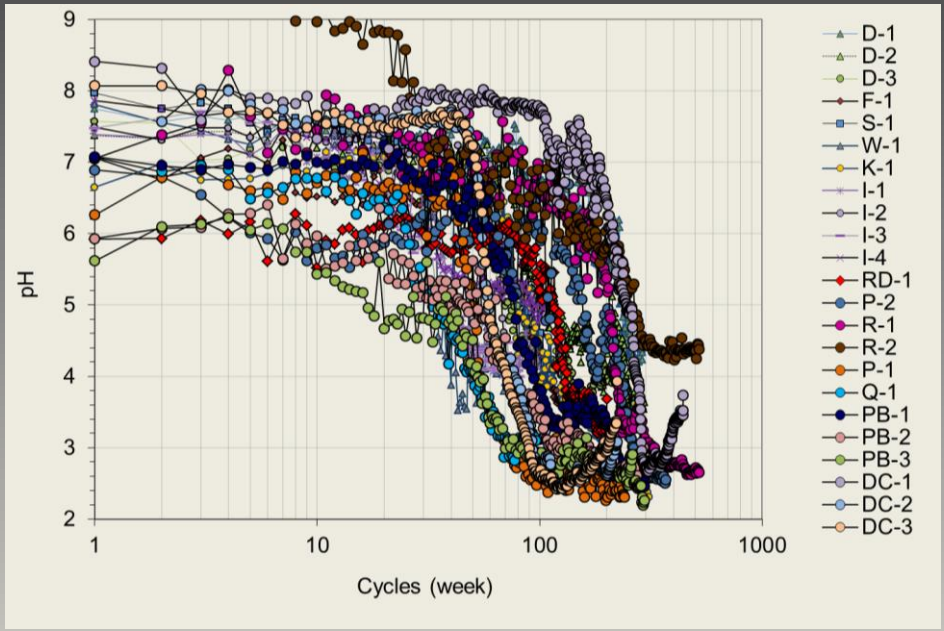
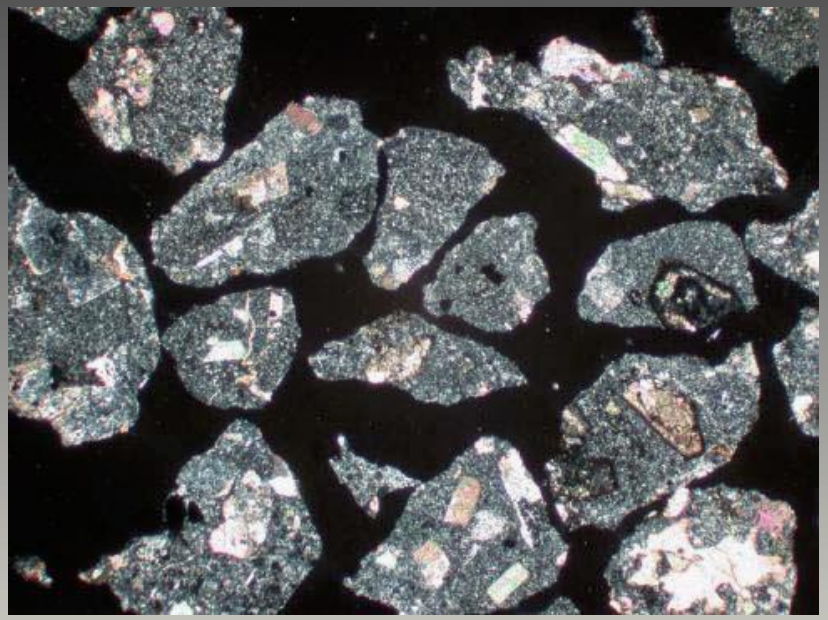
What Determines Lag Times in Humidity Cell Tests?





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Introduction

- “Lag Time” or “Time to Onset” is the amount of time for acidic conditions to develop
- Needed to assess when management plans should be in place for preventing or mitigating ARD
- Typically defined through kinetic testing
  - Observe lag time (rare)
  - Calculate lag time (subject to uncertainty)

Calculating Lag Time

$$\text{NP depletion} = \frac{TIC \text{ or } NP\ (kg\ CaCO_3\ eq/t)}{(Ca+Mg) \text{ or } SO4\ Rate\left(\frac{kg\ CaCO_3\ eq}{t \cdot week}\right)}$$

or,

$$t_{onset} = \frac{\frac{NP}{AP}}{k\left(\frac{NP}{AP}\right)_{crit}}$$

Where $k = \frac{SO4\ rate}{S}$ and $\left(\frac{NP}{AP}\right)_{crit} = 1 - 1.5$

Calculating Lag Time

- Correction factors often applied to adjust for the unavailable or unreactive NP
  - Site specific NP/AP ratios (critical NP/AP)
  - Subtraction of the unavailable NP, or
  - Division by an availability factor (Ca+Mg content of carbonates).
- Uncertainties
  - Accuracy of TIC or NP measurement
  - Accuracy of release rates
  - Availability and reactivity of NP
  - Blinding of NP by precipitates

This Study

Compiled data for tests that showed a distinct lag to onset of acidic conditions (usually >20 weeks)

- 23 tests from 12 sites
- Test durations ranged from 80 to 520 weeks!
- 9 tests still operating

Explored for relationships between lag time and:

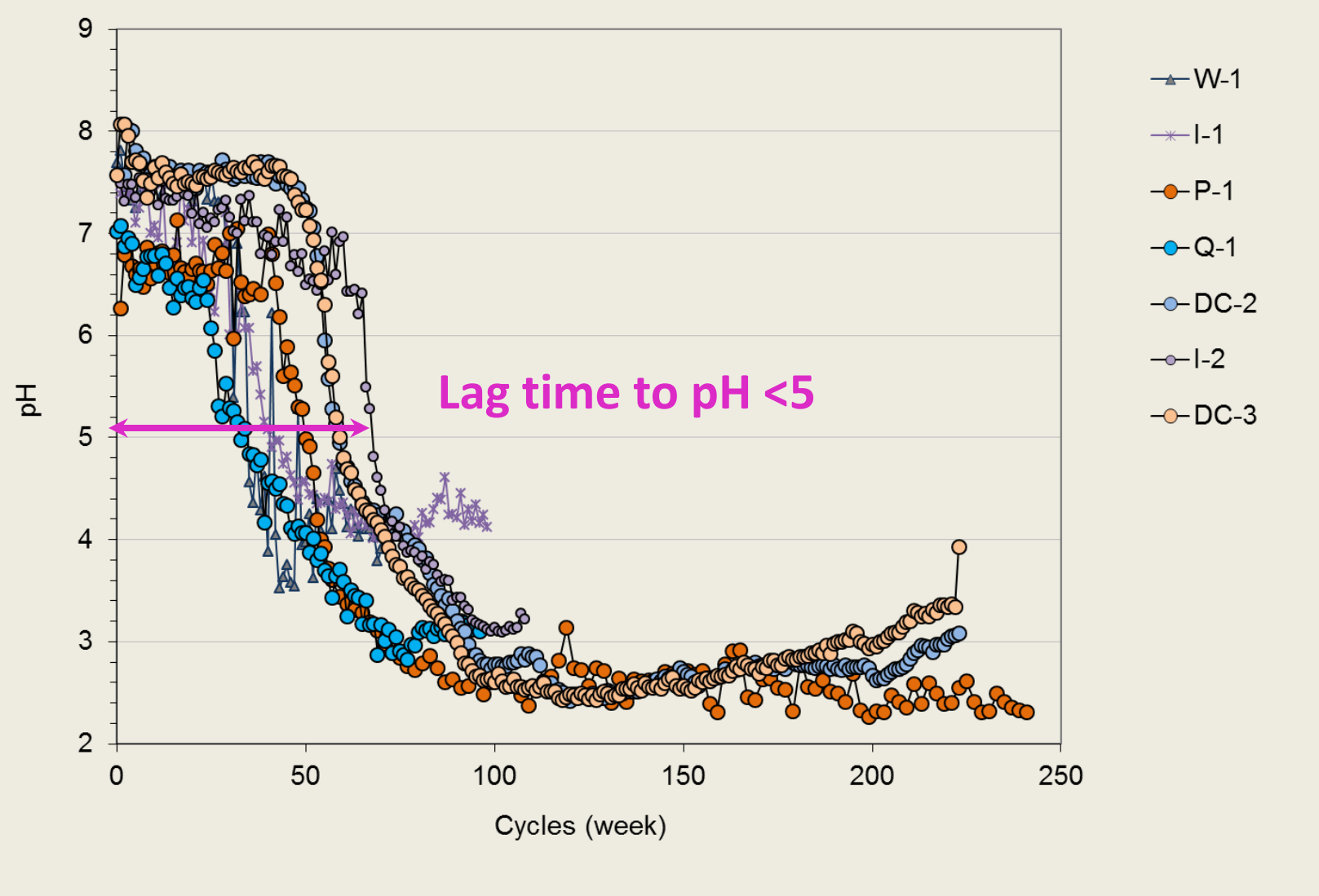
- ABA parameters (TIC, NP, AP)
- Calculated lag times
- Mineralogy
- Rate of acidification

There is Bias!

