The Geological Survey is making a geologic map of the United States, which necessitates the preparation 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, plateaux, valleys, hills, and mountains; (2) distribution of water, called drainage, as streams, lakes, and swamps; (3) the works of man, called contours, 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 outlines, or contour, of all slopes; and to indicate their grades, or degree of steepness. This is done by lines connecting points of the same elevation above mean sea-level, the lines being drawn at regular vertical intervals. These lines are called contours, and the space between any two contours is called the contour interval. Contours and elevations are printed in black.

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

**EXPLANATION.**

![Fig. 1— Ideal sketch and corresponding contour map.](image)

2. Contours define the forms of slopes. Since contours are continuous horizontal lines confining each other, and since the surface is smooth and slopes, ridges in passing (passing about) are more pronounced on the rise or fall, the height on a gentle slope one must go farther than on a steep slope, and therefore contours are far apart on gentle slopes and close together on steep ones.

For a flat or gently undulating country a small contour interval is useful; 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 Pamlico Swamps. In mapping great mountain masses, like those in Colorado, the interval may be 200 feet. For intermediate relief contour intervals of 5, 20, 35, 50, and 100 feet are used.

3. Watercourses are indicated by blue lines. If the stream flows the year round the line drawn is unbroken, but if the channel is dry by paralels and cross lines on the sheet. Where a stream sinks and reappears at the surface, the supposed underground course is shown by interrupted lines. Though the arrangement of water is also shown in blue, by appropriate conventional signs.

**Isolines:** The area of the United States (excluding Alaska) is about 9,000,000 square miles. On a map 240 feet long and 180 feet high this would cover, on a scale of 5 miles to the inch, 2,900,000 square miles. 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 the 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. Thus, there are 660,000 inches in a mile, the scale 1 inch to 1 mile. Both of these methods are used on the maps of the Geological Survey.

Three fractional scales are used on the atlas sheets of the Geological Survey: the smallest is the intermediate scale, 1 inch to 1 mile. These correspond approximately to 4 miles, 2 miles, and 1 mile of natural length to an inch of map length. Of the scale 1 mile to 20 square miles are represented on the map 250 feet long and 200 feet high; and on the 100,000,150,200, and so on, as the map levels.

The contour interval is 0 feet; therefore the contours occur at 50, 100, 150, 200, and so on, as the map levels. Along the contour at 200 feet lie all points of the surface 200 feet above sea-level and as with any other contour. In the space between any two contours occur all elevations above the lower and below the higher. It is evident that at 200 feet lies just below the edge of the contour, while that at 200 feet lies above the contour; therefore all points on this contour are at a height of more than 150 but less than 200 feet above sea-level. The summit of the hill is stated to be 200 feet above sea-level and consequently the contour 200 feet surrounds it. It is evident near all the contours are numbered. Where this is not possible, certain convenient numbers are accenteduated and numbered; the heights of others may then be ascertained by counting up or down from a numbered contour.

**Usoes of the topographic sheet.**—Within the limits of scale the topographic sheet is an accurate representation of the relief, land surface, and atmosphere of the region represented. This map may be used for reconnaissance the land surface, and culture of the region represented. Viewing the landscape, map, in every character part of the dryness or wetness, and can be obtained. In climbing ranges of property to be bought or sold; see the engineer preliminary surveys in locating routes, highways, and irrigation canals. The topography provides the material and water supply and the location of the church and house; and serve many of the purposes of a map for local reference.

**THE GEOLOGIC MAP.**

The geologic map represents 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 maps show the underground relations, as far as known, and in such detail as the scale permits.

**Rocks.**—The 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. Rocks that have not been weathered are called solid or crystalline. Deposits of these rocks have been formed on land surfaces since the earliest geological time. Through the transporting agencies of streams the superficial materials of all ages and origins are carried to the sea, where, along with material derived from the land by the action of waves, 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.

The various classes of 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 been cooled and consolidated from a liquid state. As the term implies, sedimentary, rocks are deposited on the original igneous rocks. Through the igneous and sedimentary rocks of all ages have been formed by the soil and water which rise up or down through the strata, they are generally crystalline texture. When the materials reach the surface others have been formed, resulting in the formation of sandstone to quartzite, limestones to marble, and modifier other rocks according to the nature of the materials from which they are derived. Rocks which are the result of diagenesis are produced by the action of water, steam, and the influence of other substances, and as such are called schists or slates. Rocks which are the result of disintegration are produced by the action of water, frost, water, and wind.

Sedimentary rocks—These embrace the clays, sands, and limestones. These rocks are formed by the action of water, steam, and the influence of other substances, and as such are called schists or slates. Rocks which are the result of disintegration are produced by the action of water, steam, water, and wind.

