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UNUSUAL RAVINE GEOMORPHOLOGY IN THE NORMAN UPLAND OF SOUTHERN INDIANA[1]

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ABSTRACT: Unusual physical features of some of the ravines in the Norman Upland of southern Indiana help to confirm that stream entrenchment has been an important recent geomorphic event in this region. The most common and most intriguing of these features is offset drainage in minor ravines. Other features, all in major ravines, include parallel drainage, shallow entrenched meanders, concordant spur shoulders, and duplex profiles. In the larger valleys, however, the most recent event has been alluviation. These two processes are not in conflict but are simply different aspects of the most recent geomorphic cycle, which dates from Wisconsinan time to the Present.

INTRODUCTION AND PHYSIOGRAPHIC SETTING

In this paper, I will describe and interpret some minor features of the Norman Upland, a physiographic region in southern Indiana that is bounded on the east by the prominent Knobstone Escarpment, on the west by the karst areas of the Mitchell Plain, and on the north by the Wisconsinan glacial boundary, which here marks the south edge of the Tipton till Plain (Figure 1). This physiographic region has no precise counterpart elsewhere, but in Kentucky a similar region is divided into areas known as the Knobs, Muldraugh Hill or the Muldraugh Escarpment, and part of the large area called the Mississippian Plateaus.

Rocks that underlie the Norman Upland and that determine its distinctive topography belong to the Borden Group, a series of shales and siltstones of Mississippian age that are variably resistant to erosion but that include few prominent resistant beds. Hills of the Norman Upland are therefore characterized by relatively smooth (and relatively steep) slopes. Rimrocks and ledges are not common, and natural outcrops are not abundant.

Subdivisions of the Norman Upland. In that part of the Norman Upland that lies north of the East Fork of White River (Figure 1), three major subdivisions may be recognized. Along the east edge, a narrow belt of eastward-facing hills, drained to the east by short, steep streams, is the Knobstone Escarpment. The broader part of the upland, a maturely dissected plateau, occupies most of Brown County and parts of adjacent counties. This area, the classic Norman Upland of Malott (1922), drains westward, down the regional slope of the underlying strata, by way of large integrated stream networks such as that of Salt Creek. North of the valley of Beanblossom Creek, along the north edge of the upland, the dissected plateau has been affected in a limited way by the pre-Wisconsinan glaciations,

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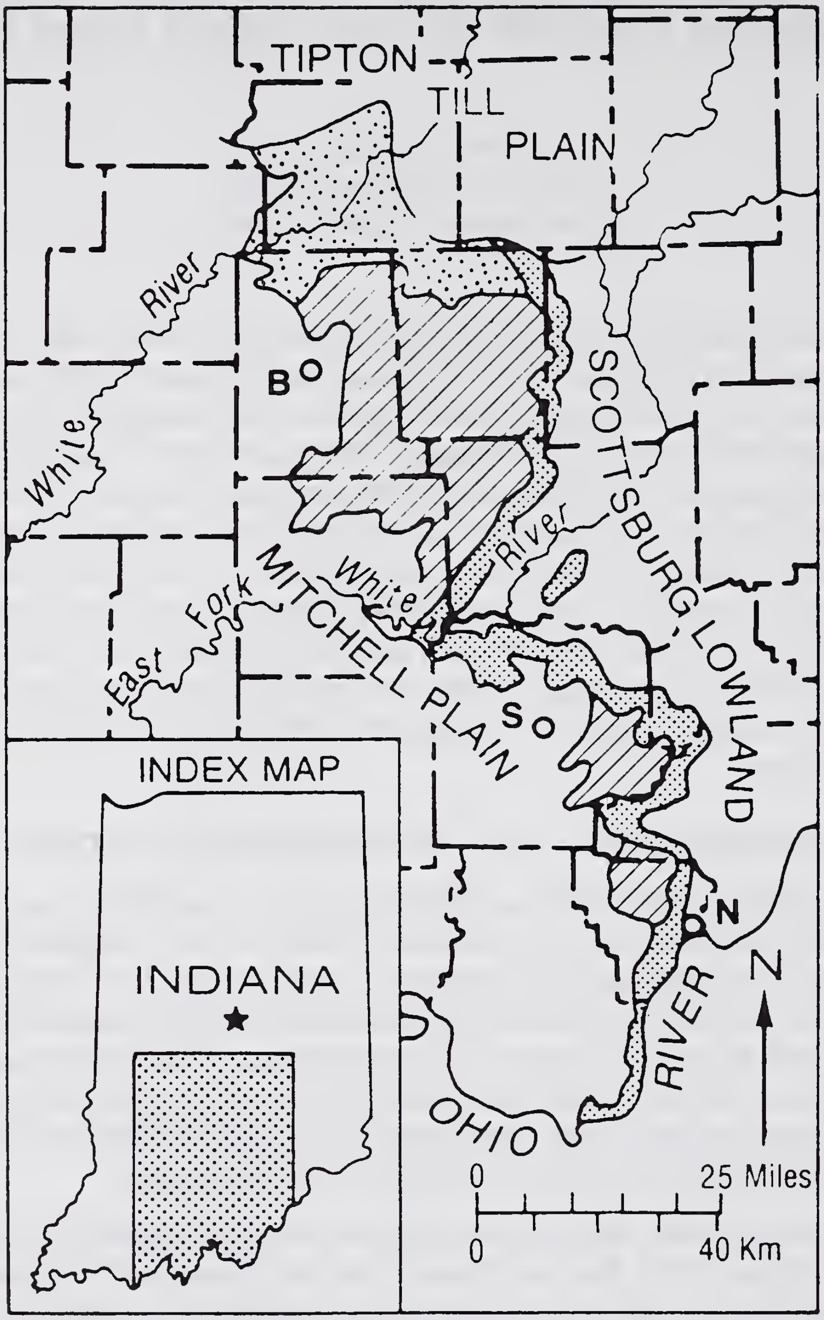

