

# How a New Cenozoic Geology and Glacial History Paradigm Explains Anomalous Monongahela River Drainage Basin Topographic Map Evidence, PA, WV and MD, USA

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## Abstract

A recently proposed and fundamentally different Cenozoic geology and glacial history paradigm (new paradigm) is used to explain previously reported and other anomalous Monongahela River drainage basin drainage system evidence (observable on detailed topographic maps in the form of barbed tributaries, asymmetric tributary drainage basins, large abandoned meander cutoffs, and poorly explained transverse drainages and abandoned transverse drainages). The north-oriented Monongahela River drainage system according to the accepted Cenozoic geology and glacial history paradigm (accepted paradigm) originated during preglacial times and was blocked by continental icesheets to form today's Ohio River. Based on Missouri River drainage basin topographic map evidence the new paradigm predicts the Monongahela River drainage system developed during immense and prolonged south- and southwest-oriented continental icesheet melt water floods. The new paradigm also predicts icesheet caused regional uplift created a deep "hole" in which a thick icesheet was located and which forced south-oriented melt water floods to flow in southwest directions along the deep "hole's" southeast rim (now the Ohio River-Atlantic Ocean drainage divide) until continued deep "hole" rim uplift and the deep valley headward erosion from space being opened up by icesheet melting reversed the flow direction to create the north-oriented Monongahela River drainage system. This new paradigm interpretation explains previously reported and other anomalous Monongahela River drainage system topographic map evidence and suggests the Monongahela River drainage system developed while a continental icesheet melted and not during preglacial time as has been commonly reported.

**Keywords:** asymmetric drainage basins, barbed tributaries, Cheat River, Greenbrier River, Shavers Fork, transverse drainages, Youghiogheny River

## 1. Introduction

### *1.1 Statement of the Problem*

Early in the 20<sup>th</sup> century topographic map interpretation was an important geomorphology research tool, yet as topographic map coverage expanded geomorphologists became less and less interested in interpreting topographic map drainage system evidence. The problem was and still is topographic map drainage system evidence can be interpreted, but those interpretations do not tell the story the accepted Cenozoic geology and glacial history paradigm (accepted paradigm) wants geomorphologists to tell. By the mid 20<sup>th</sup> century topographic map interpretation had almost disappeared as a geomorphology research tool and Arthur Strahler was a leader as geomorphologists pivoted away from trying to interpret topographic map evidence to determine drainage system and erosional landform histories. After trying to solve what were then (and still are) unsolved Pennsylvania drainage history problems Strahler (1945) rejected all previously suggested Pennsylvania drainage history hypotheses, except one for which he found no supporting evidence. Convinced the interpretation of topographic maps to determine drainage system and erosional landform histories was a non-productive research endeavour Strahler developed what he called a dynamic basis for geomorphology (1952). In other words, mid 20<sup>th</sup> century geomorphologists when trying to interpret topographic map drainage system and erosional landform evidence encountered a solid wall of unexplainable anomalous evidence.

Recently, the author of this paper after an intensive study of detailed Missouri River drainage basin topographic

map drainage system evidence proposed a new and fundamentally different Cenozoic geology and glacial history paradigm (new paradigm) which explains much if not all of what had been the Missouri River drainage basin's anomalous topographic map drainage system evidence (Clausen, 2020). The new paradigm requires what the accepted paradigm considers to be pre-glacial north-oriented Missouri River tributary valleys which are commonly considered to be components of the preglacial Bell River drainage system described by Jackson (2018), to instead have eroded headward from a melting ice sheet's location, which requires the melting thick ice sheet to have created (by deep icesheet erosion and icesheet caused crustal warping) a deep "hole" in which the large and decaying icesheet was located. Demonstration papers have been published illustrating how this new paradigm explains detailed topographic map drainage system evidence for numerous specific Missouri River drainage basin geographic areas. The new paradigm implies Ohio River drainage basin development should have been a mirror image of Missouri River drainage basin development and the study reported here tests whether the new paradigm can satisfactorily explain previously reported and other anomalous topographic map drainage system evidence found within the Monongahela River drainage basin.

### 1.2 Monongahela River Geographic Setting

The Monongahela River (see figure 1) is formed at the confluence of the north-oriented West Fork and Tygart Valley Rivers and flows in large entrenched meanders in a north direction into western Pennsylvania where it joins the south-oriented Allegheny River at Pittsburgh with the combined flow forming the Ohio River. The Ohio River first flows in a north-northwest direction roughly along the Monongahela River's alignment until the south-southeast oriented Beaver River joins it and then the Ohio River turns in a westward direction to leave Pennsylvania. The Ohio River then turns in a south direction and serves as the Ohio-West Virginia border. The north-oriented Cheat River is an important tributary joining the Monongahela River near the Pennsylvania border and another major tributary, the north-oriented Youghiogheny River, joins the Monongahela south of Pittsburgh. For considerable distances the Monongahela, Youghiogheny, Cheat, Tygart Valley, and West Fork Rivers flow in low gradient 100-meter deep or deeper entrenched meandering valleys cut into the Appalachian Plateau (also known as the Allegheny Plateau) where in Pennsylvania Van Driver (1990, p. 49-51) notes the meandering Monongahela and Youghiogheny Rivers appear to be "unaffected by the gently corrugated very large-scale northeast-trending anticlines and synclines parallel to the Allegheny Front and the more intense folds of the Ridge and Valley Province bedrock structure."

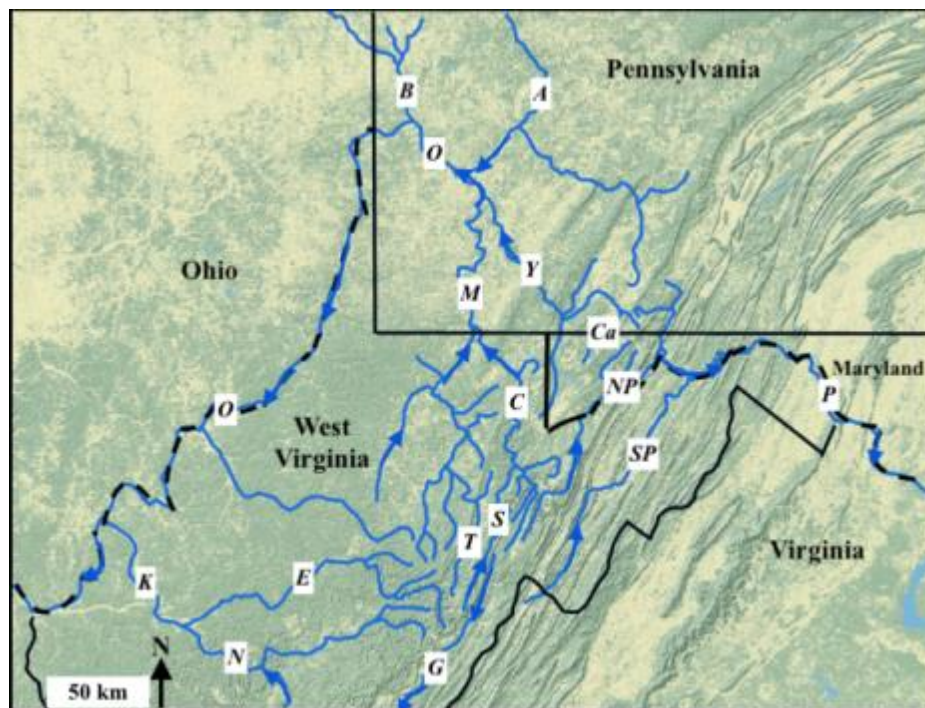


Figure 1. Modified map from United States Geological Survey (USGS) National Map website showing the Monongahela (M), Youghiogheny (Y), Cheat (C), Tygart Valley (T), Shavers Fork of the Cheat River (S), and Casselman (Ca) Rivers. Other labeled rivers are Allegheny (A), Beaver (B), Ohio (O), Potomac (P), North Branch Potomac (NP), South Branch Potomac (SP), Greenbrier (G), New (N), Kanawha (K), and Elk (E)

### 1.3 Accepted Paradigm Interpretations and Implications Pertinent to this Paper

Harper (2002, p. 10) describes the most important accepted paradigm interpretations pertinent to this paper by saying “The major rivers of western Pennsylvania existed millions of years before the Ice Age. They were mature streams that modified their channels as they meandered within relatively broad valleys. During the Ice Age, these streams cut their way downward, abandoning meanders and leaving everything from complete loops to fragments of meanders preserved as terrace remnants lining the river valleys. Some meanders were far enough inland from the eroding channels to be preserved as uncharacteristically flat swaths of land within... normally hilly topography. They can be seen at places like Carmichaels in Greene County (Monongahela River cutoff meander).” Earlier Harper (p. 2) had noted “The preglacial [north-oriented] Ohio River was a mere tributary of the Monongahela River... The mighty Monongahela flowed north out of West Virginia to Pittsburgh, and [followed] the present Ohio and Beaver River channels northwestward through Ohio and into Canada... When the Ice Age began in Pennsylvania... the advancing ice sheets blocked the northwest-flowing streams... and the mighty Monongahela was forced to flow up the valley of its minor tributary, the Ohio.”