The surface of the earth is not fixed, as it seems to be; it is very slowly rises or sinks over wide areas, and not in a series of great rises or res. The series of rocks in the mountains would have to be read down vertically, and the earth's surface would traverse Wisconsin, Iowa, Kansas, and Kansas, and extend south to Texas. More extensive changes than this have repeatedly occurred in the past.

The character of the original sediments may be altered by chemical and physical action so that new rock formations are formed. 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 a metamorphic rock. The metamorphic rocks are often produced by the action of water, steam, and other substances, and as such are called schists or slates. Rocks which are the result of diagenesis are produced by the action of water, steam, and the influence of other substances, and as such are called schists or slates.
DESCRIPTION OF THE GADSDEN QUADRANGLE

GEOGRAPHY

General relations.—The Gadsden quadrangle is bounded by the parallels of latitude 34° and 34° 30′ and the meridians of longitude 86° and 86° 30′ west of the center of the earth’s surface. Its dimensions are 345.5 miles from north to south and 290.8 miles from east to west, and it contains 882,929 square miles. The adjacent quadrangles are: on the north, North Carolina; on the east, Fort Payne; on the south, the Appalachian mountains; and on the west, Collins. The Gadsden quadrangle lies wholly within the State of Alabama, containing portions of Marshall, De Kalb, and Calhoun counties. 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. All parts of the region thus defined have a common history, recorded in its rocks, its geologic structure, and its topographic features. Only a part of this history can be read from an area so small as a single quadrangle; hence it is necessary to consider the latter in its relations to the entire province.

Subdivisions of the Appalachian province.—The Appalachian province may be subdivided into six areas well-marked by change in physiographic division, though each of which contains certain forms that have produced similar results in sedimentation, in geologic structure, and in physiographic relations. These subdivisions extend the entire length of the province, from north to south. The central division is the Appalachian Valley, which is the best defined and most uniform of the six. In its southern part it coincides with the belt of folded rocks which forms the Coan Valley of Georgia and Alabama and the Great Valley of East Tennessee and Virginia. Throughout the central and northern parts of the region, and in the later geologic age, this whole area was marked by great valleys—such as the Shenandoah Valley of Virginia, the Cumberland Valley of Maryland and Pennsylvania, and the Lebanon Valley of northeastern Pennsylvania—the western side being a succession of ridges alternating with narrow valleys. This division varies in width from 40 to 125 miles. It is sharply outlined on the south by the Appalachian Mountains and on the north by the Cumberland Plateau and the Allegheny Mountains. Its rocks are almost wholly sedimentary and in large measure sandstone, which originally have been nearly horizontal, now intersect the surface at various angles and in narrow belts. The drainage is divided into different kinds of rock, so that sharp ridges and narrow valleys of great length follow the narrow belts of hard rock, and the broad valleys of softer material. The streams of the eastern part are deeply incised, while the streams of the western part are nearly level with the interior lowlands. There is a narrow belt along the northern boundary of the region that presents a uniform upland.

The eastern part of the division is known as the eastern portion of the Appalachian Mountain range, the Allegheny Mountains, and also extending from New York to Alabama, and the lowlands of Tennessee, Kentucky, and Ohio. These mountains are the oldest, and they contain the oldest rocks of the region. The principal mountain ranges are the Allegheny, Pennsylvania, and the Blue Ridge of Virginia and Maryland. These mountains are the easternmost of the Appalachian range, and they are characterized by their sharp peaks and by the narrow valleys that separate them. The Allegheny Mountains are the highest, and they contain the highest peaks of the region. The Blue Ridge is the next highest, and it contains the highest peaks of the eastern part of the region. The Allegheny Mountains are the oldest, and they contain the oldest rocks of the region. The principal mountain ranges are the Allegheny, Pennsylvania, and the Blue Ridge of Virginia and Maryland. These mountains are the easternmost of the Appalachian range, and they are characterized by their sharp peaks and by the narrow valleys that separate them. The Allegheny Mountains are the highest, and they contain the highest peaks of the region. The Blue Ridge is the next highest, and it contains the highest peaks of the eastern part of the region. The Allegheny Mountains are the oldest, and they contain the oldest rocks of the region.
a luxuriant vegetation which probably covered low, swampy shores.