FIGURE 1. Map of south-central Indiana showing the Norman Upland and its subdivisions: Knobstone Escarpment (shaded), classic plateau area (diagonally ruled), and glacially modified area (stippled). B, Bloomington; S, Salem; N, New Albany.

and from that area northward repeated glaciation has subdued and obscured both the Knobstone Escarpment and the upland.

South of the East Fork of White River, the escarpment belt is somewhat broader and more complex. In part, this is because the escarpment incorporates some anomalous drainage features that may have originated marginal to one or another of the pre-Wisconsinan ice sheets; Muddy Fork of Silver Creek, treated as a simple instance of piracy by Malott (1922, pp. 180-186), is an example. The plateau consists only of small isolated tracts and does not exist at all south of

New Albany. There the entire width of the Norman Upland is taken up by the Knobstone Escarpment, which narrows sharply southward where the Ohio River impinges at its base.

Classification of valleys and ravines in the Norman Upland. It is convenient for purposes of this discussion to classify the valley types observed in the Norman Upland. I will refer to the valleys as **primary**, if they are occupied by through-flowing streams, such as the East Fork of White River, and **secondary**, if they are occupied by lesser streams but nevertheless have broad and active alluvial valley floors. The valleys of Salt Creek and Beanblossom Creek are secondary valleys.

Ravines are smaller, shorter, and steeper; those I classify as **major** ravines have narrow, inactive alluvial floors. Ravines designated **minor** are very steep, commonly have bedrock floors, and serve primarily to dissect the hillslopes. Minor ravines are not well delineated on the U.S. Geological Survey $7^1/_2$-minute topographic maps, but the best of these maps do illustrate the greater density of minor ravines where the underlying strata are more clayey and shale-like than elsewhere.

Note that I have not classified these features in terms of perennial versus seasonal streams; nearly all streams in the Norman Upland except those that are through-flowing and those that have controlled flow, are seasonal.

RAVINE FEATURES

Several kinds of unusual minor drainage features occur widely in the Norman Upland. Overall, these features indicate that in the Norman Upland there were earlier erosion cycles that had higher baselevels than the present one—a conclusion that is neither original nor surprising but that receives independent confirmation here. Most of these features have no counterpart in the other upland regions of southern Indiana.

Offset drainage in minor ravines. Most of the minor ravines in the Norman Upland are what Stockdale (1931, p. 49 and Fig. 4) called flume ravines. These incise the hillslopes only slightly, trend directly downslope, and are steep. Branching is uncommon, and the bedrock floor is trough-like, a result of the spalling or sheety weathering that characterizes the Borden rocks.

Some minor ravines, however, trend downslope in their upper courses but make a right-angle turn in mid-course to trend nearly parallel to the slope and to join other minor ravines before turning downslope again, through a small but sharp gap, to enter a major ravine or other larger valley (Figs. 2, 3, 4). Thus, they tend to form a rudimentary trellis drainage system. I will refer to this type of drainage as offset.

