Subaerial exposure-related discontinuities in shallow-water platform carbonate successions (Late Triassic-Pelagonian & Early Jurassic-Gavrovo Tripolitza, Greece)*

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ABSTRACT: Subaerial exposure-related sedimentary discontinuities are studied in shallow-water marine carbonate formations of Late Triassic (Pelagonian carbonate platform) and Early Jurassic age (Gavrovo-Tripolitza carbonate platform) that crop out in Peloponnesus (near Dhidyma and Leonidion villages, respectively). The successions represent carbonate platform interior deposits, showing cyclic organization (peritidal-lagoonal cycles/lofer cycles) and contain a number of small-scale discontinuity surfaces linked to subaerial exposure. At and below the discontinuity horizons, several key features of early-meteoric diagenetic alteration were encountered (e.g. circumgranular cracks, alveolar-septal structure, small karstic cavities). In several cases, the vadose meteoric diagenetic features overprint the subtidal strata, as well. The discontinuities were formed as the result of subaerial exposure and accompanied by *in situ* early diagenetic/pedogenetic alteration and microkarstification in the host carbonate sediments. Via comparison of the pedogenically altered layers in the sections studied, differences were noticed in the intensity and duration of vadose influence. Pedogenic modification is stronger in the Early Jurassic strata, reflecting a longer emersion period. A possible change from slightly wetter (Late Triassic) to relatively drier (Early Jurassic) likely semi-arid climatic conditions is discussed.

Key-words: *discontinuity surfaces, subaerial exposure, lagoon–tidal flat carbonates, Late Triassic, Early Jurassic, Peloponnesus, Greece.*

ΠΕΡΙΛΗΨΗ: Μελετώνται οι συνδεδεμένες με την υποαέρια έκθεση των ιζημάτων επιφάνειες ασυνέχειας (παλαιοεπιφάνειες ανάδυσης), οι οποίες παρατηρούνται στις μικρού βάθους ανθρακικές αποθέσεις ανωτριαδικής (Πελαγονική ανθρακική πλατφόρμα) και κατωιουρασικής ηλικίας (ανθρακική πλατφόρμα Γαβρόβου-Τρίπολης) που εμφανίζονται στις περιοχές των Διδύμων και του Λεωνιδίου της Πελοποννήσου, αντίστοιχα. Οι ακολουθίες αυτές αντιπροσωπεύουν αποθέσεις της εσωτερικής περιοχής της ανθρακικής πλατφόρμας, παρουσιάζουν κυκλική οργάνωση (περιπαλιρροιακοί-λιμνοθαλάσσιοι κύκλοι/λοφεριτικοί κύκλοι) και χαρακτηρίζονται από την παρουσία αριθμού επιφανειών ασυνέχειας μικρής κλίμακας που σχετίζονται με την ανάδυση και την έκθεση των ιζημάτων στις ατμοσφαιρικές συνθήκες (πεδογενετικές επιφάνειες). Ποικίλοι είναι οι διαγνωστικοί χαρακτήρες πρωιμοδιαγενετικής τροποποίησης των ιζημάτων στη ζώνη αερισμού του μετεωρικού περιβάλλοντος, οι οποίοι αναγνωρίζονται τόσο επί των επιφανειών ασυνέχειας όσο και υποκάτω αυτών (π.χ., συγκεντρικές ρωγματώσεις, δομή τύπου «alveolar-septal», καρστικές μικροκοιλότητες). Σε αρκετές περιπτώσεις, μάλιστα, τα διαγενετικά χαρακτηριστικά ανιχνεύονται και αποτυπώνονται στα υποπαλιρροιακά μέλη. Η γένεση των ασυνεχειών υπήρξε το αποτέλεσμα της έκθεσης στον αέρα των μητρικών-πρωτογενών ιζημάτων, η οποία συνοδεύτηκε από *in situ* φαινόμενα πρώιμης διαγενετικής/πεδογενετικής εξαλλοίωσης και μικροκαρστικοποίησης. Επιπλέον, η σύγκριση των πεδογενετικά τροποποιημένων οριζόντων, οι οποίοι απαντούν στις υπό μελέτη ανθρακικές αποθέσεις, αποκαλύπτει διαφορές που αφορούν στην ένταση και στη διάρκεια της επίδρασης των μετεωρικών διαγενετικών διεργασιών. Ο βαθμός πεδογενετικής εξαλλοίωσης των κατωιουρασικής ηλικίας ιζημάτων είναι υψηλότερος, αντανακλώντας χρονικώς παρατεταμένα επεισόδια ανάδυσης. Τέλος, η μεταβολή των πιθανότατα ημίξηρων κλιματικών συνθηκών από ελαφρά υγρότερες (Ανωτ. Τριαδικό) σε σχετικά ξηρότερες (Κατωτ. Ιουρασικό) δεν μπορεί να αποκλειστεί.

Λέξεις-κλειδιά: *επιφάνειες ασυνέχειας/ανάδυσης, υποαέρια έκθεση, περιπαλιρροιακά-λιμνοθαλάσσια ανθρακικά ιζήματα, Ανωτ. Τριαδικό, Κατωτ. Ιουρασικό, Πελοπόννησος, Ελλάδα.*

INTRODUCTION

All surfaces indicating non-deposition events of variable duration in the stratigraphic record are generally considered as *discontinuity surfaces* (hiatus). Discontinuities are attributed to sharp environmental changes and are distinguished in various types (e.g. unconformity, omission surface, firmground, hardground, palaeosol, erosion surface) (e.g. Bromley, 1975; Fürsich, 1979; Clari *et al.,* 1995; Hillgärtner, 1998; Sattler *et al*., 2005).

