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REVISED GEOLOGICAL REPORT ON HOT SPRINGS NATIONAL PARK

ARKANSAS

BY

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REGION XIX

Report No. 168

Inspected
April 12-13, 1936

FOURTH GEOLOGICAL REPORT ON HOT SPRINGS NATIONAL PARK ARKANSAS

BY: CHAS. N. GOULD

Three previous geological reports have been submitted on Hot Springs National Park, all dealing, in part at least, with the slumping along the road on West Mountain. The first report, No. 50, prepared from an inspection made June 10-14, 1926, was in response to a letter from Superintendent Libbey. As the result of the investigation made at that time, I prepared a memorandum to the regional office. Excerpts from the memorandum are presented herewith:

> "This road was built largely by EPA labor in 1935 and 1936, under the direction of the Bureau of Public Roads. It is a switchback road leading from the valley in which Hot Springs is located to the top of West Mountain. The part of the road under consideration lies on the south slope of the mountain and just above and overlooking the city.
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> "The rocks in West Mountain consists of several geological formations, namely, in ascending order, Arkansas novaculite, Hot Springs sandstone, and Stanley shale. These rocks have been tilted at high angles. It is in the part of the mountain occupied by the Stanley shale that the damage has occurred.
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> "West Mountain is covered with heavy timber, chiefly oak. The gradient, or slope of the mountain, established through long periods of time, is that which would normally be expected. The "angle of repose," or slope, is the normal slope of about twenty-five to thirty degrees.

"Into this slope the road has been cut. The sloping bank on the upper side of the road is in places twenty-five to thirty feet high, with a slope or gradient of forty-five degrees. The soil and loose rock exposed along this slope has slumped in many places over a distance of a quarter of a mile. A recent rain of something over one inch in twenty-four hours is said to have caused the damage. Many tons of loose material broke loose and slid down the bank, or was washed down gullies, in places almost filling the road.

"I am informed that the rainfall for the past few months has been much below normal, and that if the rainfall had been of the intensity usual in central Arkansas at this season of the year, the slumping would probably have been much greater.

"This is another example of man's disturbance of nature's equilibrium, established through long periods of time. The normal tree-covered slope on West Mountain was not eroded until the road was built.

"It will be necessary to take remedial measures to remedy this condition or slumping and creeping will continue indefinitely, and still larger amounts of soil and loose rock, eventually carrying large forest trees, will continue to be carried downward into the road. I consider it a major problem.

"In my judgment the drainage of the entire road system on the south slope of West Mountain is insufficient. I suggest that competent engineers study the problem.

"I know of no better method of checking the slumping and slides along the roadside than by building a retaining wall. Many walls have been built along the roads on Hot Springs Mountain, across the valley. In these cases they were straight masonry walls and rather unsightly. Planting of honeysuckle, wisteria, and other similar shrubs and vines have done much to cover the scars.

"My suggestion would be that the wall along the road in question on the south slope of West Mountain be built of rough stone, each succeeding layer being set back with plenty of space for planting shrubbery. There is an abundance of suitable rough stone for this

work in some of the novaculite quarries in the vicinity of Hot Springs. I believe that this method of constructing a retaining wall will prove satisfactory. In addition to honeysuckle and vectaria, I suggest that the bush huckleberry, native to this region, be planted on the slopes.

"I discussed the matter of the retaining wall and drainage fully with Mr. Donald S. Libbey, Superintendent of Hot Springs National Park, who very kindly went over the ground with me, and who showed me every possibly courtesy and assistance while in the park'"

The second report, No. 110, was prepared from an inspection made February 25-26, 1937, at which time I was accompanied by Engineer Diehl, Forester Wirt, and Landscape Architects Cornell and Diedorich. Superintendent Libbey and Acting Park Naturalist Lix, were with us on this inspection.

After a careful study of the situation in the field, the various technicians prepared and submitted reports. Excerpts from my Report No. 110 on the geology of the situation follows

"Rocks belonging to two geological formations outcrop on the east slope of West Mountain, namely, the Hot Springs sandstone and the Stanley shale. In ordinary stratigraphic sequence, the Hot Springs sandstone underlies the Stanley. But, at this place, the reverse is true. Throughout the Ouachita Mountains, in which Hot Springs is located, there are many folds, including anticlines and synclines, where the rocks have been sharply folded, and in some cases overturned, so that they now lie "on their backs," as shown in Figure 3 of the letter by H. P. Lix attached hereto.

