



Distribution and characteristics of overdeepenings beneath the Greenland and Antarctic ice sheets and their glaciological implications

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Understanding of overdeepening origin and glaciological significance is limited by an absence of quantitative empirical studies. To address this shortcoming, we have mapped the distribution of closed-topographic depressions (i.e. potential overdeepenings) beneath the Antarctic and Greenland ice sheets using automated GIS techniques, and have analysed the resulting database of overdeepening characteristics. The morphologies of a subset of mapped depressions that pass strict quality criteria indicate that overdeepening growth is generally allometric and that topographic confinement of ice flow enhances overdeepening depth. However, we infer that deepening slows with overdeepening age because (a) overdeepening depth is skewed towards shallow values – typically 200 to 300 m; and (b) overdeepening adverse slope steepness declines with overdeepening planform size. Analysis of overdeepening surface ice gradient to bed gradient ratio (the SB ratio) and surface ice velocity shows that velocities are highest for overdeepenings with SB ratios of ~ -1 to -1.5 . Further, this ratio is close to the preferred range of SB ratio values exhibited by the dataset. This indicates that ice flow velocity and erosion potential are modulated by the changing efficiency of subglacial drainage and sediment transport that occurs as an overdeepening grows. This is presumed to encourage sediment deposition on the adverse slope, whilst overdeepening enlargement by headward growth (e.g. quarrying) is able to continue, and this presumption is supported by analysis of overdeepening long-profiles, which indicates that overdeepenings are typically asymmetric, with the deepest point skewed toward the overdeepening head. Our observations lead to the conclusion that overdeepening formation enhances ice sheet flow and that thinning during retreat, which will produce even greater negative SB ratios, should result a slowing or stabilisation of ice sheet flow.