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This is to certify that the

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CHARACTERIZATION OF A CONOVER-BROOKSTON SOIL

MAPPING UNIT IN MONROE COUNTY, MICHIGAN

presented by

G. Hossein Asady

has been accepted towards fulfillment
of the requirements for

Master degree in Soil Sciences

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Major professor

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by
Dr. G. D. [illegible]

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CHARACTERIZATION OF A CONOVER-BROOKSTON SOIL MAPPING UNIT IN MONROE COUNTY, MICHIGAN

BY

G. Hossein Asady

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ABSTRACT

CHARACTERIZATION OF A CONOVER-BROOKSTON SOIL MAPPING UNIT IN MONROE COUNTY,MICHIGAN

BY

G. Hossein Asady

Field studies and laboratory determinations were conducted on 16 pedons within a tentative Conover-Brookston mapping unit in Monroe County,Michigan. The purpose of this study was to characterize and evaluate the major components of this mapping unit.

Field and laboratory data indicated that of the 16 pedons described in the field and sampled as Brookston and Conover,8 were truly representative of their series. Three were recognized as variants and 5 other pedons were identified as other soil series. These pedons covered the whole range of the fine-loamy family from borderline coarse loamy to borderline fine family. Only three pedons were evaluated as being developed in non-uniform parent material.

The pedons outside of the textural range of characteristics of the Brookston and Conover series varied significantly in other properties important to the use and management of these soils.

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I. INTRODUCTION AND OBJECTIVES OF THE STUDY

Brookston and Conover soil series are the poorly and somewhat poorly drained members of the Miami catena, respectively. These soils are formed under natural deciduous forest vegetation in a cool temperate, humid climate. The parent material is usually calcareous loam till and less commonly calcareous coarse clay loam till.

Brookston series, the poorly drained member of this catena, is formed in level areas of till or lake plain with a relatively high water table. The somewhat poorly drained member of this catena Conover, is formed in the upper parts of an undulating to nearly level till or lake plain with a seasonal fluctuation of water table.

The high water table is indirectly responsible for a higher than normal accumulation of organic materials in this mineral soil and the formation of a mollic epipedon in the Brookston series. Fluctuation of water table in the Conover pedons is responsible for formation of a thinner dark surface horizon which is not thick enough to qualify as a mollic epipedon, and is called an ochric epipedon. However, it is dark and thick enough to be a mollic intergrade. The humid climate has aided eluviation of silicate clays from the upper parts of the solum and illuviation of them into its lower parts with formation of an argillic horizon in both series.

The relatively thick layer of organic matter rich mineral, Ap horizons, their high base status, and the clay enriched subsoils have caused these soils to be fertile. However, the best productivity is conditioned by appropriate management, including drainage practices in the poorly drained member of the catena, to lower the natural water table.

By characterization of pedons we can determine and measure many of the physical, chemical, mineralogical, and biological properties of soils. These measurements can only be performed on a small unit of soil, a pedon, that is representative of a larger area. Characterization of soils may be resolved into two kinds of measurements; first, field observations by which many of the observable and measureable properties of a soil are determined, and second laboratory analyses that verify the accuracy of the field observations, quantify them, and determine some other soil properties as well.

During the 1978 mapping season in Monroe county, Michigan, the composition of a mapping unit tentatively named "Blount" indicated that it was more likely to be dominated by fine loamy (17 - 35% clay) rather than "fine" (35 - 42% clay) profiles. This mapping unit was then renamed T60 (Temporary 60).

This mapping unit was then transected (Figure 1) accompanied by Dr. E.P. Whiteside. It was found that from 30 point observations 27% were Conover, 27% were Brookston, 20% were Metamora, 13% were Celina, and 13% were other soil series, (1 observation of Corunna, Owosso, Pewamo, and Wasepi) each representing less than 5%. More observations done by the other members of the soil survey party also emphasized the necessity of renaming this unit. This percentage agreement of the series present with the name of the map unit is about the average observed to date in modern soil surveys of Michigan (E.P. Whiteside*).

In the light of these observations this mapping unit was tentatively named Conover-Brookston, and the author started describing, and sampling

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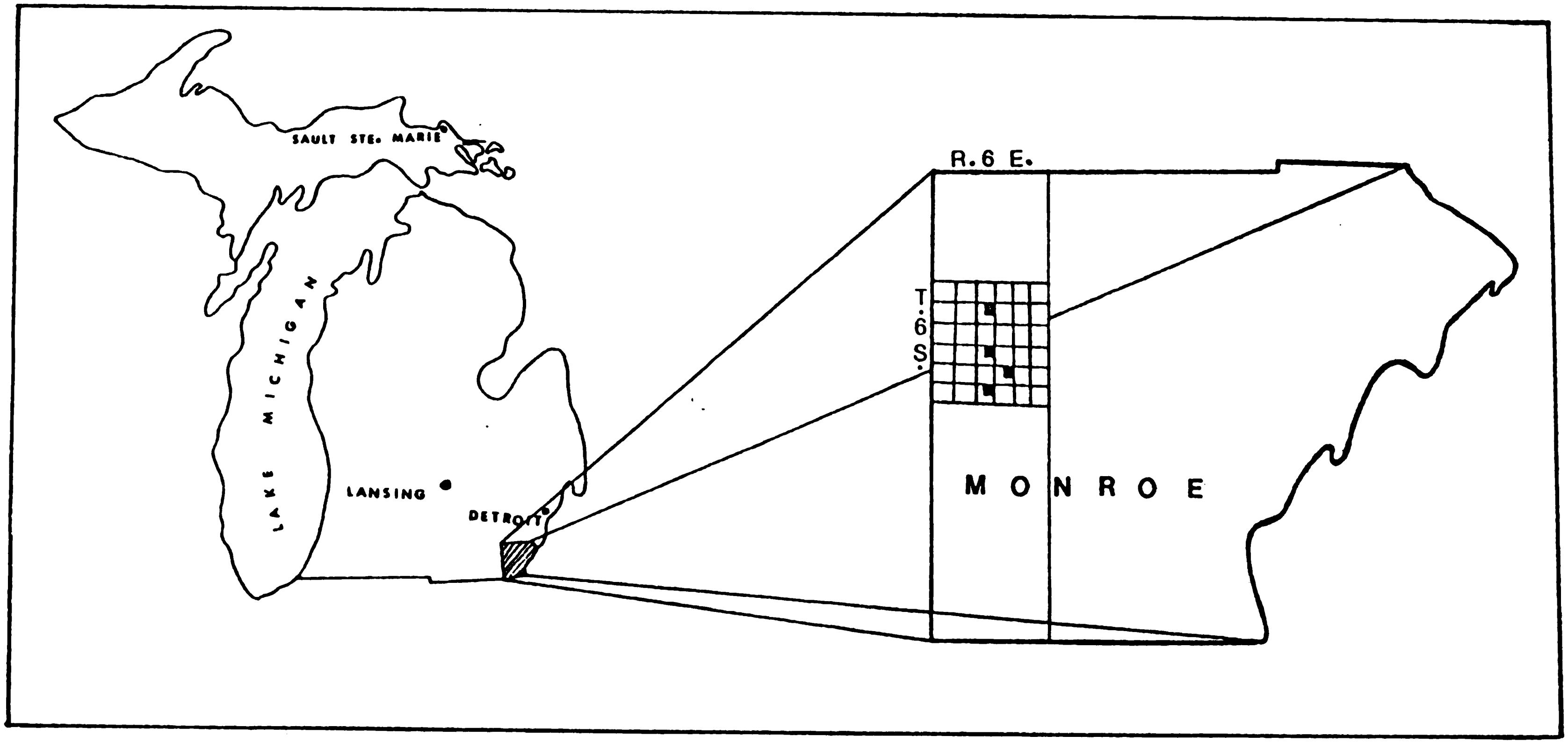
* Personal Communication



Location of transected areas

Figure 1

the representative pedons.

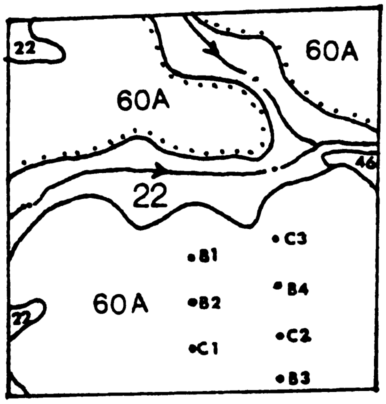
Finally, based on more observations in the context of the county, it was decided to name separate parts of this mapping unit Conover, Brookston, or Blount. Some parts of the first tentatively named "Blount" remained unchanged. The tentative Conover and Brookston pedons investigated in this study will be found in the following mapping units in the Monroe Co. soil survey report:

Tentative Brookston pedons sampled: B1, B2, B3, B4 and B5 appear in the Conover map unit (60 A), pedon B6 in the Brookston (61) and B7, B8 in the Blount (13 A) map unit (Figure 2).

Tentative Conover pedons sampled: All of the tentative Conover pedons are within the Conover map unit (60 A) except pedon C8 which is in the Blount (13 A) unit (Figure 2).

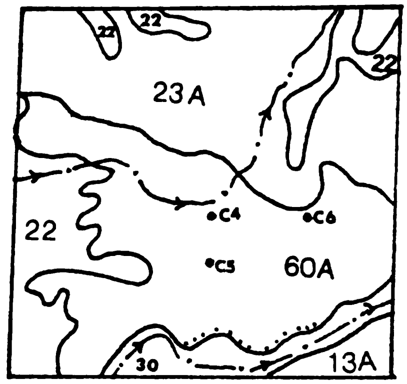
Characterization of the tentative Conover-Brookston mapping unit in Monroe county, Michigan, is the goal of this study. By characterization of these soils several objectives can be met to:

1. Aid soil scientists in correctly describing mapping units of soil in a particular area. The transects characterizing the map unit, in this case, are being evaluated by further characterizing the two principal soils present in the laboratory.
2. Determine quantitatively many of the physical and chemical properties of the soils required in agricultural planning and for other uses. (Many other soil management decisions are influenced by the knowledge of soil properties such as: soil moisture management, the amount and kind of fertilizer that should be used, the degree of stability of peds useful in management and mechanization practices, the mineralogy of



NE 1/4 of Sec. 9

T.6 S. R.6 E.



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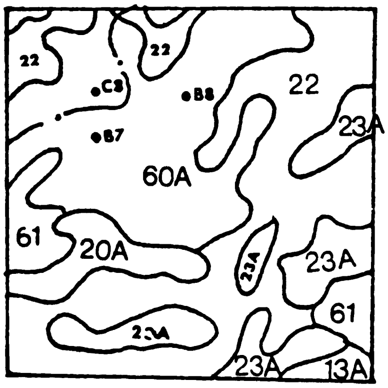

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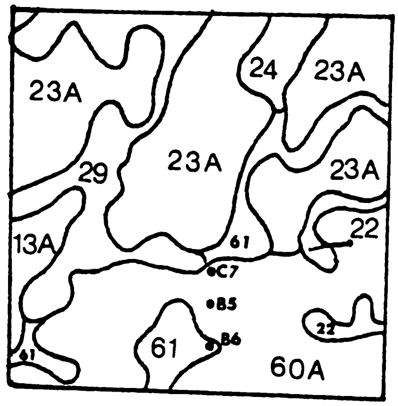
T.6 S. R.6 E.



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T.6 S. R.6 E.

Legend	
13 A	Blount loam 0-3% slope
20 A	Selfridge-Pewamo complex 0-2% slope
22	Pewamo clay loam
23 A	Metamora sandy loam 0-2% slope
24	Corunna sandy loam
29	Colwood loam
30	Sloan loam
46	Ceresco fine sandy loam
60 A	Conover loam 0-2% slope
61	Brookston loam
•B5 , •C2	Sampled pedons
—·→	Drainage way

Location of sampled pedons

Figure 2

particles which effects fixation or availability of macro- and micro-nutrients, and liming requirements.)

3. Assist in classifying the soils correctly.
4. Aid in determining the range of characteristics of the major soils within an area.
5. Determine parent material uniformity in major soils of the mapping unit.

This study was based upon the hypothesis that the Blount mapping unit would be more correctly termed Conover-Brookston, because most soils in the unit belong to the fine-loamy textural family instead of the fine textural family as is indicated by the Blount.

II. LITERATURE REVIEW

Franzmeier et al. (1977) have defined soil characterization as the determination and recording of important soil properties of a small soil unit that represents much larger soil bodies. It includes morphological properties, which are determined in the laboratory as well as those described in the field.

1. Brookston Series, and Its Classification

A. Placement in Soil Taxonomy:

The National Cooperative Soil Survey (1978) has classified the Brookston series as a member of the fine-loamy, mixed, mesic family of Typic Argiaquolls, which is a Mollisol having an argillic horizon, and an aquic moisture regime.

B. Mollisols:

Soil Taxonomy (Soil Survey Staff 1975) defines mollisols as soils having a combination of a very dark-brown to black surface horizon (mollic epipedon) that makes up more than one-third of the combined thickness of the A & B horizons or that is >25 cm thick, and that has structure or soft consistence when dry. Mollisols characteristically form under grass in climates that have moderate to pronounced seasonal moisture deficit. A few form under marshes or on marls in humid climates. The Brookston is one of those formed under marshy conditions.

C. Mollic epipedon:

From the genetic point of view Soil Taxonomy (Soil Survey Staff, 1975) defines the mollic epipedon as being formed mainly by the underground decomposition of organic residues in the presence of bivalent cations, particularly, calcium. Generally a mollic epipedon is a mineral diagnostic surface horizon which is at least 25 cm thick or at least 1/3 of solum thickness, and has a color value moist of 3.5 or less (dry color 5.5 or less), a chroma of 3.5 or less, and $>$50% base saturation.

D. Earlier profile descriptions of Brookston in Michigan:

Descriptions of series before 1938 used no standard color chart. Texture and structure terms were less standardized than today. The range of characteristics were much broader, especially in thickness of the dark surface horizon, and the texture of the surface and subsoils. The broader range in properties of earlier established soil series resulted in the later recognized series covering only part of those properties. The following profile descriptions indicate evolution of soil survey in selected counties in Michigan.

Berrien Co. soil survey report (Kerr, 1922) considers the Brookston series as having, typically a dark-gray loam surface, ranging from 7 to 12 inches in depth, underlain by heavy bluish or mottled yellow and gray clay loam. The substratum is heavy calcareous till.

In Ottawa Co. (Veatch, 1922) Brookston consists of a dark-gray fine-sandy loam surface from 6 to 15 inches in thickness which grades into lighter gray or gray and yellow mottled soil which may be either sandy-loam or clay loam in texture. This is underlain by bluish-gray clay exhibiting yellowish or brownish mottling.

Livingston Co. (Wheeting, 1923) soil survey report describes the Brookston series as consisting of a layer from 2 to 4 inches thick of leaf litter or mold the lower part of which is well decomposed. The surface layer of granular loam ranges from 8 to 12 inches in depth and varies in color from dark-gray to dark-grayish brown. There is a somewhat abrupt change into the subsoil. The texture becomes heavier, the structure becomes coarsely granular, with increasing clay content and the color is mottled brown, gray, and drab. It is mapped in association with Miami loam and Hillsdale loam.

In Hillsdale Co. (Veatch, 1924) the Brookston consists of a surface layer with dark-gray or dark-grayish brown loam from 6 to 10 inches deep. This grades to gray or drab, more coherent, and more clayey material which in turn grades to steel-gray or bluish-gray, more plastic or sticky sandy clay mottled with yellow or brown. The substratum consists of sandy clay or alternate thin layers of sand and clay.

Jackson Co. soil survey report (Veatch, 1926) considers the Brookston as having a surface layer of dark-gray loam, moderately rich in organic matter and from 6 to 10 inches thick grading into gray or drab more coherent and clayey material from 6 to 10 inches thick, beneath which is steel-gray or bluish-gray more plastic or sticky sandy clay mottled with yellow or brown. The substratum is clay or alternate thin layers of sand and clay.

In Lenawee Co. (Striker, et al. 1947) soils of the Brookston series are dark colored and poorly drained. They formed in glacial till consisting of loam or clay loam. They are in the same catena as the well drained Miami, the imperfectly-drained Conover and the very poorly-drained Kokomo soils. The Brookston soils have a thinner, lighter colored surface soil than the Kokomo, and the upper part of the subsoil is predominantely gray rather than mottled. They are coarser textured than the Pewamo.

After 1938, profile descriptions are more standardized, the range of characteristics of series are more limited, and new soil series have been established. The new soil survey of Livingston Co. (Engberg, et al. 1974, compared to the old one, Wheeting. 1923) describes the Brookston series as having a surface layer of very dark brown loam, 10 inches thick which has been developed in loam or light clay loam till. The upper part of the subsoil is dark-gray firm light clay loam that has dark yellow-brown and yellowish brown mottles. The underlying material consists of mottled-gray light olive-gray, dark-gray, and yellowish brown loam.

The thickness of the surface layer in the Brookston series was much broader than it is today. Such as; 7-12 inches (Berrien Co.), 6-15 inches (Ottawa Co.) 8-12 inches (Livingston Co.), 6-10 inches (Hillsdale Co. and Jackson Co.). With evolution of soil survey the range of characteristics became narrower, and the definitions became more standardized such as in the new Livingston County soil survey report (Engberg, 1974) the surface layer of the Brookston series is 10 inches thick. At the present time the surface layer of the Brookston series has to be at least 10 inches thick or 1/3 of the solum thickness (Soil Survey Staff, 1975).

The subsoil layers of the Brookston in Livingston Co. (1923) are somewhat heavier, and in some places are almost pure clay and silt. The substratum of clay or alternate thin layers of sand and clay has been described for the Brookston series in Jackson Co. (1926), and Hillsdale Co. (1924). These would now probably be Colwood or Lenawee series. In Ottawa Co. (1922) the subsoil texture of the Brookston ranges from sandy loam to clay loam.

By 1974 Brookston was described more narrowly in the new Livingston Co. soil survey, with 10 inches of dark surface, a clay loam subsoil, and a loam C horizon. In Lenawee Co. (1947) the C horizon is restricted to glacial till of loam or light clay loam textured, and Pewamo was recognized for the part of the former finer range of Brookston textures.

The drained Brookston soil is mentioned to yield average 40 bushels per acre corn, ½ ton timothy hay, and 20-35 bushels of oats in Berrien County (1922). Excellent yeilds of corn, hay, oats, alfalfa, and sugar beets are reported for the Brookston when properly drained in Hillsdale County (1924). In Lenawee County (1947) all of the crops commonly grown in the county are grown on the Brookston loams, and yields are usually high. The available water holding capacity, and fertility of the Brookston soils are said to be high and well suited to farming particularly to row crops. However, they have severe limitations for many non-farm uses in Livingston County (1974).

2. Conover Series and Its Classification

A. Placement in Soil Taxonomy:

The National Cooperative Soil Survey (1978) has classified the Conover soil series as a member of the fine loamy, mixed,mesic, family of Udollic Ochraqualfs. Thus, it is an alfisol with an aquic moisture regime.

B. Alfisols:

Soil Taxonomy (Soil Survey Staff, 1975) defines Alfisols as having unique properties of a combination of an Ochric or an Umbric epipedon, an argillic horizon, a medium to high supply of bases in the soil and water available to mesophytic plants more than half the year or more than three consecutive months during a warm season.

Buol, et al. (1973) identify two prerequisites for formation of alfisols: (1) a moderate abundance of a layer lattice clay, and (2) its accumulation in the subsoil enough to produce an argillic horizon.

C. Argillic horizon:

Soil Taxonomy (Soil Survey Staff, 1975) considers an argillic horizon as an illuvial horizon in which layer-lattice silicate clays have accumulated by illuviation to a significant extent.

In addition the following properties have been considered in identifying an argillic horizon:

(1) If there is no lithologic discontinuity;

a) if the eluvial horizon has $<$ 15% total clay, the argillic horizon has to have 3% more clay.

b) if the eluvial horizon has 15 to 40% clay, the argillic horizon should have 1.2 times as much clay as the eluvial horizon.

c) if the eluvial horizon has $>$ 40% clay, the argillic horizon must have 8% more clay.

