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# Soil and Lithostratigraphy Below the Loveland/ Sicily Island Silt, Crowley's Ridge, Arkansas

Donna Porter
*University of Arkansas, Fayetteville*

Sam Bishop
*University of Arkansas, Fayetteville*

# SOIL AND LITHOSTRATIGRAPHY BELOW THE LOVELAND/SICILY ISLAND SILT, CROWLEY'S RIDGE, ARKANSAS

**DONNA PORTER**
Geology Department
University of Arkansas
Fayetteville, AR 72701

**SAM BISHOP**
Geography Department
University of Arkansas
Fayetteville, AR 72701

**ABSTRACT**

Two stratigraphic units between the Loveland/Sicily Island Silt and the Pliocene sand and gravel on Crowley's Ridge were analyzed to determine their origin and assess the degree of pedogenic development. The Crowley's Ridge Loess, the upper unit, was up to 2.6 m thick, was not laterally continuous, and contained a well developed paleosol. The lower unit was a several meter thick sandy facies of the Pliocene sand and gravel which contained a weak paleosol. Particle size analysis revealed that the upper unit exhibited texture similar to the overlying loess units, with unimodal silt comprising greater than 95% of the clay-free material. The lower unit has a bimodal distribution with modes of medium sand and coarse silt, that is bedded and cross-bedded below the pedogenic horizons. Thin sections of pedogenic horizons in both units revealed clay films that are strongly oriented and abundant in the B horizons with most voids occurring in the AB horizons. In conclusion, there are four loess units on Crowley's Ridge. A significant period of weathering followed deposition of the oldest widespread loess with at least a short period of weathering following the deposition of the sandy Pliocene alluvium.

## INTRODUCTION

Crowley's Ridge is a unique landform that rises as much as 60 m above the surrounding terrain. This narrow erosional remnant trends north-south from southeastern Missouri to east central Arkansas, extending approximately 300 km (Fig. 1). It formed as a divide between the ancestral Mississippi River to the west and the Ohio River to the east. The two rivers eroded unconsolidated coastal plain sediments forming broad alluvial valleys (Call, 1891). It is widely recognized that the ridge is comprised of unconsolidated Eocene clastics overlain by Pliocene sand and gravel. Historically, these units have been considered to be overlain by three layers of Pleistocene loess; the Loveland/Sicily Island Silt being the oldest, succeeded by the Roxana Silt, and the youngest, Peoria Loess (West *et al.*, 1980; Guccione *et al.*, 1986).

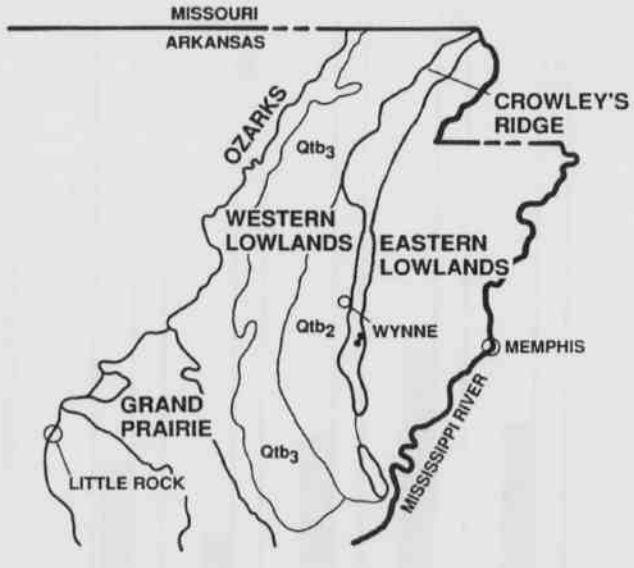


Figure 1. Location map of Crowley's Ridge and selected geomorphic regions of Northeast Arkansas. Study sites at Wittsburg Quarry and Village Creek landslide are shown by squares. Taken from Rutledge *et al.*, (1990).

