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SUBSURFACE STUDY OF GLACIAL DEPOSITS AT CLEVELAND, OHIO

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The soil[1] strata underlying the City of Cleveland, Ohio, have been laid down largely through glacial action in a complex fashion. A correlation and mapping of the strata throughout this area would be very helpful to geologic studies and engineering projects. The undertaking of a correlation of this locality is difficult because of the irregularity and complexity of glacial action, and more so because of the fact that exposures of glacial drift are to a large extent concealed by a thick blanket of alluvium deposited during the high-level stages of the post-glacial lakes. Dependence must be had to greatest extent upon the information given by soil borings.

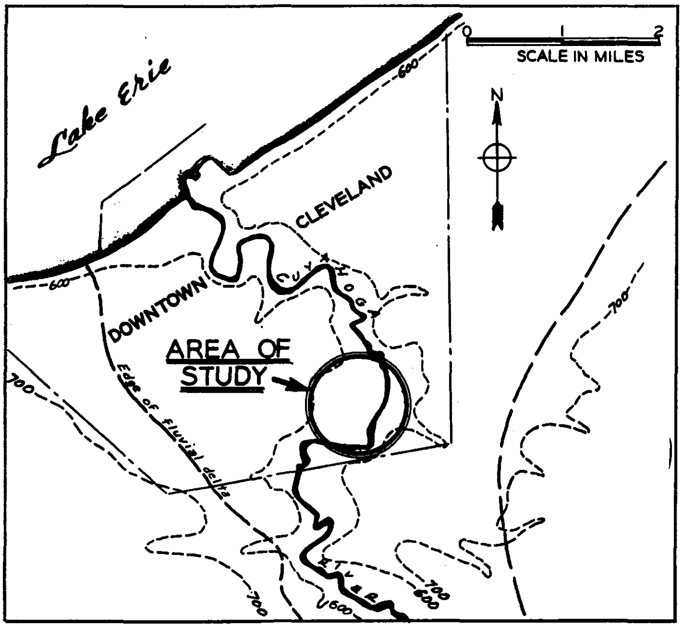

FIGURE 1. The Cleveland Region.

This paper outlines such a study for a relatively small area within the narrow valley of the present Cuyahoga River, approximately 3 miles south of Lake Erie.

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[1] In this study the term "soil" is used in the sense commonly accepted by engineers engaged in foundation and soil mechanics studies. It means essentially unconsolidated material overlying bedrock.

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From a number of soil borings in the area, continuous till sheets alternating with lacustrine clay beds are identified, and a picture of the drift sequence is obtained. Extrapolation of soil information from this area to other parts of Cleveland would be unwise until more boring data are available, because of probable rapid lateral change. But within the area studied (fig. 1) several continuous soil strata can be relied upon to large degree.

RECENT GEOLOGIC HISTORY OF THE CLEVELAND AREA

During the Tertiary period the streams of the Cleveland area developed deep, relatively narrow valleys in their northward courses into what is now Lake Erie. Then, during the Pleistocene epoch, ice sheets advanced southward into the area, dammed the streams, reduced the hills, and left the valleys largely filled with deposits of till. Of the major stages of glaciation, the last that covered this area was the Wisconsin stage. As Williams (1940) states, it has to a great degree obliterated the work of its predecessor, the Illinoian stage. The advance and recession of each major glacier was marked by many minor reversals with the seasons.

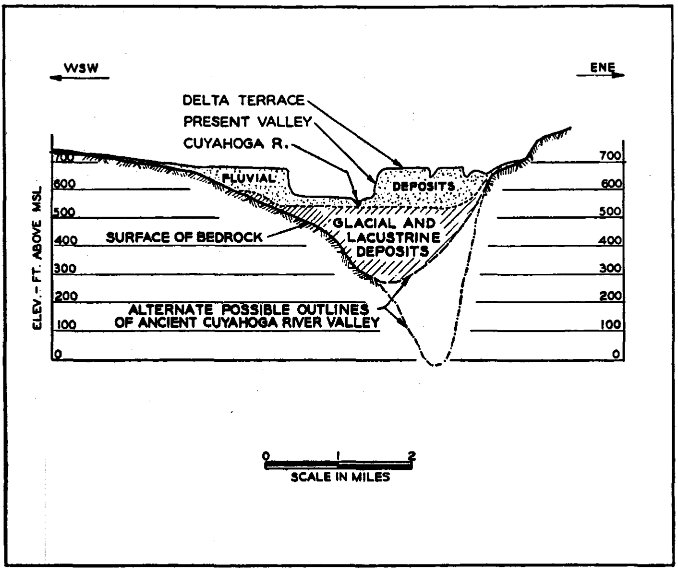

FIGURE 2. Cross Section of Cuyahoga River Valley.

