Bivalve Shell Architectures: New Insights from Pulsed Sr-Labelling and Correlative Micro/Nanoanalysis

L.M. OTTER[1*], P. TRIMBY[2], H. HENRY[1], M.R. KILBURN[3], K. EDER[4], O.B.A. AGBAJE[1], J. GIM[5], R. HOVDEN[5], J.M. CAIRNEY[4], S. MAZUMDAR[1], D.E. JACOB[1]

[1]Department of Earth and Planetary Sciences, Macquarie University, Sydney, Australia.
*laura.otter@mq.edu.au
[2]Oxford Instruments NanoAnalysis, High Wycombe, United Kingdom
[3]Centre for Microscopy Characterisation and Analysis, University of Western Australia, Perth, Australia
[4] Australian Centre for Microscopy and Microanalysis, The University of Sydney, Sydney, Australia
[5] Department of Materials Science & Engineering, University of Michigan, Ann Arbor, USA

Bivalve shells are nanocomposite materials consisting of calcium carbonate enveloped in organic membranes that are arranged into complex, 3D hierarchical architectures (e.g. nacre, crossed-lamellar). They are important paleoclimate proxy archives capable of recording various environmental parameters encoded in their chemistry during growth.

While our understanding of how shells form has experienced a recent paradigm shift away from classical ion-by-ion crystallization to crystallization via colloid attachment and transformation involving amorphous calcium carbonate (ACC) nanoparticles, this concept is not yet incorporated in environmental proxy applications [1]. Critical questions concerning the potential impact of this paradigm shift on trace element partitioning and how sub-micron growth processes are influenced by the bivalve physiology need yet to be answered.

We address these questions by presenting results from Sr-pulse-chase labelled aquaculture experiments with living bivalves of *Katelysia rhytiphora*, *Anadara trapezia*, and *Mytilus galloprovincialis* species. Pulse-chase labelling created “snapshots” of growth at the submicorn scale that were consequently investigated with an innovative combination of correlative high-resolution microanalysis using e.g. EPMA, FEG-SEM, Nano-SIMS, Micro-Raman, EBSD, (S/)TEM, and Atom Probe Tomography. Our micro-to nano-analytical results allow new insights into shell architecture, growth dynamics at the submicron scale, and also further our understanding of the mechanical properties for different shell ultrastructures.

[1] Gower & Odom (2000). J. Cryst. Growth 210, 719–734.