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A binge-purge landscape response to major latitudinal temperature gradient transitions

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The current rejuvenation of paleo-erosion rate research reveals conflicting signals of climate controls at the 105 a timescale. During the Pliocene-Pleistocene transition, low latitude rates remained relatively steady, consistent with global erosion rate stability over the past 10 Ma. Erosion rates in mountainous mid-latitudes increase after the Pliocene, perhaps owing to a greater surface area for weathering in mountainous regions and more frost-thaw cycles, but in low relief mid-latitude regions rates were greater during warm periods, consistent with the observation that modern warm-sourced rivers contribute the greatest flux globally. We test a hypothesis that explains these seemingly conflicting spatial and temporal patterns: During the rapid steepening of the latitudinal temperature gradient accompanying a global decrease in mean annual temperature (MAT) of 2°C, higher latitude regions (local deltaMAT >10°C) generated significantly more sediment.

To test this hypothesis we use the well-studied White Channel Gravel units in the Klondike Goldfields of the non-glaciated region of the Yukon, Canada. The previously established late Pliocene to early Quaternary chronology based on paleomagnetic stratigraphy and tephrochronology was supplemented with 26Al/10Be simple and isochron burial dating, and the paleo-erosion rates were established with 10Be in detrital quartz in the fluvially-dominated valley fill gravels from two valleys. Our test reveals that arctic stream sediments record slow erosion during the warm middle-Pliocene (as low as 1 cm/kyr during the regolith-producing binge phase). The duration of the saprolitization during this binge phase appears to have spanned more than 100 ka, i.e. through multiple obliquity-dominated glacial-interglacial cycles, so some variation in erosion rate is expected. However, an octupling of erosion rate occurred during the latitudinal-temperature gradient steepening. At 3.5 Ma, the end of the insolation-controlled Pliocene warm period in the arctic, the upper portion of the Lower WCG at Australia Hill records the highest paleo-erosion rate (25 cm/kyr) indicating that conditions changed to favour erosion over saprolitization. The latitudinal control also explains why fluxes decrease sharply to average 2 cm/kyr in the earliest Pleistocene once the system becomes weathering-limited and predicts that kinetically-controlled weathering rates may accelerate sediment fluxes to the oceans during future polar amplification.