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Use of French Broad River Drainage Basin Topographic Map Evidence Upstream from Asheville, North Carolina to Test a New Geology and Glacial History Paradigm, USA

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Abstract

Topographic map evidence in the western North Carolina French Broad River drainage basin (upstream from Asheville) was used to determine if a new geology and glacial history paradigm (new paradigm) can explain previously unexplained (and anomalous) drainage system evidence. The new paradigm claims: 1) the Eastern Continental Divide was uplifted as the southeastern rim of a continental ice sheet created deep "hole" (in which the ice sheet was located) as immense and prolonged southwest-oriented meltwater floods flowed across it, 2) headward erosion of south and southeast-oriented valleys (in sequence from the southwest to the northeast) diverted floodwaters more directly to the Atlantic Ocean, and 3) headward erosion of north- and northwest-oriented valleys from the developing deep "hole" (in sequence from the southwest to the northeast) diverted floodwaters to deep "hole" space (located between the rising deep "hole" rim and the ice sheet margin) and then toward deep "hole" southern exits (eventually the Mississippi River valley became the only southern exit). The new paradigm permitted the following types of drainage system evidence to be explained:1) numerous barbed tributaries flowing to a northeast-oriented French Broad River segment, 2) a larger than required northeast-oriented French Broad River valley, 3) and diverging and converging valley complexes which are found throughout the northeast-oriented oriented French Broad River headwaters drainage basin. In addition, the map evidence could be interpreted to show: 1) headward erosion of the north- and northwest-oriented French Broad River valley captured southwest-oriented flow to the north-oriented Pigeon River valley which had captured flow to the northwest-oriented Little Tennessee River valley, 2) headward erosion of the south-oriented Broad River valley captured southwest-oriented flow to the northeast- and north-oriented French Broad River and the south-oriented Toxaway River and 3) and multiple gaps identify locations where southwest-oriented water entered and exited the present-day French Broad River headwaters drainage basin.

Keywords: Asheville Basin, barbed tributaries, Blue Ridge Escarpment, Eastern Continental Divide, Great Smoky Mountains

1. Introduction

1.1 Statement of the Problem

Most topographic map drainage system and erosional landform evidence is anomalous evidence which the accepted geology and glacial history paradigm cannot explain and which geologists usually ignore. Thomas Kuhn (1970) suggests scientific disciplines when faced with anomalous evidence can do one of three things. First, the accepted paradigm may eventually explain the anomalous evidence in which case the accepted paradigm survives without any interruption. Second, the anomalous evidence may be noted and set aside for future scientists to address, which in the case of the anomalous topographic map drainage system and erosional landform evidence is what has happened. Third, the anomalous evidence may lead to a new paradigm and to a battle over which paradigm should be used. According to Clausen (2023a) Missouri River drainage basin evidence as depicted on topographic maps was used to construct a new geology and glacial history paradigm (new paradigm) which explains most (if not all) of that topographic map drainage system and erosional landform evidence, but which is fundamentally different from the accepted geology and glacial history paradigm (accepted paradigm).

The new paradigm describes two linked North American (mid and late Cenozoic) continental ice sheets. The first ice sheet was thick and created and occupied a deep "hole" in the North American continent. The deep "hole" was created as the ice sheet eroded underlying bedrock and as ice sheet weight caused underlying regions to subside and surrounding regions including mountain ranges to be uplifted while prolonged meltwater floods first flowed across a developing deep "hole" rim (see Figure 1 for the deep "hole" rim location) and were subsequently diverted by deep "hole" rim uplift to flow toward what became the deep "hole's" only remaining southern outlet (the Mississippi River valley). Ice sheet decay eventually opened up deep "hole" space the ice sheet had once occupied which enabled north-oriented valleys to erode headward across immense ice sheet marginal meltwater floods and to divert floodwaters into newly opened-up deep "hole" space and then across the deep "hole" floor.

