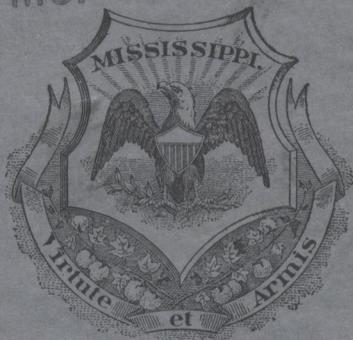


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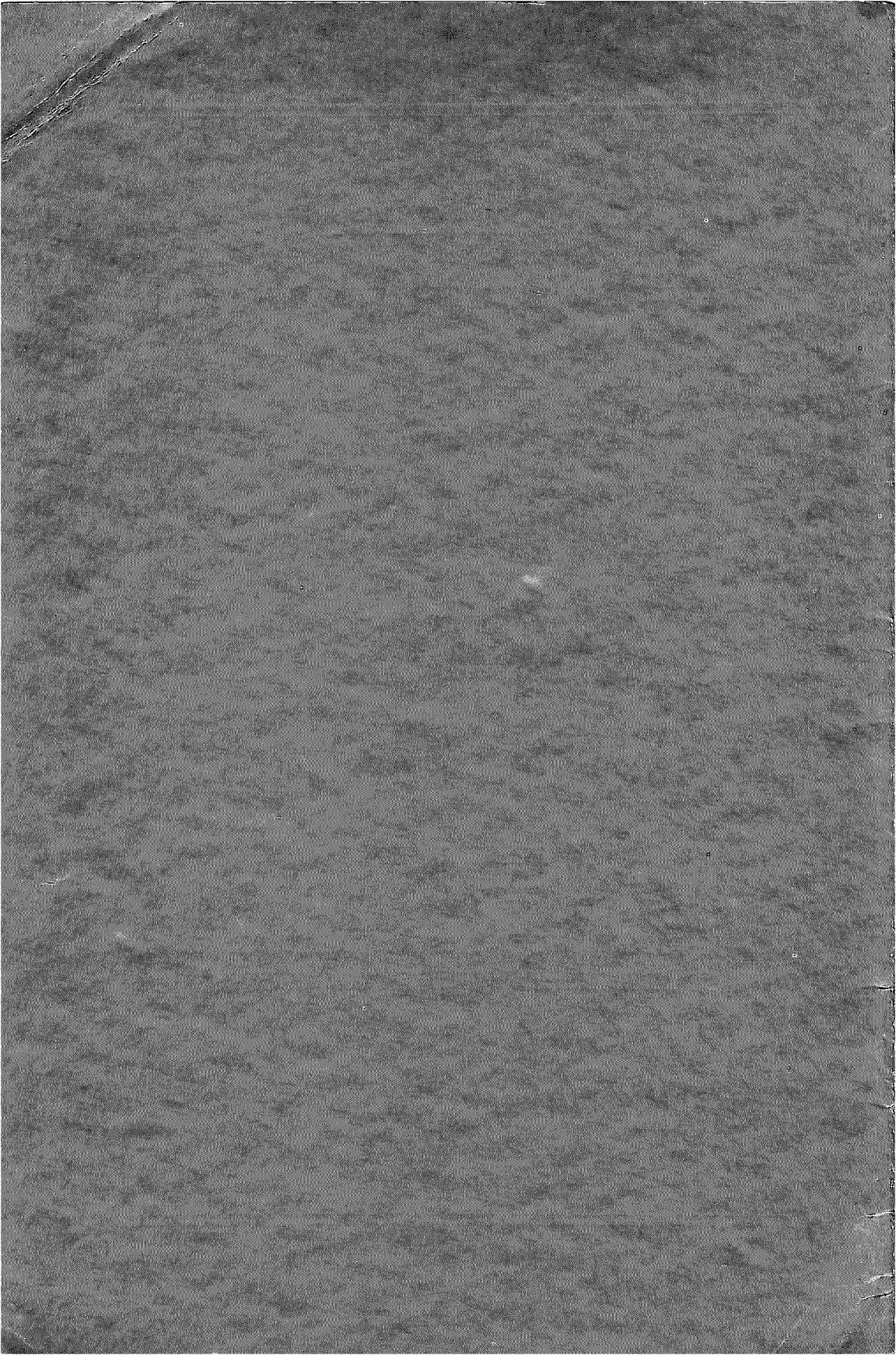


