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Yosemite Valley incision constrained by combining He-4/He-3 thermochronometry with LA-ICPMS maps of U and Th

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The incision history of Yosemite Valley has been debated for almost 100 years despite a range of important implications from glacial erosion efficiency to uplift of the Sierra Nevada. The (U-Th)/He system is sensitive to low temperatures (<100 C), and thus has the potential to constrain the timing of thermal conditions of crustal rocks as Yosemite Valley was incised. However, overdispersion of (U-Th)/He ages can represent an obstacle to extracting accurate and precise thermal paths. An alternative to analysis of (U-Th)/He ages of multiple crystals from the same rock sample is to collect a large amount of information from one or two crystals using He-4/He-3 thermochronometry, which measures the spatial distribution of He-4 within an individual crystal (Shuster and Farley, 2004). The observables are a function of both the continuous thermal path of the sample and the spatial distribution of the parent nuclides. In regions of low erosion rates and thus slow cooling rates, the He-4/He-3 spectrum commonly deviates from expected trends. This is likely due to different parts of the crystal effectively evolving separately due to radiation damage and annealing. We present data from Yosemite Valley in which the He-4/He-3 spectra for three different crystals from the same sample are internally inconsistent under the assumption of spatial uniform parent nuclides. As revealed by laser ablation ICP-MS data from polished sections through the same crystals, U and Th zonation is the cause of the differences between samples. Combining these He-4/He-3 data and U and Th zonation information for different crystals from the same sample tightly constrains its continuous thermal path. Furthermore, combining multiple samples from locations and elevations, using a 3D thermal model enables us to infer the landscape evolution history of Yosemite Valley. We find that much of the relief in Yosemite Valley was formed prior to the onset of extensive glaciation across the Sierra Nevada. Finally, we simulate the extent of glaciations for expected climatic conditions and highlight the sensitivity of glacier to changes in evolving topography.