FOSSIL RECORD OF MICROENDOLITHS IN LIVING CORAL SKELETONS

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Polyps of reef-building corals appear to exist in dynamic equilibrum with (1) zooxanthellae residenting in polyp's endoderm, (2) endolithic algae, and (3) endolithic fungi penetrating coral skeletons. Most attention has been paid on coral-zooxanthellae interactions; much less is known about endolithic algae and fungi in the coral skeleton. The fossil record has not been yet a subject of detailed studies.

In contrast of cyanobacteria and algae, which attack dead corals, those inhabiting skeletons of living corals, are less diversified and consits of specialized, oligophotic forms (mostly siphonal chlorophyte *Ostreobium queketti*), which are able to keep up with vertical skeletal accretion. For endolithic algae coral skeletons are convenient shelter, sufficently illuminated and protected by coral polyp. Endolithic algae have been considered neutral or even beneficial to coral.

Fungal endoliths have been considered potentially pathogenic and are often associated with coral diseases. Organic products with coral skeleton can serve as food for fungi. Fungal hyphae attack algal filaments (Fig. 1; Golubic *et al*., 2005) as well as polyps. Coral deposit skeletal cone structures as response to penetration of fungal hyphae (Fig. 2; Golubic *et al*., 2005).

Fine and Loya (2002) suggest that endolithic algae can be considered as beneficial to coral as possible factor contributing to survival during coral bleaching event providing an alternative source of energy.

Recent studies indicate that endolithic fungi and algae are almost always present in healthy corals. Environmental stresses cause disturbance of this consortium, and corals might fall victim of own endolithic fungi and additional, possibly bacterial, pathogens (see e.g., LeCampion-Alsumard *et al*., .1995a, b; Bentis *et al*., 2000; Fine & Loya, 2002; Golubic *et al*., 2005).

Dead corals are bored by variety of endolithic microorganisms, and they have well fossil record (Fig. 3). Although microendoliths are common in recent living corals, their fossil record is suprisingly sparse. A review of literature on fossil scleractinian corals allowed to recognize only one example. This Late Jurassicexample (Schmid & Jonischkeit, 1995) indicates on evolutionary longevity of coral-microendoliths symbiosis. A question arises, whether such associations were much rarethan recently, or it is a result of low preservational potential.

Microborings within living aragonite coral skeleton may be filled very rapodly with calcite cement, what should be taken into consideration when coral skeletons are used as archives of geochemical proxies (Nothdurft *et al*., 2007),

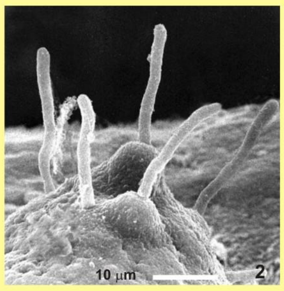
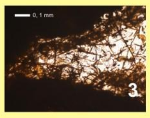
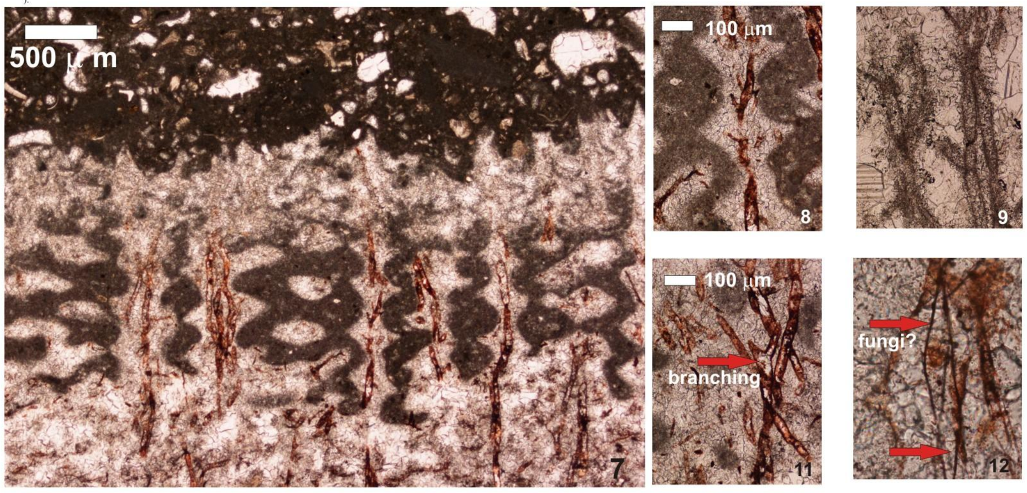