A series of glacial and post-glacial lakes existed during and after the recession of the Wisconsin glacier from the Cleveland area. Some of these lake stages were much higher than present Lake Erie. One or two were probably 15 to 30 feet lower.

TOPOGRAPHY

The general topography of Cleveland is indicated by figure 1. A delta plain, established during the time of the high-level glacial lakes, fills the pre-glacial Cuyahoga River valley to an elevation of 660 to 680 feet above sea level. Much of downtown Cleveland is built upon this delta. The present Cuyahoga River has cut its valley some 90 feet lower, and now flows at the level of present Lake Erie (573 feet above sea level) through a flood-plain ½ to 1 mile wide.

Within 5 to 8 miles of Lake Erie, the present river valley lies generally west of a pre-glacial river valley (U. S. Geol. Bull. No. 818, 1931). Bedrock slopes steeply down to the east in the area where the borings under study were made, which agrees with reports that the pre-glacial valley is very deep (fig. 2).

GLACIAL AND STREAM ACTION IN THE CUYAHOGA VALLEY

During the period of glacial advance, the Cuyahoga River valley was undoubtedly widened, and the deepest portions of the valley filled with glacial outwash and till. When the glacier front was at or near Cleveland, water was ponded to the south. During the Wisconsin stage the ice sheet covered and uncovered this area a number of times. With each advance a layer of till was deposited, usually a stiff, unstratified, stony clay. Following each recession, a blanket of stratified sand, silt and clay was laid down over the till in the waters of the ponded lake. After the final departure of the ice sheet northward, alluvium, largely sand, was brought down the valley by the river and laid over the deposits of till and lacustrine material. Deltas of various heights were formed and eroded away with

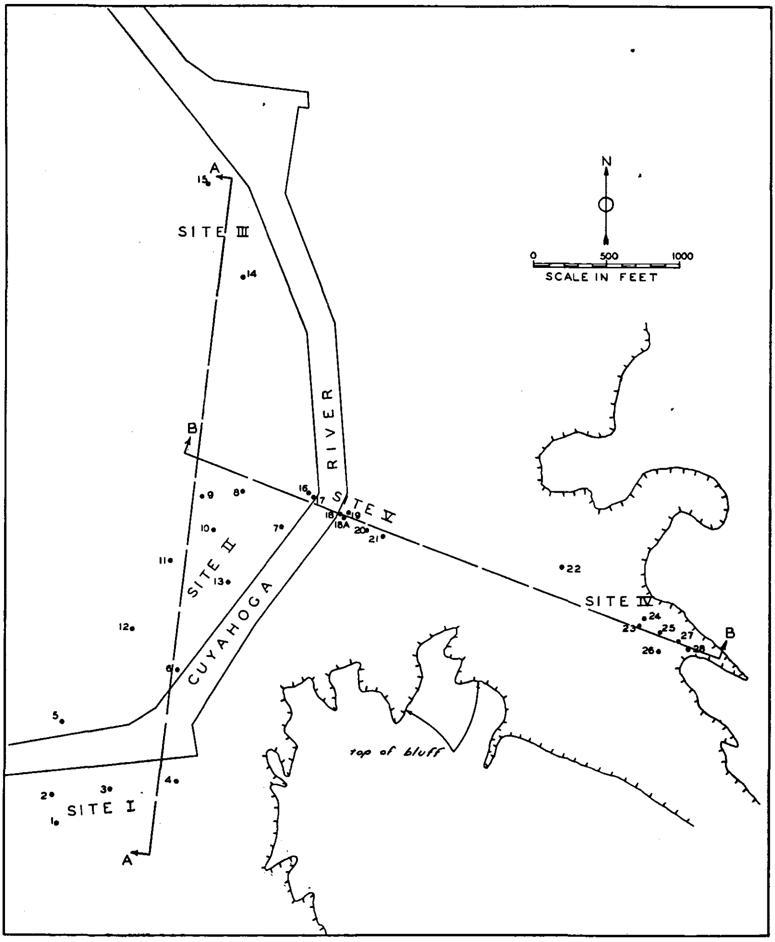

FIGURE 3. Location of Borings.

the changes in level of the post-glacial lakes. When the lake levels dropped the Cuyahoga River began to carve its new valley. While Lake Erie was at its lowest level, it is probable that the river cut its narrow valley deeper than it is at present, re-sorting some of the material found somewhat below present lake level. The unusual stiffness of topmost layers of clay in some of the bore holes is interpreted as the result of dessication of lacustrine clay during a lake stage lower than the present.

SOIL BORINGS AND LABORATORY TESTS

Data from soil borings at five sites were available for this study, as shown in figure 3, and as listed below.

