# Systematic Sub-Micron Na/Ca Banding in Cultured Planktic Foraminifera

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Mg/Ca ratios in foraminifera are often used as a proxy for past ocean temperatures. However, over the last decade, it has become clear that Mg/Ca ratios in foraminifera are not constant throughout the shell. Instead the Mg/Ca ratios within the foraminiferal calcite vary systematically between day and night, a phenomenon that has yet to be explained mechanistically. This has been shown to occur even under constant temperatures, and represents an Mg/Ca change of several fold. Determining whether elements other than magnesium also exhibit sub-micron banding is essential in order to properly interpret Me/Ca-based paleoproxies and to understand the mechanism causing Me/Ca variability. Using time-of-flight secondary ion mass spectrometry (ToF-SIMS), an isotope mapping technique with a spatial resolution of roughly 200 nm, we discovered systematic Na/Ca banding in individuals of the symbiont-bearing planktic foraminifera *Orbulina universa* that had been cultured at constant temperature. Using stable-isotope time stamps, we have been able to show that this Na/Ca banding exhibits three distinct patterns, depending on which part of the foraminifer test was analyzed. For much of the test, Na/Ca varies inversely with Mg/Ca, with high Na/Ca during the day and low Na/Ca at night. In contrast, it appears that both Mg/Ca and Na/Ca are high at the location of the primary organic membrane. Additionally, Na/Ca is low in the slower-growing inner leaflet of the *O. universa* terminal sphere. Using a combination of analytical models and complementary instrumental techniques, we test whether these patterns can be explained by active exchange of $2Na^{+}$ for $Mg^{2+}$ during biomineralization, by kinetic mineral growth effects, and/or by organic-templating processes.