These rocks afford a record of almost universal sedimentation from the Carboniferous time. Their composition and appearance indicate at what distance from shore and in what depth of water they were deposited. Sandstones marked by ripple marks and cross-bedded by currents, and shales cracked by drying on mud flats, indicate shallow water; while limestones, especially by the fossils they contain, indicate greater depth of water and scarcity of sediment. The character of the adjacent land is shown by the character of the sediments derived from its waste. Course sandstones and conglomerates, which are formed in areas where there has been a rapid stream with deposition from a coarse material, are derived from high land, on which stream grades were steep, or they may have resulted from water action in the immediately adjoining coast. Red sandstones and shales, such as make up some of the Cambrian and Silurian formations, result from the removal of erosion on a land surface long exposed to rock decay and chemical solution, and hence covered by a deep residual soil. Limestones, on the other hand, if deposited near the shore, indicate that the land was low and that its streams were too sluggish to carry off the dissolved lime and calcium, which are so hard to find as sediment and substances in solution.

The sea in which these sediments were laid down covered most of the present states of the Mississippi valley and the Mississippi Basin. The Gaudale quadrangle was near its eastern margin at certain stages of sedimentation in the Silurian period, and it is possible that some of the beds of the碳酸岩 may be correlated with the eastern border of the interior sea as it encroached upon the land. The exact position of the eastern margin of the sea in this area is not known, but it probably varied from time to time within rather wide limits.

Two great cycles of sedimentation are recognized in the rocks of this region. Beginning with the first definite record, course sandstones and shales were deposited in early Silurian times. At certain stages of sedimentation, which it seems reasonable to assume is the same as that in which its rocks are composed, probably derived largely from the land to the east. The exact position of the eastern margin of the sea in this area is not known, but it probably varied from time to time within rather wide limits. Following this period of quiet, during this cycle, came a second period, during which the land was low, probably worn down nearly to base level, affording conditions for the accumulation of the Devonian black shale and Carboniferous limestones, which in general show very little trace of shore waves. A second great period of quiet followed, but which shows no unconformity to the deposit in the southern part of Wills Valley, however, there is a heavy bed of brecce or conglomerate at the bottom of the Chikamunga. It is composed of angular or slightly rounded fragments of chert imbedded in a limestone cement. In some places these chert pebbles are few and scattered, while in others they make up nearly the whole mass of the rock. This bed of brecce or conglomerate indicates a period of disturbance at the close of the Knox dolomite when the rocks already deposited were disturbed and new sea-bottom sediments were laid down over them. These rocks were probably formed along the land border of the sea-bottom sediments. In the northern part of the quadrangle, in Bloomfield, the Knox dolomite is somewhat thinner, ranging from 300 to 500 feet, and contains a few beds of brown, sandy shale along with the coal beds. In the Knox Valley the formation shows a still further increase in thickness to 600 feet, of which a considerable portion is in the form of banded sandstone. This formation takes its name from Rockwood, Tennessee (Kingsport quadrangle). It is of great practical importance on account of its coal beds. The Knox dolomite is the main coal measure in the eastern United States.

The formation occurs as a continuous narrow strip near the center of Bloomfield Valley and a narrower strip not entirely continuous along its western boundary. It is somewhat thick, ranging from 200 to 500 feet, and contains a few beds of brown, sandy shale along with the coal beds. In the Knox Valley the formation shows a still further increase in thickness to 600 feet, of which a considerable portion is in the form of banded sandstone. This formation takes its name from Rockwood, Tennessee (Kingsport quadrangle). It is of great practical importance on account of its coal beds. The Knox dolomite is the main coal measure in the eastern United States.

The formation occurs as a continuous narrow strip near the center of Bloomfield Valley and a narrower strip not entirely continuous along its western boundary. It is somewhat thick, ranging from 200 to 500 feet, and contains a few beds of brown, sandy shale along with the coal beds. In the Knox Valley the formation shows a still further increase in thickness to 600 feet, of which a considerable portion is in the form of banded sandstone. This formation takes its name from Rockwood, Tennessee (Kingsport quadrangle). It is of great practical importance on account of its coal beds. The Knox dolomite is the main coal measure in the eastern United States.

The formation occurs as a continuous narrow strip near the center of Bloomfield Valley and a narrower strip not entirely continuous along its western boundary. It is somewhat thick, ranging from 200 to 500 feet, and contains a few beds of brown, sandy shale along with the coal beds. In the Knox Valley the formation shows a still further increase in thickness to 600 feet, of which a considerable portion is in the form of banded sandstone. This formation takes its name from Rockwood, Tennessee (Kingsport quadrangle). It is of great practical importance on account of its coal beds. The Knox dolomite is the main coal measure in the eastern United States.