Site I: 4 continuous tube sample borings to bedrock.
Site II: 5 continuous tube sample borings to a depth of 60 to 150 feet.
7 standard Gow-type borings, most of which went to bedrock, with a jar sample taken every 5 feet.
Site III: 2 continuous tube sample borings to a depth of 150 feet.
Site IV: 2 continuous tube sample borings to a depth of 50 feet.
5 standard Gow-type borings to a depth of 100 to 150 feet, with jar samples every 5 feet.
Site V: 4 borings to bedrock and 3 borings 220 feet deep, with jar samples every 10 feet, and continuous tube samples from one hole from depth 170 feet to bedrock.

From the continuous tube samples, unconfined compressive strengths and water contents were obtained. Physical descriptions of most of the samples were available. These list the type of soil, color, approximate consistency, stratification if any, inclusions, etc. In addition to the data obtained from the soil boring and laboratory reports, the writer examined some 150 jar samples from Site V, and ran such laboratory tests as were pertinent.

Samples of till from the borings are typically stiff clay, without stratification, and often contain stones and other inclusions in irregular manner. Samples of lacustrine clay deposits are usually softer than adjacent tills, and often show clear horizontal partings of silt or fine sand.

CORRELATIONS

Figure 4 shows the types of soil found in each bore hole, and apparent correlation from boring to boring and site to site. Symbols used on the figure are as follows:

Soil Types—

F = fluviatile—sand, gravel, river silt; also includes man-made fill.
L = lacustrine.
L_s = lacustrine, stratified.
L_u = lacustrine, unstratified.
T = till—unsorted material.
T_w = till, waterlaid, usually having some sorted characteristics.
O = glacial outwash.

Soil Strata—

A = fluvio-delta deposit and river-laid material.
B = generally soft lacustrine clays.
B_1 = till, soft to very stiff.
C = till, medium to stiff.
D = lacustrine clay, soft to medium.
E = stony clay till, stiff to extremely stiff.
F = lacustrine silty clay, medium to stiff.
G = hard stony clay till, and outwash of sand and gravel.

Figure 5 is a generalized recapitulation of the information of figure 4, drawn to horizontal as well as vertical scale.

It is to be noted that 4 layers, B. C. D. and E, are continuous through all the sites. Layers below E are interrupted only by the rise of the bedrock across their levels.

Layer A is also continuous as a general, fluvial deposit, but the typical grey sand of the post-glacial delta deposit, which in the present river valley has been eroded to a relatively thin layer 10 to 20 feet in thickness, is found in some drill holes to be entirely removed and replaced by a flood-plain river deposit of stony silt, peat, etc.

Till layer B_1 intrudes between layers A and B on the east (Section B-B). This till layer is absent from the area of Sites I, II, and III.

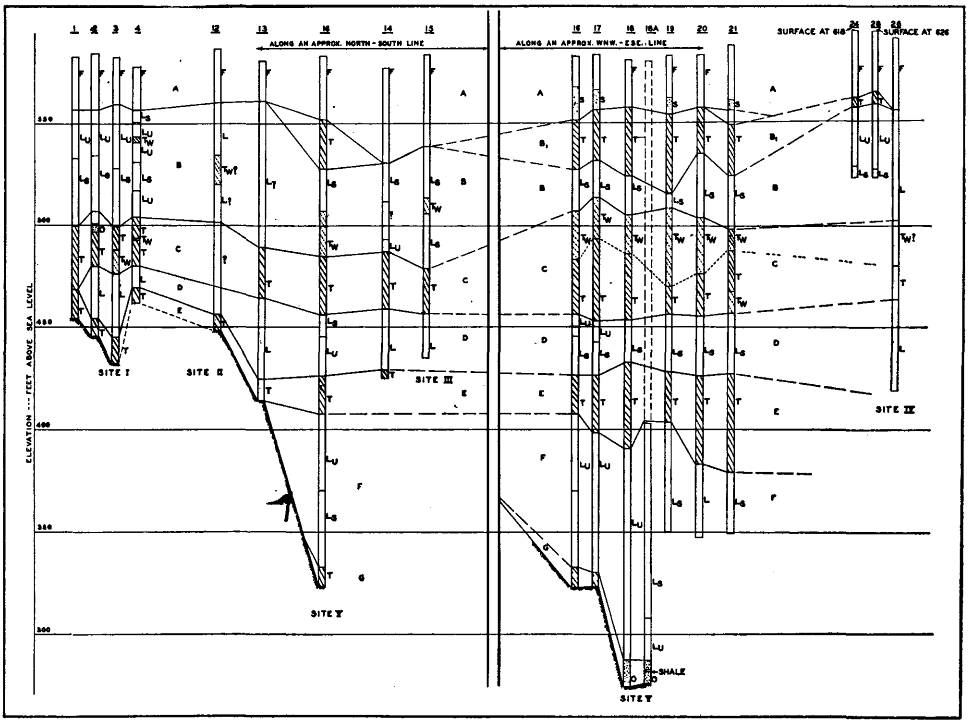

FIGURE 4. Borings and Soil Strata.

