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Genesis and Classification Considerations of Some Prairie-Formed Soil Profiles From Local Alluvium in Adair County, Iowa[1]

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Abstract. Data are presented on three profiles formed under prairie from Late Wisconsin to Recent age local alluvium of moderately fine texture. In the upper 20 inches nitrogen and base saturation values are quite similar to those found for normative upland Brunizems. Below 20 to about 50 inches, nitrogen and base saturation values decrease and increase, respectively, more slowly in the local alluvium-formed soils. It is suggested that the classic ABC soil genesis concept does not apply to the local alluvium-formed soils of this study. Rather, through cumulative effects of new parent material at the surface, this new C was transformed to an A^c horizon (c for cumulative effect), the former A_1 was transformed to a B^c horizon, and the former B became a substratum C^c horizon. Soil genesis effects in such cumulative soil genesis systems need further attention, as these soils comprise about one-fourth of the land area of Iowa, are important agriculturally, and an understanding will further knowledge of other soils of Iowa.

Perhaps as much as one-fourth of the soils of the land area of Iowa is forming from alluvial materials. Most materials are on bottom lands, but considerable local alluvium occurs in smaller drainageways. Examples of such alluvium-formed soils are the Judson and Wabash series, which prior to the past decade were classed with the Alluvial great soil group (Baldwin *et al.,* 1938; Aandahl *et al.,* 1950). However, in recent years such soils have been placed with Brunizem and Wiesenboden great soil groups, respectively (Scholtes *et al.,* 1954). In Monona County, White *et al.* (1959) classified about 18 percent of the county area as Alluvial soils, but this would have been about 60 percent based on the earlier concepts.

In these classification shifts the criteria for upland Brunizems and Wiesenbodens have been used because the norms in soil genesis and classification are strongly upland biased. To a certain extent alluvium-formed soils, as the Judson and Wabash series, have some of the characteristics of upland Brunizems and Wiesenbodens, but in many

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instances there are problems in nomenclature and in genetic concepts. For example, designating the dark upper horizon (by organic matter) of a Tama silt loam (Smith *et al.*, 1950) as an A_1 horizon has genetic implications; the organic matter is assumed to have formed in place, after the parent material was deposited. But in the case of the Judson and Wabash soils, it probably is not correct to infer that all of the organic matter formed in place, as some of it may have been in the alluvium as deposited; at any rate one is less sure that the organic matter in the Judson and Wabash series formed in place than in the case of the Tama series. It may be, however, that the upper dark colored layer has essentially similar morphology in the Tama and in the Judson and Wabash soils; research is needed to clarify this point. Another facet of the problem is whether soil centered criteria should be given unqualified preference over soil-forming factor emphasis in classification of soils.

Genetic horizon designation of subsoil layers is also a problem. If the alluvial parent material has accumulated by surficial accretions during and concurrent with soil formation, then (as philosophically discussed by Nikiforoff, 1949) the subsoil forms in a former A_1 horizon and C material is added at the surface. This is in conflict with genetic concepts of soils like Tama silt loam for which it usually is assumed the A_1 was initially like the lower subsoil material. Further, the B horizon in Tama silt loam usually is assumed to have formed from material like the lower subsoil material, but altered principally by gains of the products of soil-forming processes, either by in-place transformations or by translocations from the A_1 horizon.

Thus, the problems of genesis and classification of many alluvium-formed soils seem to be caused by non-conformance of these soils to the genetic norms for upland soils. It may well be that for alluvium-formed soils, where parent materials are added during and concurrent with soil formation, norms of soil genesis concepts may be quite different than for stable upland sites (Ruhe, 1956). Unfortunately, few data on alluvium-derived soils are available. Further, there is a lack of information on soil-forming factors of these soils to aid in study of sequence relationships among associated alluvium-formed soils.

The present study is an initial effort to take a more detailed look at the morphology and characteristics of some local alluvium-derived profiles, and an attempt to appraise their genesis.

Soils Studied

The area selected for study and the soil profile sampling sites are shown in Figure 1. This area is part of a special soil and geomorphic study in Adair County, Iowa, preliminary results of which have been reported elsewhere (Ruhe, 1956). Position 1 (Figure 1) is a slightly convex Kansan till exposure of 2 to 5 percent slope gradient, where a Shelby-like profile has developed. This position is a small extension of a broader, nearly level summit interfluve. Positions 2, 3, and 4 lie below position 1, in that order. Positions 2 and 3 are a few feet south of the small drainway, indicated on Figure 1, and occur on slightly concave slope of 2 to 4 percent gradient. It is assumed that positions 2 and 3 received materials, much of which originated from the vicinity of position 1. Position 4 is on an alluvial fan; much of its material probably came from an adjacent drainway, rather than from the vicinity of positions 1, 2, and 3.

