

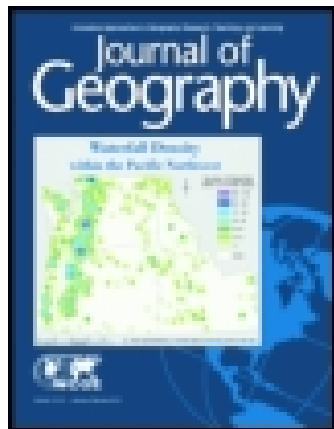
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### Canyons of Southeastern Colorado

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wind soughs and moans, and whose forest floor is carpeted by a dense, damp mat of mosses and pine needles. These mighty forests hold such absolute sway that it seems as though nothing could dislodge them; but the pioneers of the third wave now begin to creep to the north and insinuate themselves, as a wedge, along the fertile valleys. These flat-leaved deciduous trees appear to make but little advance with each advance of the procession, it becomes more evident that the third wave is slowly moving on with its oaks, hickories, ashes, maples, and walnuts, and a host of shrubs and herbaceous plants with their varied animal associates, those types which characterize the northeast to-day. Along the prairie peninsula there comes a small delegation from the Great Plains, and up the Mississippi valley a vast assemblage from the southeast, making up the great bulk of the fauna and flora of northern United States, that show southern affinities.

## CANYONS OF SOUTHEASTERN COLORADO

BY WILLIS T. LEE, TRINIDAD, COLO.

MUCH has been written of the canyons of Colorado and many photographs published illustrative of their beauty and sublimity, as well as of their geographic features. But in the public mind the canyons of Colorado are located either in the mountains or in the plateau region west of the mountains. Few people seem to know that canyons of any notable depth exist east of the mountains in what is commonly known as the Great Plains. But there are canyons in the Great Plains many miles in length and hundreds of feet in depth. While they are not so extensive as some of the better known canyons of the plateau region west of the mountains, they are of no mean proportions and their grandeur and beauty well repay the effort necessary in gaining access to them.

These canyons are found east of the mountains in the southern part of Colorado and the northern part of New Mexico, and extend eastward in the case, at least, of the Río Cimarron, somewhat beyond the eastern boundary of New Mexico. The two principal canyons of northern New Mexico are the Río Cimarron and the Canadian.

There are two Cimarron rivers in New Mexico. The one referred to here is near the northern border of the territory and flows eastward through Oklahoma and Kansas to the Arkansas river. The principal canyon of southeastern Colorado is the Purgatory. There are several smaller ones such as the Huerfano and the Apishapa but I shall confine myself in the present paper mainly to the Purgatory and its branch canyons.

The general elevation of the Great Plains is well known. Along their western border, the elevation is about a mile above sea level. Over the greater part of the plains region the elevation is too slight

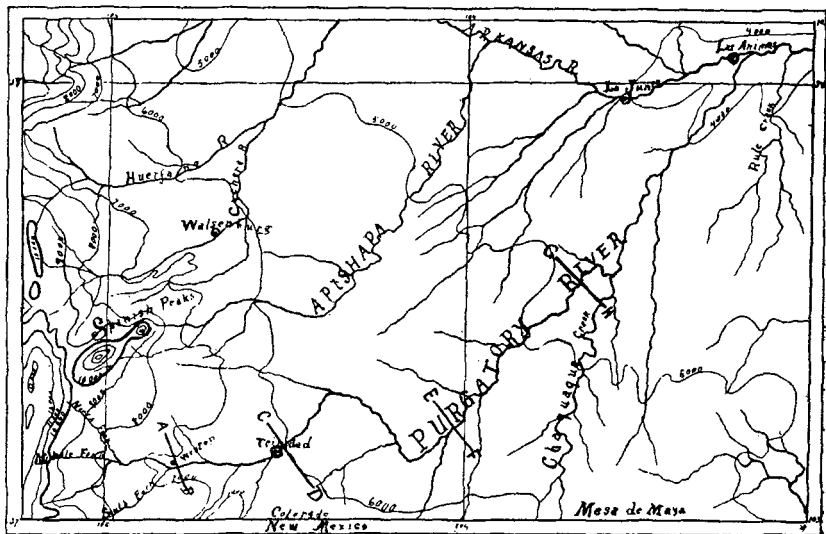


FIG. 1. MAP OF A PART OF SOUTHERN COLORADO SHOWING THE REGION IN WHICH THE PURGATORY, APISHAPA, AND HUERFANO RIVERS HAVE CUT CANYONS. (Contours taken from U. S. G. S. topographic sheets.)

