Potential biotic-abiotic nitrous oxide production in oceanic oxyclines

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Nitrous oxide (N_2O) is a potent greenhouse gas that depletes stratospheric ozone. Most oceanic N_2O emissions are from oxygen minimum zones (OMZs), where oxygen concentrations fall below detection. Incomplete denitrification at the oxycline is thought to be the largest source of N_2O in OMZs. However, N_2O can be produced by abiotic reactions between nitrogenous intermediates and metal oxides. Hydroxylamine (NH_2OH), an intermediate of ammonia oxidation, can rapidly react with manganese (Mn) oxides (NH_2OH chemo-oxidation) to produce N_2O. We provide evidence that NH_2OH chemo-oxidation by birnessite, a ubiquitous Mn oxide, rapidly and effectively produces N_2O in marine conditions. Conversion to N_2O occurs within three minutes and goes to completion. We provide preliminary evidence that the necessary substrates for NH_2OH chemo-oxidation could occur at oxyclines. We developed a method that uses SYBR Green and leucoberblin blue simultaneously to locate microbial cells and Mn oxide particles on filters (simul-staining) with differential interference contrast and epifluorescent microscopy. Simul-staining filters from the Gulf of Mexico OMZ found microbial cells associated with manganese oxide particles. While cells could not be identified, they exhibit similar morphology and size to ammonia-oxidizing archaea prevously found in the Gulf of Mexico OMZ. Our findings suggest that biotic-abiotic production of N_2O could occur in OMZs.

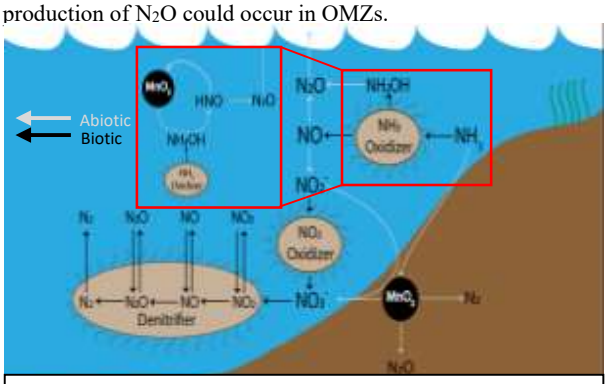

Figure 1. As ammonia is oxidized by ammonia-oxidizing microbes, NH_2OH leaks out and reacts with Mn oxides to produce N_2O.