DEPARTMENT OF THE INTERIOR

UNITED STATES GEOLOGICAL SURVEY

J.W. POWELL, DIRECTOR

GEOLOGIC ATLAS

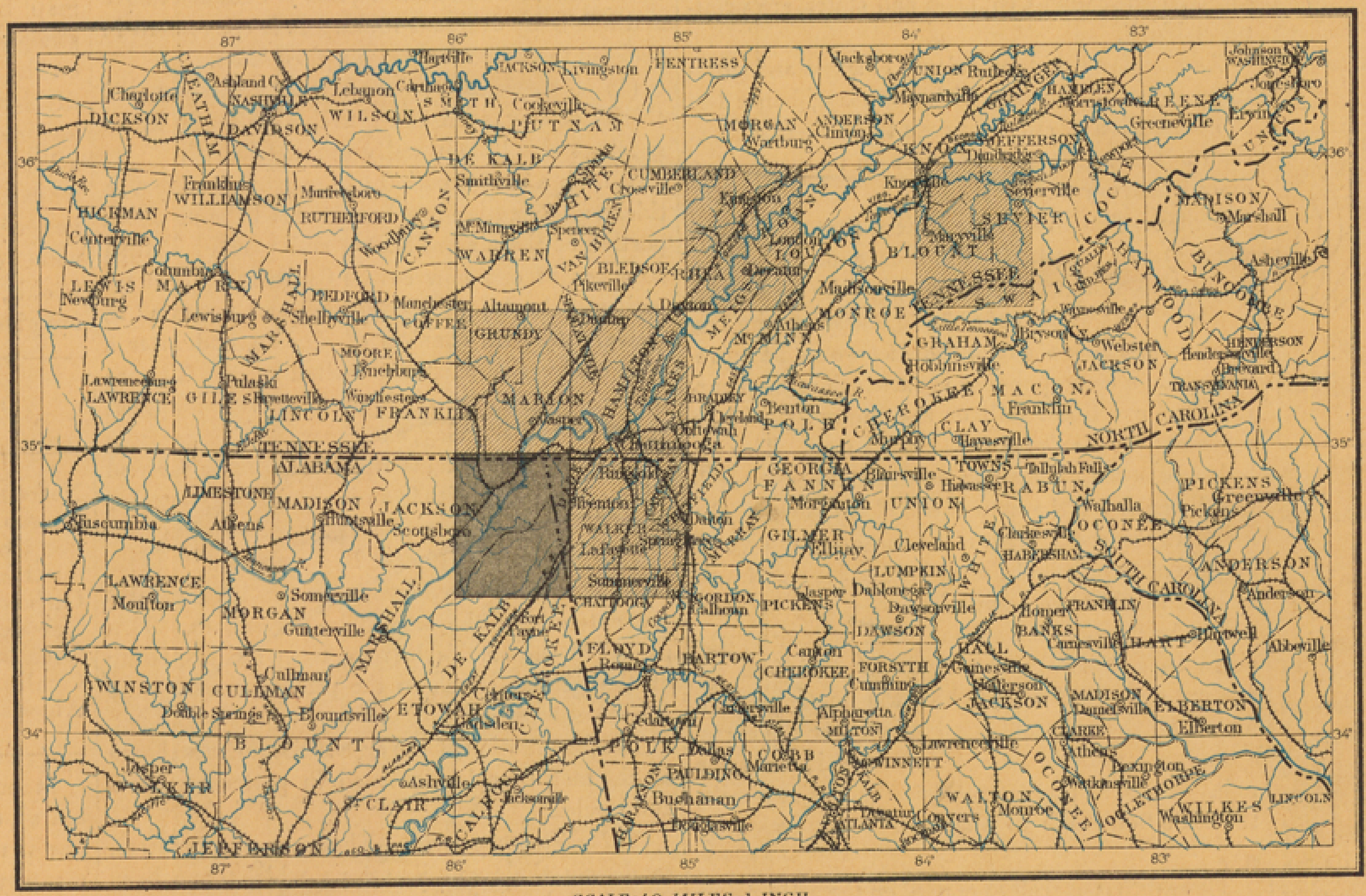
OF THE

UNITED STATES

STEVENSON FOLIO

ALABAMA - GEORGIA - TENNESSEE

INDEX MAP



SCALE: 40 MILES - 1 INCH

AREA OF THE STEVENSON FOLIO

AREA OF OTHER PUBLISHED FOLIOS

LIST OF SHEETS

DESCRIPTION   TOPOGRAPHY   AREAL GEOLOGY   ECONOMIC GEOLOGY   STRUCTURE SECTIONS

FOLIO 19   FIELD EDITION   STEVENSON

WASHINGTON, D. C.

ENGRAVED AND PRINTED BY THE U. S. GEOLOGICAL SURVEY

BAILEY WILLIS, EDITOR OF GEOLOGIC MAPS   S. J. KÜBEL, CHIEF ENGRAVER

1895

EXPLANATION.

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

THE TOPOGRAPHIC MAP.

The features represented on the topographic map are of three distinct kinds: (1) inequalities of surface, called *relief*, as plains, prairies, valleys, hills and mountains; (2) distribution of water, called *drainage*, as streams, ponds, lakes, swamps and canals; (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 printed in brown. It is desirable to show also the elevation of any part of a hill, ridge, slope or valley; to delineate the horizontal outline or contour of all slopes; and to indicate their degree of steepness. This is done by lines of constant elevation above mean sea level, which are drawn at regular vertical intervals. The lines are called *contours* and the constant vertical space between each two contours is called the *contour interval*. Contours are printed in brown.

The manner in which contours express the three conditions of relief (elevation, horizontal form and degree of slope) is shown in the following sketch and corresponding contour map:

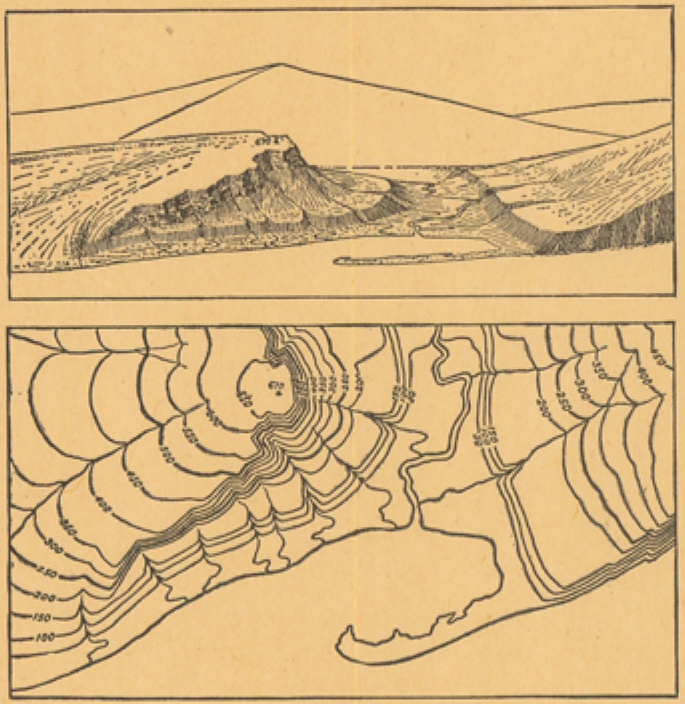


Fig. 1. The upper figure represents a sketch of a river valley, with terraces, and of a high hill encircled by a cliff. These features appear in the map beneath, the slopes and forms of the surface being shown by contours.

The sketch represents a valley between two hills. In the foreground is the sea with a bay which is partly closed by a hooked sand-bar. On either side of the valley is a terrace; from that on the right a hill rises gradually with rounded forms, whereas from that on the left the ground ascends steeply to a precipice which presents sharp corners. The western slope of the higher hill contrasts with the eastern by its gentle descent. 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 height, form and slope:

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

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

3. Contours show the approximate grade of any 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. Therefore contours are far apart on the gentle slopes and near together on steep ones.

For a flat or gently undulating country a small contour interval is chosen; for a steep or mountainous country a large contour interval is necessary. The smallest contour interval used on the atlas sheets of the Geological Survey is 5 feet. This is used for districts like the Mississippi delta and the Dismal Swamp region. In mapping great mountain masses like those in Colorado, on a scale of $\frac{1}{250,000}$ the contour interval may be 250 feet. For intermediate relief other contour intervals of 10, 20, 25, 50, and 100 feet are used.

Drainage.—The water courses are indicated by blue lines, which are drawn unbroken where the stream flows the year round, and dotted where the channel is dry a part of the year. Where the stream sinks and reappears at the surface, the supposed underground course is shown by a broken blue line. Marshes and canals are also shown in blue.

Culture.—In the progress of the settlement of any region men establish many artificial features. These, such as roads, railroads and towns, together with names of natural and artificial details and boundaries of towns, counties and states, are printed in black.

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

Scales.—The area of the United States (without Alaska) is about 3,025,000 square miles. On a map 240 feet long and 180 feet high the area of the United States would cover 3,025,000 square inches. Each square mile of ground surface would be represented by a corresponding square inch of map surface, and one linear mile on the ground would be represented by a linear inch on the map. 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 "one mile to an inch." A map of the United States half as long and half as high would have a scale half as great; its scale would be "two miles to an inch," or four square miles to a square inch. Scale is also often expressed as 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 "one mile to one inch" is expressed by $\frac{1}{63,360}$.

Three different scales are used on the atlas sheets of the U. S. Geological Survey; the smallest is $\frac{1}{250,000}$, the second $\frac{1}{125,000}$, and the largest $\frac{1}{62,500}$. These correspond approximately to four miles two miles, and one mile of natural length to one inch of map length. On the scale $\frac{1}{62,500}$ one square inch of map surface represents and corresponds nearly to one square mile; on the scale of $\frac{1}{125,000}$, to about four square miles; and on the scale of $\frac{1}{250,000}$, to about sixteen square miles. At the bottom of each atlas sheet the scale is expressed as a fraction, and it is further indicated by a "bar scale," a line divided into parts representing miles and parts of miles.

Atlas sheets.—A map of the United States on the smallest scale used by the Geological Survey would be 60 feet long and 45 feet high. If drawn on one of the larger scales it would be either two times or four times as long and high. To make it possible to use such a map it is divided into atlas sheets of convenient size which are bounded by parallels and meridians. Each sheet on the scale of $\frac{1}{250,000}$ contains one square degree (that is, represents an area one degree in extent in each direction); 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 These areas correspond nearly to 4000, 1000 and 250 square miles.

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. For convenience of reference and to suggest the district represented each sheet is given the name of some well known town or natural feature within its limits. At the sides and corners of each sheet the names of adjacent sheets are printed.

THE GEOLOGIC MAP.

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

Rocks are of many kinds in origin, but they may be classed in four great groups: Superficial Rocks, Sedimentary Rocks, Igneous Rocks and Altered Rocks. The different kinds found within the area represented by a map are shown by devices printed in colors.