Discontinuity surfaces occurring in shallow marine carbonate platform successions of cyclic/rhythmic organization and generated by periodical subaerial exposure, triggered by autocyclic or allocyclic forcing mechanisms are classified as intraformational palaeosols (Mindszenty, 2004). In shallow marine carbonate settings, the recognition of major or lower order intraformational discontinuities is of great importance. They indicate rapid and abrupt environmental changes, reflect emersion periods of long or shorter duration and may record climatic variations. Discontinuity surfaces may be traced laterally for short or long distances; they are interpreted as sequence boundary surfaces related to intervals of

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lowered sea-level and provide useful and informative tools for sequence stratigraphy and cyclostratigraphy (e.g. Wright, 1994; Grötsch,1996; D' Argenio *et al*., 1997; Hillgärtner, 1998; Strasser *et al*., 1999).

This work concerns the description and interpretation of the small-scale intraformational discontinuities, which were studied in two shallow marine carbonate successions exposed in Peloponnesus (i.e. Late Triassic Dhidymi section, Pelagonian carbonate platform, Argolis Peninsula and Early Jurassic Fokianos section, Gavrovo-Tripolitza zone, SE of Leonidion). The characteristics of the discontinuity surfaces are documented and the processes responsible for their formation are discussed, in the present paper.

GEOLOGICAL AND PALAEOGEOGRAPHIC SETTING

Cyclically organized carbonate platform successions (dolomites, dolomitic limestones, limestones) of Late Triassic age are exposed in the Dhidymi section, located in the SW part of Argolis Peninsula and of Early Jurassic age exposed in the Fokianos section, located in the coastal area of SE part of Peloponnesus (Fig. 1). Both formations are made up of Lofer-type cycles. Geotectonically, the two Peloponnesian outcrops belong to the Pelagonian (including Subpelagonian) zone of the Internal Hellenides and the Gavrovo-Tripolitza zone of the External Hellenides, respectively. Palaeogeographically, they represent two distinct carbonate platforms of the Hellenides, which were separated by a deep-water basin and constituted a segment of the Mesozoic southern Tethyan passive margin. During Late Triassic and Early Jurassic, these two domains were characterized by the development of wide neritic carbonate platforms, i.e. the Pelagonian and Gavrovo-Tripolitza platforms, located east and west of the Pindos Basin, respectively.

In the Dhidymi section (5.5 Km E of Dhidyma village) Upper Triassic (Carnian-Norian) peritidal carbonates (Lofer-type carbonates) are exposed in a thickness of 70 m (Fig. 3). It represents a part of the thick Upper Triassic–Lower Jurassic "Pantokrator facies" ("Pantokratorkalk") that constitutes the largest part of the Argolis Peninsula (Baumgartner, 1985; Gaitanakis *et al.*, 2007). These facies are also well-exposed in the Iria and Dhidymi area of the SW Argolis (e.g. Schäfer & Senowbari-Daryan, 1982; Vartis-Matarangas & Matarangas, 1991; Turnsek & Senowbari-Daryan, 1994; Matarangas *et al*., 1995). The Argolis Peninsula considered part of the Pelagonian zone and its geological structure and formations have been investigated by several authors (e.g. Süsskoch, 1967; Bachmann & Risch, 1979; Vrielynck, 1978; Baumgartner, 1985; Photiades, 1986; Bortolotti *et al*., 2003).

The Fokianos section (13 Km SE of Leonidion) exposes Lower-Middle Liassic Lofer cyclic carbonates in a thickness of 30m (Fig. 4). It forms a part of the thick Triassic-Jurassic shallow water carbonates that belong to the Gavrovo-Tripolitza zone and are exposed along the coastal area of the central-eastern Peloponnesus. Lofer cyclic Upper Triassic carbonates of the Gavrovo-Tripolitza platform have been recognized first in Peloponnesus by Kalpakis & Lekkas (1982). Furthermore, Pomoni-Papaioannou *et al*. (1986) described Upper Triassic Lofer cyclothems in the Olympus unit, which is considered as part of the Gavrovo-Tripolitza platform (Fleury & Godfriaux, 1974).

The Gavrovo-Tripolitza zone is made up of Upper Triassic to Upper Eocene thick neritic carbonate successions deposited in warm, shallow tropical seas, and Upper Eocene siliciclastic flysch (e.g. Fleury, 1980; Zambetakis-Lekkas & Alexopoulos, 2007). The "Tyros Beds" (Ktenas, 1924) (a Late Palaeozoic-Triassic volcano-sedimentary sequence) underlain the Gavrovo-Tripolitza zone in Peloponnesus and considered to be its original basement (Thiebault, 1982). The Gavrovo-Tripolitza platform began to develop in the early Late Triassic and persisted throughout the rest of the Mesozoic, on the passive continental margin of the Southern Tethys. It is considered as a Bahamian-type platform and its evolution during the Mesozoic was quite similar to that of other carbonate platforms in the peri-Adriatic belt (D'Argenio, 1974; Channell *et al*., 1979; Vlahovich, 2005).

SEDIMENTOLOGY

Facies analysis and interpretation overview

Earlier microfacies studies of the Upper Triassic carbonates formed at the passive Pelagonian margin (Dhidymi section) and of the Lower-Middle Liassic successions of the Gavrovo-Tripolitza zone (Fokianos section) resulted in recognition of a number of depositional and diagenetic microfacies (Pomoni-Papaioannou, 2008; Pomoni-Papaioannou & Kostopoulou, 2008; Pomoni-Papaioannou, 2009; Photiades *et al*., 2010). They can be classed into three major groups/associations; shallow subtidal-lagoonal, peritidal (inter/supratidal) and subaerial exposure/pedogenic deposits (Fig. 2; Table 1).

In both sites, the recognized facies associations indicate an internal platform–tidal flat depositional system. Moreover, these deposits are arranged into meter-scale, mostly shallowing-upwards lagoonal–peritidal cycles (lofer cycles). The top of the cycles (truncated in many cases) may commonly subject to vadose and pedogenic alteration related to periodical subaerial exposure events.

