# Mobilization of Lead Studied with Atomic Force Microscopy

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## Abstract

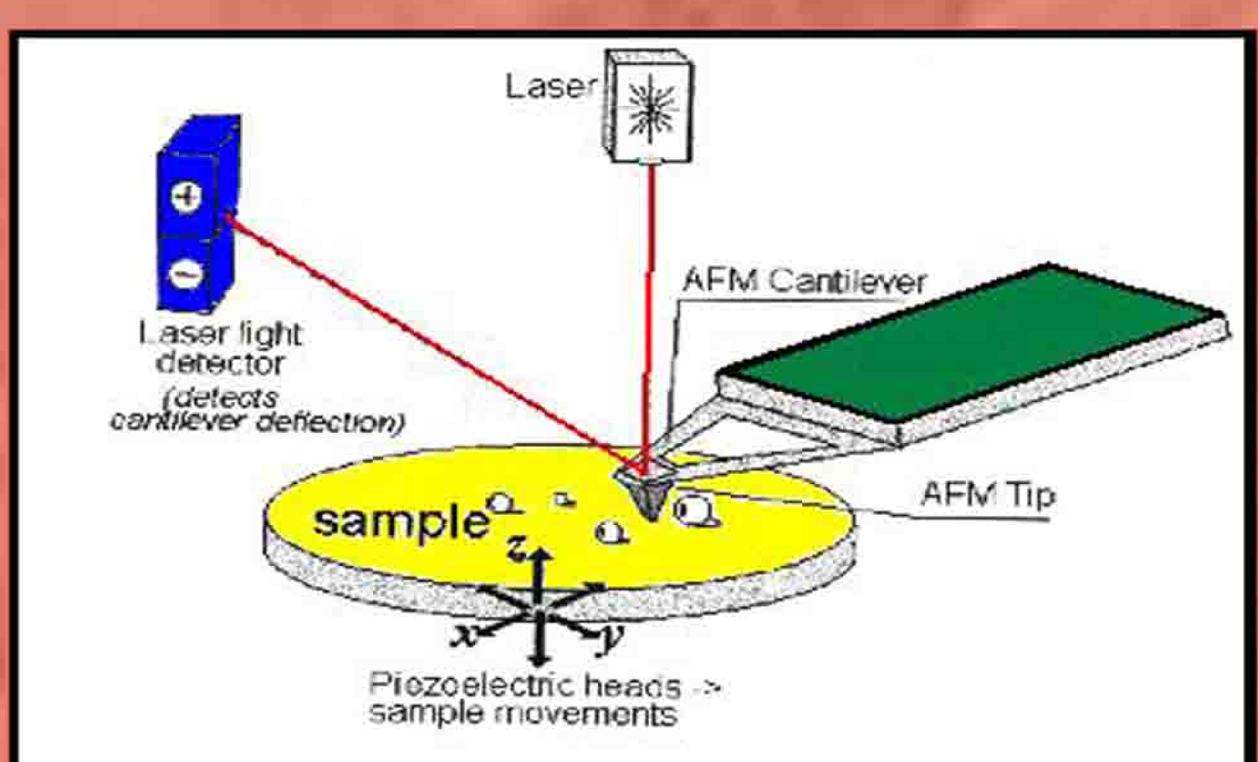
A common process for reclaiming lead contaminated soil is through in-situ immobilization of lead, forming the highly insoluble mineral pyromorphite (lead apatite). However, in the presence of low (2-3) pH levels, the solubility of lead apatite increases and lead is mobilized; i.e. can be absorbed. Low pH levels are commonly found as a result of microbial activity (lactic acid) or acid rain (sulfuric acid) in industrial areas. In this study, Atomic Force Microscopy (AFM), for the first time, was used to examine the dissolution of lead apatite at low pH levels. The dissolution process became evident by examining surface features prior to and after treatment with acid. Surveys of the surface prior to treatment show steps parallel and perpendicular to the long axis of the crystal. Surveys taken after treatment show etching occurred at the crystal steps in all samples treated. Etch pits were not observed in any sample. Treatment of the surface lasted from 24-72 hours.


