Weathering dynamics of Large Igneous Provinces (LIPs): a case study from the Lesotho Highlands

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Basaltic terrains contribute a significant component to the global silicate weathering flux despite their limited areal coverage. A strong correlation between chemical weathering flux and climatic factors such as temperature in volcanically inactive basaltic fields implies that weathering of basalt might have played an important role in maintaining the habitability of the Earth and the balance of the geological carbon cycle. However, the low erosion rate of flood basalt provinces on tectonically quiescent cratons, where the clear climate dependence of weathering rate has been observed, implies a 'supply-limited' weathering regime so that weathering flux is controlled by physical erosion rather than climate. This work tests the weathering dynamics of flood basalts by investigating the weathering flux of the Lesotho Highlands where an extremely low rate of denudation has been recorded. Stream chemistry of the rivers shows typical characteristics of basalt weathering. Strong spatial and seasonal variability of solute concentration, possibly linked to a dilution effect, is observed. However, the giant Katse Reservoir of the Lesotho Highlands Water Project (LHWP) effectively averages the spatial and seasonal variability of the solute concentration. The average solution concentration and long-term runoff of the Katse Reservoir give an average atmospheric CO_2 consumption rate of $0.259\pm0.024 \times 10^6$ mol/km^2/yr (mean ± standard deviation). The chemical weathering flux requires congruent weathering and thus a 'supply-limited' weathering regime given the low denudation rate. Nevertheless, the chemical weathering rate of the Lesotho Highlands, as well as other low-eroding basaltic plateaus, is still consistent with the global correlation between temperature and the rate of basalt weathering. Chemical detachment of rock particles, and thus denudation, controlled by chemical weathering kinetics, is suggested to reconcile the paradox between the observed temperature dependence of chemical weathering rates and 'supply-limited' weathering regimes.