

EROSION AT REDOUBT #10

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### I. Introduction

This study was initiated in order to determine the nature and extent of erosion at Redoubt #10 in the Yorktown Battlefield of the Colonial National Historical Park. The original redoubt, built during the Revolutionary War, was lost to erosion shortly after that period. Now, the reconstructed site is threatened also by erosion, although the erosion processes may be of a different sort.

While the river erodes from the shoreline, removing sediments from the base of the slopes, other processes cause mass wastage off the whole body of the slopes, the main problem presently. These include sheet washing, slumping, frost heaving, and mudflowing. Riprapping along the shoreline has deterred shoreline erosion greatly so that this aspect of the erosion is no longer critical. Instead, the stabilization of the slope is definitely the major concern.

We made our observations from January 1979 to April 1979. It would be better to make a year long study to note exactly the erosion rates for each season, but we feel that we were able to estimate the erosion occurring in one winter in specific locations anyway. Quantitative studies were done in late winter and more general observations were made in the early spring.

## II. Methods

Slope profiles of four representative slopes close to the redoubt were made by using a tape measure and a Brunton compass. We also measured some talus cones to find the volume of erosion for one winter. The cones occurred directly at the base of erodable slopes and one large cone occupied the full vertical extent of the cliff. The rest of the information was obtained from general field observations. We attempted to determine the long-range erosion by using maps from the Revolutionary War and adjusting them to the scale of modern aerial photographs with a ~~map~~ pograph. However, the results were obviously inaccurate and we decided that the old maps were not to be trusted for details.

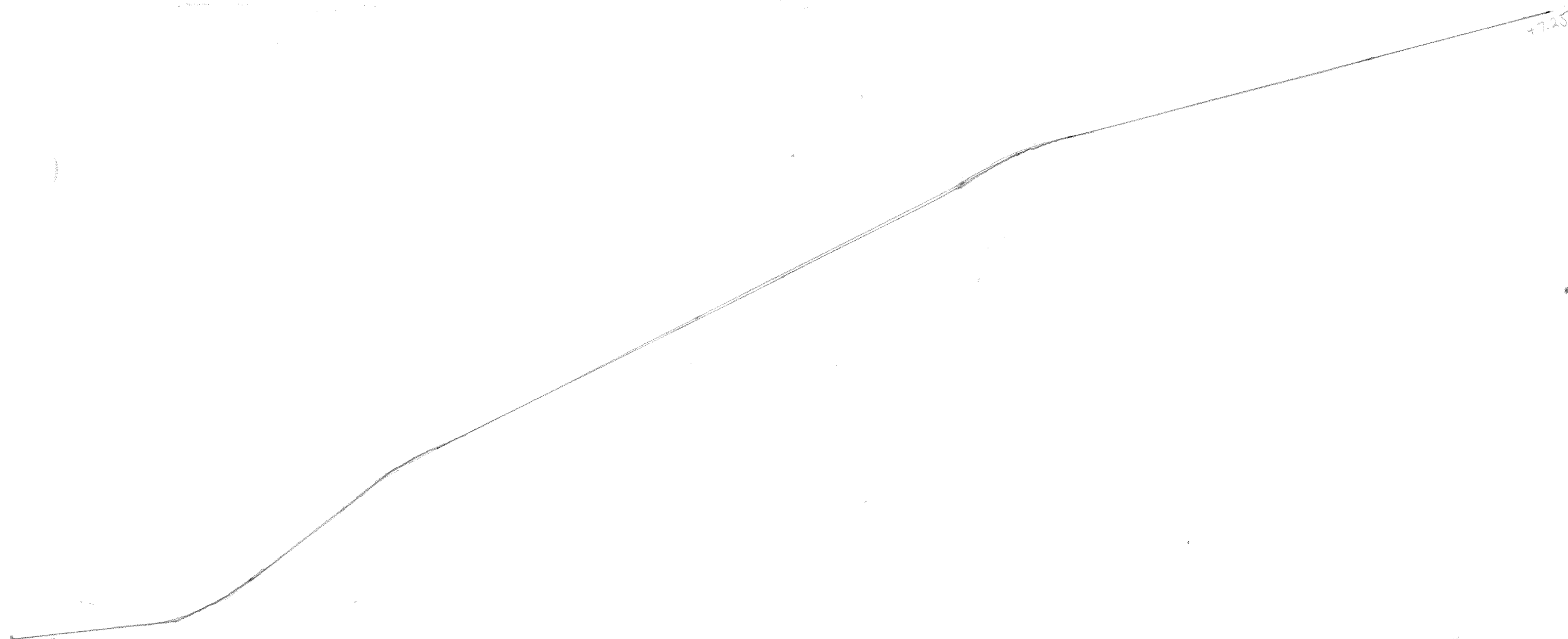
## III. Results and Discussion

The profiles and observations (Figs. 1-10) show that steepness is not as important in dictating erosion as vegetation, or the lack thereof. We saw steep, vegetated slopes that were stable and less steep non-vegetated slopes that were not stable. Slope D was more steep than Slope C but was stable because it was vegetated.



Fig. 1. Slope A- approximately 90 meters west of Redoubt #10.

Fig. 2. Slope A. This slope is located on the east side of a ravine. The slope was chosen because it was heavily vegetated, with both trees and undergrowth. The slope is convex in profile. It is stable and shows no talus cones or alluvial fans.



