Visualization of Adsorption, Absorption and Precipitation of Uranium Minerals by Environmental Bacteria for Bioremediation of Radionuclide-Contaminated Sites

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Mining and human use of uranium has created hundreds of sites globally where improperly disposed radionuclides and other toxic metals contaminate groundwater supplies and threaten human health. Bio-remediation strategies using environmental bacteria isolated from the contaminated site are non-invasive and effective, but have limitations in persistence. Understanding the mechanisms and mineral end-points of the bacterial-based bioremediation strategies will help alleviate limitations. Bacterial-based bioremediation strategies rely on either adsorption to cell-associated polymers in the extracellular matrix or the chemical reduction of uranium to an insoluble mineral. Many organisms also have the capability of reducing uranium and this can be done in conjunction with adsorption. Electron microscopy (EM) in combination with elemental analysis is uniquely suited to address open questions around the cellular mechanisms of uranium bioremediation approaches. We tested *Desulfovibrio vulgaris* Hildenborough (DvH), which is a model Sulfate-Reducing Bacterium (SRB) that has been shown to reduce and precipitate uranium (Majumder, unpublished data). Mechanisms of uranium reduction have been proposed in the intra and extra-cellularly, but it has not been verified in uranium is found inside the cell. DvH grown with and without uranium was visualized by ESEM coupled with X-ray Dispersive Spectroscopy (EDS), specifically the FEI Quanta 600 FEG Environmental Scanning Electron Microscope (ESEM) by aliquoting diluted culture onto a silicon wafer under low vacuum. Uranium mineral precipitate was observed next to the bacteria and in some instances had discrete ball-like structure. EDS spectra and mapping confirmed the presence of uranium in the precipitate, but did not detect any uranium inside of the bacteria. HRSTEM will be employed next for resolution on the Angstrom scale. EM and microanalysis initial characterization of these two bacterial systems has provided important mechanistic clues for remediation applications.

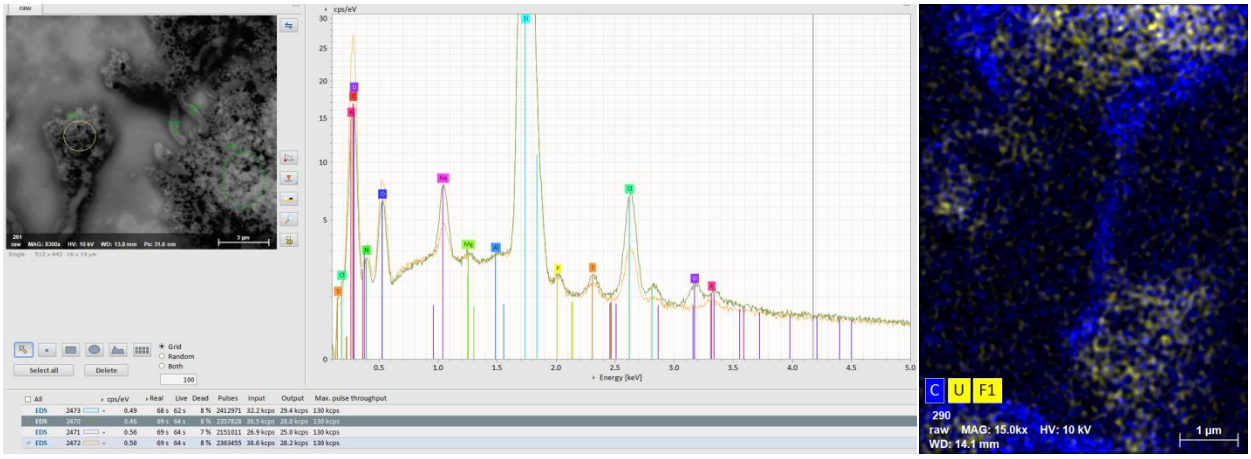

Figure 2. ESEM and EDS of DvH interacting with U. Image, spectra and elemental map.