Mapping and Characterizing Thin Loess Deposits at the Northeastern Margins of the North American Loess Sheet

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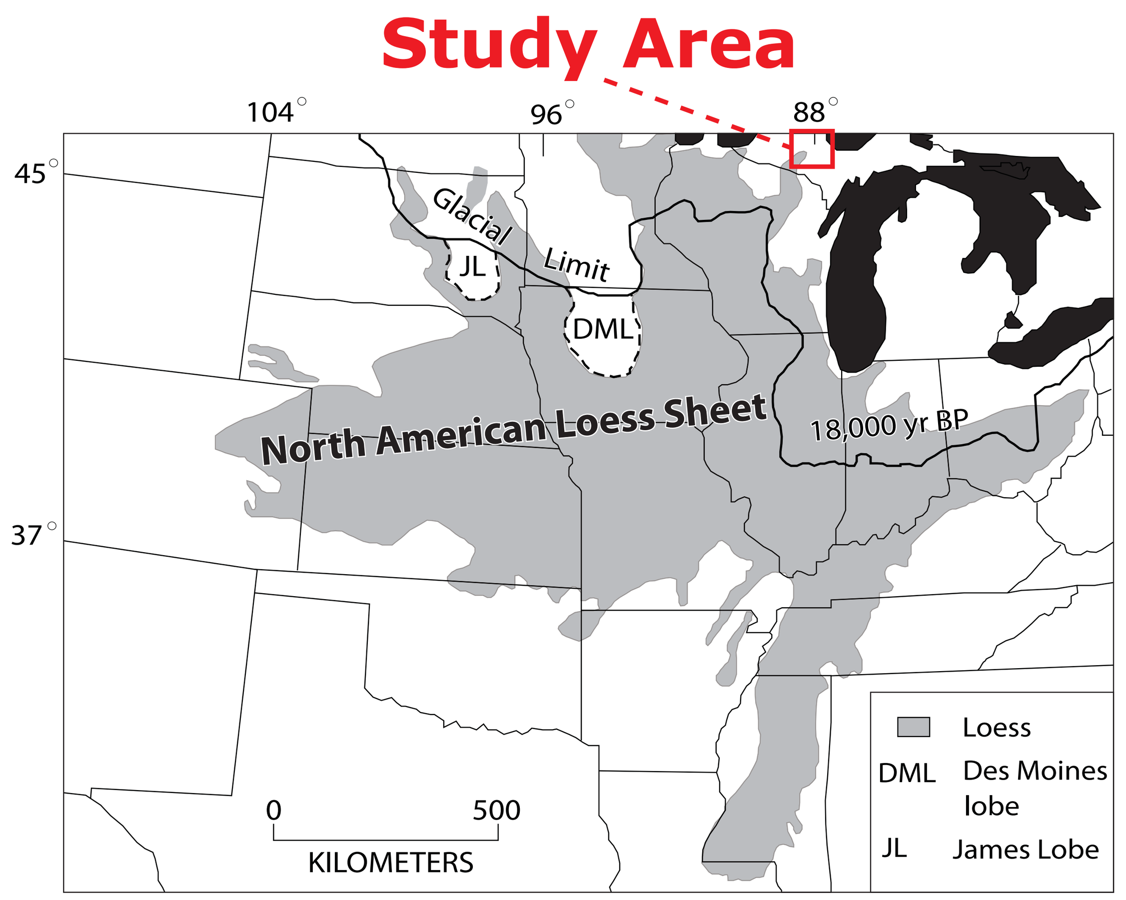


Modified from: Muhs, D. R., and E. A. Bettis. 2000. Geochemical variations in Peoria Loess of western Iowa indicate paleowinds of midcontinental North America during last glaciations. Quaternary Research 53 (2):49-61.

Abstract

This poster reports on the distribution, thickness and textural characteristics of thin, patchy loess in the western Upper Peninsula of Michigan. On this high-relief, bedrock-controlled landscape, uplands are often mantled with ~ 30-60 cm of loess, which is, in turn, usually underlain by sandy glacial sediment. Pedoturbation has mixed some of the lower, sandy materials up, into the loess. Therefore, the loess often has a bimodal textural curve, with a primary particle-size mode within the 25-75 µm fraction (the loess) and a secondary mode in the 250-500 µm fraction (sand, mixed into the loess from below). Using texture and thickness data, we identified four, relatively homogeneous loess regions, or sections, from the larger study area. Loess here had various local source areas: ground moraines, outwash plains, and the floodplains of meltwater streams. Our research (1) recognizes multiple source areas for loess, (2) develops and interprets textural data on thin loess, and (3) documents the effects of mixing within these loess deposits.

