GEOLOGIC ATLAS
OF THE
UNITED STATES

WINSLOW FOLIO
ARKANSAS - INDIAN TERRITORY

INDEX MAP

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COLUMNAR SECTION SHEET

WASHINGTON, D.C.

1897
The Geological Survey is making a geologic map of the United States, which is being issued in parts, called folios. Each folio includes a topographic map and a geologic map of a small area of country, together with explanatory and descriptive text.

**THE TOPOGRAPHIC MAP.**
The features represented on the topographic map are of three distinct kinds: (1) inequalities of surface, called relief, in places of elevation, depression, or mountain; (2) distribution of water, called drainage, as streams, lakes, and swamps; (3) the nature of soil, called contours, as roads, railroads, boundaries, villages, and cities.

**Relief**—All elevations are measured from mean sea level. The heights of many points are accurately determined, and those which are most important are given on the map in figures. It is desirable, however, to give the elevation of all parts of the area mapped, to indicate the outline or form of all slopes, and to indicate their grade or steepness.

This is done by lines of which, through points of equal elevation above mean sea level, the altitude interval represented by the space between lines being 200 feet, along each map. These lines are called contours, and the uniform altitude space between each two contours is called the contour interval. Contours and elevations are printed in brown.

The manner in which contours express elevation, form, and grade is shown in the following sketch and corresponding contour map (fig. 1).

**The sketch represents a river valley between two hills.** In the foreground is the sea, with a bay which is partly closed by a hooked sand bar. On each side of the valley there is a ridge, and the line of the front on the right a hill rises gradually, while from that on the left the ground slopes steeply, forming a precipice with this precipice the gentle slope from its top toward the left. In the map each of these features is indicated, directly beneath its position in the sketch, by contours.

The following explanation may make clearer the manner in which contours delineate elevation, form, and grade.

1. **A contour indicates a certain height above sea level.** In this illustration the contour interval is 50 feet; therefore the contours are drawn at 50, 100, 150, and 200 feet, and so on above mean sea level. Along the contour at 250 feet lie all points of the surf that are 250 feet above sea; along the contour at 200 feet, all points that are 200 feet above sea, and so on. In the space between any two contours are found elevations above the lower and below the higher contour. Thus the contour at 150 feet 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 hill at 1250 feet above sea; accordingly the contour at 650 feet surrounds it. In this illustration all the contours are numbered, and those for 250 and 200 feet are accounted for by being made heavier. Usually it is not desirable to number all the contours, and then the numbering of certain of them—say every fifth one—suffices, for the heights of others may be secreted by coming up or down from a numbered contour.

2. **Contours define the forms of slopes.** Since the term relief is unintentionally ambiguous, it should be used only to guide the trier as to areas, but not to locate the surface. The valley, for instance, the investor or owner who desires to ascertain the position and surroundings of property; save the surveyor in making surveys in locating roads, railways, and irrigation reservoirs and ditches; provide educational material for schools and homes; and be useful as a map for local reference.

**THE GEOLOGIC MAPS.**
The maps representing the geology of the region, by colors and conventional signs printed on the topographic map, show the kind and distribution of rocks on the surface of the land, and the structure sections above their underground relations, as far as known and in the order of their occurrence.

**KINDS OF ROCKS.**
Rocks are of many kinds. On the geologic map, they are distinguished as igneous, sedimentary, and metamorphic.

**Igneous rocks**—These are rocks which have cooled and consolidated from a state of fusion. Through rocks of all ages molten material has been poured into the earth. When it is spread in the form of masses, the figures or channels of various shapes and sizes, to or near to the surface. Rocks formed by the deposition of the molten material on the surface are called intrusive. When the rock occupies a fissure with the molten material poured out through them is called lava, and lakes often build up volcanic mountains. Igneous rocks thus formed upon the surface are called extrusive. Lava cool rapidly in the air, and acquires a glassy, or, more often, a partially crystalline condition in their outer parts, but are more fully crystalline in their inner portions. The outer parts of less flows are usually more compact and the explosive action often causes violent eruptions, causing ejections of dust, ash, and larger fragments. These materials, when aqueous, to form igneous brecia, agglomerates, and tuffs. Volcanic ejecta may fall in bodies of water or may be carried into lakes or seas and form sedimentary rocks.

**Sedimentary rocks**—These rocks are composed of the materials of older rocks which have been undergoing erosion for millions of years, or of volcanic ejecta which have been carried to a different place and deposited. The chief agent of transportation of rock debris is water in motion, including rain, snow, and the water of lakes and of the sea. The materials are in large part carried as solid particles, and the deposits are then said to be mechanical. Such materials, when derived from chemical, limestones, sandstones, and clay. Any one of the deposits may be separated for such, from the different materials are intermingled in many ways, producing a great variety of rocks. Another transportation agent is air in motion, or a third is ice in motion, or glaciers. The most characteristic of the wind-blown soils and sediments is that of the sandy soils known as desert sands. Another material may be air in motion, or a third is ice in motion, or glaciers. The most characteristic of the wind-blown soils and sediments is that of the sandy soils known as desert sands. Another material may be air in motion, or a third is ice in motion, or glaciers.