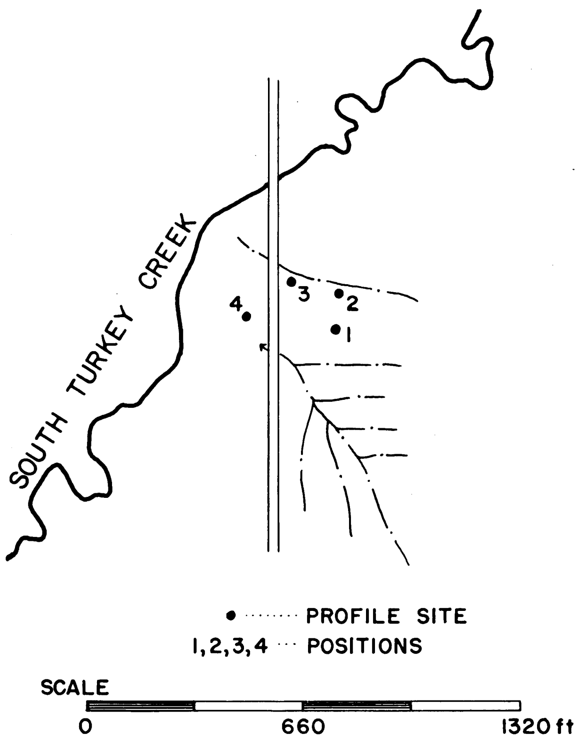

Figure 1. Location of study area and sample sites in relation to South Turkey Creek in Section 18, Township 76 North, Range 31 West, Adair County, Iowa.

Profiles of positions 1, 2, 3, and 4 presumably developed under the influence of prairie. There is no morphological evidence in any part of their profiles indicative of tree influence. Profiles of positions 1 and 2 are classed as well drained, position 3 as imperfectly drained, and position 4 as poorly drained. Time of soil formation is from late Wisconsin to Recent (Ruhe, 1956).

At each of the four positions pits were dug, the soil examined and described in detail, and profile samples collected. Details of soil descriptions and laboratory methods are given elsewhere (Poetsch, 1956).

Nitrogen content. The nitrogen data determined by the standard Kjeldahl method are presented in Figure 2. Included for comparison purposes are total nitrogen values for a Tama silt loam profile, P-27 (Smith *et al.,* 1950). The content and distribution of nitrogen in position 1 profile and that of the Tama profile are essentially duplicates. Both are upland profiles, and usually are considered as norms for well drained Brunizems.

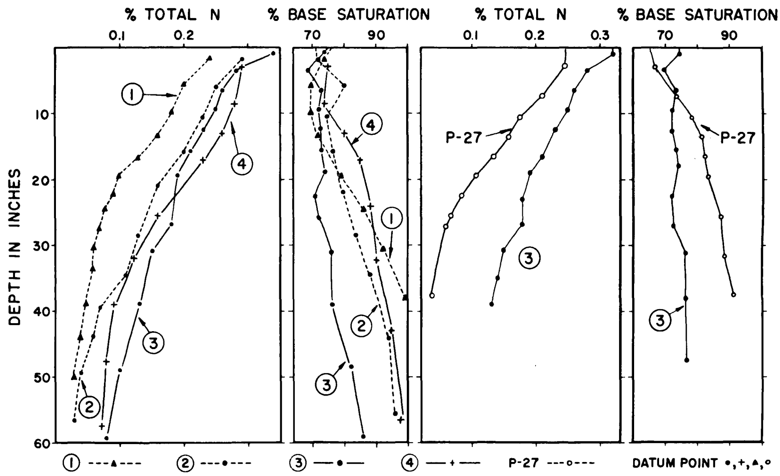

Figure 2. Distribution with depth of total nitrogen and base saturation in profiles of positions 1, 2, 3, and 4, and in a Tama profile, P-27.

Nitrogen values in positions 2, 3, and 4 profiles are slightly higher throughout than in the position 1 profile or in the Tama profile. The gradual decrease of nitrogen content with depth in all profiles is to be noted, though it decreases more slowly in positions 2, 3, and 4 profiles. As the nitrogen is undoubtedly dominantly in organic matter form, the nitrogen values reflect matter content.

By rough computation by measuring to a depth of 50 inches the area between the plotted nitrogen values and the zero percent axis, it is found the soil-forming system(s) that caused the formation of position 2 and 3 profiles resulted in 65 to 85 percent more total nitrogen to a 50-inch depth than did the soil genesis that caused the Tama and position 1 profiles to form.

Base saturation. Base saturation values of the positions 1, 2, 3, and 4 profiles, and the Tama profile are plotted in Figure 2. Base saturation is the ratio of exchangeable bases (principal ones are Ca^{++} and Mg^{++}) to the sum of total exchangeable cations (principal ones are Ca^{++}, Mg^{++}, and H^{+}) and is expressed in percent. The exchangeable H^{+} was determined by the barium acetate method, and exchangeable bases by ammonium acetate leaching (Poetsch, 1956).

