Weathering from the soil profile to the watershed: what controls the weathering advance rate?

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The weathering advance rate for residual, noneroding regolith is defined as the rate at which the interface between altered regolith and unaltered parent material propagates downward as the regolith pile thickens with time. Theoretically, for such a profile developing on infinitely thick parent material, the weathering front reaches a quasi-stationary state wherein the reaction front propagates downward but the geometry is constant with time.

If the rate of erosion of such regolith is increased to be larger than the weathering advance rate, the regolith thickness must decrease with time. For such a condition, the regolith would eventually disappear unless some process accelerates the weathering advance rate. If the weathering advance rate increases until it equals the erosion rate, then the regolith will maintain a steady state thickness. One mechanism that can control the weathering advance rate is spheroidal weathering, the process by which bedrock fractures to form corestones. The rate of spheroidal weathering may be driven by chemical reaction at the weathering interface. During spheroidal weathering, as regolith thins, the rate of weathering advance increases because porefluid chemistry becomes more corrosive and the rate of fracturing increases. Thus, the rates of erosion and weathering advance due to spheroidal weathering are coupled through porefluid chemistry.

The weathering advance rate is not, however, observed to be the same when calculated at the watershed, soil profile, and hand specimen scales. Several phenomena presumably contribute to this observation. For example, evidence suggests that corestones shrink to a limiting corestone size during spheroidal weathering. Once corestones reach this limiting size, the mechanism of weathering may change from spheroidal weathering to diffusion-controlled reaction without fracturing. A better understanding of weathering advance rates across scales will elucidate the mechanisms underlying the formation of soil profiles as well as the controls on solute fluxes in watersheds.