However, there are 2 stratigraphic units between the Loveland/Sicily Island Silt and Pliocene sand and gravel that have not been well recognized. The purpose of this study was to describe these units, determine their mode of deposition, and assess the degree of pedogenic development within each unit. The upper unit, the Crowley's Ridge Loess, has been correlated with loesses in Louisiana (Rutledge *et al.*, 1990; Miller *et al.*, 1986). The lower unit has not been named or correlated, but for the purpose of this paper will be referred to as Pliocene sand.

The units are well exposed at multiple localities near Wynne, Arkansas in Cross County (Fig. 1). The deposits and their soil profiles were described and sampled on the south face of the Wittsburg Quarry and at Village Creek State Park. At both of these locations, the Crowley's Ridge Loess pinches out laterally (Fig. 2). The units have also been recognized at the nearby Bledsoe Section by Rutledge *et al.*, (1990).

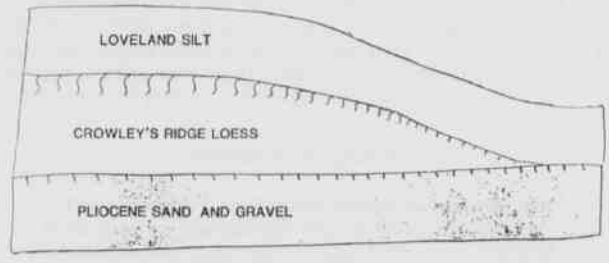


Figure 2. Diagramatic cross section of a selected portion of the north-facing wall, Wittsburg Quarry.

## METHODS

The sediment and soil profiles were described using the standard

USDA format (Soil Survey Staff, 1981). Two samples were taken from the base of the overlying Loveland Silt, and 7 samples each from the Crowley's Ridge Loess and the Pliocene sand. These samples were analyzed for grain size. Gravel and sand fractions were dry sieved and weighed. Silt and clay fractions were analyzed by the pipette method (Day, 1965). Gravel is reported as a percent of the total sample and is >2 mm. Sand is reported as a percent of the clay-free (0.002-2 mm) fraction to eliminate the effect of pedogenesis. Silt is the 0.0625 mm to 2 micron fraction, and clay is <2 microns.

Seven samples were taken for thin section examination. One from the Loveland/Sicily Island Silt, and 3 each from the Crowley's Ridge Loess and the Pliocene sand. Each thin section analysis included 230 to 260 point counts and the terminology of Brewer (1964) was used in describing micromorphology. The term cutan is defined as a modifcation of the texture, structure, or fabric at natural surfaces in soil materials due to concentrations of particular soil constituents or in situ modification of the plasma. Cutans include argillans or clay films, and other ped coatings. The term glaebule includes nodules and concretions. It is defined as a three dimensional unit within the S-matrix of the soil material and is usually prolate to equant in shape. It is recognized as a unit either because of a greater concentration of some constituent and/or a difference in fabric compared with the enclosing soil material, or because it has a distinct boundary with the enclosing soil material. S-matrix is defined as the material within the simplest primary ped in which the pedologic features occur.

## SEDIMENT

The Loveland/Sicily Island Silt is approximately 8.6 m thick at the Wittsburg Quarry (Guccione *et al.*, 1986). It was sampled because it was considered to be a loess and could be used for comparison with the underlying units being examined in this study. The upper sample was taken from the C horizon 90 cm above the base of the Loveland/Sicily Island Silt. The second sample was taken 5 cm from the base. These samples are typical of the Loveland/Sicily Island Silt in the area (West *et al.*, 1980). They are unimodal deposits with a coarse silt mode. On a clay-free basis, silt makes up greater than 95% of the sample (Table 1). West *et al.*, (1980) concluded that the relatively coarse grain size of the Loveland/Sicily Island Silt was due to a source close to the site of deposition.

