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Bare-rock bed behaving softer than till-covered bed: field evidence from Breidamerkurjokull, Iceland

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The basal conditions of glaciers and ice sheets control ice motion on a range of timescales from hours to millennia. Glaciers and ice streams with abundant deformable till at their base (i.e. soft beds) are thought to be more sensitive to changes in thickness and basal melt-water drainage than those resting upon frozen till or bare rock (i.e. hard beds). This is because soft beds are thought to be unable to support the driving stress, resulting in stress transfer to the margins and hard-bedded regions (i.e. sticky spots) through lateral shearing and along-flow stretching. Here, we present field evidence from an archetypal soft-bedded glacier, Breidamerkurjokull in southeast Iceland, which contradicts this assumption. Radar profiling across fast-flowing (> 230 m/a) ice revealed extremely smooth beds beneath slow-flowing ice, while rough beds beneath fast-flowing ice. These distinct bed reflectors imply that, in our study area, ice flows fast over the bare rock while the ice flows slow over the till. Continuous ice-motion data collected at 9 differential GPS stations over this bed transition found periods of increased basal sliding associated with significant rainfall and surface melting. During such event, ice flow is extensional over the bare-rock bed, whereas it is compressional over the till-covered bed. Using a numerical inversion of the surface motion data, we find that basal drag decreases in the bare-rock regions during sliding, resulting in a down-glacier stress transfer, where it is balanced by increasing basal drag at the till-covered terminus. We argue that till-covered beds may be able to maintain higher basal drags than bare-rock beds under increased melt water input.