

# Underground Mine Water Quality Evolution: Long-term Data Sets

West Virginia Mine Drainage Task Force  
Annual Meeting  
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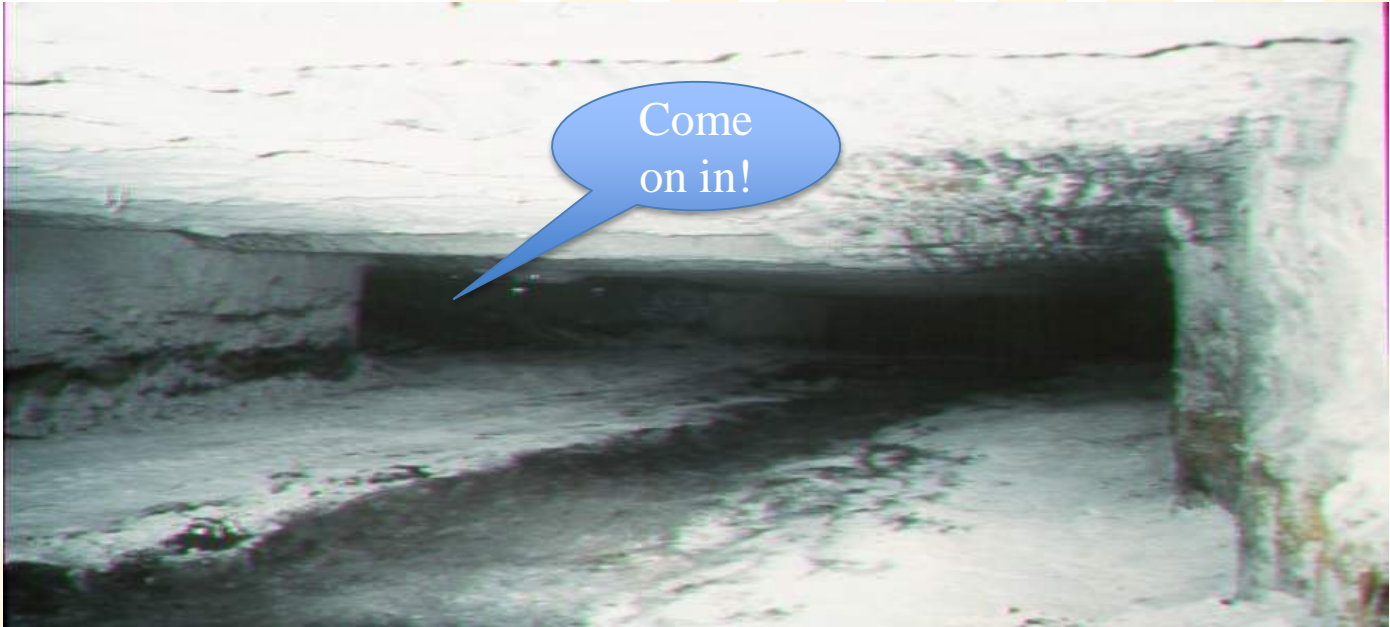
# Mine settings

- Underground mines:
  - above drainage, free draining
  - below drainage, flooded