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. The materials composing them likewise vary with locality, for the conditions of their deposition at different times and places have not been alike, and accordingly the rocks show many variations. Where beds of sand were buried beneath beds of mud, sandstone may now occur under shale; where a flow of lava cooled and was overflowed by another bed of lava, the two may be distinguished. Each of these masses is limited in extent to the area over which it was deposited, and is bounded above and below by different rocks. It is convenient in geology to call such a mass a *formation*.

(1) *Superficial rocks.*—These are composed chiefly of clay, sand and gravel, disposed in heaps and irregular beds, usually unconsolidated.

Within a recent period of the earth's history, a thick and extensive ice sheet covered the northern portion of the United States and part of British America, as one now covers Greenland. The ice gathered slowly, moved forward and retreated as glaciers do with changes of climate, and after a long and varied existence melted away. The ice left peculiar heaps and ridges of gravel; it spread layers of sand and clay, and the water flowing from it distributed sediments of various kinds far and wide. These deposits from ice and flood, together with those made by water and winds on the land and shore after the glacier had melted, and those made by similar agencies where the ice sheet did not extend, are the superficial formations. This period of the earth's history, from the beginning of the glacial epoch to the present, is called the Pleistocene period.

The distribution of the superficial rocks is shown on the map by colors printed in patterns of dots and circles.

(2) *Sedimentary rocks.*—These are conglomerate, sandstone, shale and limestone, which have been deposited beneath seas or other large bodies of water and have usually become hard.

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 in the ocean, whose shore would traverse Wisconsin, Iowa, Kansas and Texas. More extensive changes than this have repeatedly occurred in the past. The shores of the North American continent have changed from age to age, and the sea has at times covered much that is now dry land. The earth's surface 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 oceans are changed.

The bottom of the sea is made of gravel, sand and mud, which are sorted and spread. As these sediments gather they bury others already deposited and the latter harden into layers of conglomerate, sandstone, shale or limestone. When the sea bottom is raised to dry land these rocks are exposed, and then we may learn from them many facts concerning the geography of the past.

As sedimentary strata accumulate the younger beds rest on those that are older and the relative ages of the deposits may be discovered by observing their relative positions. In any series of undisturbed beds the younger bed is above the older.

Strata generally contain the remains of plants and animals which lived in the sea or were washed from the land into lakes or seas. By studying these remains or fossils it has been found that the species of each epoch of the earth's history have to a great extent differed from those of other epochs. Rocks that contain the remains of life are called *fossiliferous*. Only the simpler forms of life are found in the oldest fossiliferous rocks. From time to time more complex forms of life developed and, as the simpler ones lived on in modified forms, the kinds of living creatures on the earth multiplied. But during each epoch 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.

Beds of rock do not always occur in the positions in which they were formed. When they have been disturbed it is often difficult to determine their relative ages from their positions; then fossils are a guide to show which of two or more formations is the oldest. 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 one was formed first. Fossil remains found in the rocks of different states, of different countries and of different continents afford the most important means for combining local histories into a general earth history.

Areas of sedimentary rocks are shown on the map by colors printed in patterns of parallel straight lines. To show the relative age of strata on the map, the history of the sedimentary rocks is divided into nine periods, to each of which a color is assigned. Each period is further distinguished by a letter-symbol, so that the areas may be known when the colors, on account of fading, color blindness or other cause, cannot be recognized. The names of the periods in proper order (from new to old), with the color and symbol assigned to each, are given below:

PERIOD.	SYMBOL.	COLOR—PRINTED IN PATTERNS OF PARALLEL LINES.
Neocene (youngest).	N	Yellowish buff.
Eocene	E	Olive-brown.
Cretaceous	K	Olive-green.
Juratrias..........	J	Gray-blue-green.
Carboniferous.....	C	Gray-blue.
Devonian	D	Gray-blue-purple.
Silurian	S	Gray-red-purple.
Cambrian	Ç	Brown-red.
Algonkian (oldest).	A	Orange-brown.

In any district several periods may be represented, and the representation of each may include one or many formations. 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; and the formations of any one period are distinguished from one another by different patterns. 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. Each formation is furthermore given a letter-symbol, which is printed on the map with the capital 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.

(3) *Igneous rocks.*—These are crystalline rocks, which have cooled from a molten condition.

Deep beneath the surface, rocks are often so hot as to melt and flow into crevices, where they congeal, forming dikes and sheets. Sometimes they

DESCRIPTION OF THE STEVENSON SHEET.

GEOGRAPHY.

General relations.—The Stevenson atlas sheet is bounded by the parallels of latitude 34° 30′ and 35° and the meridians of longitude 85° 30′ and 86°. It embraces, therefore, a quarter of a square degree of the earth's surface. Its dimensions are 34.5 miles from north to south and 28.4 from east to west, and it contains 980.5 square miles. The adjacent atlas sheets are: on the north, Sewanee; on the east, Ringgold; on the south, Fort Payne; and on the west, Scottsboro. The tract contains portions of the counties of Franklin and Marion in Tennessee; Dade, Walker, and Chattooga in Georgia; and Jackson, De Kalb, and Cherokee in Alabama.

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, 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 that covered by a single atlas sheet; hence it is necessary to consider the individual sheet in its relations to the entire province.

Subdivisions of the Appalachian province.—The Appalachian province may be subdivided into three well-marked physiographic divisions, throughout each of which certain forces have produced similar results in sedimentation, in geologic structure, and in topography. These divisions extend the entire length of the province, from northeast to southwest.

The central division is the Appalachian Valley. It is the best defined and most uniform of the three. In the southern part it coincides with the belt of folded rocks which forms the Coosa Valley of Georgia and Alabama and the Great Valley of East Tennessee and Virginia. Throughout the central and northern portions the eastern side only is 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 southeast by the Appalachian Mountains and on the northwest by the Cumberland Plateau and the Alleghany Mountains. Its rocks are almost wholly sedimentary and in large measure calcareous. The strata, which must originally have been nearly horizontal, now intersect the surface at various angles and in narrow belts. The surface differs with the outcrop of different kinds of rock, so that sharp ridges and narrow valleys of great length follow the narrow belts of hard and soft rock. Owing to the large amount of calcareous rock brought up on the steep folds of this district its surface is more readily worn down by streams and is lower and less broken than the divisions on either side.

The eastern division of the province embraces the Appalachian Mountains, a system which is made up of many minor ranges and which, under various local names, extends from southern New York to central Alabama. Some of its prominent parts are the South Mountain of Pennsylvania, the Blue Ridge and Catoctin Mountain of Maryland and Virginia, the Great Smoky Mountains of Tennessee and North Carolina, and the Cohutta Mountains of Georgia. Many of the rocks of this division are more or less crystalline, being either sediments which have been changed to slates and schists by varying degrees of metamorphism, or igneous rocks, such as granite and diabase, which have solidified from a molten condition.

The western division of the Appalachian province embraces the Cumberland Plateau and the Alleghany Mountains, also extending from New York to Alabama, and the lowlands of Tennessee, Kentucky, and Ohio. Its northwestern boundary is indefinite, but may be regarded as a somewhat arbitrary line coinciding with the Tennessee River from the northeastern corner of Mississippi to its mouth and thence crossing the States of Indiana and Ohio to western New York. Its eastern boundary is sharply defined along the Appalachian Valley by the Alleghany front and the Cumberland escarpment. The rocks of this division are almost entirely of sedimentary origin and remain very nearly horizontal. The character of the surface, which is dependent on the character and attitude of the rocks, is that of a plateau more or less completely dissected, or, elsewhere, of a lowland. In the southern half of the province the surface of the plateau is sometimes extensive and perfectly flat, but oftener it is much cut by stream channels into large or small flat-topped hills. In West Virginia and portions of Pennsylvania the plateau is sharply cut by its streams, leaving in relief irregularly rounded knobs and ridges which bear but little resemblance to the original surface. The western portion of the plateau has been completely removed by erosion and the surface is now comparatively low and level or rolling.

Altitude of the Appalachian province.—The Appalachian province as a whole is broadly dome-shaped, its surface rising from an altitude of about 500 feet along the eastern margin to the crest of the Appalachian Mountains, and thence descending westward to about the same altitude on the Ohio and Mississippi rivers.

Each division of the province shows one or more culminating points. Thus the Appalachian Mountains rise gradually from less than 1,000 feet in Alabama to more than 6,600 feet in western North Carolina. From this culminating point they decrease to 4,000 or 3,000 feet in southern Virginia, rise to 4,000 feet in central Virginia, and descend to 2,000 or 1,500 feet on the Maryland-Pennsylvania line.

The Appalachian Valley shows a uniform increase in altitude from 500 feet or less in Alabama to 900 feet in the vicinity of Chattanooga, 2,000 feet at the Tennessee-Virginia line, and 2,600 or 2,700 feet at its culminating point, on the divide between the New and Tennessee rivers. From this point it descends to 2,200 feet in the valley of New River, 1,500 to 1,000 feet in the James River basin, and 1,000 to 500 feet in the Potomac basin, remaining about the same through Pennsylvania. These figures represent the average elevation of the valley surface, below which the stream channels are sunk from 50 to 250 feet, and above which the valley ridges rise from 500 to 2,000 feet.

The plateau, or western, division increases in altitude from 500 feet at the southern edge of the province to 1,500 feet in northern Alabama, 2,000 feet in central Tennessee, and 3,500 feet in southeastern Kentucky. It is between 3,000 and 4,000 feet in West Virginia, and decreases to about 2,000 feet in Pennsylvania. From its greatest altitude, along the eastern edge, the plateau slopes gradually westward, although it is generally separated from the interior lowlands by an abrupt escarpment.

Drainage of the Appalachian province.—The drainage of the province is in part eastward into the Atlantic, in part southward into the Gulf, and in part westward into the Mississippi. All of the western, or plateau, division of the province, except a small portion in Pennsylvania and another in Alabama, is drained by streams flowing westward to the Ohio. The northern portion of the eastern, or Appalachian Mountain, division is drained eastward to the Atlantic, while south of the New River all except the eastern slope is drained westward by tributaries of the Tennessee or southward by tributaries of the Coosa.

The position of the streams in the Appalachian Valley is dependent upon the geologic structure. In general they flow in courses which for long distances are parallel to the sides of the Great Valley, following the lesser valleys along the outcrops of the softer rocks. These longitudinal streams empty into a number of larger, transverse rivers, which cross one or the other of the barriers limiting the valley. In the northern portion of the province they form the Delaware, Susquehanna, Potomac, James, and Roanoke rivers, each of which passes through the Appalachian Mountains in a narrow gap and flows eastward to the sea. In the central portion of the province, in Kentucky and Virginia, these longitudinal streams form the New (or Kanawha) River, which flows westward in a deep, narrow gorge through the Cumberland Plateau into the Ohio River. From New River southward to northern Georgia the Great Valley is drained by tributaries of the Tennessee River, which at Chattanooga leaves the broad valley and, entering a gorge through the plateau, runs westward to the Ohio. South of Chattanooga the streams flow directly to the Gulf of Mexico.

