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Using paleosol mineral assemblages to reconstruct evolving changes in climate

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The use of soil minerals as a sensitive paleoclimate indicator has its foundation in the pedogenic threshold concept (sensu Chadwick and Chorover, 2001) which suggests that environmental conditions influence soil-water solute concentrations thus impacting mineral-water equilibria thresholds that ultimately will be expressed as a soil mineral assemblage. Soil mineral assemblages can be used to reconstruct Earth's climate if they are preserved in the rock record as a paleosol mineral assemblage (PMA). PMAs provide evidence of the climate-driven weathering reactions that destroy soil parent material and the equally climate-sensitive creation of solid weathering products. Therefore, soil-mineral pedogenic thresholds represent climate-controlled limits for chemical-weathering reactions resulting in distinct mineral assemblages that are interpretable in terms of evolving environmental conditions.

Paleosol mineral assemblages reveal both the weathering intensity experienced by soil parent minerals as well as the resulting products of weathering. The readily available reactants that are sensitive to weathering are feldspars and labile volcanic detritus and the intensity of weathering can be assessed by comparing their relative abundance throughout a stratigraphic succession. Weathering products are comprised of a series of diagnostic soil minerals that form during pedogenesis and have stabilities across a wide range of varying environmental conditions. The common paleosol mineral thresholds are (from wetter climates to drier climates) Al oxy/hydroxides, siderite, Fe oxy/hydroxides, kaolinite, smectite, chlorite, calcite, gypsum, and palygorskite.

This study presents the evolution of paleosol mineral thresholds through the Chinle Formation in Arizona, USA that reveals the aridification of western Pangaea during the Late Triassic. The paleosol mineral thresholds are compared to mean annual precipitation estimates based on bulk paleosol geochemistry and are shown to be a more sensitive indicator of climate change.

Chadwick, O.A., and Chorover, J., 2001, The chemistry of pedogenic thresholds, Geoderma, v. 100, p. 321-353.