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Mega-scale glacial lineations beneath Rutford Ice Stream, Antarctica

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The majority of discharge from large ice sheets takes place through fast-flowing ice streams whose speed is strongly modulated by interactions between the ice and the underlying sediment. The physical properties of basal sediments have been investigated through boreholes and seismic surveys that reveal an association between fast ice flow and saturated deformable sediments. Knowledge of the morphology of the ice/sediment interface, however, remains limited, resulting in a profusion of theories for the genesis of subglacial bedforms and a still-rudimentary understanding of the basal boundary conditions beneath ice streams. We conducted a detailed ground-penetrating radar survey of the bed of Rutford Ice Stream, West Antarctica, that reveals the presence of mega-scale glacial lineations (MSGL) and provides conclusive evidence for their association with fast-flowing ice. The survey was positioned where repeated seismic surveys over a 13 year period have demonstrated the rapid formation of subglacial bedforms beneath 2.5 km of ice (Smith et al., 2007, Geology). The appearance of the MSGL is indistinguishable from those found on palaeo-ice stream beds and the seismic data indicate that the MSGL develop only where the ice is underlain by deforming till and are absent where stiff/lodged till exists immediately beneath the ice. These data allow critical analysis of existing models of MSGL genesis, none of which can fully explain our observations. The increased resolution of this new dataset will also lead to improved treatment of basal boundary conditions in predictive ice stream/sheet models.