DESCRIPTION OF THE MORRISTOWN SHEET.

GEOGRAPHY.

General relations. — The area represented on the Morristown sheet lies entirely in Tennessee, and includes portions of Hancock, Jefferson, Knox, Cocke, and Greene counties. It is bounded by the parallel 30° and 30° 30', and the meridians 85° and 88° 30', and it contains about 450 square miles.

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 have therefore a common history, recorded in its geologic structure, and its topographic features. Only a part of this history can be described from a small atlas sheet; hence it is necessary to consider the individual sheet in its relation to the entire province.

Subdivisions of the Appalachian province. — The Appalachian province may be subdivided into the well-marked physiographic divisions, each of which certain features 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.

The western portion of the Appalachian province embraces the Appalachian Mountains, a system which is made up of many minor ranges, and which, under various local names, extends from central Alabama, through Tennessee and Virginia, to the vicinity of New York to central Kentucky. Some of its prominent parts are the South Mountain of Pennsylvania, the Blue Ridge and Catawba Mountains of Maryland and Virginia, the Great Smoky Mountains of Tennessee and North Carolina, and the Chatta Mountain of Georgia. Many of the rocks of this division are more or less crystalline, being either sediments which have been changed to gravel and sand, or by gneiss, quartz, mica, hornblende, 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 Allegheny Mountains and the lowlands of Tennessee, Kentucky, and Ohio. Its northwestern boundary is indefinite, but may be regarded as an arbitrary line coinciding with the course of the Tennessee River as far as Cairo, and then crossing the States of Illinois and Indiana. Its eastern boundary is sharply defined by the Allegheny 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 smoother or more completely worn down. In the southern half of the province the plateaus is sometimes extensive and perfectly flat, but it is often much divided by streams into large or small areas with flat tops, which they commonly termed knobs. Beyond the Blount, Jefferson, Cocke, and Greene counties.

Geographic divisions of the Morristown area. — The area represented on this atlas sheet divides into three districts, each having quite distinct surface features. These districts are the ridge district, the plateau district, and the valley district.

The ridge district, the most extensive of the three, lies in the northwestern portion of the province and includes the Tennessee River, the Nolichucky, French Broad, Holston, and Clinch rivers. All of whom rise far beyond the limits of this area, and series three are only a portion of their drainage of the province is in part eastward into the Tennessee River the Nolichucky, French Broad, Holston, and Clinch rivers. All of whom rise far beyond the limits of this area, and series three are only a portion of their drainage of the province is in part eastward into the Tennessee River the Nolichucky, French Broad, Holston, and Clinch rivers.
including Cambrian, Silurian, Devonian, and Carboniferous. Carboniferous rocks are but scantily shown; Devonian rocks are as fully represented as any other part of the Silurian, and the Carboniferous rocks almost entirely in the upper part of the Cambrian are unusually well developed.

The rocks lie in two distinct areas or groups, of a different age and composition. Southeast of a line passing through Dandridge, Loudaviit, and Wartburg are rocks which form the upper part of the shales and sandstones of Silurian age. The Silurian sandstones form Bays Mountain, and the sandstones underneath the rocks to the west are almost entirely made up of red, yellow, and brown sandstones, with the exception of the knob belt and Lick Valley. There is seen to be a rapid succession of all formations found in this district.

The sandstones are at the bottom. Few of the shales are somewhat thinner, and as much as 800 feet in thickness. They are continuous. The shales are very thin, and small seams of sandstone are interbedded with the shales. The shales are very thin, and small seams of sandstone are interbedded with the shales. Brilliant colors are common in these strata. A few of the seams of sandstone are continuous, and in such amounts as almost to become limestones.

The series is thinnest near Dandridge, where it comprises 550 feet of sandstone at the top and 400 feet of sandstone and sandy shale at the bottom. Its full thickness is not exposed, being cut off by the fault which brings the formations up to the surface.

The rocks are decomposed by solution and form a deep, red clay. From this many limestones, especially of the upper part, are precipitated, and the limestones are well developed near Maryville, in Blount County, Tennessee.

