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Early Cretaceous dendritic shrub-like fabric in karstified peritidal carbonates from southern Italy

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ABSTRACT

Lower Cretaceous (Valanginian) dendritic microfabrics occur in karstic cavities within fine-grained shallow-marine platform carbonates at San Lorenzello, southern Italy. They form dense micritic masses and clusters, generally oriented perpendicularly to cavity surfaces, surrounded by layered sparry cement. Individual dendrites, typically sub-millimetric in size, have highly irregular margins and form distinctive shrub-like masses ranging from compact and squat, to elongate and highly branched. The centimetric and irregularly elongate cavities appear to have formed through subaerial exposure, and are almost entirely filled by the micritic dendrites and associated sparry crusts. In size, shape and micritic composition, the dendrites broadly resemble a variety of similar fabrics, including hot spring travertine shrubs and calcified microfossils such as Cambrian *Angusticellularia*, which has analogs in present-day lacustrine calcified cyanobacteria. However, the San Lorenzello dendrites differ in occupying small cavities. This cryptic microkarstic dripstone setting, together with the often regular spacing and appearance of these dendritic fabrics, may be more consistent with an abiotic origin. These comparisons underscore the challenge of interpreting microdendritic carbonates fabrics in general.

1. Introduction

A wide variety of small calcified dendritic structures occur in the geological record of marine and continental carbonates. Some are organic in origin, and include calcimicrobes, commonly regarded as algae or cyanobacteria, that are abundant in Cambrian and Late Devonian reefs (Pratt, 1984; Riding and Voronova, 1985; Riding, 1991a). Others are almost certainly abiotic, such as crystal shrubs in hot spring travertine deposits (Pentecost, 1990; Chafetz and Guidry, 1999; Gandin and Capezzuoli, 2014). But there are many examples whose origins are less clear. Carbonate shrubs have been described from the lower member of the Noonday Dolomite, Neoproterozoic in age (Death Valley region, USA, Fraiser and Corsetti, 2003) as well as in ambient water Eocene lacustrine carbonates of the Green River formation (Wyoming, USA; Seard et al., 2013). At the present day, carbonate shrubs occur in hot water travertine deposits (e.g. Chafetz and Guidry, 1999; Della Porta, 2015; Erthal et al., 2017) and in ambient temperature travertine systems (e.g. Anzalone et al., 2007; Golubić et al., 2008; Seard et al., 2013). The difficulty of interpreting shrub-like structures with irregular dendritic arrangement and crystalline or micritic fabrics arises from their morphological simplicity and wide distribution. Depositional environment would seem to be a useful guide to whether these fabrics are biotic or abiotic. For example, dendritic fabrics in marine reefs and freshwater creeks could be more likely to be organic than similar fabrics in hot spring deposits. However, microbial carbonates can form in all these environments, and some hot spring travertine shrubs have long been interpreted as bacterial in origin (Chafetz and Folk, 1984; Koban and Schweigert, 1993; Cook and Chafetz, 2017). As a result, there are numerous examples of carbonate dendrites whose origins remain uncertain (Jones and Renaut, 1995, 2010; Erthal et al., 2017) and which, in a further complication, may have been produced by a combination of biotic and abiotic processes (Guo and Riding, 1994; Jones and Kahle, 1995). Most ancient examples of carbonate shrub fabrics have been described from Paleozoic marine environments, whereas most present-day examples occur in hot spring travertines. Here we describe Early Cretaceous dendritic fabrics that occur in peritidal limestones that appear to have been influenced by karstification during subaerial exposure. These examples can be compared in shape and size to a wide variety of fossil and extant shrub fabrics but are unusual due to their age, cryptic dripstone environmental setting, and complex diagenetic history.

