Proceedings of the Iowa Academy of Science

Volume 58 | Annual Issue | Article 35

1951

Use of the Morphology of Buried Soil Profiles in the Pleistocene of Iowa

W. H. Scholtes
Iowa State College

R. V. Ruhe
Iowa State College

F.F. Riecken
Iowa State College

Use of the Morphology of Buried Soil Profiles in the Pleistocene of Iowa[1]

By W. H. Scholtes, R. V. Ruhe, and F. F. Riecken[2]

Previous Studies of Buried Soils

Buried profiles of weathering have been recognized and utilized by many geologists in the determination and classification of Pleistocene deposits (1)* (2) (10) (20). In Iowa, Kay (5) used the term gumbotil for super drift clays. The gumbotil was found on tabular divides and other remnants of the Kansan drift plain, and was considered to be the result of weathering of glacial drift (8). Kay and Apfel (7) recognized gumbotil as a weathered product, but as something distinct from soil. For example, the Aftonian interglacial stage was stated by them as being represented in Iowa by "wide-spread Nebraskan gumbotil, peat, mucks, old soils, weathered sands and gravels." In Illinois, Leighton and MacClintock (9) also identified buried profiles of weathering in stratigraphic sections. Ruhe (12) recognized variations in texture of weathered tills in Shelby County, Iowa, which were a reflection of drainage conditions due to differences in topography.

Simonson (14) studied some buried soils formed from till in Iowa and concluded that the light colored band in the upper portion of exposures of the Kansan till which underlie the Peorian loess deposits in southern Iowa was the A_2 horizon of a buried soil profile. This light colored band was considered by Kay (6) to be "loess-like clay" which rested upon gumbotil.

From the time of the Nebraskan glacier in Iowa to the latest stage of the Wisconsin glacier, successively younger material has been deposited upon the soils which existed prior to each specific period of accumulation. In some cases the soils buried were formed from glacial till, whereas other soils buried were formed from loess.

If it were possible in some locality in Iowa to find a composite stratigraphic column of loess and drift deposits, providing conditions for its formation and preservation were favorable, theoretically a soil should be found on the surface of each deposit.

[1]Journal paper J-1944 of the Iowa Agricultural Experiment Station, Ames, Iowa. Project 1152.
[2]Assistant Professor of Soils, Assistant Professor of Geology and Professor of Soils, respectively.
*Figures in parenthesis refer to Literature Cited, P. 13.

Concept of Soil

A definition of soil accepted by many soil scientists is that given in the 1938 Agricultural Yearbook (19), namely "soil is the natural medium for the growth of land plants on the surface of the earth." in other words it is that part of the earth's surface in which plants grow or are capable of growing. Another definition, given by Jenny (4), is that "soils are those portions of the solid crust of the earth, the properties of which vary with soil forming factors." It is obvious that because great variations are found in soils, it is very difficult to define soil in other than general terms.