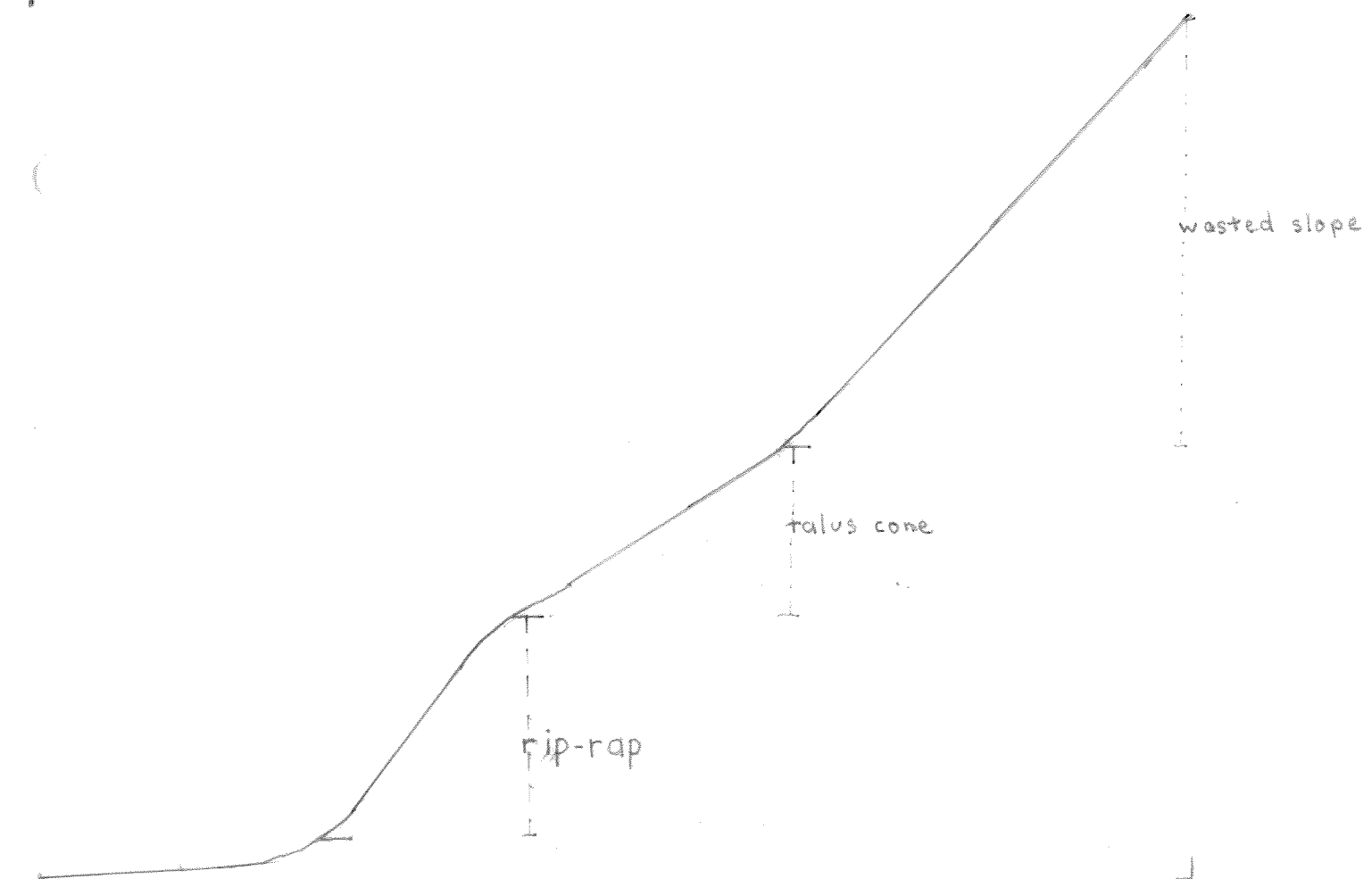
**SLOPE A**  
**NOE**

1 METER



Fig. 3. Slope B. 35 m west of Redoubt #10.

Fig.4. Slope B. This slope is obviously unstable, including a prominent talus cone-alluvial fan. It is not vegetated for the most part. The erosion occurs chiefly as sheet wash of very fine sand.



**SLOPE B**  
**N 37 E**

1 METER

12.7 m high  
16.9 m deep



line shows intersection with water table

Fig. 5. Slope C. Immediately west of Redoubt #10.

