# Late Quaternary temperatures recorded by cosmogenic $^{3}$He in Yosemite Valley rock avalanche deposits

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Since ice retreated from Yosemite Valley in the late Pleistocene, rock avalanches from near-vertical walls have deposited debris lobes on the valley floor. Measurements of cosmogenic $^{10}$Be in quartz from these deposits indicate that at least 10 distinct, large rock avalanches have occurred since deglaciation, ranging in age from ~1 to 13 ka. Due to their close proximity (< 5 km$^2$) and similar elevations (< 100 m difference), these deposits experienced different durations of exposure but very similar climate histories. We thus use measurements of cosmogenic $^{3}$He in quartz, a system subject to temperature-dependent diffusive loss at surface temperatures, to place quantitative constraints on Late Quaternary temperatures in Yosemite Valley.

The apparent $^{3}$He boulder exposure ages from five deposits are 58 to > 98% younger than the $^{10}$Be ages from the same samples, as expected due to diffusive He loss. Two of these samples did not yield measurable $^{3}$He abundances, resulting in apparent $^{3}$He exposure ages < ~120 yr. For each sample, we also quantified the kinetics of $^{3}$He diffusion with a stepwise degassing experiment on proton-irradiated quartz fragments. All samples exhibited complex $^{3}$He diffusion behavior manifest as nonlinearity in Arrhenius plots, which we fit using a multiple diffusion domain model. We use the sample-specific diffusion kinetics with the observed cosmogenic $^{3}$He and $^{10}$Be abundances to model the production and diffusion of $^{3}$He since deposition of each debris lobe for different Late Quaternary temperature scenarios. Modeling results indicate that effective diffusion temperatures (EDTs) recorded by $^{3}$He in the oldest rock avalanche deposits we examined are the same or slightly higher than the modern EDT from the instrumental record, suggesting minimal Holocene temperature variability in Yosemite Valley.