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Evidence for Late Pleistocene Loess Transport on Katabatic Winds: Great Lakes Region, USA

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Abstract

Our data for the recently deglaciated landscapes in the Great Lakes region, USA suggest that the loess here was transported primarily on katabatic winds blowing perpendicularly to the glacial front. The unique position of the study area – in a glacial re-entrant – probably added to the strength and persistence of such winds.

The Late Pleistocene loess in northeastern Wisconsin and adjacent parts of Michigan's Upper Peninsula is 25-70 cm thick. Upland areas - mainly drumlinized uplands - that were deglaciated early and remained geomorphically stable preferentially accumulated loess by providing sites that were efficient at trapping and retaining loess. Data on loess texture and thickness suggest that, in this re-entrant area, loess was mainly transported on katabatic winds that entrained silt and fine sand from proglacial outwash plains and hummocky end moraines. The loess fines markedly and becomes better sorted farther from former ice margins. Only minimal amounts of loess were deposited via westerly winds.

This research (1) provides evidence for katabatic winds as eolian transport vectors in interlobate areas and on uplands near ice margins, and (2) confirms that outwash plains and end moraines can be significant loess sources. This research is forthcoming in *Quaternary Research*.

Introduction

Thick loess is widespread across much of the central USA, especially downwind from major meltwater river valleys. Most of this loess was carried on westerly winds, accumulating to great thicknesses on the eastern sides of these valleys.

Recent work has documented new, often localized, loess sources on recently deglaciated landscapes. Many kinds of recently deglaciated landscapes – if unstable and devoid of vegetation – can supply sediment for deflation. Examples include glacial lake plains (Schaetzl and Loope (2008), hummocky end moraines (Stanley and Schaetzl 2011), outwash plains (Schaetzl 2008), and small meltwater rivers (Schaetzl and Hook (2008). Our work adds to this growing body of literature by examining loess that lies just outside several major glacial margins (Figs. 1, 2). The purpose of this study is to characterize and interpret these loess deposits, focusing on its genesis and paleoenvironmental significance .

Sites, Sampling, Lab Analyses and Data Mapping

Loess samples were taken from 419 upland sites (Fig. 3). Samples were disaggregated, homogenized, and prepared for particle size analysis (psa) on a laser particle size analyzer. All psa was done in duplicate and a mean value used for further analyses. Psa data were "filtered" to remove coarse materials, mainly medium and coarser sands, that had been mixed up, into the loess by pedoturbation (Schaetzl and Luehmann 2012). Subsequent analyses were run on these filtered data. In a GIS, we used ordinary kriging to map textural, sorting and thickness properties of the loess. These maps were our main guide for interpreting the paleoenvironment of loess deposition in this area.

Results

Loess in our study area is mainly found on uplands in a glacial re-entrant area. It is particularly thick on those uplands that are topographically high and farthest from the surrounding ice margins, probably because these areas were deglaciated earlier and thus, had longer periods of loess accumulation, facilitated by emergent vegetation.

Ice margins surround the loess deposits on three sides (Fig. 2). The loess gets progressively finer textured with distance form the ice margin, regardless of directionality (Fig. 4). This pattern suggests that loess was being transported by winds coming directly off the ice (katabatic winds) and that the main sources were the silt-rich tills in the moraines themselves, as well as proglacial outwash plains. Loess is thickest in the center of the region (not nearest the source) because it was being transported there from several directions, simultaneously (Fig. 4).

This research demonstrates that loess in the midlatitudes was not all being transported on westerly winds, and that locally strong, katabatic winds were important eolian vectors on these landscapes.

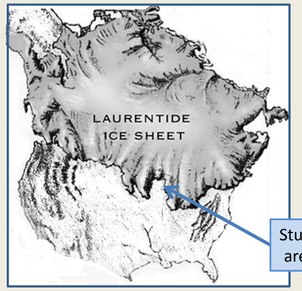

Figure 1. ABOVE. Maximum extent of the Laurentide Ice Sheet in North America, during Marine Isotope Stage 2.

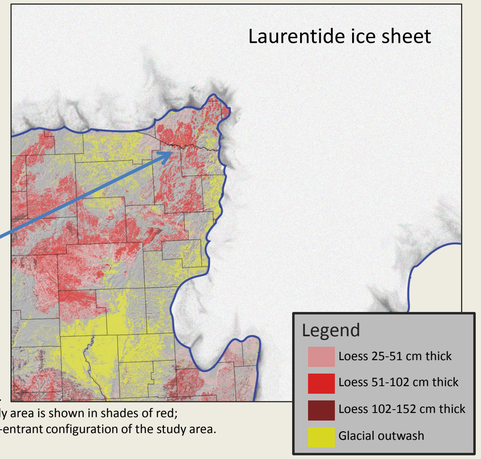

Figure 2. RIGHT. Ice configuration at the time of loess deposition, on a hillshade DEM background. The thickness and distribution of loess in the study area is shown in shades of red; outwash areas are yellow. Note the prominent re-entrant configuration of the study area.

