BEFORE BURGESS FALLS: PREHISTORIC CHANGE IN THE COURSE OF FALLING WATER RIVER, EASTERN HIGHLAND RIM, TENNESSEE

HUGH H. MILLS

Department of Earth Sciences, Tennessee Technological University, Cookeville, TN 38505

ABSTRACT—Burgess Falls occurs on Falling Water River at the contact between the resistant Fort Payne Formation and more easily eroded underlying rocks. Topographic evidence suggests that the course of the river has changed in the recent geologic past, so that Burgess Falls is a relatively new feature in the landscape. The most striking evidence is the presence of a large cutoff incised meander in Tibbs Hollow, about 1.5 km southwest of the falls. This hollow is presently occupied by a stream less than 3 km long, clearly too small to have produced the meander. Only a stream approximately the size of Falling Water River could have produced a meander of this magnitude. About 60 m above the meander floor is a shallow abandoned drainageway that links Tibbs Hollow to the present river; apparently the river formerly flowed through this drainageway into Tibbs Hollow. Most of the vertical drop across the Fort Payne Formation at that time must have occurred where this drainageway joins Tibbs Hollow rather than at the present location of the falls. Cane Creek, a nearby tributary of Falling Water River, apparently captured the river, resulting in abandonment of this older course and establishment of the present one. The capture initiated Burgess Falls, which subsequently has retreated about 1500 m upstream to its present position. Although the age of the capture is poorly constrained, very likely it is no older than Quaternary.

Burgess Falls is one of the most spectacular scenic attractions in central Tennessee (Fig. 1). Although exceptional in its height and volume of flow, Burgess Falls shares many characteristics with other waterfalls on the Eastern Highland Rim. These falls are located where the streams drop from the resistant rocks of the Highland Rim onto the softer rocks of the Central Basin to the northwest. This escarpment between the Rim and the Basin has probably retreated southeastward for millions of years, and waterfalls therefore probably have retreated in a similar direction for many kilometers. Recent examination of topographic features in the vicinity, however, suggests that Burgess Falls may have a more unusual history than most of the other falls in the area, and, indeed, may have come into existence only in the relatively recent geologic past. This paper examines evidence for a major drainage change in the vicinity of Burgess Falls, and presents a hypothesis to explain the change.

PHYSICAL SETTING

Burgess Falls (A in Fig. 1) is located along the Falling Water River at the boundary of northwestern White County and southwestern Putnam County, Tennessee, near the eroded northwestern margin of the Eastern Highland Rim. Here streams descend from an altitude of about 300 m on the Rim to about 200 m in the Central Basin. Four geological units are pertinent to the present study (Wilson and Marcher, 1968) (Fig. 2). The youngest unit, the Warsaw Formation (Mississippian) crops out over broad areas of the northwestern Eastern Highland Rim. With a thickness of 25 to 35 m, it consists of limestone, sandy limestone, and calcareous siltstone and shale. Its resistance to erosion is relatively low. Below the Warsaw is the Fort Payne Formation (Mississippian), which crops out along the margins of the Rim, particularly on the walls of incised valleys. With a thickness of 50 to 75 m, it consists of silicastone, with smaller amounts of calcareous siltstone and argillaceous limestone. It is highly resistant to erosion, and acts as a caprock to hold up the escarpment between the Rim and the Central Basin to the northwest.

Beneath the Fort Payne (and mapped with it) is the Chattanooga Shale (Devonian and Mississippian), about 6 to 9 m in thickness. It is a carbonaceous shale, with a thin sandstone near its base. It offers low resistance to erosion. Beneath the Chattanooga are the Catheys and Leipers Formations (Ordovician), mapped as a single unit (Wilson and Marcher, 1968.) The Catheys-Leipers has a maximum exposed thickness of about 45 m, and consists of calcarenite, argillaceous limestone, and limestone. It is a readily eroded unit.

Burgess Falls, like most falls along the Eastern Highland Rim escarpment, is a caprock falls located at the contact between the Fort Payne Formation and the underlying Chattanooga Shale and Leipers-Catheys Formations (B in Fig. 2). Burgess Falls proper is about 30 m high, and its top is actually located near the base of the Fort Payne; father upstream, smaller falls and rapids occur on the Fort Payne. Downstream of the falls is a gorge left behind as the waterfall has retreated eastward. This gorge in some ways is more impressive than the falls, for it is 75 m deep, extending through the entire thickness of the Fort Payne Formation. The gorge extends more than 1 km downstream, suggesting the falls has retreated at least that distance.