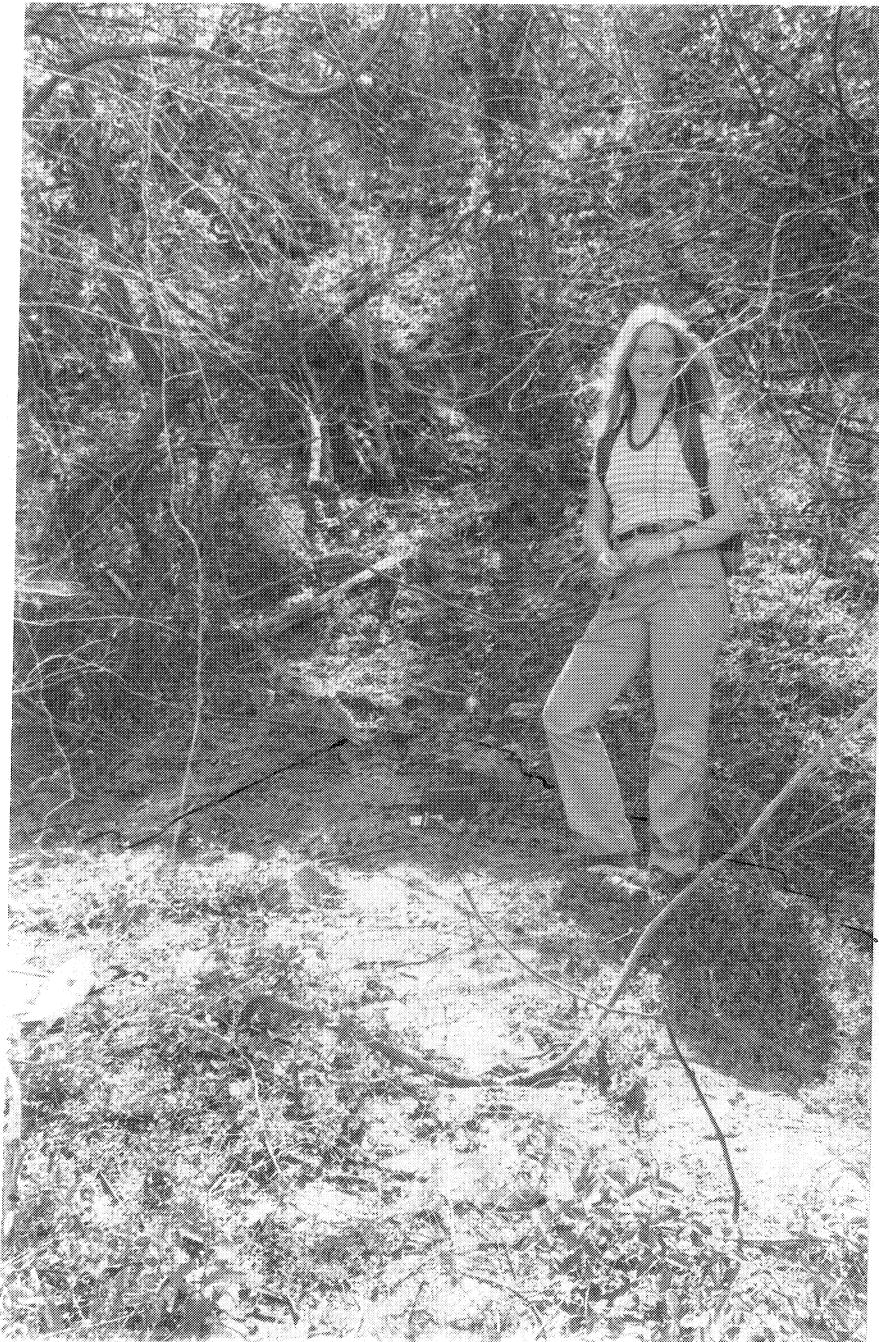


Fig. 6. Slope C. Student stands at head of alluvial fan.

Fig. 7. Slope C. This slope intersects the water table three-quarters of the way up the slope. This results in a local steepening at the intersection. A stream flows from the intersection and yields a dynamic alluvial fan, composed mostly of fine sands. We classified this as unstable.

