

PERMAFROST FEATURES NEAR THE WISCONSIN GLACIAL MARGIN IN ILLINOIS

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ABSTRACT. Involutions and other frozen ground features at four localities in northern Illinois are described. Three of them are situated a short distance beyond the limit of Wisconsin glaciation and are striking in that involutions involve humic bands in Farmdale silt. The available evidence indicates that arctic climate existed briefly adjacent to the ice front in northern Illinois and that sporadic permafrost existed in a relatively narrow marginal zone. We conclude, however, that the arctic and tundra zones did not exist in the area of southernmost extent of Wisconsin glaciers and that the southern limit of permafrost was significantly north of the southern limit of glaciation.

INTRODUCTION

Cryoturbation (or congeliturbation) phenomena resulting from the effects of repeated freezing and thawing in the active zone above the permafrost table have been the subject of intensive study in arctic regions during the past two decades. Early during this period Sharp (1942) recognized involutions in unconsolidated late Pleistocene deposits in Illinois and attributed them to the effects associated with permafrost. Sharp reviewed the pertinent literature and established, in convincing terms, the permafrost origin of the features he described. These involutions occur within water-laid sediments of mid- to late-Wisconsin age, well within the limits of Wisconsin glaciation.

Horberg (1949; 1953, p. 32-33) described contorted humus bands in the Farmdale silts and certain wedge-like projections of overlying deposits into the silts. In discussing their origin he considered as a possible mechanism the action of the permafrost zone. He concluded that the wedge-like projections were the result of ice wedges, but rejected permafrost as the major cause of the contorted bands. Concerning their origin he stated (Horberg, 1953, p. 32):

Since the deformed zones directly underlie Wisconsin till, the obvious interpretation of origin is by ice shove, although in places periglacial frost action may also have been an important process.

During the summer of 1957 we had opportunity to study involutions displayed by humus bands in the Farmdale silts adjacent to but beyond the limit of Wisconsin glaciation (fig. 1). It is our purpose here to describe briefly some of these features and discuss their probable climatic implications. The localities discussed here were selected for special attention because of their geographic location and the presence of thin humic bands that made it possible to record them by photography (pls. 1 and 2).

During part of the field study of these features we were in company with Jean de Heinzelin and Paul R. Shaffer. We express our thanks to M. M. Leighton, George E. Ekblaw, and Paul R. Shaffer who have read and criticized the manuscript.

STRATIGRAPHIC POSITION OF INVOLUTIONS

The permafrost features studied during 1957 occur within the Farmdale silts of earliest Wisconsin age. The Farmdale Loess was named by Leighton (1948) and its stratigraphic position as the first increment of Wisconsin deposition on the surface of the Sangamon Soil was clearly established (Leighton

and Willman, 1950). Although stratigraphic sections were measured at each of the localities studied, one only is presented here to illustrate the sequence of related deposits.

Section measured in fresh cuts in north bluff of Illinois River Valley, SW $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 31, T. 7 N., R. 6 E., Peoria County, Illinois

	Thickness (feet)
Pleistocene Series	
Peorian Loess	
12. Loess, massive, upper five feet leached and contains soil profile, lower part weakly calcareous, tan to gray, streaked with limonitic root tubules, with scattered nodules and locally indistinct lamination	12.0
Farmdale Silt	
11. Silt, massive to laminated, weakly calcareous in mid-part but non-calcareous above and below, light gray; locally limonitic nodules and tubules; distinct thin humic bands in upper part; humic bands show distinct involutions throughout exposure (note pl. 1)	4.5
Illinoian Till	
10. Sangamon Soil. Soil A and G zones, leached; top one foot of A zone dark gray, granular to massive, grading downward into massive gley, gray mottled with tan	5.0
9. Sangamon Soil. Till, gray, thoroughly interlaced with veinlets of hard limonite, brown, with splotches of brown stain, weathering to a "box work" surface, noncalcareous in the gray matrix but locally calcareous in iron-cemented veinlets; "ferretto zone"	2.0
8. Till, calcareous, unevenly oxidized, well jointed, gray-tan, gradational at top and bottom	3.0
7. Silt and some sand, thin zones cemented with CaCO ₃ , red, tan, and gray. Southward the silts pinch out and a cobble zone is at same stratigraphic position	2.0
6. Till, oxidized, calcareous, jointed, brown	3.0
5. Sand and gravel in discontinuous lenses, locally cemented, brown	3.0
4. Till, calcareous, pebbly, blue-gray, well jointed throughout with oxidized rinds on joints	18.0
Kansan Till	
3. Yarmouth Soil. Soil, truncated to the B ₂ horizon at top, leached, clayey, dark brown, locally spots of secondary carbonate; siliceous pebbles and cobbles present throughout; gradational with calcareous till at base and sharp contact at top except locally where blocks of this soil are incorporated in overlying till	4.5
2. Till, calcareous, gray with mottled patches of brown in upper part, jointed throughout with oxidized rinds along joints. Lenticular and irregular masses of gray to gray-tan silt and very fine sand with contorted and disorderly oriented bedding occur discontinuously in the middle part; although no fossils were found at this locality, these silts strongly resemble fossiliferous silts in a similar stratigraphic position in nearby exposures in SW $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 11, T. 6 N., R. 5 E., Fulton County	18.0
1. Sand, fine- to medium-grained, calcareous, brown with locally dark gray streaks at top, upper contact irregular. Base of section in diversion ditch at base of exposed face	4.0
Total thickness exposed	79.0