(2) If a soil has a lithologic discontinuity, between the eluvial and the argillic horizon or if only a plow layer overlies the argillic horizon, the argillic horizon needs to have clay skins in only some parts.

(3) An argillic horizon should be at least 1/10 as thick as all overlying horizons.

(4) The ratio of fine clay to total clay must be more in the argillic horizon by 1/3 or more.

G.D. Smith (1978) considers an argillic horizon as a mark of the stability of the land surface for a reasonably long period of time, a matter of not hundreds but probably a few thousands or more of years.

Thorp et al., (23) concluded from comprehensive investigation of a Miami soil that eluviation of clay from the A horizons and illuviation in the B2 horizons account for most of the differences in clay content of these two horizons.

Mickelson (23) on the other hand concluded from weathering studies of a Miami soil that little if any clay has been translocated from the surface to the subsoil even when considerable quantities of clay had been lost from the A horizons.

According to H. Smith (24) the fine clay ratio has the advantage of being a more sensitive index of clay movement and is less likely to be confounded by carbonates. Alternatively the total clay ratio (carbonate - free) could serve as an argillic horizon differentia and would have the advantage of being more widely available.

D. Earlier profile descriptions of Conover in Michigan:

Livingston Co. soil survey report (Wheeting, 1923) describes Conover series as consisting of: (1) forest litter and leaf mold 2 or 3 inches thick, (2) dark grayish-brown friable loam, 3 or 4 inches thick, which contains considerable organic matter near the top, (3) grayish-yellow loam, from 7 to 10 inches thick, which is not so friable as the material of the layer above, because of its lack of organic matter, (4) sticky, somewhat plastic clay loam, mottled with gray, brown, and yellow. Conover loam was developed under poor drainage conditions.

In Jackson Co. (Veatch, 1926) Conover loam is a moderately heavy soil which has developed under drainage conditions intermediate between those in the Miami and Brookston soils. The surface soil is brownish mellow loam with a dark or humus color to a depth of 4 to 5 inches. This is underlain by pale-yellow or grayish friable loam which gives way, at a depth ranging from 12 to 15 inches, to moderately compact granular clay showing grayish and yellowish mottling.

Lenawee Co. soil survey (Striker, et al. 1947) has described Conover series as consisting of imperfectly drained, moderately dark colored soils that are nearly level to very gently sloping. The soils have formed in highly calcareous glacial till of medium texture. These soils are in the same catena as the well drained Miami, the poorly to very poorly drained Brookston, and the very poorly drained Kokomo soils. The texture of the surface layer ranges from light clay loam to heavy sandy loam.

Conover series in Macomb Co. (Larson, 1971) are level to gently sloping, somewhat poorly drained, medium textured soils on moraines and glacial till plains. These soils developed in loamy glacial till and are less than 42 inches deep to carbonates. The surface layer of a typical Conover is dark brown loam about 8 inches thick. The subsurface layer, about 4 inches thick, is pale-brown friable loam that contains mottles of brownish yellow. The subsoil is brown and grayish brown, firm clay loam, and is mottled with brownish yellow and grayish brown. The substratum is brown, friable, calcareous loam till with mottles of brownish yellow.

In Livingston Co. soil survey report (Engberg, 1974) Conover series is described as soils developed on till plains and in basin like depressions in the hilly moraines. Included with this soil in mapping are some small areas that have a heavy silty clay loam subsoil. Also included are small areas of Metea and Metamora soils that are coarser textured in the surface layer and upper part of the subsoil than Conover soil. Poorly drained Brookston soils and very poorly drained Carlisle soils are included in small, wet, depressional areas.

As mentioned before, in the earlier soil survey reports of Michigan, no standard definitions have been used to describe the soil series. The colors are described as gray, dark-gray, bluish-gray, yellowish-brown, light olive-gray, light-olive-brown, steel-gray, drab and so forth.

The surface layer of the Conover series is 3 to 4 inches of loam overlain by 2 to 3 inches of forest litter and leaf mold, and underlain by clay loam in Livingston County (1923). In Jackson County (1926) Conover soil has 4 to 5 inches of dark surface, and in Macomb County (1971) the surface layer is about 8 inches thick.

In the 1947 Lenawee Co. soil survey, the Conover series has formed in highly calcareous glacial till of medium texture and the finer texture Conover were replaced by Blount series. In Livingston Co. (1974) Conover loam is mentioned as being formed on till plains and in basin like depressions.

In the 1974 Livingston Co. soil survey report, the variability of the Conover soils in the mapping units, that in the earlier soil survey report may have been included as variations in the series, is clearly recognized as inclusions of other series (Blount, Metea, Metamora, and Carlisle).

The Conover series was developed under poor drainage conditions in Livingston Co. (1923). In Jackson Co. (1926) Conover developed under drainage conditions intermediate between those in the Brookston and Miami soils. The Conover series consists of imperfectly drained, moderately dark colored surface in Lenawee Co. (1947). By 1971 the definition of drainage condition had been changed to somewhat poorly drained in Macomb Co. (Larson, 1971). Actually a moderately well drained soil Celina, had also been recognized in the Miami catena (see Ionia Co. Threlkeld et al. 1960). The practical significance of these soils also changed with time and technology.

The Conover is easily tilled and is suited to general farming, including the growing of corn, oats, hay, and sugar beets. In Macomb County (1971) the Conover soils have high natural fertility, moderately slow permeability, slow to medium runoff and moderate infiltration. In Livingston County (1974) the principle concern of management is maintaining adequate drainage. In Lapeer County (Earle, 1972) most of the Conover soils are farmed intensively, and corn, sugar beets, small grain, and forage crops are suitable crops.

III. HOW THIS STUDY WAS CONDUCTED

This investigation consisted of two parts: 1. Field studies and 2. Laboratory analyses.

1. Field Studies

Field studies included:

A. Selecting the sites, and describing the soils at these sites.

B. Sampling

A. Selecting the sites, and describing the soils:

Site selection is one of the most important aspects of sampling that should be considered (11). Site selection varies with the objectives of the study. In this investigation to represent a soil mapping unit of the Monroe County, Michigan, soil survey area, transects of the tentative Conover-Brookston mapping unit were made with supplemental pedon descriptions to find the most representative pedons in the mapping unit. Eight Conover and eight Brookston pedons, which were the most representative soils comprising 53% of the tentative map unit, were chosen to be described and sampled.

B. Sampling:

From each pedon two samples were taken. One from the surface horizon or Ap, and another from the control section or B2 (the control section is subject to definition of control sections for particle size classes or their substitutes in Soil Taxonomy (26). The samples were air dried and passed through a 2 mm round hole sieve.

2. Laboratory Procedures

A. Physical determinations:

a) Mechanical analyses:

The pipette method of mechanical analyses was used to separate the less than 2 mm soil particles. The following modified method of analysis was employed:

25 grams of air dry fine earth, <2 mm, was mixed with 50 ml distilled water, treated with 10 ml of 30% hydrogen peroxide (H_2O_2), and left standing overnight. The next day, it was heated to about 90°C with additional 5 ml increments of 30% H_2O_2 until all organic matter was removed. The process of heating was continued for about an hour to be sure all excess H_2O_2 was removed. Because the samples were taken from A and B horizons, and free carbonates were not present, the samples were not treated with acid.

For dispersion of particles the samples were treated with 25 ml of 5% calgon solution. The calgon solution treated samples were left overnight, and then stirred with a mechanical stirrer (milk shake type) for 15 minutes. (In a technical note titled an "Investigation of methods of mechanical analysis" by R. Laurin, 1975, good agreement was obtained between two methods of mechanical agitation; a mechanical stirrer (milk shake type) and a reciprocating shaker. So the mechanical stirrer which is less time consuming was employed.). The other processes of measuring sand, silt, and clay percentages were based on standard methods (25, 29, 15, 8). The results reported are averages of duplicate determinations. Following the above analyses the percentages of fine clay ($<$ 0.2 micron) were also determined using an aliquot of the restirred suspensions as described above.

It should be noted that for the purpose of setting a standard procedure for this investigation, some preliminary experiments were also conducted on several treatments of samples. One group was treated with calgon solution, after destruction of organic matter, filtered through a No. 50 Whatman filter paper, and then washed with distilled water (Treatment I). A second group was treated with calgon solution immediately after organic matter destruction (Treatment II). No significant differences were observed (see Tables 1 and 2). So all the samples were subsequently treated with calgon solution, after organic matter destruction, without being filtered or washed.

Two levels of calgon solution were also compared in sample dispersion; 25 ml and 50 ml. The results showed no differences (Table 2), so the smaller amount was used subsequently.

b) Fine-clay determination:

Various clay fractions less than 2 micron ($<$.002 mm) have previously been employed for soil characterization. Separations have been made by long setting or centrifugation (13). A centrifuge is commonly employed for the purpose of increasing the gravitational force, and hence the rate of particle sedimentation, which becomes important in the separation of small clay size particles.

After sampling of silt and total clay in the pipette method of mechanical analysis, a 25 ml portion of the suspension was transferred to a centrifuge tube. The time required for 0.2 μ particles to get to the point of sampling, 2.0 cm beneath the suspension surface, was calculated using Stoke's law (27) at the appropriate temperature:

$$t = \frac{\eta \log \left(\frac{R2}{R1} \right)}{3.81 \, N^2 \, r^2 \, (d1 - d2)}$$

Table 1: Observed size distributions of samples filtered or not filtered, after destruction of organic matter.

Treatments	Soils	% clay <.002 mm	% f. silt .002-.02 mm	% co. silt .02-.05 mm	% sand .05-2.0 mm	Total
I Filtered	B1-1	33.6	32.5	16.0	17.9	100.0
	B1-2	35.5	33.6	16.2	14.7	100.0
	C1-1	13.8	16.3	9.6	60.3	100.0
	C1-2	18.9	13.4	6.7	60.9	99.9
II Unfiltered	B1-1	33.7	32.5	15.2	18.6	100.0
	B1-2	35.6	34.1	13.4	16.9	100.0
	C1-1	13.8	16.0	8.2	61.9	99.9
	C1-2	19.5	12.5	6.8	61.2	100.0
Average	B1-1	33.6	32.5	15.6	18.3	100.0
	B1-2	35.6	33.8	14.8	15.8	100.0
	C1-1	13.8	16.1	8.9	61.1	99.9
	C1-2	19.2	12.9	6.7	61.1	99.9

Table 2: Observed size distributions, including fine clay, when 25.0 or 50.0 ml of calgon solution are used without and with filtering after organic matter destruction.

Treatments	Soils	% f. clay <.0002 mm	% clay <.002 mm	% f. silt .002-.02 mm	% co. silt .02-.05 mm	% sand .05-2.0 mm	Total
I 25 ml. cal. +filtered	B1-1	16.0	34.2	31.3	*	*	*
	C1-1	6.2	13.9	15.9	7.8	62.4	100.0
II 25 ml. cal. +unfiltered	B1-1	15.8	34.0	32.0	16.1	17.9	100.0
	C1-1	6.5	14.6	15.7	9.1	60.6	100.0
III 50 ml. cal. +unfiltered	B1-1	16.3	34.7	30.7	17.6	17.0	100.0
	C1-1	7.1	15.4	15.7	7.6	61.3	100.0
Average	B1-1	16.0	34.3	31.3	16.8	17.5	99.9
	C1-1	6.6	14.6	15.8	8.2	61.4	100.0

* missed data

in which:

t = time of sampling in seconds

η = liquid viscosity in poise (temperature dependent)

R1 = distance from the axis of rotation to the surface of suspension in cm

R2 = distance from the axis of rotation to the sampling depth in cm (R1 + 2.0 cm)

N = the number of revolutions per second which was 36.66 rps. (or 2200 rpm.)

r = radius of particles in cm

d1 = particle density = 2.65 g/cm^3

d2 = liquid density in g/cm^3 (temperature dependent)

An International centrifuge was used, with a head carrying four 100 ml tubes. Each tube contained 25 ml of suspension. The $< .2\ \mu$ pipette sample, removed by an automatic pipette, was 5 ml from a depth of 2 cm at a time calcuated by the above equation.

c) One-third atm. and 15 atm. water retension:

Less than 2 mm soil samples were placed in soil retaining rings about 1 cm high and 4 cm diameter on a porous plate. The plate was then covered with water to wet the samples from below, and left standing overnight. The excess water was removed and the plates were placed in a pressure cooker for 1/3 atm. water extraction and in a pressure membrane apparatus for 15 atm. water extraction. The required pressure was applied until no additional water was extracted. The samples were then oven dried at 105^{o}C and moisture percentages were computed on an oven dry basis (25, 29). In this study results are average of at least 5 determinations.

B. Chemical determinations

a) pH

Five grams of air dry soil were mixed with 5 ml of distilled water in a cup. This was shaken for 5 minutes, left standing for 10 minutes, and the pH was read with the use of a glass electrode (indicating) paired with a calomel (reference) electrode, and plugged into a reasonably good commercial pH meter. With proper standardization of the meter and using a buffer of known pH, the pH of the soil suspended in water or 0.01 M $CaCl_2$ is indicated by the voltage generated between the two electrodes (19).

b) Lime requirements

The method by Shoemaker, McLean, and Pratt, (SMP method) was used. Ten ml of SMP buffer solution were added to the soil samples saved from the pH measurements. This was shaken for 10 minutes and left standing 30 minutes before reading the pH (19).

c) Extractable phosphorus

The Bray-1 soil test method for phosphorus was used. Extractable phosphorus was measured by a colorimetric method (16).

d) Extractable potassium, calcium, and magnesium

Extractable cations were removed from the soil with 1 N NH4OAc, pH 7, with a 1:8 soil:solution ratio and a contact time of 5 minutes. The soil extract is diluted by a factor of 15 with a lanthanum solution (final concentration 1500 ppm La). The determination of K, Ca, and Mg was completed on a Perkin-Elmer 290 Atomic Absorption Spectrometer (37).

e) Organic matter

The organic matter was calculated from the organic carbon content (1.724 x O.C.). Organic carbon (O.C.) was determined by a dry combustion method using an automatic carbon analyser (1).

f) CEC and base saturation

The cation exchange capacity was determined by saturating the exchange complex with ammonium ions (1N NH_4OAc, pH 7), and extracting the absorbed ammonium. Saturation was achieved through repeated shaking and centrifuging 2 grams of soil with 20 ml of 1N ammonium acetate, pH 7. The samples were washed 3 times each with 15 ml isopropyl alcohol after through mixing and centrifuging and then transferred to distillation flasks with acidic 10% NaCl solution.

The absorbed ammonium was determined by direct steam distillation, Kjeldahl method (13, 25, 11, and 5).

The percentage of base saturation was computed as follows:

$$B.S. = \frac{Ca^{++} + Mg^{++} + K^{+}}{CEC} \times 100$$

IV. PROFILE DESCRIPTIONS

The texture and reaction, in the profile descriptions, of pedons sampled within a tentative Conover-Brookston mapping unit were corrected below based on laboratory data.

The new soil series or variants, different from Conover and Brookston, were identified in the light of the laboratory data.

1. Tentative Brookston Pedons Sampled

Pedon B1: Pella Series

Classification: fine-silty (borderline to fine), mixed, mesic, family of Typic Haplaquolls.

Location: 1320 ft. W. 1725 ft. S. of NE corner of Sec. 9, T.6S.-R.6E. Dundee Twn. Monroe Co. Michigan.

Horizon	Depth cms	Description
Ap	0-30	Very dark grayish brown (10 YR 3/2), grayish brown 10 YR 5/2 dry) dry; silty clay loam; moderate, medium, granular structure; firm; less than 5% coarse fragments; many fine roots; neutral to mildly alkaline; abrupt, smooth, boundary.
B21g	30-101	Gray (10 YR 5/1) with common, fine, distinct, yellowish brown (10 YR 5/6 & 5/8) mottles; silty clay loam; moderate, fine, angular blocky structure; firm; mildly alkaline; gradual, wavy boundary.
B22g	101-152	Gray (10 YR 5/1) with common, medium, distinct dark yellowish brown (10 YR 4/6) mottles; silty clay loam; moderate, fine, angular blocky structure; firm; mildly alkaline; gradual wavy, boundary.

C	152+	Brown (10 YR 5/3); silty clay loam; structureless, massive; friable to firm; moderately alkaline to calcareous.

Pedon B2: Brookston Series

Classification: fine-loamy, mixed, mesic, family of Typic Argiaquolls.

Location: 1320 ft. W.2060 ft. S. of NE corner of Sec. 9, T.6S.-R.6E. Dundee Twn. Monroe Co. Michigan.

Horizon	Depth cms	Description
Ap	0-28	Very dark grayish brown (10 YR 3/2), grayish brown (10 YR 5/2) dry; sandy clay loam to loam; weak, medium, granular structure; friable; many roots; slightly acid; abrupt, smooth, boundary.
II B2gt	28-76	Gray (10 YR 5/1) with common, fine, distinct, yellowish brown (10 YR 5/6) mottles; clay loam; moderate, medium subangular blocky structure; thin layers of brown (10 YR 4/4) clay skins on ped faces; firm; mildly alkaline; clear, wavy boundary.
II B3g	76-127	Gray (10 YR 6/1) with common, fine, distinct, yellowish brown (10 YR 5/6) mottles; clay loam; moderate, medium, subangular blocky structure; firm; moderately alkaline; gradual, wavy boundary.
II C	127-140	Brown (10 YR 5/3); loam; structureless, massive; friable; moderately alkaline to calcareous, moderately effervescent.

Pedon B3: Barry-variant (no argillic horizon, borderline coarse loamy)

Classification: fine-loamy, mixed, mesic, family of Typic Haplaquolls.

Location: 660 ft. W. 2640 ft. S. of NE corner of Sec. 9, T.6S.-R.6E. Dundee Twn. Monroe Co. Michigan.

Horizon	Depth cms	Description
Ap	0-28	Very dark grayish brown (10 YR 3/2), grayish brown (10 YR 5/2) dry; fine sandy loam; coarse, granular structure; friable; less than 5% coarse fragments; many roots; slightly acid; abrupt, smooth, boundary.
B1g	28-38	Dark gray (10 YR 4/1) with common, fine, faint, grayish brown (10 YR 5/2) mottles; sandy loam; weak, coarse, subangular blocky structure; friable; common, fine, roots; slightly acid; clear, wavy boundary.
B2g	38-76	Gray (10 YR 5/1) with common, medium, distinct, yellowish brown (10 YR 5/6 & 5/8) mottles; fine sandy loam; moderate, medium, subangular blocky structure; friable; neutral, clear, wavy, boundary.
B3g	76-127	Gray (10 YR 6/1) with common, medium, distinct, yellowish brown (10 YR 5/8) mottles; sandy loam; moderate, medium, subangular blocky structure; friable; mildly alkaline; gradual, wavy, boundary.
Cg	127-140+	Light brownish gray (10 YR 6/2) with common, medium, distinct olive-yellow (2.5 YR 6/8) mottles; sandy loam; structureless, massive; friable; moderately effervescent, calcareous.

Pedon B4: Brookston Series

Classification: fine-loamy, mixed, mesic, family of Typic Argiaquolls.

Location: 660 ft. W. 1980 Ft. S. of NE corner of Sec. 9, T.6S.-R.6E. Dundee Twn. Monroe Co. Michigan.

Horizon	Depth cms	Description
Ap	0-23	Very dark grayish brown (10 YR 3/2), grayish brown (10 YR 5/2) dry; loam; moderate, medium, granular structure; friable; many roots; medium acid; abrupt, smooth, boundary.
A12	23-38	Very dark brown (10 YR 3/2) with common, fine, faint, dark gray (10 YR 4/1) mottles; loam; moderate, medium, granular structure; friable; many roots; medium acid; clear, wavy, boundary.
B21tg	38-63	Gray (10 YR 6/1) with many, medium, distinct, yellowish brown (10 YR 5/6 & 5/8) mottles;loam to clay loam; moderate, medium, subangular blocky structure; clay skins on ped faces; friable to firm; neutral; clear, wavy, boundary.
B22tg	63-81	Gray (10 YR 6/1) with few, fine, distinct, yellowish brown (10 YR 5/8) mottles; loam; moderate, medium, subangular blocky structure; clay skins on ped faces; friable; neutral; gradual, wavy, boundary.
B3g	81-106	Gray (10 YR 6/1) with few, fine, distinct, yellowish brown (10 YR 5/8) mottles; loam; weak, medium, subangular blocky structure; friable; mildly alkaline; gradual, wavy, boundary.
Cg	106-127	Light brownish gray (10 YR 6/2) with few, fine, faint, yellowish brown (10 YR 5/6) mottles; loam; structureless, massive; friable; moderately effervescent, calcareous.