**Metamorphic rocks**—The origin of these rocks is ancient, but the processes of metamorphism are not understand, and they are considered to be of the same kind as igneous rock, but having undergone some process of change.

When for scientific or economic reasons it is desirable to recognize and map one or more specially developed parts of a variety of formation, such parts are called members, or by some other appropriate term, as beds.

**AGES OF ROCKS.**
Geologic time is that during which the rocks were made is divided into several epochs. Smaller time divisions are called epochs, and still smaller ones called Epochs. The age of a rock is expressed by the number of years it was formed, usually made up of layers or beds which can be easily separated. These layers are called strata. The height of the layers are said to be stratified.

The surface of the earth is not fixed, as it seems to be at first, but is very slowly rising or sinking, with reference to the sea, over wide expanses; and as it rises or 

**Appendix of formations less than 5 series is called a group.**
DESCRIPTION OF THE WINSLOW QUADRANGLE.

By A. H. Pardee.

INTRODUCTION.

LOCATION AND AREA.

The Winslow quadrangle lies mainly in the western part of Arizona, north of Arizona River. It is bounded by the Howe Rachel on the north, the Mohave county line on the east, and the Mohave county line on the west. The area of the quadrangle is about 45,000 square miles.

The quadrangle includes all of the counties of Mohave, Coconino, and Yavapai, and extends into the state of Nevada. It is divided into the following sub-divisions:

1. THE NORTHERN AREA.
2. THE SOUTHERN AREA.
3. THE EASTERN AREA.
4. THE WESTERN AREA.

DIVISIONS OF THE QUADRANGLE.

The northern area extends from the southern boundary of the quadrangle to the southern boundary of Arizona. It is divided into the following sub-divisions:

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The rocks of the Ozark region are represented by three systems from upper Achean to the Cambrian, with the possible exception of the Algonkian. The rocks constituting the Ozarkian basement are granite rocks of igneous origin. Most of the surface rocks are Cambrian, and the Ordovician age and consist mainly of sandstone and siltstone limestones. The maximum thickness of the rocks belonging to the Ozarkian age is shown below:

- Cambrian: Potosi-Chalet (Formation) 150 ft
- Ordovician: Cherokee (Formation including Sylvan sandstone member) 200 ft
- Silurian: St. Clair shales 25 ft

The data indicating that the portion of the section below the Inez limestone are taken from the reports of the Geological Survey of Arkansas, being derived from the records of a well at Cushman, Independence County. It may be noted that the rocks in the lower portion of the well are of Cambrian age.
stone, known as the Wellington sandstone. The total thickness of the formation ranges from about 150 feet east of Toln to about 300 feet in the north Appalachian part of the district. The upper part of the Fayetteville formation, which lies above the sandstone, where that is present, is exposed in the Eocene and is generally from 20 to 30 feet thick. It is a bed of shale ranging in color from green to bluish. The lower portion and contains numerous nodules, many of them 4 inches or less in diameter. Some layers are composed entirely of this rock, which is known as the “mudstone.”

The formation contains gypsum in thin veins and small crystals.

**Fayetteville sandstone.**—The Wellington sandstone, named from Wellington, in the Fayetteville quadrangle, constitutes a part of the Fayetteville formation, near its top, in the western part of the State. It outcrops on slopes in the northern part of the Window quadrangle and in the western part as far south as Evanville. In color it varies from a brown to a light gray. Thin beds of the sandstone are ripple marked, and their massive beds display cross-bedding. It is generally even bedded, and at many places can be quarried in beautiful, even-surfaced slabs of almost any thickness from 2 inches to 1 feet. The ordinary thickness is about 10 feet, but south of Prairie Grove it is about 40 feet thick and, being underlain by the weathering and rutting formation in the shale below, it breaks off in enormous blocks, leaving a steep escarpment. In the area of its outcrop this massive bed is separated from the various clay concretions found in the lower part of the shale. In the Eocene limestone perhaps the most prominent concretion is an ovoid, brown, hard, and firm in the various clay concretions found in the lower part of the shale. In the Eocene, the limestone is known as the Wellington sandstone and is generally from 20 to 30 feet thick. It is a bed of shale ranging in color from green to bluish. The upper portion and contains numerous nodules, many of them 4 inches or less in diameter. Some layers are composed entirely of this rock, which is known as the “mudstone.”

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**Fayetteville sands.**—All the rocks from the different formations in this region show that the Pittsfield limestone here is an important unit of the Mississippian series and is overlain by the Pennsylvania series of the Carboniferous system. The fossils are all of late Chester types and consist principally of species of brachiopods and bryozoa. Among the latest of these small shells, there are species of *Archaeoecis* and *Pseudocystodonta*.