Inasmuch as three of the four localities discussed herein lie near but outside the limit of Wisconsin glacial advance (fig. 1), the Farmdale silt at these localities was not overridden by any glacier and therefore the contortion of

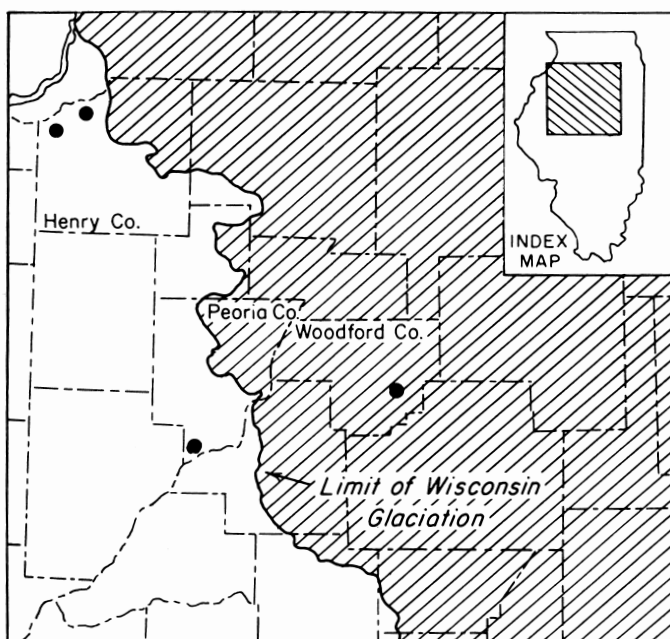


Fig. 1. Map of a part of northwestern Illinois showing location of the exposures described.

the humic bands cannot be attributed to ice shove. The stratigraphic and geographic setting indicates that the Farmdale silt was near the surface when the glacier front was just a few miles away.

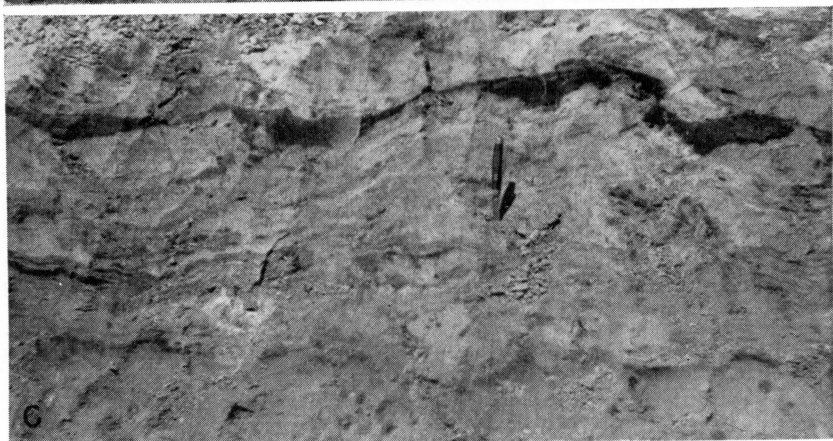
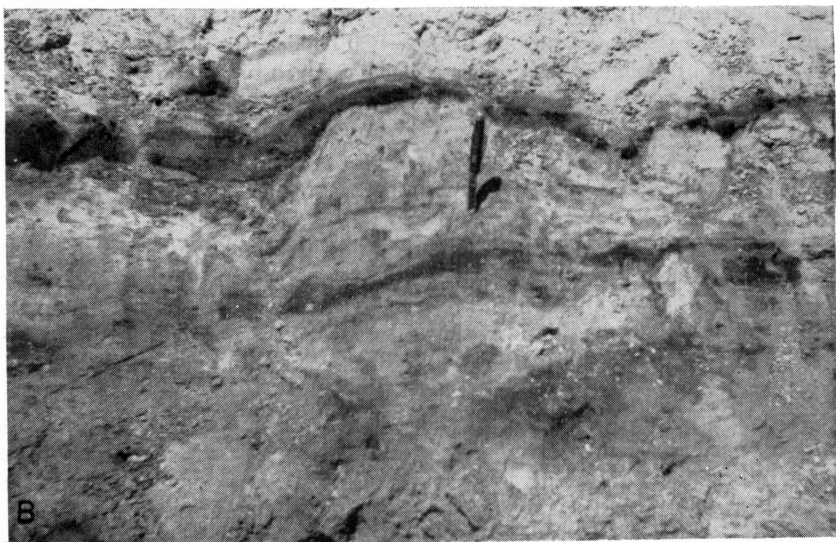
DESCRIPTION OF FROST FEATURES