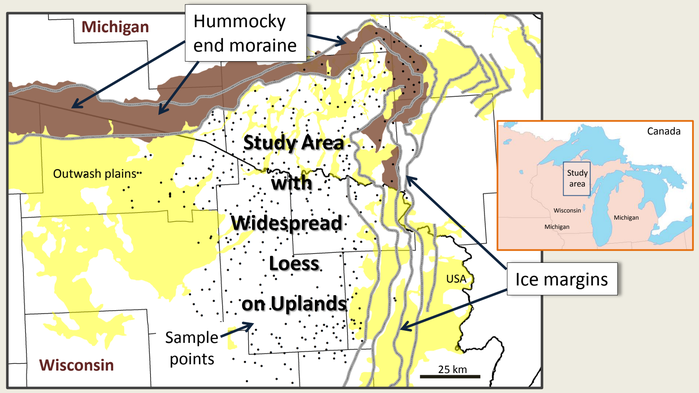

Figure 3. ABOVE. Locations of sample points in the study area. Also shown are the major outwash plains and areas of hummocky end moraine. Gray lines indicate ice margins.

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Acknowledgements

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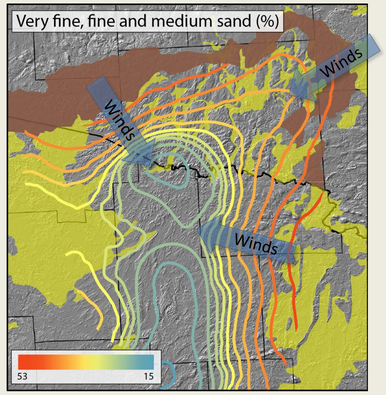
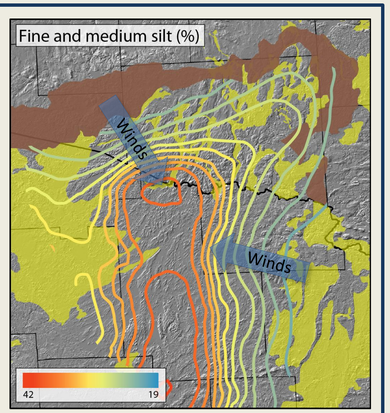
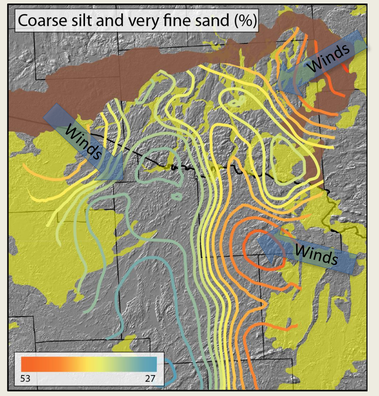


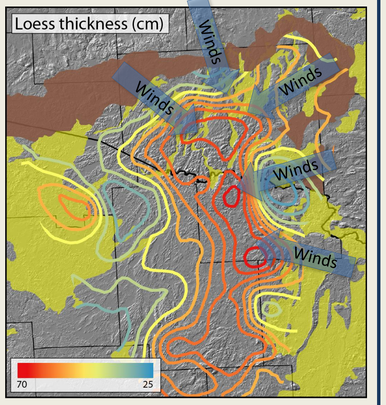
Loess typically has the highest content of sand in locations near its source area. This map shows that the loess has the most sand in locations near the proglacial outwash plains and hummocky end moraines. This pattern suggests that the loess was derived from these landforms and transported to the central part of the region, onto high drumlins here, which were probably vegetated at the time.



Fine and medium silts are easily transported by wind, dominating loess deposits far from their source areas. This map indicates that the loess has the least fine and medium silt in locations near the outwash plains and hummocky end moraines, supporting the hypothesis that it was derived from these landforms, and transported to the central part of the region.



This map, of the 40-125 um fraction, shows that the source areas to the east of the loess were contributing more of this coarse sediment. We suggest that this pattern resulted because the easterly katabatic winds were relatively stronger. Note the high concentrations of coarse silt and very fine sand in the NE re-entrant area; winds here may have been exceptionally strong.



Convergent winds from the east, northeast and north – all katabatic in nature – were transporting loess onto the drumlin fields in the central study area. Here, loess deposits are thickest and siltiest, because they were receiving sediment from multiple sources. Note, however, that loess is thickest towards the east, again pointing to the greater strength of the easterly winds.

Figure 4. Kriged isoline maps of loess characteristics across the study area, set on a gray, hillshade background. Yellow areas are outwash plains and meltwater sluiceways. Brown areas are wide, hummocky moraine tracts.