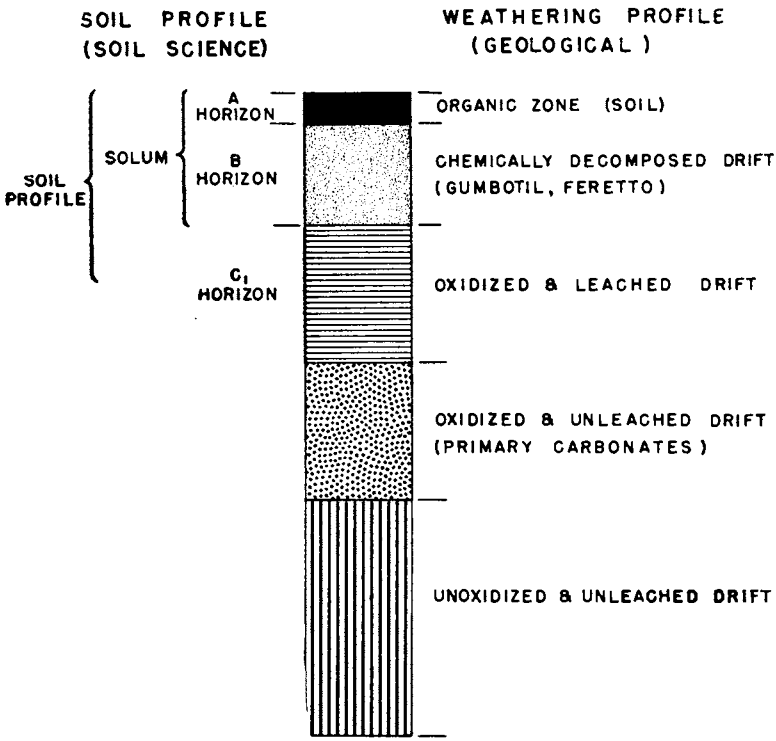

Figure 1. A vertical section of till material with a modal soil at the surface, illustrating the contrasting concepts of the soil profile and weathering profile.

Figure 1 illustrates a hypothetical section of glacial drift with a well developed soil profile formed in the upper portion. The A horizon in soil terminology usually represents the zone of organic accumulation and clay depletion. To the geologist, the dark colored A horizon is the soil, per se, or the surficial soil. The zone of clay accumulation in the profile of weathering is usually called the B horizon by the soil scientist. This highly weathered zone has been recognized by some geologists (7) (9) and designated as gumbotil, mesotil, feretto zone, etc., depending upon the characteristics of the material in question. Zones designated as gumbotil by geologists are usually called the B horizon of a soil formed from glacial till under poor drainage and aeration conditions. Planosol soils (11) which occupy extensive areas in southern Iowa are examples of modern soils with fine textured, gray colored B horizons, which have many characteristics of the buried gambotil. However, the gumbotil is much thicker, often 10 feet or more, than the B horizon of a modern Planosol which is usually about 2 to 3 feet thick. Therefore, the problem of how these great thicknesses of B horizons of buried soils, or gumbotil, were attained need further study.

The soil scientist designates the material from which the soil developed as the soil parent material or C horizon. The C horizon material may therefore be the "leached and oxidized" material of the weathering profile of the geologist, or in some instances where leaching is not greatly advanced the C material may be calcareous but oxidized, and in yet other instances the C material may be unleached and unoxidized. This is not to say though that the soil scientist is not interested in the weathering profile at times. For example, both Smith (15) and Hutton (3) in studying possible relationship between loess distribution pattern and soil profile properties examined loess at depths of 10 to 30 feet. Although the main horizons of the soil profile may be encountered within the first foot or so in some profiles, the soil profile from an agricultural point of view is often studied to as deep as four to eight feet.

Morphology of Buried Soils

The designation of a "soil" as Aftonian or Loveland refers to all the soils developed during that particular interval of weathering. But during any one weathering interval the soils formed at the surface may vary widely according to concepts of soils as defined by soils scientists.

Most of the buried soils which have been examined in some detail are those which have weathered sufficiently to produce a profile with strongly differentiated horizons. However, on some deposits the time interval before its subsequent burial may have been so short that only initial stages of weathering took place, such as oxidation of soil parent material.

What the characteristics of buried soils might be if a portion of our present landscape in southwest Iowa were to be covered in a