At the exposure in Peoria County, the southernmost locality discussed (fig. 1, pl. 1), the involutions are less intense than those displayed in Henry County (pl. 2, B and C) but are more clearly shown by the thin zones of humic staining. Although the involutions were present throughout 50 yards of continuous exposure they were uniformly of a mild type without "overfolding" or the isolation of "pods."

In contrast, in the exposures studied in Henry County (pl. 2, B and C) the involutions display "overfolding," "infolding," and isolation of "pods" surrounded by humic material, but in the photographs this higher degree of deformation is not so clearly evident because of the generally greater thickness of the humic zones.

Still different conditions are exhibited in Woodford County (pl. 2, A). Thin Farmdale silt above Sangamon Soil exposed in road cuts contains humic bands but does not contain involutions, even though the locality is more than 30 miles within the limit of Wisconsin glaciation. The Farmdale silt is overlain by an upward succession of thin Iowan Loess, a thin sand zone, and calcareous Shelbyville till. Both the loess-sand contact and the sand zone at the base of the till are contorted, and wedge-shaped cracks in the Iowan Loess are filled with the overlying sand.

PLATE 1



Exposures of Pleistocene Deposits Along West Bluff of Illinois River Valley, SW $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 31, T. 7 N., R. 6 E., Peoria County, Illinois.

A. Bluff line exposure, locality of measured section and involutions shown in B and C.
B. and C. Involutions in loess with peaty bands in the upper part of the Farmdale Loess: pocket knife gives scale.

INTERPRETATIONS

A divergence of opinion has existed for many years concerning the nature of the climate adjacent to the margins of continental glaciers that advanced into relatively southern latitudes. The European literature in general indicates the conclusion that arctic climates and permafrost existed rather extensively beyond the limits of the ice during glacial epochs. On the other hand, Frye and Leonard (1952) have presented evidence indicating relatively mild climatic conditions in close proximity to the glacier front during the maximum extent of both the Nebraskan and Kansan glaciations in their type region.

The cryoturbation features here described furnish evidence bearing on this problem in relation to the Wisconsin glaciers in Illinois. The lack of involutions in the banded Farmdale in the Woodford County exposure, coupled with the permafrost features in the thin overlying Iowan Loess, suggests that frozen ground existed just prior to the arrival at that locality of the first Wisconsin ice front (Shelbyville) but for such a short time that associated deformation did not extend as deep as the Farmdale. Furthermore, the involutions in the Peoria and Henry counties exposures are judged to extend upward into the basal (Iowan) part of the overlying Peorian Loess, and thus confirm the tentative dating as the time of maximum ice advance, and for a brief period only.