Topography of the area of the Stevenson sheet.—The country embraced within the limits of the sheet lies in the central and western divisions of the Appalachian province as defined above. Its surface is made up of broad, level plateaus alternating with narrow parallel valleys, the latter being located upon the westernmost of the sharp folds which characterize the central or valley division of the province. The position and character of both plateaus and valleys are closely connected with the character of the underlying rocks and with the geologic structure, or the relation of the strata to the surface.

The northwestern portion of the area is occupied by the Cumberland Plateau. This has been deeply dissected by streams flowing into the Tennessee River, leaving a number of mesas, or isolated remnants of the plateau, with a uniform altitude of about 1,600 feet. The central portion of the area is occupied by Sand (or Raccoon) Mountain, which is the southwestward continuation of Walden Ridge. This is a plateau similar in nearly all respects to the Cumberland Plateau. Its surface is not so deeply cut by stream channels, and there are many large areas almost perfectly smooth and so densely wooded that one may travel many miles without intimation that it is not a low as well as level country. Its altitude is a little over 1,500 feet in the northern part of the area and about 1,400 in the southern part.

The area shown in the southeastern portion of the sheet is occupied by Lookout Mountain, also similar to the Cumberland Plateau, though less so than Sand Mountain. Although essentially a plateau, its surface is not level but is highest at the edges, sloping gradually toward the center and forming a broad, gentle trough.

All these plateaus are limited by steep escarpments from 600 to 1,000 feet in height. The form of the escarpments is due to the relation of hard and soft rocks in the plateaus. By the terms "hard" and "soft" in this connection is meant greater or less capacity for resisting erosion, both corrasion by streams and solution by percolating waters. At the surface of the plateaus are hard sandstones, which resist erosion, while below are shales and limestones, which are readily worn down by the streams or removed by solution. The hard sandstone capping is constantly undermined and breaks off, forming cliffs. Thus the upper part of the escarpment is usually very steep and is frequently composed of vertical cliffs, while the lower portion has gentler slopes covered with fragments of sandstone from the cliffs above. This is the character not only of the escarpment which borders the outer portions of the plateaus, but also of that surrounding the numerous coves which penetrate the plateau from the sides.

The Cumberland Plateau and Sand Mountain are separated by Browns Valley, which extends toward the southwest about 60 miles beyond the border of the area of the sheet and then, as the Sequatchie Valley, an equal distance toward the northeast into Tennessee. The valley is almost perfectly straight throughout the whole of this distance, and is bounded either by unbroken escarpments or by salient mesas which terminate upon a common line. This linear character is the most striking feature of the valley, and is due to the regularity of the fold on which it is located. The rocks once arched continuously across from the Cumberland Plateau to Sand Mountain, forming a ridge where the valley now is. The upper rocks composing the arch have been entirely removed, and the underlying easily erodible limestones, being brought higher in the arch than elsewhere, were earlier exposed to erosion. The valley, therefore, was excavated upon them. The rocks in the eastern escarpment dip a few degrees away from the valley, and in some places in the extreme edge of the Cumberland Plateau they are found also dipping away from the valley. The altitude of the valley is between 700 and 800 feet, with rounded hills rising from 100 to 150 feet higher, while the Tennessee River and its larger tributaries are flowing at a little over 600 feet.

Crossing the eastern edge of the area of the sheet, in a direction parallel with Browns Valley, are the valleys of Lookout and Wills creeks. These are located upon two narrow folds whose points slightly overlap, being separated by a narrow trough, a part of which forms Fox Mountains.

The western fold extends northward a short distance to a point where it is crossed by the Tennessee River, while the eastern fold extends a much longer distance southward before its draining stream escapes to the Coosa. It is probable that the streams which excavated these valleys worked backward along the folds from the north and south. But the stream working from the north had a shorter distance to cut before reaching the end of its fold, and so accomplished its work first; and then, breaking through the narrow trough which separates the overlapping arches, it excavated 13 miles of the eastern fold, which properly belongs to the southward-flowing stream.

The effect of the inclined strata on the course of the streams is shown in the drainage of Lookout and Sand mountains. East and West forks of Little River and Town Creek flow for long distances close to the edge of Wills Valley and from 300 to 700 feet above it.

The streams tributary to the Tennessee River have cut backward into the plateaus on either side, forming many coves. The largest are west of the river, for there the protecting sandstone is thinnest and the conditions are most favorable for rapid erosion. Deep notches have also been cut in the western edge of the Sand Mountain plateau by the streams which drain most of its surface. As far back from the valley as these streams have cut down to the limestone they flow in deep, narrow canyons, while their upper courses are in rather shallow channels upon the sandstone.

The foregoing description and an examination of the topographic map show that in this region there are two plains nearly parallel and separated by a vertical distance of about 1,000 feet. The lower plain is apparent in the uniform altitude to which the hilltops in the valleys rise. The upper plain is the general surface of the plateau, below which the stream channels are deeply cut and above which rise a few hills and mesas.

Areas of these two plains have been recognized over nearly the entire Appalachian province, separated by a varying vertical distance, and their relations throw much light upon the history of the province during the later geologic ages. This region formerly stood much lower than now, so that the present plateau, the higher plain, was near sea-level. The land was worn down by streams flowing upon its surface till it was reduced to a nearly even plain, with only here and there a low hill remaining where the rocks were unusually hard, or where they were protected from erosion by their position. Since the surface was not perfectly reduced this is called a *peneplain*, and since it was formed near the lowest possible level of erosion it is called a *baselevel peneplain*. After the surface of the land had become reduced nearly to sea-level this region was elevated about 1,000 feet and at the same time tilted southward. The streams, which had become sluggish, were at once stimulated to renewed activity and began rapidly to sink their channels into the peneplain. Erosion progressed most rapidly upon soft rocks, so that on the western part of this area, where the sandstone capping was thin, and on the anticlines, where limestone formed the surface, the streams quickly sunk their channels down nearly to the new baselevel of erosion and then by broadening their valleys began the formation of a new peneplain. The old peneplain was preserved at the higher level where the hard rocks capped the plateau. After the formation of the second peneplain was well advanced upon areas of soft rocks, the region was again lifted and the streams began cutting their present channels within the last-formed peneplain.

GEOLOGY.

STRATIGRAPHY.

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

These rocks afford a record of almost uninterrupted sedimentation from early Cambrian to late Carboniferous time. Their composition and appearance indicate at what distance from shore and in what depth of water they were deposited. Sandstones marked by ripples 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. Coarse sandstones and conglomerates, such as are found in the Coal Measures, were derived from high land, on which stream grades were steep, or they may have resulted from wave action as the sea encroached upon a sinking coast. Red sandstones and shales, such as make up some of the Cambrian and Silurian formations, result from the revival of erosion on a land surface long exposed to rock decay and oxidation, 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 coarse sediment, the sea receiving only fine sediment and substances in solution.

The sea in which these sediments were laid down covered most of the Appalachian province and the Mississippi basin. The area of the Stevenson sheet was near its eastern margin at certain stages of sedimentation, and the materials of which its rocks are composed were probably derived largely from the land to the east. The exact position of the eastern shore-line of this ancient sea is not known, but it probably varied from time to time within rather wide limits.

Two great cycles of sedimentation are recorded in the rocks of this region. Beginning with the first definite record, coarse sandstones and shales were deposited in early Cambrian time along the eastern border of the interior sea as it encroached upon the land. As the land was worn down and still further depressed the sediment became finer, until in the Knox dolomite of the Cambro-Silurian period very little trace of shore material is seen. Following this long period of quiet was a slight elevation, producing coarser rocks; this became more and more pronounced until, between the lower and upper Silurian, the land was much expanded and large areas of recently deposited (Clinch) sandstones were lifted above the sea and eroded. Following this elevation, which completed the first great cycle, came a second period, during which the land was low, probably worn down nearly to baselevel, affording conditions for the accumulation of the Devonian black shale and Carboniferous limestone, which in general show very little trace of shore waste. A second great uplift brought these rocks into shoal water, and in some places above the sea, and upon them were deposited, in shallow water and swamps, the sandstones, shales, and coal beds of the Carboniferous. Finally, a further uplift at the close of the Carboniferous stopped the deposition of sediment in the Appalachian province, except along its borders in recent times.

SILURIAN ROCKS.

Knox dolomite.—The oldest rocks exposed within the limits of the sheet belong to the Knox dolomite, being massively bedded and somewhat crystalline magnesian limestone. This limestone, or more properly dolomite, contains a large amount of silica in the form of nodules and layers of chert or flint. Upon weathering, that part of the rock which consists of the carbonates of lime and magnesia is dissolved, leaving behind the insoluble chert imbedded in red clay. This residual material covers the surface to considerable depths, and the dolomite itself is seldom seen except in the stream channels. The whole of the formation is not exposed at any point in the Stevenson area, but on the next sheet eastward it is seen to have a thickness of from 3,000 to 3,500 feet.

The dolomite comes to the surface in a couple of narrow parallel strips which occupy the center of Browns and Wills valleys. In the latter valley the dolomite dips under all the other formations on both sides, forming an arch in the center of the valley, as shown in the structure sections. In Browns Valley the normal relations of the dolomite to the overlying formations are seen only on the southeast side; on the northwest the dolomite for a considerable distance is in contact with Carboniferous rocks along a fault, the intervening formations being entirely concealed.

Chickamauga limestone.—Next above the Knox dolomite is the Chickamauga formation, which is so named because of its typical development in the Chickamauga Valley in Georgia. It is generally a fine-grained, blue limestone, separating into slabs a few inches in thickness, which are so hard as to ring when struck with a hammer. It is highly fossiliferous, and in this respect differs widely from the Knox dolomite, which contains only rarely any traces of life. The thickness of the formation varies from 1,200 to 1,400 feet, the greatest thickness observed being in Browns Valley.

The formation is exposed in narrow bands parallel with the bands of Knox dolomite in the valleys. In Wills Valley the outcrops on opposite sides of the dolomite are nearly equal in width; in Browns Valley the outcrop west of the dolomite is not continuous, being partly concealed by the dolomite along the fault already mentioned.

Rockwood formation.—This upper division of the Silurian rocks in Browns Valley consists almost entirely of greenish, calcareous shales with some beds of blue limestone, and is about 225 feet in thickness. In Wills Valley the thickness of the formation increases to over 600 feet, and it contains a considerable proportion of calcareous sandstone interbedded with greenish clay shales.

The formation takes its name from Rockwood, Tennessee, in the Kingston area. It is of great practical importance on account of the beds of red fossil iron-ore which it usually contains. These are described under the heading Mineral Resources.

The formation occupies a continuous narrow strip along the eastern side of Browns Valley, while the corresponding strip along the western side is concealed by the faulting. In Lookout and Wills valleys the narrow strips of the formation are continuous on both sides and around the coves by which the valleys are terminated.

DEVONIAN ROCKS.

Chattanooga black shale.—Overlying the Rockwood formation is a thin stratum of shale, which appears to represent the whole of the deposition that took place in this region during the Devonian period. Typical exposures of this shale appear in the north end of Cameron Hill, within the city limits of Chattanooga, from which locality it takes its name.

