Critical Zone Studies of Shale Weathering in Lares, P.R.

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Abstract

As part of the Critical Zone Exploration Network, the University of Puerto Rico at Mayagüez and Penn State University are collaborating to collect and exchange data related to studies of the Critical Zone. The objective of this project was to prove that weathering progresses differently in different climates and fits into the general tropical soil model, where soils tend to be free of soluble cations and have a high concentration of resistant and secondary minerals. Textural analysis of two hand-dug profiles, and field description, have shown that soils formed on shales in Lares, Puerto Rico are Ultisols: they have an udic moisture regime and excessive development with an iso-hyperthermic temperature regime. Dominant soils for both, eastern US and west PR are Ultisols. This investigation showed that shale weathering progress similarly in different climates, because soils on shales in Puerto Rico (tropical climate) and soils on shales on Eastern US (template climate), had similar geochemistry. Both eastern US and western PR soils have a very low percentage of soluble cations like CaO and K_2O ranging between 0.16 and 4 % and show accumulation of sesquioxides, ranging from 6 to 20%.

Introduction

This study helps to better understand *Critical Zone* (CZ) processes in shale. The CZ is defined as "the external terrestrial layer extending from the outer limits of vegetation down to and including the zone of groundwater" (Brantley, et. al., 2006). This is the zone in which most terrestrial life is found. The *Critical Zone Exploration Network* [CZEN] was developed to incorporate a broad array of sciences including; geology, soil sciences, biology, ecology, geochemistry, geomorphology and hydrology to help understanding the CZ.

Puerto Rico participates in this collection and study climate transect as a shale site in the tropics where there is available data for water and soils down to bedrock. This project emphasizes the importance to measure the rates of formation and geologic limitations of such a widespread rock type.

Objective

Test the hypothesis that shale weathering progresses differently in different climates, and fits into the general tropical soil model, where soils tend to be free of soluble cations and have a high concentration of resistant and secondary minerals. (Buol, 2002)

Location

Fig. 1 CZEN study transect along US eastern coast and PR
(Modified from Brantley, 2009)

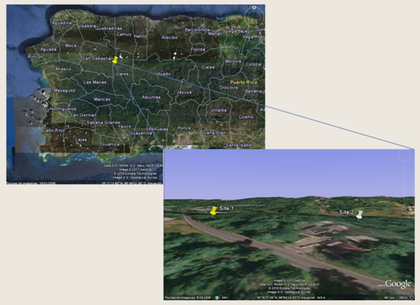


Fig.2 Location of the 2 sites

Methodology

Two different horizons of shale soil profiles in Lares, Puerto Rico were acquired by digging pits 2 m-deep. They were sampled, their physical properties were recorded, the chemical composition analyzed, and this data used as a comparison to similar soil profiles in the Eastern United States.

Climate/Weather description

- National Weather Service climate and weather data was used, both recent data and for the past 30 years in order to compare how temperature and precipitation affects.

Profile analysis

- 2 profiles of soil and shale samples were made using the Soil Pit Collection Method.
- Color of the samples was described using the Munsell Color Chart.

Laboratory Work.

- Samples were sent to the Material Characterization Lab at Penn State University for spectrochemical analysis.
- Textural analysis of the samples was done at the Agronomy and Soils Department Lab of the University of Puerto Rico-RUM.
  - The Boyoucous hydrometer method was used to calculate sand, silt and clay percentage

Figures 3 y 4: Field Work- soil pit method

Fig. 5 Lab work- Boyoucous Hydrometer method

Results

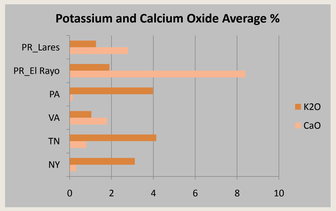
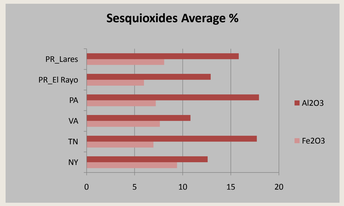


Fig. 6 Soluble cations like Ca, K, Mg and Na are some of the first elements to be depleted in tropical regions.



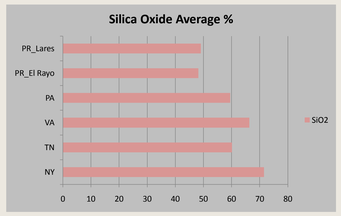


Fig. 7 and 8- The major process affecting soil composition in humid climates is the differential leaching of silica, preferentially leaving iron and alumina.

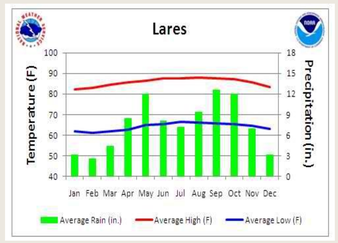


Fig. 9 Soil moisture and temperature are drivers for pedogenesis, and influence elemental distribution ranging from accumulation of elements in arid regions, to depletion of many trace and major elements in tropical regions. (NWS,2010)

Fig. 10 Eastern US is comparable to the climate of the north part of PR, and the western part with that of southern PR. (Modified from Perez,2010)

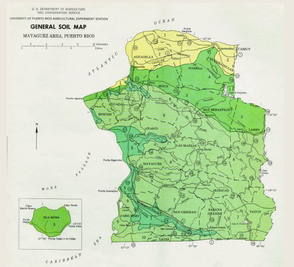


Fig. 11Textural analysis, profile descriptions, and comparison of the sampled soils to the soil survey for the Mayagüez area, has identified them as Cidralfine, Mixed, Semi-active, Isohyperthermic Typic Paleudults. (Modified from Gierbolini, 1975)

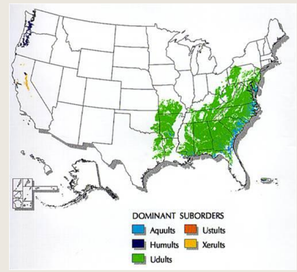


Fig.12 Dominant soils for both eastern US and west PR are Ultisols, acid soils with low natural fertility. (Perez, 2010)

Conclusion

A first analysis of the results suggest that soils above shales in Puerto Rico (tropical climate) and soils above shales in the Eastern US (temperate climate) behave similarly, rather than differently, as originally hypothesized.

The second hypothesis does seem supported in that eastern US and western PR soils do have a very low percentage of soluble cations (such as Ca and K, ranging between 0.16 and 4 %) and show accumulation of resistant and secondary sesquioxides (ranging from 6 to 20%).

Future Work

More analysis has to be done in terms of the silica-sesquioxide ratio in order to provide a better comparison and explanation between the soils, of different climates. As further local data of all the transect sites become available, it will provide additional insight into differences among shale soil development in varying climates.

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Acknowledgements

My thanks go to: My Advisor-Thomas E. Miller. Vinuel Pacheco and The Pagan Family in Lares. **Special thanks are due to:** Ashley Deere, Tim White and Jennifer Williams from Penn State University; Professor Juan Perez Bolivar of the Department of Agronomy and Soils, UPRM; Raiza Quintero and Elena Albelo