DEPARTMENT OF THE INTERIOR

UNITED STATES GEOLOGICAL SURVEY

CHARLES D. WALCOTT, DIRECTOR

GEOLOGIC ATLAS

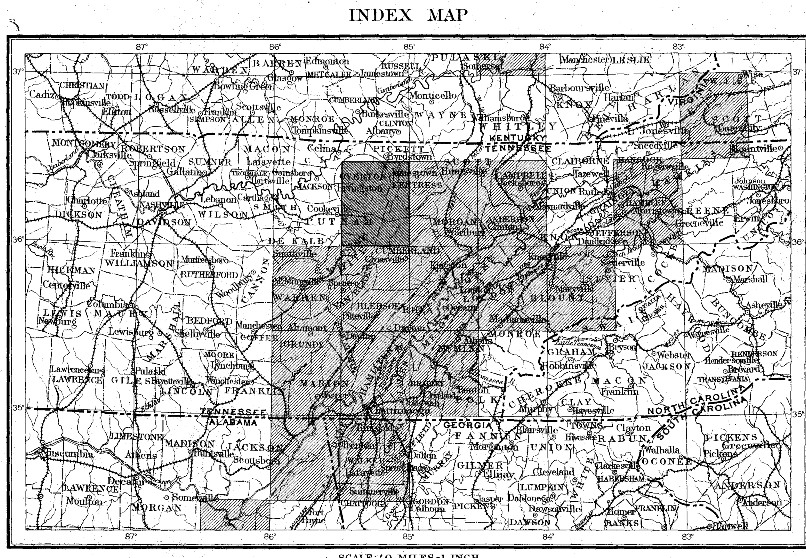
OF THE

UNITED STATES

STANDINGSTONE FOLIO

TENNESSEE

INDEX MAP



SCALE: 40 MILES-1 INCH

AREA OF THE STANDINGSTONE FOLIO

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FOLIO 53 | LIBRARY EDITION | STANDINGSTONE

WASHINGTON, D. C.
ENGRAVED AND PRINTED BY THE U. S. GEOLOGICAL SURVEY
GEORGE W. STOSE, EDITOR OF GEOLOGIC MAPS   S. J. KÜBEL, CHIEF ENGRAVER
1899

EXPLANATION.

The Geological Survey is making a geologic map of the United States, which necessitates the preparation of a topographic base map. The two are being issued together in the form of an atlas, the parts of which are called folios. Each folio consists of a topographic base map and geologic maps of a small area of country, together with explanatory and descriptive texts.

THE TOPOGRAPHIC MAP.

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

Relief.—All elevations are measured from mean sea-level. The heights of many points are accurately determined, and those which are most important are given on the map in figures. It is desirable, however, to give the elevation of all parts of the area mapped, to delineate the horizontal outline, or contour, of all slopes, and to indicate their grade or degree of steepness. This is done by lines connecting points of equal elevation above mean sea-level, the lines being drawn at regular vertical intervals. These lines are called *contours*, and the uniform vertical space between each two contours is called the *contour interval*. Contours and elevations are printed in brown.

The manner in which contours express elevation, form, and grade is shown in the following sketch and corresponding contour map:

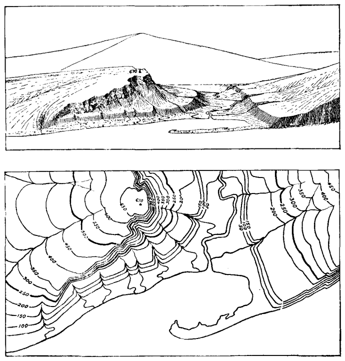


Fig. 1.—Ideal sketch and corresponding contour map.

The sketch represents a river valley between two hills. In the foreground is the sea, with a bay which is partly closed by a hooked sand-bar. On each side of the valley is a terrace. From the terrace on the right a hill rises gradually, while from that on the left the ground ascends steeply in a precipice. Contrasted with this precipice is the gentle descent of the left-hand slope. In the map each of these features is indicated, directly beneath its position in the sketch, by contours. The following explanation may make clearer the manner in which contours delineate elevation, form, and grade:

1. A contour indicates approximately a certain height above sea-level. In this illustration the contour interval is 50 feet; therefore the contours are drawn at 50, 100, 150, 200 feet, and so on, above sea-level. Along the contour at 250 feet lie all points of the surface 250 feet above sea; and similarly with any other contour. In the space between any two contours are found 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 higher hill is stated to be 670 feet above sea; accordingly the contour at 650 feet surrounds it. In this illustration nearly all the contours are numbered. Where this is not possible, certain contours—say every fifth one—are accentuated and numbered; the heights of others may then be ascertained by counting up or down from a numbered contour.

2. Contours define the forms of slopes. Since contours are continuous horizontal lines conforming to the surface of the ground, they wind smoothly about smooth surfaces, recede into all reentrant angles of ravines, and project in passing about prominences. The relations of contour curves and angles to forms of the landscape can be traced in the map and sketch.

3. Contours show the approximate grade of any slope. The vertical space between two contours is the same, whether they lie along a cliff or on a gentle slope; but to rise a given height on a gentle slope one must go farther than on a steep slope, and therefore contours are far apart on gentle slopes and near together on steep ones.

For a flat or gently undulating country a small contour interval is used; for a steep or mountainous country a large interval is necessary. The smallest interval used on the atlas sheets of the Geological Survey is 5 feet. This is used for regions like the Mississippi delta and the Dismal Swamp. In mapping great mountain masses, like those in Colorado, the interval may be 250 feet. For intermediate relief contour intervals of 10, 20, 25, 50, and 100 feet are used.

Drainage.—Watercourses are indicated by blue lines. If the stream flows the year round the line is drawn unbroken, but if the channel is dry a part of the year the line is broken or dotted. Where a stream sinks and reappears at the surface, the supposed underground course is shown by a broken blue line. Lakes, marshes, and other bodies of water are also shown in blue, by appropriate conventional signs.

Culture.—The works of man, such as roads, railroads, and towns, together with boundaries of townships, counties, and States, and artificial details, are printed in black.

Scales.—The area of the United States (excluding Alaska) is about 3,025,000 square miles. On a map with the scale of 1 mile to the inch this would cover 3,025,000 square inches, and to accommodate it the paper dimensions would need to be about 240 by 180 feet. Each square mile of ground surface would be represented by a square inch of map surface, and one linear mile on the ground would be represented by a linear inch on the map. This relation between distance in nature and corresponding distance on the map is called the scale of the map. In this case it is "1 mile to an inch." The scale may be expressed also by a fraction, of which the numerator is a length on the map and the denominator the corresponding length in nature expressed in the same unit. Thus, as there are 63,360 inches in a mile, the scale "1 mile to an inch" is expressed by $\frac{1}{63,360}$. Both of these methods are used on the maps of the Geological Survey.

Three scales are used on the atlas sheets of the Geological Survey; the smallest is $\frac{1}{250,000}$, the intermediate $\frac{1}{125,000}$, and the largest $\frac{1}{62,500}$. These correspond approximately to 4 miles, 2 miles, and 1 mile on the ground to an inch on the map. On the scale $\frac{1}{62,500}$ a square inch of map surface represents and corresponds nearly to 1 square mile; on the scale $\frac{1}{125,000}$, to about 4 square miles; and on the scale $\frac{1}{250,000}$, to about 16 square miles. At the bottom of each atlas sheet the scale is expressed in three different ways, one being a graduated line representing miles and parts of miles in English inches, another indicating distance in the metric system, and a third giving the fractional scale.

Atlas sheets and quadrangles.—The map is being published in atlas sheets of convenient size, which are bounded by parallels and meridians. The corresponding four-cornered portions of territory are called *quadrangles*. Each sheet on the scale of $\frac{1}{250,000}$ contains one square degree, i. e., a degree of latitude by a degree of longitude; each sheet on the scale of $\frac{1}{125,000}$ contains one-quarter of a square degree; each sheet on the scale of $\frac{1}{62,500}$ contains one-sixteenth of a square degree. The areas of the corresponding quadrangles are about 4000, 1000, and 250 square miles, respectively.

The atlas sheets, being only parts of one map of the United States, are laid out without regard to the boundary lines of the States, counties, or townships. To each sheet, and to the quadrangle it represents, is given the name of some well-known town or natural feature within its limits, and at the sides and corners of each sheet the names of adjacent sheets, if published, are printed.

Uses of the topographic sheet.—Within the limits of scale the topographic sheet is an accurate and characteristic delineation of the relief, drainage, and culture of the district represented. Viewing the landscape, map in hand, every characteristic feature of sufficient magnitude should be recognizable. It should guide the traveler; serve the investor or owner who desires to ascertain the position and surroundings of property to be bought or sold; save the engineer preliminary surveys in locating roads, railways, and irrigation ditches; provide educational material for schools and homes; and serve many of the purposes of a map for local reference.

THE GEOLOGIC MAP.

The maps representing areal geology show by colors and conventional signs, on the topographic base map, the distribution of rock formations on the surface of the earth, and the structure-section map shows their underground relations, as far as known, and in such detail as the scale permits.

KINDS OF ROCKS.

Rocks are of many kinds. The original crust of the earth was probably composed of *igneous rocks*, and all other rocks have been derived from them in one way or another.

Atmospheric agencies gradually break up igneous rocks, forming superficial, or *surficial*, deposits of clay, sand, and gravel. Deposits of this class have been formed on land surfaces since the earliest geologic time. Through the transporting agencies of streams the surficial materials of all ages and origins are carried to the sea, where, along with material derived from the land by the action of the waves on the coast, they form *sedimentary rocks*. These are usually hardened into conglomerate, sandstone, shale, and limestone, but they may remain unconsolidated and still be called "rocks" by the geologist, though popularly known as gravel, sand, and clay.

From time to time in geologic history igneous and sedimentary rocks have been deeply buried, consolidated, and raised again above the surface of the water. In these processes, through the agencies of pressure, movement, and chemical action, they are often greatly altered, and in this condition they are called *metamorphic rocks*.

Igneous rocks.—These are rocks which have cooled and consolidated from a liquid state. As has been explained, sedimentary rocks were deposited on the original igneous rocks. Through the igneous and sedimentary rocks of all ages molten material has from time to time been forced upward to or near the surface, and there consolidated. When the channels or vents into which this molten material is forced do not reach the surface, it either consolidates in cracks or fissures crossing the bedding planes, thus forming dikes, or else spreads out between the strata in large bodies, called sills or laccoliths. Such rocks are called *intrusive*. Within their rock enclosures they cool slowly, and hence are generally of crystalline texture. When the channels reach the surface the lavas often flow out and build up volcanoes. These lavas cool rapidly in the air, acquiring a glassy or, more often, a partially crystalline condition. They are usually more or less porous. The igneous rocks thus formed upon the surface are called *extrusive*. Explosive action often accompanies volcanic eruptions, causing ejections of dust or ash and larger fragments. These materials when consolidated constitute breccias, agglomerates, and tuffs. The ash when carried into lakes or seas may become stratified, so as to have the structure of sedimentary rocks.

The age of an igneous rock is often difficult or impossible to determine. When it cuts across a sedimentary rock, it is younger than that rock, and when a sedimentary rock is deposited over it, the igneous rock is the older.

Under the influence of dynamic and chemical forces an igneous rock may be metamorphosed. The alteration may involve only a rearrangement of its minute particles or it may be accompanied by a change in chemical and mineralogic composition. Further, the structure of the rock may be changed by the development of planes of division, so that it splits in one direction more easily than in others. Thus a granite may pass into a gneiss, and from that into a mica-schist.

Sedimentary rocks.—These comprise all rocks which have been deposited under water, whether in sea, lake, or stream. They form a very large part of the dry land.