Summarizing, sedimentological and microfacies analysis revealed that the Upper Triassic and Lower Jurassic carbonates studied, although they were accumulated in two separate and independent palaeogeographic domains of the Hellenides, have been deposited under generally similar, but regularly changing, environmental conditions. The variety of the defined microfacies allowed the identification of large internal platform areas lagoon–tidal flat systems developed during the Late Triassic and Early Jurassic in the Pelagonian and Gavrovo-Tripolitza units, respectively. These depositional settings are comparable with the Dachstein-type platforms recognized in different areas along the Late Triassic

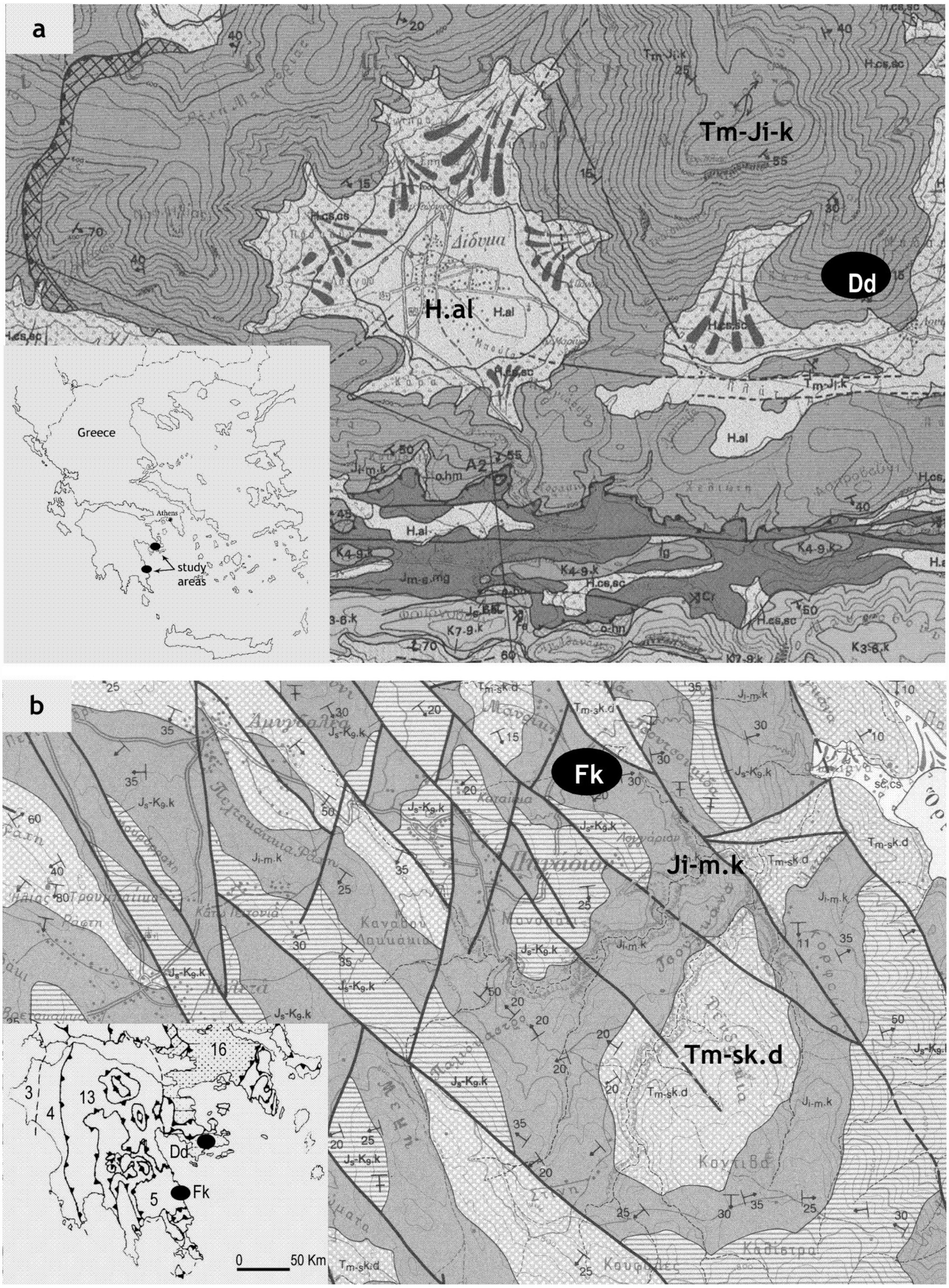


Fig. 1. **(a)** Dhidymi section (Dd); geological map showing the study area and its location (●). “Spetses-Spetsopoula Sheet” 1:50.000 (Gaitanakis *et al*., 2007). Inset map: Geographic setting of the studied areas (●); **(b)** Fokianos section (Fk); geological map showing the study area and its location (●). “Leonidion Sheet” 1:50.000 (Dimadis *et al*., 1978). Inset map: Map of the central-southern Greece showing the studied areas (●) and their setting within the geotectonic zone framework of the Hellenides (after Papanikolaou, 1986); Key: 3= Ionian zone; 4=Gavrovo zone; 5=Tripolitza zone; 13=Pindos zone; 16=Eastern Greece, Subpelagonian, Cycladic; Tm-Ji-k=M. Triassic-Lias; H.al=Alluvial deposits; Tm.sk.d=M.-U. Triassic; Ji-m.k=E.-M. Jurassic.