One of our samples mounted on an AFM holder. Note coin for size comparison

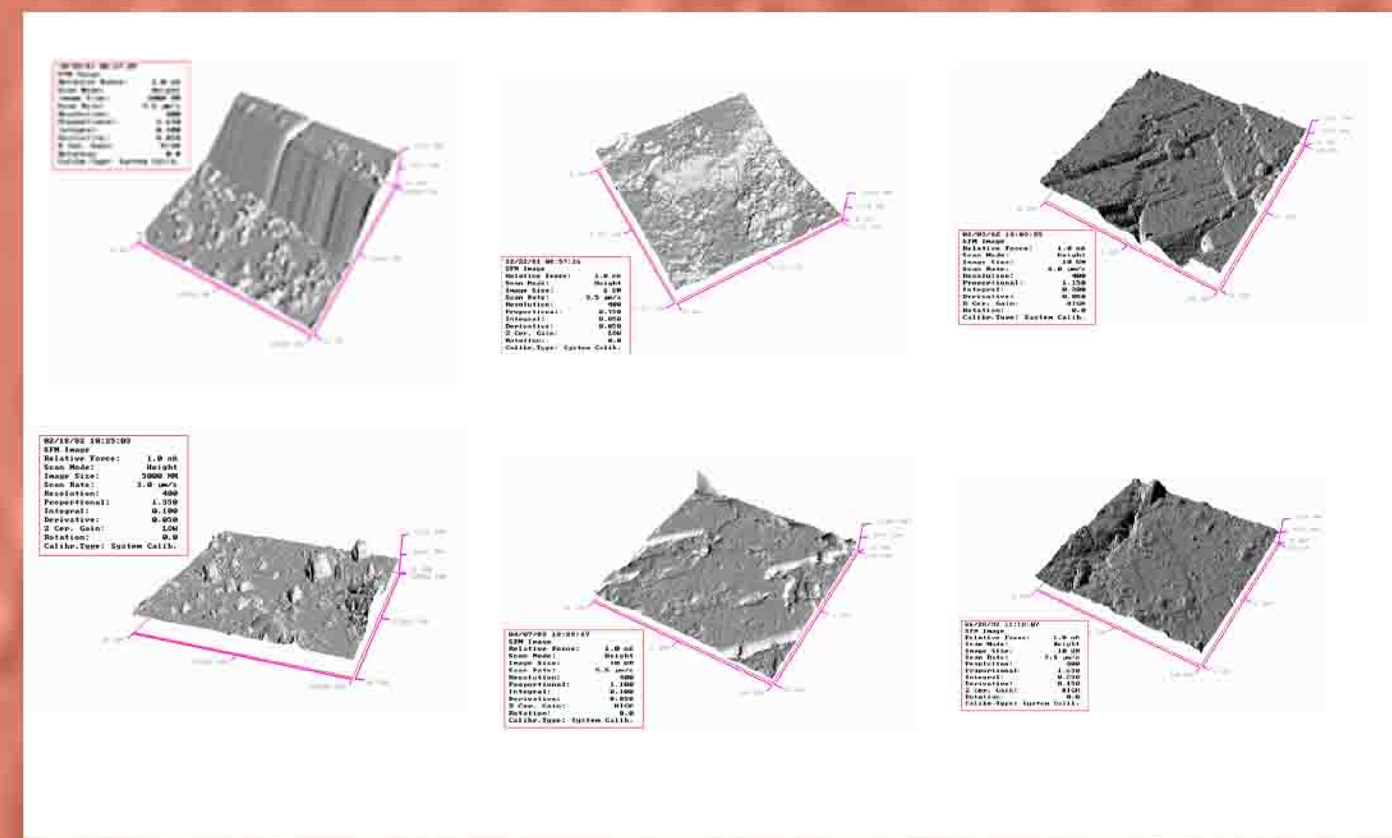
## Procedure

The images in this experiment were taken with an Atomic Force Microscope in contact mode. In this mode, a very fine pyramidal tip, mounted on a cantilever, is rastered across the surface of the sample. When a peak or valley is covered, the cantilever bends. A laser is reflected off of the tip and the movement of the reflected laser is then measured. A feedback system and a piezoelectric device are used to keep the deflection of the tip to a minimum. A computer uses this movement to map the surface of the sample.

The data in this experiment consist of a survey of surface images of the samples. We took random images of the surface of our sample. Then the sample was exposed to lactic acid of pH of ~2.0, for 24-72 hours. The sample was dried and surface images were again taken. By comparing pre-treatment and post-treatment images, we were able to define the reaction process of the dissolution of pyromorphite.