The Knox dolomite is the most important and widespread of all the valley rocks. It is named in honor of Professor W. H. Knox, who first described it. Its northwestern outcrops contain many small bed of shaly limestones. The formation varies in thickness from 70 to 250 feet, and is north of Clinch Mountain. Numerous remains of trilobites are found in the shales, which show the formation to be of middle Cambrian age.

Excepting the interbedded limestones, the formation is but little soluble. It decays down the numerous partings into thin beds of sandstone, and the shales and sandstone, which are gradually broken up by rain and frost. Outcrops are frequent, but the rock is soft and forms only a small ledge in the limestone valley. Its full thickness is not exposed, being cut off by the fault which brings the formations up to the surface.

The Knox dolomite is made up of red, yellow, and brown sandstones, with alternating beds of thin, sandy shale, which occur mainly north of the Holston. In its eastern and southern areas it is developed as a bed of massive blue limestones, and its northwestern outcrops contain many small beds of shaly limestones. The formation varies in thickness from 70 to 250 feet, and the chert are least numerous in thickness from 70 to 250 feet, and the chert are least numerous in the middle part of the formation. The chert contains a great variety of rocks, and its thicknesses are from 5 to 500 feet, and the chert is less than 100 feet. The Knox dolomite is present only near the stream cuts. The formation is covered by great depth of red clay, through which are scattered the insoluble chalks. These are slowly decomposed by the rock, and where most plentiful they constitute a large part of the soil as to make cultivation almost impossible. When weathered the chalks are white and chalky, and in angular fragments. Areas of much chalk are hard, broad, rounded ridges protected by the overlying limestones. The ridges, rich in red and blue, extend beyond the ridges of Clinch Mountain. Areas of little development of the ridges are also characteristic of the surrounding rocks. This is the case along the lower Holston, where the weathering of the chalks is very rapid, and may affect almost any depth, but they need careful cultivation to prevent washing, and they are usually good as a subsoil.

Knox limestones. The Knox limestone is the most comprehensive formation of this type of rock, which is covered by natural<br>the formations. The Knox dolomite is the most important and widespread of all the valley rocks. It is named in honor of Professor W. H. Knox, who first described it. Its northern outcrops contain many small bed of shaly limestones. The formation varies in thickness from 70 to 250 feet, and is north of Clinch Mountain. Numerous remains of trilobites are found in the shales, which show the formation to be of middle Cambrian age.
The waters over this formation are deep and rich and support narrow valleys form an irregular network. On the eastern side of the mountain district, faults and folds are important because the rock gradually crumbles into small fragments, but they also occur on a very small, even a microscopic scale. In districts where strata are folded they are often broken across, and the arch is thrust up through the rock. Such a breach or gap is called a fault. If the arch is worn away and the syncline is buried beneath the overburden, the strata at the surface all dip in the same direction. They then appear to have been deposed in a continuous series. Faults and folds are often of great magnitude, but they are usually but a few degrees. In districts where strata are folded they are often broken across, and the arch is thrust up through the rock. Such a breach or gap is called a fault. If the arch is worn away and the syncline is buried beneath the overburden, the strata at the surface all dip in the same direction. They then appear to have been deposed in a continuous series.

CARBONIFEROUS ROCKS

Newman sandstone. — The same thickness that hold the two preceding formations this sandstone is also, and it is named for its occurrence here in Newman County. Massive and shaly limestone mantle the entire formation. In the Clinch basin the massive bed, 100 feet thick, lies at the base and is overlain by thin and shaly limestone, which is less than 1,000 feet thick. Erosion has here removed the top of the formation, so that its full thickness is seen in the Powell basin. This upland position consists of massive limestone 700 feet thick, thus showing a diminution away from the mound of the limestone lying between the Clinch and Powell basins. In the latter by the fossils that it contains. It does not affect the topography, for it breaks into small fragments and is relatively small in amount.