Pedon B5: Brookston

Classification: fine-loamy, mixed, mesic, family of Typic Argiaquolls.

Location: 2150 ft. S. 1300 ft. w. of NE corner of Sec. 27, T.6S.-R.6E. Dundee Twn. Monroe Co. Michigan.

Horizon	Depth cms	Description
Ap	0-30	Very dark grayish brown (10 YR 3/2), grayish brown (10 YR 5/2) dry; loam; moderate, medium, granular structure; many fine roots; friable; neutral; abrupt, smooth, boundary.
A3g	30-46	Dark grayish brown (10 YR 4/2) with common, fine, distinct, yellowish brown (10 YR 5/6) mottles; loam; moderate, medium, subangular blocky structure; many fine roots; friable; neutral; clear, wavy, boundary.
B2tg	46-91	Gray (10 YR 6/1) with common, fine, distinct, yellowish brown (10 YR 5/6) mottles; clay loam; moderate, medium, subangular blocky structure; firm; clay skins on ped faces; mildly alkaline; clear, wavy, boundary.
Cg	91-101	Light brownish gray (10 YR 6/2) with common, fine, distinct, yellowish brown (10 YR 5/6) mottles; loam; structureless, massive; friable; calcareous, moderately effervescent.

Pedon B6: Brookston-variant

Classification: fine-loamy, mixed, mesic, family of Typic Haplaquolls.

Location: 2480 ft. S. 1300 ft. W. of NE corner Sec. 27, T.6S.-R.6E. Dundee Twn. Monroe Co. Michigan.

Horizon	Depth cms	Description
Ap	0-28	Very dark grayish brown (10 YR 3/2), grayish brown (10 YR 5/2) dry; loam to clay loam; weak, coarse, granular structure; firm; cloddy when dry; many root channels and worm castings; mildly alkaline; abrupt, smooth boundary.
B2g	28-76	Gray (10 YR 5/1) with common, medium, distinct, yellowish brown (10 YR 5/4 & 5/6) mottles; loam; moderate, medium, subangular blocky structure; firm; mildly alkaline; clear, wavy, boundary.
C1	76-101	Brown (10 YR 5/3); loam; weak, medium, subangular blocky structure; friable to firm; slightly effervescent, calcareous; gradual, wavy, boundary.
C2	101-127+	Brown (10 YR 5/3); loam; structureless, massive; friable to firm; some pebbles, $<$ 5%; moderately effervescent, calcareous.

Pedon B7: Brookston-variant

Classification: fine-loamy, mixed, mesic, family of Typic Haplaquolls.

Location: 1980 ft. W. 990 ft. S. of NE corner of Sec. 33, T.6S.-R.6E. Dundee Twn. Monroe Co. Michigan.

Horizon	Depth cms	Description
Ap	0-30	Very dark grayish brown (10 YR 3/2), grayish brown (10 YR 5/2) dry; clay loam; moderate, coarse, granular structure; friable to firm; many fine roots; less than 5% pebbles; slightly acid; abrupt, smooth, boundary.
B21g	30-46	Dark gray (10 YR 4/1) with few, medium, distinct,

		yellowish brown (10 YR 5/6) mottles; clay loam; moderate, fine, subangular blocky structure; firm; neutral; clear, wavy, boundary.
B22g	46-91	Gray (10 YR 5/1) with common, fine, distinct, yellowish brown (10 YR 5/6) mottles; clay loam; moderate, fine, subangular blocky structure; firm; neutral; gradual, wavy boundary.
B3g	91-104	Gray (10 YR 5/1) with common, fine, distinct, yellowish brown (10 YR 5/6) mottles; clay loam to loam; weak, fine, subangular blocky structure; friable to firm; mildly alkaline; gradual, wavy, boundary.
Cg	104-122+	Gray (10 YR 5/1) with common, fine, distinct, yellowish brown (10 YR 5/6) mottles; loam; structureless, massive; compact; friable; less than 5% pebbles; moderately effervescent, calcareous, some white color, strongly effervescent spots.

Pedon B8: Brookston Series

Classification: fine-loamy, mixed, mesic, family of Typic Argiaquolls.

Location 1320 ft. W. 660 ft. S. of NE corner of Sec. 33, T.6S.-R.6E. Dundee Twn. Monroe Co. Michigan.

Horizon	Depth cms	Description
Ap	0-25	Very dark grayish brown (10 YR 3/2), grayish brown (10 YR 5/2) dry; loam; moderate, coarse, granular structure; friable; many fine roots; neutral; abrupt, smooth, boundary.
B21tg	25-51	Grayish brown (10 YR 5/2) with common, fine, distinct, yellowish brown (10 YR 5/4) mottles; clay loam; moderate,

		medium, subangular blocky structure; firm; a few organic dark spots; mildly alkaline; clay skins on ped faces; gradual, wavy, boundary.
B22tg	51-127	Grayish brown (10 YR 5/2) with many, medium, distinct, yellowish brown (10 YR 5/6 & 5/8) mottles; clay loam; moderate, medium, subangular blocky structure; firm; clay skins on ped faces; mildly alkaline; clear, wavy, boundary.
Cg	127-140+	Grayish brown (10 YR 5/2) with few, fine, distinct, yellowish brown (10 YR 5/6) mottles; loam to clay loam; structureless, massive; compact; friable to firm; moderately effervescent, calcareous.

2. Tentative Conover Pedons Sampled

Pedon C1: Locke Series

Classification: fine-loamy, mixed, mesic, family of Aquollic Hapludalfs.

Location: 1320 ft. W. 2390 ft. S. of NE corner of Sec. 9, T.6S.-R.6E. Dundee Twn. Monroe Co. Michigan.

Horizon	Depth cms	Description
Ap	0-23	Very dark grayish brown (10 YR 3/2), grayish-brown (10 YR 5/2) dry; fine sandy loam; weak, coarse, granular structure; friable; less than 5% coarse fragments; slightly acid; abrupt, smooth, boundary.
B21t	23-66	Brown (10 YR 5/3) with common, fine, distinct, yellowish brown (10 YR 5/6) and grayish brown (10 YR 5/2) mottles; fine sandy loam; moderate, medium, subangular blocky structure; friable to firm; clay skins on ped faces; neutral; clear, wavy, boundary.

B22tg	66-76	Gray (10 YR 5/1) with common, medium, distinct, yellowish brown (10 YR 5/6) mottles; sandy clay loam; dark-brown (7.5 YR 4/4) clay skins on ped faces; weak, fine, subangular blocky structure; firm; neutral; gradual, wavy, boundary.
Cg	76-114+	Gray (10 YR 5/1) with few, medium, distinct, yellowish brown (10 YR 5/6) mottles; sandy loam; structureless, massive; fraible; calcareous, strong effervescence.

Pedon C2: Locke Series

Classification: fine-loamy, mixed, mesic, family of Aquollic Hapludalfs.

Location: 660 ft. W. 2310 ft. S. of NE corner of Sec. 9, T. 6S.-R.6E. Dundee Twn. Monroe Co. Michigan.

Horizon	Depth cms	Description
Ap	0-20	Very dark grayish brown (10 YR 3/2), grayish-brown (10 YR 5/2) dry; fine sandy loam; weak, medium, granular structure; friable; many fine roots; neutral; abrupt, smooth, boundary.
A2	20-36	Pale brown (10 YR 6/3); loamy fine sand; structureless, single grain; very friable; neutral; abrupt, wavy, boundary.
B2t	36-66	Brown (10 YR 5/3) with common, fine, distinct, gray (10 YR 6/1) mottles; fine sandy loam to sandy clay loam; weak, medium, angular blocky structure; firm; clay skins on ped faces; mildly alkaline; gradual, wavy boundary.
Cg	66-114+	Grayish-brown (10 YR 5/2); sandy loam; weak, medium, platy structure; somewhat compact, friable; calcareous, strong effervescence.

Pedon C3: Conover Series

Classification: fine-loamy, mixed, mesic, family of Udollic Ochraqualfs.

Location: 660 ft. W. 1650 ft. S. of NE corner of Sec. 9, T.6S.-R.6E. Dundee Twn. Monroe Co. Michigan.

Horizon	Depth cms	Description
Ap	0-18	Very dark grayish-brown (10 YR 3/2), grayish brown (10 YR 5/2) dry; fine sandy loam; moderate, coarse, granular structure; friable; many worm castings visible; neutral; abrupt, smooth, boundary.
B2t	18-64	Yellowish brown (10 YR 5/4) with common, fine, distinct, grayish brown (10 YR 5/2) and yellowish brown (10 YR 5/8) mottles; sandy clay loam; moderate, medium, subangular blocky structure; firm; clay skins on ped faces; many root channels visible; mildly alkaline; gradual, wavy, boundary.
Cg	64-114+	Gray (10 YR 6/1) with common, medium, distinct, yellowish brown (10 YR 5/6) mottles; loam; structureless, massive; friable to firm; calcareous, strong effervescence.

Pedone C4: Conover Series

Classification: fine-loamy, mixed, mesic, family of Udollic Ochraqualfs.

Location: 1490 ft. S. 1320 ft. W. of NE corner of Sec. 21, T.6S.-R.6E. Dundee Twn. Monroe Co. Michigan.

Horizon	Depth cms	Description
Ap	0-20	Very dark grayish brown (10 YR 3/2), grayish brown (10 YR 5/2) dry; loam; moderate, coarse, granular structure; friable; neutral; abrupt, smooth, boundary.
B1	20-38	Brown to dark brown (10 YR 4/3) with few, fine, faint,

		yellowish brown (10 YR 5/6) mottles; loam; moderate, fine, subangular blocky structure; friable; neutral; clear, wavy, boundary.
B2t	38-64	Yellowish brown (10 YR 5/4) with many, fine, distinct, grayish brown (10 YR 5/2) and brown (10 YR 5/3) mottles; clay loam; moderate, fine, subangular blocky structure; firm; clay skins on ped faces; mildly alkaline; gradual, wavy, boundary.
Cg	64-114+	Grayish-brown (10 YR 5/2) with common, medium, distinct, yellowish brown (10 YR 5/6) mottles; loam; structureless, massive; friable; less than 5% pebbles; calcareous, moderately effervescent.

Pedon C5: Conover Series

Classification: fine-loamy, mixed, mesic, family of Udollic Ochraqualfs.

Location: 1820 ft. S. 1320 ft. W. of NE corner of Sec. 21, T.6S.-R.6E. Dundee Twn. Monroe Co. Michigan.

Horizon	Depth cms	Description
Ap	0-23	Very dark grayish brown (10 YR 3/2), grayish brown (10 YR 5/2) dry; fine sandy loam; moderate, medium, granular structure; friable; many fine roots; less than 5% pebbles; mildly alkaline; abrupt, smooth, boundary.
II B2t	23-64	Yellowish brown (10 YR 5/4) with many, fine, distinct, grayish brown (10 YR 5/2) and yellowish brown (10 YR 5/6) mottles; clay loam; brown (7.5 YR 4/4) clay skins on faces of peds; moderate, fine, angular

		blocky structure; firm; moderately alkaline; gradual, wavy, boundary.
II B3	64-81	Yellowish brown (10 YR 5/4) with many, coarse, distinct, grayish brown (10 YR 5/2) mottles; clay loam; weak, fine, angular blocky structure; firm; slightly effervescent; gradual, wavy, boundary.
II C	81-114+	Brown (10 YR 5/3) with common, fine, distinct, grayish brown (10 YR 5/2) mottles; loam; weak, medium, platy structure; compact, friable; calcareous, moderately effervescent.

Pedon C6: Conover Series

Classification: fine-loamy, mixed, mesic, family of Udollic Ochraqualfs.

Location: 1490 ft. S. 660 ft. W. of NE corner of Sec. 21, T.6S.-R.6E. Dundee Twn. Monroe Co. Michigan.

Horizon	Depth cms	Description
Ap	0-23	Very dark grayish brown (10 YR 3/2), grayish brown (10 YR 5/2) dry; loam; weak, fine, granular structure; friable; slightly acid; many roots; abrupt, smooth, boundary.
B1	23-36	Dark brown (10 YR 3/3) with many, fine, faint, yellowish brown (10 YR 5/4) mottles; loam; moderate, medium, subangular blocky structure; friable; slightly acid; clear, wavy, boundary.
B21t	36-64	Brown (10 YR 5/3) with many, fine, distinct, grayish brown (10 YR 5/2) and yellowish brown (10 YR 5/4) mottles; clay loam; moderate, medium, subangular

Horizon	Depth	Description
		blocky structure; clay skins on faces of peds; firm; neutral; clear, wavy boundary.
B22tg	64-81	Grayish brown (10 YR 5/2) with common, fine, distinct, yellowish brown (10 YR 5/4) and brown (10 YR 5/3) mottles; clay loam; moderate, medium, subangular blocky structure; clay skins on ped faces; firm; neutral; gradual, wavy, boundary.
Cg	81-127+	Grayish brown (10 YR 5/2) with common, fine, distinct, yellowish brown (10 YR 5/4) mottles; loam; structureless, massive; friable; calcareous, strongly effervescent.

Pedon C7: Conover - variant

Classification: fine-loamy, mixed, mesic, family of Aquic Eutrochrepts.

Location: 1820 ft. S. 1300 ft. W. of NE corner of Sec. 27, T.6S.-R.6E. Dundee Twn. Monroe Co. Michigan.

Horizon	Depth cms	Description
Ap	0-25	Dark grayish brown (10 YR 4/2), light brownish gray (10 YR 6/2) dry; clay loam; moderate, medium, granular structure; firm; many roots; some worms; less than 5% pebbles; neutral; abrupt, smooth, boundary.
B2	25-51	Brown (10 YR 5/3) with many, fine, distinct, grayish brown (10 YR 5/2) and yellowish brown (10 YR 5/6) mottles; clay loam; moderate, medium, subangular blocky structure; firm; less than 5% pebbles; mildly alkaline; clear, wavy, boundary.
C	51-89+	Brown (10 YR 5/3) clay loam: structureless, massive;

firm; less than 5% pebbles; moderately effervescent, calcareous.

Pedon C8: Kibbie - variant

Classification: fine-silty, mixed, mesic, family of Aquollic Hapludalfs.

Location: 1980 ft. W. 660 ft. S. of NE corner of Sec. 33, T.6S.-R.6E. Summerfield Twn. Monroe Co. Michigan.

Horizon	Depth cms	Description
Ap	0-20	Very dark grayish brown (10 YR 3/2), grayish brown (10 YR 5/2) dry; loam; weak, fine, granular structure; friable; neutral to slightly acid; abrupt, smooth, boundary.
II B21t	20-38	Brown (10 YR 5/3) with common, medium, distinct, yellowish brown (10 YR 5/4 & 5/8) mottles; silty clay loam; moderate, medium, angular blocky structure; firm; clay skins on ped faces and in root channels; mildly alkaline; clear, wavy, boundary.
II B22t	38-69	Brown (10 YR 5/3) with common, medium, distinct, yellowish brown (10 YR 5/4) and light brownish gray (10 YR 6/2) mottles; silty clay loam; moderate, medium, angular blocky structure; firm; clay skins on ped faces; mildly alkaline; clear, wavy, boundary.
II Clg	69-81	Grayish brown (10 YR 5/2) with few, medium, distinct, light yellowish brown (10 YR 6/4) mottles; silt loam; weak, fine, angular blocky structure; friable; small lenses of shells are present; slightly effervescent; abrupt, wavy, boundary.

III C2g	81-101+	Grayish brown (10 YR 5/2); clay loam; structureless, massive; firm; strongly effervescent, light color of free lime visible.

V. RESULTS AND DISCUSSIONS

1. Evaluation of Parent Material Uniformity

Investigation of uniformity of the parent material in the tentative Conover-Brookston mapping unit indicated that lithologic discontinuities were present either in the field observations or in the laboratory data for pedons B2, C5, and C8.

A common manipulation in assessing lithologic discontinuity is to compute sand and silt separates on a clay-free basis (i.e., percent fine-sand divided by percent sand plus silt, times 100, etc.) (Tables 3 and 4). Clay distribution, because of illuviation and eluviation, is subject to pedologic change and may mask inherited lithologic differences (20). The relationship between the ratio of si/s and percentages of clay in the surface and subsoil of each pedon is plotted in Figure 3 for the Brookston and Figure 4 for the Conover pedons sampled. This relationship indicates that with increasing si/s ratio, the clay percentages increase. However, the clay percentage increase is more at low si/s ratios than at the higher ratios. The dashed line passed through Ap points is on the left side, and the dashed line through the B2 points is on the right side of the average solid line, indicating coarser textured Ap's and B2's in the Brookston and Conover pedons sampled with given si/s ratios.

The criteria of the ratio of silt/sand in the Ap horizon relative to that of the subsoil ($si/_s$in $Ap/si/_s$ in B2) (Tables 3 and 4, col. 9) seems to be the best test of initial uniformity of materials, because it relates the non-clay size distribution in each horizon to the other horizon in each pedon. In other words, it relates two major non-clay size classes in each horizon in each pedon. If the material in the Ap and B2 are originally uniform, then the ratio of $si/_s$ in $Ap/si/_s$ in B2 tends to

TABLE 3

Particle size distribution of non-clay fractions of tentative Brookston pedons sampled

Columns	1	2	3	4	5	6	7	8	9	10
Soils*	%f.silt .002-.02 mm	%co.silt .02-.05 mm	%v.fs. .05-.10 mm	%f.s. .10-.25 mm	%med.s. .25-.50 mm	%co.s. .5-1.0 mm	%v.co.s. 1-2.0 mm	si/s	si/s,Ap / si/s,B2	si/s,Ap / si/s,B2 -1
B1-1	48.2	23.9	15.0	8.9	1.8	1.4	.3	2.60	.852	-.148
B1-2	52.8	22.3	12.1	8.5	1.4	1.6	.6	3.05		
B2-1	26.3	10.4	22.6	29.6	7.6	2.7	.5	.581	.461	-.539
B2-2	38.9	16.7	19.7	16.3	4.4	2.1	1.2	1.26		
B3-1	19.1	8.9	23.7	33.3	10.1	3.7	.6	.389	1.29	+.29
B3-2	16.0	7.2	25.2	36.0	11.1	3.3	.6	.302		
B4-1	31.1	13.8	18.5	23.8	8.6	3.0	.6	.813	1.34	+.34
B4-2	24.7	13.0	20.5	27.7	9.4	3.7	.3	.605		
B5-1	35.1	11.7	34.7	12.2	2.3	2.5	1.3	.882	.689	-.311
B5-2	44.0	12.1	18.6	11.7	4.9	5.6	3.1	1.28		
B6-1	30.9	15.6	29.1	15.7	3.7	3.1	1.7	.870	1.19	+.19
B6-2	28.9	13.3	27.9	17.3	4.7	5.2	2.4	.733		
B7-1	44.1	17.4	12.1	13.9	5.7	4.4	2.0	1.60	.976	-.024
B7-2	44.6	17.4	11.7	14.6	5.5	4.2	1.7	1.64		
B8-1	29.1	12.1	15.8	25.3	9.8	5.4	2.1	.701	.854	-.146
B8-2	32.6	12.4	11.7	23.2	10.9	6.4	2.7	.821		
									Average ± .25	

*B1, B2 etc. are the pedons sampled of Brookston.
-1 is the plow layer, Ap or surface horizon, and
-2 is the B2 horizon, or subsoil in each pedon.

