CONTRIBUTION OF SOILS TO THE MAPPING AND INTERPRETATION OF WISCONSIN TILLS IN WESTERN OHIO[1]

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ABSTRACT

Soils have been an important tool in the interpretation of the Wisconsin glacial history of western Ohio. Five different tills are recognized in this area, identified by five different soils, which are distinquished on the basis of (1) presence or absence of silt (loess) cap, (2) amount of clay in B horizon, (3) amount of clay in C horizon, and (4) depth of soil profile. Where the critical difference between two adjacent soils relates to one of the first three factors, composition is considered to be the explanation; where the difference is based on the fourth factor, one soil appearing to be deeper and more weathered than the other, a difference in age between the tills is inferred, the younger till interpreted to represent the deposit made during a major readvance of the retreating glacier.

Careful evaluation of the differences between each set of adjacent soils reveals the following Wisconsin glacial history: after the very long Sangamon Interglacial, the "early" Wisconsin glacier appeared, only locally extending beyond the limits of younger deposits, followed, after a moderately long ice-free period, by the "late" Wisconsin glacier. During recession, this last glacier deposited a series of end moraines, with a major readvance (judged by soils differences) marked by the Farmersville-Reesville Moraines, and a less significant readvance marked by the Union City-Powell Moraines. The retreat preceding this last readvance must have extended north of the Ohio divide, allowing formation of an ice-front lake in which clay could accumulate, for the till subsequently deposited is rich in clay.

Glacial till is present at the surface in most of western Ohio. Much of this till is of "late" Wisconsin age, but to the south, there is a broad area of Illinoian till and, locally, near the Wisconsin-Illinoian boundary, is a narrow band of what

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is believed to be "early" Wisconsin till. Although determination of these ages has been based on many different criteria, the single most useful indicator, for almost all workers, has been the nature of the soils developed in these tills.