The Chattanooga black shale has a remarkably uniform character wherever seen within the limits of this atlas sheet and for a long distance on either side north and south. It varies in thickness from 20 to 30 feet. The upper portion of the shale, 2 or 3 feet thick, is usually dark greenish-gray in color, and often carries near its top a layer of round phosphatic concretions about an inch in diameter. The remainder of the formation is jet-black, from an abundance of carbonaceous matter, and, when freshly broken, it emits a strong odor resembling that of petroleum.

This shale, on account of its distinctive and striking appearance, has attracted much attention from miners, and has been prospected in many places for coal and for various ores, especially silver and copper. Such exploitation, however, has always been attended by failure, since there is nothing of present economic importance in the shale. Although it contains a large proportion of carbonaceous matter, which burns when it is placed in a hot fire, the amount is not sufficient to constitute a fuel, and no true coal is ever found associated with the shale. Small concretions of iron pyrites, which it often carries, have given rise to the commonly accepted but wholly erroneous belief that the shale contains valuable ores. The formation is of economic importance in the Kingston area only as a starting point in prospecting for the red fossil iron ore, which occurs below it at a uniform depth over considerable areas.

In western-middle Tennessee the Chattanooga formation is of economic importance, since it there contains a bed of phosphate rock, sometimes 3 feet in thickness. This bed, however, does not extend so far east as this sheet, at least not with sufficient thickness to be commercially valuable.

CARBONIFEROUS ROCKS.

Fort Payne chert.—This formation consists of about 200 feet of very siliceous limestone. At the base, resting on the Chattanooga black shale, are, usually, heavy beds of chert with a small amount of limestone or greenish calcareous shale. The proportion of chert decreases upward, it being replaced by limestone or shale, and the formation merges in the Bangor limestone above with no abrupt transition, so that the line separating the two formations is somewhat arbitrary. The Fort Payne chert is readily distinguished from that of the Knox dolomite by the great number of fossils which it contains. The rock is often made up of a mass of crinoid stems imbedded in a siliceous cement. On weathering, the insoluble cement remains as a porous chert filled with fossil impressions.

The formation occurs in a narrow strip on each side of Lookout and Wills valleys and forms a broader area where two lateral strips unite in Deerhead Cove. In Browns Valley the outcrop of the formation is continuous on the eastern side, but is cut out by a fault for some distance on the western side. With the underlying Chattanooga and Rockwood shales the Fort Payne chert forms the low ridges which extend parallel with the plateau escarpments along the sides of the valleys. The formation name is taken from Fort Payne, Alabama.

Bangor limestone.—In the region to the south and east of this the Fort Payne chert passes upward into shales or sandstones, but in the Stevenson area it is overlain by the Bangor limestone. Probably the Floyd shale and Oxmoor sandstone, which elsewhere intervene, are here represented by the lower portion of the limestone; that is, while sandy and muddy sediments were depositing near the shore toward the southeast, limestone was forming in the deeper water toward the northwest. The Bangor consists of from 750 to 1,000 feet of massive, blue, crinoidal limestone containing some nodules of chert. The upper portion, 50 feet or more, usually weathers to brightly colored clay-shales, and shaly beds occur at intervals throughout the formation.

Lookout sandstone.—At the close of the period occupied by the deposition of the Bangor limestone there was an uplift of the sea bottom, so that the water became shallow over a wide area, while an abundant supply of mud and sand was washed in from the adjoining land. These conditions were unfavorable for the animals whose remains are so abundant in the preceding formation, and instead of limestone a great mass of shale and sandstone was deposited. The surface also stood above sea-level at various times, long enough at least for the growth of a luxuriant vegetation which formed beds of coal.

The Lookout sandstone includes between 300 and 400 feet of conglomerate, thin-bedded sandstone, sandy shales, clay-shales, and coal, between the top of the Bangor limestone and the top of a heavy bed of conglomerate. This conglomerate is not invariably present, being represented in some places by a heavy bed of coarse sandstone. This is the case at various points along the western side of Sand Mountain and in the Cumberland Plateau west of Browns Valley. The conglomerate resists erosion more than the beds above or below, and so forms a cliff, usually the edge of the plateau escarpments. The overlying rocks are often eroded for some distance back from the edge of the plateaus, and the conglomerate occupies the nearly horizontal surface. Several beds of coal, are usually found beneath the conglomerate. The formation takes its name from Lookout Mountain.

Walden sandstone.—The Walden includes all the rocks of this region lying above the Lookout conglomerate. Its sandstones, shales, and coal beds were formed under conditions very similar to those which prevailed during the deposition of the underlying formation. The conditions, however, were probably more uniform and somewhat more favorable for the accumulation of coal. What the original thickness of the Walden sandstone may have been can not now be determined, but it is certain that much of the formation has been removed by erosion. It originally formed an unbroken sheet over the whole of this region, and still occupies the greater portion of the plateau summits, except the mesas west of Browns Valley. The greatest thickness anywhere remaining within the limits of the sheet is about 700 feet, a little east of the center of Sand Mountain. These two formations, the Lookout and Walden sandstones, constitute the Coal Measures of this region. The coal will be described under the heading Mineral Resources.

At the close of the Carboniferous this region was elevated permanently above sea-level, so that the constructive process of deposition was stopped and the destructive process of erosion began.

STRUCTURE.

Definition of terms.—As the materials forming the rocks of this region were deposited upon the sea bottom, they must originally have beeen in nearly horizontal layers. At present, however, the beds are not usually horizontal, but are inclined at various angles. When any particular bed is followed for a considerable distance it is often found forming a series of arches and troughs. In describing these folded strata the term *syncline* is applied to the downward-bending troughs and *anticline* to the upward-bending arches.

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 occupies at every point the highest portion of the anticlinal arch, and away from which the rocks dip on either side. These axes may be horizontal or inclined. Their departure from the horizontal is called the *pitch* of the axis and is usually but a few degrees. In addition to the folding, and as a result of the continued action of the same forces which produced it, the strata along certain lines have 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 altered by production of new minerals from the old, a change termed *metamorphism*.

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

In the plateau region and westward the rocks are but little tilted from their original horizontal positions and are almost entirely unchanged; 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 to a greater extent by the minute breaks of cleavage and by the growth of new minerals.

In the valley the folds and the faults developed from them are parallel among themselves and to the old land body, extending in a northeast-southwest direction for great distances. Some faults 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, so that many parallel folds bring to the surface the same formations. Most of the rocks dip at angles greater than 10°, and frequently the sides of the folds are compressed till they are parallel. The folding is greatest in thin-bedded rocks, such as shale and shaly limestone, because the thin layers were most readily bent, and slipped along their bedding planes. Perhaps the most striking feature of the folds is the prevalence of southeastward dips. In some sections across the southern portion of the Appalachian Valley scarcely 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 dip toward the southeast. The planes on which the rocks broke and moved are often parallel to the bedding planes, as the rocks slipped on the beds in folding. Along these planes of fracture the rocks moved to distances sometimes as great as 6 or 8 miles. There is a progressive increase in degree of deformation from northeast to southwest, resulting in different types in different places. In northern Pennsylvania folds are inconspicuous. Passing through Pennsylvania toward Virginia, they rapidly become more numerous and dips grow steeper. In southern Virginia the folds are closely compressed and often closed, while occasional faults appear. Passing through Virginia and into Tennessee, the folds are more and more broken by faults, until, half way through Tennessee, nearly every fold is broken and the strata form a series of narrow, overlapping blocks, all dipping eastward. This condition holds nearly the same southward into Alabama, but the faults become fewer in number and their horizontal displacement much greater, while the folds are somewhat more open.

In the Appalachian Mountains the structure is the same as that which marks the Great Valley; there are the eastward dips, the close folds, the thrust faults, etc. But in addition to these changes of form, which took place mainly by motion on the bedding planes, there were developed a series of minute breaks across the strata, producing cleavage, or a tendency to split readily along these new planes. These planes dip to the east at from 20° to 90°, usually about 60°. This slaty cleavage was somewhat developed in the valley, but not to such an extent as in the mountains. As the breaks became more frequent and greater, they were accompanied by growth of new minerals out of the fragments of the old. These consisted chiefly of mica and quartz and were crystallized parallel to the cleavage cracks. The final stage of the process resulted in the squeezing and stretching of hard minerals like quartz, and complete recrystallization of the softer rock particles. All rocks, both those of sedimentary origin and those which were originally crystalline, were subjected to this process, and the final products from the metamorphism of very different rocks are often indistinguishable from one another. Rocks containing the most feldspar were most thoroughly altered, and those with most quartz were least changed. Throughout the greater part of the Appalachian Mountains there is a regular increase of metamorphism toward the southeast, so that a bed quite unaltered at the border of the Great Valley can sometimes be traced through greater and greater changes until it has lost every original character.

The structures above described are manifestly due chiefly to horizontal compression, which acted in a northwest-southeast direction, at right angles to the trend of the folds and cleavage planes. The compression apparently began in early Paleozoic time, and probably continued at intervals up to its culmination, shortly after the close of the Carboniferous, when the greater portion of the folding was effected.

In addition to the horizontal force of compression, the province has been subjected to other forces, which have repeatedly elevated and depressed its surface. At least two periods of high land near the sea and two longer periods of low land are indicated by the character of the Paleozoic sediments. And in post-Paleozoic time there have been at least three, and probably more, periods of decided oscillation of the land due to the action of some vertical force. In every case the movements have resulted in the warping of the surface, and the greatest uplift has occurred nearly along the line of the Great Valley.

Structure sections.—The five sections on the structure sheet represent the strata as they would appear in the sides of a deep trench cut across the country. Their position with reference to the map is on the line at the upper edge of the blank strip. The vertical and horizontal scales are the same, so that the elevations represented in the profile are not exaggerated, but show the actual form and slope of the land. These sections represent the structure as it is inferred from the position of the strata observed at the surface. On the scale of the map they can not represent the minute details of structure; they are therefore somewhat generalized from the dips observed near the line of the section in a belt a few miles in width.

Faults are represented on the map by a heavy, solid or broken line, and in the sections by a line whose inclination shows the probable dip of the fault plane, the arrows indicating the direction in which the strata have been moved on its opposite sides.

Structure of the area of the Stevenson sheet.—The area embraced within this sheet shows but little diversity in its geologic structure. There are no crystalline rocks exposed and no traces of metamorphism. Over the greater portion of the area the strata are nearly horizontal, dipping but a few feet to the mile, so that their inclination can be detected only by determining the altitude of some particular bed at several widely separated points.

