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Force budget and hydro-mechanical coupling between glacier ice and deformable sediments during a small surge

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A full force-budget analysis is applied to a documented small surge of the glacier Breidamerkurjökull in SE Iceland. The surge occurred as a consequence of a longitudinal compressional wave, which produced a 250m advance of the glacier margin at a rate of between 0.4 and 1.7m per day over a 6-month period. The glacier surface velocity and profile were regularly measured and water pressures in subglacial sediments recorded at 6-hour intervals by transducers that had been emplaced in the sediment at 11 separate locations prior to the surge.

These data together with regularly measured surface runoff and known till-thickness profile allowed us to develop a model for ground-water pressure evolution during glacier advance, which agrees remarkably well with recorded data. As a result of our hydraulic modelling (and with known ice -load evolution) the water pressure and effective stress at the ice-till interface are confidently known in the marginal 250m of the glacier advance with a spatial resolution of 5m.

The force budget permits us to estimate basal traction, and with known normal effective stress dynamics at the ice-till interface, permits us to draw important conclusions about the physics of sliding over permeable and deformable sediment and about the time-dependent partitioning between sliding at the ice/bed interface and deformation within the sediment.

The surge produces significant transport of pre-existing sediments and systematic patterns of strong net erosion and deposition. The general pattern of erosion and deposition can be reconstructed, and is a product of subglacial deformation. Our model suggests that the activation of till deformation is strongly related to seasonal and di-

urnal variations of effective pressure driven by fluctuations in runoff from the glacier surface. The observations and theory permit us to constrain the rheological behaviour of the till.