When the materials of which sedimentary rocks are composed are carried as solid particles by water and deposited as gravel, sand, or mud, the deposit is called a mechanical sediment. These may become hardened into conglomerate, sandstone, or shale. When the material is carried in solution by the water and is deposited without the aid of life, it is called a chemical sediment; if deposited with the aid of life, it is called an organic sediment. The more important rocks formed from chemical and organic deposits are limestone, chert, gypsum, salt, iron ore, peat, lignite, and coal. Any one of the above sedimentary deposits may be separately formed, or the different materials may be intermingled in many ways, producing a great variety of rocks.

Sedimentary rocks are usually made up of layers or beds which can be easily separated. These layers are called *strata*. Rocks deposited in successive layers are said to be stratified.

The surface of the earth is not fixed, as it seems to be; it very slowly rises or sinks over wide expanses, and as it rises or subsides the shore-lines of the ocean are changed: areas of deposition may rise above the water and become land areas, and land areas may sink below the water and become areas of deposition. If North America were gradually to sink a thousand feet the sea would flow over the Atlantic coast and the Mississippi and Ohio valleys from the Gulf of Mexico to the Great Lakes; the Appalachian Mountains would become an archipelago, and the ocean's shore would traverse Wisconsin, Iowa, and Kansas, and extend thence to Texas. More extensive changes than this have repeatedly occurred in the past.

The character of the original sediments may be changed by chemical and dynamic action so as to produce metamorphic rocks. In the metamorphism of a sedimentary rock, just as in the metamorphism of an igneous rock, the substances of which it is composed may enter into new combinations, or new substances may be added. When these processes are complete the sedimentary rock becomes crystalline. Such changes transform sandstone to quartzite, limestone to marble, and modify other rocks according to their composition. A system of parallel division planes is often produced, which may cross the original beds or strata at any angle. Rocks divided by such planes are called slates or schists.

Rocks of any period of the earth's history may be more or less altered, but the younger formations have generally escaped marked metamorphism, and the oldest sediments known, though generally the most altered, in some localities remain essentially unchanged.

Surficial rocks.—These embrace the soils, clays, sands, gravels, and bowlders that cover the surface, whether derived from the breaking up or disintegration of the underlying rocks by atmospheric agencies or from glacial action. Surficial rocks that are due to disintegration are produced chiefly by the action of air, water, frost, animals, and plants. They consist mainly of the least soluble parts of the rocks, which remain after the more soluble parts have been leached out, and hence are known as residual products. Soils and subsoils are the most important. Residual accumulations are often washed or blown into valleys or other depressions, where they lodge and form deposits that grade into the sedimentary class. Surficial rocks that are due to glacial action are formed of the products of disintegration, together with bowlders and fragments of rock rubbed from the surface and ground together. These are spread irregularly over the territory occupied by the ice, and form a mixture of clay, pebbles, and bowlders which is known as till. It may occur as a sheet or be bunched into hills and ridges, forming moraines, drumlins, and other special forms. Much of this mixed material was washed away from the ice, assorted by water, and redeposited as beds or trains of sand and clay, thus forming another gradation into sedimentary deposits. Some of this glacial wash was deposited in tunnels and channels in the ice, and forms characteristic ridges and mounds of sand and gravel, known as osars, or eskers, and kames. The material deposited by the ice is called glacial drift; that washed from the ice onto the adjacent land is called modified drift. It is usual also to class as surficial rocks the deposits of the sea and of lakes and rivers that were made at the same time as the ice deposit.

AGES OF ROCKS.

Rocks are further distinguished according to their relative ages, for they were not formed all at one time, but from age to age in the earth's history. Classification by age is independent of origin; igneous, sedimentary, and surficial rocks may be of the same age.

When the predominant material of a rock mass is essentially the same, and it is bounded by rocks of different materials, it is convenient to call the mass throughout its extent a *formation*, and such a formation is the unit of geologic mapping.

Several formations considered together are designated a *system*. The time taken for the deposition of a formation is called an *epoch*, and the time taken for that of a system, or some larger fraction of a system, a *period*. The rocks are mapped by formations, and the formations are classified into systems. The rocks composing a system and the time taken for its deposition are given the same name, as, for instance, Cambrian system, Cambrian period.

As sedimentary deposits or strata accumulate the younger rest on those that are older, and the relative ages of the deposits may be discovered by observing their relative positions. This relationship holds except in regions of intense disturbance; sometimes in such regions the disturbance of the beds has been so great that their position is reversed, and it is often difficult to determine the relative ages of the beds from their positions; then *fossils*, or the remains of plants and animals, are guides to show which of two or more formations is the oldest.

Strata often contain the remains of plants and animals which lived in the sea or were washed from the land into lakes or seas or were buried in surficial deposits on the land. Rocks that contain the remains of life are called fossiliferous. By studying these remains, or fossils, it has been found that the species of each period of the earth's history have to a great extent differed from those of other periods. Only the simpler kinds of marine life existed when the oldest fossiliferous rocks were deposited. From time to time more complex kinds developed, and as the simpler ones lived on in modified forms life became more varied. But during each period there lived peculiar forms, which did not exist in earlier times and have not existed since; these are characteristic types, and they define the age of any bed of rock in which they are found. Other types passed on from period to period, and thus linked the systems together, forming a chain of life from the time of the oldest fossiliferous rocks to the present.

When two formations are remote one from the other and it is impossible to observe their relative positions, the characteristic fossil types found in them may determine which was deposited first.

Fossil remains found in the rocks of different areas, provinces, and continents, afford the most important means for combining local histories into a general earth history.

Colors and patterns.—To show the relative ages of strata, the history of the sedimentary rocks is divided into periods. The names of the periods in proper order (from new to old), with the color or colors and symbol assigned to each, are given in the table in the next column. The names of certain subdivisions of the periods, frequently used in geologic writings, are bracketed against the appropriate period name.

To distinguish the sedimentary formations of any one period from those of another the patterns for the formations of each period are printed in the appropriate period-color, with the exception of the first (Pleistocene) and the last (Archean). The formations of any one period, excepting the Pleistocene and the Archean, are distinguished from one another by different patterns, made of parallel straight lines. Two tints of the period-color are used: a pale tint (the underprint) is printed evenly over the whole surface representing the period; a dark tint (the overprint) brings out the different patterns representing formations.

PERIOD.	SYMBOL.	COLOR.
Pleistocene	P	Any colors.
Neocene { Pliocene / Miocene }	N	Buffs.
Eocene (including Oligocene)	E	Olive-browns.
Cretaceous	K	Olive-greens.
Juratrias { Jurassic / Triassic }	J	Blue-greens.
Carboniferous (including Permian)	C	Blues.
Devonian	D	Blue-purples.
Silurian (including Ordovician)	S	Red-purples.
Cambrian	Є	Pinks.
Algonkian	A	Orange-browns.
Archean	Æ	Any colors.

Each formation is furthermore given a letter-symbol of the period. In the case of a sedimentary formation of uncertain age the pattern is printed on white ground in the color of the period to which the formation is supposed to belong, the letter-symbol of the period being omitted.

The number and extent of surficial formations of the Pleistocene render them so important that, to distinguish them from those of other periods and from the igneous rocks, patterns of dots and circles, printed in any colors, are used.

The origin of the Archean rocks is not fully settled. Many of them are certainly igneous. Whether sedimentary rocks are also included is not determined. The Archean rocks, and all metamorphic rocks of unknown origin, of whatever age, are represented on the maps by patterns consisting of short dashes irregularly placed. These are printed in any color, and may be darker or lighter than the background. If the rock is a schist the dashes or hachures may be arranged in wavy parallel lines. If the rock is known to be of sedimentary origin the hachure patterns may be combined with the parallel-line patterns of sedimentary formations. If the metamorphic rock is recognized as having been originally igneous, the hachures may be combined with the igneous pattern.

Known igneous formations are represented by patterns of triangles or rhombs printed in any brilliant color. If the formation is of known age the letter-symbol of the formation is preceded by the capital letter-symbol of the proper period. If the age of the formation is unknown the letter-symbol consists of small letters which suggest the name of the rocks.

THE VARIOUS GEOLOGIC SHEETS.

Historical geology sheet.—This sheet shows the areas occupied by the various formations. On the margin is a *legend*, which is the key to the map. To ascertain the meaning of any particular colored pattern and its letter-symbol on the map the reader should look for that color, pattern, and symbol in the legend, where he will find the name and description of the formation. If it is desired to find any given formation, its name should be sought in the legend and its color and pattern noted, when the areas on the map corresponding in color and pattern may be traced out.

The legend is also a partial statement of the geologic history. In it the symbols and names are arranged, in columnar form, according to the origin of the formations—surficial, sedimentary, and igneous—and within each group they are placed in the order of age, so far as known, the youngest at the top.

Economic geology sheet.—This sheet represents the distribution of useful minerals, the occurrence of artesian water, or other facts of economic interest, showing their relations to the features of topography and to the geologic formations. All the formations which appear on the historical geology sheet are shown on this sheet by fainter color-patterns. The areal geology, thus printed, affords a subdued background upon which the areas of productive formations may be emphasized by strong colors. A symbol for mines is introduced at each occurrence, accompanied by the name of the principal mineral mined or of the stone quarried.

Structure-section sheet.—This sheet exhibits the relations of the formations beneath the surface. In cliffs, canyons, shafts, and other natural and artificial cuttings, the relations of different beds to one another may be seen. Any cutting which exhibits those relations is called a *section*, and the same name is applied to a diagram representing the relations. The arrangement of rocks in the earth is the earth's *structure*, and a section exhibiting this arrangement is called a *structure section*.

The geologist is not limited, however, to the natural and artificial cuttings for his information concerning the earth's structure. Knowing the manner of the formation of rocks, and having traced out the relations among beds on the surface, he can infer their relative positions after they pass beneath the surface, draw sections which represent the structure of the earth to a considerable depth, and construct a diagram exhibiting what would be seen in the side of a cutting many miles long and several thousand feet deep. This is illustrated in the following figure:

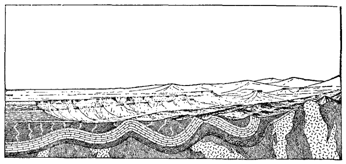


Fig. 2.—Sketch showing a vertical section in the front of the picture, with a landscape beyond.

The figure represents a landscape which is cut off sharply in the foreground by a vertical plane that cuts a section so as to show the underground relations of the rocks.

The kinds of rock are indicated in the section by appropriate symbols of lines, dots, and dashes. These symbols admit of much variation, but the following are generally used in sections to represent the commoner kinds of rock·

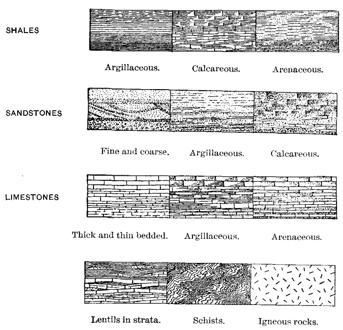


Fig. 3.—Symbols used to represent different kinds of rock.

The plateau in fig. 2 presents toward the lower land an escarpment, or front, which is made up of sandstones, forming the cliffs, and shales, constituting the slopes, as shown at the extreme left of the section.

The broad belt of lower land is traversed by several ridges, which are seen in the section to correspond to beds of sandstone that rise to the surface. The upturned edges of these beds form the ridges, and the intermediate valleys follow the outcrops of limestone and calcareous shales.

Where the edges of the strata appear at the surface their thickness can be measured and the angles at which they dip below the surface can be observed. Thus their positions underground can be inferred.

When strata which are thus inclined are traced underground in mining, or by inference, it is frequently observed that they form troughs or arches, such as the section shows. But these sandstones, shales, and limestones were deposited beneath the sea in nearly flat sheets. That they are now bent and folded is regarded as proof that forces exist which have from time to time caused the earth's surface to wrinkle along certain zones.

On the right of the sketch the section is composed of schists which are traversed by masses of igneous rock. The schists are much contorted and their arrangement underground can not be inferred. Hence that portion of the section delineates what is probably true but is not known by observation or well-founded inference.

