EXPLANATION.

The Geological Survey is making a large topographic map and a large geological map of the United States, which are being issued together in the form of a Geologic Atlas. The parts of the atlas are called folios. Each folio contains a topographic map and a geological map of a small section of country, and is accompanied by explanatory and descriptive texts. The complete atlas will comprise several thousand folios.

THE TOPOGRAPHIC MAP.

The features represented on the topographic map are of three distinct kinds: (1) inequalities of surface, called relief, as plains, prairies, valleys, hills and mountains; (2) discharge of water, called drainage, as streams, ponds, lakes, swamps and canals; (3) the works of man, called cultures, as roads, railroads, boundaries, villages and cities.

Belief.—All elevations are measured from mean sea level. The heights of many points are accurately determined and those which are most important are stated on the map by numbers printed in brown. It is desirable to show also the elevation of any part of a hill, ridge, slope or valley; to delineate the horizontal outline or contour of all slopes; and to indicate their degree of steepness. This is done by lines of constant elevation drawn above mean sea level, which are drawn at regular vertical intervals. The lines are called contours and the connecting curves of the two or more contours is called the contour interval. Contours are printed in brown.

The map gives an idea of the three conditions of relief (elevation, horizontal form) and degree of slope as shown in the following sketch and corresponding contour map:

Fig. 1. The upper figure represents a sketch of a valley, with terraces, and a hill high by 1400 feet above sea level, with the slopes and forms produced by the movement of the surface being shown by contours.

The sketch represents a valley between two hills. In the foreground is the sea with a bay which is partly divided by a long low island. The island is continuous along the eastern edge of the valley is a terrace; from that on the right a hill rises gradually with rounded forms, whereas from that on the left the ground slopes steeply to a precipice which presents sharp corners. The western slope of the higher hill with similar forms by the eastern by its gentle descent. In the map each of these features is indicated, diametrically beneath its position in the sketch, by contours. The following explanation may make clearer the manner in which contours delineate height, form and slope:

1. A contour indicates approximately a height above sea level. In this illustration the contour interval is 50 feet; therefore the contours occur at 50, 100, 150, 200 feet, and so on, above sea level. Along the contour at 250 feet in all points of the surface 250 feet above sea; and so on with any other contour. In the space between two contours occur all elevations above the lower and below the higher contour. Thus the contour at 150 feet falls just below the edge of the terrace, while that at 200 feet lies above the terrace; therefore all points on the terrace are shown to be more than 150 but less than 200 feet above sea. The summit of the highest hill is the sea level, and the valley, accordingly the contour at 650 feet surrounds it. In this illustration nearly all the contours are numbered; the heights of others may then be ascertained by counting up or down from a numbered contour.

2. Contours define the horizontal forms of slopes. Since contours are continuous horizontal lines conforming to the surface of the ground, they indicate the direction and the form of the surface. Contours are defined by intervals of various and definite proportions. The relations of contour characters to forms of the landscape can be traced in the map and sketch.

3. Contours show the approximate grade of any path or roadway. It is apparent, however, that whether they lie along a cliff or on a gentle slope, but to rise on a given height on a gentle slope one must go further than on a steep slope. Therefore contours are far apart on the gentle slopes and near together on steep ones.

For a flat or gently undulating country a small contour interval is chosen; for a steep or mountains country a large contour interval is necessary. The smallest contour interval used on the atlas sheets of the Geological Survey is 5 feet. This is used for districts like the Mississippi delta and the Desmat Swamp region. In mapping great mountains like those in Colorado, on a scale of 1:250,000, the contour interval may be 50 feet. For the irregularities shown on the drawing 10, 20, 50, 100, and 100 feet are used.

Drainage.—The water courses are indicated by means of lines on the map, which lines are drawn along the stream flows the year round, and dotted where the channel is dry a part of the year. Where the streams are of little consequence the characteristic of the surface are also shown. The thoroughfare courses are shown by a broken line. Marshes and canals are shown also in blue.

Culture.—In the progress of the settlement of any region men establish many artificial structures. Such as, walls, railroads and towns, together with names of natural and artificial details and boundaries of towns, counties and states, are printed in red.