**Pennsylvania series.**—The rocks of the Pennsylvania series constitute the great mass of the Bridgman limestones. To this series belong all the rocks above the Pittsfield limestone, and the Otisville so-called shale, which is divided into three classes, the Otisville and the Bridgman, named the county, and the Winlow.

**Morrove coupled.**

The Morris group constitutes the base of the Pennsylvania series, and everywhere within the Window quadrangle rests upon the Pittsfield limestone. It is known as the “Morris” and has been described as the “Pittsfield limestone.” At its upper limit, within this quadangle, it is everywhere overlain conformably by the Winlow formation. It occurs along the northern base of the Bridgman Mountains, in the bases of their immediate outcrops, and in the deep ravines on their southern slopes. In thickness it ranges from about 200 feet in the northern part of the quadrangle to 1000 feet in the south. The upper portion consists of shale and sandstone, and has been named by J. A. Taff the “Hale beds.” It is composed of the “Hale beds” which form part of the Window quadrangle. The upper, named the Boulton shale, consists of carboniferous sandstone, the Boulton limestone, the Brondwood, and the Boulton.

**Hale formation.**—The Hale beds, besides occurring in the Window quadrangle, is present in the Tallahatchie quadrangle, to the west, the Fayetteville quadrangle, to the north, and the Eureka Springs quadrangle, to the northeast. Its full extent is not yet definitely known, though it probably occupies most of the Bridgman Mountain area. Within the Window quadrangle it everywhere rests upon the Pittsfield limestone, and is conformably overridden by the Hale beds. It is exposed on the northern slope of the Bridgman Mountains over considerable areas where the Pittsfield limestone occurs as a thin wedge in the Window and Schrader branch, in the eastern part of the quadrangle; along the Lee and Fall creeks, in the central part of the quadrangle; and over a small area south of Mountain Fork and north of Lee Creek near the New York–Indian Territory line.

The thickness of the Zone ranges in thickness from about 100 feet to nearly 200 feet. Probably its thinnest part is in Sugar Hill, in the northern part of the quadrangle. In the lowest part of the quadrangle, in the Fayetteville quadrangle, it is probably about 50 feet thick, consists of sandy shale interbedded with thin layers of ripple-marked sandstone. The sandstone is variable in amount, and at some places almost entirely wanting. Above its basal portion the Hale consists of more or less massive carbonaceous sandstone. The relative abundance of the sandstone, which is very variable, nor are the beds persistent in character, but change within short horizontal distances. Small bodies of sandstone are penecontemporaneous with the sandy layers; and throughout most of the sandstone, especially in its massive portion, there are thin beds of shale or sand. Some beds are of a brown or sandy color, and a few are of a blue or greenish color, and a few are of a blue or greenish color. The sandstone is usually brown, composed of medium-sized grains, more or less rounded, and occurs in beds that range in thickness from 3 feet to more than 50 feet. The thick beds are remarkably similar in character, consisting of a yellowish sandstone, with some pebbles of the size of peas and smaller. Some bed lies near the base of the formation. In other parts of the Bridgman Mountains it usually ranges from 5 to 15 feet thick. Such layers are common in all the thin-bedded sandstones and cross-bedding in the more massive. These beds of sandstone, with the sandstone, form a series of similar encrinites and benches on the slopes. The sandstone, which constitute probably 75 per cent of the formation, is a rule black and carbonaceous, though less so than those of the Mesozoic series. Some of the beds in the upper middle part are more or less sandy, micaceous, and brown or brown colored, with streaks of gray or white. Lenses of the limestone above mentioned occur at several places in the summation of the western part of the Window quadrangle, but the details of their occurrence are not known. The thickest lenses observed on the south slope, away from the Window quadrangle, is a half mile west of the Cedar Creek, a small tributary of the Eden Creek. This is an elongated lens of black mudstone, and is in place in the Eocene formation. In weathering the sandstone-colored portion passes to a brownish-white, which may be given off in some cases by distinguishing it from one of the beds of the Bridge formation. Being black, it is not often observed by men, but it is usually found by careful search at the proper horizon. It was not found, however, on Sugar Hill, where the sandstone of the quadrangle and was seen at only two places in the hill just west of Boones. In some localities it is overlain by a few feet of sandstone, and at such places a slight ledge shows its exact location on the hillside.

**Hale formation.**—In the Window formation the Hale formation is abundant and specifically the same, but in the matter of variety it is an important unit of the Mississippian series, but the number of species occurring in the Hale being small in comparison with the number found in the other formations.

