Soil Morphology and Stratigraphy on an Erosional Footslope: Dickinson Experiment Station in Western North Dakota

By

D. Claypool, D. G. Hopkins, and J. L. Richardson

ABSTRACT

A first order soil survey of the crop rotation plots on the Dickinson Agricultural Experiment Station in western North Dakota was made in 1987. The site is on an erosional footslope developed in pedisediments. The soils mostly classified as fine-loamy Typic and Pachic Argiborolls. Pachic soils were observed throughout the study site and their distribution appeared to be independent of landscape position. Bt horizon thickness was independent of elevation as was the depth to carbonates. Five pedons had buried paleosols: two in higher positions and three in lower positions. Our study area is a footslope that is currently stable but the presence of buried soils indicates at least one erosional beveling and pedisediment covering. This was followed by a reintroduction of $CaCO_3$ in buried Bt horizons. We believe that these are very old soils because both the paleosols and overlying soils are well developed.

INTRODUCTION

During a first order soil survey of the crop rotation plots on the Dickinson Agricultural Experiment Station, we wanted to obtain additional information on soil-landscape relationships and soil variability (Claypool, 1987). The purpose of the survey was to enhance soil management and provide detailed soil information for interpreting crop production data. The need to identify soil variability for agronomic research in this geographic area was noted earlier (Hopkins et al., 1987). The objectives of this study were to examine the soil taxa observed as parts of a topographic system and evaluate the relationship between topography and selected soil properties.

METHODS AND MATERIALS

The study area is located in the southwest quarter of Section 32, Township 140N, Range 96W, Stark County, North Dakota (Fig. 1), and occupies about 5 acres (2 ha) of the Dickinson Agricultural Experiment Station. The climate in this area is semiarid and continental with mean annual temperature of 40 degrees F (4.6 degrees C) and mean annual precipitation of 15.5 inches (39 cm). The native vegetation was short and mid grasses (Larson et al., 1968).

The site is on an erosional footslope developed in pedisediments from the Sentinel Butte Formation of the Fort Union Group. The Sentinel Butte Formation is characterized by continental sediments, mostly fluvial, with some lignite (Groenewold, 1979). The erosional footslope contains shallow, fine textured Ustorthents above the study area and deep, medium and fine textured Argiborolls in the study area.

A topographic map of the crop rotation plots was made on a 25 feet (7.6 m) grid. Thirty-six sampling sites were established in four transects perpendicular to the slope. Soil pedons were described to 40 inches (1 m) using standard procedures from 2.5 inches (7.6 cm) diameter cores (Soil Survey Staff, 1951).

RESULTS

The study area had a planar surface with a south aspect and an average slope of 5% (Fig. 2). The soils were classified as fine-loamy Typic and Pachic Argiborolls with the exception of one sandy Entic Haploboroll. Pachic soils were observed throughout the study site and their distribution appeared to be independent of landscape position (Fig. 2). Additionally, Bt horizon thickness (Fig. 3, 4, and 5) was independent of elevation as was the depth to carbonates (Fig. 6). The greatest depth to carbonates and thickest Bt horizons were on the east side of the study area and decreased across the slope towards the west.

Five pedons had buried paleosols: two in higher positions and three in lower positions. The argillic horizons of the higher paleosols possessed moderately thick clay films, strong grades of structure, and finer textures than the overlying soils. In the lower paleosols the argillic horizons had thin clay films, weak and moderate grades of structure, and coarser textures than the overlying soils. One of the upper paleosols had an intact Ab horizon; all others were truncated or the Ab had disappeared (Fig. 3 and 4). In all cases, pedologic discontinuities and color changes marked the paleosols.

DISCUSSION

Geomorphic stability is indicated by the presence of well developed argillic horizons in soils throughout the study site. We believe that the formation of thick argillic horizons here requires a stable geomorphic surface. The argillic horizon thickness implies that these soils are very old. Given the simplicity and geomorphic stability of this surface, we expected a straight forward slope-soil morphologic relationship. The soils, however, did not conform to our expectations. Argillic horizon thickness and depth to carbonates progressively became deeper across the slope west to east rather than down the slope.

