GEOLOGICAL SURVEY OF OHIO
J. A. BOWNOCKER, State Geologist

FOURTH SERIES, BULLETIN 23

GEOLOGY OF CAMP SHERMAN QUADRANGLE

By J. E. HYDE

COLUMBUS
1921

Published by authority of the Legislature of Ohio, under the supervision of the State Geologist

Printed by The Kelly-Springfield Printing Company
Springfield, Ohio

TABLE OF CONTENTS

INTRODUCTION

Part I

THE REGION AS A WHOLE

Chapter I

THE LOCATION OF CAMP SHERMAN

Chapter II

THE TOPOGRAPHY OF THE CAMP SHERMAN QUADRANGLE

Chapter III

MATERIAL IN EXCAVATIONS AND NATURAL RESOURCES

Chapter IV

WEATHER

Chapter V

THE SCIOTO RIVER

Part II

DETAILED DESCRIPTION OF SUBDIVISIONS

Chapter VI

LOWLAND OF THE NORTHWESTERN PART OF THE QUADRANGLE

Chapter VII

HILLS WEST AND NORTHWEST OF CAMP SHERMAN

Chapter VIII

THE SCIOTO VALLEY

Chapter IX

FLAT-TOPPED PLATEAUS OF THE SOUTHWESTERN PART OF THE QUADRANGLE

Chapter X

HILLY UPLANDS OF THE SOUTHERN PART OF THE QUADRANGLE

Chapter XI

THE LOWLAND OF THE NORTHEASTERN PART OF THE QUADRANGLE

Chapter XII

THE KNOBS EAST OF CAMP SHERMAN

Chapter XIII

THE GREAT GRAVEL TERRACES SOUTHEAST OF CHILLICOTHE

Chapter XIV

THE HILL COUNTRY OF THE EASTERN PART OF THE QUADRANGLE

Part III

THE GEOLOGICAL FORMATIONS AND PHYSICAL HISTORY OF THE QUADRANGLE

Chapter XV

THE BED ROCK FORMATIONS

Chapter XVI

TOPOGRAPHIC HISTORY TO THE BEGINNING OF THE GLACIAL PERIOD

Chapter XVII

GLACIAL FORMATIONS AND HISTORY

ILLUSTRATIONS

PLATES

FIGURES IN TEXT

MAP

INTRODUCTION

Soon after the entry of the United States into the World War, a sub-committee of the Council for National Defense suggested to each of the geological surveys of those states in which cantonments were established, the preparation of a bulletin on the topography and military geology of the cantonment. The suggestion was followed, as soon as possible, by a carefully prepared outline, showing just what, in the judgment of the committee, should be included in such a bulletin. It was purposed that the bulletins should be essentially detailed hand books on the respective camps and their environs, dealing with all the natural features of the camp neighborhood that might have a bearing on any military operations or maneuvers thereabouts. The designated object was to facilitate the training of officers by presenting detailed information on the physical features of the camp at which they were training, so that in maneuvers they might best adapt themselves and their commands to these features, and thereby obtain increased safety, comfort, and military efficiency.

The present bulletin is the direct result of this suggestion. In so far as possible, the plans proposed by the committee were followed but since the work was prepared without assistance, on limited funds and in the haste incidental to the opening months of the war, it is necessarily less elaborate than was anticipated by the committee.

To prepare a work of any presumable value to the end for which it was designed, it was impossible to complete the manuscript and drawings until the fall in which the Armistice was signed. Since then, publication has been suspended during the period of disbandment and dismantling of camps, until the probable future of Camp Sherman could be learned. All indications now are that the camp is to be permanent. The bulletin is herewith issued as it was prepared during the rush of war, except for such slight changes and additions as can be made in the proof. It has not had the advantage of the very excellent volume, Military Geology and Topography,[1] which was issued contemporaneously with the completion of the manuscript.

As the volume was being set up, there was received a paper on "The Use of Geology on the West Front"[2] by Alfred H. Brooks, late Lieutenant Colonel and Chief Geologist at general headquarters, A. E. F.

(1) Military Geology and Topography, Herbert E. Gregory, Editor, various authors. Prepared and issued under the auspices of the Division of Geology & Geography, National Research Council, Yale UniversityPress, New Haven, Conn., 1918.

(2) Professional Paper 128-D, U. S. Geol. Survey, 1920. This can be had on request and should be of interest and value to every officer who has to do with men or construction in the field.

Mention may also be here inserted of the following:

In the New World of Science, Robert M. Yerkes, editor, in which "The Role of the Earth Sciences in the War" is treated by Douglas W. Johnson as follows: Contributions of Geography, pp. 177 to 195. Contributions of Geology, pp. 196 to 217, The Century Co., 1920.

The purpose for which the present bulletin was designed can be no better illustrated than by a brief quotation from Colonel Brooks' opening paragraphs.

"During the great battle of Verdun a body of troops was ordered to intrench itself on the high plateau of the Cotes de Meuse. Even a casual examination of the geological map would have shown that the plateau was underlain by hard limestone with less than a foot of soil. This material could not be excavated with the light tools furnished or even with proper equipment in the time available. As a consequence there was a large and needless loss of life.

"In part of the Lorraine sector the front-line dugouts were located by the French without any consideration of the underground-water conditions. As a consequence a large part of the dugouts constructed at great labor were quickly rendered useless by filling with water. We did the same thing. I recall an attempt at dugout construction at a locality where the responsible officer had been warned that he could not excavate to the depth required to obtain shelter. The location was in an exposed position, and a number of lives were sacrificed before the project was abandoned because of water.

"In the early part of the war, when transportation facilities were crowded to the limit, the British brought road metal from England in ignorance of the fact that a geologist was able to designate readily accessible sources in the theater of operations. A responsible officer in our own service made a requisition for filter sand to be transported across the Atlantic, though the geologists of the American Expeditionary Force had already found localities where such sand could be procured in France.

"During 1915 the German troops in the St. Mihiel sector were giving official recognition to the use of the witch-hazel stick in locating sources of underground water. The first duty of the geologist detailed to this sector was to collect data on the results achieved by this implement, so as to shake the confidence of the authorities in its efficacy. In our Army many large plants, such as hospitals and flying fields, were located without any definite knowledge of the source of needed water. In the British Army, after the first year, no well drilling was permitted without the approval of the geologist in charge of water-resource investigations. There was no such rule in the American Expeditionary Force, and many wells were drilled with no adequate knowledge of the underground-water conditions. In many instances it was not until hospitals or other large plants actually had a shortage of water that the geologist was called into consultation.

"In the early part of the war neither the British nor Germans recognized the need of geologic knowledge as a preparation for military mining. The success of the British in gaining control of the underground situation must in large measure be credited to the refinement of the geologic studies and their interpretations made by Lieut. Col. T. Edgeworth David. The attitude of the British is illustrated by a personal experience. Soon after reaching France I was sent to the British front to investigate military mining. When I was presented to Brig. Gen. R. N. Harvey, who commanded the British mining troops, and stated my mission, he said, without knowing my profession: 'The first requisite for success in military mining is to secure the services of experienced geologists. I wish I had known that at the start.'

"A large part of the German secret official manual of military geology is devoted to an attempt to convince army officers of the usefulness of geology in war. During the first two years of the war the German technical publications contained many articles advocating the use of geologists in the army and pointing out the various applications of the science to war problems. This propaganda was finally stopped by the censor under the plea that military secrets were being published."

Colonel Brooks outlines the applicability of geology to the art of war as follows:

"Geology finds its principal application to war in forecasting the physical conditions that will be encountered in the execution of certain military projects, such as the construction of fortifications, the maneuvering of troops, and the erection of engineering structures, and in determining the sources of water, road metal, and other mineral supplies.

"The problems of the military geologist are in general among the simpler problems of geology, and deal primarily with (1) the physical character of the surface formations, (2) the depth to hard rock, (3) the lithology and structure of the formations to depths of less than 100 feet, except in deep-well drilling, (4) the depth of the ground-water level, (5) the distribution of water-bearing beds, including their surface outcrops, (6) the geologic control of run-off as affecting stream volume, and (7) the distribution of rock suitable for road metal and of gravel, sand, and materials for concrete."

The writer is indebted to many who have aided by suggestions as to the scope and character of the work, or have contributed local knowledge of a special sort. Among the former must be especially mentioned Professor Douglas W. Johnson, later Major Division of Military Intelligence, U. S. A., and Colonel Bain of the 309th Engineers Regiment, which was stationed at Camp Sherman for some weeks. Among the many residents who have supplied local data, special indebtedness is acknowledged to the late J. Irwin Carson, C. E., of Chillicothe, one time assistant city engineer, whose records of weather, floods, and other physical phenomena have been of very great value, and who freely and promptly devoted himself to searching out information on any points that might be obscure.

As just stated, the chief purpose of this work is the presentation of facts bearing on military occupation. This purpose has been extended by the addition of the last three chapters, a summary of the geological and physical history of the region, which have no direct military bearing; these are intended solely for those who desire to understand something more of the region than its adaptability to military ends.

PART I

THE REGION AS A WHOLE

CHAPTER I

THE LOCATION OF CAMP SHERMAN

Camp Sherman is located on the banks of the Scioto River one mile north of Chillicothe in the south-central part of Ohio. It is on the north-south line between the Chillicothe and Roxabell quadrangles of the United States Geological Survey, lying in both but chiefly in the latter, and just south of the center of the Camp Sherman quadrangle, which has been made by combining the two. The area which is described in detail in the following pages is practically that of the Camp Sherman double quadrangle[1].

Chillicothe.—The city of Chillicothe, for many years prior to its transformation by the establishment of the Camp, had been a conservative community with relatively limited manufacturing interests and slow growth, compared with other cities of its size. The population in 1910 was 14,508; in 1890, 11,288[2]. Yet it had been one of the most important places in the State in the early days. From 1800 to 1803 it was the capital of the Northwest Territory, and from 1803 to 1810 and again from 1812 to 1816, it was the capital of the State of Ohio.

[1]The United States Geological Survey is making and publishing in conjunction with the States, a topographic map of the United States. It is issued in sheets which are of standard size, 15 minutes of latitude by 15 minutes of longitude in Ohio. The area represented by such a sheet is called a *quadrangle* and each quadrangle goes by the name of some locality in it. Ohio is one of the few states in which the mapping has been completed. The scale of the Ohio maps is approximately one mile to an inch and each sheet represents an area about 13½ miles wide by 17¼ miles long. These maps show not only county and township subdivisions, sections, towns, cities, streams, railroads, roads, houses, etc., but represent the topography, or hills and valleys also. For this reason these maps are frequently called topographic maps or sheets. The topography is represented in brown by contour lines. A contour is an imaginary line drawn on a map along the face of the hills, through all points of a definite altitude; thus, the 700-foot contour would pass through all points 700 feet above sea level, and would be found on both sides of any valley whose bottom is less than 700 feet and whose bounding hills are more than 700 feet above sea level, winding around the face of hills, and extending up both sides of any tributary valley to the point where it rises above the 700-foot elevation. Such a line behaves much like the high-water mark of a flood. These lines are drawn at definite vertical intervals, 20 feet in the Chillicothe and Roxabell quadrangles, and it is possible to determine quite accurately from the maps, the "lay of the land" at all points. These maps are by far the most accurate available. They may be obtained from the *Director, U. S. Geological Survey*, for 10 cents each, cash or postoffice money order, or frequently for the same price from some dealer in the larger towns of a region.

[2]The population in 1920, 15,831.

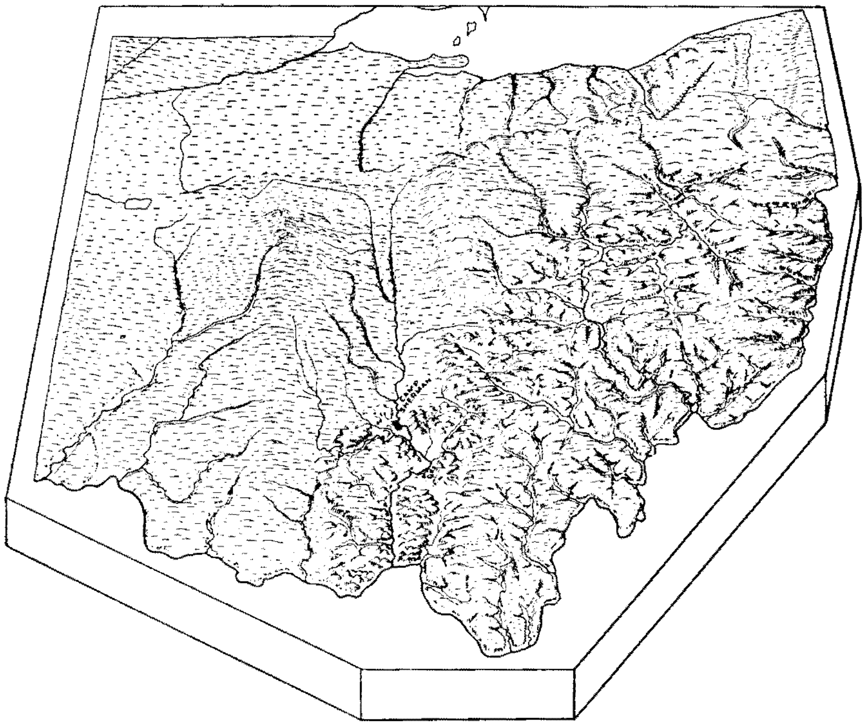


Fig. 1.—Block diagram of the chief topographic features of the State of Ohio, to show the location of Camp Sherman with reference thereto. All valleys which are indicated with streams are actual occurrences. In the representation of the hill country of southeastern Ohio, the degree of dissection is only partially indicated. There are very few flat-topped uplands. To have attempted even an approximate representation of the dissection in that part of Ohio would have been confusing.

TRANSPORTATION

Railroads.—Two of the eight railroad systems between the central northern states and the Atlantic seaboard pass through Chillicothe. The Norfolk & Western railway has its western terminus at Columbus, 50 miles to the northward, and reaches the Atlantic Ocean by a long run southward along the west line of West Virginia, thence eastward through southern Virginia to Norfolk. The Baltimore & Ohio main line, from St. Louis by Cincinnati to Washington and Baltimore, passes by the Camp. Two of the remaining systems, the Pennsylvania and New York Central, may be reached by either of these roads within 70 miles to the north and west, and a third, the Chesapeake & Ohio, may be reached at Cincinnati or at Kenova on the Norfolk & Western. Another line of the Baltimore & Ohio railroad, the one-time Cincinnati, Hamilton & Dayton, runs from Chillicothe northwestward to Dayton and eastward into southeastern Ohio. The Baltimore & Ohio railroad brings coal direct from the eastern Ohio coal fields to Camp Sherman, and the double track line of the Norfolk & Western from the great West Virginia fields to central Ohio passes within a mile, with ample opportunity to place cars on the Camp sidings through the Baltimore & Ohio.

The Scioto Valley Traction line, electric, extends from Chillicothe to Columbus, where it connects with steam and electric lines to all parts of Ohio.

Roads.—Few places in the State, of any size, are possessed of a set of pikes radiating in all directions to so many distant towns as Chillicothe. The condition is inherited largely from the days of its political ascendency in the beginning of the last century when stage roads were the only means of travel to the Capital of the State. This condition is memorialized in the names of some of the roads, Cincinnati Pike, Portsmouth Pike, Jackson Pike, Old Marietta Road, Zanesville Pike, and Columbus Pike, names whose use long antedates rapid transportation by automobile, and has been only refreshened by it.

SITUATION OF CAMP SHERMAN WITH REFERENCE TO THE TOPOGRAPHY OF OHIO

Two chief topographic subdivisions in the Camp Sherman region, The Allegheny Plateau and Central Lowland

The Camp Sherman quadrangle is unusual for Ohio in the great variety of its topographic forms. However, two areas of prime topographic importance stand out.

The northern third, roughly, is an area of rolling plain and low hill land across which the streams flow in open valleys of little depth. The central and southern portion of the quadrangle rises to much greater altitudes, is rough and hilly, in places rugged, and the streams draining it flow through deep and usually narrow valleys. (See Plate I.)

These are the two chief topographic features of the region, more important from the larger geographic point of view than even the Scioto Valley which traverses both from north to south, though perhaps less impressive on first thought.

The central and southern portion of both quadrangles is a small part of a generally hilly, rugged, upland area that stretches eastward to the Appalachian Mountains. The name *Allegheny Plateau* is given to this upland, and it is one of the important topographic subdivisions or provinces in North America. The Allegheny Plateau is terminated westward by a more or less abrupt descent of several hundred feet to lower-lying regions of less relief,that, in Ohio, are largely rolling plains. These rolling plains constitute another great topographic province, the *Central Lowland*, and the lowland in the northern third of the Camp Sherman quadrangle is its eastern margin.

The escarpment boundary between these two provinces extends in a generally north-south direction near the median line of the State, but across the Camp Sherman quadrangle, it locally trends irregularly nearly east and west. Because of this, though the Allegheny Plateau lies east of the Central Lowland in Ohio, locally in the Chillicothe district it lies south of the Lowland. (See Fig. 1, page 19.)

The Central Lowland of western Ohio.—The physiographic (or topographic) province known as the Central Lowland, with small exceptions, covers the entire upper Mississippi Valley north of the Ohio and Missouri rivers. It includes, for our purposes, all of the western half of Ohio and a narrow border around the shore of Lake Erie in the northeastern portion. In Ohio it is essentially a rolling plain which owes its character chiefly to the vast amount of clay, sand, and gravel brought from the north by the glaciers and dropped while their outer portions stood across Ohio. In this way, many of the valleys which formerly cut the western portion of the State into a moderately hilly region were obscured or filled entirely and buried from sight. There is exception to this in the southwestern portion where the ice was thin and less active near its outer limit; there valleys remain, dissecting the plain to a depth of 200 to 300 or even 400 feet, and show what must have been the character of much of the higher portions of western Ohio before the glacial period.

The most essential character of this unobscured southern portion is its plainness, and the fact that this plain surface is cut up by numerous valleys 300 or 400 feet deep does not in any way negative the fact that the surface is a plain. Many large remnants of the original plain yet remain in the flat or rolling divides between the valleys and much erosion by streams must yet be accomplished, hundreds of thousands of years of it as men count time, before these large segments of the plain will be destroyed. Since the streams have accomplished, relatively, only a small proportion of what may be accomplished by them in the dissection of this plain, it is properly described as *a plain in the youthful stage of dissection.*

The Central Lowland is much the better half of the State agriculturally. Transportation is unimpeded, railroads follow nearly or quite straight courses across the plain between the places which they are designed to connect, and were built with little difficulty. As a rule the hills are so gentle that the roads follow the section lines, running north and south or east and west at intervals of a mile; that they do not do so over a yet larger portion is a result of the different local methods adopted in laying out the lands in the pioneer days.

The Allegheny Plateau in eastern Ohio.—The Allegheny Plateau, stretching from southern New York through western Pennsylvania, West Virginia, the eastern parts of Ohio, Kentucky, and Tennessee into Alabama, is a region of generally higher altitude, greater relief,

A.—View southwestward from near Bethel Chapel (4 miles south of Kingston), across the rolling Interior Lowland to the escarpment of the Allegheny Plateau. The knob on the right is Sugarloaf. The Lowland is here composed of gravel and till of such depth that any excavation would encounter no rock. The hills of the Allegheny Plateau are composed of resistant sandstones resting on shale.

B.—View eastward from Sand Hill across the Allegheny Plateau, here dissected beyond the stage of maturity, to show its more or less disconnected knobs with steep wooded slopes and open valleys. In the distant left third is seen the Interior Lowland.

CONTRAST BETWEEN THE INTERIOR LOWLAND AND ALLEGHENY PLATEAU and much more rugged character than the Interior Lowland. It slopes irregularly westward and northwestward from the Appalachian Mountains on the east to its western margin, where the surface descends abruptly 200 to 400 feet or more to the lowlands of the Mississippi basin.

Its hilltops, at practically all places, rise to a higher altitude than the surrounding regions, even equalling or exceeding that of the adjoining portions of the Appalachian Mountains along its eastern margin. Few people would think of it as a plateau, but rather as the endless succession of rugged hills which it certainly is. It is called a plateau because it was once a continuous upland plateau with its fairly even surface at the level of the present hilltops. In certain portions, notably in eastern Tennessee, this rolling upland plateau surface is yet preserved intact, though very much cut up around its margin by deep rugged valleys where streams have commenced to dissect it.

In eastern and southeastern Ohio, streams have almost completely dissected this plateau so that the divides between them are seldom flat remnants of this surface, but narrow, rolling uplands of limited extent. On the other hand, in only a few districts has dissection gone so far that the divides have been reduced to narrow, sharp ridges. In this last case the dissection is complete or *mature*. For this reason, southeastern Ohio is described as *a portion of the Allegheny Plateau in the nearly complete or submature stage of dissection.*

In northern and central Ohio, where the plateau was heavily overrun by the glaciers, though the altitude is high, the relief is commonly slight; this is because the valleys have largely been filled, almost to the hilltops, just as the valleys in the northern part of the Central Lowland were filled. For this reason the northern part of the plateau bears more resemblance to the glaciated Central Lowland than to the rest of the plateau, and is sometimes distinguished as the Glaciated Section of the Allegheny Plateau, and the southern and southeastern parts in Ohio as the Unglaciated Section.

Some exceptions must here be made to this description of the plateau. As a matter of fact, the hilltop surface does not stretch eastward and southeastward from the brow of the escarpment, as a flat or gently rising surface, in all places. To the eye it is flat, but actually there is an imperceptible, gentle descent to the southeastward for some miles. This is true of most of the outer border of the plateau, and in Ohio the descent is so far continued that much of southeastern Ohio is a broad, shallow basin, with the hilltop surface lower than large parts of the plain of western Ohio. Where lowest, the hills commonly rise only 200 to 300 feet above the streams, but the dissection is much more complete and the country rougher than in the Central Lowland. In the higher portions of the plateau, in the extreme eastern part of Ohio, and along its northern and western margins near the limiting escarpment, the hills commonly rise 400 to 600 feet above the streams which cut through them.

From Chillicothe southward almost to the Ohio River, is a second escarpment, 15 to 20 miles east of the main one, but west of the Scioto River, also facing westward.

Travel or transportation across or through the plateau, excepting the glaciated northern portion, is difficult compared with that on the plain to the westward. The course of railroads is determined largely by stream valleys, along which they are built almost without exception. Although true of southeastern Ohio in a notable degree, it is even more strikingly so in the higher parts of the plateau farther east and southeast. Roads, over large areas, cannot be made to follow the section lines because the topography will not permit it; they follow the valleys or ridge tops.

Comparison with topography of northeastern France

These large topographic features of Ohio are, in kind, exactly like the chief topographic features of the French battle front from a point northeast of Paris eastward to the Vosges Mountains; however, they differ very materially in detail.

In Ohio, there is one plain, with one prominent westwardly facing escarpment rising above it and a long gentle slope of dissected hill country to the eastward from it, behind which, in southern Ohio, there is a second minor escarpment.

Between Paris and the Rhine Valley, there are a number of such escarpments, each facing eastward over a plain, and with westwardly sloping back slopes to the plain at the foot of the next escarpment to the westward. The escarpments in Ohio compare favorably in height and dissection with the French occurrences but the back slopes in Ohio are much gentler than the corresponding French features.

Causes underlying the chief topographic subdivisions

The cause of the topography is the same in both cases. It is found in two factors, 1st, the gentle slope of the rock formations beneath the surface, and 2nd, differences in resistance of those formations to erosion. Only the Ohio occurrence needs be discussed. In France the explanation is exactly the same except that the escarpments face eastward and the back slopes slope westward because the rocks dip gently to the westward; in Ohio, where the rocks dip eastward, the orientation of the topography is reversed.

Rock formations of Ohio and their structure.—Ohio is underlain by sedimentary rocks. That is, the *bed rocks* at all places (as distinguished from the *mantle rocks*, the soil or surface gravels and sands) were formed as sediments on the floor of an old sea that occupied the whole Mississippi

Valley. When the region was finally lifted above sea level by movements of the earth's interior, and became land, the rocks did not remain flat, but were upwarped mostly in a broad flat fold near the western margin of the State. From the crest of this upwarp they sloped westward into Indiana and southeastward across most of Ohio into Pennsylvania and West Virginia.

The inclination of the beds is very gentle, on the average perhaps 20 feet in a mile, greater in some areas, less in others. This is so flat that it is inappreciable in ordinary outcrops. Yet it is sufficient to cause the rocks which are exposed at the surface in western Ohio, between Cincinnati and Dayton, to dip below the surface to the eastward, so that at Chillicothe they are about 1,000 feet below the river level. The Berea Grit, one of the important rock formations of the Camp Sherman district, is found at an altitude of 1,040 feet, 7 miles west of the Camp; it forms the brow of the hill immediately west of the Camp at 900 feet and on the east side of the Scioto it is found 100 feet lower on the slopes of Mt. Logan at the rifle range; on the east side of Mt. Logan it has descended below drainage and from here eastward has been encountered in hundreds of wells at constantly increasing depths until at Marietta it is found 1,830 feet below the level of the city, which is at the same altitude as Chillicothe, about 600 feet above sea level.

Differences in resistance of the rock formations to erosion.—As a result of the gentle southeastward dip over most of Ohio, the rocks occur at the surface in distinct belts or zones, more or less parallel. The older rocks, which are moderately resistant limestones, form the surface of the western half of the State.

Along the median line of the State, from north to south, is a belt of shales with some very resistant sandstone formations; these last are the most resistant rocks in the State. The zone of these formations bends northeastward along the south margin of Lake Erie, because the dip in the northeast corner of Ohio is more to the southward than to the eastward. In the eastern portion, except the eastern northern border, the Coal Measures rocks form the surface with a decidedly lesser resistance than the sandstones of the median belt.

In the long process of lowering the country to its present altitude by erosion, during which hundreds of feet of rock have been removed from every part of the State, these three belts of rock have offered unequal resistance and have therefore yielded unequally. The limestones and soft shales of the western half yielded to form a broadly undulating plain of which the irregularities have been smoothed over by glaciation. Although in general a lowland, there are exceptions; the highest point in the State is in this part. The Coal Measures shales of southeastern Ohio yielded to form the broad, low, hilly basin of that district. But the obdurate sandstones which outcrop in the medial line of the State and northeastward a few miles back from the lake shore, resisted until they now stand in relief. The Berea Grit is one of these. Even though thin, they amply protect the soft shales under them wherever they remain. Where removed, the shales, unprotected, have also been carried away. As a result these sandstones are found at the crest of an escarpment which is made up in its lower slopes of shale, and the surface of the land slopes gently eastward away from the escarpment, somewhat in proportion as the resistant beds dip to the eastward.

In southern Ohio, from Chillicothe to Ohio River, two beds of resistant sandstones, separated by 300 feet of soft shale, have given origin to the two distinct escarpments described above, and the influence of the resistant beds and gentle easterly dip is yet further shown in the two broad, very gently sloping plateau surfaces that descend eastward, one from each of these escarpment crests.

Secondary modification by glaciers.—In these brief descriptions of the two chief physiographic subdivisions of Ohio, much reference is made to the effects of glaciation because it contributed so largely to the establishment of the topography as we now find it. However, the Central Lowland and the Allegheny Plateau are features that long antedated the period of glaciation. Before the glaciers advanced on them, the one was a plain partially dissected by streams, and the other a plateau, in places partially and elsewhere wholly dissected by streams. The effect of glaciers was to modify the topography formed previously by streams, and this effect was chiefly the filling or partial filling of the existing valleys with clay, gravel, or sand.

The topographic situation of Camp Sherman as a part of large military problems in Ohio and comparison with similarly located places on the French front

In the event of war waged in the United States and engagements in Ohio of the type and magnitude of those recently prosecuted in Europe, the relation of the hilly highlands and low plains, and particularly of the intervening escarpment, would become of prime military importance. It is not proposed, however, to predict that importance or to discuss the way in which the escarpment might be effective in such campaigns. To do so would require military training not possessed by the writer, and would necessitate assuming all possible attitudes and movements by the enemy with a discussion of each, based on a much fuller presentation of the geography of Ohio than is here feasible. Without seeming to enter any such broad discussion it is intended only to point out that the location of Chillicothe and Camp Sherman, topographically, is very similar to that of many places on the French battle front which were of first military importance because of their topographic location.

As has been stated, this escarpment is 200 to 400 feet high. It is the western termination of a hilly upland, and overlooks a broad, rolling lowland across which the rapid movement of large bodies of troops would be easy. In northern and central Ohio it is rounded and subdued with moderately gentle slopes, the result of glaciation; in southern Ohio where it was not glaciated it is abrupt and formidable, even though lower than to the northward.

This escarpment would, if well defended, be a formidable obstacle to an army forcibly advancing on the Atlantic states from the upper Mississippi Valley and would be the first natural line of defense of large proportions against such an army. In such an event, in all its larger aspects, the escarpment is very like any one of the half dozen escarpments successively encircling Paris to the eastward and northeastward, with their steep faces opposed to the German advance and their gentle back slopes (which are not flat but gently sloping as in southern Ohio) toward Paris, a succession of natural defenses. The Argonne is one of these, and, on a far greater scale, the Vosges another; others have no name in common usage in this country. The furious Battle of Nancy, in the first September of the war, where upwards of 400,000 German troops failed of their purpose, was against another of these escarpments, *"le Grand Curonne,"* the first objective of the kaiser's troops which they were refused and which never passed from the French.

It is significant that the kaiser, at the beginning of the war, chose to invade France through violated Belgium, at the risk of antagonizing England, because by that route his armies could pass entirely north of and around these escarpments. Had he attempted to invade from German territory directly into French territory, he would have encountered obstacles in the form of these escarpments, the full effect of which is fairly well indicated by the failure of the Germans in the battles for Nancy, Verdun, and in the Vosges.[1]

There are several natural gateways through various ones of these French escarpments, in the form of valleys cut by streams. Some of these have proved critical places in the prosecution of the war. Nancy is one; Toul another; Eperney, Rheims, Laon, and La Fere are located at gates through the innermost escarpments; Verdun is of somewhat the same character; Belfort, the gateway between the Vosges and the Swiss boundary line, of military importance since pre-Roman times, the Germans dared not approach.

Camp Sherman is located just inside one of the important gateways through the escarpment from the Inner Lowland into the Allegheny Plateau. Taken in its largest setting, it is very similar indeed to almost every one of the French places mentioned in the last paragraph.

In the event of operations across Ohio similar to those in Europe

[1]The effect of topographic features on the war is set forth in Douglas W. Johnson's volume, Topography and Strategy in the War, (Holt & Co., 1917), from which these examples are drawn.

it would probably prove to be one of the important strategic places. But there, the similarity stops, and any operations around this place would obviously depend wholly on the local topography and distribution of forces.

CHAPTER II

THE TOPOGRAPHY OF THE CAMP SHERMAN QUADRANGLE

DRAINAGE

The drainage lines of the Camp Sherman quadrangle may be easily oriented with reference to the Lowland in the northern third and the Allegheny Plateau in the southern two-thirds of the quadrangle.

The chief drainage line of the Camp Sherman quadrangle is the Scioto River, which flows southward through the middle of the region in a splendid valley 2 miles or more in width. That portion of the Scioto basin above Chillicothe would rank as the third largest drainage basin in the State, with an area of 4,371 square miles, and lies wholly in the Inner Lowland. After flowing for miles through the Inner Lowland, in a shallow open valley, it enters the hills of the Allegheny Plateau, 6 miles north of Chillicothe, and from there southward to the Ohio River continues in this hilly upland in a deep, hill-walled trench.

This is unusual behavior for a stream system. In most stream systems the headwaters are the highest part of the drainage basin, and that country bordering their lower courses is generally lower. This is reversed in the Scioto basin. The plateau regions about its lower course are much higher than those of its headwaters. Consequently there must be a much deeper valley in the hilly lower portion of its course. This is because the Scioto formerly flowed toward the northward, but its course was reversed by glacial ice.

Immediately below Chillicothe, the Scioto receives as a tributary from the west, Paint Creek, which with its tributary from the northwest, the North Fork of Paint Creek, adds some 1,300 square miles more to the Scioto basin. Paint Creek and North Fork of Paint Creek, the last commonly spoken of as North Fork, are the second and fourth largest streams of the region.

These streams also head in the Interior Lowland and have the largest portion of their respective drainage basins thereon. Both, like the Scioto, flow in broad shallow valleys, even less prominent than that of the Scioto, to where they enter the Allegheny Plateau, and from there in deep, steep-walled trenches. North Fork drains the Lowland in the northwest corner of the quadrangle but the main basin of Paint Creek lies considerably farther west.

The fifth stream, in the order of size, but one of no great interest here, is Salt Creek, which heads in the Lowland to the northeastward, in a shallow rolling valley, drains the northeast corner of the quadrangle, then flows southward into the Allegheny Plateau in a deeply trenched valley which lies in the next quadrangle east, and re-enters the Camp Sherman quadrangle in the southeast corner, to enter the Scioto a few miles below. In its general character and behavior it is similar to the

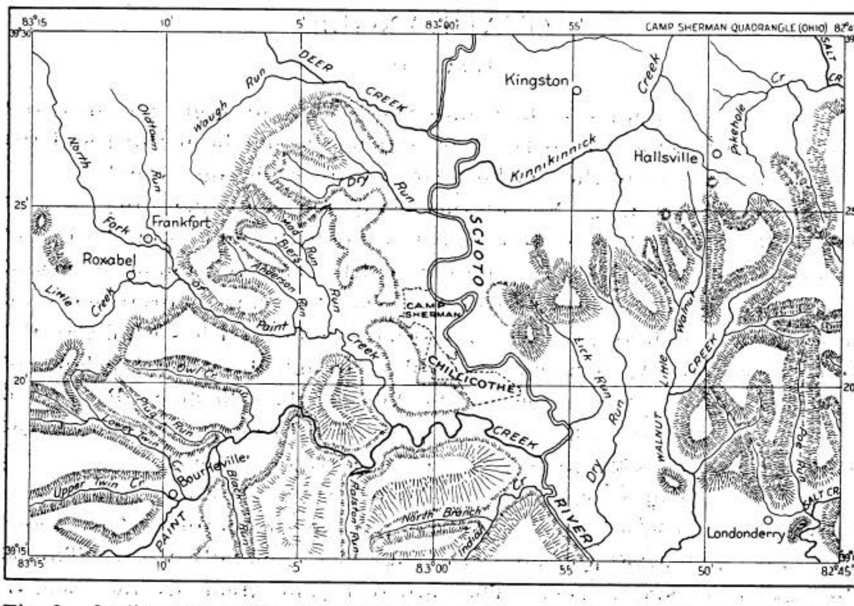


Fig. 2.—Outline map of the Camp Sherman quadrangle, showing the chief drainage lines and heights of land.

two Paint Creeks, and its location on the east side corresponds fairly well to that of Paint Creek on the west side.

The portion of the Lowland Plain of this region near the Scioto is drained by two streams that are fairly well balanced in position; Deer Creek from the northwest drains the portion west of the Scioto, the third largest stream on the two quadrangles, and Kinnikinnick from the northeast drains the portion east of the Scioto. Both of these streams lie wholly in the Lowland, flowing almost along the foot of the escarpment in their lower courses. Deer Creek drains a large basin but most of the Kinnikinnick basin lies in the Camp Sherman quadrangle.

If, now, we except the three small streams that drain the area south of Paint Creek, two of which flow northward to Paint Creek and the other to the Scioto, the remainder of the drainage of the two quadrangles heads at the escarpment on the margin of the Allegheny Plateau and flows inward, in general convergent toward the arc made by Paint Creek and the Scioto below its mouth. That west of the Scioto is gathered by many deeply intrenched small streams which flow eastward and southeastward to the two Paint Creeks. That east of the Scioto is gathered by fewer and larger streams which flow southward and southwestward to the Scioto.

THE CENTRAL LOWLAND

The Lowland in the northern part of the Camp Sherman quadrangle is of the same general rolling character observed over most of western Ohio. It is composed almost entirely of the clay, gravel, and bowlders brought down by the ice, and the rocks of the region are so buried beneath this accumulation that outcrops are rare. The plain stands at an altitude of 680 to 900 feet above sea level, but the streams which traverse it have only shallow valleys, and the hill slopes are everywhere very gentle, so that the range in elevation, though considerable, is not impressive. The topography of this region is much diversified, and is largely caused by various types of glacial deposits. These details can be better described when we come to consider the subdivisions of the quadrangle, and are reserved for that place. (See Pl. 17.)

BOUNDARY BETWEEN LOWLAND AND ALLEGHENY PLATEAU

At the southern margin of the Lowland, the hills of the Allegheny Plateau rise abruptly to a height 200 to 300 feet above its border. This steep ascent is the escarpment which limits the plateau from New York to Alabama, but it must not be imagined as an unbroken hill slope facing to the northward. It is thoroughly cut up by streams and is better pictured as the northern edge of the hills, with numerous valleys cut back into it, and occasional isolated hills standing slightly in advance of the main line. It is a completely dissected escarpment. (See Pl. 1 A, 7 A, B, and C; 17 C.)

This escarpment extends from near the northeast corner of the quadrangle southwestward to near Hopetown, 3 miles above Chillicothe, where it is cut by the Scioto River; this is opposite the upper end of Camp Sherman. From about the upper end of Camp Sherman northward 5 miles, the boundary forms the west wall of the Scioto River to Deer Creek. It then bends northwestward, westward, and southwestward to Frankfort around a large mass of hills. At Frankfort it is cut by the North Fork of Paint Creek, southwestward from which the escarpment bends westward across the west line of the quadrangle. Properly, a large group of scattered hills, north of this escarpment and lying chiefly in the quadrangle to the westward, including the high hills west of Frankfort, should be included in the Allegheny Plateau; but the dominant features of the topography of the part lying in the Camp Sherman quadrangle make it simpler, for descriptive purposes, to include that part with the Interior Lowland.

THE ALLEGHENY PLATEAU

Within the limits of this double quadrangle, the Allegheny Plateau presents more diverse features, probably, than any other portion of the same size in the State. The glaciers which came into this region from the northward in the ice age, or Pleistocene period, dissipated and weakened by their long flow to low latitude, were here stopped by the northwardly facing escarpment, or they overran the northern edge of the plateau only slightly. Where they did so overrun, they very considerably modified the plateau by rounding off the hills and filling the valleys with clay, (Pl. 9), but with this exception the topography of the Allegheny Plateau portion of the two sheets is, in almost every detail, the result of stream sculpture long antedating the glacial invasion. This is in sharp contrast to the Lowland just to the northward where most of the topographic features are the result of great quantities of debris dropped by the glaciers, the surface of which has since been but slightly modified by streams. (See Plates 1 B, 8, 13, 14, 18.)

SUBDIVISIONS CF THE CAMP SHERMAN QUADRANGLE

The natural features of the Camp Sherman region which are of particular military interest are, (1) topography; (2) water, both stream and underground; (3) conditions affecting construction and maintenance of excavations, both the resistance to digging and durability of the material in which they must be built and the ground water which may affect their habitability; (4) material for construction, stone and gravel; (5) forest conditions; (6) roads may be added because of military importance and dependency on topography.

Both for proper understanding and practical military use of information under the first four headings, an elementary knowledge of underlying geology is essential. As regards the fifth and sixth, forest and road conditions in the region depend directly on topography.

Emphasis has already been laid on the diversity of the topography within the quadrangle. Equal diversity exists in each of the other matters just listed. To such an extent is this the case that it is impossible to describe in detail the area as a whole, and it has seemed best to subdivide it into nine parts. These subdivisions have been made according to two principles: (1) The topography, geology, water conditions, trenching conditions, etc., within each of these nine subdivisions establish each as a unit distinct from neighboring subdivisions. (2) The lines between subdivisions have, however, been established as nearly as possible in coincidence with the major *geographic* lines of the region, rather than to satisfy the requirements of a strictly scientific classification of features. Each of these subdivisions is the subject of a chapter. They are as follows:

1. **Lowland of the northeastern part of the quadrangle.**
2. **Lowland of the northwestern part of the quadrangle.**
3. **The Scioto Valley.**

All of these are underlain almost wholly by glacial gravels and clays which determine the character of the topography, of which at least six types can be distinguished, the behavior of underground water,

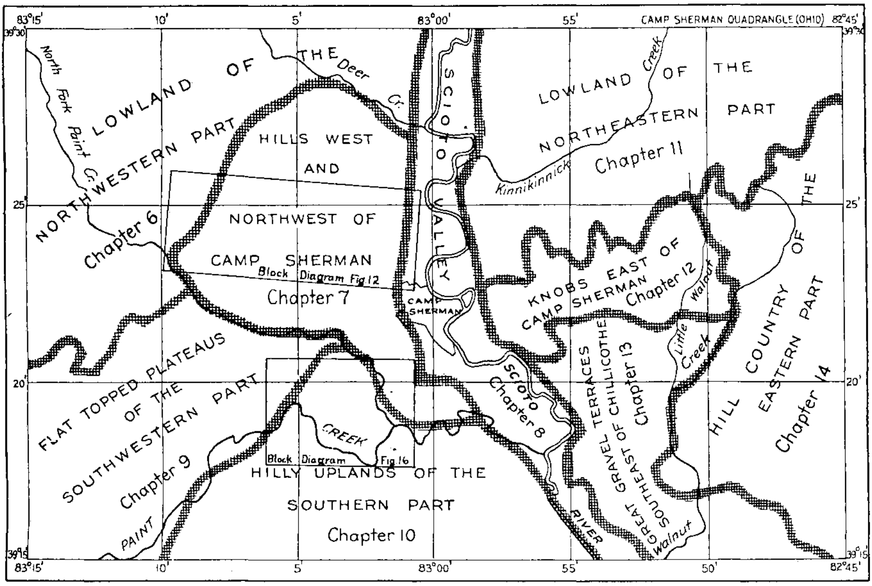


Fig. 3.—Outline map of the Camp Sherman quadrangle, showing its natural subdivisions, the chapter numbers under which each is described, and the location of block drawings, Fig. 12 on page 84, and Fig. 16 on page 110.

trenching conditions, etc. There is an abundant gravel supply, some of it of good concrete quality, but almost no stone.

The following are subdivisions of the Allegheny Plateau, and their features, except the eighth, are determined chiefly by the character of the bedrocks.

4. **Hills west and northwest of Camp Sherman.**—Flat-topped plateaus in the southeast, formed by the resistant Berea Grit, a sandstone formation, which also conditions water flowage and excavation thereon; rolling shale hills in northwest; valleys broad and open, drift-filled. No gravel but excellent supplies of building stone. Routes generally direct, across valley and upland, to destination.

5. **Flat-topped plateaus of the southwestern part of the quadrangle.**—Formed as in the last, by the Berea Grit which similarly affects natural conditions; valleys narrow and deep, with forested slopes drift-bordered. Much gravel in valleys, little of it first-grade, ample stone. A youthfully dissected portion of the plateau but with major transportation lines mostly in valleys.

6. **Hilly uplands of the southern part of the quadrangle.**—Topography largely a modification of that of the last subdivision, because

of rolling hills, rising above the plateau, with material differences in ground water and trenching conditions. Valleys not so deep, but narrow, steep-walled, and their slopes forested. Practically no gravel, ample building stone. Transportation in valleys and on uplands.

7. **The knobs east of Camp Sherman.**—High, steep-sloped, pointed knobs, more or less disconnected, with broad rolling valleys passing entirely through them from north to south. Slopes forested, little building stone, no gravel. Conditions very diverse. A portion of the plateau that has well passed the mature stage of dissection. Transportation almost wholly in valleys, roads generally fair, but with notable exceptions.

8. **The great gravel terraces southeast of Chillicothe.**—Three terraces rising from the Scioto River to 300 feet above it, the highest much dissected, the lower two but little dissected.

9. **Hill country of the eastern part of the quadrangle.**—Plateau maturely dissected and the subdivision is the most rugged, though not the highest, in the region. Abundant forests, no stone or gravel. Transportation local, mostly in valleys, roads poor.

CHAPTER III

MATERIAL IN EXCAVATIONS AND NATURAL RESOURCES

MATERIAL IN EXCAVATIONS

Of prime importance, in the military occupation of a region, is the material which will be encountered in making excavations at any designated place. If troops are allowed the minimum time to intrench, with hand tools, a position where 2 feet below the surface exist bed rocks of a resistance that can be excavated only by blasting, the result may be serious. Data of this character may be obtained readily by trained observers in advance of occupation, but this is seldom permitted by the conditions of military occupation. However, even slight data, from previously published papers or from local residents, in the hands of a competently trained man with good maps of the region, may furnish very important information on such matters. To this, and to other ends as well, any information as to character and thickness of mantle rocks and underlying bed rocks, is desirable in any region under military occupation. In any region, these follow certain principles, which, once learned, may be used in predicting the conditions at any given spot. In this general chapter, it is possible to indicate only briefly the several rock formations found in the Chillicothe quadrangle, and in the broadest way, the character of the mantle rocks which partially cover them. All details, (and it is local details that are usually most desired) are reserved to the chapters on subdivisions of the quadrangle.

Bed Rocks; Table of Formations

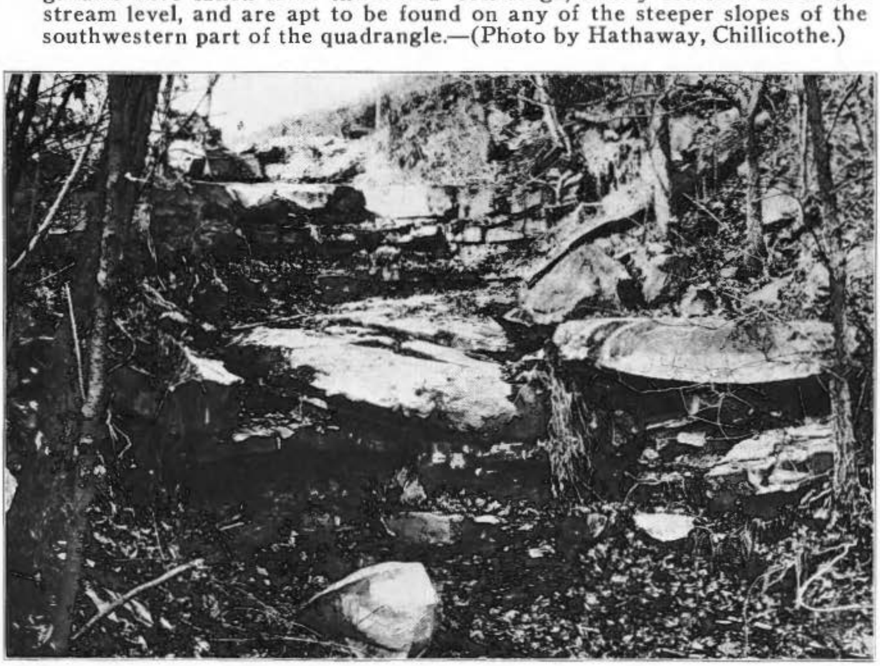
The following table shows the bed rock formations in the order of their deposition, the oldest at the bottom. The distribution of these formations at the surface is shown on the map in the pocket. In the marginal explanation of this map, may be found statements of the way each formation yields to excavation, its influence on ground water if important, its relation to the terrain and to forests. (Pl. 2, p. 36).

Mantle Rocks

These are the unconsolidated accumulations of clay, gravel, and sand which overlie the bed rocks in most places. (See Plates 3 and 4.) Practically all such owe their existence directly or indirectly to ice sheets which invaded the region from the northward. To review

	Formation	Character	Distribution and relation to topography	Uses	Thickness feet
Pennsylvanian	Pottsville	Coarse reddish or yellowish sandstones and conglomerates.	Low ledges on top of a few of highest hills east of the Scioto.	Satisfactory for coarse masonry, such as bridge abutments, but inaccessible for quarrying.	10 to 40
Mississippian	Logan	Tough gray or yellow sandstones passing into gray clay shales to the westward, the whole subdivided into a complex group of members, which are described in the text on this formation.	East of the Scioto the sandstones form the steep upper slopes of all the higher hills, but seldom give rise to low ledges. West of the Scioto the sandstones and shales form the upper slopes of a few of the higher hills in the southern portion.	The sandstones are not used except for occasional local purposes, and may be regarded as of no value, unless no other materials are available.	275
	Cuyahoga	Gray clay shales with thin layers of reddish brown sandstone.	Forms middle slopes of all high hills on the east wall of the Scioto and the lower slopes from there eastward. Forms gentle slopes above the Berea Plateau southward and southwestward from Chillicothe.	Possibly may be used for brick. Not used at present.	35 western margin to 450 on eastern margin of quadrangle.
	Sunbury	Carbonaceous black, fissile, brittle shale, locally called slate.	Forms gentle slopes above the steep Berea outcrop.	No value.	15 to 25
	Berea Grit	Gray sandstone in beds up to 1 or 2 feet with thin shales.	Gives rise to all the flat-topped hills westward and northwestward from Chillicothe. Occurs low down on the east wall of the Scioto. Occasionally forms low ledges.	An exceedingly strong and durable building stone, but subject to stain.	8 to 25
	Bedford	Gray clay shales with thin sandstones in upper portion.	Forms steep slopes below the Berea outcrop.	No value.	85 to 90
Devonian	Ohio	Carbonaceous, black, fissile shale, does not weather clayey, locally called slate.	Forms lower hill slopes west of Scioto, not infrequently bare except for scattered trees.	No value at present.	About 450

A.—Ohio shale; gorge of Paint Creek, Huntington Township. The Sunbury shale is of exactly the same character and gives rise to similar outcrops, though never as extensive as the one here shown. The blocks in the foreground have fallen from the Berea Grit ledge, nearly 300 feet above the stream level, and are apt to be found on any of the steeper slopes of the southwestern part of the quadrangle.—(Photo by Hathaway, Chillicothe.)



B.—Lower part of Berea Grit resting on Bedford shale. The upper part has less shale.

BED ROCK FORMATIONS

them here, even in summary form, would involve a discussion of their kinds and mode of origin (for which see Chapter XVII) of no significance in a military way. It is sufficient here to indicate that these accumulations are of much importance locally, elsewhere of none. The northern lowland third of the quadrangle is composed of gravels chiefly, with some clay (till), exceeding 50 feet in thickness at all places, and probably exceeding 100 feet in most places (Plate 4 A). The open shallow valleys between the rock hills of the northwestern and western central portions of the quadrangle are underlain by stiff bowlder clay or till, for the most part thick and in places exceeding 160 feet deep. This can be recognized by its matrix of structureless clay with bowlders and pebbles of various kinds of rock, imbedded in it without order or arrangement. It was formed directly by the ice (Plate 3). The Scioto Valley is bordered with gravel terraces (Camp Sherman is located on one) which are important as sources of gravel, sand, and water, as well as from the point of view of excavation conditions. Elsewhere, in the southern portion, gravel terraces of very different sort occur (Plate 4 B). In places, lake clays, treacherous and almost impossible to excavate, must be avoided (Plate 4 C). These and other subdivisions of terrain, underlain by mantle rocks affording yet other conditions of excavation, ground water, and material, are designated on the map, and the reader is referred thereto for the list of the different kinds, and to Chapter XVII for a discussion of their origin and history, if interested in that. Descriptions of the deposits are given at some length in the chapters on subdivisions of the quadrangle.

NATURAL RESOURCES

The resources of each subdivision of the quadrangle are presented in full in the various chapters on the subdivisions. It is intended to present here only a very brief summary of these resources and an index to the fuller descriptions given elsewhere. Resources not directly contributory to military occupation, such as possible clay products, mineral waters, oil and gas, have not been considered.

