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The hydrology of overdeepenings: a new supercooling threshold formula

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Overdeepenings are a hallmark glacial landform of broad geomorphologlogical and glaciological interest. Their formation mechanism has not yet been fully uncovered but subglacial drainage is likely a key factor. One prominent hypothesis (Alley & al., 2003) states that the depth of an overdeepening stabilizes at the supercooling threshold. This threshold is reached when the adverse bed slope terminating an overdeepening is sufficiently large to shut down the efficient, channelized drainage system. Classic theory (e.g. Röthlisberger & Lang, 1987) estimates this threshold at a ratio of bed to surface slope of -1.6.

Here I show how the classic theory can be extended to give an improved, more accurate threshold formula. The new formula agrees well with results from one and two dimensional subglacial drainage models. Applying it to observations of 147 overdeepenings from alpine glaciers (Linsbauer & al., 2012) and ice sheets shows that the depth of overdeepenings rarely exceeds the new supercooling threshold. Thus this work supports the stabilizing hypothesis. Conversely, the less accurate classic theory would classify most of the overdeepenings as deeper than the supercooling threshold and thus the stabilizing hypothesis would be refuted.