BULLETIN 27

GEOLOGIC CONDITIONS GOVERNING SITES
OF BRIDGES AND OTHER STRUCTURES

By
WILLIAM CLIFFORD MORSE, PH. D.
1935

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MISSISSIPPI
STATE GEOLOGICAL SURVEY

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MISSISSIPPI GEOLOGICAL SURVEY

ALFRED HUME, C.E., D.Sc., LL.D.,.....CHANCELLOR OF THE UNIVERSITY OF MISSISSIPPI

STAFF

WILLIAM CLIFFORD MORSE, PH. D.....DIRECTOR
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LETTER OF TRANSMITTAL

Office of the Mississippi Geological Survey
University, Mississippi, April 9, 1935

Dr. Alfred Hume, Chancellor
University, Mississippi

Dear Chancellor Hume:

When I submitted to you on February 28, 1935, a copy of my report to the Mississippi State Highway Department on the "Geologic Conditions of the proposed site for the Highway Bridge at Yazoo City," you, as a trained engineer, were kind enough to say in your reply of March 1, 1935, that:

"I have read your report concerning the geologic conditions at the proposed site of the Yazoo City bridge. It is extremely interesting. Few people would believe that such conditions exist."

"As I read your report, it occurred to me again that it is well that our Engineering students are required to take at least one year of Geology. I think that it would be fine if you could speak to the students composing the Engineering Club, giving them the thoughts which you have presented in the report in question. I believe that this would be quite valuable and interesting to them, especially so in connection with the pictures showing landslides."

Again on March 14, 1935, I wrote to you asking: "Would it, in your opinion, be advisable to enlarge this report by only a few pages, and then bring it out as a short bulletin by the Survey? I am particularly anxious to learn your reaction to this thought, as it has only recently come to me."

And again on March 15, 1935, you were kind enough to write, in the encouraging manner so characteristic of your dealings with the members of the University: "As to making a short bulletin to be issued by the Geological Survey, I heartily approve of such course."

Accordingly, herewith is the short bulletin for your final approval.

Sincerely yours,

WILLIAM CLIFFORD MORSE, Director

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GEOLOGIC CONDITIONS GOVERNING SITES OF BRIDGES AND OTHER STRUCTURES

By

WILLIAM CLIFFORD MORSE, PH. D.

STATE GEOLOGIST

INTRODUCTION

This short bulletin on the geologic conditions governing sites of bridges and other structures grew out of a request by the Mississippi State Highway Department for a geologic inspection of a site at Yazoo City for a new bridge across the Yazoo River on Mississippi--United States Highway Route 49-West, the approach and bridge to cost approximately \$250,000. The report, which condemns the proposed site and thereby saves the State and the Nation perhaps \$100,000, an amount almost equal to the State Geological Survey's appropriation in 15 years, and which was well received by the engineers of the Highway Department, the Chancellor of the University of Mississippi, and others, forms the basis of the bulletin. In fact the bulletin is merely the report with a few added paragraphs, in order to make it of more general application in the State, and of more value to the engineers, who have expressed keen interest in the subject of landslides. Inasmuch as the landslide terrane next to the proposed site was so old as to mask its true identity and might, accordingly, have been approved as a site without further search and study, it follows that the definite conclusions stated in the report could not have been reached by one short visit to Yazoo City; rather they are based on long years of study in many states, including Mississippi. Because of all these possibilities, the State Highway Department considered it advisable to refer the matter to the State Geologist for an opinion before making a definite decision as to the proper location for the bridge.