The formation occurs as a continuous narrow strip near the center of Bloomfield Valley and a narrower strip not entirely continuous along its western boundary. It is somewhat thick, ranging from 200 to 500 feet, and contains a few beds of brown, sandy shale along with the coal beds. In the Knox Valley the formation shows a still further increase in thickness to 600 feet, of which a considerable portion is in the form of banded sandstone. This formation takes its name from Rockwood, Tennessee (Kingsport quadrangle). It is of great practical importance on account of its coal beds. The Knox dolomite is the main coal measure in the eastern United States.
A synclinal axis is a line running lengthwise of the synclinal trough, at every point occupying its lowest part, toward which the rocks dip on either side. An anticlinal axis is a line which runs up at every point the highest portion of the anticlinal arch, and away from which the rocks dip on either side. Such axes may be horizontal, or they may be inclined. Their departure from the horizontal is called the pitch of the axis, and is usually measured in degrees.

In addition to the foldings, and as a result of the continued action of the same forces which produced it, the structure has been fractured, and the rocks have been thrust in different directions on opposite sides of the fracture; this is termed a fault. The rocks are also often rendered brittle by a change of temperature, or by a change of termometromorphism.

Structure of the Appalachian province.—Three distinct types of structure occur in the Appalachian province, each one prevailing in a separate area corresponding to one of the three geographic divisions.

In the platean region and westward the rocks are but little tilted from their original horizontal position and are almost entirely unaltered; in the valley the rocks have been steeply tilted, bent into folds, broken by faults, and to some extent altered into slates; in the mountain district faults and folds are prominent, but the rocks have been changed but little, and the mountains are composed of fossiliferous sandstone and limestone. All rocks, both those of sedimentary origin and those which were originally crystalline, were sublimated. The metamorphism of these rocks is evidence of the metamorphism of very different rocks are often so intimately intermingled that the most fossiliferous are most thoroughly altered, and those with most quartz are least altered. Throughout the eastern portion of the Appalachian Mountains there is a regular increase of metamorphism toward the southeast, so that a belt of complete alteration at the border of the Valley can sometimes be traced through great distances and greater changes until it has lost all original character.

The structures above described are manifestly due chiefly to horizontal compression, which acted in a northwest-southeast direction, right to the edge of the folds and cleavage planes. The compression appears to have been greatest in the paleozoic time, and probably continued at intervals up to its culmination, shortly after the close of the Car- boniferous, when the greater portion of the fold- ing was effected.

In addition to the horizontal force of compression, the province has been subjected to other forces which have deformed it, and to a great extent by folding. Terrestrial elevations have been traced for 300 miles, and some folds have even greater length. The crests of the anticlines are very uniform in height, so that for long distances they contain the same formations. They are also approximately equal to one another in height. The parallel folds bring the surface together in the same formations. Most of the rocks dip at angles greater than 10°, and frequently the sides are composed of the same rocks from the nearest in the fault, and pass gradually into the surface along the bedding planes. Perhaps the most striking feature of the folds is the prevalence of southwestward dips. In some sections across the southern portion of the Appalachian Valley, nearly a bed can be found which dips toward the northwest.

Out of the close folds the faults were developed, and with extremely few exceptions the fault planes lie parallel to the bedding planes. Most of the faults on the Appalachian Valley are parallel to the bedding planes, as the rocks slipped on the sides of the faults, and the fault plane is the surface that the fracture rocks moved to distances sometimes as great as 6 or 8 miles. There is a progressive increase in degree of faulting from northeast to southwest, resulting in different types in different counties.

In northern Pennsylvania faults are uncommon. Progressing through Pennsylvania, toward Virginia, they rapidly become more numerous and dips grow steeper. In southern Vir- ginia the faults are quite pronounced and often close, while occasional faults appear. Passing through Virginia and into Tennessee, the faults are more and more broken by faults, until half way through Tennessee, nearly every fold is broken and the strata form a series of narrow, overlapping masses. The structure caused by these faulting prevails southward into Alabama, where the folds become fewer in number and their hori- zontal disposition is much greater, while the folds are somewhat more open.

In the Appalachian Mountains the structure is the same as that described in the valley, but there are the eastward dips, the close folds, the thrust faults, etc. But in addition to these changes of dip, and to the folding of new massed rocks, the strata are undergoing a new system of bedding planes, a series of minute breaks was developed across the strata, producing cleavage, or the horizontal separation of the strata. It is believed to be a natural continuation of the same structure as that described in the valley, and which is essentially the same in New York and in the Adirondack region.

Structure of the Gneissic quadrangle.—This structure is for the most part the same as that which would appear in the sides of a deep trench cut across the country. Their position with reference to the surface, and the height of the strata above the surface, are determined by the vertical portion of the gneissic fold, which is almost straight and uniform.