"On West Mountain, at the site of the slumping above the road, the Hot Springs sandstone forms the crest of the ridge, while, on account of the overturned position of the beds, the Stanley shale outcrops along the slope below. Both formations dip

into the mountain, the angle of dip being approximately at right angles to the slope of the hill. The slumping along the road appears to be entirely in the material overlying the bed rock Stanley shale. This upper material is composed of a mixture of residual clay and earth, with fragments, large and small, of sandstone derived from the Hot Springs sandstone, rolled down the hill. The geological term "detritus" is used for such material.

"As shown in pits which had been dug on the mountain slope previous to our arrival, the thickness of the various members of the overburden above the shale varies from 2 feet near the upper part of the slope, to 8 or 12 feet further down the slope along the road.

"An approximate section of the detritus above the Stanley shale bed rock, as shown in the pits, is as follows:

1 to 2 feet, top soil
2 to 8 feet, earth, clay, sandstone mixture
1 to 4 feet, yellowish clay
Stanley shale

"It should be remembered that only the lower part of the Stanley shale is exposed on West Mountain. This formation is in places as much as 6,000 to 10,000 feet thick.

"The natural weathering of the rocks along the slope of the mountain, through long periods of time, has produced a slope varying from 20 to 30 degrees. This is known as the angle of repose.

"Under normal conditions when the various materials have come to a state of equilibrium, this angle remains constant and very little material is displaced or moves down the hill. On unusually steep slopes landslides sometimes occur, and on normal slopes there is frequently a very slow but constant "creep" toward the valley.

"The slumping on West Mountain, which is occurring in the detritus above the Stanley shale, is the result, chiefly, of two factors, namely gravity pull, and the lubrication of the detritus by water.

"Nature is now attempting to reestablish the angle of repose which has been destroyed by man.

"To me, it appears very probable that this slumping might have been prevented, at least in a large measure, by the construction of a retaining wall, or by other mechanical means at the time when the road was first built, and before there had been any movement of material in the slopes above. On Hot Springs Mountain, across the valley, where geological conditions are quite similar, walls were built at the time of the construction of the road and little slumping has occurred. Even at the time of my first visit such a wall would doubtless have prevented a considerable amount of slumping. But water from the January rains have so affected the slope that cracks parallel to the road are now opening up all along the mountainside above the road, as shown in figure 3. Some of them are 200 feet from the road.

"Water from future rains will continue to pour into these cracks, loosening the detritus and augmenting the sliding of the material down onto the road. As long as the laws of gravity continue to operate, and while water from rainfall continues to soften and lubricate the material, this detritus will continue to slump downhill, and this will not stop until either a natural or an artificial equilibrium has been established.

"The curing of the slumping is an engineering rather than a geological problem.

"My comments on the situation may be summarized as follows:

> The slumping on West Mountain is being caused by gravity aided by water which loosens the detritus.
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> Nature's angle of repose, or angle of rest, which had been established through long periods of time, has been disturbed.
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> Nature is now attempting to re-establish this equilibrium, and will continue to do so.
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> To check the slumping some mechanical means should be employed.

> Competent engineers, experienced in problems of this kind, should suggest the best remedy.
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> Slumping could probably have been prevented by proper means at the time when the road was built, and before the detritus had started slumping.
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> Any method of control should include a careful study of the entire drainage system of the roads on the mountain."

The third report, No. 145, was from an inspection July 10-11, 1937, and in it I recapitulate the conditions on West Mountain and submit quotations from the two various reports given above. I then comment as follows:

> "On my inspection, July 10-11, the results of which are embodied in this report, I found that little attempt had been made to remedy the situation on West Mountain. However, according to Superintendent Libbey, the Bureau of Public Roads which has had charge of the construction of the road, has been making plans to remedy the slumping. As explained to me by Superintendent Libbey, these plans include (1) the widening of the road on the downhill side, (2) the installation of concrete cribbing set into the upper part of the present roadway, (3) the building of a five-foot gutter in front of the cribbing, (4) the building of a terraced rock retaining wall in front of the cribbing, with openings provided for the plantings of shrubs and vines, and (5) a series of drains of perforated, corrugated tile in the bank above the wall, and under and through the cribbing, to take care of surplus rainfall and water percolating through the soil.
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> "It will be noted that this plan does not differ materially from the one I suggested a year ago.
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> "One effect of the installation of this cribbing and retaining wall will be to permit a portion of the rock and debris from above to come to rest behind the wall, and in a sense tend to restore Nature's "angle of repose," which was destroyed when the road was built.

