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Some Notes on the Pleistocene Geology of Shelby County, Iowa

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INTRODUCTION

Previous investigations in Pleistocene geology in Iowa have resulted in the development of the concepts of gumbotil and the flat gumbotil plains of the Nebraskan and Kansan drift sheets. During recent field work in southwestern Iowa the writer noted differences in textures of the materials of the weathered zones of these tills. Measurable differences in altitudes of the tops of these materials were also noted. Field evidence indicates that (1) the term gumbotil cannot be used to describe all types of weathered till, and (2) variations in relief exist on the surface of the weathered zones of the Nebraskan and Kansan drift sheets.

WEATHERED ZONE OF THE NEBRASKAN TILL

Gumbotil (Kay and Pearce, 1920) is recognized as the end-stage of chemical weathering of glacial till. Gumbotil (Kay, 1916) has been defined as a gray to dark colored, thoroughly leached, non-laminated, deoxidized clay, very sticky and breaking with a starch-like fracture when wet, very hard and tenacious when dry, and which is, chiefly the result of weathering of till. Distinctive features of the gumbotil are its color which varies from light or neutral gray through blue, purple, and red to brown, its plasticity when wet, is polygonal fractured surface when dry, and its composition which is dominantly clay with minor sand, granules, and pebbles. The larger particles are rock and mineral fragments, such as quartz, chert, and quartzite, which are most resistant to chemical weathering.

The writer found many exposures of gumbotil-like material in Shelby County, Iowa, which possess all the characteristics of gumbotil except a similar texture. These materials occupy the stratigraphic position of the Nebraskan gumbotil but their textural characteristics prevent their being classified as true gumbotil. Pleistocene geologists (Leighton and MacClintock, 1930) of Illinois have shown that the type of decomposed till developed is dependent upon the topographic position at which weathering has progressed. On broad, flat, poorly drained areas (broad uplands or flat divides) chemical weathering would proceed to an advanced degree; mineral material in the till would be broken down into dominantly clay-sized particules; residual pebbles would be of small average size and of a siliceous nature (most resistant to chemical weathering). This type of material was termed gumbotil. In undulatory, well

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drained areas with good subsurface drainage, a characteristic, friable, open-textured silt containing small resistant, siliceous pebbles would be developed. This material was designated silttil. Transitional between gumbotil and silttil is a material intermediate in texture between the clayey gumbotil and the friable, open-textured silttil termed mesotil. Its topographical environment of development would be in partially drained areas.

These basic types of weathered till are recognizable in the weathered zone of the Nebraskan till in Shelby County. Mechanical analyses were made of samples of these types. The analyses are not intended to establish criteria for differentiation of these weathered materials (analyses of too few samples were made) but rather to show by comparison the textural differences. The Nebraskan silttil sample was collected at a road cut in the SW cor. SE¼ sec. 31, Jefferson Twp. (T. 81N., R. 37W.). In this exposure a gray, friable, porous, sandy, pebbly, leached silttil 1 to 1½ feet thick conformably overlies the oxidized and leached Nebraskan till and is overlain by 12 feet of oxidized and leached Kansan till. The road cut exposes the material near the base of a steep slope adjacent to the east slope of the valley of the West Nishnabotna River. The mesotil sample was collected at a road cut in the NW cor. NW¼ sec. 22, Cass Twp. (T. 79N., R. 40W.). The mesotil is a grayish-brown, leached, pebbly, sandy material with shiny joint surfaces; is 5½ feet thick; and overlies the oxidized and leached Nebraskan till and is overlain by the oxidized and unleached Kansan till. This section lies on the gentle east valley slope of Mosquito Creek. The gumbotil sample was collected at a road cut in the NW¼ sec. 19, Jackson Twp. (T. 79N., R. 37W.). In this road cut a gray, leached, plastic gumbotil 4 feet thick overlies oxidized and leached Nebraskan till. Immediately above the gumbotil, Aftonian loess (Kay and Apfel, 1929) occurs and is, in turn, overlain by 5½ feet of oxidized and leached Kansan till. Topographically, this road cut is situated on the broad flat upland east of the East Branch of the West Nishnabotna River.