to allow of canyon cutting. But in southeastern Colorado and northeastern New Mexico there is an extensive uplift which has raised the surface far above the general level of the plains. This uplift has been referred to by R. T. Hill in his *Physical Geography of the Texas Region* \* as a series of benches which he calls the Mesa de Maya and the Las Vegas plains. The surfaces of these plains and mesas lie from 6,000 to 10,000 feet above sea level, and include the canyons under consideration. I shall for the present confine

\* U. S. Geol. Surv. Topographic Atlas, *Physical Geography of the Texas Region*, p. 8.

my attention to those found north of the crest of this uplift, leaving those in the southern slope for later consideration.

The forms of the canyons vary according to the rock formations penetrated by them and for this reason it will be necessary to sketch briefly the simpler facts of the geological conditions. The trunk streams rise in the crystalline area of the Sangre de Cristo Mountains and cut through the upturned formations in geological order from the Carboniferous to the Tertiary. Owing to the rock structure the rivers on entering the plains region cut these formations in reverse order from the Tertiary rocks to the Red Beds, which are of Jura Trias age. Considering the formations concerned in order from top downward—the Tertiary beds are found only on the highlands and do not properly enter into the compositions of the canyon walls. The Laramie is composed of sandstones and shales of varying hardness in which valleys of greatly varying form are cut. Underneath the Laramie lies the Fox Hills sandstone, a resistant layer which forms prominent canyon walls and escarpments. This is underlain by the soft Pierre shales, 1,200 to 1,300 feet thick, and the limestones and shales of the Niobrara and Benton formations, 600 to 700 feet thick. The next formation, the Dakota sandstone, 300 feet thick, here as elsewhere, is exceedingly resistant and usually forms precipitous walls wherever dissected by the streams. Beneath this sandstone lie the soft Morrison shales (Atlantosaurus beds) 200 to 300 feet thick, which in turn are underlain by the Red Beds. The upper series of the Red Beds, 175 to 200 feet in thickness is massive and resistant and forms rugged canyon sides.

For convenience in the description of the Purgatory river and its canyons, I shall divide its course into four divisions: (1) The head waters or mountain division extending from the sources of the various branches to the place where these branches enter the plateau region near the town of Stonewall. (2) The division included in the high plateau east of the mountains and extending from Stonewall to Trinidad, a distance of about 40 miles. (3) The broad open plain between Trinidad and the point 25 miles east of Trinidad where the river cuts through the Dakota sandstone. (4) The canyon proper extending from 25 miles east of Trinidad nearly to the Arkansas River, a distance of something like 70 miles, taking no account of the windings of the river. It is this last division which presents the greatest interest not only on account of the great variety of topographic forms and the beauty of form and color, but also because here is found a typical canyon.