Table 1. Size analysis of samples taken from profile at Wittsburg Quarry; 2 mm to 2 microns. Reported on a clay-free basis to eliminate the effect of pedogenesis.

| Horizon | Horizon Depth (cm) | Sample Depth (cm) | % Sand | | | | | | % Silt | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | VC | C | M | F | VF | Total | C | M | F | Total |
| C | | -90 | 0 | 0 | 0 | 0 | 0 | 1 | 77 | 22 | 0 | 99 |
| C | | -5 | 0 | 0 | 1 | 1 | 1 | 2 | 70 | 23 | 4 | 98 |
| ABt | 0- 79 | 13 | 0 | 0 | 0 | 0 | 0 | 1 | 69 | 28 | 3 | 99 |
| Bt | 79-149 | 73 | 0 | 0 | 0 | 1 | 1 | 2 | 66 | 28 | 4 | 98 |
| Bt | 79-149 | 102 | 0 | 0 | 0 | 0 | 1 | 1 | 70 | 25 | 5 | 99 |
| BC | 149-185 | 169 | 0 | 0 | 0 | 0 | 0 | 1 | 69 | 26 | 4 | 99 |
| C | 185-225 | 213 | 0 | 1 | 4 | 1 | 1 | 7 | 64 | 25 | 4 | 93 |
| C | 225-256 | 232 | 0 | 2 | 10 | 4 | 3 | 19 | 55 | 24 | 2 | 81 |
| 2A | 256-274 | 259 | 1 | 4 | 16 | 6 | 4 | 31 | 45 | 21 | 3 | 69 |
| 2ABt | 274-309 | 279 | 3 | 5 | 18 | 6 | 4 | 36 | 42 | 18 | 3 | 64 |
| 2ABt | 274-309 | 298 | 2 | 5 | 22 | 8 | 6 | 44 | 35 | 19 | 3 | 56 |
| 2Bt | 309-368 | 315 | 2 | 6 | 21 | 8 | 6 | 43 | 39 | 15 | 2 | 57 |
| 2Bt | 309-368 | 331 | 3 | 6 | 24 | 9 | 7 | 48 | 32 | 17 | 4 | 52 |
| 2Bt | 309-368 | 352 | 2 | 8 | 30 | 10 | 9 | 59 | 27 | 11 | 3 | 41 |
| 2BCt | 368-386 | 379 | 8 | 15 | 43 | 9 | 7 | 81 | 11 | 7 | 1 | 19 |

The Crowley's Ridge Loess has a maximum thickness of 2.4 m in the Wittsburg Quarry. The first 6 samples taken 13-213 cm below the upper contact are unimodal with a coarse silt mode. On a clay-free basis, silt makes up 93-99% of the samples. The seventh sample from the Crowley's Ridge Loess was taken 20 cm above the base of the deposit. On a clay-free basis, the percentage of sand was more than double compared to that in the overlying sample, and the silt fraction decreased to 81% (Fig. 3). This sample is interpreted as transitional between the

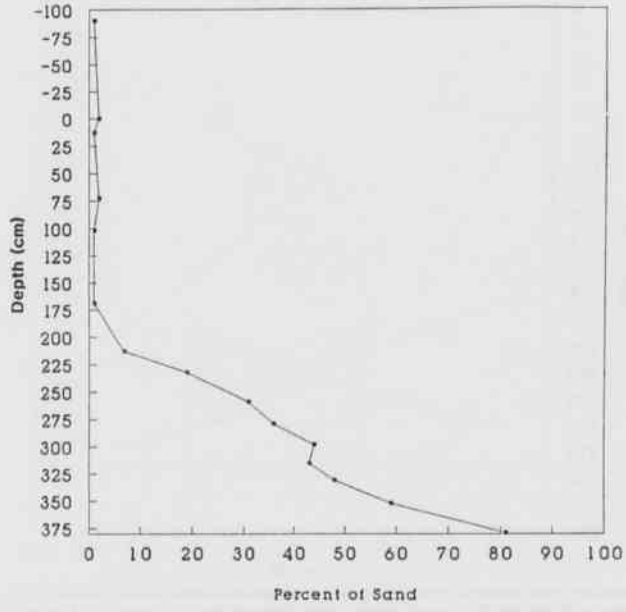


Figure 3. Percent of sand versus depth (cm). Samples were taken from Wittsburg Quarry. The contact between Loveland/Sicily Island Silt and Crowley's Ridge Loess is at zero cm. The contact between Crowley's Ridge Loess and Pliocene sand is at 256 cm.

