USE OF AGRICULTURAL SOIL MAPS IN MAKING SOIL SURVEYS

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SYNOPSIS

Soil surveys are made to obtain information relative to the type, extent of occurrence, and characteristics of the soils in a given area. The use of the pedological system of classification permits easy identification of the soils as to type, and knowledge of the characteristics of various soil types and previous experience with them can be utilized in planning and design.

A large portion of many states has been surveyed by the Department of Agriculture and maps are available showing the location of the various soil types. These maps may be used as guides in making soil surveys, and in many instances they contain all of the information desired.

When agricultural soil maps are not available or when extreme accuracy is necessary, a soil survey must be made. The pedological system of classification can be used in making the survey by anyone with some knowledge of the system, assisted by a soil identification "key".

This paper describes the use of agricultural soil maps by the North Carolina State Highway Department and a soil identification key used in making soil surveys is included. The use of the key is described.

The first soil surveys in the United States were made in 1899 by the Department of Agriculture for agricultural purposes. In the past decade soil surveys have been conducted by other organizations for engineering purposes. The soil surveys conducted by the Department of Agriculture are surficial, extending to a depth of three feet, and consist of classifying soils according to color, structure, texture, physical constitution, chemical composition, biological characteristics, and morphology, while surveys conducted for engineering purposes consist of exploring soil profiles to specified depths in which the strata of the different materials encountered are located as to position and extent of occurrence and the materials described and tested. The Department of Agriculture publishes reports of their surveys in which the different soils are described in detail and their suitability for various crops given. Included in each report is a map of the area surveyed, usually a county, showing the various types of soils that occur. The typing of the soils follows a system of classification known as the pedological system which is based on the features of the soils themselves, including that of the parent materials. Soil surveys for engineering purposes are made for some specific project and cover only a limited area. Such surveys are not published and their value is restricted to the particular project for which they are made.

Much of the work expended in making engineering soil surveys for highway purposes can be eliminated by intelligent use of agricultural soil maps. Some knowledge of the pedological system of classification is necessary and characteristics of the various types of soils must be known. Each type of soil, as classified, has characteristics peculiar to itself which will be practically the same wherever that type of soil is encountered.

THE PEDOLOGICAL SYSTEM OF CLASSIFICATION

Briefly, the pedological system of classification, as developed by the Department of Agriculture consists of separating soils into units, each unit representing soils having the same texture, color, structure, physical constitution, chemical composition, biological characteristics, and morphology.

Soil is the result of the disintegration, a mechanical process, and the decomposition, a chemical process, of rock. Some of the rock minerals, such as quartz and mica, are quite stable, and remain unchanged by chemical action as soil particles visible to the eye, while other minerals, such as feldspar, hornblend, etc., are changed by chemical action into secondary minerals of minute size which are discernible only with the aid of a microscope.

The movement of water from the surface of the soil, downward, carries the finer particles and deposits them at some level below the surface. The depth of this leaching action depends upon the amount of water, the permeability of the soil, and the length of time the process has gone on. This action produces layers of soil that are quite different. The surface layer has been divested of its fine material, with the coarser particles remaining as the predominant constituent. The sub-surface layer has accumulated the fine material leached from the surface layer, and contains more fine material than it originally possessed. The soil beneath the layers, where no water movement has taken place, remains unchanged. These layers are called "horizons" and are designated as "A", "B", and "C", respectively.

One of the requirements in soil classification is texture. Texture, when applied to soils, denotes particle size range. Particles of definite size are placed in size classes which are: gravel or stone, particles larger than 2 mm. in diameter; fine gravel, particles with diameters between 1 and 2 mm.; sand, particles with diameters between 0.05 and 1 mm., silt, particles with diameters between 0.005 and 0.05 mm., and clay, particles smaller than 0.005 mm. in diameter. Sand is subdivided into coarse sand, particles ranging in diameter between 0.5 and 1 mm.; medium sand, particles ranging in diameter between 0.25 and 0.5 mm., fine sand, particles ranging in diameter between 0.1 and 0.25 mm.; and very fine sand, particles ranging in diameter between 0.05 and 0.1 mm.