Water

Streams.—Much of the subdivision is amply watered by an unusual number of large streams, the Scioto, Paint Creek, North Fork of Paint Creek, Deer Creek, and Salt Creek, besides numerous smaller ones. The large streams all flow from areas of limestone or drift that is high in lime, and the waters at low stage, when the streams are fed from springs, are hard. No examination has been attempted to determine the availability of any of these for human consumption because of lack of facilities and because such use should require constant watch, not an opinion as to its condition at the moment when it happened to be sampled.

Ground Water.—Ground water conditions vary widely within the quadrangle. The body of ground water of chief interest to Camp Sherman is the one resident in the thick gravels of the Scioto Valley, on which the Camp is established. This is the source of an ample supply of excellent, though hard, water to the Camp and to Chillicothe (p. 99). A similar body resides in the terraces southeast of Chillicothe (p. 137). The gravelly lowlands in the northern third of the quadrangle contain a great volume of hard waters, which can be encountered almost anywhere at slight depths. (East of Scioto River, p. 121; west of Scioto, p. 80).

The flat upland plateaus of the central-western and southwestern part of the quadrangle, almost without exception, carry a fair volume of ground water, which endures throughout the year at depths of a few feet, and may prove a nuisance in trenching. These waters are usually hard and occasionally carry alum and other salts in sufficient quantities to render them disagreeable or even almost useless. Their volume is sufficient to supply small bodies of men and animals, but is so limited that large numbers occupying the region for long periods would probably have to seek other sources. This body is resident a few feet below the surface and does not extend below the Berea Grit, which is the cap rock of all these plateaus. The maximum thickness of the water-bearing portion probably does not exceed 10 or 20 feet, and below this, wells will be found only exceptionally (pp. 88 and 105). The valleys of these areas are commonly filled with gravels to considerable depths which carry large volumes of easily accessible water.

In the hilly uplands of the southern part, there is a much greater percentage of hill slope, largely underlain by shales, and much less of porous gravels in the valley bottoms. As a result, the run-off after rainfall is greater and the storage space smaller. On the whole, the ground water supply is limited, though in certain places there are abundant fine springs. (p. 114). A deep source of water, that is, exceeding 50 feet, will seldom be found.

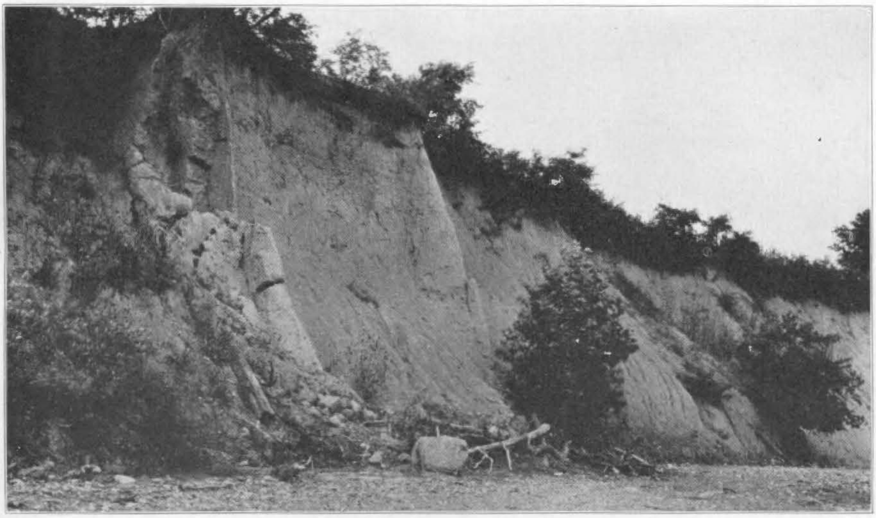
The knobs east of Camp Sherman retain only very limited amounts of water, but more is found in the thin filling of the valley bottoms between them. (p. 129). The same is true of the hill country of the eastern part. (p. 142).

No body of potable water may be expected in the bed rock at any depth, though occasionally such are encountered, probably in small crevices. There is no deep bed rock stratum which carries water worthy of search in the region.

Stone

Berea Grit.—Almost the only source of stone within the quad-

A.—Glacial till of the Late Wisconsin ice sheet, exposed in the bed of Mad Run, 8 miles northwest of Chillicothe. This is more stony than usual. The line through the middle is a recent flood mark by the stream, the portion above it is rainwashed.



B.—Cliff of Late Wisconsin till, Anderson Run, 1 mile north of Anderson. At the foot of the cliff, but not shown in the picture, there is about 2 feet of stream gravel beneath the till. This is the most striking cliff of till in the Camp Sherman region. Such material, if dry, would furnish favorable conditions for the excavation of deep dug-outs, but would require complete revetment; should a bed of gravel, like that occurring here, be dug into, it would almost certainly result in the flooding of such works.

MANTLE ROCK; TILL OR BOWLDER CLAY

rangle is the Berea Grit. This is a sandstone which is commonly 25 to 30 feet thick and is found almost wholly west of the Scioto River in the southwest quarter of the quadrangle. The stone is a hard, fine-grained, gray sandstone of excellent strength and endurance. However, its color so generally changes to a characterless brown on a few years exposure that it has never been quarried except for local uses. At one time, when stone was extensively used in building, it was much used around Chillicothe for buildings, foundations, walls, curbing, and even for gutter cobbles. The lock walls of the canal, now nearly 100 years old, were built from the same source, but the condition of the stone in them is not to be considered as an index of its durability, as they were extensively used for burning brush in the early days of the Camp.

Two important conditions affect the quarrying. Because of the limited thickness of the beds, the maximum thickness of stone obtainable is about 15 inches and much the greater part of the output of any quarry will be 6 to 12 inches thick. Unless quarrying is limited to the upper 12 or 15 feet, there will be much thin material to be discarded

The ledges most available to Camp Sherman and Chillicothe are those on the brow of the Scioto Valley wall, immediately west of the Camp, and on the north wall of Paint Creek within 2 miles west of Chillicothe. The latter is a line of almost continuous old quarry pits which could be easily reopened, with little stripping. These are described in detail hereafter. (p. 92).

There are abundant supplies of the same stone in the "flat-topped plateaus of the southwestern part of the quadrangle" (p. 107) and in the "hilly uplands of the southern part" (p. 116). East of the Scioto, within 2 miles of Hopetown to the east and southeast, there are old quarries in this rock, but the quarry face apparently will never exceed 6 feet (p. 131).

This stone is fine-grained and hard, breaking with a sharp, clean fracture and does not, under any circumstance, break down into sand. The fragments from a crusher would probably show a strength equal to that of crushed limestone fragments. For this reason, it is believed that it would make a fairly satisfactory material for concrete, provided that in crushing, care was used to exclude blocks with clay-smeared faces. This would involve much care in quarrying because of the many thin beds of shale between sandstone layers, and would prohibit any rock except from the upper 10 or 15 feet (p. 92). Such concrete could not be used where subject to abrasion, as on the surface of a roadway.

Other sources.—The Logan sandstone and the Pennsylvanian sandstone, on the high knobs east of Camp Sherman, might supply stone for local or temporary structures, but the use of the Logan is not advised, and the location of the latter is almost prohibitive to quarrying (p. 132).

Gravel

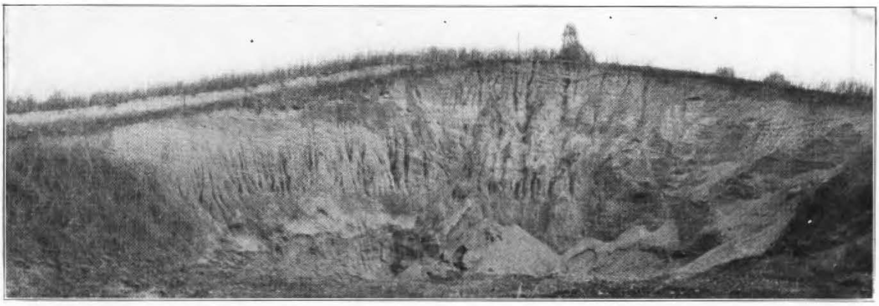
Though there are enormous quantities of gravel within the quadrangle, there are very few places where a first-grade concrete gravel can be obtained. There are two general types of gravel present.

Glacial gravels.—These are composed chiefly of limestone pebbles and have been brought in from the northward. The terraces bordering the Scioto, including the one that underlies Camp Sherman, are of gravel of this type. The Lowland of the northern third of the quadrangle is largely underlain by a similar gravel. Great quantities of it are found between Anderson and the Cattail School, 5 miles southwest of the Camp. As a rule, only limited and scattered patches of such gravels occur in the hill region west of the Scioto and north of Paint Creek. On the hills south of Paint Creek and east of the Scioto, they are practically absent.

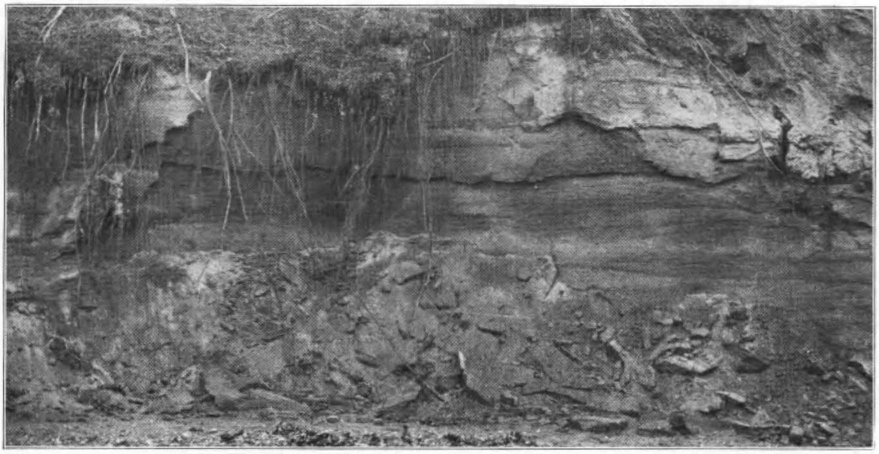
These gravels, though often not good, are much the better source of gravel material. The creek-bed, sandstone gravels, to be noted later, are almost worthless. Though chiefly of limestone pebbles, there is always a considerable percentage of granitoid, gneissoid, or schistose pebbles, frequently partially decayed or crumbly, and in that condition elements of weakness. The chief objection to these gravels is the common presence of shale pebbles, frequently thin and blade-like, and usually disintegrating. These seriously affect the strength of a concrete containing them.

Both of these undesirable elements may be largely removed by washing. The content of sandstone pebbles is negligible. The gravel from the banks of the Chillicothe Sand & Gravel Co., after washing, is reported accepted by the U. S. Government as a first-class gravel for construction work, and is used by the State Highway Commission of Ohio as a Grade A gravel, in the wearing course on concrete roadways. Yet a random test of the unwashed gravel showed 10 per cent by number of undesirable weathered granite and shale pebbles; by weight the percentage would have been considerably less due to their smaller size; such is the effect of washing. This washed gravel must be regarded as the best source available at present. Though a few gravels have been seen which, in their natural state, appear to be the equal of this washed gravel, they are usually limited in amount of available gravel and frequently difficult of access. These and other sources are commented on, in detail, in the citations below. Gravels mapped as Illinoian (see geological map in pocket at back of book) are, almost without exception, valueless.

The bed of the Scioto River above Paint Creek is the source of much good gravel. This is essentially, glacial gravel which has been washed down by floods and in part freed by natural washing of the undesirable elements. Below Paint Creek, sandstone fragments are present in the river gravels.



A.—Glacial gravel of the type found throughout the northeastern part of the quadrangle; easy to excavate but requires complete revetment; excavations dry if the neighboring streams are cut well below them, but otherwise wet; moderately good for concrete. Pit just north of Sugarloaf.



B.—Fluvio-glacial sands in lowest terrace southeast of Chillicothe. Sand suited to concrete or filtration purposes.

C.—Glacial lake clay, fairly common in Paint Creek Valley and in the higher terraces southeast of Chillicothe. The clay is too tough and wet to be excavated, and very treacherous. Near Bourneville.

MANTLE ROCK; GLACIO-FLUVIATILE DEPOSITS

Detailed descriptions are as follows:

Sandstone gravel.—In three of the subdivisions of the quadrangle, X, XII and XIV above, comprising all of the area south of Paint Creek, the knobs east of Camp Sherman and the hill country of the eastern part, practically the only source of gravel is the stream beds. These gravels have been obtained by the streams from the country rock, and as the only resistant rocks are sandstones which in small pieces are weak, the gravels are very poor.

Sand

Sand, for concrete or for filter beds, may be obtained by screening at practically every source of fine gravel. In places it may be loaded in small quantities directly from the river bed. If desired in large quantities, so that handling of gravel from the screens would be, for the time, undesirable, much the best source is in the first or Late Wisconsin gravel terrace (see geological map) on the east side of Scioto River within 1½ miles below Chillicothe. Large banks may be opened in the first large ravine from the east, one-fourth mile south of the Main Street river bridge. Large quantities are also immediately available in the bed of the stream flowing through the center of Section 27, Springfield Township. (See Plate 4B.)

Forests

Character.—Without exception the forests are hardwood. Maple, oak, hickory, elm, ash, walnut in varying proportion comprise them. Pine is seldom seen in isolated small trees. Most of the timber has been removed and, with small exceptions, only second growths remain.

Distribution and use as cover for troops.—In the Lowland of the northern third of the quadrangle, the forest cover is, without exception, of the nature of scattered, small wood-lots, for the most part of about 20 acres extent. These are distributed as they happen to have survived and bear no relation to the topography. They are too small and too scattered to be of service in concealing large bodies of troops from aerial observation. The trees, however, are generally large and there is usually little underbrush.

The forests of the plateau portion are much more extensive, but their distribution is almost wholly dependent on topography. Their area in any place is closely proportional to the area of steep slope and their distribution is almost coincident with the hill slopes. Underbrush is almost universally present and few trees of marketable size remain. These conditions make the movement or concealment of troops in the forests a matter of difficulty. Not a single road is concealed by forests from aerial observation for a distance of more than a few hundred rods.

As a source of material for construction work.—Abundant material may be obtained within a very few miles of the Camp for all purposes of smaller military construction. Material for large timbers, however, is scarce. Curiously, most of the timber in the region is in the scattered small wood-lots of the open farm lands of the northern third. It has been much more closely cut in the hilly portions where farming is more difficult, though material of tie-size is yet common there. Detailed notes will be found as follows:

Chapter V. Scioto Valley, (p. 54).
Chapter VI. Lowland of the northwestern part, (p. 82).
Chapter VII. Hills west and northwest of Camp Sherman, (p. 95).
Chapter IX. Flat-topped plateaus of the southwestern part, (p. 108).
Chapter X. Hilly uplands of the southern part, (p. 117).
Chapter XI. Lowland of the northeastern part, (p. 123).
Chapter XII. Knobs east of Camp Sherman, (p. 132).
Chapter XIII. Gravel terraces southeast of Chillicothe, (p. 140).
Chapter XIV. Hill country of the eastern part, (p. 142).

CHAPTER IV

WEATHER

SOURCE OF INFORMATION

Although the United States Weather Bureau has had an observation station at Chillicothe for a few years, the period has been too short and the observations, for various reasons, have been too irregular, to admit of a presentation of Chillicothe weather based on their data.

Mr. J. Irwin Carson, for some years assistant city engineer, has recorded the weather conditions daily at Chillicothe since January 1, 1902. After due consideration, it has appeared better to build up even at considerable labor, a discussion of Chillicothe weather on these observations, rather than to use the Weather Bureau's well digested observations at Circleville, Waverly, or Frankfort, distant from Camp Sherman respectively 16, 16, and 10 miles. This is because Mr. Carson's observations are sufficiently full to permit the derivation of information on some points that the Weather Bureau observations do not cover. The results so obtained have, however, been repeatedly checked by the Weather Bureau's data from neighboring localities and, in some matters, have been supplemented therefrom. It is fitting to here express appreciation of Mr. Carson's very carefully and apparently accurately kept record, and indebtedness to him for generously placing it at our disposal.

Following is a sample of Mr. Carson's record selected at random to show the fullness with which a day of variable weather is recorded. All days are recorded in proportional detail.

7 A. M., 62°.	Hard rain at 2 A. M., and rain at 10:15 to 10:30.
12 Noon, 74°.	Cloudy till 12:30, then clear and cloudy till 5, then clear.
7 P. M., 70°.	S. E. to S. West to S. E. wind.

The diagram showing the number of days with precipitation in each month was made up from Mr. Carson's observations at Chillicothe. Almost certainly it will not admit of close comparison with U. S. Weather Bureau data at other places, because Mr. Carson's observations do not include the amount of rainfall; hence it is not possible to accurately distinguish those days with only a trace of rainfall from those with .01 inch or more, the Weather Bureau's standard. Where the rain or snowfall of a day was clearly only a trace, it has not been counted a day with precipitation, nor has it been counted a snowfall. Days on which it "sprinkled" only 15 minutes (the duration is usually indicated by Mr. Carson) or when it "sprinkled" at 7:30, have been excluded; others have been included. But, even though it is not possible to compare

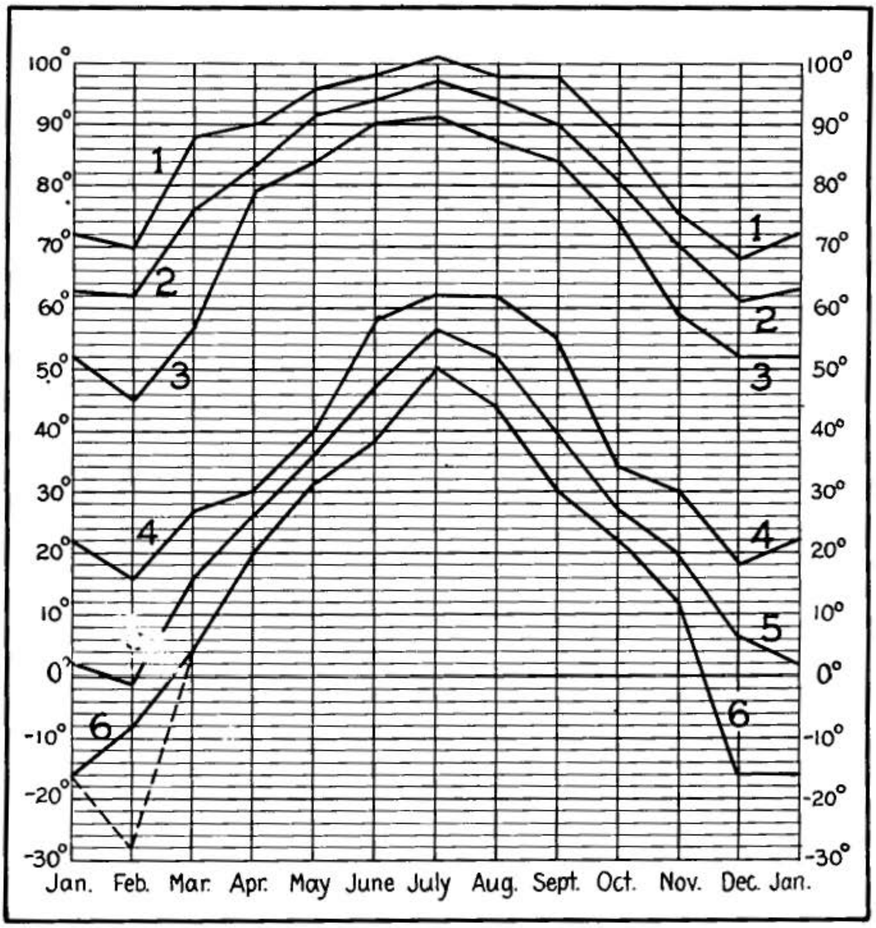


Fig. 4.—Monthly temperature ranges, for the years 1902 to 1917, inclusive, Chillicothe. The three upper curves show the maximum temperature conditions throughout the year. The three lower curves show the minimum temperature conditions.

1. The maximum temperature recorded in each month during this period.
2. The average of all monthly maxima during this period.
3. The lowest maximum recorded in each month during this period.
6. The minimum temperature recorded in each month during this period, to which, in dashed lines, is added the minimum of Feb. 10, 1899, the lowest known for Chillicothe.
5. The average of all monthly minima during the period.
4. The highest minimum that has been recorded in each month during the period.

For example: During the 16 years of which there is continuous record, the lowest January temperature was —16°, but one season, +20° was the lowest temperature recorded; this is a fair index of the range within which the lowest temperature of this month may be expected to fall. The highest temperature recorded in January in this period was 72°, but in each January, a temperature between 50° and 72° has been attained.

From this, there stands out the fact that, from the point of the extremes of temperature, July is the hottest month (as it is from the point of the average temperatures), and February is the coldest. In the latter case, however, there is seen evidences of the incompleteness of a record only 16 years in length, for in both December and January, lower minima were recorded than in February, although February on the whole, is the coldest month and is to be credited with the lowest minimum yet recorded for this region.

with other localities, it is possible to compare the various months with each other, as they are recorded by this observer.

Unless otherwise indicated, the period covered by the discussion is 1902 to 1917, inclusive.

TEMPERATURE

Mr. Carson's readings, on which the following tables are based, are made on a good thermometer that is essentially accurate, and a registering thermometer. Both are placed in the open on a brick wall, but sheltered from the sun. The readings, made three times each day, are not comparable to readings from a kiosk-protected, standardized instrument, but are believed to indicate fairly well temperatures of which an individual walking about in the open air is conscious. Compared with observations at Cincinnati, the minimum observations at Chillicothe run uniformly slightly lower and the maximum observations, on the whole, slightly higher.

The following table and its graphic representation show the range of temperature by the Fahrenheit scale in any month, as well as in the year. The lowest temperature which has been recorded at Chillicothe was prior to the 16-year period of which there is a continuous record; on Feb. 10, 1899, Mr. Carson reports that the temperature was —28 degrees F. Whether this was determined by a fairly accurate thermometer is not known, but other instruments at that time were reported lower.

The numbers before the descriptive phrases indicate the number of the curve representing the same data graphically in Fig. 4.

	Jan.	Feb.	Mar.	April	May	June
1. Absolute maximum	72°	70°	88°	90°	96°	98°
3. Least monthly maximum	52°	45°	57°	79°	84°	90°
2. Mean of monthly maxima	63°	62°	76°	83°	91°	94°
6. Absolute minimum	—16°	—8°	4°	20°	31°	38°
4. Highest monthly minimum	22°	16°	27°	30°	40°	58°
5. Mean of monthly minima	2°	—1°	16°	26°	36°	47°

	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
1. Absolute maximum	101°	98°	98°	88°	75°	68°	101°
3. Least monthly maximum	91°	87°	84°	74°	59°	52°	45°
2. Mean of monthly maxima	97°	94°	90°	80.5°	70°	61°	
6. Absolute minimum	50°	44°	30°	22°	12°	—16°	—16°
4. Highest monthly minimum	62°	62°	55°	34°	30°	18°	
5. Mean of monthly minima	56°	52°	39.5°	27°	20°	6.5°	

PRECIPITATION

Amount.—The period during which the amount of precipitation at Chillicothe is known is short. Accordingly it has been held desirable to check its probable amount and show its distribution throughout the year from neighboring stations. Observations have been made at Circleville, 16 miles north of Camp Sherman, for 22 years, and at Waverly, 16 miles south of the Camp, for 34 years, both down to 1917. At these stations and for these periods, average yearly precipitations of 36.73 inches and 40.03 inches, respectively, are indicated by the records. Frankfort, 10 miles west, northwest of the Camp, has an annual rainfall

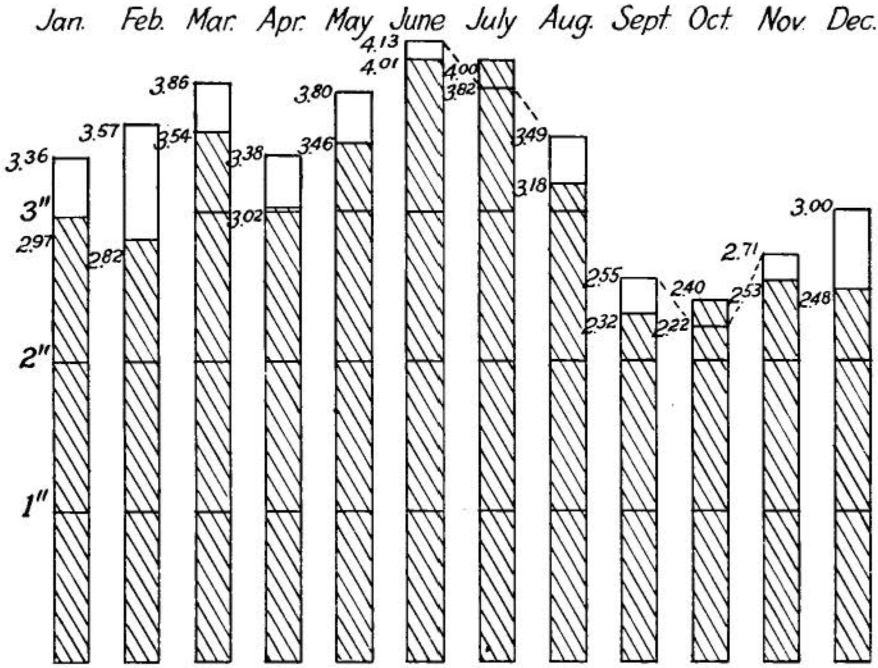


Fig. 5.—Amount of precipitation in the Chillicothe region. Graphic representation of the average amount of precipitation in each month of the year. The period over which Chillicothe precipitation is known is so short that it has been held desirable to show its probable normal amount from neighboring stations. Observations have been made at Circleville, 16 miles due north of Camp Sherman, for 22 years, and at Waverly, 16 miles due south, for 34 years, down to 1917. At these stations and for these periods, average rainfalls of 36.73 inches and of 40.03 inches, respectively, are indicated by the records. The difference is unexpectedly and unaccountably large, but the two together amply indicate for the region the distribution of rainfall through the year and its approximate amount.

The shaded portion of the columns represent the amount of rainfall in inches at Circleville: the entire height of the columns (except for July and October) represents the amount at Waverly. The average precipitation at Waverly exceeded that at Circleville in all months except July and October, when it fell short, and the Waverly rainfall for these months is indicated by a cross line connected by dashed lines with the Waverly record of adjoining columns. Otherwise, the horizontal lines indicate the even inches. The numerical values, in inches, are given at the left of the columns.

The chief point in distribution of precipitation, as indicated by these records and records of surrounding stations, are the maximum crest in June and July with a minor crest in March, and the minimum rainfall in September and October, with a minor minimum in April.

of 35.33 inches, as indicated by a 24-year record. The difference between these three stations is unexpectedly large, and is undoubtedly to be accounted for not wholly by difference in amount of rainfall, but in part by various lengths of observation period, difference in conditions surrounding rain gages, and perhaps in reading them. The very short rec-

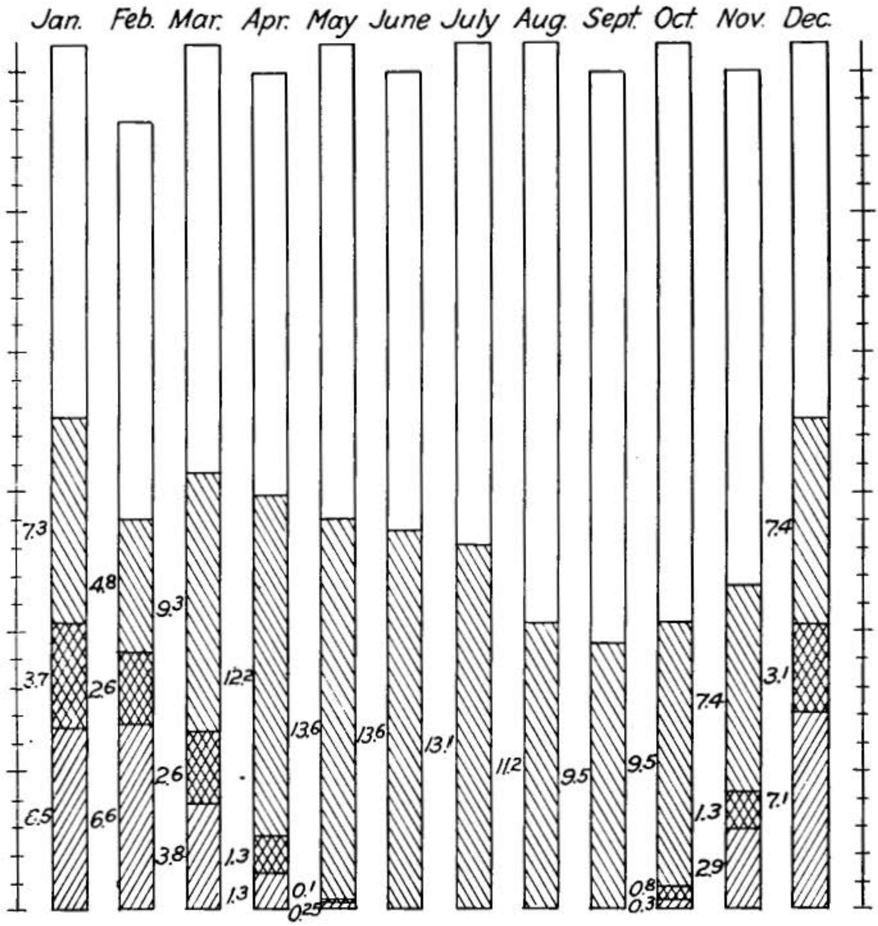


Fig. 6.—Distribution of the days with precipitation, and kind, Chillicothe. Graphic representation of the average number of days in each month without precipitation (without shading), with rain (shading inclined toward the right), with snow (shading inclined toward left), and with both rain and snow (both shadings), based on the period from 1902 to 1917, inclusive. The numerical value in days is given at the left of each column. Note that the actual number of days in each month is shown and indicated by number to the left. The February values appear to fall low because February has only 28¼ days against 30 or 31 in the other columns. If the columns had been drawn of equal length and the values reduced to percentages, February would have shown a proportion of days of precipitation practically as great as December and January, but a greater proportion of snowfalls, a considerably less proportion of rainy days, and a lesser proportion of mixed rain and snow. That is, February is the season with the relatively greatest number of snowy days, and the least number of days with rain or mixed rain and snow.

ord available for Chillicothe (Weather Bureau observer) indicates a precipitation of 37.46 inches.

Distribution through the year.—The average monthly precipitation at Circleville and Waverly has been plotted in the accompanying diagram, to visualize the amount by months. From this compilation it is seen that June and July is the season with the heaviest precipitation and September and October is the season of least precipitation. There is a noteworthy decline in the quantity in April and apparently in May, from the March and June precipitations. Comparison of these results with observations at several surrounding but somewhat more distant places indicates that this distribution by months is characteristic of the region.

Seasonal character of precipitation.—The difference in the amount of precipitation from month to month, taken alone, is so slight as to be negligible in local military affairs. Of more importance is the character of the rainfall at different seasons. The fall, winter, and spring precipitation is of the cyclonic type, and on the whole, apt to be a more or less gentle, general rain or snow of one or two days duration. Occasionally these rains are hard, and there is a record of one 16-hour February rainfall of 2 inches, which, although unusual, is probably not exceptional. During May, June, July, and August, the rainfall is dominantly of the thunderstorm type, local, convectional storms with sharp downpours of rain, in duration from a few moments to two hours or more, usually in the afternoon or evening. These are most numerous in June and the early half of July, and in some years, they may occur daily for a week or longer, giving rise to "wet spells", such that outdoor farm work is largely suspended, for though the actual number of hours of rainfall is not great, the ground or the crops are too wet to admit of operation. The crest shown by the May, June, July, and August precipitation may be considered the direct result of this thunderstorm type of rainfall.

Something of these conditions may be seen by comparing the diagram showing monthly amount of precipitation with the one showing number of days in the month with precipitation. The maximum amount of precipitation of June and July falls in a considerably less number of days than does the smaller precipitation of March or even April. This relationship would be even more strikingly shown if the relative number of hours of and the amount of precipitation could be compared for these months.

Snowfall.—Snow flies from the middle of October until in May, but it would be very exceptional to have anything like a real fall of snow in either October or May. In plotting the days of snowfall in fig. 6, such slight snows as occur in October, April, and May have been excluded from the other months, and to this extent their representations as having snowfall is misleading. From mid-November to the end of March is the season of snow, with its culmination in January and February.

Between 40 and 50 days with snowfall may reasonably be expected in this interval, but, as will be seen from the accompanying table, three-fourths of these produce less than 1 inch of snowfall. Only a very few days in each winter may be expected to exceed 4 inches. Very exceptionally, there is a single day's snowfall approximating 1 foot in depth. Apparently only 5 times in the 16 years of which there is consecutive record, has there been a depth of from 10 inches to 13½ inches on the ground, and 3 of these were due to a fall of 2 days or longer duration.

Snow seldom lies on the ground for more than a day or two, though exceptionally the ground may remain covered for a week or more. The short periods of freezing weather are succeeded too closely by milder weather and rain.

The winter of 1917-18 produced a large though apparently not exceptional amount of snow. It stands out, however, as probably the record year within human memory for the duration of snow coat. Snow lay on the ground continuously from December 6 to February 10, 65 days.

Number of days with snowfall in winters of 1915 to 1918 and depths of snowfall. The headings, as 1"-2", include 1 inch falls and all depths up to the second limit, falls of 2 inches being recorded in the 2"-3" column.

WINTER	Total depth of snowfall	Total No. days of snowfall	Trace	¼"-1"	1"-2"	2"-3"	3"-4"
1915–16	2′ 10¼″	44	15	20	4	2	1
1916–17	4′ 7¾″	43	13	15	4	3	4
1917–18	4′ 8½″	49	17	16	8	2	--

WINTER	4"-5"	5"-6"	6"-7"	7"-8"	8"-9"	9"-10"	12"-13"	13"-14"
1915–16	--	--	--	--	--	--	1	--
1916–17	1	2	1	--	--	--	--	--
1917–18	--	1	1[1]	--	--	1	--	1[1]

CLOUDINESS

The accompanying diagram of the distribution of cloudiness throughout the year has been compiled from Mr. Carson's observations. In assembling this data, the object has not been to determine cloudy and partially cloudy days after the formula of the United States Weather Bureau; as is to be expected, Mr. Carson's records do not admit of such application. They do admit, however, of determining the approximately average number of days per month that would be felt by one in the open air as clear, partly cloudy, and cloudy.

[1]These falls, 6¼ inches and 13 inches, fell within 24 hours and 23 hours respectively, but each on two days. It has appeared desirable to list each as one 24-hour fall rather than as the result of 2 days.

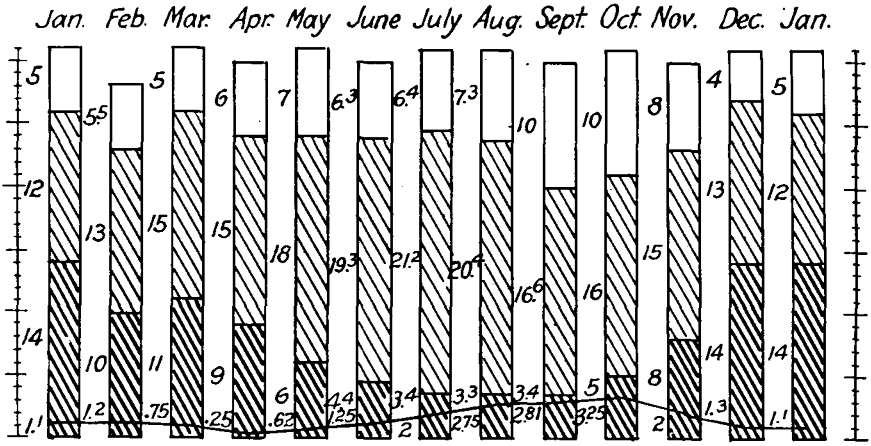


Fig. 7.—Cloud and fog conditions, Chillicothe. Graphic representation of the average number of clear, partly cloudy and cloudy days per month, and the number of days with fog per month. The first three are indicated by the intensity of the shading, cloudy being the heaviest. Number of days with fog is shown by the curve at the bottom of the diagram. Note that the blocks do not represent percentages within a month, but the actual number of days. Though the line for fog falls across the cloudy blocks, it should be pointed out that it is no part of the record of cloudy days. The great majority of fogs are dispersed by 9 o'clock in the morning, and these morning fogs are more apt to presage a clear day than a cloudy one; such a day is classed as clear in compiling the record. Only rarely is a day foggy throughout.

December and January are the cloudiest months, almost half of the days, on the average, being cloudy. Nor is there often exception to this condition; at the least 10 cloudy days may be expected. They also show the least number of clear days. September and October are the brightest months, both in the low number of cloudy days and the high number of clear days. Exceptionally, at this season, there are as many as 20 wholly clear days in a month and occasionally no cloudy days are recorded. It will be noted that, with the exception of September and October, the average number of clear days remains but little changed throughout the year. The differences are accomplished in the diminution of the number of cloudy days from January to August, and the proportionate increase in the number of partly cloudy days. It is very likely that many of the summer days here listed as partly cloudy would have been called clear days by the average individual who was giving no particular attention to the weather.

Visibility as affected by cloud conditions.—The direct effect of clouds, in the common use of the word, on visibility in the Chillicothe district is very limited. Often during the late autumn and winter storms, clouds hang so low as to sweep the tops of the high hills from Mt. Logan north to Sugar Loaf and thence eastward, or the highest hills south and southwest of Chillicothe. For a week at a time it is impossible to catch more than an occasional short glimpse of any of these hilltops and that from a very good vantage point. Doubtless the same condition obtains from time to time throughout the year.

It should be noted that many of the clear days in the Chillicothe district are, due to haze, days of low visibility. This appears to be especially true of the winter season. The hills east and northeast of Camp Sherman rise much above the hilltops west of the Scioto and, at Sugar Loaf, are abruptly succeeded by a low plain which extends for miles to the northward. These hills, for purposes of observation, dominate what is for Ohio a really remarkable range of territory. Yet, owing to the commonly hazy condition of the atmosphere, it is very seldom that anything like full use of this advantage can be made. One who attempts to secure satisfactory photographs of these hills, or from their tops, must watch for his opportunity, often for weeks, and be prepared to seize it when the proper hour comes.

FOG SEASON AND HOURS

Attention is commonly not given to fog conditions in the publication of weather data. The fog data have been assembled from Mr. Carson's records and plotted to show number of days with fog on the diagram showing cloud conditions. There is great variability in the number of fogs in successive years; the curve, therefore, which was drawn from the 16-year monthly averages is unexpectedly regular. Indeed, the regularity of the curve is the only reason for believing the fog records are sufficient to give good average results. From this it appears that August, September, and October are the months with the greatest amount of fog. April has the least. By this is not meant merely foggy days, days of low-hanging cloud or fog sheets, but thick, general fog, settled over the face of the land. (See Figure 7.)

As a rule, the fogs are morning fogs. Only exceptionally and then usually in the winter, does one last all day. On one occasion since 1901, the fog condition endured for 40 hours. Evening fogs or fogs lasting all night are more frequent but yet not worthy of special note; they are more apt to occur in fall or winter than in spring or summer.

Of very considerable importance, however, are the morning fogs, and these it is which give all the character and significance to the curve of foggy days. There is good reason to believe that this curve does not indicate the average number of such fogs; it is very probably greater. But it does appear to indicate fairly well their distribution throughout the year. During the winter months, when they are less frequent, they endure, on the average, from before daybreak until about 10 or 10:30 in the morning, occasionally until noon. In February and March, they are of shorter duration, from 8 to 9, and from April to December, on the average they disappear between 7:30 and 8 o'clock, very rarely persisting to 9 o'clock. These fogs seldom originate after daybreak. They are formed in the morning hours before daybreak and are dispersed by the sun. The later hour of sunrise in winter undoubtedly partially explains their late dispersion in winter. They are essentially a phenomenon of clear weather, and more often than otherwise, forecast a clear day. They are predominantly a lowland phenomenon, but no facts are at hand to show how often or for what duration they are found on the uplands about Chillicothe. They will undoubtedly be found lingering in the deep ravines and valleys tributary to the Scioto as late as in the Scioto Valley itself.

They are exceedingly wet, not so much because they are of the nature of a mist, but because the grass or underbrush are brought to the condition produced by heavy rain, a condition which endures sometimes for hours after the fog has been dispersed.

Visibility as affected by fogs.—Fogs are an exceedingly important factor in the visibility of the early hours of the day during the summer and autumn months. Often for a week at a time, one living in the Scioto Valley rises every morning to a bank of white, wet mist, so dense that the eye notes objects at more than 100 yards only indistinctly. Work on the ranges on the valley floor is impossible until after such a fog has been dispersed, which is, as just noted, usually accomplished by 8 o'clock, though sometimes not until 9. In the event of extensive maneuvers, such conditions might very materially facilitate the extensive shifting of effective units by one side, wholly hidden from observation by the opposing side, either from heights of land or aeroplanes.

Though no data are at hand from the Chillicothe district, it is very probable that here, as elsewhere in the Scioto Valley, and in other similar valleys of southern Ohio, the hilltops bordering the valley are free of fog long before the valley is cleared. This would apply particularly to the high hills east of Camp Sherman, from Mt. Logan northward, and to the high hills some miles south of Chillicothe and west of the Scioto.

CHAPTER V

THE SCIOTO RIVER

VALLEY OF THE SCIOTO

The trench or valley of the Scioto River is sharply defined from Camp Sherman southward by high rock hills, and varies in width from 1¼ miles, 10 miles below Chillicothe and 2 miles below Stony Creek, to 3½ miles, 6 miles below Chillicothe. At Camp Sherman it is 2½ miles wide. This portion is 300 to 400 feet deep. North of the Camp the rock hills are absent except for 5 miles on the west side, the valley is shallow, not over 200 feet, and bordered by gently rolling hills of gravel, sand, and clay.

Throughout this length there is a low flat plain, the "bottom", which is overflowed by the river in flood, and across which the river winds from side to side. Between the flood plain and the valley walls, there are in places, higher flats or terraces of gravel and sand, some of these well above flood waters. Camp Sherman is located on one of these, the rifle range on another. The portion of the valley which is low enough to be overflowed by heavy floods varies in width; 3 miles north of the Camp it is ⅗ mile, but just below Chillicothe it is 2½ miles wide.

The river at most places winds across the flood plain in curves that are from 1 to 2 or 3 miles around. The portion of the valley here described in detail is 22 miles in length, but the river in this distance flows 31 miles.

As will be shown in detail, the river at low water is a succession of quiet stretches where the water may be 3 to 15 feet deep, with knee-deep riffles at intervals of rods or miles.

CHARACTER OF BOTTOM OF CHANNEL

The bottom is of sand, gravel, and cobble with large bowlders in places; only at occasional intervals is there mud bottom. Apparently at only one place is there rock bottom, and there only for a part of the channel width, directly east of Chillicothe. Snags occur at irregular intervals throughout the whole length of this portion of the river. They are most numerous on shallow bars, standing 2 to 10 feet above low water, but they are reported in certain quiet places entirely covered at low water.

RIVER BANKS

The river banks rise normally 8 to 10 feet above low water and are commonly of sand and gravel overlain by several feet of flood plain silt.

However, where the river impinges on a higher terrace the banks may be 20 to 40 feet in height, or, rarely, 60 feet. The banks are usually steep enough to offer difficulty in climbing. Artificial levees, at many places 16 to 20 feet high, have been built not to keep floods out of the lowland but to control the direction of their violent current. It is, perhaps, not out of place to here insert a note of warning to officers who may have come to military service from regions where there is no need of levees; the levees should not be broken, either to obtain material or to gain access to a river crossing, for any reason short of actual necessity due to the presence of a real enemy, because the flood current through such a breach may wash farm lands for 3 miles below or may permanently change the course of the river.

FOREST GROWTH

Both banks of the Scioto, throughout the length of the portion described, are wooded, with the exception of short spaces at long intervals. As a rule, trees occupy only the immediate bank or a few yards at most of the bordering lowland, but in places, commonly on the inside curve of river bends, the lowlands may be timbered for 100 or 200 yards back. Sycamore is by far the commonest tree, but there is much cottonwood, maple, elm, and willow. Without exception the largest trees in the whole region may be found along the river banks. Trees 18 inches to 2 feet in diameter are not uncommon; one sycamore 19 feet in circumference was noted. The temptation may be great to obtain material for military construction from the river banks. Locations from which such material is to be taken should be selected with care that its removal may not possibly cause damage by permitting washing of the banks. The accumulated experience of a century has taught every land owner in the valley that the trees protecting his bank or levee are more valuable where they stand than as timber. However, it is believed that with care to this end, much material is available. The lowlands on the inside of curves and abandoned stream channels back from the present channel are the most likely places. It is a fair precaution that no trees should be removed from any river bank or levee or from any part of the outside bank of a bend, except, again, under real military necessity. The effects of such removal can be seen in every place on the river where the bank is bare of trees; it is being undercut. Such occurrences may be seen in the high gravel bank back of the corrals in the lower end of the Camp, or in the low banks immediately above the Camp opposite the machine gun range. (See Plates 5 and 6 for examples.)

With the exception of the trees bordering the present stream bank and the banks of recently abandoned portions of the channel, no bottom forest remains.

Directly opposite the Camp, the "Miller cut off" of the topographic map, surveyed in 1905-6, has become the river channel, and the old channel, is occupied only when the river is high. The old bed is now largely overgrown with willow from an inch to three inches in diameter, and the old banks yet retain their cover of maple and sycamore from post to tie size. In such a place there is a large amount of available structural material obtainable with less risk to river banks.

CHANGES IN CHANNEL BY UNDERCUTTING

In spite of all efforts to keep the river in its place there are changes, some slow, some rapid. Knowledge of these, particularly of the former, will permit forecast with fair certainty of the timber and bank conditions, position of channel in the stream bed, etc. The greatest tendency to undercut is on the outside of curves, where the current, in high water, is thrown strongly against the bank. Any undercutting means that the channel shifts by just as much toward the outside of the curve. The bank on the outside of a bend is almost always 10 to 12 feet high, steep, perhaps perpendicular, and the deep water lies on that side. The current is always less on the inside of such a bend, sand and gravel are dropped there, and the old channel is filled up just as rapidly as the opposite side is cut out, but by material from up stream. Such inside curves are almost always the locus of clean, bare, gravel bars with shallow water off shore, the banks are very low and frequently may be driven over with wagons; commonly there lies back of the river in such a bend, a sandy, washed bottom with unfilled remnants of old channels, too low to farm, that is let grow up as it will. There may be a width of 100 or 200 yards with large trees in it, and since the tendency of the river is to wash against the opposite bank, part of the trees from within these curves may be, in some cases, removed. These relationships are shown on Plate 5 B and C, and on 6 C.

So persistently does this condition obtain on the Scioto that it should be recognized by everyone having to do with it or its flood plain.

THOROUGHFARES AND CUT-OFFS

There occur, at many places in the flood plain of the Scioto, long, narrow, channel-like depressions of which the floors are only about 4 to 6 feet above low water of the river. These are called thoroughfares. They usually are so located that, when the river is in flood, they offer a more direct route for the water than the channel. In fact, they owe their existence to that relationship and are merely flood-water channels of the river, many of them occupied on a rise of about 6 feet. Frequently they are too low and wet to be farmed regularly, and often small ponds are found in the lowest places. These are not so much abandoned channels as potential new channels of the river, and they are closely watched by the bottom farmers for signs of impending change, and their upstream adits are commonly protected by levees. One of these begins below the mouth of Deer Creek, and extends southeastward in small development across the bottom for two miles; almost opposite its lower end, a prominent one, shown on the map, cuts directly across the curve above the County Infirmary, and from its lower end, a similar channel runs southward directly alongside the Infirmary buildings. Should the Scioto shift its channel to the upper one, it would quickly, if permitted, occupy the other two, and a wholly new channel, 4 miles in length, would be the result. This thoroughfare is shown in fig. 9, p. 66.

PERMANENCY OF CHANNEL FEATURES

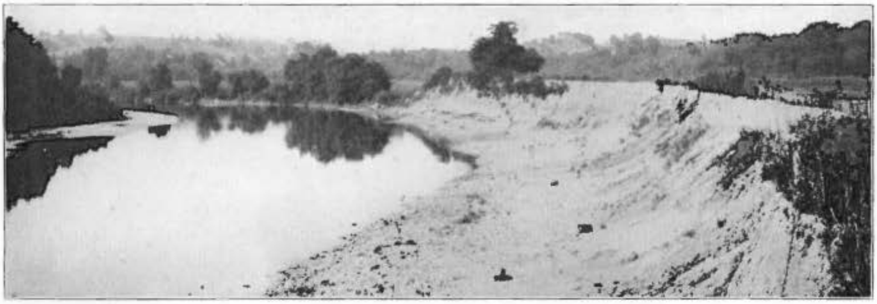
Though the tendency to shift its bed has been discussed at some length, the channel of the Scioto is fairly stable when compared with streams like the Missouri or the Mississippi below St. Louis. It is cut to such an extent in gravel, that its load does not shift rapidly under floods, as it would if its banks were sand or easily caving silt. Within the limits of the Camp Sherman quadrangle there have been two small abandonments of channel within 12 years, one at the "Miller cut off", the other at the mouth of Indian Creek, 4 miles below Chillicothe. The shifting of its channel laterally by undercutting is going on slowly at many bends. The river road to Columbus, 2 miles northwest of Kinnikinnick, has been rebuilt several times to allow for such movement, and frequent occurrences of piling or cribbing in present mid-stream tell the tale of thwarted effort to hold the slowly shifting channel in place. See Plate 5 B for another example.

The location of riffles and fords, of long reaches of shallow and deep water is, even over periods of many years, quite stable, though occasionally changing materially during some heavy freshet. Even the snags do not move much; in one known instance they have remained imbedded in the sands of a shoal for 18 years at least.

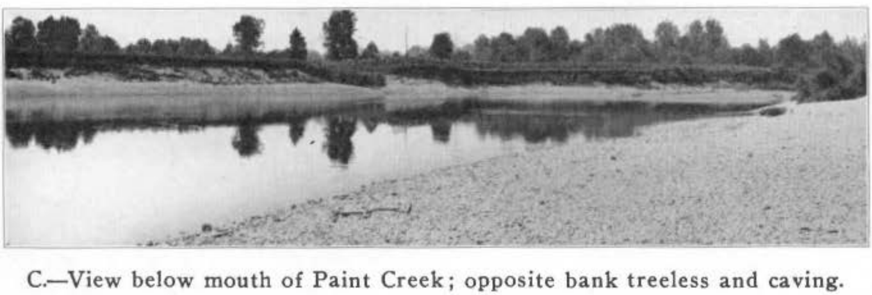
RIVER CROSSINGS

Bridges.—The Scioto is amply bridged at Chillicothe for all purposes of civil life. On the north side of the city, the Bridge Street bridge, double span, steel truss, double roadway, serves all road traffic between Chillicothe and the northeast quarter of the Camp Sherman quadrangle, including the east-side pikes to Columbus and Circleville and pikes to Lancaster and Laurelville. Just below it are the Scioto Valley Traction bridge for the electric line, and the N. & W., double-track railroad bridge. On the east the Main Street bridge, steel truss, many span, double roadway, serves all road traffic in that direction, the most important being the pike up Walnut Creek to Adelphi. Three miles southeast of Chillicothe, a many span, steel truss, double roadway wagon bridge serves the Londonderry and Richmondale pikes, and just below it, the main line of the B. & O. railroad and its recently-

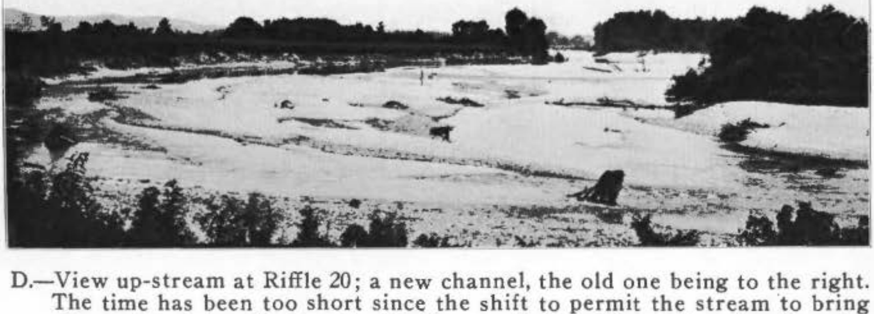
A.—View up-stream at Riffle 13, with bars and snags.



