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 folds. Each fold 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 stated on the map by numbers. It is desirable to show also the elevation of any part of a hill, ridge, or valley; 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 constant vertical space between each two contours is called the interval of contour. Contours and elevations are printed in brown.

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

2. Contours define the forms of slopes. Since contours are continuous horizontal lines conformable to the undulations of the surface, a change in the elevation of the surface causes a change in the position of the contour lines. When the surface rises, a contour line on a gentle slope must go farther than on a steep slope, and therefore contours are far apart on steep, but close together on gentle slopes.

For a fast 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 Biscayne Swamp. In mapping great mountain masses, like those in Colorado, the interval may be 250 feet. For hills of moderate elevation, intervals of 10, 20, 50, 50, and 100 feet are used.

Drainage.—Watercourses are indicated by blue lines. Usually this is a line drawn by hand, but if the channel is dry or is only a part of the year, the line is broken or dotted. Sometimes the channel is so small, or the surface, the opposite underground course is shown by a broken blue line. Lakes, marshes, and other bodies of water are shown in blue, as by appropriate conventional signs.

Culture.—The works of man, such as roads, railroads, towns, churches, and cities, are shown in tinted colors, townships, counties, and States, and artificial details, are printed in black.

Of the area of the United States (excluding Alaska) is about 3,500,000 square miles. On a map 240 feet long and 195 feet high this world area would require a scale of 1 mile to the inch, 30,000,000 square inches. 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 special 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 63,360,000 square miles in the United States, the scale 1 mile to an inch is expressed by 63,360. Both of these methods are used on the maps of the United States.

Three fractional scales are used on the atlas sheets of the Geological Survey; the smallest is 1 mile to 2,000,000 in the case of the large sheets, 1 mile to 4,000,000 in the case of the middle sheets, and 1 mile to 8,000,000 in the case of the small sheets. These correspond approximately to 4, 8, and 16 inches, and 1 mile of natural length to an inch of map length. On the scale 1 mile to 2,000,000, each square mile is a square 4 inches on a side; on the scale 1 mile to 4,000,000 each square mile is a square 2 inches on a side; and on the scale 1 mile to 8,000,000 each square mile is a square 1 inch on a side.

3. The map is being published in atlas sheets of convenient size, which are bound by parallels and meridians. Each sheet on the atlas represents a square of about 40 miles on a side. Each sheet on the scale of 1 mile to 2,000,000 contains one-quarter of a square degree; each sheet on the scale of 1 mile to 4,000,000 contains one-eighth of a square degree; and each sheet on the scale of 1 mile to 8,000,000 contains one-sixteenth of a square degree. Each sheet contains part of a county, a town, or a city, but the area covered by a certain number of sheets is bounded by the boundary lines of the States, counties, or townships.

Under the influence of dynamic and chemical forces an igneous rock may be metamorphosed, and this process may involve only a remanent of its original structure, or it may be completely changed by a change in chemical and mineralogical composition. The new structure of the rock may be changed by the development of planes of dihision, 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 microschist.

The geologists study all rocks which have been deposited under water, whether in the sea, lakes, or streams. They form a very large and important class. The materials of which most sedimentary rocks are made are carried as solid particles by the streams, or carried, and re-deposited, and the deposit is called a mechanical sediment. These may become hardened into conglomerates, sandstone, and shale, and are known by the name of clastic sediments. Some sedimentary rocks are formed by the solution of the rock by 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 limonite, chert, gyptite, sand, wax, certain clays, and coal. Any one of the above sedimentary deposits may be separated from the others, 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 shoreline of the ocean is changed. Areas of deposition may rise above the ocean, which forms the sea bed, and land areas may sink below the water and become areas of deposition. North America was gradually rising toward the east, the Atlantic Ocean area over the Atlantic Ocean, and the Mississippi River, or over the Gulf of Mexico, and the Great Lakes; the Appalachian Mountains were an archipelago, and the ocean's shore lay along the present line of the Ohio and Kan-