The Sequatchie anticline, which crosses the western side of the area shown upon the sheet, is typical of the Appalachian folds. Its length is somewhat greater than that of the combined Sequatchie and Browns valleys, for at its ends the upper rocks have not been entirely removed by erosion, but remain arched across from side to side. On the southeastern side of the anticline the rocks dip at low angles, from 8° to 12°, while on the northwestern side they are much more steeply inclined, being in some places vertical or overturned. Also upon the northwestern side of the anticline the strata are broken by a fault, and the older rocks are thrust up across the broken edges of the younger. By reason of this fault the Knox dolomite comes in contact for a long distance with the Bangor limestone, while the intervening formations are concealed. This explains the absence on the western side of the valley of iron-ore-bearing Rockwood shales. West of the Sequatchie fault the strata are almost perfectly horizontal, dipping eastward about 35 feet to the mile.

Between the broad synclines forming Sand and Lookout mountains are two overlapping anticlines, one of which terminates within the area of the sheet and the other near its edge. As shown in the structure sections, these folds are nearly symmetrical, much more nearly so than most of the Appalachian folds. Also the eastern of the two anticlines is abnormal in having for a short distance near its northern end the steeper dips on the eastern side and the gentler dips on the western side.

While the strata in Lookout Mountain, Sand Mountain, and the Cumberland Plateau are nearly horizontal, they bear evidence of having been subjected to great horizontal pressure. In many places thin beds, especially of coal and argillaceous shale, or fire-clay, have been intensely plicated and folded between layers of massive, rigid sandstone which show no change from their original position. This folding of the easily yielding strata is more common in the Lookout than in the Walden, and sometimes offers serious obstacles to mining the lower coals.

MINERAL RESOURCES.

The mineral resources of the Stevenson tract consist of coal, iron ore, limestone, building and road stone, and brick and tile clay.

Coal.—The coal-bearing formations of this region are the Lookout and Walden sandstones, which have already been briefly described. They occupy the surface of the plateaus forming 544 square miles, or about half the entire area of the sheet. Probably a large portion of the area covered by these two formations contains workable coal, though thorough prospecting is necessary to determine the position and thickness of the coal beds at any particular locality.

The only points in the area where the coal has been worked to any extent are at Cole City and Castle Rock, in Dade County, Georgia. The Lookout conglomerate is near the surface, forming cliffs about the deep valley of Nickajack Creek. As shown in the section at the Dade mines, there are five beds of coal below the conglomerate, at least four of which are locally workable. The beds show considerable variation in thickness, from a few inches up to 5 or 6 feet, and also variations in the quality of the coal. The same beds doubtless extend toward the south in Sand Mountain and will be easily accessible in the coves which the streams have cut in the western edge of the plateau. These beds below the conglomerate also occur in Lookout Mountain, and have been opened at several points north of Valley Head.

The Walden sandstone in this area has not been sufficiently prospected for coal to justify definite statements concerning it, but a short distance to the northeast, at Ætna, shown on the Chattanooga sheet, these upper coals are extensively worked. At Ætna two beds of coal are found within 100 feet above the top of the Lookout conglomerate, and two beds between 200 and 300 feet above its top. While the position of the beds undoubtedly varies considerably, still the section at Ætna may be used as a guide in searching for coal toward the south.

Iron ore.—The only iron ore sufficiently abundant to be commercially important is the red fossil ore of the Rockwood formation. This ore is very similar in appearance to that occurring at the same horizon in such widely separated localities as Wisconsin, New York, and central Alabama. It is a stratified bed of constant thickness and with definite relations to other strata of the formation over considerable areas. Like any other rock stratum, however, it is not absolutely constant, so that while the map indicates within narrow limits the areas within which the ore may occur, careful examination is required to determine whether at any particular locality its quantity and quality are such as to make it commercially valuable.

The proportion of iron in the ore usually decreases with the distance from the surface, and at considerable depths it becomes simply a more or less ferruginous limestone. This is due to the fact that near the surface the lime has been largely removed by percolating surface waters, leaving behind the insoluble iron oxide as the soft ore. Considerable quantities of this soft ore are frequently obtained by stripping off the overburden from the bed, or, where the dips are steep, by trenching along the outcrops of the beds where it is not of sufficient thickness to make mining profitable.

The outcrops of the Rockwood shales, which carry the iron ore, occur in narrow strips in the valleys parallel with the base of the escarpments. In the two anticlinal valleys on the eastern side of the area the outcrops are continuous on both sides of the valleys and around the coves in which the anticlines terminate. In Browns Valley the ore-bearing shales are continuous on the eastern side, but are concealed on the western side by a fault. The ore has been worked in both the anticlinal coves on the eastern side of the area, most extensively about 2 miles east of Rising Fawn. The strata here dip at a low angle toward the north and east, and over a considerable area the ore bed is so near the surface that it can be obtained by removing the few feet of overlying rock. Along the sides of the valley it usually dips so steeply that stripping can be carried on along the outcrops for only a short distance from the surface. The ore is probably not generally workable in Browns Valley, but there are doubtless some localities where it may be mined with profit.

Limestone.—Suitable stone for blast-furnace flux and for lime is abundant in several formations, notably the Bangor, Chickamauga, and Knox. Flux for the Rising Fawn furnace is obtained from the Bangor limestone at the base of the Lookout escarpment, north of the furnace.

Building stone.—Stone adapted to architectural uses occurs in nearly every formation in the area. That which has been most largely used is in the upper part of the Lookout standstone. Quarries in the vicinity of Sewanee, a short distance north of this area, furnished the beautiful buff and pink sandstone of which some of the imposing university buildings were constructed. Considerable stone has also been shipped from the same quarries. Some beds of light-gray oolitic limestone in the Bangor seem admirably adapted for building purposes, closely resembling the well-known Indiana oolitic or Bedford stone. Limestone of this character forms a high bluff along the Nashville, Chattanooga, and St. Louis Railway east of Shellmound, and also occurs along the same road in Crow Creek Valley.

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

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

SOILS.

Derivation and distribution.—Throughout the region covered by the Stevenson 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 decay and disintegration of the rocks on which they lie. All sedimentary rocks, such as occur in this region, are changed by surface waters more or less rapidly, depending on the character of the 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, generally quite thin where the latter is pure, but often very thick where it contains much insoluble matter.

When derived in this way from the disintegration of the underlying rock, soils are called *sedentary*. If the rock is a sandstone or sandy shale the soil is sandy, and if it is a clay-shale or limestone 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 qualities often occur side by side.

Knowing the character of the soils derived from the various geological formations, their distribution may be approximately determined from the map showing the 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 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 *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 Walden and Lookout sandstones and parts of the Rockwood formation; (2) clay soils, derived from the Bangor and Chickamauga limestones; (3) cherty soils, derived from the Knox dolomite and the Fort Payne chert; (4) alluvial soils, deposited by the larger streams upon their flood-plains.

Sandy soils.—The entire surface of the plateaus, and consequently a little more than half the area of the sheet, 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 more often contains sufficient clay to give the subsoil considerable coherence. The depth of the soil on the plateaus varies from a few inches to 12 feet or more, 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 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 also kills all except the coarser grasses, so that the pasturage is injured.

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

Clay soils.—The many valleys and coves among the mesas west of Browns Valley are underlain by limestone, whose surface is covered by a mantle of clay soil, composed of its insoluble portions. The soil is sometimes red, but more generally bluish-gray or black, especially where it forms only a thin layer upon the rocks. The steep limestone slopes of the mesas have a scanty black clay soil, but support a dense growth of red cedar. The soils covering the outcrops of Bangor and Chickamauga limestones in Browns, Wills, and Lookout valleys have a greater depth and a bright-red color. In the narrow valleys along the base of the plateau escarpments, there is often a considerable admixture of sand with the clay.

Cherty soils.—The soil derived from the Knox dolomite and Fort Payne chert consists of clay in which the chert is imbedded. The proportion of chert to clay is variable; in some places only occasional fragments occur, while in others the residual material is made up almost wholly of chert. The soil is deep-red where the clay predominates, but 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 very large this is a strong productive soil. In Browns Valley the dolomite either originally contained less chert than elsewhere or it has very largely disintegrated, leaving a deep-red clay, locally called "mulatto soil."

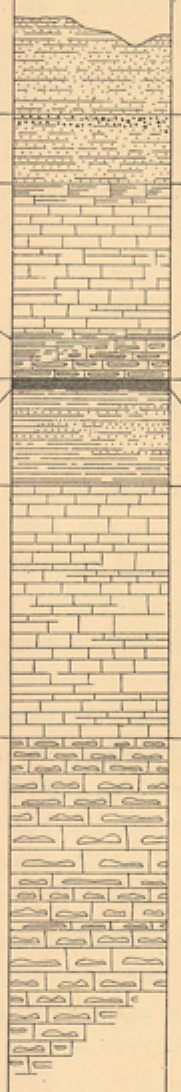
Alluvial soils.—These are confined principally to the flood-plains or bottoms of the Tennessee River, which are from half a mile to 2 miles broad in Browns Valley. The soil is a rich, sandy loam containing a considerable proportion of fine mica scales, derived from the crystalline rocks far to the eastward. Narrow strips of bottom-land occur along the creeks emptying into the Tennessee River, but their alluvial soils have been transported only a short distance, and hence are an admixture of the local sedentary soils, and generally contain a larger proportion of clay than does the alluvium of the river.

CHARLES WILLARD HAYES,
Geologist.

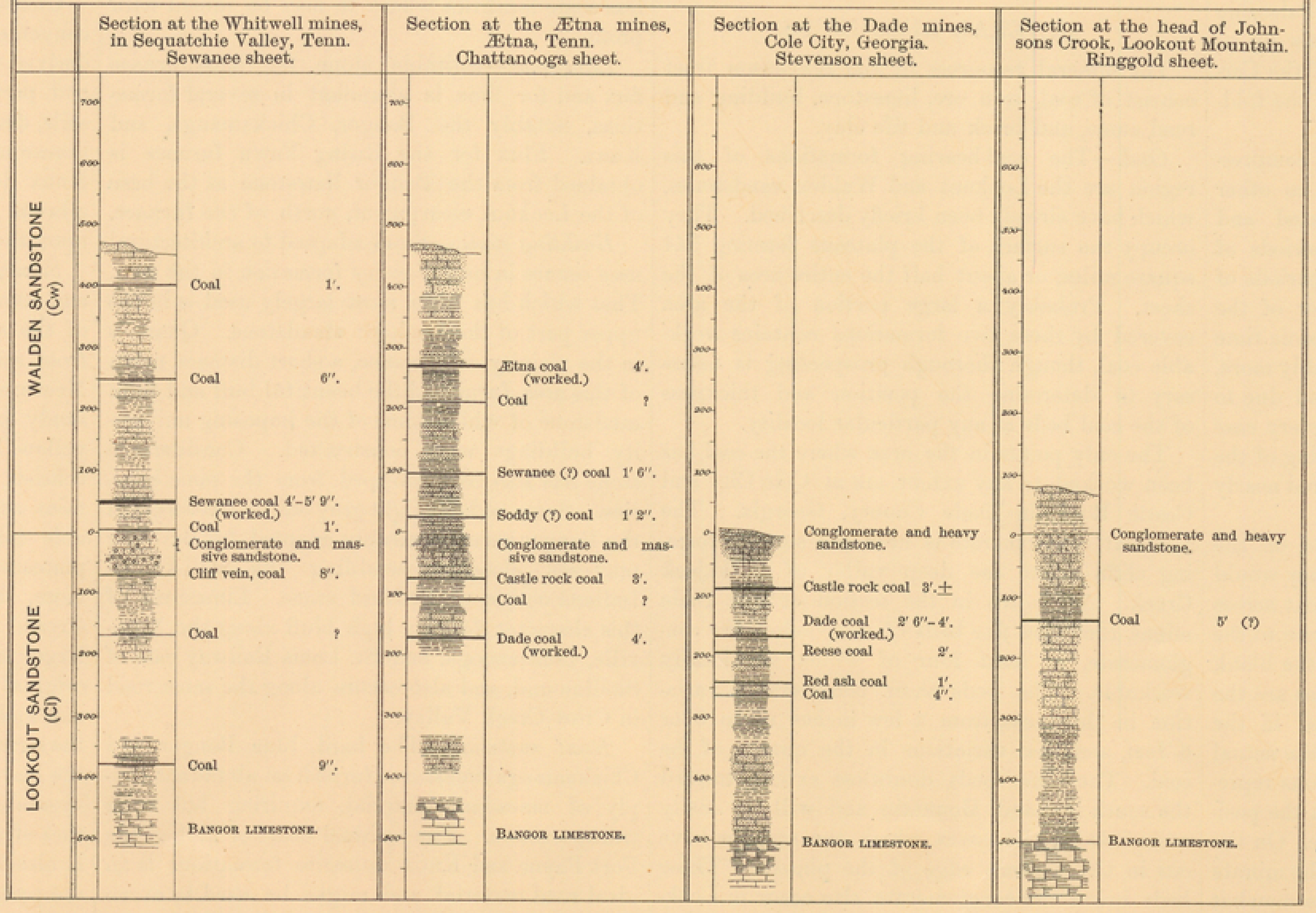
July, 1895.