B.—View up-stream above Riffle 15; bank on right was so far cut back by the 1913 flood that a road on its top was entirely cut away. Being treeless and on the outside of a sharp bend, it continues to yield to floods.



C.—View below mouth of Paint Creek; opposite bank treeless and caving.



D.—View up-stream at Riffle 20; a new channel, the old one being to the right. The time has been too short since the shift to permit the stream to bring this portion into adjustment with the remainder. Hence, the river is swift, full of snags, and rapidly undercutting the bare bank on the left.

SCIOTO RIVER BELOW CHILLICOTHE AT LOW WATER. FROM LOW WATER TO FOOT OF CHANNEL BANKS IS ABOUT 5 FEET acquired subsidiary line, the C. H. & D. railroad, cross by separate bridges. Ten miles above Chillicothe is the "County Line bridge", due west of Kingston, a steel truss bridge of several spans with a capacity of two columns or two truck trains. Ten and one-half miles below Chillicothe and one-half mile above Higby, a wagon bridge crosses the river.

River depth.—For extensive military operations these bridges are inadequate, and must be supplemented by fords and pontoon bridges. The valley has been hastily traversed for a distance of 9 miles above Camp and 13 miles below to learn something of the depth and possible crossings. At most places this has been supplemented by information from residents. This information, which is by no means complete, is here summarized, but is given in detail at the end of the chapter.

The Scioto River, like most streams of its size, is a succession of long, quiet-water stretches, with short, shallow riffles where the velocity is greater. The riffles are commonly a little greater or a little less than knee-deep but range from shin-deep to waist-deep at the lowest stage of the river, (1 foot below 0 of the Bridge Street gage). The riffles, when not too deep or too swift, and when easily approached from both banks, and with good bottom, may be counted fords. (See Plat s 5 and 6.)

Between the riffles, stretches of quiet water may be 2 miles in length or only 200 yards. These stretches may be deep, in places reported 15 feet for long distances, or they may be less than waist deep for half a mile or more, or they may be a succession of shallow places and holes. The deeper portions are of interest as possible pontoon bridge sites.

Fords.—Without doubt, there are good places to cross the river by wading in the shallower parts of some of the quiet-water stretches but it would be impossible to locate them without considerable more exploration and interrogation than has been possible.

The riffles are located on the accompanying outlines of the river and are numbered in two series, one up stream, the other down, from the riffle just above the Bridge Street bridge at Chillicothe. Above Chillicothe the following riffles appear to be most easily adaptable to become fords: 2, 3, 4, 5, 8, 9, 12, 13, 14, 16, 17, 19. Of these the best are 2, 4, 9, and 17. No. 9 is an excellent ford, and has been used as such for years and goes by the name of the Infirmary Ford. Below Chillicothe the ones which appear to be most readily adaptable are upper end of 3, 4, 5, 12, 14, 15, 18, 19. The few below the mouth of Indian Creek are difficult to approach from the west because the canal towpath was built directly on the river bank or but a few yards back from it. Approach can be had to the river at no point in this distance, except by building a roadway down this 30-foot bank.

It is difficult without actual observational experience with the

A.—Paint Creek. Riffle at Lundbeck dam, south of Chillicothe at low water.

B.—Paint Creek. Deep holes of quiet water just below riffle shown in A. Same stage of water as in A.

C.—Scioto River opposite Camp Sherman at low water, about —1 ft. of the gage. View up stream; on the right, low brush and tree covered flood plain, on the left the gravel terrace on which Camp Sherman is located. Since the establishment of the Camp, effects of erosion have been rapidly developed on this bank, due to the removal of trees, unprotected ditches flowing into the river over the gravel, and road-cuts down the bank.

D.—Deep, quiet stretch of Scioto with tree-covered clay banks. Above County Line bridge.

PAINT CREEK AND SCIOTO RIVER STREAM CHANNELS river at higher stages to learn what depths on these riffles may be waded with safety. The statements of depth of water over the riffles is based on observations made when the river was practically as low as it ever falls, at about 1 foot below 0 of the Bridge Street gage. Anything within a foot above this stage would pass as "low water" among those familiar with the river. Inquiry among those who are familiar with the stream brings out the opinion that with a rise of 1 foot above "low water" the riffles may yet be waded, but that with a rise of 2 feet the swifter, deeper ones would be dangerous. It is doubtful whether this statement allows a sufficient margin of safety if applied to the river when the "low water" is at 0 of the gage. One or two feet over 0 would bring about 2 to 3 feet more onto all the riffles than at the stage to which these notes refer, and the water would be hip to breast deep on a short man on a few of the shallowest riffles, waist to shoulder deep on most of the riffles. The most uncertain element in this is the "low water" of the countryside to which we are trying to refer the matter, and to which officers in making a crossing might be called upon to refer it. Referred to the Bridge Street gage, it appears that at 0 all of the riffles cited in the last paragraph may be used, but that a 1-foot stage by the gage would give on a short man water hip deep on those shallowest riffles which are here described as half-way to the knees, and waist deep on those which are here described as knee deep. Crossings should be attempted only with precaution at this stage, because it is suspected that some of the deeper and swifter riffles will be impassable.

It is thought best not to attempt suggestion of the ones from the above list which will be usable at 1-foot of the gage. More will depend on velocity than on depth. There have been many drownings in the Scioto River of those familiar with the crossings they were attempting; this is not because the increase makes it too deep but because the velocity becomes too great with increased depth, to keep the feet on the bottom. Most accidents in attempting to pass swollen riffles or fords come about through inaccurately judging the ability to withstand the velocity, not the depth of the water.

Changes in the course or channel of a stream are always accomplished in time of flood. Though the shallow places of the Scioto are fairly permanent during the course of several years, it must never be forgotten that a heavy flood may alter one of these features very much and a first approach to one of them after such a flood should be made with the expectation of finding some change. Fords that were formerly good crossings have been washed out until they are now deep and dangerous riffles.

Pontoon bridge sites.—For pontoon bridges, the water should be not less than 4 feet, and should deepen rapidly from both banks. At the lowest stage of the river the last qualification is met in but few places, because on one side or the other there is almost always a gently sloping bottom, such that a 4-foot depth can only be obtained 35 to 50 feet from the water's edge, if at all.

It is not as easy to determine pontoon sites as riffles, and as the knowledge of the deeper portions has been obtained entirely second-hand, it is highly probable that good sites exist besides those here indicated. Something of the depths prevailing elsewhere than at these sites is given in detail later.

Above the Camp, there is deep water, 10 to 15 feet maximum, opposite the mouth of Dry Run, just above the Infirmary. Access from the west may be easily obtained by Dry Run, but the opposite bank is a long way from the road across bottom land. Similar depths obtain down to the next riffle but there is a 35-foot bank on the south of bowldery gravels and clays, which makes approach impossible without construction of a road.

Muddy Bend, 2 miles above the County Infirmary, appears to be well adapted. The water is quiet and deep the entire width. A public road, graveled, but wide enough for one column or train only, leads to within a few rods of the western bank which may be approached from there by a short lane.

Above the County Line bridge, 1½ miles north of Deer Creek, the depths are ample for a mile, but approach on the east is impeded by a 10 or 12 foot levee and wooded lowland. (See Plate 6 D.)

North of Chillicothe, the few gravel bars which border the stream, at lowest stage, are apt to rise only a foot or two above the water; at most places there is none and any increase in depth with a rise in the river increases the depth at the water's edge by most or all of the increment. Below Chillicothe, as far down as the mouth of Indian Creek, numerous short holes up to 6 feet or more occur but apparently without exception these have shoal water on one side or the other. This portion of the river is distinguished by the presence of gravel bars of far greater extent than the portions above and below. At almost all places these rise gradually back from the water's edge on one or both sides 4 to 6 feet above the lowest water. Consequently, with few exceptions, any rise in the river does not result in greater depth at the water's edge because the water creeps over a gently sloping gravel bar, until the rise has amounted to 4 feet or more. This relationship is shown in Figures A, B, and C of Plate 5.

In the long, nearly straight stretch of river from Indian Creek to the County Bridge, 2 miles below Stony Creek, pontoon sites are hampered by the steep bank rising 25 to 30 feet or more, either directly or in two closely spaced steps from the water's edge, with the old canal bed between the bank and the road. It would not, however, be difficult to construct an approach.

Between riffles 20 and 21, at the head of this stretch, there is deep water, and apparently the east side is not so shallow but that suitable places may be found.

Between 23 and Spring Run, the depths are very irregular but some holes are of ample depth.

From Stony Creek to Mill Hollow is reported 8 to 15 feet, channel on the west side, but 4 feet near the east bank at most places.

From the mouth of Walnut Creek to the bridge, conditions are reported very much as between Stony Creek and Mill Hollow.

Ferries.—Ferries, drawing about 1 foot and worked by a cable attached to both banks, were operated for years along the Scioto. As late as the month following the 1913 flood, one was used near the Higby bridge, which was swept away. They could be easily installed at many places, but are a slow method of crossing. To boats of deeper draught the remarks on the slope of the bottom under the last heading appear to apply.

NAVIGABILITY

The Scioto has not been regarded as navigable since the first half of the 19th century, when loaded flatboats were frequently sent down the river on rising stages, destined for New Orleans, and steamboats of shallow draught occasionally ran as far up as Chillicothe at favorable stages.

At low water, that is 1 foot below 0 of the Bridge Street gage, a rowboat must be dragged over some of the riffles. At 0 stage, it is reliably reported that one may go from Chillicothe to Portsmouth and back by skiff with detachable motor, and the same statement will doubtless apply to the river for 10 miles above Chillicothe. At this stage there will be about 18 inches of water over the deepest parts of the shallowest riffles, and 30 inches over most of them, and propeller blades, unless stiff, are apt to be bent against the bottom.

At low water stages, the river is a succession of quiet pools and riffles of varying velocity. As the depth increases 2 or 3 feet, the velocity over the riffles will be very much increased so that a rowboat may not cross over them except by keeping to the banks. But as the river approaches the bank-full condition, that is about 8 feet of the gage, the riffles are partially wiped out in the general sweep of the whole current. Up to bank-full, navigation by small power boats is feasible, but the current is so strong that rowing against it is slow work. In yet higher stages, as the water spreads over the bottoms, the current is said to be rather less in the channel than at the bank-full stage. However, in heavy flood stages, when the water sweeps down the thoroughfares and across bottom lands, motor boating becomes increasingly uncertain, and in the highest stages, it is sometimes impossible to work a rowboat even up the sides of the flood.

Snags and rocks.—There are snags in the river at many places. It is understood that they occur below the lowest-water surface in the quiet reaches, but no data is at hand on their location. Since the river could only be navigated, even by the smallest motor boats, in the intervals between the riffles at that stage, it is very unlikely that such snags will impede any use by boats at higher stages. The same may be said of rocks. There are no ledges or reefs, and such rocks as occur are bowlders lying on the bottom. In the shallow reaches of the river they occur in considerable numbers and sometimes lie near enough to the surface to break the water slightly or to be seen from the banks at the lowest stage. Very few of them rise more than 1 foot and probably none of them more than 18 inches above the bottoms of the 18-inch riffles which will condition any effort to navigate the river.

At a number of shallow bars and shoals, accumulations of snags occur, either stranded stumps or overturned trees with numerous branches. These project as much as 10 feet above the lowest water and may be counted a menace to navigation in all stages in which navigation is likely to be attempted, that is, up to bank-full. The locations where notable accumulations occur are indicated on the accompanying maps and some notes are included in the detailed account of the channel which follows at the end of the chapter. Such an occurrence is shown in Plate 5 A.

FLUCTUATION IN HEIGHT OF THE SCIOTO RIVER

Information on this topic is derived chiefly from the observations of the U. S. Weather Bureau from a gage on the middle pier of the Scioto Traction Line bridge at Bridge Street, Chillicothe. Readings are presumed to have been taken daily since December, 1908, though the record shows gaps due to negligent observers as well as to an ice-torn gage, and the observations of certain periods are known to have been made at irregular short intervals and the values therefor interpolated or guessed at. Nevertheless, this record supplies a fair knowledge of what may reasonably be expected and of what may possibly occur. There is no question about the readings of the present observer.

At the time this gage was set in 1908, the zero mark was put at what was thought to be the lowest stage of the river. It appears, however, that this was done on slight observation, as the river has repeatedly been recorded below 0 in summer, since the gage was extended downward a few years ago, and the condition of the record leaves no doubt that this occurred almost every summer prior to this extension. The lowest recorded level is 1 foot below low water from September 27 to October 21, 1916. The altitude of the 0 mark is 595.5 A. T.

Danger mark is set at 14.5 feet of the gage, but the reason therefor is not apparent. It is understood that about a 9-foot stage is necessary to put the river out of banks and over small areas of the lowest farm lands. The farmers above Chillicothe maintain that at about 18 feet the floods become seriously damaging, that is, the currents across land

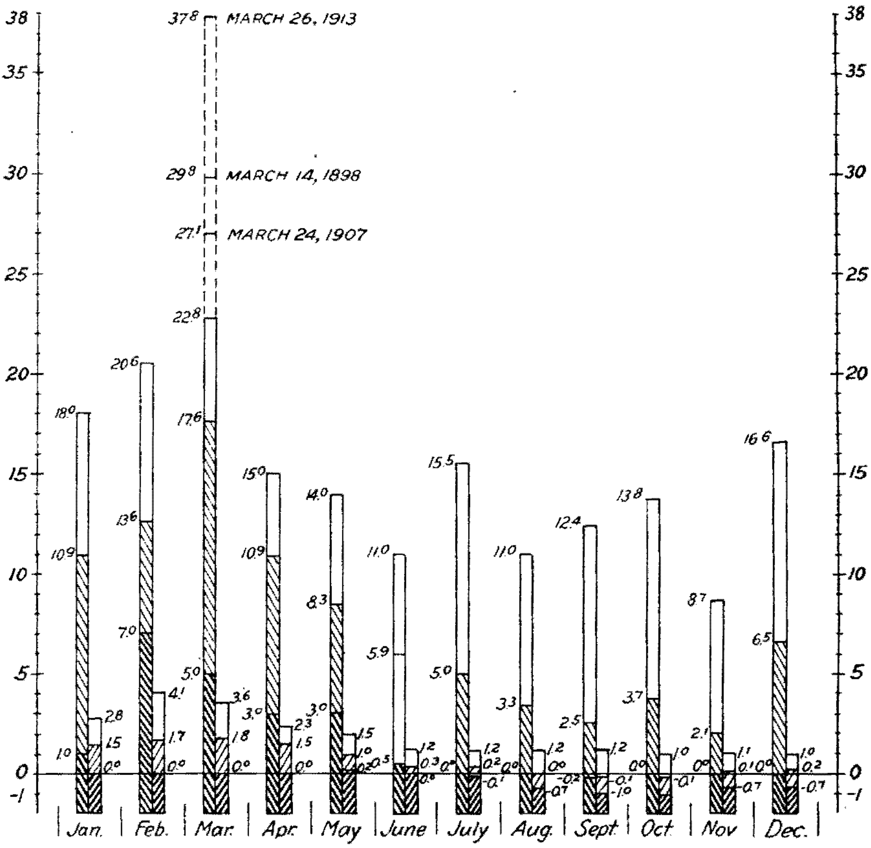


Fig. 8.—Range of high and low-water conditions in the Scioto River at Chillicothe, for 10 years, 1908 to 1917, inclusive. The high-water conditions and low-water conditions for each month are shown in adjacent columns. The left hand column of each pair shows, (a) at the top, the extreme high-water stage for the month in the 10-year period; (b) the average of all the high-water marks for the 10-year period (at top of the medium shading); (c) the lowest high-water mark recorded in the 10 years at top of the heavy shading. The right hand column of each pair shows (a) the highest low-water mark for that month at the top, the average of all the low-water marks (at top of medium shading), and the lowest low-water mark in the 10 years (at top of heavier shade). The gage readings are given opposite the graphic representation of the value, in feet and tenths of a foot.

For example: In January, the highest recorded stage of the river in 10 years was 18 feet (1916), but one year (1909) the highest stage attained was only 1 foot, which is less than the average lowest-water stage for the month, and considerably less than the low-water stage of January, 1910, when the river at no time fell below 2.8 feet. The lowest stage reached by the river in January during these 10 years was 0 of the gage, which was in 1909.

The stage attained by the flood of March, 1913, was so exceptional that it has been indicated by a dashed line, and the second highest stage in the 10-year period is indicated at 22.8 feet, because it is more normal than the 1913 stage. However, two other March floods, which occurred before this 10-year period, were much higher than the column so limited, and they have been introduced to make the representation more complete.

become washing. Obviously, a few inches of standing water on crops at certain stages might ruin them, and considerably less than 18 feet might remove wheat shocks from low land.

Late winter and early spring.—From January to early in May the river carries its greatest volume and attains its highest stage, due chiefly to winter and spring rains falling on a land which has become well filled with water. The low-water stage during these months is about 2 to 4 feet above 0 of the gage, and the low-water readings, when plotted, show an irregular, broad, very gentle curve, with the crest in February and March. This may be characterized as its winter-spring, unswollen condition, and is maintained by seepage from the ground. Superposed on each annual rise of the river are from 6 to 12 or even 15 high-water periods which have varied from 6 to 12 or even 20 days in duration; these are due to run-off from rains, occasionally influenced by melting snows or frozen ground. Each winter and spring from 2 to 6 of these rises, on the average less than half, attain to a 10-foot or a higher stage. The river is known to have attained a 16-foot stage 14 times in the winter-springs of the past 10 years, an average of 1.4 times to each season with the record for one season probably but not certainly complete. Several of these times in this 10 years it has attained 18 feet, and of this number 4 reached or exceeded 20 feet.

Extreme high waters.—Most, if not all, of the extremely high water stages which have been experienced, have come in February or March, and the majority in March, particularly in the latter half.

The following table shows the heights reached by the four floods which, in the past 10 years, have reached to 20-foot stage, with two earlier very serious floods.[1]

[1]These two were before the establishment of the Bridge Street gage, but Mr. J. I. Carson, for years assistant city engineer, determined the height *above sea level* of the backwater at Chillicothe, and from this and the altitude of 0 of the Bridge Street gage, a stage value has been assigned on the basis of the Bridge Street gage, so that they may be compared with other crests recorded thereon. This gives a stage over 2 feet higher than the *stage* which Mr. Carson reported and 1.5 feet higher than reported by U. S. Dept. of Agriculture. It appears that Mr. Carson's *stage* reading was derived from an old gage that stood for some years at the B. & O. pumping station, near Walnut Street, and at the head of a steep riffle; the present Bridge Street gage is located at the foot of the same riffle. This, and differences in the "low water" of the two, and errors in different bench marks used may explain the discrepancy. Mr. Carson concurs in the method employed to reduce these floods to the Bridge Street gage.

According to the "Daily River Stages at River Gage Stations" . . . . of the U. S. Pt. IX, 1909, p. 31, U. S. Dept. of Agriculture, the highest water stage then known for Chillicothe was 28.3 feet, on March 24, 1898.

	Stage read at or reduced to Bridge Street gage	Altitude A. T. of crest, after J. I. Carson.
1. Mar. 24, 1898	29.8 ft.	625.3 ft.
2. Mar. 24, 1907	27.1	622.64
3. Feb. 26, 1909	20.6	
4. Mar. 2, 1910	22.8	
5. Mar. 26, 1913	37.8	633.6
6. Mar. 29, 1916	21.2	

The flood of March 26, 1913

This was the result of the same storm which so disastrously flooded the Miami rivers in 1913. It remains the greatest known on the Scioto and did enormous damage in this basin and a fair proportion of it in Ross County. Since the establishment of Camp Sherman there has been some speculation by visitors as to whether the Camp is above all possible high water marks. It may be said here that, although the 1913 flood covered the lowlands now used for trenches and swept away a house standing on the immediate site of the present Camp water-supply pumping station, it reached only a small part of the Camp proper.

There is a long, sharp depression running north and south about one-third of a mile east of the main, central road of the Camp, a very old, high level channel of the Scioto. It is now occupied in part by the stables. Down this there flowed a strong current "probably deep enough to swim a horse," according to one observer, a current that would probably have been damaging to the present structures. The flood also occupied a narrow strip of low ground northeast and east of the General Headquarters building, rising into the orchard just back of it. From here a narrow stream of no great velocity and possibly 2 feet deep, flowed southward and southwestward, and entered the old canal bed above the B. & O. railroad overhead bridge. In the roadway under the B. & O. track, leading into Chillicothe, the water appears to have been between knee and thigh deep. This stream, from reports, would not have damaged the present Camp structures, except for the wetting. It was scarcely wider in most of its course, than the width of one of the barracks.

Above the B. & O. R. R. overhead bridges, on the pike, its maximum height was about 635 feet (correct to 3 inches). Even here, the height was partly due to the obstruction of the flood waters by the N. & W. railway embankment, because the water fell immediately when it broke. A much larger opening has been left in that place, and future floods will not be held back by it to such an extent.

The flood was so much greater than any that had previously been experienced or thought possible, that there has been considerable speculation as to the possibility of another flood of the same capacity to do damage, or even of a *super*flood that would materially exceed it. That flood was the result of heavy rains during several days over the Ohio watershed, falling on ground already rain-soaked. Although this rain was exceptional in amount, for duration, rainfall, and area involved, it has been exceeded three times in the past 18 years in the upper Mississippi Valley. Winter storms of such extent, however, are rare, and the March, 1913, rain was the only one of the six great 3-day storms of this basin which came in winter. The others came at seasons when the ground was in condition to absorb a much larger proportion, and by so much, diminish the percentage of run-off. The storm floods which characterize the winter stage of the Scioto are the result usually of a smaller volume of rainfall than the summer floods, falling over a greater period of time, but the proportion of run-off, due to saturated ground is far greater in winter and spring, than in summer. This may be seen by comparing the accompanying diagram of flood stages by months with the diagrams of amounts of rainfall by months and number of days with precipitation by months, given on pp. 46 and 47.

In order to provide adequate measures for all possible floods, the engineers in charge of the Miami Valley Flood Protection work made an exhaustive study of storms and floods in the eastern half of the United States. (The statements of the last paragraph concerning size and extent of storms are from their findings.) One of the chief questions is whether the possible maximum flood can be *very much* higher than that of 1913. The stages of the Ohio at Cincinnati are known for 130 years; of the Seine at Paris for 300 years; of the Danube at Vienna for nearly 1,000 years; and for the Tiber at Rome for 2,000 years. These show that the greatest flood in 1,000 years does not greatly exceed the maximum experienced about every 50 years, and that, therefore, "there has been no great exceptional flood that brought down half-again or twice as much water as the other great floods" The chief engineer's testimony before the Conservancy Court was to the effect that "the 1913 flood was one of the great floods of centuries, but in the course of 300 or 400 years we may get a flood 15 or 20 per cent greater. We think that is possible but do not believe we will ever get a flood greater than 20 or 25 per cent in excess of the 1913 flood."[1]

Spring.—About the middle of April or first of May, the low-water stages begin to fall lower and the storm-water crests become noticeably less than in March. Not infrequently, numerous storm crests continue until the end of June, or, as in 1917, to near the end of July, but commonly with decreasing height. On the average, perhaps once in each season, between May 1st and July 1st, a crest exceeds 10 feet. During this season, however, the crests, though lower, are about as numerous as in winter.

Summer and early autumn.—As a rule this spring phase passes abruptly into the summer phase by the cessation of storm waters. The river falls quickly to near the 0 mark, then much more slowly and fairly regularly to below the 0 mark. This condition of the river may set in as early as the fore part of May, or as late as July 1st, and commonly continues with only one or two low storm crests, 2 to 4 feet in height, throughout the summer and up to about November 1st. During this period it is seldom above the 0 mark, except for the few, slight storm crests, and frequently is below 0 for two weeks or a month, the lowest observed, as noted above, being 1 foot below.

[1]Engineering News, Vol. 77, Jan. 4, 1917, pp. 12–17.

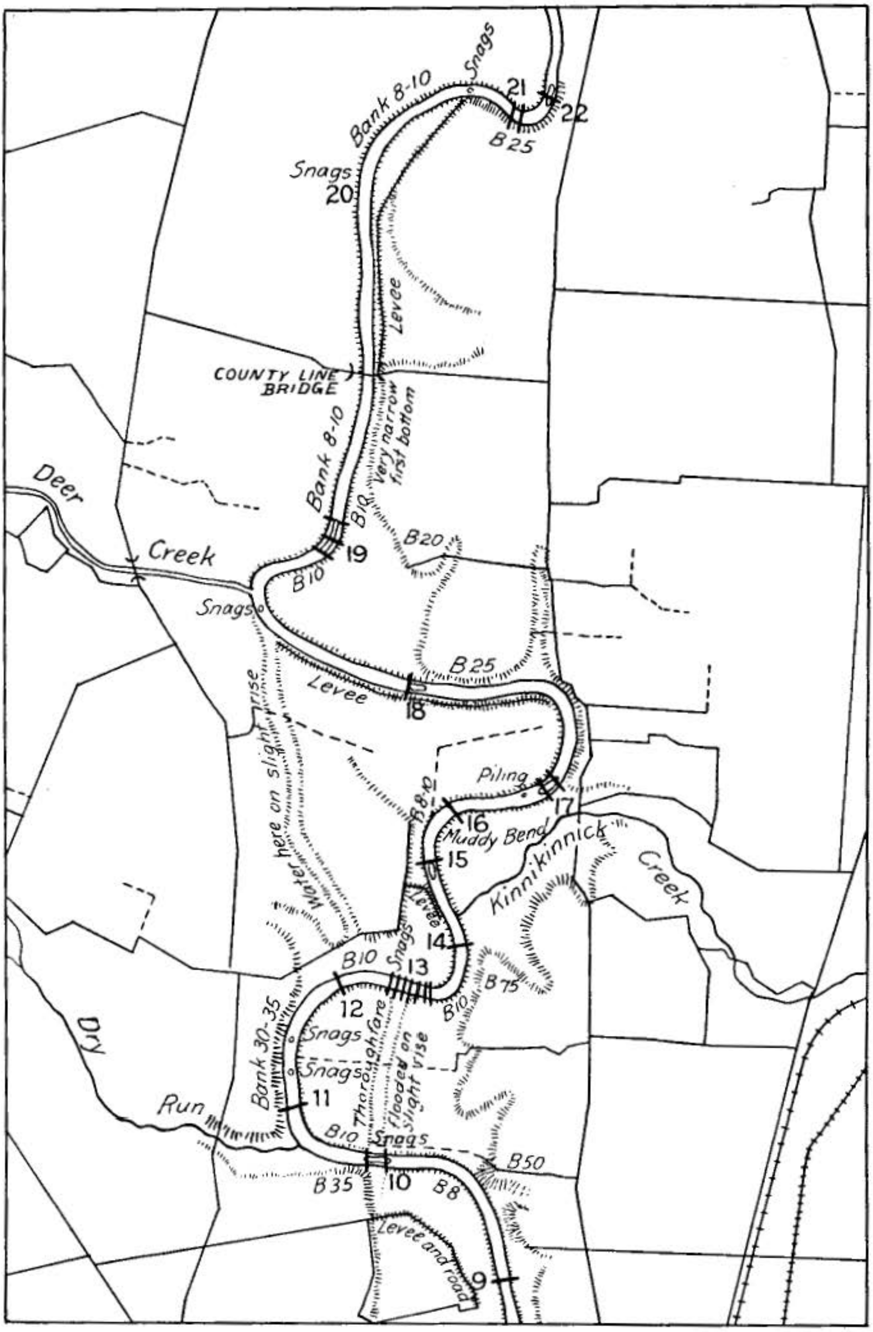


Fig. 9.—Detail of Scioto River and Valley. Northern part of Camp Sherman quadrangle. Scale, same as topographic map. Roads are indicated by a single solid line, lanes by a single dashed line; these have been put on only to aid in locating features, and are taken from the topographic map. Short heavy lines across the river denote riffles and the heavy numbers accompanying them refer to notes in the text. Bank 8-10 or B 8-10 indicates the height of the stream bank at very low water, or at about —1 foot of the Bridge Street Gage. Levees are indicated by a line with hachures on both sides.

Exceptionally, as in 1915, the normal summer condition may be omitted entirely. The average low water stage during that summer was in the neighborhood of 1.5 feet, and the 0 mark was closely approached during only a few days near the end of May and again at the end of June, when it fell to .1 of a foot. July, August, and September developed a succession of storm crests in number and height surpassing those of some winters, with a crest of 15.5 feet in mid-July, only .3 of a foot below the maximum for the year. This was succeeded by the autumnal type in mid-October at from 1 to 2 feet.

Autumn and early winter.—About the middle of October or early in November, a slight rise is commonly detected. The river rises to the 0 mark, or to 1 or 2 feet above it, where it hangs fairly steadily until the ground becomes well soaked throughout the headwaters. The storm crests which distinguish the winter-spring condition commonly begin rather abruptly late in December, or early in January. Rarely the entire autumn, as in 1911, is of the winter type, and again the winter type may not set in until late in January as in 1914. In 1912 and again in 1917, the river remained at or below low water until January 1st, typical summer stages having continued this late, with very little interruption.

ICE

For military ends, a river is a barrier proportionate to the difficulties that it opposes to crossing. In winter, as soon as it freezes hard enough that transportation may be accomplished over the ice, it ceases to be a barrier, in proportion as the obstacles opposed to crossing it have been nulled.

The deep, quiet stretches of the Scioto River always freeze over in winter. This is usually completed early in January and the ice commonly remains on until the middle of February. Very seldom does the ice form in December, and not once in 20 years does it form to the extent that it did in December of 1917. Occasionally there is no opportunity to cut ice until in February. It is a saying among the older men along the river that after the river first freezes over, an inch a night may be added until it reaches 8 inches; after that the increment is much less. However, 8 successive nights of freezing temperature are not often experienced. Among those who cut ice, if 8 inches is not attained, there is disappointment, and this thickness may be expected 6 years out of 9. Mr. J. I. Carson reports that in the ice gorge at Chillicothe in 1907, he measured blocks with a thickness of 2 feet. Sleighing on the river was a popular sport in past years, and before the bridges were built, the usual heavy loads of a farming community were hauled across the ice. In the exceptionally cold winter of 1903-4, 7 inches of ice was cut on the 15th of December and the canal remained closed because of ice conditions from November 25 to February 29, 97 days.

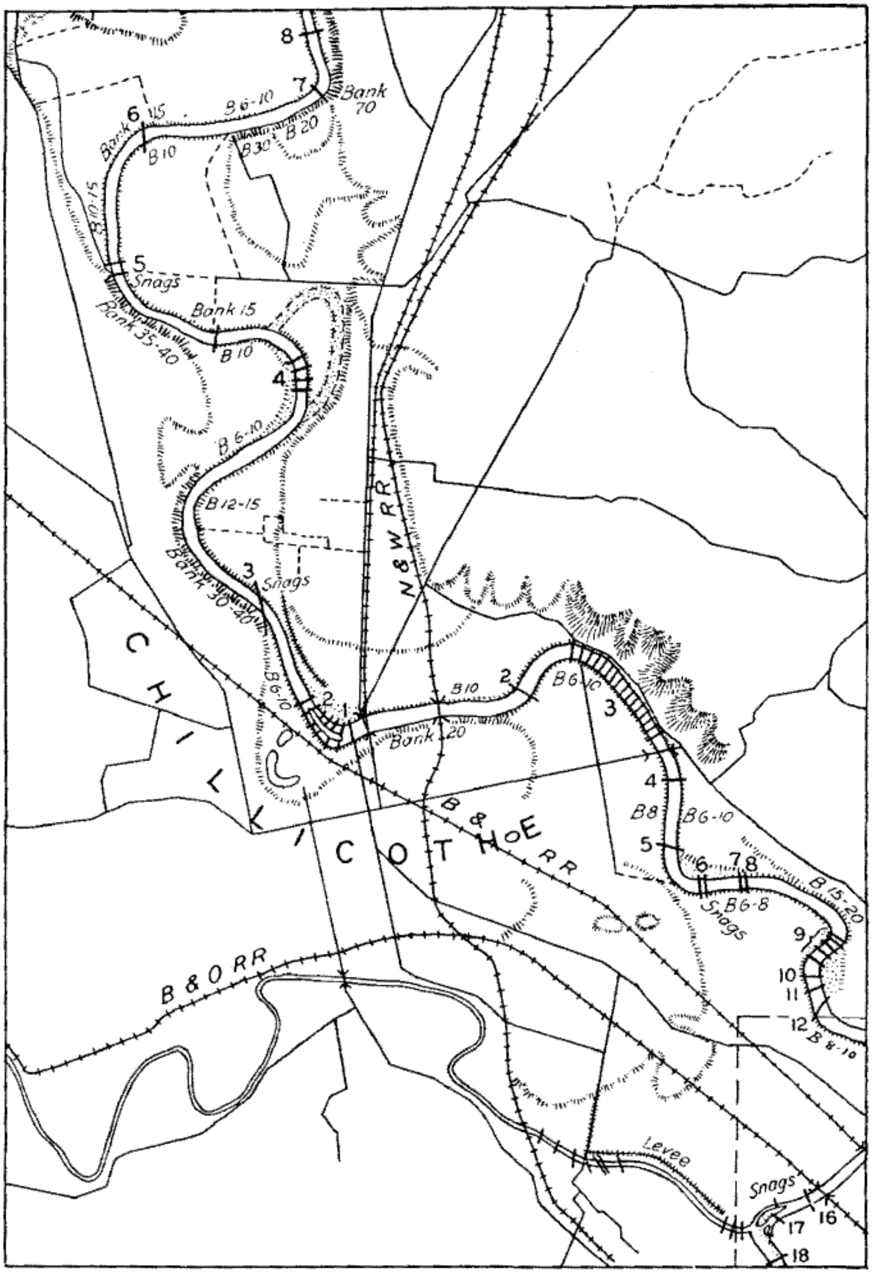


Fig. 10.—Detail of Scioto River and Valley; central portion of Camp Sherman quadrangle. Scale, symbols, etc., same as Fig. 9. North line adjoins south line of Fig. 9, p. 66. Dashed lines in southeast corner indicate overlap onto area of Fig. 11, p. 70.

The river is not so apt to freeze over the riffles, owing to the greater velocity, but some of those indicated on the map do freeze over and perhaps all, on occasion.

After the river has become frozen solidly over, (that is, over the quiet stretches), the ice may withstand considerable fluctuation in the river level without going out. If the water falls, it sags in; if the river rises, the excess may flow over the ice, covering it to a considerable depth and frequently running off without disturbing the ice, if it is firm and the anchorage does not become too much softened. If the ice is old and "rotten"from thawing, a rise is very apt to disrupt it from below, usually very abruptly, and an ice flood, with the possibilities of ice jams, is the result.

Ice may be expected to form and remain on the river only at the lower water stages of the river. Probably none will remain in the river at a 10-foot stage and certainly no thick ice will form at that or any higher stage, as the stage is not maintained long enough. Here again it is not possible to give precise data.

On Paint Creek, ice behavior is reported somewhat different, seldom remaining on the stream for any length of time; the reason for this, if true, is not known.

DETAILS OF THE CHANNEL

In the following account, riffles and notably shallow places that are easily distinguishable in the field are numbered consecutively from 1 upward in two series, one up the river from Chillicothe, the other down the river. The long riffle above the Bridge Street and Interurban bridges at Chillicothe is numbered 1. The account is to be regarded as a reconnaissance: the time and funds have not been available to make it more complete. All descriptions are at —1 foot of the Bridge Street gage. In every case, the length of a riffle or pool is in the direction of stream flow. The series extending up the river from Chillicothe is given first. (See map, Fig. 10, p. 68.)

1. Riffle, reported knee deep; gravel bottom, approach good on north by gravel bar but faced by 30-foot tree-covered bank on south, deepens rapidly in both directions.

Between 1 and 2 a short pool reported 6 feet deep.

2. Riffle, length of island, shallowest at its ends; gravel and cobble bottom; very good crossing at upper end, knee deep, gravel bar approach on east, 6-foot loamy tree-covered bank on west, not steep and can be quickly adapted; apparently deepens gradually up stream; below the upper end this riffle is crossed diagonally by two iron pipes, about 18 inches in diameter which make wagon crossing there impossible.

From 2 to 3 can be waded in few places but usually 6 feet or more along east bank, reported 10 feet in the Blue Hole, below No. 3. Bot-

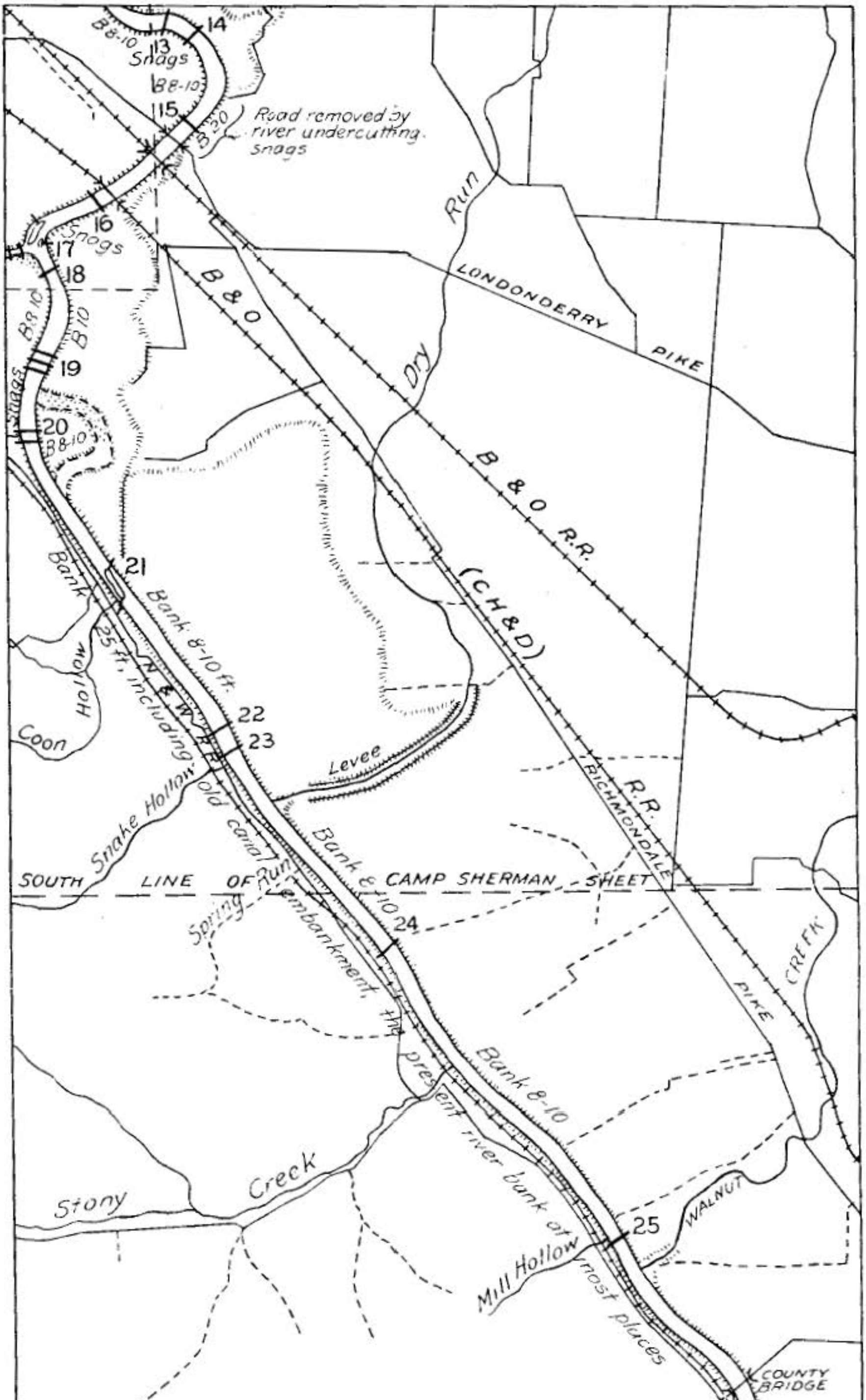


Fig. 11.—Detail of Scioto River and Valley: southern portion of Camp Sherman and northern portion of Waverly quadrangles. Scale, symbols, etc., same as Fig. 9, p. 66. Dashed lines in northwest corner indicate overlap onto Fig. 10, p. 68.

tom mostly sandy, muddy at the Blue Hole. West side shallow. Mostly levee on east side about 15 feet high, steep or caving, generally wooded.

3. "Shinbone"riffle, stands across stream at a high angle, and as a result is 300 yards across; the upstream end on the east side; very shallow, deepest at the north end where it is shin deep, a few logs and stumps but they would not impede crossing; sand and gravel; west end can be approached easily just below the south end of the 40-foot bank which faces the river along the lower end of the Camp. East approach difficult because of 6 to 8 foot steep bank, a narrow wooded bottom and a high levee. Deep water obtains along the front of the riffle between it and the east bank, waist deep 6 or 8 feet from east shore. This riffle owes its existence to the gravels that are being washed from the bare banks just above it.

For half a mile below 4 the water is shallow and can be waded at several places from knee to waist deep, gravel bottom. (See Plate 6 C.)

4. The Miller cut-off (topographic map) has become the river channel and the former channel is now largely filled and grown up to young willows. No. 4 is a long riffle with very moderate current, less than knee deep in places, with good gravel bar approaches but with 10-foot bank back of bar on east.

From 4 to 5, mostly shallow and can be waded, some of it not over knee deep, gravel bottom with bowlders in places, upper end with no approach from the Camp because of 35-foot bluffs. A few snags.

5. Riffle, at mouth of small tributary from machine gun range; 100 yards long; gravel; the lower part with numerous snags, upper 40 or 50 feet free of snags and nearly knee deep. Swift, would be risky with 18 inches more of water; water upstream deepening gradually. East approach by bar, good, west with caving 10 to 12-foot silt and gravel bank.

Between 5 and 6, little data. Lower half probably shallow, can be waded in places; channel on west side, east side with bars, bottom of gravel and cobble.

6. Riffle, sharply oblique from the west side. A large, gravel, island bar nearer the north bank, reached from the very steep 15-foot bank at the north side by a log flush with lowest water stage, but with 6 feet of water on the downstream side; in the main channel there is a riffle knee deep with gravel and cobble bottom, and with fairly swift current, but the water does not break across it; by using depths to the thigh, a crossing 40 feet wide can be distinguished. This crossing is impossible for wagons and of limited use for men because of the north approach.

Between 6 and 7, no data, all quiet water and apparently deep. The south bank is abrupt, 10 to 30 feet high, and the channel is undoubtedly on that side; the north bank is bordered by numerous gravel bars and a low, forested, badly washed bottom of 100 yards width, with an old stream channel in it.

7. Riffle about 75 feet long, stream narrow and swift, water knee deep at break, deepening fairly rapidly up stream, knee deep lower down in the swifter water; bottom rough with cobble and bowlders. Bar approach on northwest, with steep 7-foot bank and a narrow, washed, forested bottom back of it; on the southeast a steep, lightly-wooded, 20-foot bank; approaches impossible for wagons at present. This riffle should be used with care with 18 inches more of water.

Between 7 and 8 gravel bottom, channel on east side, where banks are high, but only for a few rods at south end as high as indicated on topographic map, as there is a narrow bottom; water quiet and probably deep.

8. Riffle, less than knee deep at the head and within 20 feet above it where current is light; on lower slope of riffle, thigh deep and current rapid; bottom with cobbles and small bowlders. Probably can be used without difficulty in 18 inches more of water by keeping above the current. Approaches now impossible for wagons because of 6 to 8 foot wooded banks.

Between 8 and 9, no data, quiet water. For following, see map, Fig. 9, p. 66.

9. The Infirmary Ford. For 100 feet less than knee deep and with low velocity; hard gravel bottom, some cobble. Although used as a ford for years, there is now no access on the west side except through corn fields. Approach on west can be used but bank is steep; on east reported good, with easy access to pike; has been used for heavy farm hauling, and automobiles have crossed it.

From No. 9 almost up to the fishing camp on the east side (the house mapped on east river bank at end of road on topographic map) is shallow, reported probably not over 3 or 4 feet, gravel and bowlder bottom. At the fishing camp, however, there is 8 feet. Above this at the sharp bend of the river from the westward, the river impinges directly on a 50-foot gravel bank, and there is an 8-foot channel near its base, with abruptly sloping sides. From this bend up to No. 10, the depth is reported from 2 to 5 feet, gravel bottom with bowlders and cobbles, banks 7 to 10 feet high.

10. Riffle due north of County Infirmary. An island with main channel on south and riffles at upper and lower ends. Lower one less than knee deep but very swift, probably not usable on an 18-inch rise; upper one knee deep but less swift. Bottom gravel and cobble. Approaches useless because of steep 10 to 12-foot banks. Snags in north channel, which, nevertheless, will be found the better for boats in moderate stages of the river.

From 10 to mouth of Dry Run, there is 15 feet of water with bowlders on bottom, channel on southwest side, but approach difficult because of steep 35-foot bank. From 10 feet at Dry Run the depth decreases upstream to 4 feet below No. 11, sandy bottom.

11. Riffle, less than knee deep, of moderate velocity, 100 feet long, approaches can be readily made.

From No. 11 upstream the depth is slight, from 2 to 4 feet, as far up as the lower end of the steep gravel bank just below the bend at No. 12. Numerous snags repose in this stretch, in the center and at the margin. The bottom is fine gravel and sand. At the gravel slide just mentioned at the north end of the 30-to 35-foot bank and due east of Andersonville, the channel is against the west wall and 8 feet deep, with gradually shoaling water on the east side. This deep-water channel extends for perhaps 100 yards above the north end of the 35-foot bank into the bend with a 12-foot bank on west and bar on east.

12. Riffle, moderate velocity, knee deep, gravel, bar approaches, with 10-foot wooded bank behind them. Water reported very shallow for 100 yards below riffle.

Between 12 and 13, channel on northwest bank, 6 to 8 feet deep, shoaling gently to southeast bank, sand and gravel bottom.

13. Riffle 200 yards long, island bar with snags, current not swift, but little if any over knee deep, gravel bottom, bar approaches with 10-foot wooded banks on north.

The stretch of river from 12 to the head of 13 is represented too long and too straight on the topographic map. This has been partially adjusted on the accompanying outline.

From 13 to 14, broad channel on east bank 2 to 5 feet, west bank shoaling to bar, deepening for 150 yards below 14 to 6 feet and with both banks bluff.

14. Riffle, less than knee deep, very moderate current, gravel bottom, banks bluff, 10 feet.

From 14 to mouth of Kinnikinnick Creek, channel toward east bank, about 5 feet.

15. One hundred yards above the mouth of Kinnikinnick Creek, a new channel has been formed to the southward, inclosing a small island. A long riffle at the head of this new channel, apparently about knee deep, of moderate velocity, with gravelly or stony bottom. Bank on south 8 feet, backed by a high levee, on north low.

Between 15 and the bend from the eastward, the depth is about 4 feet. In the curve, known as Muddy Bend from the character of the bottom, the depth is 10 feet, with 8-foot bank and rapidly deepening water on each side. The current is very sluggish here; a public road comes to within 150 yards of it on the west, with a lane in the interval; the opposite bank is only three-fourths of a mile from the River Pike on the east side; all in all, it appears to be a good site for a pontoon bridge.

16. Hauk ford; about knee deep, with rough, stony bottom; the best crossing is said to be from the lower end of the riffle on the west side to an island bar, and on the upper end of the riffle from the island

bar to the east bank. Water deepens gradually both up and down stream. Approaches may be quickly made.

From 16 to 17, deep water with 10 to 12 feet as maximum, channel on north shore.

17. Riffle, probably not over knee deep, deepens rapidly at lower end and gradually from upper end, gravel crossing, bar approaches, with 10-foot banks behind them.

One hundred and fifty yards above 17, in the bend, channel 6 to 12 feet deep on outside of bend, shoal on inside. The same depths hold, to 18, muddy bottom, north shore 30 feet, bluff, south shore steep 8-foot bank with high levee behind it.

18. Site of Ingham's dam. An island, water at upper end 3 feet, gravel bottom.

From 18 almost to the mouth of Deer Creek channel on outside, south bank 5 feet, sandy bottom. At the mouth of Deer Creek, deep water which probably cannot be waded and just below it is said to be 12 feet.

Above the mouth of Deer Creek the topographic map is in error in showing a stretch of river running from northeast to southwest. From Deer Creek northward and slightly northeastward, the river is so straight that the County Line bridge (one-half mile south of the County line), is visible. This has not been corrected on the accompanying outline as the exact character of the error is unknown.

From the mouth of Deer Creek to the County Line bridge is shallow and with gravel and stony bottom; by observation and reports most of it must be less than 2 feet. The banks, however, are 10 to 12 feet, steep and wooded.

19. An island 300 yards long midway of this stretch has a riffle at the head on the west and at the foot on the east, less than knee deep and of low velocity but with poor approaches.

From the County Line bridge to the bend at 20, is a quiet, deep stretch, one of the broadest on the river. There are steep banks and almost no bars on both sides, and the water is 6 to 10 feet deep. At the upper end, a 12-foot depth is reported. The upper end of this stretch is not clearly defined, near the lower end of a broad sweeping bend which is represented on the accompanying map in place of two short ones incorrectly shown on the topographic maps. (See Plate 6 D.)

From 20 to 21 shoals are reported and shown by the accumulations of snags, pools 6 feet deep, muddy bottom in places.

21 is a deep riffle, with eddy water, an old ford washed out and probably dangerous.

22. Riffle, seen from a distance only, midway of a long island.

From 21 to beyond the north line of the sheet, is reported 4 to 5 feet.

The following notes indicate the character of the Scioto River channel from Chillicothe southward to the wagon bridge $2\frac{1}{4}$ miles south of the mouth of Stony Creek, and 1 mile north of Higby. The lower $3\frac{1}{4}$ miles of this interval is on the Waverly topographic sheet. This series is numbered from riffle No. 1 of the series north of Chillicothe. (See map, Fig. 10, p. 68.)

From Bridge Street bridge eastward to No. 2, broad and quiet, reported deep.

2. Riffle, velocity very slight, not over 12 inches on northern three-fourths, hub-deep on southern part.

Between 2 and 3 there is a deep hole.

3. From head of bend to 150 yards above the Main Street bridge, all shallow, 2 to $2\frac{1}{2}$ feet in the deeper eastern part, but no riffle except lower end where it is less than 1 foot deep. One 5-foot hole above the last on east. Bottom sandy, gravelly, or bowldery, rock in places. A good ford at upper end with good approaches on east.

4. Riffle, knee deep, of moderate velocity, gravel. Approaches fair.

5. Riffle short, moderately rapid, knee deep, gravel and cobble, 8-foot bank on west.

Between 5 and 6, deep water in outside (west) of bend.

