MULTIDISCIPLINARY GEOPHYSICAL EVIDENCE FOR MODIFICATIONS TO ROCK GLACIER MORPHOLOGY AND DEBRIS DISTRIBUTION THROUGH DYNAMIC PROCESSES

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Abstract

Rock glaciers are landforms composed of both water ice and rockfall debris, and they are found in mountainous terrains on both Earth and Mars. They are found in transitional climates where subsurface ice is preserved in locations that solid ice would be unstable if it were exposed at the ground surface. A common characteristic shared by many rock glaciers is their arcuate ridge morphology. Two leading hypotheses explain the formation of these ridges on rock glacier surfaces: compressional buckling and outcropping internal debris layers that represent variations in climate and ice mass balance. These hypothesized formation mechanisms play a central role in the interpretation of surface morphology when considering rock glacier rheology and preservation of paleoclimate signals. We present evidence for the occurrence of both types of ridge formation using ground-penetrating radar and UAV-based photogrammetric surface motion measurements at Galena Creek Rock Glacier, Wyoming, USA. We describe the observed criteria for the interpretation of ridges as expressions of internal debris bands or mechanical deformation. These observations allow for the estimation of rheological parameters governing rock glacier motion. We also discuss the impacts of the debris thickness variability on estimates of ice ablation rates using thermal conduction and convection models constrained by near-surface debris temperature measurements.

By combining the debris distribution, rheological parameters, rock glacier thickness, and surface velocity data, we interpret the evolutional history of the Galena Creek Rock Glacier. We then test two methods for producing gridded bed elevation maps for use as boundary conditions in numerical flow models. One method uses a simple inversion of Glen's flow law modified to include the effects of lithic debris, and the other method solves the mass conservation equation for bulk thickness. Each method was developed for larger glaciers with less debris; therefore we discuss the strengths and weaknesses of each method when applied to Galena Creek, which is a transitional alpine debris-covered glacier/rock glacier system. This study consolidates multiple sources of geophysical information about the supraglacial debris distribution, thermal characteristics, ice thickness, bulk composition, and surface motion to recommend targeted observables for ongoing data acquisition informing reconstructions of paleoclimate, predictions of change in the cryosphere, characterization of alpine water resources, and planetary exploration.