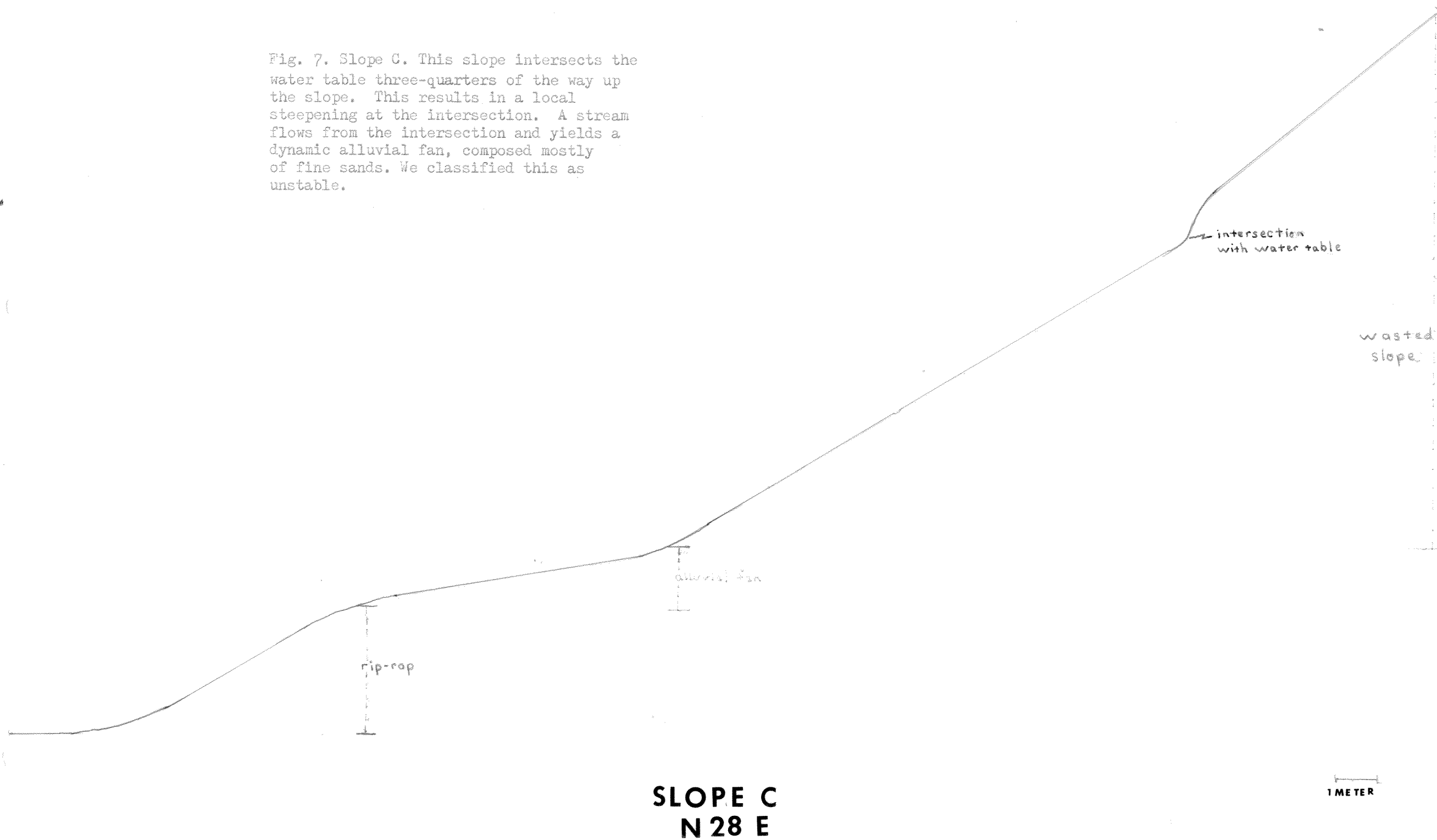
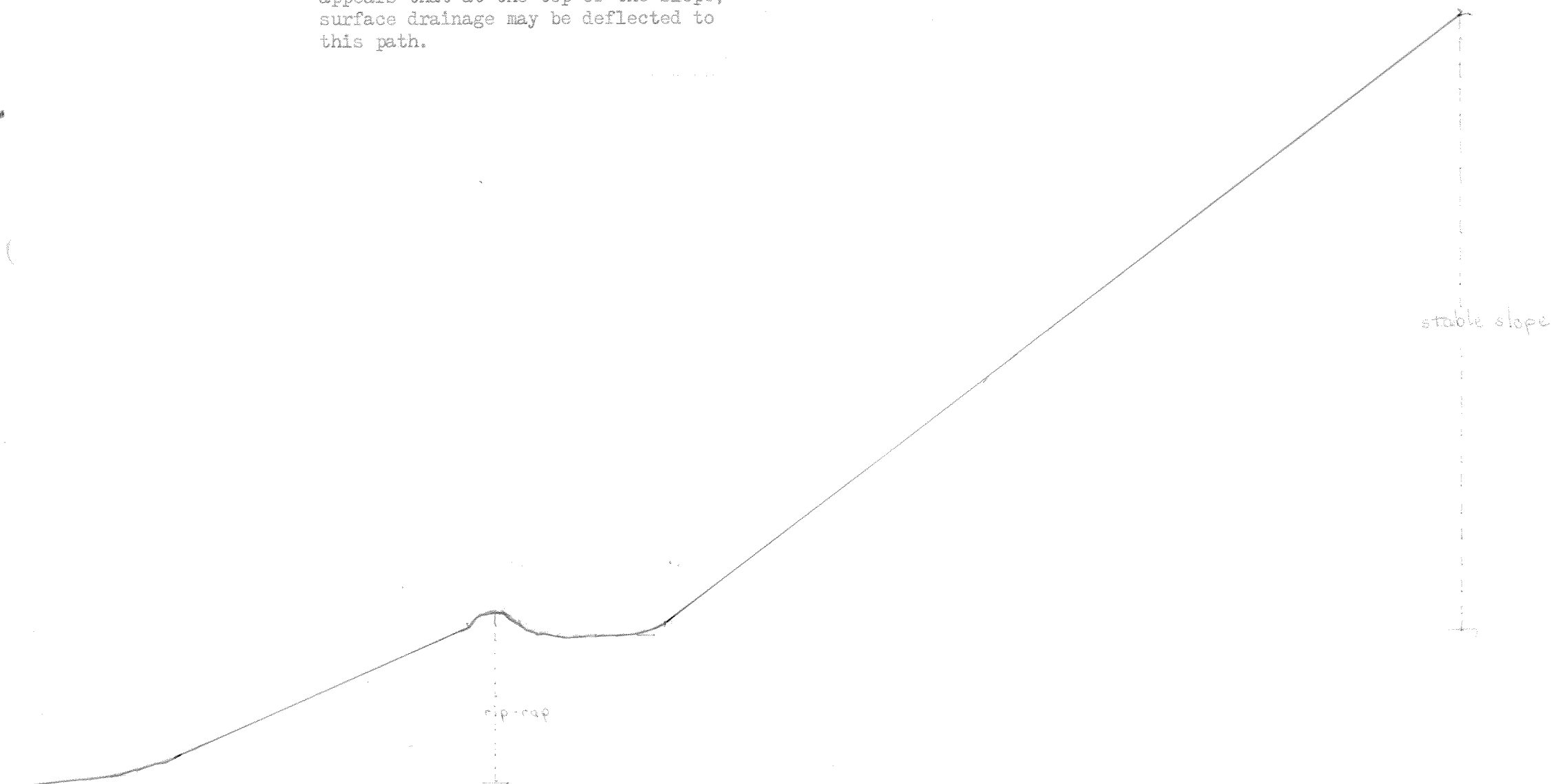




Fig. 8. Slope D. Immediately east of Redoubt #10.  
Heavily vegetated area on left, unstable  
footpath on right.