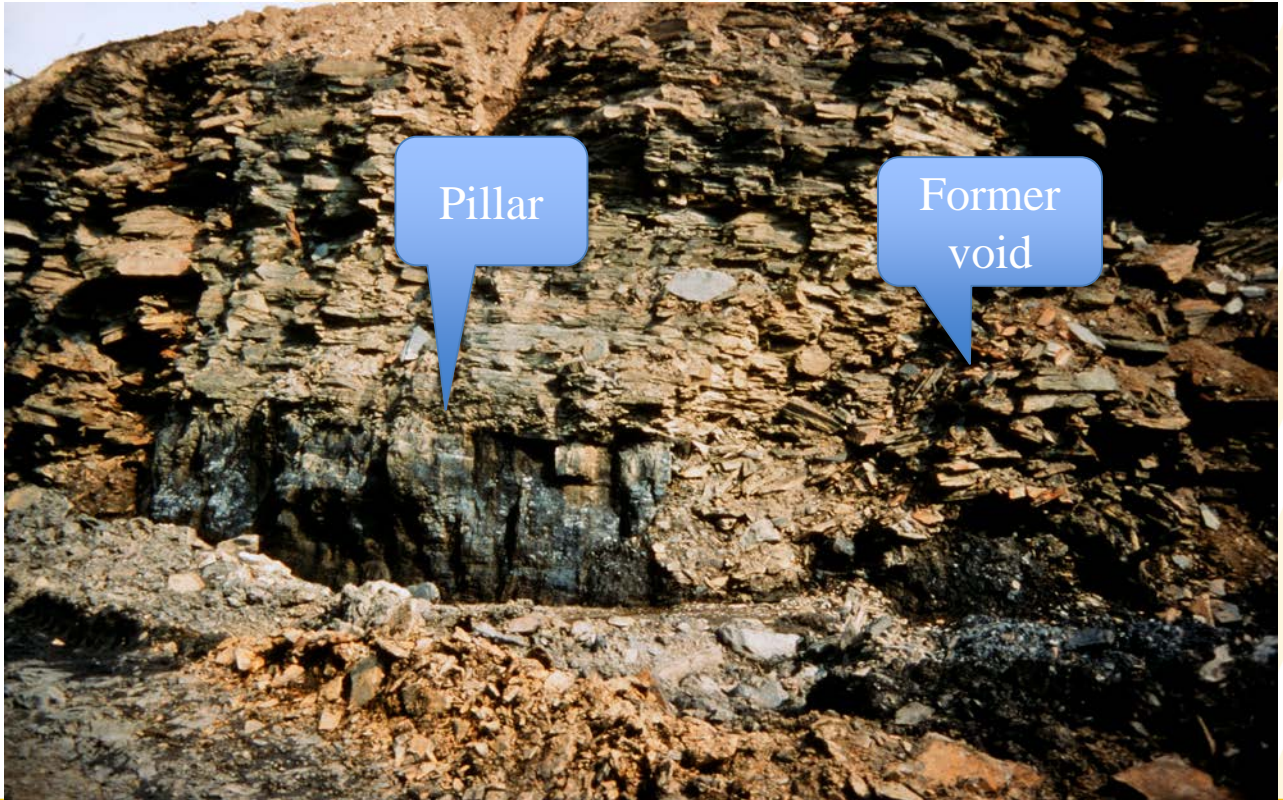


# Underground Coal Mine Voids

Often more welcoming than you might think



At least until the roof falls in



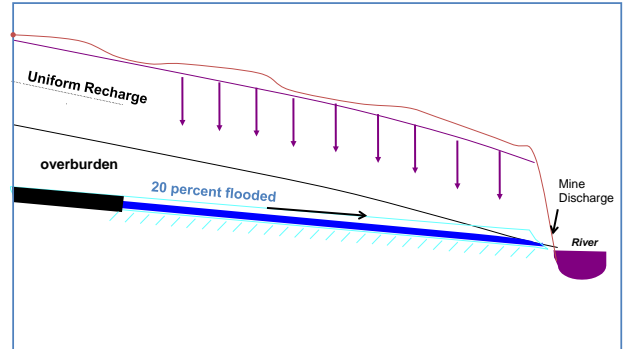
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# Mine setting influences AMD

