Why Don't they Match? The Evolution of Flow Stripes and Internal Layers on Kamb Ice Stream

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Flowstripes are ubiquitous features indicating fast ice flow on glaciers, ice streams and floating ice shelves. According to model studies by Gudmundsson and Raymond (1998) they are an expected consequence whenever velocity at the bed is large compared to shearing through the ice thickness. Under these conditions, basal undulations are effectively transmitted to the surface where they are advected for long distances downstream. Folding of internal layers depicted in radar profiles is also a common occurrence in ice streams. In the case of Kamb Ice Stream (KIS), "stacks" of internal layers folds on the scale of 1-3 kilometers in wavelength in the cross-flow direction have been traced for over 100 kilometers (Ng and Conway, 2004). The question is what relationship, if any, do these folds have with respect to surface flowstripes?

We have traced surface flowstripes in Radarsat and MODIS imagery for several hundred kilometers on KIS from the onset of streaming flow into the stagnant trunk. We compare the morphology and evolution of these features at the surface to the internal layer folds in cross-ice stream profiles at five transects along the length of KIS, including those analyzed by Ng and Conway (2004). We find little correspondence between the radar internal layer folds in the cross-flow direction and the flowstripes on the surface directly above. The wavelengths of internal layer folds generally begin with a range of 1-3 km and tend to converge downstream, ending with wavelengths typically less than a kilometer. Flowstripes, though having similar wavelengths (on the order of 1.5 to 3 km at onset), remain roughly subparallel for many kilometers, eventually becoming less distinct as the ice stagnates but retaining their separation. We are thus able to identify examples where flowstripes cross above internal layers.

The amplitude of internal layer folds we have measured decreases towards the surface in a way that suggests they are formed by stresses at the bed in the same way as flowstripes analyzed by Gudmundsson and Raymond (1998). This decay in amplitude is consistent with the scale of topography of the folds at the surface, so the issue is, if the flowstripes are the surface expression of the internal folds, why don't they match? We suggest that topographic features on the ice surface are subject to processes that can modify their morphology leading to changes in the pattern of folds relative to the internal layers below. We explore hypotheses about how flowstripes can evolve differently from the folds in internal layers.