Apatite $^4He/^3He$ Thermochronological Constraints on Topographic Development at Yosemite Valley, California

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Since the seminal work of Matthes (1930), it has commonly been hypothesized that Yosemite Valley developed first as a deep fluvial canyon and then by glacial excavation. From topographic analysis of upland tributaries, Matthes concluded that the bottom of the pre-glacial fluvial canyon was only ~500 m above the current valley floor (though glaciers also excavated a sediment-filled over-deepening of ~600 m depth). Thermochronological analysis of bedrock samples provides a test of whether, indeed, much of the relief of Yosemite Valley was formed prior to the Pleistocene. Moreover, such analysis might reveal the timing of incision of the fluvial canyon; some researchers claim that the western Sierran canyons are as young as 3 to 10 Ma (e.g., Wakabayashi, 2013) while others have suggested that they have existed throughout the Cenozoic (e.g., House et al., 1998). In principle, such hypotheses can be tested with apatite $^4He/^3He$ thermochronology, provided that the thermal signal of a given topographic scenario is both predictable with thermokinematic modeling and geochemically resolvable. Here, we present apatite $^4He/^3He$ thermochronology conducted on single crystal aliquots from 11 bedrock sites from within and around Yosemite Valley, including LA-ICPMS analyses of the spatial distributions of U and Th within the same crystals. (U-Th)/He ages vary from ~40 Ma in the heart of Yosemite Valley to >60 Ma on the adjacent upland surfaces and ~70-80 Ma in the shallower part of the canyon downstream to the west. We will discuss how the $^4He/^3He$ data constrain the thermal conditions of these sites over the last ~60 Ma and explore the geochemical complexities associated with inner crystal, non-uniform spatial distributions in U and Th, radiation damage effects on ^4He diffusivity, 3D diffusion modeling, and differences between crystal aliquots within a given rock and between rock samples. Taken together, our results suggest that the current topography developed more recently than 20 Ma but, as Matthes believed, is not largely a Pleistocene feature.