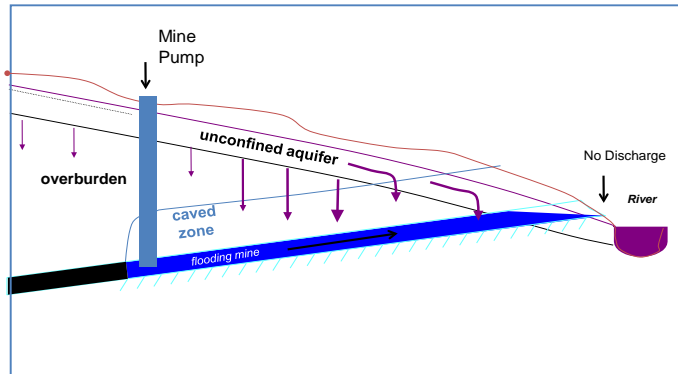
**long term, net acid, low pH**

**Unflooded, Free Draining**



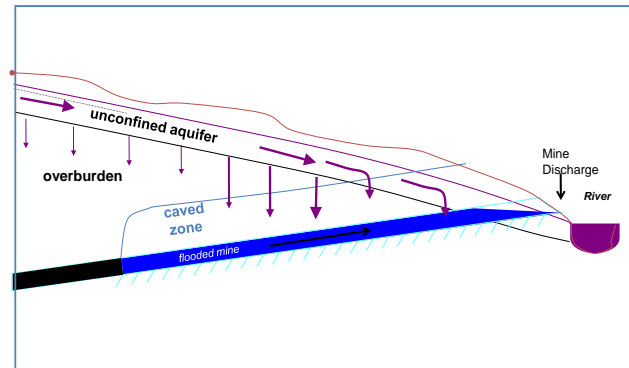
**Short term net acid to net alkaline**

**Flooded Mine Low Dilution**

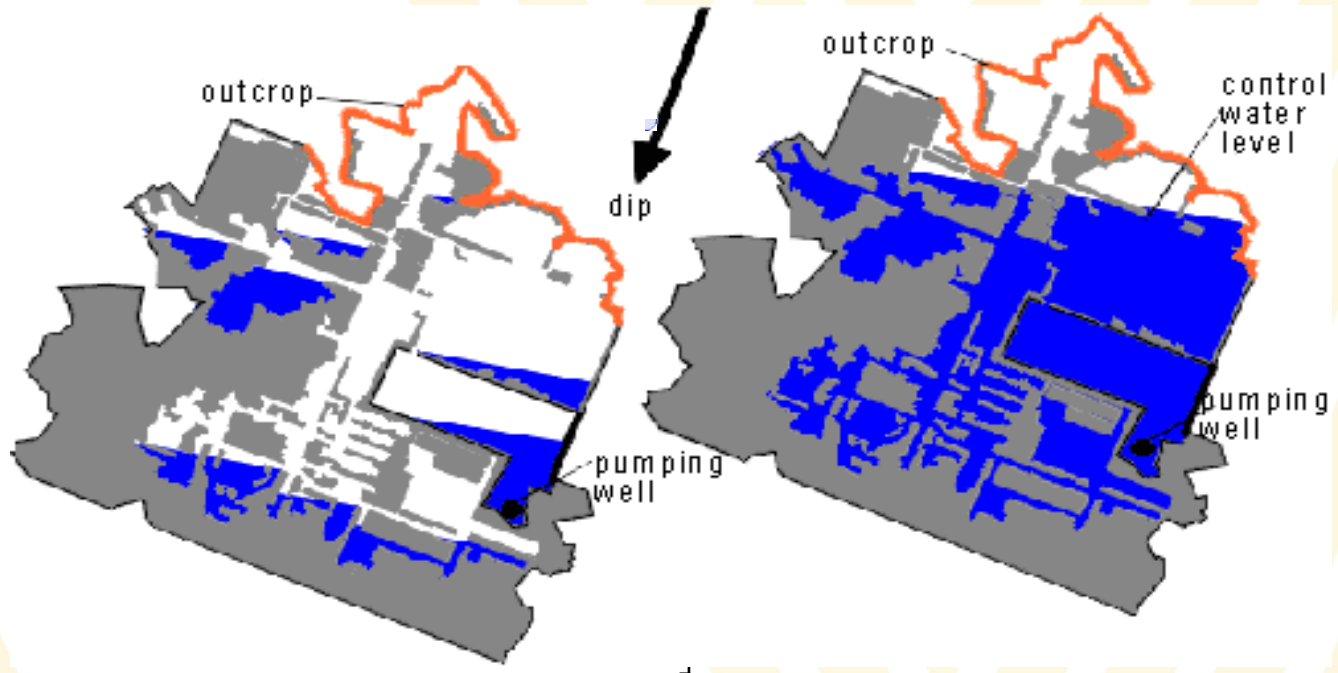


**Net alkaline, High pH**

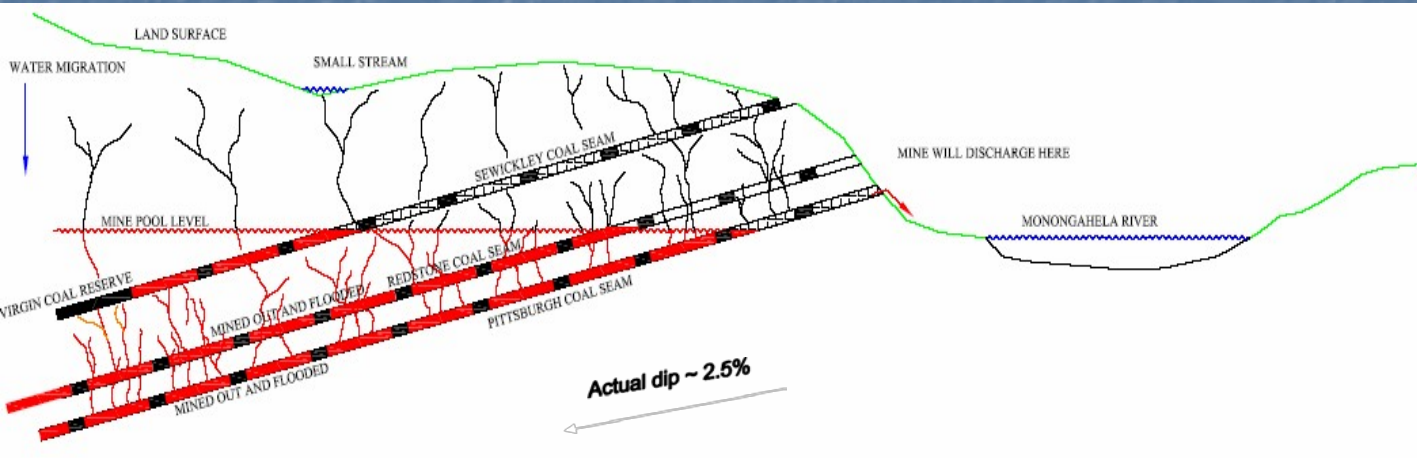