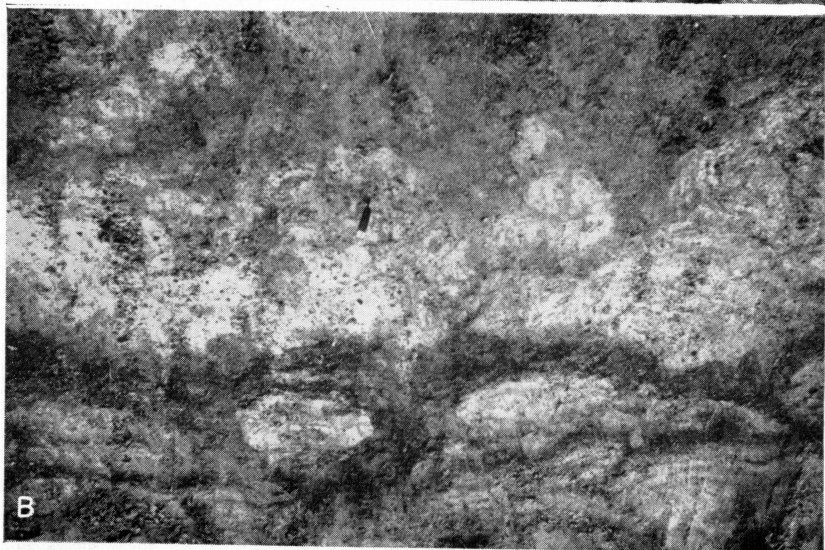
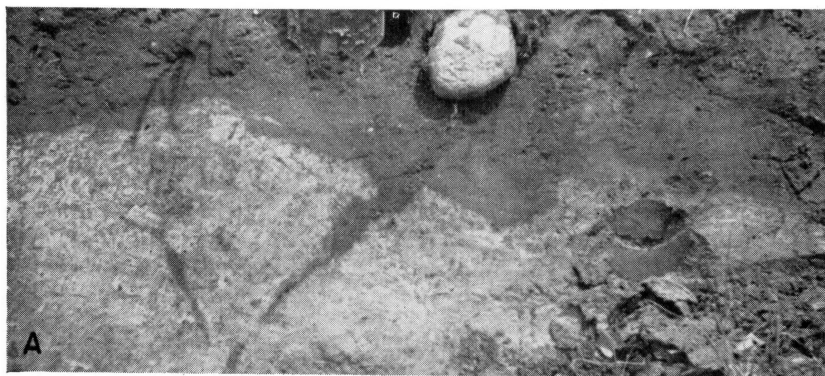
The lower part of the Peorian Loess is involved in the deformation, but its homogeneous character prevents definite recognition of involutions far above the base. Outside the area covered by Wisconsin glaciers, the Iowan Loess is so similar to the overlying loess that it generally cannot be differentiated, hence the use of the name Peorian for the undifferentiated Wisconsin Loess above the Farmdale. As 5 to 10 feet of Iowan Loess was deposited widely in this region before the Shelbyville ice arrived, the thickness of the zone affected by permafrost may be of that order. It is possible, however, that the Iowan Loess was abnormally thin at the localities in Henry and Peoria counties. Furthermore, frost features have been found at so few localities that permafrost may have been sporadic and formed only in places where topography and drainage were unusually favorable.

Correlation of these relatively rare frost features with the immediately adjacent Shelbyville moraine, one of the largest of the Wisconsin moraines, suggests that such structures may be found only near positions of moderately long stands of the ice front. If a narrow permafrost zone developed along the ice front, it seems probable the ice advanced rapidly enough to cover it, or retreated rapidly enough to abandon it, before significant deformation such as involutions could be formed. It appears that the most favorable places to find permafrost features in Illinois would be close to the larger moraines, such as the Bloomington and Marseilles. The only other occurrences of permafrost

 Frost-features in Loess.

- A. Ice wedge in loess below Shelbyville till, NE¼ sec. 9, T. 26 N., R. 1 E., Woodford County, Illinois.
- B. Involutions at the top of the Farmdale Loess, cent. N. line NE¼ sec. 2, T. 17 N., R. 2 E., Henry County, Illinois.
- C. Involutions at the top of the Farmdale Loess, SW cor. NW¼ sec. 21, T. 17 N., R. 1 E., Henry County, Illinois.

PLATE 2



features described from Illinois are related to the large Valparaiso moraine (Sharp, 1942).

Within the Wisconsin drift many layers of sand and silt interbedded with till are believed to result from repeated retreats and advances of the ice front. The preservation of these silts suggests that the ground may have been frozen when they were overridden, but the absence of deformation suggests that permafrost could not have existed in them for many years before burial by the glacier.

That an arctic climate could not have extended far from the ice is shown by the abundant snail fauna in the Peorian Loess in locations which could not have been more than 25 to 50 miles from the ice front during the major accumulation of the loess. In some locations proximity of the fossiliferous loess to the ice front may be less than 10 miles.

The fact that the intensity of involutions in the Peoria County exposure is markedly less than at the northern exposures in Henry County is at least suggestive. Cryoturbation features have not been observed in the many scores of exposures of this zone examined along Illinois Valley farther south.

Based on the foregoing data and the observations of Sharp (1942), permafrost existed for a relatively short time, and perhaps locally, adjacent to the margins of Wisconsin glaciers in northern Illinois, but became ineffective in central Illinois. It is judged that an arctic climate was not prevalent at the Wisconsin glacier border in its southernmost extent.

The inference seems clear that in this latitude the ice had advanced into a region so far from climatic conditions which favored its growth, that the arctic and tundra zones may have been effectively eliminated, rather than merely compressed.

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