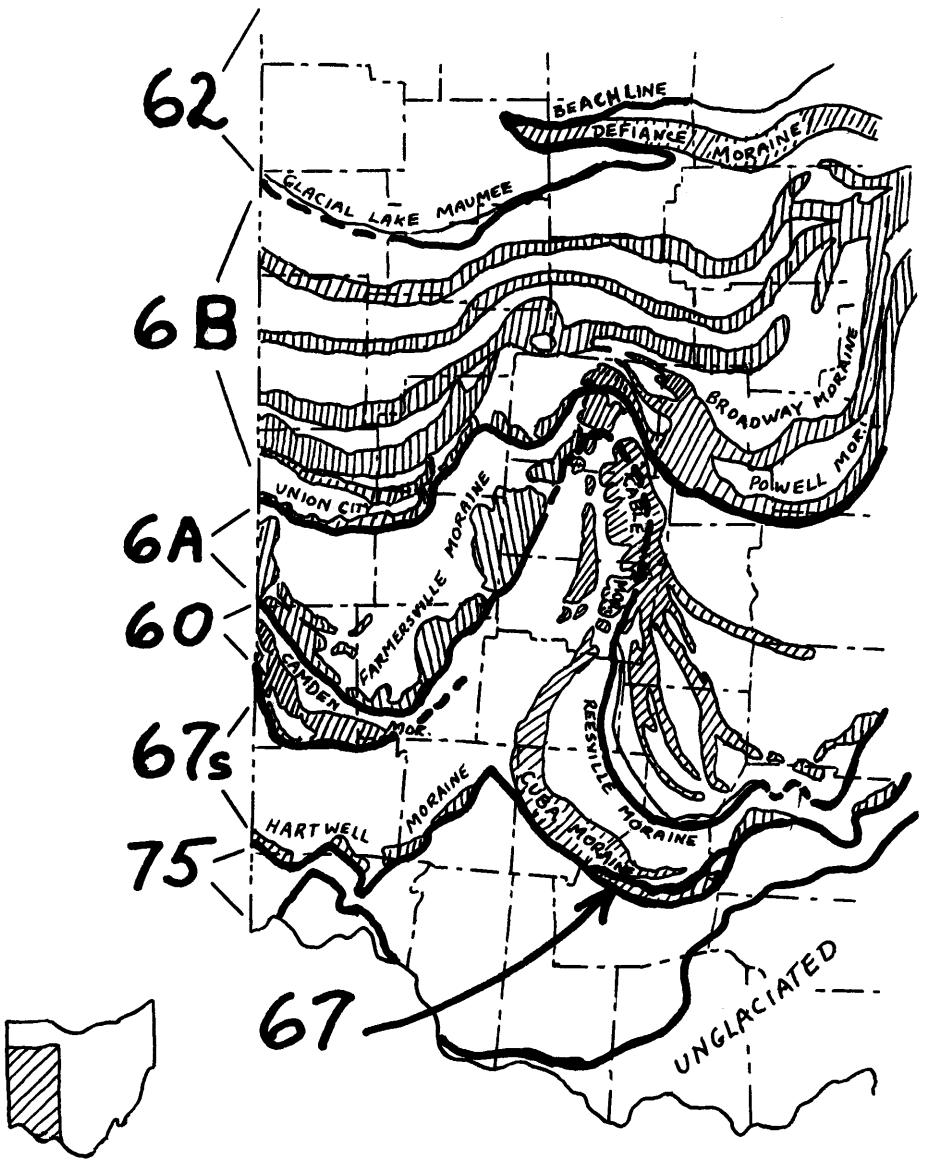

FIGURE 1. Map of southwestern Ohio showing relationship between end moraines and distribution of major till soil associations. Soils are labelled by field mapping symbols:

62—St. Clair soils
6B—Morley soils
6A—Miami 6A soils
60—Miami 60 soils
67s—"shallow" Russell soils
67—"deep" Russell soils
75—Cincinnati soils

Five different "late" Wisconsin tills are recognized in western Ohio, associated with five major soil associations. Because these soils occur in irregular east-west belts generally parallel to end moraines, as shown in figure 1, the tills with which they are related are believed to represent the sequence of deposits left by the "late" Wisconsin glacier during its retreat. Analysis of the differences between these soils, and the possible origins ascribable to these differences, has been most useful in the interpretation of the glacial history of western Ohio.

Acknowledgement must be made at this point to the many soil scientists of Ohio who, by mapping and analyzing these soils in detail, have provided both the data necessary for, and stimulating discussion contributing to, the development of this interpretation. In addition, I would like to acknowledge my great appreciation to Dr. Larry Wilding of the Agronomy Department of The Ohio State University, Mr. Richard Jones of the Ohio Division of Lands and Soil, Dr. Richard P. Goldthwait of the Geology Department of The Ohio State University, and Mr. John Burke of the Ohio Division of Geological Survey for their helpful reviews of the manuscript.

The five major soil associations developed in the "late" Wisconsin tills of western Ohio are distinguished from each other on the basis of many characteristics. Critical among these from the point of view of the geologist are: (1) the presence or absence of a silt (loess) cap, (2) the depth of the soil profile, (3) the amount of clay in the B horizon (subsoil, or zone of maximum clay accumulation), and (4) the amount of clay in the parent till (C horizon). Many important characteristics considered diagnostic by soils mappers are not included in this list because they are not easily recognized by geologists and do not contribute to the geological story interpreted from the soils. These few characteristics for the five major soil associations are summarized in table 1, those diagnostic for any single soil being printed in boldface. Also included in this table are data for a deeper soil, the "deep" Russell soil, developed in till of "early" Wisconsin age (which will be discussed below) and, for comparison, an Illinoian soil, the Cincinnati.

According to soils scientists, there are five factors which control the nature of any soil. These are: (1) parent material, (2) topography, (3) organisms, (4) climate, and (5) time. Of these, only two are critical in the interpretation of the differences in the Wisconsin-age till soils of western Ohio. The effects of organisms (i.e., plants and burrowing animals, from woodchucks down to microscopic crustacea), though unquestionably important in the development of a soil, are not believed to contribute to the diagnostic differences separating the soils listed in table 1. Climate, also, though it is important and has varied in the past, has probably not differed within the small area involved at any one time; hence, it is believed to have been unimportant in the evolution of the differences observed in these soils. In addition, by dealing not with individual soils, but with major soil associations, the factor of topography is voided as a reason for the observed differences. Thus, the only factors which can be considered responsible for the differences observed in the till soils of western Ohio are the remaining two: differences in the composition (factor 1) or in the age (factor 5) of the tills. It is possible to make a fairly reasonable guess, in each case, as to which of these is the controlling factor and from this to be able to interpret something about the glacial history of western Ohio.