In fig. 2 there are three sets of formations, distinguished by their underground relations. The first of these, seen at the left of the section, is the set of sandstones and shales, which lie in a horizontal position. These sedimentary strata are now high above the sea, forming a plateau, and their change of elevation shows that a portion of the earth's mass has swelled upward from a lower to a higher level. The strata of this set are parallel, a relation which is called *conformable*.

The second set of formations consists of strata which form arches and troughs. These strata were once continuous, but the crests of the arches have been removed by degradation. The beds, like those of the first set, are conformable.

The horizontal strata of the plateau rest upon the upturned, eroded edges of the beds of the second set at the left of the section. The overlying deposits are, from their positions, evidently younger than the underlying formations, and the bending and degradation of the older strata must have occurred between the deposition of the older beds and the accumulation of the younger. When younger strata thus rest upon an eroded surface of older strata the relation between the two is an *unconformable* one, and their surface of contact is an *unconformity*.

The third set of formations consists of crystalline schists and igneous rocks. At some period of their history the schists were plicated by pressure and traversed by eruptions of molten rock. But this pressure and intrusion of igneous rocks have not affected the overlying strata of the second set. Thus it is evident that an interval of considerable duration elapsed between the formation of the schists and the beginning of deposition of the strata of the second set. During this interval the schists suffered metamorphism; they were the scene of eruptive activity; and they were deeply eroded. The contact between the second and third sets, marking a time interval between two periods of rock formation, is another unconformity.

The section and landscape in fig. 2 are ideal, but they illustrate relations which actually occur. The sections in the structure-section sheet are related to the maps as the section in the figure is related to the landscape. The profiles of the surface in the section correspond to the actual slopes of the ground along the section line, and the depth of any mineral-producing or water-bearing stratum which appears in the section may be measured from the surface by using the scale of the map.

Columnar-section sheet.—This sheet contains a concise description of the rock formations which occur in the quadrangle. The diagrams and verbal statements form a summary of the facts relating to the character of the rocks, to the thicknesses of the formations, and to the order of accumulation of successive deposits.

The rocks are described under the corresponding heading, and their characters are indicated in the columnar diagrams by appropriate symbols. The thicknesses of formations are given under the heading "Thickness in feet," in figures which state the least and greatest measurements. The average thickness of each formation is shown in the column, which is drawn to a scale—usually 1000 feet to 1 inch. The order of accumulation of the sediments is shown in the columnar arrangement: the oldest formation is placed at the bottom of the column, the youngest at the top, and igneous rocks or other formations, when present, are indicated in their proper relations.

The formations are combined into systems which correspond with the periods of geologic history. Thus the ages of the rocks are shown, and also the total thickness of each system.

The intervals of time which correspond to events of uplift and degradation and constitute interruptions of deposition of sediments may be indicated graphically or by the word "unconformity," printed in the columnar section.

Each formation shown in the columnar section is accompanied by its name, a description of its character, and its letter-symbol as used in the maps and their legends.

CHARLES D. WALCOTT,
Director.

Revised June, 1897.

DESCRIPTION OF THE STANDINGSTONE QUADRANGLE.

GEOGRAPHY.

Extent and counties.

General relations.—The Standingstone quadrangle embraces an area of 962.7 square miles, extending from latitude 36° on the south to 36° 30′ on the north, and from longitude 85° on the east to 85° 30′ on the west. It lies wholly within the State of Tennessee and includes portions of the counties of Overton, Putnam, White, Cumberland, Fentress, Pickett, Clay, and Jackson. The adjacent quadrangles, so far as surveyed, are Wartburg on the east, Kingston on the southeast, Pikeville on the south, and McMinnville on the southwest.

In its geographic and geologic relations this quadrangle 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.

Distinction between eastern and western divisions of the Appalachian province.

Subdivisions of the Appalachian province.—Respecting the attitude of the rocks, the Appalachian province may be divided into two nearly equal portions by a line which follows the northwestern side of the Appalachian Valley along the Allegheny front and the eastern escarpment of the Cumberland table-land. East of this line the rocks are greatly disturbed by folds and faults, and in many places they are so metamorphosed that their original form and composition can not now be determined. West of the division line the rocks are almost wholly sedimentary and the strata lie nearly flat, in approximately the attitude in which they were deposited on the bottom of the sea. Since the western division lies almost wholly within the drainage basin of the Ohio River, it will be referred to in this description as the Ohio Basin.

Ohio Basin.—This portion of the province embraces the Cumberland Plateau and the Allegheny Mountains and the lowlands of western Tennessee, Kentucky, and Ohio. Its northwestern boundary is indefinite, but it may be regarded as coinciding with the Mississippi River as far up the stream as Cairo, and thence extending northeastward across the States of Illinois, Indiana, and Ohio to the western end of Lake Erie. Contrasted with the intensely folded strata of the Appalachian Valley, the rocks of this region may be classed as horizontal, but, strictly speaking, they are rarely in this position, for the horizontality of the strata is interrupted by many undulations which produce low dips in almost all parts of the field.

The Cincinnati arch.

The most prominent structural feature of the Ohio Basin is an arch in the strata, which has been styled the Cincinnati arch or anticline. The main portion of the fold enters the basin, as it is here outlined, from the direction of Chicago; it curves southward through Cincinnati and Lexington, Kentucky, and from the latter point extends southwestward to Nashville, Tennessee. Formerly the principal arch was supposed to extend from Cincinnati to Toledo, Ohio, but the sinking of numerous oil and gas wells in that region has proved that the Toledo fold is only a small branch of the principal uplift. Stratigraphically the maximum development of this fold occurs in the vicinity of Lexington, where the Trenton limestone is exposed at an altitude of 1000 feet above sea level.

Coal fields adjoining the Cincinnati arch.

Geologically this arch separates the Ohio drainage basin into two parts, or structural basins, each of which contains coal-bearing rocks. The basin on the eastern side of the Cincinnati arch is generally known as the Appalachian coal field, and that on the western side as the coal field of western Kentucky, or the central coal field of the United States. Besides these pronounced structural features, the rocks of the Ohio Basin show a number of minor folds, and in places they have been broken by small faults.

Topography of the Ohio Basin.—The altitude of this division is greatest along the southeastern margin, where some of the ridges attain the elevation of mountains. They are not continuous, and they do not form a system. At the north they constitute the Allegheny ranges, in the center they form a group of ranges limited on the northwest by Pine Mountain and on the southeast by Stone Mountain, and in the south the so-called mountains are only the escarpments of the Cumberland Plateau. The altitude of the mountainous belt varies from 500 feet in central Alabama to 2000 feet at Chattanooga, 3500 feet in the vicinity of Cumberland Gap, and from 2000 to 4000 feet throughout the northern portion of the province. From this extreme altitude on the southeastern margin, the surface descends to less than 500 feet on the western border along the Mississippi River. This descent is not regular, but is accomplished by a number of steps or escarpments which mark the present extent of particular hard beds and also the stages in the erosion of the surface to its present position. The highest and most pronounced escarpment is along the western margin of the Appalachian coal field, separating, in Kentucky, the great interior plain from the higher and more hilly region of the coal field, and, in Tennessee, marking the line between the eastern highlands and the Cumberland Plateau. In the latter State the escarpment is steep and regular and the plateau is very perfectly preserved, but in the former the rocks were not hard enough to protect the plain after it was uplifted, and as a consequence it has been completely dissected by the numerous streams which drain its surface, so as to leave a hilly region in place of the plateau, and an irregular margin instead of an escarpment.

General relations of topographic features and their significance.

The eastern and western highlands of Tennessee are doubtless remnants of a plain which once extended across the central basin from the western margin of the Cumberland Plateau to the Tennessee River, for the eastern and western areas of the plain are still connected by high land in the southern part of this State and in northern Alabama, and by the great interior plain of central Kentucky. This surface now stands at an elevation of from 900 to 1000 feet above sea level, and is separated from the lower features of the central portion of the State by a steep slope or escarpment which is generally referred to as the highland rim.

Central basin of Tennessee.

The rising of the highland surface afforded the streams an opportunity to dissect it. Where this surface was composed of soft rock, complete dissection was accomplished, and a lower plain was formed which now stands at an altitude of about 500 feet. This plain is entirely surrounded by the highland rim, and consequently is limited to this particular region, but in all probability it was formed contemporaneously with a surface of about the same general elevation in western Kentucky and southern Illinois. That portion of the plain which lies in middle Tennessee is usually known as the Nashville basin, or the central basin of Tennessee.

Since the formation of the central basin, the land has been elevated slightly and the major streams have cut narrow valleys below the even surface of the plain.

Topography of the Standingstone quadrangle.—The Standingstone quadrangle is located on the northwestern margin of the Cumberland Plateau; consequently it embraces topographic features characteristic of both this plateau and the eastern highlands.

The Cumberland plateau.

The main western front of the plateau is marked by the towns of Monterey in this quadrangle, Bon Air in the quadrangle south of this, and Jamestown in that to the east. Beyond this line long spurs project irregularly westward upon the surface of the highlands. That portion of the Cumberland Plateau which lies within this quadrangle has a remarkably even surface, the average elevation of which is 1700 or 1800 feet above sea level. The rocks dip gently southeastward, and hence the outermost exposure of any hard bed is a little higher than the same bed farther toward the interior of the plateau. The result of this arrangement of the rocks is an irregular ridge along the western front which is slightly above the general level. This ridge is most pronounced around the head of England Cove and northward toward Monterey, where it attains an altitude a little above 2000 feet. The plateau descends slightly northward, so that the highest land in the vicinity of Jamestown is only about 1700 feet above tide water.

River systems.

The drainage lines of this portion of the Cumberland Plateau all belong to the Ohio River system, but are divided between the Tennessee and Cumberland sub-systems. The divide separating these basins follows closely the western edge of the plateau through Jamestown in Fentress County, Clarkrange, and Johnson Stand (Goodwill P. O.); at the latter point it swings toward the southeast and passes west of Crossville in Cumberland County. East of this divide the principal streams are Clear Creek and Obed River, the waters of which unite in Emory River and eventually find their way into the Tennessee River. West of the divide the streams belong to the Cumberland system, the trunk stream of which lies only a few miles beyond the northwestern corner of this quadrangle. In the northeastern portion of this area the stream unite in Obey River, on the western side they flow directly into the main river, and in the south they unite in the Calfkiller River, the waters of which reach the Cumberland through Caney Fork.

The eastern highland.

A portion of the eastern highland is included in the northwestern half of this quadrangle. Its surface is generally uniform and is at an altitude of about 1000 feet above sea level. The continuity of this surface is broken by many isolated knobs which rise above it and by many spurs of the plateau which rest upon it. The surface is still further diversified by deep trenches which the major streams have cut on their way to the trunk stream. These gorges are in many places 500 feet in depth and they form serious obstacles to travel in a northeast and southwest direction along the highland. Where the streams rise on the plateau, their descent therefrom is marked by gorges which range in depth from 800 to 1000 feet and which have been aptly termed "gulfs," on account of their depth and narrowness.

Two prominent elevated plains.

The prominent topographic features of this quadrangle are two plains, one constituting the surface of the plateau, and the other capping the highland rim. These features are extremely interesting, for they record the history of certain epochs of the past which are otherwise unrepresented in the geology of this region. From the evidence to be found in this quadrangle alone it is impossible to interpret these features satisfactorily, but when contiguous areas are examined it is found that these plains are of wide extent, and consequently are due to conditions which must have prevailed over most of this province. Since the Cumberland Plateau is capped by a heavy sandstone or conglomerate, it generally has been supposed that the level surface is due alone to the protection afforded by this heavy bed; but when the plateau is carefully studied, it is found that the even surface corresponds with different beds of rock in different portions of the plateau, and that to a certain extent it bevels the upturned edges of the rocks forming the syncline. The same is true of the highland plain, therefore some agency must have carved the rocks to certain depths regardless, in a measure, of their composition, producing even surfaces over a wide extent of territory.

