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Characterization of sediments by dielectrophoresis – a new tool to explore organic matter-mineral interactions

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A key step in sedimentary carbon preservation is the adsorption of organic molecules onto the surfaces of mineral particles. Although this correlation has been known for decades, the exact mechanism by which carbon is associated with seafloor sediments remains poorly characterized. Few studies exist that explore the details of this process on individual particles (as opposed to bulk sediments) because most analytical tools cannot directly measure small changes in the specific surface and material properties of individual mineral particles. Dielectrophoresis (DEP) techniques from analytical chemistry have been demonstrated to assess extremely subtle changes in particle properties associated with adsorption by monitoring their electrophysical signature. This signature is resolvable to very low levels, allowing extremely small changes in surface charge, polarization, and polarizability to be quantified. These changes can be interpreted with respect to chemical (surface structure, organic structure), physical (particle properties) and geological (carbon preservation) principles.

We have examined ~0.5 to 5 mm particles including silica beads (a control) and natural marine sediments using DEP. We assessed sediments with and without their natural organic matter and show that particles with and without organic carbon have very different DEP behavior. This is the first demonstration of particle trapping by DEP for natural sediments (Figure. 1) and sets the stage for future studies that will explore the specific physical properties of these different materials. Ultimately the results will be quantitative and interpretable since the measured differences can interpreted with respect to measured carbon content, mineralogy, BET surface area, and the complex permittivity of adsorbed material.

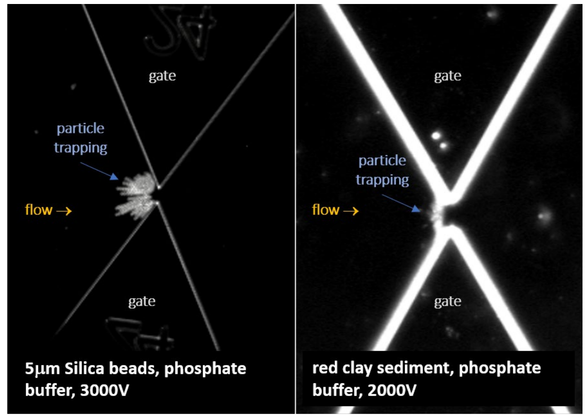

Figure 1. Left – Silica beads trapped at left side of a gate with an applied voltage of 3000V on the upstream side and 0V on the downstream side. Right – Deep sea sediment trapped at the same gate under an applied voltage of only 2000V on the upstream side indicating the conditions needed to trap sediment are different. Fluid flow is left to right.