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Freeze-on limits bed strength beneath sliding glaciers

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Discharge from sliding outlet glaciers controls uncertainty in projections for future sea level. Remarkably, over 90% of glacial area is subject to gravitational driving stresses below 150 kPa (median $\sim$70 kPa). Longstanding explanations that appeal to the shear-thinning rheology of ice tend to overpredict driving stresses and are restricted to areas where ice sheets only deform (roughly 50%). Over the more dynamic portions that slide, driving stresses must be balanced by thermo-mechanical interactions that control basal strength. Here we show that median bed strength is comparable to a threshold effective stress set by ice–liquid surface energy and till pore size. Above this threshold, ice infiltrates sediment to produce basal layers of debris-rich ice, even where net melting takes place. We demonstrate that the narrow range of inferred bed strengths can be explained by the mechanical resistance to sliding where roughness is enhanced by heterogeneous freeze-on.