There are two methods by which this cutting may have been accomplished; either by the shore action of the waves of a large body of water, or by subaerial erosion to base-level. If these plains owe their formation to the cutting action of waves, then the area which now comprises Tennessee must have been beneath the waters of the ocean at various times since the Paleozoic era. If the sea covered this territory, there must have been sediments deposited on its surface; but no such material has ever been discovered in this locality; therefore this cause seems not to have operated to produce these plains. Subaerial erosion on a land surface which is free from movement will produce a plain if time enough is allowed for the approximate reduction of the surface to base-level. The rocks will be cut down to a common level as though swept by the waves, but no deposits will be laid down by which the conditions then existing may be determined; they can be told only from the features carved from the land itself. Since this hypothesis explains the evenness of these plains and the absence of deposits upon their surfaces, it will be accepted as adequate, and the upper surface will be called the Cumberland peneplain (almost a plain), from the name of the plateau shown in this quadrangle, and the lower surface will be called the Lexington peneplain, from the city of Lexington, Kentucky, which is situated on the northern extension of the same surface feature.

Cumberland and Lexington peneplains.

Dates of the physiographic features.

No direct evidence has been found in the Standingstone quadrangle of the dates of the formation of these peneplains and their allied surface features. The Cumberland peneplain can be traced continuously southward to the margin of the Cretaceous sediments of the Gulf coast; it is also presumably a part of the great peneplain which may be traced over most of the Appalachian province and which is generally referred to the Cretaceous period. It is evidently very old, and its perfect preservation in this region is due to the heavy conglomerate which, over much of the territory happened to correspond with its surface. The evidence so far available, while not conclusive, seems to point to the Cretaceous age of this feature, and since this agrees with the evidence in other quarters it will be accepted provisionally as correct.

The Lexington peneplain must be necessarily post-Cretaceous, but its exact age has not yet been satisfactorily determined. The only definite theory advanced regarding its age makes it contemporaneous with the Eocene limestone of the Gulf slope. This has been advocated only as a working hypothesis, but, so far as known, it is in harmony with the facts found in this region, and will be accepted provisionally.

On the assumption that the Lexington peneplain is of Eocene age, the central basin, which is necessarily a later feature, would probably be referred to the Neocene period, and the gravels which are reported to lie on its surface in the vicinity of Nashville may possibly be correlated with the Lafayette formation of the Mississippi embayment. The stream valleys which are cut within the basin are later than the basin itself, and consequently are referred to the Pleistocene period. These determinations must be accepted as merely provisional, and subject to change when more direct evidence becomes available.

GEOLOGY.

GENERAL SEDIMENTARY RECORD.

All of the rocks appearing at the surface within the limits of the Standingstone quadrangle are of sedimentary origin—that is, they were deposited by water. They consist of sandstones, shales, and limestones, having a total average thickness of 1500 feet. The materials of which they are composed were originally gravel, sand, and mud, derived from the waste of the older rocks and from the remains of plants and animals which lived while the strata were being laid down.

Interpretation of the record in the rocks.

These rocks afford a more or less complete record of sedimentation from the lower part of the Silurian period to near the close of Carboniferous time. They also contain a record of the conditions of the land area which furnished the material for their formation. By knowing the conditions under which certain classes of rocks are formed, we can gain a fairly accurate idea of the distribution of land and water and of the physical aspects of the land during the deposition of the rocks of this quadrangle.

Paleozoic interior sea.

The sea in which the Paleozoic sediments were laid down covered most of the Appalachian province. On the east it was probably limited by land in the vicinity of the Smoky Mountains, but toward the west it swept far beyond the present Mississippi River. In a general way this mediterranean sea existed in this region until about the close of Paleozoic time. True, there were doubtless periods of oscillation in which land appeared within the limits here given, but in all probability such land areas were not long-lived, and the sea soon resumed its original sway. At or near the close of the Carboniferous period, however, the entire area was raised above the waves of the sea, and none but the marginal portions have since been beneath its surface.

The exact physical conditions which characterized the area now known as the Standingstone quadrangle, and the conditions which prevailed on the land area that furnished the material for its rocks, may sometime be determined with considerable certainty, but at present our knowledge of the conditions of deposition will admit of only the broadest generalizations.

The muddy limestones constituting the Silurian rocks of this quadrangle contain an abundant marine fauna, which indicates that during the closing stages of the lower Silurian epoch this quadrangle was occupied by salt water, but the muddy character of the sediment laid down in that sea points to a relatively abundant supply of material, and consequently to the proximity of the shore. The absence of all known upper Silurian rocks in this region lends weight to the supposition that the land was being gradually lifted during the last stages of the lower Silurian, and that with the inauguration of upper Silurian time this area was dry land and received no deposits upon its surface. To be sure, there is an alternative hypothesis which admits of the deposition of the upper Silurian over this entire area and of its removal by erosion during a subsequent uplift. The absence of any known remnants of these formations militates against the latter hypothesis, and consequently makes it seem probable that during the closing periods of Silurian time there was an area of land all along the western front of the Cumberland Plateau and extending some distance into Kentucky.

The absence of upper Silurian rocks explained.

The conditions which prevailed during the deposition of the Devonian black shale have not yet been determined satisfactorily. In Pennsylvania and New York this epoch is characterized by immense deposits which have no representatives in the southern and western portions of the Appalachian province, except possibly in the fine-grained, black, carbonaceous Chattanooga shale. In this district the shale ranges from 20 to 30 feet in thickness, but toward the southeast, in Georgia and Alabama, it thins to a feather edge and disappears.

Several theories have been advanced regarding the conditions which would permit of the deposition of only a few feet of carbonaceous shale in one locality while thousands of feet of sand and mud accumulated in another portion of the same province, but none has been accepted as entirely adequate. It seems probable that the Devonian sea, in the southern Appalachians, though extensive, was shallow and surrounded by low land. Neither waves nor streams could then deliver any considerable volume of sediment, and the strata representing the epoch would be thin, as compared with those derived from higher lands east and north of that portion of the Devonian sea which occupied the present Pennsylvania and New York region.

Theories relating to the Devonian land and sea.

The inauguration of the Carboniferous period produced few changes in the physical condition of the northern part of the Appalachian province. The land bordering the sea in this direction continued to afford a large amount of waste, and as a consequence the formation representing the first epoch consists of sandy shale and sandstone of considerable thickness. At the south, however, the conditions changed materially with the advent of the Carboniferous period. The sea appears to have become deeper, for it was certainly free from mechanical sediments, and a great body of cherty limestone was deposited over the entire region south of middle Tennessee. The Standingstone quadrangle is located where the transition occurs between the sandy and muddy sediments of the north and the calcareous beds of the south.

As time progressed the deposition of calcareous matter became prevalent over most of the province, except in the extreme northern part, and the great mass of the lower Carboniferous limestone was deposited. During the closing epochs of this stage, the waters of the south appear to have become more shallow and the supply of land waste more abundant, so that limestone deposition was interrupted and an unknown amount of red and green shale was laid down.

In the southern half of the province, the shale just mentioned is of irregular thickness and uncertain in its occurrence. It is now definitely known that over a large territory, of which this quadrangle is a part, these shales were eroded before the deposition of the next succeeding member. This erosion interval represents the earliest portion of Coal Measure time, when the Cincinnati arch was a land area separating the Appalachian coal basin from that of western Kentucky and the Mississippi Valley. At the beginning of this interval the sea occupied a basin along the eastern front of the Appalachian coal field and coal swamps flourished along its marshy borders, while the Standingstone quadrangle was dry land. Gradually the land subsided and the sea encroached toward the northwest, until finally it engulfed the land in this region, and in its waters were laid down the Coal Measure rocks which now show in outcrop in this territory. The advancing shore line was marked by accumulations of sand and gravel which filled the inequalities of the land and which have since been consolidated into sandstone and conglomerate. Whether this sea transgressed sufficiently to submerge the island of central Kentucky and connect with the western basin can not now be determined, but it is possible that it did, and that the sediments then laid down have been removed by erosion since the land was finally raised above the ocean level.

Erosion interval in the Carboniferous period.

At the close of the Carboniferous period the strata were raised above the water and exposed to the action of the atmosphere. During the long periods which have since elapsed no marine sediments have been deposited, but the events of the passing ages are recorded in the forms sculptured from the land and in the river deposits. They have been suggested under the heading "Topography of the Standingstone quadrangle."

STRATIGRAPHY.

The strata exposed in the Standingstone quadrangle have a thickness of about 1500 feet. The thickness of the formations, the order of succession, and their general character are given in the columnar sections, but a more detailed description of the individual beds and an indication of their probable equivalents in other fields are given in the following paragraphs.

SILURIAN STRATA.

Normandy limestone.—In the northwestern corner of this quadrangle the streams have cut deep V-shaped valleys which extend through the Devonian black shale and into underlying beds of calcareous shale and limestone to depths, in extreme cases, of 200 feet. These are the oldest rocks outcropping in the Standingstone quadrangle. They constitute the upper portion of the series of limestones and calcareous shales which Safford, in his report on the geology of Tennessee, named the Nashville series. In the McMinnville folio the southward extension of presumably these same beds have been termed the Chickamauga limestone. Neither of these terms are definite enough for detailed mapping of the central basin, therefore, the name Normandy limestone has been suggested by Dr. Safford as an appropriate term for the two uppermost members of his Nashville series. These two divisions are presumably inseparable in the field, but they are clearly distinguished from the Orthis bed, which lies immediately below. The name Normandy, from a small town in the southeastern portion of the central basin, is therefore adopted for that portion of the lower Silurian which lies above the Orthis bed.

The oldest rocks in the quadrangle.

This formation is variable in its composition in the Standingstone quadrangle, as is shown by a comparison of its various exposures. On Mill Creek the Devonian shale is underlain by a stratum of heavy-bedded brown, siliceous limestone 20 feet in thickness, below which are blue calcareous shale and thin crystalline limestone interbedded as low as the stream has cut, or for a distance of about 180 feet. In the valley south of this the heavy limestone beneath the black shale was not noticed, and the whole formation seems to be made up of thin blue limestone.

The upper Silurian rocks which are present in Kentucky and on the western side of the central basin, as well as in the Sequatchie Valley and East Tennessee are entirely absent from the Standingstone quadrangle. This territory was presumably land during the deposition of these rocks and received no sediment upon its surface.

DEVONIAN STRATA.

Throughout the southern portion of the Appalachian province the major portion of the Devonian rocks consists of black, carbonaceous shale, which grows thinner and thinner toward the south, and which, in places, lies unconformably upon the rocks beneath. North of Tennessee the Devonian increases rapidly in thickness, and many beds of coarse material are introduced into the mass of the shale.

Chattanooga shale.—This formation consists of black carbonaceous shale, and is named from the city of the same name in eastern Tennessee, where it is exposed in typical form. It varies in thickness from 20 to 30 feet, and consequently has no appreciable effect upon the topography of the region in which it outcrops. In the Standingstone quadrangle it shows in outcrop in the valleys of Eagle, Mitchell, Carter, Mill, and Spring creeks and Roaring River, but the outcrop is not extensive in any of these valleys. The excessive blackness of the fresh shale, together with its bituminous character and the presence of occasional thin seams of coaly matter, have led many persons to search for coal in this formation, but no seams of consequence have ever been found, and prospecting for such is useless.

The black shale.

CARBONIFEROUS STRATA.

Rocks of this age occupy almost the entire surface of this quadrangle. They have been divided into two great series, which differ from each other in regard to their mode of origin and their composition.

MISSISSIPPIAN SERIES.

The rocks belonging to this series are generally referred to as the lower or sub-Carboniferous. The name Mississippian is given to them because they are typically developed in the upper part of the Mississippi Valley. They are generally calcareous and of marine origin, as indicated by the fossil shells which are found in them. According to their lithologic character they may be divided into three formations.

