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Morphometric analysis of relict patterned ground in the Campine area, NE Belgium

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The Campine area (NE Belgium) is characterised by soils that mainly developed in Pleistocene sands. It is widely accepted that the region has witnessed several episodes of permafrost build-up during glacial periods. Geomorphological reconstructions applied during the last few decades aimed at determining the duration of and the climate during permafrost episodes. These reconstructions were mainly based on in-situ periglacial deformation phenomena in the shallow subsoil, such as cryoturbations and ice-wedge casts.

Recently published high-resolution LiDAR (Light Detection and Ranging) images of the area revealed the presence of soil polygon networks which resemble those that can be observed in permafrost regions today. The topographic signature consists of shallow troughs, several decimeter deep, that are organised into polygons with a diameter of several decameters up to 100 m. The shape and size suggests that the networks consist of relict thermal contraction crack polygons or patterned ground that developed during past permafrost. In this study, we aim at determining the morphometric characteristics of the polygon networks, in order to compare them with modern analogues and ultimately obtain information on past permafrost characteristics. Understanding past permafrost would greatly help to assess the future evolution of geological disposal systems for radioactive waste, because some of these are considered to experience cold climate conditions during the next 1 Ma. Radioactive waste management in Belgium is performed by ONDRAF/NIRAS.

An area of ca. 300 km^2 was visually surveyed on the DEM (Digital Elevation Model), which led to the selection of a series of networks for further analysis. Individual polygons of each network were digitised using very narrow topographic intervals, and the average area of the polygons and percentage of 4-ray and orthogonal intersections within individual networks were calculated. The results were then compared with pedological and geological properties. Finally, the obtained metrics were evaluated against those of published modern and fossil analogues.

The first results suggest that the characteristics of individual networks in the Campine area (mean polygon area and percentage of 4-ray and orthogonal intersections) are not related to subsoil characteristics. Strikingly, the mean polygon area (ca. 3000 m^2) is much higher than any of the analogues. In addition, the percentage of 4-ray and orthogonal intersections is fairly low in comparison with the analogues.

Several explanations can be put forward to understand this discrepancy between Campine polygon networks and their analogues. One possibility is that the observed networks represent an immature stage of ice-poor permafrost – this explanation is in line with the morphometric analysis. Another explanation would involve the detection method. The analogues, whether modern or fossil, are all systematically mapped using aerial imagery or field observations, whereas the Campine polygons are mapped using LiDAR images. It thus cannot be excluded that the topographic expression of so-called higher order polygons inside the main polygon is obliterated by posterior earth surface processes. We conclude that subsurface imaging is needed to solve this problem, i.e. GPR (Ground Penetrating Radar) profiling followed by trenching as ultimate verification tool.