IMPORTANCE OF THE PARENT MATERIAL ON GLEY FORMATION

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Abstract

Rates **of** gley formation on **two** diverse types **of** soil material from New Jersey, **U.S.A.** were investigated. One was an unweathered gray Marcellus shale which, under **a wet** environment,
wet environment,
develops gley features **in a normal** manner. The second **type** consisted **of** Brunswick, **a** shale **with a** very **stable red** pigment, one in which gley

formation is quite slow to develop even under very wet conditions. Water-saturated material from the C horizons of both samples with added glucose were incubated over a 3-month period. Incipient gley formation was detected in the gray shale matrix after only 8 days of incubation but the red shale, with similar treatment, did not develop any noticeable gley features over a 3-month period. The red shale contained hematite which was believed mainly responsible for the color stability during the incubation period.

Viusotzkii (1905)

(1905) is generally accredited with introducing the term gley or gley formation **to** the soil literature. He described gley as "**la** more **or** less compact, **sticky** loam or clayey parent material, which **is** not,

which **is** not, **however**, as **sticky as** the usual loam or clay, frequently **with** a more or

less clearly pronounced light

widespread phenomena

which

greenish blue tinge." Gley formation **is** more common in cool, humid climates but, in reality **it is a**

transgresses all soil zones **(Joffe, 1935)**.

With most major **systems of soil** classification focusing primarily **on** zonal **or** mature terrestric **soils in the sense** of V.V. Dokuchaev, **gley soils have traditionally been** relegated **to a minor position.** Despite **the** minor **status** of **gley** soils **within** the prime units of **classification, such soils are well provided for at** the intermediate **or lower levels of classification**.

Processes **leading to gley** formation are **very complex and, to** this day, are **understood only in** general terms. **During the early part** of **this century, information relating to poorly** drained **soils** was confined **mainly to descriptions. Starting about 1950, however,** there was **an expanded** interest in working **out reactions leading to** gley formation. Glentworth and Dion (1949), Bloomfield (1950, 1951),

Crompton (1952), Nepomiluyev and Kozy (1970), and Glazovskaia (1972)

among others made significant contributions explaining the

biochemical reactions associated with gley formation. Individual

factors such as carbohydrate supply, mineral species, mineral

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coatings, as well as temperature affect the rate of gley formation

(Pawluk and Dumanski 1973; Thomasson and Bullock, 1975; Evans et

al.,1978, among others).

Based on field observations it appears that using depth to gley

formation together with

together with intensity of the pattern are generally

reliable criteria for depicting the moisture regime and depth to the

seasonal-high water table. There are, however, many situations in

which depth to gley (or the

(or the absence of it) alone may be quite

misleading in projecting the hydric nature of the soil. This report

addresses some of these anomalies, particularly as they pertain to

the mineral substrate.

Experimental

In order to show that different geologic materials may acquire gleyic features at different rates, two diverse types of parent materials were used for comparative studies. The first was a substrate from the C horizon derived from unweathered late glacial drift of northwestern New Jersey. This sample was comprised mainly of a Devonian-age, fine to medium grained gray shale referred to as the Marcellus shale (Kümmel, 1940). Field observations indicate that when soils form on Marcellus shale under a hydric regime they develop a gley pattern in a normal manner. A second type of parent material, the Brunswick, was selected for its known resistance to gley formation. Soils formed on the Brunswick shale are also known for other peculiar properties. There are situations in which there

are extended periods of water saturation but the soils may display few,

if any, gleyic features. The Brunswick formation consists of Indian-red shale and mudstone of Triassic age. Red pigment in the shale contains hematite coatings that are quite stable (Krynine, 1950; Van Houten, 1969). This second site, located about 2 miles north of Somerville, New Jersey consisted of early (Kansan) glacial drift with the drift consisting of nearly all Brunswick shale. Like the Marcellus shale site, the sample of soil was from the C horizon.

Attesting further to the stability

the stability of the pigment within the red shale, the color of the A horizons of the contiguous, rather shallow, well-drained soils (Penn series) usually vary little from those of the underlying bedrock. The Penn soil would be considered endodynamorphic in the sense of K.D. Glinka (Ugolini, 1964).