A rather striking and widely distributed species of the Bridge formation is *Pseudoecis reticulata*, the fossil name of the bed—"Pennsylvanian limestone"—was derived. A submersal, horned corals, forming small masses, greenness, and belonging to the family *Morphosidae* of *Paleoecis hoactli*, is perhaps the most common and characteristic fossil of these limey limestones. Certain layers of the Bridge formation are locally filled with small gasteropods and pelecypods of many kinds; others are made up almost entirely of delivious branching and calcareous species of bryozoa. While the fauna of these limestones is in large part new to science, critical comparisons with described species show clearly that it is more closely related to well-known Pennsylvanian faunas than to any known fauna in the Mississippian series. The fact that some forms of Pennsylvanian age have been hitherto almost unknown imports unusual interest to their occurrence in the calcarious portion of the Window formation. At the same time it explains their strange aspect when compared with described fossils.

**Window formation.**—The Window formation is named from the town of Window, situated at the summit of the Bridgman Mountains, on the St. Louis and San Francisco Railroad. It rests upon the Hale beds, and the rocks belonging to them are the only ones that outcrop along the entire summit of the Bridgman Mountains and on the southern slopes, except in the deepest ravines, where the rocks have been exposed. Rocks of this formation also occur on the tops of the outcrops immediately north of the Bridgman Mountains. Its total thickness in the Window quadrangle is indeterminable, but approximate 2300 feet.

**Charon.—**The formation consists of alternating beds of sandstone and shale, with a thin lens of limestone. The sandstone is usually brown, composed of medium-sized grains, more or less rounded, and occurs in beds that range in thickness from 3 feet to more than 50 feet. The thick beds are remarkably similar in character, consisting of a yellowish sandstone, with some pebbles of the size of peas and smaller. Some bed lies near the base of the formation. In other parts of the Bridgman Mountains it usually ranges from 5 to 15 feet thick. Such layers are common in all the thin-bedded sandstones and cross-bedding in the more massive. These beds of sandstone, with the sandstone, form a series of similar encrinites and benches on the slopes. The sandstone, which constitute probably 75 per cent of the formation, is a rule black and carbonaceous, though less so than those of the Mesozoic series. Some of the beds in the upper middle part are more or less sandy, micaceous, and brown or brown colored, with streaks of gray or white. Lenses of the limestone above mentioned occur at several places in the summation of the western part of the Window quadrangle, but the details of their occurrence are not known. The thickest lenses observed on the south slope, away from the Window quadrangle, is a half mile west of the Cedar Creek, a small tributary of the Eden Creek. This is an elongated lens of black mudstone, and is in place in the Eocene formation. In weathering the sandstone-colored portion passes to a brownish-white, which may be given off in some cases by distinguishing it from one of the beds of the Bridge formation. Being black, it is not often observed by men, but it is usually found by careful search at the proper horizon. It was not found, however, on Sugar Hill, where the sandstone of the quadrangle and was seen at only two places in the hill just west of Boones. In some localities it is overlain by a few feet of sandstone, and at such places a slight ledge shows its exact location on the hillside. Lenses of the limestone above mentioned occur at several places in the summation of the western part of the Window quadrangle, but the details of their occurrence are not known. The thickest lenses observed on the south slope, away from the Window quadrangle, is a half mile west of the Cedar Creek, a small tributary of the Eden Creek. This is an elongated lens of black mudstone, and is in place in the Eocene formation. In weathering the sandstone-colored portion passes to a brownish-white, which may be given off in some cases by distinguishing it from one of the beds of the Bridge formation. Being black, it is not often observed by men, but it is usually found by careful search at the proper horizon. It was not found, however, on Sugar Hill, where the sandstone of the quadrangle and was seen at only two places in the hill just west of Boones.
Subdivision.—It was not found practicable to divide the formation in the Window quadrangle, because of the general similarity of the rocks from the base to the top, yet it is elsewhere subdivided into two parts, which here pass imperceptibly into each other. The upper part may correspond to the Akins shale member of the Window, described in the Tahlequah fields.

The lower portion of the Window contains most of the sandstone of the formation, and the sandstone comprises it in lighter color and flintier from base to summit of the upper part. The base of the Window formation consists of 20 to 60 feet of massive sandstone underlain by about 20 feet of slaty sandstone. These strata is the only shaly sandstone present a massive appearance, but on exposure the bedding planes are developed and the shaley appearance follows. The rapid weathering of this rock and the shale beneath it undermines the massive layers and forms the steepest and most pronounced escarpment of the region, which conspicuously marks the dividing line between the Morrow group and the Window formation.

The mode of occurrence of the basal layer of the sandstone, with its easily shaly beneath, is repeated in the several sandstones beds above it. In none of the others is the massive portion as thick, however, as in the basal bed, except in certain beds about 100 feet thick in the upper portion along Freg Bayou, just south of Lamar. As beds of this prominence are not exposed on the river, it appears that at the point mentioned they are the result of local thickening.

The thickness of the lower portion is not determined, but it probably exceeds 1500 feet. There are 900 feet exposed northwest of Hillaby, near the eastern border of the quadrangle. In Looked Mountain thickness is at least 1000 feet. A mile south of Redy, near the railroad, a well was drilled to the depth of 140 feet, apparently without reaching the Floyd formation beneath.