6. Riffle, 100 yards long, rapid and deep in upper part, lower end fairly rapid but apparently of moderate depth and usable; gravel and cobble; dangerous and liable to rapid shifting; numerous snags on south side.

7. Riffle, gentle velocity, less than knee deep, gravel, approaches bad, banks wooded, 8 to 10 feet.

8. Riffle, rapid, gravel, approaches bad.

Between 8 and 9 reported mostly less than 5 feet on east bank, west half very shallow, some holes over one's head.

9. A long riffle, not rapid but of unknown depth in upper end, probably but little over knee deep; lower end fairly swift and at least waist deep; gravel and cobble.

10. Riffle, moderately rapid, good crossing in low water, gravel, 10-foot bank behind bar on west, bar approaches with brushy, badly-washed bottom and tree-covered banks on east.

11. A deep riffle, depth not known, gravel.

12. Riffle, shallow, gravel.

13. Riffle, gravel, heavy accumulation of snags on south side, approaches bad. (See Plate 5 A, opp. p. 56. For following, see map, Fig. 11, p. 70.)

14. Riffle, to the knees on break, not swift in low water, gravel, east approach good, west with 10-foot, tree-covered bank.

Between 14 and 15, river is washing rapidly and the crossroad represented as connecting the Adelphi and Londonderry pikes has been cut away entirely. (See Plate 5 B.)

15. Riffle, estimated less than knee deep, current very moderate, gravel, many snags on southeast side, with 10-foot bank.

Between 15 and 16, at the C. H. & D. railroad bridge, is perhaps the greatest depth on the river, reported about 35 feet.

16. Riffle, no detail.

17. Above mouth of Paint Creek is a long island, with riffles; west channel with thickly scattered snags, and with riffle near head. Two channels east of it shallow with a few snags; gravel. The river is changing rapidly here.

18 and 19. Riffles, moderately swift, estimated knee deep, gravel, approaches by bars and 10-foot banks. (See Plate 5 C.)

Below 19 the river has abandoned the sharp bend to the east, and now flows directly to the mouth of Indian Creek at 20 and has occupied and enlarged the lower end of the creek channel. The upper half of the old channel is filled with gravel, the lower half is backwater.

20. Short gravel island bar, riffles at both ends, approaches by bar and 10-foot bank on west, many snags. (See Plate 5 D.)

From 17 to 20 the holes are short and mostly shallow.

From 20 to 21, broad quiet water, reported deep entire length, 15 feet for long distances, channel on west side; no bars on the east side; approaches impossible, bank on west rises very steeply 30 feet to the towpath of the canal, with the old canal trench partially water-filled in places just behind it, the whole overgrown with trees and brush; on east banks 8 to 10 feet, wooded.

21. Long, island bar obliquely across stream, full width of Coon Hollow, upper end connected with east bank, lower end with west by riffles half way to knees, gravel; approaches much as in last, on west side river bank and canal levee with narrow bottom between.

From 21 to 22, bars on west side, channel on east, mostly shallow, gravel.

22. A deep riffle, gravel.

Between 22 and 23, the remains of an old dam.

23. Riffle, knee deep, moderately swift, gravel. Approaches as above.

From 23 to mouth of Spring Run, just within the Chillicothe quadrangle, depth varies from 3 feet up to 15, around 6 feet mostly.

From Spring Run to 24, all shallow, waist deep on average, no holes.

24. Riffle, two-thirds mile north of Stony Creek, reported 18 inches deep, gravel, a good crossing but west approach bad because of 25-foot bank to canal towpath.

From 24 to Stony Creek, reported waist deep, exceptionally up to 6 feet.

From Stony Creek to 25, Mill Hollow, $\frac{1}{4}$ mile above mouth of Walnut Creek, deep water, 15 feet maximum, not less than 8, channel on west side, east side 4 feet close to bank; no bars.

25. Shallow water 3 feet or less reported here, shallow to Walnut Creek.

Walnut Creek to County bridge, 1 mile above Higby, all deep, 20 feet in places, approach on west bad because of 25-foot bank to towpath.

PART II

DETAILED DESCRIPTION OF SUBDIVISIONS

CHAPTER VI

LOWLAND OF THE NORTHWESTERN PART OF THE QUADRANGLE

This subdivision is roughly triangular and includes the entire northwest part of the Camp Sherman quadrangle. The north side extends from the valley of the Scioto west to the corner of the sheet, the west side extends southward along two-thirds of the western margin of the quadrangle. The southeastern side, or base of the triangle, is the irregular margin of the high hills of the Allegheny Plateau. The area is approximately 75 square miles. See Figure 3, p. 33, for the location of this subdivision.

TOPOGRAPHY

This subdivision is a part of the Interior Lowland. Because of the relatively low altitude of the whole it is made a single subdivision, but there is considerable difference in the topography of the parts. (See Plate 7.)

Throughout almost the whole subdivision the bedrock formations are buried beneath glacial deposits, and are not reached by even the deepest stream valleys. The topography takes its character almost wholly from these glacial deposits. In the southwestern corner, two high rock hills, together known as Ragged Ridge, project above this coating of drift, outliers from the high hills of the Allegheny Plateau to the southward.

The portion north of Deer Creek is a rather sharply rolling plain with only about 10 feet relief but with many shallow depressions and low knolls, at from 30 to 40 feet above the flood plains of that stream and of the Scioto River.

Between Deer Creek and North Fork of Paint Creek, occupying the northwest corner of the quadrangle, is a broad, rounded, circular hill, 5 miles across and 120 feet high. Except on the north, its sides slope gently and uniformly away either to Deer Creek, North Fork, or to a mile-wide, shallow valley which separates it from the high hills of the Allegheny Plateau to the southeast. The numerous small streams which drain it flow in broad shallow trenches mostly from 4 to 10 feet deep on the east and southeast, in much narrower trenches 20 to 30 feet deep on the slightly steeper southwest slopes.

Southwestward from North Fork of Paint Creek, the topography is much more diverse. The two rock hills of Ragged Ridge are by far the most prominent feature, rising 300 feet above the rolling lowlands which surround them and extend from them to the foot of the Allegheny Plateau. The rolling lowland surface is here 100 to 300 feet above North Fork, and is dissected by the steep-walled, narrow valleys of small streams to depths of 50 to 100 feet.

DRAINAGE AND STREAMS

Deer Creek.—Deer Creek flows across the northeast corner of the subdivision in a flood plain half a mile in width. It heads many miles to the northward and is one of the large tributaries to the Scioto. It is a succession of short pools and riffles with gravel bottom and at ordinary stages a crossing can be found at practically any place.

Owing to the size of its basin, its flood stages depend on general, not local rains; accordingly the rise and fall are usually gradual, and it may remain swollen for hours, or even several days, much like the Scioto. On the average, it may be counted on to overflow its bottoms, and the Columbus Pike south of the Deer Creek bridge, twice each year, usually in the late winter and early spring.

North Fork of Paint Creek.—Though not as large as Deer Creek, this stream also has a considerable basin in the lowlands northwest of the Camp Sherman quadrangle and its behavior is much like that of Deer Creek. The portion of its valley within this subdivision is a shallow trench, $\frac{1}{2}$ mile wide and about 100 feet deep, with gently sloping walls above Frankfort. Three miles below Frankfort, it is 350 feet deep, very narrow, and with steep-sided rock walls. North Fork is a succession of pools with slight, shallow riffles, on the whole sluggish at low water. Its banks are low and brushy; its bottom mud and gravel.

Deer Creek and North Fork flow from northwest to southeast. There are only three tributaries in the subdivision worthy of mention, and they lie in a line roughly at right angles to the two major streams. Waugh Run, flowing northeast to Deer Creek, and Oldtown Run, flowing southward to North Fork, lie in an open flat valley more than a mile in width which is not of their own making but is much as the glaciers left the surface. The former has entrenched itself slightly near Deer Creek.

Little Creek.—This stream enters North Fork from the southwest opposite the Oldtown-Waugh Valley. Although its basin, between Ragged Ridge and the Allegheny Plateau, is about 3 miles wide, the actual valley is a narrow, steep-walled trench 100 feet deep cut in the drift of the basin. Its valley in the lower end is more open.

Little Creek, owing to the circular character of its basin, is apt to receive a local storm over all of its headwater branches at one time instead of on one or two tributaries as is the case with elongate drainage

A.—View from north of Asher Hill westward across a small embayment in the Allegheny Plateau. The distant hill is Berea-capped shale, the northern margin of the plateau. The gentle slope up to the foot of this hill is glacial till, into which streams have cut sharp ravines 100 feet deep without exposing bed rock. One of them is marked by the line of trees in the mid-distance. The deepest military excavations would probably be free of water because of the depth of stream dissection.

B.—View from the top of Ragged Ridge eastward across the Northwestern Lowland to the Allegheny Plateau of Berea-capped shale. The Lowland is wholly of unconsolidated glacial drift. This shows the same relationship on a large scale seen in Fig. A above, but the valleys are larger and shallower and the conditions much more diverse. North Fork of Paint Creek flows from the Lowland into the plateau through the postglacial gorge at Musselman, the notch in the center of the sky-line.

C.—Morainic topography around Lattaville. View southward to McDonald Hill, which is the margin of the Allegheny Plateau. Drift probably 150 feet deep.

THE LOWLANDS IN THE NORTHWESTERN PART OF THE QUADRANGLE systems. Owing to the steep clay slopes, which occur on all of its tributaries, the percentage of run-off is high. As a result of these features, it is subject to unusual floods. The stream is liable to rise and fall with remarkable rapidity. From a small brook, ankle-deep, it has, in the time that it takes to drive the cows from a pasture, risen until it was too dangerous to attempt a crossing. The channel is wide and shallow, in response to such floods, with fine gravel bottom, in very few places stony.

The larger tributaries to Little Creek from the southward have channels with perpendicular walls 5 to 8 feet high cut in the till bottoms, with usually a coating of gravel or small cobbles over them, and commonly much brush on the banks.

GEOLOGY

Bed rocks

Along the northeast side of North Fork, for a mile below Austin, the valley wall is composed of Ohio shale, with little or no covering.

Southward from this, the two high hills of Ragged Ridge are composed of Ohio and Bedford shales, the more southerly with a small area of Berea Grit forming its flat top. The Ohio shale forms or underlies the lowlands at shallow depths for 1 to 2 miles east of these hills. All of these outcrops together constitute the remnants of a north-south rock ridge that is partially obscured by drift and has been cut across by North Fork and Little Creek.

Glacial drift

The remainder of the subdivision is composed of thick accumulations of glacial material which entirely cover the bed rocks. In the valley of North Fork at Frankfort which is a relatively low point on the surface of these deposits, the drift filling is 80 feet deep in the water works well. At no other place is its depth known. In the southern end of the subdivision, streams in places have cut 100 feet into the filling without encountering bed rock.

North of Deer Creek the drift consists of gravels, in places coarse. The topography is similar in kind to the large area of kame moraines east of the Scioto though the depressions and hillocks are much less prominent. This formation extends as far south as Andersonville in the Scioto Valley, where it wedges out. South of Deer Creek similar gravels are present but the southern limit, if indeed there is a distinct boundary, was not distinguished in the time available.

Within a short distance south of Deer Creek begins the long, very gentle north slope of the broadly-rounded hill that occupies almost the whole space between Deer Creek and North Fork. It is composed of till, but the gullies which dissect it are so shallow that there are no good exposures. The broad valley at its eastern foot, occupied by Oldtown Run and Waugh Run, is floored with the dark, thick soils of obstructed drainage, but the tills are doubtless continued thereunder and pass into those on the slopes of the rock hills to the southeast.

The district south of North Fork is largely made up of the same bowlder clays, but there are numerous kames, abrupt, steep-sided hills composed of well-assorted gravels. These rest on the bowlder clay, and in places make up fair-sized groups of hills, as in the embayment in the rock hills around Lattaville (Plate 7 C). In places, though the kame topography is not present, pockets of gravel fill depressions in the till.

A series of gravel stream-terraces from 5 to 20 feet high borders North Fork of Paint Creek. These gravels in a few places are cemented into a porous conglomerate.

WATER

Streams.—In addition to the streams mentioned above under drainage, there are numerous small streams that are almost or quite permanent the year round. Many of these are so indicated on the map, though the permanence of all cannot be vouched for. Many of the very small streamlets which drain the gentle slopes of the broad, gently-rounded hill in the northwest corner of the subdivision, carry water in pools the season through, if they do not maintain an actual flow.

Ground water.—In the area between Deer Creek and North Fork of Paint Creek, the ground water at almost all places occurs at shallow depths. Where this very gently rolling surface is entrenched by streams to a depth of 20 to 30 feet, as on Hay and the lower end of Waugh Runs and on the northeast wall of North Fork above Austin, ground water is encountered at about 25 to 30 feet; but over much the greater part of this broad divide, water usually stands in the wells at less than 12 to 15 feet below the surface and very commonly at less than 10 feet below. In the shallow gullies of the numerous streams which drain it, permanent water may commonly be obtained by setting a large tile into the ground. These conditions also obtain on the drift slopes at the foot of the Allegheny Plateau along the Westfall Road, and in the undissected portion of the Oldtown-Waugh Run Valley.

Wells on the first terrace above the flood plains around Frankfort and Roxabell secure water at 10 feet. Southeastward and southwestward this same slight depth prevails to the broken ground of the moraine which fills Little Creek basin. Wells bordering Little Creek obtain water within a few feet, practically at creek level.

Beneath the drift hills which border Little Creek, the depth of water as far as it has been determined, is variable, and in places unex-

A.—The slightly rolling flat Berea tableland northwest of Camp Sherman, looking northward from one-half mile west of View. Though underlain throughout by Berea Grit, and owing its flatness to that formation, the covering of pebbly glacial clay is probably sufficient here to permit almost the deepest excavations, but they will be found wet.

B.—Margin of the flat Berea tableland northwest of Camp Sherman, partially dissected by steep-walled stream valleys. The Berea Grit forms the brow of the hill at all places and to expect men to intrench there hurriedly, unequipped for rock excavation, would be fatal. The slopes rising gently to the right are of clay, of sufficient thickness to permit ordinary intrenchments to be rapidly made, but the deeper bomb-proofs would encounter the tough Berea and water on top of it. View southward from one mile north of Briggs School.

HILLS WEST AND NORTHWEST OF CAMP SHERMAN. THE UPLANDS pectedly so. In accordance with the depth of dissection, it is commonly encountered at about 25 feet; but occasionally on high ground, or slopes with very little higher land behind them, abundant flows are met at depths of 8 feet, in winter and spring at considerably less depths. These last occurrences are usually associated with the sands and gravels of kames which catch and retain a very high proportion of the water falling on them and feed it out slowly above their till bases. A few good springs occur around the lower slopes of the rock hills of Ragged Ridge, where the drift rests on the Ohio shale.

CONDITIONS AFFECTING EXCAVATIONS

Excavation on the rock hills of Ragged Ridge will encounter essentially the conditions that accompany the same formations to the southeastward. Probably the small Berea cap on the hill south of Bethel School does not hold water on the hilltop as it does in larger areas.

North of Deer Creek, excavation will be in loose gravels. No data are at hand on the water conditions. From Deer Creek southward to North Fork chiefly clays, probably tough and with bowlders, will be encountered. Moreover, in the latter area, the shallow depth to ground water makes it certain that the deeper excavations would be very wet even in summer, perhaps impossible because of water. Practically all of the cultivated portions of this area are tiled and the ground is not as wet in spring as formerly; the name Egypt is reported to survive from a time when the wetness of the ground seemed to require memorialization in a distinctive name. Yet even now, in places, post holes have water in them in spring due to the normal condition of the ground and not to immediate rains. Should the tiling be extensively broken in the course of excavations such as military occupation requires, there can be no doubt that in a single season, the affected area would revert to the conditions that obtained before drainage was introduced.

South of North Fork of Paint Creek, the flat lowland terraces lying slightly above North Fork and Little Creek are chiefly gravel, but in places till lies closely below the gravels. These extend for a mile south of Roxabell. Excavation would be almost wholly in gravels. In the lowlands excavations would certainly be wet the year through.

The low hills bordering this lowland on the south are also chiefly gravel, but where the land rises farther to the southward, southwestward, and westward, it is in large part tough bowlder clay. Numerous gravel hills rest on it around Lattaville, but west of Little Creek and the Porter Hollow Road, these are practically absent and the till is commonly 100 feet or more deep. (See Plate 7 A.) Probably, except in a few small places, water would offer no obstacle to the excavation and maintenance of trench systems in these hills, because the streams are deeply enough entrenched to draw it well down below the level of most of such excavations.

ROCK MATERIALS FOR CONSTRUCTION

Stone.—There is no stone in this subdivision except the small area of Berea Grit on one of the hills of Ragged Ridge. No outcrop of it was seen and it is doubtful whether it exists in thickness satisfactory for quarrying.

Gravel.—The gravels north of Deer Creek appear to be of good quality. Only a few small, old openings were examined, but the material appears to be unusually low in fragments of shale, and probably satisfactory for concrete. Otherwise they are chiefly of limestone pebbles with practically none of sandstone. These localities are along the road approaching the County Line bridge over the Scioto and on the Williamsburg Road one-third mile west of the Columbus Pike. The creek gravels of Deer Creek below Waugh Run are too high in shale fragments for good concrete. They have not been examined above Waugh Run, where there is good reason to believe they would be much better.

Between Deer Creek and North Fork of Paint Creek no gravels were observed except very small outcrops within a mile south of Deer Creek, and over most of this portion they are undoubtedly not present.

The terrace gravels along North Fork and the kame gravels which make up numerous sharp knolls from Roxabell south to beyond Lattaville are almost without exception too high in shale fragments for good concrete. As elsewhere, they are limestone gravels and the percentage of sandstone is negligible. These gravels are excellent for road dressing, and would, with care in selection, make a concrete that would probably be satisfactory for small or temporary structures, but not for a permanent first-grade concrete. Washing would undoubtedly improve them. The occurrences of gravel are indicated on the accompanying geological map.

The single exception, in the matter of shale content, which was observed, is in the undercut bank of Little Creek $1\frac{1}{4}$ miles east-southeast of Roxabell, in the irregular hill at 800 feet. The upper 15 feet of a 25 foot bank is here composed of clean limestone gravels with few pebbles exceeding 2 inches, and very low in small shale fragments. It is underlain by 10 feet of bowlder clay with interbedded gravels. This gravel is one of the few promising concrete gravels which have been seen in the Camp Sherman quadrangle, but the outcrop is a short one and the amount of shale-free gravel is unknown.

The creek gravels of North Fork and Little Creek are very high in shale.

FOREST CONDITIONS

Northeast of North Fork of Paint Creek on the great, broad till knoll, there are several widely scattered rectangular patches of forest, almost all less than 60 acres, and the largest about 160 acres. These show no control of their distribution by topography. All are hardwood, but the timber conditions were not determined.

South of North Fork the forested tracts are irregular and coincident with the steep slopes either of Ragged Ridge or of the steep-walled stream trenches which are cut into the rolling till plain. They offer no suitable shelter for encampments because of the topography. The forests are all hardwood, mostly with much undergrowth and no timber.

TRANSPORTATION

Five of the main roads which traverse this subdivision are radial from Chillicothe, from the Williamsport Road on the north to the Greenfield Road at the south. Superposed on these is a second set which radiate in all directions from Frankfort, which in pioneer days, as one of several "Old towns" was relatively much more important than at present. As the hills to the eastward have not been an obstacle to travel and have not tended to divert it around them to the northward, roads have been developed about equally in all directions. Those indicated as metaled on the Camp Sherman map are all, so far as known, good roads, but only a single one is wide enough for two columns or trains, the Washington Road.

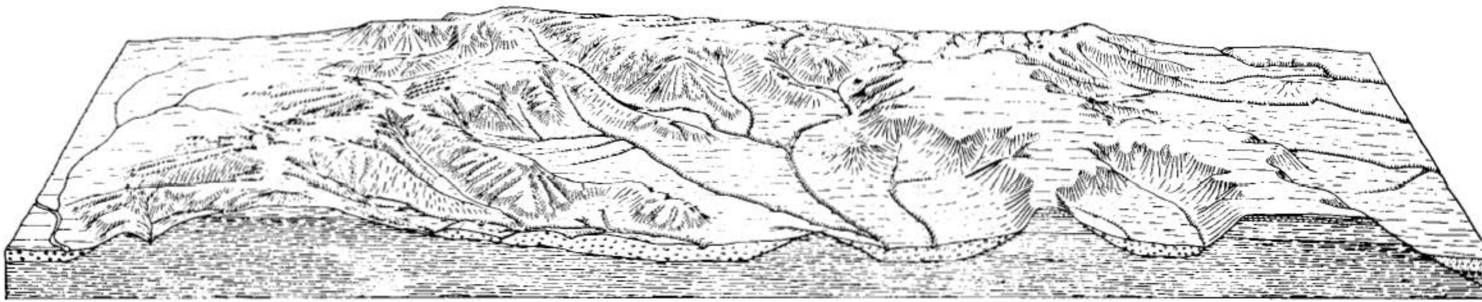


Fig. 12.—Block diagram of the topography of a portion of the "hills west and northwest of Camp Sherman", with a cross-section showing underlying geology. Portions of bordering large subdivisions are shown at either side. The location of the area is indicated on Fig. 3, page 33. It is 8½ miles wide by 3 deep. The vertical exaggeration is about 5 times. The base of the block is at 450 feet A. T. The geological formations in the foreground section are, bed rocks, from the bottom upward, Ohio shale, Bedford shale, Berea grit; mantle rock, river terrace gravel on right, till of ground moraine in center and left.

CHAPTER VII

HILLS WEST AND NORTHWEST OF CAMP SHERMAN

This area is shaped like a huge goblet with half of its base broken away; it is outlined on the east and northeast by Deer Creek and the Scioto Valley, on the southwest by North Fork of Paint Creek; its rim on the northwest is formed by the Westfall Road from Frankfort through Greenland to Deer Creek; it is drawn out into a thick stem southwest of the Camp and Chillicothe, and terminates in a broken base on Paint Creek. From the base northwest to the brim is 11 miles; the area is about 58 square miles. It is the region of considerable relief that is most accessible from Camp Sherman. See Fig. 3, p. 33, for the location and boundary of this subdivision.

TOPOGRAPHY

Hills.—The broken base and the stem to where it swells out northwestward to form the bowl, that is, the portion adjacent to Chillicothe and the Camp, consists of flat or very gently rolling upland plateaus or flat-topped, irregular ridges from which the bordering slopes descend abruptly 100 to 200 feet, precipitously in the upper 100 feet or more, gently in the lower slopes. These plateaus are partially dissected or cut up by the short, broad, open valleys of small streams which are tributary to the main streams outlining the goblet. (See Plate 8.)

The bowl is an irregular continuous ridge extending from northeast to southwest just below the rim, much cut up by broad, short, open valleys. It is not flat-topped, but composed of rolling hills in which occasional rounded traces of the flat tops are seen.

The hills are lowest in the remnant of the base, southwest of Chillicothe, scarcely 880 feet, and rise northwestward along the stem to 920 feet at the base of the bowl and to 980 or 1,000 feet in the northeast-southwest ridge just below the brim, from where they fall gently but directly to the Interior Plain.

Drainage lines.—The range of hills which forms the upper part of the bowl throws no large streams to the northwestward, but it sheds Dry Run with numerous tributaries to the east side and Mad, Biers, and Anderson runs and Sulphur Lick to the south side, the first issuing on the one side and the rest on the other side of the bowl above its base. The larger of these flow in open shallow valleys a mile in width, with broadly rolling floors, into which the streams have sunk trenches usually 10 to 20 feet deep and a few yards wide; these trenches are without exception too narrow to be farmed much, yet ample to carry all flood waters;

the banks are of bowlder clay, muddy if wet, and in places the bottom is of mud. The valleys of Biers and Anderson runs and of Sulphur Lick are peculiar in that they are notably steeper on the northeast wall. Only small streamlets drain from the flat-topped plateaus which form the base of the bowl and the stem.

GEOLOGY

Bed rock formations

Three bed rock formations are exposed over most of the subdivision. In the extreme southeast, on the hills just southwest of Chillicothe, two younger ones are present over about 1 square mile.

Ohio shale.—This is a tough, black, resistant shale, locally commonly called slate. It forms the lower slopes of the hills at all places in the subdivision; but, as the rocks dip to the southeast, it forms only about 60 feet of the lower slopes around Chillicothe, and as much as 250 feet or more of the lower slopes in the northwestern part of the subdivision.

Bedford shale.—This rests on the Ohio shale and consists of soft, gray, clay shales that weather easily to clay muds. Numerous thin sandstones occur in the middle and upper portions. It is 85 to 90 feet in thickness.

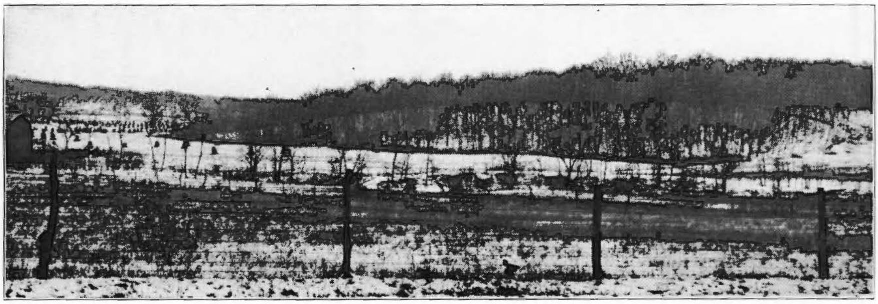
Berea Grit.—This is a hard, resistant sandstone formation about 25 feet thick. In the lower half the sandstones are in beds up to 1 or 2 feet thick with thin shale partings, but in the upper 10 or 12 feet the sandstone is continuous with numerous bedding planes. Its color is a light gray, but this changes rapidly to a characterless brown on weathering.

Sunbury shale and Cuyahoga shale.—On the first hill southwest of Chillicothe these higher formations are present, the first a thin, tough, black shale resting on the Berea and above it the soft gray clay shales of the Cuyahoga.

Dependence of topography on formations.—The character of the topography and geology are shown in the accompanying block diagram which represents an east-west section entirely across this district, from near Frankfort to the north end of Camp Sherman. The section is 8½ miles long by 3 miles wide. The topography, as is usually the case, is largely influenced by the character of the rocks. In case of military occupation of this region over a considerable period of time, requiring entrenchment, underlying geological conditions should be taken into account.

The most prominent feature in the topography is the flat uplands on the hills adjacent to the Camp, and the steep slopes which fall away from their edges (Plate 8). These uplands are due to the resistance

A.—View northwest across head of Mad Run; Bowdle School is in distant gap on left. The distant hills are gently rounded shale slopes, mantled with a few feet of glacial till on the lower parts. The broad rolling valley floor is of tough bowlder clay or till, too thick to be penetrated by the deepest excavations, but carrying abundant water at shallow depths.



B.—View southwest across the head of Bier's Run at B. M. 853. Conditions as in the view above, and showing one of the typical, deep, narrow, steep-walled, brush-covered stream channels which trench the floor, the streams of which never overflow their banks.

C.—View southwest across Anderson Run at altitude 755. The near foreground and distant ridge top are bed rock, but the intervening slopes are tough till. Typical of valleys standing across the direction of ice-flow, in that the till filling on the south side of the valley is greater in volume and makes a gentler slope than that of the north side.

HILLS WEST AND NORTHWEST OF CAMP SHERMAN. TYPICAL TILL-FILLED VALLEYS. SEE PLATE 3A FOR CHARACTER OF TILL.

of the Berea Grit, which overlies and protects the soft Bedford shales which form the steep slopes. The Berea does not lie flat, but like the other formations, dips gently to the southeastward; because of this the flat uplands are lower to the southeast and higher to the northwest. In the northwestern part of the area, where the hills are highest, the Berea has been almost entirely removed by erosion, hence the rounded, rolling character of the hills and the more numerous shallow ravines cut in the unprotected, soft, underlying Bedford shales.

Mantle rock

Glacial till.—The area has been glaciated and the broad, open valleys of Dry Run, Mad Run, Biers Run, Anderson Run, and the valley followed by the B. & O. R. R. northwest of the hospital group of Camp Sherman, all owe their present character largely to till or bowlder clay dropped or plastered in them by the ice. Originally the valleys were cut by streams to a greater depth than the present, and probably the almost stagnant glacial ice (the outermost edge lay only 4 or 5 miles to the southward) did nothing toward widening or reshaping them, except to partially fill them. The material is a tough bowlder clay or till with numerous pebbles and small bowlders. Along the lower part of Anderson Run there are cliffs of this bowlder clay some 30 feet high, but these are much the most prominent of their kind in the quadrangle. The depth of this valley filling is not known, but wells have penetrated to 500 feet A. T. without encountering rock in the valley south of the Briggs School, which indicates over 200 feet of till filling. (See Plate 10 A.)

The divides between the streams just mentioned project southeastward from the main ridge which forms the top of the cup. The southward movement of the ice across these ridges was such that it plastered great quantities of the bowlder clay on the northeast slopes but left many southwest slopes nearly free of it. As a result, between Mad, Biers, and Anderson runs and Sulphur Lick, the northeast slopes of the divides are longer and much gentler and composed of till, whereas the southwest slopes are steep, short, shale slopes, as shown on Plate 9 C, opp. p. 88.

The northwest hill slope which forms the rim of the cup, from Frankfort northeast to Deer Creek, is also largely composed of bowlder clay which almost entirely conceals the shales throughout the lower and middle slopes. The shale slope near the hilltops is notably steeper than that of the drift-covered lower slopes. The thickness of the drift cover is not known, but there are numerous gullies cut in it to a depth of 50 feet which do not expose the underlying Ohio shale. A few ravines which do cut to it show that the average thickness probably does not greatly exceed this. The upper limit of this thick drift coat in general is about at the 900-foot contour.

A considerable thickness of mantle rock covers the flat Berea uplands adjoining Camp Sherman. The thickness of this coat must be as great as 30 feet in the higher portions. Most of this is bowlder clay, but in places the mantle rock is residual clay from the shales above the Berea Grit. (See Plate 8 A, opp. p. 80.)

Terrace gravels.—A small 20-foot terrace borders North Fork of Paint Creek at Anderson. A very small deposit of sand and fine gravel rests on the till in Anderson Run Valley north of Maple Grove; it is probably of similar origin. At Musselman in the gorge of North Fork of Paint Creek, there is a very narrow terrace of sands and gravels resting on till with its upper limit 200 feet above the stream. The eastern margin of the subdivision is bounded by the extensive terraces of the Scioto Valley subdivision, to which the reader is referred.

WATER

Streams.—All of the streams which drain the subdivision appear to be permanent in their upper and middle courses. Both Biers Run and Anderson Run sink entirely into the sands and gravels of their lower courses, the former south of the Washington Pike and the latter for half a mile or more above its outlet.

Ground water.—Three important conditions affect the distribution and behavior of ground water, each operative in its own area, the last two, as outlined below, closely related. The mineral springs of Sulphur Lick (on the divide between Sulphur Lick and Anderson Run) although interesting, are unimportant in a military way.

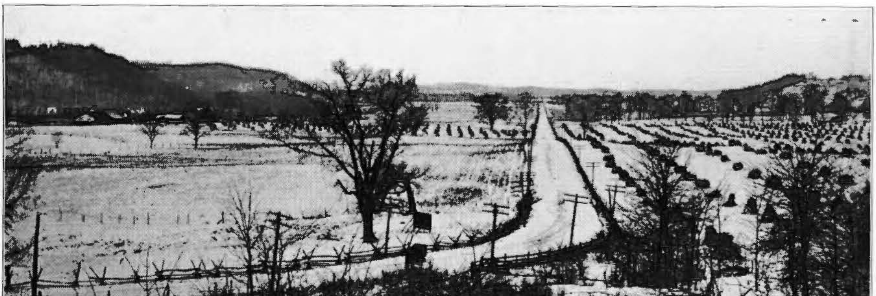
Berea uplands

The flat-topped Berea tablelands, extending from Chillicothe northwestward to 1 mile beyond View, are rimmed about, where the flat top changes to the steep side slopes, by a line of seeps and springs. These commonly occur from 5 to 10 feet below the level of the upland plain, and at intervals of rods or a mile along its edge. These springs frequently emerge from the joints in the sandstones of the Berea Grit from 2 to 10 feet below its highest outcrop, but occasionally they come out from on top of the sandstone. Practically every gully head has a spring that, if cleaned, would supply water except in the driest part of the year. Many of these springs flow persistently through the driest seasons, though the volume may be reduced to a falling column the size of a lead pencil, or even to a drop-by-drop trickle. Although never large and not forming bogs in any sense, occasional seeps are large enough that a calf may lose its life in them.

Wells dug along the margins of these tablelands yield abundant water at 8 to 20 feet, the water standing at 5 to 10 feet below the surface.

A.—View southwest across abandoned, drift-filled valley south of Briggs School and west of Camp Sherman. The foreground slope and distant hill are of Berea-capped bed rock, but the intervening valley is of till, at least 200 feet deep, gently rolling except where streams have cut steep-walled, shallow gullies, as in the middle distance.

B.—Kettle-hole in the drift filling of the valley shown above. Depressions of such depth are unusual in the Camp Sherman region.



C.—View northwest up North Fork Valley, from angle of pike west of Chillicothe and one-fourth mile southeast of elevation 677. This is near the one-time margin of the ice sheet, and the Berea-capped walls of the valley are more prominent and steeper than in the valleys to the northward, shown in A above, and in Plate IX. The gently rolling surface of the gravel drift filling, shown on right and in foreground, gives way on the extreme left and in the distance to the flood plain of North Fork.

HILLS WEST AND NORTHWEST OF CAMP SHERMAN. TILL-FILLED VALLEYS

In the interior of the plateau water doubtless occurs at the same or lesser depths.

It appears that a large percentage of the water falling on the flat tablelands, due to poor slope, soaks into the mantle rock. But it encounters the Berea within a few feet and is stopped from further descent by its thin shale beds. It then slowly follows the joint planes of the partially weathered Berea outward to the outcrop. There is considerable evidence that much of it follows the surface of the Berea and that most of the volume of water lies immediately above the Berea. Apparently there is no body of water in the Berea, except in the joint planes and loose,weathered portions; the sandstone seems to be too fine grained or too closely cemented to permit water to enter in any quantity.

The exact character of the water has not been determined, but as a rule, it is hard. Rarely a soft water spring is encountered. The springs at the Berea outcrop are a splendid source of stock water entirely around all of these flat-topped uplands.

The drift filling of the out-flowing valleys

A very large volume of water is stored within a few feet below the surface of the small, broad, open valleys within the subdivision. This is apparently held largely in the bowlder clay and in part by gravel beds in and below the clay. Water is commonly met with from 6 to 15 feet below the surface, or at about the level of the streams.

Springs are present in places low in the banks or in the bed of the streams where they exceptionally give rise to boggy places capable of engulfing a horse. In most places the water is reached by wells.

Drift slope on the northwest margin

On most parts of this slope, except where it is deeply dissected, wells encounter water at 10 or 12 feet below the surface, even near its upper margin. Seeps occur in the bottoms of gullies only 10 feet deep, and flowing springs are not uncommon in the deeper ravines. The slope is given over almost entirely to stock raising, for which there is abundant water. Where the Ohio shale outcrops there is a noticeable lack of water, and it is evident that the bowlder clay is the main reservoir.

CONDITIONS AFFECTING EXCAVATIONS

The Berea Grit uplands.—Prolonged military occupation of the flat-topped uplands in the eastern part of this area, those next to Camp Sherman, would be affected chiefly by the difficulty of entrenching around the margin of these plateaus, 1st, because of the nearness to the surface of the hard Berea sandstone, and, 2nd, because of water in the trenches.

Excavation

Anyone following the margin of these plateaus will find the Berea Grit outcropping in the heads of ravines and gullies at or immediately below the "break" of the hill, that is, where the flat upland bends abruptly into the steep hill slopes. It is not shown at any place on the uplands where it is beneath a covering mostly of glacial clays which varies in thickness from 2 to perhaps 10 feet at the margin, but is thicker over the center of the plateaus where it attains a maximum of perhaps 30 feet.

In the inner portions of these plateaus, where the covering over the Berea is thicker, it is probable that trenching operations, excepting the deeper bomb-proofs, could be carried on at most places without encountering the Berea. But near the margins where trenches would be most desired, the covering is shallow, so shallow that it is sometimes impossible to set tiling as deeply as is desired for even 100 yards back from the edge, so shallow that difficulty is often encountered in setting fence posts. Though the depth to the Berea varies from place to place, it is certain that any attempt to dig trenches along the brow of the hill would encounter the Berea at most places and in some within a few inches of the surface. Its resistance is such that blasting would be necessary to remove it with any rapidity. The most abrupt change in slope almost always occurs at the level of the highest Berea ledge. Back from this change in slope, the upland rises in a gently convex profile, almost without exception 6 to 10 feet or more. As a rule, this slope is at the rate of about 6 feet in 50, sometimes steeper, sometimes less. This does not necessarily mean 6 feet of clear digging at a distance of 50 feet back from the brow, as in many places, higher beds of Berea are apt to come in.

In a few places, the profile above the abrupt change in slope is much flatter and very gently concave. In such cases the Berea may be expected at a shallow depth well back from the brow.

As a rule, the covering over the Berea is thicker on the southernmost of the plateaus of this subdivision, and thinner at their northern end. As a corollary rule, the slopes above the top of the Berea are somewhat steeper at the southward than at the northward. In practice one familiar with the general behavior should, after some inspection of a locality, be able to indicate fairly closely the altitude of the Berea thereabouts and the conditions affecting excavations. The distribution of the Berea is shown on the accompanying geological map of the Camp Sherman quadrangle.

In mining operations, excavation will be greatly facilitated by tunneling immediately below one of the thin sandstones near the middle of the Bedford; while probably inadequate to serve even temporarily as a roof, there will be far less danger of caving than if the roof be the soft, clay-shale beds that make the bulk of this formation. The upper part of the Bedford is apt to carry so many sandstones that the excavation would be difficult, but it is much the better level, from considerations of safety of the excavators.

Water

Mention has already been made, under the heading of ground water, of the line of seeps and springs that borders the flat-topped Berea uplands at their very edge. These are the outlets for a large body of water retained in the clayey cover over the Berea, and in the weathered, upper part of the Berea itself. In winter and particularly in spring, the outcrop of the highest beds of the Berea is an almost continuous zone of seepage, and any system of trenches cut around the margins of these plateaus, nearly or quite reaching the Berea, as would be necessary, would tap this water zone and would be constantly wet. Much of the farm land of the plateau has been tiled to permit cultivation and that which has not been tiled is very wet in spring.

This body of water is partially drained away during the late spring and summer months, but numerous springs, at intervals of a few rods or hundreds of yards, continue to flow with diminished volume, and the shallow wells a few feet back from the margin, though lowered, do not fail. This means that even in the driest months, portions of the trenches cut to or into the Berea will be wet. This will be particularly true of those portions near ravine or gully heads. It is very probable, however, that a system of trenches would in summer rapidly drain the immediate portion of the water body so that any further inflow could be readily taken care of and would interfere with the water supply in neighboring wells.

The shale hills.—The Berea has been removed from almost all of the rolling hills of the northern and northwestern portion of the subdivision, and none of the difficulties due to it will be encountered. On the other hand, the construction of trenches on the upper hill slopes in the soft clays of the Bedford formation presents an entirely new problem. When wet they are sticky and soft and would soon cave in. Though permanent water on these hill slopes in places stands unexpectedly close to the surface, within 6 feet, on the whole it appears there will not be the difficulty with water as on the Berea uplands. Where the Berea is absent, the Bedford shale will not form more than the upper 80 feet of any hill, and usually less.

Below the Bedford, the Ohio shale forms the hill slopes, except where they are drift covered. It is a hard, black, slaty shale, never clayey even on long-weathered slopes, and trenches cut in it, though requiring considerable time for excavation, will be firm, permanent, and almost certainly dry if the surface water is properly handled.

The drift-filled valleys and slopes.—Excavations in the floors of the short, broad valleys which traverse this subdivision, will be chiefly in bowlder clay, tough to dig, but working up muddy in the trenches and not standing long in unprotected trench walls. Along the valley walls it may be in the tough, black Ohio shale which will require blasting, but will stand weathering.

Water conditions may be anticipated by the height of the surface above the streams. In places this is 20 to 30 or even 50 feet and probably water will not interfere except in excavations of similar depth. But where the surface lies only 10 feet above, there is a fair chance that rifle trenches, in places at least, will carry standing water much of the time. Some stock wells yield permanent water at only 6 feet depth. Unquestionably all will be wet in the winter and spring months.

On the drift slope of the northwest border, where the slopes are steep and the dissection considerable, it is unlikely that water will interfere with excavations except on the lower slopes.

ROCK MATERIALS FOR CONSTRUCTION

Stone.—The Berea Grit is capable of supplying vast quantities of building stone, but it is so bedded that the conditions for its extraction are seldom wholly satisfactory. The stone is a bluish-gray, rather fine-grained sandstone which is brown on the outcrop or weathers to an unattractive brown on exposure. But, though unattractive to the eye, it is strong and durable. The stone can be seen in many buildings, walls, and curbs about Chillicothe, some of them over 100 years old, and in places it has been used to pave gutters. In all of these only exceptionally will a block be found that has cracked along an obscure bedding plane.

The broken stone has been used as foundation for concrete roads by the State Highway Department, and is reported successful, though not preferable.

There is no record of its behavior in concrete; though not to be recommended where there are abundant gravels of moderate fineness, yet for sandstone material in concrete, its performance would probably rank well. The fragments of crushed sandstone have no tendency to crumble to a sand or to disintegrate and are possessed of a crushing strength probably not greatly less than limestone fragments of similar dimensions. Its resistance to heat in a concrete would doubtless much surpass that of limestone. In case of its use in concrete, great care should be exercised to avoid fragments with clay smears on one or more sides. Since all of the layers in the lower half or more of the formation are bedded in clay shale, crushed stone from such thin beds must inevitably carry many such smeared faces. The upper half of the formation presents no such condition and in places there are massive thick beds in the lower portion which would be readily usable, except for the stripping which would probably be prohibitive. The quarry sap should be allowed to dry from the crushed rock before using. It should not be used in a surface liable to abrasion, such as that of a concrete road. (See Plate 2 B.)

The Berea is present in its full thickness in Clark's Hill, next southwest of Chillicothe. The following section measured on the north wall of the little valley north of Cemetery Hill, shows its characteristic composition:

12467

Sunbury shale, base seen.

		Ft.	In.
Berea grit, about 27 feet.			
9.	Sandstones in beds up to 1 foot, with practically no shale, estimated	10	--
8.	Shales, with sandstones up to 1 foot, much contorted	3	6
7.	Contorted sandstone, "niggerhead"	1	9
6.	Sandstones, 1 to 6 inches	1	6
5.	Sandstone, one bed	1	4
4.	Thin sandstones, 1 to 2 inches, with shales	2	8
3.	Massive, somewhat contorted sandstone	1	9
2.	Shales with sandstones	2	6
1.	Contorted "niggerhead," hard	--	2

Bedford shale.

The section given above is typical but 100 feet distant it would not be the same, though of the same general character. The topmost member is the only one of importance; the other beds, though of good stone, would require the handling of too much waste.

The upper beds were once extensively worked along the entire southern face and most of the eastern face of this hill. It was from these quarries that all of the stone for Chillicothe was obtained in the day when there was a demand for it. The old pits are continuous for several hundred yards. The face is commonly about 10 feet high, and it was never worked into the hill; the stripping would be found light at practically all points, for a few feet at least, and large quantities could yet be obtained with less than 6 feet of stripping. The stone is irregularly bedded, though not contorted as in the lower layers, and in such thickness that it would be impossible to supply any considerable amount of stone more than 12 inches thick. To get out large quantities of this thickness would require the handling and rejection of large masses of thinner stone. Material up to 6 inches is abundant. Massive blocks are impossible. To secure these, as when a stone watering trough was desired, a local thickening of one of the beds in the lower part of the formation was resorted to.

The character of the Berea in the hill northwest of Chillicothe and next southwest of Camp Sherman is shown by the following section exposed in the ravine at "Adena", the one-time home of Governor Worthington, now owned by Mr. George Smith. The topmost beds are here present in unusual thickness.

	Ft.	In.
Berea grit, top not certainly seen, 31 feet 10 inches.		
11. Irregularly bedded sandstones, mostly 4 to 8 inches thick, some 1 foot	13	6
10. Thin, platy sandstones, 1 to 2 inches	5	--
9. Sandstone	1	8
8. Shale	1	6
7. Sandstone, contorted in places, but fairly regular ... 1 ft. 6 in. to		4
6. Thin sandstones of about 1 inch, shale partings	2	--
5. Sandstone	1	--
4. Thin sandstones up to 1 inch, shale partings	2	--
3. Sandstone	--	5
2. Thin sandstones, up to 1 inch, shale partings	2	4
1. Sandstone	--	5
Bedford formation.		

The following section is shown about a mile north of the Briggs School; the Berea is here satisfactory for quarrying, with the same reservations noted above. The top is not shown.

	Ft.	In.
Berea grit, 25 feet 3 inches.		
3. Sandstones, somewhat irregularly bedded, blocks up to 1 foot are promised	10	--
2. Thin sandstones, 2 to 4 inches, shale partings	3	3
1. Thin sandstones, 1 to 2 inches, shale partings	12	--
Bedford formation.		

One and one-half miles farther north, at View, the thick upper sandstone is absent entirely, due to erosion. In the lower shaly portion that remains there are sandstones up to 1 foot, 10 inches, which locally thicken to 4 feet, but they are imbedded in much thin material that would be waste. This occurrence is apparently typical of the northern end of this plateau.

A small quarry has been opened in the thick top beds of the Berea three-fourths of a mile northeast of Musselman. The sandstone is here 12 or 15 feet thick, and the bedding somewhat contorted. The blocks come out in irregular shape and but few of them exceed 2 feet in their longest dimension. Much of it is rejected. This stone was used as the foundation for a concrete road by the State Highway Department, in the lack of better material, and found suitable.

Gravel.—There is very little gravel within the limits of this subdivision, though vast quantities immediately outside it on three sides. The narrow terrace which borders North Fork of Paint Creek for more than a mile at Anderson, offers a very large supply. It is not opened at any place, but groundhog holes show it to be a limestone gravel high in shale fragments. At Musselman, there is a terrace only a few yards in width, 200 feet above the creek, composed in the upper part of sandy gravel, but also too high in shale fragments for good concrete.

In the drift-floored valleys within it, practically no gravel is present. A small deposit on the south bank of Anderson Run, three-fourths of a mile north of Maple Grove is the only exception noted. It contains too much of small shale pebbles to be good for concrete, though it does fairly well in sidewalks and the small constructions of a farm. The creek gravels of these streams, from Anderson Run northeast to Dry Run, are the residue washed out of the bowlder clay that makes up their banks. It is high in sandstone, in Ohio shale pebbles, and much of it is very poorly assorted, of no value except for road metal and not of the best for that.

A gravel pit, 1 mile east, southeast of Frankfort, exposes two beds of gravel, the lower coated with yellowish limonitic clay, the upper gray but with a clay dust coating the pebbles. Many shale pebbles are present and the gravels are of little value for concrete unless washed.

The gravels immediately bordering this subdivision are described in some detail under their respective subdivisions, but it may be added here that almost without exception they are too high in shale pebbles to make a first-class concrete gravel. Some of them, perhaps all, would make first-class gravel by vigorous machine washing. By far the largest supply is in the terraces of the Scioto Valley, such as Camp Sherman is built on. Those to the northward, north of Deer Creek, appear to be unusually good, but those of Deer Creek bed are too high in shale fragments. South of Anderson (on the North Fork of Paint Creek) there are abundant gravels, but almost without exception, too high in shale. A single knoll high on the south wall of North Fork of Paint Creek near Musselman offers a small supply of very excellent gravel.

FOREST CONDITIONS

The distribution of forest cover depends almost wholly on topography. Most of the forested areas are on steep slopes and they are larger and more continuous on the slopes encircling the Berea tablelands because there the slopes are steepest and most continuous. The more rolling, rounded uplands of the northwest are largely bare and such forest as occurs is in small patches, usually on the barren Ohio shale slopes. The Berea tablelands are bare.

Though the forests are capable of concealing large bodies of men from overhead observation, the terrain is not favorable to encampments or maneuvering under their protection. The distribution is shown approximately correctly on the Roxabell quadrangle, which map forms the west half of the Camp Sherman quadrangle, but this is not shown on the latter map.

Practically all first-class timber has long since been cut but some yet remains in small areas or as scattered trees. Along the steep slope facing the lower end of Camp Sherman, there are several acres with numerous good walnuts, oaks, ashes, and elms up to 2 feet in diameter. These are in the park along the approach to "Adena", one-time home of Governor Worthington. Wherever such large, sound trees suitable for sawing are found, they are usually similarly located in the approach to some old residence.

The forested slopes are usually covered with mixed growths of maple, hickory, oak, elm, ash, and walnut. The proportions vary from place to place, commonly to the exclusion of one or more of these. The trees, on the whole, range from 1 foot in diameter down, and it is not unusual to find many trees 1 foot across. Trees of stake and post size are abundant. Undergrowth is usually thick. Of the places where many trees of the larger dimension yet remain, the following were particularly noted:

The north wall of Paint Creek, above the C. H. & D. railroad (now B. & O.) just west of Chillicothe for 1½ miles, mixed growth.

The southwestern slope of the Berea tableland which overlooks Mad Run Valley, for 1½ miles, has many white oaks, in places scattered, from 1 to 2 feet in diameter, with many smaller hickories and maples and good undergrowth of saplings.

TRANSPORTATION

The plan of transportation routes is distinctly radial from Chillicothe northwestward. These roads, four in number, are direct, and the best roads in the subdivision. Travel from northeast to southwest must follow very irregular routes and, on the whole, poor roads.

The Columbus Pike along the Scioto River and the Washington Pike to Frankfort both have capacity for two columns or trains. The Clarksburg and Egypt roads, both piked, have many narrow defiles, chiefly at bridges, that restrict them to one column or train. All other roads are graveled and of one column capacity except the following, which are largely or wholly ungraveled, or otherwise worthy of attention:

1. From Musselman down North Fork to Sulphur Lick; very poor, practically unused, impassable for trucks or motors and almost so for horse-drawn vehicles, one ford with excessively steep approach.
2. Road N. from Musselman to Frankfort Pike and, with offset to W. one-eighth mile, north to B. M. 974.
3. Road on ridge N. of Shiloh "School" (a church) from B. M. 956 S. E. one-half mile and then N. E. to B. M. 853, little used.
4. One mile N. E. Bowdle School, from B. M. 1003 S. E. to B. M. 991.
5. From View, W., S. W. one-half mile, then W., N. W. two-thirds mile, little used also from View E.
6. Road S. E. from Bowdle School, ford in place of culvert.
7. Road N. from Dry Run School to B. M. 795 on Clarksburg Road, impassable for Fords, because of gullies on northern half mile.
8. Road along S. bank of Deer Creek, very narrow and rough, but passable to motors.

CHAPTER VIII

THE SCIOTO VALLEY

The Scioto Valley is one of the distinct topographic subdivisions of the Camp Sherman quadrangle. Though the valley may be variously defined, and indeed would be for different purposes, for the present object it is best to limit it to the flood plain of the river (that is, the portion covered by water during floods) and to the terraces closely bordering the flood plain. Bounded in this way, it is the trench occupied by the river just prior to the last ice invasion, which was largely filled during that invasion, and has since been partially re-excavated by the river. This furnishes more satisfactory boundaries for other subdivisions which are based on different kinds of glacial deposits or bed rocks. But even this plan has not been strictly adhered to; it has seemed expedient to discuss the terraces next east of the river and below Chillicothe in the chapter on the immediately adjacent but much older "great terraces southeast of Chillicothe".

