

Coprogenous Earth in Organic Soils of Northern Indiana¹

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Abstract

Coprogenous earth is one of the materials that occur in old lake bed sediments below organic soils. In Northern Indiana this material has a wide range of properties. It either forms a slightly viscous suspension and is slightly plastic but not sticky, or it shrinks upon drying to form clods that are difficult to rewet and that tend to crack along horizontal planes. The organic matter content is low and it has low shear strength. Where this material is exposed on or near the surface the soil may be less desirable than organic soils for pasture or cropland. As the organic materials on the surface oxidize or blow away, the underlying coprogenous earth will become more important as a constituent of the soil, creating problems in using these soils. Special precautions should be taken to preserve organic soils where they cover coprogenous earth deposits.

Introduction

The first stage in the development of an organic soil is the deposition of organic and inorganic sediments at the bottom of a lake. These sediments are called *ooze* by limnologists (Rutter, 1963). They may form in the lake itself by life processes or physical-chemical processes separating them from the water, or they may be introduced from outside the lake by inflowing water, falling of dust, etc. Whether the sediments are primarily derived from within the lake or from outside depends on the nature of its watershed. The organic components of the *ooze* originated from plankton (free-water organisms) that settle to the bottom and then, along with other sediments, are reworked by bottom animals and bacteria.

Through deposition of sediments, a lake becomes continually shallower and the shore flora continually advances farther towards the center of the lake and finally covers its entire surface. In this second stage in the development of the organic soil, filling-in is accelerated by production of large quantities of plant material which forms bog peat.

In soil morphology and classification (Soil Survey Staff, 1975), this peat and its more decomposed form, muck, are recognized as organic soil materials and the *ooze* of limnologists is called limnic sediment. Organic soil materials contain more than 12 to 18 percent organic carbon (20 to 30 percent organic matter), depending on the clay content of the mineral material, and are subdivided according to

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degree of decomposition into fibric (least decomposed), hemic, and sapric materials. The degree of decomposition is determined by two tests: the amount of fibers remaining after manipulation of the material and the color of a sodium pyrophosphate extract. Pyrophosphate dissolves dark-colored humic materials formed when peat decomposes.

Limnic sediments are subdivided into diatomaceous earth, composed of the siliceous remains of diatom organisms; marl, composed mainly of CaCO_3 ; and coprogenous earth (formerly called sedimentary peat or colloidal muck) which contains significant amounts of fecal pellets. Some limnic sediments also contain enough organic matter to be included with organic soil materials.

In Indiana there are about 500,000 acres of organic soils mostly in the sapric (muck) or hemic (peaty-muck) condition. This area is about equivalent to the area of two counties. The underlying sedimentary deposits have not been well studied. We have not seen diatomaceous earth sediments in the state, but have identified marl and coprogenous earth.

The purpose of this paper is to characterize the morphology of organic soils that contain coprogenous earth sediments and to discuss problems that may arise in using these soils.

Methods and Materials

Several sampling sites were selected to represent soils that we believed contained coprogenous earth layers. They were described (Soil Survey Staff, 1951 and 1975) and sampled from pits about 4 or 5 feet deep and from deeper auger samples. In the horizon designations, the first letter is "O" for organic soil materials, "L" for limic sediments, and "A", "B", or "C" for mineral soil materials. The lower case characters represent a subdivision of the major horizons—"a" for sapric, "e" for hemic, "co" for coprogenous earth, and "p" for a surface plow layer. A number may also be used to further subdivide thick layers. Roman numeral II represents a major change in parent materials.

For a few horizons, a soil smear was made by mixing a small amount of the material with water and spreading it thinly on a microscope slide. After it dried a cover glass was mounted with clear epoxy cement.

Shear strength was determined with a vane-shear apparatus (McKinzie et al., 1975).

W. C. Lynn and W. E. McKinzie also collected samples for chemical and physical characterization at the national Soil Survey Laboratory.

Results and Discussion

Soil Descriptions

Soil 1

Location: Montgomery County—2100 feet W and 1320 feet S of NE corner of Sec. 34, T20N, R4W.

Size of Area: 640 acres; vegetation-corn

Description:

Oap—0-28 cm (0-11") black organic matter (N 2/0) (sapric); moderate medium granular structure; very friable; neutral.

