The ecological role of benthic Foraminifera in low-oxygen environments and their use as indicators of hypoxia in the historical and geological records

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Benthic foraminifera are shell-bearing protists that form a ubiquitous component of marine soft-bottom communities from intertidal mudflats to the deepest ocean trenches. Although often overlooked by biologists, they frequently dominate meiofaunal and macrofaunal size fractions. Certain species are highly tolerant of oxygen deficiency, leading to the development in hypoxic settings of large, low-diversity populations. These assemblages are typical of oxygen minimum zones (OMZs) on bathyal continental margins. Low-oxygen tolerant species seem to play a major role in the initial processing of labile organic matter in the core of the Pakistan margin OMZ and probably in other OMZ settings as well. Foraminifera are very diverse in terms of their shell construction and morphology. Some species have delicate tests with little fossilization potential but others have a hard, calcareous or well-cemented agglutinated test and an outstanding fossil record. Fortunately, and for reasons that are not well understood, it is these fossilizable types that are most common in low-oxygen environments. They provide a valuable source of information about hypoxic events in the geological past. Where sedimentation rates are high enough to provide sufficient temporal resolution, for example off major rivers and in fjords, hard-shelled foraminifera are also very useful for reconstructing events over historical time scales (10-100s of years). In particular, they have been used to trace the onset and development of eutrophication and hypoxia arising from human activities. Foraminifera are therefore a key group to study when investigating the history of hypoxia, as well as ecological and biogeochemical processes within oxygen-depleted environments.