Introduction

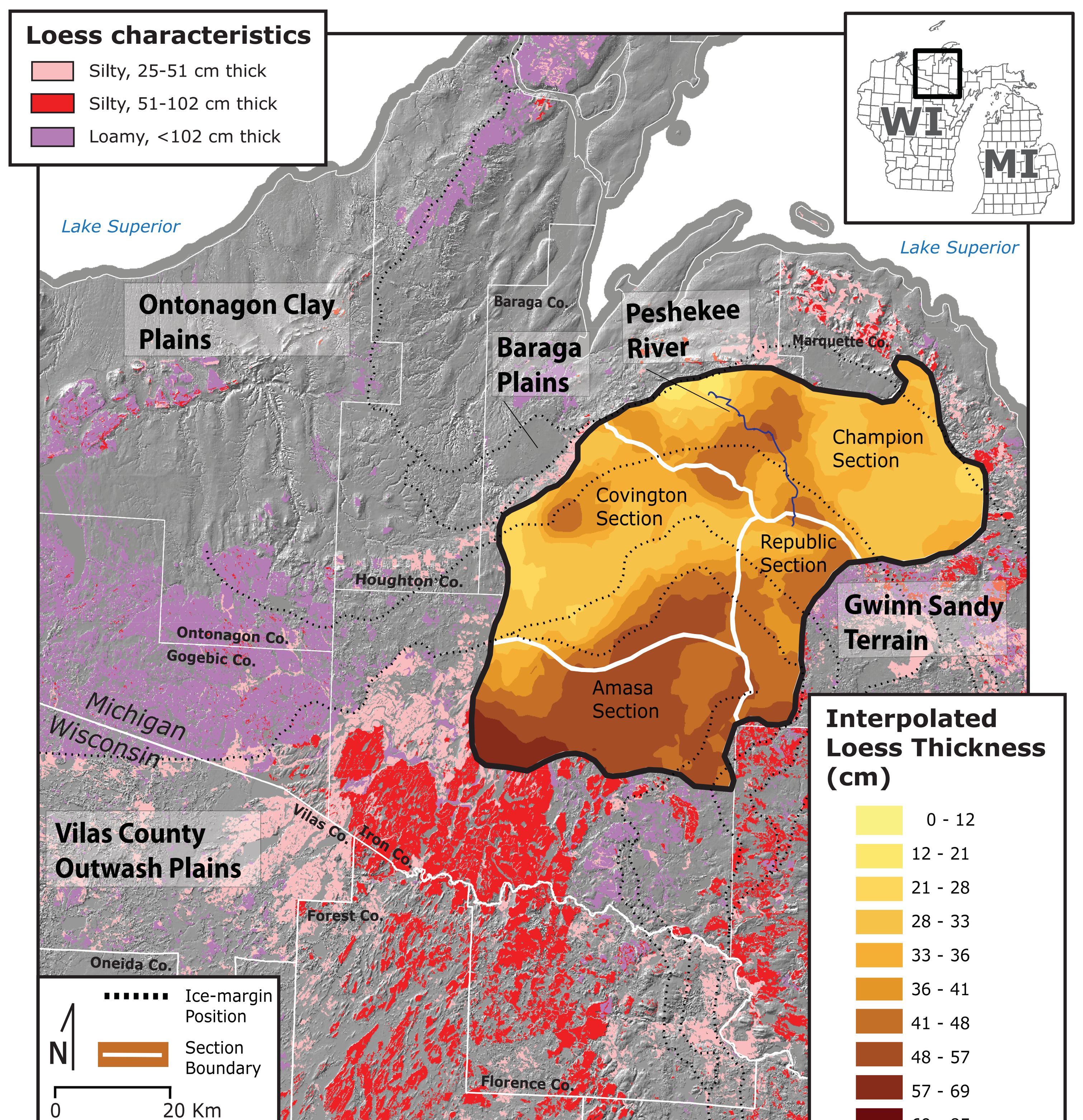
North America has some of the thickest deposits of last-glacial loess in the world. In the Midwestern USA, loess deposits can exceed 30 meters in thickness, and generally become thinner to the east and northeast, from the Mississippi River valley, until, by Michigan they may only be as thin as 30 cm, and often are thinner or absent. No previous studies have been undertaken on these thin loess deposits at the margins of the larger, thicker loess sheets of North America. Our study focuses on these thin loess deposits and examine the deposits spatially. We studied the textural and thickness characteristics of the loess, and use this information to suggest its source area(s). These data may have applications for the mechanics of the source area(s) from which the loess deposits originated, in addition to periglacial environmental conditions (e.g., wind-direction, wind-speed, and permafrost).