In many ravines of this type, it appears that the initial cross-slope diversion may have taken place at the upper edge of a colluvial apron that collected at the toeslope when the base level of the stream system was somewhat higher than it is today, and that later they were entrenched into the underlying bedrock and etched into their present configuration. Joint control is also possible; Borden rocks commonly develop joints parallel to the hillslopes, probably as a response to erosional unloading. The direction of the offset seems to conform to no regional pattern, but many of the toeslope ridges, now isolated from the mainslope by the lateral segment of the offset ravine, correlate in height with terrace remnants and other features nearby that signify the position of the former higher base level.

Ravines of this type apparently have not been commented on before, and there is no hint of them on the U.S. Geological Survey $7^1/_2$-minute topographic maps (Figs. 2, 3). In part, this may be because these features are small and the tree cover obscures them; they are, in fact, particularly difficult to observe in summer. Although they occur throughout the Norman Upland, they are more common on the steeper northward-facing slopes than on the gentler southward- and southeastward-facing ones.

Parallel drainage in major ravines. Ravines designated as major have narrow, inactive valley floors. In some of the wider ravines, tributaries from opposite sides do not join but form two channels, one along each side of the ravine. Where the streams have become entrenched, a mid-ravine ridge is quite prominent. In the examples illustrated (Fig. 5), the height of the mid-ravine ridge is accordant with benches and terraces that define a prior drainage level in adjacent parts of the drainage system. Parallel drainage is less common than the offset drainage described above.

Entrenched meanders in major ravines. In a few places, where valley floors are wide enough, small meander sets are lightly entrenched into the stony alluvium of major ravines (Fig. 6a). A lessened slope and broadened valley floor probably favor the development of these meanders.

Only a few such features are shown on the U.S. Geological Survey $7^1/_2$-minute topographic maps; a few more, mostly smaller scale, examples can be identified on aerial photographs and in the field. The feature illustrated shows that these are truly entrenched meanders, not merely diversions resulting from accumulations of colluvium or the building of alluvial fans at the mouths of minor ravines, both of which are common.

Concordant spur shoulders in major ravines. In a few major ravines, the rounded interfluves between tributary minor ravines are truncated sufficiently sharply to suggest that in the most recent cycle of erosion, the major ravine has become entrenched, and the minor ravines have been steepened (Figs. 6b, 7). Here, one may readily visualize a deeper and steeper profile associated with the present level of the ravine and a higher and gentler profile associated with an earlier drainage level. This "two-layer" topography is common throughout the Norman Upland but is best expressed where a set of concordant spur shoulders can be recognized.

This simple interpretation cannot be applied, however, to the large faceted spurs that are common in the secondary valleys. All secondary valleys in the Norman Upland have been repeatedly entrenched and partly refilled; lateral stream activity during any part of this complex history can produce spectacular spur truncations (Fig. 8) that in themselves probably have little regional geomorphic meaning.

Duplex profiles in major ravines. In a few major ravines, isolated small tracts of stony alluvium in upper parts of the ravines are separated from alluvial areas in lower parts of the ravines by a low knickpoint and a ravine segment in which no alluvium is mappable. These knickpoints can be obvious in the field but are not reliably shown on aerial photographs or on topographic maps, and although