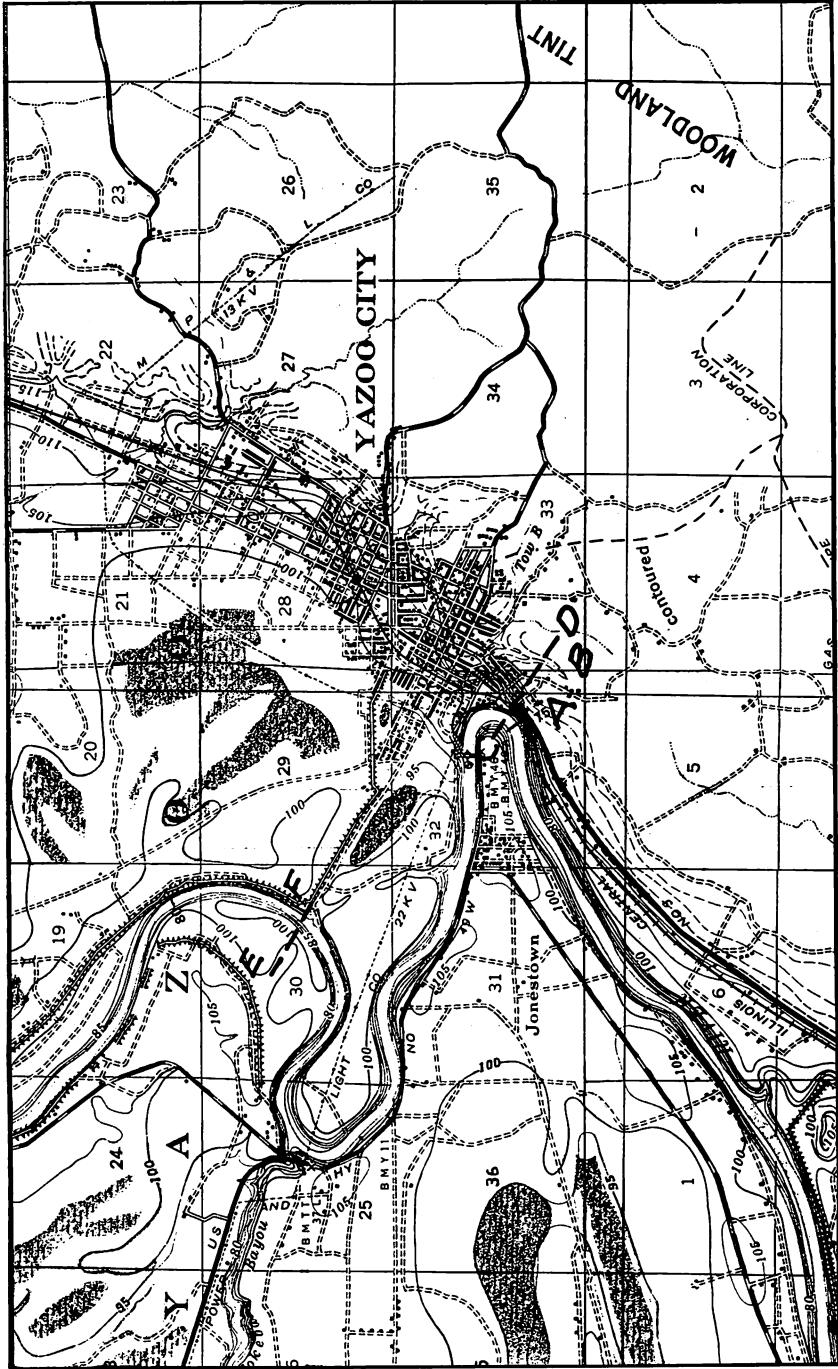


Plate 1.—Topographic map of Yazoo City environs on which only a part of the bluff was contoured. It shows the great swing of the Yazoo River against the east bluff of the valley and, consequently, the steepening of it. The first and second spur ridges east of the river are marked respectively A and B; the proposed bridge site, by the line C--D; and the recommended bridge site, by the line E--F. Valley Mississippi quadrangle.---By courtesy of the Mississippi River Commission and the War Department.

GEOLOGIC CONDITIONS OF THE PROPOSED SITE OF THE HIGHWAY BRIDGE AT YAZOO CITY

A report by William Clifford Morse of an inspection trip to Yazoo City on Saturday, February 23, 1935, in company with Highway Engineers C. W. F. Harper, C. S. Hill, and W. Ellis York, which was respectfully submitted on February 25, 1935.