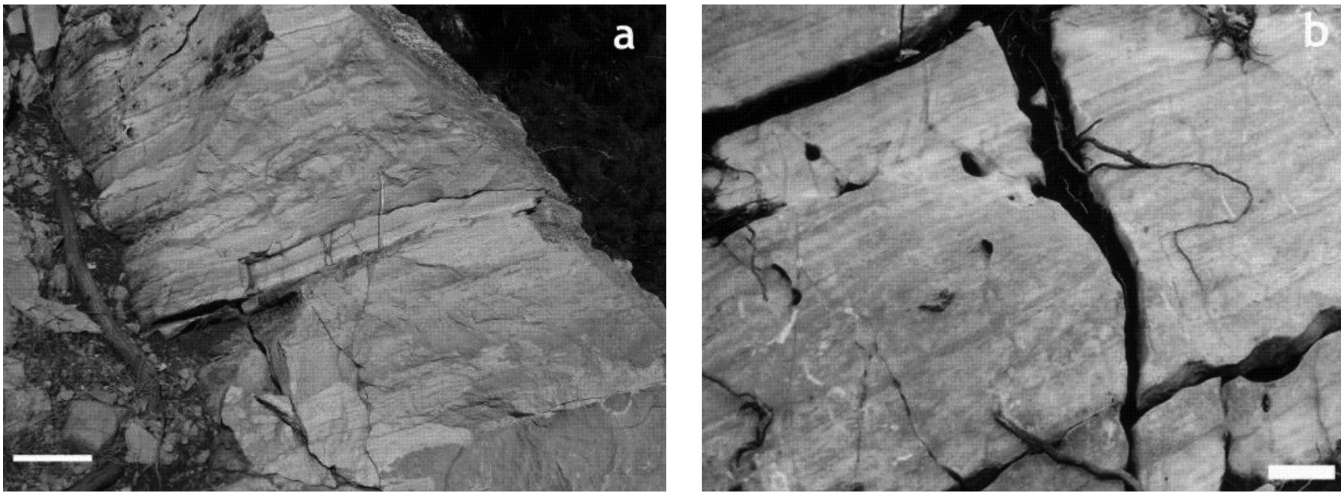


Fig. 2. Outcrop photos. **a** Subtidal beds with Megalodonts and overlying loferitic horizons (Dhidymi area). **b** Microbial laminite (stromatolite) (Fokianos area).

Tethys (e.g. Fischer, 1964; Bosellini & Hardie, 1985; Haas, 1982, 1991, 2004; Haas *et al*., 2007, 2009a, 2009b) and with the platform and tidal–flat recent deposits of Andros Island (Bahamas) and Florida Bay (e.g. Hardie & Shinn, 1986).

Sedimentary discontinuities: characteristic microfeatures and interpretation

The studied successions are usually interbedded by thin horizons. Petrographic features of these horizons point to changes and interruptions in sedimentation (Table 2).

Micromorphology — In thin section, these interbeds are characterized by an association of microfacies showing laminar-fenestral and microbrecciated peloidal-nodular fabric.

The laminar layers display a microfabric showing alternations either of dark micrite and light sparite laminae or of dense black micritic fine laminae and contain relatively large abundant voids/fenestrae of irregular shape (Figs 5d, 6c). The cavities are usually aligned parallel with the laminae and are generally filled by sparite or they have geopetal fill (Fig. 5c). In places, irregular, ovoid or tubular pores surrounded by vague concentric micritic microlaminations and separated by a network of micritic walls, i.e. alveolar-septal structure, occur as well (Fig. 6b). Microbrecciation of laminae is common, related to dissolution (microkarst phenomena) and cracking (by repeated wetting and drying events) processes producing intraclasts and a peloidal fabric. The angular micritic intraclasts and rounded peloids without internal structure show locally reverse grading. Moreover, single micritic coating around some sediment grains are common and also meniscus-type cement occur among some grains, locally. The coatings often exhibit irregularities and protuberances. In some cases, micritic filaments bound the grains (Fig. 5a).

An inhomogeneous micritic/microsparitic matrix with a peculiar microfabric reflecting *in-situ* brecciation, fracturing and micronodule formation is characteristic in the microbrecciated peloidal-nodular layers. The partial or complete development of spar-filled irregular and curved fractures and circumgranular cracks separated small areas of the groundmass resulting in the formation of rounded peloidal and nodular structures (Figs 5b, 6a, d). The micronodules/glaebules do not show an internal concentric structure as a rule and they have diffuse (orthic) or more distinct (disorthic) boundaries. However, some glaebules of irregular shaped are composed of a nucleus and poorly laminated coatings. They resemble vadose pisoids displaying only weakly developed concentric layering. In places, the glaebules are accompanied by features indicating presence of roots of plants such as Microcodium-like structures and large spar-filled globular to elongate voids that may correspond to former root paths enlarged by dissolution (Fig. 6d). Some small angular black clasts are, rarely, observed.

Interpretation — The laminated-fenestral facies resemble laminar crusts of microbial origin formed in vadose diagenetic environment (Khale, 1977; Wright *et al*., 1988) and the recognized alveolar-septal structures associated with some ovoid or tubular pores were formed via plant root-related activity (Adams, 1980; Wright, 1986; Goldstein, 1988). Moreover, there are grains with irregular micritic coating which are similar to those of microbially coated *sensu* Wright (1986). The existence of spherical to irregular glaebules/micronodules with an undifferentiated or poorly concentric structure is indicative of pedogenesis. Glaebules formation is attributed to edaphic processes (e.g. vadose dissolution, shrinkage-dessication and circumgranular cracking) or their origin may be biogenic (associated with root systems) (Esteban & Klappa, 1983; Alonso-Zarza, 2003). *In situ* microbrecciation and formation of large-sized irregular fenestrae filled with geopetal crystal silt and meniscus-like cement are common features associated with vadose meteoric early diagenetic conditions (subaerial weathering, cracking, dissolution and cementation) reflecting subaerial exposure (Esteban & Klappa, 1983; Wright & Tucker, 1991).

