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Pedogenic carbonate concretions in Iowa's loess soils: a modern carbon sink?

Introduction

Loess is windblown dust. One of the thickest loess deposits in world, the Loess Hills, is found in western Iowa. This deposit was the result of glaciations in which the silt and clay on the Missouri River flood plain, which carried glacial meltwater, was transported and deposited by the wind.

Figure 1 – Map of Loess Hills[1]

Figure 3 – Carbonate concretion

Figure 2 – Carbonate concretions observed in a loess soil profile

Within the loess, carbonate concretions can be found within the top few meters of soil and can range from pebble sized to golf ball size.

Studies have been done on similar concretions in the China Loess Plateau[2] and Hungary[3], however, despite their prevalence in the Loess Hills, they've yet to be thoroughly studied.

Questions and Methods

What are they?

X-ray Diffraction (XRD):

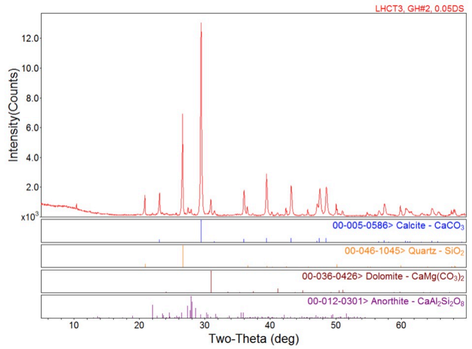

Figure 4 – Mostly calcite and dolomite with trace quartz and anorthite

How old are they?

Radiocarbon Dating:
- 2,540 ± 40 years

Uncertainties of Radiocarbon Dating of OM:
- Maximum age and time averaging?
  - OM incorporated at various stages
  - Cumulative record
- Incorporation of older OM
- Possibility of dissolution and reprecipitation

What is the carbon source?

Atmospheric Carbon Source
- Shallow precipitation
- Soil water CO2 in equilibrium with atmospheric CO2
- Paleoclimate Records
- Modern Carbon Sink
- $\delta^{13}C$ range = -6 to -8.3[4]

VS.

Organic Soil Carbon Source
- Deeper precipitation
- Sources are root respired CO_2 and allows for reconstruction of vegetation OR with root respired, meteoric water, and OM decomposition CO_2
- $\delta^{13}C$ range strongly negative[4]

VS.

Inorganic Soil Carbon Source
- Dependent on dissolved inorganic carbon (DIC) = CO_2 (*l*), HCO_3^-, CO_3^{2-}
  - Depends on pH
- $\delta^{13}C$ range ≈ 0 if DIC sourced from marine carbonates[4]
- $\delta^{13}C$ range strongly negative if DIC sourced from OM[4]

Hypothesis: Soil Inorganic Carbon Source
- Stable isotopic data matches inorganic soil carbon and marine carbonates
- Glacial deposits contain old carbonate → dissolved and reprecipitated

$\delta^{18}O$ and $\delta^{13}C$ of Carbonate Concretions vs. Other Pedogenic Carbonates

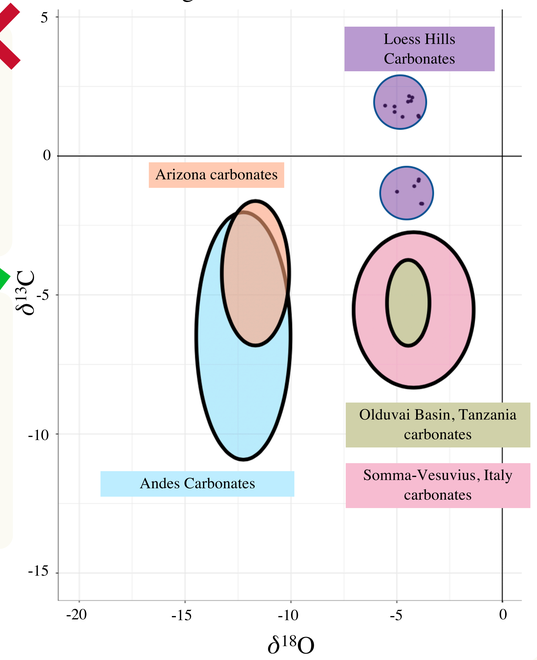

Figure 5 – Stable isotopic data for samples plotted in comparison to other pedogenic carbonate data sets, ours showing near 0 values

Conclusions

- Carbonate + Detrital Sediment Composition
- Modern Formation (< 2,540 years)
- Soil Inorganic Carbon Source --> not a modern atmospheric carbon sink

Future Directions

- How are they forming?
  - Thermodynamics and kinetics driving precipitation OR
  - Leaching from paleosol, accumulation in lower layers, and precipitation
- Are there biological roles playing a factor in their growth?
- Do they show successive growth?

References
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2 – He W, He H, Zhu M (2015) Calcium Nodules as a Proxy for Quaternary Paleoclimate Change on China's Loess Plateau. PLoS ONE 10 (12): e0143928. doi:10.1371/journal.pone.0143928
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4 - Sharp, Zachary. "Principles of Stable Isotope Geochemistry, 2nd Edition." (2017). doi: https://doi.org/10.25844/h9q1-0p82

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