TABLE 4

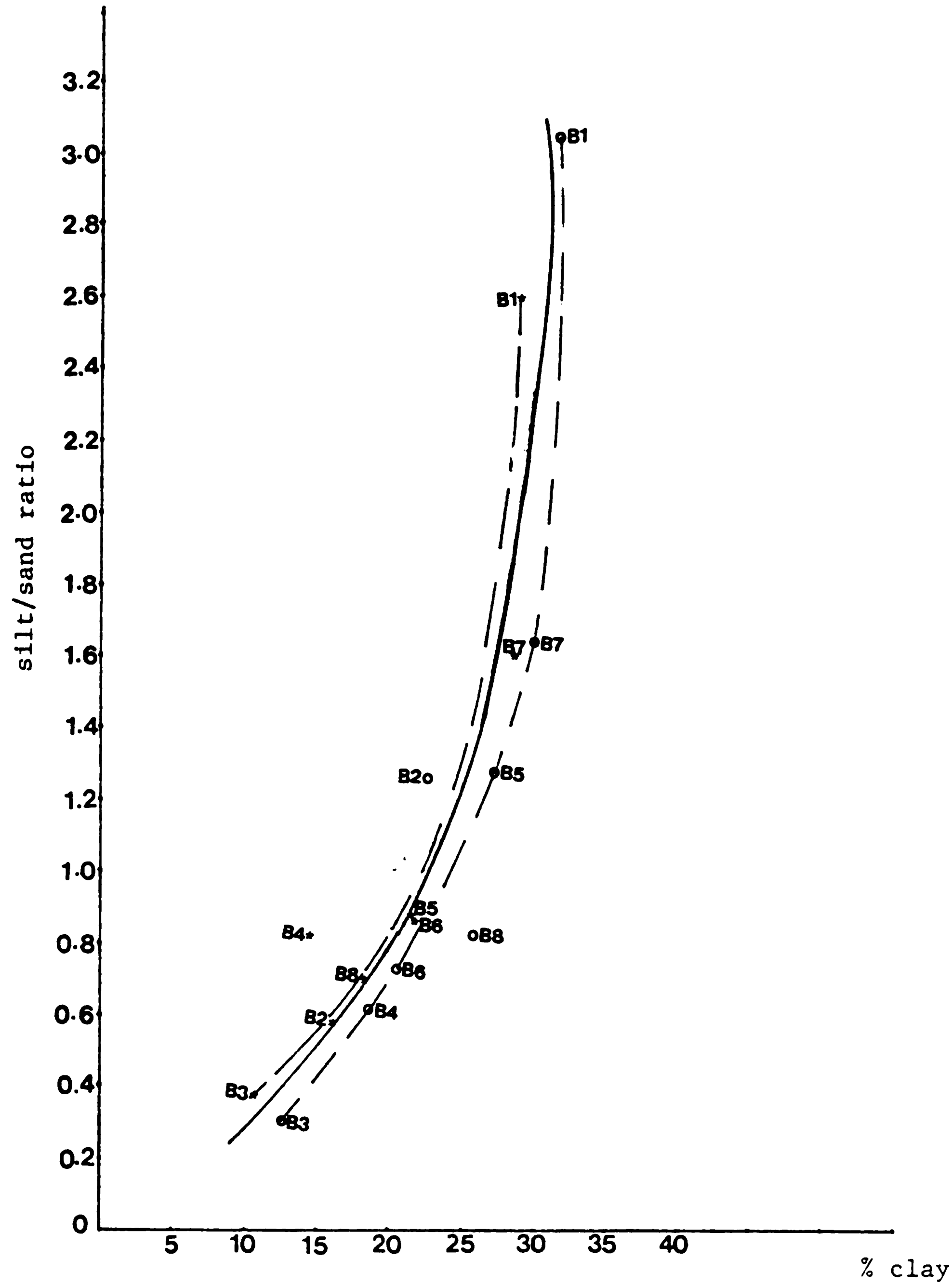
Particle size distribution of non-clay fractions of tentative Conover pedons sampled

Columns	1	2	3	4	5	6	7	8	9	10
Soils*	%f.silt. .002-.02 mm	%co.silt .02-.05 mm	%v.fs. .05-.10 mm	%f.s. .10-.25 mm	%med.s. .25-.50 mm	%co.s. .5-1.0 mm	%v.co.s. 1-2.0 mm	$\frac{si}{s}$	$\frac{si/s,Ap}{si/s,B2}$	$\frac{si/s,Ap}{si/s,B2}-1$
C1-1	18.5	9.8	16.5	33.6	12.4	8.4	.8	.398	1.23	+.23
C1-2	16.0	8.4	16.6	33.5	14.2	9.9	.9	.323		
C2-1	13.0	6.3	25.9	41.3	9.4	3.2	.4	.240	.741	-.259
C2-2	17.1	7.4	26.3	41.2	5.3	2.0	.4	.324		
C3-1	19.4	8.4	21.3	31.0	11.9	5.7	1.3	.383	.628	-.372
C3-2	27.1	10.8	21.3	28.0	7.8	3.6	.6	.610		
C4-1	30.1	17.2	20.2	18.5	7.4	4.7	1.8	.899	.904	-.096
C4-2	33.9	15.8	21.6	17.1	5.8	3.8	1.7	.994		
C5-1	21.2	15.0	17.0	22.5	12.4	7.7	2.9	.568	.633	-.367
IIC5-2	33.6	13.7	14.2	16.4	10.4	7.8	3.7	.897		
C6-1	30.6	18.3	16.3	18.2	9.2	5.5	1.7	.961	.951	-.049
C6-2	33.3	16.9	15.9	18.4	8.8	4.7	1.7	1.01		
C7-1	36.6	15.4	21.8	18.1	4.3	2.5	.9	1.09	.832	-.168
C7-2	42.4	14.3	18.1	16.6	3.8	2.7	1.3	1.31		
C8-1	26.8	19.4	23.8	17.8	5.4	4.3	1.7	.855	.299	-.701
IIC8-2	40.3	33.7	11.3	8.1	2.6	2.5	1.2	2.86		
									Average	± .28

*C1, C2 etc. are the pedons sampled of Conover.
-1 is the plow layer, Ap, or surface horizon, and
-2 is the B2 horizon, or subsoil in each pedon.

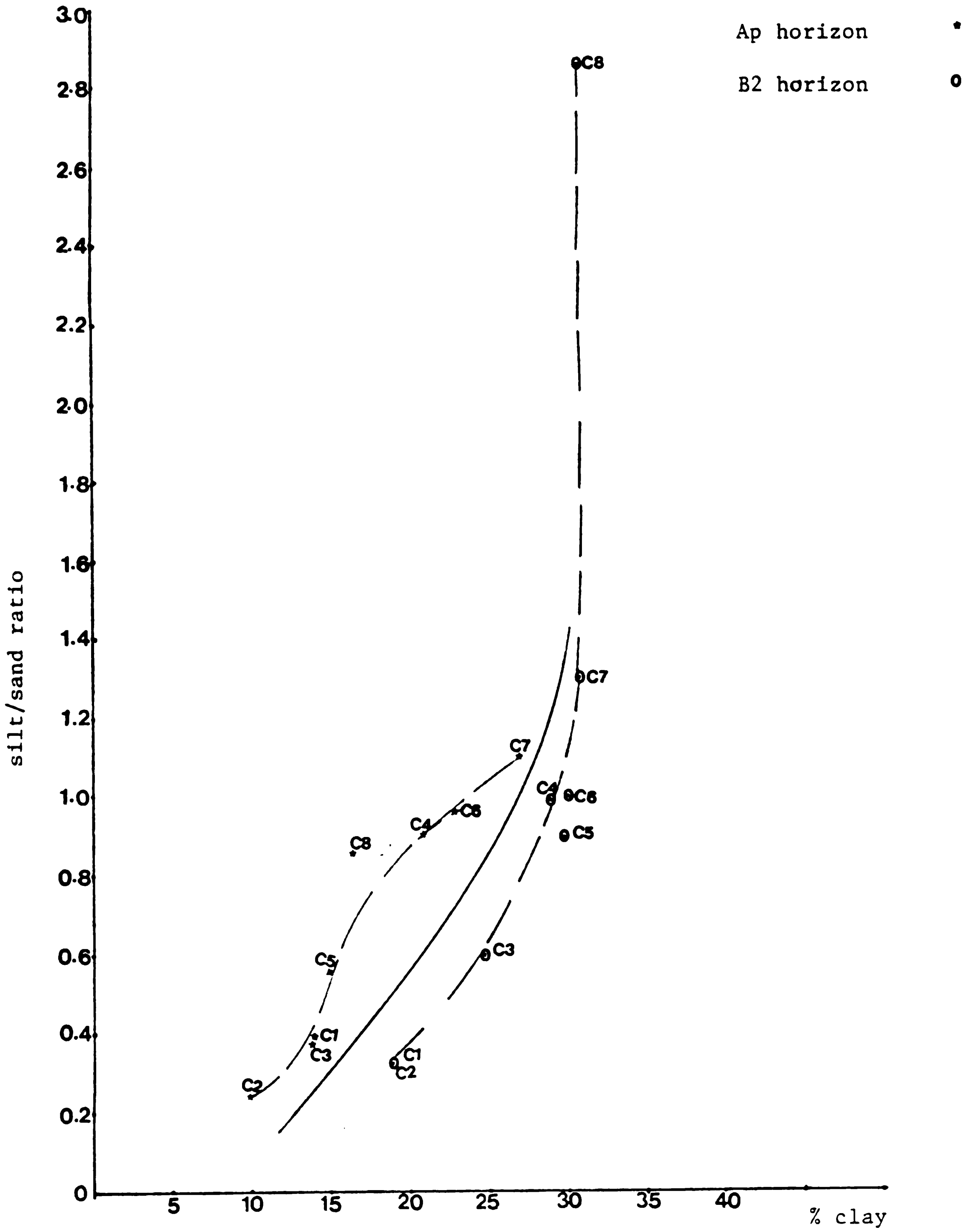
Ap horizon

B2 horizon



Relation of si/s ratio to clay contents of Brookston pedons sampled.

Figure 3



Relation of si/s ratio to clay contents of Conover pedons sampled.

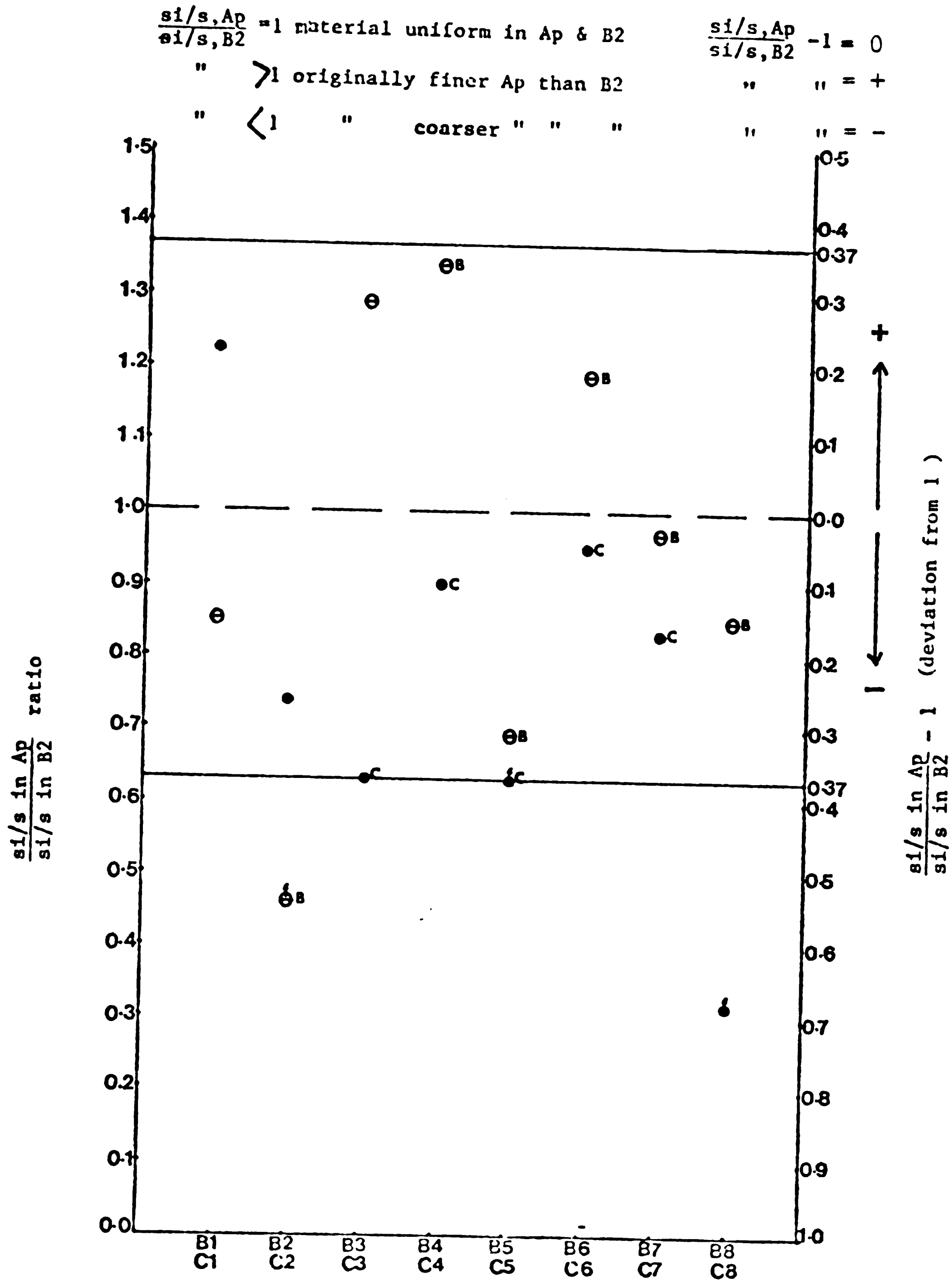
Figure 4

be one or close to one. The more the deviation from one, the more the possibility of non-uniform parent materials would be. Deviation of this ratio from one (Tables 3 and 4, col. 10) is greatest for pedons B2 and C8 (-.539 and -.701) and the least for pedons B7 and C6 (-.024 and .049) in the tentative Brookston and Conover pedons, respectively. The average deviation is equal to $\pm$ .25 for the Brookston and $\pm$ .28 for the Conover pedons sampled.

To find a reasonable criteria for distinguishing the uniform and non-uniform parent material of profiles in this study, we got help from the field observations. Profile descriptions of non-uniform Brookston and Conover pedons sampled are indicated by Roman numerals on the horizon designations for only pedons B2, C5, and C8. The ratios of $\frac{si/s \text{ in } Ap}{si/s \text{ in } B2}$ for these tentative Brookston and Conover pedons (Tables 3 and 4, col. 10) were -.539, -.367, and -.701 for pedons B2, C5, and C8, respectively. However pedon C3 had a ratio of -.372 but, it had not been recognized in the field as non-uniform parent material. By implication we said that the limit of recognizability of uniformity of parent in the field is about equal to that for C3 and C5. An average of these. -.370, is a transition profile. Subsequently, we should accept $\pm$ .37 as the break point for separating uniform and non-uniform parent material profiles in this study.

Using this criterion as indicated in Figure 5, all the uniform parent material profiles have the ratio of $\frac{si/s \text{ in } Ap}{si/s \text{ in } B2} - 1$ between $\pm$ .37. Pedons B2 and C8 have the ratio of $>$.37 which indicate non-uniformity, and pedons C3 and C5 are borderline between a recognizable range of uniformity and non-uniformity in the field (see Figure 5).

The average particle size ratios of B2/Ap (Table 5 and 6) for the uniform parent material profiles approach 1 nearer than the average of all



Sampled Brookston pedons ϴ
Sampled Conover pedons ●
Non-uniform by field criteria f
True Brookston or variant ϴB
True Conover or variant ●C

Ratio of $\frac{si/s \text{ in } Ap}{si/s \text{ in } B2}$ and its deviation from one in the Brookston & Conover pedons sampled

Figure 5

TABLE 5

Average size distribution of tentative Brookston pedons sampled.

	Horizon or ratio / Size class or ratio		Plow layer, Ap	Subsoil B2	B2/Ap ratio
Whole sample basis	%		40.2	36.7	.91
	Sand	*	38.8	37.4	.96
	%		34.6	34.7	1.00
	Silt	*	35.4	33.8	.95
	%		25.2	28.5	1.13
	Clay	*	25.7	28.7	1.11
	Texture		L	CL	-
		*	L	CL	-
Non-clay basis	%		52.7	50.4	.95
	Sand	*	51.2	51.2	1.00
	%		47.3	49.6	1.05
	Silt	*	48.7	48.7	1.00
	Si/S		.89	.98	1.10
		*	.95	.95	1.00

*Averages of those pedons considered as uniform parent material.

TABLE 6

Average size distribution of tentative
Conover pedons sampled.

	Size class or ratio \ Horizon or ratio		Plow layer Ap	Subsoil B2	B2/Ap ratio
Whole sample basis	Sand	%	51.3	40.5	.79
		*	51.8	44.8	.86
	Silt	%	30.9	32.7	1.05
		*	29.7	29.6	.99
	Clay	%	17.7	26.7	1.51
		*	18.4	25.6	1.39
	Texture		L-SL	L-CL	-
		*	L-SL	L	-
Non-clay basis	Sand	%	61.7	54.4	.88
		*	62.7	59.4	.95
	Silt	%	38.2	45.6	1.19
		*	37.3	40.6	1.08
	Si/S		.62	.84	1.35
		*	.59	.68	1.15

*Averages of those pedons considered as uniform parent material.

the pedons studied for the tentative Brookston and Conover. For the Brookston soils sampled, the ratio of sand in B2/Ap averaged .96 for the uniform pedons and .91 for all the pedons (Table 5). This ratio was even closer to one when on a clay-free basis. The ratio of sand in B2-Ap (clay-free basis) was equal to .95 for all the pedons, and 1.00 for the uniform pedons. Similar data for Conover are shown in Table 6.

The average ratio of si/s in B2 horizon relative to the Ap horizon (Tables 5 and 6) is equal to 1.00 for those sampled Brookston pedons considered as in uniform parent material, and 1.10 for all the Brookston pedons sampled. For the Conover these ratios are 1.15 and 1.35, respectively.

These values for the Conover pedons sampled indicate thay are in relatively less uniform parent material, on the average, than the Brookston pedons sampled. Indeed looking again at the individual pedon values (Tables 3 and 4, col. 10) it is evident that the uniform Brookston values vary from +.34 to -.31 while the uniform Conover values vary from -.049 to -.37 (all negative). This indicates that the Conover pedons are usually developed from coarser materials in their Ap than in their B2 horizons. However, Brookston pedons are sometimes developed from coarser materials (B5, B7, and B8) and sometimes from finer materials (B4 and B6) in their surfaces. To emphasize these relationships a C or B has been entered beside the true Conover and Brookston pedons (or their variants) in Figure 5.

Summary:

(a) Parent materials vary considerably within this map unit, from pedon to pedon, and from the surface to the subsoil of pedons normally considered from field observations to be within each series.

(b) The Conover pedons sampled usually have Ap's developed in coarser materials than their B2's.

(c) These parent material variations need to be considered when genetic relationships among the soils and mong each soil's horizons are discussed.

2. Particle Size Distribution

Particle size and minerological composition are fundamental criteria for grouping series into families of mineral soils (12). Those compositional data are averaged over a discrete thickness of soil, usually the upper 0.25 to 1.0 m (10 to 40 in.), or the upper 50 cm of the argillic horizon, referred to as the control section.

As pointed out in Soil Taxonomy (26), families and series, serve purposes that are largely pragmatic, particularly when their phases are considered. The pragmatism of soil series lies, in part, in their use as important components of the basic mapping unit names appearing on published soil survey maps in the United States.

From the particle size distribution (11) one can learn about the origin and mode of deposition of the parent material and make predictions of water holding capacity, permeability, erosiveness, power requirements for tillage, engineering classifications, and other soil interpretations.

