



## **Ice sheet – permafrost interactions inferred from the sedimentary record of Weichselian glaciation in Poland**

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Permafrost in front of the Weichselian ice sheet and its re-appearance on deglaciated terrain after ice retreat is well established. More contentious is the occurrence of permafrost beneath the ice sheet and its influence on subglacial processes and ice sheet dynamic. Here, we present sedimentological evidence of frozen ground beneath the advancing Weichselian ice sheet in central-western Poland. Special focus is on macrostructures indicating permafrost within the subglacial till, at the contact to the underlying sediments and within those sediments.

Fieldwork has been carried out in outcrops located between the LGM ice margin and the subsequent retreat phase (Poznan/Frankfurt Phase). In Tomice site there are frost-cracks, ice-wedge pseudomorphs and deformed load structures in outwash sand directly below a till layer. Numerous sandy and sandy-silty intraclasts with preserved internal lamination occur within the deposits. In Wojnowice, a large intraclast 5 m long and 1.5 m high is found within a subglacial till layer. Ice-wedge pseudomorphs occur at Kaszczor, Nietążkowo, Sława Śląska and Wojnowice sites, just beneath the subglacial tills. Furthermore, multiple meso-scale deformations such as vertical sandy and gravelly layers and glaciotectionic breccia suggesting that the ground was frozen during deformation are present in Skrzyńki, Annowo and Trąbinek. Ductile deformations were also observed, especially within fine-grained sands.

Contact zones between subglacial tills and the underlying sediments are highly variable, but erosional and deformational contacts hosting partly sheared intraclasts suggest that the bed was at least locally frozen.

Subglacial permafrost strongly influenced sediment rheology and its response to glacial stresses. We suggest that glaciotectionic deformation was controlled by the grain size-dependent amount of unfrozen water trapped in the permafrost. Fine-grained material would have relatively high content of free water and consequently low strength so that deformation was focussed in fine sand whereas the fully frozen gavel remained relatively stable. Subglacial permafrost hampered meltwater drainage in favor of water storage at the ice/bed interface which could have led to hydraulic uplifting of ice mass.

The subglacial permafrost was strongly influenced by local hydrothermal conditions. Due to the high geothermal heat flux in this part of Poland of up to 100 mW/m<sup>2</sup> it was most likely thin and discontinuous.