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The Effects of the Formation of the Wadsworth Sinkhole on the Drainage of Wadsworth and Landreth Hollows, South Central Indiana

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Abstract

The karst area of south-central Indiana contains many allogenic valleys, including Landreth and Wadsworth Hollows, which are located about 6 km north of Orangeville, Indiana. The development of these valleys is in response to solution of the Ste. Genevieve and Paoli Limestones which lie below the much less soluble or nonsoluble rocks of the Chester Series and Mansfield Formation. Sinkholes have formed in the dissolving limestone, diverting surface drainage underground.

The effects of the formation of the Wadsworth Sinkhole on surface drainage in the area were assessed through the study of stratigraphic sections exposed along the walls of Wadsworth Hollow. Imbrication of clasts, along with the topography of the bedrock surface, suggest that a former stream channel flowed to the northeast through the area. The slope of the bedrock surface and the lack of alluvial sediments in certain areas suggest that the collapse of the sinkhole may have initiated several episodes of rapid erosion and sediment influx.

Introduction

Allogenic valleys (sometimes called "hollows" on topographic maps) are common along the boundary between the Crawford Upland and Mitchell Plain in south-central Indiana where nonsoluble clastic rocks of the Mansfield Formation and Chester Series overly the middle Mississippian Ste. Genevieve Limestone and Paoli Limestone. The clastic rocks form the uplands, whose surface drainage is diverted into sinkholes along the floors of the allogenic valleys where the limestone is at or near the surface. Streams no longer flow along these valleys except during periods of excessive rainfall and runoff from the surrounding uplands.

During heavy runoff events, the flow of two such allogenic valleys, Landreth and Wadsworth Hollows, is presently diverted into the Wadsworth Sinkhole, a large collapsed sinkhole (Figures 1 and 2). However, inspection of the topographic map of the Wadsworth drainage basin (Figure 1) suggests that the drainage from these valleys formerly merged and flowed north. The water from the Wadsworth Sinkhole rises at Sulfur Creek, approximately five miles southeast of the study area (1).

The purpose of this study was to determine how the formation of the Wadsworth Sinkhole altered the surface drainage in the study area.

Methods

Alluvial deposits along Landreth and Wadsworth Hollows were examined for evidence that might indicate the direction of current flow before collapse of the sinkhole altered the surface drainage. Tabular clasts along the present stream channel show a pronounced imbrication that indicates the direction of present current flow (Figures 2 and 3, Location 4). Thus, it seemed reasonable that former directions of flow might be revealed by clast imbrication within older alluvial deposits along the channels.