Of sixteen pedons described in the field, and sampled within a tentative Conover-Brookston mapping unit in Monroe county, Michigan, 8 were identified as Brookston and 8 as Conover.

A. Brookston pedons sampled:

The results of the particle size distribution of the tentative Brookston pedons sampled are shown in Table 7. In all of these pedons fine-

TABLE 7

Particle size distribution of tentative Brookston pedons sampled

1 (columns)	2	3	4	5	6	7	8	9	10
Soils*	% sand 2.0-0.5 mm	% silt .05-.002 mm	% clay <.002 mm	% f.clay <.0002 mm	Texture	$\frac{\%\ clay-2}{\%\ clay-1}$	$\frac{\%\ f.clay-2}{\%\ f.clay-1}$	$\frac{.0002\ mm}{.002\ mm} \times 100$	ratio $\frac{.0002}{.002}-2 \Big/ \frac{.0002}{.002}-1$
B1-1	18.3	47.6	34.0	16.0	SiCL	1.05	1.01	47.0	.96
B1-2	15.8	48.2	35.8	16.1	SiCL			45.0	
B2-1	49.7	28.9	21.4	9.6	L-SCL	1.28	1.23	45.0	.96
II B2-2	13.9	40.3	27.6	11.8	CL			43.0	
B3-1	60.6	23.6	15.7	7.0	f.SL	1.12	1.17	44.5	1.04
B3-2	63.2	19.1	17.6	8.2	f.SL			46.5	
B4-1	44.3	36.0	19.7	9.5	L	1.20	1.37	48.0	1.15
B4-2	47.4	28.7	23.8	13.0	L			55.0	
B5-1	38.9	34.3	26.7	13.7	L-CL	1.20	1.04	57.0	.77
B5-2	29.7	38.0	32.2	14.2	CL			44.0	
B6-1	39.1	34.0	26.8	13.2	L-CL	.94	.83	49.0	.88
B6-2	43.0	31.5	25.4	11.0	L			43.0	
B7-1	25.4	40.7	33.8	14.8	CL	1.03	1.05	44.0	1.00
B7-2	24.6	40.3	35.0	15.5	CL			44.0	
B8-1	45.1	31.6	23.3	9.9	L	1.32	1.30	42.0	1.00
B8-2	37.9	31.1	30.9	12.9	CL			42.0	

*B1, B2 etc. are the pedons sampled of Brookston
-1 is the plow layer, Ap or surface horizon, and
-2 is the B2 horizon, or subsoil in each pedon.

and very fine- sand predominated in the sand fraction and fine-silt in the silt fraction, Table 8.

The distribution of clay in the profiles indicates some translocation of clay from the surface to the subsoil in all but pedon B6, Table 7. The clay contents of the pedons represent a slightly wider range than in the fine-loamy family (Figure 6). Of all tentative Brookston pedons sampled pedon B3 with 17.6% clay (and 63.2% sand) in the subsoil and pedon B1 with 35.8% clay (and 48.2% silt) in the subsoil are borderline to coarse-loamy and fine or fine-silty families, respectively (see Figure 6). The others are all in between these two limits.

The total percentages of fine-clay ($<$ 0.2 micron) are also shown in Table 7, column 5. The distribution patterns of fine-clay are almost parallel to those of the total clay, column 4. The clay and fine-clay show more in the B2 horizon than in the Ap except for pedon B6, columns 7 and 8 respectively. The percentages of fine-clay relative to total clay (column 9) is also shown in Table 7. These criteria are used to determine whether or not an argillic horizon is present. Only pedons B2, B4, B5 and B8 have 1.20 times as much clay in the B2 horizon as in the Ap (column 7). Of these pedons only B4 has an appreciably larger % of fine-clay in the total clay in the B2 horizon than in the Ap (column 10) but pedons B5 and B6 have appreciably less.

The criteria of an argillic horizon provide for the ratio of fine-clay to total clay in the B2 horizon to be greater by at least one-third than the ratio in the overlying or underlying horizons. This along with other requirements cited for an argillic horizon (26) is used as evidence of the presence of illuvial clay, in those cases where the clay films are not present. Thus implying that clay films and the fine-clay to total

TABLE 8

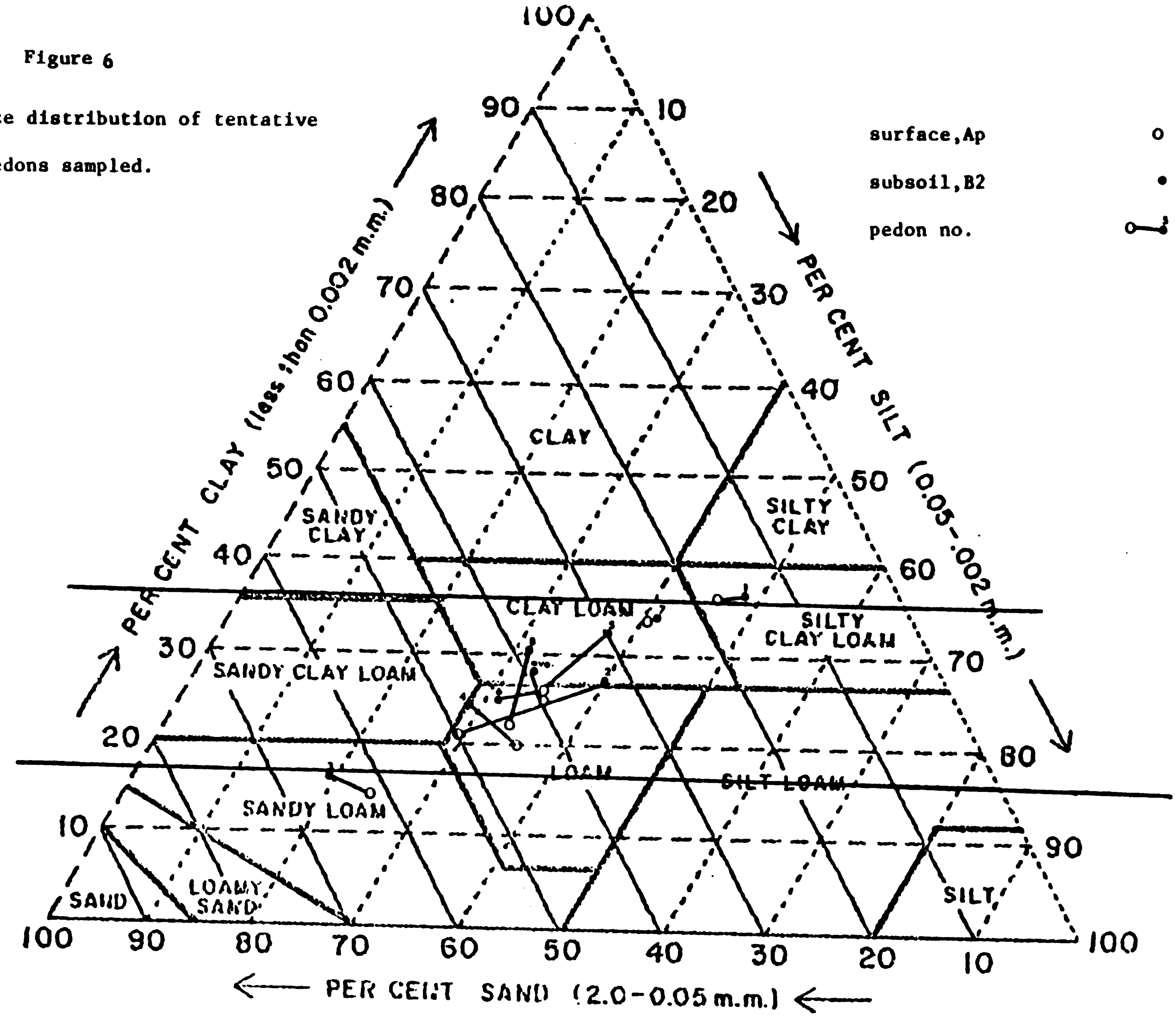
Sand and silt subfractions of tentative Brookston pedons sampled

1 columns	2	3	4	5	6	7	8	
Soils	% f silt .002-.02 mm	% co. silt .02-.05 mm	% v.f.s. .05-.10 mm	% f.s. .10-.25 mm	% med. s. .25-.50 mm	% co. s. .50-1.0 mm	% v. co. s. 1.0-2.0 mm	Remarks and % >.10 mm if < 15
B1-1	31.8	15.8	9.9	5.9	1.2	.9	.2	Pella 8.2
B1-2	33.9	14.3	7.8	5.5	.9	1.0	.4	7.8
B2-1	20.7	8.2	17.8	23.3	6.0	2.1	.4	Brookston
IIB2-2	28.2	12.1	14.3	11.8	3.2	1.5	.9	
B3-1	16.1	7.5	20.0	28.1	8.5	3.1	.5	Barry-variant
B3-2	13.2	5.9	20.7	29.6	9.1	2.7	.5	
B4-1	24.9	11.1	14.8	19.1	6.9	2.4	.5	Brookston
B4-2	18.8	9.9	15.6	21.1	7.1	2.8	.2	
B5-1	25.7	8.6	25.4	8.9	1.7	1.8	.9	" 12.3
B5-2	29.8	8.2	12.6	7.9	3.3	3.8	2.1	-
B6-1	22.6	11.4	21.3	11.5	2.7	2.3	1.2	Brookston-variant
B6-2	21.6	9.9	20.8	12.9	3.5	3.9	1.8	
B7-1	29.2	11.5	8.0	9.2	3.8	2.9	1.3	"
B7-2	29.0	11.3	7.6	9.5	3.6	2.7	1.1	
B8-1	22.3	9.3	12.1	19.4	7.5	4.1	1.6	Brookston
B8-2	22.5	8.6	8.1	16.0	7.5	4.4	1.9	

Figure 6

Particle size distribution of tentative

Brookston pedons sampled.



THE TEXTURAL TRIANGLE, SHOWING THE COMMON SOIL CLASSES clay ratio are the concurrent result of the processes involved in the genesis of an argillic horizon.

These data (Table 7 col. 10) suggest that in the investigated soils the ratio probably is set too high because clay films were found to be present but the ratio of fine-clay to total clay were not one-third or more. These results agree with those found by Laurin (18) working on similar soils in the region. Four soils studied by Laurin having a total B/A clay ratio more than or equal to 1.2 no soil had a ratio of fine-clay to total clay in the B horizons greater than the A horizons at least by one-third.

A fine-clay ratio of greater than or equal to 1.2 between the B and A horizons seems to be more suitable than the fine-clay to total day ratio of one-third or more in these Michigan soils. This criterion would be consistant with the total clay ratio presently used in the definition of an argillic horizon and would still reflect illuviation of fine-clay as does the present fine-clay to total clay ratio.

Based on this criterion and other requirements cited for argillic horizons, including field observations of clay skins in the B2, four of the tentative Brookston pedons sampled have an argillic horizon. These are pedons B2, B4, B5, and B8 (Table 7). Based on laboratory analyses and field observations, these Brookston pedons were in the fine-loamy, mixed, mesic, family of Typic Argiaquolls, and are truly representative of the Brookston series. Two others (B6 and B7) were in the fine-loamy, mixed mesic, family of Typic Haplaquolls, a Brookston-variant without argillic horizons.

The two borderline pedons, B3 and B1 have been identified as: fine-loamy (borderline to coarse loamy), mixed, mesic, family of Typic

Haplaquolls, a Barry-variant (without an argillic horizon) and fine-silty, mixed, mesic, family of Typic Haplaquolls, the Pella series, respectively.

So far our discussions were about all the Brookston pedons sampled which refer to all eight of the tentative Brookston pedons. From here onward any discussion under Brookston will refer to only those six pedons identified as Brookston or Brookston-variant. The average size distributions of all these Brookston pedons and those from uniform parent material are shown in Table 9.

B. Conover pedons sampled:

The particle size distribution of the eight tentative Conover pedons sampled are shown in Table 10. In all the Conover pedons sampled, as in the Brookstons, the fine- and very fine-sand and the fine-silt predominated in the sand and silt fractions (Table 11). In contrast to the Brookston pedons sampled, all of the tentative Conover pedons (except pedon C1, where they are nearly equal), the percentage of sand decreased with increasing depth. The distribution pattern of silt in the profiles also differs from the Brookston pedons sampled, such that 62.5% (5/8) of the sampled Conover pedons have higher percentages of silt in the subsoil than in the plow layers.

The distribution pattern of the clay particles indicate that more translocation of clay has taken place in the sampled Conover profiles (Table 10, col. 4) than in the Brookston profiles (Table 7, col. 4). The percentages of fine-clay (Table 10, col. 5) also indicate that more fine-clay is translocated from the surface to the subsoil in the Conover pedons sampled relative to the Brookston pedons (Table 7, col. 5). The percentages of fine-clay in the total clay is also usually greater in the subsoil of the Conover pedons (Table 10, col. 9) than in their surface

TABLE 9

Average size distribution of six Brookston and five Conover pedons

	Horizon or ratio / Size class or ratio	Brookston+ Plow layer Ap	Brookston+ Subsoil B2	Brookston+ B2/Ap ratio	Conover+ Plow layer Ap	Conover+ Subsoil B2	Conover+ B2/Ap ratio
Whole sample basis	% Sand	40.4	35.8	.88	46.3	36.7	.79
	*	38.6	36.5	.94	44.3	36.6	.82
	% Silt	34.2	35.0	1.02	33.5	34.2	1.02
	*	35.3	33.9	.96	34.1	34.5	1.01
	% Clay	25.3	29.2	1.15	20.2	29.0	1.43
	*	26.1	29.5	1.13	21.5	28.8	1.34
	Texture	L	CL	-	L	CL	-
	*	L	CL	-	L	CL	-
Non-clay basis	% Sand	53.7	50.3	.94	57.6	51.6	.89
	*	51.8	51.4	.99	56.0	51.4	.92
	% Silt	46.3	49.7	1.07	42.4	48.4	1.14
	*	48.2	48.6	1.01	44.0	48.6	1.10
	Si/S	.86	.99	1.14	.74	.94	1.28
	*	.93	.94	1.02	.79	.94	1.19

*Averages of those pedons considered as having uniform parent materials.
+Including Brookston- and Conover-variants.

TABLE 10

Particle size distribution of tentative Conover pedons sampled

1 (columns)	2	3	4	5	6	7	8	9	10
Soils*	% sand 2.0-0.5 mm	% silt .05-.002 mm	% clay <.002 mm	% f.clay <.0002 mm	Texture	% clay-2 / % clay-1	% f.clay-2 / % f.clay-1	$\frac{.0002\ \text{mm}}{.002\ \text{mm}} \times 100$	ratio $\frac{.0002}{.002}$-2 / $\frac{.0002}{.002}$-1
C1-1	61.3	24.4	14.3	6.5	f.SL	1.34	1.68	45.0	1.27
C1-2	61.0	19.7	19.2	10.9	f.SL			57.0	
C2-1	72.6	17.4	10.0	4.1	f.SL	1.89	2.20	41.0	1.17
C2-2	61.1	19.8	18.9	9.0	f.SL			48.0	
C3-1	61.9	23.7	14.4	5.8	f.SL	1.75	1.93	40.0	1.10
C3-2	46.4	28.3	25.3	11.2	SCL-L			44.00	
C4-1	41.7	37.5	20.7	9.3	L	1.38	1.48	45.0	1.07
C4-2	35.7	35.5	28.7	13.8	CL			48.0	
C5-1	54.4	30.9	14.7	5.8	f.SL	2.02	2.29	39.0	1.15
IIC5-2	37.0	33.2	29.7	13.3	CL			45.0	
C6-1	38.9	37.4	23.6	11.5	L	1.28	1.24	49.0	0.96
C6-2	34.6	35.0	30.3	14.3	CL			47.0	
C7-1	34.8	37.8	27.4	13.3	CL	1.12	1.05	48.5	0.93
C7-2	29.9	39.2	30.9	13.9	CL			45.0	
C8-1	44.9	38.4	16.6	6.5	L	1.85	2.26	39.0	1.23
IIC8-2	17.9	51.2	30.8	14.7	SiCL			48.0	

* C1, C2 etc. are the pedons sampled of Conover.
-1 is the plow layer, Ap or surface horizon, and
-2 is the B2 horizon, or subsoil in each pedon.

TABLE 11

Sand and silt subfractions of tentative Conover pedons sampled

1 columns	2	3	4	5	6	7	8	
Soils	% f.silt .002-.02 mm	% co. silt .02-.05 mm	% v.f.s. .05-.10 mm	% f.s. .10-.25 mm	% med. s. .25-.50 mm	% co. s. .50-1.0 mm	% v. co. s. 1.0-2.0 mm	Remarks and % >.10 mm if < 15
C1-1	15.9	8.5	14.1	28.9	10.7	7.3	.7	Locke
C1-2	12.9	6.8	13.9	27.1	11.5	8.0	.8	
C2-1	11.7	5.7	23.3	37.2	8.5	2.8	.4	Locke
C2-2	13.8	6.0	21.3	33.4	4.3	1.6	.3	
C3-1	16.6	7.1	18.1	26.5	10.2	4.9	1.1	Conover
C3-2	20.2	8.1	15.9	20.9	5.8	2.7	.5	
C4-1	23.9	13.6	16.0	14.7	5.9	3.7	1.4	Conover
C4-2	24.2	11.3	15.4	12.2	4.1	2.7	1.2	
C5-1	18.1	12.8	14.5	19.2	10.6	6.6	2.5	Conover
IIC5-2	23.6	9.6	10.0	11.5	7.3	5.5	2.6	
C6-1	23.4	14.0	12.4	13.9	7.0	4.2	1.3	Conover
C6-2	23.2	11.8	11.1	12.8	6.1	3.3	1.2	
C7-1	26.6	11.2	15.8	13.1	3.1	1.8	.7	Conover-variant
C7-2	29.3	9.9	12.5	11.5	2.6	1.8	.9	
C8-1	22.3	16.1	19.8	14.8	4.5	3.6	1.4	Kibbie-variant
IIC8-2	27.9	23.3	7.8	5.6	1.8	1.7	.8	9.9

horizons. However in no case is this ratio 1.33 as suggested by Soil Taxonomy for argillic horizons (see Table 10, col. 10).

The ratio of total clay and fine-clay in the B2 horizons compared to those of the Ap horizons (Table 10, col. 7 and 8 respectively) is 1.20 in all of the sampled Conover pedons except pedon C7. Based on these criteria and other requirements cited for argillic horizons, including field observation of clay skins on faces of peds, all of the sampled Conover pedons, except pedon C7, met requirements of an argillic horizon. There is a possibility that pedon C7 may have been somewhat eroded. As indicated in Figure 7, the tentative Conover pedons sampled covered nearly the whole range of the fine-loamy family.

Correlation of field observations and laboratory data has classified the eight Conover pedons sampled as follows: Pedons C1 and C2 were in a fine-loamy, mixed, mesic, family of Aquollic Hapludalfs, the Locke series. They have more sandy profiles than Conover. Pedons C3, C4, C5 and C6 were in a fine-loamy, mixed, mesic, family of Udollic Ochraqualfs, and are truly representative of the Conover series. Pedons C7 was in a fine-loamy, mixed, mesic, family of Aquic Eutrochrepts, a Conover-variant; and pedon C8 was in the fine-silty, mixed, mesic, family of Aquollic Hapludalfs, a Kibbie-variant, which is more silty in the control section (B2t) than Conover or Kibbie.