Distinct textural differences are exhibited by these three types of weathered till, (see figure 1). Many other exposures of these types of weathered till have been described by the writer (see literature cited); they are characteristic of the Kansan till as well as the Nebraskan till.

The writer also noted great differences in altitudes taken at the top of the Nebraskan weathered zone. These altitude variations do not agree with the postulation of a development of a relatively flat gumbotil plain (Kay and Apfel, op. cit.). Further, these altitudes vary considerably from the generalized contours of the Nebraskan gumbotil plain as given by Kay and Apfel. In general it was found that altitudes taken at the top of the gumbotil in upland areas agreed with the map of the generalized Nebraskan gumbotil plain. However, on valley slopes differences in altitudes ap-

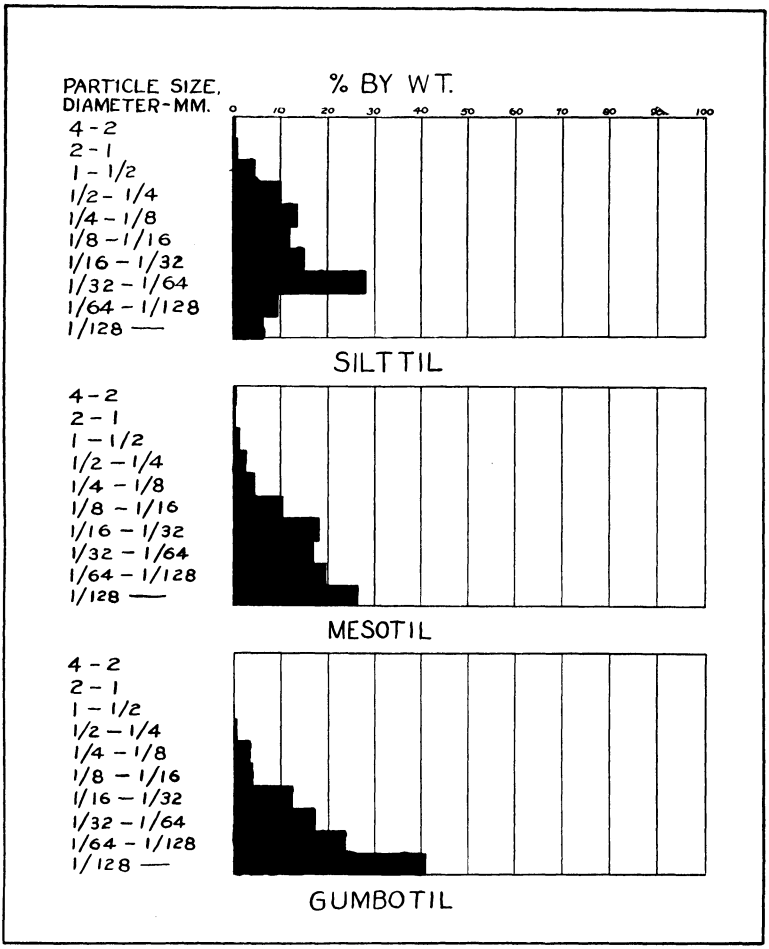

FIG. I TEXTURAL COMPARISON OF THE NEBRASKAN SILTTIL, MESOTIL, GUMBOTIL

proaching 100 feet were noted, (see figure 2). For example, a Nebraskan gumbotil 2½ feet thick is exposed in the SW cor. SE¼ sec. 8, Greeley Twp. (T. 81N., R. 38W.); it overlies the oxidized and leached Nebraskan till and is overlain by the oxidized and leached Kansan till; the top of the gumbotil is approximately 1355 feet above sea level. In the SE cor. sec. 2, Polk Twp. (T. 80N., R. 37W.), a Nebraskan gumbotil 3½ feet thick is exposed immediately below the oxidized and leached Kansan till; the top of the gumbotil is approximately 1335 feet above sea level. The Greeley