LOCATION AND TOPOGRAPHY

"The proposed site of the new Yazoo River bridge of U. S. Highway No. 49--West at Yazoo City (C-D Plate 1), here under consideration, is at the Illinois Central Railroad water tank at the southern edge of the city, where the Yazoo Valley flat joins the east bluff of the Mississippi Valley (common to both rivers). Of the three places where the Yazoo River swings eastward against the Mississippi Valley Bluff, it is, perhaps, the one of the closest contact. In any event, the river in its eastward swing has undercut, and is still undercutting, the bluff to such an extent that the bluff stands abruptly 245 feet above the flood plain of the river and to such an extent, too, that the small tributary streams have been foreshortened and, hence, have had their gradients steepened."



Figure 1.—Landslide during the winter of 1934-35 near the line of the proposed highway at the end of the second spur ridge, B Plate 1, east of the Yazoo River at Yazoo City. It embraces practically all the material from the clay contact to the top of the Loess.



Figure 2.—Photograph of greater vertical range of the same landslide. That it moved sometime during the winter of 1934-35 is attested by the upward-facing slickensided surface of the clay, which surface had not been obliterated by rainfall. End of the second spur ridge, B Plate 1, east of the Yazoo River.

GEOLOGIC CONDITIONS

“To add to this unstable condition is the geologic structure of the region. The Jackson formation (uppermost Eocene) extends upward 131.7 feet above the flood plain (itself, 100 feet above sea level); the Citronelle formation (Pliocene), 25.0 feet higher; and the Loess (uppermost Pleistocene), 88.0 feet still higher (Hand level determinations by Egr. W. Ellis York). Exposures in the shallow cuts along U. S. Highway No. 49 south of the proposed site show the lower part of the Jackson formation, the Moodys Branch member, to be clayey,

calcareous marls, filled with fossils. A small exposure in the street leading up the steep bluff directly opposite the railroad water tank, reveals two or three feet of the very top of the Jackson formation, the Yazoo member, to be an extremely dense, compact, plastic clay shale. Directly above, exposures of the Citronelle show it to be largely sand, having more intermixed gravel in the lower part and little, if any gravel, higher in its bed of 25.0 feet. Directly above these exposures, others reveal the 88.0 feet of typical Loess, broken by vertical columnar joints, which cause it to stand in vertical cliffs.

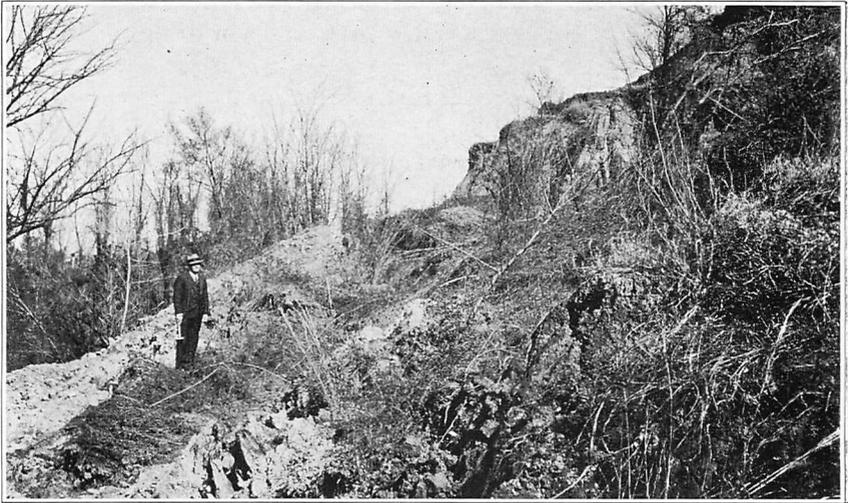


Figure 3.—Photograph of the same landslide showing more clearly the cliff source of the material of the two waves of the landslide. End of the second spur ridge, B Plate 1, east of the Yazoo River.