The structure of the gneissic fold is determined by the manner in which the strata are folded. It is determined by the manner in which the strata are folded. It is determined by the manner in which the strata are folded. It is determined by the manner in which the strata are folded. The gneissic fold is a horizontal, or nearly horizontal, fold, which is produced by the horizontal force of compression. The horizontal force of compression is produced by the pressure of the weight of the overlying strata, which is greatest at the center of the fold, and decreases toward the edges of the fold. The gneissic fold is a horizontal, or nearly horizontal, fold, which is produced by the horizontal force of compression. The horizontal force of compression is produced by the pressure of the weight of the overlying strata, which is greatest at the center of the fold, and decreases toward the edges of the fold.

The structure of the gneissic fold is determined by the manner in which the strata are folded. It is determined by the manner in which the strata are folded. It is determined by the manner in which the strata are folded. It is determined by the manner in which the strata are folded. The gneissic fold is a horizontal, or nearly horizontal, fold, which is produced by the horizontal force of compression. The horizontal force of compression is produced by the pressure of the weight of the overlying strata, which is greatest at the center of the fold, and decreases toward the edges of the fold. The gneissic fold is a horizontal, or nearly horizontal, fold, which is produced by the horizontal force of compression. A synclinal axis is a line running lengthwise of the synclinal trough, at every point occupying its lowest part, toward which the rocks dip on either side. An anticlinal axis is a line which runs up at every point the highest portion of the anticlinal arch, and away from which the rocks dip on either side. Such axes may be horizontal, or they may be inclined. Their departure from the horizontal is called the pitch of the axis, and is usually measured in degrees.

In addition to the foldings, and as a result of the continued action of the same forces which produced it, the structure has been fractured, and the rocks have been thrust in different directions on opposite sides of the fracture; this is termed a fault. The rocks are also often rendered brittle by a change of temperature, or by a change of termometromorphism.

Structure of the Appalachian province.—Three distinct types of structure occur in the Appalachian province, each one prevailing in a separate area corresponding to one of the three geographic divisions.

In the platean region and westward the rocks are but little tilted from their original horizontal position and are almost entirely unaltered; in the valley the rocks have been steeply tilted, bent into folds, broken by faults, and to some extent altered into slates; in the mountain district faults and folds are prominent, but the rocks have been changed but little, and the mountains are composed of fossiliferous sandstone and limestone. All rocks, both those of sedimentary origin and those which were originally crystalline, were sublimated. The metamorphism of these rocks is evidence of the metamorphism of very different rocks are often so intimately intermingled that the most fossiliferous are most thoroughly altered, and those with most quartz are least altered. Throughout the eastern portion of the Appalachian Mountains there is a regular increase of metamorphism toward the southeast, so that a belt of complete alteration at the border of the Valley can sometimes be traced through great distances and greater changes until it has lost all original character.

The structures above described are manifestly due chiefly to horizontal compression, which acted in a northwest-southeast direction, right to the edge of the folds and cleavage planes. The compression appears to have been greatest in the paleozoic time, and probably continued at intervals up to its culmination, shortly after the close of the Car- boniferous, when the greater portion of the fold- ing was effected.

In addition to the horizontal force of compression, the province has been subjected to other forces which have deformed it, and to a great extent by folding. Terrestrial elevations have been traced for 300 miles, and some folds have even greater length. The crests of the anticlines are very uniform in height, so that for long distances they contain the same formations. They are also approximately equal to one another in height. The parallel folds bring the surface together in the same formations. Most of the rocks dip at angles greater than 10°, and frequently the sides are composed of the same rocks from the nearest in the fault, and pass gradually into the surface along the bedding planes. Perhaps the most striking feature of the folds is the prevalence of southwestward dips. In some sections across the southern portion of the Appalachian Valley, nearly a bed can be found which dips toward the northwest.

Out of the close folds the faults were developed, and with extremely few exceptions the fault planes lie parallel to the bedding planes. Most of the faults on the Appalachian Valley are parallel to the bedding planes, as the rocks slipped on the sides of the faults, and the fault plane is the surface that the fracture rocks moved to distances sometimes as great as 6 or 8 miles. There is a progressive increase in degree of faulting from northeast to southwest, resulting in different types in different counties.

In northern Pennsylvania faults are uncommon. Progressing through Pennsylvania, toward Virginia, they rapidly become more numerous and dips grow steeper. In southern Vir- ginia the faults are quite pronounced and often close, while occasional faults appear. Passing through Virginia and into Tennessee, the faults are more and more broken by faults, until half way through Tennessee, nearly every fold is broken and the strata form a series of narrow, overlapping masses. The structure caused by these faulting prevails southward into Alabama, where the folds become fewer in number and their hori- zontal disposition is much greater, while the folds are somewhat more open.

