Geophysical Research Abstracts
Vol. 21, EGU2019-9206, 2019
EGU General Assembly 2019

A Metabolic preference of nitrate over oxygen as an electron acceptor in benthic Foraminifera from Oxygen depleted environments

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Benthic foraminifera populate a wide and diverse range of marine habitats. Their ability to use alternative electron acceptors – nitrate or oxygen – makes them keyplayers within the benthic nitrogen cycle. Nevertheless, the metabolic scaling of the two alternative respiration pathways and the environmental determinants of foraminiferal denitrification rates are yet unknown. We measured the denitrification and oxygen respiration rates for ten benthic foraminiferal species sampled in the Peruvian oxygen minimum zone (OMZ). These species were able to use both nitrate and oxygen as an electron acceptor. Denitrification and oxygen respiration rates significantly scale sublinearly with the cell volume. The scaling for oxygen respiration is lower than for denitrification, indicating that their nitrate metabolism during denitrification is more efficient than their oxygen metabolism during aerobic respiration in foraminifera from the Peruvian OMZ. The oxygen respiration rate is stronger correlated with the surface/volume ratio than the denitrification rate, most probably due to the presence of intracellular nitrate storage in denitrifying foraminifera. Oxygen can be toxic in higher intracellular concentrations and thus not be stored in vacuoles. Furthermore, we observe increasing cell volume in foraminifera from the Peruvian margin, under higher nitrate availability. This suggests that the cell size of denitrifying foraminifera is not limited by oxygen rather by nitrate availability. Based on our findings, we developed mathematical functions of foraminiferal cell volume as a predictor of respiration and denitrification rates, which can further constrain foraminiferal biogeochemical cycling in biogeochemical models. Our findings show that nitrate is the preferred electron acceptor in foraminifera from the OMZ, where the foraminiferal contribution to denitrification is governed by the ratio between nitrate and oxygen (Glock et al., PNAS, in press).