**Flooded High Dilution**



# The flooding process



# Often multiple seams are mined



# Abandoned underground mine AMD discharge, Tenmile Creek, PA



11/9/2000

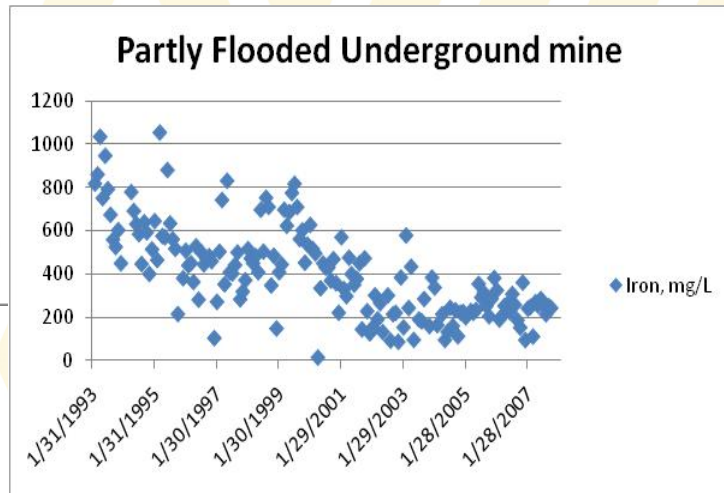
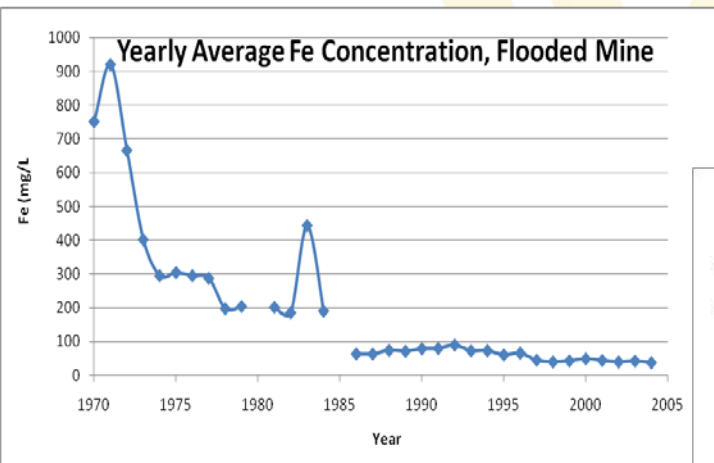


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# OSM RESULTS FROM THE FAIRMONT MINE POOL