The massive limestone in the Clinch basin weathered readily and forms law ground; the upper shaly beds resist erosion to a considerable degree and form broad, rounded knobs and hills as high as the Graysville shale. The upland position keeps the soils well drained, and they are very deep and fertile, and are also impregnated by the water. In the Clinch basin the rocks have been well weathered and tilted, and in the Raysville the rocks are fairly productive. These shales are of much importance. Two characteristic layers of the Rusk formation are the only areas of this formation in the valley of East Tennessee, and from its occurrence here in Hawkins County it is derived its name. The formation consists entirely of interbedded, massive and shaly limestones of a bluish, gray, or brown color. The thickness of these strata is 450 feet. Massive beds are more frequent at the bottom and top of the formation and attain a thickness of 20 feet. Great numbers of fossils, largely brachiopods, corals, and crinoids, are found throughout the formation, and show it to be of upper Silurian age. In general appearance this formation strongly resembles the Chickamauga limestone.

The rocks of the weathering loosely its calcareous matter and form large valleys. Outcrops are not rare, and consist usually of the massive beds. The outer edges of the beds are nearly horizontal, and from it are derived soils of great strength and fertility. By the sandy wash all around the interbeds of shales, which have been modified until they are often light and well drained.}

DOLOMITIC ROCKS

Chattanooga sand. — This formation, whose rocks may be seen in the Clinch basin in Tennessee, is found in many belts in the Clinch basin and in the Powell syncline. In this region it is composed of white sandstones, which form the knobs and hills. The sandstones are very rich in fossils, and its name. The formation consists here of shaly, sandy shales and thin sandstones.

Structure

Definition of terms. — As the materials forming the rocks of this region were deposited upon the sea bottom, they must originally have extended in nearly horizontal layers. As a result, however, the beds are usually not horizontal, but are inclined at various angles, their edges appearing smoothly and regularly terminated by the base at which they are inclined is called the dip. A bed which dips beneath the surface may elsewhere be found rising above it. When the beds between two such outcrops is called a syncline. A stratum rising from one syncline may often be found to bend over and descend into another; the fold or arch, between two such outcrops is called an anticline. Synclines and anticlines side by side simply form folds or folds, structures. A synclinal axis is a line running lengthwise in the synclinal trough, at every point occupying its lowest part, toward which the rock is inclined and which dips against the rock. The dip of the syncline or anticline is a line which occupies at every point the highest portion of the anticlinal arch, and away from which the rocks dip on the other side. The axis of the syncline or anticline may be horizontal or inclined. The dips may be normal or reversed. In the more minute dislocations, however, the individual fragments of the rocks are bent, broken, and slipped past each other, causing cleavage. Extreme development of these minute dislocations is attended by the breaking down of new minerals out of the fragments of the original. A process which is called metamorphism, or the change of rocks. During the Appalachian province, a series of three distinct types of structures occur in the Appalachian province, each one prevailing in a separate region or in a separate group of geographical division. In the plateau region and westward the rocks are generally flat and retain their original horizontal form, but they have been steeply tilted, bent into folds, broken by faults, and to some extent altered into strata. In the plateau region, these last features of the structure, but cleavage and metamorphism are equally conspicuous. The 500,000 feet of the valley region are parallel to each other and to the western shore of the ancient continent. They extend from north to southwest, and single structures may be very long. Faults 500 miles long are known, and folds of even greater length occur. The crests of most folds continue at the same height for great distances, so that they present the same formations. Often adjacent folds are nearly equal in height, and the same beds occur and reappear at the surface. Most of the beds dip at angles greater than 10°; frequently the sides of the folds are compressed until they are nearly parallel. Generally the folds are smallest, most numerous, and most closely squeezed in thin-bedded rocks, such as the Graysville shale. Perhaps the most striking feature of the folding is the prevalence of southeastward dips. In some sections across the southeast end of the Appalachian Valley nearly a square bed can be found which dips toward the northwest.
progressive change in character of deformation from northeast to southwest, resulting in different types in different places. In southern New York the folds are more nearly the same as those through Pennsylvania toward Virginia, folds are more numerous and steeper. In southern Virginia the folds are closely grouped, and often of moderate size, while near the boundary with Pennsylvania the strata dip toward the southeast and the folds are better defined.