In the Appalachian Mountains the structure is the same as that described in the valley, but there are the eastward dips, the close folds, the thrust faults, etc. But in addition to these changes of dip, and to the folding of new massed rocks, the strata are undergoing a new system of bedding planes, a series of minute breaks was developed across the strata, producing cleavage, or the horizontal separation of the strata. It is believed to be a natural continuation of the same structure as that described in the valley, and which is essentially the same in New York and in the Adirondack region.
are changed by surface waters more or less rapidly, the rapidity of the change 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 is conversely soluble, and rocks
in which it is present, such as limestone, sandstones, and shales, are very soluble and
produce a rich 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 lime
stone, 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, generally
quite thin where the latter was pure, but often very
thick where it contained much soluble matter.

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

The character of the soils derived from the vari-
ous geological formations being known, their dis-
tribution may be approximately determined from
the map showing the area 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 forma-
tional boundaries are upon the steep slopes, where
soils derived from rocks higher up the slope have
washed down and covered or mingled with the
soil derived from those below. These are called
overplanted soils, and a special map would be
required to show their distribution.

Classification.—The soils of this region may
conveniently be classed as follows: (1) Sandy soils;
derived from the Walnut, Lookout, and Oconee
sandstones and parts of the Rockwood formation.
(2) Clay soils; derived from the Ranger and
Chickamauga limestones and the Conasauga shales.
(3) Cherty soils; derived from the Knox dol-
mite and the Fort Payne chert. (4) Alluvial soils;
derived from the larger streams upon their flood-
plains.

Sandy soils.—The entire surface of the plat-
taus, and consequently more than two-thirds of
the quadrangle, is covered by sandy soils, derived
from sandstones and sandy shales of the coal
measures. At the surface the soil is a gray
sandy loam, while the subsoil is generally light-
yellow, but varies to deep red. In some places
it consists largely of white sand, but often it
contains sufficient clay to give the subsoil con-
siderable cohesiveness, so that a cut bank will
remain vertical for some years. The depth of the
soil on the plateaus varies from a few inches to
several feet, depending chiefly on the
proximity to streams and the consequent activity
of erosion. A large part of the plateau surface
retains its original forest growth, chiefly of oak,
chestnut, and hickory, while plains clothe the
steep sides of the streams 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 also kills all except the coarse
grasses, so that the pastureage is injured.

Since the sandstones occupy the highest land
the overplanted soils, or those washed down the
steep slopes to lower levels, are mostly sandy.
They are especially abundant along the plateau
escarpments, where the Ranger limestone and its
clay soils are often wholly concealed.

Clay soils.—The Big Spring Valley, Browns Valley,
and the course among the mass to the westward
are underlain by limestone whose surface is covered
by a thin mantle of clay soil composed of its
insoluble portions. In some places the rock decay
has gone to a considerable distance below the
surface and the soil is deep and bright-red in
color, but generally the limestone is covered by
a thin layer of bluish-gray or black soil. The
Ranger and Chickamauga outcrops in Bristow
Cove and Wills Valley are generally covered by
deep-red clay, while the Conasauga shale south of
Gadsden and Atala forms a stiff bluish-gray clay.

All of these clay soils are well fitted to retain
fertilizers, and hence with proper treatment may
be brought to a high state of productivity.

Clay soils.—The soil derived from the Knox
dolomite and Fort Payne chert consists of clay
in which the chert is imbedded, with some admix-
ture of sand. The proportion of chert to clay is
variable; in some places only occasional frag-
ments occur, while in others the residual material
is made up almost wholly of chert. Where the
clay predominates the soil is deep-red, but it
becomes lighter with the increase in amount of
chert, and in extreme cases is light-gray or white.
Even where the proportion of chert is consider
able this is a strong productive soil.

Alluvial soils.—These are confined principally
to the flood-plains or bottoms of the Tennessee
River, which are a mile or more broad in Brown
Valley, but become much narrower or are wholly
wanting below Fort Deposit, where the river
forms in a narrow channel between high lime-
stone cliffs. The soil is a rich, sandy loam, con-
taining a considerable proportion of fine mica
clays, derived from the crystalline rocks far to
the eastward. Narrow strips of bottom land
occur along some of the creeks, but their alluvial
soils have been transported only a short distance
and are simply a mixture of local sedentary soils.

CHARLES WILLARD HAYES,
Geologist.