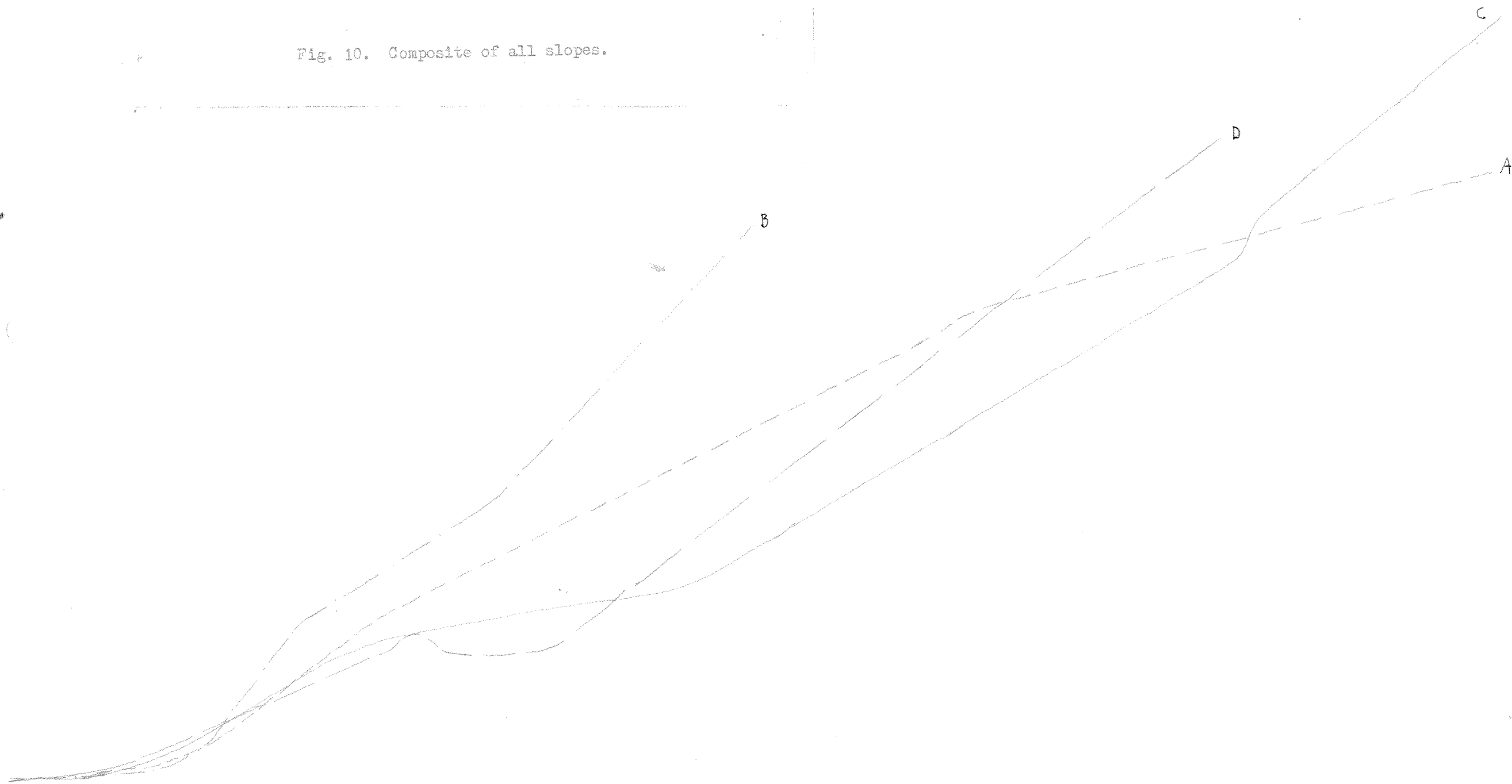
Fig. 9. Slope D. The profile line runs directly up the center of a u-shaped ravine. This area is densely vegetated and shows no erosion along the line. However, to the west of the line, but still within the ravine, a footpath shows evidence of erosion. It appears that at the top of the slope, surface drainage may be deflected to this path.



**SLOPE D**  
**N 24 E**

1 METER

Fig. 10. Composite of all slopes.



We also believe freeze-thaw effects in the winter contribute to erosion on the slopes. In the spring, heavy rains lead to sheet wash with the addition of material to the talus cones and alluvial fans. Figs. 11-18 show different examples of several types of erosion.

In other areas not specifically on the profile lines, talus cones were found in steep areas, close to footpaths. We were able to cut the cones in half and distinguish a darker layer, a thin leaf layer, and a lighter layer in the core. (Fig. 19). We understood the dark outside layer to be material that had accumulated during winter. In one case, this was estimated to be  $.64 \text{ m}^3$  of material, which was gathered from a very small area, about  $1\text{m} \times 2\text{m}$ . The cones were results of footpaths, <sup>erosion</sup> since these destroy vegetation, thereby leading to slump and sheet wash.



Fig. 11. Talus cone at base of slope.

