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Landscape evolution by soil differentiation on African catenas

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Landscapes in most of the Southern Hemisphere have escaped geomorphic agents shaping some of Earth's most charismatic stretches of land in the North. Amongst these are mountainous terrains presided over by tumultuous tectonics and landforms created by remnants of past glaciers. In Southern Africa, tectonic activities and glaciations have had a much more limited impact on the present landforms. This quiescent geomorphic regime has led to relatively stable landscapes enabling prolonged soil differentiation to culminate in catenas. Over these extended time scales the soil surprisingly emerges as a significant geomorphic agent in its own right.

Catenas in the Kruger National Park, South Africa, form on gentle <8% slopes over 100 to 2000m between hillcrests and footslopes. Erosion rates inferred from in-situ produced cosmogenic Be-10 are relatively low in the range 2 and 4m per Ma and chemical weathering is responsible for up to 80% of these losses. The long soil residence times necessitated by the slow tempo of erosion give rise to intense weathering-driven differentiation between highly leached crests and depositional areas at the foot of the catenas. The crests are as a result volumetrically collapsed relative to parent material as indicated by elevated Zr concentrations while lower down on the catenas the soil fabric becomes dilated and depleted in Zr. The collapses and dilations are measurable, and can be as much as 3m at the crest and a meter's expansion at the foot. Hence pedogenic collapse and dilation on this scale produces real changes in hillslope geomorphology. Is it thus possible for soil development outside physical erosion to act as a geomorphic agent.

Soil dilation at the footslope has a further consequence on hillslope geomorphology. Due to material build-up in footslope soils, mostly clay, soil pores are clogged resulting in diversion of water flowpaths to the surface. Over time, this process can result in a fluvial incision that migrates up the slope further altering hydrological flowpaths. Therefore, some of the patterns in fluvial dissection observed at drainage network scales may originate from pedogenic processes occurring at the pedon scale. Altogether, it is apparent that soil does impinge on geomorphology and landscape evolution, something not particularly obvious, especially outside highly stable landscapes.