Waverly formation.—This is the lowest member of the Mississippian series and derives its name from Waverly, Ohio, where the formation was first studied and where it is present in its type form. The typical Waverly consists of a mass of sandy and clayey shales in which at certain horizons occur locally beds of coarse material which has made the formation noted for economic purposes. In central Kentucky the formation closely resembles the type, except that the coarse, sandy portion appears to be more constant in its occurrence and location in the formation. Toward the Tennessee line the formation changes in its upper portion; in places it has the appearance of unconformably underlying the Newman limestone, but the evidence of such an unconformity is not satisfactory, and its existence can be determined only by a close study of the fossils occurring at that horizon. In the Standingstone quadrangle the Waverly shows many phases. Along the northern edge of the area, on the road leading north from Wirmingham to Byrdstown in Pickett County, this formation is well exposed on the north side of Obey River. At this point the Devonian black shale, which is at water level, is overlain by about 250 feet of calcareous and clayey shales, with thin beds of limestone at the base. Above the shale there is an interval of about 100 feet which is filled with earthy and siliceous limestone carrying many geodes. This is classed with the Waverly, although the evidence for such classification is not conclusive. Above these impure limestones occurs a bed of chert-bearing limestone about 100 feet in thickness which seems to be fairly constant over this territory. From the fact that chert occurs at many other horizons in small areas within this quadrangle, this belt is not always easy to determine, but in a general way it may be distinguished by the soft, chalky, friable masses of chert which mark its outcrop. Since the rocks which lie above this band consist entirely of blue or dove-colored limestone they evidently belong to the Newman, and consequently this zone, 100 feet in thickness, is regarded as the transition from the shaly and cherty, impure limestones of the Waverly to the relatively pure beds of the Newman limestone.

Shaly and cherty impure limestone.

In passing south bedded chert and limestone gradually replace more and more of the series until, on the southern borders of the quadrangle, the Waverly consists entirely of cherty limestone and heavy-bedded chert, and its outcrop forms almost as barren a country as that which characterized its outcrop in Kentucky. The hardness of this rock and the resistance to erosion afforded by the heavy mantle of residual chert have been important factors in the preservation of the highland rim. Over the central basin the Waverly chert rose above baselevel and it was removed in the formation of the Lexington peneplain. This area was thus deprived of its protecting cap of chert and consequently, in the uplift which followed, it was reduced to a lower level, while along the margin of the highland rim the chert coincided with the surface of the plain, and in the subsequent erosion has protected and preserved it at its former position.

In the Kingston, Pikeville, and McMinnville folios, the divisions of the Mississippian series have been very different from those made for areas farther north. The Standingstone quadrangle lies on the zone of transition between the northern and southern phases of this series, and consequently any subdivision will be unsatisfactory. In the McMinnville folio there have been recognized only two members of the Mississippian series, the Bangor limestone at the top and the Fort Payne chert at the bottom. In the Standingstone folio this system can not be maintained, for chert is not limited to the basal portion of the series, but occurs at many horizons and is local in its distribution. In the former quadrangle the Fort Payne chert has a thickness of 150 to 225 feet; hence it can not correspond to the Waverly, for the latter has a thickness of from 350 to 500 feet.

Correlation with adjacent regions.

In Safford's report on the geology of Tennessee he divided this series into two members, the Mountain limestone at the top and the Siliceous group at the base. The top of the latter is given as 200 feet below the Newman sandstone lentil, consequently his line of subdivision agrees approximately with the top of the transition series, which is here considered to lie between and to grade into the Waverly below and the Newman above. The term Waverly is retained here because it is a geographic name, although the character of the formation resembles more nearly that of the Siliceous group of Tennessee than that of the Waverly formation of Ohio.

The Waverly formation is the surface rock over nearly one-half of this quadrangle; it forms the surface of the highland plateau and caps all of the spurs which project from the plateau toward the central basin.

Newman limestone.—This formation includes almost all of the pure, blue limestones of the Mississippian series. It has a thickness of about 400 feet. It is named from Newman Ridge, in Hancock County, a type locality on the eastern side of the Cumberland Plateau. It is partially equivalent to the Bangor limestone, described in the folios treating of the quadrangles south of this, but it does not extend as far either up or down in the series as that formation. The Newman limestone and the Pennington shale, which overlies it, are together equal to the Mountain limestone as described by Safford. The Newman limestone is separated by a bed of sandstone into two parts. That which lies above the sandstone has a thickness of 150 feet, and that which is below has a thickness of about 200 feet, exclusive of the transition zone.

Pure, blue limestone.

Newman sandstone lentil.—In a purely stratigraphic sense this is not an important member of the Newman limestone, for it does not exceed 60 feet in thickness, and is generally considerably thinner. Along the main front of the Cumberland escarpment it is most prominent, ranging from 40 to 60 feet in thickness, but farther east, in the valley of the East Fork of Obey River, it is so thin as to be distinguished with difficulty. That it extends farther east than its visible horizon is proved by its presence in two wells drilled near Rugby in Morgan County. In one of these wells the sandstone, with the shale which usually overlies it, is 28 feet in thickness, as reported by the driller.

Although this lentil is thin, it acquires prominence by being so different lithologically from the main body of the formation, and by its pronounced effect upon the topography. Being much harder and more resistant than the limestone, it generally forms a terrace around the hill slopes, and caps long spurs that project from the western face of the Cumberland escarpment. It also forms the

A thin terrace-forming sandstone.

cap rock of many isolated hills, which are consequently flat topped. When viewed from a slight eminence, these flat-topped hills, level spurs, and the benches on the hillsides fall into line with remarkable regularity, forming the most pronounced feature of the landscape.

The major portion of the lentil is a coarse yellow sandstone, but there are usually a few feet of variegated shale overlying it and separating it from the limestone. The geographic extent of this lentil is at present unknown. It is heavy north of Obey River in Pickett County, but whether it extends into Kentucky is not known. It was seen as far south as Sparta, and probably extends somewhat farther in that direction.

Pennington shale.—This formation is named from a water gap through Stone Mountain in Lee County, Virginia. It consists principally of calcareous shale, but numerous bands of impure limestone are found within its limits, and occasionally heavy beds of sandstone occur which are easily confounded with the sandstones of the Lee formation. The Pennington shale is variously colored, but the characteristic colors are red and green. It succeeds the Newman limestone by gradual transition, and it is unconformably overlain by the Lee formation. In the Standingstone quadrangle it varies in thickness from 90 to 300 feet, and it outcrops in a band which follows all of the irregularities of the western escarpment of the Cumberland Plateau.

PENNSYLVANIAN SERIES.

This series is so named because it is typically developed in Pennsylvania, where it is known as the Coal Measures. It consists principally of sandstones and shales which are evidently the result of shallow-water deposition and fluctuating conditions of the land as well as of the sea. The marine condition which prevailed over this region during the deposition of the Mississippian series was terminated by the elevation of the sea bottom and the formation of land where previously the sea had held sway. At first the sea was presumably crowded to the southeastern margin of the present Appalachian coal field, and there is some doubt whether it existed at all within the coal field as far south as middle Tennessee. There was certainly a partially inclosed basin in western Virginia in which the coals and other rocks of the Pocahontas field were deposited, but its southwestward extension has not been determined with certainty.

A land surface in Carboniferous time.

The western margin of the Appalachian coal field was a land area which stretched from northern Ohio at least as far south as middle Tennessee, and presumably still farther. This land surface, which in the Standingstone quadrangle consisted of the Pennington shale, was affected by erosion and much of the shale was removed. The land gradually subsided and the water encroached toward the northwest, until it finally covered this quadrangle. Whether it swept across the entire western portion of the State is uncertain, for if it did, all of the material laid down in its waters has been removed by subsequent erosion. The position of this shore line as it migrated toward the northwest was marked by deposits of coarse material, such as sandstone and conglomerate, but since the movement was presumably not continuous, the deposits were laid down over irregular areas and are of varying thicknesses. The subsidence appears to have come from the south in this region, for the oldest rocks of this series occur in that portion of the quadrangle.

The result of these conditions is that the earliest Pottsville rocks have no representatives in this section, for the area was dry land during the period of their deposition. It was not until, perhaps, a third of Pottsville time had elapsed that rocks began to form in this region. This has been clearly demonstrated by the fossils of the Pottsville series, and it forms a most interesting chapter in the geologic history of this region.

Lee formation.—This formation is named from Lee County, Virginia. It includes the basal portion of the Pennsylvanian series, or the middle part of the Pottsville. It has been generally called the Conglomerate series, or the Millstone grit, but in reality it is complex, consisting of conglomerate members separated by bands of shale. The two beds of conglomerate which occur in this region are of sufficient importance to be mapped as separate formations, but for the sake of uniformity they are included with the shale in one formation, but separated in mapping as sandstone lentils in the Lee formation.

The lower conglomerate of the Conglomerate series.

Bonair conglomerate lentil.—Topographically this is the most important stratum in the southern portion of the Standingstone quadrangle. It is particularly prominent at Bonair, a mining town in White County, in the Pikeville quadrangle, and hence is given the same name. At the type locality it is about 100 feet in thickness and is composed of coarse sandstone or conglomerate. It forms massive cliffs along the western face of the table-land northward from Bonair to Monterey, but at the latter point it suddenly disappears, apparently breaking down into sandy shale which can not be distinguished from the shales that occur both above and below the conglomerate horizon. It can be traced eastward on the surface of the plateau across this quadrangle, but is not known to occur north of a line drawn from a point a little north of Monterey to a point a little north of Clarkrange. It occurs in the valley of Obed River, in the Wartburg quadrangle, but passes below water level south of Genesis and does not reappear on that stream. On Clear Creek it shows from a point south of Hudsonburg eastward into Morgan County, where it again passes below water level. It is reported as showing on Cobb Creek, a small tributary of the East Fork of Obey River in the Wartburg quadrangle, but this report was not verified. That it extends eastward and somewhat northward is proved by the records of oil wells drilled near Rugby, in Morgan and Scott counties, but it is not known in the valley of the South Fork of the Cumberland River, a few miles north of the location of the wells referred to.

It varies in thickness from 100 to 200 feet along the western margin of the plateau, and toward the east it seems to show a thickness even greater than the greatest measure obtained on the surface. In the Rubgy wells it is slightly broken up, but in all probability it is not less that 250 feet in thickness.

Coal-bearing shale at the base of the Lee formation.

In the type locality at Bonair there is a mass of shale underneath the conglomerate which is 110 feet in thickness and which carries at its base the somewhat celebrated Bonair coal. In passing northward toward the Standingstone quadrangle this shale disappears, although, from the similarity of the material and the covered condition of the outcrop, this shale is hard to separate from the Pennington shale underneath. On the road which passes south from Taylors to the top of the plateau the top of the red shale of the Pennington is well marked within 10 feet of the base of the heavy conglomerate, the interval being mainly occupied by a coal seam about 4 feet in thickness. Immediately north of this point no shales belonging to the Lee formation could be distinguished below the Bonair conglomerate. On the long spur southwest of Monterey there are a few feet of shales below the conglomerate which belong to this series, but they are very thin and are irregular in their occurrence. On the spur northwest of Monterey along which the railroad descends to the lower plain the conglomerate is not present, but the lower shale occurs in greater thickness than at any other point in the quadrangle.

In the interior the condition below the conglomerate is not well known. In the Rugby wells the Bonair conglomerate is found resting directly upon the limestone of the Pennington shale formation; hence it is probable that over much of the interior of the Standingstone quadrangle the lower shale of the Lee formation is absent.

The shale which overlies the Bonair and comes below the Rockcastle conglomerate lentil is about 125 feet in thickness; where the lower conglomerate is absent the shale beneath the Rockcastle varies from 150 to 300 feet in thickness.

The upper conglomerate of the Conglomerate series.

