

DIVERSIFICATION OF PALEOCENE PLANKTIC FORAMINIFERA AFTER THE CRETACEOUS-PALEOCENE EXTINCTION

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Morphological and cladistic analysis suggests that Paleocene planktic foraminifera split into three lineages immediately following the end-Cretaceous extinction and, ultimately, eight lineages by early late Paleocene. The founding lineage, the globanomalinids, evolved from survivors of the stratigraphically long-ranging, hedbergellid group of the Cretaceous. The hedbergellids and globanomalinids maintained low species diversities and were morphologically and ecologically conservative, deep-water taxa. *Globanomalina*, in turn, gave rise to the non-spinose *Praemurica* and the spinose *Eoglobigerina* in the earliest Paleocene. Both lineages may have initially grown at least partly in deep water since the isotopic chemistry of their shells is similar to that of the globanomalinids and all have $\delta^{18}\text{O}$ more positive than coexisting biserial woodringinids. However, within ~500-600 Ky. after the K/P boundary extinction, the praemuricates (*P. taurica*) moved into the near surface ocean where they ultimately gave rise to the photosymbiotic, *Morozovella*, *Acarinina*, and *Igorina* lineages. By contrast, members of the eoglobigerinid/subbotinid lineage continue to be isotopically similar to globanomalinids such as *G. planocompressa* and *G. compressa* which suggests they all grew at least partly in deep water.

The Paleocene radiation of planktic foraminifera is notable in that the rootstock did not fundamentally change its pattern of evolution after the extinction to take advantage of the nearly emptied oceanic habitat. Survivorship did not lead to the marked diversification of the hedbergellid/globanomalinid lineage nor dominance of their traits in the subsequent radiation. Instead, the initial diversification is concentrated in the eoglobigerinid/subbotinid group which abruptly acquired a spinose, globular shell morphology and probable carnivorous ecology analogous to modern *Globigerina*. The radiation of the morozovellid stock was delayed until about 4 million years after the K/P boundary extinction when the *Praemurica* lineage rapidly gave rise to three groups of surface-dwelling, photosymbiotic lineages: *Morozovella*, *Igorina* and *Acarinina*. This diversification may have been inspired by the acquisition of foraminifer-algal symbiosis which permitted the foraminifera to expand into low nutrient watermasses such as those occupied by extant *Globigerinoides*.

Hence, the radiation combined an initial, explosive diversification of the deep-dwelling eoglobigerinids with a more delayed radiation within the surface waters by *Praemurica* and its descendants. Once established, the main Paleocene lineages of planktic foraminifera continued to dominate the pelagic environment until renewed radiations began during the middle Eocene.