Much which has been treated under the head of drainage, water, timber, and transportation in the discussion of other subdivisions, in this case is presented in the chapter on the Scioto River. In the present chapter there remains to be considered only the essentially geological features in the valley.

The valley lies in the middle of the quadrangle except in the southern part. It is about 20 miles long, varies in width from 1¼ to 2½ miles, and has an area of about 40 square miles.

TOPOGRAPHY AND GEOLOGY

Flood plain.—The river flows through a low flat plain from one-half mile to a mile in width, which is wholly submerged at times of high water. The surface is a loamy clay soil from a few inches to several feet in thickness which is in part due to weathering of the underlying gravels, and in part sediment dropped by the river. This rests, by a sharp contact, on gravels. The topography of the flood plain is described in the chapter on the Scioto River.

Terraces.—The terraces which border the flood plain on one or both sides rise from 20 to 60 feet above the river and are also composed of gravel. These terraces usually have a surface either many yards or rods in width which is flat or slopes very gently toward the river, and are terminated on the river side by steep banks. In places there may be two or three distinct terraces, rising irregularly like great shallow steps back from the river. Beginning with the flood plain, they are known locally as the first, second, and third bottoms. The way in which they were formed is outlined in the chapter on glacial formations.

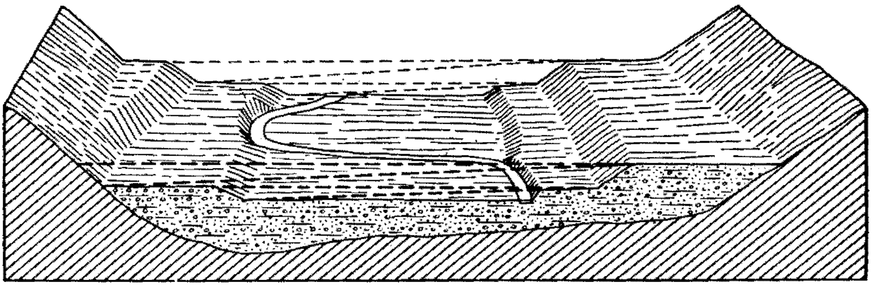


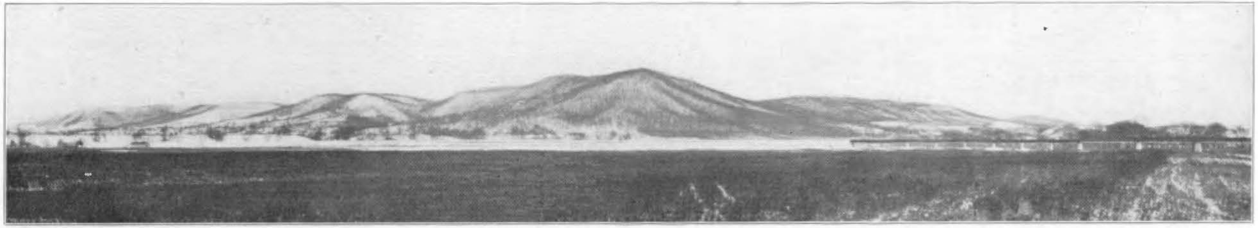
Fig. 13.—Diagram to show the relation of gravel terraces bordering the Scioto River, their different altitudes on opposite sides of the river, and the manner in which they were carved out by the stream simultaneously slowly swinging from side to side and cutting downward in the old gravel filling.

The lower ones are covered by the river at high stages, the highest ones are never reached by floods. Hence, though the flood plain and all the terraces are devoted to farming, only the higher ones are occupied for residences or used for highways or railroads. Camp Sherman and Chillicothe occupy extensive terraces. The same relationship obtained, in a way, long prior to the Anglo-American occupation of the region. Until they were largely obliterated, there were extensive Indian earthworks on every terrace on both sides of the river from the upper end of the Camp southward to the south line of the quadrangle, 11 miles.

The depth of the rock floor of the Scioto River has not been determined. Abundant drillings show that it is generally at an altitude something less than 525 feet (or 75 feet below present river level), and two wells show that in places it is more than 100 feet below the present river level, at an altitude of less than 500 feet. The depth to rock beneath the terraces is increased by the height of the terrace, except close to the rock walls of the valley.

Below the level of the Scioto, wells show that the valley filling is sand and gravel. The composition appears to vary from place to place. From a number of wells, sand with no pebbles the size of a pea is reported from about river level to 60 or 100 feet below, but elsewhere, gravels are recorded in the interval. This is probably due in part to different observers, as well as to difference in material. All are recorded as uncemented.

Beneath the upper end of the terrace on which the older part of Camp Sherman was built, very sandy gravels with pebbles up to door knob size occur to 40 feet below the river. Below the lower end of Camp Sherman a well on the towpath at the Salvation Army barracks recorded about 70 feet of sand below river level. A well on the premises of H. Knight & Son near the Main Street bridge in the east end of Chillicothe is reported as having 60 feet of sand below river level. Wells



A.—View eastward across Scioto Valley to knobs east of Camp Sherman, Mount Logan center, Mt. Eyes and Bunker Hill to left. At foot of rock hills on left, the Wisconsin gravel terraces are shown behind the railroad fill; at the foot of the rock hills on the right, beyond the railroad bridge and coincident in length with it, is the Illinoian gravel terrace.

B.—Westward across Scioto Valley from hill point in southwest corner Section 4, Springfield Township. View from foot of bed rock slope looking across the lower rolling slopes of glacial till, which descend to the valley in the middle distance. On the left, the slope of Bunker Hill, flattening gradually into the Berea Grit terrace (unbroken snowy fields) which in turn ends abruptly about one-third way across the view at Hopetown. Distant valley wall is Berea-capped tableland.

on the east side of the Scioto opposite the extreme upper end of the Camp commonly show 70 to 100 feet of sand at this horizon. These last are not typical, however, because they are located on the kame moraine and the material they penetrate is not identical in origin with the terrace gravels, though the records appear the same.

GROUND WATER

The gravels and sands which fill the Scioto Valley generally carry water up to about the level of the river, and in the terraces well back toward the rock hills the water stands well above the river level. Although the terraces may be readily distinguished topographically, their sands and gravels abut against, and very possibly are interfingered with, those of the kame moraines on the east side of the river in the northern part of the quadrangle. Similarly they abut against the old Illinoian gravels southeast of Chillicothe, though not interfingered with them. The water body which permeates the gravels of the river valley is not bounded by the lateral limits of the terraces, but is continuous with and indistinguishable from the waters which permeate these neighboring gravel masses.

The amount of water available at any place and depth in the valley filling depends largely on whether the material is sand or gravel. Where the material is chiefly sand, it may be impossible to complete a well in the presence of ample water because of the constant movement of sand into the bottom of the pipe. In all wells in which thick loose sand beds have been found they have been penetrated until a gravel bed is encountered which not only usually carries a splendid volume of water but permits the satisfactory completion of the well. In exceptional cases, failure to find such gravel bed has caused the abandonment of the well. Though the sands may be filled with water, when such a gravel bed is encountered, the water in the gravel almost invariably flows with so much greater ease into the well, that it shows a strong head, rises in the pipe half the depth of the well, more or less, and is regarded as a distinct vein.

Wells near the Scioto River, and extending only to the water table or but slightly below it, will undoubtedly be influenced by the river. If the river has been low for a considerable period, and the ground water level has fallen to near the river level, a sharp rise of the river would pour a considerable amount of water from the river into the surrounding gravels, unless there should be locally sufficient rain at the same time to raise the water table in the gravels at an equal rate, an occurrence that would be unlikely due to the time that the absorbed rain water requires to percolate into the gravels to river level. Since the water body in the gravels is fed chiefly from direct rainfall, from run-off from neighboring hills and small streams, which might require several hours of concentration to effectively raise the ground water level, it appears that this relationship may be brought into being frequently.

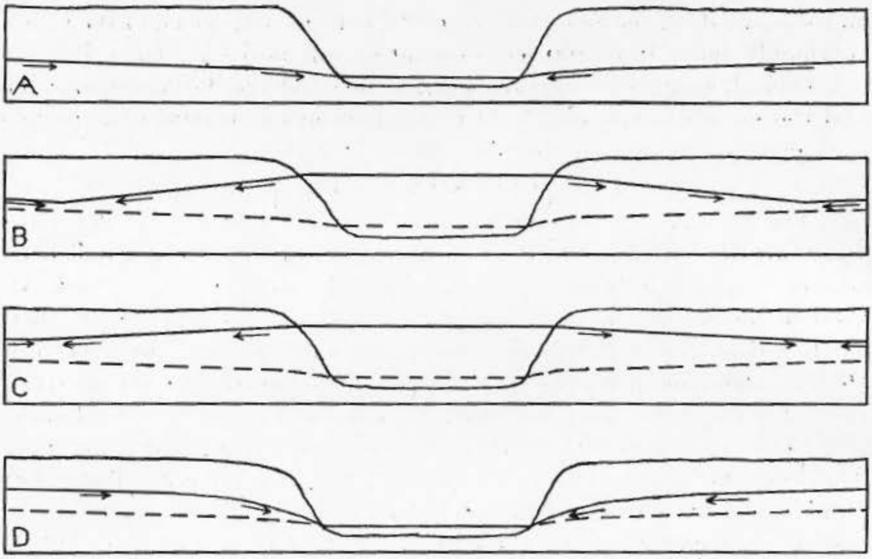


Fig. 14.—Diagrams to show the zone of ground water partially supplied from the Scioto River under the influence of flood conditions. A. After prolonged low-water, normal ground water moving toward river. B, C. Sharp rise in river, with a much slower rise in the ground water flowing toward the river on either side. This results in flow of water from river into bordering gravels. If the rise is unaccompanied by local rains, there will be no rise in the normal ground water level on either side, except as water flows in from the river. D. River fallen to low-water again, ground water level falling more slowly and ground water moving toward river. Obviously the zone of river influence on ground water is not fixed, but varies with conditions accompanying the rise.

It is not possible to say what is the extent of this zone of river influence, either vertically or horizontally, but the former is probably not much more than the vertical range of the river, 25 feet, and the latter is probably not more than a few rods. Except for this zone, the mass of water in the porous filling of the Scioto Valley is not to be regarded as Scioto River water. It is the result of absorption into the valley filling of a large percentage of the rain falling thereon, or water running onto it from the surrounding rock hills, and, excepting the prism of river influence just described, it is maintained from such sources, not from the river.

The water for Camp Sherman and for Chillicothe is obtained in the gravel filling of the valley, the former at a depth of about 55 to 85 feet below river level, the latter from wells in Yoctangee Park near the Scioto but at depths of about 70 to 80 feet below river level.

GRAVEL

The terraces of the Scioto River afford an inexhaustible supply of gravel. For road dressing it is excellent in quality, but for concrete it cannot be regarded as first-class in its natural state. It is a sandy

A.—Terrace of Wisconsin gravel and sand, freshly dissected along margin by steep-walled gullies. In the distance, the much older, higher terrace of Illinoian gravel. River Bridge, east of Chillicothe.

B.—Flat, undissected surface of Wisconsin terrace shown in A. In distance the Illinoian terrace of much older, maturely dissected deeply weathered gravel; note the rounded gentle slopes in contrast to those of A. The dissected surface of the Illinoian terrace is shown in Plate XX, Fig. B.

C.—Terrace composed wholly of bed rock (Berea Grit capping Bedford shale) bordering the Scioto Valley. View east to Sugar Loaf and Bald Hill.

SCIOTO VALLEY TERRACES

limestone gravel, with a moderate percentage of granitoid pebbles and a small percentage of sandstone pebbles. The granitoid pebbles are occasionally soft from decay, and there are numerous fragments of shale. The last are the chief objection. They are from the Ohio shale and frequently when they are unweathered and sound and solid, may escape detection but they are none the less elements of weakness in concrete. Many localities would yield a gravel satisfactory for temporary constructions or for structures in which no unusual strength demands are made on the concrete. These gravels can be greatly improved by vigorous washing, which not only removes the dust but the decayed granitoid and shale pebbles, and probably many shale fragments that would appear sound. It is probable that there are places that are exceptional to this general description, where washing would not be necessary. The only one which has been seen is at Peppers on the south line of the quadrangle; the gravel there seems to be unusually free of shale, but the face was inadequately exposed and the examination not thorough.

The general character of the gravel is shown in the pit of the Chillicothe Sand & Gravel Co., at the lower end of the Camp. Three random samples totalling 478 pebbles from ¼ inch to 2 inches in diameter, showed 4.6 per cent of sandstone or crumbly granitoid pebbles and 6.9 per cent of shale pebbles, by number. In size the shale pebbles run considerably smaller than the average and the percentage by volume would be proportionally less. These gravels, when washed, yield a product that is reported as first-class and was used as such in constructions by the U. S. Government; the product is accepted by the State Highway Commission of Ohio as grade A gravel, and used as the basis of the wearing course in concrete roadways, a very exacting use for concrete.

Small pits along the Columbus Pike north of Andersonville show a much higher percentage of shale than the sample described above.

The gravel in the large pit of the B. & O. Railroad 5 miles southeast of Chillicothe also shows many shale fragments, which are in part derived from large crumbling blocks in a layer half way up the pit, that cannot be eliminated in quantity production. Concrete in bridge abutments made from these gravels is behaving apparently satisfactorily except as numerous small deep pits are forming on the surface where these shale fragments are weathering out; the pebbles are proportionally as numerous in the body of the concrete as at the surface.

Considerable gravel for local use is obtained in the river bottom at the Main Street bridge, Chillicothe. It is clearly a river gravel, with mussel shells and lumps of earth, which would prove about equally objectionable in a concrete devised for strength or abrasion.

Washing may be accomplished by the river as well as by artificial methods. Just above the Bridge Street bridge at Chillicothe on the Scioto River is one of the most extensive gravel bars within the Camp

Sherman quadrangle. It is unique in that the municipality of Chillicothe owns it, and great quantities of gravel have been removed for street construction, for laying of sidewalks, and for sale to the manufacturers of large concrete storm-water sewer pipe. The source of this gravel is the terrace gravels farther up the Scioto River, and it is very similar in character. Gravel is present on the various parts of the bar, in all sizes, as a result of the assorting action of currents. There are occasional shale fragments in the form of thin, fresh blades, but they are less numerous than in the terrace gravels. Decayed fragments, as a result of washing by the river, are few. Being a river gravel, there are occasional small mollusc shells, but not, it appears, enough to appreciably lessen its value. Reports and casual observations of the cement walks of Chillicothe indicate that its behavior in concrete is satisfactory. It appears to be one of the best sources of gravel in the quadrangle, though probably it would not rate as Grade A under the tests of the State Highway Commission. It is reported that the supply of gravel is maintained by additions brought down by the river in freshets, but this would be contrary to experience in some portions of the Scioto, and is unexpected in view of the muddy bottom conditions reported between this bar and the gravel banks along the river at the lower end of Camp Sherman, the most immediate present source of the gravel.

Below Chillicothe, from the Main Street bridge to the mouth of Indian Creek, there is a much greater amount of gravel in the channel of the Scioto than there is above Chillicothe. It has not, however, been examined for its possible use in concrete. The gravels below the mouth of Paint Creek, of which there are enormous quantities, are probably too much contaminated by the sandstone pebbles brought in by that stream to be entirely satisfactory.

CHAPTER IX

FLAT-TOPPED PLATEAUS OF THE SOUTHWESTERN PART OF THE QUADRANGLE

This subdivision includes about 52 square miles. It lies between the Lowlands, North Fork of Paint Creek, and Paint Creek Valley; in it is included also the abandoned segment of Paint Creek Valley west of Slate Mills. See Figure 3, p. 33, for location and outline.

TOPOGRAPHY

The topography is characterized by bare, flat-topped plateaus of irregular outline, 400 feet high, with very steep wooded slopes. These are elongate from east to west, with narrow east-west valleys separating them and with precipitous ravines partially dissecting them and causing the irregular outlines. The plateaus, strictly speaking, are not flat, but rise gently from an altitude of about 1,040 feet at their eastern end to 1,200 feet at the west line of the quadrangle. Moreover, near the west line the flat upland surfaces are partially obscured by rounded hills that rise about 100 feet above them. The plateaus are due to the same

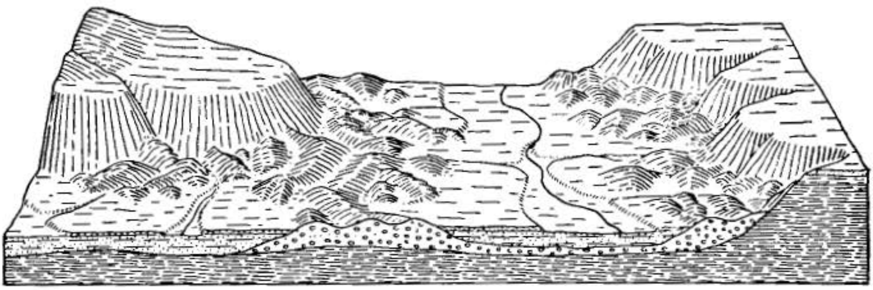


Fig. 15.—Idealized sketch of topography and geology of the "flat-topped plateaus of the southwestern part of Camp Sherman quadrangle", showing: 1, flat-topped Berea uplands on right; 2, the same on the left with rolling hills rising above them, characteristic of the western portion of the subdivision: 3, the border around the rock hills of hummocky hillocks which are the remnants of the very old Illinoian gravel terraces, now thoroughly dissected; 4, the low, undissected, fresh gravel and lake-clay terraces of Late Wisconsin age. The vertical exaggeration is about 5 times. The cross-section in the foreground shows the bedrock formations at the right, in ascending order, the Ohio shale, Bedford shale, and Berea grit. The hill in the left back shows a rounded hill of shale overlying the Berea which forms the tableland. In the middle of the foreground cross-section, the drift formations resting on the Ohio shale are Illinoian gravels overlain by Wisconsin gravels.

cause and are almost identical in character with those lying next west of Camp Sherman, but they are higher, with steeper sides, and the broad open valleys which are there present are here wanting entirely. In the largest valleys, those of Upper and Lower Twin creeks, only narrow bottoms are present, and on all larger valleys and some of the smaller ones, there are commonly sharply rolling gravel foot hills 140 to 200 feet high, of a peculiar hummocky aspect, in contrast to and lying at the foot of the steep, straight shale slopes which ascend directly to the flat plateaus. Their character is shown in Plate 16 B, opposite p. 118. Low flat terraces, 20 or 30 feet high, border the sides of the valleys in their lower portions and also Paint Creek.

GEOLOGY

Bed rocks

The hills of this subdivision are almost all rock hills. Six bed rock formations are present.

Ohio shale.—This tough black shale, locally called slate, constitutes the lower 300 feet, more or less, of all the rock hills. Almost without exception it forms steep slopes. It is difficult to excavate but will stand well in trench walls and will be found dry.

Bedford formation.—This is, in the lower half, a soft gray, clay shale, weathering easily to a sticky clay mud; the upper half contains numerous thin sandstones which make it more resistant. It is between 80 and 90 feet thick, and forms the upper part of all the steep slopes, except the uppermost 20 or 30 feet.

Berea Grit.—This formation, which is from 25 to 30 feet thick, consists of sandstones, solid in the upper 10 or 12 feet, with thin shale partings in the middle and lower portions. It is, as elsewhere in the quadrangle, gray, weathering brown, and is capable of furnishing abundant sandstone of first quality except for color and limited size of material. It is by far the most important formation in the subdivision in its effect on topography. It directly underlies all of the flat plateaus which owe their origin to its resistance and protection of the underlying formations. From the flat tablelands of Plyley Ridge, Poplar Ridge, McDonald Hill, and Beath Ridge, it appears that every trace of overlying formations has been removed.

Sunbury shale, Cuyahoga shale, Buena Vista sandstone.—These formations are found only in the rounded hilltops which rise above the Berea tablelands along the extreme western margin of the quadrangle, in Asher Hill, the irregular ridge west of Beath Ridge, and Farrell Hill.

The Sunbury shale is black and tough, like the Ohio shale on the lower slopes, and about 15 feet in thickness. The Cuyahoga is a soft, gray, clay shale quickly weathering to clay mud, some 30 to 40 feet thick. The Buena Vista sandstone, seen only in its debris, occurs on or very near the hilltops, a yellow sandstone, rather hard, and probably about 3 feet thick.

Mantle rock

In all of the larger valleys, Owl Creek, Plug Run, Lower and Upper

Twin creeks, there are extensive accumulations of glacial clays and gravels which form rolling hummocky foot hills up to 180 or 200 feet above the streams. With a little practice these hills can usually be distinguished by their peculiar topography from the higher shale hills behind them.

Nowhere else in the Camp Sherman quadrangle are the drift formations as complicated or as various as in the valleys of this subdivision. They have been described in some detail in the chapter on glacial deposits and the geologic map is relied on to supply their distribution. The relations of these deposits in a general way to the other features are shown on the accompanying sketch. The rolling 200-foot hills which border the shale hills are composed, it is believed, of Illinoian gravels, with limited deposits of what appears to be till. They are exposed at very few places, as they are covered with thick soils, contain much clay, and are apparently of little value as gravels. These were once continuous deposits in the valleys up to the top of the highest of these hills, but were deeply weathered and cut out by streams to much their present condition before the coming of the last ice sheet. It partially filled the valleys so cut, with stream gravels, lake clays, some till and kame moraine. These last deposits have since been only partially re-excavated. The deposits of the two ice sheets are in contrast topographically; the older ones stand higher and are thoroughly dissected into rolling hills, the later ones remain as low gravel terraces with flat or very gently undulating tops, or undulating till slopes. The deposits of the former ice sheet are deeply weathered to a reddish-brown, those of the later one are yet fresh and gray or blue.

Obscure drift deposits also occur on the top of the western ends of Plyley and Poplar ridges. The remainder of the uplands, except for an occasional foreign pebble, appear to be coated only by the soils produced by ages of weathering, the residuum of the shales which once rested on the Berea.

WATER

Ground water.—But little attention has been given this subject, because of limited facilities. Though the control of underground water by the valley glacial formations must be critical, nothing has been learned as to its character.

On the Berea tablelands, underground water movement is controlled in exactly the same manner and in much the same amount as on the similar uplands adjacent to Camp Sherman. Usually hilltops of such limited area do not have ample water supply the year around at shallow depths, but such is not the case on these tops. Numerous wells 8 to 15 feet deep around the edges of these plateaus have abundant water, usually with slight mineral content,but only exceptionally so high in alum as to be of no use except for stock. This water is obtained either on top of the Berea or within its upper layers. Its presence on the uplands is due to the relatively small amount of run-off from the flat surface, and the correspondingly larger amount of absorbed water. This is held in the clays and in the joints of the Berea Grit, perhaps to some extent in the sandstone itself. It cannot sink downward because of impervious shale layers, and it is slowly fed outward to the edge of the plateau, where seeps and springs are numerous the year around.

CONDITIONS AFFECTING EXCAVATIONS

Uplands.—Conditions of excavation are similar to those met on the plateaus adjoining Camp Sherman. Except along the western margin of the quadrangle, the Berea almost everywhere lies at but slight depths below the surface of the upland flats. Yet the covering of soil is sufficient that it never interferes with tillage, and fence posts may be set practically anywhere. As a rule, the flat upland lies about 10 feet above the sharp break of the hill, the 10-foot rise being accomplished in about 50 feet horizontally. At no observed point is there reason to believe that the sharp break of the hill is coincident with the highest Berea and in some places it certainly is not. How much Berea, if any, then, is to be expected in the 10-foot interval to the flat surface, is not clear. In some places, notably on the western ends of Plyley and Poplar ridges, where there is some upland drift, the surface rises rather rapidly to 20 feet above the sharp break of the hill, and the cover is obviously thicker.

Rifle trenches of full depth are certain to encounter Berea Grit, which is very difficult to excavate, in most places along the margin of the plateaus. Farther back it appears that such trenches will not seriously encounter the Berea except in restricted areas.

The problem of water in these excavations seems to be similar to that on the flat uplands next to Camp Sherman. It is present in considerable quantities at the top of or in the upper part of the Berea, and when that is encountered, is apt to be troublesome.

Slopes and valley floors.—Considerable diversity will be found here, but the character of excavation may be anticipated from the geological map. Six chief conditions obtain from place to place. 1. Slopes of tough Ohio shale, difficult digging but excavations permanent. 2. Higher foothills of Illinoian gravels; clayey gravels, excavation easy but impermanent, probably dry except in very deep excavations. (See Plate 16 B.) 3. Wisconsin gravels; material incoherent gravel. 4. Low terraces of Wisconsin gravel and lake clays; the latter give these their chief character, exceedingly tough, wet, sticky clay, which will not bear its own weight but caves or slumps, dangerous in excavations unless special care is taken. This material is shown in Plate 4 C. 5. Wisconsin till; material a tough bowlder clay, difficult to dig and excavations therein impermanent. 6. Wisconsin kame gravels at eastern end of subdivision; unconsolidated but dry except in deep excavations. (See Plate 16 C, opposite page 118.)

ROCK MATERIALS FOR CONSTRUCTION

Stone.—The Berea is seldom fully shown. As usual, it is about 25 to 30 feet thick, with heavy ledges of rock in the upper 10 to 15 feet, which are capable of supplying enormous quantities of building stone in sizes up to 1 foot thick, and may be used in concrete with the reservations indicated in the chapter on "Hills west and northwest of Camp Sherman" (page 92).

Gravel.—Fair gravel is abundant and generally distributed but of first-class concrete gravels, only three very limited deposits have been seen.

No gravels of any value may be expected in the Illinoian deposits. They are too much mixed with clay and too high in sandstone.

The chief deposits of gravel are those in the old valley of Paint Creek between Slate Mills and Plyley Ridge. Though there are enormous quantities of limestone gravel here, all exposures that have been examined show too high a content of shale pebbles for first-class concrete, except one. At the east end of Plyley Ridge there is a group of kames, the highest of which is a little over 900 feet. The gravels are coarse, with but little sand, and are partially cemented. At one place almost at the top, these gravels are practically free of shale, though blocks up to 2 feet across occur directly above it in a bed which can be easily stripped off. The pebbles are partially coated with lime which cements them together; in places they can be dug with a pick, but elsewhere are quite solid. This is one of the cleanest natural gravels in the Chillicothe district, but the quantity is very limited and is further reduced by the masses of cemented gravel, unless a rock crusher be available.

Three-fourths of a mile southeast of Musselman, there are gravel deposits on the south wall of the North Fork of Paint Creek, about 150 feet above the valley floor. A small opening shows a limestone gravel, exceptionally free from shale. Though of apparently excellent quality, the quantity is limited.

The true terrace gravels of Wisconsin age on the tributaries of Paint Creek all show, as far as examined, too high a shale content for any but inferior concrete.

The gravels associated with the lake clays also are apt to show too much shale material, but they present added difficulties. Where the gravel underlies one of the beds of lake clay, it is apt to be muddy, apparently, from the muddy waters which have trickled through it, and it is practically impossible to recover as the overlying clay, though only

5 or 6 feet thick, could be stripped only with the greatest difficulty because of its exceedingly tough, wet, dense character. One notable exception to this is on Paint Creek just north of Shott's Bridge. The gravels immediately above the flood plain are not here overlain by back-water clays, though undoubtedly they are a few yards farther back in the hill. It is limestone gravel of small size with very little sand and with practically no shale fragments of the gravel size, though numerous ones of larger size that may be readily picked by hand are present. The gravel is not clay coated. With the exception of the large shale pebbles, which prevent any but hand excavation, and a thin cover of black loamy soil which should be carefully removed to avoid introduction of organic matter, this gravel appears to be one of the very few natural first-class gravels of the Camp Sherman quadrangle.

FOREST CONDITIONS

Forest coat is confined almost entirely to the steep shale slopes. The flat uplands, the rolling drift hills at the foot of the slopes, and the valley bottoms, with little exception are cultivated. All forests are hardwood. The slopes have been left forested because of their steepness and uselessness for agriculture, hence the forests are of little use as a cover for maneuvering or encamping troops.

Though practically no timber trees remain, there is abundant structural material of other sizes and of the common sorts.

TRANSPORTATION

Although the general plan of the roads is radial from Chillicothe, as is so generally the case within the Camp Sherman quadrangle, actually they are almost entirely controlled by the topography. Roads follow each of the east-west valleys, all metaled but wide enough for a single column or train only. The Chillicothe-Greenfield Road, also east to west, follows Plyley Ridge, and portions of Poplar Ridge and McDonald Hill are traversed by fair roads, otherwise the uplands are not traversed by roads. The lane which follows Beath Ridge and its westward continuation can be traversed by small motor cars with care in good weather. Roads which cross the ridges invariably do so by very steep grades.

Transportation from north to south across this subdivision is difficult. A single road only is practical for traffic from the Lowlands southward into this subdivision, the one which passes through a very low, narrow gap west of McDonald Hill to the head of Porter Hollow. Though metaled, it is narrow. After it is the road south from the Pierce School onto Poplar Ridge and thence into Plug Run, which has two heavy grades. The Cincinnati Road in Paint Creek Valley is excellent and at all places wide enough for double columns or trains.

The topographic map is misleading with regard to a single road only in this subdivision. The road from Poplar Ridge northward to B. M. 808 on Owl Creek, though indicated metaled, is of such steep grade, so badly washed and overgrown, as to be practically impassable to vehicles.

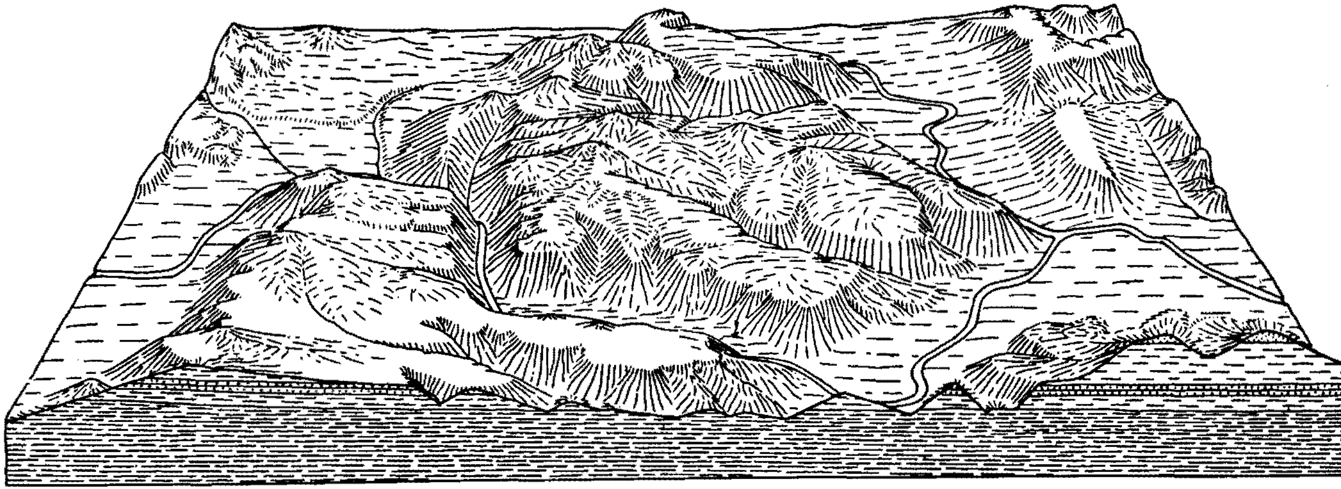


Fig. 16.—Block diagram of the topography and geology of the northern corner of "the hilly uplands of the southern part of the quadrangle". Portions of the subdivisions adjoining to the northeast and northwest are included. The area represented is indicated on the map, Fig. 3, on page 33. It is 5 miles wide by 4 deep, the vertical exaggeration is about 2½ times. The geological formations in the foreground cross-section are, from bottom upward, Ohio shale, Bedford shale, Berea grit, Sunbury shale, Cuyahoga and Portsmouth shales, undivided, and Vinton sandstone. On the left and in the center are shown the rolling, rounded, shale hills which surmount the Berea tablelands and are characteristic of the western portion of the subdivision; in the right foreground this tableland is reduced to a shoulder on the hill slopes and the shale hills above it become much more prominent and steeper, as is characteristic of the eastern portion of the subdivision. The sketch shows Paint Creek where it flows from its open valley into the post glacial gorge, from which it emerges into another open pre glacial valley. (See Chapter XVII., page 181.)

CHAPTER X

HILLY UPLANDS OF THE SOUTHERN PART OF THE QUADRANGLE

This subdivision occupies the central southern portion of the quadrangle. It is an isosceles triangle with the apex missing, bounded by the south line of the quadrangle, Scioto Valley, Paint Creek, and North Fork valleys. Its area is about 65 square miles. See Fig. 3, p. 33, for location.

TOPOGRAPHY

Excepting a few square miles east of Indian Creek in the southeast corner, the topography is a modification of the flat-topped plateaus lying to the west and north. West of Ralston Run and North Fork of Paint Creek, broadly rolling uplands, all cultivated, are the chief features in the topography. They end abruptly at the top of steep, wooded walls of narrow stream valleys cut in the uplands to a depth of 200 to 300 feet. Well back from the margins of these uplands the land rises more rapidly over the divides to hills 200 feet higher than the upland surface but also cultivated in part. East of Ralston Run the plateau or upland surface is not so prominent and it is increasingly obscure eastward to Indian Creek. It there takes the form of a more or less distinct shoulder on the hill slopes, from which wooded valley slopes descend abruptly, and hilly, partially cultivated uplands rise gradually. East of Indian Creek, practically no trace of the plateau surface is present and the uniformly wooded slopes rise steeply from the streams, 400 to 500 feet, to wooded ridge crests which consist of pointed knobs and narrow, slightly lower intervening gaps; cultivation is attempted only along the narrow ravine bottoms.

Both the gently rolling uplands and the hill shoulders owe their existence to the resistant Berea Grit, the same formation which gives origin to the flat-topped plateaus to the westward.

In a few places, the rolling uplands culminate in small, steep-sided knobs, but these are infrequent within the quadrangle, though numerous to the southward and readily visible from the quadrangle.

The streams which drain the region head on the gentle hill slopes of the upland, flow outward in short, shallow, broad, rolling valleys, descending rather gradually to where they plunge over the Berea ledge into narrow, steep-walled valleys, 200 feet or more in depth, V-shaped in cross-section, and with only a narrow bottom, if any at all. (See Plate 14, opposite page 114.)

The valleys of the latter type find their extreme of development in

Paint Creek Gorge, a section of Paint Creek Valley, 3 miles in length, with walls so steep as to be unscalable at most places and valley so narrow that there is room only for the stream along half of this distance. (See Plate 15 C, opposite page 116.)

The Berea Grit forms the upper 25 feet of all these steep walls; in many places it forms low ledges, and the slopes below it are commonly strewn with large rocks which have fallen from it. The valley of Paint Creek, where it flows through this subdivision, far from being an exception, is the most extreme of all in these respects.

GEOLOGY

The topography in all its larger features is directly the result of the underlying rock formations. The resistant Berea Grit is the most important because it gives rise to the uplands west of Ralston Run and the shoulder on the valley walls east of that stream. The deep, steep-walled stream valleys are cut in shales which underlie the Berea; the rounded rolling uplands are cut in soft shales which overlie it but are themselves partially protected by a thin sandstone, the Buena Vista, which forms the narrow, flat crest of the divide between Ralston Run and Paint Creek at 1,100 to 1,120 feet. The few high sharp knobs in which the uplands culminate 4 miles southwest of Chillicothe are due to the resistance of yet another sandstone, the Vinton formation, which overlies and there protects the shales of the surrounding uplands.

The mantle rocks are of less importance in this subdivision than in any other of the quadrangle. Almost without exception, the hills and their slopes are formed by bed rocks.

Bed rock formations

Ohio shale.—This forms the lowest slopes of the hills from Indian Creek westward, only a few feet on Indian Creek but the lower 200 feet in the western part of the subdivision. It is, as elsewhere, a tough black shale, which forms steep, frequently bare slopes, but does not give rise to clays.

Bedford formation.—Gray clay shale, giving rise to clay on weathering, which forms the upper slopes of the valley walls to just below the Berea Grit. Sandstones are present in greater or less amount in the upper 20 or 30 feet. The whole is about 85 feet thick.

Berea Grit.—Very resistant sandstones, separated by thin shales in the lower half, in all 25 to 30 feet thick. The beds of sandstone are frequently 1 foot thick. This formation constitutes the upper part of all the steep valley walls west of Indian Creek. East of Indian Creek, particularly on the Scioto Valley, it is low down near the foot of the hills, is very thin, 2 to 5 feet, and does not influence the topography.

A.—View southward from alt. 934, south of Polk Hollow School, showing the gently rolling Berea tableland, into which narrow stream gorges are cut to depths of 200 to 250 feet, and in the sky line the higher, steeper hills which distinguish the main divides of the subdivision.

B.—View northeastward from BM. 1136 in the western part of Huntington Township, showing the Berea tableland where it is well dissected by small streams near Paint Creek, which flows in the distant valley. The outcrop of the Berea Grit is just below the house and barn and at the top of the steep slopes. In the foreground and on the right are the gently sloping shale hills which rise above the Berea tablelands. In the distant center and left are the flat-topped Berea-capped plateaus north of Paint Creek. The slopes below the Berea are, almost without exception, forested, but usually only the steeper slopes above the Berea outcrop are forested.

HILLY UPLANDS OF THE SOUTHERN PART OF THE QUADRANGLE. UPLANDS

Sunbury shale.—A tough black shale like the Ohio shale, but only about 20 feet thick. Lying as it does at the foot of the long gentle slope above the Berea, outcrops are few and poor.

Cuyahoga and Portsmouth shales.—These two formations can usually be readily distinguished by the presence of the Buena Vista sandstone (next described) between them. However, in this subdivision this bed practically fails except in the portion west of Ralston Run, and the two shale formations are indistinguishable. East of Ralston Run, their combined thickness is about 360 feet, but is wholly present only on the two high knobs north of the Henness School and possibly east of Indian Creek. The shales are soft gray, clayey, very slippery when wet, interbedded with numerous, hard, thin sandstones up to a foot or two thick.

Buena Vista sandstone.—This member, of great importance from the south line of the Camp Sherman quadrangle to the Ohio River, is distinguishable only on the high ridge west of Ralston Run, where it forms a prominent, though small, flat top at 1,100 to 1,120 feet. The member is thin, probably not in excess of 10 feet, and consists of thin, soft, yellow sandstones interbedded with shales. Its rapid loss of character to the northeastward is remarkable, for, within a mile south of the south line of the quadrangle, it is an important member. East of Ralston Run it has not been distinguished in the presence of other thin sandstones.

Vinton sandstone.—These are rather hard and tough yellow sandstones which, in this subdivision, are found only on the tops of the two high knobs north of the Henness School, one known as Riley Knob, and possibly on the hilltops east of Indian Creek. The thickness has not been determined because of poor outcrops, but on the knobs may be as much as 40 feet.

Mantle rock

The first ice sheet covered most of the subdivision but remarkably little trace of it remains at present. The last sheet probably covered the low hills on either side. All told, there appear to be only five occurrences worthy of note in connection with possible military occupation. Their distribution is shown on the geological map.

1. Great accumulations of coarse Illinoian gravels occur on Black Run and south of Spruce Hill to over 240 feet above Paint Creek bottoms. They are largely composed of sandstone debris from the Berea Grit, with much clay and their general character is described in detail under the subdivision to the northwest. These are shown in Plate 16 B.
2. Similar gravels, but finer and in lesser amount, form low foot hills on the west wall of Ralston Run Valley for a distance of 2 miles.
3. Back water clays, blue, dense, tough, sticky, and wet, probably

of Illinoian age, form the rolling floor of Indian Creek as far up as its North Branch.

4. Similar clays but with interbedded gravels and of Wisconsin age form low inconspicuous terraces along Paint Creek above the Narrows. Their character is described under the subdivision to the northwestward, and is shown in Plate 4 C.

5. Fresh Wisconsin gravels form a limited but imposing group of terraces on the south wall of Paint Creek opposite the mouth of North Fork, attaining a height of over 100 feet above the valley bottom.

WATER

Ground water.—It is not possible to describe ground water behavior over the whole subdivision. Practically no attention has been given to this feature in the eastern half or to the valley waters in any part. Enough has been learned of the behavior of the upland water of the western half to show that it is considerably different from that obtaining on the flat Berea plateaus to the westward and northward, but even this cannot be presented adequately. There is considerable variability in the abundance of ground water on the uplands; in some places springs are very few and elsewhere they are abundant and strong. The factors which control this have not been determined. Probably it is due chiefly to steepness of hill slope.

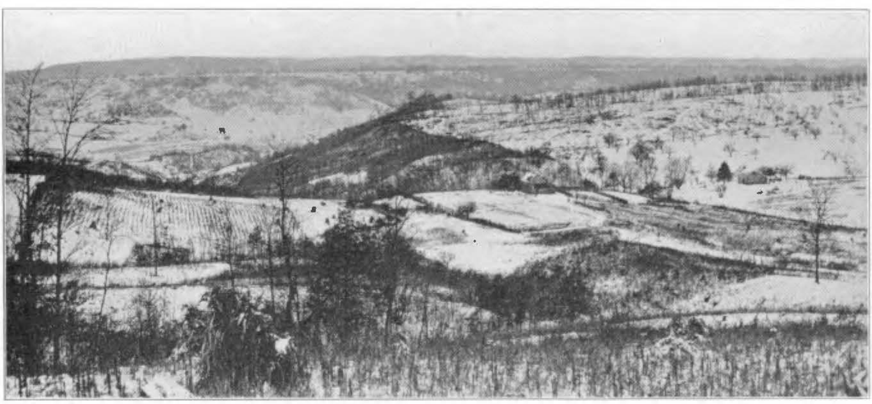
Topographically these rolling uplands are only a modification of the flat Berea uplands around about and from experience with them in three directions, one expects to find here a line of springs and seeps at the top of the Berea. Although there are a few, they are scarce and no more numerous than on slopes a little higher; the edge of the Berea Plateau here presents no problem of probably wet trenches, such as is found on the flat-topped Berea tablelands.

That portion of the upland which lies northeast of the gorge of Paint Creek is possessed of steeper slopes than usual, and there is a notable shortage of water. In fact, probably the most important natural condition affecting military occupation there is the *lack* of water. It has so far proved impossible to obtain good, potable waters in abundance. It is true that there are a very few shallow wells (that is, wells not more than 15 or 20 feet deep) which supply usable waters, though hard, in never failing amounts for family use, but the majority of residents depend on cisterns for cooking water and to a considerable extent for stock. Some of the springs and wells of which data were obtained supply a water so high in alum that stock cannot use it. In seasons of deficient rainfall it is frequently necessary to haul water from Paint Creek, which is 2 miles distant from some of the dwellings.

The hills in which this portion of the upland culminates lie nearer the western margin of the plateau than the eastern margin; in fact there

A.—View southward up Ralston Run, showing the characteristic type of valley cut by the larger streams into the Berea plateaus.

B.—View eastward from one mile north of Bishop Hill School into head of a valley in the Berea plateaus. The Berea forms brink of the distant hill.



C.—View westward from near BM. 1136, Huntington Township. The valley is that of Black Run, beyond it is Spruce Hill, the sky line is the flat-topped plateaus west of Paint Creek. The Berea Grit forms the flat tops of Spruce Hill and the distant plateaus, and the abrupt top of the steep slopes on the nearer side of Black Run; the gentle slopes rising to the right and to the foreground are cut in soft Cuyahoga and Sunbury shales, which are entirely wanting from the distant hills. The generally forested condition of the steep slopes is characteristic.

VALLEYS IN HILLY UPLANDS OF THE SOUTHERN PART OF THE QUADRANGLE is none of the plateau on the western slope, but only moderate slopes from hilltops to Berea outcrops. There is a complete absence of springs and with them, habitations, on the western slope.

The explanation appears simple why there should be abundant water on the surrounding flat Berea uplands and a diminished amount on these rolling uplands. The surface back from the Berea outcrop is more sloping. As a result, a much larger percentage of the rainfall runs off on the surface, leaving a smaller percentage to enter the ground to feed springs and wells. The relative effectiveness of this factor is well shown on the steeper western slope, with no springs, and the gentle eastern slopes with springs. A second important factor is that the ground down to the Berea is not made up of more or less pervious drift, but, excepting the clay soil, it is relatively impervious clay shales. Such ground water flowage as takes place near the surface (that is, down to depths of about 25 feet) is in the mantle rock and loose bed rock formed by the weathering of these shales.

Southwestward from the gorge of Paint Creek to a mile beyond the Bishop Hill School, this upland carries very splendid springs and shallow wells. All are on the eastward slope well above the Berea, but with slopes rising behind them for a half mile or more, much gentler than those northeast of Paint Creek. The underlying rocks are the same in both districts; hill slope appears to be the critical factor.

Yet farther to the southwest, even though the catchment area is larger, the slopes are steeper, and there is reported notably less water.

Alum water which is frequently present in springs and shallow wells is readily explained by the weathering of the shales in the presence of water, especially of the black Sunbury shale immediately over the Berea Grit. The Sunbury shale is highly carbonaceous, hence its color, and contains much pyrite. These components react with waters flowing over them to produce iron-bearing, aluminous, or hydrogen sulphide (sulphur) waters. The absence of such highly mineralized waters in such quantities from the flat Berea plateaus to the northward is readily accounted for by the almost or quite complete removal of the Sunbury shale from off the Berea by prolonged erosion, perhaps in part by ice.

A few attempts have been made to obtain water by drilling wells to considerable depths. As a result of the overlying shale, the top of the Berea is no water-bearing horizon as it is where the overlying shale is missing. Wells which have passed through it encounter the gray Bedford shale for about 90 feet and then pass into the very thick Ohio shale which is black and pyritiferous like the Sunbury shale. Water is apt to be scarce at such depths in either of these and is almost certain to be highly mineralized.

In the valleys there are numerous springs but, due to the proximity of black shales, they are usually mineralized and sometimes foul to one not accustomed to them. An exception to this is in a fine, never-failing, soft water spring of good volume at the foot of the point above Paint Creek, near the Shady Grove School.

CONDITIONS AFFECTING EXCAVATIONS

The digging of trenches at the margin of the plateau, where the upland breaks away to the steep valley slopes, will be found exceedingly difficult if the Berea Grit lies at or close below the surface. This is certain, on the whole, to prove much less formidable than on the flat Berea uplands to the northward and westward, because at many places the upland surface slopes to the Berea rim, and the Berea, a few feet back, is under sufficient cover that it may not be encountered in trenching. A similar resistance will be encountered on the higher hilltops where the Logan sandstone is present and to a certain extent will be afforded by the Buena Vista sandstone but not on the gentler, intermediate upland slopes. However, whatever may be gained by the ease of digging in on these slopes will be in part offset by the difficulty of maintaining in wet weather, trenches in the shales and surface clays weathered from them. East of Ralston Run, occasional thin sandstones, increasing in number and thickness eastward, will be encountered in these shales.

The tough, sticky, blue, back-water clays of Paint Creek (above the Narrows) and of Indian Creek should be avoided, both because of difficulty in excavation and difficulty, amounting almost to impossibility, of maintenance.

ROCK MATERIALS FOR CONSTRUCTION

Stone.—The Berea Grit is widely distributed with its normal thickness of about 25 feet, and in places with numerous beds up to 18 inches thick. Its character and quality have been indicated in the descripions of subdivisions west of Chillicothe, and these remain unchanged except for local variations. East of Indian Creek it is so far reduced in thickness as to be worthless.

Gravel.—This subdivision is deficient in gravel. The Illinoian deposits are too high in clay, even for good road material. The low terraces along Paint Creek above the Narrows are unproven and may afford limited amounts of excellent gravel, as shown by the occurrence just north of Shott's Bridge (see description of subdivision to northwest) but they are much more likely to be worthless for concrete, or unworkable because of the associated silt beds.

The terraces both great and small that border the south wall of Paint Creek Valley below Ralston Run are all, so far as examined, quite too high in shale fragments for concrete, though supplying good road dressing.

A.—Paint Creek Valley. View down stream from below Shott's Bridge. The creek leaves the valley by the distant notch in the hills, where it enters the gorge. This is a valley almost free of such terraces as border the Scioto Valley, and the flood plain extends from one rock wall to the other. Artificial levee in foreground.

B.—Rolling morainic surface of till filling of preglacial Paint Creek Valley where the ice stood across it when the creek was deflected into the gorge. View southeast from one-fourth mile southeast of Cattail School.

C.—Postglacial gorge of Paint Creek. View upstream from the angle at the southern end of the gorge. The first widening just below the gorge is shown in the foreground. The ledges on the hills of the distant left and center are Berea Grit, which underlies the surrounding plateaus.

PAINT CREEK VALLEY

FOREST CONDITIONS

As elsewhere, topography conditions the distribution of forests. From the median line of the quadrangle westward the steep slopes from the Berea outcrop to the stream are, almost without exception, forested. Because of its rolling, hilly character, much more of the upland is forested than of the flat Berea plateaus west and north. Here, too, the forest coat is generally confined to the steeper slopes, particularly of those portions which rise into knobs.

From the median line eastward to Indian Creek, with the increasing roughness of the terrain, the forest is more generally distributed, though in patches. East of Indian Creek, they are generally present, except for small clearings, with heavy undergrowth of briars and thorn that are almost impassable.

The growth is chiefly oak and hickory, with much maple. Little of it is of commercial value, though there are many scattered trees suitable for making ties. The whole, without exception, is second growth. Much of the coat, particularly east of Indian Creek, is but little more than brush or scrub.

TRANSPORTATION

Roads are largely dominated in direction and character by traffic to and from Chillicothe, but owing to irregularities in topography their plan is not radial. Four main roads, all good, serve the country south of this part of the quadrangle, the Scioto River Road, Portsmouth Pike, Ralston Run Road, and Black Run Road. The first three are held together by the east-west road on Paint Creek, but the last is quite independent and is tributary to the Cincinnati Pike. Only one of these, the Portsmouth Pike, would accommodate two trains or columns. All other roads are local only and decrease in quality with distance from Chillicothe. Travel in the east-west direction, except along Paint Creek, is more difficult than in the north-south direction. The only bridges across Paint Creek are the ones at Chillicothe and Shott's Bridge. There is a very stony ford at the sharp bend just below the mouth of Ralston Run, which could be made a very important link in the transportation between the north and south sides of Paint Creek.

CHAPTER XI

THE LOWLAND OF THE NORTHEASTERN PART OF THE QUADRANGLE

This subdivision is a roughly triangular area of lowland which lies east of the Scioto River between the margin of the high rugged hill-land of the Allegheny Plateau and the north line of the Camp Sherman quadrangle. It is a portion of the southern margin of the great Interior Lowland which stretches northwestward to the Great Lakes. Of the portion here considered, the Scioto Valley forms the western margin for 8½ miles north of Hopetown and the Allegheny Plateau the south-eastern margin for 14 miles northeast from Hopetown.

TOPOGRAPHY

The topography of this subdivision is, in general, broadly rolling and of slight relief. Distinguishable differences exist between different portions.

From the Scioto River eastward to a line running due north from Sugar Loaf Knob, there is a belt 2 miles wide extending northward over 8 miles to the north line of the quadrangle, in which the relief from the river to most of the hilltops is about 150 feet, with very few slopes of more than 60 to 80 feet.

