THE NATURE OF TWO ASSOCIATED WISCONSIN SOILS AS INFLUENCED BY POST-GLACIAL EROSION, TOPOGRAPHY, AND SUBSTRATUM

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The marked differences in profile characteristics and crop relationships between two of the major agricultural soils of north-central Wisconsin, namely, the Marathon (Gloucester, shallow phase)\(^1\) and Spencer (Colby)\(^1\) silt loams, have generally been ascribed to differences in parent material. The previous Marathon has been thought to be almost entirely residual from crystalline, granitic rocks in contrast to the impermeable Spencer which developed on clayey drift of early (pre-Wisconsin age) glaciations. Geologically, the Marathon area has been mapped as a part of the Wisconsin "Driftless" or unglaciated area (1, 3, 4)\(^2\). The following quotations from soil survey reports describe these views: "In the central part of Marathon county there is a considerable area which is usually spoken of as an unglaciated region and in which the soils are largely of residual origin. Over this area, however, it is not uncommon to find a few glacial bowlders, and there is other evidence that this region was influenced to some, though a very slight, extent by glacial action." (2, p. 23) "While a few glacial bowlders are sometimes found, the glacial action over this region was so slight as to have no appreciable influence on the formation of the soil." (5, p. 34)

Detailed soil fertility and drainage investigations of these soils showed that the above explanation of their origin was inadequate in several respects. For instance, on the uplands, numerous areas of Spencer (glaciated) were found to be entirely surrounded by Marathon (unglaciated) soils, and wide variations in illuviation and drainage were found in the areas mapped as Marathon. Since the relations of these two soils were significant

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\(^1\) The names, Marathon and Colby, first used by Weidman in his 1903 report, have been used in state soil survey reports; the corresponding names, Gloucester and Spencer, have been used in U.S. Bureau of Soils reports. The names, Marathon and Spencer, are given preference in this paper because the names Gloucester and Colby are applied to different soils in other states.

\(^2\) Figures in parentheses refer to "Literature Cited", p. 72.
in agricultural and experimental work, a study of their profiles, relative locations, and development was made.

PROCEDURE

Work in a field experiment program made possible a fairly

![Diagram of glacial drift and stream pattern in central Wisconsin.](image)

*Fig. 1. Deposits of glacial drift and general stream pattern in central Wisconsin.*
complete study of an area of about 1000 square miles in central, southwestern, and eastern Marathon and northwestern Wood county (Fig. 1). This area comprises about one-sixth of the total acreage mapped as Spencer and Marathon soils in northern Wood, northeastern Clark, western Marathon, and in Taylor, Price, Rusk, and Barron counties in north-central Wisconsin.

Previous soil surveys by Whitson, et al, (5, 6), and Geib, et al, (2), and Weidman (3), and the geological treatise by Weidman (4), were utilized in detail in the experimental work and soil studies. Numerous observations of the soil profiles and the underlying material were made. Particular attention was paid to the depth of glacial covering, presence or absence of motting in the soil profiles, the amount of illuviation as shown by the depth, cementation, compactness or imperviousness of the B<sub>2</sub> horizon, and the nature and perviousness of the underlying material. The relation of topography and location of streams and drainage channels to the distribution of the soils was studied in the field and on topographical maps made by the United States Geological Survey.

RESULTS

The soils of the region studied, with the exception of 300 square miles of Marathon soils in central and eastern Marathon county, belong to the Spencer series. The Spencer soils consist of the typical or level, and the rolling phase of the Spencer silt loam. The so-called typical silt loam was found to be planosol occurring only on the slopes of less than two per cent.

The A<sub>1</sub> horizon of the level phase Spencer silt loam is a grayish-brown, friable silt loam having a granular structure. The lighter-colored A<sub>2</sub> horizon occurs at a depth of 4 inches and is a friable silt loam with a platy structure. The B<sub>1</sub> begins at about 8 inches, and is strongly mottled, reddish-brown or yellowish-brown silt loam with a distinctly platy structure. A characteristic, whitish-gray, silty deposit of silice is found on the outside of the particles and in the fissures and cracks immediately overlying the heavier B<sub>2</sub>. At approximately 20 inches, this gives way to the dense B<sub>2</sub> which is a more or less mottled, reddish-gray silty clay, very compact, and tightly cemented with sesquioxides. Its structure is somewhat columnar when dry, it has a low water-holding capacity, is seldom penetrated by plant roots, and is very impervious to water as shown by infiltration measurements. The C horizon begins at a depth of 40 or 50 inches and consists of a sticky, impervious gray or red sandy clay locally with gray and yellow motting. Small glacial stones are common throughout the profile, and lenses of sand are locally found in the B<sub>2</sub> and C horizons. The underlying till varies in depth from six to one hundred feet.
The rolling phase of the Spencer silt loam was found on rolling land whose average slope was 4 or 5 per cent. Its profile differs from the level Spencer silt loam in that it has a less mottled B₁ and B₂, a more reddish color of the B₂ horizon, and a slightly less illuviated and cemented B₂ horizon.