Figure 2 provides a modified map from Tight (1903, Plate I) showing preglacial drainage basins even earlier workers had described and which are still recognized today. The words “Ancestral Saint Lawrence drainage basin” show that while the accepted paradigm does not consider Lake Erie a preglacial feature an ancestral Saint Lawrence drainage system is considered to have drained the Great Lakes region. For example, Thornbury (1965, p. 234) says “The basins now occupied by the Great Lakes were weak rock lowlands in preglacial time that drained eastward to the Gulf of Saint Lawrence.” Thornbury (1965, p. 210) also suggests “An early glaciation caused southward diversion of the Monongahela-Allegheny and Teays drainages from their preglacial courses to the preglacial Ohio. It is not certain whether this diversion was effected by the Nebraskan or Kansan ice sheet.” Such an interpretation requires Tight’s preglacial Pittsburgh River drainage basin (number 1 in figure 2), which includes the preglacial north-oriented Monongahela River to have flowed to an ancestral Saint Lawrence River.

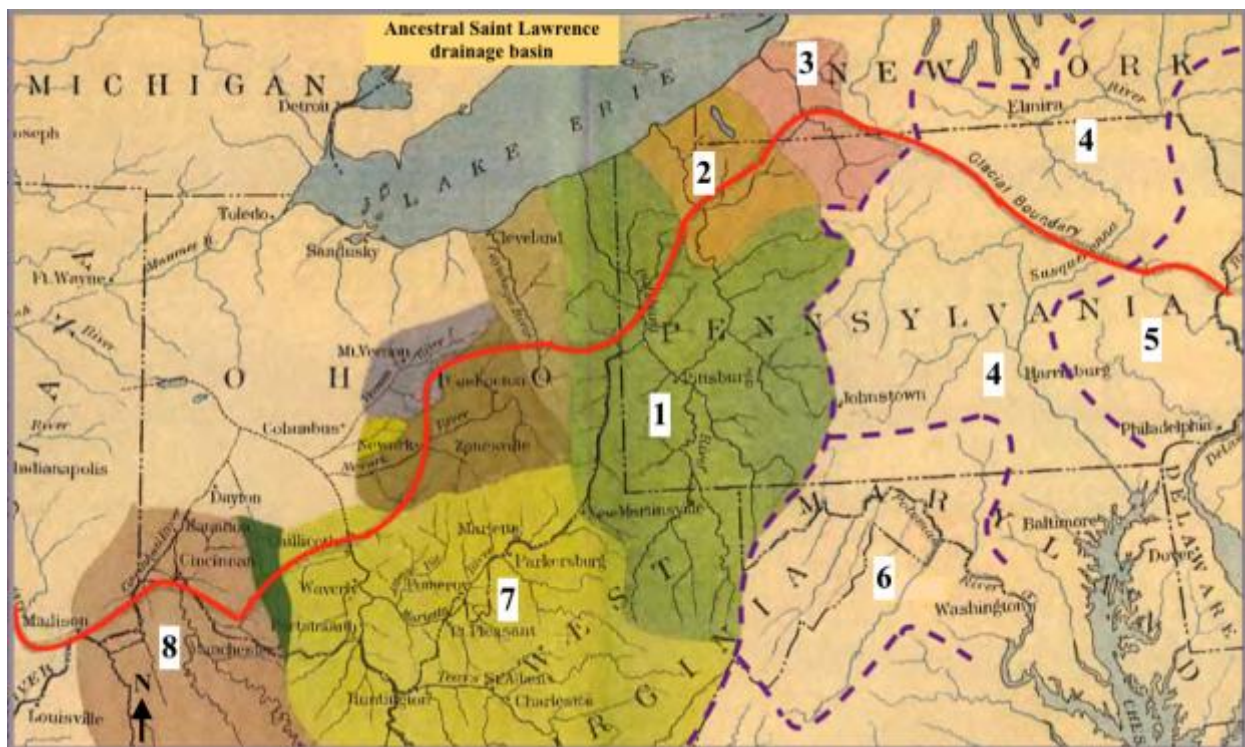


Figure 2. Modified map section from Tight (1903, plate 1) showing what the accepted paradigm considers as preglacial drainage basins which are identified as follows: 1.) Monongahela (or Pittsburgh), 2.) Middle Allegheny, 3.) Upper Allegheny, 4.) Susquehanna, 5.) Delaware, 6.) Potomac, 7.) Teays, and 8.) Cincinnati

From the accepted paradigm perspective all figure 2 numbered drainage basins are preglacial in age and originated during Tertiary time, although the lack of regional Tertiary sediments makes details difficult to determine. The Teays River (number 7 in figure 2) is described by Thornbury (1965, p.139) as “the major river of east central United States in Tertiary time” with today’s New River “probably a direct lineal descendant.” Thornbury (p. 106) commented the “New River is badly misnamed, for it ought to be called ‘Old River’; it is probably one of the oldest rivers in the eastern United States. It certainly dates far back into Tertiary time and possibly beyond that.” Ice sheet advances blocked the preglacial northwest-oriented Teays River, just as ice sheets blocked the preglacial north-oriented Monongahela River. The abandoned Teays River valley now extends across Ohio, Indiana and Illinois under glacially deposited sediments.

In spite of considerable anomalous topographic map drainage system and erosional landform evidence most geologists still consider the north-oriented Monongahela River to have had a pre-glacial origin. For example, Kaktins and Delano (1999, p. 386) show a map with preglacial drainage systems similar to those on Tight’s 1903 map. In another example, Kyshakevych and Prellwitz (2001, p. 6-7) claim “The Monongahela has always flowed north... [but] before the third ice advance, the Ohio River originally flowed north into Lake Erie... [and joined the Monongahela] in the valley of the present-day Beaver River. The ice sheet advance dammed the north-flowing Ohio River, and water impounded behind it forming a large valley-fill lake... called Lake Monongahela. ...Thick deposits of sand, mud, gravel, and cobbles can be seen in certain places within Pittsburgh, at about 920 feet [280 meters] above sea level; this deposit is known as the ‘Carmichaels Formation’, or the ‘Parker Strath’ (Wagner, 1970). ...Sometime during this high-water event, the southern portion of the Ohio River eroded through its divide, and started to flow southward.” And more recently Gray et al (2019) described Pittsburgh area drainage and glacial history in a similar manner.

#### *1.4 New Paradigm Interpretations and Implications Pertinent to this Paper*

A systematic and multi-year study of Missouri River drainage basin detailed topographic maps revealed most if not all topographic map drainage system and erosional landform evidence could be explained if, while the rim of the western half of a deep North American “hole” (see figure 3) was gradually rising, most valleys (large enough to show on 1:24,000 scale topographic maps) eroded headward in identifiable sequences across south- and southeast-oriented flood-formed anastomosing channel complexes. This finding defines the new paradigm and requires mountain range and regional uplift to have occurred as large and prolonged south- and southeast-oriented melt water floods flowed across them. Of particular importance to this study the new paradigm interprets detailed topographic map evidence to show that what are now north-oriented Missouri River tributary valleys (*e. g.* Cheyenne, Little Missouri, Yellowstone, and Powder Rivers) in eastern Montana, northeast Wyoming, and western North and South Dakota eroded headward from continental ice sheet locations across immense and prolonged east- and southeast-oriented ice sheet-marginal melt water floods (see Clausen, 2017, 2018a, 2018b, and 2018c).