As a region develops, cultural changes and gradually comes to disagree with the map; hence the representation of cultures needs to be revised from time to time. Each sheet bears on its margin the dates of survey and revision.

Scales.—The area of the United States (without Alaska) is 3,095,000 square miles. On a map 240 feet long and 180 feet high the area of the United States would cover 3,090,000 square inches. Each square mile of ground surface would be represented by a corresponding square inch of map surface, and one linear mile on the ground would be represented by a linear inch on the map. In this special case it is "one mile to one inch." A map of the United States half as long and half as high (3 feet by 1 foot) would have a scale half as great, its scale would be "two miles to one inch," or four square miles to a square inch. Scale is also often expressed as a fraction, of which the numerator is the length on the map and the denominator the corresponding length in nature expressed in the same unit. Thus, as there are 6,336 inches in a mile, the scale "one mile to one inch" is expressed by 1:6336.

Three different scales are used on the atlas sheets of the U. S. Geological Survey; the smallest is 1:63,360, the second 1:250,000, and the largest 1:20,000. These correspond approximately to four miles to two miles, and one mile of natural length to one inch of map length. On the scale 1:63,360 one inch square of map surface represents and corresponds nearly to one square mile of surface; on the scale 1:1,000,000 to about four square miles; and on the scale of 1:250,000 to about sixteen square miles. At the bottom of each atlas there is a statement further indicated by a "bar scale," a line divided into parts representing miles and parts of miles, and serving as a comparison of the scale on the map. The smallest scale used by the Geological Survey would be 60 feet long and 45 feet high. Since this is only one sixtieth of a mile, it seems to be about one scale measure of 16 times or four times as long and high. To make it possible to use such a map it is divided into atlas sheets. Where the maps is made are heavy and numbered; the heights of

The geological map represents the distribution of rocks, and is based on a topographic map—that is, a topographic representation the geologic representation is added.

Rocks are of many kinds in origin, but they may be classified in groups: (1) Nonvolcanic Rocks, that is, rocks formed of sediments; (2) Volcanic Rocks, that is, rocks formed from lava; (3) Metamorphic Rocks, that is, rocks altered from other rocks. The character and positions of the different rocks show variations. Where the land has been uplifted, one bed of rock may be overlying another bed of rock, the two may be distinguished. Each of these names is limited in extent to the area over which it was deposited, and is bounded above and below by different rocks. It is convenient in geology to call such a mass a formation.

1. Sedimentary Rocks.—These are composed chiefly of clay, sand and gravel, deposited in beds and irregular beds, usually unconsolidated. Within a period of the earth's history, a thick and extensive ice sheet covered the northern portion of the United States and part of British America, as one great glacier moved southward. The ice gathered slowly, moved forward and retreated as glaciers do changes of climate, and after a flow of ICARUS and was overthrown by another bed of ice, the two may be distinguished.

In the past several years periods several periods may be represented, and the representation of each may include one or more formations. To distinguish the sedimentary formations of any one period from those of another, the patterns of the formations of each period are printed in the appropriate period; and the formations of any one period are distinguished from one another by different patterns. Two kinds of the period-colors are used: a pale tint (the underprint) is painted evenly over the whole surface representing the period; a dark tint (the overprint) brings in the different patterns representing formations. Each formation is further distinguished by a letter-symbol, which is painted on the map with the capital letter-symbol of the period.

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DESCRIPTION OF THE SEWANEE SHEET.

GEOGRAPHY.

General relations.—The Sewanee sheet is bounded by the parallels 35° and 35°30', and the meridians 83°30' and 83°52'. It embraces, therefore, a quarter of the southeastern degree of the earth's surface. Its dimensions are 94.5 miles from north to south and 83.8 miles from east to west, and contains 9746.4 square miles. The adjacent atlas sheets are McMinville on the north, Chattanooga on the east, and Stevenson on the south, while the country to the west has not yet been surveyed.

The sheet lies wholly within the State of Tennessee, the southern limit being within about a mile of the Tennessee-Mississippi line. It embraces sections of Grundy, Sequatchie, Marion, Franklin, and Coffee counties.

