Growth strategies in Larger Benthic Foraminifera and their deviations

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Most Larger Benthic Foraminifera (LBF) build their test following very strict morphogenetic rules. Despite their essential Bauplan standards, deviations of those defaults are quite common. The tests function is not only designed to accommodate a sufficient amount of endosymbiontic cells but also to create enough accommodation space for the cells protoplasm. To exhaust their capabilities, different strategies can be observed. Multispiral growth, for example, is a common phenomenon among larger species of *Nummulites*. The construction of "wrinkles" and even secondary equatorial layers has been observed amongst the genus *Cycloclypeus.* Apart from those, some conjoined twin specimens have been investigated with the aim to determine the particular circumstances of their fusion.

This work tries to quantify these abnormal growing strategies: their occurrence in this group, their consequences in the test architecture and how they might influence the palaeobiology of the cell. The use of micro CT scans permits the measurement of any morphological detail and allows the rendering of exact three-dimensional models. These models are useful to study the cell ontogeny in specimens affected by growth deviations. The segmentation of the chamber volume sequence on specimens with multispiral growth gives insights on the cell ontogeny and helps to unveil the reason for the implementation of those auxiliary spirals and identify the underlying mechanisms. In others, the volumetric quantification of chamber growth sequences can illustrate the different ways how those giant cells can modify their test morphology to provide sufficient accommodation space for the cell and the symbionts whilst dealing with just one layer of spirals. Specimens showing pluriembryonal apparati or appear as conjoined twins are of special interest because of their ability to coordinate the joint growth of two or more cells and the internal and external factors enforcing the unification of the cells and a special growth strategy.

Cyclic variations in the test architecture found in our specimens can probably be linked to the environmental influence affecting the cell throughout its lifetime and give, concerning those variations in nummulitids, an in-depth look into some years of Eocene environmental changes, whilst abrupt variations could be linked to internal factors. To match 3D modelling technique with a quantitative approach seems to be a promising objective to get a better understanding of the cell ontogeny of LBF.