Rockcastle conglomerate lentil.—This is generally a massive conglomerate from 100 to 200 feet in thickness. Where it overlies the Bonair conglomerate it is generally soft and inconspicuous, but as soon as the lower bed disappears the upper one takes its place in the landscape, and is easily mistaken for it. The lower bed probably extends southward indefinitely, but the upper has only a limited range in this direction. Near the southern edge of this quadrangle it is locally absent, especially near the northwestern margin of the plateau. Owing to this irregular development of the upper conglomerate, the Lookout sandstone was supposed to extend northward into this area from the neighborhood of Crossville. The undoubted Lookout conglomerate is exposed in the Pikeville quadrangle in the vicinity of Lantana, on the crest of a small anticlinal fold which was supposed to extent northeastward beyond the margin of the quadrangle, but in fact the anticline soon pitches under in this direction and the Lookout passes below the surface and is soon replaced by the upper or Rockcastle conglomerate.

In the Standingstone quadrangle the Rockcastle conglomerate forms the surface rock over most of the plateau. In the southeastern corner the principal streams have cut through this cap rock, but large areas are left intact; in the northeastern corner the streams have cut far below its base and it remains only as remnants on the tops of the ridges. A few miles east of the margin of this quadrangle the plateau rises sharp and regular, and is everywhere walled about by heavy cliffs of this massive formation.

In the southeastern corner of the quadrangle there are large areas which may include some beds of the formation next above the Rockcastle, but if so they have essentially the same character as the top of the latter and can not be distinguished from it. On this account they are mapped as Rockcastle.

Overlapping of the conglomerate lenses.

This formation is the highest in the series that shows in the Standingstone quadrangle. It does not extend to the top of the Pottsville series, as has been conclusively proved from fossil plants found in higher measures a little to the eastward of this region. The replacement toward the northeast of one heavy bed of coarse material by another higher in the series is still further exemplified by the strata lying above the Rockcastle conglomerate. The latter has been traced as far northward as Livingston, Kentucky, where it disappears in the same manner that the Bonair does at Monterey, but near the northern line of Tennessee a third conglomerate comes into the series about 100 feet above the Rockcastle, so that the conglomerates are continued at least as far north as Mount Sterling, Kentucky, but not as one continuous bed. The top of the Pottsville series occurs somewhere in the shale which overlies this uppermost conglomerate.

The remainder of Paleozoic history is not recorded by rocks in this quadrangle. The long geologic ages which have elapsed since the close of the Paleozoic have likewise left no rocks by which we may interpret the conditions then prevailing, but a partial record has been preserved in the surface features which have been previously described.

STRUCTURE.

To the eye of the observer the rocks of this quadrangle appear to be horizontal, but when they are examined in detail and the altitude of one outcrop is compared with that of another, it is evident that the strata are seldom, if ever, in that position. The rocks were formed at the bottom of the sea, and since the sea bottom has generally less diversity of altitude than the present rock strata, it is evident that their present position is due to movement in the crust of the earth.

Definition of terms.—The strata when compared with a horizontal plane are found to be inclined. The inclination is known as the *dip* of the rocks. In the process of deformation the rocks have been thrown into arches and troughs. In describing these folds the term *syncline* is applied to the downward-bending trough, and the term *anticline* to the upward-bending arch. A synclinal axis is a line running lengthwise in the synclinal trough and at every point occupying its lowest part, toward which the rocks dip from either side. An anticlinal axis is a line which occupies at every point the highest portion of the anticlinal arch, and from which the rocks dip to either side. The axis may be horizontal or inclined. Its departure from the horizontal is called the *pitch*, and it is usually only a few degrees in amount.

As a result of the strains and stresses which have affected the crust of the earth, the strata in many places have been broken along certain lines, and the rocks on one side of the break have been lifted or depressed with reference to those on the other side. Such a displacement is called a *fault*. Where the rocks have been intensely folded, as in the Appalachian Valley, the breaks have developed from the compressed and overturned folds; but in the Ohio Basin the faults are due to tension, or the stretching of the strata. Faults of the former type are sometimes of great linear extent and of enormous displacement, and those of the latter are in this district generally short and of very slight displacement.

In addition to the crustal movements which have perceptibly deformed the rocks of this region, the province has been affected by vertical movements which have repeatedly elevated and depressed the surface of the land, but by amounts which are insignificant compared with the magnitude of the folds. These slight movements were not continuous, but occurred now and then, the periods of greatest activity being separated by intervals of quiet in which the agents of erosion had time to record their action on the face of the land.

Structure of the Standingstone quadrangle.—Since this quadrangle lies on the southeastern side of the Cincinnati arch it is apparent that its structure is exceedingly simple, consisting of light southeasterly dips throughout the entire area. There are variations from this regular descent, but such exceptions are local and have no effect on the structure as a whole. The total dip of the rocks across this quadrangle is about 600 feet, or at an average rate of about 20 feet to the mile. This is imperceptible to the eye, and can be determined only by careful measurements.

Structure sections.—The sections upon the structure sheet represent the strata as they would appear in the sides of deep trenches cut across the country. The sections are located at the upper edges of the blank spaces, along the lines A A and B B. The vertical and horizontal scales are the same, so that the actual form and slope of the land and the dips of the strata are shown. Minute details of structure can not be represented on a map of so small scale; therefore the sections are somewhat generalized from the dips observed in a belt of country a few miles in width along the lines of the section. The scale of the sections will not permit of the representation of all of the formations upon it, and those which have a thickness of 200 feet or less can not be clearly differentiated; therefore some of the formations have been grouped. The heavy line near the base represents the Chattanooga shale, and it is greatly exaggerated even by the single line. Above this are shown the Carboniferous formations in four groups. The southern section is not carried below the Chattanooga shale for the reason that the rocks below are but little known. The upper section cuts these Silurian limestones in the northwest corner of the quadrangle, and they are shown beneath the Chattanooga shale throughout the section.

MINERAL RESOURCES.

This quadrangle lies mainly within the Appalachian coal field, and consequently its principal mineral resource is coal, but it also includes part of one of the oldest known oil fields within the United States.

Coal.—Mining on a large scale has never been attempted in this quadrangle, although at a few points enough coal is mined to supply local needs. At Monterey a mine has been in operation a short while, but at the time of examination its output was very small. Although the opening is located at the point where the Bonair conglomerate disappears, the coal seam occurs below the horizon of that heavy bed, and has a thickness of about 3 feet.

Coal seam beneath the Bonair conglomerate.

In a general way there is a coal horizon below the Bonair conglomerate, but it is doubtful whether there is a continuous bed of coaly material at this level. All openings in this portion of the series are considered to be on the Bonair seam, simply because the mines at Bonair have given prominence to the coal lying beneath the conglomerate. At Bonair the seam is 110 feet below the base of the conglomerate, but at the southern margin of the Standingstone quadrangle the coal beneath the conglomerate lies directly at its base and almost in contact with the Pennington shale. When referred to the latter formation as a datum, these openings have the appearance of being on the same seam, but when referred to the measures above, such a supposition necessitates the disappearance of a mass of shale 110 feet in thickness. The opening referred to is on the spur east of Amanda, and the seam at this point measures 4 feet in thickness. At the falls of Devil Creek the coal is absent, or possibly is represented by a few irregular streaks of coaly material just beneath the conglomerate. A seam was also observed under the conglomerate ledge on the ridge about a mile east of Void, but the opening had fallen shut and the thickness of the seam could not be determined. A coal bloom was also seen south of Void, but no trace of coal was observed on the long spur which extends southward on the west side of the Calfkiller River.

In the interior of the plateau the area of workable coal belonging to this seam is not known. Many holes have been drilled by the Nashville and Knoxville Railroad Company to test its extent, but the information thus obtained is not at present available.

North of the line along which the Bonair conglomerate disappears there are numerous exposures of coal, but they can not be correlated with those already described, for there is no datum for measurements. In a general way there is a coal horizon close to the top of the Pennington shale which may correspond with the Bonair coal, but the evidence is not sufficient to warrant their correlation. At the mouth of Big Hurricane Creek a seam of coal 26 inches in thickness occurs at this horizon. It is reported to be somewhat thicker at an opening a little below this point and on the eastern side of the East Fork of Obey River, but it was not visited and the report lacks verification. In Buffalo Cove, in the Wartburg quadrangle, 3 miles east of Glenobey, a coal occurs at this horizon which is reported by Safford to be 5 feet in thickness, but at the opening visited it measures only 46 inches. It appears, however, to thicken eastward, for a seam measuring 54 inches and lying immediately above the limestone is reported to have been found in a drill hole east of Allardt, Fentress County, or about 8 miles east of Glenobey.

Coal seam in the shale below the Rockcastle conglomerate.

In the northeastern portion of this quadrangle there is another coal horizon at a distance of about 150 feet below the Rockcastle conglomerate lentil, or from 40 to 120 feet above the Pennington shale. This seam is reported to be 110 feet below the conglomerate at the mouth of Slate Creek, and from 4 to 5 feet in thickness. It was seen north of The Horse Pound, 140 feet below the conglomerate, but the opening had caved badly and the full thickness of the seam was not visible at this point. Safford, however, reports it as having a thickness of 54 inches. On the ridge separating the two forks of Obey River a coal which is supposed to be the same seam that has been opened in a number of places and worked for local use. It is reported as varying, in this locality, from 42 to 54 inches in thickness. On the ridge north of Little Crab it has been prospected at a number of places; one mine was in operation at the time of this survey and coal from it was being hauled to Jamestown for local use. At this mine the seam measures 44 inches in thickness.

In the region about Jamestown, just east of the margin of the quadrangle, the coal appears to lie in "swamps" or basins, for it has been found by drilling that the area of workable coal which occupies the ridge between the forks of Obey River and an area of thick coal east of Allardt, in Fentress County, are separated by a strip of land which is almost entirely barren of coal.

In the southeastern corner of this quadrangle, where the two conglomerate lentils are fully developed, a few small seams of coal were seen, but nothing that gave promise of being commercially valuable. No exposure was seen that could be identified as the Sewanee coal, which is so prominent in the plateau region south of this quadrangle and extends eastward to Chattanooga and northward on the eastern front of the Cumberland Plateau at least as far as Rockwood. Its position in the series is immediately above the Bonair conglomerate, but if it is present here it is presumably too thin to be of importance. It appears, however, only a few miles southwest of Crossville, so the southern margin of this quadrangle must be about the line along which it disappears.

Petroleum.—Since the settlement of this portion of the country oil springs have been known in the Standingstone quadrangle, from which by crude methods a few gallons or a few barrels of heavy lubricating oil were obtained in the course of a year. Some of the most noted of these oil springs occur on Spring Creek, near the line separating Overton and Putnam counties. Several wells have been drilled in the vicinity of these springs, in the hope of reaching the reservoir from which they are supplied, but in all cases they are reported to have penetrated no reservoirs and even to have revealed only slight indications of oil at a few horizons. This part of the field has been sufficiently well tested to show that the surface or subsurface accumulations which supply the springs are of very small extent, and the drilling of one well to a depth of 1549 feet has shown that there is no deep-seated supply. The record of strata passed through by the drill in this well is fragmentary, but that which is available is given at the close of this report as Section B.

Spring Creek oil springs.

The Spurrier oil district.

The only field in this quadrangle that has yielded oil in commercial quantities lies at the junction of the East and West forks of Obey River, near the boundary line between Pickett and Fentress counties. Like the Spring Creek field, the oil along Obey River comes from horizons which are near the surface, and the deeper wells are dry. The oil occurs at various horizons below the Chattanooga shale, but the most productive wells find their supply at depths of from 150 to 200 feet below the Devonian shale.

At the time the field work for this folio was done there were no facilities for the storage of oil in this field, and consequently no one knew exactly the capacities of the various wells. Since that time tanks have been erected and tests have been made, but reliable information regarding these tests is difficult to obtain. The Bob's Bar well, the most productive in the district, is reported to have originally yielded under the pump 250 barrels a day, but now its production is reduced to only a small fraction of its first output. At the present time, according to report, it is being pumped eight or nine hours out of the twenty-four, and at this rate its daily production is about 30 barrels. Its total production to date is also reported to be a little over 14,000 barrels.