Many of the argillic horizons observed in these pedons were effervescent in acid indicating the presence of carbonates. This represents a change in pedogenic processes. The formation of an argillic horizon usually occurs after $CaCO_3$ has been removed (Soil Survey Staff, 1975). Therefore, we assume that the carbonates in a Btk horizon were reintroduced after a Bt horizon formed.

INTERPRETATIONS

Our study area is a footslope that is currently stable but the presence of buried soils indicates at least one erosional beveling and pedisediment covering. This was followed by a reintroduction of $CaCO_3$ in buried Bt horizons. We believe that these are very old soils because both the paleosols and overlying soils are well developed.

The variation in Bt horizon thickness, plus the depth to carbonates are accounted for by differential erosion across the slope. Therefore, it is likely that geomorphic and pedogenic processes have not been uniform because of differential rill and interrill erosion. In older landscapes such as this, we probably should expect a complex geomorphic history.

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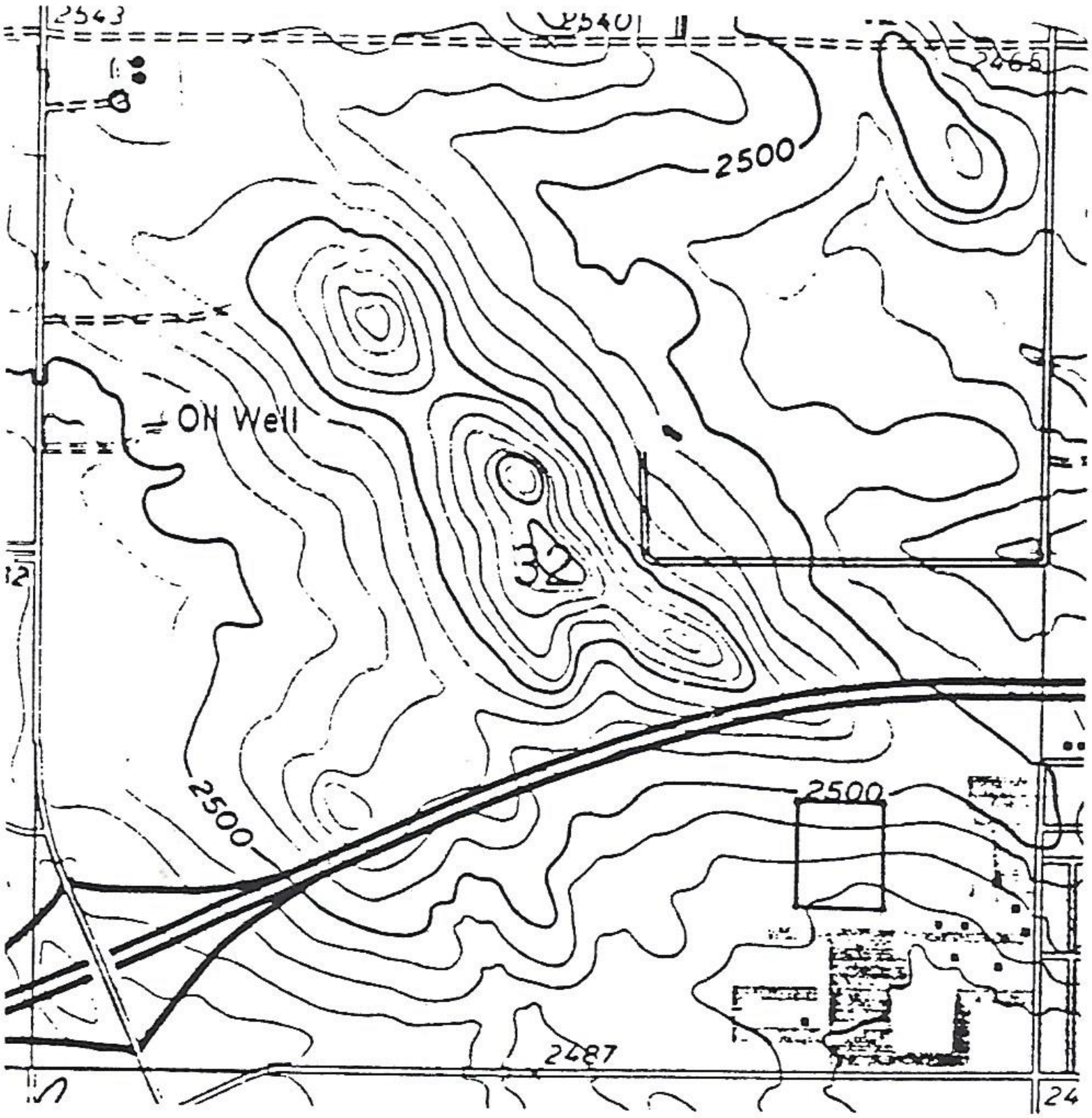

