

Basal ice accretion, availability of basal water, ice stream stoppage and potential restart of Kamb Ice Stream

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The West-Antarctic Ice Sheet (WAIS) contains enough ice to raise global sea level by 5 to 6m. A few up to several hundred meters per year fast flowing ice streams dominate its dynamic. These ice streams have been in the focus of Antarctic research since Mercer (1968) raised concerns about a possible collapse of the WAIS. Recent changes in the behavior of these ice streams, stoppage of Kamb Ice Stream (KIS), switched the WAIS to a positive mass balance, currently counteracting global sea-level rise. For an accurate assessment of the WAIS future it is essential to determine whether these changes are transitional or are indicative of the end of the Holocene WAIS decay.

Several mechanisms have been proposed to explain the stoppage of KIS. They all involve a decrease in basal lubrication, either due to changes in subglacial water drainage or due to basal freeze-on. However the exact timing and spatial extend of such reduction in the availability of basal water is sofar unknown.

Borehole videos from the base of Kamb Ice Stream (West-Antarctica) revealed a 12 to 14 m thick layer of clear sediment laden basal ice and a 1.5 m tall water filled cavity. This basal ice layer has formed by freeze-on of basal water to the ice sheet/stream base in contact with the ice streambed and represents a several thousand yearlong record of basal conditions, covering the time prior, during and since the KIS-stoppage. We have used the sediment content in the accreted ice as a proxy for the availability of basal water in the sub-ice stream drainage system and beneath the former shear-margin to obtain further constrains on events leading to the KIS-stoppage. The timing of these events fits well with dynamical changes in the UpC area over the past half a millennium.

While limited since ~300 yrs it appears that basal water was present at all time in the sub-ice stream drainage system. However it also appears that the resupply of basal water to the ice stream shear margin was interrupted around the time of stoppage (~130 yrs. ago), leading to the subsequent accretion of a thick frozen-on till layer. The cause for such interruption may be found in a continuing reorganization/evolution of the subglacial hydrological system. Since about 60 years basal water has found its way back to the former ice stream shear margin, leading to the accretion of sediment poor basal ice and the formation of an at least 1.5 m tall water filled cavity. Gradual leaking of basal water from this cavity into the sub-ice stream drainage system may have increased the availability of basal water in the ice stream. Here the availability of basal water is equal or exceeds the amount of basal water used in the freeze-on process since ~ 20 years.

While the downstream extent of this relubrication of the ice streambed is unknown it is clear that a downstream propagation of the lubrication front towards the grounding line could lead to a restart of the ice stream sooner than ice stream models would predict.

Overall the basal ice record confirms that the shutdown of Kamb Ice Stream was due to basal freeze-on and a limited availability of basal melt water. It appears that the cause for the limitation has disappeared and basal water is currently building up. We further conclude that relubrication of the Kamb Ice Stream is underway and that a restart of Kamb Ice Stream may occur sooner than expected.