Case Study: 20 Years of ARD Mitigation after a Bactericide Application

James J. Gusek
Sovereign Consulting Inc.
Van Plocus
Diamond Engineering
HISTORY

Geophysical Mapping and Subsurface Injection for Treatment of Post-Reclamation Acid Drainage

Van G. Plocus and V. Rastogi

Paper presented at the 1997 National Meeting of the American Society for Surface Mining and Reclamation (ASSMR)

Austin, Texas, May 10-15, 1997

See: www.asmr.us
Outline

• Introduction to the ARD Tetrahedron/First Principles of ARD Suppression
• 1995 Bactericide Injection Event Summary
• 19 Years of Data
• Some Ideas of Why the Effects Linger
ARD is a global **bacterial infection**.

There are plenty of geo-antibiotics available but the current situation might be a lack of education. We’ve know about this for over 25 years.

What’s needed is a mining-analogue to an I-V drip of tetracycline and/or oral antibiotics.

And then there’s the question: Do we need to **Vaccinate** or **Medicate** and what do these concepts mean?
Acid Rock Drainage Tetrahedron

Fuel
Air
Heat

Oxidizer
(Air, Fe\(^{+3}\))

Water

Pyrite

Bacteria

ARD
Acid Rock Drainage Tetrahedron

DO NOTHING = PERPETUAL TREATMENT

DO SOMETHING (anything) = PATHWAY TO WALK-AWAY
Acid Rock Drainage Tetrahedron

Water

Oxidizer
(Air, Fe$^{+3}$)

Pyrite

Good Bacteria

“PROBIOTIC”

PATHWAY TO WALK-AWAY
“Control of acid generation for prolonged periods greatly enhances reclamation efforts and can reduce reclamation costs by reducing the amount of topsoil needed to establish vegetation. Three natural processes resulting from strong vegetative cover for three years or more can break the acid production cycle. These processes are:

1. A healthy root system that competes for both oxygen and moisture with acid-producing bacteria;

2. Populations of beneficial heterotrophic soil bacteria and fungi that are reestablished, resulting in the formation of organic acids that are inhibitory to *T. ferrooxidans* (Tuttle et al. 1977); and

3. The action of plant root respiration and heterotrophic bacteria increase CO$_2$ levels in the spoil, resulting in an unfavorable microenvironment for growth of *T. ferrooxidans*.”

Fisher Site Location
Site was mined and backfilled in 1984.
Fisher Site Location

282 meters

Legend:
- DRILL HOLE
- OVERBURDEN HOLE
- MONITORING WELL
- BOG

NaOH Amendment (Pre-injection event)
Site Imagery (2003 & 2011)

300 feet/92m
1995 Injection Event

- Geophysics targets three ARD-generating zones; seep pH was 5.5; iron 17 mg/L and higher
- Passive treatment alone could not meet discharge limits
- Multiple injection boreholes on a tight spacing
- Injection of 20% NaOH solution simultaneously into 12 shallow (3 m deep) boreholes with packers
- Injection of 2% sodium lauryl sulfate bactericide
- Cost of reagents: $8,400
- Seepage continues to be net alkaline 19 years later, bond release is imminent
Acidity & Alkalinity Loading

- INJECTION EVENT
  JUNE, 1995

- NEGATIVE ACIDITY "TIPPING POINT"
  JUNE, 2008

Acidity & Alkalinity Loading

SAMPLING DATE


Site Drought

Performance Data (1 of 3)
Performance Data (2 of 3)

Iron and Manganese Loading

Fe & Mn Loading Rate (Kg/day)

Injection Event JUNE, 1995

Drought

NEGATIVE ACIDITY "TIPPING POINT" JUNE, 2008

Fe Load
Mn Load

Sampling Date
Performance Data (3 of 3)

Declining sulfate trend

INJECTION EVENT JUNE, 1995

NEGATIVE ACIDITY "TIPPING POINT" JUNE, 2008

Site Drought

Post-Drought Rinsing?
Why Does It Still Work – 20 Years Later?

1) The initial “flooding” injection of caustic neutralized the residual acidity in the mine waste so that the subsequent application of bactericide was “protected” from chemical attack;

2) The bactericide solution (2% sodium lauryl sulfate) would have followed the preferential pathways established during the stage 1 injection of caustic to inhibit the activity of the acidophilic community; and

3) The well-established revegetated surface of the site provided a steady supply of bacteria inhibiting organic acids (and continues to do so) which appears to have suppressed the “reinfection” of the site that would have otherwise occurred.

Theory: if organic matter had been added to the backfill during mining, steps 1 & 2 would have been unnecessary.
19 Years of Hindsight
1) Geophysical investigation was very successful in identifying ARD “hot spots”.

2) Agronomic amendments could have helped to mature the site vegetation faster and the groundwater improvements might have been observed sooner.

3) The initial conditions were not the worst ARD chemistry compared to some other sites, but the improvements appear to be sustainable.
Acid Rock Drainage Tetrahedron

Water

Oxidizer
(Air, Fe$^{+3}$)

Pyrite

Bacteria

(Diamond Engineering Associates)
Acid Rock Drainage Tetrahedron

Water

Oxidizer
(Air, Fe$^{+3}$)

Pyrite

Good Bacteria

“PROBIOTIC” PATHWAY TO WALK-AWAY
Thank You

DO SOMETHING (anything) as a first step on the
PATHWAY TO WALK-AWAY

jgusek@sovcon.com

and

vanplocus@diamond-engineering.com