May, 1896.
<table>
<thead>
<tr>
<th>Period</th>
<th>Formation Name</th>
<th>Horizon</th>
<th>Columnar Section</th>
<th>Character of Rocks</th>
<th>Character of Topography and Soil</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carboniferous</td>
<td>Waukesha sandstone</td>
<td>Cw</td>
<td>390-50</td>
<td>Coarse sandstone and sandy shale with beds of coal and fire-clay.</td>
<td>Broad, level plains intersected by narrow, weedy groves (gray, yellow, and red, sandy loams.</td>
</tr>
<tr>
<td></td>
<td>Lockport sandstone</td>
<td>Cl</td>
<td>555-655</td>
<td>Clayey and coarse sandstone; sandy shale with beds of coal and fire-clay.</td>
<td>Cliffs of plains and mesas. Steep, clayey cliffs.</td>
</tr>
<tr>
<td></td>
<td>Bangor limestone</td>
<td>C2</td>
<td>660-800</td>
<td>Shaly limestone.</td>
<td>Steep slopes forming the lower part of the plains and mesas. Block and red clay soils.</td>
</tr>
<tr>
<td></td>
<td>Ossian sandstone</td>
<td>Cc</td>
<td>6.5-20</td>
<td>Clayey, blue-gray shale.</td>
<td>Low, sandy ridges.</td>
</tr>
<tr>
<td></td>
<td>Fort Payne shale</td>
<td>Cc</td>
<td>20-80</td>
<td>Clayey and sandy shale.</td>
<td>Low, sandy ridges.</td>
</tr>
<tr>
<td></td>
<td>Chickamauga limestone</td>
<td>Sc</td>
<td>100-200</td>
<td>Black, fine-grained sandstone.</td>
<td>Low, sandy ridges, parallel to the sides of the alluvial valleys. Clayey and sandy soils.</td>
</tr>
<tr>
<td></td>
<td>Chickamauga limestone</td>
<td>Sc</td>
<td>200-300</td>
<td>Black, fine-grained sandstone.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Blackwood formation</td>
<td>B</td>
<td>300-500</td>
<td>Blue-gray sandstone with interbedded sandy shale.</td>
<td>Level valley.</td>
</tr>
<tr>
<td></td>
<td>Knox dolomite</td>
<td>B</td>
<td>500-800</td>
<td>Greenish clay shale with thin beds of blue sandstone.</td>
<td>Low, wide valley.</td>
</tr>
<tr>
<td></td>
<td>Conemaugh shales</td>
<td>C1</td>
<td>800-1000</td>
<td>Greenish clay shale with thin beds of blue sandstone.</td>
<td>Level valley.</td>
</tr>
</tbody>
</table>

**Names of Formations.**

<table>
<thead>
<tr>
<th>Period</th>
<th>Formations</th>
<th>Horizon</th>
<th>Columnar Section</th>
<th>Character of Rocks</th>
<th>Character of Topography and Soil</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Millstone grit or Conglomerate.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Bangor limestone</td>
<td>C2</td>
<td>660-800</td>
<td>Upper sub-carboniferous or Morrisonian limestone.</td>
<td>Mountain limestones.</td>
</tr>
<tr>
<td></td>
<td>Ossian sandstone</td>
<td>Cc</td>
<td>6.5-20</td>
<td>Lower sub-carboniferous or Silurian group.</td>
<td>Black shale.</td>
</tr>
<tr>
<td></td>
<td>Fort Payne shale</td>
<td>Cc</td>
<td>20-80</td>
<td>Black sandstone.</td>
<td>Black shale.</td>
</tr>
<tr>
<td></td>
<td>Chickamauga limestone</td>
<td>Sc</td>
<td>100-200</td>
<td>Black sandstone.</td>
<td>Black shale.</td>
</tr>
<tr>
<td></td>
<td>Blackwood formation</td>
<td>B</td>
<td>300-500</td>
<td>Clinton or Red Mountain formation.</td>
<td>Black shale.</td>
</tr>
<tr>
<td></td>
<td>Knox dolomite</td>
<td>B</td>
<td>500-800</td>
<td>Greenish clay shale with thin beds of blue sandstone.</td>
<td>Low, wide valley.</td>
</tr>
</tbody>
</table>

C. Willard Hayes, Geologist.
in tunnels and channels in the ice, and forms characteristic ridges and mounds of sand and gravel, known as eces. The material deposited by the ice is called glacial drift, that washed from the ice onto the adjacent land is called moraine. It is usually also a class as surficial rocks the deposits of the sea and of lakes and rivers that were made at the same time as the ice itself.

**AGES OF ROCKS**

Rocks are further distinguished according to their relative ages, for rocks were not formed all at once, 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 a formation, the unit of geologic mapping.

Several formations considered in this work 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 their deposition are given the same name, as, for instance, Cambrian system, Cambrian period.

As sedimentary deposits or strata accumulate, the younger strata rest on those that are older, and the relative ages of the deposits may be determined by observing their relative positions. This relationship holds except in regions of intense disturbance; sometimes in such regions the disturbed areas of the beds have been so great that they are 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 a guide to show which of two or more formations is younger.

