskinolina*? sp. and diverse unidentified orbitolinids.

The whole assemblage of calcareous algae and foraminifera indicate a Berriasian-earliest Valanginian age (e.g., Darsac, 1983; Salvini-Bonnard, et al., 1984; Arnaud-Vanneau et al., 1988; Boisseau, 1987; Altiner, 1991; Granier & Deloffre, 1993; Bucur, 1999; Chiocchini et al., 1994; Neagu, 1994; Bucur et al., 1995; Ivanova, 2000; Granier & Bucur, 2011; Schlagintweit & Enos, 2013) (Fig. 19).

Fig. 15 Limestones from the Padina Brașoavei outcrop (Urdărița horst). The arrows indicate the discontinuity surface.

CONCLUSIONS

Reefal limestones („Upper massive limestones"of Patrulius et al., 1980; Cheile Dâmboviţei Formation cf. Dragastan, 2010) are present in the lower part of the Cheile Dâmbovicioarei carbonate succession. They pass gradationally into intraclastic/bioclastic-dominated shoals which are overlain by peritidal carbonate deposits. A gradational boundary marks the transition from reefal to shoals limestones. Such evidence indicate a continuity of sedimentation in this part of the carbonate platform. Reworked blackened bioclasts originate mainly from shallow or coastal platform areas. These depositional settings were dominated by topographically elevated areas where terrestrial plant colonisation was common. Reworked carbonate intraclasts include reefal fragments together with inner platform intraclasts and bioclasts. Carbonate sediment accumulated in outer platform bioclastic shoals, under high-energy conditions.

The intraclastic/bioclastic-dominated shoals -peritidal limestone transition is marked by a sharp boundary since the entire area was subaerially exposed. These deposits are overlain by hundreds of meter thick peritidal limestones (Cheile Dâmbovicioarei Formation, Patrulius 1976; Patrulius & Avram, 1976). Cyclic water depth changes are indicated by the stacking patterns of the peritidal facies. Individual bed and bedset facies evolution point to a distinct transition from subtidal/intertidal to supratidal depositional environments. Incomplete sequences dominate the Cheile Dâmbovicioarei carbonate succession. This transition can be explained by the progradation of coastal deposits (lacustrine/brackish water swamps) over marine intertidal/supratidal carbonates. Alternatively, it may be explained by lateral migration of tidal litoral facies belts. Bedscale depositional cyclies are marked by microfacies changes or the formation of submarine erosional surfaces and short-term subaerial exposure horizons. Such horizons contain sedimentary features associated with dissolution processes, cementation, erosion and pedogenetic brecciation. These processes form as a consequence of sea-level fall and negative accommodation space in some morphological areas of the carbonate platform. Incipient regional sea-level fall is clearly marked in the upper part of the carbonate succession. In this case, two distinct levels of pedogenetically brecciated limestones form good outcrop exposures in the Padina Braşoavei area (Urdăriţa Horst). A platform scale discontinuity caps the topmost part of this limestone unit (Grădinaru et al., 2016).

In conclusion, the associated carbonate depositional environments point to an important progradation of the Getic Carbonate Platform during the Late Tithonian-earliest Valanginian.

The accomodation space became increasingly reduced during deposition of the upper part of the succession, as indicated by the outer platform-peritidal facies transition. As a consequence, the carbonate platform started to migrate/shift laterally. Rivulariacean-type cyanobacteria were the main carbonate producers in the peritidal component of the limestone succession.