In addition to Falling Water River, two other streams will be discussed. These are Tibbs Hollow (D in Fig. 2) and Cane Creek (G in Fig. 2). Note that all three streams, at least in their lower reaches, have incised through the Fort Payne Formation and Chattanooga Shale into the Leipers-Catheys Formations.

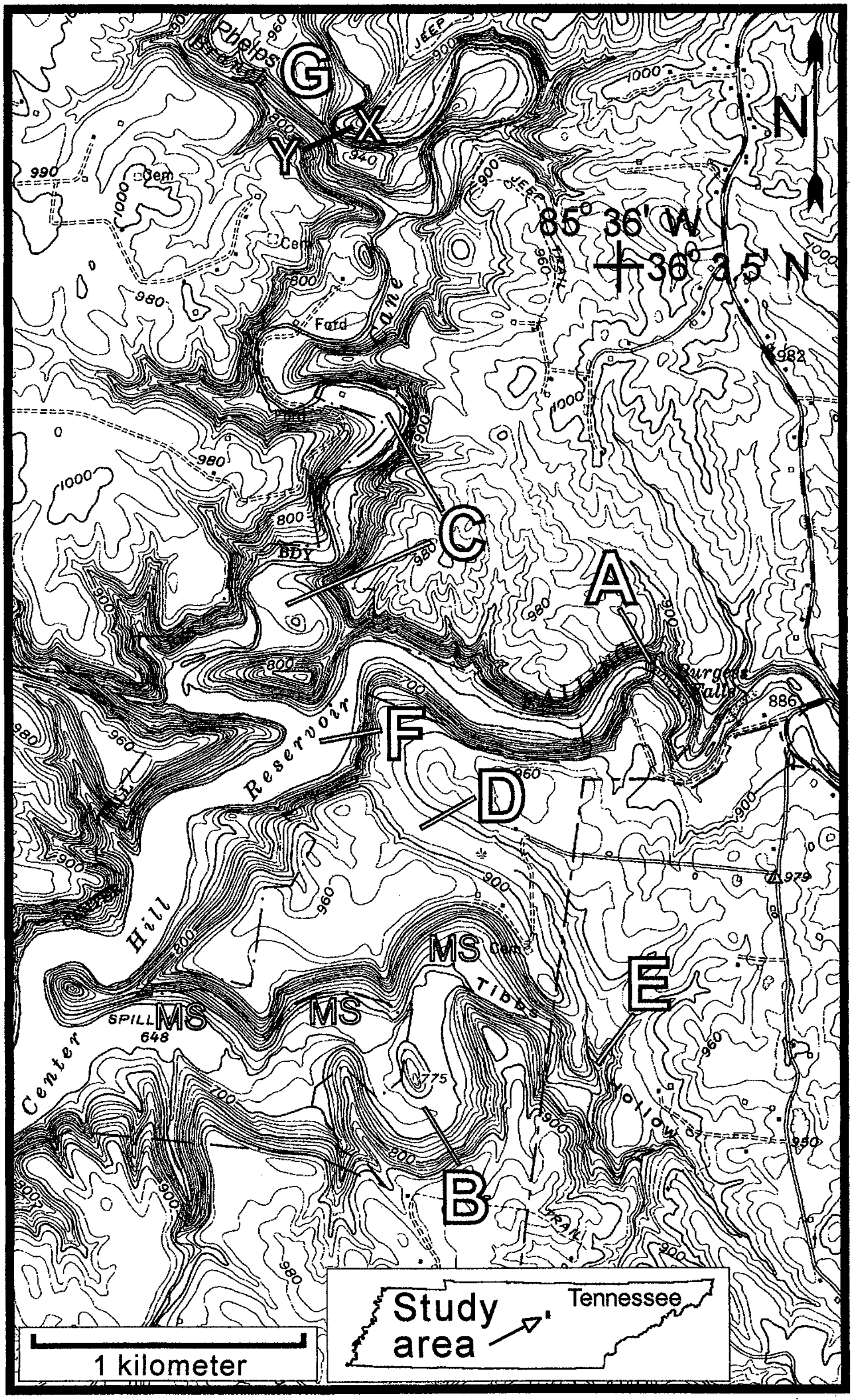

FIG. 1. Topographic map of the study area (from Burgess Falls 7.5-min quadrangle). The contour interval is 20 ft (6.1 m). Points indicated with letters are identified as follows: A is Burgess Falls, B is cutoff incised meander in Tibbs Hollow, C is meanders of Cane Creek, D is a shallow valley, E is where a small stream joins Tibbs Hollow, F is proposed site of Falling Water River capture by Cane Creek, G is Phelps Branch.