Textural classification of soils consists of grouping them according to particle size range. Particle size range grouping is based on the amounts of particles belonging to certain size classes present in the soil. The particle size range groups used in textural classification of soils by the Bureau of Chemistry and Soils are defined as follows.

Sands, soils containing less than 20 percent silt and clay, the rest of the material being sand. Sands are classed as coarse, medium, fine, and very fine. Coarse sand contains 35 percent or more of fine gravel and coarse sand and less than 50 percent of other grades of sand. Medium sand contains 35 percent or more of fine gravel, coarse and medium sand and less than 50 percent of fine or very fine sand. Fine sand include 50 percent or more of fine and very fine sand. Very fine sand contains 50 percent or more of very fine sand.

Sandy Loams, soils containing from 20 percent to 50 percent of silt and clay. They are designated as coarse, medium, fine, and very fine in accordance with the predominant sand class group present.

Loams, soils containing 20 percent or less of clay, from 30 to 50 percent of silt, and from 30 to 50 percent of sand.

Silt Loams, soils containing 20 percent or less of clay, 50 percent or more of silt, and 30 percent or less of other classes.

Clay Loams, soils containing from 20 to 30 percent of clay, from 20 to 50 percent of silt, and from 20 to 50 percent of sand.

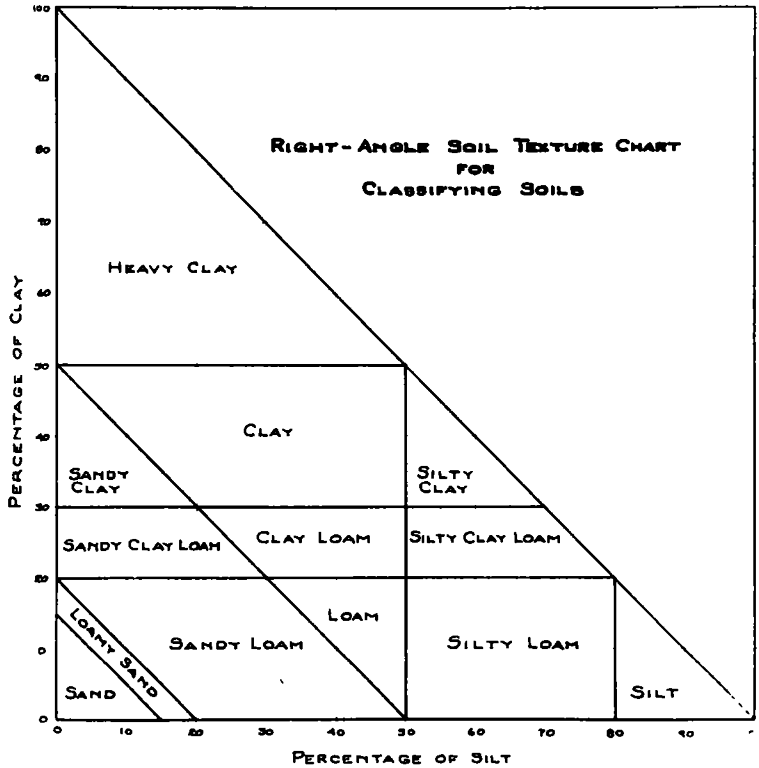

Figure 1.

Clays, soils containing 30 percent or more of clay and 70 percent or less of other classes.

Soils containing gravel or stone are designated as "gravelly" or "stony".

