Elongation analysis From Prevailing Winds of Glacial Landforms in Northern Illinois. K. Allred[1], W. Luo[2] and M. Konen[3], [1]Department of Geography, Northern Illinois University, Davis Hall Room 118, DeKalb, IL 60115 (kallred@niu.edu), [2](wluo@niu.edu), [3](mkonen@niu.edu).

Introduction: Glacial landforms, including ice-walled-lake plains, have been identified on Mars (see [1] for more information). This study examines the relationship between the general orientation of the ice-walled-lake plains and the prevailing wind direction. It offers a potential terrestrial analog for better understanding the morphology and processes of glacial landforms on Mars.

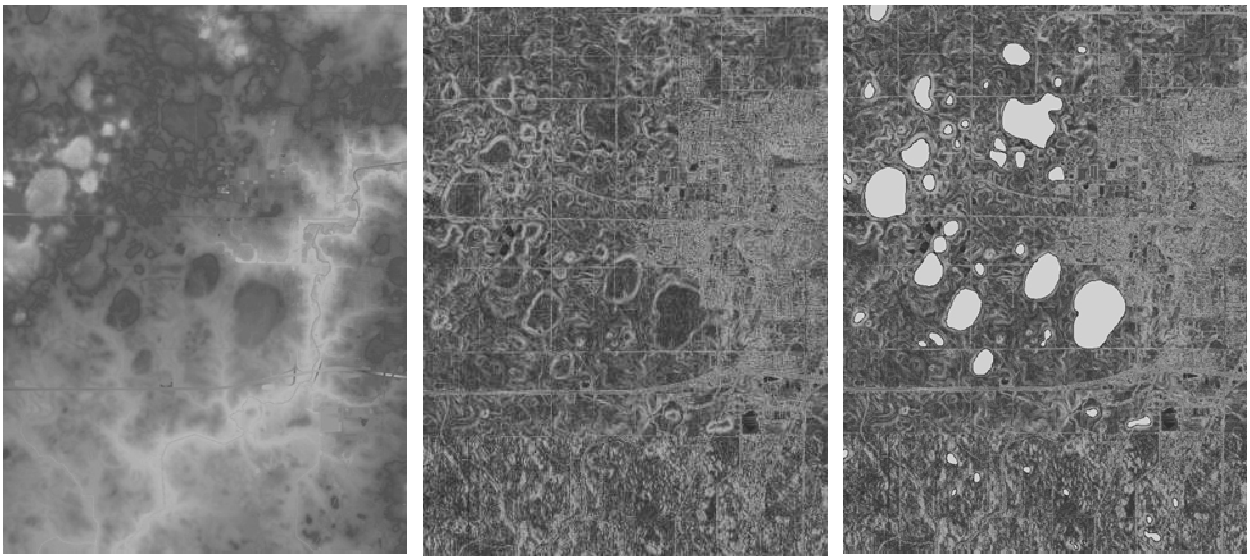
Ice-Walled-Lake-Plains The advancement and recession of the Wisconsin glaciers (25,000 to 13,000 years before present) [2] have left a hummocky landscape throughout portions of the northern United States, characterized with small mounds and shallow ponds. Found throughout the mounds and ponds are ice-walled-lake plains, landforms that result from supraglacial sediment infiltration into lakes created by terrain that has dropped from ice melting at different rates [3]. Ice-walled-lake plains are slightly elevated landforms characterized by a raised rim at the edge sloping towards a depressed center. They range from 2 to 50 meters in height, but are often limited to only approximately 10 meters, and can be up to 2 kilometers in width. The ice-walled-lake plains start as circular structures, which tend to elongate as ellipses, but sometimes merge together to form irregular shapes with multiple lobes.

Northern Illinois Sand Dunes Sand dunes were mobilized across the northern Midwest states at the end of the Quaternary period ranging from 4 to 14 meters and are presently anchored by forests or grassy vegetation [4]. Recent studies focused in northwestern Illinois have concluded that the dunes were created from sand in the Rock River region during approximately the same timeframe as the glacial movement that created the ice-walled-lakes. The dunes were compared and found to have a common orientation of N 65° W, outlining the predominant wind direction of the period since the sand dunes formed parallel with the wind [5].