Base saturation is quite similar in all profiles in about the upper 20 inches, ranging from about 65 to 75 percent. Base saturation in position 1 and Tama profiles increases gradually with depth, reaching 90 to 100 percent at 40 inches. In position 3 profile base saturation remains at 80 percent or less to 60 inches. This profile is intermediate in natural drainage and thickness of the alluvium to positions 2 and 4 profiles. In positions 2 and 4 profiles base saturation values are slightly higher than in position 1 in the upper 20 inches, but are slightly lower below 20 inches.

Evidently, in positions 2, 3, and 4 profiles, base saturation values are lower to a greater depth than in position 1 and in the Tama profile. The comparison of the Tama and of the position 3 profiles in Figure 2 illustrates this point. If base saturation is used as an index of base leaching, then positions 2, 3, and 4 profiles are slightly more intensely leached of bases to lower depths than the position 1 and the Tama profiles.

Bulk density. Bulk density values are plotted in Figure 3. Bulk density was determined by the core method, and results can be considered as giving grams of oven-dry solid materials per cubic centimeter. The data show position 1 profile has higher bulk density values higher in the profile than other positions. There apparently is some relationship between lower bulk density values and higher nitrogen values.

Particle size data. The greater than 2 millimeter, sand (.062 to 2 millimeter), and less than 2 micron clay particle size data are plotted in Figure 3.

The 2 millimeter (or greater) particles are plotted for only positions 1 and 2 profiles, as positions 3 and 4 profiles have only a few tenths percent of these larger sized particles. In position 2 profile the largest amount is in the 40- to 50-inch depth, which may be a lag gravel or stone-line layer. It is absent in positions 2, 3, and 4 profiles.

The sand-sized particles are present in greater but uniform amounts in the Kansan till-derived profile of position 1 than in the other profiles. Then the amounts of sand decrease progressively, going from position 1 to the position 4 profile. The exception is in the 35- to 60-inch layer in position 2 profile where sand content is highest for any of the profiles.

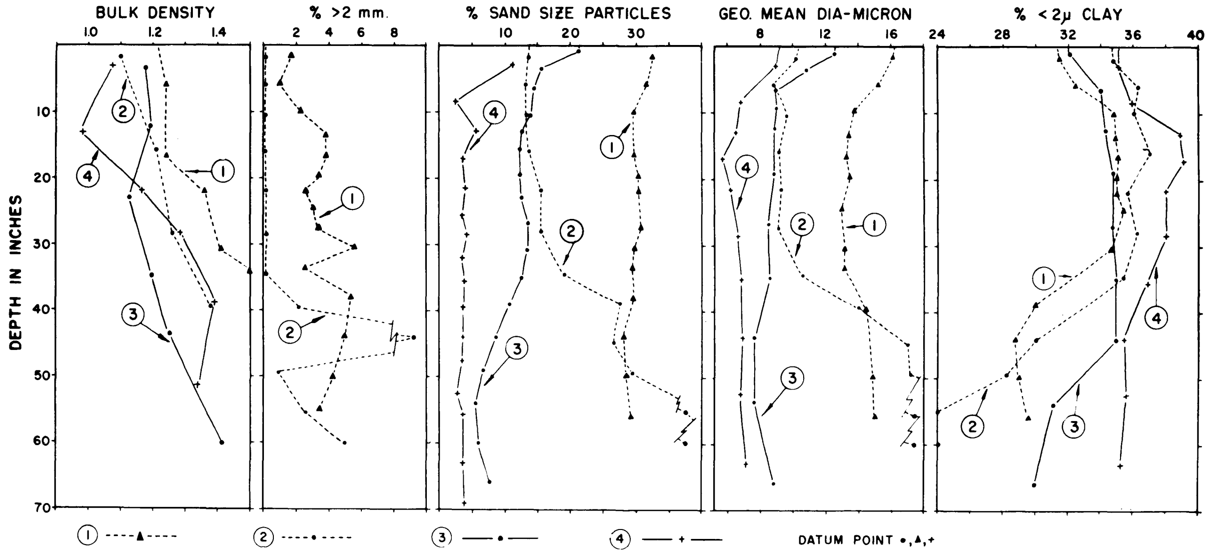

Figure 3. Depth distribution of bulk density, of particle sizes (greater than 2 mm., sand (.062 to 2 mm.), clay (less than 2 microns)), and geometric mean diameter values in profiles of positions 1, 2, 3, and 4.