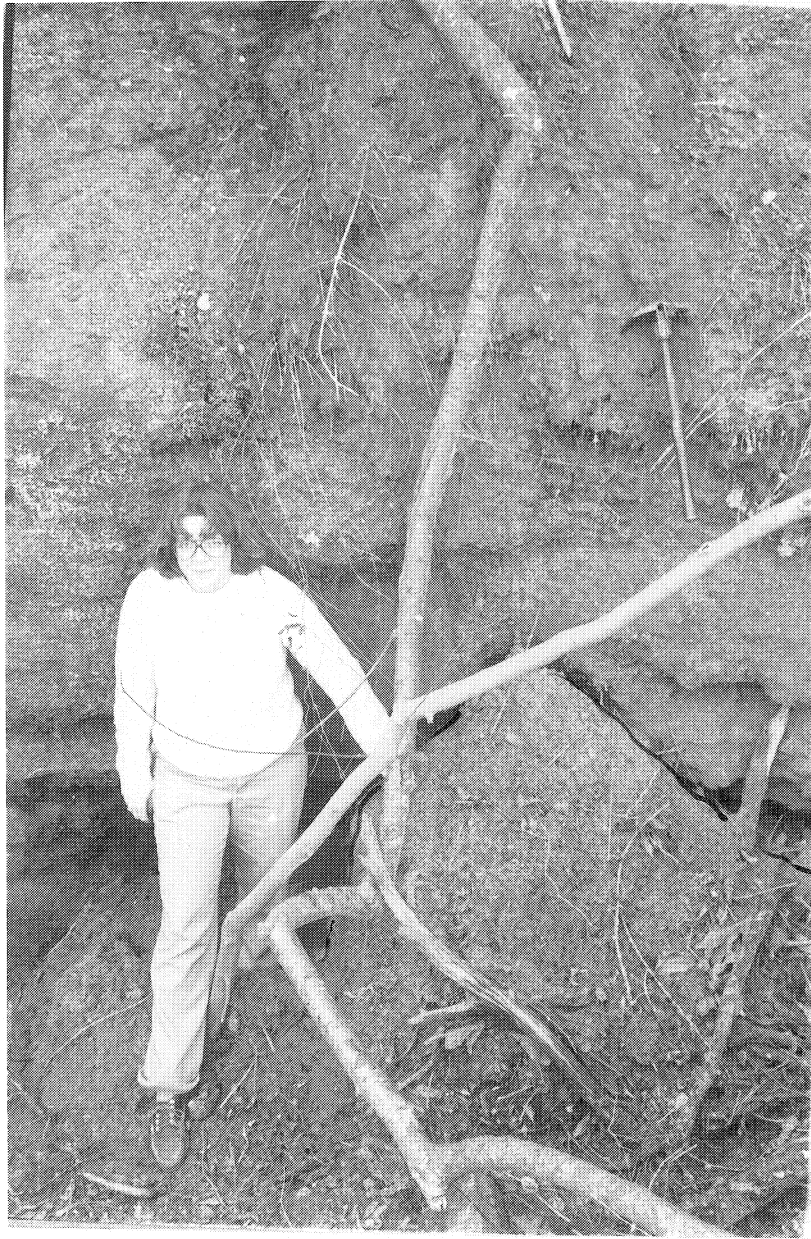


Fig. 12. Block of earth has fallen as a whole from point shown by shovel in cliff.