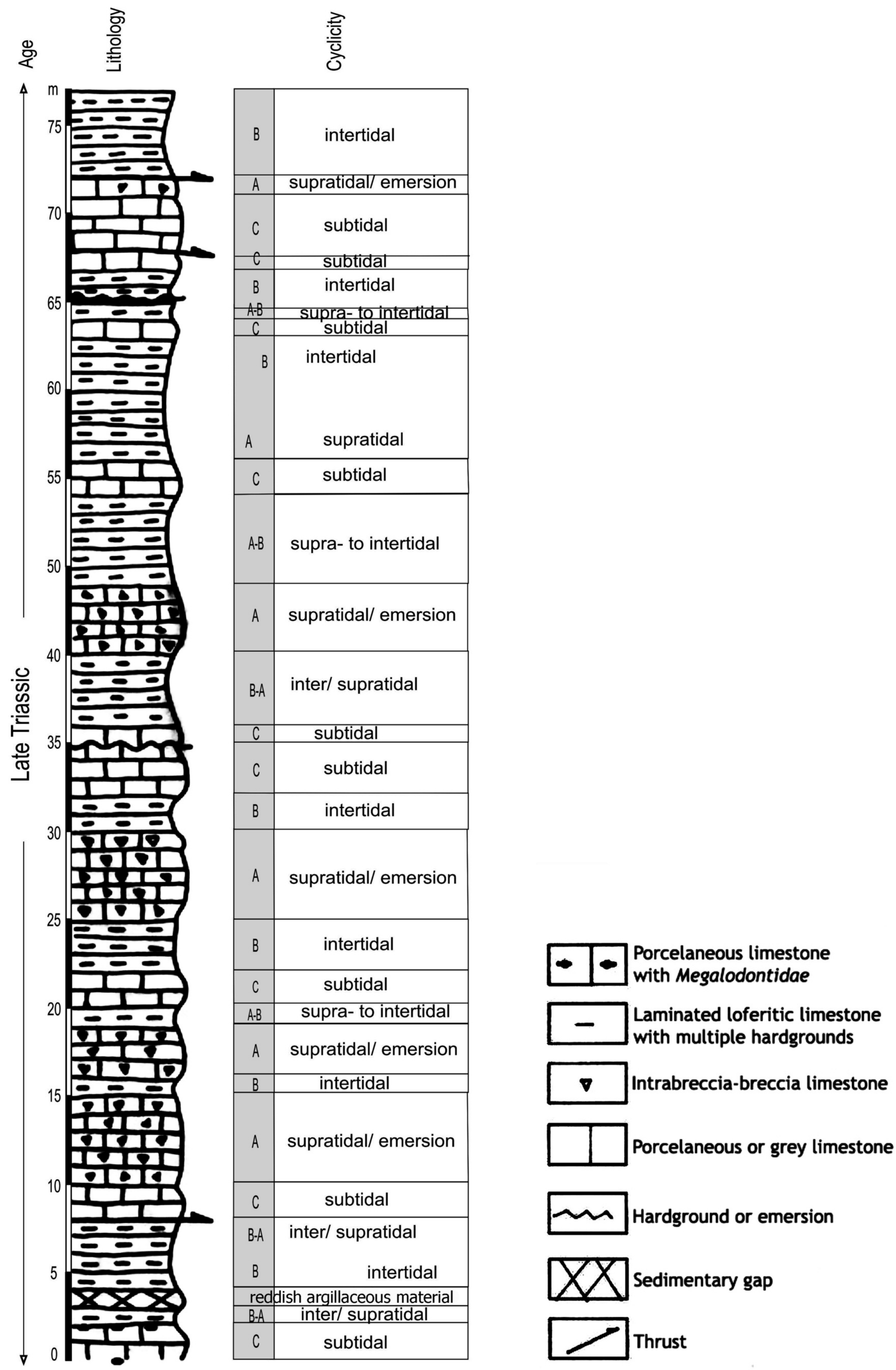
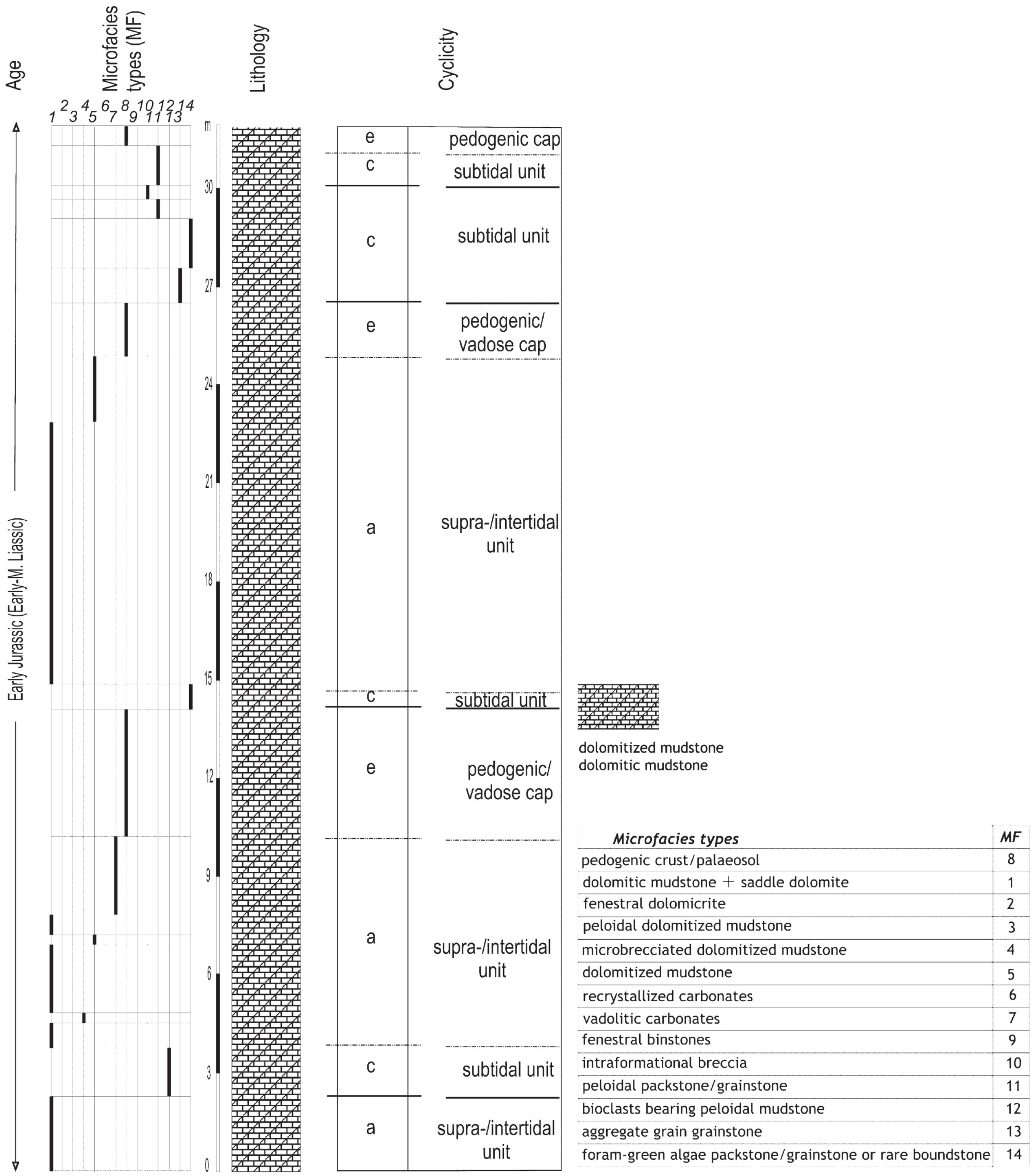


