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

Smith, Craig R., Christophe Rabouille

Limnol. Oceanogr., 47(2), 2002, 418-426 | DOI: 10.4319/lo.2002.47.2.0418

ABSTRACT: The depth of biogenic particle mixing, i.e., the mixed-layer depth (L), is fundamental in models of organic-matter recycling and paleoreconstructions for deep-sea sediments. Factors postulated to control L 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 L, POC flux, biogenic mixing intensity (Db), and POC reactivity. We use excess ^{210}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 ^{210}Pb, 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 ^{210}Pb (and estimated L) is much more likely to be controlled by POC flux than by (1) the sediment inventory of excess ^{210}Pb or (2) biogenic mixing intensity (D_b). In addition, L is negatively related to oxygen penetration into the sediment ($r = -0.629$) and not significantly related to predictions of 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 sediment-mixing 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.