Since the passage of water from the surface of the soil carries the fine particles from the surface layer and deposits them in a lower layer, it is obvious that the textural classification of the soils in the various layers of a soil profile will be widely different. For this reason the textural classification of a soil type, as classified by the Bureau of Chemistry and Soils, refers to the texture of the surface layer only. When classifying soils for engineering purposes, however, it is necessary to give the textural classification of the soils in the various layers of the profile. Figure 1 is a chart that may be used in classifying soils according to texture. It will be noted that this chart contains more groups than used by the Bureau of Chemistry and Soils, which makes it more applicable to the textural classification of the soils in an entire soil profile.

As stated before, the textural classification of a soil as used by the Bureau of Chemistry and Soils refers to the material in the surface layer or "A" horizon. This alone is not of much value to any one interested in the soils in the entire profile; however, when the textural classification is given in combination with the soil series, one has information on the texture of the surface layer and the color, structure, physical constitution, chemical composition, biological characteristics and morphology of the lower layers. A soil classified in this manner is called a soil "type" which is the smallest unit in soil classification. An example of a soil type is Cecil sandy loam. "Cecil" designates the soil series and "sandy loam", the texture of the surface soil. Soils belonging to a particular soil type are alike in all features, including the parent material, so if a soil survey shows the existence of only three types of soils, one needs test data only on three samples representing these three types. If this test data is available from another survey, it will be applicable, unless considerable detail and extreme accuracy is required.

Except in cases when a soil material of a certain quality and texture is sought, as in highway work when a soil type base, sub-base, or surface is to be constructed, the classification of a soil as to type is unnecessary. The series classification, which gives all of the features of the soil profile, including the parent material, except the texture of the surface soil, is important. A knowledge of the characteristics and reputation of soils belonging to certain soil series and the possession of their test data eliminates the necessity of much sampling and testing on the average highway project. About all of the information necessary on the average soil survey is the location of various soil series that occur, however, in some instances soundings are made to determine the elevation of rock, certain types of soils, and water table.

In the foregoing, reference has been made to the soil type as being the unit of soil classification. Soil types are grouped into several categories that denote certain common features. For instance, a certain physiographical or geological area may produce certain soil types, or certain areas that are exposed to very different climatic conditions may produce other soil types. This grouping of soils in categories facilitates their identification and study.

Soils of the world are placed into two Great Divisions, Pedocals and Pedalfers. Figure 2 shows their distribution in the United States. Soils of the Pedocal Division are soils that have developed under arid conditions which permitted the accumulation of calcium in their profiles. Soils of the Pedalfer Division are soils that have developed under humid conditions and have had their soluble salts removed by leaching. Their profiles contain high percentages of silica, iron, and aluminum.

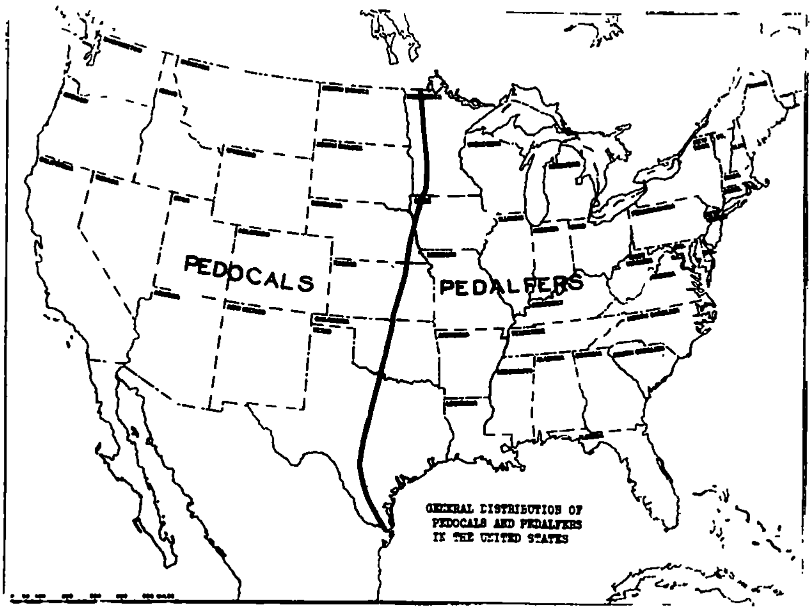

Figure 2.

