MEMORANDUM REPORT ON GEOLOGIC CONDITIONS IN THE CHERRY HILL CUT OF THE RICHMOND, FREDERICKSBURG & POTOMAC RAILROAD

This memorandum report is based mainly upon a brief inspection of the cut along the Richmond, Fredericksburg & Potomac Railroad, a short distance north of Cherry Hill in Prince William County. This inspection was made at the request of Mr. E. M. Hastings, Chief Engineer. A detailed examination of the geologic conditions in that area was not made, nor has there been any detailed geologic survey made of that general area. Thus the opinions expressed below must be considered more or less tentative.

Two problems merit primary consideration in any study of this cut: (1) The cause, or causes, of slides and (2) possible prevention of future slides. Both of these problems involve a consideration of local geologic conditions, as well as of engineering features. This memorandum report deals only with the geology, although a few suggestions as to remedial measures are made.

Topography.-- The Cherry Hill cut has been made through the nose of a broad ridge which lies between Powells Creek on the north and Quantico Creek on the south. The cut is in a spur ridge along the northeast part of the main ridge. Potomac River flows along the eastern base, with a narrow intervening strip of flat land. As shown on the topographic map of the Quantico quadrangle (scale 1:62,500; contour interval 20 feet), surveyed in 1925 by the U. S. Army Engineers, this ridge rises to an elevation of about 160 feet

above Potomac River. The crest of the ridge is flattish to gently sloping, but the slope becomes steeper toward the Potomac. This steeper slope represents, in part at least, the valley slope cut by Potomac River. There is a moderate slope from the flattish crest southward toward Cherry Hill station. About half a mile west of the river, the ridge is deeply cut by a ravine tributary to Powells Creek and from that point westward numerous deep ravines intersect the northern slope of the ridge.

Geology.- The formations exposed in the Cherry Hill ridge are in the Cretaceous system, and are called the Patuxent and Patapsco formations. The Patapsco overlies the Patuxent, which in turn probably lies upon a basement of crystalline rocks and slate. The Patuxent formation consists mainly of interbedded arkosic sand, gravel and clay. The Patapsco formation is composed of clay, sandy clay, and sand. Although positive identification was not made, it seems probable that the materials exposed in the Cherry Hill cut belong in the Patapsco formation. These formations are described in some detail in Virginia Geological Survey Bulletin 4, and their distribution is shown on the "Geologic Map of Virginia," published by the Geological Survey in 1928.

Geologic conditions in the cut.-- The vertical section exposed in the south part of the Cherry Hill cut shows a thick bed of sandstone at the bottom, overlain by a thick bed of clay, above which is another thick bed of sandstone. As the lower bed of sandstone is of slight importance in this connection, it will not be discussed.

The upper sandstone is a friable, somewhat loosely consolidated mass of coarse angular quartz grains and grains of decayed feldspar. Much of the feldspar has weathered to a clayey mineral. Preliminary microscopic examination shows that the sand grains are coated with a claylike material. This sandstone contains scattered pebbles, some of which are locally segregated in small lenses. This rock is strongly cross laminated. Most of the laminations, or subsidiary bedding, dip northeastward toward Powells Creek. There are few clay seams in this upper sandstone. At the base of the sandstone is a narrow zone containing considerable iron oxide, which appears to have been precipitated there from ground water circulating through the sandstone.

The bed of clay is a rather homogeneous mass of bluish-green clay, but it is very sandy in places. It contains thin bands of sand. (A detailed microscopic examination might show planes of structural weakness in it.) The contact with the overlying sandstone is even and sharply defined. The contact with the lower sandstone is irregular and uneven. The clay is locally so compact and resistant to weathering that it makes a small overhanging ledge above the lower sandstone. It is so impervious in places that water passing through the overlying sandstone emerges along its upper contact and seeps or flows down its face. This clay is resistant to weathering, except that it spalls off in small fragments under alternate wetting and drying and freezing and thawing.