Oa —28-66 cm (11-26") dark reddish brown (5YR 3/2) organic matter (sapric); moderate very coarse prismatic structure; friable; neutral.

Lco—66-183 cm (26-72") very dark grayish brown (10YR 3/2) and olive gray (5Y 4/2) coprogenous material; massive, soft, non-sticky, non-plastic, slight rebound when compressed, gelatinous; neutral above 94 cm and moderately alkaline below. Fine sand layer at 94-99 cm.

Lco and Cg—183-326 cm (72-130") similar to above horizon except that gray fine sand horizontal bands 2 to 5 cm thick occupy about 20 percent of the horizon.

Remarks: A vertical wedge shaped projection 15 cm wide at 28 cm and coming to a point at 94 cm filled with organic material similar to that in the plow layer was observed on both sides of the pit. This cracking indicates high shrinkage of materials at these depths. Other thinner crack fills were also observed. The fine sand layer at 94-99 cm conducted water into the sampling pit. Apparently this layer facilitates drainage of the soil.

Soil 2

Location: White County—1420 feet S and 485 feet W of NE corner of Sec. 3, T27N, R2W.

Size of Area: 40 acres; vegetation-corn

Description:

Oap—0-23 cm (0-9") black (N 2/0) organic matter (sapric); moderate medium granular structure; very friable; neutral.

Oa2—23-40 cm (9-16") dark reddish brown (5YR 2/2) organic matter (sapric); weak thick platy structure; very friable; neutral.

Oa3—40-70 cm (16-28") black (10YR 2/1) organic matter (sapric); moderate thick platy structure; firm; neutral.

Lco—70-176 cm (28-70") dark gray (5Y 4/1) coprogenous material; weak coarse platy structure in the upper part and massive below 176 cm; firm, soft, smooth, slight rebound when compressed; non-plastic, not sticky, strong effervescence; moderately alkaline.

Remarks: Material between 176 and 450 cm is olive (5Y 5/4) and has strong effervescence. It appears to be marl.

Soil 3

Location: White County—1320 feet W, 300 feet N of SE corner of Sec 1, T28N, R5W.

Size of Area: 160 acres; vegetation-grass.

Description:

Ap —0-23 cm (0-9") very dark gray (10YR 3/1), silt loam high in organic matter; moderate medium granular structure; friable; some evidence of burning of organic layer; neutral.

Lco—23-41 cm (9-16") dark gray (5Y 4/1) silt loam; weak very coarse subangular blocky structure; smooth, non-sticky, non-plastic, firm, strong effervescence; moderately alkaline.

IIBg and Cg—41-152 cm (16-60") gray (10YR 5/1) fine sand; strong effervescence; moderately alkaline.

Remarks: This profile represents several hundred acres of soil observed in White County. The material between depths of 23-41 cm has characteristics of coprogenous earth. It is somewhat more weathered than that observed in thicker deposits.

Soil 4

Location: Cass County—SE $\frac{1}{4}$ of NE $\frac{1}{4}$ of Sec. 6, T27N, R1W.

Size of Area: 40 acres; vegetation-corn.

Description:

Oap—0-28 cm (0-11") black (N 2/0) organic matter (sapric); moderate fine granular structure; very friable; slightly acid.

Lco—28-58 cm (11-23") very dark grayish brown (10YR 3/2) and dark brown (2.5Y 4/2) coprogenous material; moderate medium platy and weak medium angular blocky structure; firm, slight rebound when compressed, smooth, non-sticky, non-plastic; evidence of shrinkage on drying. V-shaped wedges filled with surface material; neutral.

IIC—58-150 cm (23-60") pale brown fine sand; single grained; loose; strong effervescence; moderately alkaline.

Remarks: The material below 28 cm and above 58 cm has characteristics of coprogenous earth. Part of the coprogenous earth is being turned up on the surface when plowed. When dried it rewets slowly. There is evidence of difficulty in turning with the plow. Large hard flakes occur on the surface.

Soil 5

Location: LaPorte County—1980 feet W and 1320 feet N of SE corner of Sec. 32, T35N, R3W.

Size of Area: 80 acres; vegetation-corn.

Description:

Oap—0-26 cm (0-10") black (10YR 2/0) organic matter (sapric); weak fine granular structure; very friable; very strongly acid.