By treating the Ohio River drainage basin as a Missouri River drainage basin mirror image the new paradigm predicts massive and prolonged south- and southwest oriented floods should have flowed between the Ohio River and the Ohio River-Atlantic Ocean drainage divide with deep “hole” rim uplift forcing south-oriented floodwaters to flow in a southwest direction while headward erosion of northwest- and north-oriented valleys (from the southwest to the northeast) captured the floodwaters and diverted the water toward the ice sheet location. These predictions mean it should be possible to interpret detailed topographic map evidence to show southwest-oriented flood flow moved into the Monongahela River drainage basin from the Susquehanna and Potomac River drainage basins, south- and southwest-oriented floodwaters flowed through the present-day north-oriented Monongahela River drainage basin into the New River drainage basin (further to the south), Cheat River drainage system development captured southwest-oriented flood flow moving to the Tygart Valley River drainage basin, Youghiogheny River drainage system development captured southwest-oriented flood flow moving to the Cheat River drainage basin, and Potomac River drainage system development captured southwest-oriented flood flow moving to the Youghiogheny River drainage basin. In a preliminary test Clausen (2021) used the new paradigm perspective to demonstrate the Casselman River drainage system (a Youghiogheny River tributary) developed during massive south-oriented oriented floods, although that study did not address the larger Monongahela River drainage basin.

## **2. Research Method**

The study reported here began by searching the geology literature to identify previously reported Monongahela River drainage basin anomalous drainage system evidence (observable on detailed topographic maps). The evidence was then observed and reinterpreted using a new paradigm perspective and detailed topographic maps



(originally mapped at a scale of 1:24,000) which can be now found on the United States Geological Survey (USGS) National Map website and (in some cases) on historic topographic maps used by geologists who first reported the anomalous evidence. Specifically, the question was asked, if viewed in the context of the new paradigm predicted immense south- and southwest-oriented melt water floods would the previously reported anomalous evidence still be anomalous evidence or would it be explainable evidence?



Figure 3. Modified map from the USGS National Map website with a red line showing the new paradigm deep “hole” rim probable location. Letters refer to river names as follows: A-Allegheny, C-Cheyenne, LM-Little Missouri, M-Monongahela, N-New, P-Powder, and Y-Yellowstone. Rivers are not shown unless they are discussed in the text

In addition, detailed topographic maps covering the entire Monongahela River drainage basin area were scanned to determine whether previously reported anomalous evidence was located only in isolated regions or was commonly found. After determining the anomalous topographic map evidence (often in the form of barbed tributaries and transverse drainages) was present throughout the entire Monongahela River drainage basin a decision was made to use examples of identifiable (but not previously reported) anomalous evidence to illustrate how the new paradigm’s predicted south- and southwest-oriented floods flowed from what are now the Susquehanna and Potomac River drainage basins into and through the Monongahela River drainage basin to reach what is today the north-oriented New River drainage basin.

### 3. Research Results

#### 3.1 Previously Reported Monongahela River Drainage Basin Anomalous Evidence

Geologists using what in the early 1900s were newly available detailed topographic maps noticed topographic map drainage system evidence was not consistent with the then (and still) accepted Monongahela River drainage system history. For example, Stone (1905, p. 2) in the USGS Waynesburg Quadrangle folio comments, “A noticeable feature of this quadrangle is that besides flowing east [to the Monongahela River], all of the main [tributary] streams have longer tributaries on the north than on the south. In other words, the streams do not lie midway between the divides, but crowd the south side of the drainage basin. ...No adequate explanation of this

lack of symmetry in the drainage basins has yet been found. This unsymmetrical arrangement occurs in several counties in southwestern Pennsylvania. It cannot be ascribed to the present structure of the rocks, because it disregards anticlines and synclines. ...So far as the character of the rocks is concerned the tributaries on both sides of the streams should be of equal length" (figure 4 illustrates a section of the 1904 Waynesburg Quadrangle topographic map Stone used). From the new paradigm perspective these asymmetric tributary drainage basins are precisely what would be expected if a south-oriented Monongahela River valley and its tributary valleys had eroded headward during massive and prolonged south-oriented melt water floods.

South-oriented or barbed tributaries in the north-oriented Monongahela River drainage basin, like those in figure 4, are common throughout the Monongahela, Youghiogheny, Cheat, West Fork, and Tygart River drainage basins. For example, in Preston County [WV] where the Cheat River flows in a north direction Hennen and Reger (1914, p. 46) report "the tributaries... are extremely irregular in their development. ...On the east side, however there are long tributaries. These streams do not flow northward to correspond with the current of the parent stream, but have a contrary course toward the south, making obtuse angles above instead of below their mouths with the Cheat. This condition might lead to a belief that Cheat once flowed toward the south, but such a belief is untenable because the main tributaries of the river in Randolph and Tucker counties are regular and convincing." Even though barbed tributaries are found everywhere in the Monongahela River drainage basin Thornbury (1969, p. 120) reports "barbed drainage patterns usually have only local extent and will be found at or near the headwater positions of drainage systems. ...Most barbed patterns are the result of stream piracy" resulting from drainage system reversal, although "less commonly the drainage reversal may have been effected by warping or tilting of the land or may represent drainage changes effected by glaciation." The abundant barbed (south-oriented) tributaries can be explained if as the new paradigm predicts a major drainage reversal occurred, however the accepted paradigm requires the Monongahela River to have always flowed in a north direction and hence the barbed tributaries from the accepted paradigm perspective are anomalous evidence.



Figure 4. Modified section of USGS 1904 Waynesburg Quadrangle topographic map used by Stone (1905).

Dashed red lines show drainage divides surrounding the Castle Run drainage basin which drains to north-oriented South Fork Tenmile Creek, which joins south-oriented Tenmile Creek with their flow moving in an east direction to the north-oriented Monongahela River (east of figure). The contour interval is 20 feet (6 m)



Campbell (1902, p. 3-4) in his Masontown-Uniontown Quadrangles folio discusses abandoned meander channels which he says “are from 140 to 150 feet [43-46 meters] above water level, and ...of frequent occurrence from Pittsburgh, PA to Morgantown, WV. ... but no adequate explanation of their origin has been offered. They have been described as ‘oxbows’ or ‘abandoned channels’ as though it were the most reasonable thing in the world for a stream to abandon its channel. ...western Pennsylvania is a rugged region, with a general upland rising 500 feet [152 meters] above the water level of the principal stream. In such a region it is an extremely difficult and slow process for a stream to cut off any of its meander, and it is manifestly impossible for it to establish a totally new course unless the conditions under which it operates are very different from those which normally affect the development of the stream” (figure 5 illustrates a section of the 1901 Masontown Quadrangle topographic map Campbell used to observe the abandoned meander channel in which the town of Carmichaels is located). Campbell proposed ice jams dammed the north-oriented Monongahela River and caused the river to cut new channels. In discussing the Brownsville Quadrangle Campbell (1903, p. 3) notes the “Youghiogheny River is likewise affected [with abandoned channels] from its mouth to the edge of mountainous region at Connellsville, and even above this point there is an excellent example”.

