Constraints on regolith formation and erosion rates at the Susquehanna Shale Hills Critical Zone Observatory, PA, determined using meteoric ^{10}Be

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Abstract

New meteoric ^{10}Be data from 73 samples of bulk regolith collected along north- and south-facing hillslopes at the Susquehanna Shale Hills Critical Zone Observatory (SSHO) provide first-order constraints on the timescales of regolith formation. The SSHO is located in the presently temperate climate zone of central Pennsylvania; however, sustained periglacial climate during the time of maximal extent of the Laurentide ice sheet (~19-21 ka) and deforestation during mid-19th Century charcoal production may have exerted significant influence on regolith production. Here, we quantify soil residence times and corresponding rates of regolith production and erosion on the north- and south-facing slopes at SSHO, using meteoric ^{10}Be in samples of regolith collected at 25 locations along each hillslope from ridge top to toe slope. Hillslopes within the SSHO are relatively planar, but exhibit a pronounced asymmetry; north-facing slopes are steeper (~20°) than south-facing slopes (~15°). Meteoric ^{10}Be concentrations decrease systematically with depth at all 6 profile sites. Meteoric ^{10}Be inventories are similar at the north and south ridgetop sites (1.89 ± 0.55 at/cm^2 and 1.63 ± 0.41 at/cm^2, respectively) and generally increase with position downslope. Assuming that the delivery of meteoric ^{10}Be to regolith is balanced by its removal via erosion, the total meteoric ^{10}Be inventories at the north and south ridgetops are consistent with soil ^{10}Be residence times of 10.5 ± 3 ky and 9.1 ± 2 ky, and with steady lowering rates of ~ 16 m/My and ~ 19 m/My, respectively. Increases in meteoric ^{10}Be inventories downslope are consistent with relatively slow creep, with transport velocities of 0.45 cm/y and 0.38 cm/y for the north and south hillslopes, respectively. Comparison of our results with previously-published estimates of regolith production rates inferred from U-series disequilibrium reveals that estimates of steady-state erosion calculated using meteoric ^{10}Be are

considerably slower than regolith production rates. We are currently exploring whether this result implies non-steady erosion in the SSHO, or whether it results from differences inherent in the different isotopic techniques. Overall, the meteoric ^{10}Be results suggest that most of the regolith on hillslopes within the SSHO watershed formed during the Holocene since the time of periglacial influence. In turn, estimated erosion rates on the ridgetops may reflect average lowering since that time.

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