Figure 1. Topographic map of a portion of the Dickinson Experiment Station: Section 32, Township 140N, Range 96W, Stark County, North Dakota. Contour interval is 20 feet. The study area is located in the southeast corner.

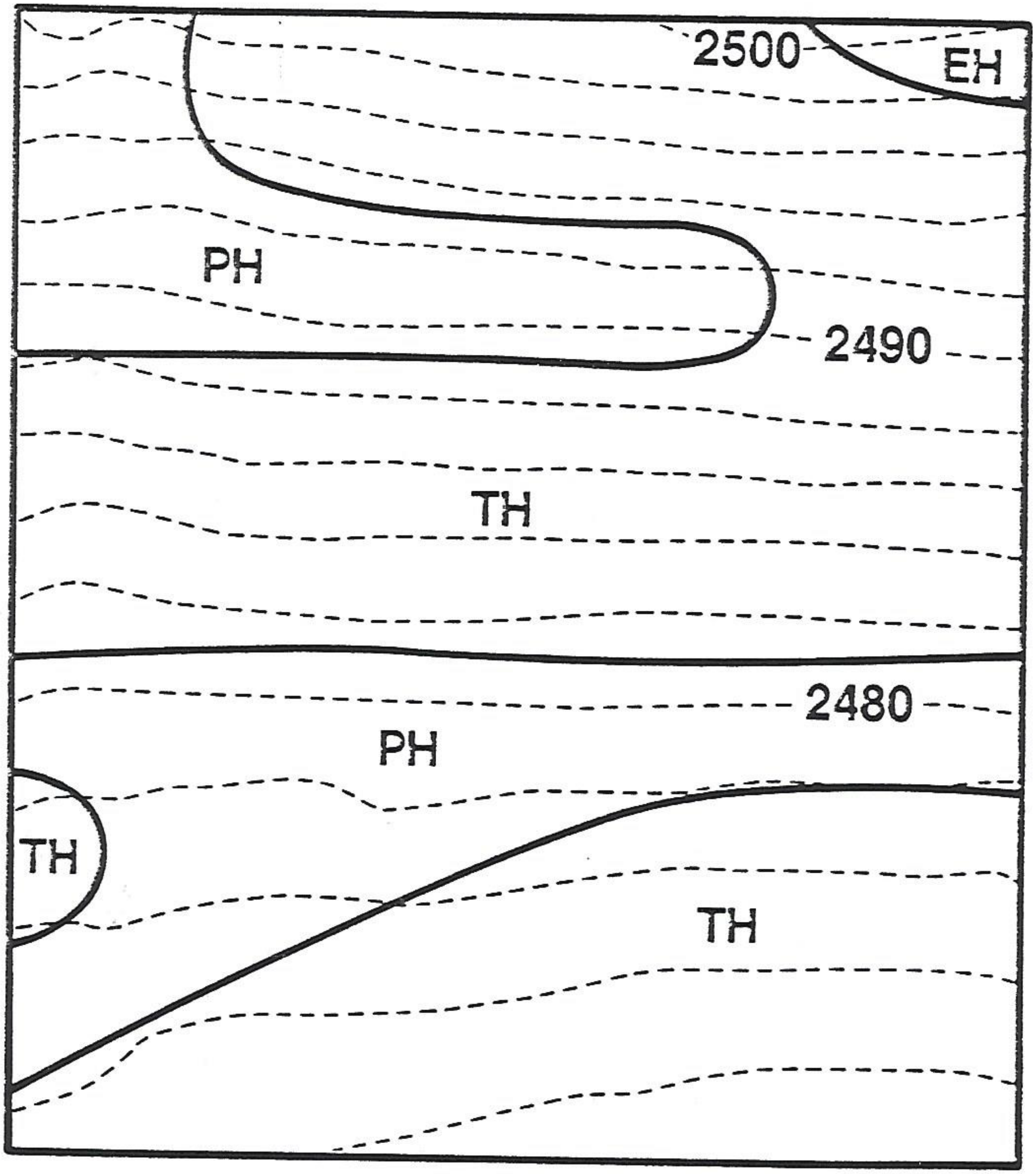

Figure 2. Topographic and soil map of the 5 acre study area. EH are Entic Haploborolls; PH are Pachic