Biogeochemical Investigations Across Oxidation-Reduction Boundaries at the Hanford Site SFA

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The area near the Columbia River shore at the 300 Area comprises a complex system where microbial populations are controlled by processes occurring across lithologic boundaries where contrasting nutrient availability and mobility impose transitions in oxidation-reduction potential. In addition, while the regional hydrologic gradient is generally from surrounding uplands toward the Columbia River, seasonal and short-term changes in river stage cause rapid fluctuations in the gradient such that the flow direction and velocity change abruptly. River water intrudes the aquifer during abrupt gradient reversals caused by rises in the river stage, imposing extreme fluctuations on local groundwater composition. Our focus is on three biogeochemically distinct formations: the underlying Columbia River basalt flows, intermediate fluviolacustrine Ringold sediments, and uppermost catastrophic flood deposits of the Hanford formation. The uppermost Ringold and the Hanford sediments are the environmentally accessible and impactful stratigraphic components within these strata, and are hydrologically coupled to the Columbia River.

A series of passive multilevel samplers were deployed across known fine-to-coarse lithologic boundaries at the top and bottom of the Ringold formation's uppermost mud. Aqueous and dissolved gas samples were analyzed for the metabolically sensitive solutes O_2, NO_3^-, NO_2^-, SO_4^{2-}, Mn^{2+}, Fe^{2+}, HS^-, N_2O, H_2, and CH_4. Across the gravel-mud boundary from the Hanford to Ringold formations, the concentrations of SO_4^{2-}, Mn^{2+}, NO_2^-, H_2, and CH_4 increased with depth, while the concentrations of O_2 and NO_3^- decreased. At the lower mud-gravel boundary, within the Ringold formation, HS^- increased with decreasing depth (i.e., into the mud). Fe^{2+} and Mn^{2+} were present throughout the sampled Ringold formation, and H_2 and CH_4 increased with depth near the gravel-mud boundary deeper in the section. Anaerobic metabolism within the fine portions of the Ringold formation apparently supported anaerobic microbial populations that actively consumed available electron acceptors. The presence of H_2 and CH_4 suggested that perhaps fermentation reactions drove a supply of electron donors, and the contrast in HS^- and SO_4^{2-} gradients across the lithologic boundary suggested that advection existed from the Ringold into the Hanford formation. PCR analyses showed that nitrate reducers increased in abundance below the gravel-mud boundary, while sulfate and metal reducers were most abundant at the boundary.

We continue to target zones of varying microbial ecology across boundaries within the stratigraphic column that separate strata with varying lithologic contrast, and at locations with varying distance to, and influence by, the Columbia River.