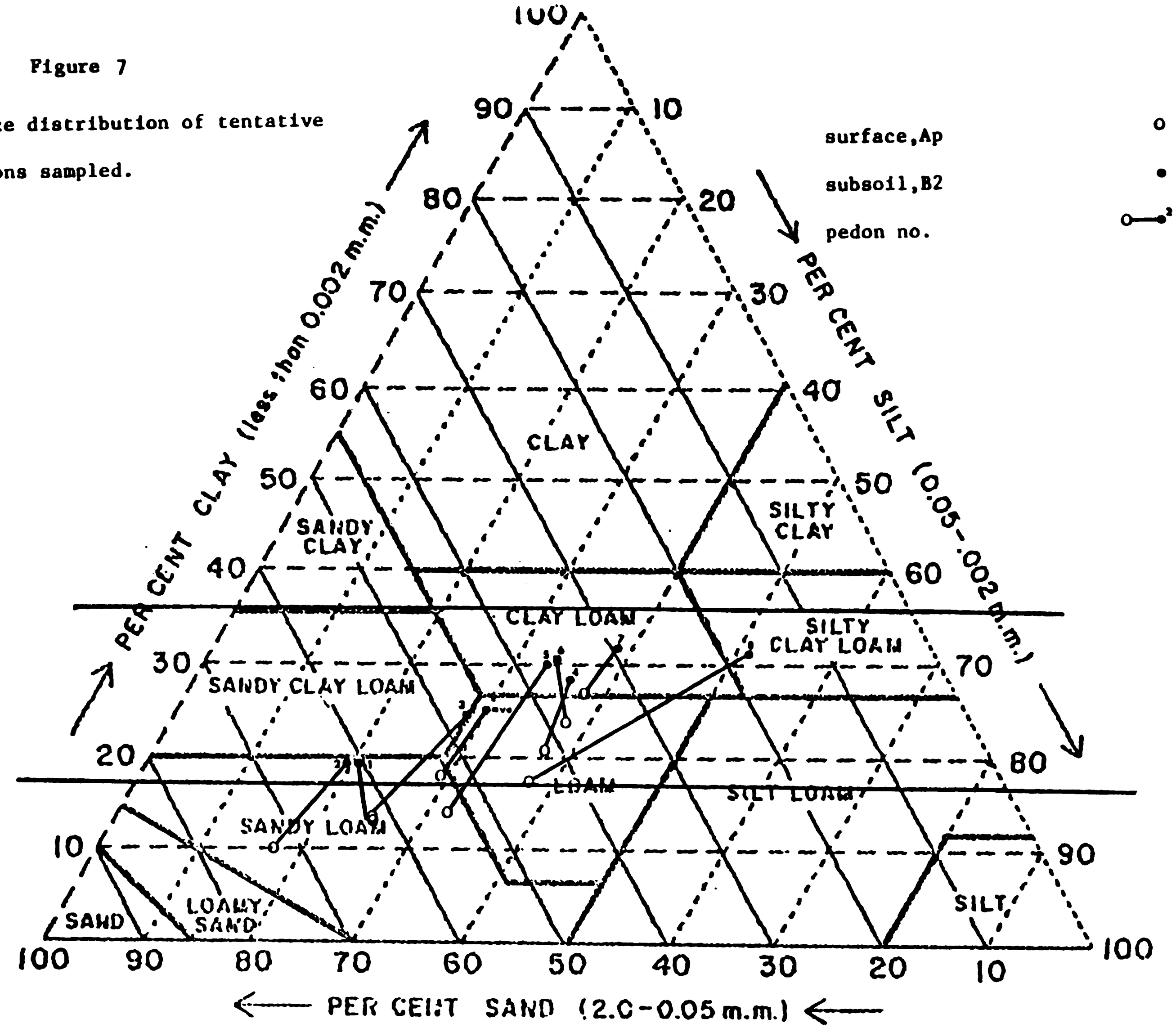
So far we were dealing with the eight tentative Conover pedons sampled, but from here onward Conover pedons will refer to only those four pedons identified as Conover and a Conover-variant.

As far as the degree of fineness of the Conover pedons is concerned, the average composition of the Conover pedons are as shown in Table 9.

It is concluded that, the particle size distribution patterns of the

Figure 7

Particle size distribution of tentative Conover pedons sampled.



THE TEXTURAL TRIANGLE, SHOWING THE COMMON SOIL CLASSES

Brookston and Conover pedons indicate the following:

(a) The Conover pedons averaged coarser than the Brookston profiles in their Ap horizons.

(b) Excess of moisture (poor drainage) in the wet part of the landscape, the Brookston pedons, has reduced translocation of clay from the surface to the subsoils.

(c) Conditions of somewhat poor natural drainage in the Conover pedons favored movement, and accumulation of clay in the subsoil. They occur in that portion of the landscape which had somewhat deeper water tables that are subject to considerable seasonal fluctuations.

3. Water Retention

A. One-third bar percentage:

It has been found experimentally that the water percentage of many medium textured soils at the moisture equivalent corresponds closely to a water potential of -33 joules/kg (1/3 bar equivalent suction) (29). The amount of water held at 1/3 bar equivalent suction has been recognized as the upper limit of available water (Table 12) at field capacity.

B. Fifteen bar percentage:

As water infiltrates the soil and moves into dry zones some of it is also used in the process of evaporation or transpiration. Since these processes continue after infiltration ceases, water continues to be lost from the soil. As each increment of water is lost from the soil, the work that must be done to remove the next increment increases (29). Because the extracting power of plant's cells for water is limited, when this negative force get to 15 bar equivalent suction, the plant cells can not keep up with their needs and plants wilt. The wilting point is a range

TABLE 12

Water retention percent of tentative Brookston & Conover pedons sampled@

Soils	1/3 atm. H_2O %	15 atm. H_2O %	1/3-15 atm. H_2O %	Thickness* cm	Ava. mois. cm solum		Ava. mois. cm to 68 cm		Remarks
B1-1	38.7	16.5	22.2	30	8.1	43.4	8.1	19.1	Pella
B1-2	35.0	16.9	18.1	122	35.3		11.0		
B2-1	29.4	11.7	17.7	28	6.0	32.6	6.0	16.7	Brookston
IIB2-2	29.2	12.4	16.8	99	26.6		10.7		
B3-1	25.0	9.2	15.8	28	6.4	29.1	6.4	15.6	Barry-variant
B3-2	21.7	7.8	13.9	99	22.7		9.2		
B4-1	27.8	9.8	18.0	38	8.3	25.7	8.3	16.0	Brookston
B4-2	25.9	9.9	16.0	68	17.4		7.7		
B5-1	30.5	12.4	18.1	30	6.6	21.7	6.6	16.0	"
B5-2	30.2	14.7	15.5	61	15.1		9.4		
B6-1	32.7	13.6	19.1	28	6.5	18.8	6.5	16.7	Brookston-variant
B6-2	27.9	11.9	16.0	48	12.3		10.2		
B7-1	35.6	16.1	19.5	30	7.1	25.8	7.1	16.7	"
B7-2	31.5	15.7	15.8	74	18.7		9.6		
B8-1	27.6	11.3	16.3	25	5.0	35.6	5.0	15.8	Brookston
B8-2	29.6	13.9	15.7	102	30.6		10.8		
C1-1	24.5	8.4	16.1	23	5.6	18.1	5.6	16.2	Locke
C1-2	22.9	8.5	14.4	53	12.5		10.6		
C2-1	19.4	6.1	13.3	20	4.0	14.5	4.0	14.9	Locke
C2-2	22.5	8.6	13.9	46	10.5		10.9		
C3-1	22.3	7.7	14.6	18	4.0	15.3	4.0	16.3	Conover
C3-2	26.2	11.2	15.0	46	11.3		12.3		
C4-1	28.7	10.8	17.9	20	5.4	16.3	5.4	17.3	Conover
C4-2	28.4	13.2	15.2	44	10.9		11.9		
C5-1	22.7	8.1	14.6	23	5.1	20.2	5.1	16.8	"
IIC5-2	29.3	13.4	15.9	58	15.1		11.7		
C6-1	28.8	11.7	17.1	23	6.0	20.5	6.0	17.3	"
C6-2	28.6	13.3	15.3	58	14.5		11.3		
C7-1	31.5	13.8	17.7	25	6.7	13.4	6.7	17.8	Conover-variant
C7-2	29.5	13.7	15.8	26	6.7		11.1		
C8-1	22.4	7.5	14.9	20	5.1	19.6	5.1	19.3	Kibbie-variant
IIC8-2	31.7	14.2	17.5	49	14.5		14.2		

@Average of II replicates

*Thickness of A and B horizons.

or water content, and permanent wilting is usually in the vicinity of 15 bar equivalent suction (Table 12).

C. Available water percentage:

The difference between the percentage of moisture held at 1/3 bar and 15 bar equivalent suctions (Table 12) is the percentage of available water. The available water percentages are higher in the plow layer than the subsoil in all of the Brookston pedons and in most of the Conover pedons (C4, C6 and C7).

Because of lack of information about bulk density in this study, the average bulk density of some other pedons from Michigan have been used in calculating available moistures in the solums as follows:

Soils	Bulk density		Sources
	Ap	B2	
Brookstons and a Pella	1.22	1.60	Average of two pedons studied by Dr. Erickson.
Barry-variant	1.45	1.65	Averages of 3 pedons, two from Lapeer and one from Ingham Co.
Conovers and Lockes	1.52	1.64	Averages of 2 pedons, one from Dr. Erickson's study and one from Ohio.
Kibbie-variant	1.64	1.73	Averages of 3 pedons, 2 from Monroe, and Washtenaw Co. Michigan and one from Ohio.

The thickness of available moisture held in the whole solum (A + B horizons) was greater in the Brookston (26.7 cm, 10.5 in.) than in the Conover (17.1 cm, 6.7 in.) pedons. This was largely because of the deeper solum in the Brookston than in the Conover soils. If the available moisture depth of the Brookstons and Conovers was calculated for the average solum depth of the Conover pedons (68 cm) these numbers were very comparable (Table 12). The average depth of available water in the Brookston pedons was then 16.3 cm (6.4 in.), and inthe Conover it remained 17.1 cm (6.7 in.).

The Brookston average available water to 68 cm was more than that of the coarser Barry-variant (15.6 cm, 6.1 in.) and less than that of the finer Pella series (191. cm, 7.52 in.) (Table 12). The average depth of available water to 68 cm depth in the Conover pedons, 17.1 cm (6.7 in.), was more than that of the coarser Locke series, 15.55 cm (6.13 in.), and less than that of the finer Kibbie-variant, 19.3 cm (7.6 in.). In the Kibbie and Pella, the existence of more silt seemed to be responsible for the higher available water retention, and in the Barry-variant and Locke, the coarser sandier textures were responsible for less available water retention.

4. pH and Lime Requirements

Soil reaction is expressed in terms of "pH" which measures the hydrogen ion activity in the soil solution. It shows the environment in which plant roots exist, and characterizes the acidity of the soil solution that could cause corrosion of pipes in the soil (11). A soil having a pH of 7.0 is neutral, neither acid nor alkaline. A soil having a pH of 6.0 is mildly acid, a pH of 5.0 is 10 times more acid. On the other hand, pH 8.0 is mildly alkaline. Most well-drained Michigan soils, in their natural state have a pH lower than 7.0. This is desirable from the standpoint of availability of most nutrients (36).

Liming, as the term applies to agriculture, is the addition to the soil of any calcium or calcium- and magnesium-containing compound that is capable of reducing acidity. Lime strictly refers only to calcium oxide

(CaO), but practically the term almost universally includes such materials as calcium carbonate, calcium-magnesium carbonate, and calcium silicate slag (31). The estimated lime requirements of acid soil samples is determined by measuring the total soluble and exchangeable hydrogen and aluminum content. The degree of acidity is reported as the "lime index." This method of determining the lime requirement is more precise than estimates made from soil pH measurements alone, since it measures total acidity instead of just the active acidity of the soil.

The results of pH measurements and lime indices for the Brookston and Conover pedons are shown in Tables 13 and 14, columns 1 and 2 respectively. In both soils the Ap horizon is more acid than the subsoils. Three of the Brookston pedons need liming in their Ap horizons (Table 13, columns 11 and 12). One of the Conover pedons needs liming (Table 14, columns 11 and 12). The maximum lime recommendation in any season is 5 tons per acre. If the lime index (BpH) is less than 6.5 the soil should be retested two years after application for additional lime needs (36). The amount of lime needed depends on the desired pH. In Tables 13 and 14, columns 11 and 12, lime requirements for two pH's (6.5 and 6.8) are calculated for the depth of the plow layers.

In all of the pedons studied the pH results indicate that the coarser-textured surface layers tended to have lower pH levels than finer-textured surface layers. Thus, the median (not the mean, because pH is logarithmic) pH of the Brookston pedons are 6.7 for the surface, and 7.4 for the subsoil; compared to those of the finer-textured, Pella which are 7.3 for the surface and 7.7 for the subsoil, and those of the coarser-textured, Barry-variant which are 6.1 for the surface and 7.3 for the subsoil (Table 13, col. 1).

Similarly, the median pH of the Conover pedons were 7.02 for the plow

TABLE 13

Chemical analyses of tentative Brookston pedons sampled

Soils	pH	BpH	Extractable Elements lbs/ac P	K	Ca	Mg	Extractable Bases meq/100g K	Ca	Mg	% O.M.	L.R.* T/A to pH 6.5	L.R.* T/A to pH 6.8	Remarks
columns	1	2	3	4	5	6	7	8	9	10	11	12	
B1-1	7.3		139	352	7573	714	.45	18.93	2.97	4.41			Pella
B1-2	7.7		2	280	6187	751	.36	15.46	3.12	1.28			
B2-1	6.5	6.9	89	248	5440	492	.32	13.60	2.05	4.67	.61	1.2	Brookston
II B2-2	7.4		2	216	4693	554	.27	11.73	2.30	1.22			
B3-1	6.1	6.7	80	176	3733	309	.22	9.33	1.28	3.78	2.9	3.1	Barry-variant
B3-2	7.3		2	128	3627	369	.16	9.06	1.53	.98			
B4-1	5.9	6.6	120	216	3520	394	.27	8.82	1.69	3.22	3.3	3.6	Brookston
B4-2	7.0		2	144	4480	665	.18	11.20	2.77	.74			
B5-1	7.2		49	264	5227	603	.34	13.06	2.51	2.91			"
B5-2	7.7		2	200	6293	628	.25	15.73	2.61	1.43			
B6-1	7.6		57	216	5973	886	.27	14.93	3.69	4.02			Brookston-variant
B6-2	7.7		2	160	4800	480	.20	12.00	2.00	1.09			
B7-1	6.2	6.8	82	296	6187	505	.38	15.46	2.10	4.43	2.0	2.4	"
B7-2	7.1		2	232	5973	529	.30	14.93	2.20	1.24			
B8-1	7.1		61	184	5120	480	.23	12.80	2.00	3.60			Brookston
B8-2	7.6		2	168	5973	542	.21	14.93	2.25	1.50			

*Lime requirements for the depth of the plow layers (Ap).

TABLE 14

Chemical analyses of tentative Conover pedons sampled

Soils	pH	BpH	Extractable Elements lbs/ac				Extractable Bases meq/100 g			%	L.R.* T/A	L.R.* T/A	Remarks
			P	K	Ca	Mg	K	Ca	Mg	O.M.	to pH 6.5	to pH 6.8	
columns	1	2	3	4	5	6	7	8	9	10	11	12	
C1-1	6.3	6.9	85	144	3840	297	.18	9.60	1.23	5.65	.5	1	Locke
C1-2	6.9		3	144	4053	468	.18	10.13	1.95	1.09			
C2-1	6.8		85	144	2453	251	.18	6.13	1.04	2.10			Locke
C2-2	7.4		2	112	4160	492	.14	10.40	2.05	2.67			
C3-1	7.2		82	152	3413	443	.19	8.53	1.84	3.67			Conover
C3-2	7.6		2	144	5760	714	.18	14.40	2.97	.55			
C4-1	7.2		78	184	4693	369	.23	11.73	1.53	3.33			Conover
C4-2	7.6		2	160	5547	566	.20	13.86	2.35	1.02			
C5-1	7.8		70	152	5440	183	.19	13.60	.76	3.17			Conover
IIC5-2	7.9		3	136	7040	480	.17	17.60	2.00	1.36			
C6-1	6.0	6.7	169	264	4373	406	.34	10.93	1.69	3.22	2.4	2.6	Conover
C6-2	7.0		3	192	5333	529	.25	13.33	2.20	.97			
C7-1	6.9		52	224	6080	566	.29	15.20	2.35	3.33			Conover-variant
C7-2	7.6		2	184	6613	628	.23	16.53	2.61	1.45			
C8-1	6.6	7.1	36	136	2987	345	.17	7.46	1.43	1.62			Kibbie-variant
IIC8-2	7.4		2	168	7467	775	.21	18.66	3.22	1.34			

*Lime requirements for the depth of the plow layer (Ap).

layer and 7.5 for the subsoil; compared to 6.5 in the surface and 7.1 in the subsoil of the coarser-textured Locke, and 6.6 in the surface and 7.4 in the subsoil of the finer-textured Kibbie-variant (Table 14, col. 1). The same trends were found in the previously reported study of Michigan corn fields (22).

5. Available Nutrients

Available phosphorus and potassium are being measured by soil testing methods in soil testing laboratories. In addition to indicating the nutrient status of the profile, phosphorus values sometimes show the location of buried horizons in which phosphorus accumulated at one time by biocycling (11). In conversion of extractable nutrients (meq/100g) to available nutrients (lbs/ac) it was assumed that an acre of surface soil weighs 2 million pounds.

A. Available phosphorus:

The available phosphorus of the Brookston pedons ranged from 49 lbs/ac. to 120 lbs/ac. in the surface and was only 2 lbs/ac. in the subsoil (Table 15, col. 1). Their average available phosphorus in the plow layer was 76 lbs/ac. and 2 lbs/ac. in the subsoil (Table 15, col. 1).

The available phosphorus level of the Conover pedons ranged from 52 lbs/ac. to 169 lbs/ac. in the plow layer and from 2 to 3 lbs/ac. in the subsoil (Table 16, col. 1). The average available phosphorus of the surfaces and subsoils were 90 lbs/ac. and 2.4 lbs/ac., respectively.

The range of available phosphorus in the plow layers of the Brookston and Conover pedons were within the range of available phosphorus levels for the SMG 2.5, formerly studied by L.S. Robertson et al. for Michigan corn fields (22).

The available phosphorus in the Pella series was 139 lbs/ac. in the

TABLE 15

Available nutrients of the Brookston pedons*

Soils	Availablable P lbs/ac	Exchangeable Bases lbs/ac K	Ca	Mg	Exchangeable Bases meq/100g K	Ca	Mg	Total Exch. bas. meq/100g	% K	% Mg
columns	1	2	3	4	5	6	7	8	9	10
B2-1	89	248	5440	492	.32	13.60	2.05	15.97	2.00	12.84
IIB2-2	2	216	4693	554	.27	11.73	2.30	14.30	1.89	16.08
B4-1	120	216	3520	394	.27	8.82	1.69	10.78	2.50	15.68
B4-2	2	144	4480	665	.18	11.20	2.77	14.15	1.27	19.57
B5-1	49	264	5227	603	.34	13.06	2.51	15.91	2.14	15.78
B5-2	2	200	6293	628	.25	15.73	2.61	18.59	1.34	14.04
B6-1	57	216	5973	886	.27	14.93	3.69	18.89	1.43	19.53
B6-2	2	160	4800	480	.20	12.00	2.00	14.20	1.41	14.08
B7-1	82	296	6187	505	.38	15.46	2.10	17.94	2.12	11.70
B7-2	2	232	5973	529	.30	14.93	2.20	17.43	1.72	12.62
B8-1	61	184	5120	480	.23	12.80	2.00	15.03	1.53	13.31
B8-2	2	168	5973	542	.21	14.93	2.25	17.39	1.21	12.94
Average -1	76	237	5244	560	.30	13.11	2.34	15.75	1.90	14.86
Average -2	2	186	5368	566	.23	13.42	2.35	16.01	1.44	14.68

*For the depth of 16.9 cm (6 2/3").