The two Great Divisions of soils may each be sub-divided into other groups whose features have been affected by development under variations in rainfall within the arid and semi-arid regions, in the case of the Pedocals, and by variations in temperature in the humid regions, in the case of the Pedalfers. The following is a list of the Great Soil Groups in each of the Great Divisions.

1. Pedocals. (Soils of arid regions and semi-arid regions containing accumulations of lime).

Great Soil Group	Climate
1. Tschernozem soils	Semi-arid
2. Chesnut Brown soils	Semi-arid (less rainfall than above)
3. Brown Grassland soils	Semi-arid (less rainfall than above)
4. Gray Desert soils	Arid

II. Pedalfers. (Soils of humid regions containing accumulations of iron and aluminum.)

Great Soil Group	Climate
1. Tundra soils	Frigid to sub-frigid
2. Podzol soils	Cold temperate
3. Brown forest soils	Temperate with forest
4. Prairie soils	Temperate with tall grasses
5. Red and Yellow soils	Warm temperate
6. Laterites	Sub-tropical to tropical

Brown Forest soils due to development under lower temperatures, characteristic of the high altitudes. In this State the soils are grouped into four soil provinces, the Atlantic Coastal Plain, the Piedmont Plateau, the Appalachian Mountains, and the River Flood Plains. Divisions or sub-provinces are also recognized within these provinces. Figure 3 shows the physiographic provinces of the State and Figure 4 shows the soil provinces and their sub-divisions. With the "Key" to the identification of North Carolina soils is a geologic map showing the geological divisions of the State. (Note: The appendix, "Key to the Identification of North Carolina Soils", will be found folded in at the back of this bulletin.) Figure 5 is a map of the State showing the normal annual precipitation.

Soil surveys have been made and reports and soil maps prepared by the Department of Agriculture for 90 of the 100 counties in North Carolina. Figure 6 is a map of the State showing the counties that have not been mapped. Figures 7 and 8 are photographic copies of sections of soil maps of two counties in the State and are typical of the other maps. On the original maps soil types are shown in different colors with letter symbols designating the types of soils.

Agricultural soil maps are of inestimable value to the Soils Department of the

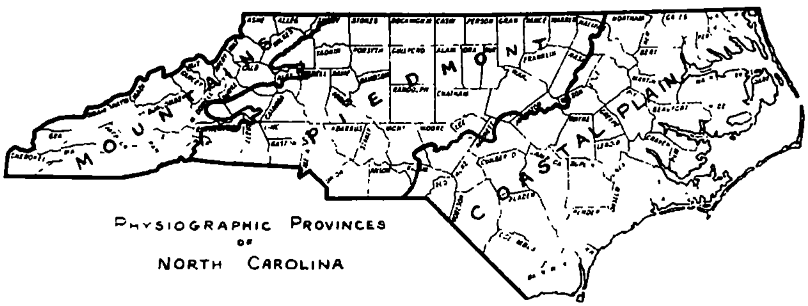

Figure 3.

NORTH CAROLINA SOILS

With the exception of the true mountain soils, the soils of North Carolina belong to the Red and Yellow Great Soil Group. The true mountain soils belong to the

North Carolina State Highway and Public Works Commission. Many soil problems are solved by locating the proposed road on the soils map and noting the type and (or) series of the soils that are traversed by the road. Certain soil types are known

