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Structural post-mortem ordering of planktic foraminifer shell carbonate and potential effects on the fidelity of geochemical proxies

ANTHEA I. ARNS[1,2], OSCAR BRANSON[3], DAVID EVANS[4], ANDREAS LEINEWEBER[5], LENA HEINS[1], JANNE REPSCHLÄGER[1], ANNE JANTSCHKE[6], STEPHAN E. WOLF[7], JAN LEITNER[1,8], GERALD H. HAUG[1,2] AND RALF SCHIEBEL[1]

[1]Max Planck Institute for Chemistry
[2]ETH Zurich
[3]University of Cambridge
[4]University of Southampton
[5]Technische Universität Bergakademie Freiberg
[6]Johannes Gutenberg University
[7]Friedrich-Alexander University Erlangen-Nürnberg (FAU)
[8]Heidelberg University

The calcareous planktic foraminifers provide an outstanding proxy archive for environmental signals, for example, via the trace element and isotope composition of the shell. Interpreting such geochemical data requires a rigorous, reliable link between environmental parameters and measurable proxies. This link is often obscured by the complexity of the system, in part caused by a range of unknown (e.g., metabolic or inorganic) processes during the biomineralisation process. For robust proxy calibrations, a systematic understanding of both biomineralisation and post-depositional shell alteration is therefore essential, but remains incomplete.

We present new synchrotron-based high-resolution X-ray powder diffraction data on the crystallography of foraminifer shells spanning live-caught specimens to million-year-old fossils. Across a range of common species, based on the broadening of the Bragg reflections, we find a generally higher degree of crystallinity and evidence for less disorder for sediment-sourced (coretop) than live-caught shells. This early post-mortem structural change of the shell carbonate of planktic foraminifers could reflect consolidation of an initially disordered material, consistent with crystallisation of an amorphous precursor, resulting in a specific shell microstructure. Such a consolidation process may release water (containing dissolved ions) or produce impurity-rich regions in the crystalline phase, potentially influencing the composition of the shell. This could have important implications for our interpretation of geochemical data, and particularly interpreting the geochemistry of foraminifera in the sedimentary record with calibrations derived from live-caught specimens.