

Multiple embryos in the *Lepidocyclina pustulosa* group as possible indicators of palaeoenvironmental conditions: The case of the Late Eocene Toluviejo Formation (Sinú Domain, Caribbean, Colombia)

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The Middle-Late Eocene Toluviejo Formation of the Sinú-San Jacinto folded belt (Caribbean, Colombia) contains 15-75 m thick, grey, massive limestone sequences that are interbedded with terrigenous nearshore to offshore mudstones to quartzose sandstones and conglomerates. The formation accumulated in a transitional continent-ocean setting, probably on oceanic crust. We studied over 80 polished thin sections under light microscopy and cathodoluminescence (CL) to analyse carbonate microfacies and Larger Benthic Foraminifera (LBF). The overall facies distribution is 3-fold: (1) Facies close to the shoreline are dominated by low diversity operculinid assemblages, rich in detrital elements. (2) Shallow offshore facies are characterized by round lepidocyclinids, associated with, and often encrusted by, corallinacean algae, *Sporolithon* and structureless microbial crusts. The matrix is rich in carbonate/detrital mud and sand-sized detritals. (3) Distal offshore facies on structural highs show abundance of flat, current-sorted lepidocyclinids without a noticeable detrital component. Facies 1 and 2 are clearly under the influence of suspension- and dissolved-nutrient input, probably carried offshore by freshwater lids of river plumes. Facies (2) contains abundant specimens of the *Lepidocyclina pustulosa* group of which the macrospheric forms show complicated embryonic apparatuses, which suppose double or multiple embryos. Detailed observation under CL allows to count up to 6-8 embryos, often seen aligned in the equatorial plane. The embryonic apparatus occupies often more than half of the diameter of specimens. The tendency towards large, very flat embryonic apparatuses (diameter measured in axial cuts up to 2,5 mm for a thickness of 0.2-0.3 mm) is closely correlated with abundant coralline and microbial encrustations, oxide-stained carbonate/detrital mud and probably some preserved organic matter.

The presence of multiple embryos has been reported by several authors and has also been used as a morphological criterion to establish new taxa (e.g. *Pliolepidina tobleri*). A recent paper has demonstrated multiple embryos of the Recent *Spiroclypeus carpenteri* by means of microCT, and has discussed the possible causes of formation of tests with more than one proloculus: During asexual reproduction a large number of individuals are released from the mother's test into the environment. If the daughter cells do not manage to get sufficiently separated from each other, they may start to build several deuteroloculi around each other. Low water energy in the habitat of *Spiroclypeus* has been suspected by these authors to prevent the complete dispersion of juvenile forms and thus favouring the growth of forms with multiple embryos.

The abundance of mud and of fragile algal and microbial mats in our facies (2) advocates for a low bottom water hydrodynamic regime for the samples in which practically all macrospheric forms observable in thin sections have multiple proloculi. Environmental factors other than water energy could also play a role: Many authors have reported teratological growth of benthic Foraminifera in hypersaline environments, or waters polluted by heavy metals. In our case, salinity could have been below normal marine values and both suspended and dissolved organic matter from tropical rivers could have "polluted" the habitat of *Lepidocyclina* by excess nutrients and heavy metals leached from basaltic rocks abundantly present in the Eocene drainage basin. Contemporaneous, distal offshore, flat *Lepidocyclina* accumulations totally lack multiple embryos. These facies also lack a detrital component and show current sorting/orientation of tests.