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What controls the mixed-layer depth in deep-sea sediments? The importance of POC flux

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ABSTRACT: The depth of biogenic particle mixing, i.e., the mixed-layer depth (1), is fundamental in models of organic-matter recycling and paleoreconstructions for deep-sea sediments. Factors postulated to control I in the oxygenated deep sea include particulate organic carbon (POC) flux, oxygen penetration into the sediment, and a balance between the downward mixing and decay of labile POC. We explore the dependence of ℓ on biogeochemical characteristics by compiling, from 36 sites in three oceans, an internally consistent set of deep-sea estimates of I, POC flux, biogenic mixing intensity (Db), and POC reactivity. We use excess 2^{-10} Pb as a tracer for L and Db to avoid the confounding effects of tracer-dependent mixing. We find that L, estimated from the penetration depth of excess 219Pb, varies systematically with POC flux, with an asymptotic function explaining 88% of the variance in L. Stepwise multiple regression suggests that the penetration depth of excess 219Pb (and estimated L) is much more likely to be controlled by POC flux than by (1) the sediment inventory of excess 2¹⁴Pb or (2) biogenic mixing intensity (D_e). In addition, L is negatively related to oxygen penetration into the sediment (r = -0.629) and not significantly related to predictions of $\it L$ from a recent mixing/POC-decay model. We conclude that in the food-poor deep sea, POC flux substantially controls the size and activities of the sedimentmixing benthos and, in turn, the thickness of the biogenic mixed layer. Thus, in contrast to previous suggestions, average mixed-layer depth is not environmentally invariant but rather responds predictably to ecologically important parameters such as POC flux.

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