Goldschmidt 2022 Abstract
https://doi.org/10.46427/gold2022.11589

Microbe-mineral dynamics within a 'grass-to-glass' soil profile at a late Iron Age archaeological site with implications for long-term storage of nuclear waste glasses

JACQUELINE WELLS[1], ANDREW PLYMALE[1], CAROLYN PEARCE[1], EMILY GRAHAM[1], CHRISTOPHER BAGWELL[1], COLIN BRISLAWN[1], TANYA CHEEKE[2], VINCENT DANNA[1], SARAH FANSLER[1], BRUCE AREY[1], MARK BOWDEN[1], TAMAS VARGA[1], DANIELLE SAUNDERS[1], JESSICA ALLEN[3], JOSE MARCIAL[1], KIMBERLY TYRRELL[1], JAMIE WEAVER[4], ROLF SJÖBLOM[5], EDWARD VICENZI[6], JOHN S MCCLOY[2], EVA HJÄRTHNER-HOLDAR[7], MIA ENGLUND[7], ERIK OGENHALL[8], DAVID PEELER[1] AND ALBERT KRUGER[9]

[1]Pacific Northwest National Laboratory
[2]Washington State University
[3]Eastern Washington University
[4]National Institute of Standards and Technology
[5]Luleå University of Technology
[6]Smithsonian Institution
[7]National Historical Museums (SHMM)
[8]Geoveta
[9]US Department of Energy, Office of River Protection

Presenting Author: jacqueline.wells@pnnl.gov

Immobilization of nuclear waste within silicate glasses for subsurface disposal is generally accepted as the best practice for final waste disposal. However, our complete understanding of glass weathering over relevant time scales is limited. Microbes alter glasses through mechanical and biochemical processes, with glass serving as a nutrient source for metabolic processes, and/or a substrate for biofilm growth. To study the behavior of silicate glass waste forms over long time scales in near-surface environments, archeological glass artifacts can be used as analogues to evaluate glass alteration due to the natural environment. In this study, samples obtained during a recent excavation of a Swedish vitrified hillfort were examined to determine the interactions of the anthropogenic glass and surrounding rock with the native soil and subsurface microbial communities over the past ~1500 years. The objective was to infer processes and microorganisms that could contribute to the weathering of anthropogenic materials as a function of depth in a "grass to glass" profile. Samples were interrogated by a suite of multidisciplinary techniques, including microscopy, tomography, X-ray diffraction, microbial sequencing, and biogeochemical measurements. Detailed characterization of the interface revealed relationships between the enriched microbial community on the vitrified material, and how it differed from the microbes present in the native rock and soil. Fungal and prokaryotic organisms associated with the vitrified wall layer have been implicated in mineral and glass weathering through mechanisms that control the solubility of critical macro- and microelements. For example, fine material from one vitrified wall sample with an unusually high Archaeorhizomycetes fungal abundance was also depleted in several of these elements, in comparison with other fines samples from the same layer. Since microbial community composition is driven by changes in metabolic processes; from phototropism at the surface, to other energy sources (organic carbon, reduced nitrogen, iron, and manganese) beneath the surface, these sources will also drive mineral weathering and nutrient cycling. Our results indicate that microbial processes influence anthropogenically-engineered and natural materials through acquisition of nutrients, and provide information on long-term alteration of glass in contact with a near-surface environment, which is relevant to disposal of low activity nuclear waste.