The distinctive characteristic of both the Morley and St. Clair soils is the high percentage of clay in the C horizon. All other tills in the chart have a distinctly smaller amount of clay. The reason for this high percentage of clay was long theorized to be the result of a history of ice retreat, with subsequent formation of an ice-front lake in which lake clays accumulated, followed by readvance of the ice, which picked up some of the newly deposited clays and incorporated them into the till that it subsequently deposited. Later, in a graduate study dealing with the characteristics of the tills of central Ohio, Wenner (Wenner,

1959; Wenner, Holowaychuk, and Schafer, 1961) showed that the calcium-magnesium ratio, which is suspected to be higher for lake clays, was markedly higher for tills in which the Morley soils were formed (2.3–3.3) than it was for all the other more southern, less clayey tills (1.3–1.8). Other evidence supporting this inferred history is the extensive occurrence, in Seneca County, of buried lake clays, whose cover of till proves that a readvance of the ice must have followed a period of lake clay accumulation. Morley and St. Clair soils differ from each other in the relatively higher clay content present in the C horizon of the latter.

TABLE 1

Chart presenting significant characteristics of major till soil associations in western Ohio

Soil		Soil Characteristics					Distribution	
Name	Mapping symbol	Thickness of silt cap	Depth of leaching (at well-drained site), inches	Clay content of B horizon, %	Clay content of C horizon, %	Ratio of clay in B / clay in C	Boundary to south	Boundary to north
St. Clair*	62	gen. absent	23–30	45–52	**38–46**	1.2	gen. near glacial Maumee beachline	at change to lake bottom sediments
Morley**	6B	gen. absent	20–36	40–55	**21–41**	1.5	Union City (Bloomer)-Powell Moraines	gen. near glacial lake Maumee beachline
Miami**	6A	gen. absent	16–30	40–50	15–27	**2.2**	Farmersville-Reesville Moraines	Union City (Bloomer)-Powell Moraines
Miami***	60	**<18**	20–40	33–40	15–27	**1.8**	Camden-Cuba Moraines	Farmersville-Reesville Moraines
"Shallow" Russell***	67s	**>18**	**35–60**	33–40	15–27	1.7	Hartwell-Cuba Moraines	Camden-Cuba Moraines
"Deep" Russell***	67	**>18**	**60–84**	33–40	15–27	1.7	Wisconsin boundary	Hartwell-Cuba Moraines
Cincinnati***	75	**1–5ft**	**100–120**	33–40	15–27	1.7	Illinoian boundary	Wisconsin boundary

*Numerical data provided by Richard B. Jones, Division of Lands and Soil, Ohio Department of Natural Resources.
**Numerical data provided by Dr. Larry Wilding, Department of Agronomy, The Ohio State University.
***Numerical data drawn in large part from material made available by Dr. George Schafer, U. S. Soil Conservation Service, and Dr. Nicholas Holowaychuk, Department of Agronomy, The Ohio State University.

Thus, the differences between the Morley and St. Clair soils, and between the Morley and Miami 6A soils, are not a result of significant differences in age, but are related to differences in composition (clay content, specifically) of the tills in which the soils were formed.

Miami 6A soils do not have such high percentages of clay in the C horizon (till) as do the soils to the north, but the amount of clay in the B horizon is unusually large; for some reason, Miami 6A soils exhibit considerably greater clay contents in the B horizon, as compared to that in the C horizon, than do any of the other soils discussed in this paper, as illustrated by the ratios in column 5 of table 1. Why this is true is not known, but the lack of major differences in depth of soil profile and intensity of weathering suggest that the Miami 6A and Morley soils do not differ particularly in age, the characteristics which distinguish these soils being a result of the different compositions of the tills.

Miami 60 soils differ from the Miami 6A soils (table 1) in being deeper and in having a lower percentage of clay in the B horizon. In addition, they have a more weathered appearance (related to modification of the original till-like appearance by somewhat increased porosity, clay flows on the ped or soil lump surfaces, and somewhat brighter oxidized colors). Unlike the soils to the north, already discussed, Miami 60 soils are also characterized by a zone below the typical B horizon which lacks the intensity of structural development and weathering of the typical B, though it is still leached, and which is called the C_1 horizon by some and the B_3 or B_{23} by others. (Such an horizon is also present, and usually somewhat thicker, in the soils occurring farther to the south, the two Russell soils and the Cincinnati soil.) The line separating the Miami 6A and Miami 60 soils generally follows an end moraine (Farmersville Moraine to the west, Reesville to the east), which suggests that the differences between the Miami 6A and the Miami 60 soils record, in part, a small age difference. That this age difference is not of major (stadial) proportions is clear for two reasons: (1) the differences in the soil characteristics indicated above, though clearly developed, are not excessive, and (2) radiocarbon dates (Forsyth, 1961a; Goldthwait, 1958) show that the last glacier, the "late" Wisconsin, reached its maximum position near Chillicothe and Cincinnati about 18,000 years ago and yet was entirely out of Ohio by about 14,000 years ago. During this brief time of 4,000 years, the entire story of the "late" Wisconsin glacial retreat, including the formation of all the major Ohio end moraines, must have taken place, so that no great length of time was available for the interval between the deposition of the till characterized by the Miami 60 soils and the till in which the Miami 6A soils were developed. The lack, in the Miami 60 soils, of a clay increase commensurate with that in the Miami 6A (see column 5 in table 1) indicates that there is also a significant difference in the composition of the tills. Thus, considering both their distribution and the nature of their associated soils, these two tills are believed to be distinguished on the basis of moderate differences in both composition and age.

