Selenium Attenuation via Naturally-Induced Reductive Precipitation in the Southeast Idaho Phosphate Patch

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Background/Objectives. Phosphate mining in the Southeastern Idaho Phosphate Patch (Phosphate Patch) has resulted in groundwater impacts due to the oxidative release of selenium and other metals and metalloids from waste rock. Selenium is of particular concern given its relative mobility in the environment and its toxicity to ecological receptors. Previous studies have documented selenium attenuation in reducing conditions in stream sediments, wetland environments, unsaturated sub-oxic conditions, and saturated sub-oxic conditions, among others. This process represents an important natural attenuation mechanism for selenium, with implications for both mine planning/permitting and design of reclamation strategies. The objective of this work was to further evaluate conditions that lead to reductive selenium attenuation in groundwater.

Approach/Activities. Groundwater geochemical data collected at several former mines within the Phosphate Patch have been evaluated and compared with waste rock/backfill leachate at seeps and springs (representing a potential source to groundwater), background groundwater quality, and results of laboratory experiments (including saturated and unsaturated column tests performed on selenium-bearing waste rock). Selenium attenuation was evaluated based on comparison with sulfate, noting that the onset of selenium reduction is generally observed in the Phosphate Patch before sulfate reduction as water transitions from oxic to sub-oxic. These results were then compared with redox-indicator water quality parameters where available, including concentrations of dissolved oxygen, iron, and manganese.

Results/Lessons Learned. Field results indicate that selenium attenuation via reductive precipitation is observed in both unsaturated and saturated low-oxygen environments beneath or adjacent to waste rock piles. Specifically, while the release of selenium is ubiquitous within shallow zones of dumps and backfills, attenuation largely relies on dump configurations that lead to consumption and limited replenishment of pore gas oxygen. However, this effect does not necessarily follow simple relationships (such as waste rock thickness) and is highly unique to site-specific conditions. Owing to the abundance of organic carbon associated with shale in the waste rock, it is further suggested that development of reducing conditions in the waste rock itself is a more important process than reduction in underlying aquifers where organic carbon sources may be low. The results suggest that a better understanding of the conditions leading to selenium reduction may be leveraged in the optimization of mine closure strategies, such as capping and covering of waste rock zones.