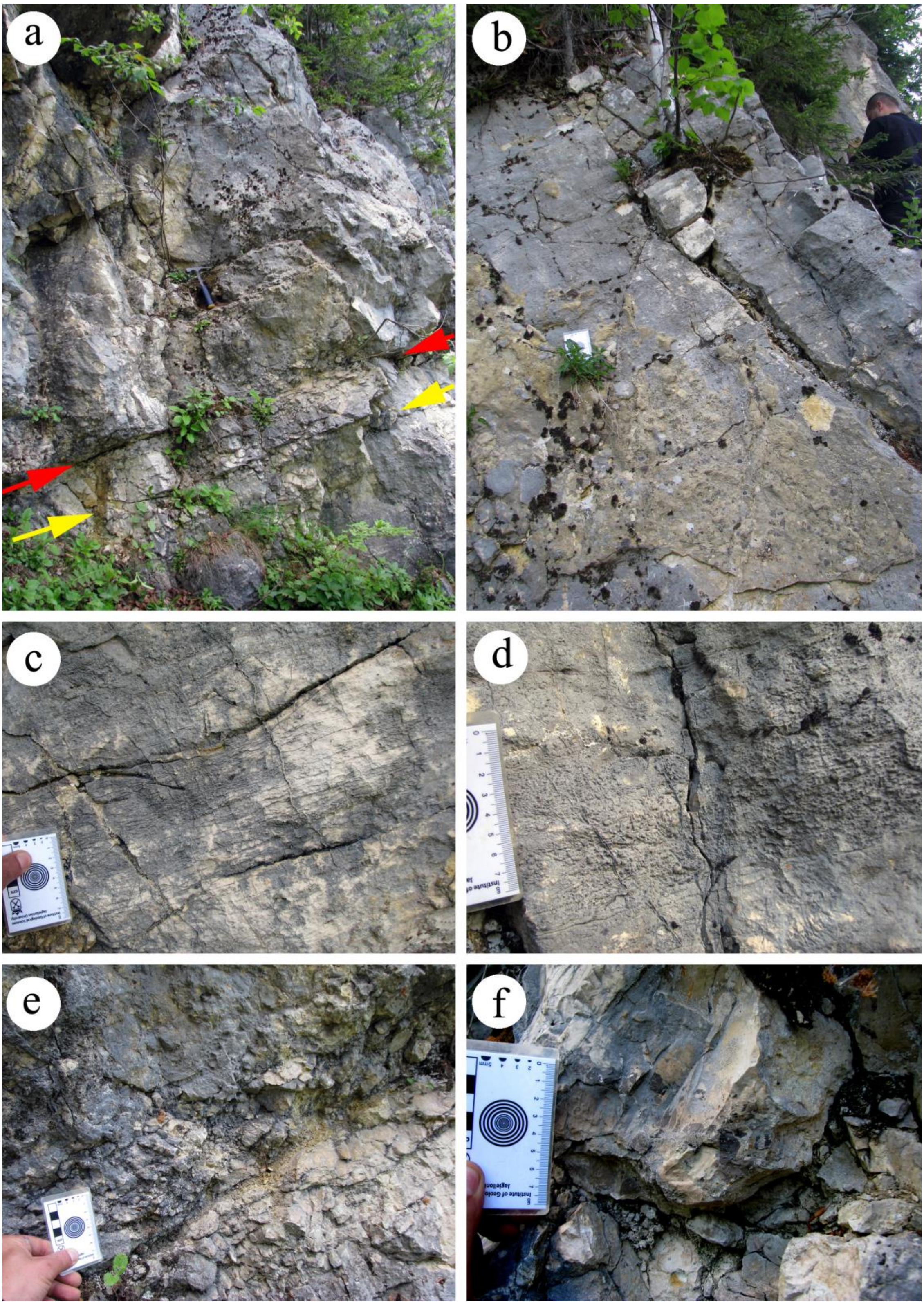

Fig. 16 Limestones from the Padina Brașoavei outcrop (Urdărița horst). **a** Limestones from the lower part of the succession [(the yellow arrows indicates the first brecciated level (with green-greyish matrix), while the red arrows indicate the second, black pebble bearing brecciated level]. **b** Well-bedded limestones from the upper part of the succession. **c, d** Fine laminated fenestral limestones from the lower part (c) and the upper part (d) of the succession. **e** The first brecciated level, with green-greyish matrix. **f** Black pebble-bearing level.

