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# GENERAL STATEMENT ON THE CEDAR CREEK SLIDE
## MONTROSE, COLORADO

by

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The Cedar Creek slide is located about ten miles east of Montrose in southwestern Colorado, along the Denver Rio Grande and Western Railroad. It occupies an area about 1,000 feet square and has a maximum height above the railroad grade of more than 300 feet. The slide occurred on the north edge of a large undulating mesa composed of massive to thin-layered Mancos shale capped by 15 to 25 feet of coarse boulder gravels.

The upper part of the slide is composed of large blocks which slide down as unified masses. In addition to their downward movement, they show a backward rotation of the blocks along an axis parallel to their length. The shale, which makes up the great part of the blocks, is largely intact, but the capping gravels are usually shattered so that the top of each block is covered by a jumble of boulders, soil and disintegrating shale. From the bases of these blocks down to the railroad grade, the slide is composed of rolling slopes and rounded benches. In this lower section, movement is by plastic flow and deformation rather than by sliding and has imposed a pattern of pressure ridges and troughs crossed by two sets of wide deep cracks, one set radiating from the base of the slide blocks, and the other paralleling the pressure ridges.

The whole slide appears to be underlain by one single welldeveloped slip plane. The slip plane is actually exposed only near the head of the slide in several isolated areas which are seldom more than a few feet in diameter. The blocks now breaking off from the head and west margin of the slide are roughly wedge-shaped so that their planes of initial movement merge with the main plane at the base of the wedge. The decreasing size of most of the recent blocks and the increasingly close spacing of cracks now developing in back of the active face indicate a gradual slackening of activity in the slide as a whole.

Laterally, the slide can be divided into two parts. The east half is now largely dry. No appreciable quantities of water, other than that supplied by natural precipitation, appear to penetrate it. It has one major slide block with a few small ones forming narrow steps up to the top. No water is impounded on the tops of these blocks. The upper portions of the block faces are maintained at very steep angles but the lower parts are modified and mantled by debris. Below the major block are only moderate rolling slopes and ridges.

The west half, which receives large quantities of water from the irrigation ditches on the mesa above, shows more variety of conditions and is the site of nearly all current activity. This side has two major slide blocks with several smaller ones above them which are starting to break off and move down from the west margin. Both large blocks hold ponds of water on their inner margins. Although there was no visible movement of these blocks while the slide was under close observation, evidence was supplied by the slopes and benches below them. Here the ridge and trough structure became increasingly prominent and new cracks appeared and deepened from day to day. Maximum activity during August, 1946 occurred in the northwest corner of the slide where clay and shale ridges moved outward several feet in response to increased pressure from the blocks above and to the noticeably increased amount of water that followed a period of irrigation on the mesa top.

## Principal Causes of Movement in the Cedar Creek Slide.

The causes underlying the Cedar Creek landslide movements can be attributed to two factors.

A. The underlying factors of component materials, topographic and bedrock conditions, and vegetation cover in this area are favorable to movements of the types represented at Cedar Creek although they do not directly produce movement.

The Mancos shale is a fine-grained consolidated mud with negligible pore space so that the fresh rock is almost impervious to water. Ground waters encountering the shale move along the top of the bed except where joints or other fractures give admittance to the shale. However, on contact with water, the shale breaks down readily into slippery clays and silts. Thus any fracture or joint which admits water may be a potential slip plane where the shale can be converted to an efficient mud lubricant. The slip plane along which the major movements occurred was found to contain about half a foot of soft, slick wet clay.

Exposure of the shale to air results in rapid decrepitation, producing from the solid shale an abundant surface cover of loose material. The addition of water can readily convert this material into moving masses.

A third factor is the loose, porous nature of the capping boulder gravels which act as a giant sponge to absorb an unusually high percentage of any water supplied to the mesa and to feed it to the shales below.

The natural vegetation cover is generally a sparse growth of scrub oak, sage, and other low brush that would not be very effective in stopping a sliding or flowing mass of earth.

In addition to the factors given above, the north-facing side of Cedar Creek valley provides other conditions which favor slide movement. Moisture contributed by man or nature will evaporate less rapidly than on the south-facing side, and hence will have greater opportunity to penetrate the underlying material. The apparent low-angle dip to the north of the shale beds and the gravel-shale contact would tend to lead ground waters toward the cliff faces where the slides develop on the north-facing side and away from the cliff faces on the opposite side of the valley. For at least a mile on either side of the Cedar Creek slide, old scars and more recently active slides indicate that such movements have long been characteristic of the north-facing side of the valley. The south-facing slopes, on the other hand, show no good evidence that slides have occurred there recently or in the past.

B. Actual movement in the Cedar Creek slide can be almost entirely attributed to the relatively large amount of water supplied to that area.

The average annual precipitation is low, but at least 600 acre-feet of irrigation water is released annually on the part of the mesa immediately behind the slide. Of this amount about 350 acre-feet is used in a 10-acre area where the locations of irrigation ditches and natural drainage lines lead the surplus water into the slide area. The porous underlying boulder gravels take up the water not held by the topsoil and plants and transmit it along the shale contact to the face of the slide. Here, part seeps down along the slip plane, transforming the clay into a perfect lubricant on which the overlying shale blocks can move readily. The remainder flows over the surface and through the overburden of clay, silt, boulders, and broken pieces of shale that mantle the tops and sides of the slide blocks. The quantity thus supplied is often sufficient to start this debris in motion by the double process of lubricating the unstable mass and at the same time adding weight to it.

While the moisture provided by rain and snow might have produced the Cedar Creek slide just as it has activated the older slides in the vicinity, it is doubtful whether the slide would have attained its present size or would show such prolonged activity without the additional quantities of water that have been supplied since the irrigation was started in 1927.

A secondary factor aiding the activity of the slide has been the removal of debris necessary to keeping the railroad in operation. The process of clearing the debris that overwhelmed the tracks has removed the toe of the slide which acted as a partial support to the material above. Removing this support leaves a considerable weight of material resting insecurely on its base of wet, slippery clay, ready to move down again as soon as increased moisture content reduces the internal friction sufficiently. If the toe could have been left untouched, some movement would have continued but at a slower and a decreasing rate. The recent slides to the west of the main Cedar Creek slide have not been altered by human agency and show much less activity, although they were probably initiated by the same agency and at about the same time.

## Recommendations.

The most important step is to cut off the chief water supply to the slide by stopping irrigation of the land just behind its head. It would not be necessary to remove all that land from irrigation if construction of a large French drain to divert the water were found feasible. Such a drain would have to be located 150 to 200 feet back from the top of the slide and have a minimum depth of fifteen feet. Construction of a grouted wall down to the top of the shale might be another possible method of diverting the irrigation water. In any case, loss of the lubricating agent would raise the internal friction in the mass and tend to stabilize the slide.

As a secondary measure, construction of some type of cribbing or retaining wall along the inner margin of the railroad cut might be desirable as protection against debris-falls and as a partial control to any renewed sliding or flow that might result from a season of unusually heavy precipitation. Establishment of a sufficiently heavy vegetation cover would serve a similar purpose.

The suggestions given above are intended to remedy already existing conditions but cannot be considered absolute insurance against new activity, even though the main causes are nullified. If the railroad grade could be relocated to the south-facing side of the valley, it would be removed not only from the existing problems of the Cedar Creek slide but also from the potential landslide areas adjacent to it.