In its geographical and geological relations this area forms a part of the Appalachian province, which extends from the Atlantic coastal plain on the east to the Mississippi lowlands on the west, and from central Alabama to southern New York. The region thus defined has a common history recorded in its rocks, its geologic structure, and its topographic features. Only a part of this history can be read from the area so small as that covered by a single atlas sheet; hence it is necessary to consider the individual sheet in its relations to the entire province.

Subdivisions of the Appalachian province.—The Appalachian province may be subdivided into three well-marked, physiographic divisions, each of which is characterized by a distinctive rock formation. These divisions are long narrow strips of country extending the entire length of the province from northeast to southwest.

The central division is the Appalachian valley. It is the best defined and most uniform. It coincides with the belt of folded rocks, which in the southern portion forms a narrow strip along the Tennessee and Alabama and the great valley of East Tennessee. Throughout the central and southern portions of the eastern side alone is marked by great valleys, such as the Shenandoah valley of Virginia, the Cumberland valley of Maryland and Pennsylvania, and the Lea valley on the northeastern part of the State; while the western side is ribbed by a succession of narrow ridges without continuous, intermediate valleys. This division varies in width from 40 to 125 miles; it is sharply outlined on the southwest by the Appalachian mountains, a system made up of many minor ranges which, under various local names, extends from southern New York to central Alabama. Some of its peaks, such as the Smoky mountains of Tennessee and North Carolina, and the Cohutta mountains of Georgia, together with many other less important ranges. Many of the rocks of this division are more or less crystalline, being either sediments which have been changed to rock by intense pressure, or degrees of metamorphosis, of igneous rocks which have solidified from a molten condition, such as granite and diabase.

The western division of the Appalachian province embraces the Cumberland plateau and the Allegheny mountains, a region extending from New York to Alabama, and the lowlands of Tennessee, Kentucky, and Ohio. Its northwestern boundary is indicated by the arbitrary line coinciding with the Mississippi river as far up as Cairo, and then crossing the States of Illinois and Indiana. Its eastern boundary is sharply defined along the Allegheny front and the Cumberland escarpment by the Allegheny mountains. The region between 82°30' and 83°52' and by the present course of the Ohio and the Mississippi rivers to the Gulf.

The rocks of this division are almost entirely of marine origin, and remain very nearly horizontal. The character of the surface, which is dependent on the character and attitude of the strata, varies from gentle slopes or less completely dissected, or elsewhere of a level. In the southeastern part of the province the surface of the plateau is characterized by extensive lowlands, where often it is cut by stream channels into large or small flat-topped hills. In West Virginia, the State of Pennsylvania the plateau is sharply cut by its streams, leaving in relief irregularly rounded knobs and ridges which bear little relation to the underlying geologic surface. The western portion of the plateau has been completely removed by erosion and the surface is now comparatively smooth.

Altitude of the Appalachian province.—The Appalachian province as a whole is broadly dome-shaped, with a gradual ascent towards the north, rising from an altitude between 1,700 and 2,000 feet on the south to 1,900 or 2,000 on the north, and deeply cut by stream channels, especially in the southern portion of the sheet, so that the present surface has only a small portion of the plateau. The portion that remains, however, is still distinctly a plateau. The surface in general is quite smooth and so densely wooded as to conceal many miles with the illusion that it descends to 2,300 feet in the valley of New river, 1,900 to 2,000 feet in the James, from 500 to 1,000 feet on the Potomac, and so on. These figures represent the average elevation of the valley surface, below which the stream channels are seen from 250 to 250 feet, and above which the valley ridges rise from 500 to 600 feet.

The plateau division is in altitude from 1,400 to 1,500 feet above sea level, and is limited to the Allegheny mountains. These longitudinal streams empty into a number of larger transverse rivers, which cross one or the other of the barriers limiting the valley. In the northern portion of the province they form the Delaware, Susquehanna, Potomac, James, and Kanawha rivers, each of which breaks through the Appalachian mountains by a narrow gap and flows eastward to the sea. In the central portion of the province in Pennsylvania and Ohio the longest streams form the New or Kanawha river, which flows westward in a deep narrow gorge through the Allegheny mountains of Pennsylvania, and turns from the apparently natural course and, entering a gorge through the plateau, runs westward to the Ohio. From this stream the valley flows directly to the Gulf. There is abundant evidence that the divide between the Tennessee and Coosa basins is comparatively recent and that formerly the Tennessee river flowed directly across the present divide in the mountains and by the present course of the Coosa and Alabama rivers to the Gulf.

