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Geometric and Topologic Characterization of Periglacial Polygonal Networks in Adventdalen, Svalbard, Norway

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Polygonal terrain patterns commonly occur in periglacial regions of the Earth, where seasonal processes of freezing and thawing cause the soil to expand and contract, leading to the formation and growth of cracks. Understanding the formation of this type of networks on the Earth and tracing their evolution (including differentiating ages of formation) can provide us with many insights into the history of similar patterns on Mars, in whose surface they occupy vast extensions, most likely due to the presence of frozen water in the soil.

Thus, analogue studies of this type of structure on the Earth are important. In this work, we describe the geometric and topologic characteristics of a number of networks of ice-wedge polygons occurring in a coastal valley, the Adventdalen, on the Norwegian archipelago of Svalbard, in the Arctic, at 78° N. The aim of the study is to try and find the similarities and differences between them and to relate those with factors such as soil characteristics and topography.

Given the logistic problems in conducting a complete on site study of all those networks, spread out over many kilometers, the study was conducted through the analysis of remotely sensed imagery: 53 images (four-band RGB+NIR and 0.2 m/pixel of spatial resolution), acquired by the Norwegian Polar Institute in 2009 during their aerial photogrammetric campaign, were purchased and processed. They were orthorectified with an ASTER Global Digital Elevation Model (a product of METI and NASA). Polygonal networks were identified and digitized into a GIS. They occupy a total area of almost 10 km^2.

The areas covered by the individual networks studied range between $4x10^3$ and 10^6 m^2. Individual polygon sizes vary widely, from 6 to $7x10^3$ m^2, with an average of 300 m^2. The variation is less pronounced for the networks that are most clearly traceable in the images (which reduces typical errors such as those that create large polygons occupying the area of several smaller ones that go unnoticed in the images).

For each polygon present in the networks studied, topological parameters such as number of neighbors and valences of the vertexes were obtained, using an automated process previously developed by this team for the analysis of Martian networks. Shape descriptors like area, circularity, compactness and elongation were also calculated. The analysis of this multivariate data is being performed, with the goal of determining what, if any, are the relations between terrain morphology and network presence, and its influence on polygon geometry.

Favorable topographic conditions for network formation seem to be flat terrains with water accumulation zones, although they can be found in slopes with gradients up to 25^o. It is believed that larger polygons are older, and that, after repeated seasonal freezing and thawing, new and thinner cracks form inside the early polygons, thus dividing them into smaller ones.