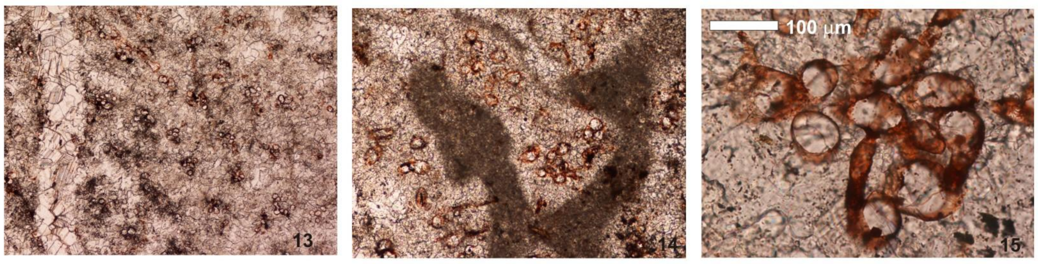
Fig. 1. Light micrograph showiing borings of *Ostreobium quekettii*, which contain thin fungal filaments (arrow).
Fig. 2. Hyphae of endolithic fungi protruding into skeletal pore of coral. Conical cones deposited by polyp in defence of fungal attack. Island, Moorea, F.P. (from Golubic *et al*., 2005).



Microbial ferrugenous encrustation on coral septum. External part is extensively bored inward. Cenomanian, Germany.



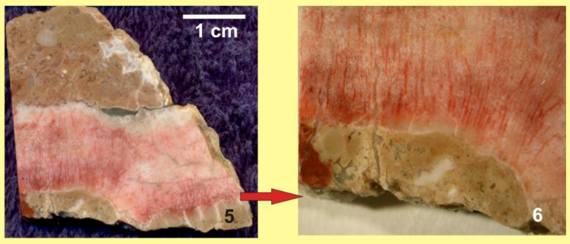
Filaments of ?*Ostreobium* sp. within coral septa. Longitudinal section. Note branching pattern of filaments. Thin (fungal?) filaments occur inside of algal filament on Fig. 12. Apart of filamenst on Fig. 9, others are impregnated by Fe.



Transverse section through coral skeleton. On Fig. 13 interseptal space is filled by sparitic cement. The skeleton is strongly recrystallized and skeletal structure is not visible. Filaments occur in aggregates.

APTIAN

Coral sample with red coloured band. In this sample only this zone contain microendoliths.



Polished slab of platy coral. Microendoliths occur in nearly all studied sample.

A spectaculr case of the coral-microendoliths association was recognized in the Early Cretaceous (Lower Aptian) reef limestones from the Rarau Mts. (East Carpathians, NE Romania).