All of the broad plateau division of the province, except a small portion in Pennsylvania and another in Alabama, is drained by streams flowing toward the Gulf, and the portion of the eastern of the Appalachian mountain is drained eastward to the Atlantic, while the western part is drained westward by tributaries of the Tennessee or southwestern by tributaries of the Coosa.

Topography of the Sewanee sheet.—The country embraced in the atlas sheet lies almost wholly within the western division of the Appalachian province. Crossing its southeastern corner is the Sequatchie valley, located upon the westernmost of the sharp folds which characterize the central or valley division of the province. The larger part of the sheet is occupied by the Cumberland plateau, with its gradual ascent toward the north, rising from an altitude between 1,700 and 2,000 feet on the south to 1,900 or 2,000 on the north, and deeply cut by stream channels, especially in the southern portion of the sheet, so that the present surface has only a small portion of the plateau. The portion that remains, however, is still distinctly a plateau. The surface in general is quite smooth and so densely wooded as to conceal many miles with the illusion that it descends to 2,300 feet in the valley of New river, 1,900 to 2,000 feet in the James, from 500 to 1,000 feet on the Potomac, and so on. These figures represent the average elevation of the valley surface, below which the stream channels are seen from 250 to 250 feet, and above which the valley ridges rise from 500 to 600 feet.

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GEOLOGY.

Sedimentology.
The sedimentary record.—All the rocks appearing at the surface within the limits of the Swae-son axis are of sedimentary origin; that is, they were deposited by water. They consist of sandstones, shales, and limestones, presenting great variety in composition and appearance. The materials of which they are composed were originally gravel, sand, and mud, derived from the wear of older rocks, or from remains of plants and animals which lived while the strata were being laid down. Thus some of the great beds of limestone were formed by the skeletons of various sea animals, and the beds of coal are the remains of a luxuriant vegetation which probably covered low, swampy lands.

These rocks afford a record of almost uninterrupted sedimentation from early Cambrian to late Carboniferous time. Carbonate and sandstone formations and appearance indicate the nearness to shore and the depth of water in which they were deposited. Sandstones marked by cross-bedding and by current lines and shales eroded on the sea flats indicate shallow water; while limestones, especially those from the Coal measures, indicate a greater depth of water and absence of sediment. The character of the adjacent land is also shown by the character of the sediments derived from its waste. Coarse sandstones and conglomerates, such as the basal sandstones of the Coal measures, were derived from land high on which streams were steep, or they may have resulted from wave action on the sea encroached upon a sinking coast. Red sandstones and shales, such as make up some of the Cambrian and Silurian formations, result from the return of erosion on a land surface long exposed to rock decay and oxidation, and here covered by a deep residual soil. Limestones, especially those deposited near the shore, indicate that the land was low and that its streams were too sluggish to carry any considerable sediment except the finest and most saline or saline in solution.

The sea in which these sediments were laid down covered most of the Appalachian province and the Mississippi basin. The area of the Swanse sheet was near its eastern margin and the materials of which its rocks are made were therefore derived largely from the land to the eastward. The exact position of the eastern shore line of this area is unknown, but it probably varied from time to time within rather wide limits.

Two great cycles of sedimentation are recorded in the rocks of this region. Beginning with the first definite record, coarse sandstones and shales were deposited in eastwardly directed streams. A second, which comprised the eastern border of the sea interior as it encroached upon the land. As the land was worn down and the sea advanced, this second deposit became finer, and finally the second, in the Knob dolomite of the Cambrian period, was laid down in the manner described above. The upper part of these sedimentary formations is of great economic importance, and the deposits of coal that they contain are important for the formation of the Appalachian coal fields, which are in part the result of the erosion of these rocks.

DEVONIAN ROCKS.

Chattanooga shales.—Overlying the Rock- ford formation is a thin stratum of shale which appears to represent the whole of the deposition which took place in this region during the Devonian period. Typical exposures of this shale are found in the north end of Como river, within the coal limits of Chattanooga, from which locality it takes its name. The Chattanooga shale is a remarkably uniform character within the limits of the Chattanooga basin, and, when freshly broken, exhibits a strong or light red color that is characteristic.

