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DISCUSSION

ACCRETION-GLEY AND THE GUMBOTIL DILEMMA

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The paper being discussed (Frye, Shaffer, Willman, and Ekblaw, 1960) should be read carefully by all Pleistocene geologists and by soil scientists working in continentally glaciated areas, for it has to do with facts, principles, and terms that are of much use in working out the glacial and interglacial history of the Pleistocene.

Gumbotil as defined (Kay, 1916a, 1916b; Kay and Pearce, 1920) is well known to Pleistocene geologists. The identification and interpretation of gumbotil in Iowa have helped materially in differentiating the Nebraskan, Kansan, Illinoian, and Wisconsin drift sheets and in establishing the current Pleistocene classification in glaciated North America. More than 150 exposures of gumbotil have been observed in Iowa (Kay and Apfel, 1929; Kay and Graham, 1943), and more than 40 sections showing relations of gumbotil to underlying till have been measured and described in detail. Samples from 11 members of these sections have been subjected to laboratory analysis. The authenticity of none of these occurrences is questioned in the paper under discussion. To be sure, most of these particular exposures are now covered. This is inherent in glacial and interglacial materials. However, new exposures that show the same essential characters appear temporarily from time to time.

Definitive characters of gumbotil are given below. Gumbotil is (1) compact clay, sticky when wet, and hard when dry; (2) completely leached; (3) contains little or no easily weatherable material except near the base; (4) breaks up when wet into small, starchy, polyhedral pellets with shiny sides, the "soil structure" of modern soil science (Soil Survey Manual, 1951, p. 225-230); (5) is massive not stratified; (6) seldom exceeds 15 feet in thickness; (7) contains pebbles of rocks and minerals that are difficultly weatherable, such as quartz, chert, and quartzite similar to pebbles in underlying till, and these pebbles become gradually larger and more numerous from top to bottom; (8) nowhere lies directly on fresh till but grades downward through oxidized and leached and oxidized and unleached to unoxidized and unleached till; (9) contains "ghost" pebbles, cobbles, and boulders of crystalline erratics, especially in its lower part; (10) except where uncovered by erosion is overlain by unweathered or only slightly weathered till or loess. Of these characters number (8) is particularly important. Taken together they constitute a specific definition that includes all gumbotils and excludes all nongumbotils. The term "gumbotil" by definition is applicable only in areas that have been glaciated, and exclusively to glacial geology.

These facts led Kay and his associates to the conclusion that gumbotil resulted from long-continued weathering of till following deposition by an ice sheet before being covered by material deposited from a much younger ice sheet. Is this "dogma" (Frye and others, 1960, p. 185) or an approved method of scientific investigation?

After quoting the original gross definition of gumbotil, Frye and others (1960, p. 185) state:

> This definition is both empirical and genetic. As will be explained, it is this dualism of the definition that produces the present dilemma.

It is intimated that if gumbotil had been defined empirically and not genetically there would be no dilemma. If such features are to be defined without reference to origin, what will be done with the terms "till," "drift," "outwash," "valley train," "drumlin," "kame," "ground moraine," "delta," "alluvium," "colluvium," "sand dune," "beach," "stalactite," "volcanic ash," etc.? After all, what is the main use of classification and nomenclature if not to record historical conditions and events?

The authors cite eight clays in Illinois, Iowa and Kansas that have been called gumbotil (Frye and others, 1960, p. 187-189). Of these, two are said to be gumbotil, both empirically and genetically, and from the descriptions the present writer agrees. The other six are thought to be gumbotil empirically but not genetically, thus adding to the dilemma; then the authors proceed to point out ways in which the "samples" differ from gumbotil. This writer contends that these differences are definitive and that these clays should not have been called gumbotil. Some of these clays are calcareous, some are stratified, some contain no pebbles similar to those in underlying drift, none grades into unaltered till through zones of partly weathered till, and one is 30 feet thick. Furthermore, two of them are said to lie on Wisconsin till. Kay and his associates were quite familiar with tills of Wisconsin age and found no gumbotil on them. These till sheets are too young to have been weathered to gumbotil. In fact, the absence of gumbotil is one of several criteria for the separation of the Wisconsin from older till sheets. The authors are to be commended for having called attention to these misidentifications. As always, care should be taken to identify accurately before making interpretation.

Now what about the term "gley" that is proposed as a possible substitute for gumbotil (Frye and others, 1960)? But the terms "gley," "gleyed," "gleying" and "gleization" are not defined. Indeed, definitions of these terms are confused in English language literature.

The concept of the soil profile and the formation of gley as a part of this profile was started by Glinka in Russia and introduced in this country by Marbut (1927), as recorded by Leighton (1958, p. 704-706) and Frye and others (1960, p. 185). However, only three references to gley are found in the Marbut translation of Glinka (1927, p. 105, 168, 169). All refer to the normal profile as developed under certain climatic conditions. No reference is made to intensely weathered material such as gumbotil, and for a very good reason; the drifts of Russia are mostly of late Pleistocene age and too young to have been maturely weathered. Glinka never saw gumbotil and made no place for it in the Russian classification of soils.

