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Subglacial processes revealed by the internal structure of drumlins, Stargard drumlin field, NW Poland

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Numerous studies have provided insight into processes operating under contemporary and palaeo-ice sheets. Many of these studies concerned drumlins, landforms whose formation is essential to the understanding of subglacial soft-bedded systems. Despite the interdisciplinary efforts involving sophisticated analytical and interpretative tools the “drumlin problem” remains elusive and continues to generate much controversy.

In this study the geological composition of two drumlins from the Stargard drumlin field (NW Poland) in the terminal area of a major last-glacial palaeo-ice stream was examined in three excavated trenches at macro- and microscales. In each trench, sediment description and fabric analyses were conducted, and samples collected for micromorphological, AMS (anisotropy of magnetic susceptibility) and grain size measurements.

Both investigated drumlins are mainly composed of macroscopically homogeneous till with minor, max. 5 cm thick sand stringers and sparse silty inclusions. Distinct features are (1) a highly deformed, up to 18-cm thick till layer with clay- and pebble-sized clasts at the top, and (2) a continuous thin intra-till clay layer. Till macro-fabric measurements reveal a very high clustering strength and low isotropy index. AMS eigenvectors V1 vary significantly, but the dominant direction is consistent with the macrofabric measurements. Most of the observed microstructures indicate ductile deformation of the till.

The overall observations suggest a shallow subglacial deformation not affecting the entire till thickness at any time intervening with ice/bed separation facilitating enhanced basal sliding. The intra-till clay layer of low hydraulic conductivity contributed to elevated pore-water pressure in the sediment causing its fluidization and deformation. Intervening thin-skinned sediment deformation and basal de-coupling resulted in fast ice flow that, coupled with material release from the ice sole and its accretion at the ice/bed interface facilitated drumlin build-up and shaping.