Geophysical Research Abstracts
Vol. 16, EGU2014-95, 2014
EGU General Assembly 2014

Basal Crevasses Reveal a Dynamic Ice-Ocean Interface in an Embayment of the Whillans Ice Stream Grounding Line, West Antarctica

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The transition from limited- or no-slip conditions at the base of grounded ice to free-slip conditions beneath floating ice occurs across the few-kilometers-wide grounding zone of ice sheets. This transition is either an elastic flexural transition from bedrock- to hydrostatically-supported ice (often tidally influenced), or a transition from thicker to thinner ice over a flat bed, or some combination of these processes. In either case, the stress-change in the basal layers of ice can result in brittle deformation that may produce crevassing. Thus the position and morphology of basal crevasses reveal important information about the stress state across the grounding zone.

We conducted ground-based radar surveys at two locations of the Whillans Ice Stream grounding zone, one over a subglacial peninsula where the transition to floatation is abrupt, and the second over a subglacial embayment where several dynamic subglacial lakes drain to the ocean, likely resulting in episodic high sediment and water flux across the grounding line. Our surveys indicate a complex pattern of basal crevasses. Some are associated with steeper surface slopes, but others appear to be related to ice flexure across an incised basal channel carrying water and sediment to the ocean. Here we image pairs of crevasses from either side of the channel that produce curious signatures in the radar profiles showing a high degree of symmetry at both shorter and longer arrival times than the nadir bed echo. In other locations, due to the high reflectivity of seawater and the relatively shallow ice thickness, we image many off-nadir crevasses where the radar energy is first reflected from the ice-water interface and then from the crevasse, producing an echo signature with a reversed phase due to the second reflection. In several cases these crevasse echoes appear to mimic the geometry of a sub-ice “wedge” dipping into the sediment, while in reality the radar never penetrates below the basal interface. Our results indicate that basal crevasses offer a rich, but unexploited, dataset for diagnosing stress state and ice/ocean interaction processes across grounding zones and that special care is needed when interpreting subglacial returns in radar data.