The general sequence is that of a basal till, Layer G, (which in some borings may be weathered shale or a mixture of weathered shale and till), overlain by alternating lacustrine clay and till units. The lowest till layer, G, is interpreted as Illinoian. The three overlying till sheets, E, C, and B_1 are interpreted as deposited by three advances of the Wisconsin ice. Layer E, which is more compact than the till of the two overlying sheets may be Tazewell, and the two upper sheets may be early Cary and late Cary, respectively. This postulated Wisconsin sequence correlates with that recently determined by White (1950) for Wisconsin till deposits at the surface south of Cleveland, in Summit, Medina, Portage, and adjacent counties. Still farther south, Illinoian till exists at the surface beyond Wisconsin drift (White, 1942).

Pockets of stratified material occur in the till sheets at various points. These are "water-laid till," released from the ice into ponds or streams beneath the glacier, and sorted before final deposition. Other instances of water-laid till are isolated bands of sorted or unsorted till, surrounded on all sides by typical lacustrine deposits. In such case, samples may show definite stratification, yet have pebbles and sand particles scattered through the bands of clay. This is also typical of water-laid till, indicating the dropping of the till intermittently into a ponded area from an overlying ice sheet or from floating ice cakes. In short, glacial deposits do not adhere strictly to the three common classes ascribed to them: till, outwash, and lacustrine deposits; but may vary through a range of combinations.

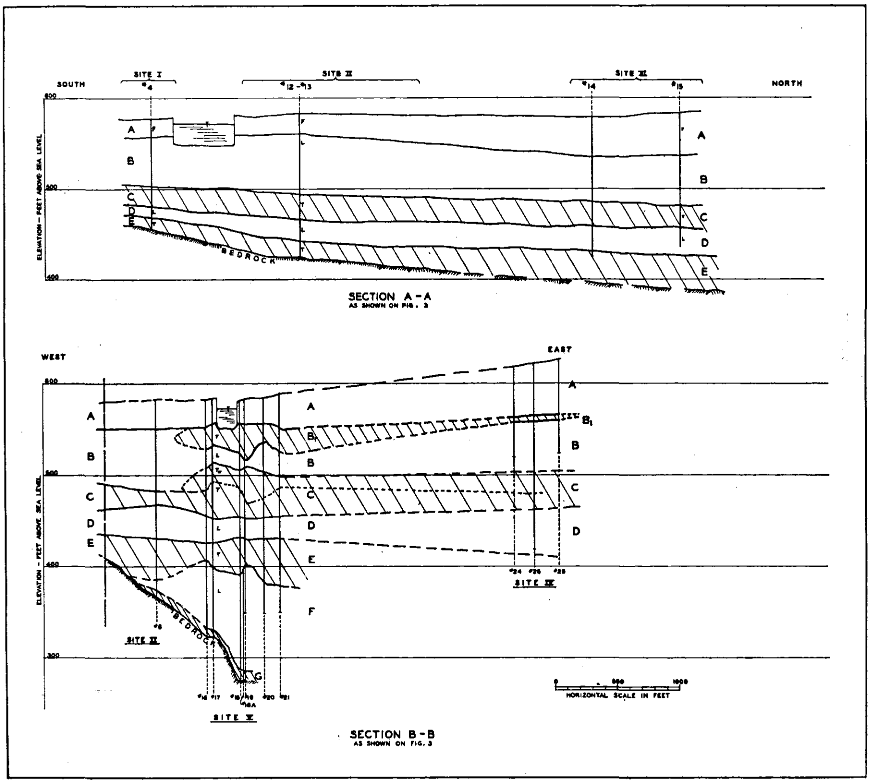

FIGURE 5. Generalized Soil Strata.

Top and bottom borders of each till sheet are irregular by their very nature, and also from the erosion of melt-water streams laced through and under the ice. In spite of the irregularities of glacial deposits, the continuous layers indicated in figures 4 and 5 seem well substantiated by the borings.

All layers of clay beneath Layer A have been precompressed by the load of the delta material, which extended up to elevation 680 at the end of the Glacial Lake Warren stage. Earlier, the delta was probably at an elevation between 760 and 800, the levels of Glacial Lake Maumee. Thus, as noted by Peck (1948), without regard for the weight of the ice sheet which acted upon some of the clay layers, these have all been subjected to precompression on the order of the weight of from 100 to 200 feet of sand, perhaps 5 to 10 tons per square foot.

Location of bedrock eastward from the river is not indicated by the borings available in this study. It may continue at a steep slope downward into the sea level gorge indicated by some of the old gas well reports (U. S. Geol. Surv. Bull. No. 661, 1917), or it may conform to a more characteristic valley cross section for shale. In the latter case, the level of the bedrock found in the Site V borings may represent very nearly the lowest points of the preglacial valley.

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