2. Geological and stratigraphic settings

The dendritic fabrics described here occur in Valanginian limestones at San Lorenzello, in a well-exposed section of the thick Early Cretaceous shallow water carbonate succession that is widespread in the southern Apennines, Italy. The section is located on the south-eastern slope of the

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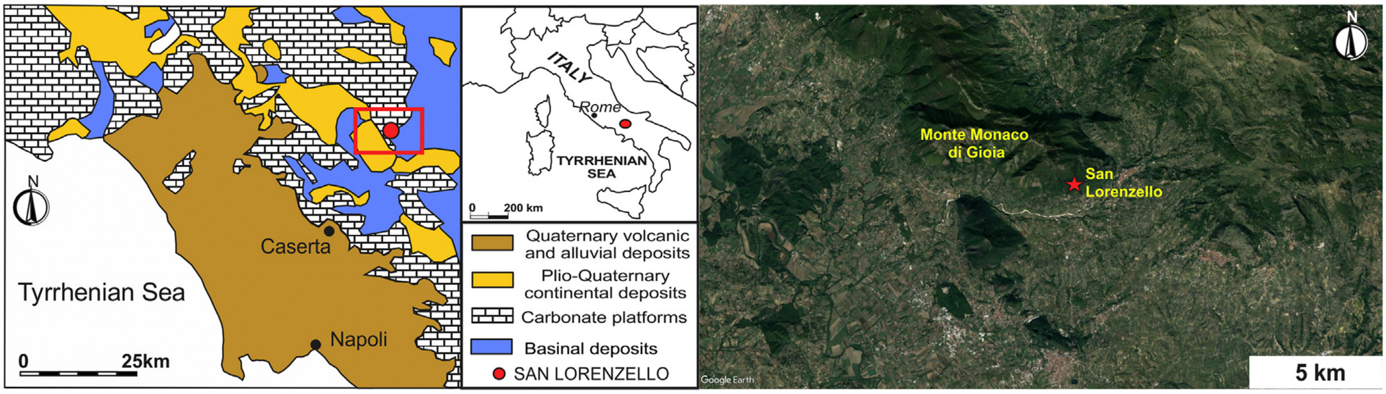

Fig. 1. Geological setting and location of the San Lorenzello section. (For interpretation of the references to color in this figure, see the web version of this article.)

Monte Monaco di Gioia (Matese Mountains, Campania), 70 km north of Naples (Fig. 1, Amodio, 2006; Amodio et al., 2008a, b), along the road from San Lorenzello to the viewpoint of Colle la Sella-La Pizzuta. Monte Monaco di Gioia is part of the Southern Apennine N-E verging fold and thrust belt, produced by Apulian–Ionian composite plate migration (Malinverno and Ryan, 1986; Patacca and Scandone, 2007; D'Argenio et al., 2011) during Africa–Europe collision. This deformation history started with late Triassic–Liassic rifting, which fragmented a tropical intracratonic carbonate platform into a number of carbonate platforms and basins (Mostardini and Merlini, 1986; Patacca and Scandone, 2007). These paleogeographic domains were part of Adria (also called Apulia) on the continental margin to the south of the Alpine Tethys Ocean (Fig. 1). During the Late Cretaceous, they were progressively incorporated into the Alpine–Apennine–Dinaric orogenic system by collision of the Euro-Asiatic and Afro-Adriatic continental margins (Malinverno and Ryan, 1986; Shiner et al., 2004; Vitale and Ciarcia, 2013). Current paleogeographic reconstructions infer two large carbonate platforms, the Apennine platform to the west and the Apulia platform to the east, separated by the Lagonegro Basin (Mostardini and Merlini, 1986; Vitale and Ciarcia, 2013). In this context, the San Lorenzello section is part of the Apennine platform.