“To an elevation of 131.7 feet above the flood plain, therefore, the bluff consists of clayey material which is most nearly impervious at the top where it is in contact with the overlying porous sand and gravel of the Citronelle, itself in contact with the overlying porous Loess. The rainwater, transformed into groundwater, descends through the Loess and thence through the sand and gravel until it reaches the clay which it cannot penetrate. Consequently, it must flow along this clay contact until it reaches the valley side, which intersects the contact plain. Here the water issues as seeps and springs. Accordingly, it not only adds its weight to the mass, already in an unstable condition of equilibrium, but also lubricates the underlying clays, making them plastic and extremely slippery. Such contacts of underlying impervious

clays and overlying porous beds always result in landslides, and the bluffs at Yazoo City are no exception to this rule. As a matter of fact some of the Loess has already slipped away to the very top of the bluff (Figure 7), 245 feet above the valley flat, which developed a crack in the northwest corner of the concrete lined and capped city reservoir, that permitted its waters to pour forth in a roaring torrent--resulting in its abandonment.

"Such conditions are not limited to the contact of underlying impervious clays and overlying porous formations, but obtain along contacts of underlying impervious clays and overlying porous mantle rock, formed from the decay of other beds and even of the clay itself. In fact such contacts, which are more or less parallel with the surface of the hills and bluffs, are as steep as the surface itself, and consequently permit slipping even more readily than do the contacts of the other type. The sides of the bluff and tributary valleys, likewise show that the Yazoo City region is no exception to this rule. In fact the Illinois Central and U. S. Highway No. 49. each has had to be protected from the mantle rock sliding on to its roadway, by means of a line of piling.

"Both sides of the two small spur ridges (A and B Plate 1) extending north and parallel with the river, the tracks, and the present highway No. 49 at the proposed bridge site are simply a jumbled mass of many such landslides. They vary in age, from those whose distinguishing features are so disguised by age (Figure 8) as to make the determination of their origin difficult, to those that slipped so recently (Figure 1, 2, and 3) that their slickensided exposed surfaces have not been destroyed by a heavy rain. Similar conditions obtain on the sides of other minor spurs between other small tributaries of Tow Branch, farther toward the east.

"For a half mile or for even a mile, therefore, the eastern highway approach to a bridge at this site would have to be constructed over a terrane that, in most places, has slipped in the past; that, in some places, is still slipping up to the present moment; and that, in most or all places, will continue to slip for an indefinite period, or until a state of equilibrium is reached in the untold ages of the future. To dump material for a highway fill upon any of the four sides of these two spur ridges, the western most side of the western of which is the Yazoo Bluff itself, would simply be to add to this unstable condition. Undoubtedly it would hasten the initiation of the slipping which would inevitably follow. To remove any of this unstable material and any additional stable material beneath would also disturb the present temporary equilibrium and would also hasten the initiation of slipping. Even

though the east pier of the bridge at this site could be seated in the bed rock of clayey, calcareous marls, the construction of fills and the excavation of cuts would initiate sliding of such magnitude as to threaten the pier, as to dissipate the fills, and as to fill the cuts. Hundreds and hundreds of tons of landslide material would have to be removed at

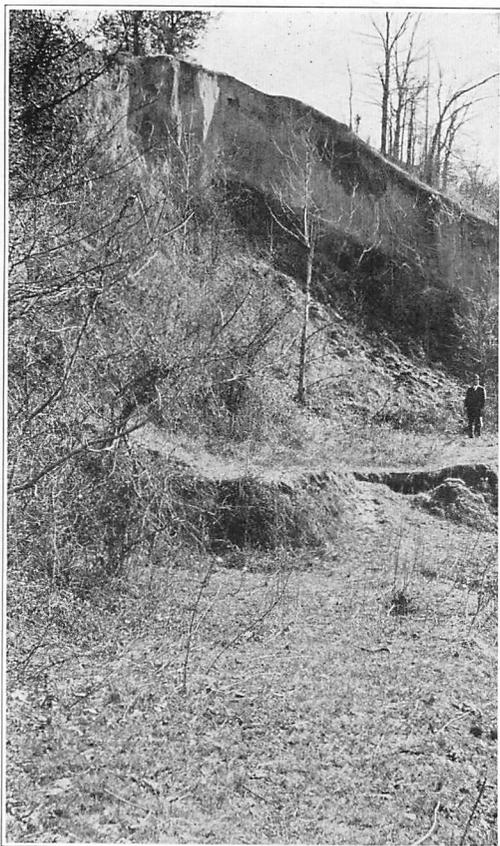


Figure 4.—Landslide involving material to the top of the Loess in the very crest of the ridge; on the west side and near the end of the second spur ridge, B Plate 1, east of the Yazoo River.

intervals for years to come, even if the pier itself were not thrown out of alignment by the impact. In short, to construct a main thoroughfare approach to a bridge at this site is simply to invite disaster. It is an impossible location.

