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Release of nitrite and ferrous iron from marine aggregates: anoxic nanozones?

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An important part of the decomposition of organic matter in sea water occurs in sinking marine aggregates, which play an important role in the cycling of carbon as well as nutrients and trace metals. Within aggregates the oxygen depleted by bacterial respiration may not be rapidly replaced, generating anoxic or hypoxic microzones (Ploug and Jørgensen 1999). Reduced compounds such as SH_2, CH_4, Mn^{2+} and Fe^{2+} which are not predicted to be present in oxygenated waters, have been found in sinking particles (Karl and Tilbrook 1994).

Estuarine water was collected, enriched in phytoplankton and rotated on a roller table in order to coagulate particles and form artificial marine aggregates. Individual aggregates were isolated and transferred to small beakers. The oxygen saturation across the particles was found to drop from 80% in the diffusive boundary layer to 50% in the centre of the aggregate. Ferrous iron and nutrients in the beakers were also monitored over time: the concentration of NO_3^- around aggregates was found to be constant or decrease down to 50% in 5 days whereas the amounts of NO_2^- increased by 300%. The Fe^{2+} concentration in the beakers was found to increase by 400% in 7 days.

The artificial marine snow was also incubated with different electron acceptors and donors, under anaerobic (N_2/CO_2) conditions. Bacterial communities initially present in the samples were able to strongly reduce ferric iron as well as nitrate and to grow significantly in the presence of high concentrations (10-15mM) of glucose and sulphate, inferring fermentation and sulphate reduction.

Inside marine aggregates Fe(III) and NO_3^- require anaerobic conditions to be reduced, but even in the centre of the particles examined anoxic microzones were not detected. However, in these marine aggregates, the reductions may have been occurring inside anoxic nanozones that are too small to be detected by a standard oxygen microelectrode (10μm) and abundant enough to reduce measurable amounts of ferric iron and nitrate. Trace metals and nutrients may be reduced just as consequence of anoxia occurring in these nanozones or, more probably reflect an active role of anaerobic bacteria that significantly increase the reduction processes. However, whilst in the present study with high substrate concentration, bacterial reduction appears to occur, the same process under natural conditions has yet to be fully demonstrated.