Recent field and laboratory studies by soils scientists suggest that the differences between the Miami 6A and Miami 60 soils are not in all places clear-cut. The problems they encounter, however, seem to me to be best interpreted as the effects of local compositional variations in the tills superimposed on the characteristic differences due to the variations in overall composition and age discussed above.

The Russell soils are characterized specifically by a silt (loess) cap greater than 18 inches thick; Miami 60 soils may also have a silt cap, but it is never this thick. The "shallow" Russell soils and the Miami 60 soils generally occur associated together in a complex distribution, the identification of the soil in any one site depending only on the thickness of the surface silt. In such areas, it is apparent that the underlying till is the same unit; only the thickness of the capping silt varies. Thus, no difference whatsoever exists between their ages.

To the west, in Preble, Butler, Montgomery, and Warren counties, some recognize a line called the "Silt Line" (Forsyth, 1961b), which separates areas dominated by "shallow" Russell to the south from areas characterized by a higher percentage of Miami 60 soils to the north. In addition, in Indiana, silts containing identical gastropods have been recognized both to the south at the surface, where "shallow" Russell soils are more common than Miami 60, and beneath a younger till to the north, where Miami 60 soils dominate. This would indicate that there must be a slight difference in age between the till with the Miami 60-"shallow" Russell soils to the south and the till with the same soils to the north. Though both Miami 60 soils and "shallow" Russell soils occur on both sides of this line, the "shallow" Russell soils are more common to the south, suggesting a significantly greater amount of loess deposition at the earlier time. These areal distributions are distinct from the general tendency for deeper soils to be present wherever

the surface silt is thicker, an observation also reported by Gooding (1963: 678). To the east, in the Scioto lobe, this distinction is not apparent; it is possible that this "silt line" may be present, but it has not yet been recognized.

The overall separation of the Miami 60 and "shallow" Russell soils is clearly on the basis of the nature of the parent material—of the presence or absence of a thick silt cap—and not on the basis of age.

The "deep" Russell soil is another story. It differs from the shallow Russell soil mainly in degree, being markedly deeper and appearing considerably more weathered. From this, it is believed that the significant differences between these two tills are quite clearly related to age. Because "deep" Russell soils are restricted in occurrence, being recognized only in a very narrow belt along the Wisconsin boundary in Highland and western Ross counties, their interpretation has been a problem. However, older Wisconsin drift recognized below buried soils elsewhere in the state (La Rocque and Forsyth, 1957; Forsyth and La Rocque, 1956; Forsyth, 1957; Forsyth, 1958) and terraces along the Hocking River valley with both elevations and soils intermediate in character between those of typical Wisconsin and typical Illinoian terraces (Kempton and Goldthwait, 1959), both interpreted to be of "early" Wisconsin age by Goldthwait and Forsyth (Kempton and Goldthwait, 1959; Forsyth, 1957), suggest a similar interpretation here. "Deep" Russell soils, therefore, are believed to identify the area where "early" Wisconsin till occurs at the surface. The intensity of development in this "early" Wisconsin soil here and also in the buried sites suggests that the time of the late Altonian ice advance of the Wisconsin stage in Illinois and Wisconsin, about 31,000 years ago (Frey and Willman, 1960) was entirely occupied in Ohio by soil formation, developed in what Frye and Willman would call early Altonian and what we have called "early" Wisconsin till. Thus, differences between the "deep" and "shallow" Russell soil profiles are believed, with little question, to represent a significant difference in age and no appreciable variation in composition.

Throughout the discussion of the Russell soils, parentheses are used for the modifiers "shallow" and "deep" because this distinction is not officially recognized by soils mappers. Individual soils scientists recognize this distinction, and indeed it is they who have contributed the most to its recognition (especially Mike Stout, personal communication), but no formal differentiation of the soils is made, hence the parentheses.

