# Extreme basalt weathering results from high soil $CO_2$, unsaturated conditions and organic acids

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The intensity of weathering across the Hawaiian archipelago is strongly correlated with the surface exposure age and integrated climate history. Intense basalt weathering results from exposure to elevated soil $CO_2$ concentrations, unsaturated conditions throughout the rock/soil profile, and/or release of organic acids from plant exudates, all in a regime with high water/rock ratios from rainfall > 2000 mm/year. The result is complete loss of base cations and primary minerals within the first 20,000 years of weathering [1]. Furthermore, this weathering regime can decrease soil pH to values between 4.0 – 4.5, depleting soil profiles from all its buffering capacity.

We have developed a set of 1-D reactive transport models (RTM), to investigate the role of these weathering agents driving basalt weathering. The effect of soil $CO_2$ effect is explored in three ways: diffusion of $CO_2$ from atmosphere, fixed $CO_2$ fugacity in the profile, and by soil organic matter respiration. We test the sensitivity of gases as weathering agents by studying different degrees of water-column saturation in the profile. Organic acids play a role as ligand-promoted dissolving agents. Lastly, because of the Fe-rich nature of the weathered soils, including Fe(II) oxidation is essential to understand this abundance.

Depth of weathering fronts is controlled by the degree of water-column saturation: further unsaturation allows downward propagation of reactive gases ($CO_2$ and $O_2$) in the profile. Organic acids are the principal drivers for low soil pH, however they only play a role in the topmost part of the profile. High $CO_2$ concentrations through the profile, either by elevated atmospheric $CO_2$, fixed fugacity or by production are necessary to produce representative pH profiles. The RTM predicts high $CO_2$ consumption rates by silicate weathering within the first thousand years, which stabilize as buffering capacity is lost from the rock. Finally, the models predict precipitation up to 30% volume of secondary phases, such as allophane and ferrihydrite. Some Al is exported by ligand complexation while Fe largely is retained in soil.

These results show that intense weathering of basaltic lava flows can play a role as long-term climate modulators, because of fast $CO_2$ consumption rates.

[1] Vitousek, *et al.* (1997) GSA Today **7**, 1-8.