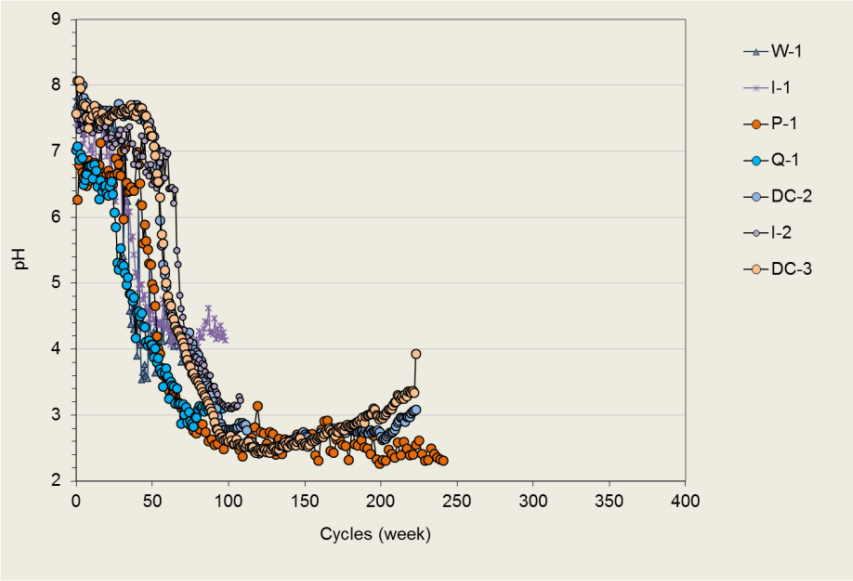
Not Included:

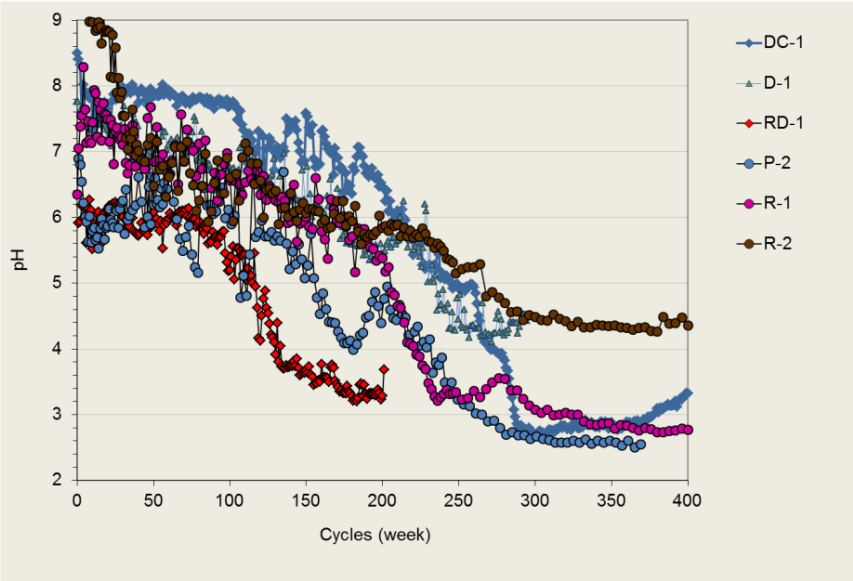
- Tests where acidic conditions developed immediately
- Tests where acidic conditions were predicted to occur but didn’t occur

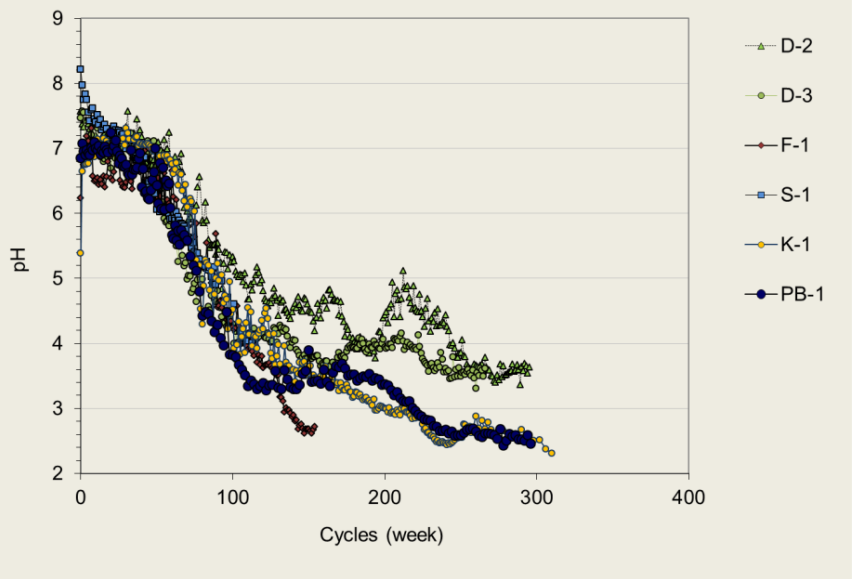
pH Profile

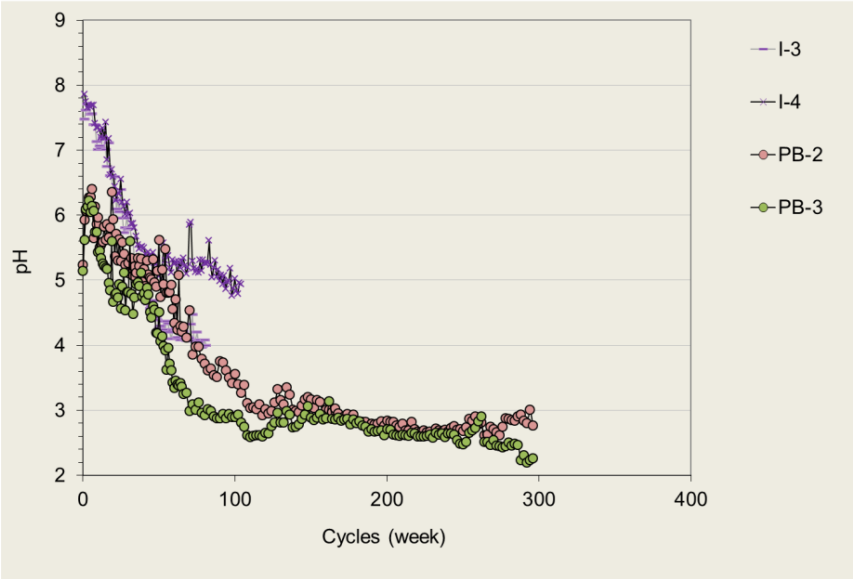

pH
9
8
7
6
5
4
3
2
0
50
100
150
200
250
Cycles (week)
Lag time to pH <5
W-1
I-1
P-1
Q-1
DC-2
I-2
DC-3

pH Profiles (comparison)