TABLE 16

Available nutrients of the Conover pedons*

Soils	Available P lbs/ac	Exchangeable Bases lbs/ac			Exchangeable Bases meq/100g			Total Exch. bas. meq/100g	% K	% Mg
		K	Ca	Mg	K	Ca	Mg			
columns	1	2	3	4	5	6	7	8	9	10
C3-1	82	152	3413	443	.19	8.53	1.84	10.56	1.80	17.42
C3-2	2	144	5760	714	.18	14.40	2.97	17.55	1.02	16.92
C4-1	78	184	4693	369	.23	11.73	1.53	13.49	1.70	11.34
C4-2	2	160	5547	566	.20	13.86	2.35	16.41	1.22	14.32
C5-1	70	152	5440	183	.19	13.60	.76	14.55	1.30	5.22
IIC5-2	3	136	7040	480	.17	17.60	2.00	19.77	.86	10.12
C6-1	169	264	4373	406	.34	10.93	1.69	12.96	2.62	13.04
C6-2	3	192	5333	529	.25	13.33	2.20	15.78	1.58	13.94
C7-1	52	224	6080	566	.29	15.20	2.35	17.84	1.62	13.17
C7-2	2	184	6613	628	.23	16.53	2.61	19.37	1.19	13.47
Average -1	90	195	4800	393	.25	11.99	1.63	13.88	1.80	11.74
Average -2	2.4	163	6059	583	.21	15.14	2.43	17.77	1.18	13.67

*For the depth of 16.9 cm (6 2/3").

surface and 2 lbs/ac. in the subsoil layer. These figures were 80 lbs/ac. and 2 lbs/ac. for the Barry-variant surface and subsoil, respectively (Table 13, col. 3). The available phosphorus in the surface and subsoils of Locke series or Kibbie-variant were 85 lbs/ac. and 2.5 lbs/ac. (ave.) or 36 lbs/ac. and 2 lbs/ac., respectively (Table 14, col. 3).

The recommendations for application of phosphorus were based on soil tests, crop to be grown and the yield goal as shown in Table 17 for Michigan soils.

B. Exchangeable potassium:

The exchangeable potassium of the Brookston pedons ranged from 184 lbs/ac. to 296 lbs/ac. in the plow layer and from 144 lbs/ac. to 232 lbs/ac. in the subsoil (Table 15, col. 2). The average exchangeable potassium was 237 lbs/ac. in the plow layer and 186 lbs/ac. in the subsoil of the Brookston pedons (Table 15, col. 2).

The exchangeable potassium content of the Conover pedons ranged from 152 lbs/ac. to 264 lbs/ac. in the surface soil and from 136 lbs/ac. to 192 lbs/ac. in the subsoil (Table 16, col. 2). The average exchangeable potassium content was 195 lbs/ac. in the plow layer and 163 lbs/ac. in the subsoil in the Conover pedons (Table 16, col. 2).

The exchangeable potassium, average values in the Brookston pedons (Table 15, col. 2) were between those of the finer textured Pella profile (with 352 lbs/ac. in Ap and 280 lbs/ac. in B2) and the coarser textured, Barry-variant (with 176 lbs/ac. in Ap and 128 lbs/ac. in B2) as shown in Table 13, col. 4. The average values of exchangeable potassium in the Conover pedons (Table 16, col. 2) were more than those of the coarser textured profiles, Locke (with 144 lbs/ac. in Ap and 128 lbs/ac. in B2) as shown in Table 14, col. 4. The Kibbie-variant (non-uniform material) had 136 lbs/ac. potassium, exchangeable in the Ap and 168 lbs/ac. in the

TABLE 17. Phosphate—phosphorus recommendations for field crops on mineral soils.(36)

Available Soil Phosphorus-pounds of Phosphorus (P) per acre						*POUNDS PER ACRE ANNUALLY RECOMMENDED* P_2O_5	*P*
					0-39	250	110
				0-39	40-79	200	88
				40-59	80-99	150	66
			0-19	60-79	100-119	125	55
		0-19	20-39	80-99	120-139	100	44
	0-19	20-39	40-59	100-119	140-159	75	33
0-19	20-39	40-59	60-79	120-139	160-179	50	22
20-39	40-59	60-79	80-99	140-159	180-199	25	11
40+	60+	80+	100+	160+	200+	0	0
Alfalfa 3-4T topdressing Buckwheat Clover Corn[1] 60-89 bu Cover crops Field beans[1] 15-29 bu (9-18 cwt) Grass pasture (unimproved) Grasses Timothy, Orchard, Brome Kidney beans[1] 15-29 bu (9-18 cwt) Millet Oats 50-79 bu Rye Soybeans 20-40 bu	Alfalfa 5-6T topdressing Alfalfa 3-4T seeding Barley[1] 40-69 bu Birdsfoot Trefoil Corn[1] 90-119 bu Corn silage[1] 10-14T Field beans[1] 30-50 bu (19-30 cwt) Kidney beans[1] 30-50 bu (19-30 cwt) Oats 80-120 bu Soybeans 40+ bu Sorghum Sudangrass Wheat[1] 25-39 bu	Alfalfa 7+ T topdressing Alfalfa 5+ T seeding Barley 70-100 bu Corn[1] 120-149 bu Corn silage[1] 15-19T Wheat[1] 40-65 bu	Corn[1] 150+ bu Corn silage[1] 20-30T Sugar beets 13-23T Wheat[1] 65+ bu	Sugar beets[1] 24-28T Potatoes[1] 150-299 cwt	Potatoes[1] 300-500 cwt		

To use this table, look for the crop to be grown showing the yield potential nearest your expected yield goal. Then find the position of the soil test range in the overlying column of figures. To determine the phosphate (P_2O_5) needed, follow dashed line to the appropriate column on the right side.
EXAMPLE: Crop to be grown—corn, yield goal 110 bu. per acre
Soil test—28 pounds of P/A
Recommendation—50 pounds of P_2O_5

[1]*Banding 25 lb P_2O_5/A will stimulate early plant growth, but will not necessarily increase yield.*

B2 horizons (Table 14, col. 4).

The current potassium recommendations in Michigan are shown in Tables 18 and 19 for different profile texture classes. The Brookston, Conover and Kibbie pedons belong to the loams group; the Locke and Barry pedons are in the sandy-loams group.

C. Exchangeable calcium

Calcium, an essential part of plant cell wall structure, provides for normal transport and retention of other elements in the plant. Calcium is also thought to counteract the effect of alkali salts and organic acids within a plant. Calcium is absorbed as the ion Ca^{++} and exists in a delicate balance with magnesium and potassium in the plant. Too much of any of these three elements may cause insufficiencies of the other two (35). Well limed soils are rich in calcium. Even soils needing lime, to correct acidity, generally contain sufficient calcium for most plants. The poor growth of plants on acid soil is usually due to excess soluble manganese, iron/or aluminum. Research at Purdue University found the calcium content of water for Indiana varied from 8 to 450 ppm and averaged 30 ppm. Assuming a ratio of 400 to 1 as the amount of water needed to produce one pound of dry matter, even the lowest reading of 8 ppm would supply sufficient calcium to plant roots (36).

Taking a look at the amounts of exchangeable calcium in the plow layers and subsoils (Table 15 and 16, col. 3) indicate that all the Brookston and Conover pedons have sufficient Ca for plant growth. Less than 50 lbs/ac. of calcium is utilized in the production of a 100-bu corn crop (21).

The average exchangeable calcium values of the Brookston pedon surfaces and subsoils (5244 and 5368 lbs/ac. respectively, Table 15,

TABLE 18. Potash—potassium recommendations for field crops on sandy loams and loamy sands.(36)

Available soil potassium–pounds of K per acre					*POUNDS PER ACRE ANNUALLY RECOMMENDED* K_2O	K
				0-59	300	249
			0-59	60-119	250	208
		0-59	60-119	120-179	200	166
	0-59	60-119	120-169	180-239	150	125
0-59	60-119	120-169	170-209	240-279	100	83
60-119	120-169	170-209	210-239	280-309	75	62
120-169	170-209	210-239	240-269	310-339	50	42
170-209	210-239	240-269	270-299	340-359	25	21
210+	240+	270+	300+	360+	0	0
Barley 40-69 bu Buckwheat Corn 60-89 bu Cover crops Field beans 15-29 bu (9-18 cwt) Grass pasture (unimproved) Grasses Timothy, Or- chard, Brome Kidney beans 15-29 bu (9-18 cwt) Millet Oats 50-79 bu Rye Soybeans 20-40 bu Wheat 25-39 bu	Barley 70-100 bu Clover Corn 90-119 bu Corn silage 10-14T Field beans 30-50 bu (19-30 cwt) Kidney beans 30-50 bu (19-30 cwt) Oats 80-120 bu Soybeans 40+ bu Sorghum Sudangrass Wheat 40-65 bu	Alfalfa 3-4T seeding Alfalfa 3-4T topdressing Birdsfoot Trefoil Corn 120-149 bu Corn silage 15-19T Sugar beets 18-23 T Wheat 65+ bu	Alfalfa 5-6T seeding Alfalfa 5-6T topdressing Corn 150+ bu Corn silage 20-30T Potatoes 150-299 cwt Sugar beets 24-28T	Alfalfa 7+ T topdressing Potatoes 300-500 cwt		

TABLE 19. Potash—potassium recommendations for field crops on loams, clay loams and clays.(36)

Available soil potassium–pounds of K per acre					*POUNDS PER ACRE ANNUALLY RECOMMENDED* K_2O	*K*
			0-59	0-119	300	249
		0-59	60-119	120-169	200	166
	0-59	60-119	120-169	170-209	150	125
0-59	60-119	120-159	170-209	210-239	100	83
60-119	120-159	160-199	210-249	240-279	60	50
120-179	160-209	200-239	250-269	280-299	30	25
180+	210+	240+	270+	300+	0	0
Barley 40-69 bu Buckwheat Corn 60-89 bu Cover crops Field beans 15-29 bu (9-18 cwt) Grass pasture (unimproved) Grasses Timothy, Orchard, Brome Kidney beans 15-29 bu (9-18 cwt) Millet Oats 50-79 bu Rye Soybeans 20-40 bu Wheat 25-39 bu	Barley 70-100 bu Clover Corn 90-119 bu Corn silage 10-14T Field beans 30-50 bu (19-30 cwt) Kidney beans 30-50 bu (19-30 cwt) Oats 80-120 bu Soybeans 40+ bu Sorghum Sudangrass Wheat 40-65 bu	Alfalfa 3-4T seeding Alfalfa 3-4T topdressing Birdsfoot Trefoil Corn 120-149 bu Corn silage 15-19T Sugar beets 18-23T Wheat 65+ bu	Alfalfa 5-6T seeding Alfalfa 5-6T topdressing Corn 150+ bu Corn silage 20-30T Potatoes 150-299 cwt Sugar beets 24-28T	Alfalfa 7+ T topdressing Potatoes 300-500 cwt		

col. 3) were between those of the finer textured Pella profile (with 7573 lbs/ac. in Ap and 6187 lbs/ac. in B2) and the coarser textured Barry-variant (with 3733 lbs/ac. in Ap and 3627 lbs/ac. in B2) as shown in Table 13, col. 5. The average calcium content of Conover surfaces and subsoils (4800 and 6059 lbs/ac. respectively, Table 16, col. 3) were more than the average values of the coarser textured Locke profiles (with 3191 lbs/ac. in Ap and 4106 lbs/ac. in B2) as shown in Table 14, col. 5. The Kibbie-variant had much higher calcium in the B2 than Ap horizon (2987 and 7467 lbs/ac. respectively, Table 14, col. 5), because it was developed from non-uniform materials. The calcium content of the Conover-variant was higher in its surface than any of the other Conover pedons studied.

D. Exchangeable magnesium

Magnesium is a part of the chlorophyll in all green plants and essential for photosynthesis. It also helps activate many plant enzymes needed for growth. Magnesium is a relatively mobile element in the plants. It is absorbed as the ion Mg^{++} and can be readily translocated from older to younger plant parts in the event of a deficiency (35). Magnesium deficiency is most likely to occur in acid soils with a sandy loam, loamy sand or sand plow layer with a subsoil as coarse or coarser than the plow layer, and in similar soils limed with calcitic limestone or marl. Present soil test criteria for recommending magnesium in Michigan are: (1) if the exchangeable magnesium level is less than 75 lbs/ac. or (2) if as a percent of total bases (calcium plys magnesium plus potassium expressed as meq/100 g soil), potassium exceeds magnesium or (3) if the soil magnesium (as a percent of total bases)is less than 3 percent (36, 21).

Based on the above criteria and the data in Table 15, columns 4, 9, 10 and Table 16, columns 4, 9, 10 none of the Brookston and Conover pedons showed magnesium deficiency.

The exchangeable magnesium ranged from 394 lbs/ac. to 886 lbs/ac. in the plow layer and from 480 lbs/ac. to 665 lbs/ac. in the subsoil of the Brookston pedons (Table 15, col. 4). The average exchangeable magnesium was 560 lbs/ac. in the plow layer and 566 lbs/ac. in the subsoil (Table 15, col. 4). The average values of magnesium in Brookston are between that of the finer textured Pella profile (with 714 lbs/ac. in Ap and 751 lbs/ac. in B2) and the coarser textured, Barry-variant (with 309 lbs/ac. in Ap and 369 lbs/ac. in B2) as indicated in Table 13, col. 6.

In the Conover pedons, the exchangeable magnesium ranged from 183 lbs/ac. to 566 lbs/ac. in the plow layer and from 480 lbs/ac. to 714 lbs/ac. in the subsoil (Table 16, col. 4). The average magnesium content was 393 lbs/ac. in the plow layer, and 583 lbs/ac. in the subsoil (Table 16, col. 4). The average values in Conover are more than those of the coarser textured, Locke (274 lbs/ac. in Ap and 480 lbs/ac. in B2, Table 14, col. 6). The Kibbie-variant has much more exchangeable magnesium in the subsoil than the Ap as a result of the non-uniformity of its parent material (Table 14, col. 6).

E. Total bases

The average total bases have been calculated for the whole pedons sampled as shown in Table 20. These figures indicated that the total exchangeable bases for the average thicknesses of surfaces and subsoils were more in the Brookston than in the Conover pedons. The total bases of the Brookston pedons were in between those of the finer textured Pella series and the coarser textured Barry-variant (see Table 20). In the Conover pedons the average exchangeable bases were more than those of the

TABLE 20

The average total bases of the whole pedons sampled

Soils	Horizons	Average thickness cm	Average total bases* lbs/ac	Average total bases for the ave.thickness lbs/ac	Average total bases in Ap+B2 horizons lbs/ac (or tons)
Barry-variant	-1	28.0	4,218.	6,988.	15,260. (7.6)
	-2	38.0	4,124.	9,272.	
Brookston	-1	28.5	6,041.	10,187.	31,190. (15.6)
	-2	58.0	6,120.	21,003.	
Pella	-1	30.0	8,639.	15,335.	67,441. (33.7)
	-2	122.0	7,218.	52,106.	
Locke	-1	21.5	3,564.	4,535.	16,112. (8.1)
	-2	41.5	4,714.	11,577.	
Conover	-1	22.0	5,388.	7,014.	21,912. (11.0)
	-2	37.0	6,805.	14,898.	
Kibbie-variant	-1	20.0	3,468.	4,104.	28,488. (14.2)
	-2	49.0	8,410.	24,384.	

* For the thickness of 16.9 cm (6 2/3")

coarser textured Locke series. The Kibbie variant had almost 5 times as much exchangeable bases in its subsoil as in its plow layer.

F. Summary

(a) Based on the current soil nutrient interpretations (11), the surface layer of both the Brookston and Conover pedons were very high ($\geq$ 71 lbs/ac.) in P, and their subsoils were very low (0-10 lbs/ac.) in P.

(b) The exchangeable potassium was more uniform in the profiles of both Brookston and Conover pedons. These values were mainly in the medium (151-210 lbs/ac.) to high (211/310 lbs/ac.) range.

(c) The Brookston pedons contained more exchangeable bases in their solums than the Conover pedons, largely because of their greater thicknesses.

(d) The average total exchangeable bases in the Brookston pedons were in between those of the finer textured Pella series and the coarser textured Barry-variant.

(e) The average total exchangeable bases in the Conover pedons were more than those of the coarser textured Locke series.

(f) The Kibbie series had a substantially greater amount of exchangeable bases in its subsoil than in its plow layer (non-uniform material).

(g) The available nutrients found in this study were within the range of the available nutrients found in soils of the same soil management group in Michigan corn fields by L.S. Robertson et al. (21 and 22). However, these values show a narrower range in values than those in the soils formerly studied.

6. Organic Matter

Soil organic matter is composed of plant and animal residues in various stages of decomposition along with the living micro-organisms that are decomposing these materials. Some soils, called peat or muck are composed largely of organic material (29).

Organic carbon is a component of soil organic matter. Organic matter percentages are usually estimated by multiplying organic carbon perdentages by 1.724 (11).

The result of organic matter determinations in the Brookston and Conover pedons sampled are shown in Tables 13 and 14, col. 10. The average organic matter percentages of the Brookston and Conover pedons are indicated in Tables 21 and 22. These values are 3.81% and 1.20% in the Brookston, and 3.34% and 1.07% in the Conover, surfaces and subsoils, respectively. The Brookston pedons are better supplied with organic matter.

Organic matter commonly exerts a profound influence upon the physical properties of soil, such as its structure, water percolation rate and water retention. Decomposing organic materials provide substances which cause soil particles to stick together into aggregates. Hydrogen bonding between clays and carboxyl groups of organic matter has been shown to occur (29). Ionic bonding of carboxyl groups to exchange sites and physical absorption are also known to occur.

Additions of organic matter to soil improves many of the soil properties related to plant growth. It is a major source of nitrogen, through both nitrogen fixation (by legume green manures) and nitrification, and barnyard manure may supply many of the essential trace elements. The intermediate decomposition products of organic matter increase the

TABLE 21

Cation exchange capacity (CEC), extractable bases and percent base saturation (B.S.) with related soil properties in sampled Brookston pedons

Soils	CEC meq/100g	Estractable bases meq/100g	% B.S.	% O.M.	% clay	CEC/100g clay	Remarks
B1-1	37.2	22.35	60.0	4.41	34.0	109.	Pella
B1-2	28.8	18.94	65.8	1.28	35.8	80.9	
B2-1	22.3	15.97	71.6	4.67	21.4	104.	Brookston
IIB2-2	21.8	14.30	65.6	1.22	27.6	79.0	
B3-1	19.0	10.83	57.0	3.78	15.7	121.	Barry-variant
B3-2	17.0	10.75	63.2	.98	17.6	96.6	
B4-1	21.7	10.78	50.0	3.22	19.7	110.	Brookston
B4-2	20.6	14.15	68.7	.74	23.8	86.6	
B5-1	28.8	15.91	55.2	2.91	26.7	108.	"
B5-2	26.4	18.59	70.4	1.43	32.2	82.0	
B6-1	29.0	18.89	65.1	4.02	26.8	108.	Brookston-variant
B6-2	21.6	14.20	65.7	1.09	25.4	85.1	
B7-1	31.2	17.94	57.5	4.43	33.8	92.3	"
B7-2	25.8	17.43	67.6	1.24	35.0	73.7	
B8-1	25.5	15.03	58.9	3.60	23.3	109.	Brookston
B8-2	26.7	17.39	65.1	1.50	30.9	86.4	
Averages All pedons -1	26.8	15.96	59.4	3.88	25.2	107.6	-
-2	23.6	15.72	66.5	1.18	28.5	83.8	
Brookstons* -1	26.4	15.75	59.7	3.81	25.3	105.2	-
-2	23.8	16.01	67.2	1.20	29.2	82.1	

*Including Brookston variants.