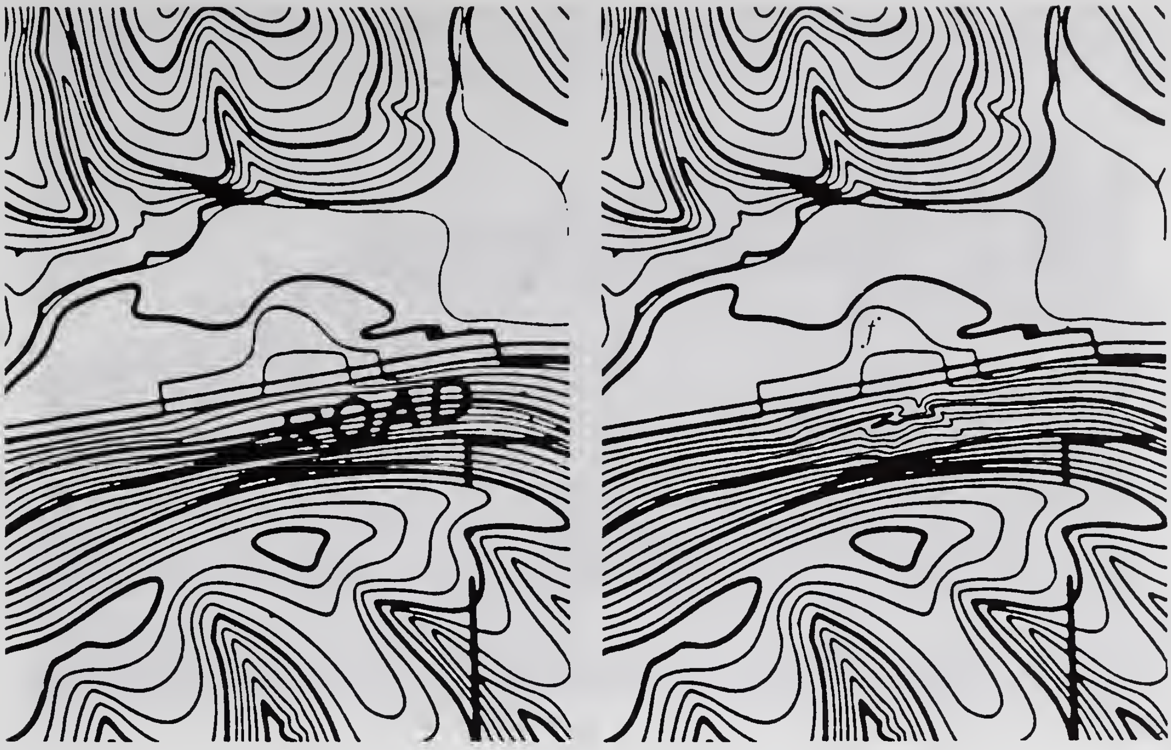

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FIGURE 2. Maps showing offset drainage in a minor ravine tributary to Kerr Creek, Monroe County (Sec 32, T9N, R1E): (a) as shown on U.S. Geological Survey 7½-minute Unionville Quadrangle (enlarged 3x); and (b) as modified on the basis of field observations. An alluvial fan (*f*) is at the mouth of the ravine.