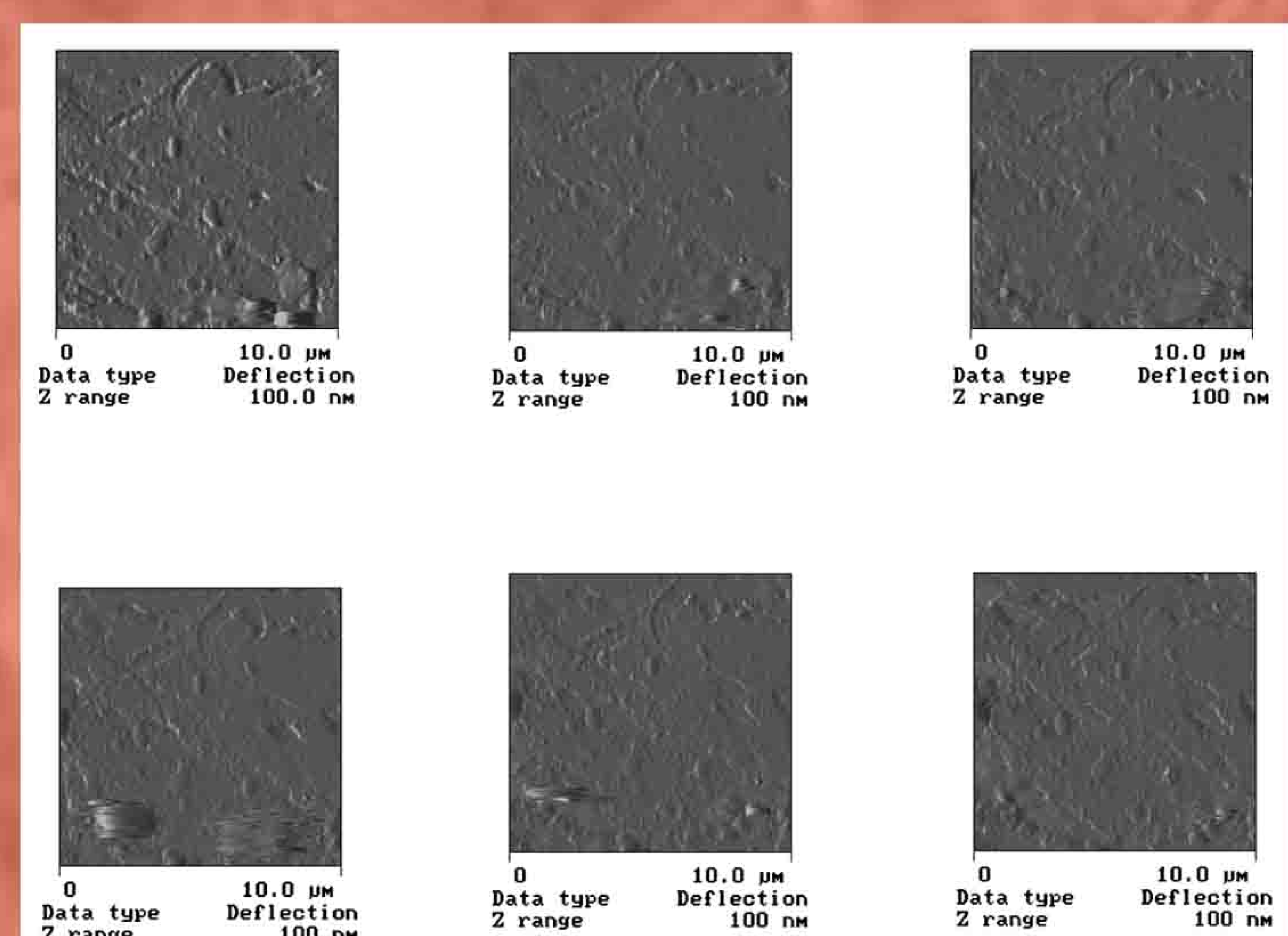



Schematic drawing of an Atomic Force Microscope



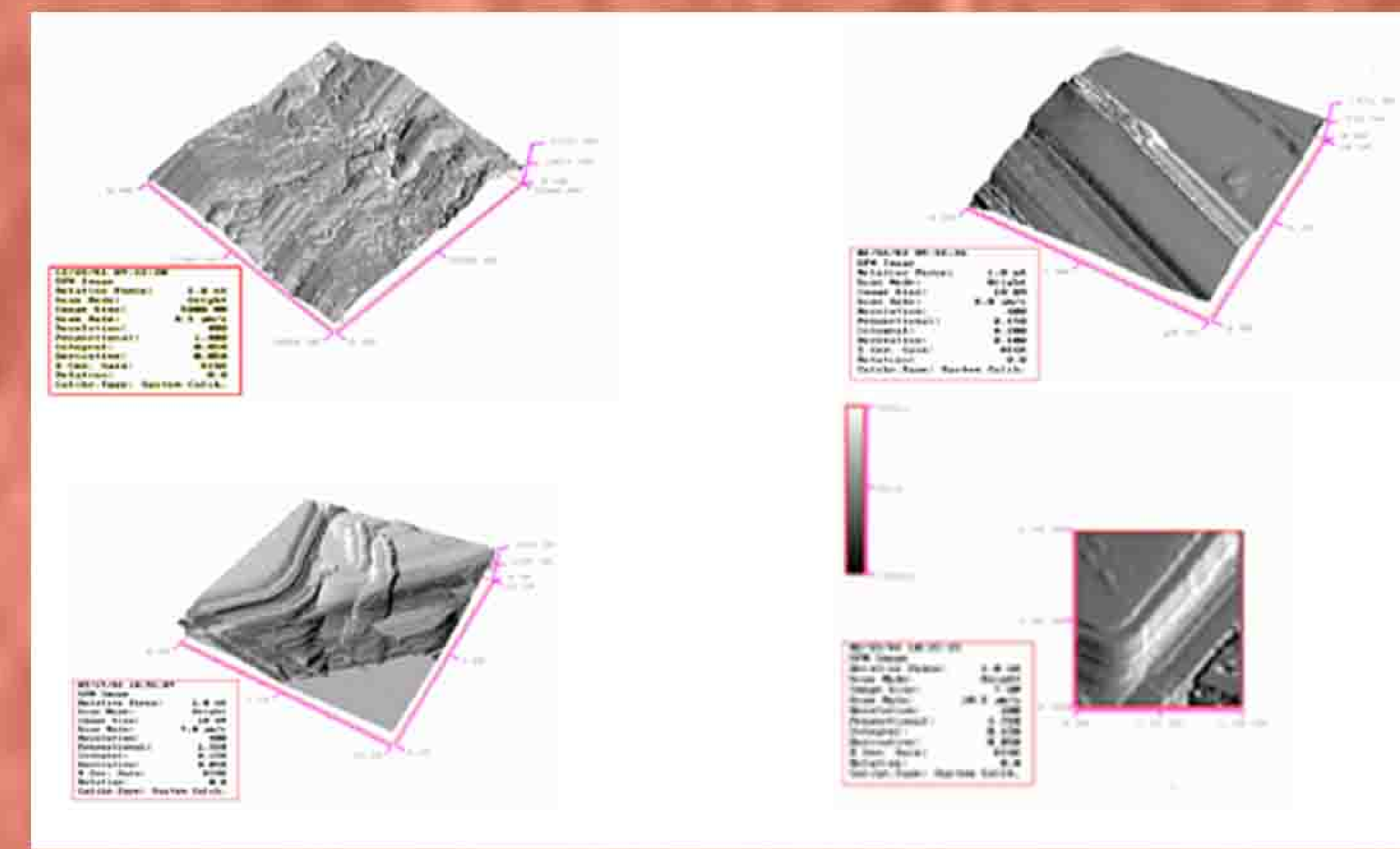
## Pre-Treatment

The surface appeared rocky/sandy with large (~200nm) "boulders". The steps observed show that a crystal structure is evident.




## Sequence

This is a sequence of images that was taken in-situ. The pH of the acid was ~1.5, much stronger than the acid that was used in the other treatments, but the length of treatment was much less. The duration of this emtire sequence of images was 25 minutes. One can see evidence of etching at surface edges.



## Post-Treatment

Some of the features seen in the post-treatment images were washed or smoothed surfaces, rounded steps and angular slopes. Taking images from our samples that were treated for more than forty-eight hours proved to be a bit difficult. The sample was too rough for our microscope to accurately map the surface. The size and slope of the features were too big. This shows that the sample was etched too much for clean imaging.

## Conclusions

The comparisons of the samples show that the dissolution of the pyromorphite proceeds at step edges; this is a known as a surface-controlled reaction. Understanding how this reaction proceeds is important to studying real-life applications of lead contamination.

## Further study

To completely understand the process of this reaction, additional experiments must be performed. Conducting more in-situ experiments would help us to show the type of reaction that is taking place during exposure to lactic acid. Experiments are currently being done with non-biological acids and preliminary results show similar trends.

## Acknowledgments

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For further information, see web page http://physics.weber.edu/inglefield/webpage/AFMLab.html