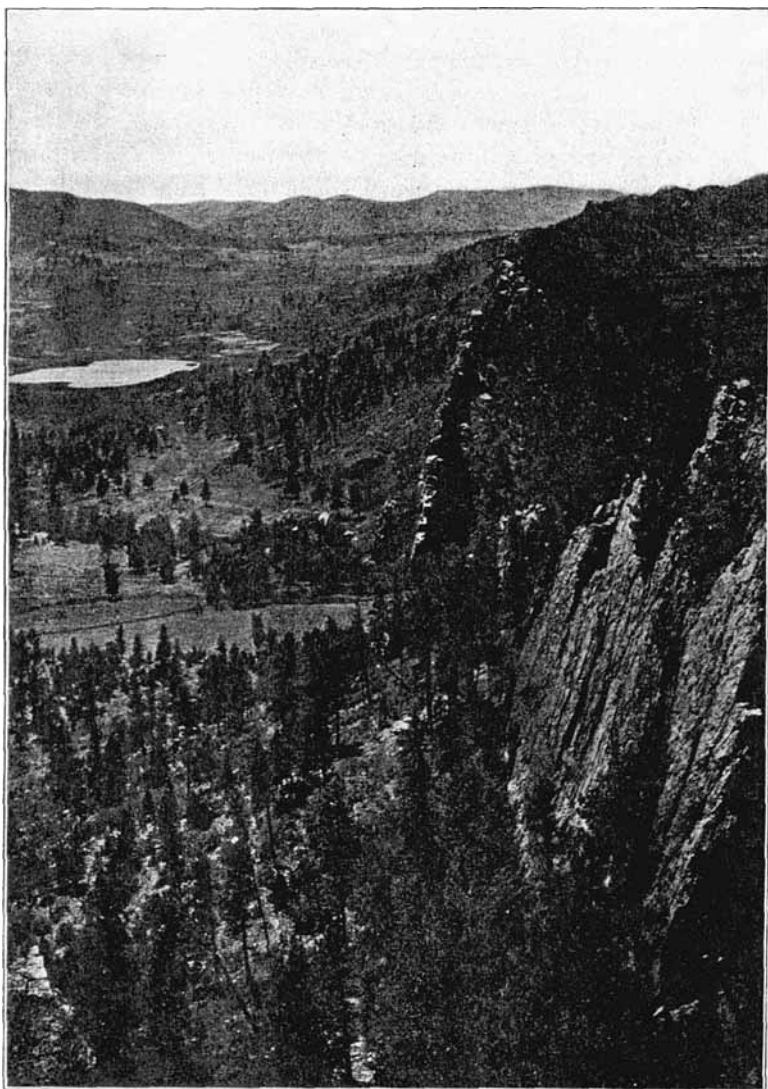


FIG. 2. THE "STONEWALL," SHOWING THE RIDGE FORMED BY THE UP-  
TURNED DAKOTA SANDSTONE WHICH APPEARS ON THE SERRATE CREST. The  
"Park" at the left is formed by the erosion of the Cretaceous shales, that at the  
right of the wall by the erosion of the Morrison shales. (Photograph by Walter  
Dearden.)

1. There are three main branches of the Purgatory, the South Fork, the Middle Fork and the North Fork. These unite shortly after leaving the foot hills proper. The canyons in which these streams flow are in no way remarkable. They are deep narrow V-shaped valleys such as are to be found throughout the mountain region.

Perhaps the most unusual and noteworthy feature in this part of the river's course is what is locally known as the "stone wall." The sedimentary formations are so strongly upturned along the foot-hills that they stand nearly vertical. The Dakota sandstone resting as it does, in its upturned condition, between the soft Morrison shales

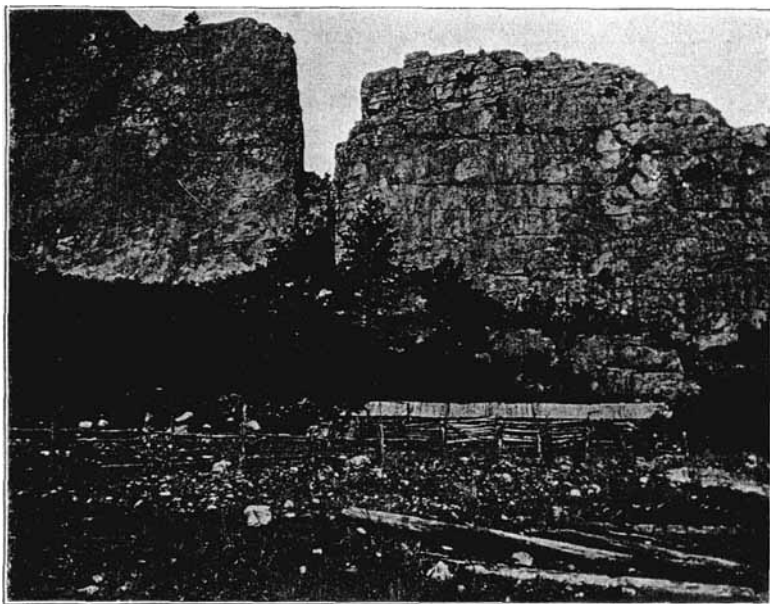


FIG. 3. THE "STONEWALL" NEAR THE TOWN OF STONEWALL, COLORADO.

on the one hand and the soft shales of Colorado and Montana age on the other has been left in the process of erosion as a prominent wall. The Morrison shales west of the wall—stratigraphically below—have been worn away leaving a more or less continuous depression. The equally soft shales to the east have also been deeply eroded and long "parks" formed parallel to the wall. The result is that a ridge whose crest is the serrate edge of the Dakota sandstone extends along the mountain front for a distance of about forty miles. In other localities the Dakota sandstone is not so nearly vertical and

is known as the Dakota "hog-back." Along the crest of the ridge in the region under consideration the Dakota rises as a sheer wall to a height in places of several hundred feet. Figure 3 is a photograph of the "stone wall" taken near the town of Stonewall where the Middle Fork of the Purgatory emerges from the foothills.