Argiborolls; TH are Typic Argiborolls. Contour interval is 2 feet.

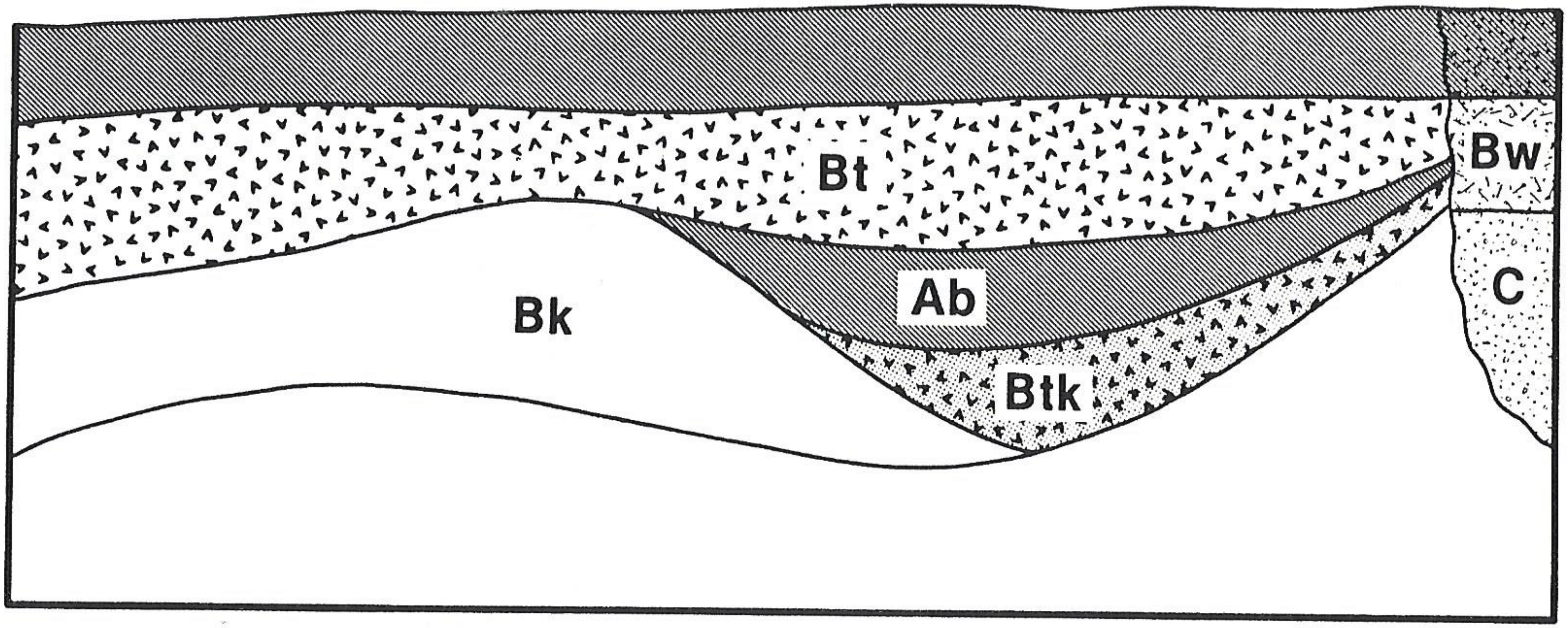

Figure 3. Cross-slope transect of upper portion of the study area at approximate elevation of 2496 feet. Note buried A horizon, Bw horizon, and thick Bt horizon. Depth of solum is 38 inches at left and 21 inches at right. Vertical scale is exaggerated.