Fig. 3 Dhidymi section.

DISCUSSION

Origin of discontinuities — The observed laminated-fenestral and brecciated nodular layers are interpreted as pedogenic in origin and represent exposure-related surfaces (small-scale discontinuity surfaces/ intraformational palaeosols). It is confirmed by various features preserved in these facies which are indicative and/or diagnostic of meteoric early diagenetic conditions (e.g. circumgranular cracks, glaebules, alveolar-septal structure) related to subaerial exposure, subsequent by weathering and pedogenic alteration (ESTEBAN & KLAPPA, 1983; JAMES & CHOQUETTE, 1990; WRIGHT & TUCKER, 1991; ALONSO-ZARZA, 2003). Such features are characteristics of soils and have been documented and described by several au-



Microfacies types	MF
pedogenic crust/palaeosol	8
dolomitic mudstone + saddle dolomite	1
fenestral dolomicrite	2
peloidal dolomitized mudstone	3
microbrecciated dolomitized mudstone	4
dolomitized mudstone	5
recrystallized carbonates	6
vadolitic carbonates	7
fenestral binstones	9
intraformational breccia	10
peloidal packstone/grainstone	11
bioclasts bearing peloidal mudstone	12
aggregate grain grainstone	13
foram-green algae packstone/grainstone or rare boundstone	14

Fig. 4 Microfacies interpretation and sedimentary cycles of the Fokianos section.

TABLE 1
Summary of microfacies associations defined in the studied platform carbonates and environmental interpretations.

Section	***Dhidymi (Late Triassic)***		
Microfacies associations	bio-peloidal & foram-algal carbonates (C): dolomitic limestones with Megalodonts, calcareous algae and benthic forams, peloidal dolostone	fenestral, laminar carbonates (B): fenestral dolomitic mudstone, dolomitic stromatolite mudstone	pedogenically altered carbonates (A): pisoidic dolomite, terrestrial stromatolite/ laminar dolocretes, "soil conglomerates"
Environment	*shallow subtidal-lagoonal*	*tidal-flat*	*subaerial*
Section	***Fokianos (Early Jurassic)***		
Microfacies associations	bio-peloidal & foram-algal carbonates (C): foram-green algae pack/ grainstone, peloidal mudstone	fenestral & homogeneous unfossiliferous carbonates (B): fenestral bindstone, dolomitic mudstone, saddle dolomite, vadoids	pedogenically altered carbonates (A): pedogenic crust (glaebular, laminated fabrics, pisoids, root-like structures)
Environment	*shallow subtidal-lagoonal*	*tidal-flat*	*subaerial*

TABLE 2
Summary of characteristic subaerial-related microfeatures observed in the studied platform carbonates.

Pedogenic processes and microfeatures	**Dhidymi (Late Triassic)**	**Fokianos (Early Jurassic)**
Laminated -fenestral fabric		
Peloidal fabric		
Microkarsification (small karstic cavities)		
Cracking (circumgranular cracks, irregular cracks)		
Micronodulization (glaebules, incipient pisoids)		
Meniscus-type cement		
Geopetal internal sediment		
Irregular micritic grain coatings		
Root activity (alveolar-septal structure, root voids)		
Microccodium-like structures		
In situ microbrecciation		

thors in recent and ancient carbonate strata from various localities (e.g. James, 1972; Harrison & Steinen, 1978; Wright, 1982; Pomoni-Papaioannou & Dornsiepen, 1987; Pomoni-Papaioannou & Galeos, 1989; Klappa, 1980; Esteban, 1976; Goldstein, 1988).

Overall, the significant meteoric features recorded in the studied pedogenic horizons support that these facies are formed via diagenetic alteration and microkarstification of the host/primary carbonate sediments (tidal–flat deposits) in meteoric vadose environment during subaerial exposure events. The presence of fossil root-related structures suggests the contribution of the terrestrial vegetation in the pedogenesis.

However, no evidence of mature pedogenic alteration or development of distinct soil horizons were observed in these sedimentary strata, reflecting short-term subaerial exposure intervals (intermittent/ephemeral subaerial exposure) and only incipient palaeosol formation (Hillgärtner, 1998). However, the alveolar-septal structures recognized in both studied sections, support prolonged phases of subaerial exposure to terrestrial conditions (long-term/terrestrial subaerial exposure) (Esteban & Klappa, 1983; Sattler *et al.*, 2005). Furthermore, the pedogenically altered layers in the Lower Jurassic carbonates compared to the Upper Triassic ones appear to be better-evolved. It suggests that the subaerial exposure period was longer in the Early Jurassic sediments since time and degree of palaeosol maturity are considered to be directly linked (Wright, 1994; Mindszenty, 2004).