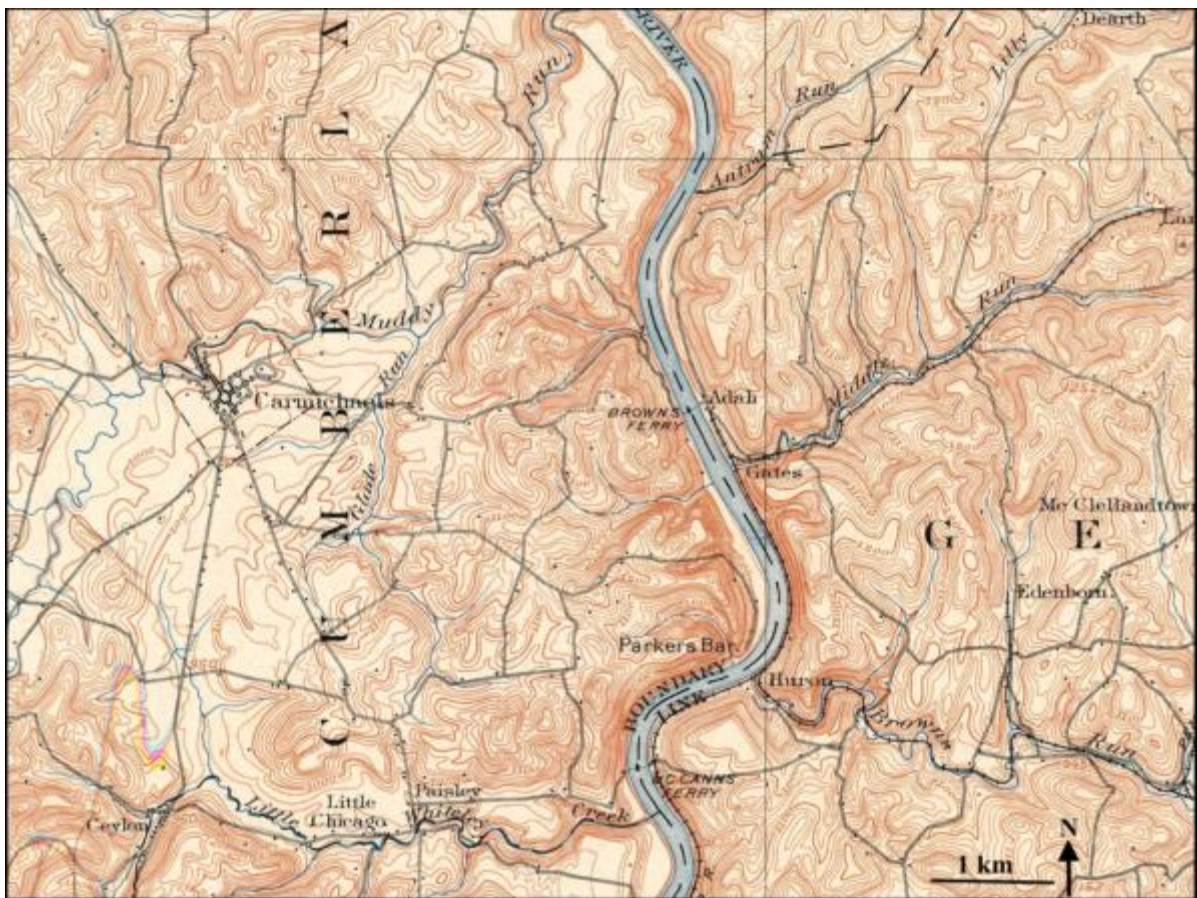


Figure 5. Section of USGS 1901 Masontown Quadrangle topographic map used by Campbell (1902) illustrating an abandoned channel and barbed (south-oriented) tributaries flowing to north-oriented Monongahela River. Carmichaels is located in the abandoned channel now used by northeast-oriented Muddy Creek and south- and east-oriented Little Whiteley Creek drainage. Contour interval is 20 feet (6 m) and the elevation at Carmichaels is about 1000 feet (304 meters). The Monongahela River elevation is about 780 feet (238 m)

Fenneman (1938, p. 302-304) discusses the abandoned channel problem and observes “At least three hypotheses ... deserve attention. (1) Complete obstruction of northward drainage by ice, which ponded the waters, in which sediments then accumulated [to block former channels]. (2) Local dams of ice, which held back the streams and caused the necessary deposition on their upstream sides. (3) Overloading of streams which flowed from the ice, causing aggradation, not only in their own valleys but of the north-flowing streams with

which they united. ...As all the preglacial drainage... escaped to the north... nothing is more certain than that the main streams were blocked by the Pleistocene ice and lakes must have formed. At none of the places in question have lake sediments been actually observed at levels high enough to superpose drainage along present lines. Evidence of important lacustrine deposits is weak in the Monongahela basin, for which the hypothesis was first put forward.” Fenneman failed to consider the new paradigm perspective in which immense south-oriented melt water floods reversed their flow direction as ice sheet melting opened up formerly icesheet occupied space which permitted deeper north-oriented valleys to erode headward in south directions along what had been major south-oriented flood flow channels (leaving channel segments abandoned where the north-oriented valley headward erosion cut across previous south-oriented flood flow channel meanders).

The Monongahela River drainage system includes hundreds of transverse drainages (also referred to as water gaps) and abandoned transverse drainages (wind gaps or divide crossings). Strahler (1945) after study of Pennsylvania Susquehanna and Delaware River drainage basin water gaps could not explain their origins and concluded that trying to do so was a non-productive research activity. More recently Clark (1989, p. 209) commented, “The origins and evolution of transverse drainage were stumbling blocks to classical, historical geomorphologists, and many problems still remain. ...Many unsolved problems include: post-Alleghenian tectonic effects, rates and timings of uplift, erosion and deposition, whether litho-tectonic weaknesses are most pronounced in gap areas, and establishing a numerical chronology for drainage development.” The problems are complicated by the number of transverse drainages found in Ridge and Valley Province drainage systems. For example, Lee (2013) identified 653 transverse drainages within the Susquehanna River drainage basin and noted smaller streams account for the vast majority of those transverse drainages. From the new paradigm perspective, abundant transverse drainages would be expected to develop as massive and prolonged south-oriented melt water floods flowed across geologic structures present in the new paradigm’s rising deep “hole” rim area.

### *3.2 Additional Monongahela River Drainage Basin Anomalous Topographic Map Evidence*

Figures 6-12 illustrate how topographic map evidence (which from the accepted paradigm perspective is anomalous) can be interpreted from the new paradigm perspective to show how large and prolonged floods flowed from the Potomac River drainage basin in a south-southwest direction across the Monongahela River drainage basin and into the New River drainage basin. Figure 6 illustrates the Ohio River-Atlantic Ocean drainage divide crossing abandoned valleys that link southwest-oriented Little Youghiogheny River headwaters with northeast-oriented Crabtree Creek headwaters. The map area is between the north-northeast oriented Youghiogheny River (northwest) and north-northeast-oriented North Branch Potomac River (southeast) and shows Deep Creek (D in figure 6) which flows in a northwest and then southwest direction across ridges and a through valley now crossed by drainage divides seen in figure 7 to reach the north-northeast-oriented Youghiogheny River. Downstream (southwest) from the figure the southwest-oriented Little Youghiogheny River turns in a northwest direction to join the north-northeast oriented Youghiogheny River (seen in figure 7). Downstream (northeast) from figure 6 northeast-oriented Crabtree Creek flows to the southeast-oriented Savage River, which flows to the north-northeast oriented North Branch Potomac River which eventually joins the Potomac River. Massive quantities of water flowing in south-southwest diverging and converging channels eroded the now parallel (and now abandoned) through valleys. The southwest-oriented floodwaters moved across the figure 6 map area to the figure 7 area and also eroded the unseen, but adjacent and now north-northeast oriented Youghiogheny and North Branch Potomac River valleys. Ridges seen in figure 6 probably emerged as floodwaters flowed across the region by deep erosion and/or by tectonic uplift. Southwest-oriented flood flow into the map area ended when southeast-oriented Savage River valley headward erosion (from what was probably a south-southwest oriented flood flow channel on the North Branch Potomac River alignment) beheaded and reversed the flood flow to create the northeast-oriented Crabtree Creek drainage system and Crabtree Creek-Little Youghiogheny River drainage divide.

Figure 7 is located west and south of figure 6 and shows the north-northeast oriented Youghiogheny River (Y), northwest-oriented Little Youghiogheny River (LY), and a through valley linking the northwest-oriented Little Youghiogheny River with south-southwest oriented White Meadow Run (WM), which joins the north-oriented Youghiogheny River as a barbed tributary (south and west of the figure). The structurally defined White Meadow Run valley can be traced across drainage divides in a north-northeast direction from figure 7 to Millers Run and further to Deep Creek (shown by letter D in figure 6), both of which have cut deep valleys leading to the Youghiogheny River. The structurally defined through valley continues in a northeast direction to where it is drained by northeast- and southeast-oriented Monroe Run, which flows to the Savage River in the Potomac River drainage basin. The Little Youghiogheny River as seen in figure 6 begins as a southwest-oriented drainage route and makes a right-angle bend to become a northwest-oriented drainage route and then crosses several ridges, but



when today's northwest-oriented valley was formed drainage was in the opposite direction and a southeast-oriented flood flow channel diverged from south-southwest flood flow in the Youghiogheny River valley to cut across emerging ridges and other south-southwest oriented flood flow channels (in the White Meadow Run and Cotton Run valleys) and converged with southwest-oriented flood flow that continued to the present-day Youghiogheny River headwaters and then flowed across the modern-day Youghiogheny-Cheat River drainage divide (seen in figure 8) and continued flowing in a south direction along the alignment of the Shavers Fork (Cheat River) to the southernmost point in the present-day north-oriented Monongahela River drainage basin before entering the south-southwest-oriented Greenbrier River valley.