The term "gley" is not listed in the Russian-English science dictionaries available to this writer. According to Russian language dictionaries and encyclopedias, translated for the writer by Miss Ada M. Stoflet of the State University of Iowa Library, the Russian word "gley" was derived from a Greek word that means glue or, as defined by Liddell and Scott (1925), "any glu-

tinous substance, gum". As an adjective it means sticky, watery, muddy, marshy, gummy (Preobrazhensky, 1951). The Great Soviet Encyclopedia (1952) under "Glei (gley)" lists soil composed of anaerobic bacteria in marshy places and makes no mention of the soil profile.

It seems, therefore, that in Russia gley is any sticky clay, and of course all clays are more or less sticky when wet. A large variety of clays is included. No mention is made of genesis or parent material. Russian gley could be found in almost any area whether it had been glaciated or not. It is not a term that applies especially in Pleistocene geology.

Nor is gley mentioned frequently or clearly defined in standard works of soil science in the United States. Even Marbut (1951) did not use the term in ten lectures delivered in 1928. He had much to say about the soil profile as described originally in Russia, about laterite and lateritization, about soil classification and nomenclature, but did not even mention gley or gleying.

Even where the term "gley" does appear in American literature, its defintions and usages are little if any less general or more specific than in Russian. In the most recent edition of the Soil Survey Manual (1951) mention is made of

> intensely gleyed layers as in hydromorphic soils (p. 175); G. Horizon—developed wholly or partly by gleying. Involves saturation of the soil with water for long periods in the presence of organic matter. One may speak appropriately of a "gley soil" but hardly of a "gley horizon," since the genesis of the whole profile is involved. Besides the G., other horizons may be somewhat gleyed. Occasionally it may be necessary to differentiate in the description between fossil gley and active gley (p. 180); g: a gleyed horizon, as Bg or Bag (p. 181).

Any B zone has apparently been gleyed and is a gley.

The paragraph from page 184 of the 1951 Soil Survey Manual quoted by the authors (Frye and others, 1960, p. 186) seems to relate to "accretion-gley," but in this paragraph neither gley nor gleying is defined. That the gley of the Soil Survey Manual does not include gumbotil is suggested by the footnote (p. 152) which is as follows:

> In the Middle West, the term *gumbotil* is applied to tenaceous clays, generally gray, plastic when wet, and hard when dry, which have been weathered from Nebraskan, Kansan, and Illinoian till during the interglacial period.

In the paper under discussion (Frye and others, 1960, p. 186), the quotation from Senstius (1958, p. 362) might have included the following: "The *underclay* of coal deposits is nothing else but fossil gley." This kind of gley called "peaty gley" seems unrelated to gumbotil.

Joffe lists six index references to "Glei" (1949, p. 56-57, 65, 418-432, 517, 601, 602). Mention is made of iron and calcareous concretions in loess ("pipestems" and "loess kindchen" of Pleistocene geology); glei or glei-like materials formed in fresh water or marine marshes; and clays due to gleying of glauconitic Tertiary formations in New Jersey. A close relation between podsols and glei-horizons is brought out, but the term "gley" is used in more than one sense and parent material is not important.

The four authors (Frye and others, 1960, p. 186) outline five ways in which gumbotil or gumbotil-like clays can be formed. Only one (5) results in

gumbotil as originally defined. Just how many and what of the genetic methods result in accretion-gley is not made clear. By numbers (2) and (3) accretion-gley is formed. The deposit resulting from number (1) would be calcareous, unless leached after deposition, stratified, and without pebbles; in fact these are the conditions that result in the formation of *varves*. If there are four or five or six conditions of formation and all are to be called gley, would not other modifiers besides "accretion-" be required? What would these other modifiers be? Especially, what kind of gley would gumbotil be if the term "gumbotil" were to be abandoned? If the four authors mean that there are only two genetic types of gleyed material, accretion-gley and material gleyed in situ, and the term "gumbotil" is abandoned, the type that is formed in situ is still left without a name. It should be noted that "Humic-Glei" and "Low-Humic Glei" soils (Thorp and Smith, 1949, p. 119), "Meadow soil or gley soil" (Robinson, 1949, p. 354) and "Gley Podsols" (Robinson, p. 361), "Peat-podzolic-glei soil" and "Peat-gley soil" (Joffe, 1949, p. 428), and "peaty gley" (Senstius, 1958, p. 362) are in current use pedologically.

In summary it should be said that the authors of this important paper should be commended for having brought this matter to the attention of Pleistocene geologists and pedologists; that gumbotil as originally defined can be distinguished readily enough from other clays; that ordinary care should be taken in distinguishing among clays of different sorts and origins; but that, in the opinion of this writer, gumbotil should continue to be called gumbotil, at least by Pleistocene geologists.

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