A laboratory study of biogeochemical processes in an arsenic-contaminated aquifer

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Groundwater arsenic contamination is a significant health risk to millions of people worldwide. Microorganisms save energy by reducing arsenate, ferric iron, sulfate, and other electron acceptors. In aquifers, these processes can potentially degrade water quality by mobilizing arsenic. Here we show in an arsenic-contaminated volcaniclastic aquifer how microbial metabolisms change aquifer chemistry and release arsenic into groundwater. We mixed sloughed sediments from the aquifer with synthetic groundwater to construct a series of batch reactors. These reactors included a biological control of sterilized sediments, a microcosm of native aquifer conditions, and two ethanol-stimulated microcosms (with and without sulfate addition). We incubated these microcosms for two months and monitored the chemistry in the solid, aqueous, and gas phases. In the reactor simulating native conditions, arsenate was reduced; however, no significant reduction of ferric iron or sulfate was detected. In the microcosm amended with ethanol, significant reduction of arsenate and ferric iron occurred, releasing arsenic into groundwater. In the microcosm with the addition of both ethanol and sulfate, significant reduction of arsenate, ferric iron, and sulfate occurred, producing significant sulfide minerals, and maintaining groundwater arsenic at relatively low levels. These data highlight the compounding effects of microbial reduction of arsenate, ferric iron, and sulfate on the occurrence and mobility of groundwater arsenic.