Crowley's Ridge Loess and the underlying Pliocene sand. Probably mixing between these two units has occurred in this transition zone.

In the field there was a significant change in lithology, pedology, and weathering characteristics between the Crowley's Ridge Loess and the Pliocene sand. The Pliocene sand was 130 cm thick. The grain size distribution on a clay-free basis was bimodal with modes in the medium sand and coarse silt fractions (Table 1), and the percent of sand increased with depth. Total sand fraction increases from 7% of the sand plus silt fractions in the upper part of the unit to 81% at the base of the Pliocene sand.

The same units were also examined approximately 8 km (5 mi) southwest of the Wittsburg Quarry at the Village Creek landslide. The deposits were similar to those at Wittsburg Quarry (Fig. 4).

## SOIL

The Loveland/Sicily Island Silt, the Crowley's Ridge Loess and the Pliocene sand were described in the field, examined in thin sections, and the grain size was quantified in the laboratory to determine if buried soils were present. The lower 90 cm of the Loveland/Sicily Island Silt was examined for comparison with the underlying units. The C horizon of the Loveland/Sicily Island is a massive, yellowish brown, silty horizon with at least 10% clay (Table 2). The lower 30 cm of the deposit is a transition zone. It contains a greater amount of clay (33%) than the unmodified loess. A thin section of a sample from the transition zone contained feldspar, mica, and secondary calcite in addition to the abundant quartz grains.

A strong paleosol was developed in the Crowley's Ridge Loess, which was less developed laterally as the loess unit pinches out. Field observations of the upper 79 cm suggested that this is an ABt horizon (Table 3). It is a yellowish brown/strong brown silty clay, with distinct yellowish red clay films. In thin section, void content was 13% compared to 4% in the above C horizon (Fig. 5). A high percentage of non-planar voids indicated the presence of root pores and/or burrows, characteristics

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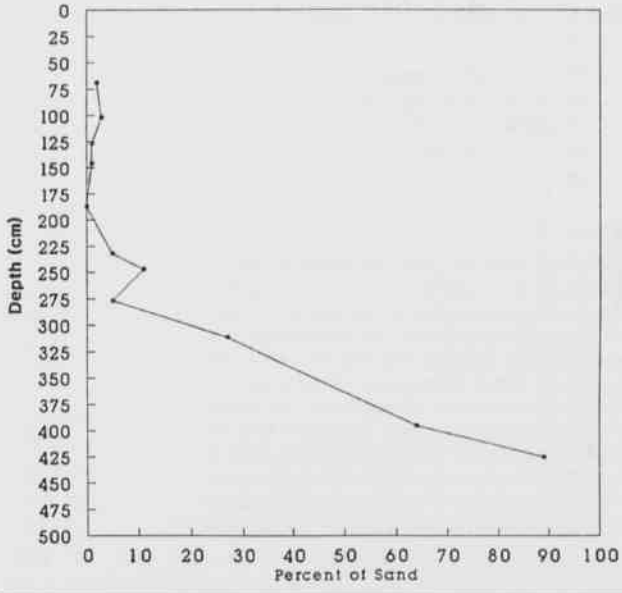


Figure 4. Percent of sand versus depth (cm). Samples were taken from Village Creek landslide. The contact between Loveland/Sicily Island Silt and Crowley's Ridge Loess is at approximately 80 cm. The contact between Crowley's Ridge Loess and Pliocene sand is at 235 cm.