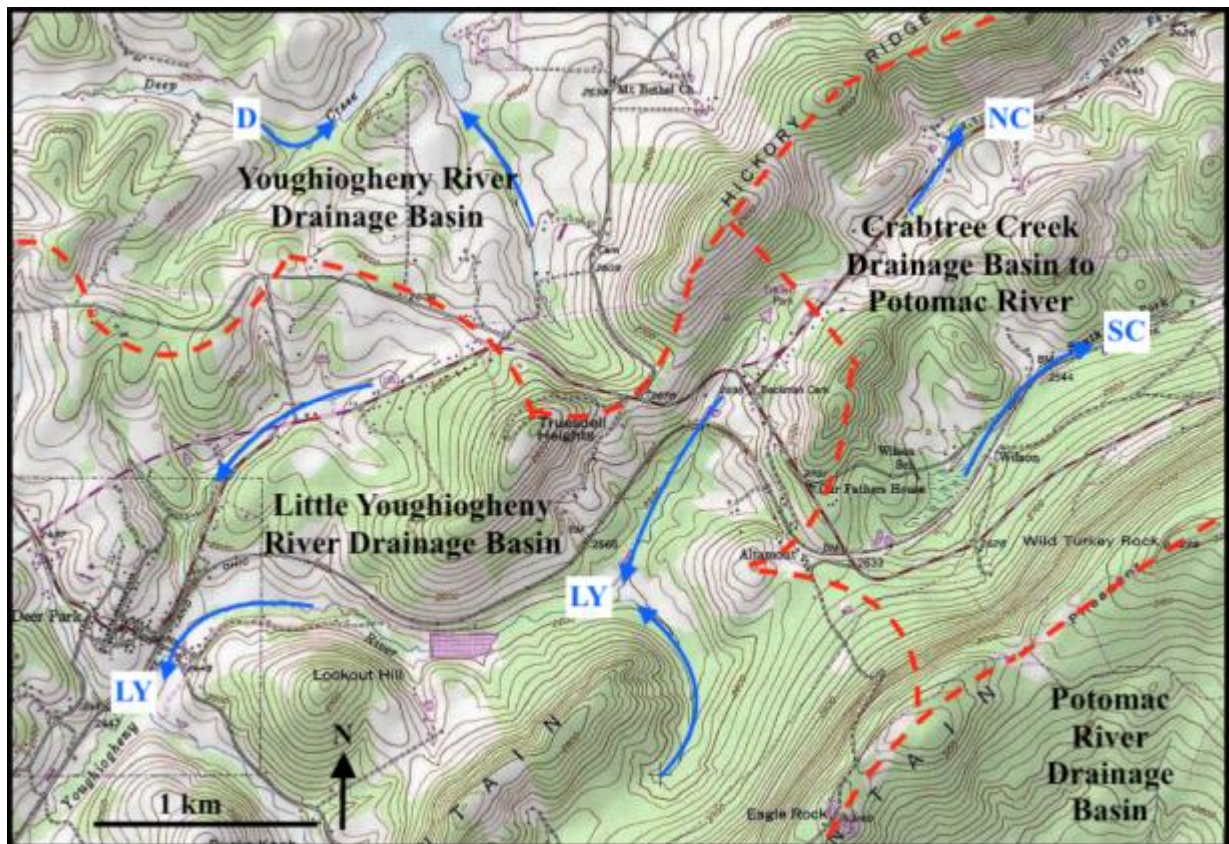


Figure 6. Modified topographic map from the USGS National Map website illustrating through valleys linking southwest-oriented Little Youghiogheny River headwaters (LY) in the Youghiogheny River (Ohio River) drainage basin with northeast-oriented North and South Forks Crabtree Creek (NC and SC) headwaters in the Potomac River (Atlantic Ocean) drainage basin. The dashed red lines show major drainage divides. The contour interval is 20 feet (6 meters)

Figure 8 is located to the south and west of figure 7 and illustrates a 100-meter-deep northeast-to-southwest oriented through valley at Aurora, WV that crosses the Youghiogheny-Cheat River drainage divide. The Youghiogheny River is visible along the figure 8 east edge (the unseen West Virginia-Maryland border is located just east of the figure). Rhine Creek is the northeast-oriented stream joining the Youghiogheny River (in the figure northeast quadrant) at an elevation of 732 meters and Wolf Creek is the west-southwest oriented stream in the Cheat River drainage basin. West of the figure Wolf Creek turns to flow in a south-southwest direction before making a U-turn to flow for a short distance in a northwest direction so as to join what is now the north-oriented Cheat River at an elevation of 437 meters. Based on the elevations water flowing in a southwest direction eroded the through valley and the Wolf Creek and Wolf Creek tributary valleys which are seen along the figure 9 west edge. The unseen Wolf Creek U-turn is interpreted to be evidence south-oriented drainage in the Cheat River valley was reversed to flow in a north direction while southwest oriented flood flow still moved across the Youghiogheny-Cheat River drainage divide. The shallow Youghiogheny River valley seen in the figure 8 northeast corner suggests not much Youghiogheny River downcutting has occurred since south-oriented flow in



the Youghiogheny River valley was reversed, a reversal which also reversed flow in the northeast-oriented Rhine Creek valley and which created the Youghiogheny-Cheat River drainage divide.

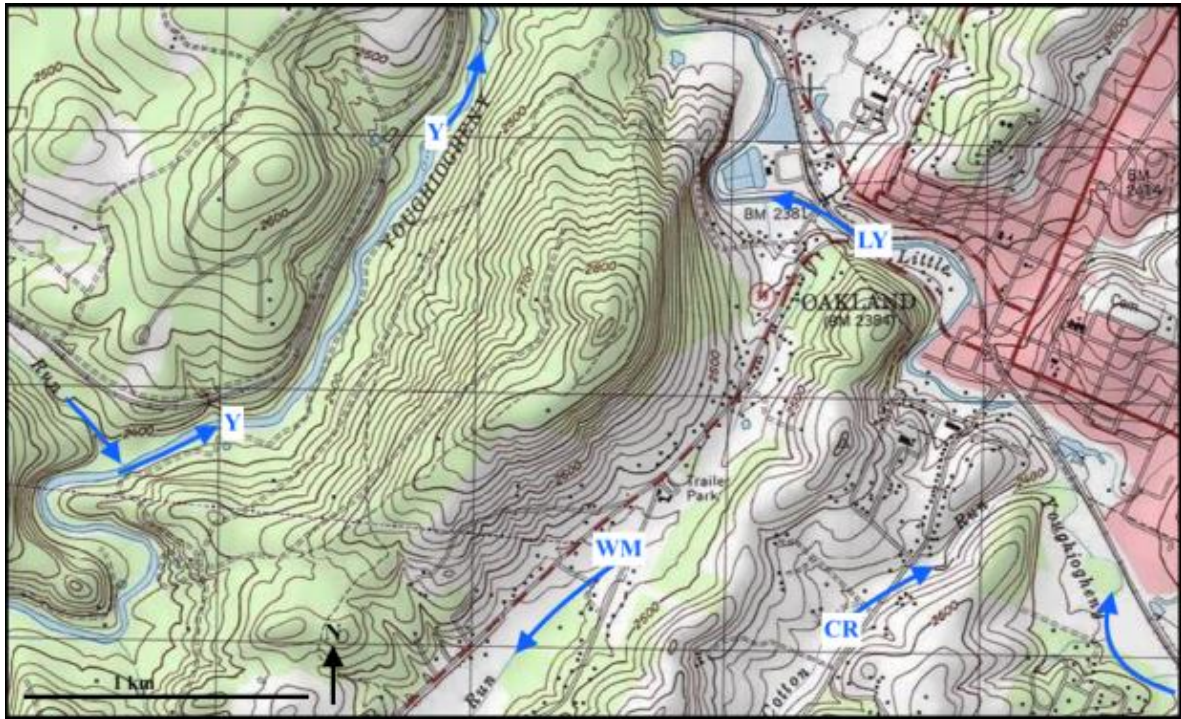


Figure 7. Modified topographic map from the USGS National Map website. Letters identify drainage routes: Y-Youghiogheny River, LY-Little Youghiogheny River, WM-White Meadow Run, and CR-Cotton Run. The arrows indicate flow directions. The contour interval is 20 feet (6 m)



Figure 8. Modified topographic map from the USGS National Map website illustrating a northeast-to-southwest oriented valley linking northeast-oriented Rhine Creek (R) in the Youghiogheny River (Y) drainage basin with west-oriented Wolf Creek (W) and a southwest-oriented Wolf Creek tributary (WT) in the Cheat River drainage basin (Cheat River is to the west of the figure). Dashed red line shows Youghiogheny-Cheat River drainage divide. The contour interval 20 feet (6 m)



To the south of figure 8 the north-oriented Cheat River is now formed where north-northeast oriented Shavers Fork and northwest-oriented Black Fork meet. Black Fork further to the southeast is northwest-oriented Dry Fork. As seen in figure 1 north-northeast oriented tributaries join northwest-oriented Dry Fork-Black Fork from the south and southwest and south-southwest oriented tributaries also join Dry Fork-Black Fork from the north (as barbed tributaries). Through valleys similar to those seen in figure 6, 7, and 8 link southwest-oriented Dry Fork-Black Fork tributary headwaters with north-northeast oriented North Branch Potomac River headwaters and suggest south-southwest oriented flood flow moving along the North Branch Potomac River alignment continued southward in what are now north-northeast oriented Dry Fork-Black Fork tributary valleys. Some south-southwest oriented flood flow that had been moving across Youghiogheny River headwaters areas seen in figures 6, 7, and 8 probably continued in a south-southwest direction along today's north-northeast Shavers Fork alignment to reach the figure 9 area where north-northeast oriented Shavers Fork makes a west-oriented jog before continuing in a north-northeast direction to its confluence with northwest-oriented Black Fork.

