The potential of bamboo corals to record environmental conditions in their calcitic skeletons

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Abstract

The ocean's physicochemical variability (e.g. temperature) is not well understood despite its importance for the world's climate because of rare instrumental time series. This issue can be resolved through natural archives that recorded past environmental conditions such as corals. The cosmopolitan calcitic bamboo corals (Isididae) belong to the subclass of Octocorallia and are long-lived, thus offering the potential to record environmental parameters over a wide range of oceanic conditions. This study provides a detailed look into the chemical composition of bamboo coral skeletons to distinguish between environmental and biomineralisation controls over the skeletal composition.

The ability of bamboo corals to record seawater temperature and nutrient conditions was investigated in chapter two this thesis. For this purpose the distribution of Mg and Ba, respectively, in the calcitic internode of an Atlantic specimen from the Blake Plateau off Florida was measured. We observed that the mean Mg/Ca composition of a bamboo coral can be used to reconstruct the ambient seawater temperature while mean Ba/Ca was found to record $[Ba]_{SW}$. Conversely, microscale variations suggest environmental variability which cannot reflect ambient seawater conditions. Instead, the coral physiology has a strong impact on skeletal formation and with that on the micron-scale skeletal Mg and Ba composition. The physiological impact on the skeletal composition is further indicated by chemical patterns formed along regions of nearly simultaneous growth excluding an environmental impact for the origin of these patterns. If ambient seawater conditions exerted the sole control over these elemental ratios, a certain environmental parameter such as temperature should cause the same response everywhere along the region of simultaneous growth. Further, we propose that the observed isolated microscale compositional features are related to tissue attachment. Taken together, these results suggest that bamboo corals can be used as temperature and $[Ba]_{SW}$ recorder when utilising mean skeletal compositions, while variations on the micrometre scale exceed that ambient conditions and are hence controlled by internal physiological processes.

The use of skeletal Na and S contents as environmental proxies in marine calcifiers is debated. Therefore it was evaluated in chapter three whether these potential proxies record ambient seawater conditions in two Atlantic bamboo corals from the Bear Seamount and the Blake Plateau during the time of their growth. The microscale distribution of Na and S can show a concentric structure and zig zag patterns as found for Mg. The comparison of the variability of two Atlantic samples revealed that with increasing variability of salinity, the variations of Na in the sample are higher. Nevertheless, we cannot exclude a coincidence. As seen in chapter two for Mg and Ba, the microscale heterogeneity indicates a main control of the coral physiology over the skeletal composition. We present a calcification model that is capable of explaining the Na and S inverse correlation. This model includes Ca pumping and bicarbonate active transport while assuming conservative behaviour of Na and S in the calcifying fluid. Although the inverse correlation of Na and S can be explained without the involvement of skeletal organic matter, it cannot be excluded as an additional minor influence on the skeletal incorporation of these two elements. The results suggest that the skeletal microscale distribution of both Na and S are mainly influenced by physiological processes rather than ambient environmental conditions.

The B elemental as well as its isotopic composition in calcium carbonates have been used to study the carbonate system, and in particular ambient pH, of the calcifying fluid. Chapter four describes the B/C and B isotopic spatial distribution in an Atlantic (Bear Seamount) and a Pacific (Monterey Canyon) bamboo coral specimen measured in the bulk internode material and the purified calcite fraction. We found a correlation between bulk δ^{11}B values and B/C on the samples employing the laser ablation approach, allowing for a preliminary estimate on potential δ^{11}B variations based on the B distribution in bamboo corals. The range of the δ^{11}B values collected with laser ablation sampling is larger than obtained from the drill sampling. This observation can be explained with averaging significantly larger areas by drill sampling but mainly with the compositional difference of the skeletal phases we

measured. We found that the solution-based measurements indicate a lower pH up-regulation of the calcifying fluid than scleractinian corals which agrees with earlier studies. Nevertheless, our results suggest that the skeletal boron isotopic composition of bamboo corals might besides CF pH be influenced by borate influx to the CF, organic matter induced isotope fractionation or kinetic isotope effects.