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Elimination of taphonomic bias in late Paleocene to early Eocene paleoenvironmental reconstructions by means of experimental dissolution studies on foraminifera

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Fossil foraminifera provide a prime tool in marine paleoenvironmental reconstructions. Their shells record physico-chemical conditions in the water column and on the sea floor, which through geochemical analyses are being employed in paleoclimatic, paleoceanographic and stratigraphic researches. Furthermore, the quantitative and taxonomic compositions of foraminiferal assemblages provide insight into numerous aspects of depositional conditions, such as productivity, temperature, etc. Selective dissolution can severely alter the composition of the fossil foraminiferal assemblages. Although preferential dissolution in foraminiferal assemblages is widely recognized in modern and Quaternary deep-sea sediments, the phenomenon is often neglected in studies dealing with Paleogene sediments. Uncritical use of foraminiferal assemblages, without a serious assessment of their preservation may lead to distorted paleoenvironmental reconstructions.

We carried out dissolution experiments on upper Paleocene to lower Eocene foraminiferal assemblages and selected taxa from the central Pacific (Allison Guyot and Shatsky Rise) and the Tethys (Dababiya, Egypt) in order to reveal the effects of differential dissolution on the composition of foraminiferal assemblages. Dissolution phenomena are a recurrent problem of upper Paleocene to lower Eocene foraminiferal assemblages, especially in connection with the Paleocene-Eocene Thermal Maximum (PETM). In some sequences severe dissolution is easily recognized by the absence of calcareous foraminifera in clay beds. However, less severe dissolution is rarely documented as such, although there are various more subtle indications, such as increased fragmentation and depressed absolute abundance and P/B ratios. Our study aims to investigate the effects of differential dissolution on the quantitative composition of planktonic and benthic foraminiferal assemblages. More specifically, we aim at developing objective criteria for the evaluation of dissolution in foraminiferal assemblages used in early Paleogene paleoenvironmental reconstructions, with an emphasis on the PETM.

Our experiments confirm two general observations on modern foraminifera: 1) planktonic foraminifera are much more vulnerable to dissolution than benthic foraminifera, leading to depressed P/B ratios and 2) dissolution susceptibility differs between size fractions, with the smaller specimens (less calcite) dissolving more rapidly than bigger ones, leading to a larger average size of the remaining specimens. During the experiment, the planktonic assemblage becomes more and more enriched in the resistant muricate genera Acarinina and Morozovella. Smooth taxa such as Globanomalina and Zeauvigerina disappear first, followed by the cancellate Subbotina. The high relative susceptibility of Subbotina is unexpected, since poorly preserved assemblages often contain abundant specimens of this genus. Our experimental data suggest that Subbotina must have been strongly dominant in the primary assemblages, which could be indicative of strong upwelling. Amongst the benthic assemblage of Dababiya dissolution leads to a relative enrichment of Lenticulina and the agglutinated Gaudryina. Biserial, triserial and porcelaneous taxa are most susceptible to dissolution, whereas thick-shelled rotaliines, such as Alabamina, Cibicidoides and Anomalinoides, have an intermediate susceptibility.

Our data enable to objectively identify various degrees of dissolution in foraminiferal assemblages retrieved from Paleocene-Eocene transitions. In this way taphonomic artifacts can be readily distinguished from primary paleoenvironmental signals affecting the composition of the assemblages. When applied to studied PETM sequences in Egypt, we observe that 25-30% of the samples analyzed for foraminiferal assemblages show signs of strong dissolution. An evaluation of published records across the PETM and other postulated hyperthermals

(LDE, ELPE, Elmo, X-event) reveals that partial dissolution of foraminiferal assemblages is a widespread phenomenon during these events. In part this reflects the effect of corrosive bottom waters and the combustion of organic carbon during deposition, but in some instances (e.g. in Egypt) it rather reflects deep weathering of sequences rich in pyrite and organic matter. Our data and comparative analyses on published records show that an objective taphonomic assessment must be part of every paleoenvironmental reconstruction based on quantitative foraminiferal data.