

Coral calcification in temperate region and the role of dissolved inorganic carbon (DIC) and pH in the calcifying fluid

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Coral skeletons, which consist of calcium carbonate, are one of the main agents for maintaining shallow coral reef structures across tropical to temperate regions. Corals precipitate their skeleton from a calcifying fluid (CF) which is located between the coral skeleton and tissue within a micrometer thickness region. Ongoing ocean acidification (OA) in the upper oceans due to absorption of increasing atmospheric CO₂ may affect the chemical composition of coral CF, and hence potentially reduce the coral calcification. Understanding the interaction between the chemical composition of coral CF and the declining pH of seawater in the natural coral-reef settings is crucial. In this context, the temperate regions are of prime interest because the degree of OA in the temperate area is higher than that in the tropical area due to inherently low seawater temperature. However, the carbonate dynamics and interactions between temperate coral CF and changes in ambient seawater is unclear.

Here we report a ~70-year record of changing dissolved inorganic carbon (DIC) and pH of CF in a massive *Porites* coral growing near its latitudinal habitable limits at Kushimoto, Japan. The annually resolved boron components ($\delta^{11}\text{B}$ and B/Ca) and Li/Mg, which are the proxies of carbonate chemistry in coral CF and temperature, are reported here. The geochemical data provide constraints on both the carbonate composition of the CF and ambient temperature during calcification. We find that the reconstructed DIC_{CF} and pH_{CF} are significantly higher than that of seawater, thereby enhancing the kinetics for precipitation of the corals calcium carbonate skeleton. DIC_{CF} is negatively correlated to the pH_{CF}, which is in agreement with the tropical coral. The ΔDIC (DIC_{CF}-DIC_{seawater}) in temperate coral is higher than that in tropical coral at given temperature (24-25°C) and there is an inverse correlation between seawater temperature and DIC_{CF}. These findings imply that corals strongly manipulate the chemical composition of their CF in response to changes their ambient environment. To understand the role of the aragonite saturation state (Ω_{CF}) and temperature for temperate coral calcification, we calculate Ω_{CF} and calcification rate based on the inorganic chemical reactions of carbonate (Burton and Walter 1987). The comparison between measured and calculated calcification rate indicates that the temperature mainly controls calcification rate, not Ω_{CF} in the natural setting. These results imply enhanced resilience to OA but the high vulnerability of temperate corals to thermal stress due to recent global warming.

Burton EA, Walter LM (1987) Relative precipitation rates of aragonite and Mg calcite from seawater: Temperature or carbonate ion control? *Geology* 15(2):111-114

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