The effect of anisotropoy on flow of Siple Dome, West Antarctica

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Polycrystalline ice near an ice divide shows a crystal fabric (preferred crystal orientation) that typically has c-axes clustered vertically. We explore the effect of this fabric on the flow pattern near an ice divide. Our finite-element ice-sheet flow model uses a nonlinear flow law that accounts for deformation due to crystal fabric. We found that the resulting deformation depends on the vertical profile of crystal fabric, and that fabric significantly alters the flow pattern only when the fabric tightens to a cone angle of less than about 30 degrees. (The cone angle is the half angle of the cone within which the c-axes align.) A vertically-oriented fabric tends to decrease the steady state thickness of a divide and to amplify the special divide flow pattern that is produced by the stress-dependent viscosity of a nonlinear fluid.

The borehole sonic velocity log for Siple Dome shows a large increase in velocity (and therefore stronger crystal fabric) for ice that was deposited as snow during the Wisconsin when compared to that deposited during the Holocene. Using a comprehensive flow model for Siple Dome, we show that this change in fabric significantly changes the pattern of flow for Siple Dome. In particular, it introduces a bed-parallel shear band several hundred meters above the bed that behaves like a "false bed" for ice sheet flow. Also, the shear band enhances the difference between the flank and divide vertical strain-rate profiles. The flank/divide difference is a key characteristic of the special divide flow pattern resulting from the nonlinearity of ice that produces the isochrone pattern known as the "Raymond Bump". An important effect of this false-bed effect, and its association with the Wisconsin/Holocene climate transition, is that the shear band has strengthened and moved deeper in the ice sheet since the climate transition, affecting the dynamic history of the ice sheet. Finally, we compare the sonic velocity log for Siple Dome, with that recently available for three boreholes in Greenland.