2. The second division of the river's course is perhaps less interesting than the first division. The canyon is a V-shaped valley whose sides are more or less rugged according as the layers of the Laramie formation through which it cuts happens to be hard or soft. In general the valley sides are not so rugged but that they are clothed with vegetation. This part of the course, about forty miles in length, lies within the dissected plateau situated east of the mountains. The streams have penetrated the Tertiary sands and gravels (leaving remnants of them on the hill tops north of the river) and the extrusive sheets of basalt which still cap the mesas to the south and east; they have penetrated the Laramie which is 800 to 2,500 feet thick and have cut, in the vicinity of Trinidad, 550 feet below the base of the Laramie. In this distance of forty miles there is a fall of about 2,050 feet making an average gradient of 51 feet to the mile.

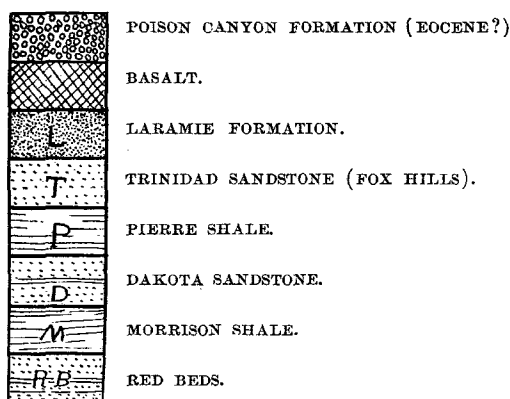


FIG. 4.

It may be of interest in this connection to know that the coal lands dissected by the Purgatory and its branch streams in this plateau region are probably the richest in Colorado. Coal is extensively mined in this region and many new mines are opening at the present time. The coal lands capped by the Tertiary formation north of the river and by the extrusive sheets of basalt south of the river form the high plateau extending eastward from the mountains.



Near the town of Sopris, a few miles west of Trinidad, the river descends into a narrow canyon the walls of which are maintained by the hard stratum of Fox Hills sandstone. The walls at Trinidad rise 550 feet above the river bed. The lower 400 feet of the walls are made up of Pierre shale. The highlands to the northwest are capped with Tertiary sands and gravels and those to the south and east with extrusive sheets of basalt. The basalt cap and possibly the Tertiary as well, mark the original surface, so far as known, upon which the present streams began to work. The surface of the basalt sheet is 3,636 feet above the river bed at Trinidad. This figure may be taken as a measure of the downward cutting which the Purgatory has accomplished at this point.

3. The third division extending from Trinidad eastward for twenty-five miles is in no sense a canyon. At Trinidad the river

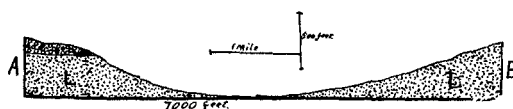


FIG. 5. CROSS SECTION OF PURGATORY VALLEY AT WESTON.

emerges from the hills of the dissected plateau upon a broad undulating plain. At this point the Fox Hills sandstone turns north, away from the river's course and makes a prominent escarpment for many miles. This escarpment forms the eastern edge of the dissected plateau previously referred to. From the foot of the escarpment eastward, the surface is occupied in turn by Pierre shales, the Niobrara and Benton limestones and shales, and the Dakota sand-

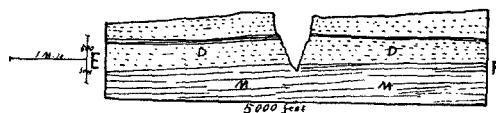


FIG. 6. CROSS SECTION OF A PART OF THE PLAINS 30 MILES EAST OF TRINIDAD, A FEW MILES BELOW THE POINT WHERE THE PURGATORY PLUNGES INTO ITS CANYON.