The upper portion of the Window formation is the surface rock in the southeastern part of the quadrangle from Floyd Bayou southeastward, extending westward beyond Redy, on the railroad. It also occurs south of Waller and east of Lee Creek, in the southeastern part of the quadrangle. It consists of thick beds of dark carbonaceous shale containing dark color and some black slate. The amount of sandstone is relatively smaller than in the lower division. Coal from 3 to 8 inches thick is found in the shale but it has not been observed at a sufficient number of points to determine whether it occurs at only one horizon or at more than one. The thickness of this subdivision within the Window quadrangle is not determinable from present data, but it probably reaches 900 feet.

STRUCTURAL GEOLOGY.

STRUCTURE OF THE DEEPER EINVALID.

Structure of the Ouachita Plateau.—The general structure of the Ouachita plateau is simple. As stated above, the structural center of the Ouachita upfold is the St. Francis Mountains. From this structural center the rocks dip to the north, west, and south. The dip is at most places so slow that it cannot be detected in single exposures, but it is sufficient to carry the older rocks, which outcrop around the central portion of the upfold, for beneath the surface in northern Arkansas.

Near the northern base of the B enthus formation is common. A line of faults extending in a general east-west direction runs from near the western border of Arkansas to the eastern border of the Ouachita plateau. The exact location of this line is not known, but it appears to be near the eastern edge of the Ouachita plateau. This line is also marked by a series of anticlines and synclines, which form the structure of the northern half of the quadrangle that of a low anticline.

MONOPOCAL FORMATION.

Frico monocline fold.—A pronounced monocline fold extends south from east of Mountain Mission, near the western border of the quadrangle. Another, of equal importance, extends north from Whitehead Hollow. Each of these folds is about 2 miles wide and the dip probably nowhere exceeds 10°. The two monocline folds appear to unite in the valley of Black Fox Creek, from which they extend as one fold to the eastern border of the quadrangle. This structural feature is well marked at the head of the railroad above the town of Frico and is therefore called the Frico monocline. On the main grid map these folds can be traced by lines of lower formations, such as the Pitkin and Halls, in the deep ravines south of the divide, where these lower rocks have been cut into along the tops of the folds and views are thus exposed over small areas, as shown on the map.

SYNCLINES AND ANTICLINES.

Near the middle of the western portion of the quadrangle there is a narrow triangular-shaped syncline, formed by the northern limb of the Frico monocline fold, and the southern limb on the other side of the syncline that of a low anticline.

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HISTORICAL GEOLOGY.

GEOMORPHIC REGIONS

Alluvial valleys, or the regions of the Ark Basin were formed by the flood waters of the Arkansas River, the general direction of which was from the east to the west.

Photospheric regions.

Oscillations of the region. - The forces which produced the above-mentioned uplift and which resulted in the folding of the rocks along east-west lines in the vicinity of the Arkansas River, caused them to be uplifted vertically upward so as to leave the rock beds practically horizontal in the Ozark region.

However, it should be remembered that a monocline fold, which has already been described under the heading "Structural geology," extends southward from the western terminus of the Missouri Fold to the southern base of the Ozark Mountains. The present altitude of the rocks is not the result of a single impulse that first lifted them from beneath the water and, for at least twice since the first uplift the region subsided sufficiently to bring the waters of the Gulf of the St. Lawrence in again, resulting in the water's boundary being fixed in the Gulf as far north as the mouth of the Ohio River. This subsidence occurred during Tertiary time and the following uplift forced the water farther back to about its present position.

The structure of the Ozark region is the composite one resulting from the initial uplift from the sea and its subsequent movements. This is the case in all the Ozark mountains, which are rather of the same height as the plains around them, and which are so nearly horizontal, that it is concluded that the forces producing the uplift acted in a vertical and not in a horizontal direction. There is little of the lateral thrust that tends to produce folds. The region on a whole was lifted bodily upward. There is reason for believing that by a late movement the Ozark Mountains were forced up higher than the country further north. This is indicated by the present height of those Ozark mountains, which is greater than that of any other part of the Ozark uplift, by the drainage, which is north and south from the divide; by the deep and youthful character of the canyons through which the streams flow; and by the drainage centered into White River and westward into the Arkansas, along the north base of the mountains. It is therefore thought that the Ozark Mountains were not only the first, but also the largest, part of the region of the Ozark to receive the normal load of the land, or in other words, to be uplifted.

Erosion of the region. - Had the region not suffered after uplift, it would have stood much higher than it now stands, and the surface of the Window quadrangle would have been a flat, broad area, with its summit humblows feet lower than its northern one; but no sooner was the region lifted out of the sea than streams began to form on its surface. The lines of drainage at first developed were White River to the north and Arkansas River to the south. From these main streams tributary streams gradually cut back toward the divide, many of them having now passed beyond that line, so that their heads interlock in the manner already described. From these smaller streams even smaller ones have been developed in such numbers that the region is now completely dissected by them.