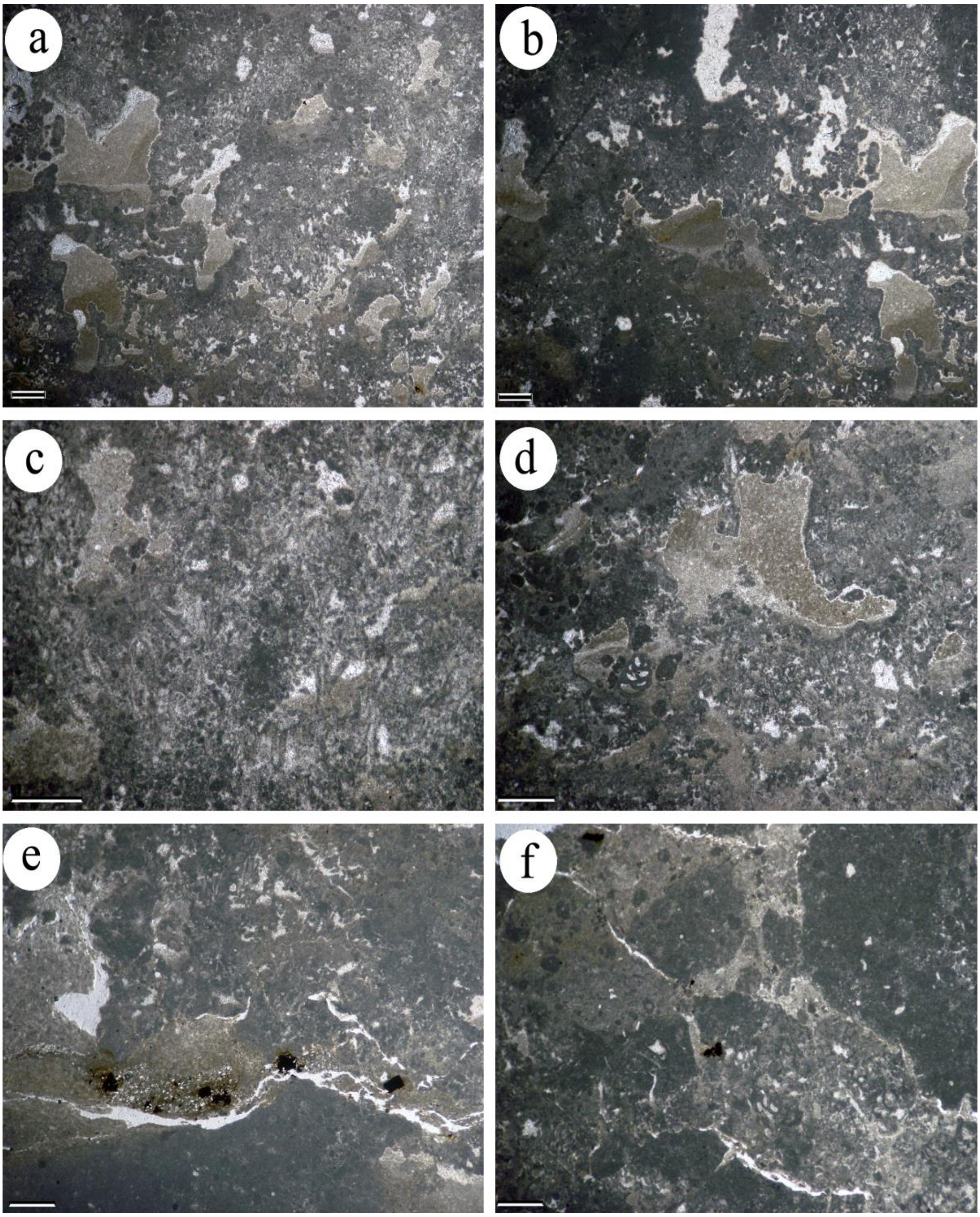

Fig. 17 Carbonate facies from the breccia levels. **a-d** Peloidal-bioclastic packstone with cyanobacteria, ostracods and foraminifera (d); cavities are filled with vadose silt and gravitational terrigenous material. **e-f** Breccia with horizontal (e), circumgranular and vertical (f) cracks. Scale-bar = 1 mm.