Oe —26-40 cm (10-16") reddish brown (5YR 4/3) partly decomposed organic matter (hemic); moderate thick platy structure; friable; strongly acid.

Lco1—40-198 cm (16-78") very dark gray (10YR 3/1) and dark gray (5Y 4/1) coprogenous material; moderate, thin to thick platy structure; soft, smooth, non-plastic, non-sticky, rubbery like, moderate rebound when compressed; neutral to 64 cm and moderately alkaline below; carbonates occur as short white threads and fine skeletal remains.

Lco2—198-228 cm (78-90") gray (N 5/0) coprogenous earth and marl; massive; slightly sticky; violent effervescence; moderately alkaline.

IIC—228-254 cm (90-100") gray (N 5/0) fine sand; single grained; loose; violent effervescence; moderately alkaline.

Remarks: Material in this profile between depths of 40 cm and 198 cm has the characteristics of coprogenous materials. Wedge shaped crack fills 7 cm wide at 40 cm and tapering to a point at 89 cm are filled with black organic material from the surface. The filled cracks indicate high shrinkage of the material at a time when the soil was dry.

Soil 6

Location: Steuben County—2500 feet W and 1500 feet S of the NE corner of Sec. 2, T37N, R14E.

Size of Area: 160 acres; vegetation-mint.

Description:

Oa —0-73 cm (0-29") black (10YR 2/1) and very dark brown (10YR 2/2) organic material (sapric); very friable; granular on the surface and weak coarse platy below; very friable; neutral.

Lco—73-187 cm (29-75") dark grayish brown (2.5Y 4/2) and olive gray (5Y 4/2) coprogenous material; weak very thick to thin platy structure; firm, soft, smooth, gelatinous, greasy feel, slight rebound when compressed; moderately alkaline (many fine white calcareous threads and fine shell remains).

IIC—187-200 cm (75-80") gray (5Y 5/1) coarse sand; single grained; loose; violent effervescence; moderately alkaline.

Remarks: Landowner indicated that the surface is about 40 inches lower than it was originally before drainage. Present owner has farmed this area since 1934. It was originally drained about 1900. A row of willows planted as a windbreak shortly after 1900 have a diameter at the base of about 130 cm (52"). Materials between depths of 73 and 187 cm have characteristics of coprogenous material.

Soil 7

Location: Steuben County—3100 feet W and 3000 feet N of SE corner, Sec. 23, R14E, T38N.

Size of Area: 300 acres; vegetation-corn.

Description:

Oa —0-38 cm (0-15") black (10YR 2/1) organic matter (sapric); moderate fine granular structure on the surface and moderate thin to thick platy below; very friable; soft; strongly acid.

Lco—38-177 cm (15-70") very dark gray (10YR 3/1) and dark gray (5Y 4/1) coprogenous material; weak thin to thick platy structure; firm; non-sticky, non-plastic, slight rebound when compressed, gelatinous, greasy feel; neutral.

IIC—177-225 cm (70-90") gray (N 5/0) clay; massive; very firm, sticky and plastic; strong effervescence; moderately alkaline.

Remarks: Few seed pods and grass stems in the coprogenous material. V-shaped crack fills are 2 to 3 cm wide at 42 cm and wedge

out at 80 cm. They are filled with organic material from the surface. These cracks indicate high shrinkage when the coprogenous materials were dry.

Microscopic Examination

Soil 1, Lco horizon, 75 cm depth: Mainly angular quartz grains plus a few calcite, feldspar, and other mineral particles, mostly in the size range 10 to 50 μm . Large fragments of organic fibers and aggregates of organic matter around 200 to 1000 μm and numerous small shreds of organic matter.

Soil 2, Lco horizon, 120 cm depth: Mineral portion is almost entirely calcite grains, mainly 2 to 20 μm in diameter, that are roughly equi-dimensional in size and irregular in outline. Many larger brownish aggregates of organic matter with diffuse edges. A few isotropic small animal remains, around 10 to 100 μm , and a few calcite shell fragments.

Soil 7, Lco horizon, 100 cm depth: Matrix is light yellowish brown jell. Within the jell are irregular shreds of plant tissue; round, opaque particles 10 to 40 μm in diameter that are brown to black in reflected light (fecal pellets); angular quartz grains and rounded calcite grains 10 to 100 μm in diameter; and a few isotropic skeletal remains of small animals.

