Microscale oxygen distribution in invertebrate burrows from Willapa Bay, Washington

M. E. ZORN, S.V. LALONDE, M. K. GINGRAS, AND K.O. KONHAUSER

Department of Earth and Atmospheric Sciences, University of Alberta, Edmonton, Alberta, Canada (mzorn@ualberta.ca)

Previous work on oxygen diffusion in bioturbated sediments has assumed that oxygen penetration increases proportionally with increases in the surface area of the sediment-water interface. This assumption is flawed as it fails to consider the effects of different burrow linings on the rate of oxygen diffusion into the surrounding sedimentary media. In this study, thin tipped microsensors were used to measure oxygen profiles in burrow walls constructed by seven intertidal invertebrates, collected from mud and mixed sand-mudflats at Willapa Bay, Ws.

Collectively, these animals produce a variety of burrow architectures, ranging from small, unlined temporary burrows to large, thickly lined, semi-perminant to permanent structures. Results from the microsensor analysis show that the oxygen diffusion profiles through the burrow walls differed between the seven species. When compared to the profile at the sediment-water interface, the effect of the burrow walls on oxygen penentration depths can be grouped into three categories: (1) no change to oxygen diffusion, (2) enhanced oxygen diffusion, (3) impeded oxygen diffusion.

Species with simple, temporary burrows neither enhance or impede oxygen diffusion relative to the surrounding sediment. Burrows which incorporate coarser grains into the burrow walls than the ambient sediment thereby enhance the permeability and the diffusion rates. Animals that produce thick mucus linings, but display no grain-size selection relative to the surrounding sediment, impede the diffusion of oxygen into the sediment. The significance of these observations show that oxygen diffusion in burrowed sediment cannot be represented as a simple linear relationship correlating surface area and oxygen penetration. Rather, it is a more complex function of surface area and burrow architectures. These findings also demonstrate that burrowing behaviour is an effective means of controlling O_2 content within a burrow sub-environment, and likely other dissolved gases (i.e., H_2S and CO_2) as well.

Wide range of infaunal animal behaviors means the geochemical impacts of sediment-animal interactions are extremely variable

MURRAY K. GINGRAS

Earth and Atmospheric Sciences, 1-26 Earth Science Building, University of Alberta, Edmonton, Alberta, Canada, T6G 2E3, mgingras@ualberta.ca

Geochemical conditions within and adjacent to burrow subenvironments are imposed by various modifications of the local substrate produced by the burrow dweller. Among these modifications are increased area of the sediment-water interface, admixing of the sediment and pore water, preferential selection of grain size, and installation of organic substrate within and around burrows.

The above modifications are prevalent in varying degrees according to the nature of the bioturbating organism. Some animals enthusiastically excavate sediment at depth and redeposit it at the sediment-water interface. Other infauna pull sediment downwards by mining from below. Several animals filter plankton and fine sediment from the water, or dredge it from the sediment-water interface.

The range of animal sediment interactions can be categorized into behavioral groups, each of which has general geochemical significance. (1) Sediment processors manipulate large amounts of sediment, induce sediment convection, and coat the sediment grains with polysaccharides: the organic coating is commonly oxidized in the sandy (permeable) media and may have little diagenetic impact. (2) Sediment dwellers, which live in open, static burrows with pockets of stowed organic media: in this case the organics are commonly stowed within or below the suboxic zone, lower the pH locally, and provide a concentrated substrate for microorganisms leading to localized sulfate reduction. (3) Sediment miners, which occupy a vertical, heads-down position and ingest sediment from the suboxic or anoxic zone: in these cases fecal discharge carries sediment experiencing reducing conditions to the oxygenated sediment-water interface. (4) Sediment swimmers / bioturbators, which rapidly admix sediment and porewater, commonly reprocessing the sediment several times before it passes into the historical records: such activities lead to a lower oxic and suboxic zone, can impart larger volumes of mucous (polysacharides) onto the sediment grains, and may modify early calcite and aragonite cementation patterns in sandstone.