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 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 sea covered less and less of the earth, more animal life has been formed and remain in modified forms life became more varied. But during most of history the sea has not existed in earlier times. New species of animals and plants have appeared and have become extinct, and have not survived; 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 and formed a chain of life from the time of the oldest fossiliferous rocks to the present.

When two formations are remote from one another, it is impossible to observe their relative positions, the characteristic fossil types found in them may determine which one was deposited first. Fossils remain found in the rocks of different areas, of different provinces, and of different continents, affect the most important names 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 the pale blue, and with the color or colors and symbol assigned to each, are given below. The names of the periods, especially those of the great periods, are the names of the characteristic fossils found in them, and the names of the sections of the first (Pleistocene) and the last (Archean) the formations of any one period, with the exception of Pleistocene and Archean, are distinct.

The formations of any one period, with the exception of Pleistocene and Archean, are distinct

<table>
<thead>
<tr>
<th>Periods</th>
<th>Colors</th>
<th>Symbols</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eocene</td>
<td>Orange</td>
<td>E</td>
</tr>
<tr>
<td>Cretaceous</td>
<td>Yellow</td>
<td>C</td>
</tr>
<tr>
<td>Triassic</td>
<td>Blue-green</td>
<td>T</td>
</tr>
<tr>
<td>Jurassic</td>
<td>Gray-green</td>
<td>J</td>
</tr>
<tr>
<td>Tertiary</td>
<td>Blue-green</td>
<td>T</td>
</tr>
<tr>
<td>Quaternary</td>
<td>Orange</td>
<td>Q</td>
</tr>
</tbody>
</table>

The period-color are used in section 2 (the underlay) is printed evenly over the whole surface representing the relations. The arrangement of rocks in the earth's crust is a sequence, and a section exhibiting this arrangement is called a structural section.

The geologist is not limited, however, to the natural and artificial settings for his information concerning the earth's crust. Knowing the manner of the formations of rocks, and having traced the relations among beds of the surface, he can infer their relative positions after they pass beneath the surface, thus sections that 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, in a section several miles in length and several thousand feet deep. This is illustrated in the following figure:

**Fig. 2** — Sketch showing a vertical section in the front of the system, with a landscape above.

The figure represents a landscape which is cut through by a vertical plane, and then a cutout of the landscape that cuts a section so as to show the underground relations of the rocks. Many of them are indicated in the section by appropriate symbols of lines, dots, and dashes. These symbols consist of such variations in width as to distinguish the sections used in sections to represent the different kinds of rock:

**The VARIOUS GEOLOGIC STRUCTURES**

**Arroyal section** — This section shows the arrows are formed by the various formations of rocks, a laud, which is the key to the map. To ascertain the meaning of any particular colored path, it is necessary to look at the label, which is the name of the formation and to look for that color, pattern, and symbol in the legend, where he will find the name and type of the formation, and to find an arrow, it is necessary to find any given formation, its name should be sought in the legend and its color and pattern noted, when the arrows on the map correspond in color and pattern may be traced out.

The legend is also a partial statement of the paleostructure of the rocks. The formations are arranged according to origin into horizontal, sedimentary, and igneous, and within each class are placed in the order of age, so far as known, the youngest at the top.

**Structural section** — This section exhibits the relations of the formations beneath the surface. Arrows, when superimposed on a map, indicate the general position of the various beds, their relative positions, and their direction of movement as determined by the 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 structure of the earth, and a section exhibiting this arrangement is called a structural section.

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

**The horizon** of the plateaus rest upon the upturned, eroded edges of the beds of the second set at the left of the section. The overlying younger formations, the bending and degradation of the older strata must have occurred before the deposition of the older beds and the accumulation of the younger. When younger strata rest upon an eroded surface, the section between the two is an unconfornmity surface, and the surface of contact is an unconformity.

The third set of formations is of clear lines, strata and igneous rocks. At some period of their history the strata were piled by processes of erosion and deposition. 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 strata and the beginning of deposition of the strata of the second set. During this interval the strata suffered metamorphism; they were the scene of erosion activity; and they were deeply eroded. The contact between the second and third strata, 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 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 material, including 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 section shows a concise description of the rock formations which constitute the local record of geologic history. The diagram and verbal statements form a summary of the facts relating to the character of the rock formations, and to the essential relations of the order of accumulation of successive deposits.

The rocks are described under the corresponding headings, and their characters are indicated in the column diagrams by appropriate symbols. The thickness of formations are given under the heading “Thickness of bed,” 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 shown in the column arrangements, 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 placed 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 depression and constitute interruptions of deposition of sediments may be indicated graphically or by the word “unconformity” in the column section.

Each formation shown in the column section is accompanied by its name, a description of its strata and formation, and a symbol used in the maps and their legends.

CHARLES D. WALCOTT.
Director.

Revised July, 1890.