The structures above described are the result of compression, which operated in a north-south direction, at right angles to the trend of the strata and the direction of the faulting. These compressive forces were limited in effect to a narrow zone. Broader in its effect and intense at any point, the vertical force was felt throughout the province.

Three periods of high land near the sea and three periods of low land are indicated by the character of the Paleozoic sediments. In periods of Paleozoic time, also, there have been at least four and probably more periods of decided oscillation of the sea. These changes are reflected in the strata of each period and in the manner in which they were deposited. In most cases the movements have resulted in the warping of the surrounding land, and the greatest uplift has occurred along the line of the Great Valley.

Structure of the Morristown area.—The rocks of the region are of use in the natural state, as marble, building stone, and road material, and in the marble and shales developed from them, such as sand, salt, lime, cement, and clay. Through their soils they are valuable for crops because the rocks beneath them are deep enough, and the soil is rich in lime and clay. The climate of the region is such that the rocks are covered with soil and timber, and in the grades which they establish the land is much improved.

The variations in all of these characters are due to differences in the sediment at the time of deposition, the character of the bedrock, the nature of the fossils, and the climatic conditions. The variations are pronounced in the limestone, which is abundant in the region, and the thickness of the marble beds, in places as great as 300 feet, is by no means available for commercial use. The use must be of a peculiar kind, must occur in blocks of marble, and the latter beds are of good body, but lack the most desirable and must be cut into slabs and sawed to be used. These changes are illustrated by the disappear­ance of the white marble northeast of Thorn Hill in the belt running north of Clinch Mountain, its place being taken by blue and gray marbles. These changes are not of good quality, but lack the most desirable and cannot be used for building stone.

The available localities for quarrying are limited by the hardness of the marble beds. The best situations are those in the belt south of Clinch Mountain, where the strata dip at a high angle and there is little stripping to be done. Here the location of the marble, well above drainage, gives it an added advantage. In the areas north of Clinch Mountain the dip is such as to carry the bedding planes above the surface, but it is not steep enough to avoid considerable stripping. Good marble abounds in these areas, but it is not available in as large quantities as the marble beds are in a more favorable location, and all of reasonable purity take a good polish and are highly valued.

The position of the rocks underground is calculated from the observed and the known thickness of the formations.

Two regions exist in this area in which the types of deformation differ materially, one being of a nature peculiarly characteristic of the Carboniferous period, and the other being of a nature peculiarly characteristic of the period of the Mesozoic era, or Triassic period. The first type of deformation is illustrated by the formation of the smaller folds of the Knox dolomite for the little folds and crumplings of the surface, and the second type of deformation is illustrated by the formation of the larger folds of the Knox dolomite for the little folds and crumplings of the surface, the larger folds and crumplings of the surface, the larger folds and crumplings of the surface, and the larger folds and crumplings of the surface.

The rocks of the ridge district have been deformed by several periods of faulting, and the evidence of this faulting is best shown in the folds. These folds are generally so obscured by faults that the strata form a series of narrow, overlapping folds. The axis of the folds is shown in the northwestern part of the region, and the greatest uplift has occurred nearly along the line of the Great Valley. The rocks of the ridge districts have been deformed by several periods of faulting, and the evidence of this faulting is best shown in the folds. The axis of the folds is shown in the northwestern part of the region, and the greatest uplift has occurred nearly along the line of the Great Valley. The rocks of the ridge districts have been deformed by several periods of faulting, and the evidence of this faulting is best shown in the folds. These folds are generally so obscured by faults that the strata form a series of narrow, overlapping folds. The axis of the folds is shown in the northwestern part of the region, and the greatest uplift has occurred nearly along the line of the Great Valley.
their use keeps it well drained. An objection to their use is the rapid wear of iron shoes and tires by their sharp edges.

