OSMRE National Technology Transfer Team (NTTT), **Applied Science Fact Sheet***
U.S. Department of the Interior, OFFICE OF SURFACE MINING RECLAMATION AND ENFORCEMENT

Backfill Geochemical Model and Treatments for Lessening Solute Mobility and Improving Aquifer Water Quality in Restored Coal Mine Pits, Powder River Basin

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Project Description and Objectives:

Open-pit mining utilizes waste rock for landscape restoration during the post-mining period, which may include the construction of backfill aquifers. With the reintroduction of groundwater to a backfill aquifer, weathering of the waste rock may release contaminants that were previously unavailable in the overburden/interburden material (Fig. 1). Such changes to water quality are not easily predicted given the limited presence of such contaminants in groundwater found within the overburden material before mining. The goal of this study was the characterization of the contaminant sources and weathering processes in backfill waste rock through benchtop weathering experiments, evaluation of newly available contaminant sources through geochemical modeling of waste rock weathering, and an evaluation of potential construction options for reducing contaminant release.

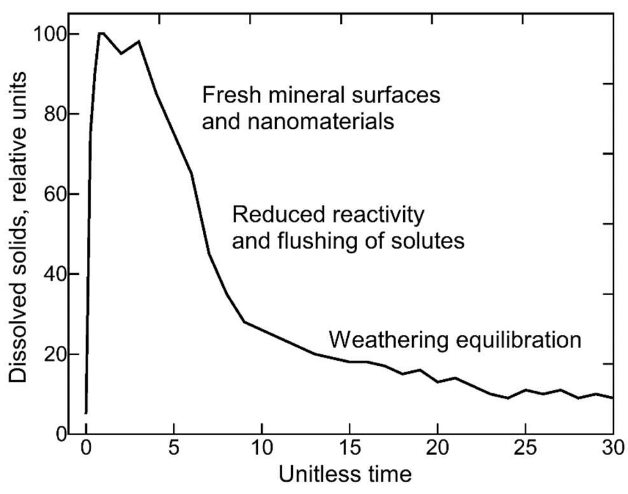

Fig. 1. Typical solute trend with weathering of fresh waste rock.

Applicability to Mining Reclamation:

Impacts on water quality from newly available contaminant sources in waste rock are highly variable, but such impacts have been documented for up to 15+ years in backfill aquifers of the Powder River Basin. The primary issue is not our lack of mineral weathering knowledge, but our ability to identify contaminant source availability with waste rock generation.

Methodology:

Waste rock from the Cordero Rojo open-pit coal mine in the Powder River Basin was exposed to benchtop leach column experiments for 20 weeks. Column leachate was collected for analysis of Eh, pH, specific conductance, alkalinity, and cation and anion concentrations as unfiltered and 0.45-µm and 0.2-µm filtered concentrations.

To better predict the mobilization of high-priority contaminants, such as arsenic and selenium, basic forward geochemical models were constructed to replicate the typical modeling scenario for the identified mineral sources of arsenic and selenium. Enhanced models were constructed to capture newly available source contributions (Fig. 2) to supplement the initially identified contaminant sources and weathering processes.

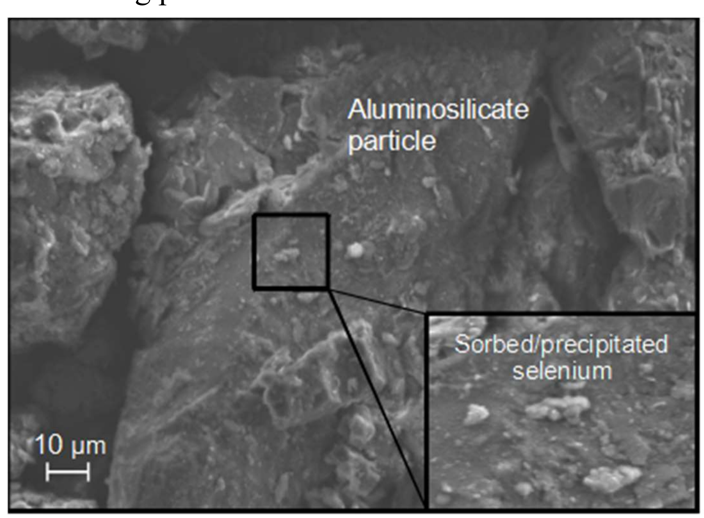

Fig. 2. The identifiable presence of a sorbed selenium (e.g., selenite) on pre-experimental plagioclase particle in the waste rock.