As mentioned earlier, the facies associations forming the studied carbonates (subtidal-lagoonal, inter-supratidal and meteoric diagenetic/pedogenetic facies) indicate that they were deposited in a very shallow marine environment which was periodically interrupted by subaerial exposure episodes (restricted platform–tidal flat system). They are cyclically arranged into meter-scale peritidal-lagoonal cycles (lofer cycles). The uppermost part of the cycles often exhibit signs of pedogenesis. Features of vadose meteoric diagenetic overprint also occur in subtidal deposits, supporting that the recognized intraformational discontinuities and related pedogenic alteration phenomena (palaeosols and microkarsts) may have been the result of relative sea-level drops (allocyclic forcing), which induced emersion of large parts of the carbonate platform (Strasser, 1991; Wright, 1994).

Palaeoclimatic indications — Various microfeatures of pedogenesis preserved in these platform deposits are related to physical, chemical and biological processes which were influenced by the climatic conditions. The microfabrics (e.g. nodules, root-related structures) of the better-evolved pedogenic layers associated with the Early Jurassic strata suggest relatively arid settings. In contrast, the vadose diagenetic features (e.g. pervasive dissolution, co-occurrence of pedogenic and microkarst features) detected in the Late Triassic car-

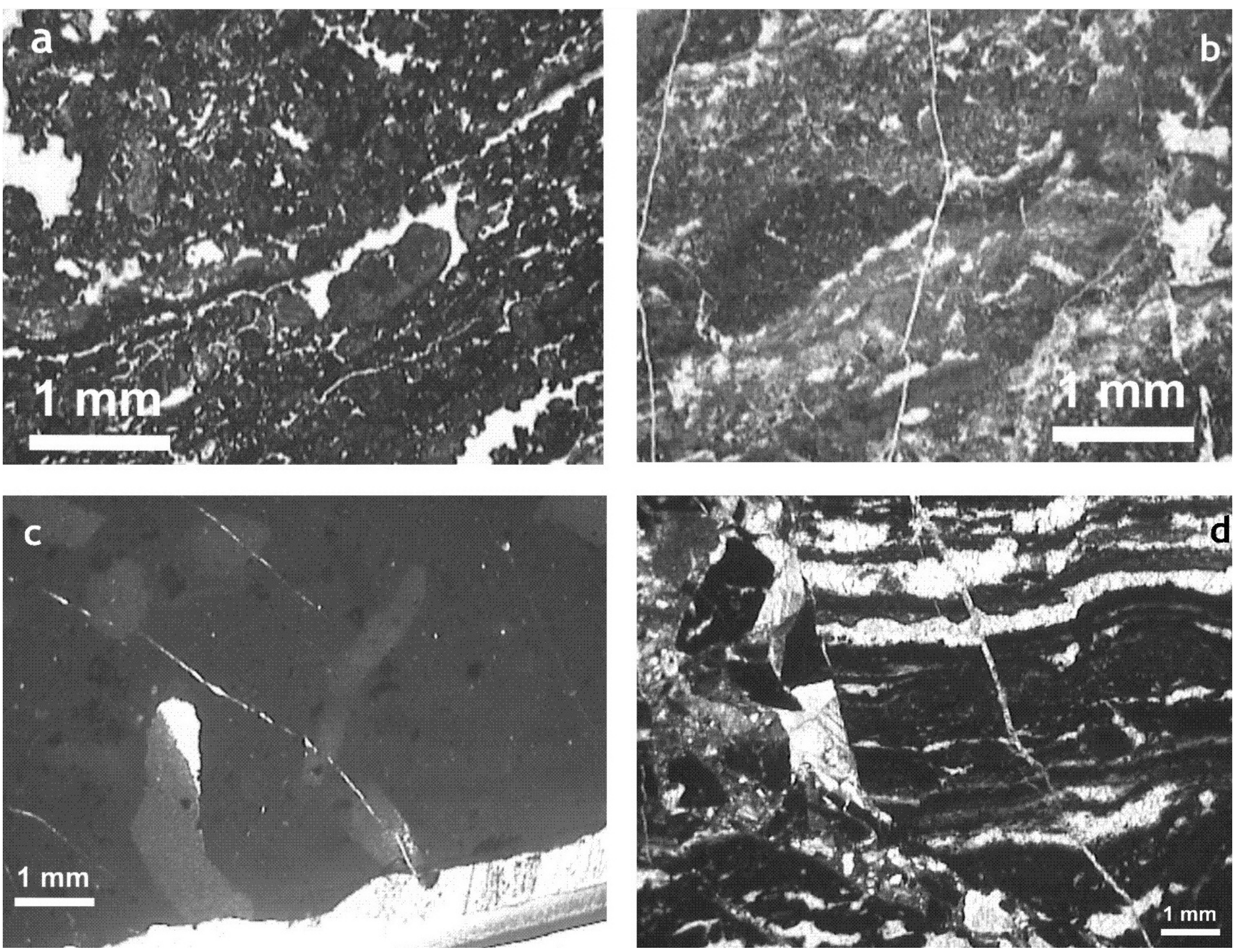


Fig. 5. Subaerial exposure-related carbonate microfacies (Late Triassic, Dhidymi section). **a** Dolocrete crust showing micritic grain coatings. Circumgranular cracking. **b** Incipient glaebules in a micritic/microsparitic graoundmass. Circumgranular cracks. **c** Solution cavities probably root-casts filled with sediment of vadose origin in reddish mudstone. **d** Laminar calcrete with alternated irregular and wavy micritic and sparite laminae. *In-situ* brecciation.

bonates are indicators of less dry conditions. In general terms, calcrete fabrics (e.g. vadose pisoids, laminar features, rhizoliths) developed under semi-arid to arid climatic conditions, while palaeokarstic surfaces (e.g. evidences of extensive dissolution, iron minerals) formed under humid-seasonal and humid regimes (ESTEBAN & KLAPPA, 1983; JAMES & CHOQUETTE, 1990; JIMÉNEZ DE CISNEROS *et al*., 1993; WRIGHT, 1994).

Taking into consideration the above discussed phenomena, although there are no conclusive evidences of the climatic signature, a palaeoclimate trend is traceable i.e. a change from the semi-humid climate in the Late Triassic to the relatively drier (probably semi-arid) one in the Early Jurassic.

