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Green River Alluvial Terraces at Mammoth Cave and Glacial Valley Trains on the Ohio River: Genetic Correlation Revisited

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Introduction

The following analysis details how a correlation has not been successfully demonstrated between tributary back-ponding caused by glacial valley trains in the Ohio River Valley and two purported Wisconsin-aged alluvial terraces on the Green River at Mammoth Cave National Park (MCNP). This issue is important because the Ohio River impoundments continue to be reported as a genetic cause after nearly 30 years:

> *At present, the Green River valley at Mammoth Cave is filled with 10 m of sediment that accumulated behind Wisconsinan valley trains in the Ohio River (Granger et al., 2001, p. 834).*

In the subsection *Geomorphic History of the Ohio River Basin*, by F.-D. Miotke, in Miotke and Palmer (1972), the senior author compares terrace heights above each river:

> *The elevation of the Green River terraces roughly ten feet higher than those of the Ohio at Owensboro is in accordance with the normally higher gradients of other tributary rivers further up the Ohio valley (p. 26).*

However, Miotke commits errors in his calculation of three landform heights above the Ohio River (Table 1a). For example, the Ohio River's upper terrace (Tazewell) is 64 ft above the river rather than the reported 44 ft (341+64=405). These faulty comparisons apparently led Miotke to the invalid "roughly ten feet higher" statement for the Green River, and thus an unjustified terrace correlation based on relative heights. Presumably, Ohio River alluvial landforms are greater than those of the Green River

Table 1a: Revised Ohio River data

Ohio River (near Owensboro)	**Elevation (ft AMSL) (Ray, 1965)**	**Height above natural Ohio River (ft)**
Natural low water	341	0
Floodplain	380	~~21~~ 39
Cary terrace	390	~~39~~ 49
Tazewell terrace	405	~~44~~ 64

Table 1b: Revised Green River data

Green River (at Turnhole Bend)	**Elevation (ft AMSL)**	**Height above natural Green River (ft)**
Natural low water (approximate)	~410	0
Flood channel or First bottom	**435-440**	**25-30**
Second bottom (rare)	**445-450**	**35-40**
Third bottom (primary terrace)	**455+**	**45+**

because of the Ohio River basin's larger size and its direct glacial-outwash legacy. A review of this publication by Watson (1972) failed to notice the calculation errors concerning landform heights above the Ohio River.

Table 1b shows the author's most recent field observations (3/28/15) of Green River landform elevations at Turnhole Bend (shown in bold). These data are based on an approximate natural low-water datum of 410 ft for the Green River prior to impoundment by Lock and Dam #6 at Brownsville. The revised terrace heights above the Green River are 10-15 ft lower than Miotke's estimates.

Field Observations at Turnhole Bend

The first alluvial bottom above the Green River is nearly ubiquitous. This narrow floodplain is typically less than 100 ft wide and experiences frequent inundation. Also termed a flood channel, it has a rough surface because of localized deposits of mud, sand, and wood debris alternating with scour pits around tree roots. Riverside slumping of alluvium is common with individual scars up to 100 ft in length. The second bottom is mostly missing along the upstream and downstream portions of Turnhole Bend, where a steep scarp rises 15-20 ft from the flood channel to the third bottom. It is often missing or indistinct elsewhere along the river. The third bottom and highest observed Green River alluvial terrace is extensive at Turnhole Bend, ranging from about 300-500 ft wide. It rises to an elevation of about 455+ ft, or 45+ ft above the natural low water level of ~410 ft. Miotke's upper alluvial terrace reported at 465-470 ft elevation is exaggerated at 55-60 ft above the revised datum of ~410 ft.

Both terraces at Turnhole Bend contain natural levees and back-swamp channels or sloughs, creating relatively smooth terrace treads that slope gradually away from the river. These features show that the terraces at Turnhole Bend are active alluvial units currently inundated and partially shaped by major floods. The observed terrace elevation agrees with the 440 ft elevation contour (20 ft contour interval) paralleling mapped Quaternary alluvium (Qal) at Turnhole Bend and matches the description noted on the Rhoda Geologic Quadrangle map: *Along major rivers, clay and silt occur as high as 30 feet above normal water level* (Klemic, 1963) (adjusted to 40 ft above natural low water level of ~410).