"My judgment is that when this wall has been installed it should go far toward solving the problem. Only time can tell where or not it will be 100% effective.

"Measures are also being taken to correct the drainage situation as suggested in my first memorandum. Considerable yet remains to be done along this line, but progress is being made."

At the time of my inspection, which forms the basis of the present report, I found that after many delays the work of stabilization of the road had started in November 1937, seventeen months after my first report in June, 1936, had been submitted.

Mr. Winter, engineer of the Bureau of Public Roads, and his assistant, Mr. Crohn, accompanied Superintendent Libbey and me to the site of operations and we discussed various problems in the field.

During the twenty-two months since the time of my first visit in June, 1936, the slumping and sliding of the detritus on the mountainside above the road has continued. Each rain starts new sliding. Hundreds of truck loads of dirt and rock have been removed from the road. A number of valuable forest trees, some of them two feet in diameter, have slid down the slope so that they had to be removed.

At the present time a crew of men, under the direction of the Bureau of Public Roads, is being employed building cribbing and a retaining wall, or rock rampart, to prevent the slumping, as shown in figures 1 and 2.

The cribbing consists of concrete stretchers 6 x 8 inches and 8 feet long, with cross headers 6 x 8 inches by 5 feet, all bolted together with 3/4 inch bolts. Figures 3 and 4 show this cribbing in place. This cribbing is bottomed on solid clay and is inclined toward the hill. The crib is filled with rock, as shown in figures 2 and 3. The front of the crib is faced with a wall, or rampart, shown in figures 5 and 6, constructed of large boulders, some of them weighing up to two tons. A section of this wall is shown in figure 7. The spaces between the boulders are being filled with soil for the planting of native shrubs, as shown in figures 7 and 8.

This cribbing and wall appear to be constructed in a workmanlike manner, and it appears to me very likely that it will serve its purpose and keep the material from above from slumping onto the road.

I do not believe that this cribbing and wall will stop the slides, for, as I have pointed out in my former reports quoted above, Nature's angle of repose has been destroyed, and great cracks have been opened on the hillside above the road. The force of gravity, aided by lubrication induced by rainfall, will continue to pull great masses of detritus down hill. But it appears probable that the cribbing will catch the debris as it slides down and prevent it from reaching the road.

I still believe that a considerable part of the slumping is due to a defective system of drainage on the mountainside, particularly on the switch-back road immediately above the area that is sliding. In my first report I suggested that a careful study be made of the entire drainage system on West Mountain. A part of this trouble has been corrected. There are still two culverts, however, one of which is shown in figure 9, which cross under the upper road and, after rainfall, discharge their accumulated load of water on the area where cracks are forming and which is sliding.

On the night of April 15, 1936, at the time of my last visit to Hot Springs, 2½ inches of rainfall within a few hours. Next morning I drove over the road. The hillside was saturated with water and both culverts on the upper road were carrying a stream of water under the road. This water ran downhill, saturating the slope and causing additional slumping.

For these reasons, I wish to renew my former recommendations, namely, that a study be made of the drainage problems along the road on West Mountain. I further recommend that steps be taken to remedy existing conditions.

It is my judgment that had such a study been made to stabilize the slope at the time the road was built in 1935 and 1936, the slumping might have been largely prevented.

Even at the time of my first inspection in June, 1936, it was not too late to prevent a considerable part of the damage.

Excessive rains have loosened the soil above the road and, lacking a natural support from below, this mass of material did the only thing possible - it slid down the hillside into the road. Certainly had the remedial measures been undertaken soon after June, 1956, the expense would have been much less than that which is being incurred at this time, and the results obtained would probably have been much more satisfactory.

But it is my judgment that the plan now in operation, although belated, will do much toward remedying the evil. Only time will tell whether or not it will be entirely effective in stopping the slides. Certainly there will remain a series of unsightly scars above the road extending for a distance of nearly half a mile, which will not be cured for many years, and at considerable expense. Views of this landslide above the cribbing are shown in figures 10 and 11.

Superintendent Libbey is to be commended for doing all in his power to correct the evil. He has concurred whole-heartedly in the recommendations of the technicians and has given every assistance.

Respectfully submitted

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