

‘Low-acid’ sulfide oxidation using nitrate-enriched groundwater

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Acid drainage (AMD/ARD) is undoubtedly one of the largest environmental, legislative and economic challenges facing the mining industry. In Australia alone, at least \$60m is spent on AMD related issues annually, and the global cost is estimated to be in the order of tens of billions \$US. Furthermore, the challenge of safely and economically storing or treating sulfidic wastes will likely intensify because of the trend towards larger mines that process increasingly higher volumes of lower grade ores and the associated sulfidic wastes and lower profit margins.

While the challenge of managing potentially acid forming (PAF) wastes will likely intensify, the industrial approaches to preventing acid production or ameliorating the effects has stagnated for decades. Conventionally, PAF waste is segregated and encapsulated in non-PAF tips to limit access to atmospheric oxygen. Two key limitations of the ‘cap and cover’ approach are: 1) the hazard (PAF) is not actually removed; only the pollutant linkage is severed; and, 2) these engineered structures are susceptible to physical failure in short-to-medium term, potentially re-establishing that pollutant linkage.

In an effort to address these concerns, CSIRO is investigating a passive, ‘low-acid’ oxidation mechanism for sulfide treatment, which can potentially produce one quarter as much acidity compared with pyrite oxidation under atmospheric oxygen. This ‘low-acid’ mechanism relies on nitrate, rather than oxygen, as the primary electron acceptor and the activity of specifically cultured chemolithoautotrophic bacteria and archaea communities. This research was prompted by the observation that, in deeply weathered terrains of Australia, shallow (oxic to sub-oxic) groundwater contacting weathering sulfides are commonly inconsistent with the geochemical conditions produced by ARD. One key characteristic of these aquifers is the natural abundance of nitrate on a regional scale, which becomes depleted around the sulfide bodies, and where pH remains neutral.

The "low-acid" oxidation of sulfides with nitrate as an electron acceptor has been demonstrated at the laboratory scale. In 90-day microcosm respirometry experiments, we exposed a mixture of pulverized quartz and pyrite -rich ore to natural, high-nitrate groundwater and inoculated the microcosms with a culture of aerobic and anaerobic nitrate-dependent iron and sulfur-oxidising microorganisms, which were enriched from ore, groundwater and activated waste water. Incubations were performed under both oxic and anoxic conditions, in addition to abiotic controls. Initial results show that oxidation of the sulfides under nitrate-rich and microbially enhanced conditions does produce less acid than the same material under oxic conditions, and to some degree can match the models as long as oxygen ingress can be controlled. These results are the focus of further research into how this process can be enhanced and whether it can be applied in the field.

Nitrate-driven oxidation of sulfides could potentially be used as a new approach to reduce acid generation and leaching of contaminants from waste dumps, in a passive or actively managed process designed to deplete and/or ameliorate (i.e. through surface passivation) the mineralogical hazard. Developing our understanding of biological aspects of these processes may also allow testing of longer-term "bio-caps" for various tailings and dump materials.