The shales, on account of their distinctive and striking appearance, have attracted the attention of miners, and has been prospected in many localities for coal and various ores, especially silver and copper. Some of these deposits have been abandoned, and others have been worked by small operators, but the deposits of the Chattanooga are not well known or thoroughly explored.

The sandstone, as its distinctive and striking appearance, has attracted the attention of miners, and it has been prospected in many localities for coal and various ores, especially silver and copper. Some of these deposits have been abandoned, but others have been worked by small operators, and the deposits of the Chattanooga are not well known or thoroughly explored.

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southern portion of the Appalachian valley nearly a bed can be found which dips towards the northwest.

Out of the close folds, the faults were developed and with extremely few exceptions the fault planes dip toward the southeast. The planes on which the rocks on both sides of the principal fault plane, the arrows indicating the direction in which the strata have been moved on its opposite sides as six and eight miles. There is a progressive increase in degree of deformation from northeast to southwest, resulting in the strata dipping as far east as eight miles. Pennsylvania faults are inconspicuous.

Passing through Pennsylvania towards Virginia they rapidly increase in size and dip greatly over. Passing through Virginia and into Tennessee the folds are more and more broken by faults, until, half way through Tennessee, nearly every fold is broken and the strata form a series of narrow, overlapping blocks, all dipping eastward. This condition holds nearly the same statewide into Alabama, but the faults become fewer in number and their horizontal displacement much greater, while the folds persist.

The Appalachian mountains in the structure is the same as that which marks the great valley; there are here the same broad anticlinal folds, the same thrust faults, etc. In addition to these changes of form, which took place mainly by motion on the blocks and which are now due to the strata only a few feet to the east and north, their inclination can be determined only by de
termining the latitude of some particular bed at the surface. The outer corner of the sheet belongs to the central division of the Appalachian province, which is char
acterized by steep narrow folds.

The Sechuanticus antilpne is typical of the Appalachian folds. In length it is somewhat greater than the Sechuanticus valley, for at its center the upper rocks have not been removed by erosion but remain as a high arch. This arch forms the northern terminus of the Sechuanticus valley. On the southeastern side of the antilpne the rocks dip at low angles, from 8° to 12°, while on the northwestern side of the Sechuanticus valley the attitude is almost vertical, being in some places vertical or overturned. Upon the northern side of the antilpne the inclined stretch is terminated by a thrust across the edge of the younger. North of Jasper the Banger limestone west of this thrust, while the adjacent sandstone above the limestones, the three intermediate formations which normally occur being entirely concealed. South of Jasper this displacement occurs from the coast, the fault plane is not so great and only the Chattanooga and Rockwood sandstones are concealed. The Sechuanticus valley is not as large as the Sechuanticus valley on the western side of the valley of the iron ore bearing Rockwood formation.

The Sechuanticus valley the rocks are not folded but have a gentle eastward dip. As shown by over the top of the Banger limestone has a gradual rise from an altitude of 1,570 feet near the valley, 1,900 feet at Sechuanticus, 1,830 feet at the western edge of the plateau, which is an average of about 50 feet per mile. The top of the Lookout sandstone rises in the same distance only about 500 feet, or about 25 feet per mile, since that formation is 250 feet thinner at the western escarpment than at Sechuanticus valley. While no considerable folds have been formed in these rocks they are well adapted to the development of a great horizontal pressure. In many places thin beds, especially of coal and argillaceous shale or limestone, have been metamorphosed by the pressure on the layers of massive, rigid sandstone, which show no change from their original position. This pressure has been sufficient to cause the Virginia, which is much more common in the Lookout strata than in the Walden and sometimes offers serious obstacles to mining the lower coals.

MINERAL RESOURCES.

The mineral resources of the Sewanee sheet consist of coal, iron ore, limestone, building and road stone and brick clay. Coal.—The productive coal-bearing formations, consisting of the Lookout and Walden sandstones, are so compressed between the layers of massive, rigid sandstone, which show no change from their original position. The coal field extends from the town of Franklin, 50 miles to the north, to the mouth of the Bear River, 35 miles to the south. The coal is from 6 to 14 inches thick; it may correspond to the Bear River coal section, and to the upward horizon shown in the Sewanee and Tracy sections. The lowest bed is from 4 to 14 inches thick and apparently corresponds to the upper bed in the Creek coal section and to the upward horizon shown in the Sewanee and Tracy sections. The lower bed is from 6 to 14 inches thick; it may correspond to the Creek coal section, or, more probably, to the one below it.