The characteristic of original sediments may be changed by chemical and dynamic action so as to produce metamorphic rocks. The metamorph-

Sedimentary rocks, as the original igneous rocks, are generally deposited on the original igneous rocks. The igneous rocks are called intrusive. Within their rock structures they are very slowly and hence are generally of crystalline texture. When the chasms 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 crystal line condition. They are usually more or less porous and the igneous rocks thus formed upon the surface are called extrusive. Explosive action often accompanies voluminous eruptions, causing the formation of ash and larger fragments. These materials when consolidated constitute brocken, agglomerates, and tuffs. The ash when expelled from an active volcano is called pumice, and when it has become stratified, it is called pumiceous. When the age of an igneous rock is often difficult or impossible to determine. When it occurs as a part of sedimentary rock, it is younger than that rock, and when a sedimentary rock is deposited over an igneous rock, it is considered as older.

Some of these glacial wash was deposited
DESCRIPTION OF THE McMINTIN SHEET

GEOGRAPHY.

General relations.—The McMinnville sheet is bounded by the parallels 35° 30' and 38° 6' and by the meridians 88° 30' and 88° 46'. The district mapped embraces the square section of land in the State of Tennessee, comprehending the principal part of the ancient Gulf province of Tennessee, with the centre of the earth's surface. Its dimensions are 343 miles from north to south and 29 miles from west to east, and it contains about 39,800 square miles.

The adjacent sheets are the Elkville and Civil War sheets on the east and the Sequatchie and Coosawattee on the west. The cross reference to the east and west has not yet been surveyed.

The district lies wholly within the State of Tennessee, embracing in a square section the counties of Cannon, Sumner, and Trousdale, and the western part of Stewart, with portions of Cannon and Trousdale.

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

Shaping of the land.—The McMinnville sheet is cut by parallel valleys, the north-south valleys of the Tennessee River and the east-west ridge of the Cumberland Plateau. The plateau area is subdivided into three parallel valleys, the Tennessee Valley to the west and the Cumberland Valley to the east.

The Tennessee Valley is a series of broad, flat-bottomed valleys extending from north to south, with the Tennessee River flowing through the center. The Tennessee Valley is about 200 miles long and 20 miles wide, with a width of about 10 miles near the mouth of the river.

The Cumberland Plateau is a broad, flat-topped plateau that extends from east to west, with the Cumberland River flowing through the center. The plateau is about 300 miles long and 30 miles wide, with a width of about 10 miles near the mouth of the river.

The surficial geology of the McMinnville sheet is characterized by the presence of alluvial fans, terraces, and pediments, with the alluvial fans being the most prominent feature.

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The rocks which form the surface throughout the whole of the Middle Tennessee region are the Devonian series, and the coal occurs in the upper part of this formation, which is composed of limy and sandstone beds. The coal occurs in thin seams, often only a few inches thick, and is interbedded with sandstone and shale. The thickness of the coal seams varies greatly, ranging from 2 to 20 feet in thickness. The seams are often faulted and folded, and the bedding is often overturned. The coal is generally of good quality, with a high percentage of fixed carbon and low sulfur content.

MINERAL RESOURCES

Coal—The productive coal-bearing formations in the Tennessee Valley include the Chattanooga, the Lookout Mountain, and the Tennessee Valley Coal Measures. These formations cover a large area of eastern Tennessee, and the coal is of bituminous type, with a high percentage of volatile matter. The coal is generally of good quality, with a high percentage of fixed carbon and low sulfur content.

The Chattanooga formation consists of a series of coal beds, each of which is separated by a layer of shale or limestone. The coal beds are generally thin, often only a few inches thick, and are often faulted and folded. The coal is of good quality, with a high percentage of fixed carbon and low sulfur content.

