TITLE: From minerals to hillslopes: Towards an integrated framework for interpreting chemical and physical erosion

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ABSTRACT BODY: Traditional frameworks for conceptualizing hillslope denudation distinguish between the movement of mass in solution (chemical erosion) and mass moved via mechanical processes (physical erosion). At the hillslope scale, physical and chemical erosion rates can be quantified by combining measurements of regolith chemistry with cosmogenic nuclide concentrations in bedrock and sediment, while basin-scale rates are often inferred from riverine solute and sediment loads. These techniques integrate the effects of numerous weathering and erosion mechanisms and do not provide prima facie information about the precise nature and scale of those mechanisms. For insight into erosional process, physical erosion has been considered in terms of two limiting regimes. When physical erosion outpaces weathering front advance, regolith is mobilized downslope as soon as it is sufficiently loosened by weathering, and physical erosion rates are limited by rates of mobile regolith production. This is commonly termed weathering-limited erosion. Conversely, when weathering front advance outpaces erosion, the mobile regolith layer grows thicker over time, and physical erosion rates are limited by the efficiency of downslope transport processes. This is termed transport-limited erosion. This terminology brings the description of hillslope evolution closer to the realm of essential realism, to the extent that measurable quantities from the field can be cast in a process-based framework. An analogous process-limitation framework describes chemical erosion. In supply-limited chemical erosion, chemical weathering depletes regolith of its reactive phases during residence on a hillslope, and chemical erosion rates are limited by the supply of fresh minerals to the weathering zone. Alternatively, hillslopes may exhibit kinetic-limited chemical erosion, where physical erosion transports regolith downslope before weatherable phases are completely removed by chemical erosion. We show how supply- and kinetic-limited chemical erosion can be distinguished from one another using data from a global compilation of physical and chemical erosion rates. As a step towards understanding these rates at the level of essential realism, we explore how the hillslope-scale regimes of supply- and kinetic-limited chemical erosion relate to existing conceptual frameworks that interpret weathering rates in terms of transport- and kinetic-limitation at the mineral scale.

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