The sulfur cycle of marine sediments

B. B. JØRGENSEN

Center for Geomicrobiology, Aarhus University, 8000 Aarhus C, Denmark (bo.barker@bios.au.dk)

The sulfur cycle of marine sediments has been studied for half a century, yet very basic questions remain to be answered in order to understand the pathways and quantitative significance of sulfur transformations during early diagenesis. Transport-reaction models are used to estimate the net reduction of sulfate and its coupling to organic matter mineralization. A cryptic sulfur cycle, not detected by such models, has now been recognized beneath the main sulfate zone. I suggest that such a cryptic cycle takes place throughout the entire sediment column by concurrent sulfate reduction and sulfide oxidation. In oxidized near-surface sediments, sulfate reduction rates may be high. Here, recycling is particularly intense and may involve fascinating adaptations among bacteria specialized to utilize the available energy from sulfide, e.g. as electron-conducting cable bacteria or as migrating sulfur bacteria with nitrate tanks. Deeper down, sulfide continues to be oxidized by buried Fe(III), although the net process is sulfate reduction. This re-oxidation of sulfide involves disproportionation and other complex pathways and is experimentally and isotopically obscured by isotope exchange between several reduced sulfur species such as sulfide, polysulfide, elemental sulfur and iron sulfides. While sulfide recycling in the sulfate zone is difficult to detect, and is therefore controversial, it becomes evident in the methanogenic sediment beneath the sulfate zone. Importantly, there appears to be a continuous, monotonous decrease in organic matter mineralization rates with age and depth down through the sulfate zone and into the methanic zone. The upward diffusive flux of methane to the sulfate-methane transition therefore integrates most of the deep methanogenesis, which is otherwise difficult to quantify. The sulfate to methane flux ratio into the sulfate-methane transition is often larger than the 1:1 stoichiometric ratio of anaerobic methane oxidation, possibly due to additional organoclastic sulfate reduction within that zone.