The Lookout Mountain formation consists of a series of thin coal beds, each of which is separated by a layer of shale or limestone. The coal beds are generally thin, often only a few inches thick, and are often faulted and folded. The coal is of good quality, with a high percentage of fixed carbon and low sulfur content.

Iron ore—Two varieties of iron ore occur in the Tennessee Valley: iron ore and brown hematite. Iron ore is a mineral containing iron, with a high percentage of iron oxide. The iron ore is usually used for the production of pig iron, while the brown hematite is used as a source of iron ore.

The iron ore occurs in small quantities, typically less than a few hundred pounds per ton of rock. The iron ore is usually found in the Chattanooga and Lookout Mountain formations, and is often associated with the coal seams. The iron ore is of good quality, with a high percentage of iron oxide and low sulfur content.

The brown hematite occurs in small quantities, typically less than a few hundred pounds per ton of rock. The brown hematite is usually found in the Tennessee Valley formation, and is often associated with the coal seams. The brown hematite is of good quality, with a high percentage of iron oxide and low sulfur content.

In conclusion, the Tennessee Valley is a region of significant mineral resources, with a variety of productive coal-bearing formations, as well as small quantities of iron ore and brown hematite. The coal is of high quality, with a high percentage of fixed carbon and low sulfur content, and is used for a variety of purposes, including the production of electricity and steel. The iron ore and brown hematite are of good quality, with a high percentage of iron oxide and low sulfur content, and are used for a variety of purposes, including the production of pig iron and steel.
COLUMNAR SECTIONS

GENERALIZED SECTION FOR THE McMINNIVILLE SHEET.
SCALE: 100 FEET = 1 INCH.
VERTICAL DISTANCES ARE MEASUREMENTS FROM THE TOP OF LIRIODENDRON COALS.

<table>
<thead>
<tr>
<th>Forma</th>
<th>Formation Name</th>
<th>Columnar Section</th>
<th>Total Feet</th>
<th>Character of Rocks</th>
<th>Character of Topography and Soil</th>
<th>Soils</th>
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VERTICAL SECTIONS; SHOWING THE POSITION AND THICKNESS OF COAL BEDS.
SCALE: 100 FEET = 1 INCH.
VERTICAL DISTANCES ARE MEASUREMENTS FROM THE TOP OF LIRIODENDRON COALS.

<table>
<thead>
<tr>
<th>Formation</th>
<th>Section on the North Side of the Fork, a North to Southwest Inclination.</th>
<th>Section on the South Side of the Fork, a South to Southwest Inclination.</th>
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CHARLES WILLARD HAYES,
Geologist.
January, 1896.

The decay of the upper portion of the Fort Payne chert.

In other portions of the highland rim, particularly in western middle Tennessee, these accumulations of limonite attain considerable volume and supply numerous furnaces.

The second variety of iron ore which may be found in this district in commercial quantities is the carbonate or black band ore. At many points in the district mapped on the adjacent Swanes sheet a bed of this ore occurs at the contact of the Bangor limestone and the Lookout sandstone. In Hubbard Cove, a few miles from the southern limit of the McMinnville sheet, the bed has been opened, and is about 35 feet thick. Although not observed in the McMinnville district, it is probable that the same bed occurs in the corresponding position.

Six. - Stone adapted to architectural uses is found in nearly every formation shown on the sheet, but has been quarried in only a small way for local use. Somewhat extensive quarries of a pink sandstone occurring in the Lookout have been opened near Swanes, and the same stone occurs in the northeastern corner of the McMinnville district. Distance from lines of transportation, however, renders this of little present value. Good building stone also occurs in the Bangor limestone along the eastern half of the district mapped, and in the Chickamauga limestone in the northeastern corner.

Ch. - The hard, blue Bangor and Chickamauga limestones furnish an abundant supply of mascoma material, which with little transportation could be made excellent roads in all the valley portion of the district. The residual chert in areas underlain by the Fort Payne is an excellent road material and might be used with advantage in surfacing macoma roads. Unfortunately these abundant materials are as yet wholly unutilized.

