Geophysical Research Abstracts
Vol. 12, EGU2010-8148-1, 2010
EGU General Assembly 2010

Quantifying Landscape Response to Past (Last Glacial) and Present Day Erosion with Detrital Thermochronology

Todd A. Ehlers (1), Greg M. Stock (2), Kenneth A. Farley (3), and Brian Yanites (4)

(1) University of Tuebingen, Department of Geosciences, Tuebingen, Germany (todd.ehlers@uni-tuebingen.de), (2) National Park Service, Yosemite National Park, El Portal, CA 95389, (3) Division of Geological and Planetary Sciences, California Institute of Technology, Pasadena, CA 91125, (4) University of Michigan, Geological Sciences, Ann Arbor, MI 48109

Quantifying landscape response to climate change is limited by insufficient knowledge of spatial and temporal variations in catchment erosion. Detrital cooling ages collected from Quaternary glacial moraines and modern river sediments provide a tool to address these problems. We use detrital thermochronology to quantify spatial variations in alpine glacial erosion during the Last Glacial Maximum (LGM). Results are compared to the distribution of present-day erosion recorded in samples from modern river sediments, and predicted patterns in glacial erosion from a plan-form (shallow-ice approximation) glacial erosion model.

The elevation dependence of detrital apatite (U-Th)/He (AHe) ages is used as a sediment tracer to track the elevations where glacially eroded sediment is produced from bedrock. We measured $\sim$204 AHe single grain ages from three moraines located between 2.3 and 3.7 km elevation in the Lone Pine catchment, Sierra Nevada, California. Measured AHe age probability density functions (PDFs) were compared with predicted PDFs, calculated by convolving bedrock age-elevation relationships with catchment hypsometries clipped at different altitudes to reflect variable source elevations of sediment. Statistical comparison of the PDFs using a Monte Carlo approach and Kuiper test are used to evaluate the spatial distribution of erosion in the catchments.

Results from the lowest elevation moraine indicate sediment is produced from the lower 50-70% of catchment elevations at the 95% confidence level, suggesting erosion near the base and sides of the glacier outweigh erosion from higher elevation head wall retreat and rock fall onto the glacier. Furthermore, grain-age distributions from different sediment size fractions are virtually indistinguishable, suggesting either both size fractions are sourced from similar elevations, and/or a significant disaggregation of coarse-grained material into finer material during transport. Finally, the intermediate to high-elevation moraines within the cirque indicate glacial erosion is possibly uniform and occurs over 70-100% of the elevations above the sample location. These spatial variations in glacial erosion are in stark contrast to previously published results from the neighboring fluvial dominated Inyo Creek where a uniform distribution of erosion is observed from detrital AHe analysis of modern river sediments. Taken together, these results demonstrate: (1) a high sensitivity of detrital thermochronology to spatial variations in glacial and fluvial erosion processes, and (2) an increase in topographic relief and/or significant down-valley widening during glaciation as supported by the abundance of sediment sourced from lower elevations in the catchment.

Observed patterns of glacial erosion are in general agreement with initial predictions from a plan-form glacial erosion model calibrated to the study area. Model predicted glacial erosion rates during the Last Glacial Maximum are highest over the same range of elevations that detrital thermochronometer data indicated moraine sediment was sourced from. Work in progress is evaluating the sensitivity of model predicted patterns in glacial erosion to different climate histories.