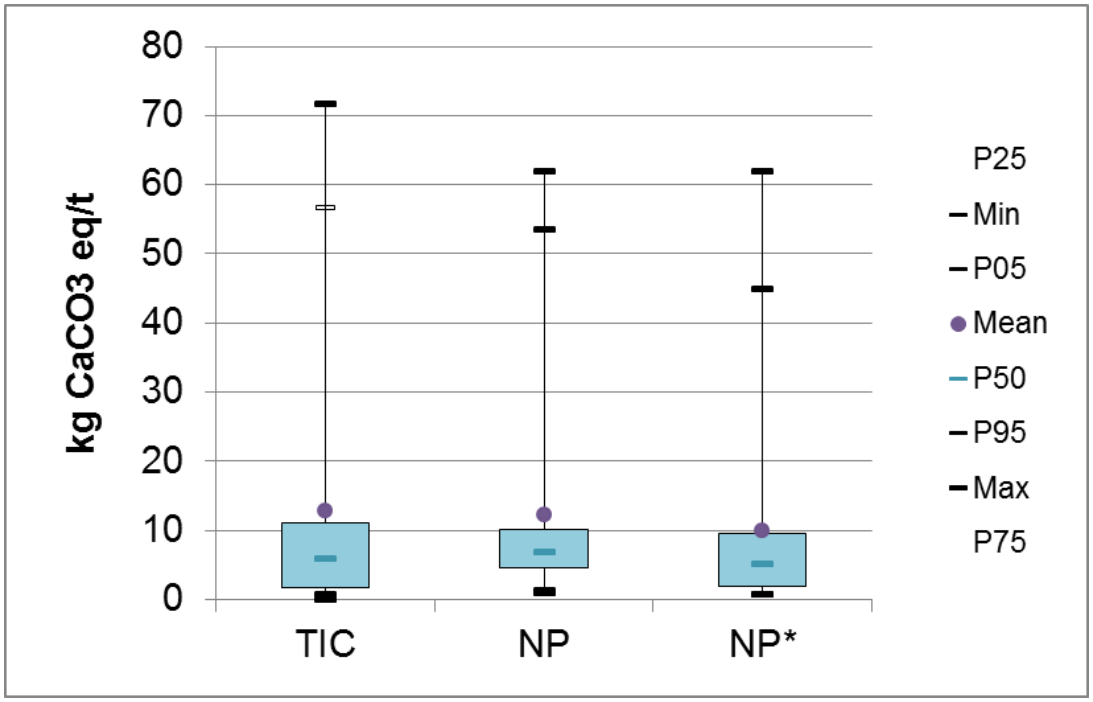


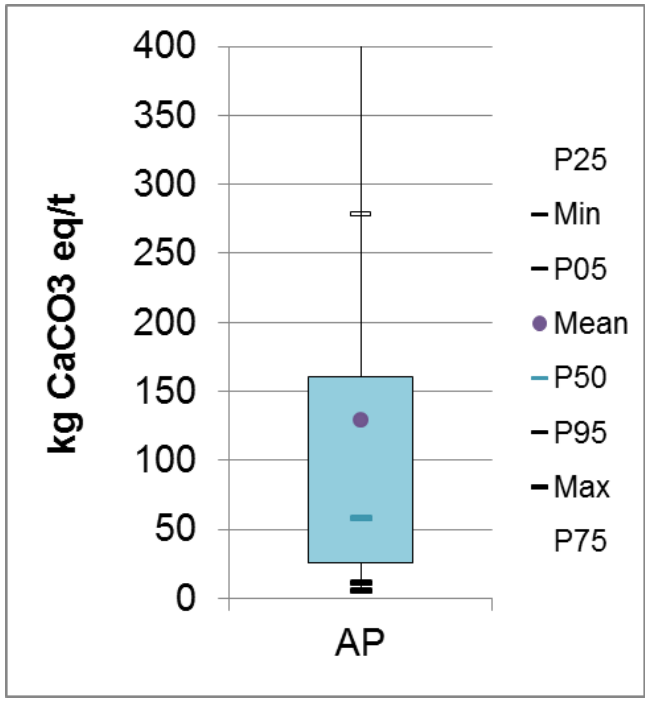






General Characteristics of these Tests





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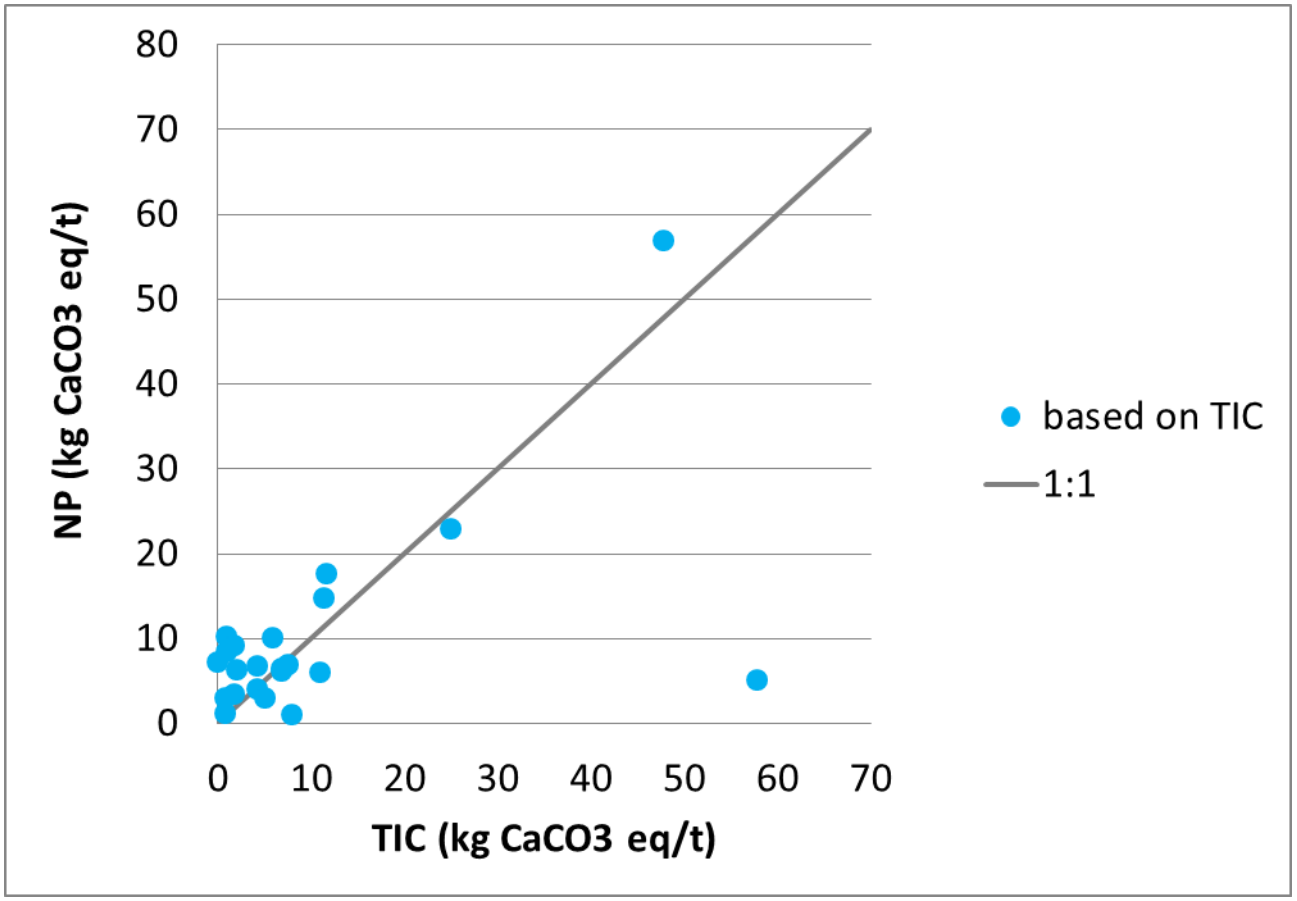