Ch. - The residual deposits resulting from the weathering of the Bangor and Chickamauga limestones are red and blue clays, generally well adapted for making brick. This is utilized for supplying local demand near the larger towns. At some points this clay is suitable for pottery and tile. In the vicinity of Smithville a bed of white clay resulting from the weathering of shales in the upper part of the Fort Payne is used for pottery. Several beds of fire-clay which are associated with the coal probably contain material well adapted for making firebrick, but they are as yet wholly undeveloped.

SOILS.

Derivation and distribution. - Throughout the region covered by the McMinnville atlas sheet there is a very close relation between the character of the soils and that of the underlying geologic formations. Except in limited areas along the larger streams and on the steepest slopes, the soils are derived directly from the breccia and disintegration of the rocks on which they lie. All such sedimentary rocks as occur in this region are changed by surface water more or less rapidly, the results depending on the character of the cement which holds their particles together. Siliceous cement is nearly insoluble, and rocks in which it is present, such as quartzite and some sandstones, are extremely durable and produce but a scanty soil. Calcareous cement, on the other hand, is readily dissolved by water containing carbonic acid, and the particles which it held together in the rock crumble down and form a deep soil. If the calcareous cement makes up but a small part of the rock, it is often leached out far below the surface, and the rock retains its form but becomes soft and porous; but if, as in limestone, the calcareous material forms the greater part of the rock, the insoluble portions collect on the surface as a mantle of soil, varying in thickness with the character of the limestone, being thickest where the limestone is coarse and thin where it is very thickly bedded.

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

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

Classification. - The soils of this region may conveniently be classed as (1) sandy soils derived from the Walnut and Lookout sandstones; (2) clay soils, derived from the Bangor and Chickamauga limestones; (3) sherry soils, derived from the Fort Payne chert; (4) alluvial soils, deposited by the larger streams on their flood-plain.

Sandy soils. - The Cumberland Plateau is formed of sandstones and sandy shales, and its soil is a sandy loam. At the surface it is gray, while the subsoil is generally light-yellow, but varies to deep-red. In some places it consists largely of sand, but in others it contains sufficient clay to give the subsoil considerable cohesiveness, so that a cut bank will remain vertical for some years. The depth of soil on the plateau varies from a few inches to ten feet or more, diminishing in proportion to streams, where erosion is most active. A large part of the plateau retains its original forest growth, chiefly of oak, chestnut, and hickory, while pines clothe the steep sides of the stream channels. The practice of burning off the leaves each fall prevents the accumulation of vegetable mold and has delayed a just appreciation of the agricultural possibilities of this region. It has been found well adapted to fruit-growing, particularly for grapes and apples.

Since the sandstones of this region occupy the highest land, the overplaced soils, or those washed down to lower levels, are mostly sandy. They are especially abundant at the foot of the escarpment surrounding the plateaus, where the Bangor limestones and their clay soils are often wholly concealed.

The delta deposits formed by streams emerging from gorges cut in the plateaus also give considerable areas of sandy soil, overlying rocks which would themselves produce clay or sherry soils.

Clay soils. - These are derived chiefly from the Bangor and Chickamauga limestones, and their distribution coincides with the outcrops of these formations, as shown on the geologic map. They sometimes have a deep-red color, but where the mantle of residual material covering the rock is thin it is often dark-brown-gray. The soil in the many caves which penetrate the Cumberland Plateau is derived chiefly from the Bangor limestone. It is a bluish clay with a slight admixture of sand from the rocks capping the plateau, and is exceptionally fertile. It is especially adapted to clover and grain. Considerable areas of red-clay land occur on the highland rim between the foot of the plateau and the inner edge of the Barrens. A deep red-clay soil characterizes also the isolated areas of Bangor limestones in the central and western portions of the district mapped.