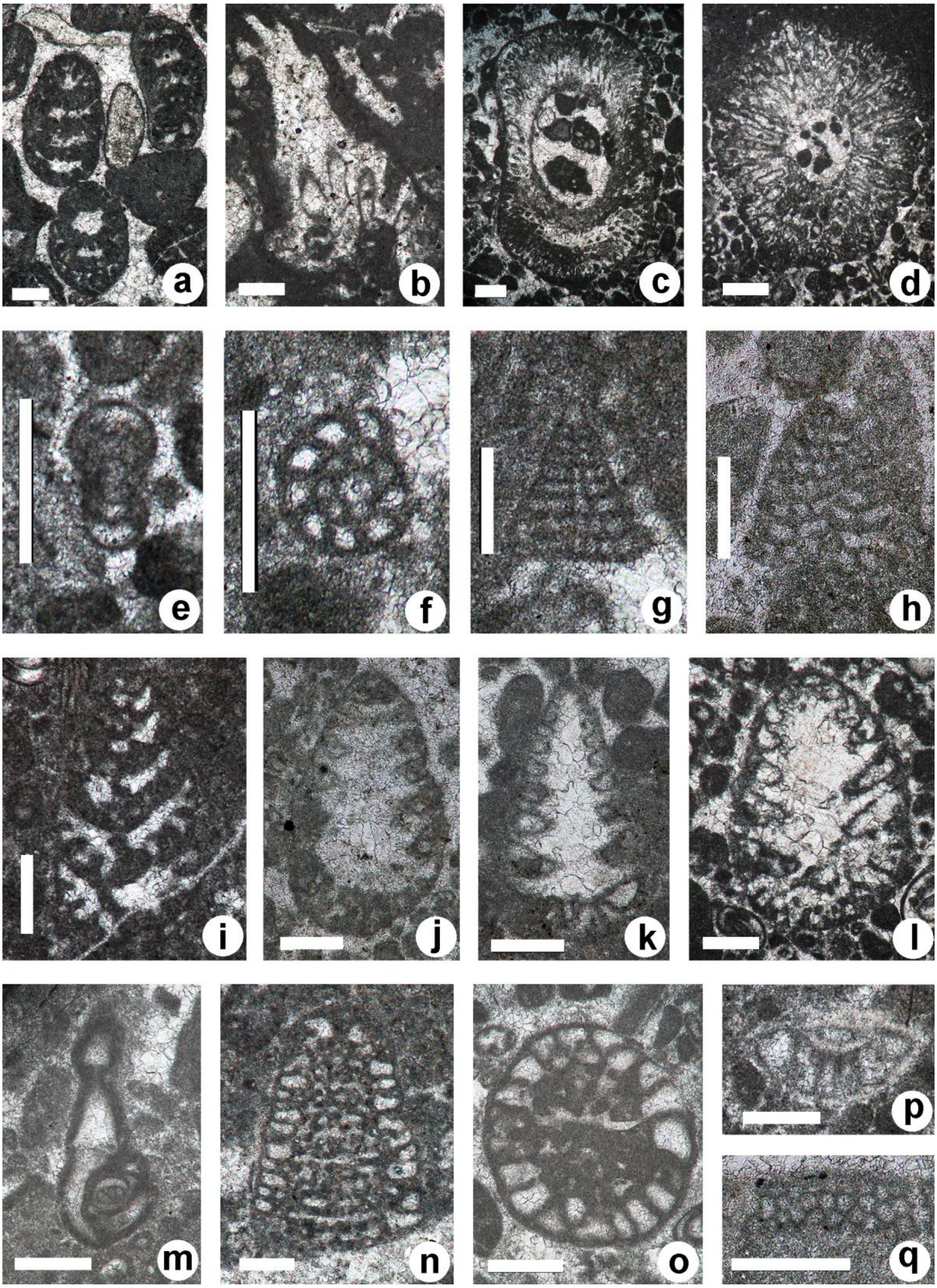

Fig. 18 Main microfossils from the Cheile Dâmbovicioarei Formation. **a** *Bramkampella arabica*; **b** *Selliporella neocomiensis*; **c** *Pseudocymopolia jurassica*; **d** *Salpingoporella praturloni*; **e, f** *Haplophragmoides joukowskyi*; **g** *Montsalevia salevensis*; **h** *Scythiolina* sp.; **i** *Pseudotextulariella courtionensis*; **j** *Coscinoconus cherchiae*; **k** *Coscinoconus* cf. *perconigi*; **l** *Coscinoconus* cf. *campanellus*; **m** *Danubiella gracilima*; **n, o** *Paracoskinolina*? *jourdanensis*; **p** *Protopeneroplis ultragranulata*; **q** *Thaumatoporella parvovesiculifera*. Scale-bar = 0.25 mm (a-c, e-q); 0.50 mm (d).

