

Iron Chemistry Analysis and Pedogenesis of Two Late Cenozoic Paleosols in East Central Pennsylvania

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Introduction:

Soil formation (pedogenesis) reflects the integrated (paleo)environmental conditions when the soil is exposed at the surface. Buried soils preserve a record of these conditions as paleosols. Studying these ancient buried soils provides a way to study paleoenvironmental conditions and can shed light on the paleochemical environment in which they were formed.

For this study, we report on two deposits along the north side of South Mountain. The first is a four meter thick deposit formed as a kame delta from a pre-Illinoian glaciation in Emmaus, Pennsylvania. The second, at Valley Quarries in Mainsville, is a ten meter thick soil developed through alluvial fan deposits.

We use iron crystallinity to track relative weathering of the parent material. Early pedogenesis generates amorphous iron-oxy-hydroxides that progressively turn into more crystalline phases like hematite as it ages. An oxalate digestion removes the amorphous iron (FeO), and a dithionite digestion (FeD) will remove the crystalline form of iron. Correspondingly, ratios of FeO/FeD begin relatively high, and decrease with time.

Here we find that the deep red buried soils in the Emaus and Mainsville sites have iron ratios ranging from 0.088 to 0.143, whereas the overlying, modern, brown surface soils have values of 0.21 to 0.35. These ranges are compared to globally-assembled values from the literature, where the soil ages are known and range from 100 to 1,000,000 years old. The deep red color and abundance of iron oxides suggests a warm moist climate dominated while these soils were forming.

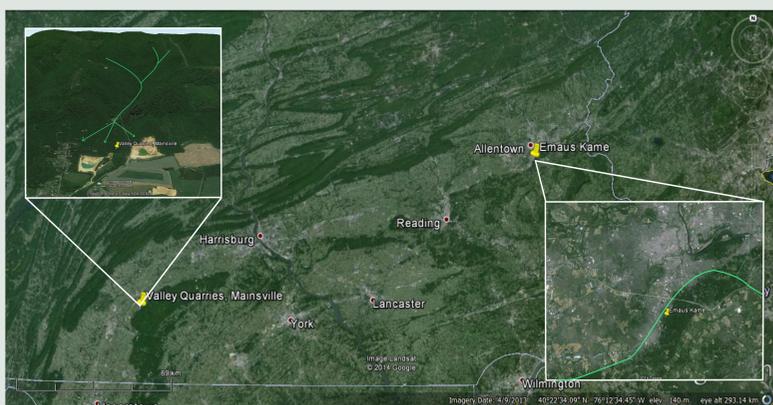


Figure 1: This map shows the locations of each soil pit. They are both on the north side of South Mountain. The left inset demonstrates how the paleosols at Mainsville formed as part of an outwash plain. The inset on the right shows the extent of the Pre-Illinoian glaciation.

Methods:

Field:

- Hand Dig soil pits
- Soils then described using NRCS protocols.
- Sampled soil pits in intervals of 10 - 40 cm

Lab:

- Performed PSDA analysis
- Dried and crushed samples for iron digestions
- Iron removal via oxalate and dithionite
- Diluted samples were then analyzed with an ICP mass spectrometer to determine concentrations of iron

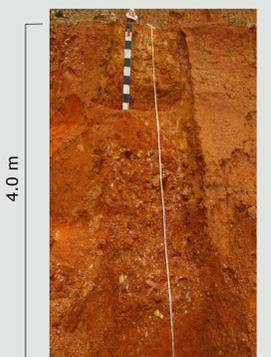
Emmaus paleosol



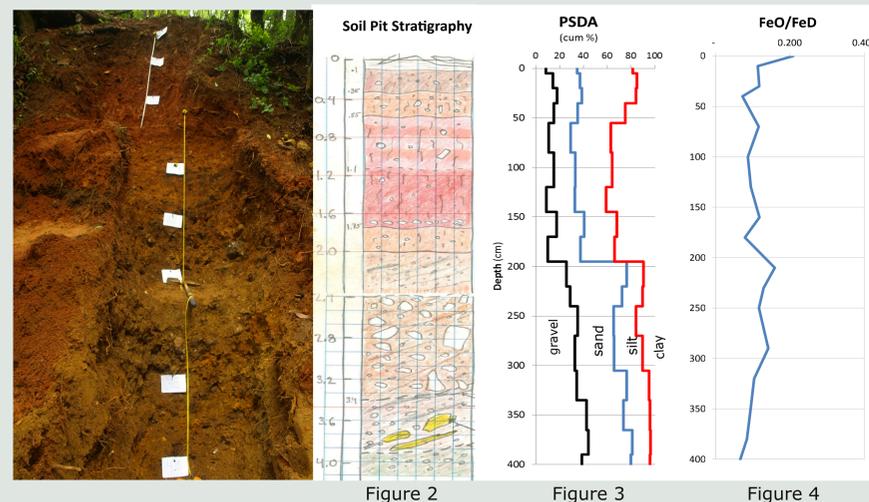
Ultisol - found in humid and tropic environments