Structure.-- As shown by the contacts of the sandstone with the clay the beds in this cut dip gently toward Powells Creek. The main

direction of dip of the beds, however, as indicated on the blue print of the "Cross Section of Cut North of Cherry Hill," is toward Potomac River. This profile shows that the lower contact of the clay ("marl") is + 63.0 feet on the west side of the tracks and is at + 49.0 feet on the east side of the tracks. This gives a difference in elevation of 14 feet. The distance between the two points, along the dip of the beds, is approximately 105 feet. Thus the dip of the beds here, according to the above data, is about 8° SE. This is in harmony with the known dip of the beds elsewhere.

Slide factors.-- Several factors may be involved in the cause of slides in this cut. Some of them are related to the geologic conditions, but certain non-geologic factors may be contributory. It should be noted that both the large slide which took place when the cut was being excavated, and the smaller slide which occurred in December, 1933, occurred at, and on both sides of, the contact between the clay and the overlying sandstone.

Some of the possible geologic factors involved in the slides are ground water intake into the upper sandstone, subsurface flow of water along the contact between the sandstone and the relatively impervious clay, expansion of clay in the cut, and freezing and thawing of moisture in the rock. Contributory factors may include a slope which is not in equilibrium under the existing geologic conditions and the effects of vibration.

The flattish crest of the ridge west of the cut and the gentle southward slope across, and more or less at right angles to the dip of

the cross lamination in the upper sandstone affords moderately favorable conditions for the intake of rain or melting snow into this sandstone. Water entering this sandstone would have a tendency to move both northward toward Powells Creek and eastward toward Potomac River. Its downward movement would be impeded or stopped at the contact of the sandstone with the underlying clay. It is possible that the new cut intersected some established lines of ground water movement. It may be possible, though not very probable, that excavation and blasting in the cut rendered the upper sandstone more permeable to water.

With the upper surface of the clay becoming at times saturated with ground water and with an overlying burden of sandstone resting on a smooth contact surface which slopes toward the cut, conditions become very favorable for slumping and sliding after times of prolonged precipitation.

There may also be some tendency for the clay to expand somewhat under relief of pressure as and after the cut was made, but so close to the surface it is doubted whether this is even a minor factor. Repeated freezing and thawing at the contact of the upper sandstone and the clay may be a factor. Vibration, such as that due to rapid passage of heavy trains or to mild earthquake shocks or even to heavy gun fire, may be a contributory factor, especially if other conditions are at any time especially favorable for slides.

Cause of the slide on December 6, 1933.-- From this brief preliminary study of the geologic conditions at the Cherry Hill cut, it appears that the slide on December 6, 1933, was due to the

saturation of a small area of the rock on the west face of the cut, on a slope which was not in equilibrium under the existing geologic conditions of dipping beds, sandstone resting on clay, and ground-water movement along the sandstone-clay contact. Hence a mass of rock broke away from the sandstone and possibly also from the upper part of the clay. It is possible that this mass of rock struck the southbound track with such force because it richocheted, at least in part, from the overhanging ledge near the bottom of the clay bed.

The lack of serious difficulty with slides along the old line of tracks was probably due in part to two factors. That line of track was at the base of a slope which had been largely produced by the natural process of erosion through centuries, and thus would have approached closely a profile of equilibrium. Further, the slope immediately west of the tracks had very little of the upper sandstone left on it and thus the clay was not loaded beyond its capacity, even if ground water seeped along its upper surface. It is possible also that ground-water movement was somewhat northeastward and thus upon a slope which has been intersected by the new cut.

It would be interesting to study the records of precipitation in the area since the cut was excavated, the alternation of cycles of freezing and thawing, and to obtain data on vibration in the area.

Suggested remedies.-- It is hardly within the province of this brief study to make final recommendations. However, from the above discussion of geologic conditions it appears that two problems to

be solved in order to prevent possible future disastrous slides are: (1) To decrease the load of the upper sandstone upon the underlying clay, and/or (2) to curtail as much as possible the entrance of water into this sandstone and its movement along the sandstone-clay contact in such amounts as to saturate the clay and lubricate the slope upon which the sandstone might slide.

Arthur Bevan, State Geologist,
State Commission on Conservation and Development,
University, Virginia,
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