Physical Properties

Field tests show the shear strength of the coprogenous material to be very low. It ranges from 50 to 100 pounds per square foot compared to 150 to 300 pounds per square foot for organic materials and 400 to 600 pounds for a representative clay loam.

Shrinking characteristics are illustrated by a field test on Soil 7, horizon Lco. A block of moist soil $2.5 \times 4 \times 9.5$ cm was carved out and allowed to dry. When it was air dry it measured $1.3 \times 2 \times 4.8$ cm, representing 13% of the original volume.

Discussion

Coprogenous earth is defined in Soil Taxonomy (Soil Survey Staff, 1975) as a limnic layer that

(1) Contains many fecal pellets a few hundredths to a few tenths of a millimeter in diameter; (2) Has a color value, moist, < 5 ; (3) Either forms a slightly viscous water suspension and is slightly plastic but not sticky or shrinks upon drying to form clods that are difficult to rewet and that often tend to crack along horizontal planes; (4) Is normally but not necessarily nearly devoid of fragments of plants that can be recognized with the eye; and (5) Yields a saturated sodium pyrophosphate extract on white filter paper that has higher color value and lower chroma than 10YR 7/3 or the cation exchange capacity is < 240 meq per 100g of organic matter (measured by loss on ignition) or both.

These layers have a range in particle size and a C-N ratio (12 to 20) that are consistent with advanced decomposition. They have both a low and a narrow range in cation-exchange capacity

(80 to 240) meq per 100g of organic matter by loss on ignition which indicates little decomposition influenced by exposure to air. In places these layers show a platy structure. Olive or olive brown colors of organic layers of organic soils are characteristic of coprogenous earth layers. The common colors are Munsell hues 2.5Y or 5Y, values of 3 or 4, and chroma of 2.

The horizons designated Lco meet the field-identifiable parts of the definition of coprogenous earth. The three horizons observed with the microscope, however, vary greatly in their characteristics.

The Lco horizon of Soil 1 consists mainly of silt-size mineral particles carried into the lake from the watershed and mixed with organic materials.

Soil 2 consists mainly of CaCO_3 grains. It would qualify as marl in Soil Taxonomy except that its color (5Y 4/1) is darker than the required color value of 5 or more. The material below 176 cm would qualify as marl. Marl deposits consist of calcite precipitated by the photosynthetic activity of plants as they remove CO_2 or HCO_3^- from dissolved bicarbonates and of shells and shell fragments of snails (Ruttner, 1963). It is usually deposited in the shore zone of lakes rather than in deep water. In Soil 2 it appears that photosynthetic precipitation is the most important factor because of the small size of calcite particles and low content of shells.

Soil 7 has layers most like the definition of coprogenous earth. It contains some round, dark bodies, probably fecal pellets, but they did not comprise a large proportion of the material. It also has some of the characteristics of *gyttja* (Ruttner, 1963), namely the grayish-brown color and the elastic consistency.

From this limited number of microscope observations it appears that coprogenous earth includes a wide range in materials. Perhaps similar materials could be grouped together better if the definitions were modified. The definition of marl could be based on CaCO_3 content rather than color. Then horizons such as the Lco of soil 2 would be called marl instead of coprogenous earth. Because of the importance of the unique physical properties of layers such as the Lco of soil 7 they could be placed in a separate class using shrinking on drying as a differentiating characteristic. There still would be a need for a "catch-all" class to include materials that do not have distinctive characteristics, but this class could be defined so that it is less inclusive than the present coprogenous earth class.

Some materials identified as coprogenous earth have such low shear strengths when moist that they cannot support the weight of wheel tractors, and cattle may sink into them. We have observed that when they are plowed and allowed to dry the clods do not wet-up again very readily.

These properties present obvious problems for using coprogenous materials for growing crops or grazing. In cultivated areas, the thickness of the organic soil material over limnic sediments is being reduced gradually by compaction, oxidation, and wind erosion. In this study, estimates of subsidence since the areas were first drained range from

50 cm (20 inches) to 125 cm (50 inches). It is apparent that measures should be taken to preserve the organic soil overlying the coprogenous earth materials if the soils are to continue to be used for agriculture.

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