Sustained Treatment of AMD Containing Al and Fe^{3+} with Limestone Aggregate

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Limestone Advantages

- Limited solubility
  - cannot over-treat
  - Can install years of treatment capacity
- Can store on site in open piles without loss
- Not hazardous
- Less than 20% the cost of lime and caustic alternatives

Limestone Disadvantage

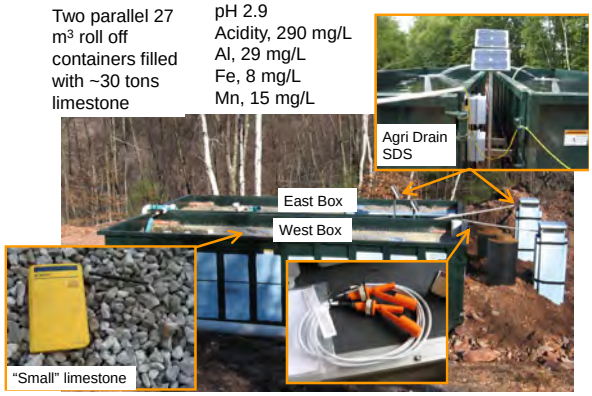
- When exposed to acidic water containing Al and Fe^{3+}, solids quickly form
- Solids foul limestone aggregate, greatly decreasing its effectiveness

Project Goals

Understand the ways that the limestone treatment effectiveness is reduced by Al and Fe solids.

Develop a treatment approach can overcome these limitations and provide sustainable treatment of low pH AMD with limestone aggregate

Construction of Experimental Flush Units



Experimental

- Measure performance of limestone units
  - Influent and effluent samples
    - pH, alkalinity, acidity, sulfate
    - Total and dissolved Al, Fe, and Mn
- Vary operational parameters
  - Flow rate
  - Water level in limestone bed
  - Drainage trigger (time, water level, chemistry)

Solids

Solids form when alkaline conditions arising from calcite dissolution cause:

- $Al^{3+} \rightarrow Al(OH)_3$
- $Fe^{3+} \rightarrow Fe(OH)_3$

Solids accumulate in the aggregate in two manners

Solids accumulate in pores

Solids form scale on limestone

Scale flakes off revealing clean LS surface

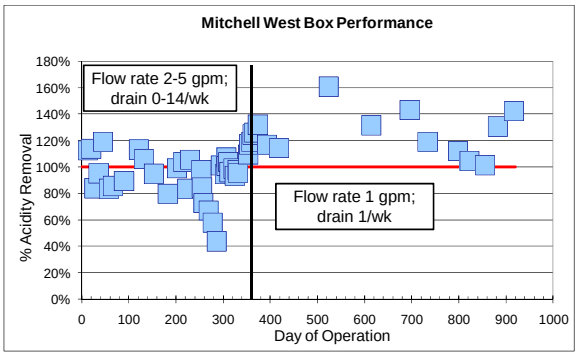
What happens when a limestone bed is drained empty?

- Solids in aggregate pores are flushed away
  - porosity is restored
- Some scales are dislodged, exposing clean limestone surface
  - Alkalinity generation is restored

Treatment Goal

- Identify the retention time necessary to achieve treatment goals
- Identify the bed drainage schedule that maintains treatment effectiveness

Long-term alkalinity generation



Average effluent chemistry since change to 1 gpm and 1/wk drainage (580 days)

	pH	Acid	Fe	Al	Mn
Influent	3.0	246	9.7	27.2	14.6
Effluent	6.9	-60	0.6*	2.6*	2.8**

Metals are mg/L and acidity is mg/L $CaCO_3$
*Suspended solid; **dissolved

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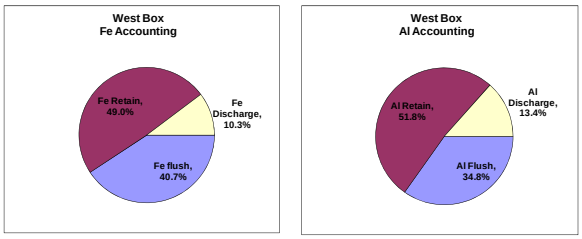
Average alkalinity generation rate: 100 g/m^2/day

Solids in a drained limestone bed
(average over 917 day period)



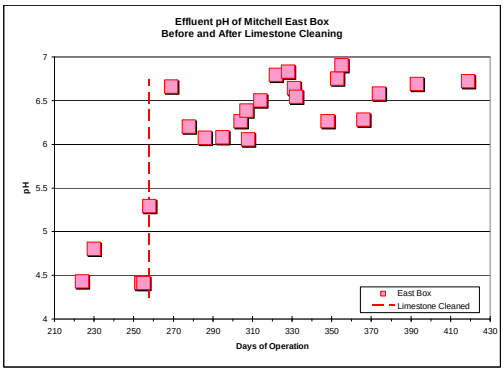
Solids accumulation will eventually affect calcite dissolution and bed performance:

- Limestone must be either replaced or cleaned

Cleaning limestone bed with an excavator and AMD flow

Cleaned limestone aggregate

- Cleaning cost: $5/ton
- New limestone costs $22/ton



Summary

1. Effective treatment of acidic Al and Fe^{3+} contaminated mine water can be achieved with limestone aggregate as long as the bed is regularly drained empty.
2. Fouled limestone aggregate can be cleaned and its alkalinity generation restored.
3. Sustainable Mn removal can be achieved at pH levels between 6.5 and 7.0.