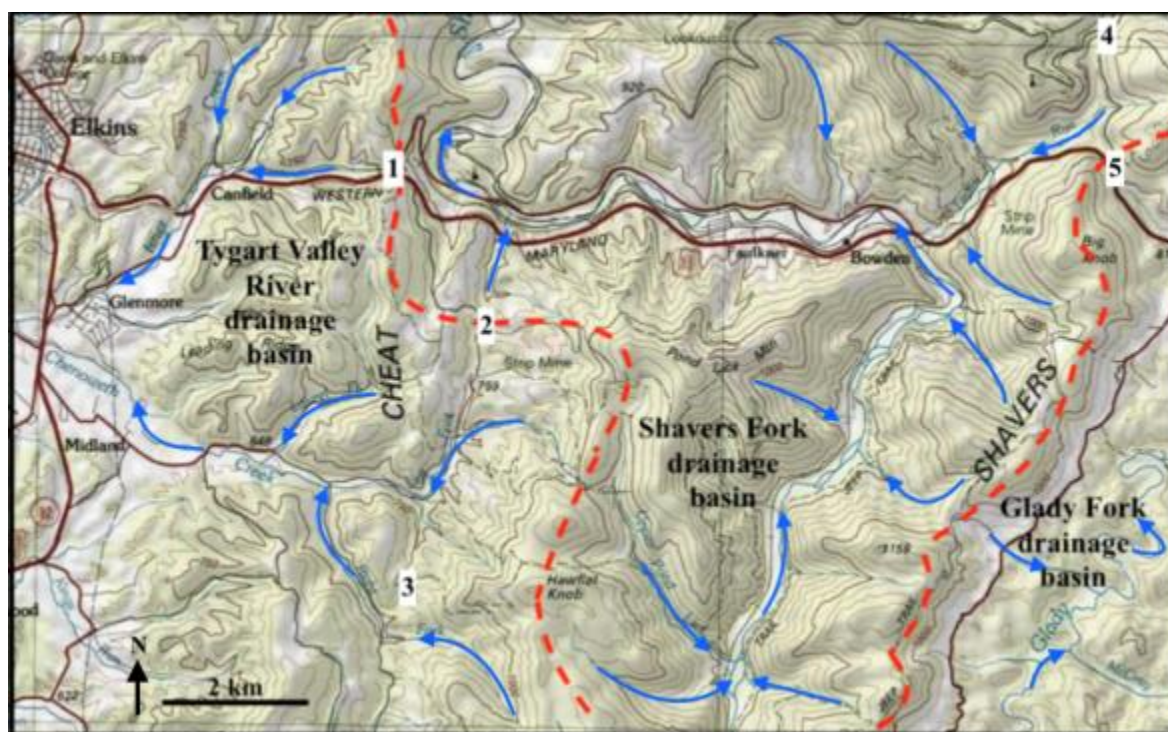


Figure 9. Modified topographic map from the USGS National Map website showing present-day north-oriented Shavers Fork (of the Cheat River) flanked by the north-oriented Glady Fork (of the Cheat River) and Tygart Valley River drainage basins. The red dashed lines show drainage divides. Numbers identify locations discussed in the text. The contour interval is 50 meters

Figure 9 illustrates the Shavers Fork valley east of Elkins, WV. Note the large number of south-oriented (barbed) tributaries indicating a drainage reversal has taken place. The west-oriented Shavers Fork jog is interesting as the Cardwell et al (1968) geologic map shows Shavers Fork upstream (south) from figure 9 flowing along a central valley in the deeply eroded north-northeast oriented North Potomac Syncline while after making its westward jog downstream from figure 9 (north) Shavers Fork flows in a north-northeast direction along the eastern flank of the central valley of the adjacent deeply eroded north-northeast oriented Deer Park Anticline. Floodwaters moving in a south-southwest direction flowed across Youghiogheny River headwaters areas as seen in previous figures and entered the figure 9 map area to diverge just east of location 1 with one channel continuing in a south direction across drainage divides at locations 2 and 3 and another channel moved water westward and in a southwest direction into what is now the north-northeast oriented Tygart Valley River drainage basin (located west of figure 9). Another southwest-oriented flood flow channel with water that had moved along the present-day North Branch Potomac River alignment entered the figure 9 map area at location 4 and diverged



with one channel turning in a southeast direction at location 5 with that water converging with south-southwest oriented flood flow on today's north-northeast Glady Fork alignment (which further to the north had diverged from the southwest-oriented channel flowing to location 4). Southwest-oriented floodwaters flowing past location 4 probably diverged again just east of Bowden (where Shavers Fork now turns to flow in a west direction) with one channel eroding the west-oriented valley while the other channel continued in a south-southwest direction along the Shavers Fork alignment.

Upstream (south) from figure 9, along the present-day north-northeast oriented Shavers Fork route, the eroded North Potomac Syncline structure is more apparent as a topographic feature in figure 10 where the Tygart Valley River drainage basin (west) and Glady Fork drainage basin (east) flank the narrow Shavers Fork drainage basin. Cheat Mountain forms the divide between the Shavers Fork and Tygart Valley River drainage basins and Shavers Mountain forms the divide between the Shavers Fork and Glady Fork drainage basins. Location 1 identifies a gap cut across Shavers Mountain between the towns of Bemis and Glady. South-oriented (barbed) tributaries to today's north-northeast oriented Shaver Fork suggest a drainage reversal has taken place and the gap at location 1 suggests south-oriented flow in the Shavers Fork valley diverged at Bemis with one channel continuing in a south-southwest direction while the other channel diverged to flow across what must have been an emerging Shavers Mountain to Glady where it converged with south-southwest oriented flow moving on the West Fork Glady Fork alignment and to diverge again to flow along the present day north-oriented East Fork Glady alignment (east of Beech Mountain). North-northeast oriented Glady Fork is formed at the confluence of its north-northeast oriented West Fork and north- and northwest-oriented East Fork. Between figure 9 and figure 10 is a low drainage divide between north-northeast oriented West Fork Glady Fork headwaters and south-southwest oriented West Fork Greenbrier River headwaters indicating south-southwest oriented flow on the Glady Fork alignment continued into the south-southwest oriented Greenbrier River drainage basin. Location 2 identifies a gap suggesting south-southwest oriented water flowed along the Cheat Mountain western flank.