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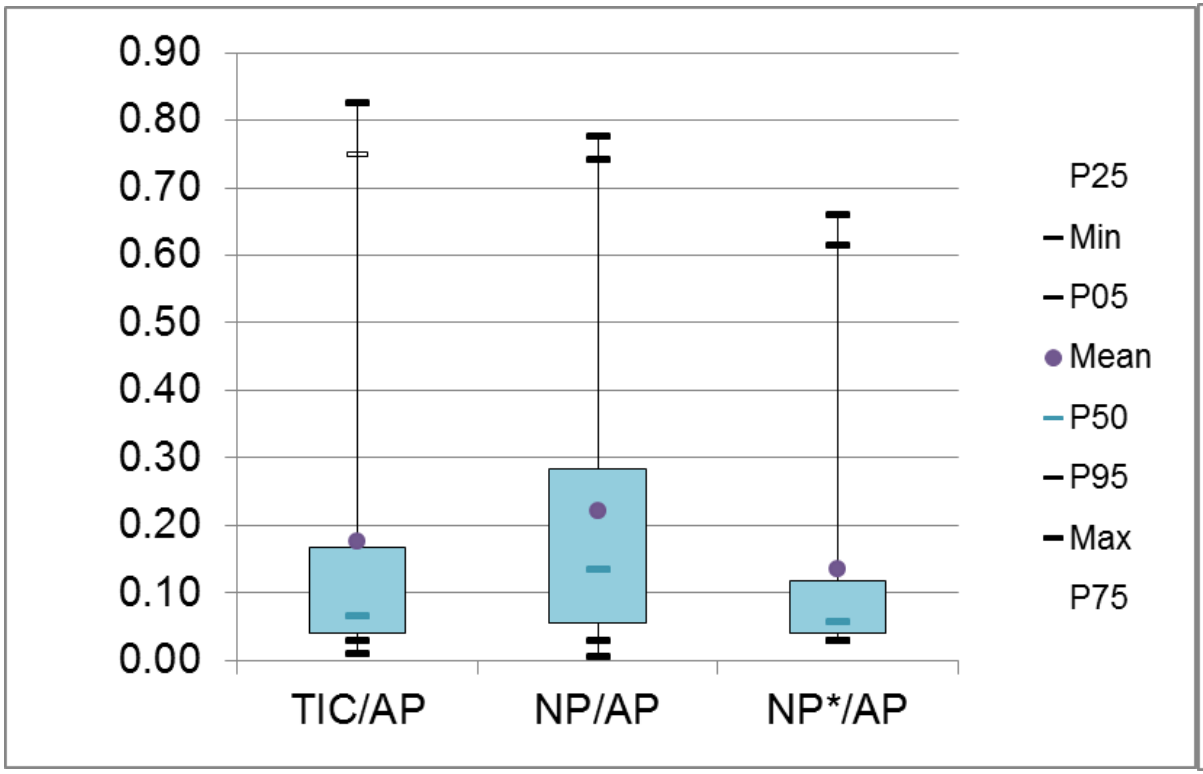
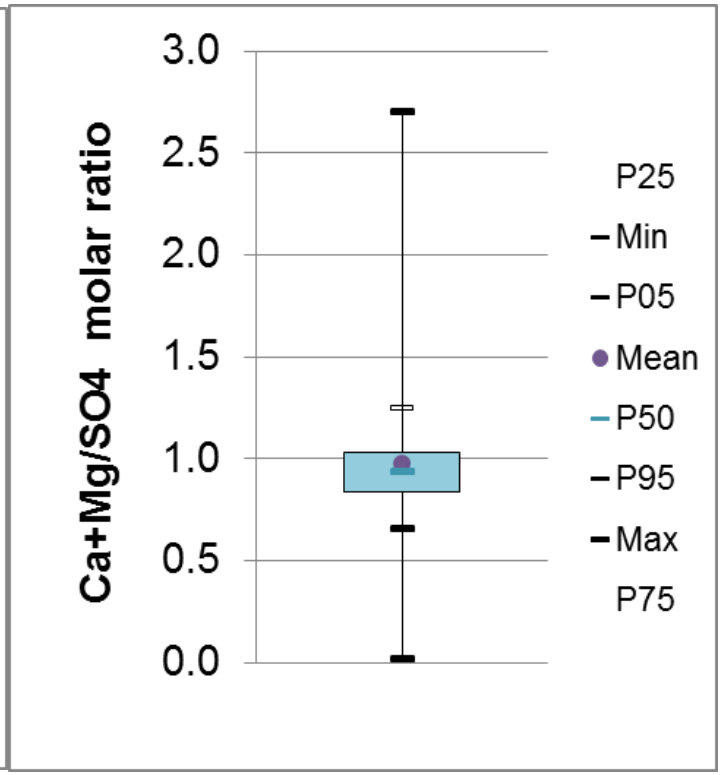
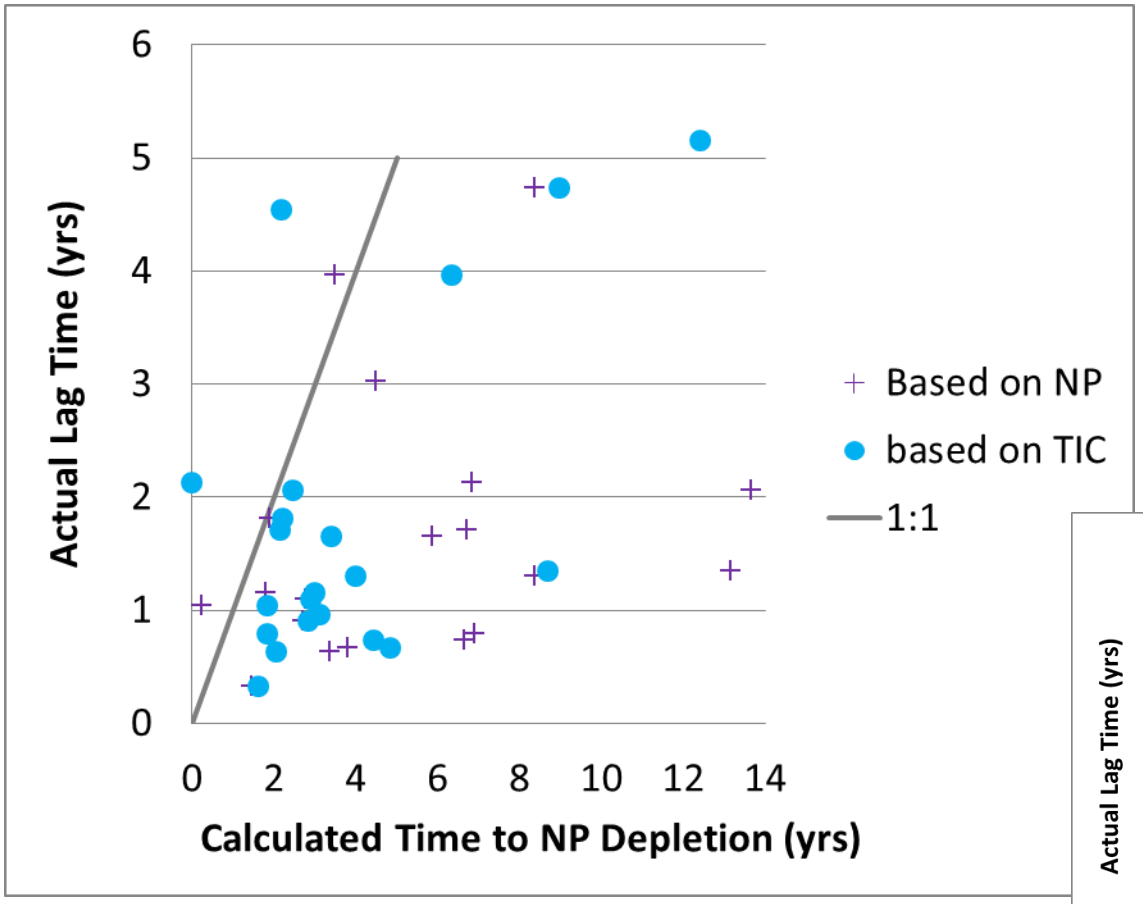
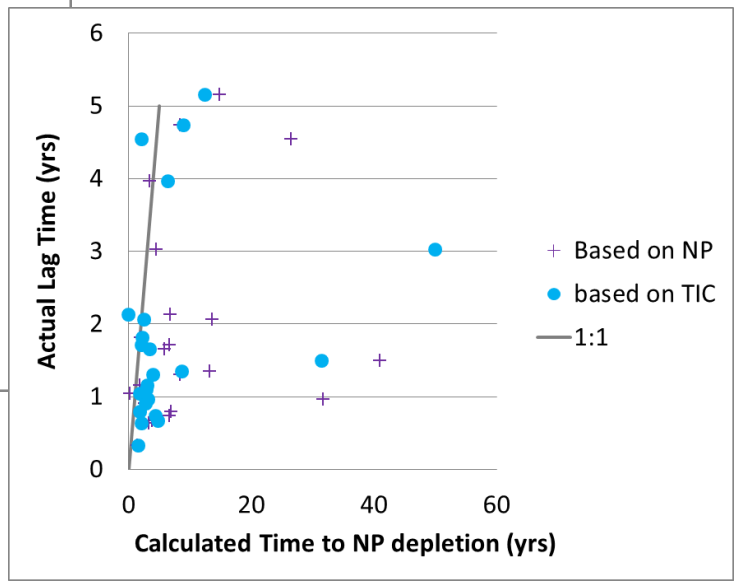