The Rogeville shale has long been found local use for road metal, and in some regions roads are built along its outcrop. It secures a smooth surface and good drainage for the road, but is not especially durable. The Rome sandy shales are used near their outcrops with great success. The material is abundant, easily worked, and fairly lasting, and it secures excellent drainage. Roads built on the Grainger sandstone outcrops are much like the Rome formation roads; their surfaces are smooth and well drained, and the material is abundant and readily broken.

Other formations which could be used for road building are the various limestones and the Clinch sandstone. The latter is worked on the roads across Clinch Mountain with fair success. The road-bed formed of this rock is very hard, but is liable to wash when broken fine enough to have a smooth surface, because the rock contains no cementing material.

Lead.—Ores of this metal are found 3 miles south of Morristown. No mining has been done of any consequence, and the developments are small. The ore is cerussite, and is mingled with calamine and blende. These occur as small. The ore is cerussite, and is mingled of any consequence, and the developments are small. The ore is cerussite, and is mingled

Lime and cement.—Many beds in the Knox dolomite and Chickamauga limestones have been hewn into excellent lime. The greater part of the dolomite has too small a proportion of calcareous matter for such a purpose, but available beds occur both at the top and bottom of the formation. Of the Chickamauga beds the marble would supply the best of lime, but it is more valuable for ornamental uses. Various Cambrian limestones are of sufficient purity to produce good lime, but are practically untried. The massive beds of the Newman limestone also would furnish good material. In the Chickamauga limestones some reddish-brown argillaceous beds, low down in the formation, are adapted by composition to produce hydraulic cement. Of all these materials little use has been made, and the various rocks have been burned near at hand when wanted, so that no industry has been established.

Brick clay.—Clays suitable for the manufacture of brick are abundant throughout the region. They are derived from the wash of various formations, chiefly the Knox dolomite, the Cambrian limestones and Nolichucky shale, and the Athens and Sevier shales. They collect in depressions of the surface upon or near these formations, and are very widely distributed. The suitability of the clay is largely determined by the slopes of the surface; the finer and purer deposits are found in the basins surrounded by gentle slopes. On the low ground of Lick Creek and the Nolichucky and French Broad valleys good clays are widespread and deep, and no tract of any considerable size is without a deposit. Only local use has been made of these clays, and bricks have been burned in the immediate neighborhood of their use.

Timber.—Many formations produce timber of value, and usually there is a distinct association of certain trees with one formation. All of the formations are timber-covered in suitable localities. The Knox dolomite is always marked by a good growth of oak, chestnut, and hickory. In the hollows of the Athens, Sevier, Rockwood, and Rome formations grow poplar, chestnut, oak, and pine. Areas of Chickamauga limestone are especially durable. The Kome sandy shales are built along its outcrop. It secures a smooth surface and good drainage, but is not used near their outcrops with great success. The Kome formation roads; their surfaces are smooth and well drained, and the material is abundant and readily broken.

Water-power.—A natural resource of this region which is thus far little used is the water-power. The supply of water in the streams is abundant and fairly constant; sherry districts and Sevier shale areas are poorly watered, but others are fed by countless springs and by rivers rising in mountainous regions. Over most of this region the streams grade are light, particularly so in the rivers. Two districts of considerable size, however, possess systems of falls. Where Holston River approaches the Knox dolomite area, which underlies Rogeville, Morristown, and Morsey Creek, the smaller streams regularly have heavy grades for a short distance back from the river. Similar sets of steeply falling streams descend from Copper and Chestnut ridges into Clinch River. In these localities high grades are maintained against the wear of the streams by the hardness of the Knox dolomite, and actual falls are common. The supply of water is not great, but it is steady except in the driest seasons, being fed chiefly by springs. Other falls of small size, but great in number, descend over the hard beds in the water-gaps of the Rome and Grainger formations. At present only occasional saw-mills and grist-mills utilize this power, but in the future it may become of value for manufacturing purposes.

Arthur Keith,
Geologist.