ABSTRACT: The main objective of this project is to examine the role of phosphohydrolases in naturally occurring subsurface bacteria for the purpose of promoting the immobilization of uranium through the formation of insoluble uranium phosphate minerals. Our prior work focused on pure culture and soil column studies that utilized contaminated soils from the DOE Oak Ridge Field Research Center (ORFRC) to demonstrate that microbial phosphatase activity liberated enough inorganic phosphate (PO$_4^{3-}$) from synthetic organophosphate compounds to promote uranium-phosphate mineral formation under oxic and anoxic conditions at different pH (pH 5.5 and 7). Simultaneously, addition of exogenous organophosphate was shown to promote the formation of intracellular polyphosphate. The objective of the present research was to examine the potential of utilizing phytate, a naturally-occurring and abundant organophosphate in soils, as a phosphorous source to promote U(VI)-phosphate biomineralization by natural microbial communities. While phytate hydrolysis in aerobic incubations of ORFRC soils was not evidenced at pH 7.0, complete hydrolysis was observed both with and without electron donor at pH 5.5, suggesting indigenous microorganisms express acidic phytases in these soils. The presence of uranium accelerated phytate hydrolysis but decreased the rate of hydrolysis of inositol intermediates as a result of a possible toxicity effect on the indigenous population. The abundant production of inorganic phosphate drastically decreased uranium solubility via formation of ternary sorption complexes and precipitation of U(VI)-phosphate minerals. Two phytase-positive microorganisms identified as *Bradyrhizobium* and *Variovorax* species by 16S rRNA sequencing were isolated from these soils. To determine the effect of uranium on phytate hydrolysis by ORFRC microorganisms, *Variovorax* sp. was exposed to increasing concentrations of uranium then incubated aerobically in pH 5.5 artificial groundwater amended with an electron donor and phytate as the sole phosphorus source. The hydrolysis of phytate by cells exposed to uranium was incomplete compared to unexposed cells, yet cells grew even in the presence of elevated uranium concentrations. Simultaneously, total inorganic phosphate production decreased linearly with increasing uranium concentrations, indicating a significant uranium toxicity effect on the cells. More importantly, exposure to increasing uranium concentrations resulted in earlier onset and more rapid accumulation of inorganic phosphate compared to identical reactors without uranium, suggesting phytate hydrolysis is activated as a uranium detoxification mechanism. Overall, the results of this study demonstrate the ability of natural microbial communities to liberate phosphate from phytate in acidic soils and the potential utility of phytate-promoted biomineralization of U(VI)-phosphate minerals as a uranium immobilization strategy.