Lake Elongation The common orientation of lakes residing in a particular area has been a question since the middle part of the 20th century [6] and has been a basis for research in many parts of Alaska. A theory pioneered by Livingstone [7] and proven mathematically by Rex [8] shows that most lakes affected by wind are elongated perpendicular to said wind direction. This occurs because of the rip current which circles the lake that is formed when the wind passes over the lake surface and meets the opposite shoreline.

Methodologies: A total of 270 ice-walled-lake plains throughout DeKalb County in Northern Illinois were identified from aerial photography and 1.5 meter (5 feet) resolution digital elevation model (DEM) derived from LiDAR data, both of which were provided by the county administration. The landforms were manually digitized using ArcGIS 10.0 software to make a collection of polygons grouped together in a single shapefile.

Because the ice-walled-lake plains are elevated above the surrounding landscape and have a raised rim,



(a) **(b)** **(c)**

Figure 1 **a) DEM of a portion of DeKalb County, b) identical area within DeKalb County after "Slope" analysis c) "Slope" raster with ice-walled-lake plain polygons**

the "Slope" function within the ArcGIS software was used to make the landforms more visually predominant. Figure 1 shows the raw DEM of a portion of the study area within DeKalb County (a), the slope analysis of the same area (b), and the digitized ice-walled-lake plains within the area (c). The GIS software allowed us to overlay specific layers in varying order during the delineation process to make sure that the correct landforms were identified while other landforms with similar characteristics were not used in the analysis.

After the ice-walled-lake plains were visually identified and digitized, the centroid for each ice-walled-lake plain polygon was calculated, giving coordinates for future reference. The "Zonal Geometry" tool creates a best fit ellipse for each polygon and was next used to calculate the major and minor axis length, and major axis orientation, amongst other attributes. The resulting orientation is the angle counterclockwise with east being the reference. Therefore, a calculated orientation of 90 degrees would be straight north, and 180 degrees would be straight west. Furthermore, the minimum bounding rectangles (MBR) for each landform were calculated to compare overall length and width ratios.

Results: The immediate objective of this study is to examine the relationship between the orientations of the ice-walled-lake plains in the DeKalb County region as compared to the prevailing wind direction at the time of the ice-walled-lake formation. Since the predominant wind direction has been established as N 65° W, we expect the landforms to be perpendicular to that, or approximately N 25° E. Figure 2 shows a trend in the orientation of the ice-walled-lake plains that were identified to be N-NE. The average direction of the 270 selected landforms is N 05° E (with a standard deviation of 45°), which is approximately 70 degrees clockwise from the established wind direction.

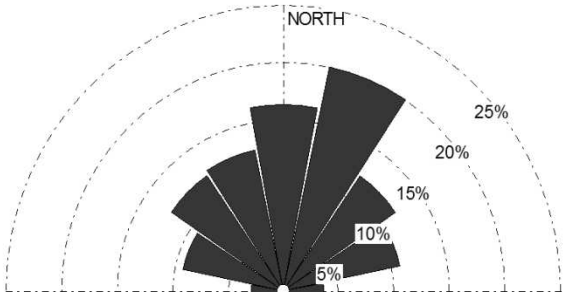


Figure 2 **Ice-walled-lake plain orientations**

Because the lakes should have been elongated perpendicular to the wind, it was expected that those with a high length to width ratio would yield more defined results. The ratios varied from 1.03 to 8.63, but averaged only 1.6. Of the 270 landforms that were tested, 128 of them had a length to width ratio above 1.5, but only 38 of them were above 2.0. The landforms with a ratio above 1.5 yielded nearly the exact same orientation and variance as the entire group, averaging a direction of N 03° E with a standard deviation of 44°. Therefore, some elongation of a significant amount of the ice-walled-lakes in the region is present, but with a wide variance and not exactly perpendicular to the defined wind direction as expected.

Conclusions and Future work: The results are generally consistent with previous understanding of the relationship between ice-walled-lakes and prevailing wind direction. The elongation deviating from the expected 90 degree from wind direction may result from small lakes coalescing into large ones, altering their shapes. However, more work (including field work) is needed to confirm this.

This study also created a training data set for machine learning algorithms that can automate the identification process. Future work will test the automatic procedure on Earth and apply it to identify similar features on Mars.

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