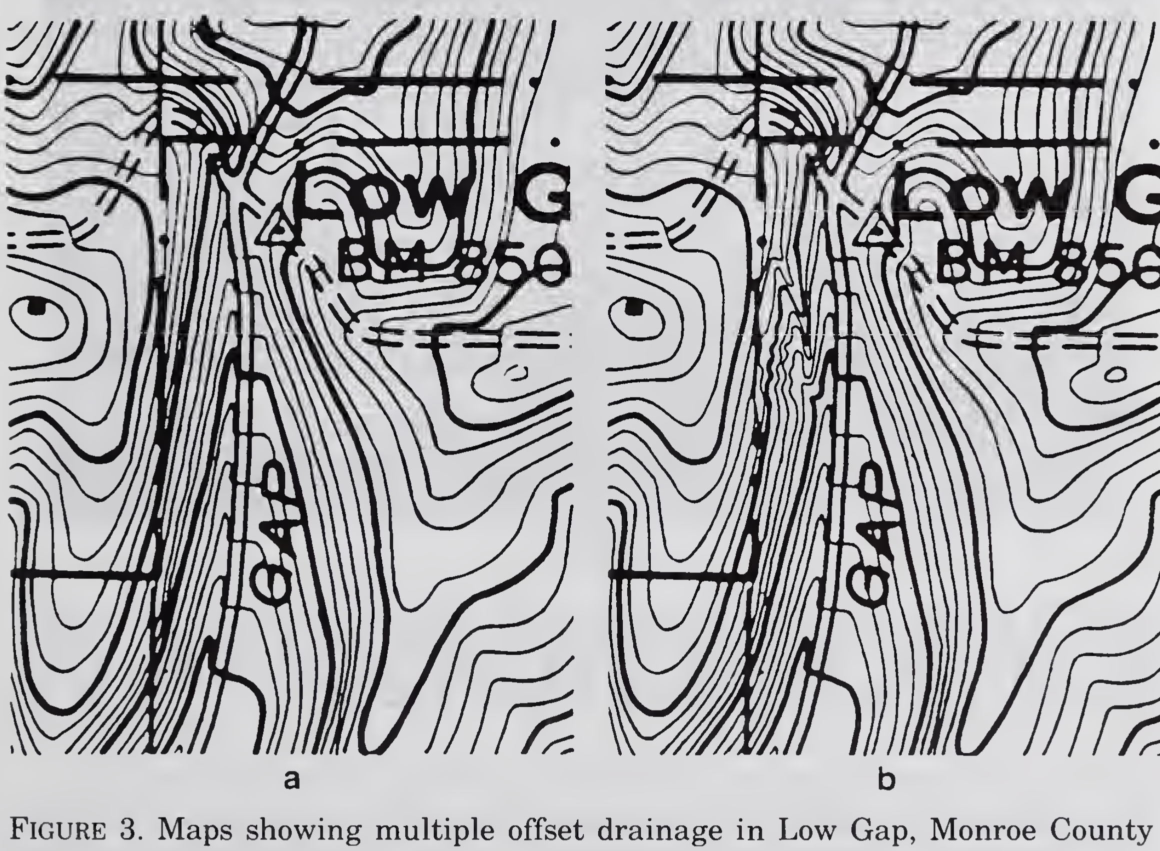

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FIGURE 3. Maps showing multiple offset drainage in Low Gap, Monroe County (Sec 11, T10N, R1E): (a) as shown on U.S. Geological Survey 7½ Hindustan Quadrangle (enlarged 3x); and (b) as modified on the basis of field observations.

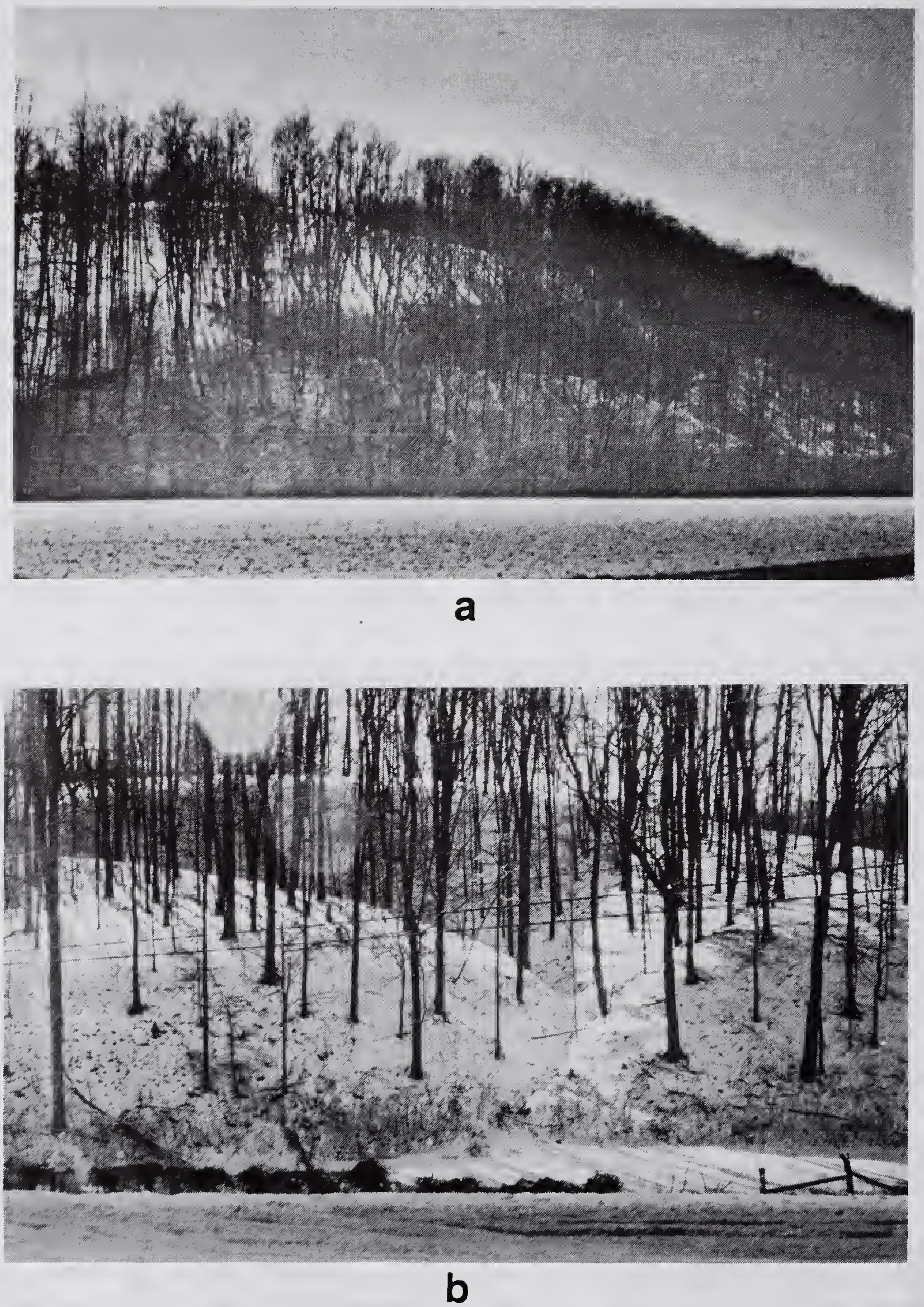

FIGURE 4. Photographs showing offset drainage in minor ravines: (a) near Gnawbone, Brown County (SW$\frac{1}{4}$, SW$\frac{1}{4}$, Sec 19, T9N, R4E); and (b) upper end of Henderson Creek, Brown County (NW$\frac{1}{4}$, Sec 28, T9N, R4E).