Methods

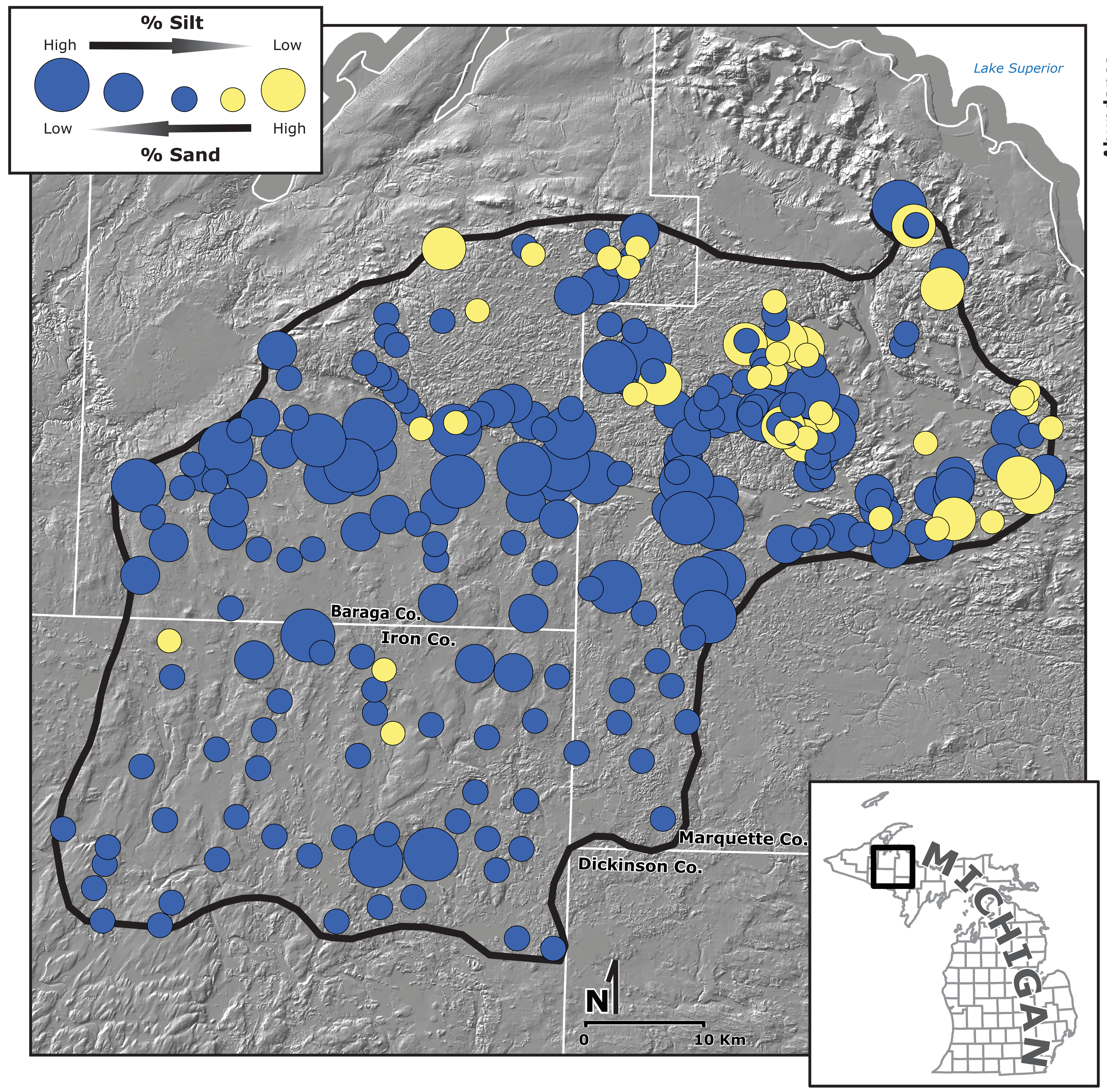
Loess was sampled on broad, stable uplands at 267 sites across the study area, and analyzed using laser diffractometry. Excel software was used to plot continuous textural curves for the loess samples. Most loess samples had either a single textural mode in the 25-75 µm fraction, or a bimodal textural curve - with a dominant mode in the 25-75 µm fraction and a secondary mode, usually in the 250-1000 µm fraction (see figure below). We assumed that the 25-75 µm fraction likely indicates the eolian sediment within each sample, whereas the peak in 250-1000 µm fraction points to contributions from the underlying, sandy parent material. Unique to this study, we assigned each sample to an eolian textural curve (ETC) type, based on the particle size signatures. All 267 samples were fit into one of five eolian textural curve types (see figure below).