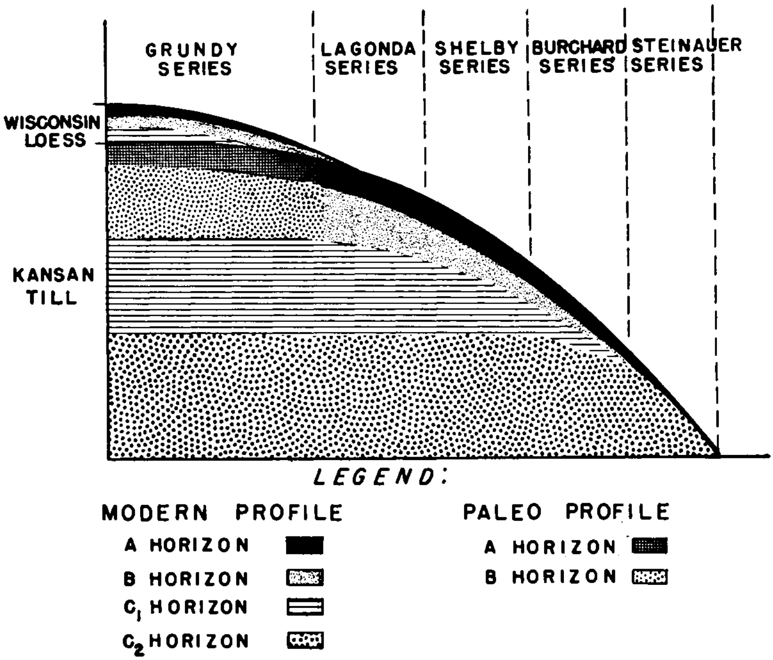

Figure 2. The relationship of stage of development of soils to a geochronosequence in southern Iowa.

short period of time by a considerable accumulation of loess can be illustrated by data from a recent highly detailed soil survey of the Beaconsfield Experimental Farm in Ringgold County, Iowa. Figure 2 illustrates the occurence of soils in a geochrono-sequence on the Beaconfield Experimental Farm. In the Burchard soil the B horizon would consist of only slightly weathered Kansan till, but the Steinauer soil would have no B horizon, as the unleached till lies immediately below the A horizon. The Shelby soil has a more strongly developed B horizon than the Burchard and Steinauer soils, and the Lagonda soil in turn has more strongly developed B horizon than the Shelby soil. The soil forming conditions at the particular place where each soil developed were not the same, hence the soils differ. Were these soils to be buried, they would vary from highly weathered soils to slightly weathered soils.

Figure 3 (11), illustrating a major soil association in central Iowa, shows a topo-sequence and a bio-sequence of soils. In a topo-sequence, or catena of soils, all soil forming factors are similar with the exception of the slope on which they occur. The Clarion catena includes soils of the Glencoe, Webster, Nicollet, Clarion, and Storden series. In a bio-sequence of soils, vegetation is the variable in soil

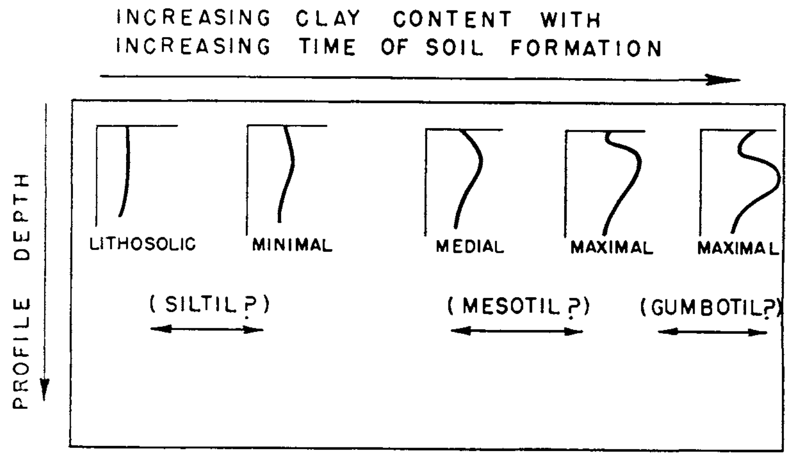

Figure 3. Soil characteristics as influenced by position in a toposequence.

formation, and Clarion-Hayden soils are members of a bio-sequence. As with a geo-chronosequence, soils occurring in a topo or bio-sequence differ considerably in their morphology and their physical and chemical properties. Soils of a topo-sequence which were buried by a younger deposit would vary considerably from each other, depending upon the slope on which they developed.

If one were to compare profile development of buried soils on one deposit versus another deposit, in attempting to evaluate the stratigraphic interval of weathering, soil must be compared in each case with soils that have developed under similar conditions. As it would be almost impossible to be sure that given conditions were the same for buried soils on different deposits, caution should be exercised in using buried soils in regional studies of weathering. Therefore, if the stage of development of a soil profile is to be utilized in regional correlations of stratigraphic horizons as advocated by Richmond (10), the soil on each buried surface must of necessity be closely examined and evaluated in respect to the soil forming factors. As mentioned previously, the buried surface of the oldest deposit may possibly contain soils which are comparable to those which occur on our youngest deposits as well as soils which have strongly differentiated horizons.

