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The Fe redox cycling mediated organic matter transformation in the marginal sea

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The marginal sea serves as a critical zone for material transport and cycling between land and ocean. The complex hydrodynamic conditions in this region facilitate the widespread development of unsteady sedimentation, which significantly alters sediment redox conditions and subsequently influences the cycling of key elements at the sediment-water interface. Our research focuses on the biogeochemical processes of iron and explores its role in the molecular transformation of dissolved organic carbon under the dynamic redox conditions of marine surface sediments. Our results demonstrate that frequent redox oscillations in surface sediments significantly enhance the contribution of iron oxides as electron acceptors to organic carbon mineralization. A series of complex iron mineral phase transformations maintains the physical stability of this "redox battery," enabling its sustained function at redox interfaces. Further investigation reveals that the reoxidation of reduced iron (Fe(II)) and the associated generation of reactive oxygen species promote both the rapid degradation of small molecular organic carbon and the polymerization of certain organic molecules, thereby regulating carbon stabilization processes. The poorly crystalline iron oxides formed upon oxidation efficiently adsorb and co-precipitate organic carbon, exhibiting pronounced selective preservation of terrigenous organic carbon. Studies in sandy sediments of the marginal sea indicate that although this poorly crystalline iron phase accounts for only about 1/1000 of the sediment weight, the dissolved organic carbon bound to it constitutes approximately half of the total adsorbed carbon in sediments, playing a crucial role in intercepting terrigenous organic carbon during seawater filtration through sandy sediments. Collectively, iron redox cycling in the land-ocean critical zone exerts significant control over terrigenous organic carbon interception, as well as organic carbon remineralization, stabilization, and burial processes.