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How do exceptionally preserved coleoid fossils in the Jurassic strata of Southern England (indicating local anoxic conditions) co-exist with assemblages of microfossils that indicate oxic conditions on the sea floor?

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Statoliths and arm hooks are distinctive microfossils in many Jurassic sediments and are two of the preservable remains of coleoid cephalopods. In many micropaleontological samples of Jurassic age collected in the Wessex Basin one finds the ear bones (statoliths) and arm hooks of coleoid cephalopods associated with the usual assemblages of foraminifera and ostracods. While these slightly unusual microfossils have been known for ∼100 years (or more), they were curiosities rather than significant indicators of cephalopod evolution. Our understanding of both statoliths and arm hooks changed with the investigation of the Christian Malford lagertstätte in Wiltshire (Hart et al., 2016). At this locality, in both excavations and cored material, very significant numbers of statoliths and onychites were found, closely associated with exceptionally preserved Belemnotheutis antiquus (Pearce), Mastigophora brevipinnis Owen, Romaniteuthis sp. and Trachyteuthis sp. Some of these fossils preserve muscle tissue, content of ink sacks, and other soft parts of the squid, including tentacles with hooks in-situ and the head area with statoliths present in life position (Wilby et al., 2004).

The preservation of soft-tissue material is usually taken to indicate anoxic or dysaerobic conditions within the enclosing sediments and, perhaps, on the sea floor. In the processed residues that contain the statoliths and hooks there are abundant species-rich, assemblages of both foraminifera and ostracods. Such occurrences appear to be incompatible with an interpretation of sea floor anoxia. This problem has been described as the 'anoxic benthic foraminiferal paradox' by Friedrich (2010). It is known that some agglutinated foraminifera can tolerate low-oxygen environments, but these assemblages of foraminifera include both calcareous and aragonitic taxa. Some of the aragonitic taxa (e.g., Epistomina spp. contain the organic linings of their tests (Wilby et al., 2004), again confirming exceptional preservation conditions.

The mudstones of the Oxford Clay Formation may have been compacted by 70–80% during de-watering and burial and, in such a fine-grained lithology 'samples' collected for microfossil examination probably represent several thousand years and, therefore, a huge number of foraminiferal life-cycles. Such samples (even if only 1–2 cm thick) could, potentially, include several oxic-anoxic cycles and, if coupled with compaction, generate the apparent coincidence of well-preserved coleoid fossils and rich assemblages of benthic foraminifera.

The interpretation of any microfossil samples should, therefore, consider the implications of compaction, which will vary within any transgressive–regressive cycles and impact on the microfossil interpretation of sequence stratigraphy. Using the interpretations of Oxford et al. (2004) it would appear that the concentrations of epistominid foraminifera and the position of the 'Christian Malford Squid Bed' are located within a zone of maximum flooding and, therefore, quiet deeper-water conditions on the sea floor.

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