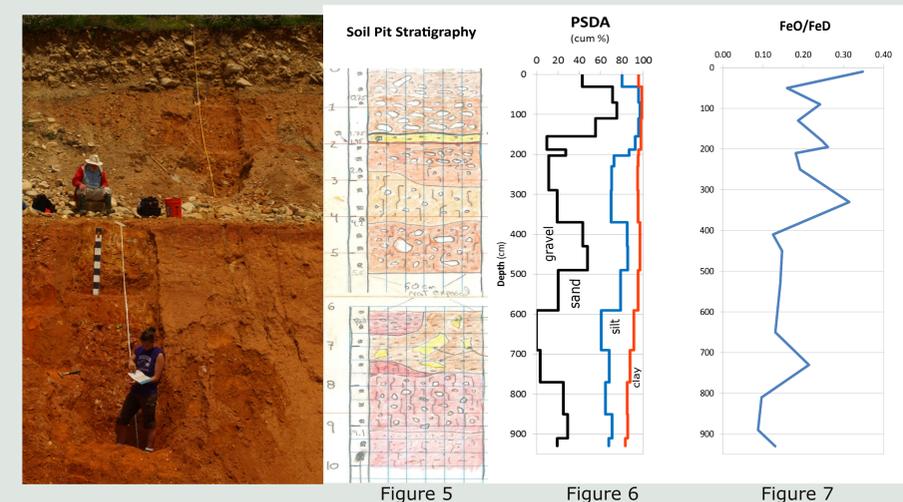
Mainsville paleosol



Emmaus, Pennsylvania



Mainsville, Pennsylvania



Figures 2 & 5 show the stratigraphy of each soil pit. Figures 3 & 6 show the particle size distribution analysis (PSDA) and Figures 4 & 7 show the amorphous to crystalline iron ratio. Figures 2 & 5, along with the soil pit photos, show brown layers overlying the red layers suggesting that the buried soils were formed under much different environmental conditions than modern conditions. Stratigraphic columns drawn by Frank Pazzaglia.

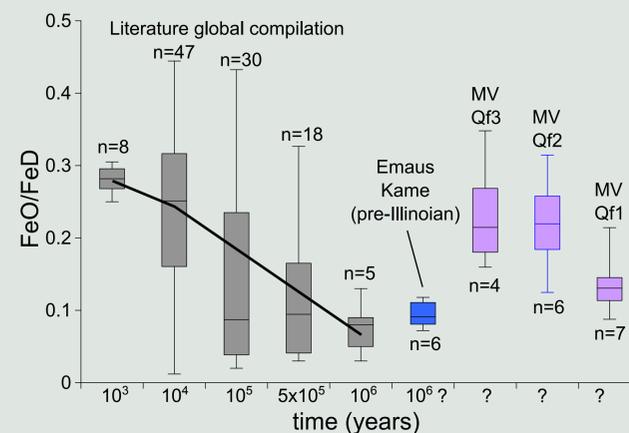


Figure 8: This shows the oxalate extractable iron to dithionite extractable iron ratios compiled from literature in comparison to the Emaus Kame values (blue) and the Mainsville values (purple)

Conclusions:

- According to literature that evaluated similar soil profiles, these paleosols have relative ages of 1×10^5 to 1×10^6 years old.
- Modern brown soils overlying red soils indicate a different climate, most likely warm and moist based on comparison to modern tropical soils, during the formation of the paleosols.
- Upper brown colored soil layers have iron ratio values ranging from 0.21 to 0.35 and the deep red buried soils have iron ratio values ranging from 0.088 to 0.143 indicating that the red paleosols are much older than the overlying brown units.

Future Work:

We currently have samples from a Penn State ag farm site that exposes colluvial fans at the base of Tussey Ridge. The same process will be followed to analyze this site as the previous two sites. Along with PSDA and iron chemistry analysis, a tau plot will be created for all three sites after the samples are fluxed. This will allow us to better understand how much overall chemical alteration has occurred, and the flux of mobile elements in the profile. We are also looking to finish one more site on the Coastal Plain of Maryland because we know the absolute age of the parent material, which is between 3 and 10 Ma.