Late Wisconsin Permafrost Conditions as Evidenced by Patterned Ground in the Saginaw Lowlands, Eastern-Central Lower Michigan

Christopher L. May,1 Anthony D. Kendall,1 David P. Luschn,1 Randall J. Schaetzl,1,2 Remke L. Van Dam,1 Kristine E. Stanley,1 Jonathan K. Archer1

1. Michigan State University, Department of Geologic Science, East Lansing, MI 48824, 2. Michigan State University, Department of Geography, East Lansing, MI 48824

Introduction

Patterned ground has been widely observed on floodplains, interfluvial areas, and low lying areas of the Northern Hemisphere since the late 1800s. Its formation is thought to result from repetitive freezing and thawing cycles that generate discontinuous polygonal and linear patterns (Brunnschweiler, 1969). The criteria for identified patterned ground has been defined by the American Society of Photogrammetry and Remote Sensing (2011) as “any patterned ground (polygonal or linear) of discontinuous or continuous nature, as measured in the field, in aerial photography, or in remote sensing.”

Methods

Four study sites were selected for detailed characterization using electrical resistivity (ER) methods, soil descriptions, and grain-size analyses of samples. Electrical resistivity (ER) methods, which measure the resistance of earth materials to electrical current flow, were used to identify trends and lateral variations in soil properties associated with polygonal ground in the study area. Measured resistivity is inversely proportional to the soil matrix conductive clay percentage.

GIS mapping

The cloud-field polygon patterned ground feature present in the Saginaw Lowlands allows them to be identified using aerial photography under some conditions. The higher elevation of polygon interiors causes lower soil moisture contents and a higher reflectance than polygon boundaries. In this study, we employed constant spread traverses (CSTs) and multi-electrode arrays using Dipole-Dipole and Wenner electrode configurations (Reynolds, 1989). The Wenner configuration is less sensitive to lateral variations in soil resistivity, while the Dipole-Dipole configuration is especially sensitive to laterally discontinuous or vertical features. CSTs do not provide depth information and were used as a fast exploratory tool.

Discussion

A total of 1,020 km² of patterned ground was mapped in the Saginaw Lowlands. The selectedstriated nicks are composed of polygons with an orientation of ~0 degrees. The orientation of the polygon shows no correlation with the slope of the land surface.

The patterned ground is primarily found between the Glacial Lake Washtenaw and Mille Lacs lake levels. Max in their investigation, the formation of the patterned ground was likely contributed to the permafrost levels (Lake Washtenaw 148.4 k.sl and Lake Mille Lacs 134 k.sl). Electrical resistivity methods were successfully used to characterize the polygon centers and edges. Observed resistivity differences resulted from soil moisture content changes for Site A to Site B, and resistivity differences for Site C to Site D. Soil pits showed strong differences between polygon center and edges. Except for Site C, where a sand cap was present, texture was too comparable. This suggests that differences in soil formation probably resulted from from tectonic background stress.

At Site D, complimentary methods confirmed the presence of a sandy forested structure. This structure, close to the location of a Romanstein crack found in a previous study, suggests a forested environment in the past.

Evidence from Site D points to a thermokarst excess, rather than ice-wedge reactivation, as the process of formation of the rootlet feature known as the Saginaw Lowlands.

References


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