# CASE STUDIES

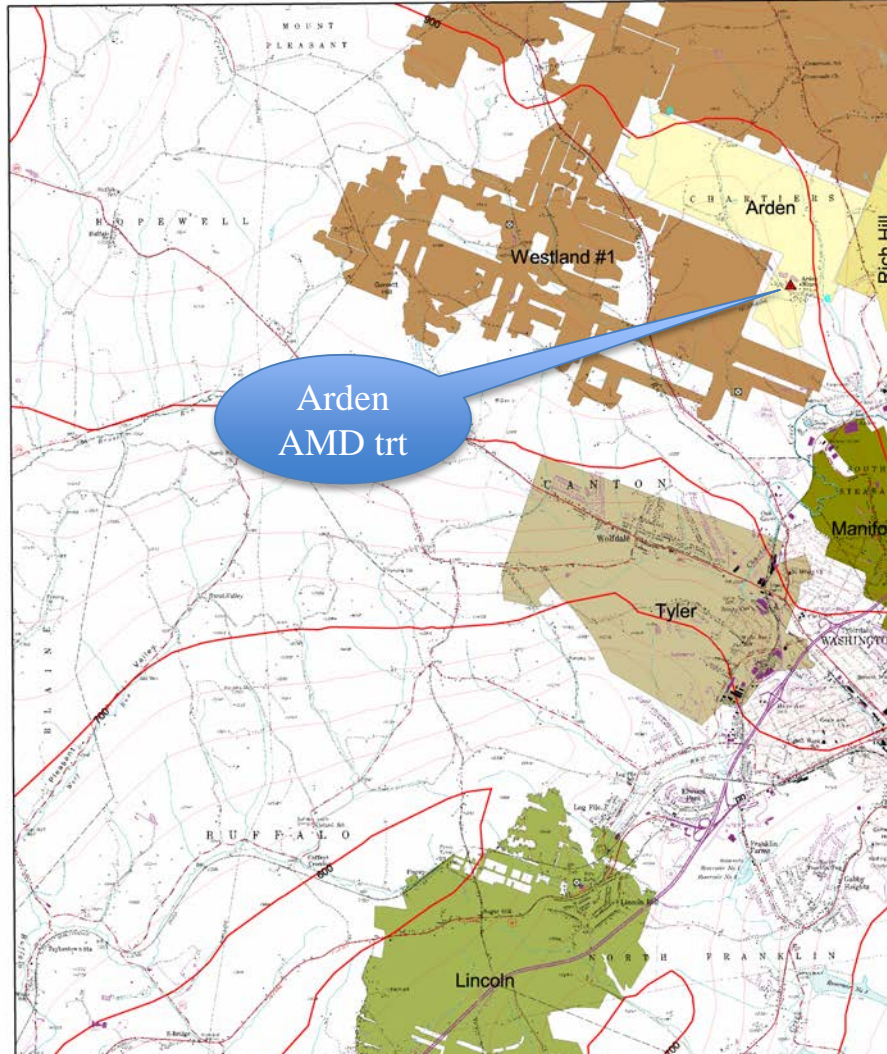
- **Montour 4 Mine**
  - 60% flooded
  - pumped from back of the mine
  - sampled at the Hahn AMD treatment plant
  - 22 year record
- **Westland 1 Mine**
  - 50% flooded
  - pumped near entry
  - sampled at the Arden AMD treatment plant
  - 13 year record



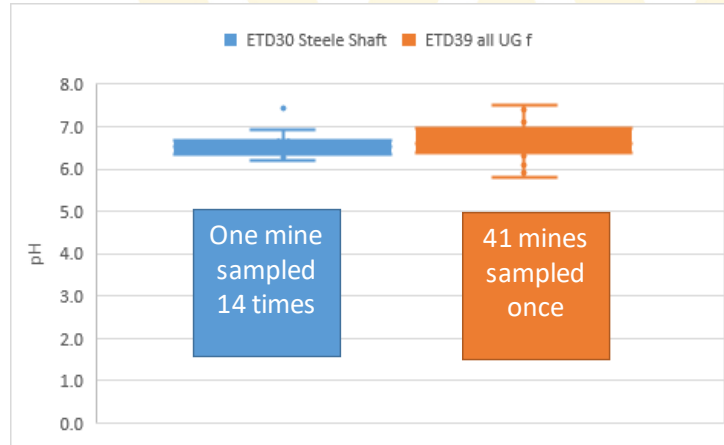


# Westland 1 Mine

AMD moves  
downdip from  
Westland through  
Arden Mine



# pH in flooded UG mines averages about 6.6

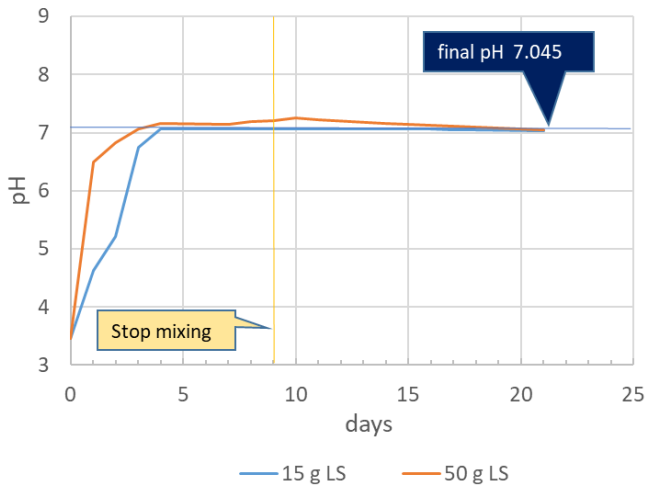


Source	n	lower confidence limit	average	upper confidence limit
ETD30 field data	14	6.24	6.58	6.91
ETD39 field data	41	6.48	6.63	6.78

