Untangling palaeoenvironmental signals in nummulitid morphometry to enhance biostratigraphic diagnosis in shallow-marine carbonate deposits

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Within the larger benthic foraminifera (LBF) the group with undivided chambers, Nummulitids, and the group with chambers subdivided into chamberlets, Heterosteginids, are well-known markers for biostratigraphic and palaeoenvironmental interpretation of Cenozoic shallow-marine carbonate deposits. Morphometric analyses of equatorial thin-sections have been widely used for the genera *Nummulites, Assilina* and *Heterostegina* to fine-tune relative dating based on the LBF biozonation, while palaeoenvironmental and palaeobiogeographic interpretations are based on assemblages. The presented studies show that palaeoenvironmental and palaeogeographic trends can be filtered by detailed investigation of diagnostic features in oriented thin-sections improving biostratigraphic interpretation. Until now, 149 isolated specimens of the genera *Nummulites*, *Operculinoides*, *Palaeonummulites* and *Heterostegina* have been investigated from seven different localities in western and central Cuba with a time range from early Lutetian to latest Priabonian (Rupelian?). By means of agglomerative cluster, principal component and canonical discriminant analyses based on morphometric data we could clearly differentiate trends along geological time and palaeoenvironmental/palaeobiogeographic gradients. To crosscheck these trends, our results have further been integrated with planktic foraminifera and nannoplankton biostratigraphy. Within Nummulitids, the tightly-coiled genus *Nummulites* exhibits the most prominent changes through time. This is primarily represented by the increasing size of the first embryonic chamber. *Operculinoides* and *Palaeonummulites* with varying laxity of the spiral exhibit weaker changes along geological time, which are mainly represented by spiral and chamber shape. In *Heterostegina*, changes through time are strongly reflected in chamber and chamberlet shape, while the size of the embryonic apparatus is less important. Generally, the laxity of spirals leading to higher morphological variability enabled a stronger response of test shape to palaeoenvironmental changes. These taxa span longer time intervals exhibiting weak evolutionary trends as has been observed in the studied sections by the genus *Operculinoides*.