

Thick debris-bearing basal ice layer beneath Ice Stream C, West Antarctica: Are ice stream tributaries a source or a sink of water?

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High subglacial water pressures play a key role in facilitating fast ice streaming in West Antarctica. It is clear that spatial and temporal distribution of water volumes and/or pressures must be incorporated into numerical models aimed at simulating past behavior and future stability of this ice sheet. Yet, subglacial water balance over long spatial and temporal scales is difficult to constrain with observations.

The recent discovery of up-to-25-m-thick layer of debris-bearing ice in the UpC area of Ice Stream C provides a new constraint on the behavior and history of the subglacial water system at and upstream of this site. The layer was found at three locations along a transverse profile from the Sticky Spot into the Ice Stream C. It consists of clear ice interlayered with sediment-rich ice. The large thickness and the general morphology of this layer is similar to those attributed typically to generation by basal freeze-on. We pose two initial hypotheses concerned with the possible origin of this layer: (A) freeze-on during stoppage of Ice Stream C, and (B) accretion during ice transport within tributaries. We believe that the hypothesis (A) can be discounted because with a thickness of 12 to 25 m the layer is too thick to have formed entirely since the stoppage of Ice Stream C ~150 years ago. Based on evaluation of the modern basal thermal energy balance, Kamb (2001) estimated that only ca. 1 m of ice was accreted since the stoppage. Assuming a reasonable range of basal freezing rates between ~1 and ~10 mm/yr, it would take ~20,000 to ~2,000 years to accrete ~20 m of basal ice. Within this time span ice may have moved from deep within the catchment area of the ice stream into its present day location (~100 to ~1,000 km transport distance at a typical tributary velocity of ~50 m/yr). Drilling in the interior of the WAIS (Robin, 1983) and in the Siple Coast ice streams (Engelhardt and Kamb, 1997) showed that the ice base is at the pressure melting point and that liquid water is present at the ice-bed interface. As indicated in the hypothesis (B), the basal ice may have been accreted during the several thousand years required to transport ice from the interior reservoir to UpC through the tributaries. Using finite-difference and analytical models we are presently testing this hypothesis by quantifying the major components of the basal

thermal energy balance in the tributaries: heat conduction away from the bed, geothermal flux, and shear heating.

Ice stream tributaries are commonly treated as a subglacial source of water that then gets transported downstream to help lubricate ice stream flow. If our models will show that the basal ice layer found at UpC may have formed in the tributaries, we will have the basis to postulate that tributaries are sinks of subglacial water. Otherwise, alternative hypothesis/es for generation of the thick debris-bearing ice at UpC will have to be generated.

References

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