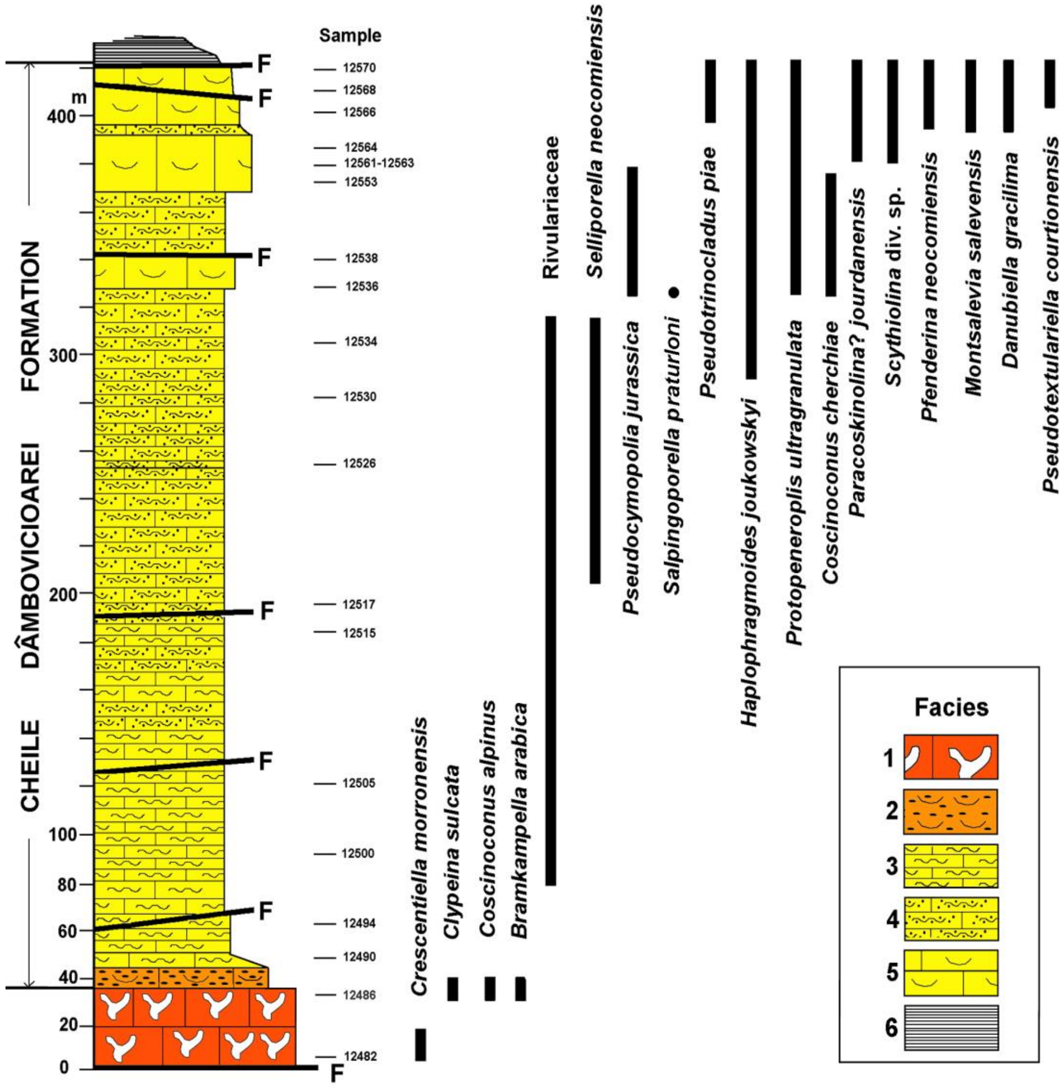

Fig. 19 Distribution of main microfossils from Dâmbovicioarei Gorges. Facies legend: 1, reef limestone; 2, intraclastic bioclastic rudstone/grainstone with black pebbles; 3, predominantly micritic-fenestral limestone; 4, predominantly peloidal-cyanobacterial fenestral limestone; 5, bioclastic-intraclastic rudstone and grainstone; 6, marls; F-fault.

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REFERENCES

Alonso-Zarza, A.M., Wright, V.P. 2010 Palustrine Carbonates. Developments in Sedimentology, 61: 103-131.

Altiner, D., 1991. Microfossil biostratigraphy (mainly foraminifers) on the Jurassic-Lower Cretaceous carbonate successions in north-western Anatolia (Turkey). Geologica Romana, 27: 167-213.

Armenteros, I. & Daley, B., 1998. Pedogenic modification and structure evolution in palustrine facies as exemplified by the Bembridge Limestone (Late Eocen of the Isle of Wight, southern England. Sedimentary Geology, 119: 275-295.

Armenteros, I., Daley, B. & Garcia, E., 1997. Lacustrine and palustrine facies in the Bembridge Limestone (late Eocene, Hampshire Basin) of the Isle of Wight, southern England. Palaeogeography, Palaeoclimatology, Palaeoecology, 128: 111-132.

Arnaud-Vanneau, A., Boisseau, T. & Darsac, C., 1988. Le genre Trocholina Paalzow 1922 et ses principales espèces au Crétacé. Revue de Paléobiologie, Vol. Spec. 2 (Benthos 86): 353-377.

Boisseau, T., 1987. La plate-forme jurassienne et sa bordure subalpine au Berriasien-Valanginien (Chartreuse-Vercors). Analyse et corrélation avec les séries de bassin. Thèse Univ. Grenoble, 413 pp.

Bucur, I.I., 1978. Microfacies of the white limestones from the northern part of the Piatra Craiului massif. Biostratigraphic considerations. Dări de seamă ale şedinţelor, Institutul de Geologie şi Geofizică, 64(1976-1977), 2: 89-10 (in Romanian)

Bucur, I.I., 1997. Representatives of the genus *Protopeneroplis* (Foraminifera) in the Jurassic and Lower Cretaceous deposits in Romania. Comparisons with other regions of the Tethyan area. Acta Palaeontologica Romaniae, 1: 65-71.

Bucur, I.I., 1999. Stratigraphic significance of some skeletal algae (Dasycladales, Caulerpales) of the Phanerozoic. In: Farinacci A. & Lord A.R. (eds.), Depositional episods and bioevents. Palaeopelagos Spec. Publ. 2: 53-104.

Bucur, I.I., Conrad, M.A., Radoičić, R., 1995. Foraminifers and calcareous algae from the Valanginian limestones in the Jerma River Canyon, Eastern Serbia. Revue de I.I. etal., 2009

Bucur, I.I., Săsăran, E., Iacob, R., Ichim, C. & Turi, V., 2009. Upper Jurassic shallow-water carbonate deposits from some Carpathian areas: new micropaleontological results. In: The 8th symposium of IGCP 506, Marine and non-marine Jurassic: global correlation and major geological events. University of Bucharest, August 28-September 3, 2009, pp.13-14.

