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Seismic monitoring of biopolymer accumulation and permeability reduction in sands

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Bacterial colonization and the spread of biopolymer, gel-like material, on porous media are known to decrease permeability by several order of magnitude and to cause bioclogging thereby altering the hydraulic flow systems of porous media. Attention to microbial bioclogging has been increasing owing to the increasing demand of microbial soil treatment and soil improvement. Successful microbial bioclogging treatments require geophysical monitoring techniques to provide appropriate spatial and temporal information on bacterial growth and activities in the subsurface; such monitoring datasets can be used to evaluate the status of plugged sections and optimize re-treatment if the plug degrades. Therefore, this study investigated the feasibility of using P- and S-wave velocity and attenuation for monitoring the accumulation of bacterial biopolymers and the permeability variations during bioclogging. In sand-packs, Leconostoc mesenteroides was cultured and stimulated to produce insoluble biopolymer and generate bioclogging. During such bacterial bioclogging, permeability and high-frequency P- and S-wave responses were monitored. P-wave velocity was consistent and S-wave velocity was increased with biopolymer accumulation. Both P-and S-wave attenuation, evaluated by using spectral ratio method, were increased with increasing biopolymer saturation. Increases in seismic attenuation are closely linked to the biopolymer saturation and permeability reduction. Herein, we also presented a theoretical model to correlate biopolymer saturation, permeability, and seismic attenuation by modifying three-phase Biot model and Pride-Berryman double-porosity model.

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