The geometric mean diameter was calculated following the logarithmic device suggested by Krumbein and Pettijohn (1938), and discussed elsewhere (Poetsch, 1956). The geometric mean diameter data (in microns) show a very striking trend for progressive decrease in values from position 1 to position 4 profiles. The exception is the value for position 2 profile below 35 inches. As pointed out earlier, position 1 profile lies highest on the landscape, and positions 2, 3, and 4 profiles lie successively farther away and downslope from position 1. The particle size data show that in this small side-valley waterway as one proceeds downslope, the alluvium increases in fineness. It is of interest to note that the 2 mm. particles were found only in position 2 profile. To a considerable extent, the profiles studied are members of a parent material or geo sequence.

Comparison to Other Soils

Reference has already been made to the fact that positions 2 and 3 profiles have considerable similarity to the Tama profile (Smith *et al.,* 1950) in regard to profile content and distribution of nitrogen, and in base saturation values. Poetsch (1956) considered that the position 4 profile was quite similar to that of Taintor soil (Simonson *et al.,* 1952), a Wiesenboden. A consistent difference occurs, however, in that the positions 2, 3, and 4 profiles have what might be called thicker profiles.

On the basis of nitrogen and base saturation values, as well as subsoil colors, positions 2 and 3 profiles seemingly should be classified with Tama soils in the Brunizem great soil group (Simonson *et al.,* 1952), but they likely would have been placed with the Alluvial great soil group in 1938 (Baldwin *et al.,* 1938). This shift, it seems, is largely a result of change in emphasis on differentiating criteria with more emphasis on soil centered criteria and less emphasis on soil-forming criteria. By earlier concepts, stating that positions 2 and 3 profiles had formed from alluvium would have been tantamount to classifying them with the Alluvial great group, 1938 concept. Currently, stating that these profiles have thick, dark colored, fine granular structured, slightly acid upper layers more or less automatically qualifies them for consideration as Brunizem or closely related great soil groups.

Some Soil Genesis Aspects

It has been pointed out that in major soil centered criteria the soil profiles of positions 2 and 3 apparently are morphologically very similar to the Tama soils. The paths of formation apparently are somewhat different.

For the Tama profile (Smith *et al.,* 1950), it is considered that the Wisconsin loess parent material was deposited relatively rapidly, and the soil profile developed wholly subsequent to deposition of the loess. The classic "ABC" situation of soil genesis seems to apply (Figure 4). The A_1 formed from material like the C (parent material); moisture and products of soil reaction could move from the A to the B horizon. The B horizon formed from material like the C.

For profiles of positions 2, 3, and 4 the path of soil genesis probably is like that shown schematically for a "cumulative" soil genesis system in Figure 4. If this concept is correct, the classic ABC situation obviously needs modification in such soil genesis situations (Nikiforoff, 1949). The data in Figures 2 and 3 lend support to the view that parent material was being added at the surface. Thus, the present A_1 horizon probably formed in the new surficial C material, and the present B in a former A_1 horizon. The soil system as regards gains of parent material was not static. There are

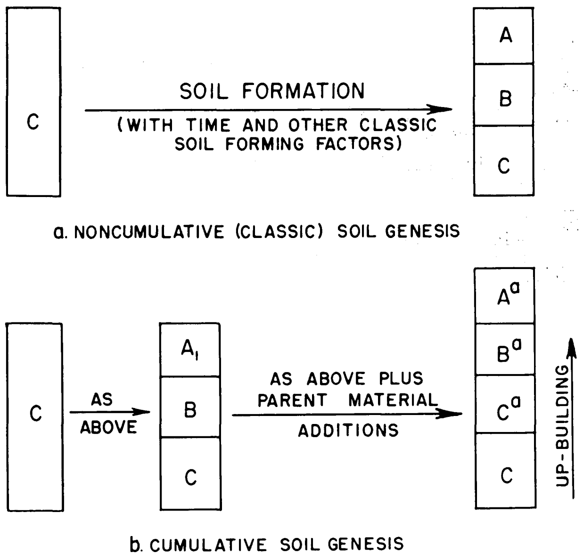

Figure 4. Conceptual formation of soil profiles in non-cumulative (ABC) and cumulative ($A^cB^cC^c$) soil genesis systems.

a number of aspects of this kind of soil-forming system that are at variance with the classic ABC "non-cumulative" soil genesis system. The path of genesis of individual horizons is not simply C transformed to an A_1 or B directly, but the genetic path is new surficial C into a new A_1 and the former A_1 into a B horizon. And a former B becomes a substratum not to be confused with C material. To clarify partially the genetic aspects we have used the superscript "c" to indicate that the particular horizon has been formed in part by up-building or accumulation of parent material at the surface

(Figure 4), which illustrates, we consider, the path of soil genesis of positions 2, 3, and 4 profiles.

Data presented in this study show that one of the main effects of cumulative soil genesis in the profiles studied was the greater depth distribution of nitrogen and base saturation compared to the normative non-cumulative soil genesis system.

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