This has been much more effective in the region north of the Boston Mountains than in the mountainous themselves, for it has reduced a large part of Missouri and northern Arkansas to a comparatively smooth surface, leaving the Boston Mountains standing up above the line thus formed, their front forming a rather bold escarpment. The summits of many of the outlying peaks of the Boston Mountains stand several hundred feet above the general level of the area about them, furnishing incontrovertible evidence of a part of the erosion which has taken place over the area.

It appears that the origin of the Ozark region is not far from the time that the Great Basin was formed. The preservation of the Ozark region from the marked erosion which has affected the region to the north and west is due to the fact that the Ozarks were never so deeply dissected, as that of a flat plain. The divide was located by the structure, and only the boundaries of the streams flowing south through the Boston Mountains.
along the small streams the rocks of the antline are least removed. Their preservation in place and their occasional appearance in the gravel of which they are in part composed, and which is able to withstand erosion for a long time. Most important among these sandstone beds is the heavy ledge at the base of the Winnebago formation. The steep slopes within the Window quadrangle caused the streams that flow northward and southward from the divide to cut down their beds rapidly, with much tilt or lateral cutting, a process which has formed the steep, narrow valleys of the region. Soft and hard rocks have given rise to numerous small waterfalls and rapids, which appear along the course of each stream at the outcrops of the hard layers.

Streams develop easily in the direction of the dip and along the strike of rocks, but with difficulty in other directions. This is well exemplified in the streams of the southern part of the Window quadrangle. By reference to the topographic map it will be seen that the main streams south of the divide flow nearly southward, with here and there a slight extending outward or westward. The northward streams develop more slowly, with the strike of the southward-dipping rocks. The abrupt turn of Cove Creek to the east, north of Grapevine Key, is caused by the reverse of the strike, the southward extension of the lithic rocks along the Frisco monocline. The influence of the strike on the course of streams is observed also in the courses of Walker Creek and Cedar Creek, which flow west of Redy, in those of McCulin Branch west of Chester and Jack Creek south of Patrick Mountain, and in the lower part of Little Malberry Creek. The tendency of streams to follow fault lines is shown in Cove Creek from its source to its juncture with Bubbling Brook. It then continues northward along the strike to reach Malberry Creek, and in the lower part of Garrett Hollow.

The effect of structure is shown not only in the main streams of the region, but is even more marked in their tributaries. It is interesting to note that the northern tributaries of Lee Creek, Walker Creek, Cedar Creek, and Little Malberry Creek are numerous and comparatively strong and well developed, while those from the south are few and feeble. This condition is due to the general southward dip of the rocks, permitting streams flowing in that direction to develop with ease but prohibiting the development of large northward-flowing streams.

ECONOMIC GEOLOGY.

MINERAL RESOURCES.

The resources of the Window quadrangle consist of limestone, clays, a small amount of coal and possible of natural gas and oil, and sands, water, and timber. Of these, the most important to the resource development of the region is the limestone and the only point at which clay is utilized is near Prairie Grove, where one plant uses it for manufacturing brick and tile. It is probable that the limestone and clay which occur in association at the northern base of the Boston Mountains would make good cement. Coal is mixed only for local blacksmithing.

LIMESTONE.

The Pittkin limestone occurs in sufficient amounts at all points of its outcrop to permit its being quarried. It is a fairly pure limestone, free from impurities in large quantities, the region, they may yet be discovered in deposits large enough to be profitably extracted. Small amounts may also be found by surface prospecting near Morrow post-office. Prospecting for zinc and lead within the Window quadrangle has given the most promising places along those parts of the White River fault, Price Mountain fault, and Evanville fault which are most clearly defined by these three large faults. The tops of these surface. These tops can be located by reference to the local geologic map.

COAL.

The Coal in the Floyd shale—In the Floyd shale at a few places there is a bed of coal, such as that from the Pittkin, owing to the large amount of slina that is included in these formations—in one or a few inches thick, in another, of a fragment of water from the Window formation is soft, coming from sandstone.

Mineral springs—About 15 miles northeast of Dam, a strong stock, which has been inclined and is locally used for medicinal purposes. It issues from the Winnebago formation, at a head-waters, in the northwestern part of the quadrangle, a similar spring issues from the Wendington sandstone.

Gens of the water—The flowing in the streams of the Window quadrangle is practically utilized except for domestic and stock purposes. The city of Fayetteville, south of the quadrangle, receives its water supply from West Fork of White River, the water being pumped 2 miles into a reservoir on a hill overlooking the city. The water supply of Van Buren, south of the quadrangle, is procured from Lee Creek. Many of the springs on the hills could be utilized for irrigating small vegetable and fruit farms, and water could be piped from them into houses below, or forced by hydraulic masts to those above.

Soil.

Practically all the soils within the area are resid-ual, and they have been formed by the disinte- gration of the rocks on which they rest. Only narrow strips along the lower parts of creek, Frog Bayou, and Malberry river are composed of alluvium.