Factors of Soil Formation

As soil properties are a function of climate, vegetation, time, parent material and topography differences in any of these soil forming factors is reflected in the kind of soil formed. The morphology of any one soil is a record, in a sense, of the environmental conditions which were operative in its development. Therefore, from the morphology of buried soils it is possible to make certain inferences pertaining to conditions which were factors in their formation.

The general type of vegetation, that is trees or grass, under which a soil develops is usually evidenced in the morphology of the soil by color of the surface layers. In Iowa the forest-derived soils have lighter colored surface horizons than grass-derived soils if they have developed from parent materials of similar age. However, some soils, as the Planosols, which form under either grass or trees have quite light colored surface layers. In these instances, it is not easy to establish by surface color alone whether the soil developed under grass or trees. Soils such as the Wiesenboden soils have thick, black surface layers and develop under grass vegetation on flats with poor drainage conditions. Thus Planosols, Brunigra and Wiesenboden soils may develop under grass vegetation, but only the latter two groups of soils have dark colored surface layers. Likewise, Planosols and Gray Brown Podzolic soils have light colored surface layers, but it would not be possible to infer from surface color alone that they had developed under forest vegetation. Therefore, inference about the soil forming factors from soil morphology must result from careful examination of the characteristics of both the B horizon and surface layers.

Drainage conditions under which soils form also affect the morphology. Wiesenboden soils, for example are developed under conditions of poor drainage and aeration, and the B horizons usually have gray colors indicating reduction of iron has occurred. Where drainage is intermittently poor and good, iron and manganese concretions and mottlings occur. In most Brunigra soils, drainage conditions are usually good with brownish colors in the B horizons. Where, however, soil development has resulted in the formation of clay in the B horizon, as in some maximal Brunigra soils, restricted water and air movement due to decreased permeability may also cause mottling or incipient gleying in the B horizons. Thus, natural drainage conditions under which the soil developed can be inferred to a considerable extent from the soil morphology.

The morphology of buried soils may also indicate the stage of development attained by members of any one great soil group. For example, the Seymour soil series which occurs in southern Iowa is a soil developed under a grass vegetation from loess parent material. So, too, are the Marshall and Monona soil series which occur in southwestern Iowa. All three series are classified with the Brunigra

(16) Great Soil Group, yet they differ in degree of development due principally to differences in time of weathering (3). Thorp and Smith (17) suggested a subdivision of certain Great Soil Groups. They proposed that soils of a Great Soil Group whose characteristics are weakly developed for the group as a whole be considered "minimal" members of that group. Soils whose characteristics are developed beyond the modal for the group were considered "maximal," and those with intermediate properties were called "medial." On this basis the Seymour soil series would be considered a maximal Brunigra, the Marshall series a medial Brunigra, and the Monona series a minimal Brunigra.

Figure 4 illustrates the relationship between degree of development of soil profiles, and increasing time of soil formation, with all other soil forming factors remaining essentially unchanged. This relationship has been illustrated by Smith (15), Ulrich (18), Hutton (3) and in opinion of the authors is quite consistent also with the observations by Kay (6) in his evaluation of the relative duration of the weathering of the interglacial ages. If the only variable in soil formation was the factor of time, then the degree of development of the soil profile on any buried surface might be an indication of the length of the weathering interval. It would seem that this situation would need to apply also where Richmond (10) attempted to correlate stratigraphy on the basis of degree of soil development. It seems to the authors that at the present stage of study of buried soils, and because buried soils are variable in morphology, their use in interpreting paleo-ecological conditions and in dating geological strata should be made with considerable caution. However the authors are convinced that an important tool is present in the morphology of the buried soils in possible reconstruction of past geological history including ecological and climatic history, but that much needs to be learned yet regarding their use.

