Evaluation of knickpoint erosion using detrital apatite thermochronometry

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Project Overview

This study investigates the spatial distribution of erosion in stream channels to understand how bedrock and faulting may influence the development of knickpoints in stream channels. Sediments from the mouth of the stream channel were collected to capture the mechanism of knickpoint formation and evolution of longitudinal stream channels. The hypothesis for this study consisted of two parts. If faulting created knickpoints, then a high proportion of the stream sediment would be sourced from locations near the knickpoints assuming the stream would actively incise bedrock to return the system to equilibrium after disturbance from faulting. If the knickpoints are instead controlled by lithology, then there would be an absence of sediment sourced from the knickpoint elevations because the bedrock is more resistant to erosion. Detrital mineral analyses and rock mass strength (RMS) quantification were completed to test these hypotheses.

Sacramento Mountains

Figure 1. Western front of the Sacramento Mountains.

BSG funding supported sample collection and RMS observations in Dog Canyon in the Sacramento Mountains, New Mexico, which are composed of Paleozoic sedimentary bedrock and Tertiary intrusions (Figure 1). A distinct escarpment defines the western boundary of the range formed by normal faults. Eight bedrock and two sediment samples were collected from Dog Canyon for low temperature (U-Th)/He apatite thermochronometry. Most apatite minerals were small or contained low uranium contents, producing high uncertainty in the final ages. RMS assessments were based on 7 parameters at each bedrock unit and included intact rock strength, degree of weathering, spacing of joints, joint orientations, width of joints, continuity of joints/degree of infill, and outflow of groundwater. Intact rock strength was also measured using a Schmidt hammer. The results of the rock mass strength analyses supported the hypothesis that the rock strength is likely to control the position of the knickpoints. All knickpoints were located at the boundary or within the three strongest rock units within Dog Canyon.

Teton Mountains

BSG funding also supported analyses of detrital apatite minerals in the Teton Mountains, Wyoming, which are composed of metamorphic and igneous rocks overlain by Paleozoic sediments. The Teton normal fault defines the eastern boundary of the range. Apatite minerals from four streams were dated with low temperature thermochronometry. The highest proportion of minerals in each catchment came from bedrock sources aged between 10-20 Ma (Figures 2-4). Preliminary analyses indicate the positions of highest erosion occur below concavities in the channel profile near the outlet of the canyons.

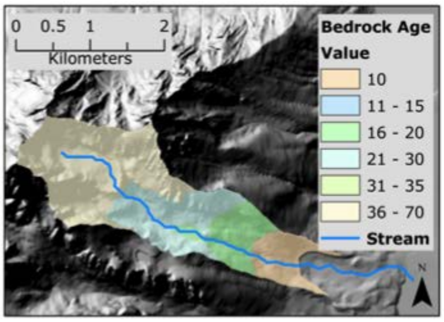

Figure 2. Predicted bedrock ages in Glacier Gulch.

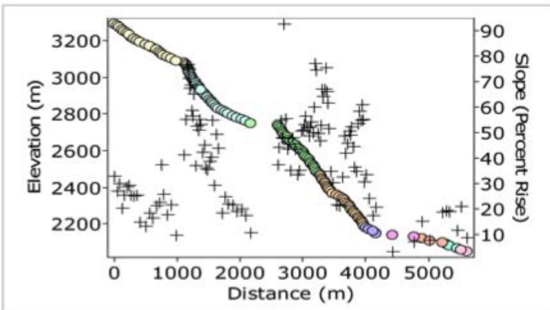

Figure 3. Glacier Gulch stream profile and slope.

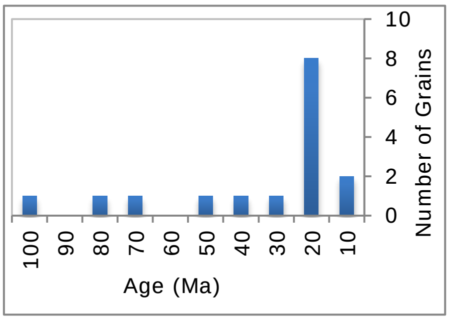

Figure 4. Stream ediment age distribution from Glacier Gulch.

Outcomes

The BSG funding supported fieldwork and analyses that were presented by two of my undergraduate students at the Geological Society of America Annual Meeting in Baltimore, Maryland, USA in November 2015. We are currently preparing results from the Sacramento Mountains for publication. Final analyses and statistical comparisons between data from catchments in the Teton Range are ongoing and will be in preparation for publication in 2017.