Table 2. Size analysis of samples taken from profile at Wittsburg Quarry. Includes a percent of the < 2 micron fraction to assess the effect of pedogenesis.

| Horizon | Horizon Depth (cm) | Sample Depth (cm) | % Total Gravel | % Sand | | | | | | % Silt | | | | % Clay |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | VC | C | M | F | VF | Total | C | M | F | Total | |
| C | | -90 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 70 | 20 | 0 | 90 | 10 |
| C | | -5 | 0 | 0 | 0 | 1 | 0 | 1 | 2 | 48 | 16 | 3 | 66 | 33 |
| ABt | 0- 79 | 13 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 41 | 17 | 2 | 59 | 41 |
| Bt | 79-149 | 73 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 41 | 17 | 3 | 61 | 38 |
| Bt | 79-149 | 102 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 46 | 16 | 3 | 65 | 34 |
| BC | 149-185 | 169 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 53 | 20 | 3 | 76 | 24 |
| C | 185-225 | 213 | 0 | 0 | 1 | 3 | 1 | 1 | 5 | 47 | 19 | 3 | 68 | 27 |
| C | 225-256 | 232 | 1 | 0 | 2 | 7 | 3 | 3 | 14 | 40 | 17 | 1 | 58 | 28 |
| 2A | 256-274 | 259 | 0 | 1 | 3 | 12 | 4 | 3 | 23 | 34 | 16 | 3 | 52 | 25 |
| 2ABt | 274-309 | 279 | 1 | 2 | 4 | 14 | 5 | 3 | 29 | 34 | 15 | 3 | 52 | 19 |
| 2ABt | 274-309 | 298 | 1 | 1 | 4 | 17 | 6 | 4 | 32 | 26 | 14 | 2 | 42 | 26 |
| 2Bt | 309-368 | 315 | 1 | 2 | 4 | 15 | 5 | 4 | 30 | 27 | 10 | 2 | 39 | 31 |
| 2Bt | 309-368 | 331 | 1 | 2 | 4 | 15 | 6 | 4 | 30 | 20 | 10 | 2 | 33 | 37 |
| 2Bt | 309-368 | 352 | 2 | 1 | 5 | 19 | 6 | 6 | 38 | 18 | 7 | 2 | 27 | 35 |
| 2BCt | 368-386 | 379 | 6 | 5 | 11 | 31 | 6 | 5 | 58 | 8 | 5 | 1 | 13 | 28 |

associated with an A horizon. Planar voids were also more abundant in this horizon due to stronger soil structure. Cutans increased to 22% relative to 4% in the above C horizon (Fig. 6). This increase in cutans was consistent with the increase in clay content which reached a maximum of 41% in the underlying ABt horizon (Fig. 7). The Bt horizon was 70 cm thick; structure was weaker, and clay content decreased to 34%. Clay films were common but thin, decreasing in abundance toward the base of the horizon.

The lowest pedogenic horizon in the Crowley's Ridge Loess has been classified as a BC horizon due to the continued presence of thin clay films. Structure was massive throughout the BC and C horizons. In thin section, the transitional C horizon, 20 cm from the base of the loess, contained weakly developed cutans within vesicles and along planar voids (Fig. 8).

Table 3. Soil Description of the Wittsburg Quarry

| HORIZON DEPTH (cm) | THICKNESS (cm) | HORIZON | COLOR | TEXTURE | STRUCTURE | SPECIAL CHARACTERISTICS |
|---|---|---|---|---|---|---|
| -90 | | C1 | 10YR 5/4 Yellow brown. | Silt | Massive | Loveland Silt |
| -5 | | C2 | 10YR 5/4 Yellow brown with 10YR 5/8 yellow brown mottles. | Silty clay loam | Massive | Transition zone |
| 0-79 | 79 | ABtb | 10YR 5/4 Yellow brown with abundant 5YR 5/6 yellow red and 7.5YR 5/8 strong brown mottles. | Silty clay | Moderate medium subangular blocky | Manganese stains lining root pores/worm burrows. Clay films common to many at base. |
| 79-149 | 70 | Btb | 10YR 5/6 Yellow brown and 10YR 6/8 brown yellow. | Silty clay loam | Weak medium subangular blocky | Clay films common, thin; becoming few, thin towards base. |
| 149-185 | 36 | BCb | 10YR 5/8 Yellow brown with 10YR 7/3 pale brown along vertical joints. | Silt loam | Massive | Few, thin clay films. |
| 185-225 | 40 | Cb1 | 10YR 5/8 Yellow brown with 10YR 7/3 very pale brown mottles. | Silty clay loam | Massive | No clay films. |
| 225-256 | 31 | Cb2 | 10YR 5/8 Yellow brown. | Silty clay loam | Massive | Transition zone |
| 256-274 | 18 | 2ABb | 10YR 5/8 Yellow brown. | Silt loam | Weak medium subangular blocky | Abundant root pores. |
| 274-309 | 35 | 2ABtb | 7.5YR 5/6 Strong brown. | Loam | Moderate medium subangular blocky | Scattered pebbles. Common root pores. Common to many clay films. |
| 309-368 | 59 | 2Btb | 7.5YR 5/6 Strong brown with 5YR 4/4 reddish brown mottles at base. | Clay loam | Moderate medium subangular blocky | Scattered pebbles. Common distinct clay films. |
| 368-386 | 18 | 2BCb | 7.5YR 5/6 Strong brown with many coarse 2.5YR 4/6 red mottles. | Sandy clay loam | Weak fine subangular blocky to massive towards base | Many scattered pebbles. Few thin clay films. |

