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CROSSROADS IN EARTH AND PLANETARY MATERIALS

Block-by-block and layer-by-layer growth modes in coral skeletons

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Abstract

Understanding the dynamics of biomineral growth is a challenging goal of biomineralogy that can be achieved in part by deciphering biomineral structures and chemistries. The morphology, structure, and chemistry of six skeletons of *Corallium* and *Paracorallium* species (*C. rubrum*, *C. elatius*, *C. johnsoni*, *C. niobe*, *P. japonicum*, and *P. thrinax*) from the Mediterranean, the Atlantic, and the Pacific oceans have been studied by X-ray micro-computed tomography, polarized light microscope, scanning electron microscope, and electron microprobe. All species have two types of biomineral structures: an inner skeleton and sclerites that are small grains of Mg-calcite found in the living tissues surrounding the skeleton. All skeletons display a central core surrounded by an annular domain. In the species studied by electron microprobe (*C. rubrum*, *C. elatius*, and *P. japonicum*), the central core and the annular domains display different chemical compositions with the core richer in magnesium and poorer in sulfur than the annular domain. In terms of structure, special emphasis has been put on central cores for which little data are available. The central cores are made of sclerites and sclerite aggregates within a cement consisting of fine layers of Mg-calcite. On the other hand, the annular parts are made of fine concentric layers of calcite crystallites with only rare sclerites. These contrasting features imply two different growth modes: (1) a "block and cement" mode taking place at the apex of a branch and associated with a fast axial growth rate (~2 mm/yr); and (2) a layer-by-layer mode occurring below the apex and associated with a slow radial growth (~0.2 mm/yr). The change from a growth mode to another is anatomically controlled by the presence of a continuous network of gastrodermal canals around the sub-apical skeleton, preventing to a large extent the aggregation of sclerites. It is generally accepted that the *Coralliidae* family exhibits different types of skeletogeneses. In contrast with this idea, we observe that all studied Corallium species display remarkable similarities in terms of skeletogenesis and a unifying growth model for the *Corallium* genus is proposed. Similarities and differences with previous models are discussed. The present study shows that the morphological criterion initially used to establish the genus *Paracorallium* in the *Coralliidae* family is inadequate.

Keywords: *Corallium*, *rubrum*, *japonicum*, *johnsoni*, skeletogenesis, block and cement, layer-by-layer, biomineral growth