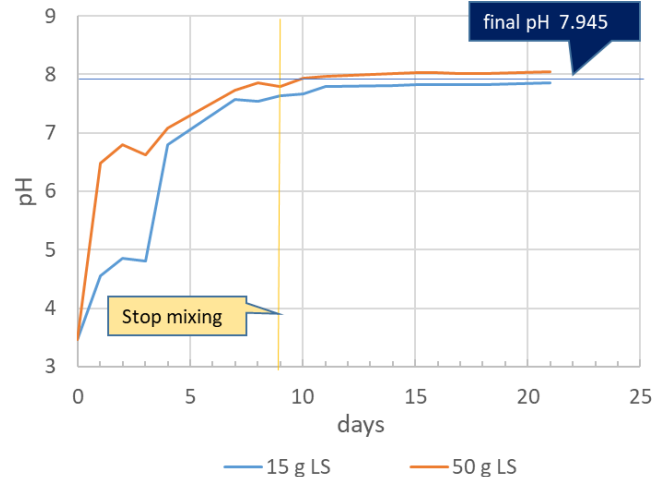


# Limestone in sealed and unsealed containers with AMD-21 days

Limestone in AMD, Confined



Limestone in AMD Unconfined



# Four Marcellus horizontal wells

## -Confined, anoxic

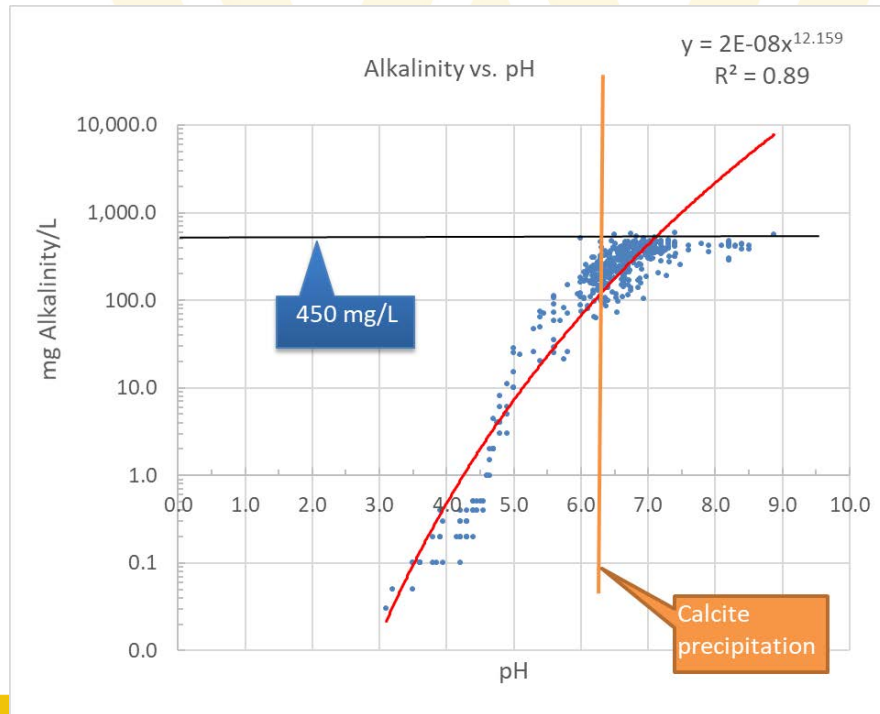
- Depth- 7400 ft
- Carbonates- 5 to 50%
- Pyrite- 5-15%

	age (yrs)	n	avg pH
MW 3H	1.3	19	6.12
MIP 5H	1.3	18	6.08
MIP 4H	5.3	7	6.20
MIP 6H	5.3	7	6.29
all			6.17



# Montour 4: alkalinity vs. pH

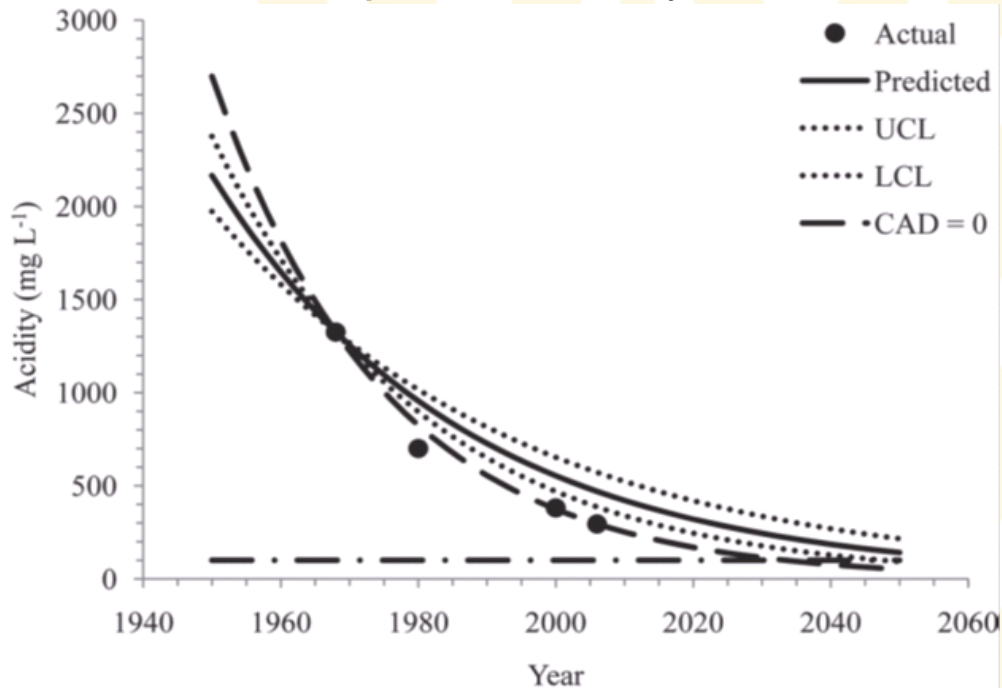
Good model fit until calcite starts to precipitate in the sample bottles due to CO<sub>2</sub> degassing