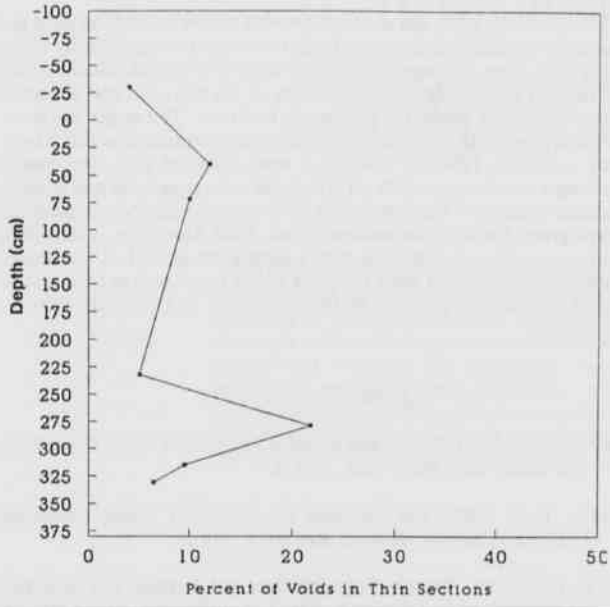


Figure 5. Percent of voids in thin section versus depth (cm) at Wittsburg Quarry. Contact between Loveland/Sicily Island Silt and Crowley's Ridge Loess is at zero cm. Contact between Crowley's Ridge Loess and Pliocene sand is at 256 cm.

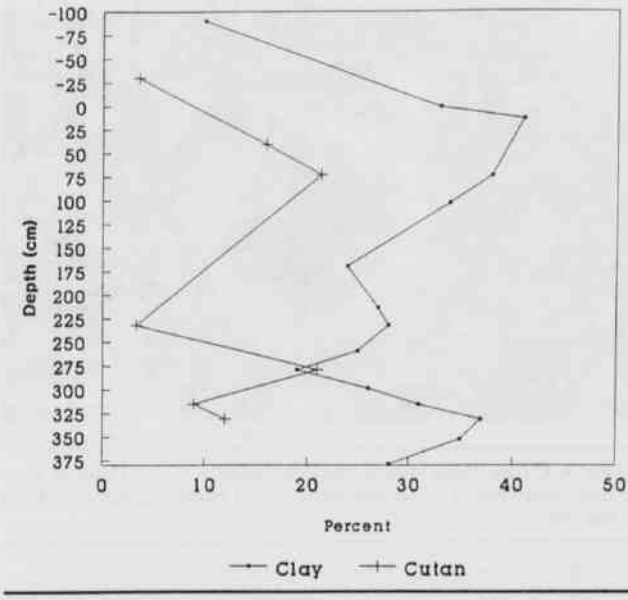


Figure 7. Percent of clay/cutans versus depth (cm) at Wittsburg Quarry. Cutan data is from thin sections. Clay data is from size analysis of the < 2 micron fraction. Contact between Loveland/Sicily Island Silt and Crowley's Ridge Loess is at zero cm. Contact between Crowley's Ridge Loess and Pliocene sand is at 256 cm.

