Fungal cell-serpentine mineral interfacial recognition & interaction

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Microorganisms interact with minerals to extract critical elements needed for respiration and cellular energy production. While this general principle is well-understood, the differences in microbial response to cololizing nutrient-rich and nutrient-poor minerals is far from clear. Furthermore, the specific scheme microbes employ at cell-mineral interface to release nutrients remains to be elucidated. In this study we examine the interfacial interaction of a native fungus with Fe-containing serpentine, feldspars, and glass to explore the cell-mineral recognition and dissolution processes. Surface Enhanced Raman Scattering (SERS) measurements of the cell surfaces first gave a sharply different pattern when the microbes were attached to minerals (serpentine and feldspar) and glass. Detailed observations revealed the Raman signals were also signficantly different at hypha-tips and -body sections and on the spores, suggesting that, unique to fungus, cellular activity may be distinct when mineral is associated with the long thread-like hyphae and the spherical spores. Meanwhile, the fungi grew 2- to 3-times longer in their hyphae and produced 15 to 20% proteins when the substrate changes from glass to serpentine, and showed more than a unit pH decrease at the cell surfaces before (suspended) and after attachment to serpentine grains. More importantly, Focused Ion Beam Transmission Electron Microscopy analyses on the cross-section of cell-serpentine interfaces found exclusive Fe loss from the mineral phase in comparison to mineral-water interfaces, and serpentine amorphisation undernearth the etch pits formed by hyphae but not those by spores. Lastly, bulk experiments provided evidence suggesting markedly heightened bioprouction of siderophores and drastically enhanced bioweathering if cells are allowed to be physically interact with the mineals grains. Put it together, these findings indicate that fungi are able to recognize mineral subtrate using membrance proteins or excellular probes, and attack the target using chemical forces (decease pH on cell surfaces), biochemical forces (siderophores), and mehenical forces (turgor pressure at hypha tips).