“Objection may be raised to these assertions of condemnation on the grounds that both railway and highway cuts have been successfully

made in Loess deposits. There are such cuts. An example is the cut of the United Railways of the City of St. Louis, where this line crosses the divide of the Missouri Valley proper at Creve Coeur Lake. Despite the fact that the Loess walls of this cut are practically vertical and can almost be reached by one standing on the end of the ties, nevertheless, less talus material from the freezing and thawing of the Loess in winter accumulates in the drainage ditches of this cut, than accumulates in the



Figure 5.—Landslide topography which was produced by a slip that extended to the top of the Loess on the east side of the first spur ridge, A Plate 1, east of the Yazoo River.

drainage ditches of the more gently sloping railway cuts in the hard Mississippian limestone southwest of the same city. But this Creve Coeur Lake cut is entirely within the vertical limits of the Loess. In another railroad cut in the Loess in the southwest St. Louis environs, the base of the Loess was reached and a thin interval of three or four feet of the underlying Pennsylvanian clay was penetrated. Slipping of the Loess along the contact continues to give trouble and the wooden piers of the small overhead bridge of a secondary road have been thrown out of verticality by the Loess slipping in toward the tracks against them. In the City of St. Louis itself, the Market Street car line in its diagonal ascent up the east side of the River des Peres in southeastern Forest Park was repeatedly thrown out of alignment by the mantle rock slipping on the moist surface of the underlying Pennsylvanian clays. Train load after train load of broken brick and cinders were dumped

along this stretch, which material would hold for a while, only to slide away eventually, when gravity stresses accumulated. Finally the mantle rock was removed in a descending cut into the valley and in an ascending cut out of it, both at right angles to the valley, and the old diagonal location was abandoned.

"The disappearance of nearly the whole of 'Natchez under the Hill' was due to the slumping of the Loess into the Mississippi River along the Hattiesburg clay which lies underneath the Loess and the Citronelle sand and gravel about at water level. And the repeated necessities of Mr. Andrew Learned to raise parts of the foundation of



Figure 6.—Characteristic hummocky landslide topography resulting from a slip which truncated the end of a short spur ridge between the first and second spur ridges east of the Yazoo River.

his mother's home, also 'under the Hill' at the mill, reveal the almost continual slipping of the superjacent material on the underlying clay. Surely no more evidence needs to be presented of the slipping of overlying beds along their contact with underlying clays."

AN ALTERNATIVE LOCATION

"By extending U. S. Highway No. 49--West in a westerly direction along the small levee for a mile and a half from the Illinois Central Railroad, an intersection of the Yazoo River is had, where the river has a very gentle curve (E-F Plate 1). A cursory examination of this

place, lasting only a few minutes, seemed to indicate a site for a bridge that would not be subject to any of the problems of landslides whatsoever. Surely this site eliminates most or all of the problems of the other proposed site."

ADDENDUM

The author of this bulletin has always been interested in the importance of recognizing old landslides, sites of potential landslides, and the possible destructive effect of landslides. To such an extent is this true that for years he has incorporated in his mimeographed lecture notes for students in general and engineering geology the fact