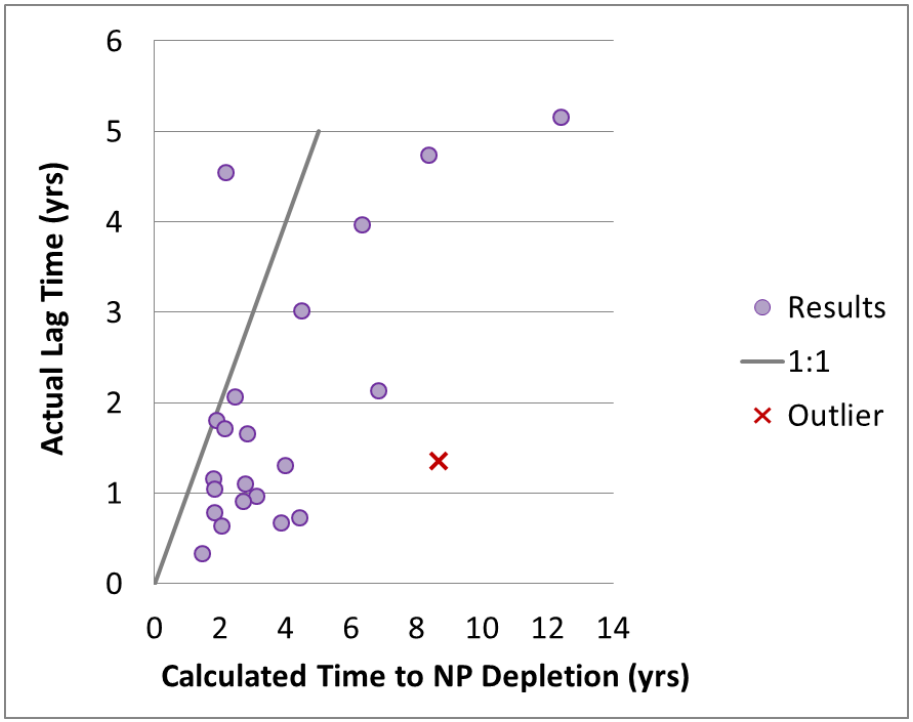
Calculated versus Actual Lag Times





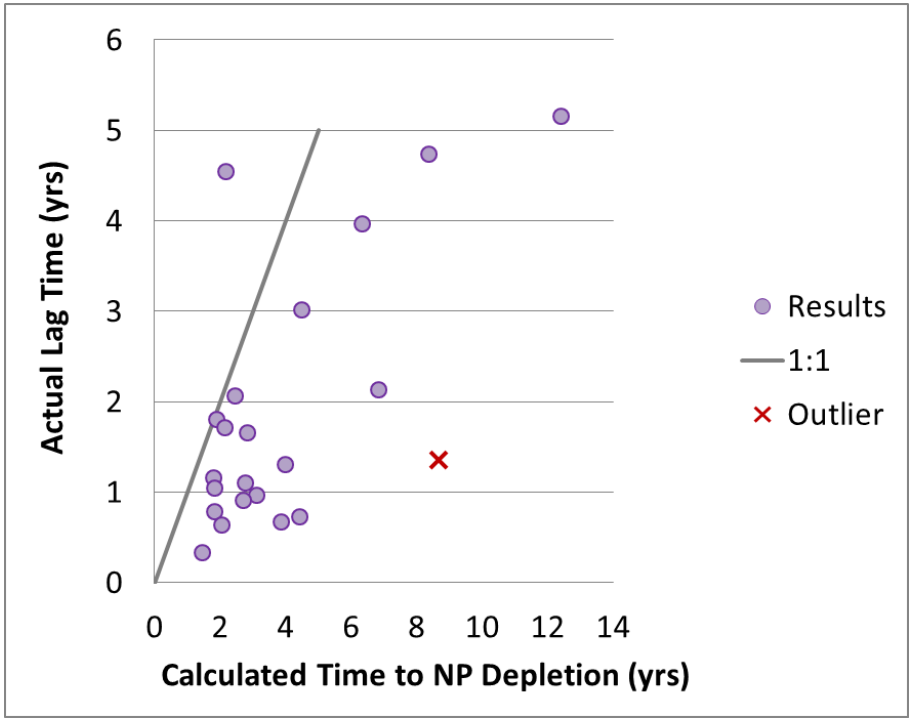
Calculated versus Actual Lag Times

"Best NP" Prior to Correction

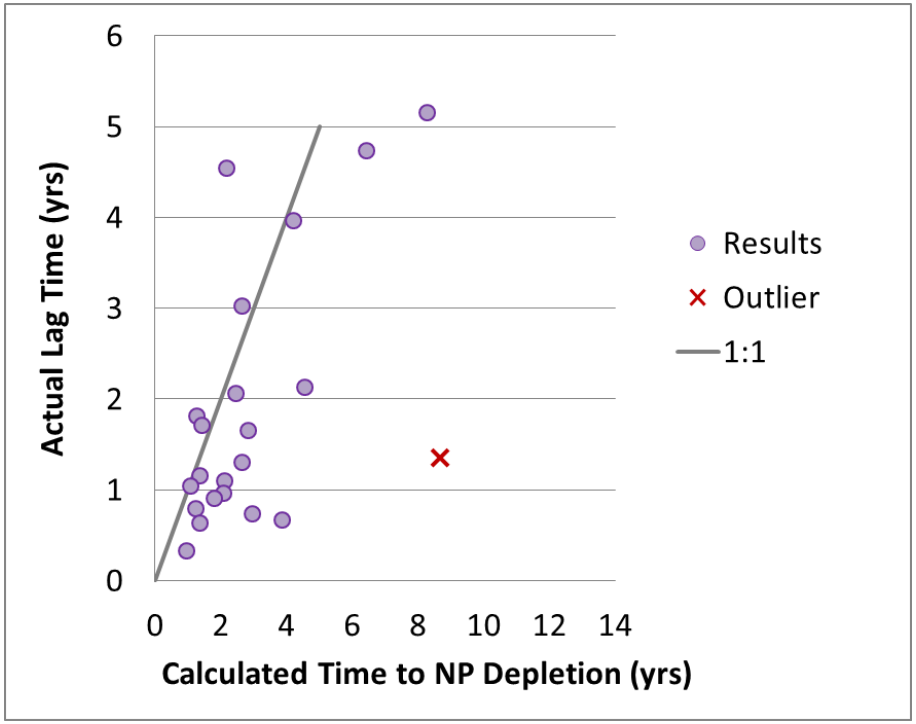


Calculated versus Actual Lag Times

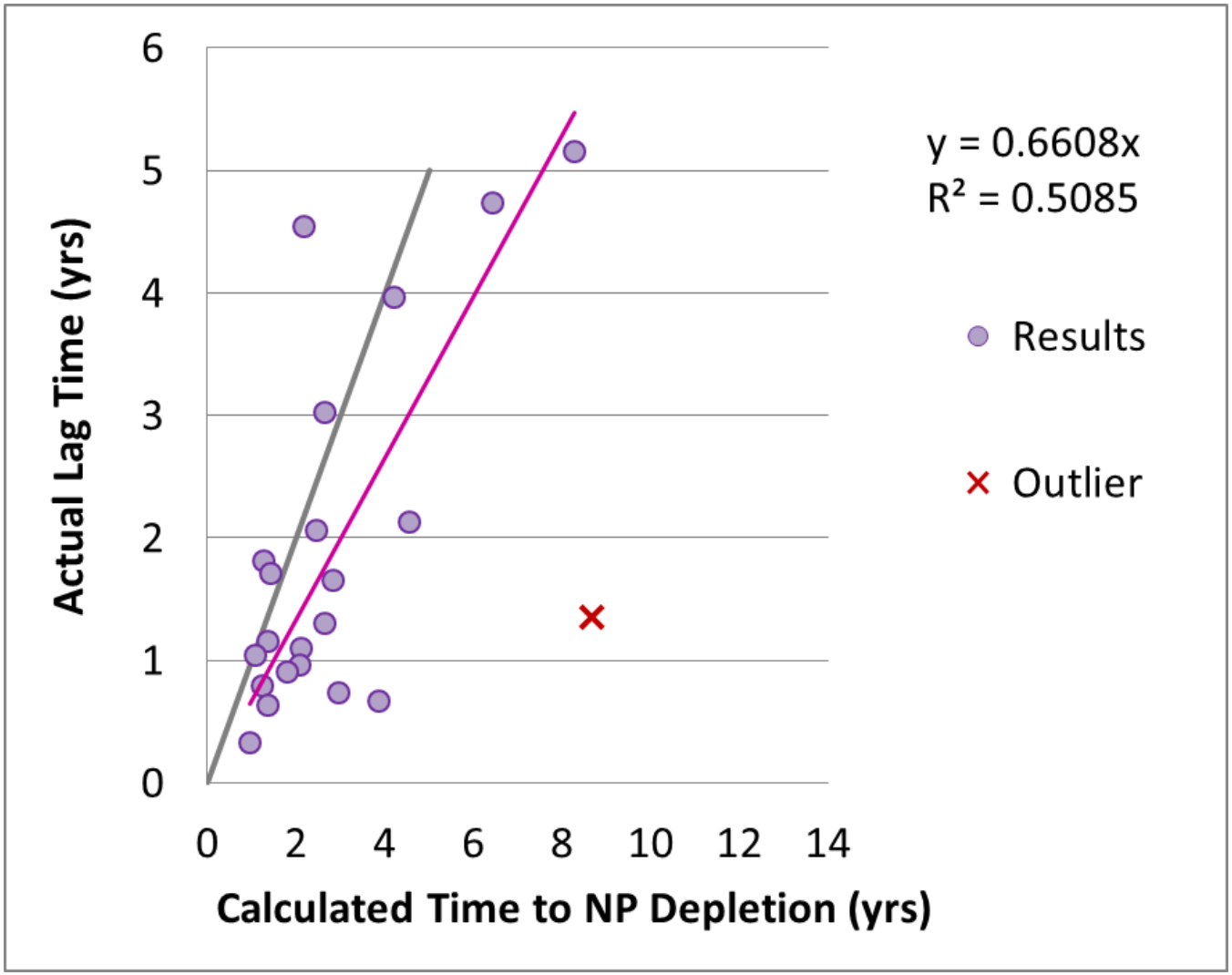
"Best NP" Prior to Correction



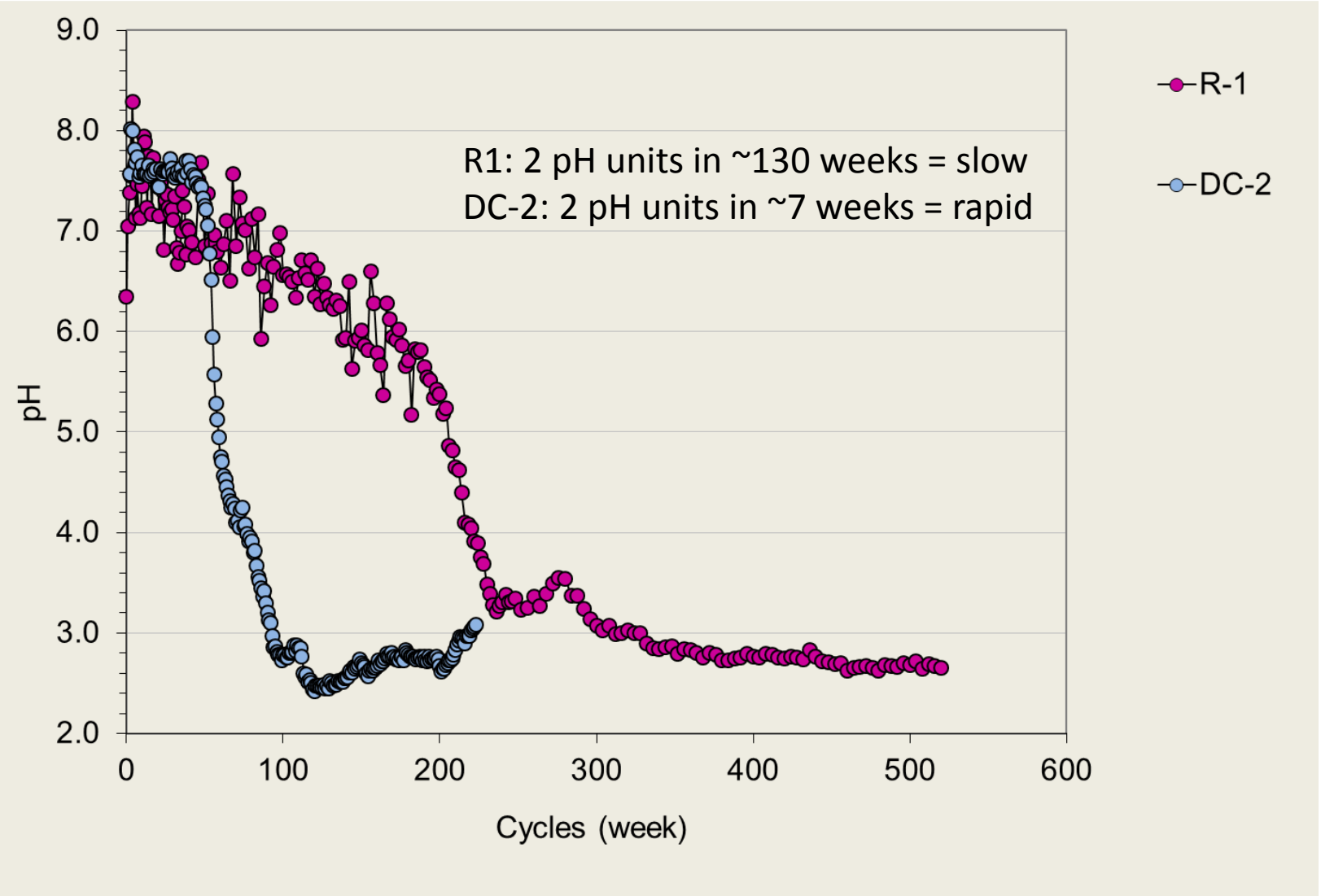
Corrected for Critical NP/AP



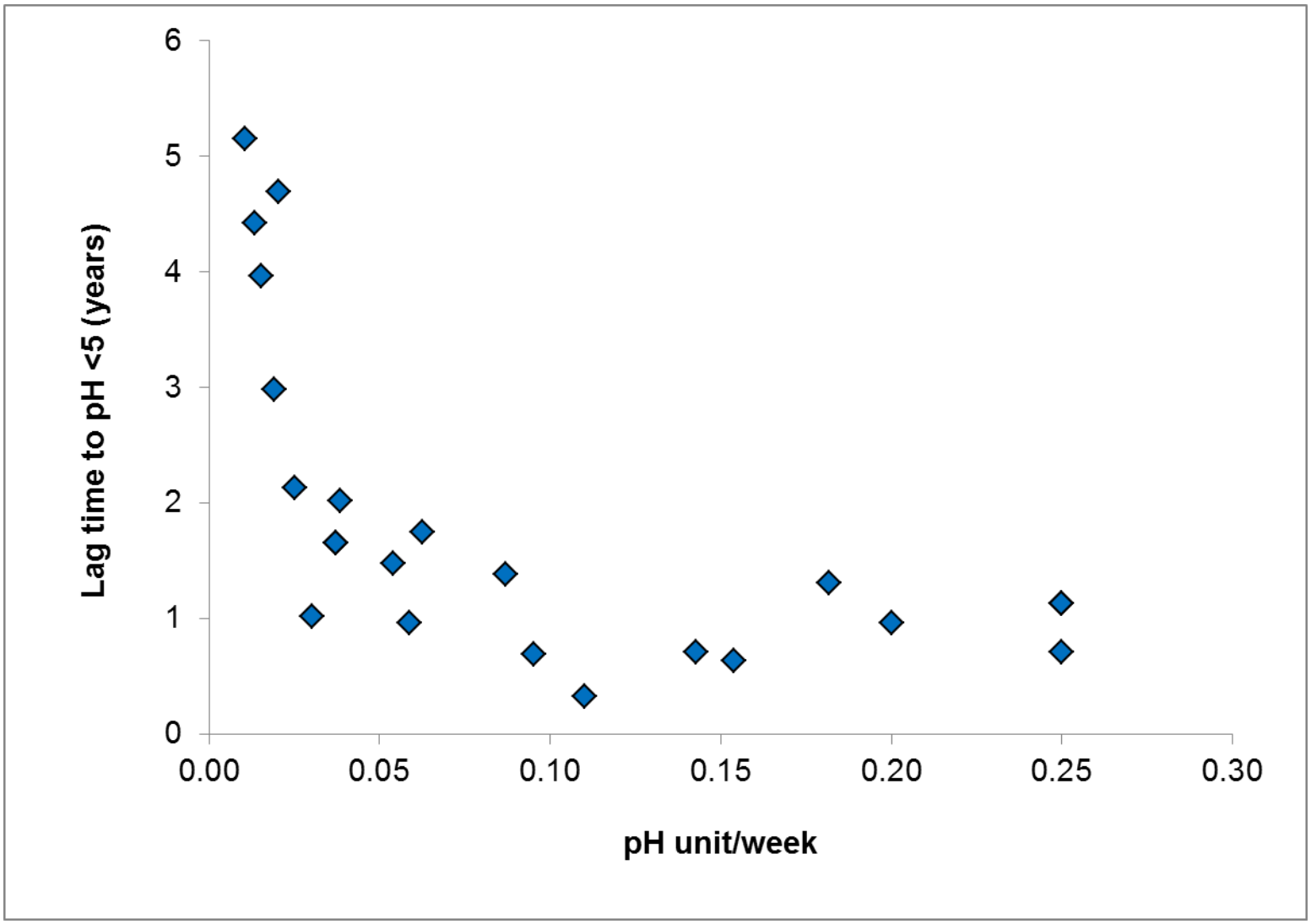
