Investigating the Role of Intact Rock Strength in Modulating Fracture Geometry Influences on Bedrock River Erodibility at the Bedform Scale

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Project Summary

This project sought to test whether the influence of fracture geometry on bedrock river morphology varied across lithologies of varying intact rock strength using field surveys of 9 bedrock river reaches of the Washington Cascade Mountains, USA. Field surveys measured channel bed morphology, fracture geometry, and intact rock strength using a somewhat novel method of close-range (< 2m from ground surface) Structure-from-Motion (SfM) photogrammetry in difficult-to-access (Figure 1), steep bedrock rivers, chosen to minimize alluvial bed cover and maximize variability in both fracture geometry and intact rock strength. Field surveys were designed to facilitate a facet-detection point cloud analysis of channel bed topography to obtain detailed measures of bed morphology. Unfortunately, the field site selection and methodology were unsuitable for obtaining the data needed to robustly evaluate the potentially interacting influence of rock strength and fracture geometry on bedrock river morphology.

Field sites were selected to cover the range of rock strengths needed to test whether rock strength influences how bed morphology relates to fracture geometry. However, the range of surveyed lithologies (metagabbro, banded rhyolite, clastic rhyolite, andesite, tonalite, and monzonite) exhibited remarkably similar rock strengths, despite their varied mineralogy and fracture geometry, preventing a robust test of this hypothesis.

In addition, the technical ropework needed to safely access many of the field sites made it difficult to collect images in patterns that work well for SfM photogrammetry. As a result, only 6 of the 9 surveyed reaches produced reasonable SfM topographic models, and those 6 were still hampered by moss and wet rock or shallow water, which produced spectral variability and glare that induced errors in topographic reconstruction and limited the spatial extent of accurate topographic reconstruction of the channel bed (Figure 2).

While fracture geometry and rock strength measurements were successful, the reconstructed channel-bed topography did not cover the study reaches sufficiently enough to derive unbiased measurements of the proportion of sculpted versus plucked surface, bed roughness, and the orientation of plucked faces, all essential to testing the proposed hypotheses.

Lessons Learned

While this project was unsuccessful, it yielded important insights for methodological improvements that could facilitate this work in the future. Future data collection should accommodate the lighting and photo alignment problems faced in the studied bedrock rivers. Field sites should also be chosen to minimize both alluvial cover and vegetation cover (including the lichen and moss that grow on many bedrock surfaces). That may be difficult in temperate environments, as channels with low enough water to accurately survey tend to also have epilithic vegetation, so arid environments may be a more ideal setting for this work. While the proposed relatively inexpensive, SfM-based approach may work for some environments, terrestrial LiDAR would be much more likely to successfully generate the data needed for this project, although it can be prohibitively costly and difficult to use in remote environments.

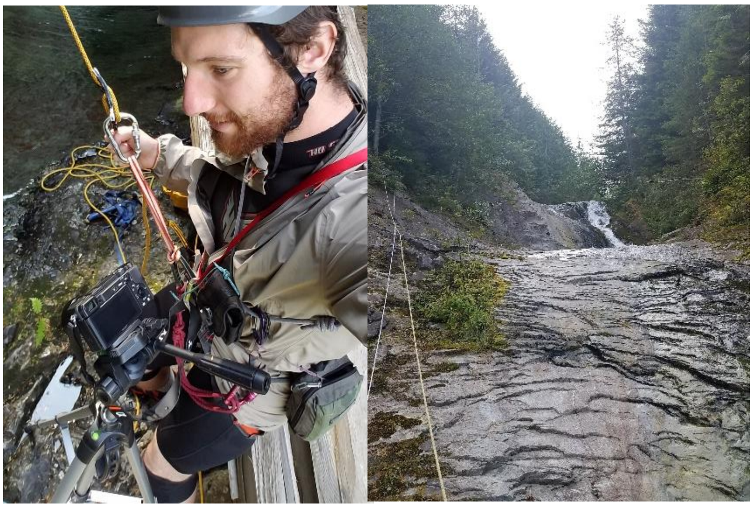

Figure 1: Examples of the technical ropework needed to access study sites.

Figure 2: Example of an SfM model. Moss (green) and shallow water or wet rock (grey) inhibited accurate topographic reconstruction.