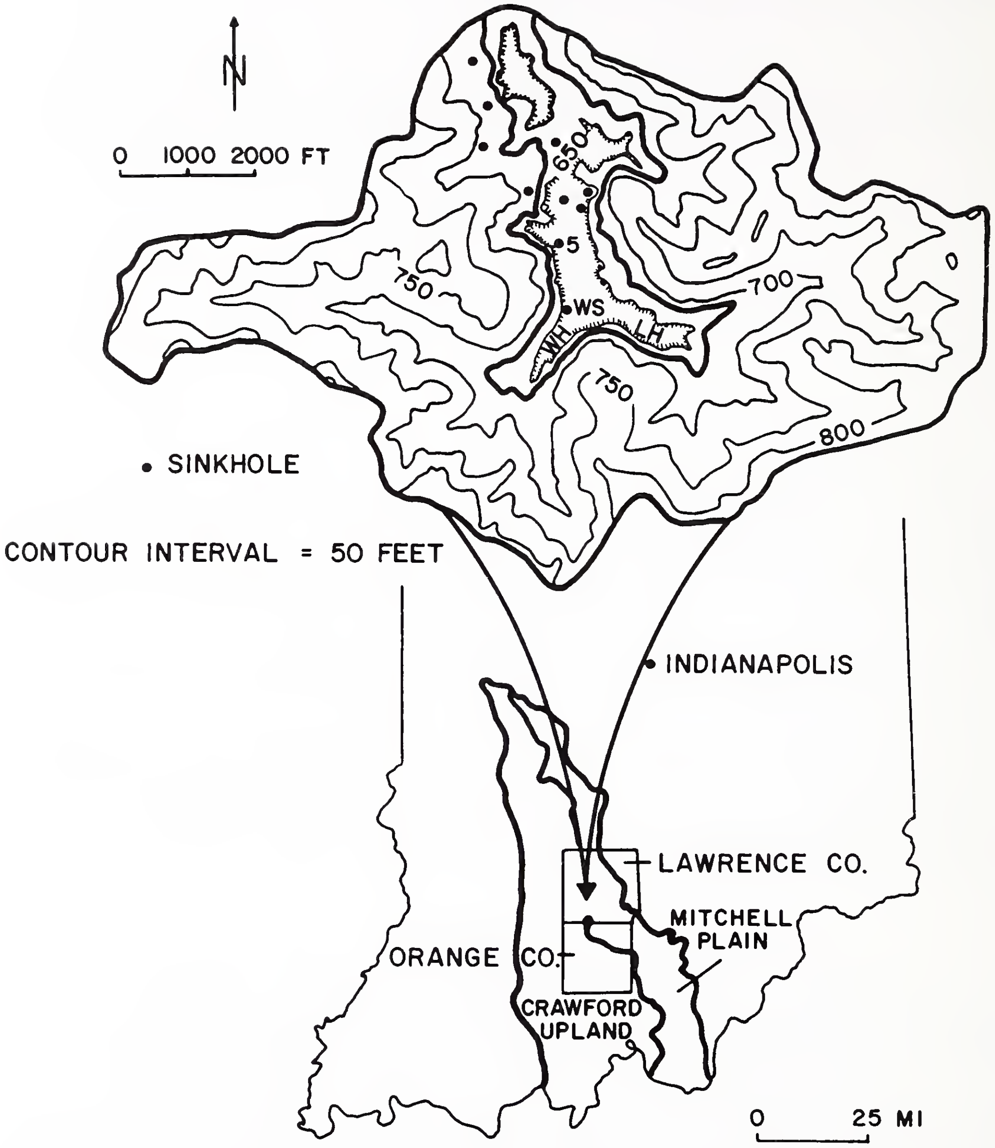

FIGURE 1. Location map of study area and topographic map of the Wadsworth Hollow drainage basin, modified from U.S. Geological Survey 7.5-minute Georgia, Indiana, Quadrangle. The heavy solid line on the drainage-basin map is the contact between the Ste. Genevieve and Paoli Limestones in the valleys and the overlying clastics of the Chester Series and the Mansfield Formation. LH-Landreth Hollow, WH-Wadsworth Hollow, WS—Wadsworth Sinkhole, 5-location of stratigraphic section 5 (See text).

Stratigraphic sections were investigated at selected locations along channel walls, including digging below the level of the modern stream channel (Figure 2, Locations 1, 2, and 3; Figure 1, Location 5). The attitudes of tabular clasts from the deposits at these locations were measured and converted to azimuths in the directions of current flow (Figure 3). Such data were collected for thirty clasts from each sampled unit.

The sample locations were generally restricted to areas where good exposures of alluvial sediments were present along the channel walls. Many areas along the channel have experienced slope failure, expecially near the sinkhole, rendering impossible the collection of clast-orientation data.