Examples of Buried Soils and Possible Interpretation

In a study of paha (14) several buried soils were observed and their morphology examined. Buried profile #1 occurring in Kansan till beneath several feet of Wisconsin loess had the following morphology:

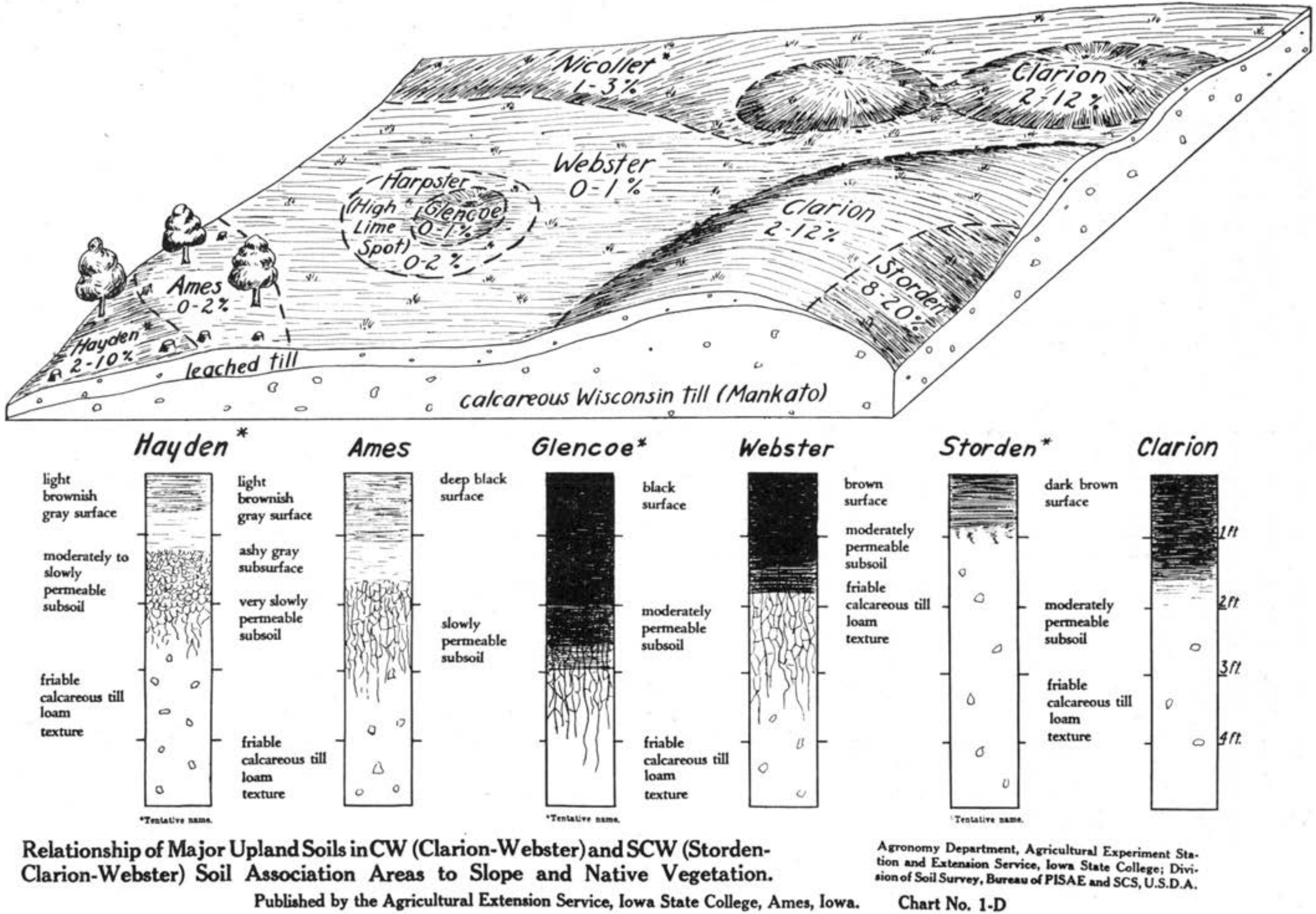

Figure 4. The relationship of increasing clay content with increasing age of the landscape when other soil forming factors remain constant.