stone. A wide area has here been degraded to the condition of a rolling plain. The amount of degradation can be estimated from the height of the mesas south of the Purgatory which stand at a maximum elevation of 3,636 feet above the river bed and which are, as previously stated, probably parts of the original surface upon which the present Purgatory River began to flow. From this max-

imum elevation which obtains in Fisher's Peak, the mesa surfaces decline to the east diminishing somewhat the elevation above the river bed. It should be noted in this connection that Fisher's Peak is not a *peak* in any sense of the word. It is a projecting point of the high mesa and not a summit rising from the mesa surface as has been stated in some published accounts of this region. It has the appearance of a peak from the vicinity of Trinidad because the observer gazes up at the projecting angle which is the point of the mesa nearest to him. This rise of 3,636 feet within a horizontal distance

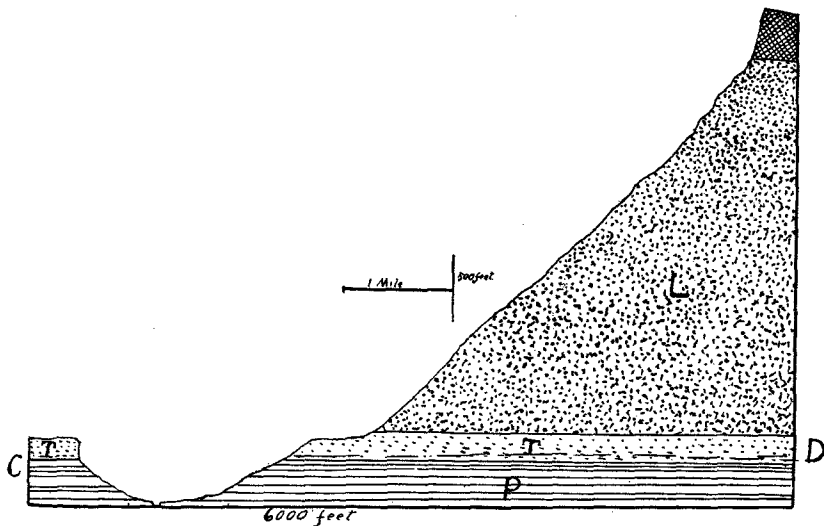


FIG. 7. CROSS SECTION OF PURGATORY VALLEY AT TRINIDAD, FROM FISHER'S PEAK TO SIMPSON'S REST (FOX HILLS ESCARPMENT). The basalt at the top is the cap rock of Raton Mesa.

of five miles gives this projecting angle the appearance of being a peak rising from the general surface of the mesa. An excellent photograph of this "peak" has been published by Mr. Hill in his geological folio of this region.\* Figure 8 is a near view of the "peak" showing the character of the protecting cap. The photograph is illustrative of the "palisades" fringing the mesas on all sides. The sides of the "peak" are nearly vertical but this is not shown in the illustration since the photograph was taken looking upward.

\* U. S. Geol. Surv. Geological Atlas, Elmore Folio.

The mesas south of the river extend eastward at least 80 miles. Beyond this I cannot speak from personal observation. There are many more or less isolated mesas, the more important of which are Johnson's Mesa, Raton Mesa and Mesa de Maya. These were formerly connected as one great table land to which Mr. Hill has applied the name Mesa de Maya from the easternmost of these great mesas. This name is peculiarly appropriate as it means "the table of mail" or "the armored mesa." The mesas or table lands are capped with basalt having a maximum thickness of about 500 feet. The basalt is

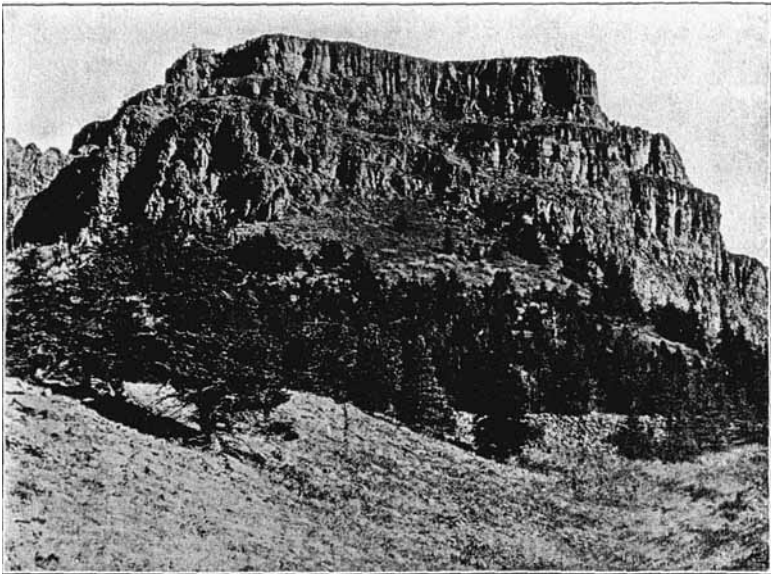


FIG. 8. FISHER'S PEAK, TAKEN FROM A POINT NEAR THE FOOT OF THE "PALISADES." The columnar basalt at this point is about 500 feet thick.