Several seams appear north of the Little Sechuanticus river, as shown on the Victoria and White documents. The Sechuanticus valley has been opened another section. Like any other rock layer, however, it is not absolutely con
stant, so that, while the map indicates within narrow limits, it is not clear to which the ore may occur. Careful examination is required to determine whether, at any particular locality its quantity and quality are such as to make it commercially valuable.

The proportion of iron in the ore usually does not appear in rocks; it is not genuine, and it is not generally a good ore. The surface, at and that makes it a very important ore. The presence of iron in the ore is not objectionable, except as it renders mining more difficult, for it removes the necessity of adding other elements to the furnace.
The outcrop of the Rockwood formation occurs a narrow strip along the eastern side of the Sequatchie valley, the strata dipping at low angles, from 8° to 15°, toward the east, below the Waverly ridge. The corresponding outcrop of the formation on the western side of Sequatchie valley is concealed by a fault, as already explained, and as shown in the structure section.

The ore is extensively worked at Inman, where the bed is 53 feet thick. It is separated from the overlying Chattanooga black shale by 90 feet of bluish, calcareous sand. A bed of bluish limestone 3.5 feet thick occurs immediately above the clay. At the outcrop the ore is mined by strip mining, from 20 to 30 feet of overlying rock being removed. In some places the amount of lime increases gradually from the outcrops downward, while in others a sharp line separates the soft from the hard ore. The workings have reached over 500 feet from the surface with no important change in thickness or quality of the ore. Taking the average of many analyses the hard ore contains 24.5 per cent. of metallic iron and about 9.7 per cent. of lime. The Inman ore is used at the South Pittsburg furnace, generally being mixed with limonite from Alabama.

Carbonato.—The spathic or black band iron ore has not yet been utilized in this region, though considerable quantities probably exist. It is not generally so uniform in quality or quality as the hematite, although, like that ore, it occurs in a regularly stratified deposit. It is found almost exclusively at the contact of the Banger limestones and Limestone sandstones. The bed has been observed at various points on Crow creek, in Lost creek, in the baring at Tracy, in Beeswax springs, and at the head of Hubbard cave. At the last named locality it has been opened and is about 3.5 feet thick. The change which the ore undergoes from carbonate to limonite may there be observed in all its phases. At the outcrop it consists almost wholly of limonite shells. A short distance from the surface it is composed of nodules coated with limonite, but containing a core of unchanged carbonate within. Still further from the surface the bed is unchanged carbonate. The latter is light yellow and resembles in appearance a fine grained, earthy limonite. The limonite shells are partially filled with clay, which is the earthy matter originally disseminated through the carbonate, together with some unchanged carbonate.

An analysis of different portions of the ore shows the following composition: (1) the unchanged carbonate; (2) the completely oxidized limonite shell; and (3) the residual material partially filling the latter.

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<th>SiO₂</th>
<th>Fe₂O₃</th>
<th>CaO</th>
<th>MgO</th>
<th>MnO</th>
<th>P₂O₅</th>
<th>Total</th>
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It is thus seen to compare favorably with other spathic ores, being comparatively low in silicates and phosphorus.

Although this ore may not at present compete successfully with the more abundant and easily accessible hematite, it will probably be utilized in the near future.

Limestone.—The supply of limestone on the Sequatchie sheet is sufficient for blast furnace flux and for lime is abundant and convenient of access. At the North Pittsburg furnace Banger limestone is used from a quarry on the mountain side above the furnace. It contains from 3 to 9 per cent. of magnesia.

The Banger limestone is also extensively burned for lime at Cherworn.

