Understanding and quantifying physical erosion processes in the volcanic island of Santa Cruz (Galapagos, Ecuador)

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Abstract : Understanding erosion and weathering processes in volcanic soils is important for scientific and societal matters. Volcanic soils are prone to chemical weathering and have among the highest chemical weathering rates worldwide. When not highly weathered, they are typically very fertile soils for agriculture. Few quantitative data exist on geomorphic processes in pristine volcanic ecosystems, as most volcanic ecosystems are prone to intensive land use and management. We took the opportunity to study natural physical erosion and weathering processes in one of the central islands, Santa Cruz, of the Galapagos archipelago. By controlling for the age and composition of the basaltic parent material, we focused on the unique natural soil-landscapes that developed along the sharp hydroclimatic gradient that is characteristic for Santa Cruz Island. In five main natural vegetation zones (coastal and arid zone, transition zone, moist zone and the highland zone), soil and bedrock samples were collected in 11 sites. The extent of chemical weathering was determined using geochemical mass balances. Meteoric ^{10}Be isotopes ($^{10}Be_m$) were used as a geochemical tracer of soil processes over long time scales (> 10^3 years), as this technique allows one to quantify physical erosion rates based on $^{10}Be_m$ inventories. To account for incomplete retention of $^{10}Be_m$ in the weathering profiles, we used the chemical mass losses of the stable isotope ^{9}Be. The physical erosion rates were calculated from the corrected $^{10}Be_m$ inventories, the $^{10}Be_m$ delivery to the surface and the radioactive decay constant. The results show strong spatial variation in chemical weathering extent and erosion, that coincide with the observed hydroclimatic gradient.