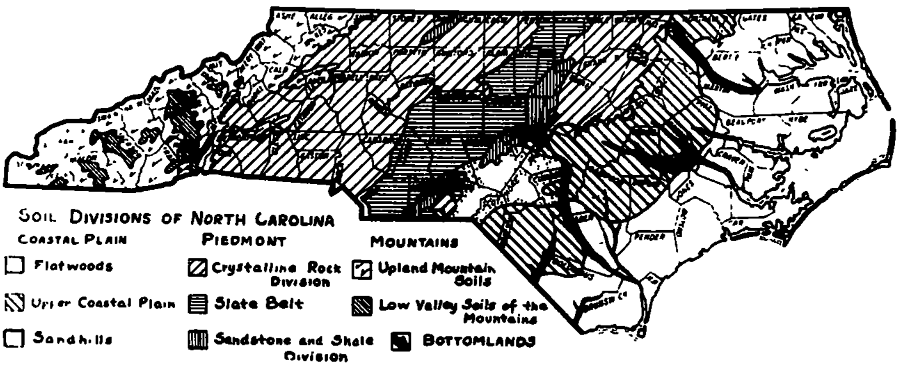

Figure 4.

to be satisfactory materials for soil type base or surface construction, and if they are shown on the maps, this information is of great assistance to the material investigator sent to the project to locate these types of materials. Sand deposits for sand asphalt pavements are also often located in this manner. Soils belonging to certain soil series are known to make poor subgrades and their presence or absence can be ascertained by an examination of the soils map. Greater detail, if required, must be obtained in the field, but the soils map may be used as a guide.

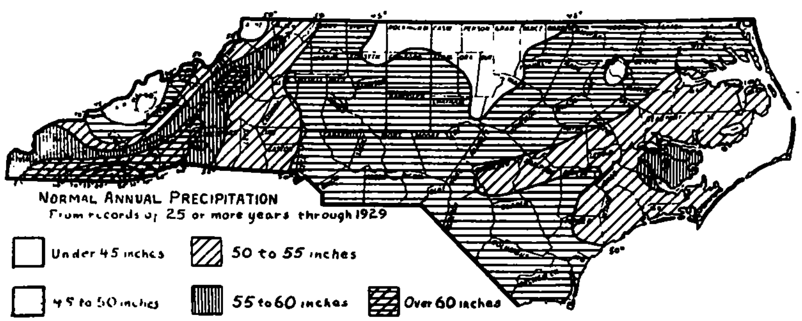

Figure 5.

Much cement stabilization has been done in North Carolina, and practically all of the preliminary estimates of the cement required have been determined from soil maps. The exact disposition of the cement required was determined in the field after grading operations were complete by a trained soils man capable of identifying soils by their series group. This procedure is possible because the Soils Department has previously determined the cement requirement for soils belonging to the most common series in the State, it having been discovered several years ago that the cement requirement for a definite horizon of a definite soil series was the same regardless of where the soil was located.

Many other uses are made of agricultural soil maps in North Carolina, among them being the determination of the need for pervious sub-bases to act as blotter courses beneath concrete pavements for the prevention of the detrimental effects of pumping action. It is believed from experience that all subgrade soils that are not granular type soils will eventually cause trouble by permitting detrimental pumping to occur. (Granular type soils are considered those soils belonging to the PRA Subgrade Groups below A-4). A knowledge of the subgrade groups to which the soils in the profiles of the various soils series that occur in the State belong permits a quick determination of the need of a sub-base beneath a concrete pavement.

When an agricultural soil map of a county is not available or when more accuracy and detail are required than furnished by a map, it is necessary to make a soil survey. Surveys of this type are made by men trained to identify soils by their series group. Soil identification keys have been prepared for this purpose and one will be found in the Appendix to this article following the last paper in this Bulletin.