more or less columnar and forms palisades bordering the mesas. From the palisades on the north the surface descends rapidly at first but gradually becomes less precipitous until it finally merges into the undulating plain over which the river now winds.

This descent of a maximum of 3,636 feet within a distance of five to fifteen miles gives opportunity for the formation of many swift side streams. These streams have developed long, sloping debris-covered mesas similar to those which I have described elsewhere from Boulder, Colorado.\* Their debris caps are composed largely of

\* The Origin of the Debris-covered Boulder, Colorado, *Jour. Geol.*, Sept.-Oct., 1900.

basaltic material from the tops of the mesas, although in many places crysalline débris from the mountain brought down by the river appears commingled with the fragments of basalt. These débris-covered mesas may be seen in typical development a few miles south-east of Trinidad.\*

4. In the last or fourth division of its course, the Purgatory enters the most picturesque and interesting, as well as the most inaccessible and unknown part of its course. About twenty-five miles east of Trinidad it cuts through the Dakota sandstone and gradually works its way downward through the Morrison shales and deep into the Red Beds, making a canyon seventy miles long, measured in a straight line, and 900 feet in maximum depth. Throughout the length of this region the Dakota sandstone is the rim rock. The rolling plain described in the third division is evidently a plain of

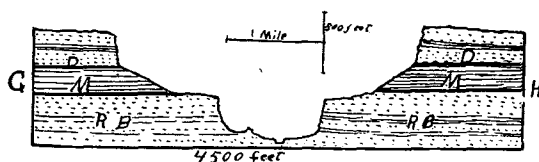


FIG. 9. CROSS SECTION OF THE PURGATORY CANYON WEST OF ITS JUNCTION WITH CHAQUAQUA CANYON. The cliffs of the Dakota and the Red Beds, the even slope of the Morrison shales, and the bench at the top of the Red Beds are found here in typical development.

degradation. In passing from the western border of this plain eastward, one passes in succession over the Pierre, Niobrara, Benton and Dakota formations. But the surface in the region of the canyon proper is, with minor exceptions, a broad stratum plain controlled by the Dakota sandstone. The two merge into one general plain similar to that south of Mesa de Maya which Mr. Hill calls the Las Vegas Plateau. It differs, however, from the Las Vegas Plateau in that it is not bordered by escarpments as is the case south of Mesa de Maya. On the contrary the general surface of the country in the vicinity of the canyon proper follows the Dakota sandstone which dips to the north and east. The surface therefore descends by a gradual slope to the valley of the Arkansas River.

The Dakota is massive and resistant and forms persistent cliffs 100 to 300 feet high wherever dissected by the streams. From the base of these cliffs the canyon sides descend in comparatively gentle

\* See map. U. S. Geol. Surv., Geological Atlas, Elmore Folio.

slopes for a vertical distance of 200 to 300 feet over the Morrison shales. The regularity of the slope is often interrupted by the Dakota débris, but in general the slope is governed by the shales and is somewhat uniform. At the base of this slope occurs an extended bench formed by the upper series of the Red Beds. The bench varies from a few feet to several miles in width and is often perfectly denuded exposing the bare rock for long distances. From this bench to the bottom of the canyon the walls are made up of the red sandstones and shales of the Red Beds. The controlling layer