Minerals of the clay fraction of the Marcellus site consisted of light mica, chlorite, goethite, and lepidocrocite. Those of the Brunswick clay fraction consisted of light mica, chlorite, kaolinite, goethite and hematite.

Initial solution of the trivalent iron oxide phases governs the gley process (Bloomfield, 1.c.). Accordingly, stability of the hematite within the red shale was projected to have a controlling influence on the

the rate of gley formation. In order to show the different stability levels of the iron

iron pigment within

within the soil

materials, certain laboratory tests were performed. The gray shale sample contained only 2.72% Fe_2O_3, over half of which was dithionate

extractable (Table 1). On the

contained 6.30% Fe_2O_3 with the other hand the red shale sample only about one third of it being dithionate extractable.

A second set of samples were treated with 1% D-glucose, placed in transparent plastic boxes, water saturated and incubated at room temperature for 3 months. Sluries from the boxes were then centrifuged and the iron contents of the supernatant liquids determined. The gray shale yielded a value of 0.51% (expressed as Fe_2O_3) whereas that of the red shale was only 0.13%. Putting it another way about 19% of the total iron in the gray shale sample was solubilized with D-glucose over the 3-month period but with the red shale the value was only about 2% (Table 1). These data show the different solubility rates of the iron compounds within the two types of soil materials.

Direct observations as to possible changes in color of the water-saturated soil were also made over the 3-month incubation (fermentation) period. After 8 days, incipient gley features had developed within the D-glucose-treated gray shale (Table 2) and after 3 months gley features were more evident with the gray shale fermentation matrix reacting in a manner as described earlier by Bloomfield (1.c.). The surface of the slurry in the fermentation box also developed a thin bluish-steel gray surface scum which was assumed to consist largely of iron compounds (Puustjarvi, 1952). On the other hand the red shale samples, even after 3 months of incubation, did not develop any detectable gley features. The red shale samples did, however, develop a deep metallic purple surface scum as described for the gray shale (Table 2).

Since the easily observable features of gley formation primarily involves iron chemistry it was decided to add finely ground (<325 mesh) iron-bearing minerals minerals to the samples and determine if the addition of such materials would induce a more rapid rate of gley formation. Accordingly, hematite, hornblende, ilmenite and magnetite were added to separate samples at 1% concentrations to both the gray and the red shale samples. After incubating the

samples over a 3-month period, with and without D-glucose, there was no evidence that the added iron-bearing minerals increased rates of gley formation.

Application

Soil classification has traditionally focused on the mature, well-drained soils while those having hydric properties have been generally relegated to secondary importance. But with wet areas now receiving increased public attention soil scientists have been called upon to quantitatively establish "wetland" guidelines. The procedure generally consists of empirical color comparisons (certain chroma and values of the soil color [Munsell] charts) and estimating percentages of certain colors within the soil matrix. While such a procedure is proper, color alone does not provide for the many anomalies nor does it always address the multiplicity of conditions.

In order to provide a more reliable set of criteria for recognizing hydric soils it appears that nature of the soil material along with the geomorphology (time, slope, position, etc.) of the site also need to be considered.

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Table 1. Selected properties of the C horizons (<2mm) of some New Jersey soils.

Gray Devonian Shale

	(Marcellus)	Red Triassic Shale (Brunswick)
PH	4.9	4.1
Organic carbon	0.12%	0.07%
Total Fe_2O_3	2.72%	6.30%
Dithionate extractable Fe as Fe_2O_3 **	1.50%	1.89%
Solubilized Fe as Fe_2O_3* after D-glucose incubation ***	0.51%	0.13%

* Sample digested by the Groves' (1951) method and Fe determined by the Hsu (1967) method.

** One extraction by the Mehra and Jackson (1960) method.

*** After 3 months under water-logged conditions.

Table 2. Rates of gley formation on different types of material and under different treatments (<2mm).

	3 days	8 days	3 months
Gray Devonian shale (Marcellus)			
untreated			
D-glucose			
Red Triassic shale (Brunswick)			
untreated			
D-glucose			

No gley evident

+ Incipient gley formation

++ Moderate gley formation

C

Surface **scum** formation

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+

++

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