Chiocchini, M., Farinacci, A., Mancinelli, A., Molinari, V. & Potetti, M., 1994. Biostratigrafia a foraminiferi, dasicladali e calpionelle delle successioni carbonatiche mesozoiche dell'Appennino centrale (Italia). Studi Geologici Camerti, Vol. Spec. "Biostratigrafia dell'Italia centrale", pp.9-128.

Darsac, C., 1983. La plate-forme berriaso-valanginienne du Jura méridional aux massifs subalpins (Ain, Savoie). Sédimentologie, minéralogie, stratigraphie, paléogéographie, micropaléontologie. Thèse, 3e cycle, Université Grenoble, 319 pp.

Davies, G.R., 1970. Carbonate bank sedimentation, Eastern Shark Bay, Western Australia. In: Logan, B.W., Davies, G.R., Read, J.F. & Cebulski, D.E. (eds.), Carbonate sedimentation and environment, Shark Bay, Western Australia, AAPG, Memoir 13: 85-168.

Dimitrescu, R., Patrulius, D. & Popescu, I., 1971. Geological map of Romania, scale 1: 50000, sheet 110c (Rucăr). Institutul de Geologie şi Geofizică, Bucureşti.

Dragastan, O. N., 2010. Platforma Carbonatică Getică. Stratigrafia Jurasicului şi Cretacicului inferior, reconstituiri paleogeografice, provincii şi biodiversitate. Editura Universităţii Bucureşti, 621 pp.

Dunagan, S.P. & Driese, S.G., 1999. Control of terrestrial stabilization on Late Devonian palustrine carbonate deposition: Catskill Magnafacies, New York, U.S.A. Journal of Sedimentary Research, 69 (3): 772-783.

Enos, P., 1977. Holocene sediment accumulations of the South Florida Shelf Margin. In: Enos, P. & Perkins, R.D. (ed.), Quaternary sedimentation in South Florida, Geological Society of America, Memoir 147: 1-130.

Fernández, J.C.G. & Meléndez, N., 1991. Rhythmically laminated lacustrine carbonates in the Lower Cretaceous of La Serrania de Cuenca Basin (Iberian Ranges, Spain). Spec. Publs. Int. Ass. Sediment., 13: 245-256.

Francis, J. E., 1986. The calcareous paleosols of the basal Purbeck Formations (Upper Jurassic) Southern England. In: Wright V.P. (ed.), Paleosols: their recognition and interpretation. Blackwell Scientific Publications: 112-138.

Freytet, J. E., 1973. Petrography and paleo-environment of continental carbonate deposits with particular reference to the Upper Cretaceous and Lower Eocene of Languedoc (Southern France). Sedimentary Geology, 10: 25-60.

Freytet, P., 1984. Les sédiments lacustres carbonatés et leurs transformations par émersion et pédogenèse. Importance de leur identification pour les reconstitutions paléogéographiques. Bull. Centres Rech. Explor.-Prod. Elf-Aquitaine, 8 (1) : 223-247.

Freytet, P., Verrecchia, E.P., 2002. Lacustrine and palustrine carbonate petrography: an overview. Journal of Paleolimnology 27: 221-237.

Ginsburg, R.N., 1975. Tidal deposits: a casebook of recent examples and fossil counterparts, 428p., Sprinder-Verlag

Ginsburg, R. N., Harris, P. M., Enerli, G. P. & Swart, P. K., 1991. The growth potential of a bypass margin, Great Bahama Bank. Journal of Sedimentary Petrology, 61 (6): 976-987.

Grădinaru, M., Lazăr, I., Bucur, I.I., Grădinaru, E., Săsăran, E., Ducea, M.N. & Andrăşanu, A., 2016. The Valanginian history of the eastern part of the Getic Carbonate Platform (Southern Carpathians, Romania): Evidence for emergence and drowning of the platform. Cretaceous Research, 66: 11-42

Grammer, G. M., Ginsburg, R. N. & McNeill, D. F., 1991. Morphology and development of modern carbonate foreslopes, Tongue of the Ocean, Bahamas. In: Larue, D. K. & Draper, G. (eds.), Transactions of the 12th Caribbean Geological Conference: 27- 32.

Granier, B. & Bucur, I.I., 2011. Stratigraphic range of some Tithonian-Berriasian foraminifers and Dasycladales. Re-evaluation of their use in identifying this stage boundary in carbonate platform sertings. In: Grosheny, D., Granier, B. & Sanders, N. Platform to basin correlations in Cretaceous times. Abstracts. Buletin del Instituto de Fisiografia y Geologia, 2011: 79-81.

Granier, B. & Deloffre, R., 1993. Inventaire critique des algues dasycladales fossiles IIe partie – les algues dasycladales du Jurassique et du Crétacé. Revue de Paléobiologie, 12 (1): 19-65.