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Additional leach columns were amended through the introduction of soil, zeolite, compaction of the waste rock, and rinsing of the waste rock to evaluate available options for reducing contaminant transport. A soil layer is present in the overburden that could be separated during overburden removal and added as a layer-specific amendment during backfill. Similarly, zeolite is a readily available and low-cost soil amendment that has a long history of being used to reduce the transport of cationic solutes. Compaction was tested as a possible amendment with the consideration of enhanced construction techniques to increase compaction of the waste rock to lessen available groundwater pathways that could interact with the newly available contaminant sources. The rinsing amendment is a difficult treatment for the construction of backfill aquifers but was considered as a treatment if backfilling was delayed and the temporarily stored waste rock was exposed to greater weathering prior to backfill aquifer construction.

Highlights:

Important conclusions of the study include:

1. After an early weathering stage, all environmental parameters slowly evolved towards a chemical equilibrium of neutral, oxidizing, and low solute weathering.
2. Over the course of the column experiment, the concentration trend of certain elements indicated individual weathering processes.
3. Enhanced geochemical models were able to capture new source contributions (Fig. 3).
4. The leachate from the amended columns indicated that compacted and rinsed waste rock were able to reduce the release of solutes in comparison to the unamended leachate and the soil and zeolite amendments.

Results and Findings:

1. During the leach column experiment, leachate Eh and pH substantially varied during the first 55 days, which corresponds to a period of high specific conductance and alkalinity values. Correspondingly, anion and cation concentrations were the largest during this early weathering stage and the filter fractions assisted in identifying multiple weathering processes, such as particle transport, salt dissolution, and sulfide oxidation. After this early weathering stage, all environmental parameters slowly evolved towards a chemical equilibrium with the loss of nanomaterial availability and newly available reactive minerals.
2. The concentration trend of certain elements indicated particular weathering processes—cadmium and nanoparticle transport, selenium and salt dissolution, and arsenic and the oxidation of pyrite.
3. The compaction amendment (10 % volume reduction) restricted the flow of water and the interaction with the new contaminant sources.

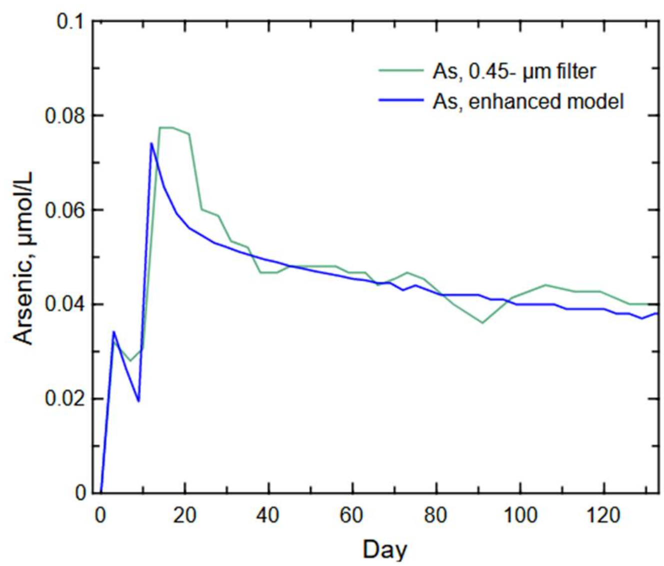

Fig. 3. Arsenic concentrations predicted from the enhanced arsenic model of desorption/salt dissolution and oxidative dissolution of arsenic-bearing pyrite compared to leachate concentrations.

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