The Illinoian soil, which was included for the sake of comparison, is clearly older than all the other soils shown on the table, including the "deep" Russell soil, on the basis of depth of profile, intensity of weathering, and also other soil characteristics.

The glacial history of Wisconsin time in western Ohio, as interpreted from the soils data, begins with an "early" Wisconsin ice advance, correlated with Frye and Willman's earlier Altonian (Frye and Willman, 1960), Dreimanis' Early Wisconsin till (Dreimanis, 1960b: 113), and possibly White's Millbrook Till (White, 1961). The strong profile differences between the Clermont and "deep" Russell soils represent the effects of the long period of pre-Wisconsin (Sangamon) weathering to which the older soil was subjected. Following this weathering interval, the "early" Wisconsin ice advanced, reaching a position a few miles south of the subsequent "late" Wisconsin boundary in Highland and Ross counties and, elsewhere in Ohio, to a less advanced point not now recognized. The following ice-free interval, though clearly indicated by the soils data, was much more brief than the earlier Sangamon interval, as evidenced by the less pronounced differences between the "deep" Russell and "shallow" Russell profiles.

Though many radiocarbon determinations are available to date the "late" Wisconsin ice advance, there are no finite dates from "early" Wisconsin till in Ohio. One date, on wood from outwash believed to date from the retreat of this glacier (Dr. R. P. Goldthwait, personal communication, 1962), has been received

from Groningen (Dr. J. C. Vogel, personal communication, 1962). This date, 46,600±2000 (GrN–3219), taken together with values that appear to date the same time in Europe and with estimates made by many glacial geologists in America (Dreimanis, 1960b; Frye and Willman, 1960) suggest that the "early" Wisconsin ice was in Ohio about 45 to 70,000 years ago.

The subsequent glacier, the "late" Wisconsin is correlated with the Woodfordian of Illinois (Frye and Willman, 1960), the Catfish Creek and Port Stanley drifts of Ontario (Dreimanis, 1960a), and the Navarre-Kent, Hayesville-Lavery, and Hiram Tills of White (1960; 1961). It advanced southward across western Ohio to a point beyond that reached by the "early" Wisconsin ice in most areas, so that "late" Wisconsin drift generally forms the Wisconsin boundary. Many radiocarbon dates tell clearly when and how fast this glacier advanced into Ohio (Goldthwait, 1958; 1959; Forsyth, 1961a). It appeared near Cleveland about 25,000 years ago, reached its maximum position near Chillicothe and Cincinnati about 18 to 20,000 years ago, and was melted back out of Ohio by 14,000 years ago.

Early in the retreat of this last glacier, there was a significant decrease in the amount of loess being deposited in southwestern Ohio. The reason for this change is not known; perhaps there was a change in the regimen of the meltwater streams whose deposits, when dry, provided a source for the loess, or perhaps later land surfaces lacked the characteristics necessary for loess lodgement.

Later in the retreat of the glacier, a fairly significant readvance occurred, which brought till now characterized by Miami 6A soils south against (and probably over) till associated with Miami 60 soils, thus creating the strongest soils change recognized within the area of "late" Wisconsin till in western Ohio, a line which may turn out to be very useful in future inter-state correlation.

Once the glacial margin had retreated to a point north of the Ohio divide, an ice-front lake was formed, in which fine sediment accumulated. A subsequent minor readvance is then believed to have occurred, interpreted to have resulted in the high clay content of the till deposited next, the till in which the Morley soils were formed. The southern boundary of this clay-rich till has been traced eastward to a point where it meets the southern boundary of White's Hiram Till (White, 1961) as mapped by Totten (1962), so the till characterized by the Morley soils, and presumably also that associated with the St. Clair soils, appears to correlate quite clearly with White's clay-rich, but less limy Hiram till. The ice appears to have made several more very minor, similar readvances in its subsequent retreat out of Ohio.

Thus, it can be seen that soils have been a major tool in the interpretation of the glacial history in western Ohio. Pedologic maps showing distribution of soils become geologic maps of the different tills, which themselves are recognized basically by variations in the characteristics of the soils. And, from an interpretation of these differences, a story has unfolded (following the retreat of the Illinoian glacier and the subsequent very long ice-free Sangamon interval) of: a first major glacial advance (the "early" Wisconsin), a moderately long ice-free period, a second glacial advance ("late" Wisconsin), and a final glacial retreat characterized by several minor readvances, leading to modifications of the tills which, in turn affected the nature of the soils developed in them, and from which we read this history.

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