Textural data for each sample, as well as information about loess thicknesses, were examined in a GIS. Using the geostatistical wizard module of ArcMap 10, these data were spatially interpolated and mapped using ordinary kriging (see "interpolated map" figures to the right).

Source Areas



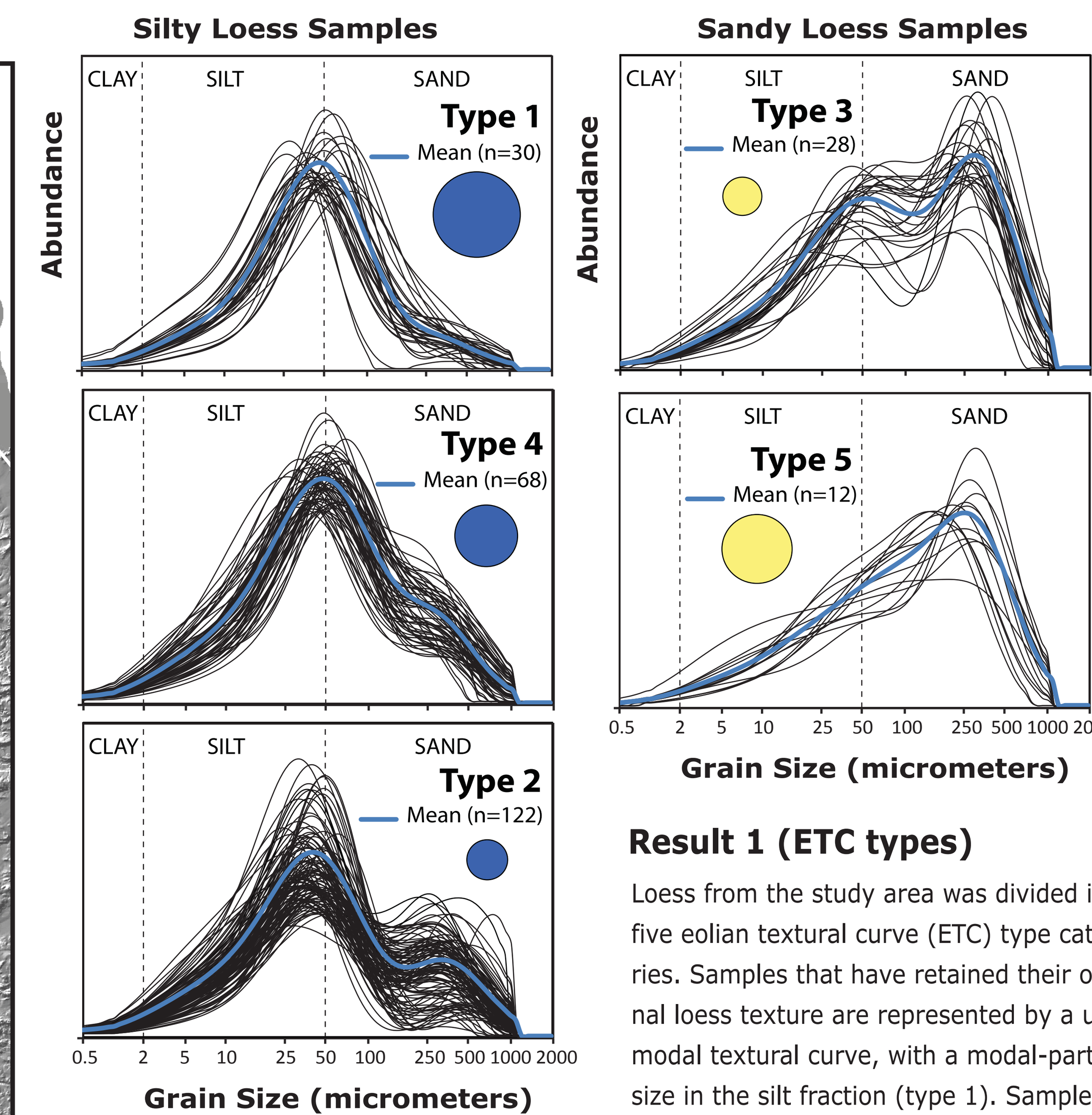
Site Locations and Percent Silt Contents