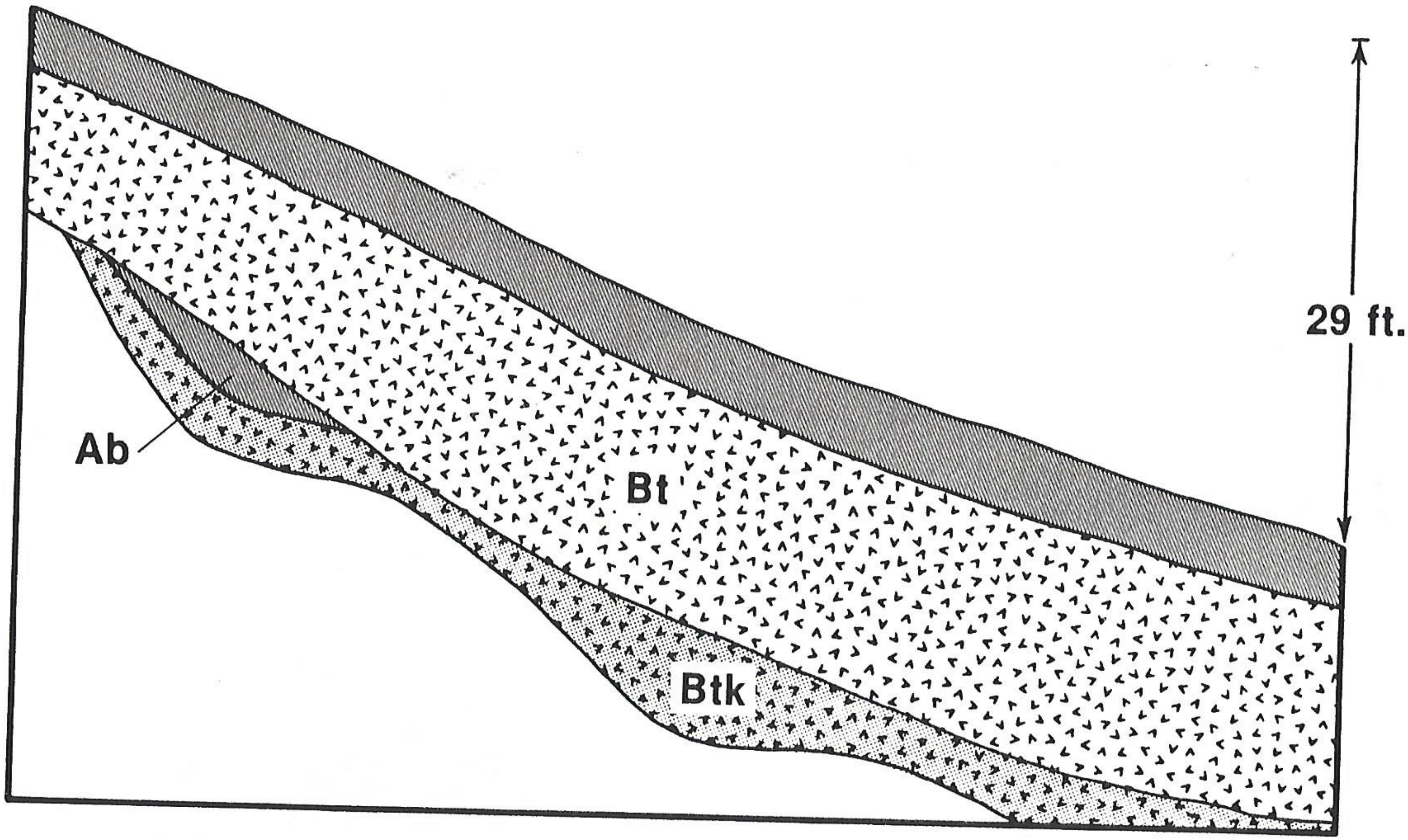

Figure 4. Downslope transect of the east-central part of the study area. Elevations range from 2500 to 2471 feet. Solum depth at left is 17 inches and is 46 inches at right. Vertical scale is exaggerated and the profile thickness even more exaggerated to illustrate slope relationships.

