Influence of subglacial conditions on ice stream dynamics: Seismic and potential field data from Pine Island Glacier

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A synthesis of geophysical and glaciological data sets are used to investigate the relationship between ice dynamics and the underlying geology at one location on Pine Island Glacier. We find correlations between subglacial geology and variations in flow of the overlying ice. Seismic reflection amplitudes indicate a layer of soft water-saturated sediment immediately beneath the ice. Beneath this, gravity and magnetic data indicate basement rocks containing a significant geological boundary, aligned in the ice-flow direction. Crossing this boundary, the ice velocity decreases whilst bed roughness and modeled basal drag both increase. The acoustic impedance of the soft sediments at the ice-bed interface shows no significant change across the boundary. The smoother glacier bed, overlying thicker (>100 m) sediments, appears to facilitate the fastest flow. Where the bed is rougher the soft sediment layer beneath the ice is very thin (≤10 m) and overlies basement rocks; we propose that the rough surface of the basement rocks beneath this thin sediment increases the basal drag on the ice, through the intervening soft sediment, without a detectable influence on the sediment's acoustic properties.

Changes in the sub-bed (i.e. deeper than the ice-bed interface) lithology appear to account for the contrasting basal drag and ice velocity patterns at this location. Repeated surveys would indicate whether this is a steady state, or whether subglacial erosion in the near future could remove the thin, soft sediment layer, perhaps leading to long-term changes in the glacier's flow.