Building stone.—Stone adapted to architectural uses occurs in nearly every formation on the sheet. That which has been mostly largely used is in the upper part of the Lookout sandstone. Quarries in the vicinity of Sequatchie furnished the building stone and pink sandstone of which some of the imposing university buildings were constructed. Considerable stone has also been shipped from the same quarries. Some beds of light gray dolomite limestone in the Banger seem admirably adapted for building purposes, closely resembling the well-known Indianola oolite or Bedford stone. Lime from some of this character forms a high bluffs along the Nashville, Chattanooga and St. Louis railway east of Signal mountain and also occurs along the same road in Cove creek valley.

Road material.—The hard blue Banger and Chickamauga limestones furnish an abundant supply of macadamia material, requiring but little transportation. The residual chert or flint of the Fort Payne and Knox dolomite formations is an ideal road material and might be used to excellent advantage for surfacing in macadam roads.

Clay.—The residual deposits resulting from the solution of the Chickamauga limestones are red or blue clays, and are generally well adapted for making brick. Some portions of the Banger limestones leave a residual clay suitable for brickmaking and also for drain tile. Several beds of fire clay which are associated with the coal probably contain material well adapted for making brick, but they are as yet wholly undeveloped.

SOILS.

Derivation and distribution.—Throughout the region covered by the Sequatchie adobe sheet there is a very close relation between the character of the soils and that of the underlying geological formations. Except in limited areas along the larger streams and on the steepest slopes, the soils are derived directly from the deep and disintegration of the rocks on which they lie. All sedimentary rocks, such as occur in this region, are changed by surface waters more or less rapidly, depending on the character of the soil which holds their particular mixtures. Silicious material is nearly insoluble and rocks in which it is present, such as quartzite and some sandstones, are extremely clayey. Clayey material is more soluble and produces a sandy loam. Consequently, cement, on the other hand, is readily dissolved by the water containing carbonic acid and by the water of the soil. This cement holds together in the rock crumbly down and form a deep soil. If the calcareous cement makes up a small part of the rock it is often leached out far below the surface, and the rock retains its form but becomes soft and porous; but if, as in limestones, the calcareous material forms the greater part of the rock, the insoluble portions collect on the surface as a mantle of soil varying in thickness with the character of the limonite, being generally quite thin where the latter is pure, but often very thick where it contains much insoluble matter.

When derived in this way from the disintegration of the underlying rock, soils are called secondary. If the rock is a sandstone or sandy shale the soil is sandy, and if it is a clay shale or lime- stone the soil is clay. There are abrupt changes in the character of the rocks, sandstones and shales alternating with limestones, so there are abrupt transitions in the character of the soil, and soils differing widely in composition and agricultural qualities often occur side by side.

Knowing the character of the soils derived from the various geological formations, their distribution may be approximately determined from the map showing the soil geology, which thus serves also as a soil map. The only considerable areas which the boundaries between different varieties of soil do not coincide with the formation boundaries are in the river bottoms and upon the steep slopes, where soils derived from rocks higher up the slope have washed down and mingled with or covered the soil derived from those below. The latter are called overplowed soils, and a special map would be required to show their distribution.

Classification.—The soils of this region may conveniently be classed as (1) sandy soils, derived from the Waverly and Lookout sandstones; (2) clay soils, derived from the Banger and Chickamauga limestones and Rockwood shale; (3) alluvial soils, deposited by the larger streams upon their flood plains; and (4) sandy soils.—The Cumberland plateau is forming of sandstones and sandy shales, and its soil is a sandy loam. At the surface it is gray, while the subsurface is generally light yellow, but varies to deep red. In some places it consists largely of sand, but in others it contains sufficient clay to give the subsoil considerable cohesiveness, so that a cut back will remain vertical for some years. The depth of soil on the plateau varies from a few inches to ten feet or more, diminishing in proximity to streams where erosion is most active. A large part of the plateau retains its original forest growth, chiefly of oak, chestnut and hickory, while pines cloth the steeper sides of the stream channels. The practice of burning off the leaves each fall prevents the accumulation of vegetable mold and has delayed a just appreciation of the agricultural possibilities of this region. It has been found well adapted for fruit-raising, particularly for grapes, and the Swiss colonists at Grundy make considerable quantities of wine.

The soil of the "Barrens," on the extreme northwestern portion of the sheet, is a light gray, sandy loam, well suited to the soil of the plateau, but is even less productive. It is not wholly a residual soil derived from the underlying rocks, but was deposited either in standing water or on a low land surface near the mouths of streams, when this region stood nearly at sea level.

