Remediation of acid mine drainage from hydrothermally-altered coals

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In the Illinois Basin, abnormal accumulation of metals in coals is spatially linked to the Permian-age mafic to ultramafic igneous activity that produced local enrichments of iron, sulfur, and trace metals (e.g., V, Cr, Cu, Ni, Zn, Mo, Co, REY). Mining, processing, and disposal of these hydrothermally-altered coals, has produced large volumes of acid mine drainages (AMD), which are low-pH waters with elevated sulfate and metal content. Prevention and treatment of these AMD has presented challenges.

Recent field and laboratory investigations by our team [1] have shown that a combination of geochemical (i.e., carbonate addition) and biological (i.e., microbial reduction of sulfate and ferric iron) treatment technologies can contribute to AMD remediation through alkalinity production and sequestration of potentially toxic contaminants in solid precipitates. Key aspects in designing optimal bioremediation strategies are: (1) selection of optimal microbial inoculum, (2) type of the organic substrate, and (3) knowledge of contaminant mobility and long-term stability of the neoformed precipitates since changing environmental conditions can often result in remobilization. We find evidence that active Fe redox cycling mediated by various microorganisms that catalyse the dissimilatory oxidation of Fe(II) (FeOB) or reduction of Fe(III) (FeRB), as well as the competition for limited carbon and energy sources, have a negative impact on the long-term precipitate stability. Additionally, the nano- and micron-scale detrital particles originating from the weathering coal mine wastes were important vectors in: (1) AMD contaminant transport and sequestration by promoting heterogeneous nucleation and growth of Fe-rich neoformed precipitates in oxic zones, and (2) contaminant remobilization by promoting phase transformation and dissolution of neoformed minerals in anoxic zones.

Improved knowledge of pollutant dynamics is not only of fundamental importance for understanding transport, immobilization and sequestration of contaminants but also could lead to novel, effective technologies for pollution control in watersheds affected by coal mining activities.

[1] Lefticariu, L. et al. (2015) *Applied Geochem* 63, 70-82.