a b

FIGURE 5. Maps showing parallel drainage in major ravines: (a) near T.C. Steele State Memorial, Brown County (Secs 12 and 13, T8N, R1E; and Secs 7 and 18, T8N, R2E), as shown on U.S. Geological Survey $7^1/_2$-minute Belmont Quadrangle (enlarged 1.5x); and (b) tributary to Muddy Fork, Monroe County (Sec 11, T9N, R1W), as shown on U.S. Geological Survey $7^1/_2$-minute Unionville Quadrangle (enlarged 1.5x). Note accordance of the crests of the mid-valley ridges with terrace and bench levels in adjacent streams and with valley-floor levels upstream.

they surely indicate a lowering of baselevel, they probably have no regional significance, because they do not correlate from one ravine to another. Furthermore, some ravines have more than one knickpoint.

Distribution of alluvial soils in major ravines. The typical valley-floor soil series in the stony alluvium of major ravines is the Burnside. Although Burnside soils are entisols and lack true argillic horizons, they do have recognizable and somewhat complex B-horizonation. This, along with their history of infrequent flooding, suggests that Burnside soils are relicts or near-relicts and that alluvial accretion on these areas now is very slow. In contrast, soils characteristic of the secondary valleys, such as those of the Haymond and Wakeland series, lack B-horizonation altogether and historically have been flooded frequently. These properties imply relatively rapid alluvial accretion, an important part of which may relate to deforestation and other land-use changes of the past two centuries.

Burnside soils occur typically in elongate to irregular tracts that at their downvalley ends merge with larger areas of the more active alluvial soils, commonly at or not far below the transition from major ravine to secondary valley.