(Location: SW¼ Sec. 27, T83N, R3W, Tama County)

Depth (Inches)	Horizon designation	Horizon morphology
0-3	A_1	Pale brown (10YR 6/3 moist)* gritty silt loam; many iron and manganese concretions; weakly developed platy structure.
3-8	A_2	Pale brown (10YR 6/3 moist) silt loam; coarse well developed platy structure.
8-10	B_1	Yellowish brown (10YR 5/4 moist) silt loam; weakly developed sub-angular blocky structure
10-18	B_2	Yellowish brown (10YR 5/4 moist) heavy clay loam; sub-angular blocky to angular blocky structure.
18+	B_3	Yellowish brown (10YR 5/6 moist) clay loam; sub-angular blocky structure.

*Color designations according to Munsell Color Standards.

From the morphology of this buried profile it is classified here with the Gray Brown Podzolic Great Soil Group and is considered to have developed under a forest vegetation. The B horizon is well oxidized and indicates that good drainage existed on the portion of the landscape where this soil developed. The clay accumulation is beyond the modal range for Gray Brown Podzol soils in this area, hence the soil would be designated as a buried maximal Gray Brown Podzol. The B horizon of this soil would be designated as the feretto zone by some geologists.

Buried soil #4 from the study of the paha was located beneath several feet of Wisconsin loess in the upper part of the Kansan till. Following is the morphological description:

(Location SW¼ Sec. T83N, R11W, Benton County)

Depth (Inches)	Horizon designation	Horizon morphology
0-7	A_1	Light yellowish brown (10YR 6/4 moist) gritty silt loam; massive structure; considerable iron staining.
7-12	A_2	Mottled strong brown to light brown (7.5YR 5/6-6/4 moist) silt loam; weakly developed platy structure.
12-20	B_2	Strong brown (7.5YR 5/6) very heavy clay loam; coarse blocky structure.

From its morphology this profile too has been developed under forest vegetation. The B horizon is well oxidized and indicates good drainage, doubtless due to the sloping topography upon which it occurred. The clay accumulation is beyond the modal for forest-derived soils in this area and therefore is classed as maximal in its development. The B horizon of this soil would be designated as the feretto zone by some geologists. From its morphology, principally the strong brown color of the B horizon, it is possible that this profile, is an intergrade between a Gray Brown Podzol and a Red/Yellow Podzol (14). In comparing morphology of these two buried soils to present Gray Brown Podzolic soils in the same area, it seems that the buried soils have weathered either for a longer period of time than present soils, or weathered under somewhat warmer climatological conditions than present soils. It has been observed by one of the writers that the B horizons of buried soils derived from Illinoian till in Southern Indiana also have the strong brown color. It has also been observed by the authors that the B horizon of buried soils formed from Loveland loess in western Iowa has a rather strong brown color. This strong brown color has not been observed by the authors in Gray Brown Podzolic soils formed from Wisconsin loess, and as it is not a characteristic color of the Wisconsin till Loveland loess, or Kansan till in Iowa, it must be due to weathering. This strong brown color is undoubtedly due to the hydrated iron oxide, perhaps goethite. At the present time the reason for the strong brown color of the above mentioned soils is not known; that

Table 1

Summary of the morphology of different great soil groups in Iowa, and the soil forming factors which are responsible.

Great Soil Group	Main Morphological Features	Main Soil Forming Factors
Brunigra soil (minimal)	Dark surface; loamy B horizon.	Grass, good drainage, younger deposits.
Brunigra soils (maximal)	Med. dark surface; clay B horizon. usually with mottling.	Grass, fair drainage, older deposits.
Gray Brown Podzolic Soils (minimal)	Light colored surface; loam B horizon.	Trees, good drainage, younger deposits.
Gray Brown Podzolic Soils (maximal)	Light colored surface; clay B usually, with mottling.	Trees, good drainage, older deposits.
Wiesenboden soils	Black surface; mottled, gray B horizon.	Grass, poor drainage.
Planosol soils	Med. to light colored surface; mottled gray, clay B horizon.	Grass or trees; intermittent poor drainage; usually on older deposits.

is, whether due to time or climate, but solution of the problem of color origin will likely aid in interpreting paleo-ecological and geological conditions.