The San Lorenzello section is about 86 m thick and Late Valanginian-Early Hauterivian in age. In the last two decades, detailed studies of the biostratigraphy, sedimentology, cyclostratigraphy and sequence-stratigraphy (D'Argenio et al., 1997; Ferreri et al., 2004; Amodio, 2006) have been carried out (Fig. 2). The section consists of well-bedded gray limestones and whitish to gray dolomitic limestones (wackestones, packstones) with benthic foraminifers, green algae and molluscs (subtidal deposits). Mudstone and loferitic mudstone-wackestone (peritidal deposits) horizons are subordinate. High-energy deposits of intraclasts and bioclasts with erosional bases locally form episodic intercalations (tempestites). A hierarchy of shallowing-upward cycles (elementary cycles, bundles, superbundles), which can be linked to orbital oscillations, shows a good fit with the Valanginian-Hauterivian time scale (Ferreri et al., 2004). Bulk carbonate carbon-isotope values of a high-resolution curve also show a similar response to original climate-ocean forcing (Amodio et al., 2008a, b). C-isotope correlation of these data with coeval curves from the hemipelagic La Charce (Vocontian Basin, France) and pelagic Capriolo (southern Alps, northern Italy) sections assists recognition of the Valanginian-Hauterivian boundary at San Lorenzello, about 50 m from the base of the section (Amodio et al., 2008a, b).

3. Methods

Re-sampling of the San Lorenzello section for micropaleontological and biostratigraphical analyses revealed a 30 cm-thick horizon containing dendritic fabric, 37 m above the base of the section in the uppermost Valanginian (see red star in Fig. 2). Detailed stratigraphic description and facies analysis in the field, using a 10× hand lens, was integrated with examination of 15 thin sections and about 10 polished slabs, using standard petrographic techniques to recognize textures, grains (skeletal, non-skeletal), and sedimentary and diagenetic structures. Additional thin-section studies were made to elucidate cement types and their sequence of development to characterize the cavity-fillings deposits in which the dendrites occur.

4. Carbonate dendritic facies and its environmental interpretation

The carbonate dendritic structures have been recognized within a single horizon, about 30 cm thick. They occur sporadically at a level near the top of elementary cycle 41 (Fig. 3, see Amodio, 2006; Amodio et al., 2008b). Based on previous biostratigraphic studies, the age of these deposits is Late Valanginian (about 135 Ma).

The carbonates at this horizon are wackestone and wackestone-packstone with miliolids, textularids, and ostracods. Less common *Hedstroemia*-group, nerineid gastropod, bivalve, and dasycladalean (*Salpingoporella annulata*) fossils also occur. Peloids are very abundant in the matrix. The overall biotic associations of these deposits are typical of marginal-marine environments, consistent with innermost shallow lagoon and ephemeral tidal/supratidal settings. In previous studies, this lithofacies was codified “MO2” and included in the “Mili-Ostracod limestones” lithofacies association (Fig. 2, see also Tab. 1, p. 56, in Amodio, 2006).

The dendritic fabric occurs within fenestral cavities (Fig. 4) in the upper part of a weakly laminated horizon. The fenestrae are roughly concordant with the stratification and include irregularly distributed keystone vug and birdseye structures. These cavities appear to have been variously formed by desiccation, gas bubbles, burrows and soft sediment deformation. The internal sediment of the cavities is commonly fine grained (micrite, or laminated silt), and locally contains ostracods and peloids (Fig. 5a). The fenestral cavities are millimeter to centimeter in size, and appear to have been irregularly enlarged by meteoric waters during emersion of the platform. Lowering of the sea level, even by just a few meters, produced a subaerial discontinuity. The lithified surface created by early cementation shows borings and discoloration (Fig. 5b, Amodio, 2006). Evidence of meteoric-vadose diagenesis and karstic features immediately below this surface extends downwards for several tens of centimeters. We observed no signs of pedogenesis, but pervasive dissolution indicated by karstic cavities with geopetal crystal silts and botryoidal cements is evident (see Section 6).

5. Description of carbonate dendritic fabric

The dendritic structures have only been observed within microkarstic cavities and typically occur within botryoidal cements (Fig. 5c–f). Individual San Lorenzello dendrites are typically densely micritic sub-millimetric masses (typically 50–300 μm in size) with distinct highly irregular margins. They show distal elongation and