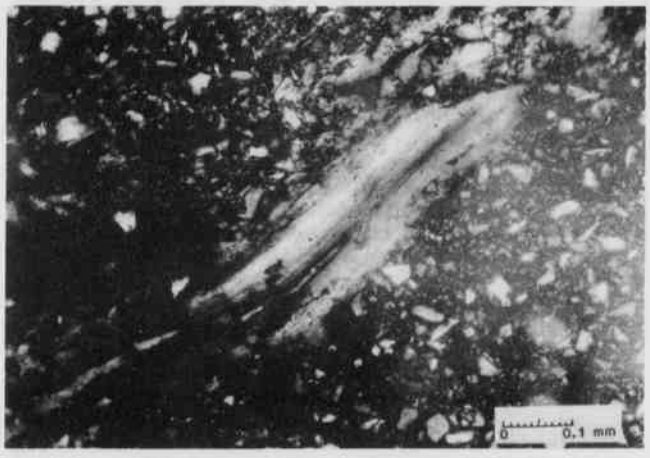


Figure 6. Cutans lining planar void in the ABt horizon of the Crowley's Ridge Loess at Wittsburg Quarry. This feature is 60 cm below the upper contact of the unit.

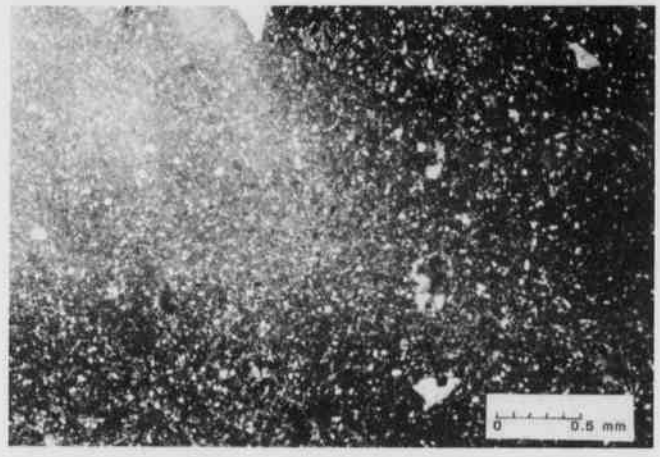


Figure 8. Massive structure in the C horizon of the Crowley's Ridge Loess at Wittsburg Quarry.

A weak paleosol was developed in the Pliocene sand. Field observations of the upper 18 cm suggested that this is an A horizon (Table 3). The horizon contained a few light gray mottles and pores were common. Structure graded to moderate medium angular blocky in the underlying strong brown loam of the ABt horizon. Clay films were common to many and distinct. In thin section, cutans increased from 3% in the overlying C horizon of the Crowley's Ridge Loess to 21% in the ABt horizon (Fig. 7). Voids increased from 4% in the overlying C horizon to 22% in the ABt (Fig. 9).

Clay increased to a maximum of 37% in the Bt horizon (Fig.7). This was a strong brown clay loam with many distinct yellowish red and very pale brown mottles. Common, distinct clay films were observed in the field. The 2 thin sections from this horizon exhibited fewer voids than in the overlying A horizon (Figure 5). Cutans decreased from 21% in the overlying ABt horizon to 9-12% in the Bt horizon (Figure 7). In the A horizon, the cutans lined abundant voids. However, in the B horizon, the cutans lined the planar voids or ped faces. Sesquioxide and manganiferous glaebules noted in thin section corresponded with the megascopic presence of red mottles. The lower horizon, a BC, was a strong brown sandy clay loam with many coarse red mottles. A few thin clay films were observed. The boundary with the underlying gravel was abrupt.

Soils developed in the Crowley's Ridge Loess and Pliocene sand at the Village Creek Landslide were less developed than those at the Wittsburg Quarry. The percent of clay only reached a maximum of 24% in the Crowley's Ridge Loess and 8% in the Pliocene sand (Figure 10). The weaker soil development may be due to higher erosion rates at this site.

