Abstract: Using hydrogeophysical methods to understand the spatial distribution of the bedrock-regolith interface in the Rio Icacos watershed (Luquillo Critical Zone Observatory, Puerto Rico).

Xavier Comas¹, William Wright¹, Scott Hynek², Joe Orlando², Heather Buss³, and Susan L. Brantley⁴

¹ Department of Geosciences, Florida Atlantic University, Davie, FL, USA; ² Department of Geosciences, Penn State, Univ. Pk, PA, USA; ³ School of Earth Sciences, University of Bristol, Clifton, UK; ⁴ Earth and Environmental Systems Institute, Penn State, Univ. Pk, PA

1. Abstract

The Rio Icacos watershed in the Luquillo Mountains (Puerto Rico) is a unique site due to the rapid weathering rates and formation of altered materials (i.e., regolith) in the critical zone. The watershed is characterized by a quartz diorite bedrock with a system of heterogeneous fractures that apparently drive the formation of corestones and associated spheroidal fracturing and rindlets. Although spatially limited, direct observations along drilled boreholes from previous studies have conclusively shown that regolith thickness increases with topography, from 20-30 m at the hornfels-facies ridges to several m in the quartz diorite-dominated valleys to tens of centimeters on ridges near the major river knickpoints. In this study we used a suite of hydrogeophysical methods (mainly ground penetrating radar, GPR, and terrain conductivity measurements), to characterize regolith thickness and the lateral distribution of fracturing along km-long transects across topographic gradients. GPR common offset profiles detected vertical areas of concentrated chaotic reflections and diffraction hyperbolas (in contrast to reflection-free areas) associated with fracturing and corestone-rich zones. Terrain conductivity measurements also detected contrasts in electrical conductivity associated with both the presence of fractures/corestones and regolith thickness variability. This research demonstrates the potential of hydrogeophysical measurements for understanding variability of bedrock-regolith interface in the Icacos watershed at large (i.e. km) scales.

2. Methods

a) Ground Penetrating Radar (GPR): Mala unshielded 50, 100, and 200 MHz antennas; shielded 160 MHz HDR. Common offset (CO) and common midpoint (CMP) surveys.
b) Terrain conductivity: electromagnetic multi-frequency sensor (GEM-2 by Geophex).
c) LIDAR: data available from NSF supported National Center for Airborne Laser Mapping.
d) Drilling: data available from previous studies. Wells LGW1 and LGW2.

3. Study Site

4. Results

4a. Results (plot scale)

4b. Results (basin scale)

5. Discussion/conclusions

- GPR surveys detected sharp vertical contrasts between areas of enhanced GPR reflections and reflection-free areas reaching depths of 20 + m.
- Enhanced GPR reflection areas show correspondence with:
  • alternating sequences of quartz diorite and regolith from the drilling
  • decreases in electrical conductivity and increases in magnetic susceptibility from terrain conductivity measurements.
  • valley areas from LIDAR that are filled with corestones as confirmed from field observations.

6. References

Brantley, S.L., H. Buss, M. Lebedeva, R.C. Fletcher, L., 2011 Investigating the complex interface where bedrock transforms to regolith, Applied Geochemistry 26, S12-S15

7. Acknowledgements

This research was supported by NSF (EAR-1331841, PI McDowell). We thank Philip Oviatt, Mala Geosciences USA, and Geophex for their continuous support with geophysical equipment. We also thank Greg Mount (IUP) for field support.