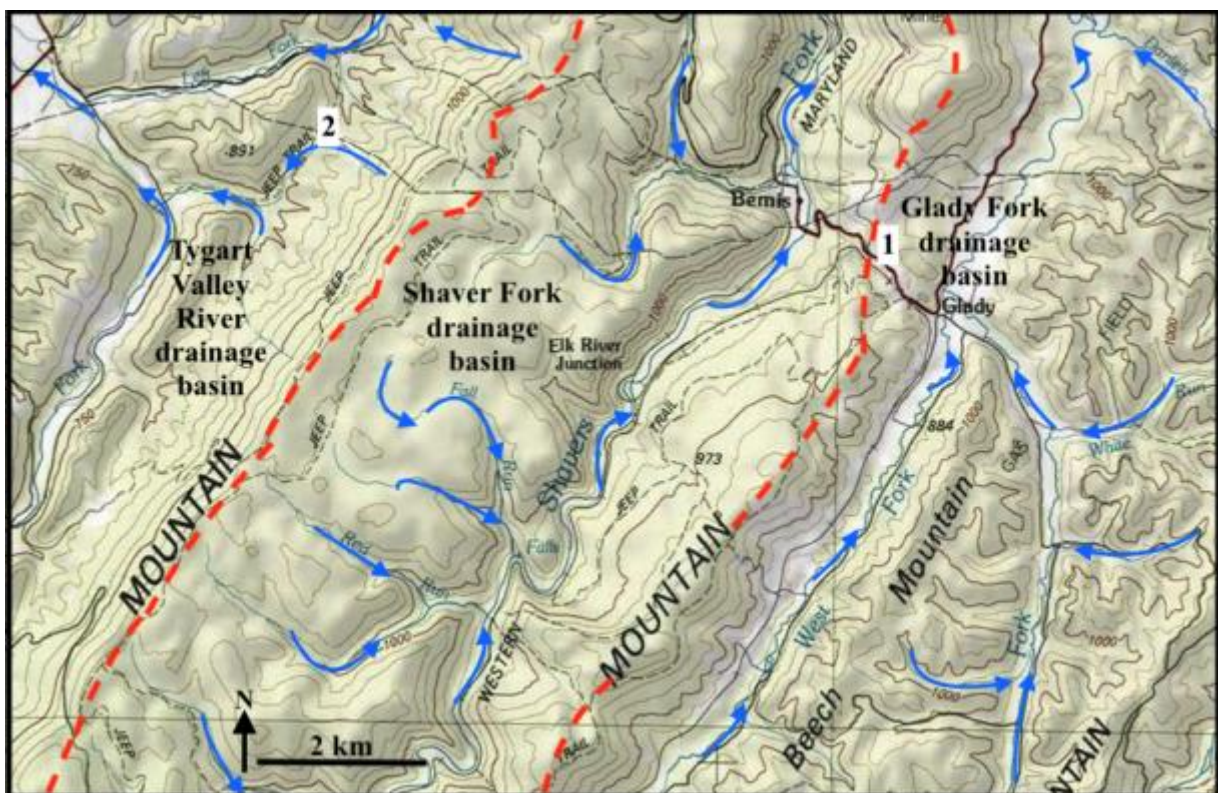


Figure 10. Modified topographic map from the USGS National Map website showing north-northeast oriented Shavers Fork drainage basin flanked by Glady Fork drainage basin (east) and Tygart Valley River drainage basin (west). The red dashed lines show drainage divide locations. Numbers identify locations discussed in the text. The contour interval is 50 meters

Figure 11 shows the north-northeast oriented Shavers Fork drainage basin flanked by the south-southwest oriented Greenbrier River drainage basin (east) and north-northeast oriented Tygart Valley River drainage basin (west). The south-southwest oriented Greenbrier River is formed at Durbin (in the figure southeast quadrant) where its west-oriented East Fork and south-oriented West Fork meet and after flowing in a south-southwest direction the Greenbrier River eventually joins the north-oriented New River, which as previously described is the accepted paradigm's "preglacial" Teays River drainage route (see figures 1 and 2). In figure 11 the south-southwest oriented West Fork and Greenbrier River flow along the base of Back Allegheny Mountain (which north of figure 11 is known as Shavers Mountain) at elevations lower than the adjacent north-oriented Shavers Fork valley elevations (suggesting deeper erosion in the Greenbrier River drainage basin). West of Cheat Mountain, the north-northeast oriented Tygart Valley River also flows in a deeper valley than the north-oriented Shavers Fork valley. Numbers 1 and 2 (in figure 11) identify gaps cut across the Shavers Fork-Greenbrier River drainage divide. The gap at location 1 was eroded by south-oriented water diverging from what is now north-northeast oriented Shavers Fork into the south-southwest oriented Greenbrier River drainage basin. The gap at location 2 suggests south-southwest oriented water diverged from the Greenbrier River drainage basin to converge with southwest-oriented water in the Shavers Fork valley (which would not be possible today). These gaps, as well as gaps at locations 3 and 4, were eroded by diverging and converging south-oriented flood flow channels as the new paradigm predicts.

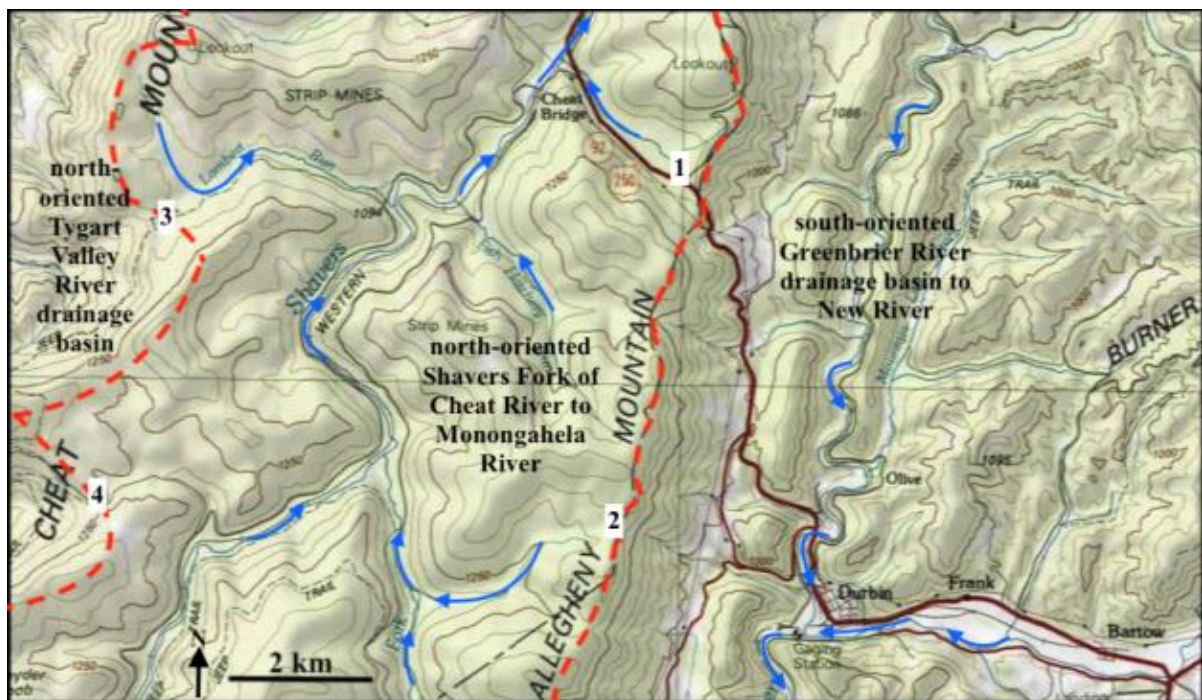


Figure 11. Modified topographic map from the USGS National Map website showing north-oriented Shavers Fork (Cheat River) drainage basin between the south-oriented Greenbrier River (east) and north-oriented Tygart Valley River drainage basins. The dashed red lines show drainage divide locations and numbers identify locations discussed in the text. The contour interval is 50 meters

Figure 12 shows Thorny Flat, which is the southernmost point in the Monongahela River drainage basin, which at 1443 meters is also West Virginia's second highest point. Thorny Flat is where the erosion resistant Cheat Mountain ridge curves around the North Potomac Syncline southern nose to become Back Allegheny Mountain and is where Shavers Fork originates. Interestingly the north-northeast oriented Tygart Valley River drainage basin also originates in figure 12 (west of number 2 and north of number 3). Another intriguing figure 12 feature is at location 1 where Leatherbark Run turns from flowing in a southwest direction from Bald Knob to flow in a southeast direction across Back Allegheny Mountain to reach the south-southwest oriented Greenbrier River. Price and Reger (1929, p. 62) observed south-oriented Leatherbark Run to be within 300 meters of north-oriented Shavers Fork and noted "A fine example of imminent capture can be seen ...in the near future, geologically speaking, the upper two miles [3.2 km] of Shavers Fork will become a part of the Greenbrier River



drainage.” What they do not explain is how Leatherbark Run with its small upstream drainage basin was able to obtain enough water to erode a water gap across Back Allegheny Mountain. From the new paradigm perspective, the Leatherbark Run water gap is further evidence supporting south-oriented flood flow movement along what is today the north-northeast oriented Shavers Fork alignment. Prolonged south-oriented floodwaters eroded the water gap as the Back Allegheny Mountain ridge (and surrounding ridges) emerged (by uplift and/or by erosion). Further, the northeast-oriented Shavers Fork valley segment immediately upstream (south) from location 1 suggests southwest-oriented floodwater eroded an unlabelled gap cut across Cheat Mountain leading into the Elk River drainage basin. Not as well explained by either paradigm is the 2 km long north-oriented Shavers Fork headwaters valley segment just to the north of Thorny Flat.