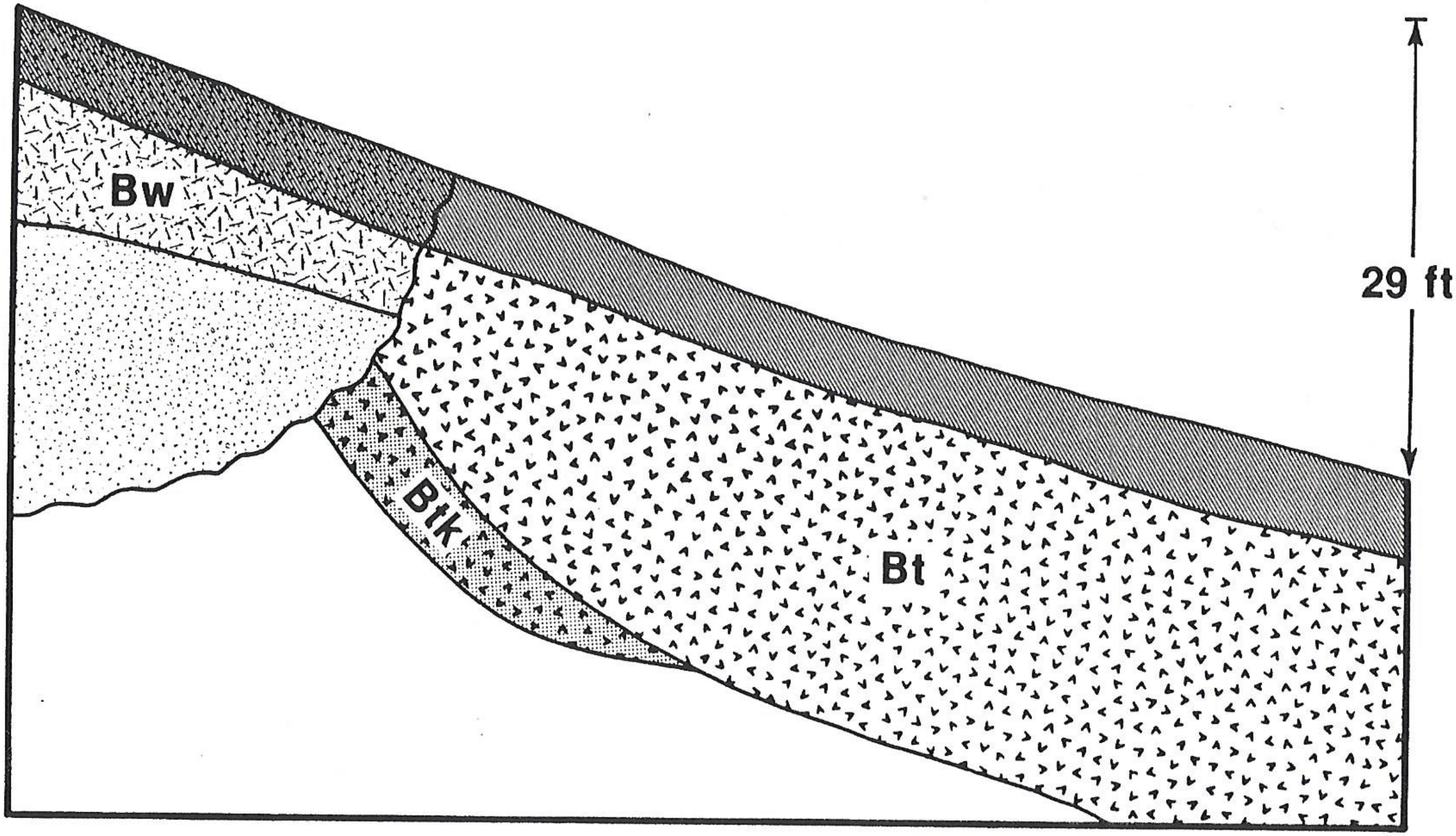

Figure 5. Downslope transect of eastern part of the study area. Elevation ranges from 2501 feet to 2471 feet. Length of slope is 575 feet. Depth of the solum at left is 35 inches and is 48 inches at right.