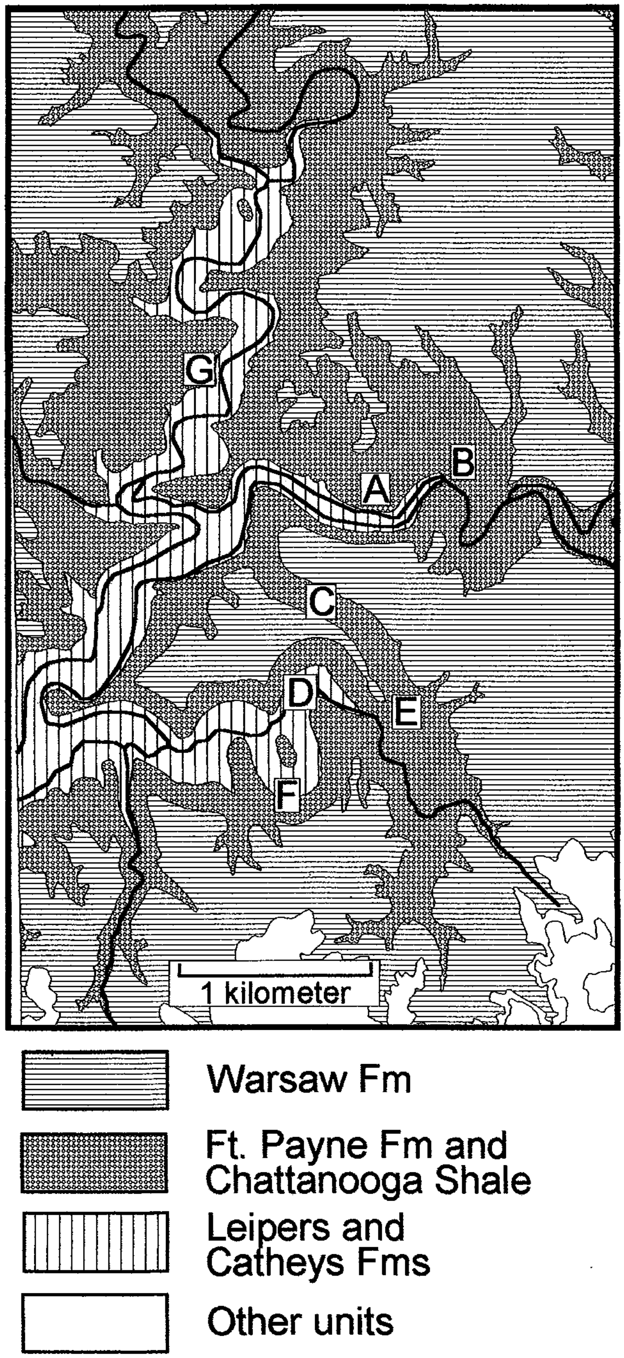

FIG. 2. Geologic map of the study area (from Wilson and Marcher, 1968). A is Falling Water River, B is Burgess Falls, D is Tibbs Hollow, and G is Cane Creek. Locations designated by other letters are discussed in the text.

OBSERVATIONS

The large cutoff incised meander located in Tibbs Hollow about 1.5 km southwest of Burgess Falls (B in Fig. 1) is the most striking evidence of drainage change. There are well-established relationships between meander size (i.e., meander wavelength, amplitude, or radius of curvature) and stream size (i.e., stream discharge, length, or drainage-basin area). The relationships are true for both alluvial meanders on floodplains (e.g., Leopold and Wolman, 1957; Dury, 1964) and for incised or bedrock meanders (e.g., Dury, 1964; Braun, 1983). The Tibbs Hollow stream, which is less than 3 km long, appears too small to have made this cutoff meander and the three associated meander scars on the north wall of the hollow (MS in Fig. 1). The Tibbs Hollow meander scars show an average meander wavelength of about 400 m. By comparison, note that meanders of Cane Creek (C in Fig. 1), with an average wavelength of 280 m, are somewhat smaller, even though Cane Creek is 24 km long. The evidence thus suggests that a stream substantially larger than Cane Creek made the Tibbs Hollow meanders. The only such stream in the vicinity is Falling Water River, which has a length of 58 km.