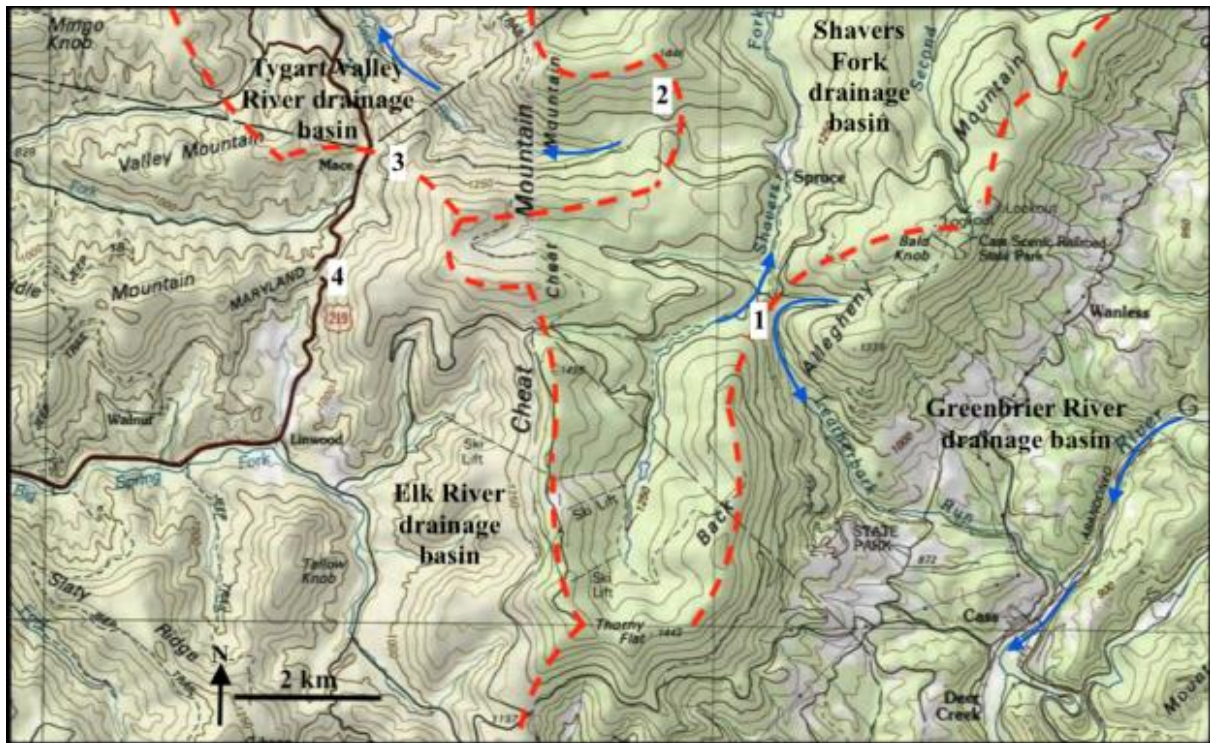


Figure 12. Modified topographic map from the USGS National Map website showing the Monongahela River drainage basin's southernmost point. Dashed red lines show drainage divides and numbers refer to locations discussed in the text. The contour interval is 50 meters

The gap at location 2 (in figure 12) shows water once flowed between the Tygart Valley River and Shavers Fork headwaters while the gaps at locations 3 and 4 are evidence south-oriented flood flow moved from today's north-oriented Tygart Valley River drainage basin in a southward direction across valleys of west-oriented streams flowing to what is today a north-oriented Elk River headwaters segment. As seen in figure 1 the Elk River today after flowing in a north direction turns in a southwest direction to reach the northwest-oriented New and Kanawha Rivers. The north-oriented Elk River headwaters valley probably originated as a south-oriented flood flow channel in which south-oriented flood flow that had moved through the present day north-oriented Tygart Valley River drainage basin continued southward across the gaps at locations 3 and 4 and was beheaded and reversed by Elk River valley headward erosion. West-oriented tributary valleys previously had eroded headward from that south-oriented channel in sequence from south to north to capture south-oriented flood flow which until being beheaded and reversed had been captured further to the south by southwest-oriented Gauley River valley headward erosion. When the northwest-oriented New River valley eroded headward from an icesheet location (which would have been before the north-oriented Monongahela River valley eroded headward from an icesheet location) the Elk River and Gauley River valleys eroded headward from that valley to capture south-oriented flood flow that had been moving to what at that time was south-oriented flood flow in today's north-oriented New River drainage basin. South-oriented flood flow moving into the figure 12 map area ended when deep "hole" rim uplift raised the region and forced major drainage reversals, which headward erosion of



the deep north-oriented Monongahela River valley (from the icesheet location) then captured as the present-day Monongahela River drainage system was being assembled.

#### 4. Discussion

Early investigators reported anomalous Monongahela River drainage basin topographic map evidence and by the mid 20<sup>th</sup> century geomorphologists knew most USGS topographic map drainage system and erosional landform evidence could not be explained. Thomas Kuhn (1970) notes scientific paradigms in addition to explaining observed evidence also identify anomalous evidence, or evidence an accepted paradigm cannot explain. According to Kuhn, regardless of the paradigm being used scientists will always encounter anomalous evidence and one of three things will then happen. First, by conducting further research scientists may find ways to explain the previously unexplained evidence and the paradigm will continue without serious interruption. Second, the anomalous evidence will be reported and left unsolved (as occurred with Monongahela River drainage basin anomalous evidence reported here) in the hope future scientists will find ways to explain it. Third, the anomalous evidence will lead to a new paradigm (as has happened with the anomalous topographic map evidence) and to a battle over which of two competing and incommensurable scientific paradigms should be used. In such battles Kuhn notes one paradigm should not be used to judge the other, but instead the two incommensurable paradigms should be judged based on their ability to explain the observed evidence.

Published literature pointing out Monongahela River drainage basin anomalous evidence dates back to the early 20<sup>th</sup> century, yet appears to have been ignored by more recent investigators. For example, Harper (2002) must have been aware of Campbell's (1902, 1903) and Fenneman's (1938) comments regarding the Monongahela River drainage basin large abandoned meander channels, yet he does not report those landform features as anomalous evidence. Likewise, Swift (2020) in his study of Monongahela River tributary knickzones almost certainly observed the same asymmetric tributary drainage basins Stone (1905) had reported as anomalous evidence, yet Swift does not discuss the asymmetric drainage basin problem nor does Swift who must have observed barbed tributaries discuss the abundance of south-oriented or barbed tributaries flowing to the north-oriented Monongahela River. It almost seems as though the accepted paradigm has blinded modern-day geologists so they are unable to see obvious anomalous evidence. Of much greater importance is the inability of geomorphologists to explain most of the USGS detail topographic map drainage system and erosional landform evidence (not just in the Monongahela River drainage basin, but throughout the entire United States) and the geomorphology research community's apparent lack of interest in trying to do so. No Cenozoic geology and glacial history paradigm can claim to correctly describe North America's Cenozoic geologic and glacial history unless that paradigm can also explain the topographic map drainage system and erosional landform evidence, yet the geology research community continues to flesh out a Cenozoic geology and glacial history paradigm that is unable to explain most of the well-mapped detailed topographic map drainage system and erosional landform evidence.

#### 5. Conclusions

Contrary to commonly accepted interpretations and most published literature the Monongahela River drainage network did not originate as a preglacial north-oriented river system because detailed topographic map drainage system and erosional landform evidence in the form of barbed tributaries, asymmetric drainage basins, abandoned valleys (divide crossings), and transverse drainages can be used to demonstrate the Monongahela river system developed when continental icesheet related crustal uplift and the opening up of deep "hole" space (in which the icesheet had been located) caused what had been massive and prolonged south-oriented melt water floods to reverse their flow direction so as to flow northward into deep "hole" space a decaying continental icesheet had once occupied. A recently proposed new Cenozoic geology and glacial history paradigm in which a thick continental icesheet (located where ice sheets are typically reported to have been) created and occupied a deep "hole" explains much if not all of the Monongahela River drainage basin detailed topographic map drainage system and erosional landform evidence, but leads to a fundamentally different Cenozoic geologic and glacial history than what the accepted Cenozoic geology and glacial history paradigm describes.

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