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Visualizing Nacre Growth and the Amorphous to Crystalline Phase Transformation in Strontium-Labelled Bivalve Shells

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Marine shells contain trace element and isotope signatures that are used to decipher past environmental conditions. Previous studies indicate that these signatures are incorporated into metastable precursor phases, such as amorphous carbonate, that later transform into crystallin carbonate phases. However, our understanding on the uptake and incorporation mechanisms of these signatures into the amorphous phase as well as the corresponding phase transformation mechanism is yet incomplete.

Here we present combined observations from NanoSIMS analysis, atom probe tomography (APT), and Photo-induced Force Microscopy (PiFM) capturing growth processes from the meso- down to the atomic scale [1]. This was achieved by growing the shells in controlled aquaculture experiments where they were alternatingly exposed to normal and strontium spiked seawater – an approach generally referred to as pulse-chase labelling. Our mesoscale results show that nacre tablet growth follows a two-step process with extensional and space-filling growth components. Further, we show that the space-filling nanogranules in nacre tablets exhibit heterogeneous Sr concentrations at nanometre to atomic length scales as they comprise distinct Sr-enriched and Sr-poor areas. The observed within-granule heterogeneity points towards an ACC to aragonite transformation via localised dissolution and reprecipitation within the confinement of organically sheathed nanogranules.

References:

[1] L Otter, K Eder, M Kilburn, L Yang, P O'Reilly, D Nowak, J Cairne (accepted): Growth dynamics and amorphous-to-crystalline phase transformation in natural nacre.