Since the sandstones of this region occupy the highest land, the overplowed soils, or those washed down to lower levels, are mostly sandy. They are especially abundant at the foot of the escarpment surrounding the plateau, where the Banger limestones and its clay soil are often wholly concealed. The delta deposits formed by streams emerging from gorges cut in the plateau also give considerable area of sandy soil, overlying rocks which would themselves produce clay or cherty soils.

 Clay soils.—These are derived chiefly from the Banger and Chickamauga limestones, and their distribution coincides with the outcrops of these formations, as shown on the geologic map. They sometimes have a deep red color, but where the mantle of residual material covering the rock is thin it is often dark bluish gray. The rocks generally weather more rapidly where they have a steep dip than where they are nearly horizontal. The soil in many valleys which penetrate the Cumberland plateau is derived chiefly from the Banger limestones. It is a bluish clay with a slight admixture of sand from the rocks capping the plateau, and is exceptionally fertile. It is especially adapted to clover and grain. Considerable areas of red clay land occur on the highland rim between the foot of the plateau and the inner edge of the Barrens.

Curly soils.—More than a third of the area of Sequatchie valley is underlain by the Knox dolomite. The soil derived from this formation consists of clay, in which chert is imbedded. The proportion of chert to clay is variable; in some places only occasional fragments occur, while in others the residual material is made up almost wholly of chert. Where the clay predominates the soil is deep red, but becomes lighter with the increase in amount of chert, and in extreme cases is light gray or white. When the proportion of chert is very large this is a strong, productive soil, especially adapted to fruit raising. The soil derived from the Fort Payne chert is similar to that from the Knox dolomite, but the areas of the Fort Payne are much smaller and usually on steep slopes, so that its soil is relatively unimportant.

Alluvial soils.—The Sequatchie, Flint, and Tennessee rivers are bordered by moderately broad flood plains or bottoms covered with alluvial soil. A strip of such soil from a quarter to a half a mile wide usually occurs along one side of these streams, with a bluff upon the opposite side. The soil of these bottoms is a rich sandy loam, in the case of the Tennessee containing a considerable proportion of fine sand mix derived from the crystalline rocks far to the eastward. These alluvial soils constitute the most continuously productive land of this region.

CHARLES WILLARD HAYES,
Geologist.

June, 1894.
pour out of cracks and vortices and flow over the surface as lava. Sometimes they are thrown from volcanoes as ash and pumice, and are spread over the surface by winds and streams. Often lava flows are interbedded with sediments.

It is desired to find any given rock in the rocks of the earth, which formed during what is called the Archean period, were igneous. Igneous rocks have intruded among masses beneath them, and are not shown in color and pattern may be changed out from volcanoes at all periods of the earth's development. These rocks occur therefore with sedimentary formations of all periods, and their ages can sometimes be determined by the ages of the sediments with which they are associated.

Igneous formations are represented on the geologic maps by patterns of triangles or rounded forms printed in any brilliant color. The location of their formation is known by the symbol called the basalt, or the basaltic symbol, which is used to represent the basalt of the lava. The basaltic symbol is designed so that it can be understood on the map without the aid of a legend.

Geologic history of the district. The formations are arranged in groups according to the order of their deposition. The igneous rocks are generally subdivided into layers, each layer being a stratum of a different type. The strata are shown on the map by their position, and numbers are assigned to each stratum to indicate its position in the sequence of deposition.

The section and landscape in Fig. 2 are hypothetical, but they illustrate only relations through which the strata are divided. The section on the map should be read in the following way:

1. The strata are shown in their correct order of deposition.
2. The thickness of each stratum is indicated by the length of the line representing it.
3. The distance between the strata is shown by the interval between the lines.
4. The contact between the strata is shown by a dotted line.
5. The slope of the strata is shown by a line at the angle of the slope.
6. The strike of the strata is shown by a line parallel to the strike of the strata.
7. The dip of the strata is shown by a line perpendicular to the strike of the strata.
8. The orientation of the strata is shown by a line parallel to the orientation of the strata.
9. The cross-section of the strata is shown by a line at the angle of the cross-section.
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