Halley, B.R., Harris, M.P. & Hine, C.A., 1983. Bank margin. In: Scholle A.P., Bebour D.G. & Moore C.H (eds): Carbonate depositional environments. AAPG Memoir 33: 463-506.

Hardie, L.A. & Shinn, E.A., 1986. Carbonate depositional environments modern and ancient. Part 3: Tidal flats, 74 p., Colorado School of Mines Quarterly

Harris, P.M., Kendall C.G.St. C. & Lerche, I., 1985. Carbonate cementation – a brief review. Society of Economic Paleontologists and Mineralogists: 79-95.

Ivanova, D., 2000. Middle Callovian to Valanginian microfossil biostratigraphy in the West Balkan Mountain, Bulgaria (SE Europe). Acta Palaeontologica Romaniae, 2 (for 1999): 231-236.

Lazăr, I., Grădinaru, M., Andrăşanu, A., Bucur, I.I., Săsăran, E., Stoica, M., 2017. Jurassic to Cretaceous Evolution of the Eastern Getic Domain Rucăr-Bran Zone Field Trip Guide Book. Editura Universității din București, 46 pp., ISBN 978-606-16-0911-6.

Longman, M.W., 1980. Carbonate diagenetic textures from nearsurface diagenetic environments. Am. Ass. Petrol. Geol. Bull., 64 (4): 461-487.

Lucia, F.J., 1972. Recognition of evaporiye-carbante shoreline sedimentation. In: Rigby, J.K. (ed.), Recognition of ancient sedimentary environments. Society os Economic Palentologists and Mineralogists, Special publication, 16: 160-191.

McIlreath, I. A. & James, N. P., 1984. Carbonate slopes. In: Walker R. G. (ed.), Facies Models, Reprint series 1: 245-257.

Monty, C.L.V., 1976. The origin and development of cryptalgal fabrics. In: Walter, M.R. (ed.), Stromatolites, Developments in Sedimentology, 20: 193-250.

Mullins, H.T., Heath, K.C., Van Buren, M. & Newton, C.R., 1984. Anatomy of a modern open – ocean carbonate slope: northern Little Bahama Bank. Sedimentology, 31: 141-168.

Neagu, Th., 1994. Early Cretaceous *Trocholina* group and some related genera from Romania. Part I. Revista Espanola de Micropaleontologia, 26 (3): 117-143.

Patrulius, D., 1969. Geology of the Bucegi Massif and Dâmbovicioara Couloir. 321 p., Editura Academiei RSR, Bucureşti (in Romanian).

Patrulius, D., 1976. Upper Jurassic –Lower cretaceous carbonate rocks in the eastern part of the Getic carbonate platform and the adjacent flysh troughs. In: Patrulius, D., Drăgănescu, A., Baltres, A., Popescu, B. & Rădan, S.- Carbonate rocks and evaporates – Guidebook. Institute of Geology and Geophysics, Guidebook series 15 (International Colloqium on carbonate rocks ans evaporates, Romania), pp. 71-82.

Patrulius, D., Avram, E. 1976. Stratigraphie et correlation des terrains néocomiens et barrémo-bédouliens du Couloir de Dâmbovicioara (Carpathes Orientales). Dări de seamă ale şedinţelor, 62 (4): 135-160.

Patrulius, D., Antonescu, E., Avram, E., Baltres, A., Dumitrică, P., Iordan, M., Iva, M, Morariu, A., Pop, G., Popa, E. & Popescu, I., 1980. The complex petrologic and biostratigraphic study of the Jurassic and Neocomian formations from the Romanian Carpathians and Dobrogea in view to evaluate the ore-deposit potential. The Leaota-Braşov-Perşani Mountains area. Institute of Geology and Geophysics, unpublished scientific report, 142 p. (in Romanian).

Patrulius, D., Dimitrescu, R. & Popescu, I., 1971. Geological map of Romania, scale 1:50000, sheet 110d (Moeciu). Institutul de Geologie şi Geofizică, Bucureşti.

Playford, P.E. & Cokbain, A.E., 1976. Modern algal stromatolites at Hamelin Pool, a hypersaline barred basin in Shark Bay, Western Australia. In: Walter, M.R. (ed.), Stromatolites, Developments in Sedimentology, 20: 389-411.

Platt, N.H., 1989. Lacustrine carbonates and pedogenesis: sedimentology and origin of palustrine deposits from the Early Cretaceous Rupelo Formation, W Cameros Basin, N Spain. Sedimentology, 36: 665-684.

Platt, N.H., 1992. Fresh-water carbonates from the Lower Freshwater Molasse (Oligocene, western Switzerland): sedimentology and stable isotopes. Sedimentary Geology, 78: 81-99.