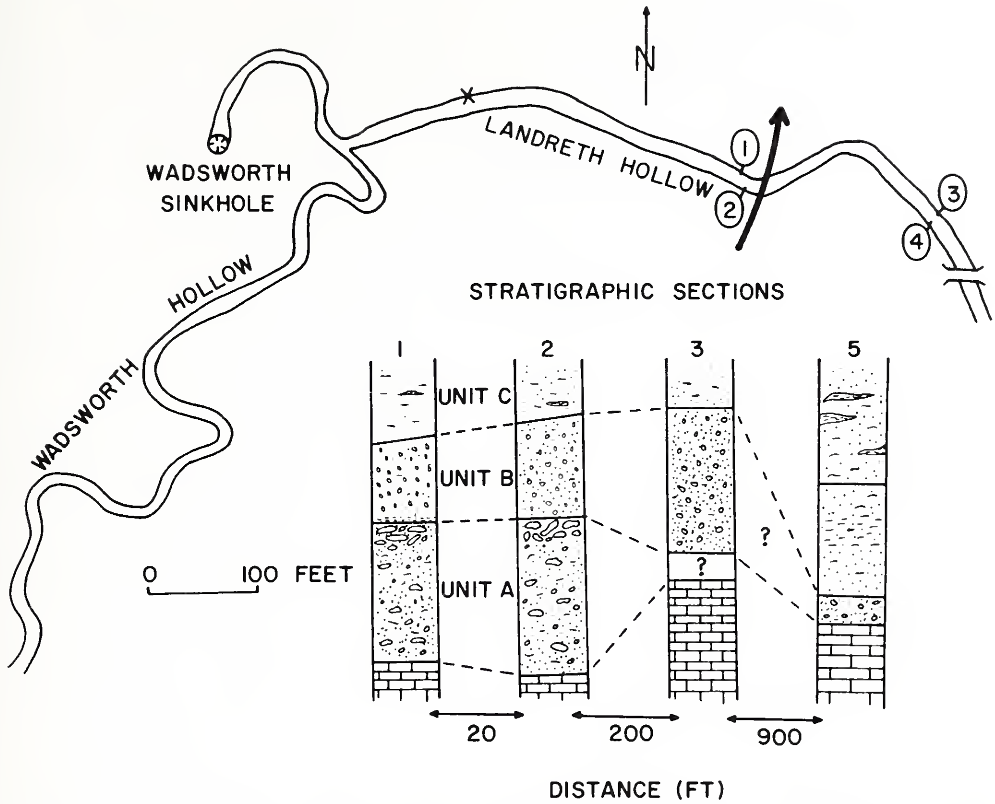

FIGURE 2. Drainage map of the study area showing locations of sampled stratigraphic sections 1 through 3 and stream-bed location 4 (circled), location of the stratigraphic section near Wadsworth Sinkhole in which no clasts were found (x), and inferred paleodrainage route (heavy arrow). Correlation diagram of stratigraphic sections 1 through 3 and 5 (for the location of the latter, see Figure 1).

Data Analysis

Because of the restrictions noted above, the closest stratigraphic section to the Wadsworth Sinkhole from which clast-orientation data could be obtained is Location 1 (Figure 2). In a stratigraphic section closer to the sinkhole (marked with an x in Figure 2) no clasts were found above bedrock. At Location 1 two clast-bearing stratigraphic units were found. Clasts from the upper Unit B reveal a westerly direction of stream flow (Figure 3), the direction of flow of the present ephemeral stream. However, clasts from the lower Unit A reflect a northeasterly direction of current flow (Fiture 3), although the preferred orientation of clasts in this unit is not as strong as in Unit B. Nevertheless, the data could reflect deposition by a former stream channel with a direction of flow different from the present stream.

Both clast-bearing stratigraphic units are also present at Location 2 slightly upstream along the opposite bank (Figure 2). Clasts from Unit B reflect a westerly to northwesterly direction of current flow, but for the underlying Unit A a northeasterly direction is indicated (Figure 3). The preferred orientation of clasts in Unit A at Location 2 is much stronger than at Location 1.

At Location 2 the stratigraphic section was excavated to a depth of 1.3 m below the modern stream channel without reaching bedrock. The increased depth to bedrock at this location may support the contention that a former stream channel is present here. We believe that the northeastward-flowing paleochannel was located in the vicinity of Locations 1 and 2 (Figure 2).