In addition, two bedrock strath terraces exist above the main alluvial terrace at Turnhole Bend. The major strath is a dissected limestone bench consisting of rounded divides between sinkholes as much as 20 ft deep. At an elevation of 500-510 ft and up to 500 ft wide, the strath lies about 100 ft above the natural river level and is prominent at this and other meander bends along the river. Miotke and Palmer accurately show this landform in Figure 52, which is labeled Yarmouthian-Illinoian (?). However, a minor strath located between the major strath and the upper alluvial terrace is missing from this illustration. This narrow sinkhole-dissected landform, probably related to the previous interglacial stage, is not readily shown by topographic contours and can be difficult to view in the field because of woodland and cedar thickets. At an elevation of about 465-470 ft, this rocky strath is located at the same position as the Upper Wisconsin terrace illustrated in Figure 52 as a broad sandy alluvial terrace sloping toward the river. When compared with the revised terrace profile shown in Figure 1, it appears that Miotke and Palmer may have omitted the rare second bottom and mistook the 1st strath as the upper alluvial terrace. The

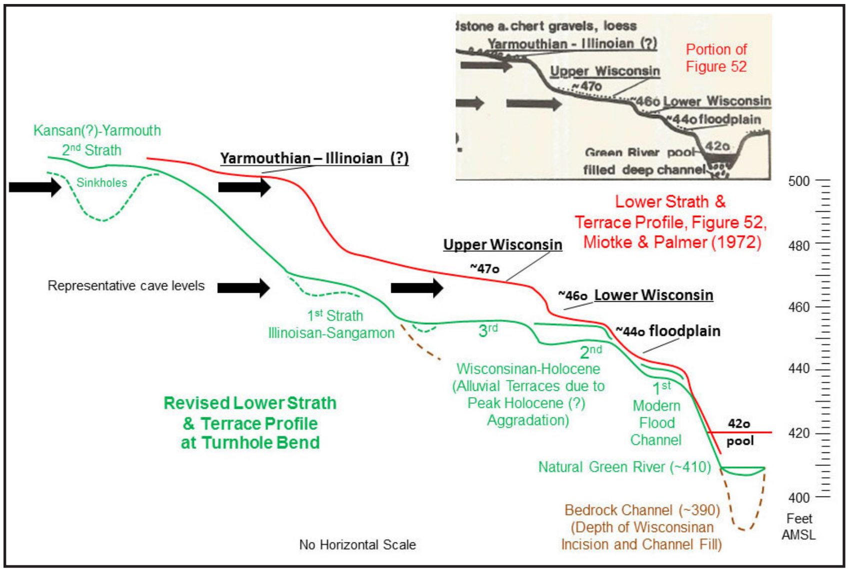

Figure 1: Comparison of bedrock strath and alluvial terrace profile at Turnhole Bend by Miotke (above, from Figure 52) and revised profile by Ray (below, from field observations on 3/28/15).

lowest representative cave level shown in Figure 52 aligns with the minor strath rather than an upper alluvial terrace, as shown.

Based on natural low-flow levels, the Green River elevation at Turnhole Bend is 69 ft (21 m) above that of the Ohio River near Owensboro, a basic relation reflecting the distance and significant gradient between the two sites. Using observed elevations, the two Green River terraces are about 50-60 ft (15-18 m) higher in elevation than the Tazewell and Cary-aged glacial outwash terraces of the Ohio River. Green River terraces are not likely to have accumulated “behind Wisconsinan valley trains in the Ohio River” when at Mammoth Cave those terraces are considerably higher in elevation and 135 valley miles (218 km) distant from the back-ponding Ohio River. Interestingly, the Ohio River floodplain alluvium of known post-Cary (Holocene) age stands up to 39 ft above the low river elevation of 341 ft, which is similar to the total height of the Green River bottomlands of 45+ ft above the natural low water level of ~410 ft. This similarity in height above natural river levels would be reasonable if the Green River terraces were also Holocene in age, whereas the Ohio River outwash terraces are comparatively greater.