Given this likely association between Tibbs Hollow and Falling Water River, the next feature I sought was a connection between these two streams. The shallow valley trending northwest to southeast, about 1 km southwest of Burgess Falls (D in Fig. 1), seems to be the most likely candidate. Located about 60 m above the floor of Tibbs Hollow, this valley is presently occupied by small local streams, one flowing to the southeast where it joins Tibbs Hollow (near E in Fig. 1) and another short ephemeral stream that flows northwest into the present valley of Falling Water River. It seems unlikely that either of these streams is large enough to have made the valley. A karst origin for the valley also seems unlikely, as large karst features are rare in the Fort Payne and Warsaw Formations, and the form of the valley does not resemble karst morphology. Additional evidence favoring a previous occupancy of this valley by a larger stream is the presence of scattered rounded pebbles along the valley. The pebbles are of two types. First, there are pebbles of local lithologies, particularly sandstone from the Warsaw Formation, that fall into the "rounded" class of Powers (1953). These probably were rounded during transport by the stream that flowed through the valley. Second, there are "well rounded" pebbles composed of igneous or metamorphic quartz. These undoubtedly are derived from Pennsylvanian conglomerates that cap the Cumberland Plateau and its outliers at least 16 km to the east. The rounding of these clasts, of course, occurred mainly before they were deposited during the Pennsylvanian Period, and thus provides no evidence of late Cenozoic stream transport. On the other hand, the presence of these clasts testifies to transport by a stream that headed on the Cumberland Plateau, from whence the pebbles were derived. The Falling Water River, which heads on the Cumberland Escarpment just west of Monterey, is such a stream. Alternatively, the quartz pebbles could have been let down onto the present surface as the Pennsylvanian caprocks (which once covered the Eastern Highland Rim) eroded away, or they could have been carried to their present location by streams still older than the one in question. However, though scattered, the quartz pebbles are more plentiful in this valley than they are on the flanking uplands, a finding that supports the occupation of the valley by a stream that headed on the Plateau.

The abandoned valley has been excavated into only the upper 15 m of the Fort Payne Formation. Because regional dip is to the southeast, upstream of this location excavation into this formation must have been even shallower. Consequently, as waterfalls are associated with the Fort Payne or with the contact between the Fort Payne and the weaker underlying units, there would have been no falls where Burgess Falls is presently located. Instead, during the time that Falling Water River flowed through this valley, any falls must have been located downstream of the valley, where the stream descended through the Fort Payne Formation into Tibbs Hollow. Although probably in the general

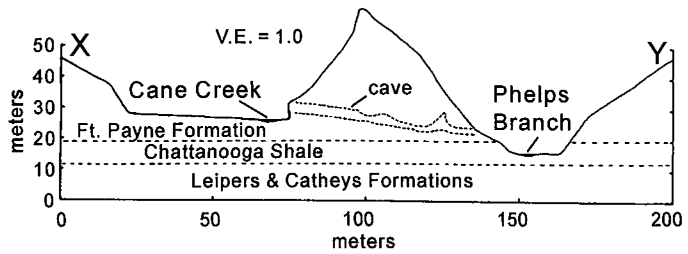

FIG. 3. Topographic profile surveyed along line X–Y on Fig. 1, showing the interfluve between Cane Creek and Phelps Branch. Also shown are geologic units and the cave through interfluve.

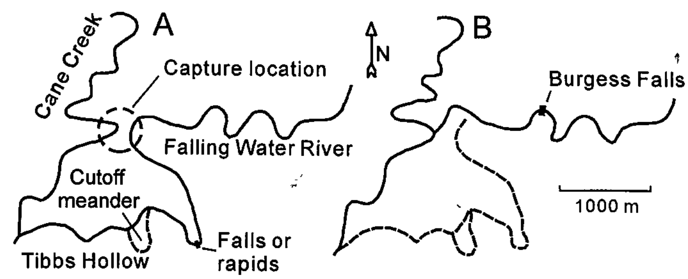

FIG. 4. Stream diagram summarizing drainage changes in the vicinity of Burgess Falls. A = hypothesized former stream courses. B = present stream courses.

vicinity of E in Fig. 1 (also E in Fig. 2), exactly where the valley joined Tibbs Hollow is not evident. The course of the present small stream near E shows rapids, but no evidence of a waterfall comparable to the present Burgess Falls. This absence may indicate that there was no waterfall at that time. However, it also is possible that subsequent mass wasting has reduced any steep slopes associated with abandoned waterfalls.