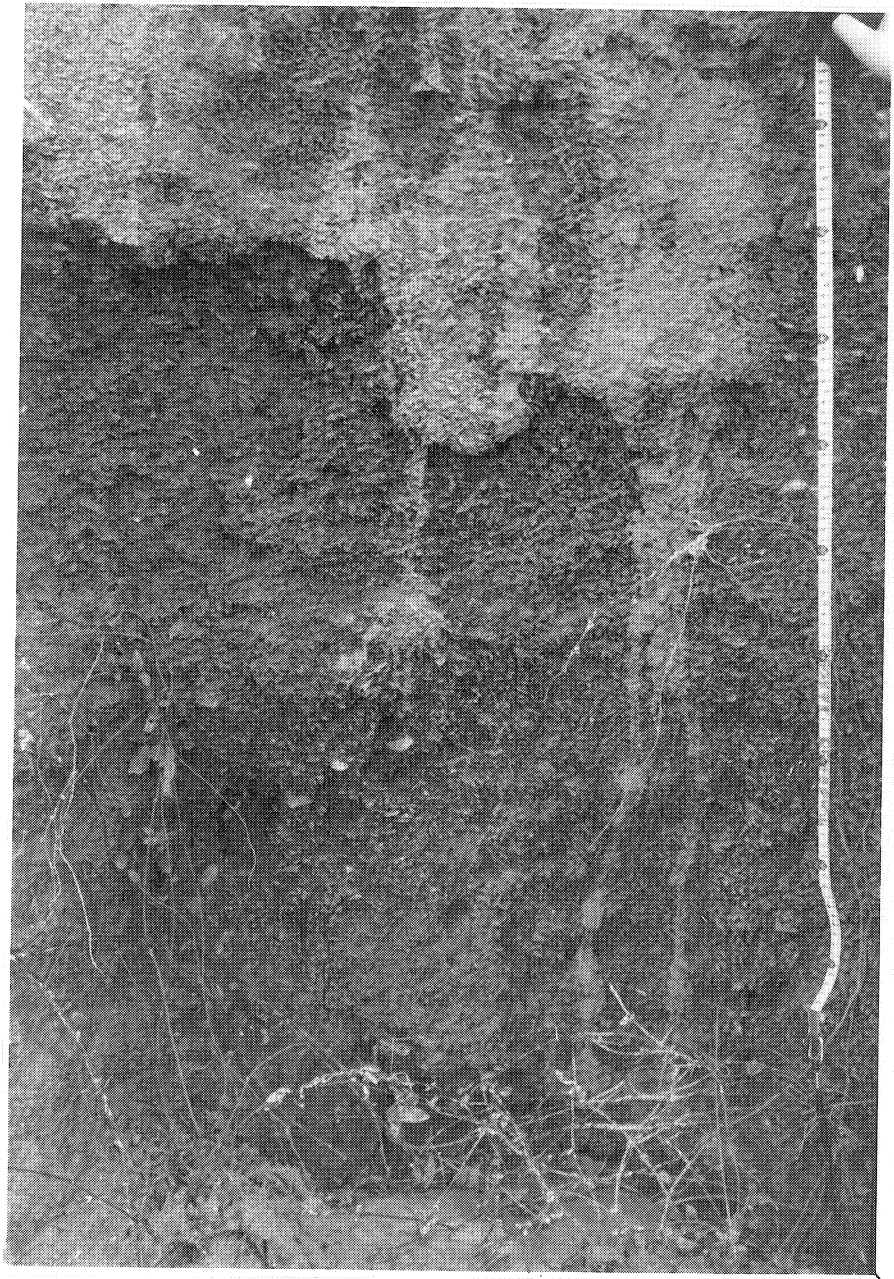


Fig. 13. Lighter formation above is washing onto lower formation.



Fig. 14. Material of slopes has filled interstices of riprap.

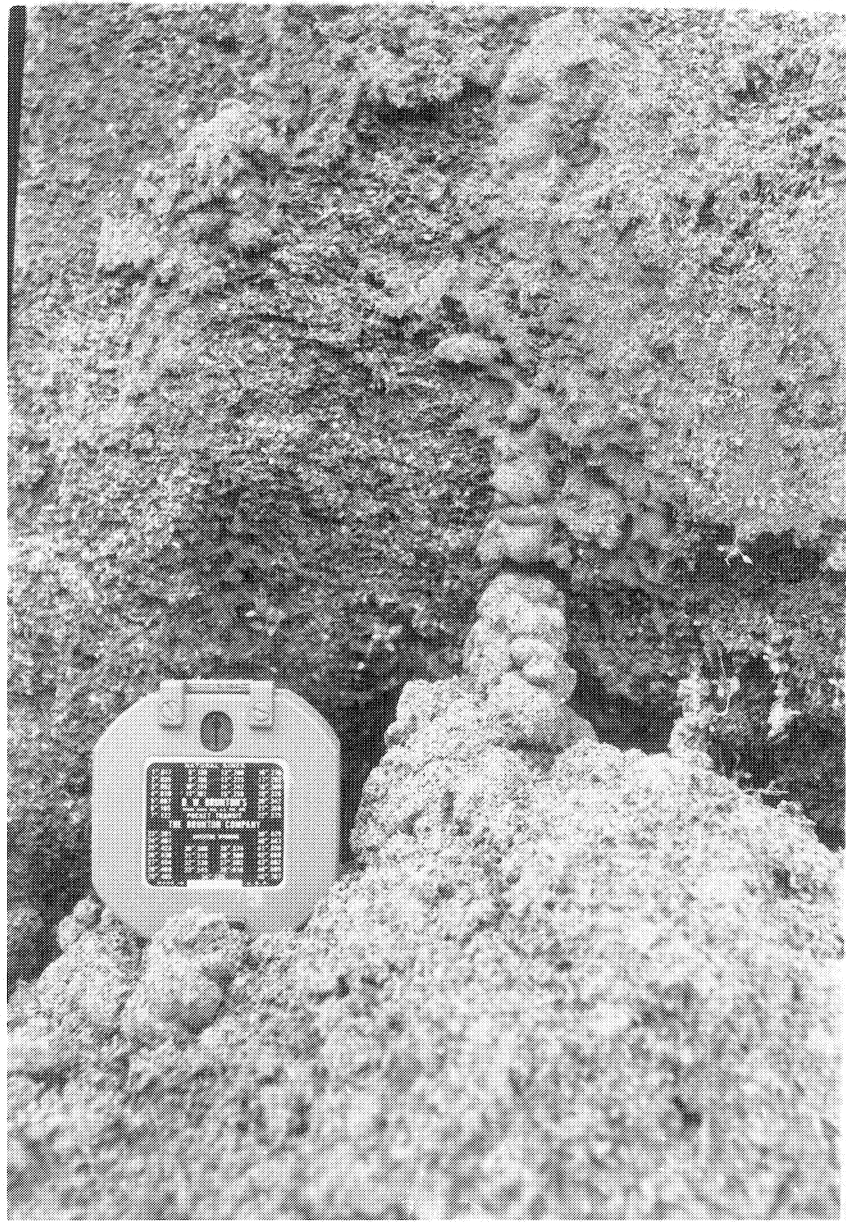


Fig. 15. Slow washing of slope forms "drip cone".



Fig. 16. Freeze-thaw has uncovered a lightly vegetated slope.