Result 4 (Source Areas)

Loess in the study area likely originated from both distant and local source areas; several different kinds of landforms and landscapes contributed eolian sediment. The very southern regions of the study area were deglaciated first, while ice was occupying the northern regions of the study area. The Vilas County Outwash Plains of Wisconsin were likely a (fairly distant) source for the silty loess that today occupies these regions, i.e., the Amasa section. After the ice margin retreated further, the Baraga (outwash) Plains and the Ontonagon Clay Plains likely became sources for loess in the western regions of the study area, i.e., the Covington section. The surrounding moraines and the Gwinn Sandy Terrain were sources for loess in the eastern regions of the study area, both likely contributing loess to the Republic section. The loess deposits in the northern regions of the study area, termed the Champion section, are sandy, thin and patchy, compared to the loess deposits towards the south. Loess here was likely sourced from small intermittent meltwater streams (e.g., the Peshekee River) and small, isolated outwash plains.

Eolian Textural Curve Types



Result 1 (ETC types)

Loess from the study area was divided into five eolian textural curve (ETC) type categories. Samples that have retained their original loess texture are represented by a unimodal textural curve, with a modal-particle size in the silt fraction (type 1). Samples that are bimodal, with a modal-particle size in the silt and sand fraction, represent loess samples that have been mixed with the underlying, sandy sediments (types 2 and 3). Some samples have a "shoulder" curve – a type of gradation between a unimodal silt or sand curve to a bimodal textural curve (types 4 and 5). Thus, we found two types of loess in this thin loess region:

(1) Silty loess, which has a silt mode (or shoulder) between 25-75 µm, and a secondary sand mode (or shoulder) between 250-1000 µm (i.e., types 1, 2 and 4).

(2) Sandy loess, which has a sand mode between 250-1000 µm, and a secondary silt mode (or shoulder) between 25-75 µm (i.e., types 3 and 5).

Silty loess is dominant in the southern regions of the study area, where the loess deposits are generally thicker. Sandy loess is more common near the northern margins of the study area, where loess deposits are thinner.

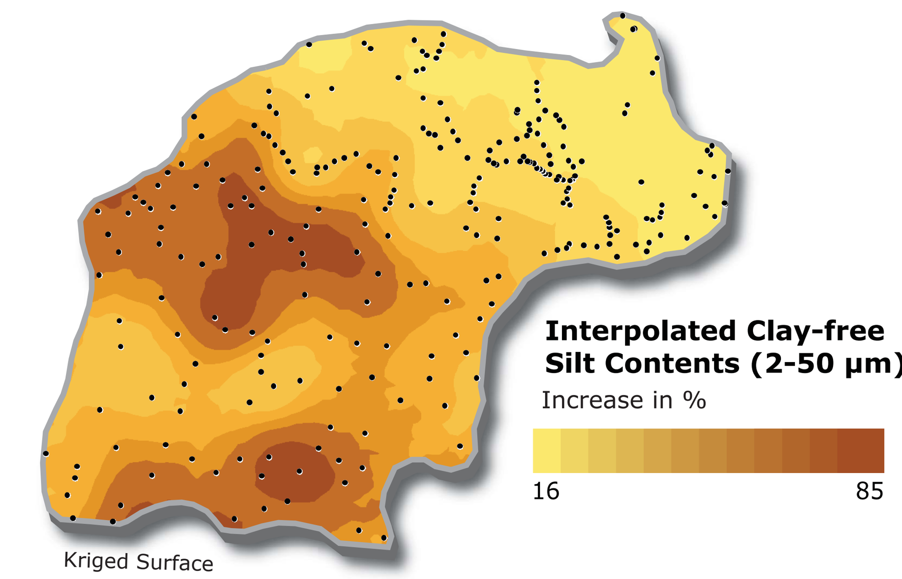
Result 3 (Loess sections)

