Foraminifers form their shells via metastable carbonate phases

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An ever increasing number of calcifying organisms is found to form their shells via non-classical crystallization pathways that involve metastable calcium carbonate phases, such as amorphous calcium carbonate and vaterite (deYoreo et al., 2015). Stepwise crystallization of calcite or aragonite via metastable precursors is not only energetically favourable, but preserving some variablity in crystallinity likely contributes to the optimization of the shell's mechanical properties (Wolf et al., 2016).

Using Focussed Ion Beam assisted Transmission Electron Microscopy, FTIR and Micro-Raman Spectrometry we show here that planktic as well as benthic foraminifer shells contain vaterite and/or amorphous calcium carbonate (Jacob et al., 2017). In planktic foraminifer species *O. universa* and *N. dutertrei* vaterite is a transient phase and over time transforms to low-Mg calcite, indicating that these organism form their shells indeed via non-classical crystallization.

The discovery of a stepwise crystallization pathway of calcite in foraminifer shells supersedes the long-standing paradigm that planktic foraminifera construct their shells by the direct precipitation of calcite from seawater. While the exact mechanism of transformation is unknown and partition coefficients for vaterite and amorphous calcium carbonate are not yet available, these findings have important ranificatios: They provide the foundation for testing models currently discussed for trace element incoporation and isotope fractionation in foraminifer calcite and for explaining the significant and unexplained differences between foraminiferal and inorganic calcite geochemistry.

De Yoreo et al. (2015) *Science* 349, aaa6760; Jacob et al. (2017) *Nature Communications* 8, 1265; Wolf et al. (2016) J *Structural Biology* 196, 244.