Summary

Soil, as defined by soil scientists may occur on the surface of buried geological deposits. Buried soils may belong to several different great soil groups, depending upon the conditions under which they were formed. Upon any buried surface, or exposed surface, soils may vary from highly weathered to relatively unweathered profiles; they may have the full sequence of soil horizons if well developed and uneroded, or they may be partially or wholly truncated so that some or most of the soil horizons are missing. Consequently extreme caution should be used in correlating geological horizons on the basis of the magnitude of profile development of buried soils. To correctly evaluate such a correlation, comparable soils on the surfaces of the geological deposits would have to be utilized. However, from the morphology of buried soils it is often possible to infer the flora, environmental conditions, drainage, and weathering interval during the time of soil development.

Literature Cited

1. Frye, J. C. Use of fossil soils in Kansas Pleistocene stratigraphy. Proc. Kansas Acad. Sci. 52:478-482. 1949.
2. Hunt, C. A. and Sokoloff, V. P. Pre-Wisconsin soil in the Rocky Mountain Region. Geol. Survey, Prof. paper 221-6:109-123. 1950.
3. Hutton, C. E. Studies of loess-derived soils in southwestern Iowa. Proc. Soil Sci. Soc. Amer. 12:424-431. 1947.
4. Jenny, H. Factors of soil formation. McGraw-Hill, New York. 1941.
5. Kay, G. F. Gumbotil, a new term in Pleistocene Geology. Sci. 44:637-638. 1916.
6. .... Some features of the Kansan drift in southern Iowa. Bul. Geol. Soc. Amer. 27:115-117. 1916.
7. .... and Apfel, E. T. The Pre-Illinoian Pleistocene geology of Iowa. Iowa Geol. Survey Rpt. 34:1-304. 1928.
8. ....and Pierce, V. N. The origin of gumbotil. Jour. Geol. 28:89-125. 1920.
9. Leighton, M. M. and MacClintock, P. Weathered zones in the drift sheets of Illinois. Jour. Geol. 38:28-53. 1930.
10. Richmond, G. M. Interstadial soils as possible stratigraphic horizons in Wisconsin chronology. Bull. Geol. Soc. Amer. 61:1497. 1950.
11. Riecken, F. F. and Smith, G. D. Principal Upland soils of Iowa. Joint paper. Iowa Agric. Expt. Sta. and U.S.D.A. 1949.
12. Ruhe, R. V. Some notes on the Pleistocene Geology of Shelby County, Iowa. Proc. Ia. Acad. Sci. 55:281-286. 1948.
13. Scholtes, W. H. Properties and classification of the Paha loess-derived soils in northeastern Iowa. Unpub. Ph.D. thesis, Iowa State College. 1951.
14. Simonson, R. W. Studies of buried soils formed from till in Iowa. Proc. Soil Sci. Soc. Amer. 6:373-381. 1941.
15. Smith, G. D. Illinois Loess. Univ. of Ill. Agric. Expt. Sta. Bul. 490. 1942.

16. ...., Allaway, W. H. and Riecken, F. F. Prairie soils of the Upper Mississippi Valley. Advances in Agron. 2:157-205. 1950.

17. Thorp, J. and Smith, G. D. Higher categories of soil classification: Order, Suborder and Great Soil Groups. Soil Sci 67:117-126. 1949.

18. Ulrich, R. Some Physical Changes accompanying Prairie, Wiesenboden, and Planosol soil profile development from Peorian Loess in southwestern Iowa. Proc. Soil. Sci. Amer. 14:287-295. 1950.

19. United States Department of Agriculture. Yearbook of Agriculture, Soils and Men. 1938.

20. Veatch, J. O. Pedalogic evidence of changes of climate in Michigan. Proc. Mich. Acad. Sci. 28:385-391. 1937.