The study area is an assemblage of several overlapping, heterogeneous loess regions. These loess sections usually vary by loess thicknesses, texture, and modal particle-size, and also source areas.

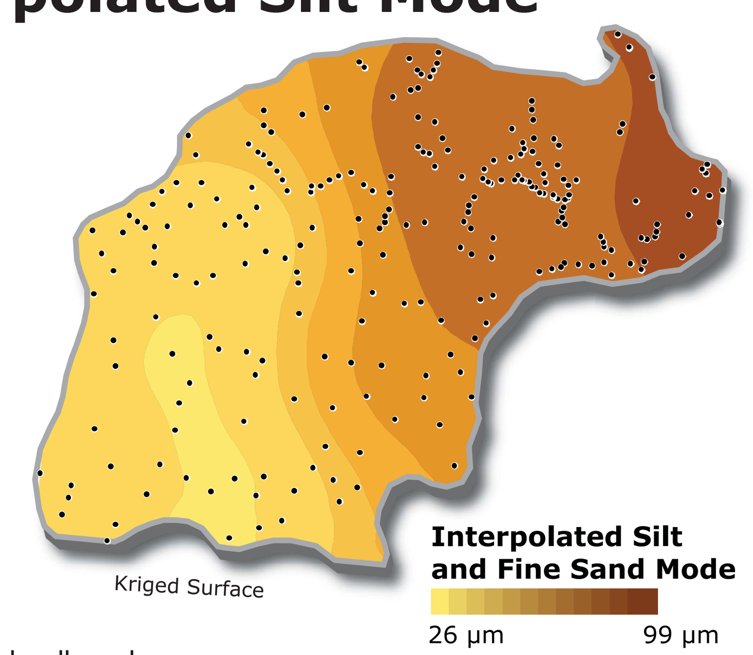
Section	Mean loess thickness	Total silt	Modal particle-size[1]
	(cm)	(%)	(µm)
Amasa	52.4	52.20	38.6
Covington	36.2	52.60	40.2
Republic	42.5	49.60	49.8
Champion	32.9	38.60	52.9

[1]Mean modal particle-size is within the 26-99 µm fraction

Interpolated % Silt Contents

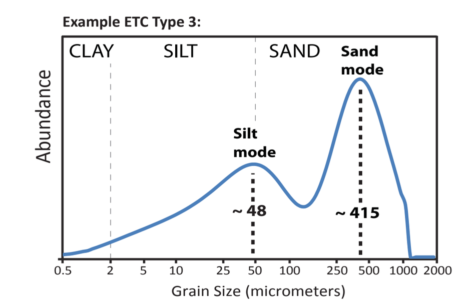


Interpolated Silt Mode



Result 2 (Silt mode distribution)

The mode of each sample is diagnostic to its origins; silty mode samples are similar "traditional" losses, commonly originating from distant sources. Conversely, sandy samples reflect local-source, coarser loess. Because these loess deposits are thin, each of these two types may or may not have had some mixed-in sediment from below. In order to determine where locally vs longer-distance sourced loesses exist, we mapped the "silt mode" of each sample, by assigning each sample its modal value within the 26-99 µm fraction. This mode was then added to a GIS shapefile and a kriged surface was created in order to interpolate the trend in modal particle-size of the loess. Sample types 1-4 were used to generate the silt mode map.



The silt mode map illustrates a prominent southwest to northeast spatial trend, with the southern regions of the study area having samples with the finest modal particle size (~ 26 µm), and the northeastern region having samples with a coarser mode (~ 99 µm). Loess deposits generally become progressively finer in texture away from the source area(s).

Loess Sections