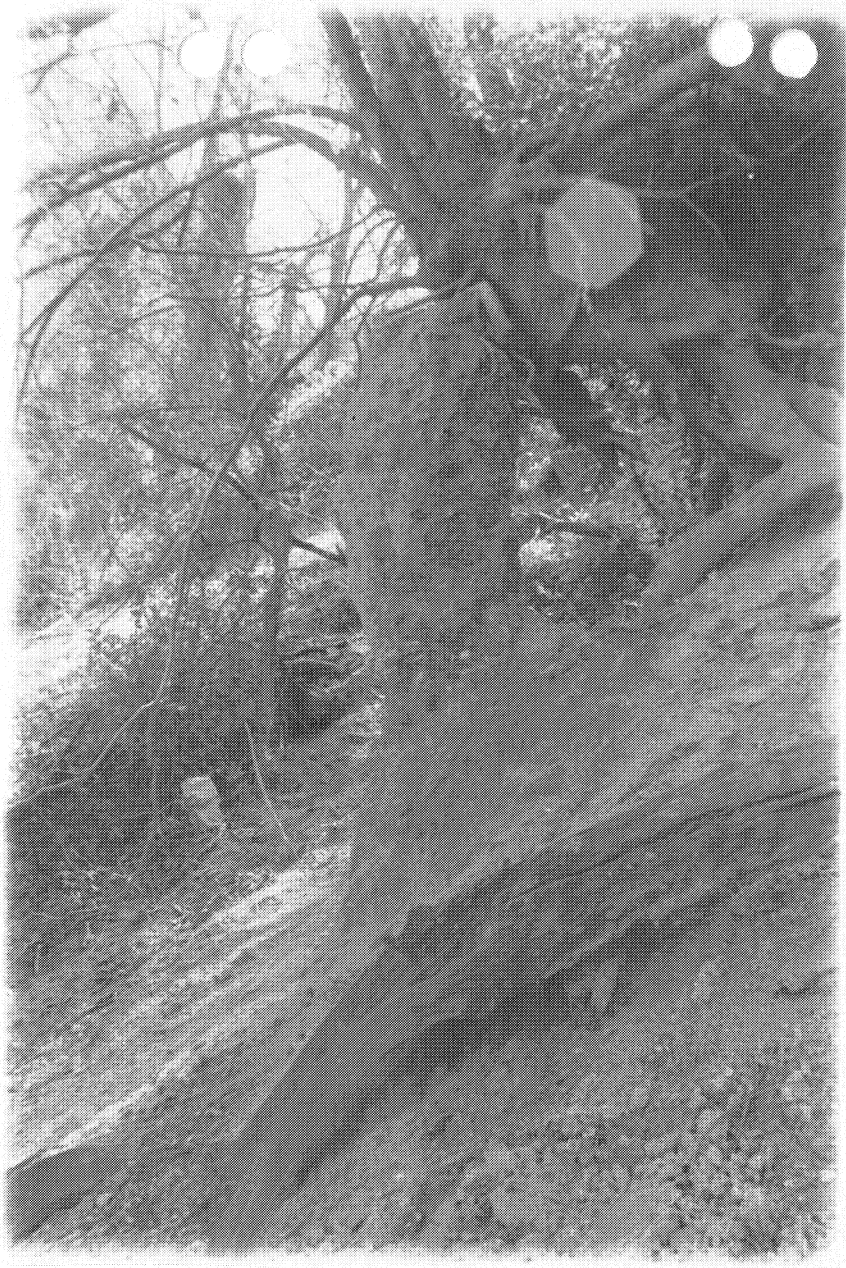


Fig. 17.  
Isolated arch-  
combination of wind  
and water erosion.



Fig. 18  
Mudflows.



Fig. 19. Talus cut in half to show dark, outer layer, leaf layer, and light, inner layer. The dark layer shows one winter's erosion.

#### IV. Recommendations

We have seen that erosion is quite serious in this area and control measures should be taken as soon as possible. We suggest a two-fold solution to the problem. In keeping with the natural surroundings of the park, we recommend vegetation establishment. Several excellent sources and agencies are available for advice on the best seed mixtures, planting schedules, and tacking agents. In particular, A Manual For Establishing a Vegetative Cover In Highway Corridors of Virginia by Wright, Perry, and Blaser of VPISU contains valuable information that could be applied to this area, since they performed studies on Coastal Plain sediments. Chemical binders were found to be no more effective than the conventional straw and asphalt method (Wyant, Sherwood, and Walker, 1972). In this area, care must be taken to topsoil especially sandy areas in addition to mulching and seeding because they do not contain the necessary plant nutrients to support a healthy plant population. It will be necessary to establish a thick winter as well as summer growth, since we have seen the area suffers heavily in the winter due to frost heaving.

In their manual, Wright, Perry, and Blaser gave a list of problems characteristic of coastal plain soils. They include low pH, low mineral deposits, warm temperatures, and droughtiness of the sandy soils. All of these must be considered when choosing a plant type, planting schedule, and necessary supplementary maintenance measures.

In the area of Slope C, right below the redoubt, the soil is so waterlogged from the water table that vegetating the slope

may be difficult. A drainage pipe that takes the water directly from the water table intersection to the river might be helpful. If a pipe that has holes along the sides were used, then some of the water would seep out and keep the soil moist without making it soggy.

The next aspect of the problem concerns human traffic. We suggest that the Park Service either ban the slopes to visitors or have one terraced walkway down to the beach. In several areas, the formation of talus cones was due entirely to human traffic.

## V. Bibliography

- Wright, D.L., Perry, H.D., and Blaser, R.E. 1975. Manual for establishing a vegetative cover in highway corridors of Virginia. Virginia Polytechnic Institute & State University. Blacksburg, Virginia.p.77.
- Wyant, D.C.1972. Sherwood, W.C., and Walker, H.N.. Erosion prevention during highway construction by the use of sprayed on chemicals. Virginia Highway Research Council. Charlottesville, Virginia. p.77.