The dominant characteristic of the topography is groups of rolling gravel hills, always undulating, frequently hummocky, and occasionally with sharp slopes. These groups are from a mile to three miles in length, notably elongate in the north-south line, with flat valleys from a quarter to a half mile wide running north and south between them. The smaller knolls, hillocks, or ridges which compose such a group frequently show the same trend, so that the whole topographic grain of this belt runs north and south. This is much more striking than it is represented on the topographic map. The terrain within this belt is of a character shown nowhere else within the Camp Sherman region. In addition to such peculiar opportunity for tactical lessons as the larger features may present, there is abundant and varied opportunity for practice in moving men over ground with numerous knolls and hummocks a few feet high separated by shallow depressions a few rods wide.

This type of topography finds its most pronounced expression in the small hill group in the western half of Section 29, Green Township, where the height is greater, the slope steeper, and the hummocky character sharper, than elsewhere (Plate 17 A).

Eastward from this belt the topography is rolling, and shows none of the north and south texture found nearer the river. In the southern part, lying at the foot of the high rugged hills of the Allegheny Plateau,

A.—Hills with moderate slope rising above the Berea plateaus, southwest of Poke Hollow School and north of Paint Creek gorge. Excavations will encounter soft clay shale beneath a few feet of clay mantle rock, except on the highest hilltops where numerous beds of tough sandstone occur.

B.—Thoroughly dissected terrace of Illinoian gravel, 2 miles south of Bourneville. Hills rising to 240 feet above Paint Creek Valley, of worthless gravels, covered by a clay soil-coat which is usually many feet thick. The irregularities of topography are due to stream erosion.

C.—Kames at junction of Paint Creek and North Fork, west of BM. 705. The sharply rolling surface with shallow depressions is characteristic, and, as here, usually denotes coarse gravels of considerable thickness below a thin soil. The irregularities of topography are due to irregular deposition in cracks torn in the ice as it flowed past a sharp shale hill to the westward (left) of the view.

PAINT CREEK VALLEY AND HILLY UPLANDS OF SOUTHERN PART OF QUADRANGLE there is a belt about 2 miles in width, running from Sugar Loaf northeastward by Hallsville to Adelphi, of rolling hill-land. It is an important watershed, whose hilltops attain an altitude of about 900 feet, 100 to 160 feet above the broad open valleys of the headwaters streams. It is shown in Plate 17 B and C, and in Plate 1 A. The slopes are moderate at most places; rarely would they be called steep. This is the terminal moraine built up by the last great ice sheet, the edge of which rested against the high hills to the southward which blocked its path. The hills of the Allegheny Plateau rise 200 to 300 feet above these rolling uplands. A number of streams head on the south margin of this belt and flow southward through gaps into the much higher hills of the Allegheny Plateau, Walnut Creek, six of the small headwater branches of Little Walnut Creek, and two of the branches of Dry Run.

Northwest of this belt of rolling hilly moraine and sub-parallel to it, lie the valleys of Kinnikinnick and Pike Hole creeks, the former flowing southwest, the latter northeast, both, for the most part, a mile or more in width and with gentle slopes on either side.

North of these streams are broadly rolling hills, whose mile-long slopes rise very gently 80 to 100 feet above these valleys.

Kinnikinnick Valley and Creek.—The valley of Kinnikinnick is an ill-defined, irregular depression between hills of glacial drift, its nearly flat bottom a mile in width except for shallow constrictions southeast of Kingston and for 2 miles east of Kinnikinnick. In its upper courses, the channel is cut only 1 to 2 feet below the wide bordering lowlands, but it deepens down stream until above and below Kinnikinnick Village it is 4 to 6 feet deep. Kinnikinnick Creek in time of flood, seldom overflows its banks seriously. To be 2 feet deep out of banks, in its lower course, would be very exceptional. General spring rains or heavy summer thunder storms over several of its headward branches may cause floods. Both the rise and fall are rapid; a 6-foot rise in 3 hours is reported.

In its upper reaches, where the bottom is broader and flatter, and the channel shallower, a width of one-fourth mile is reported when in extreme flood, but this was before the farm lands were tiled and the channel cleared of brush.

Pikehole Valley and Creek.—The valley of Pikehole Creek, a prairie nearly 2 miles in width, with black mucky soil, was formerly a large marshy tract, but by ditching and tiling it has been made one of the most productive spots in the region. The ditches in the middle and lower course are 8 to 12 feet deep, steep-walled, and have water of slight current in them at all times.

Salt Creek to which Pikehole Creek is tributary, flows across the extreme northeast corner of the quadrangle and is the largest stream in the subdivision.

GEOLOGY

Glacial drift.—The geology of the district is simple. With three known exceptions, the hills of the whole subdivision are composed of gravels, interbedded with sands and exceptionally with beds of pebbly clay. (See Plate 4 A.) These were laid down chiefly by waters intimately associated with the melting edge of he ice sheet. The 2 mile wide belt which lies against the hills of the Allegheny Plateau is the equivalent of the terminal moraine elsewhere and is best called a kame moraine. The belts of gravel hills running north and south near the Scioto River are kame moraines of more prominent character with occasional groups of typical kames where the hummocky character is most pronounced. These hills have been but little modified by the streams since the ice formed them. None of the larger valleys have been formed by stream-cutting, the streams have merely adapted themselves to the topography left by the ice. This explains the larger features of the drainage and the character of the valley bottoms, where broad flats with obstructed drainage have slowly been changed into prairies with black, mucky soils, the result of marsh accumulation.

Occurrences of bed rock.—The bed rock which underlies the whole subdivision at an almost unknown depth comes to the surface at only three points, so far as known. (1) Cuyahoga shale forms the south side of the hill south of Hallsville; this is only a very short distance from the margin of the Allegheny Plateau. (2) The Berea Grit was formerly quarried for local use within the trapezoidal area that is the southeast part of Kingston, and the overlying Sunbury shale is reported in wells a few rods to the eastward in Section 3. This area of bed rock appears to be of no great extent. (3) At Delano, the Scioto Valley Electric line has made a shallow cut in the Ohio shale, and a few rods northwest of this, in a roadside gutter, the overlying Bedford shale is present.

Depth of drift.—No well record has been obtained which shows the depth of bed rock below the present surface, away from the few outcrops, though a few wells must have penetrated it. In one instance, a well 191 feet deep penetrated to an altitude of about 500 A. T., or 120 feet below the Scioto River without encountering rock. This is on the Robert Herron place, one-fourth mile southwest of Kinnikinnick and apparently within the pre-glacial Scioto Valley. A well at the crossroads 1 mile southwest of Hallsville is 115 feet deep and reported without rock, but its bottom is higher than the creek to the northward.

WATER

Permanent streams.—All of the large streams, Kinnikinnick, Pike Hole, Congo, and Salt creeks, are permanent, and many of their smaller tributaries. The hilly 2-mile-wide belt just east of the Scioto has less of small permanent streams than the rolling hills of lesser height to

A.—Looking eastward to kames in Section 29, Green Township, hills 160 feet high, of very coarse, dry gravel.

B.—View northward over terminal moraine of Wisconsin ice sheet, in the southwest corner of Section 15, Colerain Township. This rolling topography is typical of glacial till or gravelly till of great depth. Probably bed rock at all places is 100 feet or more below the surface. Excavations in low places may be expected persistently too wet for occupation.

C.—Southward across rolling hills of thick Wisconsin till of the Lowland, to the high rock hills at the margin of the Allegheny Plateau in northeast part of Section 25, Green Township. Hill on left is Job's Knob. Three heads of Walnut Creek rise in the low gaps between and on either side of these knobs, and flow southward into the Plateau. This shows the ease of passage from the Lowland into the hilly Plateau.

LOWLAND OF THE NORTHEASTERN PART OF THE QUADRANGLE the eastward. This is a fair index of the depth of ground water below the surface in the two districts

Ground water.—In the belt parallel to the Scioto River and from Hopetown northward, shallow wells even on the hills occasionally get water at from 10 to 20 feet and are said not to fail. This is exceptional, and it is commonly necessary to drill 60 feet on the hills before encountering a promising volume, and numerous wells stopped at this depth have since been sunk to 75 feet. Wells from 100 to 175 feet deep are not unusual. Lower down on the hill slopes the depth is less but even near the streams 40 feet may be necessary to secure water. Springs are not numerous. The records of these wells show sands often in considerable thickness and gravels with some clay. Along the western foot of these hills, where they border the Scioto Valley, a line of springs is found and wells are commonly very shallow, 10 to 20 feet.

In and around Kingston, under the influence of the shallow cover over the bed rock, wells commonly encounter permanent water at 10 to 20 feet even though it is on a hilltop. Over the low rolling drift hills northeastward and eastward to Whistler, permanent water is obtained on the highest hills at 40 feet, and at decreasing depths toward Kinnikinnick and Pikehole valley floors where heavy volumes of water are commonly obtained at 10 feet or less.

Southeast of these valleys, water is obtained on some of the high hills at 18 feet, but 30 to 40 feet is more usual. Springs are not uncommon on the lower slopes in the southern part near the rock hills of the Allegheny Plateau.

CONDITIONS AFFECTING CONSTRUCTION OF TRENCHES

From the foregoing it is evident that over all the hills of this subdivision, excepting the very few places where rock occurs at the surface, trenches would be constructed in unconsolidated gravels and sand, except as there is commonly 1 to 3 feet of clayey soil. In the bolder hills, near the Scioto River, the soil will frequently be found missing and the gravels very coarse and with small bowlders. Further, the deepest excavations now made in the construction of trench systems would very seldom encounter anything else except sand and gravel. In the valleys, the soil is deeper, and it is probable that at many places rifle trenches would not penetrate the soil and surface clay into the underlying gravels.

In the 2-mile-wide belt of hills paralleling the river, rifle pits and their accessory shallower excavations can be dug at almost any place on the uplands and middle slopes without danger of water, but the deeper cave shelters going to a depth of 30 feet very probably would be wet in occasional places even on the higher hills. Rifle pits along the western foot of these hills where they border the "River Road" will surely have water in them in spring, and in places, unless carefully selected, throughout the year; excavations of 15 feet are liable to have water in them at all times. In the broad valleys between the hills of this belt, probably water will not interfere with trenches except in winter and spring, but the deeper shell-proofs are almost certain to encounter water at any season.

In the more gently rolling hills eastward from the N. & W. railway, the ground water stands nearer the surface than in the hills to the westward. On most of the higher hills, rifle pits, it is believed, will be dry the year round, but at many places on the lower hill slopes it is certain that they will have water in them in the spring. For example, the graves in the cemetery on the hilltop southwest of Whistler are reported dry the year round, but in the two within 3 miles southwest of Hallsville, both within 20 to 40 feet above near-by streams, the graves are wet, that is, with standing water, in the spring. Shell-proofs between 30 and 40 feet deep, on the hills, are apt to encounter water at all times, and on the lower slopes are almost certain to.

Water occurs at shallow depths in the valleys of Kinnikinnick and Pikehole creeks; in the latter, especially, water would stand in the rifle trenches in some places at all times. Wells of strong volume are encountered at 10 feet or even less and numerous springs and boggy places an acre in extent never dry out, though the valley bottom is well ditched and tiled.

Of the few known localities where rock occurs near the surface, the only one of practical significance is in the hill on which Kingston stands. The western portion of the hill is underlain by the Berea Grit at an altitude of about 790 feet, and the underlying soft Bedford shale is at shallow depths under the town to the westward. The Berea, though it has not been seen owing to lack of present outcrops, it is confidently believed, does not exceed 8 feet in thickness, as against 30 feet west of the Scioto, and is composed of less massive beds, with more shale. Such is its character just west of Sugar Loaf knob. How far eastward the Berea underlies this hill is not known, possibly not beyond the center of Section 3. The shallow depth at which all wells in the town obtain abundant water, 10 to 20 feet, shows what may be expected in trenches.

MATERIALS FOR CONSTRUCTION

Stone.—There is no stone within this subdivision of value for construction. The Berea Grit at Kingston is, as just intimated, almost certainly thin, and in courses probably ranging between 2 and 10 inches.

Gravel.—The gravels of the subdivision are excellent for ordinary road metal. They are limestone gravels with a moderate percentage of harder pebbles and a small and, for this purpose, negligible amount of sandstone and shale. They are so universally present that localities need not be cited.

A.—View north to head of Walnut Creek; from center of Section 22, Colerain Township, where Walnut Creek enters the high Allegheny Plateau. The distant hills in the Interior Lowland are of bowlder clay, the Late Wisconsin terminal moraine; hill on left is at side of valley on margin of Allegheny Plateau, where creek flows from Lowland to Plateau.

B.—View north to broad, open gap at head of Dry Run. Section 35, Green Township. Hays Hill on left. Road typical of this division.

C.—View northwest, gap at head of Dry Run, Section 3, Springfield Township.

D.—One of the higher, narrower gaps at head of Lick Run, east of Bunker Hill.

PASSES FROM THE INTERIOR LOWLAND THROUGH THE KNOBS EAST OF CAMP SHERMAN. SEE ALSO PLATE XVII, C.

As a result of the shale and sandstone pebbles present, the gravel derived from the hill banks is not good for concrete roads. The sandstone was derived chiefly from the Berea, and its pebbles are fairly hard, but if exposed to the abrasion on the surface of a concrete road, would quickly wear out, leaving a hole. This is even more true of the shale pebbles. These were derived from the black, slaty Ohio shale and as they occur in the gravel, are round or flat pieces, often several inches across, much inclined to split into thin blades as a result of weathering. When these gravels have been washed some distance along a stream bed, the shale fragments may be practically absent as a result of attrition, except in small sizes of a fraction of an inch, and in this form the gravels are much more satisfactory and have been used from Kinnikinnick Creek by the State Highway Commission to some extent for concrete foundation for brick roadways.

For concrete in which strength is desired, most of the bank gravels are not of the best because of the thin blades of Ohio shale which, in a concrete mass are almost the equivalent of as many voids of the same size and shape. Some gravels, such as that from the Scioto Traction Company's bank at Kinnikinnick, are very poor for concrete on this account. Washing very materially improves the quality by removing entirely the more decayed fragments and reducing the larger ones. The bank gravels have been used locally for concrete making.

The small bank 1½ miles southwest of Kingston, S. W. quarter of Section 5, Green Township, is one of the best in the matter of slate and sandstone pebbles, that has been examined in the district. It is a kame gravel, however, and pockets of excellently assorted gravel are intimately associated with irregular beds and masses of bowlder clay which must be kept out of concrete. As a result, it may be operated by hand loading, but could not be operated by steam shovel. This gravel, it is believed, if properly selected in the bank, would prove thoroughly satisfactory for concrete.

There is reason to believe that the pronounced hills of the 2-mile-wide kame belt on the west afford the best gravels, though it has seldom been possible to examine them, due to lack of openings. The very prominent group of gravel hills in the western half of Section 29, Green Township, is suggested as a likely place for prospecting.

FOREST CONDITIONS

No extensive forests occur in this subdivision. There yet remain occasional wood-lots, commonly about 20 acres in extent. These are invariably so scattered and small that they are useless as a screen for maneuvering or concealing large bodies of men, as forests have repeatedly served in important engagements in the European war. They are more thickly scattered 2½ miles west-southwest of Kingston; within 1 to 2 miles southeast of Kingston; within a mile north of Sugar Loaf;

within a mile northwest of Hallsville; and on both sides of the road from Whistler northwest to Oak Grove School.

In these small groves are usually preserved fair stands of oak, chiefly white oak, with numerous ash, hickory, maple, and walnut trees, varying in size from 10 inches to 2 feet and usually with considerable undergrowth. The group northwest of Whistler is probably the most extensive of all.

TRANSPORTATION

The chief roads in the subdivision spread fanwise northward from a center at Hopetown; from Hopetown to Chillicothe all road traffic is carried on one pike so that the Bridge Street bridge at Chillicothe is the real focus. From Hopetown northward and northeastward, between the Scioto River and Kingston, there is a moderate amount of divergence in roads that serve the countryside northward and from Columbus east to Lancaster and Zanesville. At Hopetown and again $3\frac{1}{4}$ miles north thereof, roads diverge sharply eastward, slightly northeastward, toward Adelphi and Laurelville, along the northern foot of the Allegheny Plateau.

As a result of this distribution, the transportation of the subdivision falls into two parts that are almost coincident with the two chief topographic subdivisions.

Near the Scioto River, and as far back from it as Kingston, the chief transportation lines, including the railroad and electric line, run north and south. This includes the 2-mile-wide belt of hills with a north-south trend, but the routes, while facilitated by this topographic trend, are not determined by it in any sense. The east-west routes in this section are far less important and proportionately poorer.

Eastward from Kingston two chief roads, with several less prominent roads, run east and west, and the roads running from north to south are narrower, poorer, and badly connected. A railroad, now dismantled, once operated from Kingston southeastward to Hallsville and thence northeastward along the margin of Pikehole Valley to Adelphi. The grade yet remains though the bridges, trestles, and track are all removed. In the event of movements of large bodies of troops southward from the plains into the plateau or in the opposite direction, the chief roads of the region would all pour their traffic directly into the narrow funnel north of Chillicothe with its throat at the Bridge Street bridge. Not only these but all other north-south roads are irregularly and inconveniently distributed to serve readily the roads leading southward through the passes into the Allegheny Plateau, described in the following chapter, yet these would materially supplement the Scioto Valley roads. The deficiency in road across Pikehole Creek is inherited from the days when it was an undrained marsh.

The notes given below probably do not cover all the roads but will partially supplement and correct the Camp Sherman topographic sheet.

The following roads are wide enough to accommodate two columns of troops or two trains and are adequately piked:

The River Road, running due northward along the east side of the Scioto Valley.

The pike from Hopetown to Kingston and then northwest and north to Circleville.

The pike from Kingston northeast to Lancaster.

The County Line Pike, except for occasional narrow bridges and fills, and its continuation to Whistler.

The Circleville-Adelphi Pike, some narrow places.

The Chillicothe-Adelphi Pike, from Kinnikinnick to Hallsville to Adelphi. There are a number of short stretches with narrow grade.

Road from Whistler south to Hallsville, narrow in places.

All other roads are sufficiently wide for a single column or train. Most of them are graveled, but with foundation inadequate to withstand prolonged heavy traffic. Exceptions to this, and other facts, follow:

The road from one-fourth mile south of Kinnikinnick west to the River Road, does not exist.

Road northwest from Kinnikinnick is but little used, a grassy lane.

The small section of road, one-half mile due south of Kingston, running west for a scant half mile from B. M. 778 to road from Courtright, does not exist.

Road 1 mile east of Kingston running north-south on line between Sections 2 and 3, is not open, unimproved.

Road $3\frac{1}{2}$ miles east of Kingston running south from Section 31 to north part of Section 7, unimproved, little used.

Southeast of Kingston 4 miles, the northerly of two roads running east and northeast from the eastern part of Section 23 to the north center of Section 24 is abandoned.

Southeast of Kingston 3 to 4 miles, north-south road in Section 23, poor and little used.

Southeast of Kingston $4\frac{1}{2}$ miles, north-south road in Section 18, fair but little used, grassy.

All roads north of Chillicothe-Hallsville Pike, between Hallsville and north-south road in center of Section 2, Colerain Township, are very poor lanes.

Road south, in center Section 21, Colerain Township, dirt road.

The road which branches off of the main pike to the northeast at the Scioto River bridge, Chillicothe, past the rifle range, is continued on the topographic sheet, as a lane for half a mile north of Bunker Hill. As a matter of fact it is continued as a good dirt road through the low gap between Bald Hill and Sugar Loaf, connecting at B. M. 818, Section 33, Green Township, with the irregular road running northeast and 1 to 2 miles south of the Chillicothe-Adelphi Pike. In places it is broad and surfaced with limestone. This is the old "Marietta Road", and is yet open. Though lying outside the area, it might be an important link in its transportation.

A.—View northeast up Dry Run Valley, Section 14, Springfield Township. Open flood plain, bordered by low, unforested, dissected shale terraces, with the steep wooded slopes of the shale-sandstone hills behind them.

B.—View north across the dissected Illinoian gravel terrace of Lick Run to Rocky Knob. The terraces at the foot of Rocky Knob, showing as snow slopes at a slightly higher level, are in part cut in shale. The lower slopes of the knobs are soft clay shale, the upper of tough sandstone.

C.—View northwest from Sand Hill road, Bald Hill on right, the Interior Lowland in distant center, the Scioto trench in distant left but not distinguishable.

THE KNOBS EAST OF CAMP SHERMAN. SEE ALSO PLATES I, XI, XII-C, XVII-C, XVIII, AND XX-A.

CHAPTER XII

THE KNOBS EAST OF CAMP SHERMAN

This subdivision is a quadrangular area lying nearly east and west (slightly northeast, southwest), 7 miles long and 4 miles wide. The western end of this quadrangle is the group of knobs from Mount Logan north to Sugar Loaf, which overlooks Camp Sherman. It is bounded on the east by a line that extends from the head of Little Walnut Creek across a low divide into Walnut Creek.

TOPOGRAPHY

Knobs.—This subdivision has the greatest relief of any part of the Camp Sherman region. It is distinguished by knobs, some of them isolated, others grouped into short ranges. The last is particularly true of the western half where the hills are highest, the relief greatest, and the general aspect is roughest. Mount Logan rises something over 680 feet above the Scioto River at its foot, and the top of Rocky Knob is some 50 or 60 feet higher than Mount Logan. Almost without exception these knobs have steep, forested slopes. Their tops are small and abruptly rounded, or, if ridge-like, a succession of such tops connected by a narrow, sharp-crested divide. The group extending from Rocky Knob north to Bald Hill, 2 miles in length, is the only one of which the top has sufficient area to be cultivated or occupied. (See Plates 1, 11, 12 C, 17 C, 18, 19, and 20 A.)

Valleys.—The valleys which drain the subdivision are all small; with numerous tributaries, they head along the extreme northern margin, mostly on the south slope of the moraine which abuts against these hills on the north, and run off southward, converging slightly toward the medial one, which is the nearly north-south valley of Dry Run. The head of Little Walnut Creek is actually outside the northern margin of the plateau. The two heads of Dry Run are practically at its northern margin; the divide of one is so low that it is inappreciable, and of the other so low as to be in no way an impediment to road traffic. In addition, many of the smaller tributaries head in low gaps, so that there are seven well-defined passes along the northern margin and two poorer ones. These passes or gaps are shown in Plate 18 and also in 17 C.

These valleys have narrow flat bottoms seldom over 100 yards in width. They are bordered by low foot hills on either side which rise with moderately steep slopes 150 to 200 feet above the narrow floors, the dissected remnants of what was at one time a series of terraces at about 860 feet. These low hills are largely cleared and farmed. From them rise the knobs. As a result, though the valleys are narrow, it is only in places, usually near the heads, that the high knobs close in sufficiently to constitute the immediate valley walls. A typical valley is shown in Plate 19 A.

Streams.—Four small streams, with their tributaries, drain this subdivision. Of these, the portion of Dry Run within the subdivision, as its name implies, is apt to be dry during the late summer and autumn months, though water exists in the gravels beneath its channel. The others appear to be permanent. The channels of all are shallow, cut 4 to 5 feet in the stream wash which composes the flood plain. The channels of the larger tributaries heading on steep slopes may be as much as 8 or 10 feet deep.

The valleys of all four are bordered by steep slopes at practically all places and run-off is rapid. The bottoms of all are flooded by storms which endure only a few hours and the rise and fall are rapid. Walnut Creek, the largest, may be expected to flood its bottoms once or twice yearly, chiefly in spring.

GEOLOGY

The geology, in so far as it bears on possible military occupation, is simple. Only the formations of importance are listed in this connection.

Bed rock formations

Berea Grit.—On the slope toward the Scioto the Berea Grit is present at about 800 feet, and, in part, forms the prominent rock terrace at 840 to 860 feet just back of Hopetown and again at the foot of Sugar Loaf. The slopes below this are composed of Bedford and Ohio shales except as they are drift-covered near Dry Run. (See Plate 12 C.)

Cuyahoga formation.—The lower slopes of the hills overlooking the Scioto River, from the Berea up to an altitude of about 1,100 or 1,120 feet, are formed chiefly by the moderately soft, easily disintegrating clay shales of the Cuyahoga. From the Scioto east to Walnut Creek the whole of the lower slopes are of Cuyahoga shale, from about 1,100 feet downward to the valley bottoms.

Logan formation.—The upper slopes of the knobs are composed of 150 to 250 feet of Logan sandstones, mostly fine-grained, rather soft, but tough and resistant, with some shales. The knobs are really due to the resistance of these beds to erosion, and the upper slopes without exception are very steep because of this underlying formation. It very seldom, however, forms low cliffs, no matter how steep and debris-covered the slopes may be.

Coal Measures.—The very tops of a few of the highest knobs are formed of the coarse sandstones and conglomerates of the basal member of the Coal Measures. The only occurrences of importance are on the irregular ridge top extending from Sand Hill southward to Rocky Knob and on the spur toward Bunker Hill. It here forms discontinuous ledges, usually 5 to 10 feet high, but attaining 30 feet on Rocky Knob.

Drift or mantle rock formations

Illinoian gravels.—The next regional subdivision to the southward is made up largely of great, dissected terraces of Illinoian gravel with their greatest altitude at about 860 feet. The upper surface grades into that of the shale terraces in the Knob area, which also rise to about 860 feet, and it is impractical to attempt to distinguish the two by their topography. Indeed, the shale terraces commonly carry a sufficient amount of pebbly material on them to frequently make their distinction by any means difficult. There is, however, one large portion of the Knob area in which these terraces are largely made up of Illinoian gravels, a continuation of the deposits next southward. This is on Walnut Creek above Tucson and extending over the low divide between it and Little Walnut Creek.

The Illinoian gravels and sands are distinguished by their reddish-brown color, by their high content of clay, by the low percentage of or absence of limestone pebbles, and by the high percentage of pebbles of resistant rock, chiefly chert. Though occasionally cemented to form conglomerates, they are usually only slightly so, and may in places readily be eroded into gullies. They exercise a noteworthy control on the ground water and distribution of springs. Cuyahoga shale in places forms the backbone of these terraces.

Wisconsin gravels—These have been noted certainly in only one place, at the junction of the forks of Dry Run above Jarvis. Compared with the Illinoian gravels, they are fresh, gray, free of clay, and high in limestone pebbles. The accumulation is a very small one.

WATER

Streams.—This is outlined in the discussion of the topography.

Ground water.—Five influences, operating in as many different places, appear to control almost wholly the distribution of shallow ground water. Search for potable water at depths by deep drilling almost certainly will be unsuccessful.

1. Hillside and gully debris and valley filling

All the larger stream valleys are filled to an unknown, but probably not considerable depth by stream-washed and drifted debris. The streams do not flow on rock except where they impinge on their valley walls. The lower ends of all the larger tributary ravines and gullies are similarly filled. As habitation is almost wholly confined to the valleys, the majority of the inhabitants obtain their water supply from wells sunk in this material to depths of 10 to 40 feet. On the flat bottoms of the larger valleys, permanent water is usually obtained at depths of 10 to 15 feet. Where the slopes are steeper, as in the upper ends of these valleys, or on the moderately steep alluvial fans at the mouth of ravines, permanent water usually lies deeper, sometimes 30 to 40 feet below the surface. Though these wells may penetrate to a slight depth into the underlying shales, the true source apparently is the gravels. The water is commonly soft, occasionally with lime or iron.

Springs and seeps from this material, while not uncommon at the foot of slopes, are not much used.

On the whole, the body of water existing at depths of 10 to 20 feet below the narrow flat bottoms 1 or more miles below the valley heads is more reliable and "more permanent" than that obtained at greater depths near the valley heads. This narrow bottom is the chief factor in determining small camp sites in the subdivision.

2. Terrace gravels

Where the Illinoian terrace gravels attain a considerable thickness, springs are commonly found at the foot of the slopes and are the chief source of supply around Tucson, where there is a heavy outflow.

3. Coal Measures sandstone

On the irregular hilltop from Sand Hill southeastward to Rocky Knob, and on the spur extending southwestward toward Bunker Hill, these coarse sandstones absorb enough rainfall to maintain throughout the year a few springs at or near their base, and these have doubtless been a contributing factor to the habitation of this hilltop by a few families, the only one of the knobs which is permanently inhabited. The outflow, however, is scant in dry seasons, and at no time adequate to maintain a large body of men or animals.

4. Berea Grit

On the 840 to 860-foot terrace overlooking the Scioto River, a line of seeps and springs is found at the level of the top of the Berea Grit, tha is, at about 800 feet. North of Dry Run (emptying into the Scioto) the rocks are buried under considerable drift cover, but here also both springs and wells appear to be chiefly controlled by this influence, though the wells, commonly 25 to 30 feet deep, do not encounter rock and the springs may emerge on Sunbury shale, which lies next above the Berea.

5. Logan sandstones and Cuyahoga shales

Apparently these are a very meager source of ground water. They must, however, slowly feed out considerable amounts that are concentrated in the valley wash below in bodies that are of a size to be usable.

CONDITIONS AFFECTING EXCAVATIONS

On the terrace overlooking the Scioto, the Berea occurs where the gently sloping or rolling uplands blend into the steep lower slopes. The cover of shales over the Berea is sufficient, and the slope upward from the outcrop of the Berea such that trench excavations would encounter it only on the immediate brow of the hill. Similarly, it appears that there would be no undue amount of water in the trenches, unless locally at the immediate brink, though it should be expected in deeper excavation.

Excavation on the tops of all the high knobs obviously must encounter the tough Logan, or on the very top of a few, the coarse, massive, Coal Measures sandstones, both difficult of excavation. It would be rash to order entrenchment in the Logan with picks and shovels, unless there be 12 to 20 hours in which to accomplish it. The Coal Measures sandstone would require blasting. On the river hills, 1,100 to 1,120 feet, appears to be the lower limit of the sandstones, and farther east it descends somewhat, though little. The excavations will be quite permanent. Water appears to offer no difficulty here.

The lower slopes below the 1,100-foot contour are composed of soft clayey shales, except as occasional sandstone beds up to 1 foot may be encountered. Over considerable portions the debris of hillside wash is probably so thick that the shales would not be encountered except in the deeper excavations. In either case the material will be found soft and slippery when wet.

The valley bottoms below the soil are composed largely of sandstone fragments imbedded in clay. Yet they are commonly tiled and excavations are apt to encounter water at slight depths except in the dry seasons.

On the single large area of Illinoian sands and gravels, excavation will be easy and dry, probably, at all seasons except near the foot of slopes. The sands are slightly cemented, but not enough to prevent rapid erosion in gullies. Trenches will require complete revetment and dugouts must be timbered.

ROCK MATERIALS FOR CONSTRUCTION

Stone.—The Berea Grit is the best source of stone for masonry. Small quarries were formerly operated in the head of the small ravine just back of Hopetown, and on the southeast slope of Bunker Hill. The former has less stripping and the quarry face is only 6 feet. In any case there will be much waste in the stone, in the form of small debris. These quarries would furnish a satisfactory material for the foundation of roads, though not for the surface. Blocks of a thickness exceeding 1 foot cannot be regularly obtained, and most of the output will be of lesser thickness.

The Coal Measures sandstones are almost surely satisfactory for masonry if care is used to avoid quarry sites where there are pebbles of rotten chert in the rock. Probably blocks up to 2 feet in thickness or more could be obtained. But the hilltops are much too inaccessible for extensive quarrying. The Sand Hill and the hill south are the only ones where road transportation is, or could be readily developed.

Gravel.—Gravels occur in the Scioto Valley next west of this subdivision and in the subdivision to the northward, though of poor quality. Within the boundaries of the subdivision only a single gravel deposit has been observed, and it very small, of a quality really satisfactory for road material. It is too high in slate fragments to be satisfactory for concrete. This is in the angle at the junction of the forks of Dry Run, one-third mile above Jarvis. It is possible that other similar accumulations may be found above or below it and on Dry Run but they cannot be extensive. The Illinoian gravels and sands are too high in clay and limonitic dust to be of use. The stream gravels in every case are sandstone gravels.

FOREST CONDITIONS

Distribution.—Forest distribution depends directly on topography. Slopes that are too steep for farming are almost without exception covered with some form of forest cover; this includes practically all the steep slopes above the 900-foot contour. A few only are notably bare, as the north end of Bunker Hill and Job's Knob in the northeast corner, Section 25, Green Township. Hilltops, when flat enough, are farmed, as is the most of the ridge top from Sand Hill south nearly to Rocky Knob, and the tops of Bald and Bunker hills. These are almost the only ones that are bare. Hardwood only obtains, except for occasional, widely scattered, small pines.

Cover.—Though covering without break irregular areas of a square mile or more, use of the forests as cover for maneuvers is rendered difficult by the steep slopes and the general presence of underbrush, commonly enough to impede progress on foot. The topography prohibits its use as cover for camps. Every road in the subdivision is so far free of such protection as to be virtually subject to complete aerial observation.

Material for construction.—The forests of the subdivision constitute the largest source of timber near Camp Sherman. It is impossible to describe where various materials may be obtained because, first, the subdivision, for lack of time, has not been examined in detail, and, second, because large areas of the forested slopes are unfenced, hence cannot be readily bounded, and the various growths shade into each other.

But little large timber yet remains, and some of that is being cut under the stimulus of the present great demand. None of it is the original stand. Scattered fair trees of white oak, chestnut, elm, hickory, and maple occur on both sides of Mount Logan. On the northeast slope of Bald Hill there is a stand of several acres of maple, ash, and walnut, some basswood, trees up to 18 inches in diameter. Doubtless other small patches exist. There probably is not as much actual timber in the subdivision as is to be found in the scattered wood lots of the rolling plains to the northward.

White oak and hickory and inferior oaks, maple, ash, and elm, of a size to make one or two ties at the butt and sometimes four, are not infrequently found in patches and scattered on the lower slopes; and everywhere over the upper and lower slopes, trees of a size to make posts. The middle and lower slopes commonly carry a moderate undergrowth of young shoots of a size to make woven revetments. A heavy growth of such small poles was noted in the low gap at a little over 900 feet southeast of Mount Eyes.

Oaks and hickories are the dominant trees of the region. The white oak is usually found on the lower slopes only, and the hilltops carry a growth of scrubby rock-chestnut-oaks of post size. Chestnut is practically absent.

TRANSPORTATION

Transportation routes through this subdivision are almost wholly along north-south lines, following the streams, and as there are no divides of any consequence, it is possible to pass quite through it along several routes, unimpeded by grades. Like the streams, they converge southward. There are several roads that run by steep grades from the Scioto eastward across the high hills adjacent to the valley, but transportation in the east-west direction elsewhere is difficult. Any such goes to the east-west roads lying to the northward or southward outside the subdivision.

The roads are poor. None of them are wide enough for more than one column and none of them are graveled throughout. In winter they are likely to be heavy. The ones indicated as by-roads on the map are apt to be almost impassable because of briars and bushes. Several of the short east-west roads are very poor, so that travel in this direction is even more obstructed than appears from inspection of the map. The one through the south part of Section 10, Springfield Township, is of this sort; also the one running west from Tucson through the southern part of Section 8, Harrison Township.

At least one important road, not much used but almost as good as a pike, is not represented on the map, the old "Marietta Pike". It follows the road through the center of Section 5, Springfield Township, which is indicated on the map as a lane, and is continued through the gap south of Sugar Loaf to the lane in the center of Section 33, Green Township.

There are several foot paths. At least one of these is convenient from the lane in the western half of Section 8, Springfield Township, through the gap between Bunker Hill and Mount Eyes to the head of Lick Run. Foot paths of some degree of usability exist along the tops of most of the ridges that have any length at all.

CHAPTER XIII

THE GREAT GRAVEL TERRACES SOUTHEAST OF CHILLICOTHE

This subdivision consists of two parts. First, a triangular area with its base, 6 miles long, resting on the Scioto Valley and its apex at Tucson; the east side is at the foot of the high hills which form the east wall of Walnut Creek Valley, including Rattlesnake Knob (at Smith's store), and the north side lies at the foot of the high knobs of Springfield Township; the area of this portion is about 18 square miles. Second, from the southern corner of the triangle an old abandoned valley, 1½ to 2 miles wide, extends eastward for about 6 miles to beyond Londonderry, with an area of about 10 square miles; it is partially filled with gravel and the streams which now flow across it, Walnut and Salt creeks, have no relation to the one which formed it long ago.

TOPOGRAPHY

Hills.—These are a series of four gravel terraces each more or less distinct. The highest rises to altitudes of 860 to 880 feet, 300 feet above the Scioto River; it occurs farthest from the Scioto along the northern margin of the subdivision, at the foot of the high knobs of the next subdivision to the northward, and passes up into the valleys between these knobs. It is almost completely dissected by stream gullies to a depth of 120 to 200 feet and only small irregular remnants of the original flat upland surface remain, which, however, slope distinctly to the southward. These terraces are shown in Plates 11 A, 19 B, and 20.

The middle terrace is highest at the north, where, north of Mt. Carmel Church, its surface lies at about 760 feet; from there it slopes southward to about 700 feet at the B. & O. railroad, and to 680 feet near Londonderry, or to about 120 feet above the Scioto River. It is dissected by a number of long shallow gullies, 40 to 60 feet deep, with broad expanses of the undissected flat terrace surface between. This surface is the locus of one of the finest farming districts in the quadrangle.

The two lowest terraces, really one subdivision, border the Scioto River, one at about 660 to 680 feet, the other at 620 to 640 feet; to the southeastward they practically merge into one. These terraces are fresh and undissected except for short steep gullies along the terrace faces. The former is shown in Plate 12 A and B.

Drainage.—Drainage is by Lick Run, Dry Run, Walnut Creek, and Salt Creek, the last in the extreme southeast corner of the quadrangle. All flow southerly, the three last named in open flood plains one-third to one-half mile or more in width. All are permanent except that Dry Run below the Londonderry Pike, in dry seasons, is a bed of sand and gravel. Depth of valley varies, depending on which of the terraces it is cut in. The valley of Lick Run is cut entirely in the highest terrace and is from 140 to 160 feet deep. Dry Run Valley in the northern third of this subdivision is cut 150 feet deep in the highest terrace, the middle third, cut in the middle terrace, is 40 to 70 feet deep, and the southern end, cut in the lowest terrace, is very shallow. Walnut Creek is similar to Dry Run except that for 2 miles behind Rattlesnake Knob it flows in a deep, rock-walled valley.

The stream channels are shallow, of Lick Run and Dry Run about 3 feet and of Walnut Creek about 5 feet deep.

GEOLOGY

Glacial gravels.—The geology is simple. The terraces are composed of stratified gravels which have been partially dissected since their deposition.

The two oldest terraces, that is, the highest and middle ones, are composed of Illinoian gravels and sands,[1] largely red or brownish in color, high in chert and other resistant pebbles, and low in limestone pebbles, which have probably largely been leached or silicified in the course of time, and high in clay as a result of long weathering and disintegration of the non-resistant pebbles. In many places beds of dense, fine, sticky, gray, water-laid clay are interbedded, usually rather deeply below the surface. The surface, particularly of the upper terrace, has a thick, reddish, loamy clay soil. In places on the middle terrace it can be shown that the reddish-brown color is restricted to the upper 10 to 25 feet and the clays and gravels below that are blue-gray in color; the depth of the reddish color here shows the depth to which weathering in the form of oxidation has been carried. This zone is yet thicker on the upper terrace. Many of the older gravels are very coarse, with egg-sized pebbles and larger, and some up to 1 foot or more have been seen. The coarser gravels, as a rule, are found well below the surface of the terrace.

The low terraces bordering the river are composed entirely of gray, river-laid gravels and sands, the latter frequently yellowish but never, so far as noted, red. The zone at the top in which weathering is prominent is never thick, seldom more than a foot or two. These gravels and sands are much younger, of Late Wisconsin age. Most of the pebbles are limestone and chert pebbles are rare.

Both the Illinoian and Wisconsin gravels may be cemented into

[1]There may be some question as to the age of the middle terrace which is not nearly as dissected as the upper one, which needs not be discussed here. This phase is considered in the chapter on glacial formations.

A.—View westward from the northeast corner Section 22, Springfield Township. On right, Mounts Logan and Eyes, rock hills. At their foot, sloping from them to the distant left, and in the foreground, are remnants of the Illinoian gravel terrace, dissected by Lick Run and its tributaries. These gravels are deeply weathered and clayey soils 25 feet thick may be expected.

B.—View eastward from the northeast corner Section 21, Springfield Township, across the maturely dissected Illinoian gravel terrace, to the distant rock hills of the eastern part of the quadrangle.

GREAT GRAVEL TERRACES SOUTHEAST OF CHILLICOTHE. SEE ALSO PLATE XII-B.

conglomerates. This is a phenomenon of depth solely, and is apparently found only where the beds are at least 30 or 40 feet below the surface. However, by no means all of the gravels at these or greater depths are cemented, in fact cementation appears to be rather exceptional.

Bed rock formations.—At several localities small areas of the bed rock come to the surface and even form low hills above it. Their location can be seen from the accompanying geological map. These are entirely of Cuyahoga shale, a rather soft, clay shale, with enough thin sandstone that the debris of the latter is prominent.

Probably the Cuyahoga shale lies but a short distance below the surface in many places. It probably forms the backbone of the point between Walnut and Little Walnut creeks, and again between Little Walnut and Dry Run.

The maximum depth of the gravels is unknown. Between Lick Run and the Scioto River, it certainly attains 140 feet with no rock, as shown by the ravines which dissect the upper terrace. No wells so far as they are known have approached this depth, though they commonly penetrate 60 or even 100 feet.

WATER

Streams.—This is one of the most abundantly watered subdivisions of the quadrangle. Besides the permanent streams mentioned above, Lick Run, Dry Run, Walnut and Salt creeks, there are numerous small streams which are fed by unfailing springs. There are peculiarities in behavior. For example, the small ravine with the lane in Section 27, Springfield Township, is dry except after rains, while the next one to the northwest has a heavy permanent flow of water from springs. In this case the first mentioned has much more sand poured into the stream, perhaps because of a difference in the amount of dissection and the character of the farming, and the flow of water is below these sands. The one to the northwestward has no such sand filling in its channel and is in the first deeply cut valley south of the rock hills.

Ground water.—Springs are abundant, and many of them are remarkably strong. Wherever valleys or large gullies have been cut well below the surface of either the middle or upper terrace, springs are apt to be present near the foot of the valley slopes. Since no such valleys are cut in the lowest or Wisconsin terraces, they are not present to such an extent there. The gravel and sand composition of the terraces is the cause for the absorption and storage of a large proportion of the water falling on the subdivision. This finds its way out at the foot of slopes bordering the deeper stream valleys unless, as is common, there are beds of clay in the sands which cause the water to emerge higher. There are many springs which are located 10 or 20 feet up the slopes for this reason.

On the highest terrace, that is, with surface at 800 to 860 feet, wells are commonly sunk 60 to 80 feet to obtain water, but a good supply is almost always the result.

On the middle terrace, water is obtained at considerably less depths, from 15 to 25 or 35 feet, the last two being the more usual figures.

CONDITIONS AFFECTING EXCAVATIONS

All ordinary trench excavations on the surface of the highest and middle terraces will be in a reddish or yellowish loamy pebbly clay, not, it is believed, tough to dig. Probably at no place on the original upland surface will true gravels be encountered, but where excavations are made in much dissected portions, they may be met. The excavations will be dry at all seasons, except for the moisture from immediate rains, and will fall in rapidly unless protected. The clay-soil coat is commonly 10 or 12 feet thick. In the places where Cuyahoga shale is indicated on the accompanying geological map, excavation will be in clay shale with thin tough sandstones. Troops cannot be expected to dig in with intrenching tools on these last areas, unless much more time is allowed.

Excavations made on the slopes of stream valleys are certain to encounter these clay soils in much less thickness, and sands, gravels, and tough sticky blue clays very difficult to dig are almost certain to be met. In every case these gravels and sands are not of the sort to cave badly, though excavations should be protected against it. The cemented gravels, which occasionally are found on the lower slopes, will yield with difficulty only to the pick, and should be avoided. Trouble may be anticipated from water on all lower slopes, and judgment must be used.

Excavations in the two lower terraces and valley bottoms will encounter far less soil, and probably at most places will meet the gravels at less than 3 feet. The gravels at the surface are not at all consolidated and will cave quickly. Water may be encountered anywhere below 15 feet.

There are interbedded in the gravels of the middle terrace, beds of lake clay, tough, wet, sticky. The pick may be easily driven into this, and can then be extracted only with patience and at the cost of loosened and possibly broken pick handles. Though exceedingly difficult to excavate, these will, as long as wet, flow and cave slowly and excavation in these clays, or under them, should be avoided if possible. It is improbable that they will be encountered in rifle trenches anywhere on the uplands, though in any excavation beyond 15 feet they are apt to be met. On the slopes of the small valleys which dissect the terraces, they are certain to be met in the central and eastern portions of the subdivision; they are practically absent from the hills along the Scioto River.

As long as tunnels in the middle terrace are kept to the gravels and beds with considerable residual clay content, their excavation is the usual problem of gravels, somewhat lightened by a slight cementation; excavation will be easy and maintenance of the tunnel a matter of timbering. But if tunneling is attempted in connection with any of the beds of lake clay, special problems must be met. It is exceedingly difficult to dig, and creeps slowly under slight load.

Tunneling in the lower Wisconsin terraces bordering the Scioto will encounter only sands and gravels, unconsolidated except in a few places.

Depths at which water-bearing gravels may be expected are indicated approximately by the depths to ground water given above, but will fluctuate with the seasons.

MATERIALS FOR CONSTRUCTION

Stone.—No stone suitable for construction exists in the subdivision.

Gravel.—The Wisconsin gravels in the terraces next the Scioto River are the best available supply. They are excellent for road material, but not wholly satisfactory for concrete because of the fragments of Ohio shale in them. A large pit has been opened by the Baltimore & Ohio Railroad just west of Dry Run. In certain layers there are large slabs of Ohio shale which are too much decayed and too fragile to be successfully eliminated in whole from the product. In addition there is much small material of the same sort scattered through it. The result, when used for concrete, may be seen in near-by Baltimore & Ohio Railroad concrete bridge abutments, of which the surface is pitted with scattered holes up to 1 or 2 inches in diameter where shale fragments have weathered out. The output could undoubtedly be much improved by washing.

An old pit at Peppers, on the south line of the quadrangle, was too badly tumbled in for satisfactory examination, but the gravel appears to be unusually free of shale fragments.

On the whole, the older gravels of the middle and upper terraces may be regarded as unavailable for concrete material. They are frequently high in sandstone pebbles, usually in clay, and are apt to have their pebbles and grains coated with limonitic dust. In places, however, poor outcrops have been seen of beds that promise an excellent quality of gravel if the clay content is not too high. These were particularly noted in the railroad cut 1 mile northwest of Schooley. It is possible that the overlying cover of sands, clays, and soils would prohibit the working of the gravel even if it proved satisfactory. It is free of shale pebbles and low in sandstone.

Creek gravels are poor in every case. All are too high in sandstone, some of them estimated 75 per cent, and Lick Run gravel is very high in black shale fragments. The sandstone fragments, moreover, were derived chiefly from the Logan and Coal Measures sandstones which are particularly weak in small fragments.

Sand.—The only large source of sand, requiring no screening, which has been noted, is in the Wisconsin terrace of this subdivision, one-fourth mile south of the Main Street Scioto River bridge, where pits may be opened, and in the bed of the streamlet flowing through the center of Section 27, Springfield Township.

FORESTS

There are no extensive patches of forest. Such forest cover as remains is chiefly controlled by the topography; over the steep sides of ravines and gullies and their narrow bottoms small trees have frequently been left standing and very commonly such slopes are badly grown up with underbrush. This is especially likely to be the case in the ravines of the highest terraces. Of the rectangular wood-lots of 10 to 20 acres, which are numerous in the northern third of the quadrangle, practically none remain. The flat lands of the middle and lower terraces are essentially clear of forest.

TRANSPORTATION

Transportation routes are fundamentally radial from Chillicothe. In the northern half of the triangular portion they are chiefly east-west in direction, where they pass around the southwestern end of the knobs, shifting to northerly to serve the valleys of the Walnut creeks. In the broad, abandoned valley and along the Scioto, it is northwest-southeasterly in response to these natural courses of travel. The Richmondale Pike, which follows the Scioto Valley, is ample for two columns, but the Londonderry and particularly the Adelphi Pike are narrow in places.

Transportation in the north-south direction is more restricted. The routes are lacking in continuity and the roads are poorer.

A single change only need be noted, but an important one. One-half the length of the short road at the mouth of Lick Run, which connects the Adelphi and Richmondale pikes, was washed away by the 1913 flood, and has never been reconstructed.

CHAPTER XIV

THE HILL COUNTRY OF THE EASTERN PART OF THE QUADRANGLE

This subdivision is remote from Camp Sherman and inaccessible, one in which military maneuvering would be difficult. Lack of time and resources have required the cutting short of the work at some quarter and it has seemed expedient that it should be at the expense of this subdivision. It has not been entered during the present work but the geology of it is known from earlier work.

The subdivision is trapezoidal in outline, comprises about 50 square miles and the longest side, 14 miles, is along the eastern margin of the quadrangle.

TOPOGRAPHY

The topography is the roughest of any part of the quadrangle, though the hills are not as high as elsewhere. The region is one in the complete stage of dissection. Streams have cut valleys into it, and their tributaries have cut ravines and gullies until no portion remains of the original upland which must have been present. There is a long, narrow, crooked, medial ridge or main divide lying roughly north and south, with numerous valleys heading against it and with many long, irregular, narrow, branch ridges ramifying outward from it between these valleys. The ridges are broken into a succession of distinct tops by shallow gaps but these seldom break the continuity seriously. The hills on the medial and branch ridges are of essentially the same height, except that those along the western margin rise somewhat the higher.

GEOLOGY

The geology is simple. The Cuyahoga shale forms the lower slopes at all places. Its upper limit is probably about 900 feet in the southeastern part and at about 1,050 to 1,100 along the western margin. It is a blue-gray clay shale, weathering rapidly to clay muds, with thin interbedded sandstones. Over this lies, the Logan formation, tough, gray or yellow sandstones. On the very tops of the hills, coarse Coal Measures sandstones are present in small amounts in a very few places.

There are no glacial gravels except along the borders. Along the northwest margin the Wisconsin gravel moraines lie against this subdivision. Where the valley of Walnut Creek lies against the western side, local deposits of Illinoian gravels may be expected like those which make up the west wall of the valley below Charleston.

WATER

Ground water.—No data have been obtained on ground water. It may be pointed out, however, that the bed rock geology is essentially the same as that of the knobs next to the westward, described in an earlier chapter, and the valley floors are covered with debris of local origin in the same way as in the Knob subdivision. A similar behavior of ground water in the valleys may be expected. For the most part, however, the debris cover on the valley floors is not as thick and the streams commonly flow on the Cuyahoga shale. The volume of available ground water may be expected proportionally less. On the slopes and hilltops, the supply of water at many places is precariously short in summer, and, on the whole, may be regarded as limited.

CONDITIONS AFFECTING EXCAVATIONS

This may be best inferred by reference to the effect of the Cuyahoga and Logan formations in the Knob subdivision next to the westward.

MATERIALS FOR CONSTRUCTION

Stone.—No stone is known which is satisfactory for construction work, and it is unlikely that any exists. The Logan formation, however, contains much that could readily be used if necessary. It can occasionally be seen in old chimneys and foundations where it has withstood the weather well. It is, however, an intractable sort of stone to work.

Gravel.—Within the entire subdivision there probably exists no deposit of gravel even good for road material. Such gravels occur immediately to the northward and perhaps just within the northern border. The creek gravels are all of sandstone fragments.

