Séminaire du LGGE

salle L. Lliboutry

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"The Role of Ice Deformation and Crystal Fabric in Ice-Core Record Interpretation"

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Ice-Age ice has smaller crystals and higher concentrations of impurities than Holocene ice. Under the stress conditions found in the central regions of ice sheets, these properties cause it to develop a more strongly-aligned vertical crystal-orientation fabric, which is significantly softer than Holocene ice in simple-shear parallel to the bed. In many regions of the Antarctic and Greenland ice sheets, the Ice-Age ice is now at depth and its flow properties may dominate the ice flow patterns, particularly where sliding is minimal. Through time, the contrast in fabric and flow properties between Ice-Age ice and Holocene ice is magnified by a climate-flow-fabric feedback loop: the softness of Ice-Age ice concentrates deformation within that ice, inducing crystal rotation and further strengthening the fabric. This characteristic deformation of Ice-Age ice can significantly affect the ice-flow history near an ice core site such as WAIS Divide and affect the interpretation of the ice-core record, for example when extracting paleoaccumulation rates from the depth-age and layer-thickness profiles.

We present preliminary models of deformation including the effects of crystal fabric for the WAIS Divide site and compare it to other similar deformation studies at Siple Dome and other ice-core sites. Our results for WAIS Divide are based on fabric measurements from other ice core site because the measurements are not yet available for the WAIS Divide site. We show the range of behavior that might be expected for the WAIS Divide site ranging from similarities to Siple Dome to Greenland summit sites. At Siple Dome, the Ice-Age fabric is highly aligned and there is an abrupt transition from Ice-Age to Holocene fabric, resulting in a strong shear band several hundred meters above the bed. Greenland summit ice cores, on the other hand, do not have as abrupt of a transition from Ice-Age to Holocene fabric; therefore, no distinctive shear band appears in the flow pattern on a scale similar to that at Siple Dome.

The variable strain rates due to anisotropy in the crystal fabric result in differential thinning of annual layers through both space and time (and may result in folding); certain aspects of ice-core interpretation rely on knowledge of these past thinning rates. We present a first attempt at quantifying this dynamic behavior for the WAIS Divide site and its possible effect on the ice-core interpretation.