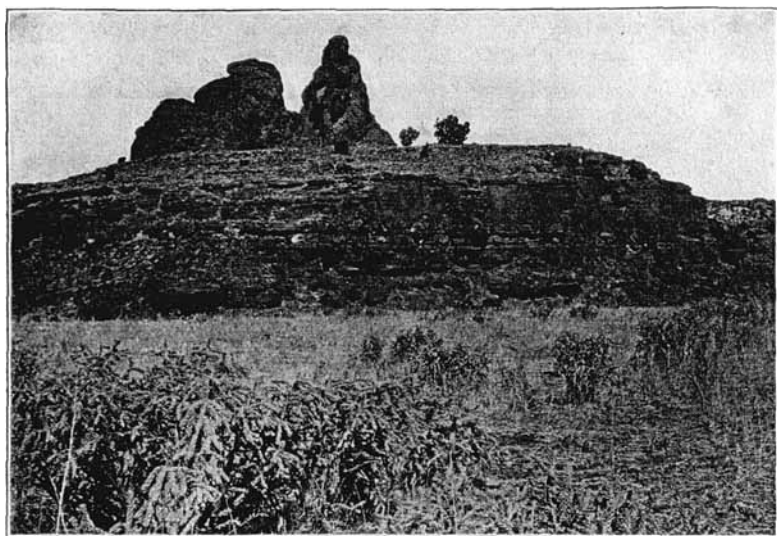


FIG. 10. A MESA BUTTE OF RED SANDSTONE, CHAQUAQUA CANYON. The foreground is a stratum bench sparsely covered with bush cactus. The size of the cliff may be estimated from the horse and wagon at its base.

of this series lies near the top. It is a massive coarse sandstone 175 to 200 feet thick. Below this massive layer the walls are made up of thinner sandstone layers alternating with red shales. It is in this red sandstone series that the wonderful beauty of form and color resides, which makes the canyon memorable to those who have once seen it. The region is locally known as the "Red Rocks Country."

The width of the canyon varies greatly according to locality. The upper third is a little more than a mile in width with a maximum depth of about 400 feet. Below this it widens and deepens to its maximum dimensions. Where Chaquaqua Creek enters the Pur-

gatory, the canyon floor is 900 feet below the surface of the rim rock. This descent is accomplished within a horizontal distance of a little less than two miles. In some places the canyon broadens until it is several miles in width, while in others it narrows until the floor is little wider than the river bed.\* This deeply dissected portion extends for a distance of about 40 miles, then gradually passes to a less deeply dissected region and finally merges into the comparatively open plain.

The increased dimensions of the canyon both in depth and width in the region of its junction with Chaquaqua Canyon is probably due in some measure at least to a local uplift. The general surface of the plain at the head of the canyon is about 5,500 feet above sea level. Seventy miles farther down the river the surface lies approxi-

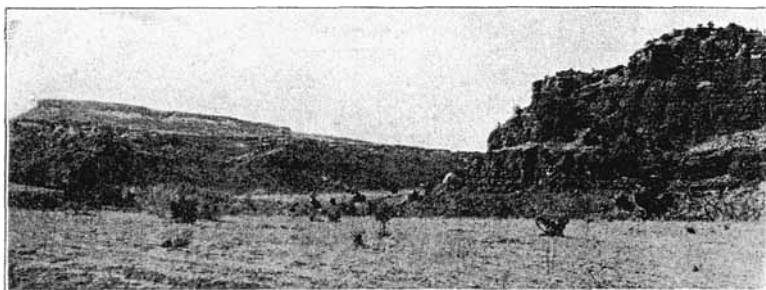


FIG. 11. THE JUNCTION OF THE PURGATORY AND RED ROCKS CANYONS, taken from a stratum bench shown in the foreground. In the left background the precipitous edge of the rim rock (Dakota) appears. Beneath the Dakota occurs the envelope of the Morrison shales. The middleground with the cliff at the right shows the Red Beds with a broad bench at the top. The canyon at this point is 400 feet deep.

mately 4,000 feet above sea level. If the surface, which in general is formed by the Dakota sandstone, had a uniform dip it should lie at an elevation of about 4,750 feet near the mouth of Chaquaqua Canyon. It lies, instead, at an elevation of about 5,300 feet, 550 feet higher than a uniform dip would place it. From the head of the canyon, therefore, to the mouth of Chaquaqua Creek, a distance of thirty-five miles, the rim rock lies practically horizontal. In the lower thirty-five miles of the canyon the surface elevation is lowered about 1,300 feet.

Where the canyon is cut in the Red Beds the various hard layers of sandstone form more or less distinct benches. The floor of the

\* See U. S. Geol. Surv. Topographic Map, Timpas Sheet.

canyon is, in many places, a succession of benches one above another like huge steps. In the wider portions of the canyon these benches appear either as broad shelves along the canyon sides or as low, flat topped mesas rising from the canyon floor.