COLUMNAR SECTION.

GENERALIZED SECTION FOR THE STEVENSON SHEET.
SCALE 1000 FEET = 1 INCH.

Period.	Formation Name.	Symbol.	Columnar Section.	Thickness in Feet.	Character of Rocks.	Character of Topography and Soils.
CARBONIFEROUS	Walden sandstone.	Cw		500+	Coarse sandstone and sandy shale with beds of coal and fire-clay.	Broad, level plateaus, intersected by narrow rocky gorges. Gray, yellow, or red sandy loam.
	Lookout sandstone.	Cl		280— —320	Conglomerate. Sandstone and shale with beds of coal and fire-clay.	Cliffs of plateau escarpments.
	Bangor limestone.	Cb		700— —1000	Shaly limestone. Massive, blue, crinoidal limestone. Calcareous shale.	Steep slopes, forming the lower part of the plateau escarpments. Black or red clay-soil. Narrow valleys.
	Fort Payne chert.	Cp		175— —225	Cherty limestone and heavy beds of chert.	
Dev.	Chattanooga black shale.	Dc		20–40	Carbonaceous shale.	
SILURIAN	Rockwood formation.	Sr		225— —775	Calcareous, sandy, and clay-shales, with beds of red fossil iron ore.	Sharp, narrow ridges, parallel to the sides of the anticlinal valleys. Cherty and sandy soil.
	Chickamauga limestone.	Sc		1170— —1450	Blue, flaggy limestone, with some mottled earthy beds.	Level valleys. Shallow residual deposits of red or blue clay; scanty, blue clay-soil where the rocks are nearly horizontal and deeper, red clay where the beds are steeply inclined.
CAMB.	Knox dolomite.	Sk		3000+	Magnesian limestone, white, gray, or light blue, generally granular and massively bedded, containing nodules and beds of cherts.	Low ridges and irregular, rounded hills; deep, residual deposits of red clay and chert; red clay with a few fragments of chert, grading into white or gray soil composed almost entirely of chert.

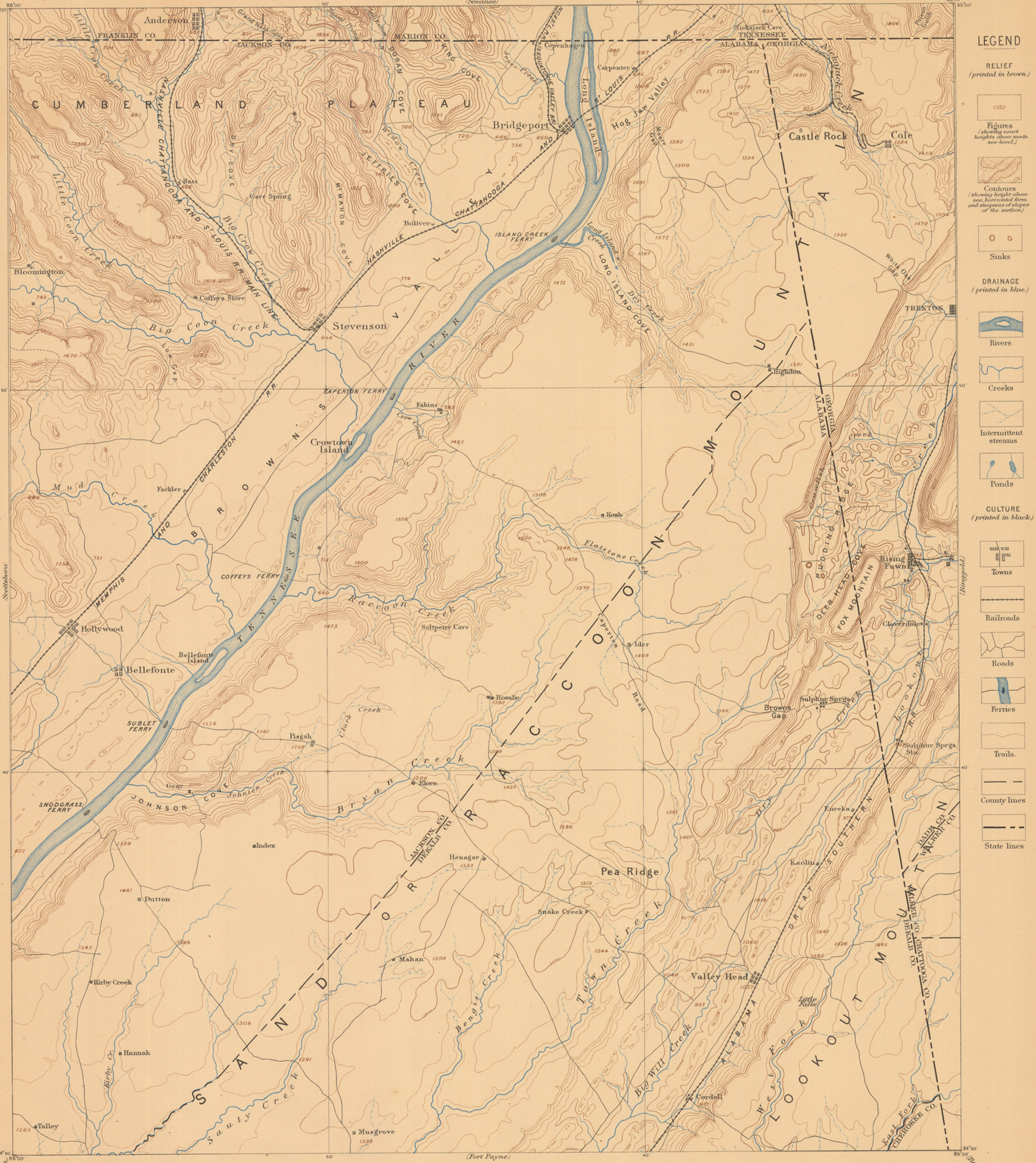
VERTICAL SECTIONS SHOWING THE POSITION AND THICKNESS OF COAL BEDS.
SCALE 250 FEET = 1 INCH.
VERTICAL DISTANCES ARE MEASURED FROM THE TOP OF THE LOOKOUT CONGLOMERATE.



U.S. GEOLOGICAL SURVEY
J.W. POWELL, DIRECTOR

TOPOGRAPHY

ALA.-GA.-TENN.
STEVENSON SHEET



Henry Gannett, Chief Geographer
Gilbert Thompson, Geographer in charge
Triangulation by the U.S. Coast and Geodetic Survey.
Topography by Louis Nell.
Surveyed in 1884.

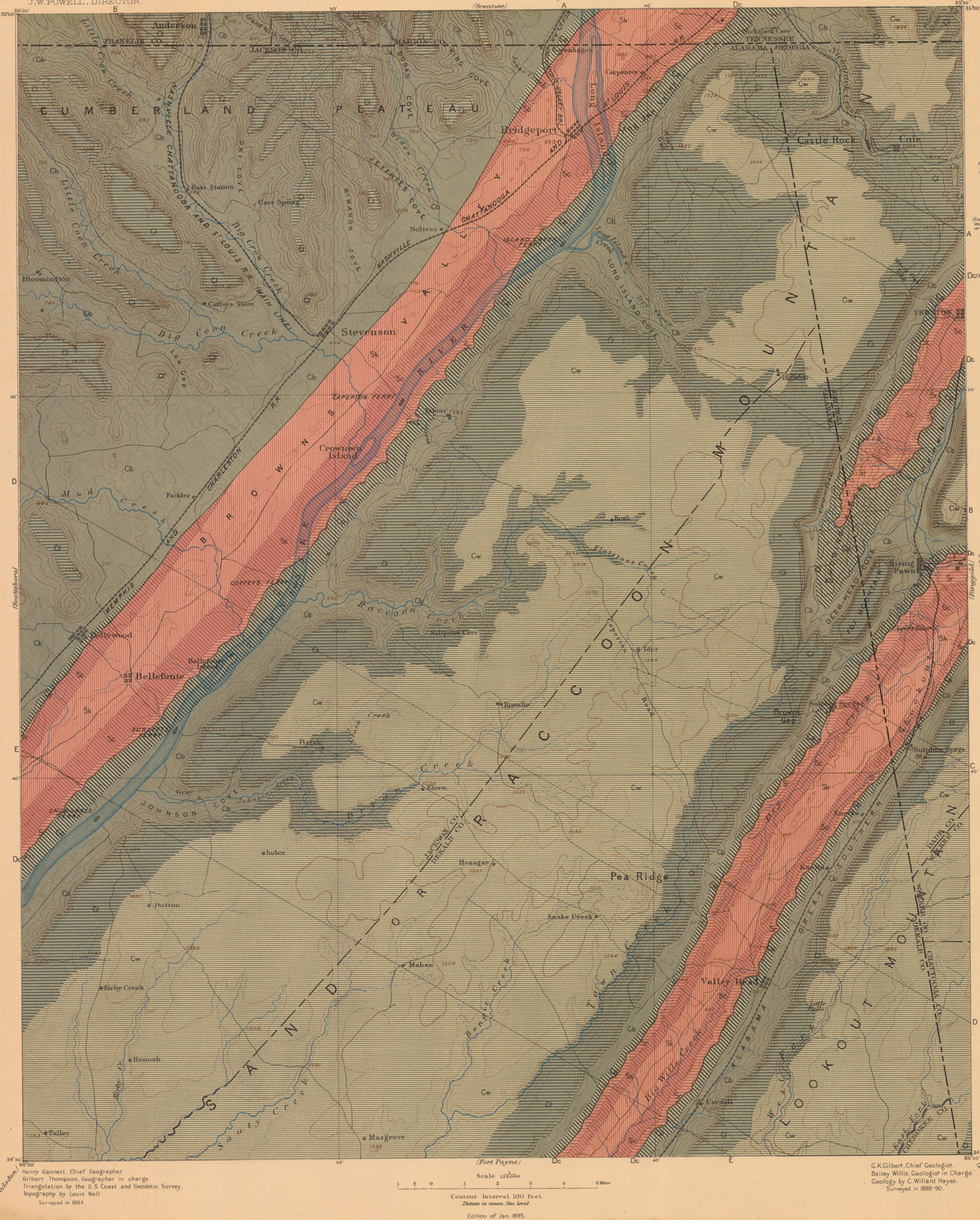
Scale 1:125,000

1 ½ 0 1 2 3 4 5 Miles

Contour Interval 100 feet
Datum is mean Sea level.