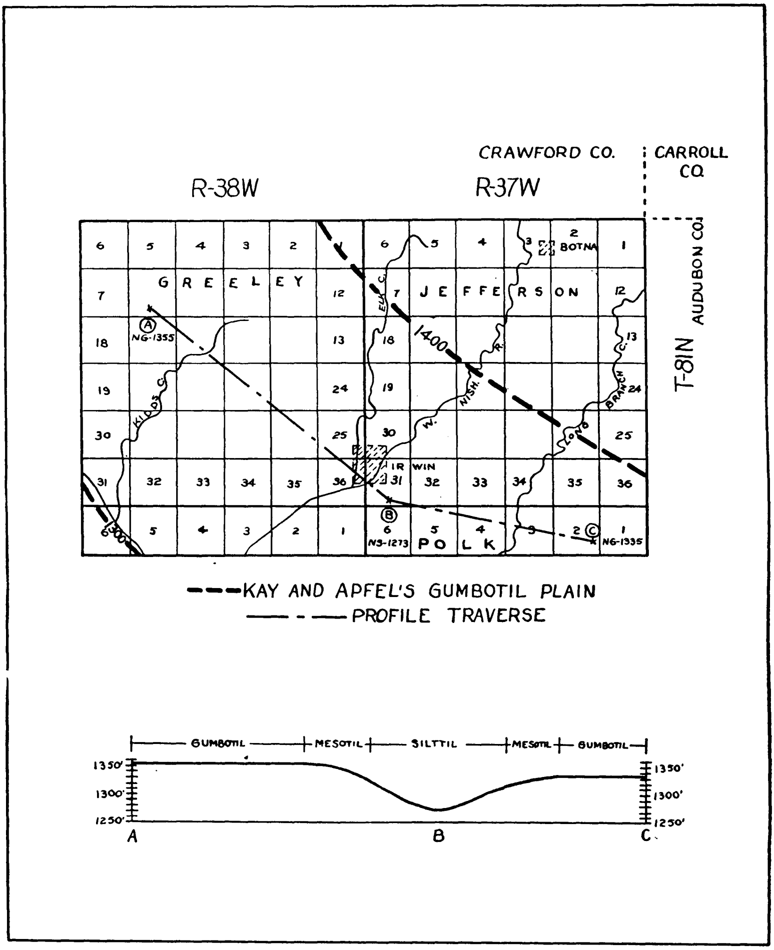

FIG. 2. SURFACE OF THE WEATHERED ZONE OF THE NEBRASKAN TILL IN NORTHEASTERN SHELBY COUNTY

section is located on the upland west of the West Nishnabotna River and the Polk section is located on the upland east of the West Nishnabotna River. Both of these altitudes compare favorably with Kay and Apfel's generalized contours. However, in the SW cor. SE¼ sec. 31, Jefferson Twp. (T. 81N., R. 37W.), a Nebraskan silttil (locality of the sample used in the mechanical analyses) is exposed. The top of this silttil is approximately 1273 feet above sea level; it is located topographically on the east valley slope of a small tributary approximately half a mile above the point of junction of the tributary and the West Nishnabotna River. The silttil exposure falls relatively close to a line of traverse between the above mentioned gumbotils. The line of traverse roughly parallels Kay and Apfel's generalized contours. The top of the silttil is 82 feet lower than the Greeley gumbotil and 62 feet lower than the Polk gumbotil. The altitude of the top of the silttil is also approximately 80 to 100 feet lower than Kay and Apfel's generalized altitudes. This field evidence indicates that the topographical expression of the Nebraskan weathered till is not a relatively flat plain, but that differences in relief with gentle to steeper slopes exist. The surface of the weathered till slopes from upland flats to valley floors.

CONCLUSIONS

The textural differences exhibited by types of weathered tills which are reflections of their topographical environments of development (good drainage, partial drainage, and poor drainage) and the measurable differences in altitudes of the tops of weathered till exposures indicate that the concept of the gumbotil plain is not tenable in Shelby County. It holds true on flat uplands but not on valley slopes. The term gumbotil is applicable only to that material which developes as a result of chemical weathering on broad flat uplands. Chemical weathering of till on valley slopes results in the development of silttil and mesotil. Field evidence indicates that variations in relief do exist on the surface of the weathered zone of the Nebraskan till. This concept applies also to the surface of the weathered zone of the Kansan till.

