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# Knickpoint formation, rapid propagation, and landscape response following coastal cliff retreat at last-interglacial sea-level highstand: Kaua‘i, Hawai‘i

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The propagation of knickpoints through a landscape is recognized as a highly efficient mechanism of channel incision, and exerts a first-order control in communicating changes in base level throughout a landscape. However, few settings allow reconstruction of the long-term rate of knickpoint retreat. Here, we use cosmogenic 3He exposure dating of olivine within basalt to document the retreat rate of a waterfall in Ka’ula’ula Valley, a small catchment on the Na Pali coast of Kaua‘i, Hawai‘i. We constrained the exposure age of 18 features (in-channel boulders, stable boulders on terraces, and in-channel bedrock) along the length of the channel that allow us to discriminate between models of knickpoint propagation. Cosmogenic exposure ages are oldest near the coast (120 ka) and systematically decrease with upstream distance towards the waterfall (<10 ka). Upstream of the knickpoint, cosmogenic ages are approximately constant (10-20 ka). This data indicates that the waterfall has migrated 4 km up valley over the past 120 ka at an average rate of 33 mm/yr. Steady-state vertical erosion appears to dominate upstream of the waterfall, where the channel has incised $\sim$100 m into the original surface of the shield volcano. Our results indicate the lateral rate of knickpoint retreat exceeds rates of vertical channel incision by three orders of magnitude, and that knickpoints may be the primary driver of relief generation in Hawaiian catchments. Submarine landslides have been proposed as the cause of knickpoints in Kaua‘i streams; however, the bathymetry off the northwest Kaua‘i coast lacks evidence for large submarine flank collapse. Alternatively, we propose substantial cliff erosion during the last interglacial sea-level highstand generated a waterfall at the coast, which has subsequently propagated inland. Superimposing Kaua‘i’s subsidence history and Pleistocene sea level fluctuations indicate that the only time waves could have eroded cliffs at Ka’ula’ula Valley’s entrance over the past 1.5 Ma was during the last interglacial, $\sim$130-120 ka. Knickpoint generation during sea level high stands, as opposed to the typical case of sea-level fall, may be an important relief-generating mechanism on other ocean islands and stable or subsiding coasts.