The parent material of the Spencer soils was found in all instances to be a sandy and clayey till which, according to Weidman (4), was deposited by at least three early, pre-Wisconsin glaciations. Other workers have considered this drift to be deposited by only one glaciation, probably of Illinoian age (1). In any case, it is a rather smooth drift and is now considered to be of much later origin than previously thought. The term “pre-moraine” instead of “pre-Wisconsin” has been suggested for it by Professor F. T. Thwaites. At present the depth of the non-calcareous zone in the drift varies from 3 to 20 or more feet. The depth of the till with which the level Spencer silt loam is associated, was found to vary from 6 to 100 feet, while that of the rolling phase often was much shallower, the minimum depth being around 3 feet. Underlying the till are large areas of coarse and fine-grained granites, and Cambrian sandstone which, regardless of their porosity, apparently exert no influence upon the nature of the overlying till and soil.

The level Spencer silt loam was found to be limited to uplands that have not been encroached upon by active drainage systems (Fig. 1). Hilly moraines, kettle holes, kames, eskers, and other glacial surface features are lacking on these uplands at present. The rolling phase was found on areas nearer to the deep drainage systems which are now actively dissecting the area (Fig. 2).

The profile of the Marathon soils differs distinctly from that of the adjacent Spencer soils, particularly in the lack of mottling, and the presence of a more shallow, less strongly cemented, and more pervious B₂ horizon in the Marathon. However, the Marathon silt loam as mapped in reconnaissance surveys is quite variable, ranging from a heavily illuviated soil, having a solum 2 to 2½ feet in depth with a heavy B₂ horizon, to one having a youthful profile with no B₂ horizon. Rounded glacial stones were found intermixed throughout the solums of all profiles studied. The B₂ horizons were found to be underlain for the most part by a decomposed, coarse-grained granitic bedrock, which had been considered to be similar to the parent material of the soil itself. This granite weathers very easily into a granular, porous mass
which grades slowly into a less decomposed, less porous material, and finally into solid, unweathered rock at a depth of ten or fifteen feet. Infiltration measurements showed that the weathered granite is extremely pervious to water movement.

The location of the Marathon soils, the amount of illuviation as shown by the depth, compactness, and cementation of the B$_2$ horizon, and the depth of the solum with its glacial stones were found to vary according to the proximity of the soil to the numerous streams which dissect central Marathon county.

The Wisconsin river flows in a southerly direction through the
Marathon area (Fig. 2). A number of tributaries, the Pine, Trapp, Big and Little Eau Claire rivers flow into the Wisconsin from the southeast. Tributaries from the southwest, the Big Rib, Little Rib, and Big and Little Eau Pleine rivers, further dissect the area. The valleys cut by all of these streams in pre-glacial times apparently were not greatly altered by glaciation. This region is notable, along the upper Wisconsin river, for the number of deep-channeled streams per unit area. On the steeper slopes close to these streams, the youthful Marathon soils having a solum of about one foot in depth were found. On the gentle slopes more distant from the streams, the soil had a heavy, deep B horizon, which increased in depth with distance from the stream, until the Marathon soil graded into soils of the Spencer series (Fig. 2).

On undissected uplands between the streams and within the borders of the Marathon soil area, isolated local areas of both the level and rolling phases of the Spencer silt loam were found, for the most part, surrounded by soils of the Marathon series (Fig. 2). In some instances, a regular succession of soils was found; the level, mottled Spencer silt loam on the flat upland; the rolling phase Spencer on the more rolling slopes; the non-mottled Marathon soil with a heavy, deep B horizon on steeper, more dissected areas; and, finally, on the valley sides near the stream, the more youthful and less illuviated form of the Marathon.

Small areas of Marathon gravelly silt loam were found upon hummocky, much dissected, granite hills located at points where two drainage systems are at present intersecting. This soil, devoid of glacial stones, consists of a brown or dark-brown silt loam, six to ten inches in depth overlying granite. The granite, to a depth of six or eight feet, has decomposed into a coarse-grained, loose mass of angular fragments of about one-half inch in diameter.

DISCUSSION

The prevalence of a wide variety of glacial stones over the whole of the Marathon and Spencer area points to the conclusion that glaciation and deposition of drift occurred over the entire area. The part occupied chiefly by the Marathon soils was formerly included in the “Driftless Area,” but glacial stones found high on the monadnock quartzite hills of the region show that the ice was once quite deep over much of the area. The presence of a pre-glacial granitic peneplain is suggested by level uplands of uniform
height. This pre-glacial peneplain was probably dissected by pre-glacial streams and drainage ways, forming a topography somewhat similar to that now existing. Apparently the glacial till was then deposited more or less uniformly over the area but the greater fall to the level of the streams in the Marathon area caused post-glacial erosion to proceed more rapidly there than in the Spencer area. The depth of till was never great enough to cause the streams to be diverted for any appreciable period from their pre-glacial drainage ways.

