Always supply limited: a new approach to solve the Cenozoic weathering paradox

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The co-evolution between global cooling and increasing continental weathering flux argues strongly an uplift-driven climate change during the Cenozoic Era. However, dominance of unweathered rock fragments in catchments of the highly eroded terrains suggest that increase of weathering flux might be largely hampered in later stage of tectonic uplift due to a kinetically limited weathering regime yet weathering flux seems to increase monotonously with erosion rate in some of the most tectonically active regions. Balance of carbon cycle also requires a constant global weathering flux and thus implies a decreasing weathering flux in the kinetically limited regions through the weathering-climate (pCO_2) feedbacks. Here a model interpretation on the global riverine uranium isotope shows that weathering, expecting for few cases, is always controlled by the supply of fresh surface. A site-specific dissolution depth of ~10 nm can be constrained using the recoiling distance of 234 nuclei as an internal scale. Weathering surface became passivated soon after its exposure due to the secondary precipitates. Weathering flux is proportional to the supply of deep fractures in the mass wasting dominated threshold landscapes. Higher erosion rate, and potentially higher tectonic stress, would generate more fractures for weathering reaction. Increasing supply of fractures in response to tectonic uplift may have served as a persistent forcing for the Cenozoic cooling. In contrast to traditional interpretation, the balance of carbon cycle is suggested to be maintained by the tectonic inactive regions, where the supply of fresh rocks is modulated by climate (pCO_2) sensitive diffusional processes. A correlation between temperature and erosion rate in tectonically stable basaltic terrains is reported to support this interpretation.