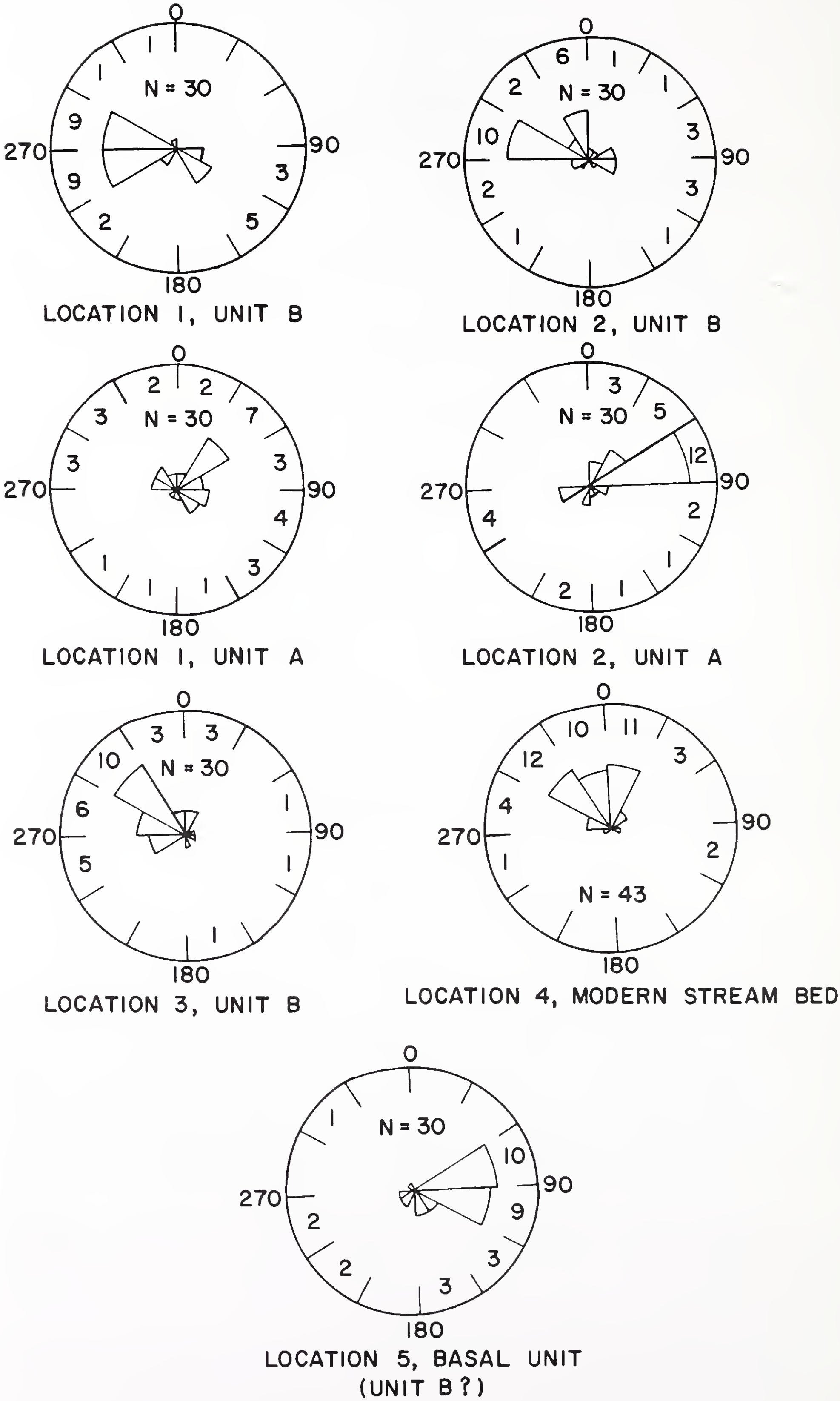

FIGURE 3. Clast-orientation data for stratigraphic sections 1 through 3 and 5 and the stream bed at Location 4. N-number of clasts.

At Location 3 slightly downstream from the bridge over Landreth Hollow (Figure 2) only Unit B was encountered, although Unit A may occur below the depth of the excavation. A northwesterly direction of current flow is indicated (Figure 3, Location 3), which compares favorably with clast-orientation data for the present stream channel (Figure 3, Location 4). This area is located far enough into Landreth Hollow that the stream is unlikely to have experienced a drastic change in flow direction.

There are several sinkholes along the valley north of Wadsworth Sinkhole (Figure 1), but only one contains alluvial sediments (Figures 2 and 3, Location 5). Imbrication of clasts indicates an easterly direction of flow, which is obviously contrary to that predicted by the orientation of the valley. However, the flow as indicated by these clasts was probably from a tributary to the west (Figure 1).

We acknowledge that some of the clast-orientation data could be explained in terms of meandering paleochannels. The present channel at Location 4, whose overall flow direction is N32°W, bifurcates into several subchannels that meander somewhat, which is reflected in the scatter of the clast-orientation data (Figure 3). However, we do not believe that channel meandering is an adequate explanation for the relatively strong northeasterly flow pattern as reflected in the data collected from Unit A, especially at Location 2.

Cross sections along Landreth Hollow (Figure 4) and Wadsworth Hollow (Figure 5) show that the contact between bedrock and the alluvial sediments slopes toward Wadsworth Sinkhole. Along Landreth Hollow, the lower contact of the silty uppermost alluvial sediments (Unit C) with underlying Units B and A, if projected toward the sinkhole, terminates against a large outcrop area of limestone bedrock along the stream channel (Figure 4). This outcrop probably marks the rim of the sinkhole.