The depth of drift remaining in the Marathon area varies considerably. With the exception of glacial outwash, only a thin mantle of glacial material is present near the Wisconsin River or its deep channeled tributaries. In some places, this glacial covering has been entirely removed by post-glacial erosion. Farther back from the stream channels or toward their heads, erosion has been less active and glaciated material over two and one-half feet in depth is found. The uplands not encroached upon by drainage systems, have lost much less of their original drift deposits and are still covered with relatively deep glacial drift. It is also highly probable that the original deposit of till was thinner over some local areas and on the slopes to the pre-glacial drainage-ways.

The poorly-drained Spencer silt loam appears to be limited to the uplands with their deeper drift covering. Because of the lack of erosion, the topography has remained level and the surface runoff is greatly reduced. The lack of soil removal and the increase in percolating water have led, in such locations, to the formation of a planosol with a cemented, deep, and impervious B₃ horizon. This horizon, and the clayey underlying till, have inhibited water movement to the extent that a highly mottled, poorly-aerated soil has resulted. The combination of insufficient surface with poor internal drainage has greatly lowered the agricultural value of this soil.

The rolling phase of the Spencer silt loam occurs where the smaller tributaries of the Wisconsin River are cutting back into the regions of deeper till (Fig. 2). The B₃ horizon appears to be sufficiently impervious, and the underlying clayey till of ample depth to seriously impede the internal drainage of the soil. Under these conditions, mottling is still a dominant feature, although it is somewhat less pronounced than in the level Spencer. As a consequence of the rolling nature of the topography, excellent
surface drainage has resulted, and these soils are therefore more desirable for farming than the level Spencer soils.

The Marathon silt loam, for the most part, is limited to areas in close proximity to well-developed drainage systems (Fig. 1). Here, the erosion has been rapid and the glacial mantle exists at depths of two and one-half feet or less. Because of the increased rate of post-glacial erosion and the porous nature of the underlying granite, profile development has been slow and the B₂ is either quite friable or non-existent. As a consequence of the permeable subsoil and the porous underlying granite, the internal drainage is excellent, and mottling is entirely absent. With an increase in the steepness of the slopes there is a corresponding decrease in the thickness of the glacial mantle, and more youthful, less-illuviated soil profiles result. This is strikingly demonstrated by the absence of B₂ horizons in the soils of the steeper slopes close to the deep drainage systems.

The borders between the more mature phases of non-mottled Marathon silt loam and the mottled, rolling phase, Spencer silt loam are in most places sharp and well defined. The depth of glaciated material seems to be the dominant factor in determining the type of soil. Evidently, where the glaciated material is deeper than two and one-half feet, it impedes the drainage sufficiently to result in the formation of the mottled, rolling phase, Spencer silt loam.

The Marathon gravelly silt loam shows the least profile development of all the soils of the area. This type occurs on tracts devoid of glacial material and is found only between two active drainage systems which are cutting down the divide between them (Fig. 1). This would indicate that post-glacial erosion has been largely responsible for the lack of drift. The water-retaining power of the soil mantle and the underlying decomposed granite is extremely low and is a limiting factor in crop production.

Eventually, as the drainage systems deepen and erosion progresses, the soils will undergo a cycle of successive changes. As the regions of deeper till are eroded, the level Spencer silt loam will pass into the rolling phase of the Spencer silt loam. When the glacial material has been reduced to a depth of about two and one-half feet, at which point the underlying porous material, where present, appears to exert its favorable influence on water movement, the non-mottled, more-illuviated phases of the Marathon silt loam will supersede the rolling phase of the Spencer
silt loam. As geologic time progresses, more and more till will be removed and the less-illuviated phases of the Marathon silt loam will form. Finally, as the drainage systems intersect, the last traces of glacial material will be removed and the very immature, drouthy Marathon gravelly silt loam will be formed. The areas farthest and most protected from the deep drainage systems will retain their glacial covering longest.

SUMMARY

The results of a field study of the influence of post-glacial erosion, topography, and substratum upon the formation and character of the Spencer (Colby), and Marathon (Gloucester) soils of central Wisconsin is presented. The region occupied by these soils, including a portion previously thought to be a part of the Wisconsin "Driftless Area," apparently was entirely covered by a clayey till laid down by an early pre-moraine ice invasion. Differential post-glacial erosion, varying with the proximity of the drift to deep-channeled pre-glacial drainage systems, has since occurred, which, coupled with the original depth of drift, is closely related to the distribution of present-day soils. Where post-glacial erosion has been slight, and relatively deep drift is found, the poorly-drained, mottled level phase Spencer is found; where the topography is rolling and post-glacial erosion has been more active, the more shallow rolling phase Spencer occurs. Where the present glacial covering is so thin that the underlying, porous, decomposed granite is within 30 inches of the surface, the entirely different, well-drained, non-mottled Marathon occurs. Where all the till has been removed the drouthy Marathon gravelly silt loam is formed.

As the drainage systems deepen and erosion progresses, the soils in this area appear to pass, in regular succession, from the Spencer, level phase, through the rolling phase, to the Marathon silt loam and finally to the Marathon gravelly silt loam. This relation of a number of soils ranging from a strongly-illuviated planosol to a rather coarse, steep, and drouthy soil is the key to soil formation in the area studied and to the distribution of soils with regard to topography, altitude, and location of streams.

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LITERATURE CITED