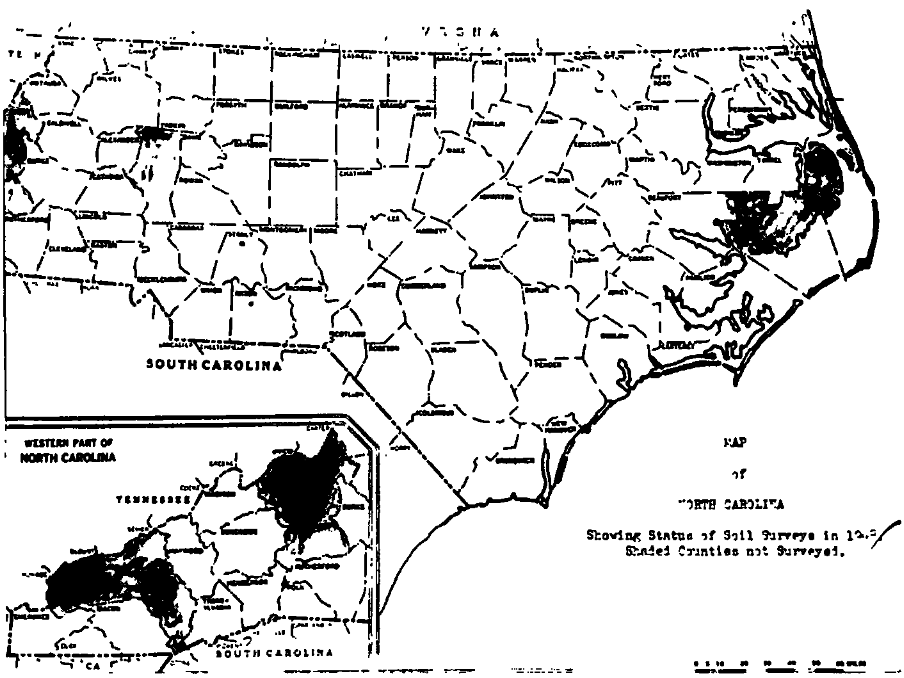

Figure 6.

This key consists of a geologic map of the State and a detailed description of all of the soil series groups found in the four soil provinces of the State. The manner of describing the soils and their arrangement in groups, having certain features in common, permits easy identification.

The soil series groups of the Coastal Plain Province are divided into sands, soils with friable "B" horizons, soils with plastic "B" horizons, organic soils, and miscellaneous soils materials. These divisions, with the exception of the organic soils, are sub-divided according to drainage, such as drainage well established, fairly well established, and poorly established. The organic soils division is sub-divided into two groups, fibrous, partially decayed organic matter and well decayed organic matter. Some of the sub-divisions are further grouped according to the color of the "A" horizon material.

The soils series of the Piedmont Plateau provinces are grouped into three divisions, the crystalline rock division, the slate belt division, and the sandstone and shale division. The crystalline rock division is subdivided into soils series derived from acid crystalline, basic crystalline, mixed acid and basic rocks, and mica and quartz mica schist. The slate belt division is sub-divided into two divisions, soils series derived from slates and fine grained volcanic rocks and mixed slates and basic rocks.

The soils series of the Appalachian Mountain Province are grouped into four divisions, high mountain soils, low mountain soils, old high terrace soils, and miscellaneous soils. The high mountain

Figure 7.

soils division is sub-divided into soils series derived from acid crystalline rocks, basic crystalline rocks, mica schists, slates and schists, schists and acid crystalline rocks, and from sandstone, shale and quartzite. The low mountain soils division is sub-divided into soils series groups derived from acid crystalline rocks, basic crystalline rocks, schists, from sandstone, shales, slates, and quartzite, and from limestone.

The soils series of the River Flood Plains Province, sometimes called Bottomlands, are separated into divisions, first bottoms or soils subject to frequent inundation by floods, and second bottoms or older deposits from floods that are rarely inundated. The soils series of these two divisions are further separated according to drainage and origin of the parent material.

The procedure for identifying a soil as to series using the soil identification key follows certain orderly steps which finally eliminates all other soils except the one to which the soil in question belongs. First, the soil province and subprovince in which the soil occurs is determined by use of the geologic map with the key or the map of the soil provinces in Figure 4. Second, if the soils in the sub-province are separated according to parent material, drainage, or both, or color of the "A" horizon material, the separation fitting the soil in question must be determined. This procedure finally eliminates all soils series groups except a few and the exact identification is made from the detailed description of the color, arrangement, texture, and structure of the soils in the profile.

