Rock avalanches on glaciers

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This thesis examines relations between rock avalanches and the glaciers on which they are deposited. The sedimentological and geomorphological characteristics of four landslides on two glaciers are investigated by field mapping and geomatics, and the response of one glacier to landslide loading is examined by field surveying, satellite remote sensing, and modelling.

Three debris sheets on Black Rapids Glacier, Alaska, have coarse blocky rims. Longitudinal flowbands in these debris sheets, as well as in the one deposited on Sherman Glacier, Alaska, separate bands of different block size, and are produced by shearing within the moving debris. Elongated blocks are parallel to flow, except at the perimeter of the debris sheets, where they are aligned nearly perpendicular to flow. Blocks on the Sherman Glacier debris sheet have been reoriented by glacier flow since the landslide in 1964. The matrix of all four debris sheets does not systematically change with depth or distance from the source. However, it becomes coarser over a timescale of decades due to weathering.

Black Rapids Glacier surged in 1936-1937. Between 1949 and 1995, the glacier gradually returned to a pre-surge hypsometry, with significant thinning in the ablation area, and thickening in the accumulation area. Maximum elevation changes along the glacier centerline in the ablation and accumulation areas, determined by DEM differencing, are, respectively, -249 m and +63 m (-5.4 m a\(^{-1}\) and +1.4 m a\(^{-1}\)). Centerline thickening of +62 m between 1949 and 1995 (+1.4 m a\(^{-1}\)), just above the Loket tributary in the upper part of the ablation zone, indicates dynamic thickening following the 1936-1937 surge.

The response of Black Rapids Glacier to the three rock avalanches is spatially and temporally complex. Increases in measured and modelled surface velocity across the debris sheets are much greater than velocities observed higher on the glacier. The velocity recorded at the downglacier margin of the debris doubled between 2002 and 2004, resulting in a reversed longitudinal velocity gradient. The changes in ice dynamics are related to the landslides through their effect on mass balance.