CONCLUSIONS

- Results of investigation of cyclically organized peritidal carbonate successions (Lofer-type carbonates) of Late Triassic (Pelagonian carbonate platform) and Early Jurassic age (Gavrovo-Tripolitza carbonate platform) in Peloponnesus are discussed in this study. The studied successions contain a number of small-scale discontinuity surfaces, which recorded several typical vadose diagenetic features (e.g. circumgranular cracks, alveolar-septal structure, meniscus cement, small-size karstic cavities).
- The recognized subaerial exposure-related sedimentary discontinuities are accompanied by *in situ* early diagenetic/pedogenetic alteration and microkarstification of the host carbonate sediments under meteoric vadose diagenetic conditions during periodic subaerial exposure events.
- The pedogenetic horizons/emersion surfaces represent often the end members of the lagoonal-peritidal shallowing-upwards cycles. In some cases, the vadose features also overprint subtidal deposits, suggesting sea-level control.
- Based on comparison of the pedogenically altered lay-

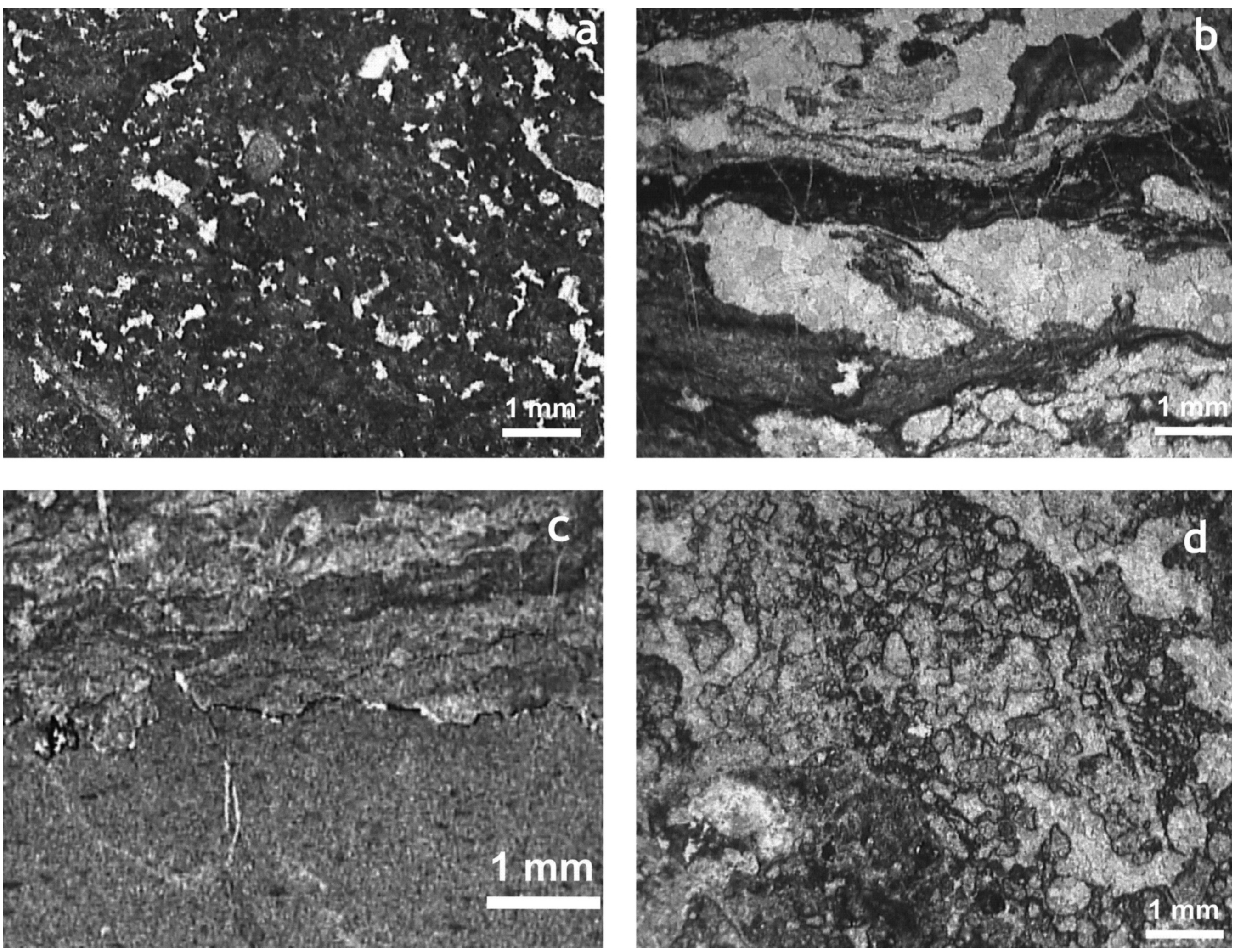


Fig. 6. Subaerial exposure-related carbonate microfacies (Early Jurassic, Fokianos section). **a** Pelleted fabric with spar-filled circumgranular cracks enlarged by vadose dissolution. **b** Microlaminar micritic coatings around spar-filled sub-cylindrical pores interpreted as former root voids. **c** Pedogenic laminar layer made up of alternating micritic (dark) and microsparitic (lighter) undulating laminae. **d** Composite nodule made up of microsparitic peloids with micritic coating. It is surrounded by large elongated cavities infilled with sparite and resembling root structures.

ers in the sections studied, differences in the intensity and duration of meteoric influence have been interpreted. The grade of pedogenic modification and palaeosol maturation is stronger in the altered horizons associated with the Early Jurassic strata, witnessing longer subaerial exposure/emersion periods. In contrast, the Late Triassic sediments were less intensely affected by early meteoric diagenesis suggesting that they experienced only ephemeral/short emersions.

- The various carbonate pedo-features preserved in the studied platform deposits suggest climatic control, as well. The studied Late Triassic and Early Jurassic carbonates were deposited in a semi-arid to semi-humid environment. A change from slightly wetter (Late Triassic) to relatively drier (Early Jurassic) semi-arid climatic conditions can be assumed.

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