Some of the side canyons in the region where the Purgatory is deepest are scarcely less noteworthy than the main canyon. Some are extended and varied like Chaquaqua Canyon. Others are short and steep like Red Rocks Canyon, Iron Canyon and a score of others. Chaquaqua is the largest of the branch canyons and is about thirty miles long. Its scenery is no less grand and beautiful than that of the main canyon.

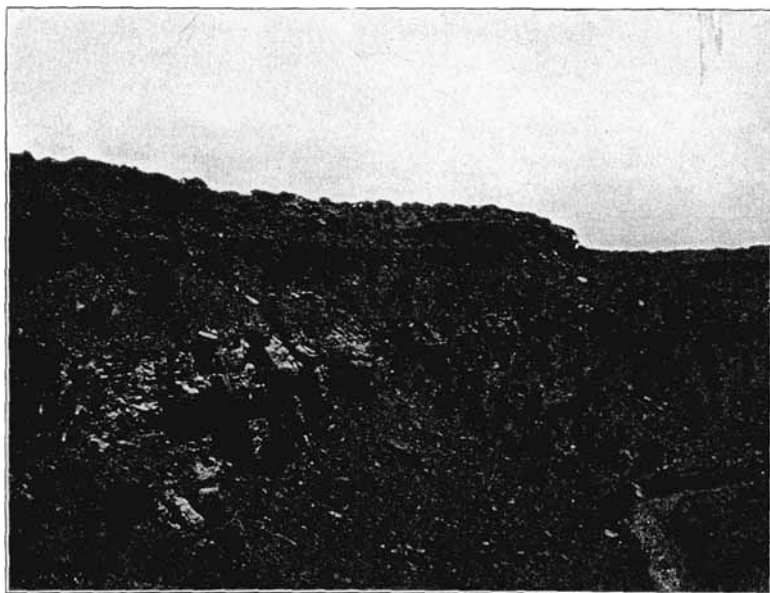


FIG. 12. APISHAPA CANYON.

The river is comparatively swift in the canyon and is still corrodng its bed. In the 70 miles of the canyon, measured in a straight line, the river flows at least 80 miles, perhaps more, and descends 1,600 feet. Assuming that 80 miles expresses the actual length of the river the average gradient is about 20 feet to the mile. Some of the short side canyons have a much higher gradient. Iron Canyon for example descends 400 feet in about three miles or about 133 feet per mile.

The Purgatory is called a river. But the eastern reader must not think of it as comparable to the rivers which he is familiar with in the East. At ordinary times the water of the river if gathered together would make a stream something like five feet wide and a foot deep at the average rate of flow. Some of the branch canyons have no permanent streams. Chaquaqua Creek has excavated a canyon about thirty miles long with a maximum depth of 900 feet, and yet there is so little water in the stream during the dry months that the bed of the creek is used as a wagon road. In our trip up the canyon we drove for about ten miles in the bed of the stream and were nowhere inconvenienced by the water. But during the spring and early summer especially when the snows are melting from the mountains, the river swells to somewhat notable proportions, and it is subject also to sudden torrents during the summer months. The highlands of the plateau region east of the mountains which are drained by the Purgatory are subject to frequent sharp showers sometimes called "cloud bursts" which make sudden and destructive floods. It is to these floods that we must look for an explanation of the great abrasive power evidenced in the formation of the Purgatory canyon.

In the Apishapa canyon \* we have a beautiful illustration of a young canyon. The Apishapa River is smaller than the Purgatory and flows parallel with it. The canyon is cut in the region where the uplift—perhaps better defined as a large monocline—previously described, extends across the course of the river. The canyon is about fifteen miles long with a maximum depth of something over 300 feet. The canyon walls are exceedingly precipitous and made up almost wholly of Dakota sandstone. The stream flows in a deep narrow gorge to which side canyons have not developed to any notable extent. The "river" flows only part of the year. The name, Apishapa, is an Indian word meaning *stinking water*, so called from the stagnant pools formed along its course during the dry months when there is no permanent stream. The force of the stream is spent in cutting downward. The canyon from rim to rim is one fourth of a mile to one mile wide and the floor is little wider than the stream during times of flood.

\* See U. S. Geol. Surv. Topographic Map, Apishapa Sheet.