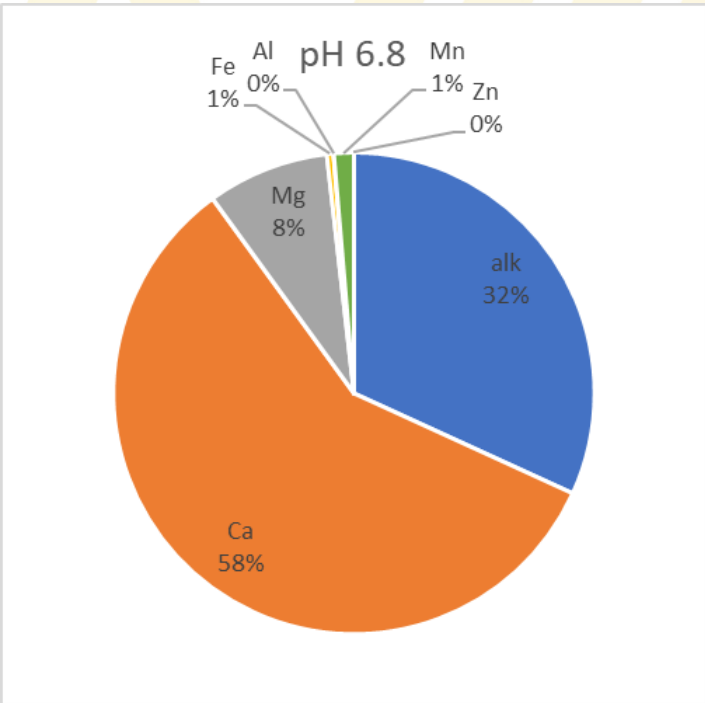
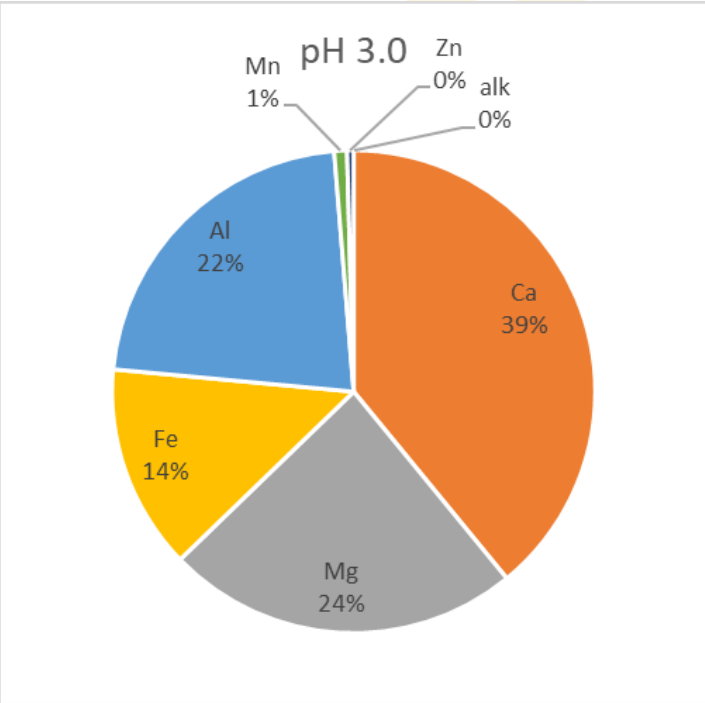