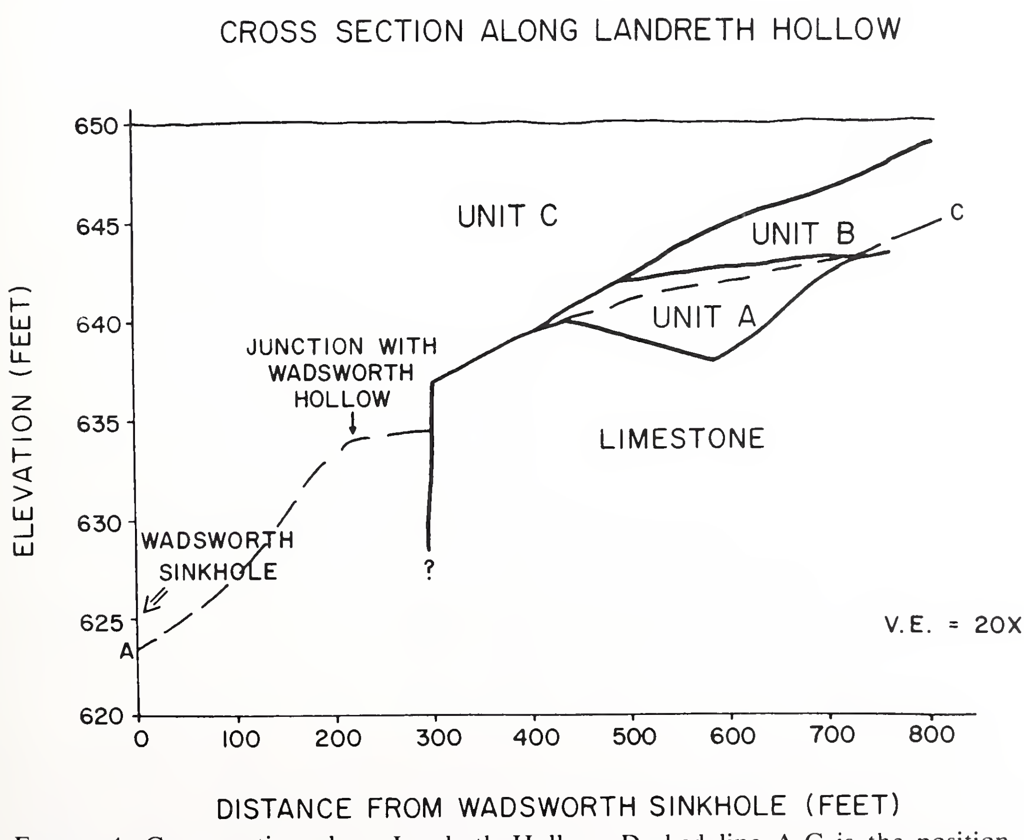

Figure 4. Cross section along Landreth Hollow. Dashed line A-C is the position of the stream bed where it does not follow the surface of the limestone outcrop.

When the sinkhole formed by collapse, sediments overlying the bedrock were surely eroded into the sinkhole until this limestone rim was exposed. The rim then probably protected the remainder of Units B and A upstream from further significant erosion. This scenario may explain why no clast-bearing alluvial sediments were encountered in the stratigraphic section marked x (Figure 2) or in the valley north of Wadsworth Sinkhole (Figure 1).

Similar relationships hold for Wadsworth Hollow (Figure 5), but the clast-bearing alluvial sediments are located farther from Wadsworth Sinkhole.