Calculated versus Actual Lag Times



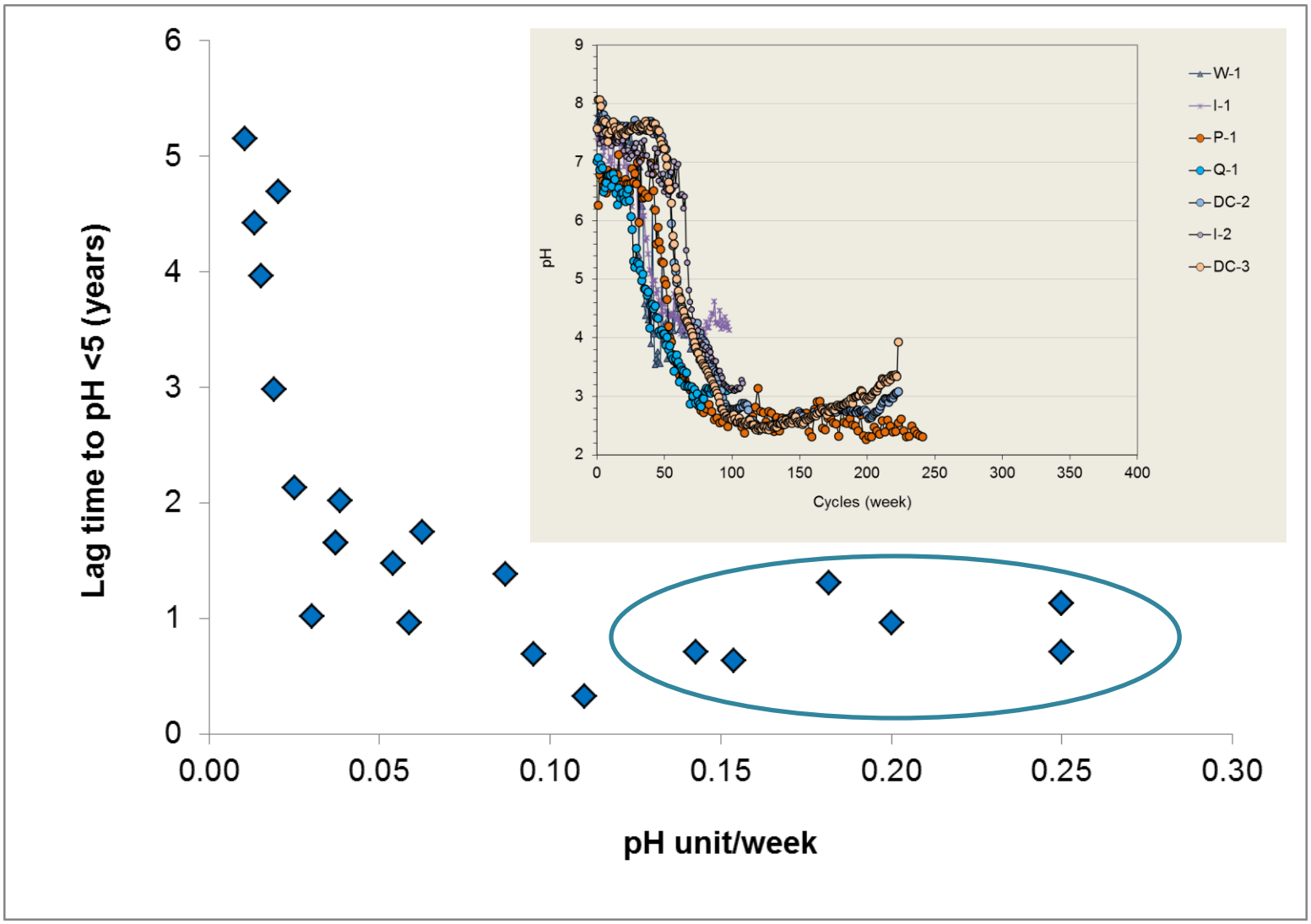
Rate of Acidification



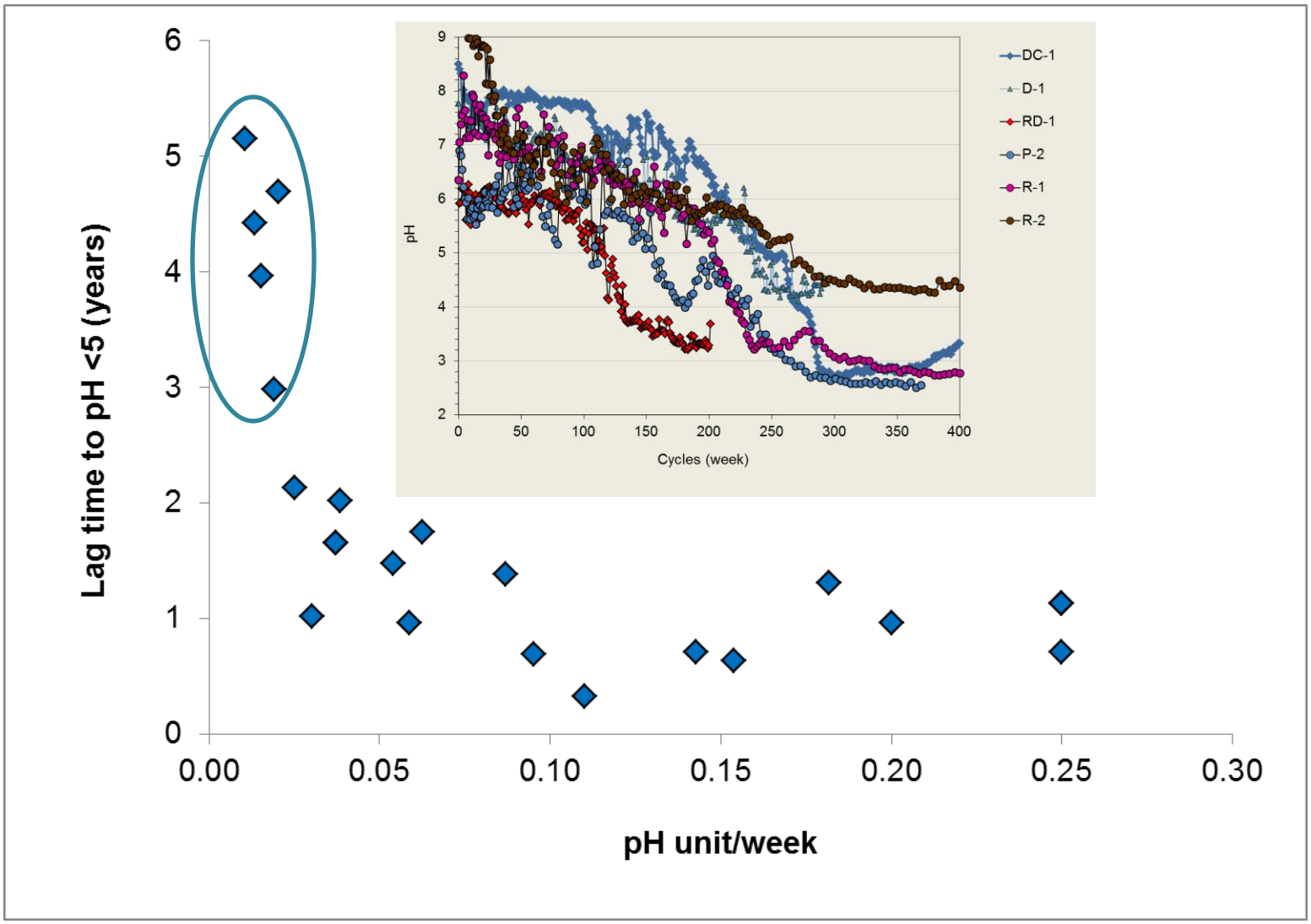
Lag Time versus Rate of Acidification



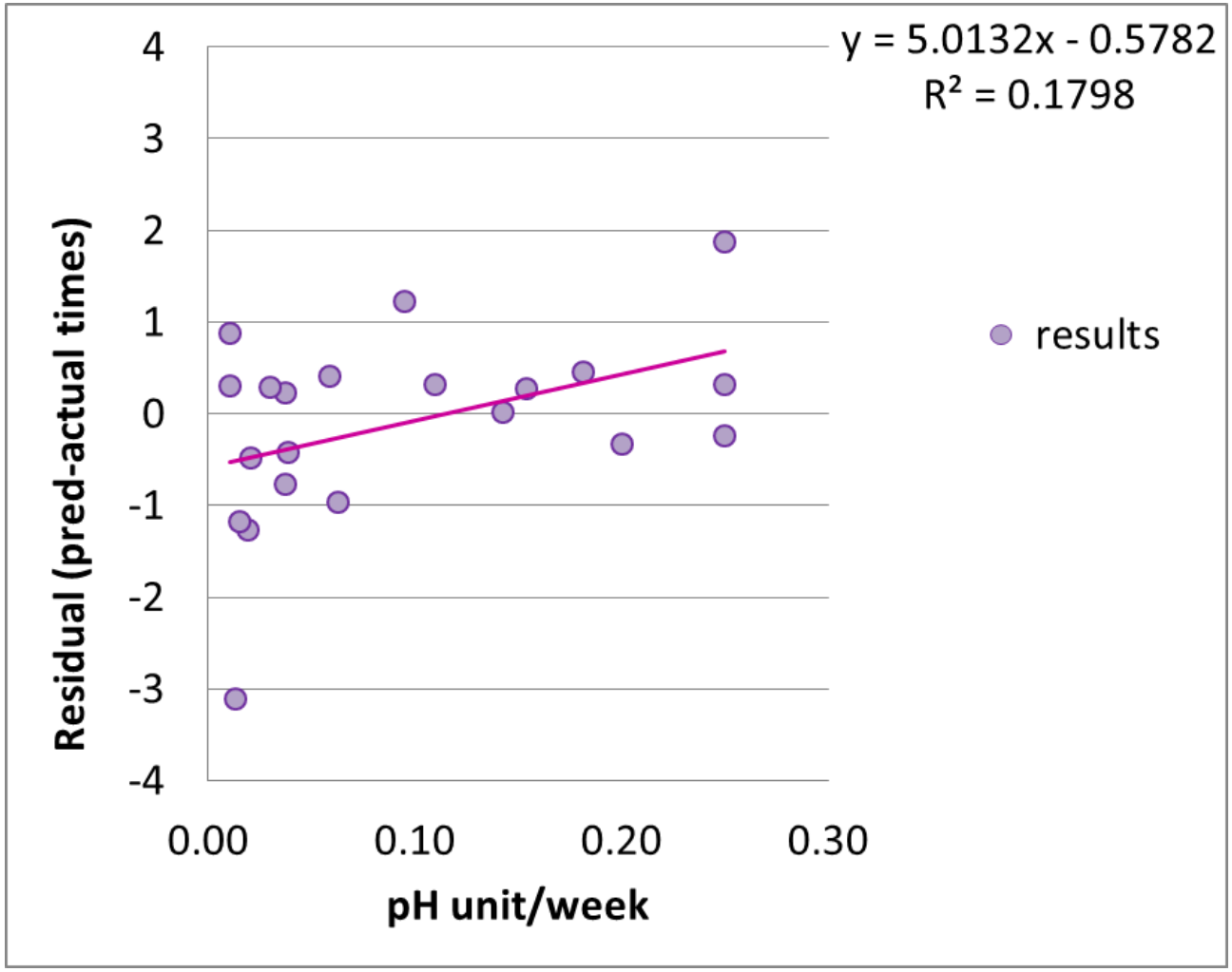
Lag Time in Fast Tests



Lag Time in Slow Tests



Residual Analysis



What Else

No clear patterns

Some indications

- Samples with higher than expected lag times were buffered by silicate minerals or contained iron carbonates
- Samples with lower than expected lag times had NP measurements that were inconsistent with mineralogy or TIC (possible lab errors)

Blinding by precipitates did not seem to be a factor

- No relationships of faster than expected lag times in samples with high TIC or high SO4 production.

Conclusions

- All of these tests had low NP and high sulphide with NP/AP or TIC/AP ratios <0.8
- Calculated lag times were typically longer than actual lag times, but were related (r^2 ~ 0.5)
- Estimates of lag time can be improved by selecting the most appropriate NP (usually the lesser of TIC or NP), and by applying correction factors to account for availability/reactivity
- Tests with the longer than expected lag times showed a relatively gradual development of acidic conditions and slow rates of acidification
- The results emphasize the value of running some tests for an extended period of time.*

Thank-you