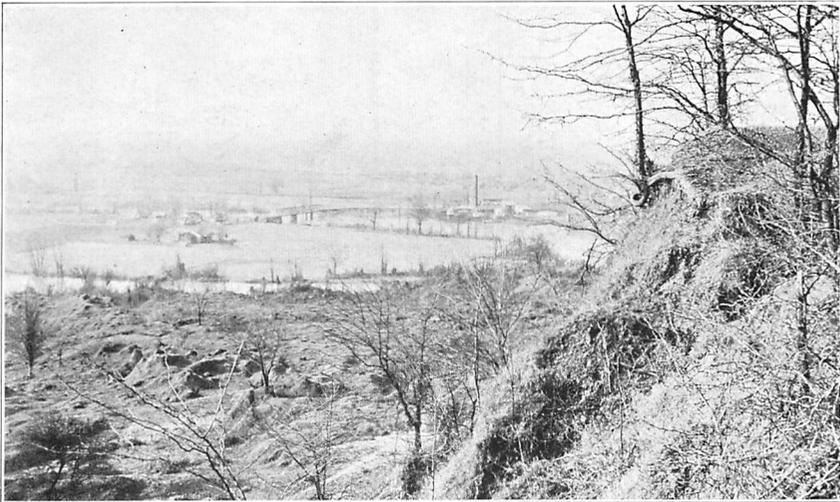


Figure 7.—Landslide topography embracing practically the whole vertical face of the east bluff of the Yazoo Valley at this point --west side of the first spur ridge, A Plate 1, east of the river. The camera, trained North 22° West toward the proposed bridge site, shows the area south of the site and almost but not entirely to the banks of the river.

that: "Mr. Henry Laviors of Paintsville, Kentucky, General Manager of the Northeast Coal Company and of the Southeast Coal Company, states that in making a drift opening for a mine he moves as few of the trees and as little of the mantle rock as possible in order not to disturb the equilibrium, which disturbance would, most probably, in turn, initiate landslides. Contrast this procedure of a trained and experienced

mining engineer with that of the highway engineer who located the main thoroughfare of that section of the state. Not only were extensive and expensive fills, similar to railway grades, made, but enormous cuts, where a slight bend would have reduced by half the amount of material to be moved in the cut. Some of these cuts so disturbed the equilibrium of the mantle rock that landslides, which carried so much material on to the roadway that hundreds of tons have had to be removed, happened before the road was completed and subsequent to its completion, and the end is probably not yet in sight" (page 156).



Figure 8.—Looking east toward the proposed line of the highway leading up the east bluff of the Yazoo Valley. The escarpments and terraces of the landslides are so masked by age as to be readily mistaken for peculiar loess erosion features; an example showing the necessity for inspection by a trained and experienced geologist.

In response to the author's letter of inquiry on February 4, 1935, concerning the present condition of these slides, the son, Mr. Harry Laviers, who succeeded his father to the general managership, replied on February 27, 1935, that: "I would also like to advise you that I drove from Paintsville today and in two places between Paintsville and Prestonsburg the highway department is still struggling with slides which have carried away about half the road and which they do not seem to be able to stop." Thus landslides unnecessarily initiated

at two places on this highway before its completion, during the summer of 1925, were still an unsolved problem nearly ten years later on February 27, 1935, and were, consequently, still a continuous item of great expense.

As previously stated, the conclusions set forth in the report are based on the author's years of study and observation in many states and are not the result of the present field experience of a day. If time and funds had permitted, it would have been well to have studied other localities in the State. Since neither time nor funds are available, however, it has been thought best to draw on the author's experience and present the present brief bulletin in the hopes that it will serve a useful purpose in aiding the engineer in avoiding sites of potential landslides, for such places exist wherever surface slopes cut impervious clays underlying either other formations or the mantle rock.

March 1, 1935

Mr. William Clifford Morse, Director,
Mississippi Geological Survey,
University, Mississippi.

Project No. NRH--179-G, Yazoo County.

Dear Sir:

This will acknowledge receipt of your letter of February 25th and enclosure of your report covering geologic conditions at the proposed bluff site for the bridge over Yazoo River at Yazoo City.

We appreciate very much your interest and cooperation in making this inspection and also commend you for the excellent manner in which the results of your investigations were presented. Our attention has consequently been directed to numerous conditions which would have no doubt been otherwise probably overlooked, and we are now convinced that the bluff location is unquestionably unsuited for the bridge site.

We wish again to thank you for your splendid cooperation in this matter, and to also offer the facilities of this department at any time we can be of any service whatsoever to you.

Yours very truly,

MISSISSIPPI STATE HIGHWAY DEPARTMENT

By

C. S. HILL, Bridge Engineer

CSH:LCE

CC: Mr. R. A. Harris