Deep wells drilled for oil.

The local operators are very hopeful that the field will maintain its present standing for a long time in the future, but, according to the most experienced oil men, the prospect is not very encouraging. In the belief that this subsurface supply of oil would be short lived, considerable money has been spent in drilling for deep-seated reservoirs, but in every case the quest has been unsuccessful in developing pools of oil. The evidence afforded by these deep wells regarding the occurrence of oil is entirely negative, but even this may be of inestimable value to future generations. At Little Crab, in Fentress County, the Forest Oil Company drilled to a depth of 2185 feet without finding oil in paying quantities. No record of this well section below 620 feet has been obtained, but so far as known it is represented by Section E. Within a mile of Spurrier the South Pennsylvania Oil Company, at last accounts, was drilling at a depth of 1506 feet without oil. The same company drilled a well at Livingston to a depth of 2080 feet without finding any indications of oil. The record of this well is given in Section C. A well was also drilled by this company near Cookeville to a depth of 1990 feet, with a result similar to that at Livingston. This well is shown in Section A. Several other wells in this quadrangle have been drilled to various depths, but, according to general report, without finding oil in paying quantities.

Apparently this field has now been so well tested that it is safe to say that there is no prospect for a deep-seated supply of oil, and that the only dependence in the future is upon the shallow wells on Obey River. From the lessening output of these wells it seems probable that they will not be long lived, and consequently the outlook for this field is not especially encouraging.

In late years so much has been written concerning the relation of petroleum deposits to geologic structure that it is well, perhaps, to consider for a moment the geologic structure in this region with reference to the productive wells. In order to make this relationship more easily understood, the well sections mentioned above have been prepared. The wells occur at intervals along a line commencing at Cookeville on the west and extending through Livingston, Spurrier, and Rugby to near the line of the Cincinnati Southern Railway on the east. Their geographic arrangement is shown on the diagram accompanying the sections. Considerable allowance must be made in the interpretation of these sections because of the difficulty which the driller experiences in classifying the material brought up by the sand pump. He is especially likely to confuse calcareous shale with thin-bedded limestone, and bedded chert or cherty limestone with sandstone. The sections have been plotted according to the notes of the driller, and consequently in Sections A, B, and C all the rock below the Devonian black shale is indicated as limestone, when, doubtless, it should be interbedded shale and limestone, corresponding to the outcrop of the Normandy limestone in this and adjacent quadrangles. Sections F and G are from wells drilled in the Wartburg quadrangle, but since the wells were not finished at the time of the publication of that folio the sections were not included in it. The records were, however, kept with such great care that their presentation in published form is highly desirable, hence they are inserted in this folio. The exactness of these records makes the identification of formations an easy matter, so that they are valuable not only in showing the geologic structure, but in showing the characters of the formations far beyond the limits of their outcrops.

Geologic structure of the oil field.

The oil horizon occurs only a short distance below the black shale, and while it is probable that there is an unconformity at the base of the black shale, it is presumably so small that the beds are practically parallel; hence the easily identified black shale will serve as the datum plane from which to determine the attitude and depth below the surface of the oil-bearing horizon. The section line as represented by these wells does not correspond, throughout its entire length, with the line of greatest dip, but westward from Livingston it curves to the south and corresponds more closely with the line of strike. Consequently in this part of the section the dips are lighter than they would be were the section to continue beyond Livingston in the same line as that from Rugby to Livingston, but in no case would the dips in the western part of the section be so steep as those in the other part. In all of the wells, except that at Little Crab (Section E), the elevation of the head of the well has been carefully determined, so that the sections give the actual positions of the beds pierced by the drill. No such determination has been made for the Little Crab well, and its location in the section is only approximately correct.

From Cookeville to Spurrier the section shows a gradual descent of the black shale. East of this point its position is somewhat uncertain, owing to the lack of information regarding the elevation of the Little Crab well, but presumably it is nearly horizontal from D to E. Beyond E the dips increase and the black shale sinks rapidly to 400 feet below sea level at G. In the description of the Wartburg quadrangle it was stated that the Bob's Bar well is on the crest of a small anticline, but at that time the exact structure of the Spurrier field was not known, and the statement has no weight. An examination of the section given below will show that it is impossible under any interpretation to have the Bob's Bar well (D) on the crest of an anticline; indeed, it is more probable that it is located in a slight synclinal fold or on a horizontal terrace of the generally eastward-dipping rocks. As in many other oil fields of the United States, the accumulation here occurs in gently dipping rocks, and it seems to have little connection with the attitude of the rocks, unless it marks a bench or terrace in the structure. It seems probable that the occurrence of oil pools in this field is more likely to be influenced by the porosity of the rock at the oil horizon than by the geologic structure of the region.

Limestone.—This kind of rock is abundant in the western half of the Standingstone quadrangle. Much of it is too siliceous for the manufacture of lime, but toward the top of the Newman formation there is an abundance of blue limestone of sufficient purity for this purpose. Much of the rock is well suited for building stone and for road metal, but the uses to which the former can be put in such a region are few, and for the latter there is no demand, for the community has not awakened to the superlative importance of good roads. Layers of lithographic stone occur in many places; possibly some of it may be found with a grain sufficiently even for use in the arts, but evidently the mass of it can be used only for the roughest sort of work, if, indeed, it can be used at all. It should be thoroughly tested in order to determine its value.

Clay.—Clay is of frequent occurrence, both the residual limestone clay for brick making and the under clay of the coal seams for the manufacture of pottery ware. The former has been used to some extent for local purposes, but the latter has received no attention, and information regarding its extent and value can not be obtained until the coal seams have been more thoroughly prospected.

SOILS.

In this region the soils are the result of the decay and disintegration of the rocks forming the surface, and consequently they vary in their composition much as the rocks vary from which they are derived. Since this is the case the geologic map, showing the outcrop of the different kinds of rocks, may be made to serve as a soil map with a close approximation to correctness, except on exceedingly steep slopes, where the waste from the rocks occupying the upper part of the slope may be carried down and deposited in the valley, completely covering the soil derived from the valley rocks themselves. This is particularly true where the valleys are composed of easily soluble rocks, such as limestone, and the upper slopes are made of sandstone or sandy shale. In such cases the more insoluble, siliceous material from the uppermost rocks will gradually be washed down into the valley, burying to a great degree the soil formed from the rock in place and rendering the valley of small account for agricultural pursuits. The rocks of this quadrangle may be grouped into three general classes, limestone, shale, and sandstone; and the soils resulting therefrom may also be divided into the same number of classes; but, since the rocks grade imperceptibly from one to the other, it naturally follows that the soils show a corresponding gradation, which in some cases makes classification difficult and of doubtful value.

Limestone soil.—As a rule, the best soil is produced from a calcareous rock, either limestone or calcareous shale; but the great variation in the composition of such rocks permits of an equally great variety of soils derivable from them; consequently the fact that a soil is derived from limestone is no evidence that it is as productive as other limestone soils. The most important constituent in a fertile soil is phosphate of lime, and consequently that formation which carries the most of this desirable ingredient will produce the richest soil. Throughout the bluegrass portions of Kentucky and Tennessee the lower Silurian limestones are especially rich in this element, and the soils produced from them have a productiveness which has made that region famous. The lowermost beds, or those outcropping near the center of the Nashville Basin, contain a higher percentage of phosphate of lime than the Normandy limestone, but the latter contains a sufficient amount to make a productive soil, where the surface conditions are favorable for its accumulation. In this quadrangle the surface conditions on the outcrop of the Normandy limestone are such that only a little soil can accumulate on the steep slopes, and consequently the region has no very great agricultural value, but in adjacent areas, where the surface is more rolling and less precipitous, this limestone ranks high as a producer of fertile soil.

The Newman limestone probably ranks second in this respect. It is relatively pure, but appears to lack the phosphate of lime which has made the lower limestone so valuable. This formation has a much more extended outcrop than the Normandy limestone, but as it usually outcrops on the steep slopes of the Cumberland Plateau, its soil can not be farmed so advantageously as some of the poorer soils derived from more sandy formations. The lower portion of the Newman limestone and the great bulk of the Waverly formation carry so much chert and arenaceous impurities that the soil covering their outcrops is extremely siliceous and not well adapted to agricultural pursuits. It is true, nevertheless, that the region covered by this soil is a plain, with low relief, and consequently can be utilized to the full extent of its value. Over much of the outcrop of the Waverly formation the soil is white and siliceous and so unproductive that it has received the name of "The Barrens."

The Pennington shale is sufficiently calcareous to produce a fair soil, but the formation is too thin to be important and its outcrop is generally on slopes so steep that they are practically uncultivated.

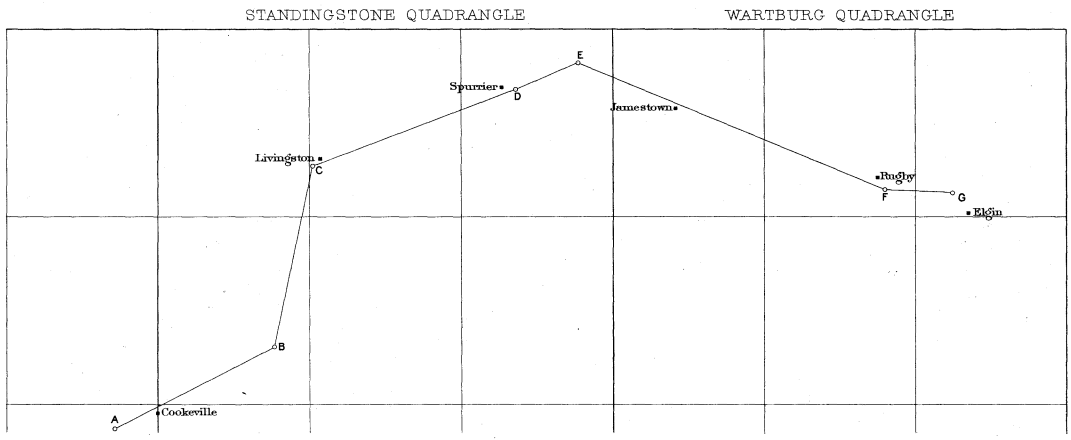
Sandstone and sandy shale soil.—The shales of the Lee formation are so prevailingly sandy that the soils derived from them can with difficulty be distinguished from those which are derived from the sandstone. The territory occupied by the Lee formation consists of a plateau and of hilly regions produced by the dissection of this same surface feature by the streams. The soil of this section is sandy and unproductive, and the region is only thinly inhabited. The native forest covering consists largely of pines and oaks, but the trees are not large and the woods are so open that they may be traversed in almost any direction regardless of roads.

From the above brief description it will be seen that, with regard to the character of the soil, this quadrangle may be divided into two districts. The surface of the Cumberland Plateau forms one of these divisions, and it is noted for the thinness and poorness of its soil. The highland plain forms the other district, and, though it is much better fitted for agriculture, it still leaves much to be desired in the way of a rich, productive soil.