Discussion

Weller (1927, p. 77) considered the maximum level of glacial “Green Lake” to be about 420-440 ft, and that the easternmost extension of late Wisconsin ponding occurred near the mouth of Honey Creek, more than 18 miles down-valley of Turnhole Bend. Stein (1980) and Morey et al., (2002) show the upstream extent of lake silts ending near Big Reedy Creek, about 29 miles down-valley of Turnhole Bend. Stein’s longitudinal profile of the Green River also shows a flat lake plain below Paradise, KY, more than 70 miles down-valley of Turnhole Bend (Figure 2). This lake plain, lying at about 385-390 ft elevation, undoubtedly developed in lake waters impounded behind the Tazewell and Cary valley-train terraces at 410 and 390 ft, respectively. The lake

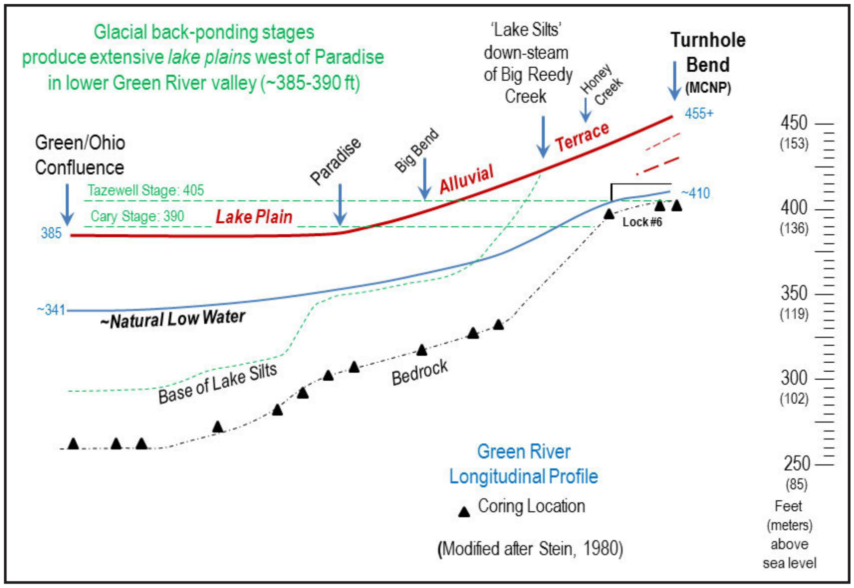

Figure 2: Green River longitudinal profile showing main alluvial terrace merging with lake plain formed by back-ponding during Tazewell and Cary glacial outwash stages on the Ohio River. The main alluvial terrace at Turnhole Bend lies 65-70 ft higher than the lake plain.

plain extends about 62 miles up the lower Green River valley, which is just over the 44 mile reach of Wisconsin ponding on the Kentucky River (Andrews, 2004, p. 97).

Geochronology based on ^{14}C dating is unavailable for the Mammoth Cave terraces, but, since Miotke's correlation with Ohio River terraces was based on inaccurate data and interpretations, a Holocene age for the upper portion of the Green River alluvial fill remains a viable hypothesis. Herrera (2007) investigated alluvial terraces 0.5-40 km up-valley of MCNP, and identified two primary alluvial landforms. The main bottomland terrace was described as Early Holocene alluvium, at >143 m (470 ft) elevation, and narrow stream-bordering floodplains were labeled as Lower Holocene alluvium. He obtained several ^{14}C dates from low floodplain sediments. Organics sampled from three boreholes 3.2-3.5 m deep returned modern dates (120-180 ± 40 yr BP), and two island bank exposures were determined to be younger. A single older date of 2320 ± 40 yr BP was obtained from an island deposit 5 m deep suggesting a remnant of late Holocene deposits buried by the modern floodplain (Herrera, 2007, p. 88).