FOREST CONDITIONS

This is the most extensively forested subdivision of the Camp Sherman quadrangle. With the exception of an occasional tree, these are hardwood forests, with oaks and hickory dominant. It is probably safe to say that considerably more than nine-tenths of the hill slopes are forested or grown up to brush. In districts where farming is difficult, as it is in this, the timber crop is likely to be kept closely cut. There probably are no extensive bodies of timber, though small patches of moderate size and of tie material may be expected.

TRANSPORTATION

Roads, with few exceptions, are poor. There is only one that is a through route, the Adelphi Pike, which runs through the narrows of Walnut Creek, thereby avoiding grades. All others serve local communities only. Their general plan, like that of the drainage, is radial from the central ridge. It is a fair index of the roughness of the ridges, that few of the roads follow their tops; most of the inhabitants live in the valleys and the roads run up the valleys to their heads and then across the ridge by exceedingly steep grades to the heads of other valleys. Where they cross a ridge, they are apt to be very stony in the upper portion and rutted and washed throughout.

PART III

THE GEOLOGICAL FORMATIONS AND PHYSICAL HISTORY OF THE QUADRANGLE

CHAPTER XV

THE BED ROCK FORMATIONS

THE MISSISSIPPI BASIN AND ITS SEDIMENTS

The bed rocks of the Camp Sherman quadrangle are all of the sort known as sedimentary. They are sandstones or shales, and were formed first as deposits of sand or mud at a time when conditions were favorable in this area to receive such sediments. The same rock strata that occur in the quadrangle also extend for miles beyond its limits, and in order to understand these conditions, it is necessary to picture the whole of the Mississippi Basin, from the eastern margin of the Appalachian Mountains (and including them) westward to the Rockies and from Canada south to the Gulf, as a great shallow ocean basin, much like the present Hudson Bay. It was in this that these sediments accumulated, later to be hardened into rocks, during an exceedingly long period of time. The floor of the basin rose and sank from time to time, so that the water was now shallower, now deeper, and with this, shore conditions, with mud and sand might obtain at any place, to be succeeded with deepening water, by clear water and limestone formation. Sometimes it was quite dry, and again deltas spread across it. This resulted in a succession of deposits, various in character as the conditions surrounding their deposition changed. The sedimentary rocks laid down under any one of these conditions, during a definite period of time, are called a formation. Many formations were deposited each on top of the next older, to be covered in turn with a later one. In this way they accumulated to a thickness of several thousand feet.

After these had been compressed and consolidated into the rocks as they now occur, the whole basin was elevated to form land, accompanying the folding of the Appalachian Mountains. It then ceased (at least in Ohio and neighboring states) to be a basin of deposition and the rocks became subject to stream erosion. All the valleys of the region were formed by streams cutting downward in these rocks, and all of the outcrops are the result of erosion exposing the rocks to observation.

The period of sedimentation was very long, millions of years, and is called the Paleozoic Era. The conditions of erosion endured equally long and are comprised in what are known as the Mesozoic Era and Tertiary Period. In this chapter, are described the rocks themselves and their formation; in the succeeding chapter is described the history of their erosion.

ROCK STRUCTURE

When the region was uplifted to form land, the uplift was not uniform everywhere, hence the rocks at some places do not lie flat. Indeed, except a very few places, they are gently inclined. This is true in the Camp Sherman quadrangle. The rocks are inclined, or dip to the east-southeastward, and the slope, measured on one of the formations, the Berea Grit, is about 27 feet per mile on the average. The direction in which there is no dip, or the strike, in general is about 20 degrees east of north, but varies locally.

As a result the rocks occurring at any given altitude across the quadrangle differ from place to place. Older rocks will occur near the western margin and younger rocks near the eastern margin.

THE FORMATIONS

The bed rocks of the Camp Sherman quadrangle range in age from late Devonian to early Pennsylvanian. The mantle rocks, of which there is an unusual development, are Pleistocene and Recent, and are treated in another chapter.

The bed rock formations are as follows, the youngest at the top:

Pennsylvanian	
Pottsville sandstone	10 to 40 feet.
Mississippian	
Logan sandstone	275 feet.
Cuyahoga shale	35 to 450 feet.
Sunbury shale	15 to 25 feet.
Berea Grit	8 to 25 feet.
Bedford shale	85 to 90 feet.
Devonian	
Ohio shale	about 450 feet.

The Ohio shale

This is the oldest formation occurring at the surface in the Chillicothe quadrangle. It is a hard black shale which splits into thin plates and flakes on weathering but does not weather into a clay. It is locally called slate. It derives its black color from the large amount of carbonaceous material in it, sufficient that under favorable conditions accumulations of loose shale may take fire and burn for weeks; this gives rise to red banks which have by some been thought a possible source of the name of Paint Creek.

In the hills west of Frankfort, near the western margin of the quadrangle, a thickness of 360 feet of this formation is exposed. This includes almost the whole of its thickness and it seems unlikely that as much as 30 feet of the basal portion is below the level of North Fork. The formation is there probably between 380 and 400 feet thick. This estimate is based on the occurrence of limestone 70 feet below North Fork in the waterworks well at Bainbridge, or at about 650 A. T. Occasionally, also, concretions several feet in diameter occur imbedded in these shales, slightly above the bottom of the deepest stream valleys along the western margin of the quadrangle; these are present only near the bottom of the Ohio shale, and their exposure is further evidence that almost the whole formation is above drainage.

The dip of the rocks to the southeastward carries this formation so far underground that at Chillicothe only about 80 feet of the lower hill slopes is composed of Ohio shale, and east of Chillicothe, where the Scioto sweeps against the foot of Mount Logan, only 25 feet at the top of the formation remains above the river level.

The flowing well at the curb on South Paint Street, Chillicothe, opposite the paper mill, encountered the limestones below the Ohio shale at a depth of 409 feet, 44 feet of which (probably excessive) was attributed to the "Hamilton shale". This indicates that the Ohio shale at Chillicothe is at least 425 feet and possibly 445 feet in thickness.

One of the chief characteristics of this shale is the occurrence of marcasite (iron sulphide) in grains and small nodules throughout. This, together with the high content of carbonaceous matter, has given inception to chemical reactions that have mineralized the waters flowing through the shale at practically all places. Indeed, it is sometimes difficult to obtain water satisfactory for household purposes in the hills composed of these shales. The waters flowing from them are commonly high in iron and occasionally carry sulphuretted hydrogen, alum or other ingredients to such extent as to be unusable. When they carry magnesium sulphate or other salts of medicinal virtue, as do the springs north of Sulphur Lick and 7 or 8 miles northwest of Chillicothe, hotels and "lick" resorts are commonly developed around them. It is reported that in some places springs flowing from these shales have deposited travertine and limonite (hydrated iron oxide), the latter in the form of ochre. Probably these deposits, now largely removed, were the occasion for the naming of Paint Creek.

The Ohio shale gives rise to very poor soils. Often it does not maintain sufficient vegetation to prevent washing, and frequently the steeper slopes are bare of any vegetation except stunted rock-chestnut oaks.

Excavation in the material is not easy; the designation shale is apt to be misleading in this respect. It is tough and resistant, but will readily withstand the weather.

Bedford formation

This formation is about 85 feet thick. It occurs in full thickness in the east wall of the Scioto from Sugar Loaf south to Mount Logan but is not seen east of this because it is below the level of the streams. West of the Scioto it is found in all the rock hills except those bordering the Scioto near the south line of the quadrangle, where it is below drainage. Its thickness is about 85 feet and variation from this is surprisingly small.

The lower half consists of soft, gray, clay shales with perhaps three to five thin hard sandstones, 2 to 8 inches thick. Near the middle of the formation, sandstones a fraction of an inch thick appear, usually ripple-marked, and frequently occurring as 2-inch-wide lenses where the sandstone thins out in the troughs between ripples. These increase in numbers upward so that near the top the formation consists chiefly of rippled sandstones up to 1 or 2 inches thick with very little shale in the partings. The ripples trend northwest to southeast in every case, and this direction obtains without exception from the Ohio River to Lake Erie. It is clearly the result of parallelism to the shore line of that time, which probably lay to the northwestward.

One of the few fossil-bearing horizons of the region occurs in the basal 3 to 4 feet. This horizon carries a fairly abundant fauna from central Kentucky northward to Cleveland, but the bed is seldom exposed and then in steep walls, can only be collected when moderately damp, and on the whole is a very unsatisfactory source of fossils.

This formation is found in the upper part of the steep slopes, just below the flat uplands that characterize the region west of the Scioto. Though excavation is relatively easy in the lower half, any excavations are apt to cave in almost immediately. In the upper half such work will be much more difficult but more permanent. The occurrence of the formation is such, however, that extensive excavations in it are unlikely.

Berea Grit

This formation consists of blue-gray sandstones, hard and durable, and, from the military point of view, is the most important bed rock formation in the region.

The distribution is practically that outlined above for the Bedford formation. From Chillicothe westward it is about 25 feet thick, and, by its resistance to weathering and erosion, has given origin to the flat-topped plateaus which are the chief feature in the topography of that portion. It outcrops at the very top of the long steep slopes which descend from these plateaus, and the flat uplands are practically coincident with the top of the formation, except that soil covers it sufficiently that farming is not interfered with seriously by the Berea debris.

Farther south, in Huntington Township, where younger formations rest on the Berea, it gives rise to a broad, sloping upland bench that is the most prominent feature in the topography. Where the Berea has been removed, exposing the less resistant Bedford, the hills are rolling with many more small gullies, as in the hills 4 to 7 miles west and northwest of Camp Sherman.

On the east side of the Scioto River, the Berea occurs from Sugar Loaf south to Mount Logan, but its thickness is only about 8 feet. Formerly it was exposed and quarried at Kingston but no outcrop now exists. Even in this thickness, the Berea is the chief cause of the rock terraces at 840 to 880 feet back of Hopetown and at the foot of Sugar Loaf.

Along the west side of the Scioto River, southeast of Chillicothe, the Berea is of even lesser thickness, from 2 to 4 feet, commonly consists of two or three thin courses of sandstone with shale beds, and exercises no influence on topography. It is only a few feet above the level of the N. & W. railway tracks and at the mouth of Stony Creek is below the level of the tracks.

The lower half or more of the Berea is of exactly the same character as the upper half of the Bedford, except that the sandstone beds are thicker and more numerous, commonly up to 1 foot. The sandstones are similarly rippled and the ripple direction is the same. Nevertheless the base of the Berea is a sufficiently distinct horizon that it may, on any outcrop, be easily established to within a very few inches. Where the usual thickness of about 25 feet is present, the upper 10 or 12 feet is practically continuous sandstone, but with unrippled bedding planes at intervals of a few inches or a foot. The beds in the lower half are frequently contorted and rolled, in which condition there is much variation in thickness of the bed and it does not admit of working as do the undisturbed beds, though just as hard and durable; this is the form known to quarrymen as "nigger head". It is only found in those portions which have, or originally had, shale beds or partings.

The Berea Grit was formerly extensively quarried at numerous localities from the Ohio River to Cleveland. With the decline in use of stone for building and structural purposes most of these places have ceased to produce. It was once quarried near Chillicothe in a fairly large way for stone for local use. This is treated in detail under constructional materials, and it is sufficient to add here that the stone was very durable and strong. It may be seen in numerous old buildings and stone walls, gutters, curbs, canal locks, etc., around Chillicothe. It has two defects. It is of such hardness and is possessed of so distinct a reed or texture causing it to split parallel to the bedding, that it was of little use when carving was desired. The second defect is that the pleasing, soft, light gray color of the fresh stone is quickly blemished by brown stains, due to the oxidation of pyrite grains in the stone.

If care is exercised in the selection to avoid stone with partings, neither of these features is of consequence in ordinary masonry work.

From the point of view of military occupation of the region, the Berea is an important formation. It forms the brow of all the flat-topped hills which dominate the topography west of the Scioto River, and in the digging of trench systems over the region, should be avoided, as far as possible. The Berea, moreover, dominates the flow of shallow underground waters to such an extent that a line of springs and seeps is found around the margin of all of these plateaus. This is indicative of the water conditions which would obtain in excavations which might there encounter the Berea.

Sunbury shale

This formation consists of tough black carbonaceous shale, locally called slate, exactly similar to the Ohio shale. It may be easily distinguished, however, by the beds above and below it, and by its slight thickness. It is about 15 feet thick near the western margin of the Camp Sherman quadrangle, and thickens slightly to the eastward to about 25 feet along the Scioto River.

The distribution is the same as for the Berea Grit unless it has been removed from the flat uplands and this seems to be the case over extensive areas. South of Paint Creek, and again along the western margin of the quadrangle as far north as Asher Hill, where a considerable thickness of overlying formations are preserved, the Sunbury is duly present and occasionally seen. It also occurs on the hill immediately west of Chillicothe, where it outcrops along the south margin. This last, however, is probably the only place north of the North Fork of Paint Creek where it is preserved, and it is apparently entirely absent from Plyley Ridge, Poplar Ridge, McDonald Hill, and Beath Ridge. This appears to be the result of prolonged weathering which has removed all of the overlying formations except a residuum of soil several feet thick. Possibly, in the interior of these flat uplands, where they are highest, below the soil, remnants of the shale may remain; some evidence for this exists in the character of the water which is strong in iron or alum at some places. The Sunbury reacts on waters flowing through it the same as the Ohio shale, to form mineral springs, so that on at least one upland area, that between the Narrows of Paint Creek and Slate Mills, it is difficult to obtain suitable water.

The Sunbury shale weathers easily, so that it forms gentle slopes above the Berea ledges. For this reason it is not often seen in good outcrops. The best one in the quadrangle is at the junction of the two headwaters branches of Lick Run, on the east side of Mount Logan. This is also its most easterly occurrence.

The Sunbury shale yields a few fossils on search, a small *Lingula*, a small *Orbiculoidea*, and minute teeth from an unknown source, called *conodonts.*

Cuyahoga formation

This formation consists of soft, gray, clay shales with occasional thin, reddish-brown sandstones a few inches in thickness.

It is found in its best development east of the Scioto, where it forms the middle or lower slopes of all the rock hills from the Scioto River east to the borders of the quadrangle. Along the eastern margin it is probably 450 feet thick, but the lower portion is below drainage. It thins to the westward so that at Mount Logan it is about 350 feet thick, the upper portion of which is probably a part of the overlying Logan formation, as explained under that heading. West of the Scioto the thickness diminishes further. Eight miles south of Chillicothe, where the Portsmouth Pike crosses the divide between Indian and Crooked creeks, it is about 260 feet thick (this is outside the Camp Sherman quadrangle); on the divide between Black Run and Ralston Run it is about 120 feet, and in the low knobs rising above the Berea plateaus at the west margin of the quadrangle, it is only about 35 feet. West of the Scioto the Cuyahoga is found only in the southern third of the quadrangle.

The determination of these thicknesses depends on the proper identification of the overlying member, the Buena Vista sandstone. This has been accomplished almost entirely in the Piketon quadrangle next to the southward, where the Buena Vista is much more continuous.

The rather coarse reddish-brown sandstones of this formation are thickest and most numerous in the eastern and southeastern part of the quadrangle and thin westward so that they practically disappear west of Ralston Run. A few miles east of the quadrangle in Hocking County, the formation is composed almost entirely of coarse sandstones and conglomerates and the changes within the quadrangle are but a part of the larger change from conglomerates to shale.

Where largely unprotected by overlying sandstones, as it is in the southwest corner of the quadrangle, this formation forms gentle slopes. South of Chillicothe the brown sandstones are restricted to the lower half and their upper limit determines the top of most of the hills over the small area between Ralston Run and Indian Run. East of Indian Run, and particularly east of the Scioto River, where this formation is capped by the resistant Logan sandstones, it forms steep slopes, not, however, as steep as those on the overlying sandstones.

No fossils are known from the Cuyahoga formation in the Camp Sherman quadrangle, except the Hexactinellid sponge, *Hydnoceras*, and *Grammysia*, which are rarely found in the easternmost portion.

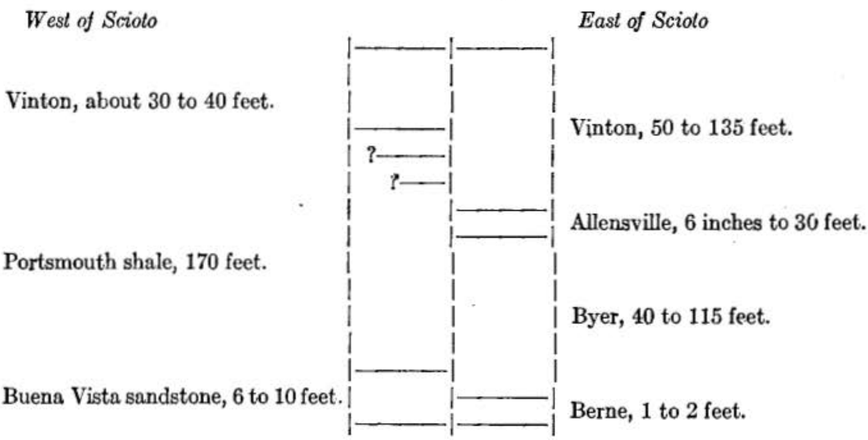
Logan formation

The formations below the Logan in the Camp Sherman quadrangle persist throughout the area of their outcrop without much change in character. The Logan formation, however, changes materially in character within a few miles. It is typically one of sandstones, and as such is well developed in the eastern part of the quadrangle, but these pass largely into shales to the westward.

Several members of this formation have been recognized within the Camp Sherman quadrangle, but their outcrops are, as a rule, poorly exposed, and in places are considerably interrupted. A complete interpretation of them could not be attempted under these conditions, and the one here presented is based on their relations, as worked out in Scioto and Pike counties from 20 to 50 miles farther south, where the outcrops are far better and more continuous. What has been observed in Ross County is, however, all in keeping with this explanation.

The chief fact in this interpretation is that, to the southward, the Byer member changes into shales westward, except the basal portion which persists and is correlative with the Buena Vista sandstone. Similarly the Allensville member within a very few miles changes from a fine pebble bed to shales indistinguishable from the underlying ones. Possibly the lower part of the Vinton also passes into shale. To this shale member, extending from the Buena Vista upward to the Vinton member, the name Portsmouth shale has been applied.

In that part of the Chillicothe quadrangle lying west of the Scioto River, the Logan is represented largely by shale, the equivalency to the formation east of the Scioto being much as in the following table:



East of the Scioto River.—The Logan formation consists typically of fine-grained, rather tough sandstones and shaly sandstones, gray under cover, but yellowish or buff on weathered outcrops. These sandstones are found in the tops and upper slopes of all the rugged hills lying east of Walnut Creek in the eastern part of the quadrangle, and of the knobs extending from these westward to Mount Logan and Sugar Loaf. Typically, that is, as it occurs east of Walnut Creek, in the east-

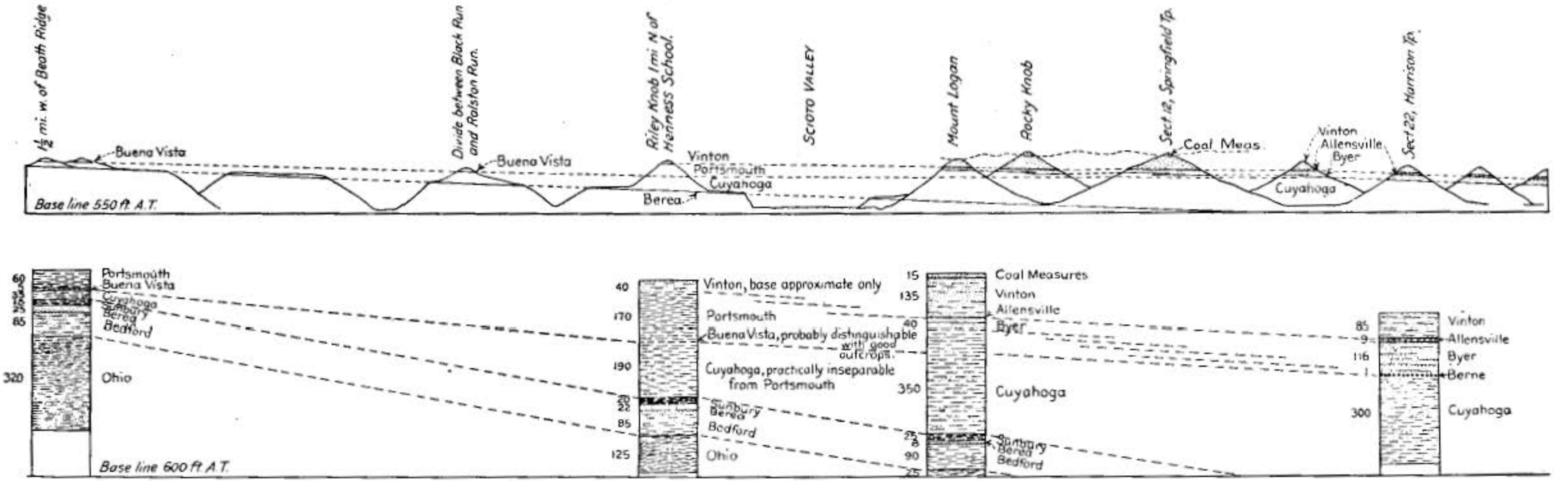


Fig. 17.—East-west geological sections across the southern portion of the Camp Sherman quadrangle. The upper is semi-diagrammatic, in that hills and terraces not in the line of sections have been brought in, with a slight perspective, to give more completely the distribution of the formations, to suggest more fully the character of the changes in them from place to place, and the dependence of the topography on them. The horizontal scale in each is about 1 inch to 3.43 miles. The vertical scale of the upper is about ¼ inch to 700 feet. The lower shows four measured rock sections in detail, with thicknesses in feet, vertical scale 4 times that of the upper diagram.

ern part of the Camp Sherman quadrangle, four members can be readily distinguished as follows, the youngest at the top:

Vinton member, fine-grained, gray and yellow sandstones and shales	50 to 60 feet.
Allensville member, fine-grained, yellow sandstones with numerous beds of pebbles up to 2 mm. or $\frac{1}{12}$ inch in diameter	10 to 30 feet.
Byer member, fine-grained yellow sandstones	80 to 115 feet.
Berne member, conglomerate with pebbles one-eighth to one-fourth inch in diameter	1 to 2 feet.

Berne member

This member is present on the head of Bull Run in the northeastern part and on the head of Poe Run in the southeastern part of the quadrangle, from 1 to 2 feet in thickness. Though it is found persistently from here eastward to Logan and northward to Newark, usually with this thickness, probably it does not extend as far west as Walnut Creek. This is the first member to disappear westward within the Camp Sherman quadrangle.

Byer member

This member, of fine-grained, yellow, tough sandstones is from 80 to 115 feet thick along the eastern margin of the Camp Sherman quadrangle. From Walnut Creek westward to Chillicothe, the outcrops are very poor, but it is evident that no such thickness occurs. It has not been possible to obtain the exact thickness anywhere, but it appears certain that it is not over 40 feet along the Scioto River, and probably it is less.

From what is known of its behavior to the southward it is highly probable that this diminution is due to the passage of its lower portion into shales to the westward. Such sandstones as persist are of typical Byer character. At all places west of the Scioto River within this quadrangle, it is equally probable that the upper beds of the Byer are also represented by shale.

Allensville member

This is the critical member of the Logan formation because the Vinton and Byer are, at present, indistinguishable unless separated by this member. It persists from the Ohio River northward two-thirds of the distance to Lake Erie along the eastern margin of its outcrop belt, hence it is an important subdivision, but it disappears westward by rapidly changing into shales, just as the Byer sandstone does, and in about the same place.

The distinguishing lithological character is the numerous beds from a fraction of an inch to 2 feet thick, of quartz pebbles, none of them exceeding one-eighth or one-sixth inch in diameter. It attains a thickness of 25 to 30 feet, seldom exceeded in the State, along the eastern margin of the Camp Sherman quadrangle, but west of Walnut Creek is usually much thinner, and, owing to poor outcrops, is seldom seen except as stray blocks in the debris on the hill slopes. Its occurrence has been satisfactorily established on all the knobs overlooking the Scioto River above Chillicothe, from Mount Logan to Sugar Loaf, but it is very thin. Its thickness is apparently 6 inches on the small 1,140-foot point of Mount Eyes just north of the gap which separates it from Mount Logan, and similarly 6 inches of small pebbles represents it on the road which crosses the ridge just south of Sand Hill, where the rocks for 29 feet above and 10 feet below are nicely shown. Its debris has been seen on numerous slopes from here eastward to Walnut Creek.

In a few occurrences the approximate altitude can be determined and there is occasionally an unexplained discrepancy of 15 or 20 feet away from the expected position. From this it appears that, whereas it is represented by a single thin bed of pebbles, it is not represented by the same thin bed in all occurrences, but by a higher one at one place, and a lower one elsewhere.

Vinton member

Taken over a considerable area, there is no lithological feature which will distinguish this member adequately from the Byer, and its fossils, while quite distinct, are practically inaccessible over most of the region. In the eastern part of the Camp Sherman quadrangle it is decidedly more shaly than the Byer, but this distinction is lost as the Byer becomes more shaly westward, and on Job's Knob, Section 25, Green Township, the Vinton is largely bedded sandstone, as indeed it is in all the more westerly occurrences of its outcrop belt.

East of Walnut Creek it varies in thickness from 50 to 75 feet but as it usually forms the hilltop, its whole thickness is seldom present. West of Walnut Creek greater thicknesses are found. In the knobs of Section 12, Springfield Township, 2 miles west of Walnut Creek, the Vinton member is something over 100 feet, probably about 130 feet, and overlain by Coal Measures sandstones; however, practically none of it is shown. Where the road goes over Sand Hill just east of the Scioto, the Vinton is about 50 feet thick, and overlain by the same sandstones. On Mount Logan it is about 135 feet. This variation in thickness of the Vinton member is due to the irregular way in which it was eroded before the Coal Measures rocks were laid down upon it.

An unusual feature of the Vinton is a bed of gray, crystalline, hard, sandy limestone, usually reddish on old outcrops, which occurs 3 feet above the base in the Sand Hill road. The same bed has been seen from Mount Logan to Sugar Loaf, and what is believed to be the same one is well shown on Job's Knob, 4 miles northeast of Sugar Loaf, in the northeast corner of Section 25, Green Township. But whereas the Allensville member occurs 3 feet below this bed at Sand Hill, at Job's Knob, though the interval is not exposed, the greatest amount of debris occurs 40 feet below this bed. Probably the Allensville is represented by different beds in the two localities, as suggested above.

West of the Scioto River.—West of the Scioto, there are but a few small occurrences of rocks of the Logan formation. It is chiefly shale and the members are so different in character from those east of the river that they must be described separately.

Buena Vista sandstone

This occurs in the southwestern part of the quadrangle on the highest ridge tops. It is here unimportant and would not be distinguished except that farther south it is a prominent member over 500 square miles, and a valuable quarry stone. The occurrences in the Camp Sherman quadrangle are the northernmost ones in the State and probably it never extended much beyond this, but passed into shales or thinned out.

On the high divide between Ralston Run and Black Run in Huntington Township, the Buena Vista is from 7 to 10 feet thick, composed of a few beds of sandstone each from 2 to 5 inches, separated by thicker beds of shale. The sandstones are gray, weathering yellowish, break readily and cleanly under the hammer, and usually show *Spirophyton* markings. These features distinguish it from the sandstones of the Cuyahoga a little lower which are harder, reddish-brown, with limonitic plates along the joints, and generally free from *Spirophyton.* A mile south of the margin of the sheet, at Selby Knob, the Buena Vista is 15 feet thick, and its sandstone beds are thicker and more numerous.

This member occurs at several places along the western margin of the quadrangle where rounded hills rise above the Berea plateaus, from Farrell Hill north to Asher Hill. The member is here probably 4 or 5 feet thick (no good outcrop has been seen) with rather harder sandstones.

The Buena Vista gives rise to distinct flat-topped plateaus similar to, but, in the Camp Sherman quadrangle, much less prominent than those of the Berea. This is best shown in the narrow flat top of the ridge between Black Run and Ralston Run, where the Buena Vista stands at between 1,100 and 1,140 feet.

A few miles to the southward, in Pike County, the Buena Vista can be followed eastward into the lower part of the Byer member. In the Camp Sherman quadrangle this is not possible because the Buena Vista either disappears entirely to the eastward and northeastward, or becomes so inconspicuous as to be indistinguishable on the grassy and wooded slopes of the few hills which might carry it. The only places where its horizon is surely preserved, but the bed is unknown, are the 1,200-foot hill 1 mile northeast of Paint Creek Narrows, and three hills rising from 1,180 to 1,260 feet on the south wall of Paint Creek within 4 miles southwest of Chillicothe. These hills present either no outcrops or very poor ones.

In the rugged hills of Franklin Township between Indian Creek and the Scioto River, Logan sandstones cap the few hills rising from 1,000 to 1,040 feet, but are very poorly shown. The base is at about the proper altitude for the Buena Vista, but their thickness appears to be considerable, though with much shale. For lack of sufficient data they have been mapped merely as Byer. The hills are too low for them to be Vinton. This assignment is established as approximately correct by the exact determination of the Buena Vista 3 miles to the southwestward, base at about 1,025, where the Portsmouth Pike crosses the divide between Indian and Crooked creeks.

Portsmouth shale

The Portsmouth shale, which is the equivalent of the Byer, Allensville, and probably part of the Vinton sandstone to the eastward, is a soft, gray, clay shale. There remains on the high hilltops 60 to 100 feet of it along the western margin of the quadrangle, from Asher Hill southward. It would be unhesitatingly classed with the shales below the Buena Vista, if the importance of that bed had not been learned elsewhere.

On the three high hills within 4 miles southwest of Chillicothe, this member is quite indistinguishable from the Cuyahoga, in the present poor outcrops. It appears, however, that it there constitutes the upper 170 feet of a total thickness of shales of about 360 feet. This proportion is obtained only by projecting the position of the Buena Vista into this shale mass.

Vinton member

West of the Scioto, this is preserved only on two small knobs which rise to 1,260 feet, one of them known as Riley's Knob, 4 miles southwest of Chillicothe. The sandstones are typical "Logan", as shown by the debris. They are fairly hard, gray to yellowish. No fossils were seen and the equivalency of these beds to the Vinton is established as probable only by the whole structure of the Cuyahoga and Logan formations set forth above. The thickness on these knobs is not certain, as the base is obscure, but is probably about 40 feet.

Pennsylvanian rocks

Several of the high knobs east of the Scioto are capped with coarse reddish or yellowish quartz sandstones and conglomerates. These frequently form low ledges which are as much as 30 feet high on Rocky Knob, where the formation is thickest and best shown. Possibly, it is 40 or 50 feet thick there, but usually there are only 10 or 15 feet of these rocks. Mount Logan, Rocky Knob, Sand Hill, the hill east of Bunker Hill, and the tips of the knobs in Section 12, Springfield Township, are the only ones which carry it. Probably there are occurrences along the ridge top east of Walnut Creek (at least one is known), but they have not been followed in detail. This sandstone is undoubtedly one of the members of the Pottsville formation, but which one is not apparent.

CHAPTER XVI

TOPOGRAPHIC HISTORY TO THE BEGINNING OF THE GLACIAL PERIOD

TOPOGRAPHIC EVOLUTION OF THE APPALACHIAN PROVINCE AND MISSISSIPPI LOWLAND

Of the physiographic history of the Camp Sherman quadrangle, down to the Pleistocene or Glacial Period, little can be written. The rock formations of the region were laid down as sediments beneath the surface of a shallow sea which intermittently occupied the Mississippi Basin from the Appalachians to the Great Plains. These formations, described in the preceding chapter, belong to the great Paleozoic Era of geological time. They became consolidated from sediments to rocks long before the end of that era, when they were elevated above the level of the ocean by movements of the earth's crust accompanying the formation of the Appalachian Mountains.

As long as the rocks lay below sea level, they were protected by the water, but when lifted even slightly above sea level, streams flowing across the newly-formed land surfaces would at once begin erosion. The period of disturbance which closed the Paleozoic, and converted this broad area from a basin receiving sediments to an upland subject to erosion, was one of the profound changes in the history of the continent.

There is ample evidence that Ohio and the adjoining states to the eastward and southward were not lifted at once to their present altitude. There is proof within this region of at least five uplifts, with long periods between when the crust was stationary. If stationary long enough, that is, hundreds of thousands of years, streams would cut the whole surface to the condition of a plain. Such a plain is called a peneplain. Marked uplift of a land mass increases stream velocities and is followed by increased downward cutting; but long after the streams have cut downward into such an uplifted land surface, features remain on the uplands that are the result of the period of quiet preceding the uplift. To such an extent is this true that many regions which are now hilly and rugged uplands dissected by deep stream valleys, carry in their hilltop portions the evidences that they were once plains but little above sea level. In other words, they are uplifted and dissected peneplains.

If the period of quiet, though very long, is not long enough to form a plain, a system of broad, open valleys may be developed on the land, with divides rolling or in high relief, depending on various conditions. The streams of such a region, when uplifted, would be rejuvenated and would cut narrow trenches, in depth proportional to the uplift. Here evidences of the old valley floors would remain in the hilltops long after the uplift, and indeed frequently after the whole region had been cut into small ravines and hills.

Over eastern and southern Ohio, eastern Kentucky, and the adjoining states to the eastward, there are found, at one place or another, the proof of at least four long periods of quiet, when streams were tending to reduce the relief to a plain, and of the intervening uplifts when stream action was quickened. Evidence of as many as three may be found at one place. Moreover, the evidence at one place corroborates that at other places, though the correlations are by no means yet complete over the whole.

Such an episode as the removal of all hills by stream erosion and the establishment in their place of a plain extending over several states requires a vast length of time, and, if one attempts at all to think of the time lapse in terms of human experience, it must be in millions of years.

THE CAMP SHERMAN QUADRANGLE, A PART OF THE APPALACHIAN PROVINCE AND MISSISSIPPI LOWLAND

The Camp Sherman district unquestionably behaved, during all this prolonged period of land evolution, in no way different from the region between New York and Alabama of which it is a very small part. When the whole was uplifted, it was also; when the whole remained stationary for a prolonged period with widespread reduction of the region by stream erosion, such must have been the condition within the Camp Sherman quadrangle. Yet surprisingly few traces remain within its boundaries of the stages in evolution which are shown in surrounding districts and which it also must have passed through.

The succession of stages can be made out much more completely to the southward, between the Camp Sherman quadrangle and the Ohio River, and it is possible to understand something of the local topographic history in this light. But nothing has been published on this district and of many of the problems of southeastern Ohio knowledge has not yet advanced beyond the controversial stage. Obviously, under these circumstances, it is useless to attempt to present anything but an outline of the probable topographic history of the Camp Sherman quadrangle.

THE CUESTA TOPOGRAPHY OF SOUTHERN OHIO

Repeated mention has been made of the diversity in the topography of this quadrangle. The various types found over the rock hills of the plateau portion, though apparently but little related to each other within the quadrangle, may be readily correlated and understood from relations obtaining between its southern margin and the

Ohio River. Moreover, this understanding is essential to a proper interpretation of the stages in topographic history of which remnants are believed to exist in the Camp Sherman quadrangle.

In addition to the major escarpment which extends from New York into Tennessee, past Chillicothe, mention was made in an introductory chapter of a minor escarpment that extends from the Camp Sherman quadrangle to the Ohio River. The major escarpment passes northwest of Chillicothe to beyond Frankfort and there bends southward, crossing the Ohio River 20 miles west of Portsmouth. The lowland which borders it to the westward stands at an altitude of about 1,000 feet. From this the escarpment rises abruptly 300 feet or more, and from its crest a rolling plain or plateau, flat over large areas, extends eastward, cut by deep, steep-walled, narrow stream valleys. To the eye, this upland appears to stretch away to the eastward horizontally, except for local irregularities, but actually it descends through a distance of about 20 miles until it is no higher than the plain at the foot of the westwardly facing escarpment. The major escarpment is shown in Plates 1 A, 7 A, B, and C, and 17 C. The upland is shown in Plates 8, 13, and 14 C.

There it encounters a row of steep-sided, pointed knobs which rise 200 to 300 feet above it, and stretch in a roughly north-south line from Sugar Loaf, above Chillicothe, to Scioto Brush Creek, in central Scioto County, where they become a second upland of hills. South of this, the plateau to the westward increases in height so that this second upland cannot be distinguished from the westerly one. From the south line of the Camp Sherman quadrangle southward to Scioto County, these knobs are isolated or in small groups, with gaps of miles between them; in Scioto County, they give place to continuous, extensive masses of high, rugged hill country, with an occasional large stream valley breaking through them from the westward to the Scioto River. The hills which rise above the plateau are shown in Plate 13 A, though not in typical development.

In Scioto County, the hills east of the second escarpment all rise to about the same altitude, and a view from the top of any one shows an essentially even, horizontal sky line. There are, however, no flat tops or rolling uplands as to the westward; the hills are narrow, irregular ridges, all forested, and the whole region is completely dissected by deep, steep-walled ravines. This is the most rugged and least used portion of the State. Though the hills appear to rise to the same height, and by their tops to mark out a flat plain, they gradually diminish in height to the eastward until, some 20 miles away, they, also, are no higher than the Interior Lowland west of the chief escarpment.

The chief or westernmost escarpment, which faces westward, and the long gentle eastward slope from its crest constitute a cuesta. Since the east slope is largely composed of flat or rolling uplands, it is a cuesta in the partial or youthful stage of dissection.

The second or eastern escarpment, and its long, gentle, east slope constitute in Scioto County a second cuesta, but it has been so thoroughly cut up by streams that no remnant of a flat upland now remains and it is a cuesta in a stage of complete, or mature, dissection. Northward, from Scioto County, to the Camp Sherman quadrangle, this cuesta has been yet further dissected, until only scattered knobs remain of the once continuous hills. This portion is in a much more advanced stage of dissection, that of late maturity.

THE RELATION OF FEATURES IN THE CAMP SHERMAN QUADRANGLE TO THE CUESTAS OF SOUTHERN OHIO

In the Camp Sherman quadrangle, the flat-topped or rolling plateaus which gently slope from the major escarpment eastward to the Scioto River, are the eastern slope of the first, or westernmost, cuesta. They are described as three subdivisions of the quadrangle, (1) "The hills west and northwest of Camp Sherman," (2) "The flat-topped plateaus of the southwestern part," and (3) "Hilly uplands of the southern part of the quadrangle." The high knobs from Mount Logan to Sugar Loaf, overlooking the Camp, are the escarpment of the second cuesta, but its relations to the eastern slope of the first are here obscure because the Scioto cut its valley along the line of juncture. Only a small remnant of this slope now remains at the foot of the second escarpment, the rock bench at 800 to 900 feet back of Hopetown and directly opposite Camp Sherman, and the narrow rock terrace at the western foot of Sugar Loaf, shown in Plate 12 C. The second cuesta is here continuous for several miles, but from its escarpment eastward, the stage of dissection is advanced maturity; only scattered knobs with low gaps remain as far as Walnut Creek; this is the subdivision of the quadrangle described as "The knobs east of Camp Sherman". The stage of dissection is much more advanced than in the southern end of this cuesta in Scioto County, but considerably less so than the central part in Pike County where only isolated knobs remain. This dissection is shown in Plate 1 B. "The hill country of the eastern part of the quadrangle" is a yet more easterly portion of the same cuesta which is still lower and has been only maturely dissected.

The cause of the cuestas has been touched in an introductory chapter. They exist because of gently inclined beds of resistant sandstone with intervening beds of non-resistant shales. The westernmost escarpment (which assumes its normal north-south trend only beyond the western margin of the quadrangle) is due to the outcrop, at its crest, of the Berea Grit. The gentle east slope of this cuesta is due very largely in the Camp Sherman quadrangle to the eastwardly-dipping Berea Grit, but south of Paint Creek, this surface follows higher rocks, chiefly the Buena Vista sandstone. The soft shales which overlie the Buena Vista are removed by erosion, except in the knobs and escarpment of the second cuesta, where they are in turn overlain and protected by the Logan sandstones.

STAGES IN EVOLUTION OF THE TOPOGRAPHY OF THE ALLEGHENY PLATEAU

The word peneplain was first used to designate a plain of vast extent from which essentially all hills have been removed by an enormously long period of stream erosion. The conception then was that the whole was essentially a plain, but in some places with low rolling relief and above which, in other places, hills or even mountain groups might rise, due to the superior resistance of their rocks or some advantage of position whereby they withstood or escaped erosion. To such an eminence the name monadnock was given, from Mt. Monadnock which is the type of such features. Such a plain is the result of a geological period of erosion and is, obviously, the surface of the earth at the end of such a period. Wherever any such plain, completed at some time in the geological past, can yet be detected, it is clearly the land surface of that time, and is so designated even though it has remained practically unmodified down to the present and is the land surface of the present also. If it has been uplifted and dissected, so that only traces of it remain, perhaps only as a uniformly unbroken, flat sky line of hilltops, with no remnant of the surface enduring, it is yet to be distinguished as the trace of the land surface of that period in which it was cut.

The conception of the peneplain was established on a firm basis by the description of the one of which traces are now found in the uniform tops of the Appalachian Mountains, the Cretaceous or Kittitiny peneplain. There followed at once the discovery that there had been, since the uplift and dissection of that peneplain, other long periods of erosion which were interrupted by further uplift when the region had been reduced to one of broad, well-defined valleys and low divides, but before it had attained anything like the plainness which the original conception of the peneplain demanded. The traces of such old valley floors and low rolling divides are now known from over most of the eastern United States, thoroughly dissected, following uplift, by steep-walled valleys 200 to 500 feet or more in depth, preserved only in the very tops of these hills, and to be reconstructed by passing an imaginary plain from hilltop to hilltop. Obviously, any trace of these old valleys and divides is to be regarded as the land surface of the particular geological epoch in which it was cut, and dated back to that epoch, when that is determinable. It is unfortunate that the word peneplain was used in describing such an uncompleted plain, because it rapidly came to have a double meaning, (1) its original use for what is or was essentially a plain, and (2) as a synonym for any former land surface which could be traced, no matter how imperfect a plain it may have been when it was reuplifted. This was later in part corrected by the proposal of "strath" for the remnants of former narrow valley stages, now preserved as rock terraces or benches on the valley walls well above the present streams.

In western Pennsylvania four former land surfaces were developed in succession, each after a prolonged period of stability of the earth's crust. The Cretaceous peneplain was first formed after inconceivably long erosion, a plain standing but slightly above sea level. Its trace is now preserved on the tops of the Appalachian Mountains. After it was completed, the whole land mass of eastern North America was uplifted several hundred feet. This increased the slope of the streams, which cut valleys into the former plain, nearly down to the new sea level, below which they could not cut. After another period of erosion, the divides were cut away and a new plain was formed several hundred feet below the first one, thereby removing all trace of the Cretaceous peneplain except in the mountains which were not reduced because of the greater resistance of the rocks in them. This second plain is the Harrisburg peneplain. Later the whole region was again uplifted and there was further entrenchment of the streams to the level of the Worthington plain. The time during which the land was stable, following this, was less than in the previous cases because the district was not reduced to a peneplain but only to the stage of broad, open valleys, with low rolling divides between, the Worthington peneplain. It was not, properly, a peneplain in western Pennsylvania, but in southeastern and western Ohio, and central Kentucky, large areas at this time were reduced quite to that condition. Another uplift caused entrenchment of the streams in these broad valleys, to the level of the Parker stage, but only a relatively short period of stability ensued and the valleys formed were not nearly the width of those on the Worthington land surface. One more uplift caused further entrenchment to or below (where the valleys are partially filled with gravels) the present level of the streams, which have opened out broad valleys and removed all traces of the Parker floor except in occasional favorable places.

The Harrisburg peneplain is continued westward across the Ohio River into Ohio, and forms the hilltops of much of northeastern Ohio and of the river counties, Jefferson, Belmont, and the northern half of Monroe. The old valley floors of the Worthington stage can be readily distinguished in the rolling uplands of these counties. Just west of the western line of these counties and southward from the median east-west line of Monroe County in the Ohio Valley, the hilltop surface falls away to an altitude of about 1,000 feet or less, the level of the Worthington plain, which here over several counties of southeastern Ohio was cut to the aspect of a peneplain, from which all traces of the

Harrisburg plain had been removed except for possible vague glimpses in a few high divides. These two plains in the "lowland" of southeastern Ohio were called by Tight respectively the Tertiary and Cretaceous peneplains,[1] a correlation that followed on Campbell's application of the phrase Cretaceous peneplain in northwestern West Virginia.[2] It is impossible here to discuss the problems of these correlations or to present even the evidence in support of the new one here adopted but it is believed to be adequate.

From the lowlands of southeastern Ohio, with hilltops at an altitude of 900 to 1,000 feet, the land gradually, imperceptibly to the eye, rises to the westward and to the crest of the easterly of the two cuestas described above. It there drops abruptly by a 200-foot escarpment to the gentle eastern slope of the westerly cuesta, along which it rises to 1,300 feet at the crest of the next escarpment, the margin of the Allegheny Plateau, to descend abruptly to the rolling hills of the Interior Lowland. The surface of the Interior Lowland along the foot of the escarpment and for some 30 miles or more to the westward is a rolling irregular upland at an altitude of 1,000 feet, more or less, dissected by streams to a depth of 200 feet or more. It is at essentially the same altitude and of much the same character as the Lexington peneplain which forms the surface of the Interior Lowland of central Kentucky, which is similarly dissected by streams, and in the writer's opinion, is to be correlated therewith. This suggests as highly probable the correlation of the Lexington peneplain with the Worthington peneplain of the southeastern Ohio "lowlands" and of western Pennsylvania, a correlation which, in the writer's opinion, is in much closer accord with what is known of Allegheny Plateau topography than any hitherto proposed.

PROBABLE HISTORY OF CUESTA SLOPES OF SOUTHERN OHIO AND CORRELATION WITH PLATEAU STAGES

The problem of determining the chief stages in the topographic evolution of the Camp Sherman quadrangle is the one of determining the significance and history of the gentle eastward slopes of these cuestas. The eastern slope of the westerly cuesta has already been described as an upland surface partially dissected by streams, but with many remnants of the original surface. This, to the eye, has every appearance of a peneplain in a youthful stage of dissection. Similarly the eastern slope of the more easterly cuesta, where it is intact, has the character of a peneplain but in the mature stage or stage of complete dissection.

---

[1]The first of these names lacks definiteness because there are several erosional stages of Tertiary age, and there is no evidence in support of and much against the assumed Cretaceous age of the upper.

[2]Tight, Prof. Paper, U. S. G. S. No. 13, pp. 24, 27, 1903.
Campbell, Charleston Folio, U. S. G. S. No. 72, 1901.

But much of the detail of the topography of the westerly cuesta is due to the unequal resistance of the gently inclined, alternating soft shales and hard sandstones which compose it. So much so is this the case that the flat uplands which resemble an old peneplain are largely coincident with and directly determined by immediately underlying resistant beds. In the Camp Sherman quadrangle, this control of the uplands by hard-rock formations is complete. The thoroughly dissected, eastern slope of the second cuesta, likewise, is coincident with resistant beds of a somewhat different character which, in part at least, accounts for the difference in stage of dissectio n.

Two interpretations are possible which are not mutually exclusive. 1. That the dip slopes as now found were developed wholly as a result of the removal of the non-resistant beds from the resistant beds by erosion, without the intervention of a stage in the reduction of the region. 2. That the dip slopes of the cuestas were formed by the method under 1, essentially as they now exist, exclusive of the features produced by subsequent entrenchment, at a past geological period as a part of the land surface of that period, and that, accordingly, these slopes are correlative with some one of the old land surfaces which denote such past periods.

It is not necessary to discuss the first of these if the evidence for the second is ample. The evidence is believed sufficient to assert that the dip slopes of southern Ohio are dissected, old, land surfaces. Along their eastern margin they pass imperceptibly into horizontal rolling or dissected upland surfaces that are independent of hard-rock formations and that appear to admit of no other correlation than with the Worthington or Lexington peneplain. The isolated knobs of the eastern cuesta in Pike County rest on this surface in a way which is, apparently, conclusive that they are monadnocks thereon and that the eastern cuesta was dissected to the stage of isolated knobs standing on that peneplain, before the rejuvenation and dissection took place.

This leads to the conclusion that, during the Lexington-Worthington stage, southern Ohio was essentially a peneplain with two cuesta monadnocks rising above it. The dip slope of the western one was undissected and is yet well preserved over large areas. Though perhaps not properly called a part of the Lexington peneplain, it is a part of thy Lexington land surface. The dip slope of the eastern one was, at the time this peneplain was most nearly complete, almost certainly maturely dissected and a region of hills, just as it is now but with less relief. For this reason its sky line of even hilltops, sloping gently to the eastward, has a somewhat different significance. It was not, at the time of completion of the Lexington peneplain, a gently sloping plain; if it ever was in that condition, it must have passed through it much earlier in the Lexington epoch to attain the stage of dissection which the outliers of the cuesta, the "Knobs" of Pike County, show existed when the Lexington plain was completed. Nevertheless, the rugged surface of the eastern cuesta is a part of the Lexington land surface.

APPLICATION OF STAGES OF PLATEAU HISTORY TO CAMP SHERMAN QUADRANGLE

The probable interpretation of certain features in the Camp Sherman quadrangle may now be considered, in the light of this interpretation of the topographic evolution of southern Ohio. The flat but slightly sloping plateaus of the southwestern part of the Camp Sherman quadrangle, Plyley, Poplar, and Beath ridges, McDonald and Spruce hills, are remnants of the once continuous, eastern dip-slope of the western or Berea cuesta, as has been pointed out before. This surface, it is believed, was essentially continuous and unbroken, except near its western margin, at the time of completion of the Lexington peneplain; at that time the whole region was at a lesser altitude than at present, that is nearer to sea level, and none of the streams had cut below a level that now stands probably between 900 and 1,000 feet above sea level. Where the eastern limit of the slope lay at the time of completion of the peneplain, that is, where it passed into an essentially horizontal position near the level of the contemporaneous stream plains, it is impossible to say, but probably it was very close to the present 1,000-foot contour on these slopes. It unquestionably terminated at this altitude against the high rolling hills of Huntington Township which rose above the old plain and are the rounded knobs of the dissected eastern cuesta. From Black Run eastward to Indian Creek, numerous rounded hills rise to an altitude of about 1,000 feet, between these scattered knobs, with no explanation in the underlying rocks for their uniformity in height, as they are cut in shale. This 1,000-foot level is probably the Lexington peneplain, but so dissected, being in shale, as to be scarcely recognizable and quite impossible of recognition as a peneplain except as one is known to exist at this level in surrounding districts. Similar areas occur east of the Scioto River, all small and disconnected. The rock terrace between Hopetown and Bunker Hill and the amphitheater-shaped head of Dry Run between Bunker Hill, Sand Hill, and Sugar Loaf, both are areas of rounded shale hills with altitudes from 800 to 900 feet. Occasional rounded, dissected, narrow terraces and isolated low hills formed of shale lying in between and south of the knobs and east of Chillicothe, and a considerable group of such hills southwest and west of Lickskillet, all point to the presence of a gradation plain at one time at an altitude something over 900 feet, which has now been entirely destroyed. Whether attributable to the Lexington stage, or to a somewhat later plain, the "900-foot" plain around Cincinnati, it is impossible to determine. After the Lexington peneplain had been uplifted and its dissection had begun, the sloping plain cut on the Berea would be further extended eastward as the streams cut down to that formation, and the present continuation of the dip slope to an altitude of 900 feet is not to be regarded as in any way indicative that that was the extent of the dip slope in the Lexington stage.