Edition of Jan. 1895.

AREAL GEOLOGY



LEGEND

SEDIMENTARY ROCKS

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

CARBONIFEROUS

- Cw — Walden sandstone (Coarse sandstone and sandy shale with beds of coal, usually workable in Lookout Mt.)
- Cl — Lookout sandstone (Conglomerate and massive sandstone. Shale with beds of coal, two or three locally workable)
- Cb — Bangor limestone (Massive, blue and shaly limestone)
- Cp — Fort Payne chert (Cherty limestone)

DEVONIAN

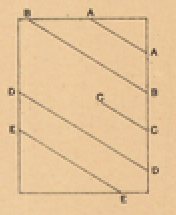
- Dc — Chattanooga black shale (Carbonaceous shale)

SILURIAN

- Sr — Rockwood formation (Calcareous, sandy and clay shales, with beds of red fossil ore, generally workable)
- Sc — Chickamauga limestone (Blue, flaggy limestone)
- Sk — Knox dolomite (Grey, magnesian limestone: granular, and massively bedded: contains chert)

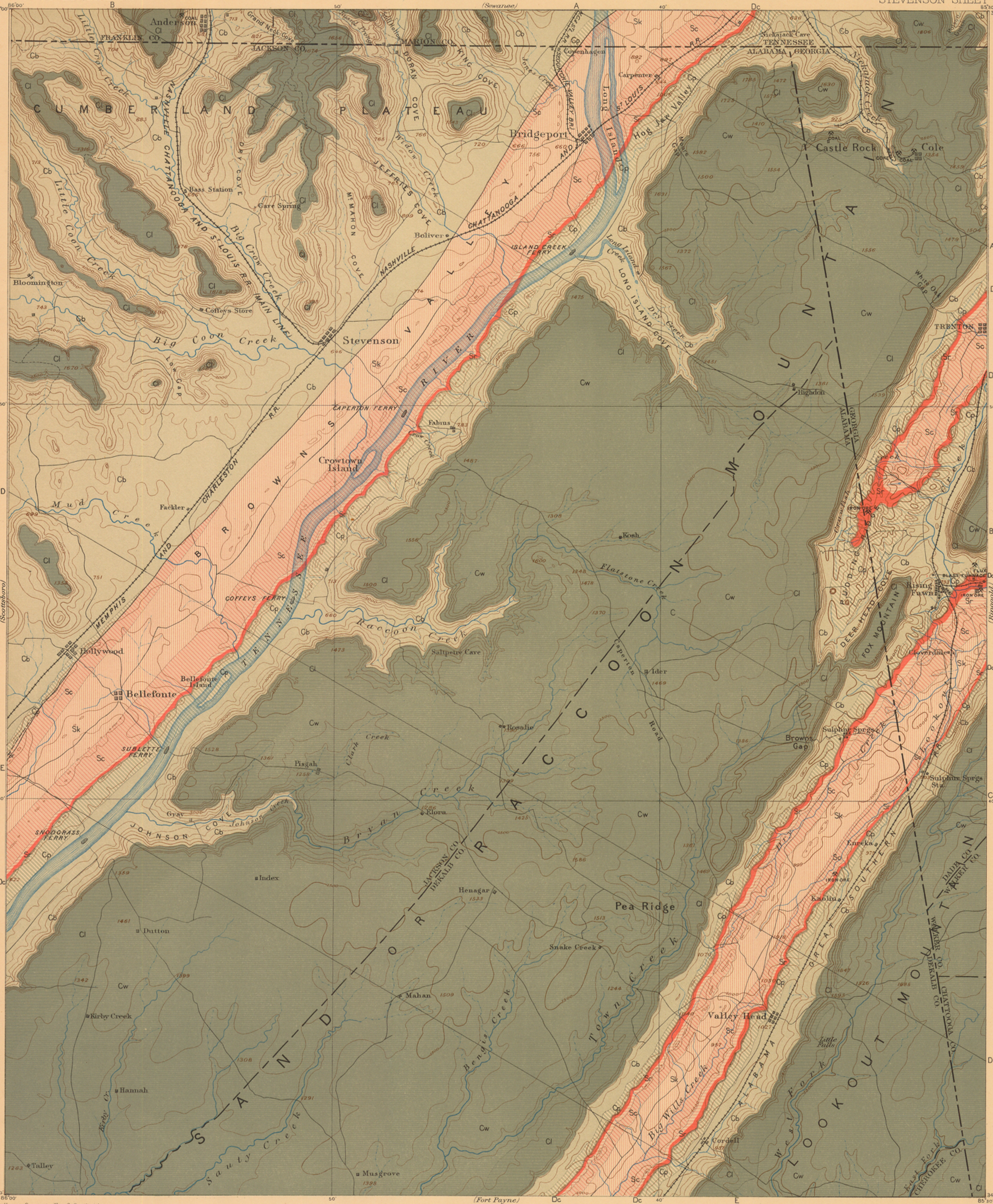
Faults

Sections



Henry Gannett, Chief Geographer
Gilbert Thompson, Geographer in charge
Triangulation by the U.S. Coast and Geodetic Survey.
Topography by Louis Nell
Surveyed in 1884.

G.K. Gilbert, Chief Geologist.
Bailey Willis, Geologist in Charge.
Geology by C. Willard Hayes.
Surveyed in 1888-90.



LEGEND

SEDIMENTARY ROCKS

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

CARBONIFEROUS

Cw — Walden sandstone
(Coarse sandstone and sandy shale with beds of coal, usually workable in Lookout Mt.)

Cl — Lookout sandstone
(Conglomerate and massive sandstone. Shale with beds of coal, two or three locally workable.)

Cb — Bangor limestone
(Massive, blue and shaly limestone)

Cp — Fort Payne chert
(Cherty limestone)

DEVONIAN

Dc — Chattanooga black shale
(Carbonaceous shale)

SILURIAN

Sr — Rockwood formation
(Calcareous, sandy and clay shales, with beds of red fossil ore, generally workable.)

Sc — Chickamauga limestone
(Blue, flaggy limestone)

Sk — Knox dolomite
(Grey, magnesian limestone; granular and massively bedded; contains chert)

Faults

Sections

Mines and Quarries

Known productive formations

Coal
(Probably productive)

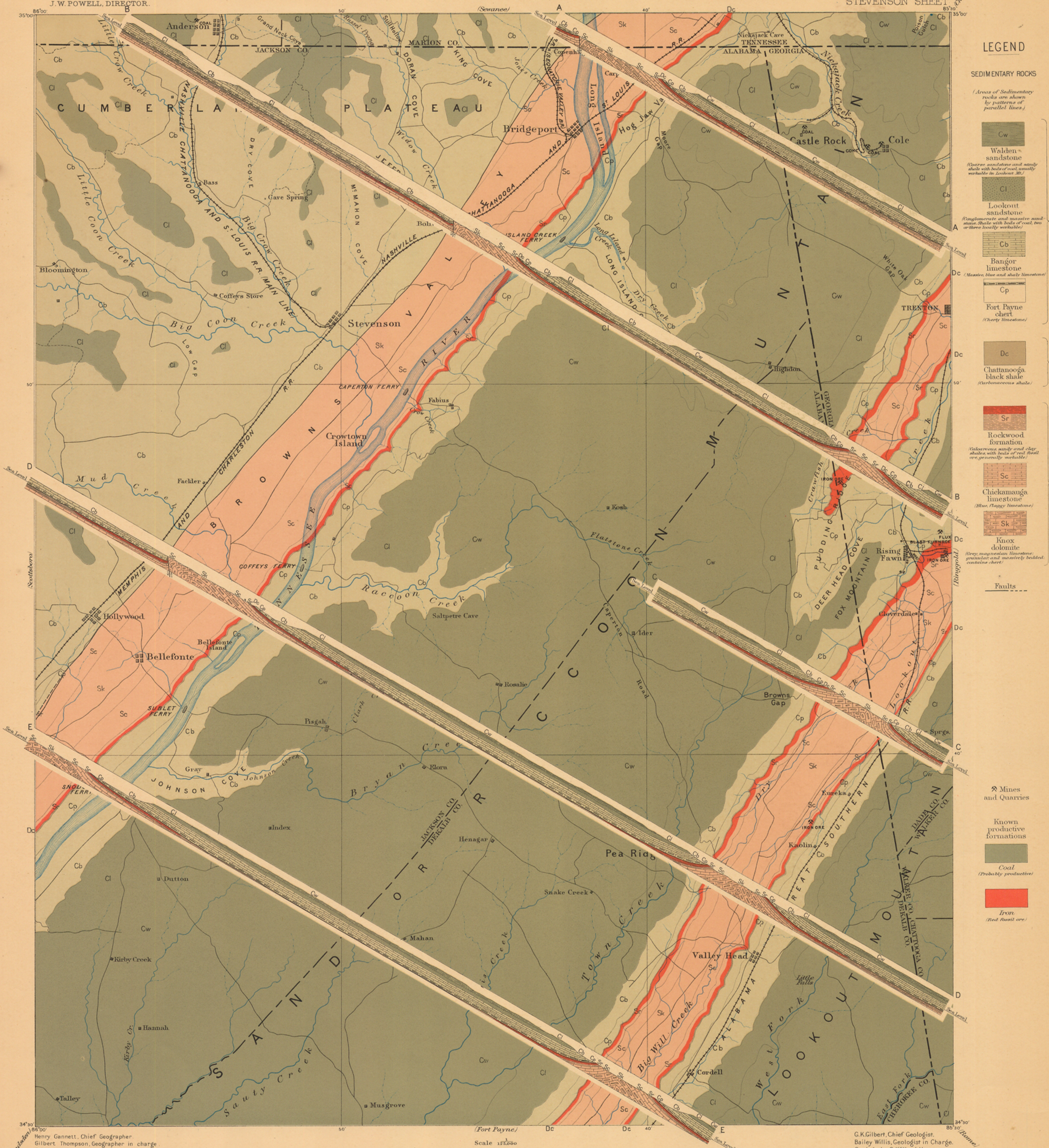
Iron
(Red fossil ore)

Henry Gannett, Chief Geographer
Gilbert Thompson, Geographer in charge
Triangulation by the U.S. Coast and Geodetic Survey.
Topography by Louis Nell
Surveyed in 1884.