Clayey soils. - Outcrops of the Fort Payne occupy something more than a third of the area of the sheet and the chert which makes up so large a portion of this formation determines the character of the residual soil derived from it. The calcareous portion of the rock is removed by solution, leaving the insoluble silicious constituent as a deep residual mantle upon the surface. The soil derived from the lower part of the formation, where the chert is heavy and abundant, is usually very rich and difficult to cultivate, but rather fertile. That derived from the upper part of the formation is light-gray, very silicious, and so finely divided that it appears to be almost free from grit and is readily borne by the wind. The subsoil is usually reddish or yellow, and contains considerable clay, with angular quartz fragments, which increase in abundance with depth. This gray, silicious soil characterizes the "barrens" of the highland rim. The land is by no means barren, but has obtained the name by contrast with the seemingly inexhaustible red-clay lands adjacent. With proper cultivation and the use of fertilizers this soil becomes highly productive.

Alluvial soils. - All the streams of this region are more or less rapidly deepening their channels, and hence have very narrow, if any, flood-plain. At the northern edge of the district mapped Caney Fork, has cut down nearly to the level of the Cumberland River. It is now widening its valley, and is bordered by narrow strips of alluvial soil for several miles within the district. From the vicinity of Greenbrier bend to the mouth of Collins River the stream flows in a narrow gorge and has no flood-plain. Further up on Caney Fork and its tributaries, where the streams flow on the highland rim, they are again bordered by strips of alluvial soil. This is a sandy-clay loam, and owes its fertility largely to the vegetable matter which it contains.
in tunnels and channels in the ice, and forms characteristic ridges and mounds of sand and gravel, known as charm, or as ridges and mounds of gravel sand, respectively. The material deposited by the ice is called glacial drift; that washed from the bed of the ice or from the adjacent land is called solifluction. It is found in several classes as surficial rocks the deposits of the sea and of lakes and rivers which accumulated at the same time as the ice deposited.

**AGES OF ROCKS**

Rocks are further distinguished according to their relative ages, for rocks 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 of the earth. The rocks composing the entire system and the time taken for its deposition are given the same name, as, for instance, Cambrian system.

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 the order of the strata may be reversed. The absence of beds has been so great that their position is reversed, and it is often difficult to determine the relative ages of the deposits by their relative positions; then fossils, or the remains of plants and animals, are a guide to which of two or more formations strata belong.

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 simplest kinds of marine life existed when the oldest fossiliferous rocks were deposited. From time to time more complex kinds developed, and at the simpler stages, living in modified forms life became more varied. But during each period there lived plant and animal life that existed in earlier times and have not existed since; these are characteristic types, and they define the age of any bed or rock stratum of the earth in which they are found.

When two formations are remote from one another and it is impossible to observe their relative positions, the characteristic fossil types found in them may determine which one was deposited first. Fossil remains found in the rocks of different areas, of different provinces, and of different periods, 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 the oldest to the newest) are assigned to the single layers, each of which and have not existed since; these are characteristic types, and they define the age of any bed or rock stratum of the earth in which they are found.

**The various geologic sheets.**

**Archaic sheet.** This sheet shows the areas comprised by the various formations of the earth, each of which is a kind of rock, legible in the key to the map. To show the meaning of any particular colored pattern, it is necessary to refer to the legend. The legend indicates the field color, pattern, and symbols used in the formation. All the formations which appear on the sheet are shown on this sheet by fainter color-patterns, and the geological formations, and to the column diagram 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 1,000 feet to 1 inch. The order of accumulation of the sediments is shown in the column 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 age of the rocks is shown, and the total thickness of each system.

The intervals of time which correspond to the formations of the earth and to the corresponding interruptions of deposition or sedimentary deposits may be indicated graphically by the word "unformity." Each formation shows in the column section, accompanied by its name, a description of its characteristics, and is stereotyped as used in the maps and their legends.

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