Platt, N.H. & Wright, V.P., 1991. Lacustrine carbonates: facies models, facies distributions and hydrocarbon aspects. Spec. Publs. Int. Ass. Sediment. 13: 57-74.

Platt, N.H. & Wright, V.P., 1992. Palustrine carbonates and the Florida Everglades: towards an exposure index for the fresh-water environment? Journal of Sedimentary Petrology, 62 (6): 1058-1071.

Pratt, B.R., 1979. Early cementation and lithfication in intertidal cryptalgal structures, Boca Jewfish, Bonaire, Netherland Antilles. Journal of Sedimentary Petrology, 49 (2): 379-386.

Pratt, B.R., James, N.P. & Cowan, C.A., 1992. Peritidal carbonates. In: Walker, R.G. & James, N.P. (eds.), Facies models. Response to sea level change. Geological Associations of Canada: 303-322.

Riding, R., 1991. Classification of microbial carbonates. In: Riding, R. (ed): Calcareous algae and stromatolites, Springer-Verlag: 21-51.

Riding, R., 2000. Microbial carbonates: the geological record of calcified bacterial-algal mots and biofilms. Sedimentology, 47 (1): 179-214.

Salvini-Bonnard, G., Zaninetti, L. & Charollais, J., 1984. Les foraminifèrs dans le Crétacé inférieur (Berriasien moyen-Valanginien inférieur) de la région de la Corraterie, Grand-Salève (Haute Savoie, France): inventaire préliminaire et remarques stratigraphiques. Revue de Paléobiologie, 3 (2): 175-184.

Săndulescu M., 1984. Geotectonics of Romania. 336 p., Editura ştiinţifică, Bucureşti (in Romanian)

Săsăran E., 2006. *Calcarele Jurasicului superior-Cretacicului inferior din Munţii Trascău*, 249 p., Presa Universitara Clujeana, Cluj-Napoca (in Romanian).

Schlagintweit F. & Enos P., 2013. Uppermost Jurassic? - Neocomian shallow-water carbonates of the Blake Nose, USA: DSDP Site 392A revisited. Acta Palaeontologica Romaniae 9 (1): 39-56

Schmid, D., 1996. Marine microbolites and microencrusters from the Upper Jurassic. Profil, 9: 101-251.

Shapiro, R. S., 2000. A comment on the systematic confusion of thrombolites. Palaios, 15: 166-169.

Shinn, E.A., 1968. Practical significance of birdseye structures in carbonate rocks. Journal of Sedimentary Petrology, 38 (1): 215-223.

Shinn, E.A., 1983a. Tidal flat. In: Scholle, A.P., Bebour, D.G. & Moore, C.H.. (eds.) Carbonate depositional environments. AAPG Memoir 33: 171-210.

Shinn, E.A., 1983b. Birdseyes, fenestrae, shrinkage pores, and loferites: a reevaluation. Journal of Sedimentary Geology, 53 (2): 619-628.

Shinn, E.A. & Lloyd, R.M., 1969. Anatomy of a modern carbonate tidal-flat, Andros Island, Bahamas. Journal of Sedimentary Geology, 39 (3): 1202-1228.

Shinn, E.A. & Lidz, H.B., 1988. Blackened limestone pebbles: fire at subaerial unconformities. In: James N.P. & Choquette P.W. (eds.): Paleokarst. Springer: 117-131.

Strasser, A., 1984. Black pebble occurrence and genesis in Holocene carbonate sediments (Florida Keys, Bahamas, and Tunisia). Journal of Sedimentary Petrology, 54 (4): 1097-1109.

Strasser, A. & Davaud, E., 1983. Black pebbles of the Purbeckian (Swiss and French Jura): lithology, geochemistry and origin. Eclogae geol. Helv., vol. 76 (3): 551-580.

Tandon, S.K. & Andrews, J.E., 2001. Lithofacies associations and stable isotopes of palustrine and calcrete carbonates: examples from an Indian Maastrichtian regolith. Sedimentology, 48: 339-355.

Tucker, E. M. & Wright, V. P., 1990. Carbonate Sedimentology. 482 p., Blackwell Scientific Publications

Vera, J.A. & Jiménes de Cisneros, C., 1993. Paleogeographic significance of black pebbles (Lower Cretaceous, Prebetic, southern Spain). Palaeogeography, Palaeoclimatology, Palaeoecology, 102: 89-102.

Wright, V.P. & Platt, N.H., 1995. Seasonal wetland carbonate sequences and dynamic catenas: a re-appraisal of palustrine limestones. Sedimentary Geology, 99: 65-71.

Wright, V.P., Alonso-Zarza, A.M., Sanz, M.E. & Calvo, J.P., 1997. Diagenesis of Late Miocene micritic lacustrine carbonates, Madrid Basin, Spain. Sedimentary Geology, 114:. 81-95.