

Large organic colloids drive biogeochemical reactions downstream of sediment interfaces in simulated aquifers

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Alluvial aquifers characteristically exhibit a multitude of juxtaposed sediment layers with sharply contrasting physicochemical and hydrologic properties. Water movement across interfaces between these layers results in mixing of porewaters of distinctly different chemical compositions, stimulating a host of biogeochemical processes. Recent observations suggest that (initially) oxic groundwater flow coming in contact with fine-grained, anoxic sediments lead to the establishment of resilient secondary reducing “halos” in downstream coarse-grained sediments. This has implications for the solubility and mobilization of e.g., trace elements and downgradient water quality.

Here, we demonstrate through iterative coupling of laboratory column experiments, microbial analyses, and reactive transport simulations that this phenomenon is primarily driven by exports of colloidal/particulate organic matter >0.15 μm , which may include live microbial cells. In other words, dissolved exports and abiotic reactions alone cannot explain the establishment of reducing “halos” in coarse-grained zones. Instead, we conclude that large, suspended, organic-containing exports (including anaerobically metabolizing microbes) from fine-grained sediments comprise the components needed for this switch in overall biogeochemical activity to take place. We expect the establishment of reducing halos to be strongly enabled by the higher abundance of electron acceptors in the recipient (previously oxic) environment. The halos are also likely to be sensitive to changes in fluid residence times and microbially mediated sulfate reduction rates. Unequivocally, we show that neglecting to account for colloidal/particulate (up to several μm -size) exports AND their reactivity could lead to erroneous groundwater quality assessments for alluvial groundwater aquifers and downgradient stream recipients.