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Mg/Ca micro-distribution in foraminiferal test – Implication of laboratory culture experiments

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The magnesium/calcium (Mg/Ca) ratio in the tests of foraminifera has rapidly developed as a paleo-temperature proxy in paleoceanography because the magnesium content of calcite is a function of its precipitation temperature. Many studies have established the equation between Mg/Ca and temperature using sediment trap, plankton net, sediment core top and culture specimens. These empirical equations are useful to apply paleoenvironmental reconstruction. However, the foraminiferal uptake of elements has not fully understood yet.

Pelagic foraminiferal test are consist of almost pure calcite. A general magnesium content of foraminiferal test is smaller than expected magnesium contents in calcite which is precipitated from seawater by two orders of magnitude, according to results of inorganic precipitation experiments. Moreover, magnesium amount in test is also different among species. Meanwhile, the relationship between Mg/Ca and temperature is different from species to species. These suggest that uptake of elements from seawater is positively controlled by foraminiferal biology.

In this study, we studied about chamber formation processes and magnesium and calcium micro-distributions of foraminiferal test in order to investigate an incorporation of elements from seawater to calcareous tests through foraminiferal organisms. The foraminiferal chamber formation process was observed under inverted microscope from first to last in laboratory. The elemental measurements were carried out by electron probe microanalyzer (EPMA) on seven cultured specimens and natural populations. We used juvenile specimens produced during asexual reproduction in the laboratory. The whole tests of cultured specimens are calcified under well-controlled physicochemical conditions. It is advantage of living culture in order to evaluate the influence of ambient environments on foraminiferal test chemistry because any factors are variable systematically by an experimental design.

Elemental micro-mapping measurement indicated heterogeneous distribution of magnesium. There are several magnesium concentrated bands in both planktonic and benthic species. High magnesium bands correspond to organic layers in the test. The intrachamber variation was also observed in addition to high magnesium bands. The variation was not random, but showed a weak planar distributional pattern. Microscope observations documented the precipitation of calcite does not occur evenly over the organic membrane of the developing chamber during their calcification process. We speculate variable Mg/Ca values within their test walls, which resulted from the pattern of chamber formation and from minor variations of Mg/Ca within one chamber wall.

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