Soil of the Boone formation.—The soil overlying the Boone formation consists of a mixture of clay and silt fragments, the insoluble residue of that formation. In most places it is fairly productive, but is apparently due to a prevention of evaporation of the soil by the loose silt fragments of the surface.

Soil of the Fayetteville formation.—The disinte-gration of the Fayetteville shale, which covers a considerable portion of the northern portion of the area, is much finer in texture than the silt, free from stone debris. This soil is cold and wet, and would doubtless be much improved by under-draining.

The bench of the north slopes at the base of the Pittkin limestone is of unfruitful material, the soil being the product of the joint weathering of the upper slopes of the Fayetteville formation and the limestone above, but as the width of this bench does not exceed 200 yards, it is adapted only to small vegetable and fruit farming.

Soil of the Morrow group.—The soil overlying the Morrow group, consisting of the Prairie City shale, sandstone, and limestone, forms a soil of excellent quality when it is so situated as to permit the drainage of excess water, as it does over the majority of the considerable areas in the northern part of the quadrangle. The unusually rich soil about Boulve is underlain by a large mass of shale, which distin-guishes it from all others of the region. The Floyd shale, which constitutes the upper part of the group, forms a poor, unproductive soil.

Soil of the Window formation.—As a rule the northern slopes above the Floyd shale are too steep and their soil is too poor and rocky to be worth much as agricultural land. The soils at the top and on the south slope of the Boston Mountains are formed by the disintegration of sandstones and shales, and although fairly productive, are not rich. Their partial fertility is due primarily to the dressing away of the humus by the hot rays of the summer sun. The narrow flood plains along the lower parts of Lee Creek, Frog Bayou, and Malberry River are, of course, productive.

The area was formerly covered by an excellent growth of timber, but all timber of commercial value is rapidly being removed. The principal varieties are oak, hickory, and pecan. Some walnut is found. The bench on the north slope at the base of the Pittkin limestone carries a good deal of grassland, but the north slopes have rich growths of black beech, this is rapidly being removed and shipped for posts. Some pine and a small amount of scrub grow on the south slopes.

January 1907.
COLUMNAR SECTION

GENERALIZED SECTION FOR THE WINLLOW QUADRANGLE.

Table: Formation Names and Characteristics

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<th>Formation</th>
<th>Character of Rocks</th>
<th>Character of Topography and Soil</th>
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<tr>
<td>Window formation</td>
<td>Sandy conglomerate, in places coal bearing, alternating with rather massive beds of brown to gray silicaceous sandstone.</td>
<td>Slopes below the Window formation. Poor soil.</td>
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<tr>
<td>Floyd shale</td>
<td>Dark shale interbedded with thin layers of sandstone.</td>
<td>Good soil.</td>
</tr>
<tr>
<td>Haywood formation</td>
<td>Calcareous sandstone, pitted on weathered surface by small cavities, with interbedded limestone beds.</td>
<td>Well-rounded hills and hill slopes. Good soil.</td>
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<tr>
<td>Pikill limestone</td>
<td>Light gray to brown sandstone, locally showing ripple marks and cross-bedding.</td>
<td>Low sandstone bluff, producing a large amount of drifts. Base of slopes and gullies in northern and western parts of quadrangle. Good soil when mixed with overwash.</td>
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<tr>
<td>Fayetteville shale</td>
<td>Light gray sandstone, containing small cavities and limestone interbedded near the base.</td>
<td>Level areas in the northeastern part of the quadrangle. Good soil.</td>
</tr>
<tr>
<td>Boose formation</td>
<td>Light gray sandstone, containing chert in beds and lenses.</td>
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TABLE OF FORMATION NAMES

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<th>Formation</th>
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Notes:
- In 1946 a reworking of the Haywood sandstone, the Geological Survey of Arkansas confused the nomenclature and stratigraphic positions of these formations.

*For an explanation of the abbreviations used in the table, see the survey's Monograph on Arkansas Geology, Vol. 10, 1946.
As sedimentary deposits or strata accumulate the younger rock on those that are older, and the relative age of the deposits may be determined by observing their positions relative to each other in sections except in regions of intense disturbance; in such regions sometimes the beds have been reversed, and it is often difficult to determine their relative ages from their positions; then fossils, or the remains and imprints of plants and animals, indicate which of two or more formations is the oldest.

Seafloor sediments often contain the remains or imprints of plants and animals which, at the time the strata were deposited, lived in the sea or were washed from the land into lakes or seas, or were buried in surficial deposits on the land. Such rocks are called fossiliferous. By studying fossils it has been found that the life of each period of the earth's history was a great extent different from that of other periods. Only the genera and families of marine life existed when the oldest fossiliferous rocks were deposited. From time to time more complex kinds developed, and as the simpler ones lived on in modified forms life became more varied. But during each period there lived peculiar forms, which did not exist in earlier times and have not existed since; these are characteristic types, and they define the age of any bed of rock in which they are found. Other types passed out of period to period, and thus linked the systems together, forming a chain of life from the time of the oldest fossiliferous rocks to the present. While two sedimentary formations are remote from each other and it is impossible to observe their relative positions, the characteristic fossil types found in each of them may determine which was deposited first. Fossil remains found in the strata of different areas, provinces, and continents are of the most important means for combining local histories into a general earth history.

