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Detection of Sr and Ca Stable Isotope Fractionation during $CaCO_3$ Formation from Seawater to Investigate the Mechanism of Biomineralization

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Summary

Marine organisms such as shellfish, sea urchins, and corals efficiently fix calcium ions (Ca^{2+}) in seawater as calcium carbonate ($CaCO_3$) through biomineralization. In this process, species-specific proteins called biomineralization proteins control the crystal polymorphism of $CaCO_3$. Although controlling the polymorphism of $CaCO_3$ crystals using biomineralization proteins may lead to the development of a low-cost and highly efficient technology for fixing atmospheric CO_2 as $CaCO_3$ using Ca in seawater, the mechanism of controlling $CaCO_3$ crystal polymorphism by biomineralization proteins has not been elucidated. This study aimed to investigate the function of biomineralization proteins by detecting Sr and Ca stable isotope fractionation that occurs during $CaCO_3$ crystals formation through biomineralization process by several kinds of shellfish and artificially reproduced biomineralization reaction system or in.

Since the magnitude of stable isotope fractionation of Sr and Ca that occurs during $CaCO_3$ crystal formation is minute, a highly precise and accurate technique for measuring Sr and Ca stable isotope ratios ($^{88}Sr/^{86}Sr$ and $^{44}Ca/^{42}Ca$) is essential. Firstly, the following techniques to achieve precise and accurate $^{88}Sr/^{86}Sr$ measurement were developed. (1) effective Sr/matrix separation method using Sr resin: to achieve precise and accurate $^{88}Sr/^{86}Sr$ measurement using multi-collector inductively coupled plasma mass spectrometry (MC-ICP-MS), highly effective Sr/matrix separation prior to the measurements is essential. In this study, Sr/matrix separation procedure using Sr resin was optimized, resulting in good Sr/matrix separation and high Sr recovery (97 %). (2) Highly sensitive $^{88}Sr/^{86}Sr$ measurement method using MC-ICP-MS: since the amount of synthetic $CaCO_3$ crystals obtained from the artificial biomineralization reaction is extremely small, improvement of the sensitivity of $^{88}Sr/^{86}Sr$ measurement using MC-ICP-MS was carried out, resulting in a four-fold increase in sensitivity compared to the conventional method. Finally, the optimized Sr/matrix separation procedure was applied to the synthetic $CaCO_3$ crystals and shell samples, and effective Sr/matrix separation was achieved.