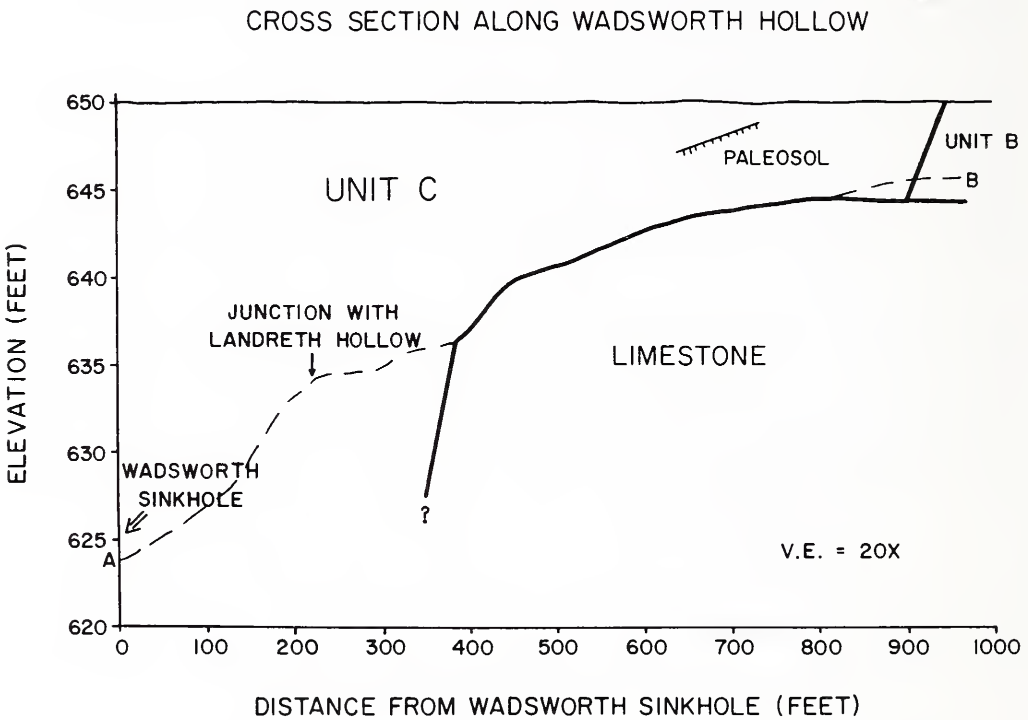

FIGURE 5. Cross section along Wadsworth Hollow. Dashed line A-B is the position of the stream bed where it does not follow the surface of the limestone outcrop.

History of Sinkhole Collapse and Sedimentation

It is likely that the Wadsworth Sinkhole experienced more than one episode of collapse. The first collapse probably rerouted the streamflow from northeastward out of the drainage basin to westward into the sinkhole. The stream exiting Landreth Hollow was diverted toward the sinkhole, and the stream in Wadsworth Hollow was shortened. When the collapse occurred, a strong current stripped much of alluvial Unit A near the sinkhole and transported large quantities of sediment into the sinkhole. When bedrock was exposed at the rim of the sinkhole erosion of Unit A was retarded farther upstream. A zone of very large clasts at the top of Unit A may reflect an erosion surface produced at this time when clasts too large to transport were left as a lag deposit.

Unit B was then deposited, with its clasts at Locations 1 and 2 indicating the new flow direction for the lower part of Landreth Hollow. Overbank deposition occurred frequently in the area adjacent to the channel. Eventually the land surface stabilized, and a soil developed at the top of the overbank deposits (Figure 5).

A second collapse (or possibly reopening of the clogged sinkhole) caused the soil and alluvial deposits near the sinkhole to be washed into the sinkhole. This interpretation would account for the absence of Unit B near the sinkhole and the sloping lower contact of Unit C toward the sinkhole. Overbank deposition again occurred, eventually burying the soil formed during earlier land-surface stability. A new period of stability ensued, and the present ground soil began to form.

Conclusions

The history of geologic events suggested here is undoubtedly not the only interpretation that can be made from the data presently available. Furthermore, this history is also undoubtedly incomplete, because, in lieu of equipment to cut major trenches through the alluvial sediments of the area, our efforts at data collection are certainly quite limited. Nevertheless, the available stratigraphic evidence suggests that collapse of the Wadsworth Sinkhole did result in reversal of part of the surface drainage of the drainage basin and that sinkhole collapse accompanied by sediment transport into the sinkhole probably occurred on more than one occasion.

The study area experienced alternate periods of sinkhole collapse (or unplugging) followed by overbank deposition, stabilization of the land surface, and soil formation. Regarding the future, it is interesting to note that the present stream flowing through Wadsworth Hollow loses much of its flow into small swallow holes before reaching the Wadsworth Sinkhole. One of these swallow holes may someday collapse, further altering the surface drainage, as has happened in the past.

Acknowledgments

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