# Updip, net acid UG mines

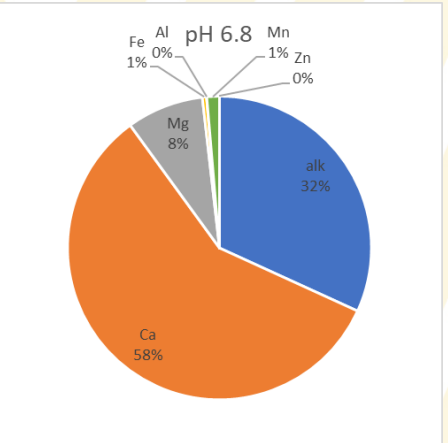
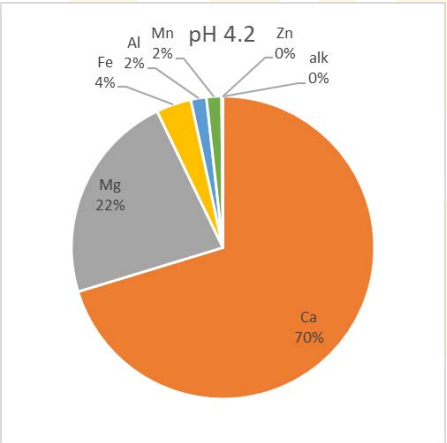
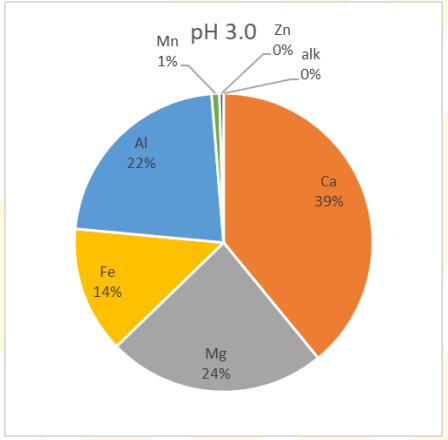
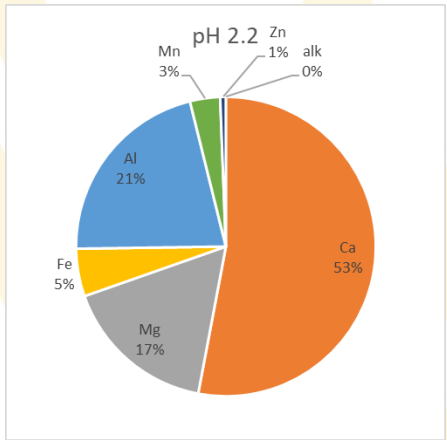
Decay in acidity over time: 38 Upper Freeport mines  
100% per hundred years



# Ionic composition of AMD



# Ionic composition of AMD



# Major Chemical Factors

- Initial flooding, ferrous sulfate dissolution
- Gradual replacement with groundwater
- Oxygen depletion:
  - terminates pyrite oxidation
- Acid neutralization
  - Does not affect ferrous ion
- Treatment of net alkaline, ferrous ion water

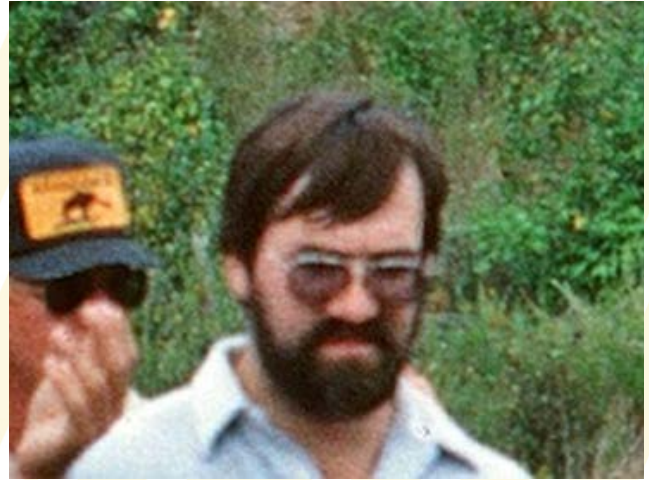


# Using this knowledge to build an environmentally friendly UG mine

1. Alkaline injection equipment installed and tested prior to portal sealing and surface reclamation
2. Injection of alkaline conditioned water conducted so oxygen is not carried into the mine
3. Continuous monitoring of raw water flow and pH
4. Lime dosing of raw water to net alkalinity
5. Weekly analysis of raw water to allow for adjustment of the alkalinity dosing rate
6. Alkaline addition may be suspended when:
  1. Maximum flooding level reached and
  2. the raw water analysis indicates that the pH of the water is greater than 6.0 standard units, and when the alkalinity of the raw water exceeds acidity by at least 20mg/L



**Credit:**  
Bruce Leavitt  
generously provided  
much of the data  
presented here



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