In view of the fact that the term gumbotil cannot be applied to all of the types of weathered till the writer questions the advisability of its continued use as an all-inclusive term. Field evidence indicates that it can be applied only to the material developed on broad flat uplands. The terms silttil and mesotil, introduced by Leighton and MacClintock, adequately describe the types of materials developed on valley slopes under conditions of good to partial drainage, and may be used advantageously in the description of Pleistocene sections. The writer believes that the terms silttil and mesotil as well as the term gumbotil should be employed in the descriptions of the Pleistocene deposits of Iowa.

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COMPLETE SYSTEMS OF INVARIANTS OF THE CYCLIC GROUPS OF EQUAL ORDER AND DEGREE.*

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Consider a cyclic substitution of order n:

$$S \equiv (x_0 x_1 x_2 \ldots\ldots\ldots x_{n-1})$$

Let $y_i = x_0 + \varepsilon^i x + \varepsilon^{2i} x_2 + \ldots\ldots\ldots\ldots \varepsilon^{(n-1)i} x_{n-1}$,

$$\varepsilon = e^{\frac{2\pi i}{n}},\ i = 0\ 1, 2, \ldots\ldots (n-1).$$

Then $n x_i = y_0 + \varepsilon^{(n-i)} y_1 + \varepsilon^{2(n-i)} y_2 + \ldots\ldots + \varepsilon^{(n-1)(n-i)} y_{n-1}$.

Hence, if $P(x)$ is a polynomial $x_0, x_1, x_2, \ldots\ldots\ldots x_{n-1}$, we have

$$P(x) = \Pi(y) \equiv \sum_{\alpha_0 \cdots \alpha_{n-1}} a_{\alpha_0, \alpha_1, \cdots \alpha_{n-1}} y_0^{\alpha_0} \cdot y_1^{\alpha_1} \ldots\ldots \cdot y_{n-1}^{\alpha_{n-1}}.$$

Now y_i has the property $S \cdot (y_i)^r = \varepsilon^{ir} \cdot y_i^r$, $r = 0, 1, \ldots (n-1)$.

$$\therefore S \cdot \Pi(y) = \sum_{\alpha_0 \cdots \alpha_{n-1}} a_{\alpha_0, \alpha_1, \cdots \alpha_{n-1}} \cdot \varepsilon^{\alpha_1 + 2\alpha_2 + \ldots (n-1)\alpha_{n-1}} y_0^{\alpha_0} \cdot y_1^{\alpha_1} \cdots y_{n-1}^{\alpha_{n-1}}.$$

If $\alpha_1 + 2\alpha_2 + \ldots\ldots\ldots + (n-1)\alpha_{n-1} = nr$, $r = 1, 2, 3, \ldots\ldots\ldots$

the individual terms of $\Pi(y)$ are invariant under S.

Hence, a necessary and sufficient condition that $P(x)$ be invariant under the cyclic substitution S is that it be expressible as the sum of products of arbitrary powers of y_0 and expressions like

$$y_1^{\alpha_1} \cdot y_2^{\alpha_2} \ldots\ldots\ldots\ldots y_{n-1}^{\alpha_{n-1}}, \text{ Where}$$

(1). $\alpha_1 + 2\alpha_2 + \cdots + (n-1)\alpha_{n-1} = nr$, $r = 1, 2, 3, \ldots\ldots\ldots\ldots$

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* See also: "On Complete Systems under Certain Finite Groups", Bull. of the Amer. Math. Soc., Vol. 37(1931), page 570, and "A Complete System for the Simple Group G_{60}^{6}", Ibid., Vol. 43(1937), page 438.

In this paper, solutions of this set of equations will be given for the cases, $n = 1, 2, \ldots, 10$, resulting in descriptions of the complete systems of invariants of the cyclic groups of equal order and degree, n for $n = 1, 2, \ldots, 10$. It should be observed that, for a given n, the problem resolves itself into finding those partitions of n and of its positive multiples that involve only integers $< n$ and do not involve integers whose sum is a lower multiple of n. Since the problem is one of partitions, it has no general solution.

We begin by defining the complete system of solutions of the equations (1) for any prime, positive integer, n, as the set of solutions in positive integers such that every other solution in positive integers is the sum of positive, integral multiples of solutions of the set.

