Geomorphology and chemical weathering on basaltic islands

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We are investigating the relationship between geomorphology and chemical weathering on actively eroding basaltic oceanic islands in the tropics, using the Hawaiian islands as a natural experiment. Our field sites include the islands of Kaua'i and Hawai'i, which represent the extremes in ages and soil development on the islands. Hawai'i is largely dominated by constructive volcanic shield topography. On Kaua'i early shield topography has been heavily dissected by fluvial erosion, creating a landscape of high relief characterized by serrated ridges and deep fluvial valleys. Less than ~10% of Hawaii's surface has undergone fluvial erosion while only ~20% of Kauai's original shield topography remains. This system, where relief increases substantially with age as the volcanic edifice is eroded by fluvial erosion, is very different from the conventional school of thought which postulates that after relief is created by an initial disturbance subsequent erosion will smooth the relief and lower it. We wish to investigate how the competing effects of increasing age and weathering are offset by increasing incision and development of relief.

Initial observations indicate a link between Si concentration in river water and hillslope, where watersheds with steeper slopes exhibit higher concentrations of Si than do streams draining more gently sloping topography under similar flow conditions. In the Waimea Canyon on Kaua'i we have observed a nearly 4-fold increase in Si concentrations in the trunk of the river as it plunges over the edge of the Koke'e Plateau (the only remnant of Kauai's original volcanic shield, ~1000 m a.s.l.) into the canyon (~300 m a.s.l.) and mixes with tributaries originating from the western wall of the canyon. The low Si concentrations in river water coming off the plateau reflect interaction with highly weathered and Si-depleted soils. The Si concentrations in the canyon tributaries tend to be 5-6 times higher than in the river water before it flows off the plateau, indicating that the tributaries tap sources of groundwater that has interacted with fresh rock at depth in the volcanic pile. Streams draining young bedrock on Hawai'i, where the river profile still follows to a large degree the original shield topography, have nearly as low Si concentrations as rivers draining old, stable shield surfaces, indicating that rivers in an early stage of incision do not tap groundwater sources. Groundwater that discharges directly to the ocean is an important geochemical pathway on Hawai'i and our data indicate its Si-concentrations are similar to the highest Si concentrations observed in the Waimea Canyon tributaries.

Development and application of novel organic proxies

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Sediments contain a myriad of organic compounds which potentially contain information on past microbial communities and the environments in which they lived. Research over the last few decades has improved our knowledge on the structure and origin of these compounds and their use as qualitative and quantitative proxies for past climatic conditions is rapidly increasing. Recently we developed several novel proxies based on the distribution and isotopic composition of terrestrial and aquatic biomarkers. Analysis of different soils from all over the globe showed a significant correlation between the distribution of branched tetraether lipids, derived from bacteria, and mean annual air temperature. We used this correlation to reconstruct continental temperature changes in several climatically important periods such as glacial-interglacial changes in the Quaternary and Cenozoic periods of global warming and cooling. Further validation of this proxy is currently underway by e.g. analysing soils surrounding hot springs. These soils are geothermally heated thereby providing a natural temperature gradient in soils of similar composition.

Another proxy which we are currently developing is the relative deuterium content of algal biomarkers as a proxy for sea water salinity. First results show a significant correlation between the δD of long chain alkenones with salinity and δD of growth water. This has been used to reconstruct past salinity changes in the Holocene Black Sea and the Aegean Sea during time of sapropel S5 deposition. Further culture studies are now underway to examine other factors influencing the δD of alkenones and to test other biomarkers as potential paleosalinity proxies.