

Permafrost evolution in the last glacial period: the case of unique ring forms in Northern Poland

There is intense debate within the Earth sciences regarding permafrost degradation and the role it is playing in current climate changes, mainly by releasing greenhouse gases into the atmosphere. This discussion, which is especially being conducted in relation to possible scenarios, also requires extensive knowledge on the evolution of the periglacial zones that functioned in successive Pleistocene glacial–interglacial cycles – and especially during the transgression and recession of the last, Late Weichselian ice sheet. Although the literature recognises the role of permafrost in both subglacial and post-glacial processes, there remain many unexplained issues relating to the persistence of permafrost under the ice sheet, as well as its entry into – and subsequent degradation in – areas undergoing deglaciation.

The authors of the project have analysed digital terrain models to discover a complex of about 80 ring forms in the Żarnowiec Moraine Plateau near Wejherowo in Northern Poland that are morphologically unique in young-glacial parts of the entire Central European Lowland. Each of these forms consists of a distinct circular rampart of up to 7 m high and a central depression filled with organic sediments (lake gyttja and peat) of up to 6 m thick. Preliminary geomorphological observations carried out within the ring forms suggest two research hypotheses as to their genesis: (1) – They are remnants of frost mounds (lithalsas and/or pingos) originally created in the presence of discontinuous permafrost, probably in the Younger Dryas; in testing this hypothesis, we will also investigate the potential role of methane explosions in creating the ring forms (2) – They are “doughnut” ring forms whose genesis is associated with glacial processes accompanying ice sheet retreat in the presence of subglacial permafrost from the initial stages (anaglacial phase) of the last glacial period. In our opinion, what both research hypotheses have in common is, on the one hand, a global factor associated with permafrost evolution in the glacial cycle and, on the other, local hydrogeological conditions. Archival analysis of drillings penetrating the Quaternary layers in the study area reveals the presence of a hydrogeological window connecting three Quaternary aquifers. Hence also, both the permafrost that occurred under the ice sheet, and that which persisted after the ice sheet had receded, was susceptible to the ascent of groundwater and the formation of taliks within the permafrost.

As part of the project, the authors have planned a number of field and laboratory works (geomorphological mapping, a detailed determination of the geological structure of the circular ramparts and the organic infills of their central depression, soil analysis, geophysical work, hydrogeological modelling, collection of bottom sediments in nearby lakes, sedimentological and palynological analyses, and radiocarbon datings), which will allow the research hypotheses to be tested. A detailed determination of the morphogenesis of these unique ring forms (especially from the perspective of local hydrogeological conditions), as well as the reconstruction of geomorphological processes and their progress over time, will allow the authors to bring numerous valuable insights to the discussion on the evolution of permafrost in the last glacial period and its real role in the morphogenesis of glacial and post-glacial landform transformation.