Scale $\frac{1}{125{,}000}$
1 ½ 0 1 2 3 4 5 Miles
Contour Interval 100 feet
Datum is mean Sea level

Edition of Jan. 1895.

G. K. Gilbert, Chief Geologist.
Bailey Willis, Geologist in Charge.
Geology by C. Willard Hayes.
Surveyed in 1888-90.



Henry Gannett, Chief Geographer.
Gilbert Thompson, Geographer in charge.
Triangulation by the U.S. Coast and Geodetic Survey.
Topography by Louis Nell.
Surveyed in 1884.

Scale $\frac{1}{125,000}$

Contour Interval 100 feet
Datum is mean Sea level

Edition of Jan. 1895.

G.K. Gilbert, Chief Geologist.
Bailey Willis, Geologist in Charge.
Geology by C. Willard Hayes.
Surveyed in 1888-90.

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

It is thought that the first rocks of the earth, which formed during what is called the Archean period, were igneous. Igneous rocks have intruded among masses beneath the surface and have been thrown out from volcanoes at all periods of the earth's development. These rocks occur therefore with sedimentary formations of all periods, and their ages can sometimes be determined by the ages of the sediments with which they are associated.

Igneous formations are represented on the geologic maps by patterns of triangles or rhombs printed in any brilliant color. When the age of a formation is not known the letter-symbol consists of small letters which suggest the name of the rocks; when the age is known the letter-symbol has the initial letter of the appropriate period prefixed to it.

(4) *Altered rocks of crystalline texture.*—These are rocks which have been so changed by pressure, movement and chemical action that the mineral particles have recrystallized.

Both sedimentary and igneous rocks may change their character by the growth of crystals and the gradual development of new minerals from the original particles. Marble is limestone which has thus been crystallized. Mica is one of the common minerals which may thus grow. By this chemical alteration sedimentary rocks become crystalline, and igneous rocks change their composition to a greater or less extent. The process is called *metamorphism* and the resulting rocks are said to be metamorphic. Metamorphism is promoted by pressure, high temperature and water. When a mass of rock, under these conditions, is squeezed during movements in the earth's crust, it may divide into many very thin parallel layers. When sedimentary rocks are formed in thin layers by deposition they are called *shales;* but when rocks of any class are found in thin layers that are due to pressure they are called *slates.* When the cause of the thin layers of metamorphic rocks is not known, or is not simple, the rocks are called *schists,* a term which applies to both shaly and slaty structures.

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

Metamorphic crystalline formations 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 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 only.

USES OF THE MAPS.

Topography.—Within the limits of scale the topographic sheet is an accurate and characteristic delineation of the relief, drainage and culture of the region represented. Viewing the landscape, map in hand, every characteristic feature of sufficient magnitude should be recognizable.

It may guide the traveler, who can determine in advance or follow continuously on the map his route along strange highways and byways.

It may serve the investor or owner who desires to ascertain the position and surroundings of property to be bought or sold.

It may save the engineer preliminary surveys in locating roads, railways and irrigation ditches.

It provides educational material for schools and homes, and serves all the purposes of a map for local reference.

Areal geology.—This sheet shows the areas occupied by the various rocks of the district. On the margin is a *legend,* which is the key to the map. To ascertain the meaning of any particular colored pattern on the map the reader should look for that color and pattern 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 colored 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 of the district. The formations are arranged in groups according to origin—superficial, sedimentary, igneous or crystalline; thus the processes by which the rocks were formed and the changes they have undergone are indicated. Within these groups the formations are placed in the order of age so far as known, the youngest at the top; thus the succession of processes and conditions which make up the history of the district is suggested.

The legend may also contain descriptions of formations or of groups of formations, statements of the occurrence of useful minerals, and qualifications of doubtful conclusions.

The sheet presents the facts of historical geology in strong colors with marked distinctions, and is adapted to use as a wall map as well as to closer study.

Economic geology.—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 geologic formations which appear on the map of areal geology are shown in this map also, but the distinctions between the colored patterns are less striking. 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 in this map, and it is accompanied at each occurrence by the name of the mineral mined or the stone quarried.

Structure sections.—This sheet exhibits the relations existing beneath the surface among the formations whose distribution on the surface is represented in the map of areal geology.

In any shaft or trench the rocks beneath the surface may be exposed, and in the vertical side of the trench the relations of different beds may be seen. A natural or artificial 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.*

Mines and tunnels yield some facts of underground structure, and streams carving canyons through rock masses cut sections. But the geologist is not limited to these opportunities of direct observation. 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. Thus it is possible to draw sections which represent the structure of the earth to a considerable depth and to construct a diagram exhibiting what would be seen in the side of a trench many miles long and several thousand feet deep. This is illustrated in the following figure:

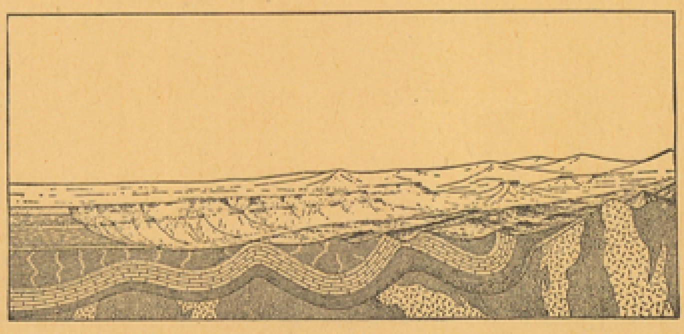


Fig. 2. Showing a vertical section in the front of the picture, with a landscape above.

The figure represents a landscape which is cut off sharply in the foreground by a vertical plane. The landscape exhibits an extended plateau on the left, a broad belt of lower land receding toward the right, and mountain peaks in the extreme right of the foreground as well as in the distance. The vertical plane cutting a section shows 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:

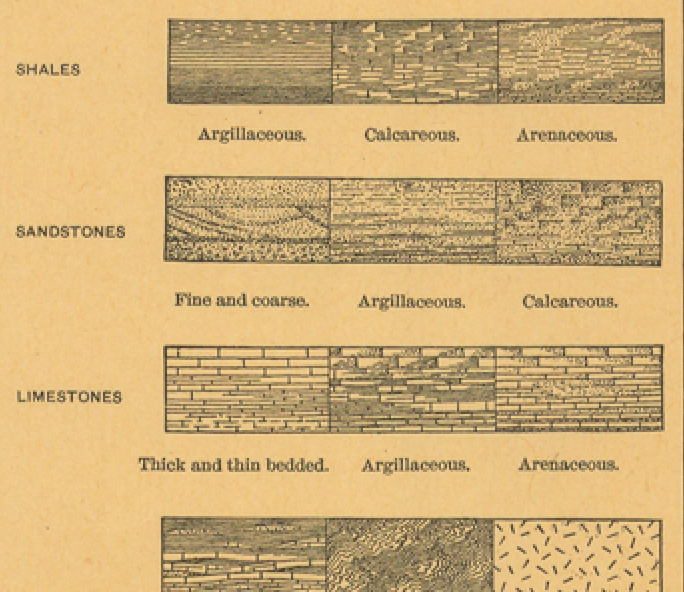


Fig. 3. Symbols used to represent different kinds of rocks.

The plateau in Fig. 2 presents toward the lower land an escarpment which is made up of cliffs and steep slopes. These elements of the plateau-front correspond to horizontal beds of sandstone and sandy shale shown in the section at the extreme left, the sandstones forming the cliffs, the shales constituting the slopes.

The broad belt of lower land is traversed by several ridges, which, where they are cut off by the section, are seen to correspond to outcrops of sandstone that rise to the surface. The upturned edges of these harder 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 thicknesses 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. Where they are now bent they must, therefore, have been folded by a force of compression. The fact that strata are thus bent is taken as proof that a force exists which has from time to time caused the earth's surface to wrinkle along certain zones.

The mountain peaks on the right of the sketch are shown in the section to be composed of schists which are traversed by masses of igneous rock. The schists are much contorted and cut up by the intruded dikes. Their thickness cannot be measured; their arrangement underground cannot be inferred. Hence that portion of the section which shows the structure of the schists and igneous rocks beneath the surface delineates what may be true, but is not known by observation.

Structure sections afford a means of graphic statement of certain events of geologic history which are recorded in the relations of groups of formations. In Fig. 2 there are three groups of formations, which are distinguished by their subterranean relations.

The first of these, seen at the left of the section, is the group of sandstones and shales, which lie in a horizontal position. These sedimentary strata, which accumulated beneath water, are in themselves evidence that a sea once extended over their expanse. They are now high above the sea, forming a plateau, and their change of elevation shows that that portion of the earth's mass on which they rest swelled upward from a lower to a higher level. The strata of this group are parallel, a relation which is called *conformable.*

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

The horizontal strata of the plateau rest upon the upturned, eroded edges of the beds of the second group on the left of the section. The overlying deposits are, from their position, 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 or upon their upturned and eroded edges, the relation between the two is *unconformable,* and their surface of contact is an *unconformity.*

The third group of formations consist of crystalline schists and igneous rocks. At some period of their history the schists have been 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 group. Thus it is evident that an interval of considerable duration elapsed between the formation of the schists and the beginning of deposition of strata of the second group. During this interval the schists suffered metamorphism and were the scene of eruptive activity. The contact between the second and third groups, marking an interval between two periods of rock formation, is an unconformity.

The section and landscape in Fig. 2 are hypothetical, but they illustrate only 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 sections.—This sheet contains a concise description of the rock formations which constitute the local record of geologic history. The diagrams and verbal statements form a summary of the facts relating to the characters of the rocks, to the thicknesses of sedimentary formations and to the order of accumulation of successive deposits.

The characters of the rocks are described under the corresponding heading, and they are indicated in the columnar diagrams by appropriate symbols, such as are used in the structure sections.

The thicknesses of formations are given under the heading "Thickness in feet," in figures which state the least and greatest thicknesses. 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 columnar arrangement of the descriptions and of the lithologic symbols in the diagram. The oldest formation is placed at the bottom of the column, the youngest at the top. The strata are drawn in a horizontal position, as they were deposited, and igneous rocks or other formations which are associated with any particular stratum are indicated in their proper relations.

The strata are divided into groups, which correspond with the great periods of geologic history. Thus the ages of the rocks are shown and also the total thickness of deposits representing any geologic period.

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, not only by the description of its character, but by its name, its letter-symbol as used in the maps and their legends, and a concise account of the topographic features, soils, or other facts related to it.

J. W. POWELL,
Director.