Herrera's modern floodplain dates agree with Knox (2006), who determined that historical floodplain deposits, commonly inset against a previous floodplain, in Wisconsin and across the American Midwest are largely the result of abrupt river-regime responses to widespread deforestation and cultivation practices over the last 175-200 years. These modern dates conflict with Miotke, who interpreted this low flood-channel unit as the sole Holocene-aged landform (2nd table, p. 52). Elsewhere, early to mid-Holocene alluvial fills have been dated in Nebraska (Brice, 1966), Iowa (Ruhe, 1969), Wisconsin, Illinois, and Indiana (Gooding, 1971), and Tennessee (Brakenridge, 1984).

Verified by recent field observations, straths and alluvial bottoms at Turnhole Bend are mapped in Figure 3 on a recently available

LiDAR KY-DEM 5ft hillshade basemap (KYAPED, 2015). Strath ages (A & B) are estimated based on glacial/interglacial cycles (Paillard, 2001; Martin, 2007), with the most recent cycle (C) subdivided into three alluvial bottomlands attributed to Holocene (?) through Modern times.

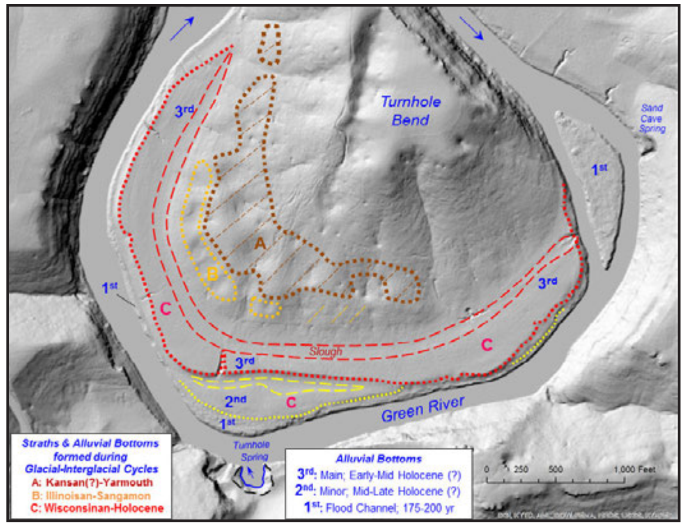

Figure 3: Shaded-relief LiDAR image showing estimated boundaries of two bedrock straths and three alluvial bottoms of the Green River at Turnhole Bend, including proposed ages.

Key Findings

This reassessment does not differ with the demonstrated linkages between cave levels and regional Green River strath development. A correlation with glacial back-ponding appears to be accurate for the lower Green River valley, west of Paradise, where over 160 mi^2 of flat alluvial/lacustrine plains, or lake plains, lie at about 385-390 ft elevation. However, a genetic correlation of alluvial terraces in MCNP with Ohio River glacial terraces cannot be substantiated by Miotke's work. Significant findings of this research include:

- Relative to heights above each river, Ohio River landforms are 9-19 ft (3-6 m) higher than those of the Green River.
- Green River alluvial terraces are 50-60 ft (15-18 m) higher in elevation than, and 135 valley miles (218 km) upstream from, glacial terraces of the Ohio River, making a correlation based on back-ponding very unlikely.
- The Green River's second bottom is usually missing or indistinct, whereas the third bottom or main alluvial terrace is conspicuous along the river.
- A minor bedrock strath can be identified just above the main alluvial terrace at Turnhole Bend and other sites. This key landform was not described by Miotke.

This Wisconsin/Holocene hypothesis applies to the genesis and sequence of terrace construction in absence of a demonstrated back-ponding control as far upriver as the Mammoth Cave Plateau. This hypothesis is supported by a) corrected elevation data for the Ohio and Green rivers and revised landform comparisons, b) a published Green River profile showing MCNP considerably upstream and higher in elevation than identified lake plains and silt deposits in the lower valley, and c) modern post-settlement dates for the Green River flood channel. Pleistocene dynamics in unglaciated rivers can probably best be characterized as sequential glacial-interglacial cycles producing vertical river oscillations within overall valley incision. At Turnhole Bend, a major Green River channel incision during the low-sea Wisconsinan Stage was reversed by Tazewell/Cary-aged channel filling and ensuing Holocene floodplain construction, vertically totaling as much as 65 ft (20 m). Within the gorge, the river and bottomlands currently develop a fairly consistent overall width of about 650 ft (200 m).

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