All that can be said regarding the probable early history of the hills of the second or eastern cuesta is indicated above. Its history is yet more obscure than that of the westerly one.

It was probably at this time that the difference in topography between the Allegheny Plateau (comprising the two cuestas) and the Lowland to the northward was developed. No remnant of the Lexington peneplain remains in the Lowland third of the quadrangle, however, for it has all been removed by subsequent further erosion.

Uplift terminated the formation of the Lexington peneplain; the streams, with steepened slopes and swifter currents cut their valleys downward as deep trenches in the old plain, tributaries also cut similar but smaller trenches, and much of the present topography is due to this rejuvenation.

The history from the time of this uplift to the opening of the glacial period was not simple, as is well enough known from the surrounding districts. However, no certain trace of it has been picked up within the quadrangle. The streams entrenched themselves in this quadrangle to about the level of the present Scioto flood plain. This is shown by the presence, 1, of many old valleys at this level and higher to the southward and southeastward, now abandoned by the streams that made them and partially dissected by later streams, and, 2, by rock benches at the same altitude as the old valleys, on the sides of the present valleys, remnants of former high-level floors. At that time the Scioto River flowed opposite to the present direction. It received the drainage from much of West Virginia and southern Ohio (the Ohio River was not then in existence) and carried it all past the present site of Chillicothe but to the northward. The old floors of that time occur in southern Ohio, along the Scioto and its tributaries, and are well shown in the abandoned Beaver Valley east of Waverly, but they slope to the northward and near Chillicothe they would, if present, pass below the modern river bed. These are termed the Teay or California stage, and are correlative with the Parker floors of western Pennsylvania. After the entrenchment from the Lexington level to the Teay or Parker level, there ensued a considerable length of time, sufficiently long that the larger streams opened out valleys a mile or two in width, the floors just mentioned. During this time the soft shales, unprotected by Berea Grit, which must have formed the Lexington peneplain in the northern or Lowland third of the quadrangle, were so far removed that the surface of that part of the quadrangle was without exception lower than it now is. Later there was another uplift which permitted the streams to cut their valleys yet deeper, at least 100 feet below the present Scioto but how much more is not known, and the valleys were again widened to about their present width.

Whether this last uplift preceded or followed the first advance of the ice is not certain. In any event, this brings the history of the land surface of the district approximately down to the opening of the glacial period. All of the larger features and many of the smaller ones of the landscape, except of course those added by the ice, had been formed essentially as we now find them. The Allegheny Plateau in the southern two-thirds rose high above the northern lowland third. It was dissected to the southwestward by numerous deep, steep-walled valleys cut into the flat-topped plateaus; the knobs of the central portion, those opposite Camp Sherman and Chillicothe were much as we now see them, with rather open valleys between them; the eastern portion of the quadrangle had been cut into endless rough hills and valleys; the Scioto and Paint Creek valleys were as we now find them or were much deeper, and most of the smaller ravines as well as larger tributaries were established much as they now exist, except as the ice caused certain disarrangements of the drainage to be noted later.

CHAPTER XVII

GLACIAL FORMATIONS AND HISTORY[1]

GENERAL RELATIONS

After the rocks, the bed rocks, of the region, had been carved into the topographic forms that now exist; after the Interior Lowland and Allegheny Plateau had been brought to the condition of lowland and highland respectively; the Scioto and Paint Creek valleys established much as they now appear; after the Allegheny Plateau had been dissected to its present aspect of hills and smaller valleys, gullies, and ravines, the region was invaded by glaciers from the northward. These glaciers covered the northern part of North America, and extended southward well into the United States. The ice slowly moved southward across the present Lake Erie Basin into Ohio in strong volume, but it encountered resistance in the eastern half of the State in the form of the hilly Allegheny Plateau. As a result, the eastern half of Ohio was glaciated only in the northern part. Across the western Ohio lowlands where there was no such obstruction, it flowed much farther southward until it crossed the Ohio River in the vicinity of Cincinnati.

As has already been noted, the margin of the Allegheny Plateau extends across the Camp Sherman quadrangle in an irregular east-west line, with the lowland to the northward, an exception to the north-south direction obtaining elsewhere across the State. The ice in its southward course into this quadrangle encountered the margin of the plateau, rising some 300 to 500 feet across its path, and was largely stopped by this obstruction, though lower, outlying portions, such as the hills northwest of Camp Sherman, were quite overrun and buried.

Not once, but five times, the ice sheets invaded the northern part of the United States, and after each invasion there was a long period when climates as mild or milder than that of the present prevailed. So long were these interglacial epochs that they were comparable in duration to the time that has elapsed since the last retreat of the ice, possibly 35,000 to 50,000 years ago, and indeed there is no reason known why we may not now be living merely in a mild interglacial epoch, rather than in postglacial time, as it is commonly named.

It is in the Mississippi Valley that the evidence is found of five ice invasions. In Ohio there is distinct evidence of three of these occupations. Probably nowhere else in the State is the evidence of two invasions more conclusive than in the Camp Sherman quadrangle.

[1]It is a pleasure to record the generosity with which Mr. Frank Leverett placed at the writer's disposal, his field maps and data on the region. These have been freely used in the preparation of this chapter.

The two invasions here represented were the last, or Late Wisconsin ice sheet, and one of the early ones, called the Illinoian. There are some features that seem to have been formed by one of the intermediate sheets, perhaps the Early Wisconsin, but the evidence accumulated to date is too obscure for presentation.

Each of these ice sheets left two chief kinds of deposits, those made more or less directly by the ice itself, called moraines, and those gravels dropped chiefly by the streams flowing away from the edge of the melting ice with enormous loads of debris. The last may be found many miles beyond the limit reached by the ice itself.

Both sheets left heavy deposits of debris. The deposits of the last ice sheet, however, entirely covered those of the preceding in the portion of the Camp Sherman quadrangle which it invaded, as, indeed, it did over almost all of Ohio. It did not, however, extend quite as far south as the earlier one, and it did not obscure some of the stream gravels of that sheet.

The features which serve to distinguish the two sets of debris are the result of difference in age and location. The Illinoian deposits have been exposed to the agents of weathering for so much greater length of time that many of the less resistant pebbles are disintegrated, and the more soluble ones have been largely removed, so that very few limestone pebbles are found, while other limestone pebbles have been changed to chert, and there is a great amount of reddish clay matrix in the gravels, the residuum, in part at least, from this weathering. In addition, streamlets have been eroding these accumulations for a very much greater length of time than the debris of the last ice sheet, and the older deposits, as a result, are gullied into knolls, hummocky hills, and small ravines in a way that is not seen in deposits of Wisconsin drift. These two characteristics, composition and topography, together with the location of the Illinoian deposits south of those of the Late Wisconsin sheet, serve to distinguish the two accumulations readily in this region.

ILLINOIAN DRIFT

Ice deposits, extent

It is not possible to distinguish sharply the farthest limit to which the Illinoian ice sheet advanced, because there remains to mark its outermost occupation, only a thin scattering of pebbles and bowlders of foreign origin over the uplands outside the limits of the Wisconsin sheet. Indeed it is not wholly certain that there is within the quadrangle any till, that is bowlder clay directly deposited by the ice, which can be attributed to this ice sheet. Certain very coarse accumulations that appear to be in part till, on the upper end of both Twin creeks, have been tentatively so referred. Relying solely on the upland pebbles, this ice sheet unquestionably covered Ralston Run and the region to the westward and the upland between Paint Creek and North Branch of Indian Creek quite to the latter. East of the Scioto, the outer limits appear to have followed Walnut Creek,to near its head, and from there extended eastward across the hills.

It is not certain from direct evidence, that this ice sheet covered the high knobs east of Camp Sherman. It slowly pressed through the low gaps between them, even occupying the passes between Bunker

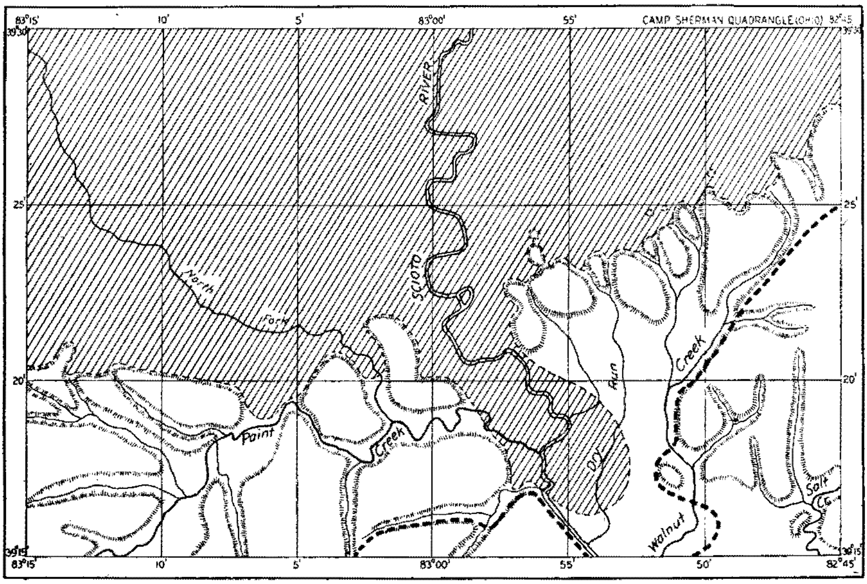


Fig. 18.—Outline map of Camp Sherman quadrangle showing, by shading, the approximate area covered by the Late Wisconsin glacier, and by heavy dashed line the approximate outer limit of the Illinoian sheet. Manuscript maps graciously loaned by Mr. Frank Leverett have been the basis of this map, but the boundaries here adopted, in places, are extended somewhat beyond his.

Hill, Mount Eyes, and Mount Logan, attaining a height of 450 feet above the present Scioto; this is shown by the presence of debris up to these heights. It is held probable, however, from indirect evidence, that this ice sheet covered at least the Sand Hill-Rocky Knob ridge and Mount Logan. Innumerable bowlders of Pottsville sandstone, which could only have been derived from these hilltops, occur abundantly scattered over their southern slopes, and some very large ones, 10 or 15 feet in their longest dimensions, are present in association with the Illinoian gravels, where they could not possibly have come to rest by gravitation and stream action alone. These critical bowlders are in the northeastwardly flowing gullies of the southeast quarter of Section 16, Springfield Township.

Gravels

At the present time, streams of water from the melting ice invariably flow from the edge of glaciers in all but very high latitudes. Those flowing from the ice edge in Ohio were of very considerable volume, for they were fed by the ice wastage for miles behind the actual edge. Such streams today are almost always loaded with gravel and sand, and are milky with fine mud. So great is the load of sand and gravel, that the streams now flowing from the edge of glaciers are mostly aggrading or filling up their beds to great depths by the excess which they are unable to carry. Should such water be impounded by ice obstruction of outlet in a depression, such as a long valley system, the new outlet of which is decidedly higher than the main portion of the basin, gravels and sands will be built up, interspersed perhaps with beds of fine clay settled from the muddy waters at times or in places where coarser materials do not happen to be accumulating. Such obstruction of outlets was of common occurrence in connection with the movement of the Pleistocene ice front. After the removal of an ice sheet, streams were free to resume something of their normal habits, though frequently with new outlets or reversal of direction, and being no longer loaded by debris from the ice, dissection and removal of the great gravel accumulations in their valleys commonly went on. Obviously, the longer the time that has elapsed since the retreat of the ice, other things being equal, the more complete will be the dissection and removal of such deposits.

There remain in the Camp Sherman quadrangle, great terraces of gravel, more or less completely dissected, remnants of a once much more extensive valley filling which was accumulated by the streams flowing from the Illinoian ice sheet. These occur within the area which was covered by the Illinoian sheet at the time of its greatest advance, and must have been formed after that ice had withdrawn somewhat from the outermost position. Of these, there are two chief areas, (1) Paint Creek Valley and its tributaries, (Plate 16 B), and (2) the terraces east and southeast of Chillicothe (Plates 19 B and 20.A and B).

1. Paint Creek Valley and its tributaries. — In the southwest corner of the quadrangle, on Plug Run, Lower and Upper Twin creeks, Black Run, and on the wall of Paint Creek south of Bourneville, there are extensive areas of hummocky hills rising to 200 or 240 feet above the streams. They form distinct foothill borders to the higher, steeper, shale hills behind them, and their hummocky character is in contrast to the more even shale slopes. They consist of gravels which are composed chiefly of pebbles of resistant rock. If there ever were many limestone pebbles, they have been largely removed by weathering. That this is the case is evidenced by the great amount of reddish clay in which the gravels are imbedded, and the thick soils which coat the hills, clays of much the type produced by weathering of limestone. South of Bourneville, these gravels are composed in places, almost entirely of Berea Grit fragments, many of them of large size and obviously from local sources. The gravels on the Twin creeks without doubt were largely dropped by streams flowing from ice on their heads.

The highest of these hills rise to an altitude of about 900 to 940 feet and, though very few of them attain this altitude, it appears that this represents the original level up to which the valleys were entirely filled with these gravels. At one place, a mile west of the Round Top School on Upper Twin Creek, there is yet preserved an area of about one-fourth square mile of the original surface of this deposit, flat and undissected except by small stream gullies around its sides. This remnant, it is true, stands mostly at from 900 to 920 feet, but the amount of weathering which has gone on of materials in these deposits is such that they must have settled considerably and irregularly, more where there was a higher content of limestone or thicker mass, and less where they are composed more largely of Berea fragments or where the thickness was less over the slopes of rock hills.

No exposure of these gravels has been sufficient to show their structure. It is not known whether they are alluvial, that is, laid down by streams which are building up their beds, or built up in waters ponded in Paint Creek and its tributaries behind an ice dam.

Much less extensive deposits of similar gravels occur on Ralston Run, but whether these are to be associated in origin directly with those farther west is not clear.

The same gravels occur at the foot of the east end of Plyley Ridge and at creek level on Anderson Run one-third mile north of Anderson. Both of these are largely overlain by Late Wisconsin deposits and only exposed by stream valleys cut into them since the latter ice sheet retreated.

2. Terraces east and southeast of Chillicothe.—These deposits extend from Chillicothe eastward to the hills behind Walnut Creek, southward to the Scioto Valley, and thence eastward in a broad open valley to the extreme southeast corner of the quadrangle. They are limited to the north by the hilly country of Springfield Township, except for broad areas of these deposits which extend up Walnut Creek and its tributaries into these hills.

There are two very distinct terraces within this area, one with its upper surface at 800 to 860 or even to 920 feet, commonly 200 to 260 feet above the Scioto River, the other with its surface at 680 to 740 feet, or 80 to 140 feet above the Scioto. The first occupies the portion of the area, roughly, north of the Chillicothe-Adelphi Pike, the latter lies south of this pike except for very small portions. The higher terrace, with its original surface mostly at 820 to 860 feet, is much the more completely dissected; in this respect it is comparable with the Paint

Creek occurrences, though the dissection of the latter is the more complete. However, only limited remnants of the original surface, southeast of Mount Logan, now remain.

The lower terrace is decidedly in contrast with the upper one, in that the dissection is immature and extensive areas remain intact. It is unquestionably a later surface. The surfaces of both, where intact, slope appreciably to the southward.

The short length of time available for work has not permitted a complete determination of the materials composing each of these terraces and comparison of one with the other. On superficial examination they appear to be much the same, though it is suspected that the material of the lower terrace was formed under different conditions and is the less weathered. Because of lack of sufficient evidence to permanently separate them, they have been treated together as Illinoian in age, but it is probable that the lower terrace is much younger in age, though certainly antedating the Late Wisconsin epoch; very probably it is Early Wisconsin.

The older terrace consists largely, if not entirely, of gravel and sand, which varies much in composition and coarseness from place to place. Much of it is poorly assorted and obscurely stratified. Near the Scioto River the amount of foreign material is high, but between Lick Run and Little Walnut Creek the amount of unrounded, local material is so great that it is often difficult, in the absence of exposures, to know whether one is dealing with rock or drift slopes. Some of it is very coarse, with blocks up to 1 foot in diameter, and bowlders up to 15 feet in longest dimension are associated with it, though not certainly imbedded in it. These gravels and sands are believed to be largely if not entirely river laid.

The sands and gravels are now much weathered, limestone pebbles in places are wanting entirely and are never common; pebbles of resistant rock types are everywhere in evidence, and they are usually reddish or brownish in color. A considerable reddish clay matrix is usually present, probably the result of weathering. A thick coating of reddish-brown residual clay soil forms the surface. In places the deeper gravels are consolidated into a conglomerate.

It has been suggested[1] in explanation of that portion of these deposits in Lick Run Valley that two lobes of the Illinoian ice sheet, one flowing down the Scioto Valley and the other down Walnut Creek, met and enclosed between them and the Mount Logan-Rocky Knob hill group, a considerable depression which at once became a lake and was filled by gravels, sands, and clays. This explanation was applied only to the occurrences around Lick Run, but the deposit extends far up Walnut Creek and is not to be accounted for by such localized conditions.

[1]Campbell, M. R., The Country around Camp Sherman, on back of the first (1918) edition of Camp Sherman quadrangle.

The upper limits of these gravels and the ones on Paint Creek are so nearly identical that it is suspected that they were determined by a common condition, and that the problem is not a local one. The writer is not able to state either that lake sediments are absent or present in these higher gravels. However, all that were seen by the writer are in the lower Early Wisconsin terrace.

As already stated, the surface of the lower terrace is less dissected and to all appearances younger. In addition, it is flat except for a uniform, gentle, southerly slope and it penetrates up small valleys cut in the higher terrace and behind rock hills. These features all indicate that it is the original surface of the deposits which form it and not a degradational terrace, produced in the process of erosion of the higher terrace. They further emphasize the greater age of the higher terrace, because these deposits were accumulated in part in valleys cut in the higher terrace, which must have reached a stage of dissection approaching that now observed.

The lower terrace is composed of sands and gravels, the structure of some of which indicates that they were spread out in standing water. In addition there are beds of water-laid clay, blue, nearly gritless, tough and tenaceous, wet and sticky. The clays are exceedingly difficult to excavate, yet when wet, will flow under their own weight if not restrained. Clay beds as much as 10 feet thick are known. The gravels, sands, and clays are interbedded.

The gravels and sands in the upper 20 to 30 feet are oxidized to a yellowish or reddish color, and the upper 10 feet, more or less, is a reddish, yellowish, or brownish, loamy sandy clay with numerous small pebbles of chert and other resistant rocks imbedded in it, a residual soil it is believed. Below the oxidized zone the sands, gravels, and clay beds are unoxidized, blue or gray in color. Insufficient attention has been given to the rock composition of the unweathered gravels for generalization but limestone pebbles are present in considerable abundance in places in the lower terrace.

A small area, much dissected, of water-laid clays which fill the lower end of Indian Creek Valley 20 to 40 feet above creek level, apparently belongs to this same set of deposits, but has been largely removed by the stream. The stage of dissection is the sole reason for their reference to one of the early ice sheets.

The deposits of the lower terrace, with their surface but little broken, are continued eastward to Salt Creek as the floor of a large valley which is now occupied only by streams which cross it, as Walnut Creek and Salt Creek. This abandoned segment reunites with the Scioto south of the Camp Sherman quadrangle. The same deposits form great terraces on the west wall of the Scioto above Waverly, rising to a maximum altitude of 700 feet. East of Waverly they form the filling up to 700 feet or more of a valley entirely unoccupied by the stream that made it, to beyond the Ohio Valley and back into West Virginia nearly to Charleston.

These clays and some of the associated sands, unquestionably, were formed in a standing body of water, impounded in this valley system which, prior to that time, had its outlet to the northward past Chillicothe. Obstructed by ice, the lake was formed and remained until it found a new outlet by breaking across the hills between Ohio and Kentucky to form the Ohio River as we now know it. By that time the silts and sands had accumulated which have just been described.

INTERVAL BETWEEN ILLINOIAN AND LATE WISCONSIN ICE EPOCHS

In the upper Mississippi Valley there is evidence that during this interval, which was very long, there occurred two ice occupations, with three intervening epochs of mild climate much like that of the present. As indicated in the last section, the 680 to 740-foot terrace southeast of Chillicothe may be the result of one of these ice sheets. There are also very gently rolling obscure hills of drift on the uplands immediately southwest of Camp Sherman, and also on the western end of Plyley and Poplar ridges that may belong within this interval, though the only reason for excluding them from the Late Wisconsin is that the slopes are very gentle as though softened by length of time. The Late Wisconsin tills have been found directly south of all of these in valleys, and it may well be that these occurrences are only the weak upland phase of the Late Wisconsin drift.

If these occurrences do not represent this interval then the only known record of this long time in the Camp Sherman region is one of erosion; for the Illinoian gravel terraces, by the time of the Late Wisconsin occupation, had been dissected to practically the condition now observed. This is known because the Late Wisconsin gravels lie in large valleys cut in these older gravels, whereas the smaller streams flowing over the Wisconsin gravels have had time to scarcely more than cut channels in them. Moreover, weathering has, since the Late Wisconsin gravels were formed, only formed a weathered zone and soil bed about 1 foot thick. From this it must be apparent that the Illinoian gravels which are weathered to unknown depths (the 700-foot terrace to something more than 30 feet depth) have been exposed to weathering and erosion a far longer time than the Wisconsin gravels. When it is recalled that the Late Wisconsin sheet is now generally believed to have begun the recession from its outermost position at least 35,000 to 50,000 years ago, it follows that the interval between the Illinoian and Late Wisconsin occupations must have been a matter of hundreds of thousands of years.

LATE WISCONSIN DRIFT

The remains of this ice sheet are much clearer and fresher than those of the earlier sheet. The areas to which the Illinoian drift give character are relatively small, both in the State as a whole and in the Camp Sherman quadrangle, but about half of the total surface of the quadrangle is composed of drift from the Late Wisconsin ice sheet of such depth that it is so shown on the geological map.

Extent of ice

The outer limit to which this ice sheet attained can be much more satisfactorily determined, though it is not now possible to locate the exact line throughout its length. This ice sheet did not overrun the margin of the Allegheny Plateau to the extent that the earlier one did. East of the Scioto River the ice piled up along the lower slopes of the escarpment but did not, apparently, cover even the outermost hills, such as Sugar Loaf. It undoubtedly surrounded several of them, so that they appeared as islands in a sea of ice.

In the westernmost part of the quadrangle, from Lattaville westward, the ice was stopped by the abrupt, northwardly facing escarpment of the plateau. The two chief hills of Ragged Ridge (west and slightly northwest of Roxabell) for most of the time of ice occupation were islands standing 40 and 80 feet respectively, above the ice fields, but it is possible that at times they were quite covered.

Between Lattaville and the Scioto River there is a broad, northwardly projecting wedge of the plateau within which the hills are 200 to 300 feet lower than on the two sections just mentioned. Nor is it probable that the opposing escarpment was as steep. Here the ice overran the escarpment quite to the base of the wedge, and from the center of the base, it pushed a short lobe 2 or 3 miles southward into Paint Creek Valley. North of North Fork of Paint Creek probably every hill was covered by ice except the two small ones due west of Chillicothe and south of the Cincinnati Road. It almost certainly overran the whole of Plyley Ridge because fairly heavy accumulations of fresh, ice-laid, bowlder clays occur on the south wall of Owl Creek, next to the southward, throughout its length.

A lobe of ice undoubtedly pushed into the Scioto Valley past Chillicothe, although fresh, unweathered bowlder clay has been noted at only two places as evidence of it, one at an altitude of about 750 feet in the ravine north of the Cemetery Hill at Chillicothe, and the other at an altitude of 680 to 700 feet on the hills in the obtuse angle between Indian Creek and its North Branch, 4 miles south of Chillicothe.

Ice deposits

The outer limit of the ice sheet described in the last division is the southern limit of the deposits formed in direct connection with the ice. These are of two types, moraines and kame moraines.

Moraine.—This is restricted, practically entirely, to the portion west of the Scioto River and south of Deer Creek. It consists of tough, gray, bowlder clay, not very stony. It forms the surface of the lowland of the northwest corner where it was laid down chiefly beneath the ice sheet and has been but very little modified by stream action since. South of North Fork, heavy accumulations of bowlder clay were formed in the heads of all the valleys taking their source on the escarpment. The ice clearly piled well up against this slope, and locally pushed up onto the adjacent tablelands. This is probably all terminal moraine and has been cut up by numerous stream valleys to a depth of 100 feet. (See Plates 3 and 7.)

The ice partially filled the broad open valleys of the plateau north of North Fork of Paint Creek with ground moraine and to a notable extent plastered bowlder clay onto the north slopes of hills, but left their south slopes but little changed. As a result the northern walls of the valleys are commonly steeper than the south walls, a feature that is found, also for the same reason, on Owl Creek. Streams have dissected these deposits slightly. (See Plates 9 and 10.)

On the east side of the Scioto River, the first terrace above Chillicothe, between the N. & W. railway and the high hills, is of similar till, but overlain by gravels.

More details are given in the regional descriptions and distribution is shown on the geological map.

Kames.—Wherever a large flowing mass of ice of the sort under consideration becomes badly cracked or broken, so that surface waters pour into the cavity, quantities of assorted gravel are apt to accumulate in the cavity, restrained by the ice walls, to finally form a hill after the ice melts. Such hills are called kames. They are distinguished not only by their stratified gravel composition, usually with very steep bedding (the bedding may be brought to the vertical attitude by ice movements around the deposit), but also by their steep slopes, isolated position or sharp grouping, and sometimes by the trend of a group.

Several are found around Roxabell, chiefly to the southward, and around Lattaville. The reason for the latter is not clear, but the former lie in groups or lines that trend distinctly toward the gorge of North Fork of Paint Creek. The ice flowing into this gorge may have been sheared and broken so as to result in the formation of kames. There is a striking group of low kames at the lower end of Paint Creek Gorge, south and southwest of Anderson. These are arranged radially in lines curving from easterly to southeasterly, and focusing at the lower end of the last rock hill at the mouth of the gorge. These appear to have been formed in cracks or channels developed in the ice as it spread from the mouth of the gorge, and perhaps encountered a weak southwardly flow from over the hills of South Union Township. These deposits southward lose their sharp character and pass into a rolling, hummocky plain of little relief and numerous depressions, but composed of stratified gravels, perhaps best called a kame moraine. (See Plate 16 C.)

Kame Moraine.—East of the Scioto River with the single small exception of bowlder clay in the river terrace, just cited, the deposits from this ice sheet all show the assorting influence of water. The whole great lowland area of the northeastern part of the quadrangle consists of stratified gravel and interbedded clay deposits of the kame-moraine type. The topography, described in detail under that subdivision, is rolling and diverse. There is little dissection of the region by streams, far less than in the till sheets south of Roxabell, which may be due to the ready absorption of rainfall into the gravels and the correspondingly reduced run-off, as well as to lesser gradients. The gravels are typical kame gravels, frequently interbedded with beds high in clay and probably of direct glacial origin, with bedding commonly highly inclined and occasionally almost vertical. (See Plates 1 A, 4 A, 17 B and C, and 18 A.)

Along the Scioto River, from Hopetown northward, these are grouped in north-south belts of more pronounced kame character. These have their most extreme form in a prominent belt of true kames running northward from near Sugar Loaf, which is apparently the key to the origin of the meridianally trending belts next the river. Though the ice was stalled against the escarpment to the eastward, a lobe flowed southward down the Scioto for several miles which must have required a considerable ice current to maintain. Sugar Loaf is at the angle between the escarpment and the east wall of the Scioto Valley. Northeastward the ice was stagnant, westward and northwestward it was in motion. This would cause and maintain a zone of tension and fracture between the two which would corner primarily at Sugar Loaf, and secondarily at the 880-foot rock hills immediately east of Hopetown. The line of prominent kames near Sugar Loaf appears, almost certainly, to have originated in connection with this tension zone, and with it, the less pronounced belts farther northwest. (See Plate 17 A.)

The area west of the Scioto and north of Deer Creek appears to be similar in character to the kame moraines east of the river, but the relief is much less. This portion wedges out southward and is terminated near Andersonville.

Terraces and gravels

Prior to the coming of the Late Wisconsin ice sheet, the larger streams had cut out valleys in the Illinoian gravels to greater depths and widths than their present flood plains. As the Wisconsin ice sheet melted away, the debris-loaded, swollen Scioto refilled its valley with gravels to a height at least 60 feet above the present river, and North Fork of Paint Creek to 20 to 40 feet above its present level. A single small terrace remnant on Paint Creek south of the mouth of North

Fork, now standing over 100 feet above the stream, indicates that the valleys were filled to this depth above the present streams.

With the retreat of the glacier from these stream basins, both the volume and the load decreased, but the latter most, and the streams began to cut into and remove the new gravels. They swung slowly from side to side as they cut downward; in this way, flat flood plains were cut at successively lower levels, to be removed later as the streams swung back at a lower level. In some places, the stream in a return swing did not entirely cut its way back to the old position, and a remnant of the filling remained with a small portion of one of the earlier, higher valley floors as its surface. These form a series of terraces on both sides of the streams, at various levels. Camp Sherman is located on one of these terraces. (See Plates 6 C, 12 A and B, and Fig. 13, p. 98.)

It is only on the two streams mentioned (except possibly Deer Creek which was not examined) that extensive terraces of this type occur. Yet there were several streams in the quadrangle which carried the melting waters of this ice sheet. It is rather unexpected that they do not occur more extensively on Paint Creek above its gorge, which must have carried large volumes of water for some time after the ice withdrawal was begun. The other streams are small and headed on the ice front at the time of its maximum advance. East of the Scioto these were the several branches of Walnut Creek and Lick Run, west of the river Plug Run and Lower Twin Creek. On Lick Run there is known only a single low remnant of these gravels. On the head of Plug Run gravels were seen but not examined. On Lower Twin there are more extensive but yet low terraces of this age. This sparseness on the small streams suggests that the heavy gravel loads were fed to the streams chiefly as the mass melted backward, and after it had withdrawn from the heads of these small streams.

Lake clays and associated gravels

There are, along Paint Creek and in the lower ends of its tributary valleys, terraces composed of stiff, tough, tenaceous, fine, gray clay, interbedded with gravels. The terraces rise to about 40 feet above the flood plain of Paint Creek. There appear to be at least two clay beds, one of which is 6 feet thick. The interbedded gravels are probably stream laid in intervals between the backwater conditions. The condition of ponded water in this valley up to this level was possibly produced by slight advances of the ice, of short duration, which covered the outlet at The Narrows to a depth equal to the height of the clay beds. One of these clay beds is shown in Plate 4 C.

Drainage changes

When a large mass of thick ice flows into the outlet of a valley, the stream flowing out at that place is obstructed and the waters imponded. They will rise until they find a way out over the ice, or between the ice and adjacent hills, or, if the ice is high enough, will rise until they overflow the lowest point in the rim of hills around the valley. If the obstruction remains long enough, the stream will cut its new outlet lower, and perhaps so low that it will continue by the new outlet after the withdrawal of the ice.

Such incidents were common along the ice margin, and as a result many anomalies in drainage are found. The normal character of a stream valley in a region of flat-lying sedimentary rocks, such as the Camp Sherman quadrangle, is to be narrowest and have its steepest walls and highest divide around its headwaters, and to widen down stream. These relations, however, are occasionally reversed.

Two excellent examples of such changes occur within the Camp Sherman quadrangle and can be readily appreciated from the topographic map.

Paint Creek.—The valley of Paint Creek is from 1 to 1½ miles wide down to 5 miles west of Chillicothe. There it abruptly turns to the right and enters a gorge 300 to 350 feet deep, the walls of which are the steepest slopes within the quadrangle, and which is so narrow that there is not room for a road between creek and wall. The pike from Chillicothe to Cincinnati was first placed in this gorge, but it has been wholly removed by the stream. This is The Narrows. These conditions persist for 1½ miles when it widens somewhat but continues very narrow to where Ralston Run Valley enters it. It does not, however, even with the accession of North Fork, attain a width equal to that above the Narrows. These conditions are shown on Plate 15 and in Fig. 16, page 110.

From The Narrows, however, an open valley continues in line with Paint Creek Valley and equal to it in width, with a rolling floor slightly higher than that of Paint Creek. This valley connects by a short, narrower valley with the Scioto directly opposite Camp Sherman, the valley followed by the Baltimore & Ohio railroad. Though this last valley is narrower than the remainder of Paint Creek Valley, its rock floor is at an unknown depth, something below 500 feet above sea level, and it is generally believed to be the preglacial outlet of Paint Creek. In The Narrows, Paint Creek flows on rock, but about a mile above where it enters the gorge, the rock floor is something more than 45 feet below the present flood plain.

The outlet was blocked when the Late Wisconsin ice sheet stood at its outermost position. The waters found their way out over the hills to the southeastward into a short tributary of Ralston Run which thereby suddenly became the main valley of Paint Creek Valley. Every feature of this part of the valley bespeaks its humble origin, its narrowness, crookedness and steep walls, and particularly its attitude to Ralston Run Valley and the tributaries to it.

Similar changes outside the quadrangle to the southwestward apparently discharged a large stream of water into Paint Creek and thereby added greatly to its drainage basin.

North Fork of Paint Creek.—Clearly there was a preglacial divide where Musselman is now located, from which short tributaries flowed to the east and northwest. The rock floor at Frankfort is 80 feet below the present creek level. In this case it appears that the preglacial drainage had little in common with the present drainage. The most prominent lowland is formed by the valleys of Little Creek, Oldtown Run, and Waugh Run, and extends from southwest to northeast, with Roxabell and Frankfort in it. This is believed to mark the chief preglacial drainage line. Northwest of this lies high land, the rock hills of Ragged Ridge, and the broad upland of the northwest corner of the quadrangle. Bed rock occurs on both walls of North Fork where it crosses this obscure highland, suggesting that there is here a partially buried rock ridge running north and south. The preglacial topography has been almost entirely obliterated by till and has been buried to depths at least as great as 80 feet. North Fork of Paint Creek is, then, not merely a reversed stream, but practically a new stream which flows across both the old divides and drainage lines. (See Plate 7 B.)

Other drainage problems.—Enough has been seen to know that interesting details remain to be worked out of the drainage along the ice margin. In places streams flowed along the ice margin, between it and the escarpment against which the ice lay. Obviously these were only temporary streams which shifted with a slight change in the ice front. These results, it appears probable, would be of local interest only.

Some of these streams have remained permanently where they were so established. A small stream which heads one-half mile south of Lattaville and flows westward to the head of Porter Hollow was determined when the ice front lay banked against McDonald Hill. Two miles west-southwest of Lattaville is a yet more striking occurrence, in the stream which flows eastward and northeastward from the foot of Asher Hill. Its course also was clearly determined when the ice nearly filled this valley head. The water from it found its way out along the foot of the ice, against the hill slope, and a stream became established there. When the ice melted away, apparently rapidly, another set of streams formed and flowed down the slope of the moraines thus uncovered. Both streams have since become deeply intrenched, the one next the hill largely in shales at the side of the valley, the other in till near its center.

The slope of the surface of the ice sheet

Mr. Frank Leverett has brought to the writer's attention some scattered observations which promise that in this region may be determined fairly accurately the slope of the upper surface of the last ice sheet.

Neither Mr. Leverett nor the writer had time to pursue this problem, as the former's time was very limited and that of the latter was devoted to determining only where the drift was thick enough to be of significance in any possible military way.

The ice, which must have been of very great thickness over northern Ohio, was thinned southward by melting and flowage into warmer latitudes. This thinning was sufficient to give the upper surface a distinct slope. Near the outer margin there was not, it appears, a steeply sloping wall of ice of any considerable height.

Four miles south of Chillicothe and three-quarters of a mile northwest of Massieville, till of this ice sheet occurs up to about 700 feet. Three and one-half miles north of this, in the ravine southwest of Chillicothe and immediately north of Cemetery Hill, bowlder clays occur up to about 750 feet. Three miles northeast of the last, in the northwest corner of Section 17, Springfield Township, the upper limit appears to be at about 780 feet. Yet a mile and one-quarter farther, on the north slope of Bunker Hill, drift obscures the rock to 900 feet, and is common up to 920 feet; though it occurs as sparse pebbles up to 960 feet, the first figures 900 to 920 feet, in kind of observation, are much more in keeping with the other observations in the series. One and three-fourths miles north-northeast, drift fills the gap between Bald Hill and Sugar Loaf and extends easily up to 950 feet.

While not prepared to assert that these few rather fortuitous observations are indicative of the highest drift at the points of examination, or that the slope thus outlined was the slope of the ice surface, which indeed must have fluctuated considerably with slight advances and retreats during a very long time, and which undoubtedly for limited periods stood considerably above this profile, yet it is believed to approximate fairly well to the average slope of the ice in the Scioto Valley. This indicates, for a distance of 8½ miles, an average slope of about 18 feet per mile except in the first real constriction of the Scioto Valley south of the lowlands, where a slope of about 100 feet per mile is indicated. The north slope of Bunker Hill received the direct impact of ice flowing down a channel 4½ miles wide. Owing to a rock bench due west of Bunker Hill, extending to Hopetown, the main current of ice was here reduced to a width of 3 miles or less, and the east bank of the main current was at Hopetown, not Bunker Hill, although shallow ice covered the bench to Bunker Hill.

These circumstances unquestionably must have operated to cause a damming back of the ice above Bunker Hill, its concentration and more rapid flow in the narrower throat at Hopetown, and a steeper slope to the southward from this point, comparable to the rapids in a stream.

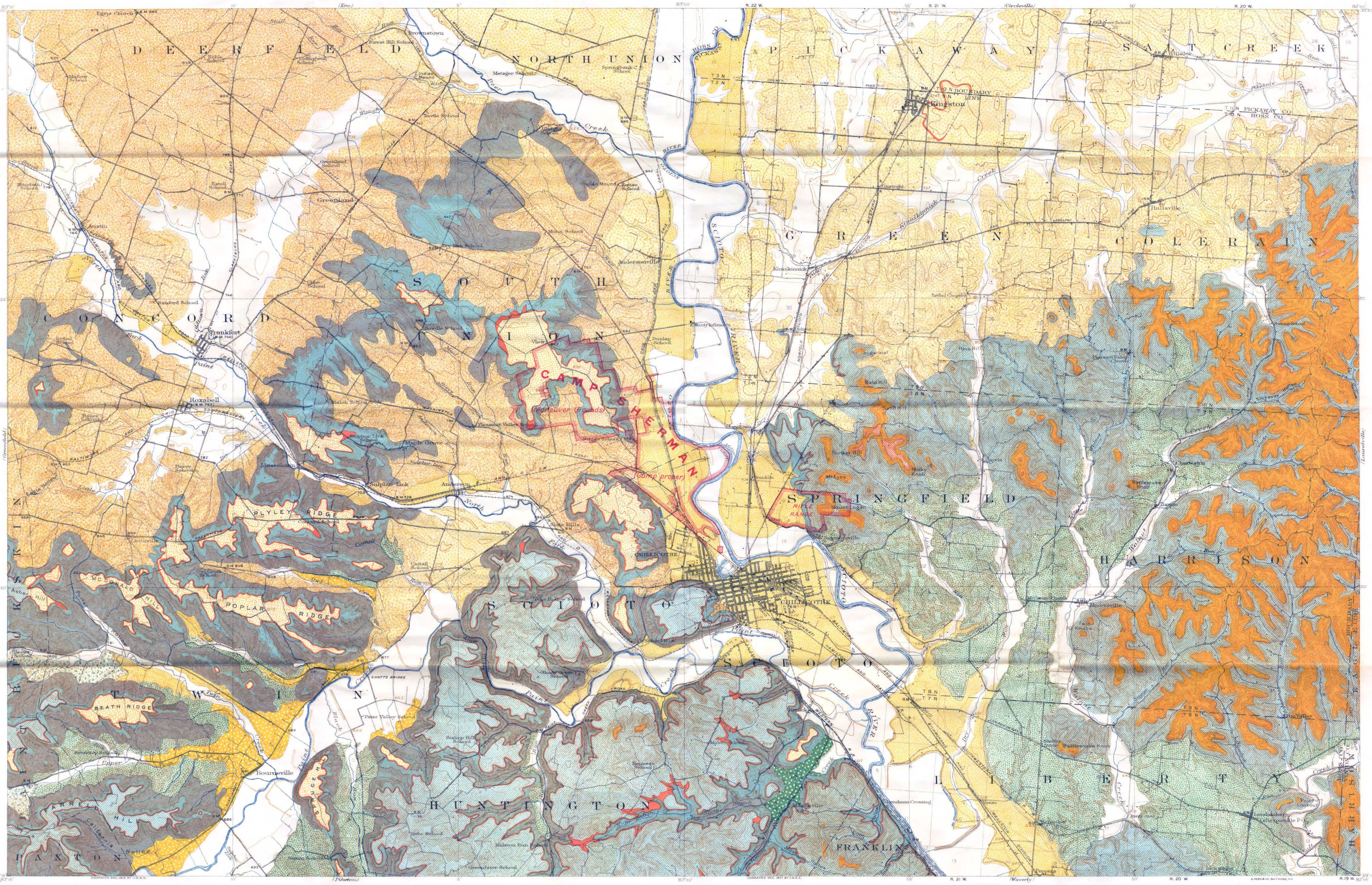
These figures, it must be emphasized, indicate only the slope of a small lobe of ice pushed forward from the main mass into the Scioto Valley.

The use of the upper limit of abundant drift as data from which to deduce the slope of the ice surface from place to place, does not appear, however, to be reliable for all parts of the escarpment. This method permits one to draw no conclusions as to ice slope along the hills bordering the lowlands around Frankfort and Roxabell. On the hill slopes from 1 mile south of Greenland to opposite Frankfort, this upper limit is at about 900 feet. For $1\frac{1}{2}$ miles southwest of North Fork along the hill facing Dry Run, the upper limit seldom attains to 900 feet. But from here southwestward and westward, the limit of heavy coat stands higher, attaining to 1,050 feet in the hills around the head of Dry Run, where the ice unquestionably overrode onto the 1,100-foot uplands and into Owl Creek next to the southward.

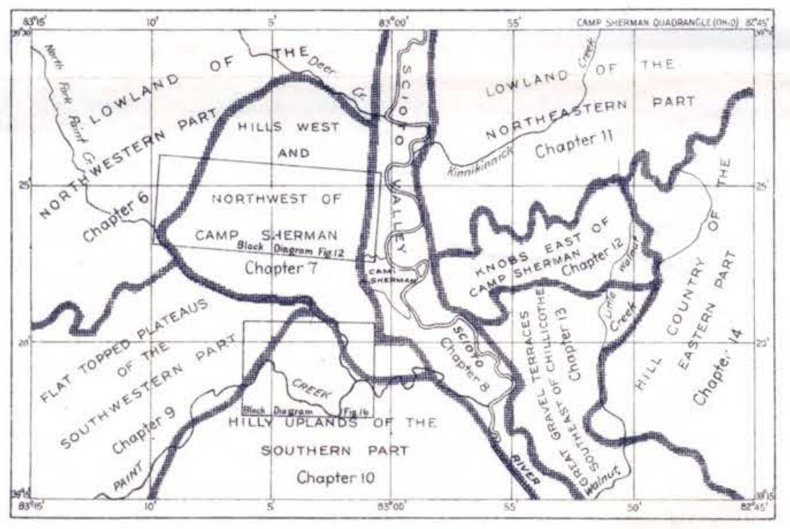
In the valley head around Lattaville, drift is abundant to over 1,020 feet, but was not noticed above that. In the next valley to the westward, due north of Asher Hill, drift is common up to 1,060 feet. Yet on Ragged Ridge, 5 miles due north of the last, abundant drift was noted only up to 1,060 feet, where it ends abruptly, though the hill almost certainly was ice covered.

INDEX[1]

[1]Prepared by Ethel S. Dean.



KEY MAP



Scale 62500

Contour interval 20 feet.
Datum is mean sea level.

MANTLE ROCKS

RECENT VALLEY DEPOSITS

Flood plains and flat valley bottoms, even though they are never flooded, are uncolored. Several kinds of material are represented in these areas. On the flood plain bordering large streams, such as Scioto River, the Paint Creeks and Deer Creek, this is chiefly clayey alluvial soil, in places reaching 6 to 10 feet thickness or more. Along the narrow valleys in the rock hills of the eastern and southern part of the quadrangle, the soils are usually a thin coating over a mass of stream-washed sandstone detritus. On Pikehole Creek, the material is a thick peat soil ("muck"), a reclaimed swamp, incapable of supporting heavily loaded wheels when wet. Soils similar to the last but more clayey are found in Kinnikinnick, Oldtown, and Waugh Run Valleys, all of them treacherous to heavy transportation after prolonged wet weather, and should be avoided in tank operations or in movement of heavy artillery. Excavations in all such areas may be expected to encounter water within a very few feet of the surface, will require complete revetment, and should be avoided. These areas are rarely wooded and then only in small patches.

RECENT OR GLACIAL UPLAND CLAYS

Thin coating of clays on flat-topped plateaus. In places these are in part of glacial origin, as northwest of Camp Sherman, but in the southwestern portion they appear to be residual from the weathering of clay shales. They rest directly on the very hard Berea Grit, are seldom more than 10 feet and are commonly less than 5 feet thick at the margins of the plateaus, but in the interiors may possibly attain 30 feet. Excavation of regulation trenches at the margin of such plateaus can be expected only by troops equipped with picks, and preferably prepared to blast; entrenchment cannot be accomplished on a few hours notice. Water in considerable volume may be expected everywhere at the base of these clays, but probably can be exhausted in time by drainage, ditches or pumps. Excavations will require revetment. Rarely wooded.

LATE WISCONSIN DRIFT

TERRACE GRAVELS

Gray, unconsolidated gravels, mostly of limestone pebbles, in terraces bordering stream valleys, usually with only a few inches of soil covering them. Southeast of Chillicothe, the material is partly sand. Except near stream level, may be expected dry. The best source of concrete material in the quadrangle, but practically all will require washing to make a first grade concrete. Rarely wooded except on slopes.

LAKE CLAYS AND GRAVELS

Beds of lake clays up to 6 feet in thickness, dense, gritless, damp, exceedingly difficult to excavate with a pick, caving readily. Yields sticky, wet clay soils. Should be avoided in excavations or maneuvers. The associated gravels are almost equally difficult to excavate because of the over-lying clays.

KAMES & KAME MORAINES

Gravels and gravelly clays, rarely consolidated, usually covered with a few inches of clay soil. In places may furnish excellent concrete gravel if properly selected. Thickness more than 50 feet at practically all places. Water conditions various, depending on elevation above surrounding streams. As a rule, can be relied on in wet weather for tank operation. Unforested except for small wood-lots.

MORAINE

Tough boulder clays, commonly 50 to 100 feet thick, can be readily excavated, though not rapidly; excavation impermanent and must be revetted. Water almost always present, in abundance, at depths corresponding to height above neighboring drainage. Seldom forested, except on steep ravine walls southwest of Roxabell.

PRE-WISCONSIN, MOSTLY ILLINOISAN DRIFT.

TERRACE GRAVELS

Deeply weathered gravels composed of pebbles of insoluble rock, such as chert, gneiss, sandstone, etc., rarely of limestone, covered with reddish clayey soils 25 feet or more thick. Worthless for concrete material. Deeply dissected by streams and abundantly water-bearing near level of the streams. Excavations on hills will be dry except for run-off from rainfall, but will require complete protection. Stiff, wet lake clays will be encountered in beds between gravels near stream level and in the deeper portions, almost impossible of excavation, and in which excavations could scarcely be maintained; these must be avoided. Deforested except steeper slopes.

LAKE CLAYS

Character and behavior same as Wisconsin lake clays described above.

MORAINE

Apparently boulder clays; material coarse, age uncertain. Excavations as described above under Wisconsin moraine; no water.

BED ROCKS

PENNSYLVANIAN

POTTSVILLE SANDSTONE

Coarse sandstone, 10 to 40 feet in thickness, pebbly in places. Confined almost exclusively to the top of the high knobs east of Camp Sherman, where they may form low ledges. Can be excavated by blasting only; soil covering thin or absent. Occasional weak springs occur near the base but the water content is unimportant. A suitable stone for masonry, if carefully selected, but inaccessible.

MISSISSIPPIAN

LOGAN SANDSTONE

Fine-grained gray or yellow sandstones, 275 feet thick in eastern portion of quadrangle, much less in western portion. These sandstones always form steep slopes with little or no soil; the sandstones are tough and can be excavated with pick and shovel only with great labor. Free of water. Excavations will require little or no revetment. Slopes are usually wooded.

PORTSMOUTH, CUYAHOGA, AND SUNBURY SHALE

With the exception of the 15 to 20 foot black Sunbury shale at the base, these are gray clay shales with thin sandstones, in all, some 300 to 400 feet thick. Where these shales underlie the steep slopes east of Scioto River, stony clay soils of only a few inches thickness will be found mantling the shales; west of the river where the slopes are gentler these soils may be several feet thick. Excavations can be made with trench tools, will require revetment, but may be expected dry if surface water is kept out. When the shale is encountered in excavation, the thin sandstones may be found troublesome and on the ridge in the southwestern part of Huntington township, south of B. M. 1136, a stubborn sandstone member near the 1100 foot contour should be avoided in hasty entrenchment. Springs within the outcrop area of these formations are uncommon. On the steep slopes east of the Scioto such are impermanent but west of the Scioto and south of Paint Creek, occasional springs with year-round flow occur; these are always of good water. Springs are more numerous at the base of these formations at the top of the Berea Grit but the waters are commonly high in iron or alum from the Sunbury shale. East of Scioto River, the outcrop of these formations is almost wholly wooded. In the few places where slopes are gentler, they may be bare. Westward from Scioto River and south of Paint Creek, woodland is generally present depending on the slope. West of Ralston Run it is scattered in patches only on the steeper slopes.

BEREA GRIT

Hard, fine-grained, brown or gray sandstone, commonly 25 to 30 feet thick, and composed of beds usually from an inch to 1 foot thick. On the Scioto River at the south line of the quadrangle, this formation is reduced to about 2 feet. This is the most important formation in the region west of the River. The flat tops of the plateaus north of Paint Creek are almost immediately underlain by it and owe their origin to its resistance. South of Paint Creek it gives rise to a series of broad gently rolling uplands deeply dissected by streams which have cut through the Berea. At the outcrop this formation will present difficulty in excavations and entrenchment should not be ordered except with sufficient time and adequate tools. On the flat-topped plateaus, it will be encountered at shallow depths, often several rods from the brow of the hill. A line of springs occurs around the top of its outcrop wherever it gives rise to an essentially flat surface; these are commonly high in alum and occasionally unusable. The water comes, not from the Berea but from the overlying clays (see "Recent or Glacial Clays" above) and may be troublesome to trench systems. South of Paint Creek, the Berea will seldom be a factor in trench systems except at its immediate outcrop, because of the slopes rising from it, and water at this horizon will be negligible. An excellent stone for masonry. Forests commonly cover hill slopes to the top of the Berea Grit.

BEDFORD SHALE

Soft gray clay shale, 90 feet thick, with numberless thin sandstone lenses and a few thicker sandstones in the upper part which render that portion more resistant. Gives rise to stiff stony clay soil which, when wet, will prove heavy to tanks or ordinance. Can be excavated without difficulty but trenches impermanent; dry. Outcrop slopes usually steep and wooded.

DEVONIAN

OHIO SHALE

Black, carbonaceous shale, several hundred feet thick, but base not exposed. Almost without exception, this is exposed only on steep slopes either with no soil covering or one of a few inches only. Very tough and difficult to dig, excavations should be blasted. Does not weather into clay and will furnish adequate foundation for heavy artillery and ample support to heavy transportation, slopes permitting. Formation dry, except for rare occurrence of water in joints; such water heavily impregnated with iron or alum. Slopes usually wooded.