Sometimes it may be difficult to determine the location of the River Flood Plains Province, but the proximity, size, and flood area of the streams will determine its boundaries.

Example of Identifying a Soil as to Series Group - A soil is located in the south-central portion of Caswell County. According to the geologic map it is located in the crystalline rock division of the Piedmont Plateau Province. (The symbol Cg designates the rocks to be carboniferous granite which are acid crystalline. Intrusions of basic rocks may occur, but

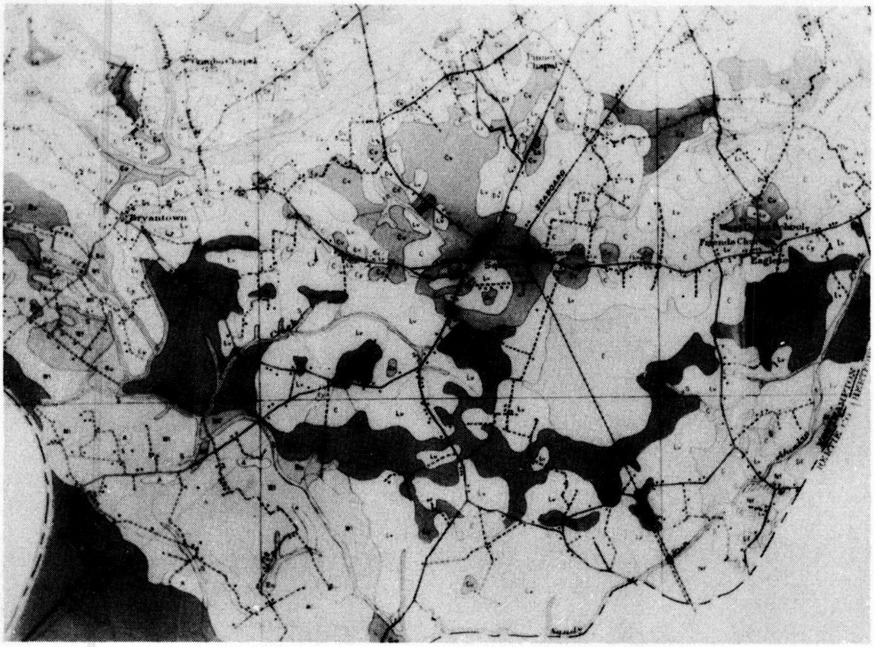

Figure 8.

an examination of the rocks in the area will check the type of rock as acid crystalline rocks are light colored, while basic crystalline rocks are dark to green in color.) The topsoil or "A" horizon material is a brownish-grey sandy loam and the sub-soil is a stiff, but brittle, red clay with mica flakes and free quartz. This soil belongs to the Cecil series. The type classification is Cecil sandy loam.

A discussion of the characteristics, uses, and treatments of the various soils occurring in this State is not within the scope of this article. This is material for a Soils Manual which is being prepared by the Soils Department. The amount of work and data necessary for such a manual is large and its preparation requires a considerable expenditure of time, however, when it is completed, it will contain valuable information on the soils of North Carolina from an engineering standpoint.

This paper covers the subject of how agricultural soil maps may be used in conducting soil surveys for engineering purposes. The methods described have been used by the Soils Department of the North Carolina State Highway and Public Works Commission since 1938 with success, and the data accumulated and experience gained so far are used constantly. Additional data and experience through the years will enable the Soils Department to solve soils problems quickly and economically by the use of agricultural soils maps and the pedological system of classification of soils.

The author has drawn freely from the "Atlas of American Agriculture", Part III, and Bulletin No. 293 of the Agricultural Experiment Station of the North Carolina State College of Agriculture and Engineering for the description of the pedological system of classifying soils.