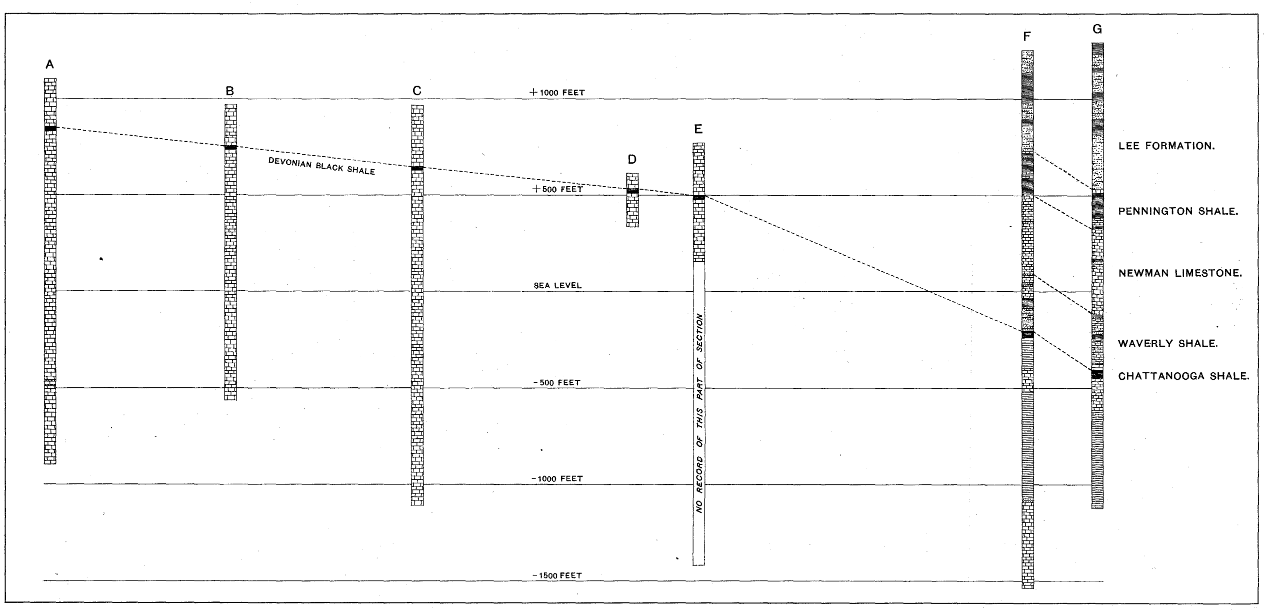
MARIUS R. CAMPBELL,
Geologist.

May, 1899.

DIAGRAM SHOWING LOCATION OF WELL BORINGS ILLUSTRATED IN TABLE OF WELL SECTIONS.
APPROXIMATE SCALE: 6 MILES = 1 INCH.



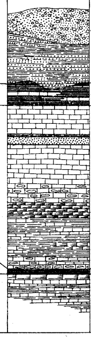
SECTIONS OF DEEP WELLS IN THE STANDINGSTONE AND ADJACENT QUADRANGLES.
SCALE: 500 FEET = 1 INCH.



COLUMNAR SECTIONS

GENERALIZED SECTION FOR THE NORTHERN PORTION OF THE STANDINGSTONE QUADRANGLE.

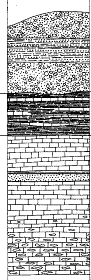
SCALE: 500 FEET = 1 INCH.



Period.	Formation Name.	Symbol.	Columnar Section.	Thickness in Feet.	Character of Rocks.	Character of Topography and Soil.
Carboniferous	Rockcastle conglomerate lentil.	Cler		100–200	Coarse sandstone or conglomerate.	Caps the plateau and generally forms a line of cliffs along its margin. Sandy soil.
	Lee formation.	Cle		100–300	Sandy shale and thin-bedded sandstone, usually containing one or more seams of coal.	Steep slopes of the escarpment and of the stream valley.
	Pennington shale.	Cpn		100–120	Red and green shales and impure limestone. Surface outcrop usually characterized by an abundance of geodes.	Steep slopes. Good soil, but not well situated for farming.
					Light-blue limestone. Contains locally nodular chert.	Hilltops and slopes. Good soil.
	(Newman sandstone lentil.)	(Cns)		(20–60)	Heavy-bedded, yellowish-brown sandstone.	Forms a terrace on the escarpment and flat-topped hills on the outliers of the plateau. Sandy soil.
	Newman limestone.	Cn		400–500	Light-blue limestone.	
				100–150	Cherty limestone band forming the transition from the Waverly to the Newman.	
	Waverly formation.	Cwv		350–450	Dark, siliceous, and argillaceous limestone. Calcareous shale and thin beds of limestone. Toward the south bedded chert gradually replaces the shale of this formation.	Forms the eastern rim of the Central Basin of Tennessee. Soil, generally poor and siliceous.
Dev.	Chattanooga shale.	Dc		20–30	Black, carbonaceous shale.	No appreciable effect on topography.
Sil.	Normandy limestone.	Sn		200+	Local bed of dark, impure limestone. Blue calcareous shale and thin-bedded limestone.	Narrow valleys with steep walls.

GENERALIZED SECTION FOR THE SOUTHERN PORTION OF THE STANDINGSTONE QUADRANGLE.

SCALE: 500 FEET = 1 INCH.



Period.	Formation Name.	Symbol.	Columnar Section.	Thickness in Feet.	Character of Rocks.	Character of Topography and Soil.
Carboniferous	Rockcastle conglomerate lentil.	Cler		100–180	Coarse sandstone or conglomerate.	Caps the upper terrace of the plateau. Sandy soil.
	Lee formation.	Cle		125	Sandy shale and thin-bedded sandstone, with occasional thin seams of coal.	Forms the slopes between the conglomerate terraces.
	Bonair conglomerate lentil.	Cleb		100–200	Massive sandstone or conglomerate. The Bonair coal occurs immediately below this conglomerate.	Caps the escarpment south of Monterey, usually forming a line of cliffs along its margin.
	Pennington shale.	Cpn		100–250	Red and green shales and impure limestone.	Steep slopes of the escarpment.
					Light-blue limestone. Contains locally nodular chert at various horizons	Steep slopes. Soil is good, but the slopes are too steep to be farmed advantageously.
	(Newman sandstone lentil.)	(Cns)		(40)	Heavy-bedded, yellowish-brown sandstone.	Forms a terrace on the escarpment and flat-topped hills on the outliers of the plateau. Sandy soil.
	Newman limestone.	Cn		440–550		
					Light-blue limestone which graduates downward into cherty, impure limestone, and finally into bedded chert.	Forms the eastern rim of the Central Basin of Tennessee. Soil, generally poor and siliceous.
	Waverly formation.	Cwv		200+		

NAMES OF FORMATIONS.

Period.	Names and Symbols used in this Folio.		Keith: Wartburg Folio.	Hayes: Kingston, Pikeville, and McMinnville Folios.	Safford: Geology of Tennessee, 1869.
Carboniferous	Rockcastle conglomerate lentil.	Cler		Walden sandstone.	Upper Coal Measures.
	Lee formation.	Cle	Lee formation.		Conglomerate.
	Bonair conglomerate lentil.	Cleb	Shale in Lee formation.	Lookout sandstone.	Lower Coal Measures.
	Pennington shale.	Cpn	Pennington shale.	Bangor limestone.	Mountain limestone.
	Newman limestone.	Cn	Newman limestone.		
	Newman sandstone lentil.	Cns	Newman sandstone lentil.		
	Waverly formation.	Cwv	Waverly formation.	Fort Payne chert.	Siliceous group.
Dev.	Chattanooga shale.	Dc	Chattanooga shale.	Chattanooga black shale.	Black shale.
Sil.	Normandy limestone.	Sn	Chickamauga limestone.	Chickamauga limestone.	Nashville series.

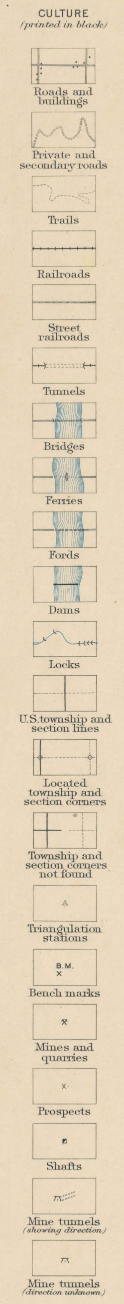
M. R. CAMPBELL,
Geologist.

U.S.GEOLOGICAL SURVEY
CHARLES D.WALCOTT, DIRECTOR

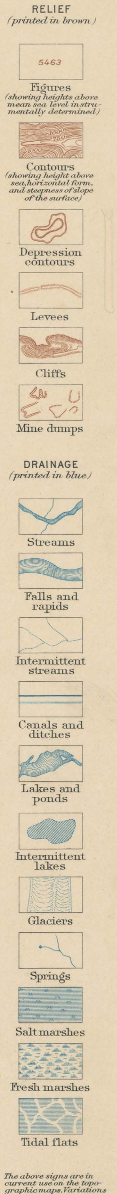
TOPOGRAPHIC SHEET

TENNESSEE
STANDINGSTONE QUADRANGLE

CONVENTIONAL SIGNS



CONVENTIONAL SIGNS



Henry Gannett, Chief Topographer.
H.M.Wilson, Chief Geographer in charge.
Triangulation by U.S.Coast and Geodetic Survey and Gilbert Thompson.
Topography by A.E.Murlin.
Surveyed in 1893-4-5.

Scale $\frac{1}{125000}$

1 ½ 0 1 2 3 4 5 Miles

1 ½ 0 1 2 3 4 5 Kilometers

Contour interval 100 feet.

Datum is mean sea level.

Edition of Nov. 1898.

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HISTORICAL GEOLOGY SHEET

TENNESSEE
STANDINGSTONE QUADRANGLE

LEGEND

SEDIMENTARY ROCKS

(Areas of Sedimentary rocks are shown by patterns of parallel lines.)

CARBONIFEROUS

Cler — Rockcastle conglomerate lentil *(coarse sandstone or conglomerate; lentil in the Lee formation)*

Cle — Lee formation *(sandstone and shale with coal seams)*

Cleb — Bonair conglomerate lentil *(coarse sandstone or conglomerate; lentil in the Lee formation)*

Cpn — Pennington shale *(red and green calcareous shale with beds of impure limestone)*

Cn — Newman limestone *(blue limestone, cherty at various horizons)*

Cns — Newman sandstone lentil *(coarse yellow sandstone in the Newman limestone)*

Cwv — Waverly formation *(blue calcareous shale, impure limestone, and bedded chert; merges into Newman limestone at the top)*

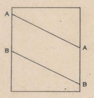
DEVONIAN

Dc — Chattanooga shale *(black carbonaceous shale)*

SILURIAN

Sn — Normandy limestone *(thin blue limestone and calcareous shale; contains oil horizons in the vicinity of Spurrier 100 to 300 feet below the Chattanooga shale)*

Sections



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Edition of June 1899.

Geology by Marius R. Campbell,
Joseph A. Taff, and Walter C. Mendenhall.
Surveyed in 1896.

U.S. GEOLOGICAL SURVEY
CHARLES D. WALCOTT, DIRECTOR

ECONOMIC GEOLOGY SHEET

TENNESSEE
STANDINGSTONE QUADRANGLE

Henry Gannett, Chief Topographer.
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STRUCTURE-SECTION SHEET

LEGEND

SEDIMENTARY ROCKS

SHEET SYMBOL / SECTION SYMBOL

CARBONIFEROUS

Grouped on the sections as Cle:

- Cler — Rockcastle conglomerate lentil (*coarse sandstone or conglomerate; lentil in the Lee formation*)
- Cle / Cle — Lee formation (*sandstone and shale with coal seams*)
- Cleb — Bonair conglomerate lentil (*coarse sandstone or conglomerate; lentil in the Lee formation*)

- Cpn / Cpn — Pennington shale (*red and green calcareous shale with beds of impure limestone*)

Grouped on the sections as Cn:

- Cn / Cn — Newman limestone (*blue limestone, cherty at various horizons*)
- Cns — Newman sandstone lentil (*coarse yellow sandstone in the Newman limestone*)

- Cwv / Cwv — Waverly formation (*blue calcareous shale, impure limestone, and bedded chert; merges into Newman limestone at the top*)

DEVONIAN

- Dc / Dc — Chattanooga shale (*black carbonaceous shale*)

SILURIAN

- Sn / Sn — Normandy limestone (*thin blue limestone and calcareous shale; contains oil horizons in the vicinity of Spurrier 100 to 300 feet below the Chattanooga shale*)

Known productive areas

Coal (*in the Lee formation*)

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