It is often difficult or impossible to determine the age of an igneous formation, but the relative age of such a formation can sometimes be ascertained by observing whether the strata or other sedimentary formations of known age are cut by the igneous mass or are deposited upon it.

Similarly, the time at which metamorphic rocks were formed from the original mass is shown by their relation to adjacent formations of known age; but the age recorded on the map is that of the original mass and not of their metamorphism.

Colors and patterns.—Each formation is shown on the map by a distinctive combination of color and pattern, and is identified by a special letter symbol.

The various geologic sheets:

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

The legend is also a partial statement of the geologic history. In its formations are arranged in the order of their development, starting with the original—sedimentary, igneous, and crystalline of unknown origin—and within each group they are placed in the order of age, as far as is known, the youngest at the top.

The formations are shown at the scale of 75,000,000, covering a distance of 1,000,000 miles, or approximately 800,000 miles.

Structural geology map.—This sheet shows the relations of the formations to the topographic features and to the geologic formations. The formations which appear on the structural geology map are shown on the map by faint color patterns. The result, thus printed, affords a subdued background upon which the shapes of the formations may be emphasized by strong colors. A line symbol is printed at each mine or quarry, accompanied by the name of the mineral or ore that is mined or quarried. For regions where there are important mining districts or where strata are not exposed, groups of mines or quarries are shown on the map by faint line patterns, to show additional economic features.

The plate in fig. 2 presents toward the lower land an escarpment, or front, which is made up of bedrock, forming the cliffs, and shales, constituting the slopes, as shown at the extreme left of the section. The broad belt of lower land is traversed by several ridges which are seen in the section to correspond to the outcrops of a bed of sandstone that rises to the surface. The upturned edges of this bed form the ridges, and the intermediate valleys follow the outcrops of limestone and calcareous shale.

Where the edge of the stratum appears at the surface their thickness can be measured and the angles at which they dip below the surface can be observed. Thus their positions underground can be inferred. The direction that the intersection of a bed with a horizontal plane will take is called the strike. The inclination of the bed to the horizontal plane, measured at right angles to the strike, is called the dip.

Arches are frequently curved in troughs and arches, as shown in figs. 2. The arches are called abutments and the troughs abutments. But the abutments, shales, and limestones were deposed beneath the sea in nearly flat strata; that they are now bent and folded is proved by forces that have thrust a part of the formation above the rest. When this has happened, the arches and troughs are wrinkled along certain zones. In places the strata are broken across and the forces have slipped past each other. Such breaks are termed faults. Two kinds of faults are shown in fig. 4.

On the right of the sketch, fig. 2, the section is composed of arches which are traversed by masses of igneous rock. The strata are much contorted and their arrangement underground cannot be inferred. Hence that portion of the section delineates what is probably true but is not known by observation or well-founded inference.

The section in fig. 3 shows three sets of formations, distinguished by their different ground relations. The uppermost of these, seen at the left of the section, is a set of sandstones and shales, which lie unconformably upon the older strata. The intermediate strata are now high above the sea, forming a plateau, and their change of elevation shows that a portion of the plateau has been raised from a lower to a higher level. The strata of this set are parallel, a relation which is called conformable.

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

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

The third set of formations consists of crystalline schists and igneous rocks. At some period of their history the schists were planked by pressure and traveled by emplacements of molten rock. But the pressure and intrusion of igneous rocks have not affected the overlying strata of the second set. Thus it is evident that a considerable interval elapsed between the formation of the schists and the beginning of deposition of the strata of the second set. During this interval the schists suffered measurable metamorphoses; they were the scene of eruptive activity; and they were deeply eroded. The dip of the first and second sets is another, and the unconformity marks a time interval between two periods of rock formation.

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

Columnar section sheet.—This sheet contains a concise description of the sedimentary formations which occur in the quadrangle. It presents a summary of the facts relating to the character of the rocks, the thickness of the formations, and the order of accumulation of successive deposits.

The rocks are briefly described, and their characters are indicated in the columnar diagram. The thickness of formations are given in figures which state the least and greatest measurements, and the average thickness of each 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—the older formation at the bottom, the youngest at the top.

The intervals of time which correspond to each column of strata are shown at the top of the columnar diagram by means of the appropriate scale. The thickness of the formations represented in the columnar diagram are not in all cases proportional to the thickness of the strata in the quadrangle. The strata may be thick or thin, and the same thickness may be shown in the columnar diagram by means of a line equal to the thickness of the strata in the quadrangle.

Charles D. Walcott

Revised January, 1904.
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