Pathways of organic carbon oxidation in a deep lacustrine sediment, Lake Michigan

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ABSTRACT: Rates of microbial iron reduction and other pathways of organic carbon (Corg) oxidation were investigated in sediment from a 100-m deep site in Lake Michigan. Total benthic mineralization rates of 6.8 and 8.0 mmol m^{-2} d-1, respectively, were determined from benthic flux measurements and by summation of dissolved inorganic carbon (ΣCO_2) accumulation rates measured in anoxic incubations of sediment in discrete depth intervals to 18 cm depth. Carbon oxidation rates were highest near the sediment surface and decreased asymptotically toward zero. A C_{org} half-life of 0.06 yr was estimated in the oxic zone, but the half-life increased by more than two orders of magnitude in the deep anoxic layers. Mineralization in the oxic zone (0-2.1 cm) accounted for 37% of the total SCO2 production, whereas microbial iron reduction was the most important pathway of carbon oxidation, accounting for 44%; sulfate reduction accounted for 19%, and methanogenesis was negligible. Denitrification accounted for <3% of Corg oxidation. Sulfate reduction was suppressed in the upper 5 cm, where oxygen, manganese, and iron reduction prevailed. Below this zone, sulfate reduction peaked but coexisted with microbial iron reduction. All Mn reduction was apparently coupled to iron and sulfide oxidation in the upper 6 cm. Below that level, a transient accumulation of iron monosulfide and pyrite implied that sulfate reduction increased during the 19th century because of anthropogenic atmospheric sulfur deposition. Sediment mixing through bioturbation was crucial for the cycling of Mn, Fe, and S, and estimates of biodiffusion coefficients were 0.02-0.3 cm^2 d^{-1}.