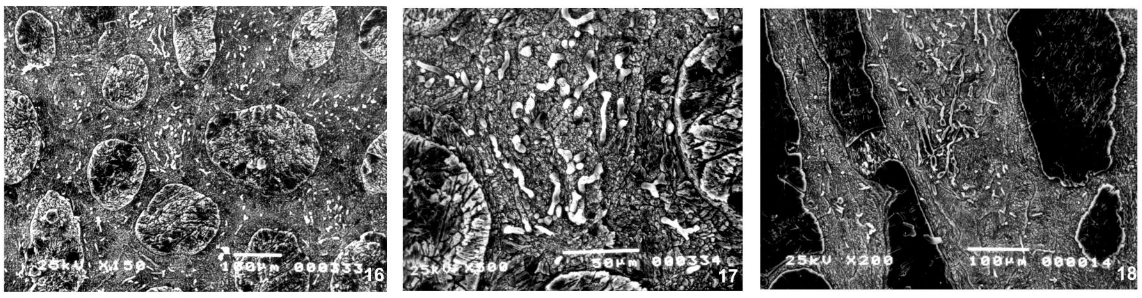
Among sclaractinian corals, in three examples (suborder Microsolenina) numerous large siphonaceous microendoliths were identified. Red coloured aggregates of filament, partly impregned with iron oxides, are avisible macroscopically. Individual filaments attain 20-80 µm in diameter. The filaments extend in the direction of skeletal growth. Transverse sections revealed that even up to 12 filaments can be concentrated in the central parts of skeletal elements. Thin filaments (ca. 10 µm in diameter) were also observed within some larger filaments. Larger microendoliths possibly represent the chlorophyte *Ostreobium* sp., although they are more variable and on average much larger than recent *O. queketti*, as common reported from skeletons of recent living corals. A similar associations has been reported in the skeleton of Late Jurassic coral (Schmid & Jnischkeit, 1995; figs 19-20). Interestingly, microendoliths were recognized only in microsoleninans, the corals which were adopted to live in low-light environments due to depth or turbidity (e.g., Insalaco, 1996; Rosen *et al*., 2002).

PALAEOCENE

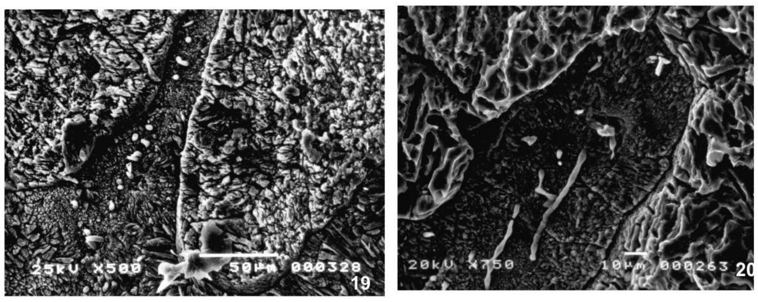
A second case of microendoliths reported here as observed in scanning electron microscope, are common within scleractinian and octocoral (*Polytremacis* sp.) skeletons from the Palaeocene Babica Clays, Polish Flysch Carpathians, S Poland).

Solitary and small colonial corals (usually 3-10 cm in diameter), often with well preserved aragonitic microstructure, occur as redeposited specimens within flysch deposits. Corals were cut and etched in solution of HCl (many microborings were filled with subsequent precipitants), and resin casts were prepared for some samples (when microborings remained vacant) .

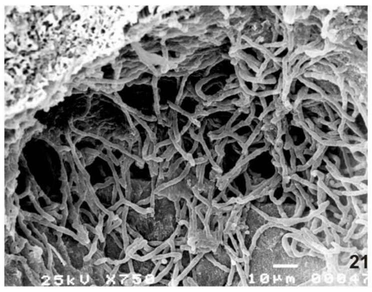
Remains of microendoliths possibly represent red algae (*Paleoconchocelis* sp.), green algae (*Reticulina elegans*), cyanobacteria (*Scolecia filosa*), and fungi. They occur in the central parts of skeletal elements. Microbial attack from the exterior was not observed, moreover skeletal elements are hardely affected by micritization. Coralline algae encrusting some of the corals were not affected by microborers.



Mineralized microendoliths (?*Paleoconchocelis* sp.) in cenosteum of octocoral *Polytremacis* sp. Transverse (Figs 16-17) and longitudinal (Fig. 18) sections.



Endolithic filaments within septa of *Fungia* sp. Transverse section.



Resin casts of microborings (?*Ostreobium* sp.)

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