For a given n,

$$\begin{array}{c} n, 0, 0, \ldots 0 \\ 0, n, 0, \ldots 0 \\ 0, 0, n, \ldots 0 \\ \ldots\ldots\ldots\ldots \\ 0, 0, 0, \ldots n \end{array}$$

are all solutions. Hence, no solution belonging to the complete system of solutions involves an integer $> n$ and the complete system of solutions consists of a finite number of solutions.

(2) Let α_i', $i = 1, 2, \ldots (n-1)$

be any solution of (1) belonging to the complete system.

Then $$\sum_{i=1}^{n-1} i\alpha_i' = \kappa_1 n.$$

Let α be any integer $< n$, belonging to the exponent k, mod n. Then

$$\sum_{i=1}^{n-1} i\alpha^j \alpha_i' = \kappa_1 \alpha^j n, \; j = 1, \ldots k.$$

Hence, the k sets

$$(3)\; \alpha_{i\alpha^j} = \alpha_i', \quad \begin{cases} i = 1, 2, \ldots (n-1), \\ j = 1, 2, \ldots k, \end{cases}$$

where the subscripts $i\alpha^{j}$ are reduced to their least, positive values, mod n, are all solutions of (1).

We shall call the solutions (3) a set of conjugate solutions. If k is the greatest integer to which any integer belongs, mod n, we shall call the solutions a complete set of conjugate solutions.

If the solution (2) belongs to the complete system of solutions of (1), then all its conjugates do. For, suppose that for some j, the solution (3) is the sum of two other solutions belonging to the complete system of solutions, namely

$$\alpha_{i\alpha^{j}} = \alpha'_i - \beta_i \qquad \alpha_{i\alpha^{j}} = \beta_i, \quad i = 1, 2, \ldots\ldots (n-1)$$

Then $\sum_{i=1}^{n-1} i\alpha^{j}(\alpha'_i - \beta_i) = \kappa_2 \alpha^{j} n$

and $\sum_{i=1}^{n-1} i\alpha^{j}\beta_i = \kappa_3 \alpha^{j} n.$

or $\sum_{i=1}^{n-1} i(\alpha'_i - \beta_i) = \kappa_2 n$

and $\sum_{i=1}^{n-1} i\beta_i = \kappa_3 n.$

But then $\alpha_i = \alpha'_i - \beta_i$ and $\alpha_i = \beta_i$, $i = 1, 2, \ldots (n-1)$, are solutions, which is contrary to the supposition that the solution (2) belongs to the complete system of solutions.

The solution of the equations (1) for a given positive, integral value of n is laborious even for as low values of n as 7 or 8. However, the existence of conjugate sets simplifies the work. The solutions belonging to a complete set of conjugates are permuted according to the group of the integers $< n$ and prime to it. Other sets of conjugates are permuted according to the self-conjugate subgroups of this group, including the identity group. Considerations of symmetry make it easy to find the solutions that correspond to the identity group. As for the others, one member of a set of conjugate solutions leads immediately to the others. The work can be arranged systematically so as to make it possible to check the solutions for completeness and at the same time to exclude solutions that do not belong to the complete system of solutions.

For a given n, the solution of the equations gives the number of polynomials of each degree in the complete system of invariants of the group and this is the point of greatest interest in connection with them. Even for very low values of n, the selection of actual sets of linearly independent polynomials of each degree to represent the complete system of invariants is a matter of very great difficulty and has not been attempted. For $n = 1, 2, \ldots\ldots, 10$, the number of polynomials of each degree in the complete system of the cyclic groups of degree and order n is given in the following table:

Number of polynomials of each degree in the complete system.

Group	Degree 1	2	3	4	5	6	7	8	9	10	Total Number
G_1^1	1										1
G_2^2	1	1									2
G_3^3	1	1	2								4
G_4^4	1	2	2	2							7
G_5^5	1	2	4	4	4						15
G_6^6	1	3	6	6	2	2					20
G_7^7	1	3	8	12	12	6	6				48
G_8^8	1	4	10	18	16	8	4	4			65
G_9^9	1	4	14	26	32	18	12	6	6		119
G_{10}^{10}	1	5	16	36	48	32	12	8	4	4	166

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