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Intracellular control on calcification in benthic foraminifera

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Correlations between seawater chemistry and the composition of foraminiferal calcite are the reason why their fossil tests (i.e. shells) are currently among the most popular tools to recontstruct marine paleoenvironments. However, most species produce calcite that differs greatly in its trace element and isotopic composition from inorganically precipitated calciumcarbonates. Moreover, these compositions are known to vary greatly among species and with ontogenetic development, potentially limiting their paleoclimatological application. These variabilities indicate that foraminifera physiologically control the composition of the intracellular fluids from which they precipitate their tests. The fact that most species produce calcite with a very low Mg content suggests that between seawater vacuolization and chamber formation, foraminifera discriminate between Ca2+ and Mg2+. This then results in an active removal of most of the magnesium during the production of an intracellular calcium-pool. Recent application of a suit of fluorescent probes has started to reveal the control on intracellar pH and Ca2+-cycling in the benthic foraminifer Ammonia tepida. Time-lapse recordings of juvenile individuals show how Ca2+-containing and high-pH vesicles are transported towards the site of calcification during chamber formation. Confocal laser scanning microscopy allows the visualization at a high resolution of the location and timing of the production of these calcifying vesicles. Membrane cycling during seawater vacuolization and utilization of Ca2+- and carbonate-containing vesicles can also be qualified with a fluorescent probe and combined with those for calcium- and pH to develop a mechanistic understanding of seawater modifications and resulting trace element and isotopic fractionations during calcite precipitation by benthic foraminifera.