DISCUSSION

The evidence for a prehistoric change in the course of Falling Water River raises questions about why such a change occurred, and how Burgess Falls became established in its present location. The cause may have been capture of the Falling Water River by its tributary, Cane Creek, in the vicinity of F (Fig. 1). Imagine Falling Water River taking a sharp bend to the southeast near F, into its now-abandoned valley. Suppose that Cane Creek at the time was separated from Falling Water River at F by a narrow divide, occupying the present-day valley southwest of F and joining Falling Water River at the mouth of Tibbs Hollow. Note the pronounced clockwise bend that would have existed in the valley of Cane Creek near F at that time. Because streams in incised valleys erode toward the outside of their bends, this bend would have had a strong tendency to erode eastward. If one also assumes that Cane Creek was flowing at a lower level than Falling Water River, then, when the Cane Creek meander eventually cut through the divide, the waters of Falling Water River would have been diverted into Cane Creek, resulting in the abandonment of the former course through Tibbs Hollow.

That such captures of streams by their tributaries can take place is demonstrated by a nearby present-day example. Phelps Branch (G in Fig. 1), a tributary of Cane Creek, is in the act of capturing Cane Creek. At G, Phelps Branch is 8 m lower than Cane Creek on the other side of the ridge to the northeast. On both sides, meanders are cutting into the divide, narrowing it. As the two meanders approach each other, capture of Cane Creek by the lower Phelps Branch appears inevitable. Already, a sizeable part of the discharge of Cane Creek passes to Phelps Branch via a cave formed by flow of water along the hydraulic gradient (Fig. 3).

For an analogous capture of Falling Water River by Cane Creek to have taken place, the assumption must be made that at the time of capture, Cane Creek was substantially lower than was Falling Water River. The geologic map (Fig. 2) suggests that this is a reasonable assumption. Note that as measured from their confluence, Cane Creek has cut through the Fort Payne Formation for an upstream distance about three times that shown by Falling Water River. This indicates that Cane Creek reached a lower elevation somewhat earlier than did Falling Water River, and hence would have been in a position to capture the latter.

One final question to address is the location of Burgess Falls roughly 1500 m upstream from the point at which the capture took place. The capture would have almost instantaneously (at least in the geologic sense) produced a waterfall at the point of capture. Presumably, the waterfall has subsequently retreated headward 1500 m since the time of capture. This retreat has left a deep, narrow gorge, with walls as high as 75 m between the point of capture and the present location of the falls. This depth may not reflect the elevation difference between Cane Creek and Falling Water River at the time of capture, as both streams have probably cut down substantially since then.

The age of the capture and therefore the establishment of the modern drainage course is difficult to pin down. One way to do this is to use rates of waterfall recession and stream incision that have been determined for other areas to estimate the age of the post-capture gorge below Burgess Falls. The retreat of caprock falls can be very rapid (Ford, 1968). Niagara Falls, for example, has been retreating on the order of 1 m/yr throughout the Holocene (Tinkler, 1993), and St. Anthony's Falls on the Mississippi River in Minneapolis, Minnesota, has been retreating at a rate almost as great for at least several hundred years (Wright, 1972). That rate would produce a capture age for the Falling Water River of 1500 yr, which seems unlikely. Unfortunately, few other waterfall recession rates are available, and so this method cannot shed much light on the age question. More data are available for stream incision rates. One nearby incision-rate estimate is by Sasowsky and others (1995) for the East Fork Obey River near the Cumberland Escarpment. Based on cave-sediment magnetostratigraphy, they estimated a downcutting rate of 60 m/million years. This rate is probably too slow for the Falling Water River gorge, where incision associated with waterfall retreat would probably be relatively swift. Using this rate as a conservative estimate, however, indicates that the age of capture is unlikely to be older than Quaternary.

SUMMARY AND CONCLUSIONS

Unusually large meanders in a valley now occupied by a small stream, and the presence of an abandoned drainageway linking this valley to the present river, provide the chief evidence for a prehistoric change in the drainage course of Falling Water River. The hypothesized drainage change is summarized in Fig. 4. Figure 4A shows the ancient drainage of Falling Water River and Cane Creek in this vicinity, together with the speculated location of the falls/rapids at that time, and Fig. 4B shows the present drainage, with the abandoned course shown in dashed lines. The change in drainage may have occurred because of a capture of Falling Water River by its tributary, Cane Creek, at the location indicated in Fig. 4A. Since the capture, the falls appear to have receded about 1500 m from the point of capture to the present location of Burgess Falls. Although dating of the capture and therefore the initiation of Burgess Falls is problematic, the age is likely to be Quaternary.

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