TABLE 22

Cation exchange capacity (CEC),extractable bases and percent base saturation (B.S.) with related soil properties in sampled Conover pedons

Soils	CEC meq/100g	Extractable bases meq/100g	% B.S.	% O.M.	% clay	CEC/100g clay	Remarks
C1-1	19.1	10.01	57.6	5.65	14.3	133.	Locke
C1-2	19.8	12.26	61.9	1.09	19.2	103.	
C2-1	14.2	7.35	51.7	2.67	10.0	142.	Locke
C2-2	17.8	12.59	70.7	2.10	18.9	94.2	
C3-1	15.6	10.56	67.7	3.67	14.4	108.	Conover
C3-2	23.5	17.55	74.7	.55	25.3	92.9	
C4-1	22.4	13.49	60.2	3.33	20.7	108.	Conover
C4-2	24.8	16.41	66.2	1.02	28.7	86.4	
C5-1	17.6	14.55	82.6	3.17	14.7	120.	Conover
II C5-2	25.5	19.77	77.5	1.36	29.7	85.9	
C6-1	22.3	12.96	58.1	3.22	23.6	94.5	Conover
C6-2	24.7	15.78	63.9	.97	30.3	81.5	
C7-1	30.9	17.84	57.7	3.33	27.4	113.	Conover-variant
C7-2	26.1	19.37	74.2	1.45	30.9	84.5	
C8-1	15.6	9.06	58.1	1.62	16.6	94.0	Kibbie-variant
II C8-2	25.6	22.09	86.3	1.34	30.8	83.1	
Averages: All pedons -1	19.7	11.98	61.7	3.33	17.7	114.0	-
Averages: All pedons -2	23.5	16.98	71.9	1.23	26.7	88.9	
Averages: Conovers* -1	21.7	13.88	65.2	3.34	20.2	108.7	-
Averages: Conovers* -2	24.9	17.77	71.3	1.07	29.0	86.2	

*Including Conover variant.

solubility of inorganic soil minerals, thus releasing, potassium, phosphorus, and other nutrients for plant growth, and at the same time they may reduce the size of the residual soil particles.

Organic matter along with clay, has many colloidal properties that are valuable to the soil. It has a high cation exchange capacity, and it is a colloidal moderator, binding sandy soils into aggregates and loosening massive clayey soils so that they too form desirable aggregates. It improves the soil's water-retaining ability, and conditions the soil, so that water infiltration and drainage are improved. The aeration of soils rich in organic matter is usually better than that of organic matter deficient soils. Organic matter rich soils are not easily compacted by tillage and other land-working operations (29).

In comparison to clay colloids, the soil organic matter fraction commonly has a higher cation exchange capacity but doesn't have a fixed capacity to combine reversibly with cations normally found in the soil solution. Among ions of equal valence the complexing tendency is a factor which affects the amount of retention. Thus the cupric ion which has a strong tendency to form stable complexes is retained in greater amounts than other divalent cations such as Ba and Ca. Organic matter can even absorb copper from very dilute solutions (3).

7. Cation Exchange Capacity (CEC), Base Saturation and Extractable Bases

A. Cation exchange capacity:

Cation exchange capacity and base saturation (Tables 21, 22) provide information about the capacity of the soil to hold the cations plus the leaching of bases from the soil and their replacement with hydrogen ions. Calcium and magnesium are the most abundant extractable bases, with lesser amounts of sodium and potassium.

In the profiles studied, CEC varies directly with the clay contents in the Ap and the B2 horizons of both the Brookston and Conover pedons. However in the Ap horizons organic matter also contributes to the exchange capacity. This is indicated in Figure 8 for the Brookston and Conover pedons, where the surface horizons, higher in organic matter have higher CEC's for a given clay content (Tables 21 and 22).

CEC of the Brookston pedons ranged from 20.6 to 26.7 meq/100 g in the subsoil and from 21.7 to 31.2 meq/100 g in the surface layer. The CEC of the Ap horizons (Table 21) is more than that of the subsoils in all Brookston pedons but B8. This is because of higher organic matter content of the mollic epipedon of the Brookston soils, and the low increase in clay with depth.

In the Conover pedons the reverse situation is true (Table 22,) the CEC of the subsoils exceeds that of the surface soils (except in pedon C7). This is because of less organic matter content of the Ap horizons in the Conovers relative to the higher clay content of their argillic subsoil horizons.

CEC of the Conover pedons ranged from 15.6 and 30.9 meq/100 g in their surfaces and from 23.5 to 26.1 meq/100 g in their subsoils (Table 22).

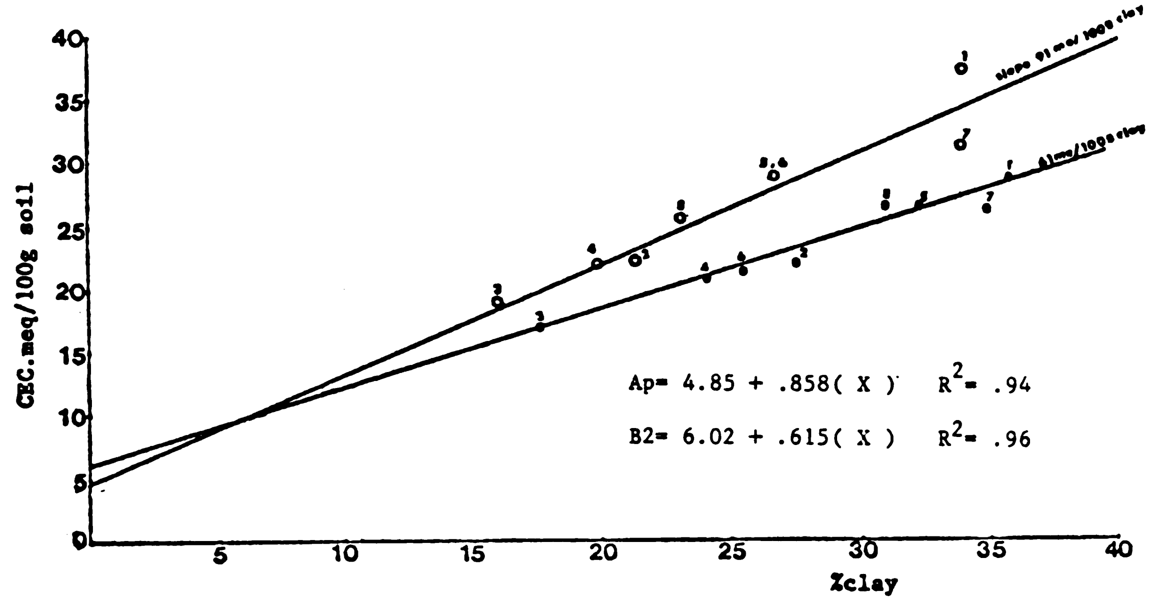
The average cation exchange capacity of the Brookston pedons was 26.4 meq/100 g of Ap and 23.8 meq/100 g of subsoil. These values were 21.7 meq/100 g of Ap, and 24.9 meq/100 g of subsoil for the Conover pedons. Comparison of these numbers indicated that the Brookston soils had more buffering capacity in their surfaces to hold and release cations required for plant growth. This may effect the rate of fertilizer

Relation of CEC and % clay in the sampled Brookston & Conover surfaces and subsoils.

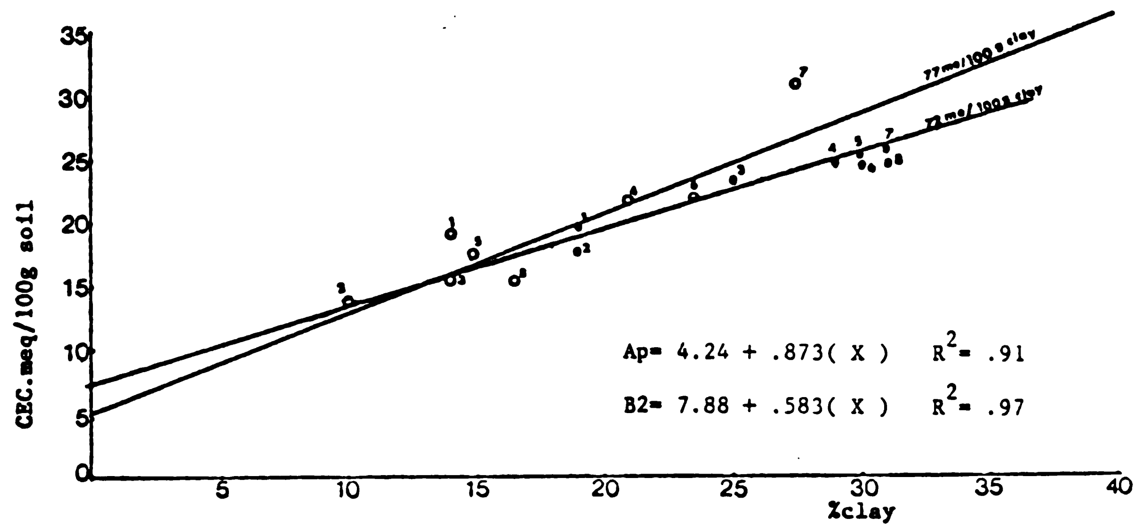
surface, Ap o

subsoil, B2 •

pedon no. 4



Brookston pedons sampled



Conover pedons sampled

Figure 8

application and will prevent leaching of nutrients to some extent. These values were also consistent with the fact that the Brookston pedons are richer in organic matter, and have finer surfaces than the Conover. The difference between the average CEC of the Brookstons compared to the Conovers is greater in the Ap horizon (+4.7 meq/100 g) and less in the subsoil or control section (-1.1 meq/100 g).

B. Base saturation:

Base saturation is the percentage of CEC which is occupied by the basic cations. Base saturation as indicated in Tables 21 and 22 is $\geqslant$ 50% in all pedons within the mapping unit. Thus, one of the requirements of a mollic epipedon in the poorly drained Brookston or udollic in the somewhat poorly drained Conover pedons was met.

Base saturation of the surface layers of the Brookston pedons ranged from 50.0% in pedon B4 to 71.6% in pedon B2. In the Conover, B.S. in the surface ranged from 57.7% to 82.6%. The average B.S. in the Brookston pedons was 59.7% for the plow layer, and 67.2% for the subsoil. The average B.S. in the Conovers was 65.2% in the plow layer, and 71.3% in the subsoil.

The subsoils of all the Brookston and Conover pedons sampled in the map unit were more supplied with basic cations (higher % B.S.) than the surface soils. Only two pedons had more base saturation percentages in their plow layers (C5 and B2, Tables 21 and 22). Both of these are from non-uniform parent materials. This indicated more leaching of the basic cations from the surface to the subsoils in profiles from uniform parent materials.

Comparison of the average B.S. in the Brookston and Conover pedons indicated that the Conover pedons were more saturated with basic cations than the Brookstons. However the Brookston pedons, had more extractable bases (meq/100 g) in their surfaces than the Conover pedons. This may be explained as the higher water table in the Brookston pedons causes more substitution of hydrogen ions for basic cations.

C. Extractable bases:

Assuming equal bulk density and Ca CO_3 equivalent (say 21%, the average amount of acid soluble material in the C horizon of Brookston and Conover pedons, from a paper by H.H. Bailey and E.P. Whiteside) of the C horizons initially, the amount of Ca lost from the surface and subsoil during the soil forming processes is calculated in Table 23, as follows:

21% Ca CO_3 x 0.4 Ca/ Ca CO_3 = 8.4% Ca = .084 Ca in the initial material. $\frac{\text{Thickness cm}}{\text{16.9 cm (6 2/3 in.)}}$ x 2 x 10^6 lbs/ac. soil x .084 = lbs/ac. Ca lost from that thickness.

Comparison of these results with those indicated in Table 20, illustrated that even though the Brookston pedons have lost more Ca in the processes of soil formation, they still have more extractable bases in their Ap + B2 horizons relative to the Conover pedons. This suggests that extractable bases may have originated by more hydrolysis of minerals and release of the basic cations in the Brookston profiles than in the Conover pedons.

TABLE 23

The average Ca lost from the soils*
during soil formation processes

Soils	Horizons	Average thickness cm	Ca lost lbs/ac	Ca lost from Ap+B2 horizons lbs/ac(or tons)
Brookston	-1	30.0	298,224.	889,703.
	-2	59.5	591,479.	(444.8)
Conover	-1	21.5	213,727.	571,596.
	-2	36.0	357,869.	(285.8)
Locke	-1	21.5	213,727.	626,271.
	-2	41.5	412,544.	(313.1)
Barry-variant	-1	28.0	278,343.	656,094.
	-2	38.0	377,751.	(328.0)
Pella	-1	30.0	298,224.	1,511,004.
	-2	122.0	1,212,780.	(755.5)

*Those from uniform parent material.

VI. CLASSIFICATION

1. Individual Pedons

The 16 pedons studied within a tentative Conover-Brookston mapping unit in Monroe Co. Michigan were classified as shown in Table 24. Actually only 8 of the original 16 pedons (50%), sampled as Conover and Brookston, were truly representative of these series. Three more pedons (19%) were identified as variant of these series. This illustrates the need for careful quantitative studies of taxonomic units in current soil surveys in Michigan. The remaining 5 pedons (31%), along with the other 14 on the transects of 30 pedons (19/30, 63%) were identified as other soil series outside the range of the Conover or Brookston series and their variants.

2. Map Unit

In the light of this study the % composition of the former tentative Conover-Brookston mapping unit, based on the 30 point transect observations was as follows:

Profile text. no. \ Nat. drain. class	% W.d. and mod. w. drained		% Somewhat p. drained		% P. drained		Total
	a	a	b	b-s	c	c-s	
1.5 CL					Pewamo 3		3
2.5 Loam		Celina 13	Conover* 17	Kibbie 3	Brookston* 20	Pella 3	56
3/2 SL/L	Owosso 3		Metamora 20		Corunna 3		26
3.0 SL			Locke 7		Barry-variant 3		10
4.0 SL			Wasepi 3				3
Total	16%		50%		32%		98%

*Including variants of these series.

TABLE 24

Classification of the sixteen pedons studied

Pedons	Series name	Natural drainage condition	Classification	SMG
B1	Pella	poorly drained	fine-silty (borderline to fine), mixed, mesic, family of Typic Haplaquolls	2.5 c-s
B2	Brookston	"	fine-loamy, mixed, mesic, family of Typic Argiaquolls	2.5 c
B3	Barry-variant	"	" " " " " " Typic Haplaquolls	3.0 c
B4	Brookston	"	" " " " " " Typic Argiaquolls	2.5 c
B5	Brookston	"	" " " " " " " "	2.5 c
B6	Brookston-variant	"	" " " " " " Typic Haplaquolls	2.5 c
B7	Brookston-variant	"	" " " " " " " "	2.5 c
B8	Brookston	"	" " " " " " Typic Argiaquolls	2.5 c
C1	Locke	somewhat poorly drained	" " " " " " Aquollic Hapludalfs	3.0 b
C2	Locke	"	" " " " " " " "	3.0 b
C3	Conover	"	" " " " " " Udollic Ochraqualfs	2.5 b
C4	Conover	"	" " " " " " " "	2.5 b
C5	Conover	"	" " " " " " " "	2.5 b
C6	Conover	"	" " " " " " " "	2.5 b
C7	Conover-variant	"	" " " " " " Aquic Eutrochrepts	2.5 b
C8	Kibbie-variant	"	fine-silty, mixed, mesic, family of Aquollic Hapludalfs	2.5 b-s

These data illustrate that 50% of the observations were naturally somewhat poorly drained, and 32% were poorly drained. The dominant profile texture was loam (SMG 2.5 a+b+c, 56%). Because 57% of the observations are Metamora, Brookston and Conover, the most suitable name for this mapping unit would have been Brookston-Matemora-Conover, based on the field and laboratory evidence.

In the final field legend, approval in the final field review of Monroe Co. Michigan, 22 out of the 30 point observations in the tentative Conover-Brookston mapping unit studied, were within the new Conover map unit. One was in the Brookston and seven were in the Blount map unit, from which the Conover-Brookston was originally separated. Hence, the composition of the newly established Conover mapping unit, in the light of this study was as follows:

Profile text. no. \ Nat. drain. class	% W.d. and mod. w. drained		% Somewhat p. drained		% P. drained		Total
	a	a	b	b-s	c	c-s	
1.5 CL					Pewamo 5		5
2.5 Loam		Celina 18	Conover* 23		Brookston 14		55
3/2 SL/L	Owosso 5		Metamora 18				23
3.0 SL			Locke 9		Barry-variant 5		14
4.0 LS			Wasepi 5				
Total	23%		55%		24%		102%

* Including its variant.

These results indicate that the portion of the tentative

Conover-Brookston map unit that is now in the newly established Conover mapping unit was dominantly (55%) somewhat poorly drained, including 41% Conover and Metamora. Thus, Conover-Metamora seems to be the most suitable name for that portion of this mapping unit.

In comparing the above composition of the tentative Conover-Brookston map unit (revised with the aid of the laboratory studies; 11/30 = 37% Conover + Brookston) with those based on field work alone (16/30 = 53% Conover + Brookston) it is evident that the transects of the map units, after their delineation, are over-optimistic as to their homogenity. However, both transects to more quantitatively characterize the map units on modern soil surveys, and additional studies of the component pedons of individual series are needed to approach truly quantitative soil surveys for modern land use planning purposes.

VII. CONCLUSION

This study was carried out to characterize the major components of the Blount mapping unit in Monroe county, Michigan. On the basis of transect observations it was determined that the major soils of the unit were Conover and Brookston instead of Blount. It was also concluded that; parent materials varied considerably from pedon to pedon and from the surface to the subsoils of pedons recognized in the field to be in the same soil series. The Conover pedons sampled had apparently been developed from coarser materials in their Ap's than in their B2's. The Brookston pedons averaged finer than the Conover pedons in the Ap horizons.

The poorly drained conditions in the Brookston pedons sampled was responsible for reducing the clay translocation from the surface to the subsoil. The somewhat deeper water table in the sampled Conover pedons have favored translocation of clay from the surface to the subsoil. The 16 pedons sampled covered the whole range of the fine-loamy family from coarse-loamy to borderline to the fine to fine-silty family.

The solum depth was greater in the poorly drained pedons than in the somewhat poorly drained pedons. Consequently the amount of available water held in the solum was greater in the Brookston than in the Conover pedons. The depth of available moisture was also greater in the pedons finer than the Brookston or Conover, and less in the pedons that were coarser.

The coarser-textured pedons had lower surface pH's than the finer-textured pedons, such that, in the sampled tentative Brookston pedons, the pH increased from Barry ----> Brookston ----> Pella, and in the sampled tentative Conover pedons it increased from Locke ----> Conover

----→ Kibbie. Of the 16 pedons, only 6 pedons had lime requirements in their surfaces.

The surface horizons of the Conover and Brookston pedons were rich in available phosphorus content but their subsoils were very low in available phosphorus. Their exchangeable K levels were medium to high and the exchangeable K was uniformly distributed in the profiles of the sampled Brookston and Conover. The available base levels increased from the coarser-textured to the finer-textured pedons, and those bases were predominantly Ca and Mg. The organic matter content was somewhat greater in the poorly drained Brookston pedons than the somewhat poorly drained Conover pedons.

The cation exchange capacity of the Brookston pedons was greater than in the Conover pedons, and it also increased from the coarser-textured to the finer-textured pedons sampled for each series. The base saturation was more than 50% in all the pedons studied, and the Conover pedons were somewhat more saturated with basic cations than the Brookston pedons. However, the Brookston pedons had more extractable bases (per acre) in their solums.

Classification of the 16 pedons studied indicated that only 8 pedons were truly representative of the Brookston and Conover series. Three more pedons were identified as variants of these series, and 5 others were representative of other soil series. In the light of this study the most suitable name for this mapping unit would have been Brookston-Metamora-Conover. The results of this study indicated that the field transects of the map units after their delineation are over-optimistic as to their homogeneity. For truly quantitative soil surveys, additional studies of the component pedons of the individual series are also needed for modern land use planning.

VIII. NEEDS FOR MORE INVESTIGATION

In the results of this study it was found that the translocation of clay and fine-clay was less than generally believed to be representative of the poorly drained Brookston and the somewhat poorly drained Conover soils. Only 4 of the 6 Brookston pedons and 4 of the 5 Conover pedons studied contained an argillic horizon based on their total clay contents. None of the Conover or Brookston pedons sampled had a ratio of fine-clay to total clay in the subsoil more than one-third greater than that of the surface layers. Soil Taxonomy (26) recognizes this as a criterion for an argillic horizon. Hence, more work is needed to investigate the process of clay translocation particularly under poor natural drainage conditions. The validity of the proposed alternative criterion, that the ratio of fine-clay to total clay in the subsoil needs only to equal or exceed that of the surface layers of Michigan soils, needs more general testing for possible use in Soil Taxonomy.

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