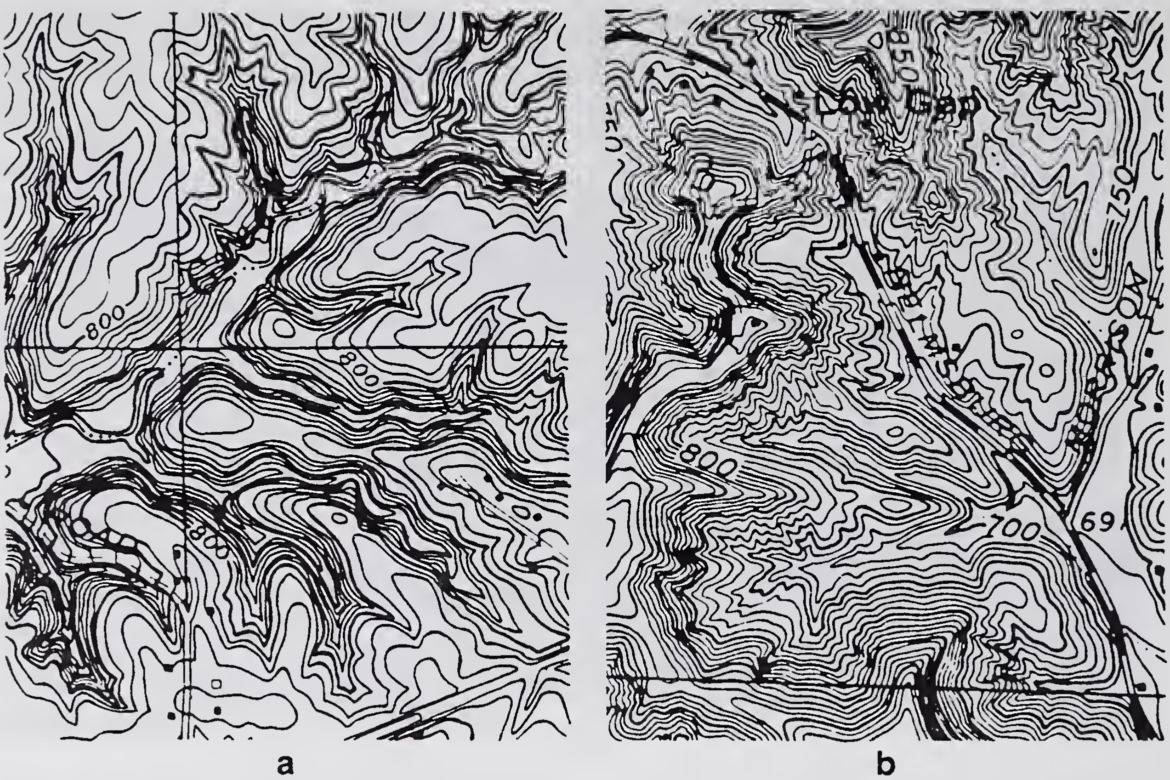

FIGURE 6. Maps showing: (a) entrenched meanders in alluvium in a major ravine, upper Griffy Creek, Monroe County (Secs 13, 14, 23, and 24, T9N, R1W), as shown on U.S. Geological Survey 7½-minute Unionville Quadrangle (enlarged 1.5x); and (b) concordant minor spur shoulders (see also Figure 7) along major ravines that head at Low Gap, Brown County (Secs 3 and 10, T9N, R2E), as shown on U.S. Geological Survey 7½ Belmont Quadrangle (enlarged 1.5x).

They also occur in isolated patches in upper parts of major ravines, typically above a knickpoint and in areas where the ravines widen just a bit. The alluvial deposits in which Burnside soils are formed are increasingly stony downward and appear to represent a geologic episode when erosion was much more active than it is today.

Two possible scenarios may be suggested for these deposits: (1) a rigorous periglacial climate *per se* or (2) geomorphic stresses related to rapid and possibly repeated climatic change from moderate to periglacial and back to moderate climate. In either scenario, the implication is that these coarse alluvial deposits date for the most part from Wisconsinan time.

GEOMORPHIC IMPLICATIONS AND DISCUSSION

Common among the features described above is the indication that the most recent geomorphic process to affect the ravines in this region has been entrenchment. Recent entrenchment is confirmed by other features observed in the secondary valleys. The valleys of Salt Creek and its major tributaries, for example, contain two sets of terrace remnants that stand a few feet above the present valley floor (Gray, 1989). Underlying the higher of these terraces is sandy outwash that is pre-Wisconsinan in age, as indicated by a thick paleosol atop the sand and a

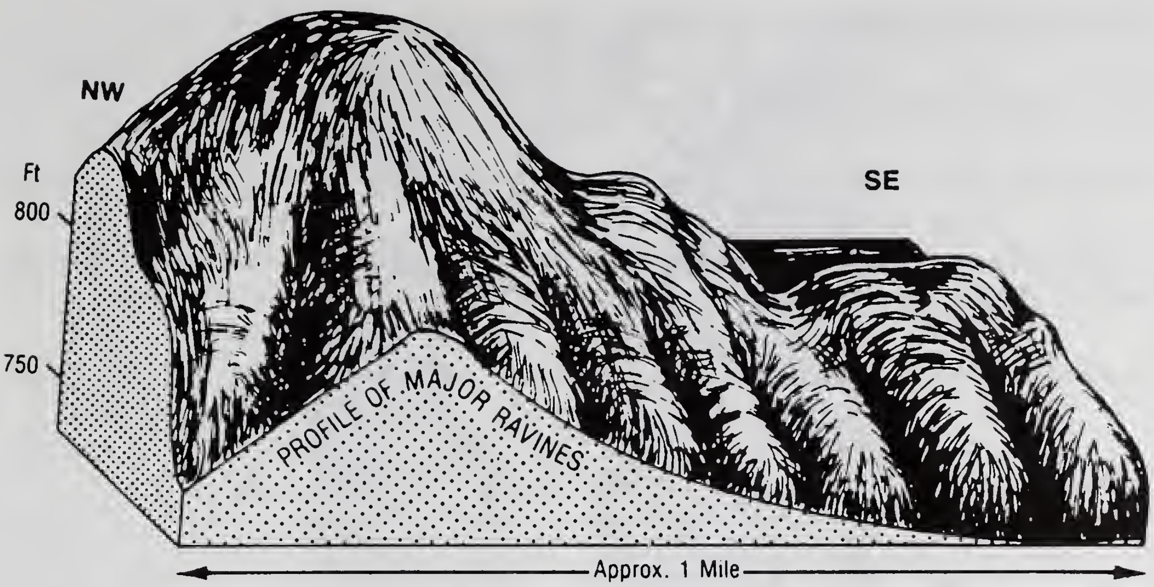

FIGURE 7. Block diagram through Low Gap, Brown County, showing concordant minor spur shoulders along major ravines. See also Figure 6b.

thick mantle of loessial silt that caps the paleosol. The lower terrace lacks the outwash and consists principally of silt, and because it contains no well-developed paleosol, it probably is Wisconsinan in age.

