Subglacial sediment homogenization by clast ploughing

J.A. Piotrowski[1*], W. Narloch[2] and W. Wysota[2]

[1]*Department of Geoscience, Aarhus University, DK-8000 Aarhus C, DENMARK*
*(*correspondence: jan.piotrowski@geo.au.dk)*

[2]*Department of Earth Sciences, N. Copernicus University, PL-87-100 Toruń, POLAND*

Large Pleistocene ice sheets moved primarily by some combination of basal sliding and bed deformation. The latter process, besides contributing to the forward movement of ice, has been suggested to effectively mix the subglacial material by intergranular advection producing homogeneous basal tills as depositional end-products. Pervasive deformation in a soft, water-saturated, several-metres-thick basal sediment layer that yielded in response to glacier stress has been postulated as a widespread process under the Scandinavian, British-Irish and Laurentide ice sheets.

Here we investigate in detail properties of a massive basal till of Weichselian glaciation at Sønderby, western Denmark in a single vertical profile spanning over 5 m of the till thickness and sampled in 26 closely spaced intervals. Grain-size distribution, fine-gravel composition, macroscopic and AMS till fabrics, micromorphological structures, and grain-shape characteristics all exhibit remarkably low variability indicating profound mixing of the material by a common and consistent process. We suggest that the mixing was primarily caused by clasts projecting from the ice sole that ploughed the bed before they were lodged and stabilized. Such clasts, typically with flattened and striated upper surfaces ubiquitously occur in the Sønderby till. Calculations show that every part of the till during its formation must have experienced multiple ploughing events that cumulatively generated a well-mixed, homogenous basal till.

These results question the model of pervasive subglacial sediment deformation inferred from till properties as the predominant mechanism of ice-sheet movement and subglacial sediment transport in favour of localized and non-pervasive, yet efficient, clast ploughing.