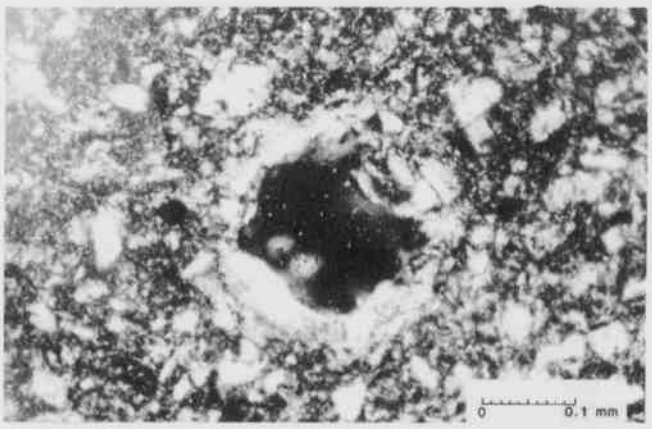


Figure 9. Cutan lining void in the ABt horizon of the Pliocene sand at Wittsburg Quarry. This feature is 27 cm below the upper contact of the unit.

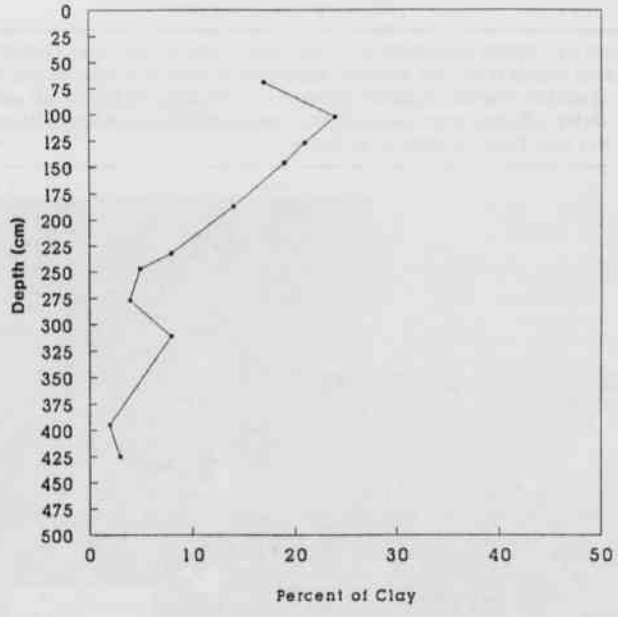


Figure 10. Percent of clay versus depth (cm) at Village Creek landslide. Clay data is from size analysis of the < 2 micron fraction. Contact between Loveland/Sicily Island Silt and Crowley's Ridge Loess is approximately 80 cm. Contact between Crowley's Ridge Loess and Pliocene sand is at 235 cm.

## CONCLUSION

The unimodal silt, similar in grain size and topographic position to the Loveland/Sicily Island Silt is loess and as a result, 4 loess units have been identified on Crowley's Ridge. Soil development is significant with clay content reaching a maximum of 41% in this unit. Based on other studies done on the ridge (Rutledge *et al.*, 1990), we have designated this unit to be the Crowley's Ridge Loess.

The biomodal grain size distribution with modes in medium sand and coarse silt indicate that the second unit below the Loveland/Sicily Island Silt is not a loess, but more likely is of an alluvial origin. Medium sand increases in abundance toward the base of the alluvium and is bedded and crossbedded below the pedogenic horizons. The upper horizons, silt loam grading to clay loam, may have been deposited as distal overbank sediment. This unit contains a weak paleosol with clay content reaching a maximum of 37%. It is thought to be preglacial and possibly Pliocene because of the dominance of chert and scarcity or absence of erratic grains found in the sediment (Call, 1889; Guccione, *et al.*, 1986).

Consequently, we conclude that a significant period of weathering followed deposition of the Crowley's Ridge Loess and at least a short period of weathering followed the deposition of the sandy Pliocene alluvium.

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