The outwash terrace is lacking in secondary valleys south of the East Fork of White River, but a terrace corresponding to the lower one on Salt Creek is present. Other evidence of recent regional lowering of base level includes abandoned meander loops at several levels that are scattered along many of the primary and secondary valleys of southern Indiana (Gray, 1989). Deposits in these valleys, however, show that entrenchment has not been the most recent geomorphic process to affect them. The broad floors of the primary valleys are underlain by alluvium and thick outwash deposits; the floors of secondary valleys are underlain by fine-grained slackwater and alluvial deposits that thicken downvalley (Gray, 1971). Clearly, in these valleys the most recent major geomorphic event has been active valley filling. Most of these deposits are Wisconsinan to Holocene in age (Gray, 1974), and soils of the valley floors confirm that this process is continuing.

At least two hypotheses may be presented to explain this seeming paradox. First, one might suggest that the slackwater deposits and silty alluvium occupy the valley system up as far as the backwater curve would indicate and that the upper reaches of the system are as yet unaltered from a previous stage of entrenchment. This would imply that the junction between the lower and upper parts of the system might be abrupt, but this in fact is not so. The lower valley deposits merge rather gently with the upper valley deposits; that is, the junction between active alluvial areas and inactive alluvial areas is irregular, diffuse, and generally unclear, although in most places it is somewhere in the upper ends of the secondary valleys and below the mouths of the major ravines. This hypothesis would also imply that the upland area and all the tributary valley network is an inactive relic. If this were so, deep paleosols should be widespread, but in fact they are not. Therefore, I can set this hypothesis aside, at least provisionally.

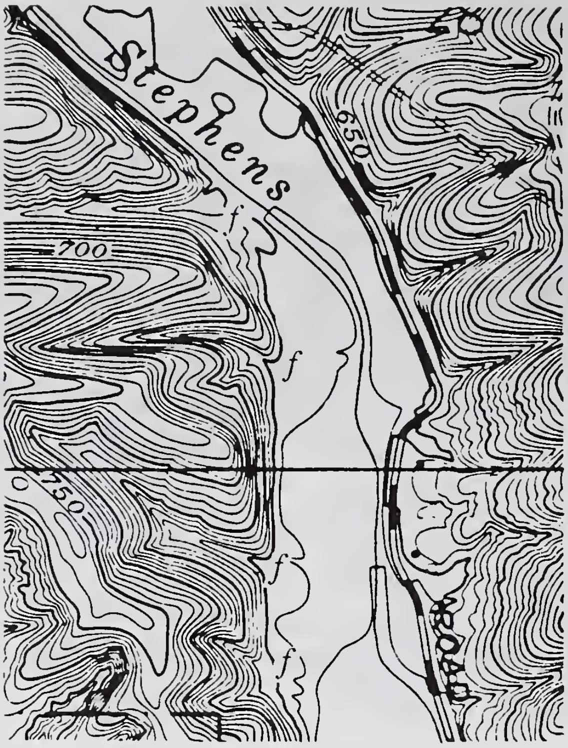

FIGURE 8. Map showing large facets on spurs adjacent to Stephens Creek, Monroe County (Secs 28 and 33, T9N, R1E), as shown on U.S. Geological Survey 7½-minute Unionville Quadrangle (enlarged 1.5x). Except that these spurs predate the alluvial fans (*f*), they probably have no regional significance.

A second hypothesis suggests that the gradient of the typical valley system in the Norman Upland is poised on a sort of teeter-totter. As the lower part of the system is being alluviated, the upper tributary network is still being entrenched. The diffuse boundary between these activities is the fulcrum of the teeter-totter, a sort of alluvially neutral zone, and the entrenchment recorded by the ravines of the Norman Upland as the latest geomorphic event to affect them probably is mostly coeval with the latest episode of valley filling in the lower parts of the secondary valleys. This process couple apparently dates from Wisconsinan to Holocene.

I favor this second hypothesis as being more consistent with the facts presently on hand. It is also consistent with the concept that geomorphic systems are dynamic and include zones of erosion, transportation, and deposition that shift with changes in regional conditions. As Schumm (1973, p. 300) concisely put it, "the components of a geomorphic system need not be in phase."

A corollary conclusion is that the minor geomorphic features observed here are best understood in a broader context that includes the more complete history recorded in the valley fill of the secondary valleys. Thus, even in regions as uncomplicated as the Norman Upland, geomorphic elements such as hillslope evolution and stream processes should not be studied in isolation, but in concert.

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