**The effect of Bed Thickness on Hillslope Morphology and Sediment Size in Last Chance Canyon, New Mexico**

**ABSTRACT**

Here we explore the effect that variance in rock properties have on sediment production and hillslope shape in Last Chance canyon. Many studies assume that diffusive soil mantled landscapes produce convex hillslopes. However, in Last Chance canyon, predominantly bedrock hillslopes in the more thinly bedded sandstones have a form similar to a diffusive soil mantled landscape, while hillslopes in the more thickly bedded carbonates resemble a dramatic bedrock landscape. Here, the ratio of runoff to near surface infiltration during storm events are affected by the amount of bedding planes and by the storm hydrograph. Also, the distance between bedding planes influences the sediment flux and size from hillslopes. We hypothesize that 1) storm events can more easily pluck pieces away from the more fractured sandstone bedrock and they do so more often, 2) precipitation tends to infiltrate into sandstone more readily than in the thickly bedded carbonate causing for the bedrock to become more erodible, and 3) for these two reasons hillslopes are more diffusive in sandstone sections than in carbonates. We use drone surveys to generate high resolution DEMs and orthomosaics to examine the topographic form of hillslopes, to measure sediment sourced from the two distinct lithologies in Last Chance canyon, and to measure the distances between bedding planes. We will model hillslopes by coupling a hillslope sheet-wash component with the OverlandFlow model to examine how diffusivity, critical slope, and sediment production vary among rock layers.

Variance in relevant bedrock properties influences the production and size of sediment on hillslopes (Johnstone and Hilley, 2015), erosion rates (Dixon et al, 2012), and landscape form (Glade, 2017; Hurst, 2013). Rock properties, specifically fracture spacing, has been shown to influence rock surface slope (e.g., Brook and Tippett, 2002; Matasci et al., 2015; Moore et al., 2009; Selby, 1980), erosion, and imprints its signature into the topography (Molnar et al., 2007; Clarke and Burbank, 2011; St. Clair et al., 2015; Voigtlander et al., 2017; Eppes and Keanini, 2017; Eppes et al., 2018). Soil depth, a function of both soil production and erosion rate, has been shown to affect hillslope convexity (Roering, 2008). Soil mantled hillslopes are thought to generate convex hillslopes, however, in Last Chance canyon, sandstone hillslopes with predominantly exposed bedrock are convex in shape and resemble soil mantled hillslopes. But what about these bedrock hillslopes causes them to look like soil mantled hillslopes? Why do predominantly sandstone hillslopes appear diffusive while carbonate hillslopes are steep and shear?

In this study, we seek to understand the effect that changes in rock properties have on sediment production and erosion. More specifically, we ask what controls weathering, soil production, and sediment movement on hillslopes with high spatial variability in rock properties? how is sediment removed so that diffusive looking landscapes are generated in thinly bedded sandstone and not in the more thickly bedded carbonates? To answer these questions, we will couple a hillslope sheet wash component with the overland flow model to explore sediment delivery from hillslopes to channels. We will inform our model runs with realistic hydrographs reconstructions and field measurements of sediment size. and distance between bedrock beds. We will also measure sediment depth, bulk lithology of less than gravel sized colluvium, and the lithology of larger sized sediment.

**Hypothesis**

We hypothesize that spacing of beds influences hillslope morphology and that more thinly bedded rocks create more diffusive, convex hillslopes. Water infiltrates more readily and to greater depths in more fractured bedrock, increasing the potential for sediment production at the surface. Less intense storm events will be able to remove the smaller sediments produced in the more thinly bedded sandstones and will more easily pluck and erode into this more fractured bedrock.

Likewise, the more thickly bedded hillslopes will have steeper slopes and will not appear diffusive nor convex. In these sections, water will tend to run off hillslopes and only larger storms will be able to pluck and transport larger sized sediment from these sections.

**Methods**

To calculate potential to transport sediment from hillslopes we will use the Landlab OverlandFlow component, which is based on a simplified calculation of the shallow water equations (de Almeida et al., 2012), to rout rainfall across a DEM and determine water discharge and flow depth across a DEM for each time step. We will use this to find water depth and surface water slope on hillslopes and calculate shear stress using those data along with fluid density and gravity.

We will couple the Landlab OverlandFlow model with a hillslope sheet-wash component inspired by model developed by Katerina Michaelides (2012) to identify run off generation, sediment transport, and erosion on hillslopes. Our coupled models will be applied at event scales to explore sediment delivery from hillslopes.

We will gather precipitation data from the NOAA’s Hydrometeorological Studies Center (figure 7). With these data we will determine relevant statistical information regarding storm durations and intensities. These data will be used to inform the OverLandFlow component and generate storms using the STORM model (2018) which mimic real storms from Last Chance canyon.

We will use a DJI mavik 2 pro to take photos 20 meters above some select hillslopes to build high resolution orthomosaics, measure grain sizes, and measure bedding thicknesses. We will use SediNet to determine grain size distributions for different hillslopes. These sediment measurements will be used to inform our numerical experiments. Because of the large variance in bedding plane distributions (figure 8), field work is necessary to determine the distances between bedding planes. We will also measure sediment depths and sediment lithology in the field and use these data to inform our model predictions.

**Analysis**

To link interplay between rock properties and the storm properties to hillslope morphology, we model sediment flux from different rock types for different storms. Preliminary analysis has demonstrated that hillslopes steepen in more thickly bedded rock and appear more diffusive in more thinly bedded rock (figure 9). Both the scales and resolution at which hillslopes are measured will affect analysis. Hillslope profiles measured at lower resolutions (figure 9) or larger scales (figure 8) blur changes in local slope. Storms which pluck colluvium from the two different lithologies will have different recurrence intervals. More frequent, less intense storms should be able to pluck bedrock from the sandstone hillslopes more often than in carbonates. Infiltration will be considered within the model equations. We expect that precipitation more readily infiltrates into sandstones, widening and generating new fractures, and making bedrock more erodible. We will compare modeled sediment size distributions and bedding plane thicknesses between sandstones and carbonates. This approach will help elucidate how variance in bed spacing allows for diffusive hillslopes to be generated from bedrock.