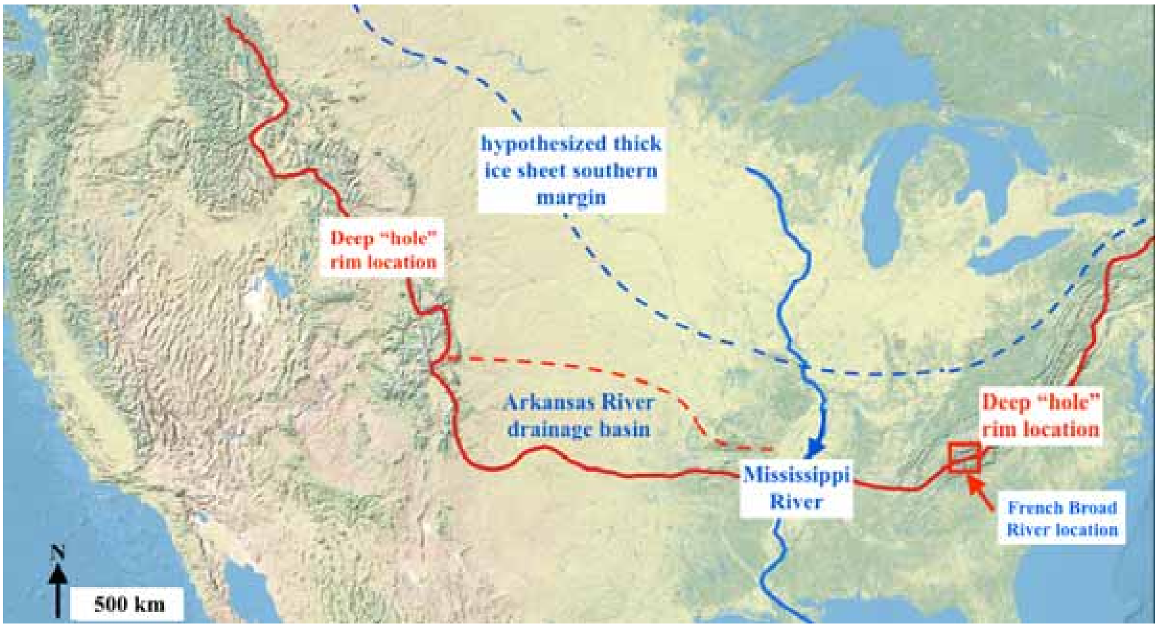

Figure 1. Modified map from the United States Geological Survey (USGS) National Map website showing the French Broad River study area location in relation to the deep "hole" rim and the hypothesized thick ice sheet southern margin

At first ice sheet marginal meltwater and other drainage which had been diverted into newly opened-up deep "hole" space flowed through ice-walled (and eventually bedrock-floored) canyons to reach southern exits and eventually reached the Mississippi River valley, but as ice sheet decay progressed new and shorter ice-walled canyon routes across the deep "hole" floor to northern oceans opened up. Diversion of meltwater floods and other drainage from the Gulf of Mexico to northern oceans ended climatic conditions responsible for the thick ice sheet's decay and created much colder climatic conditions. The colder climates caused the north-oriented drainage to freeze around thick ice sheet remnants so as to create a second and much thinner continental ice sheet (glaciation in what were at that time newly uplifted mountain ranges probably occurred at this time). The second ice sheet did not produce immense and prolonged meltwater floods (as the first ice sheet had done) and did not significantly alter the underlying deep "hole" floor, although it blocked the newly formed north-oriented drainage routes which led to the development of the ice sheet marginal Missouri and Ohio River routes.

The study reported here sought to determine whether the new paradigm perspective provides explanations for previously unexplained detailed topographic map drainage system and erosional landform evidence in the North Carolina French Broad River drainage basin (upstream from Asheville). The study region was chosen because it is located along the deep "hole" rim and along what is today the Eastern Continental Divide (see Figure 1). Clausen (2023a) includes a list of more than 40 published papers in which the new paradigm perspective was used to explain considerable topographic map drainage system and erosional landform evidence in various geographic regions (similar in size to the region studied here). However, most of those previously published studies dealt with regions west of the Mississippi River and the new paradigm's ability to explain eastern North American drainage system and erosional landform evidence (as depicted on topographic maps) has not been adequately demonstrated.

1.2 Geographic Setting

The French Broad River originates near Rosman, North Carolina where its south-oriented North Fork and its southeast-oriented West Fork meet and then are joined a short distance downstream by its northwest- and north-oriented Middle Fork and its northwest-oriented East Fork. Once formed the French Broad River meanders in a northeast direction before turning in a north direction to reach Asheville. From Asheville the river continues in a north and northwest direction through a deep valley which cuts across the Great Smoky Mountains and enters Tennessee where the river turns in a southwest and eventually west direction to join the southwest-oriented Holston River so as to form the southwest-oriented Tennessee River (see Figure 2). The Tennessee River eventually turns in a north direction to reach the west-oriented Ohio River which in turn flows to the south-oriented Mississippi River. Immediately to the south and west of the French Broad River headwaters are south-oriented Toxaway River headwaters which flow to the south-southeast oriented Savannah River, which in turn flows to the Atlantic Ocean. Immediately to the north of the Toxaway River headwaters are Little Tennessee River headwaters which flow in a generally northwest direction across the Great Smoky Mountains to join the southwest-oriented Tennessee River.

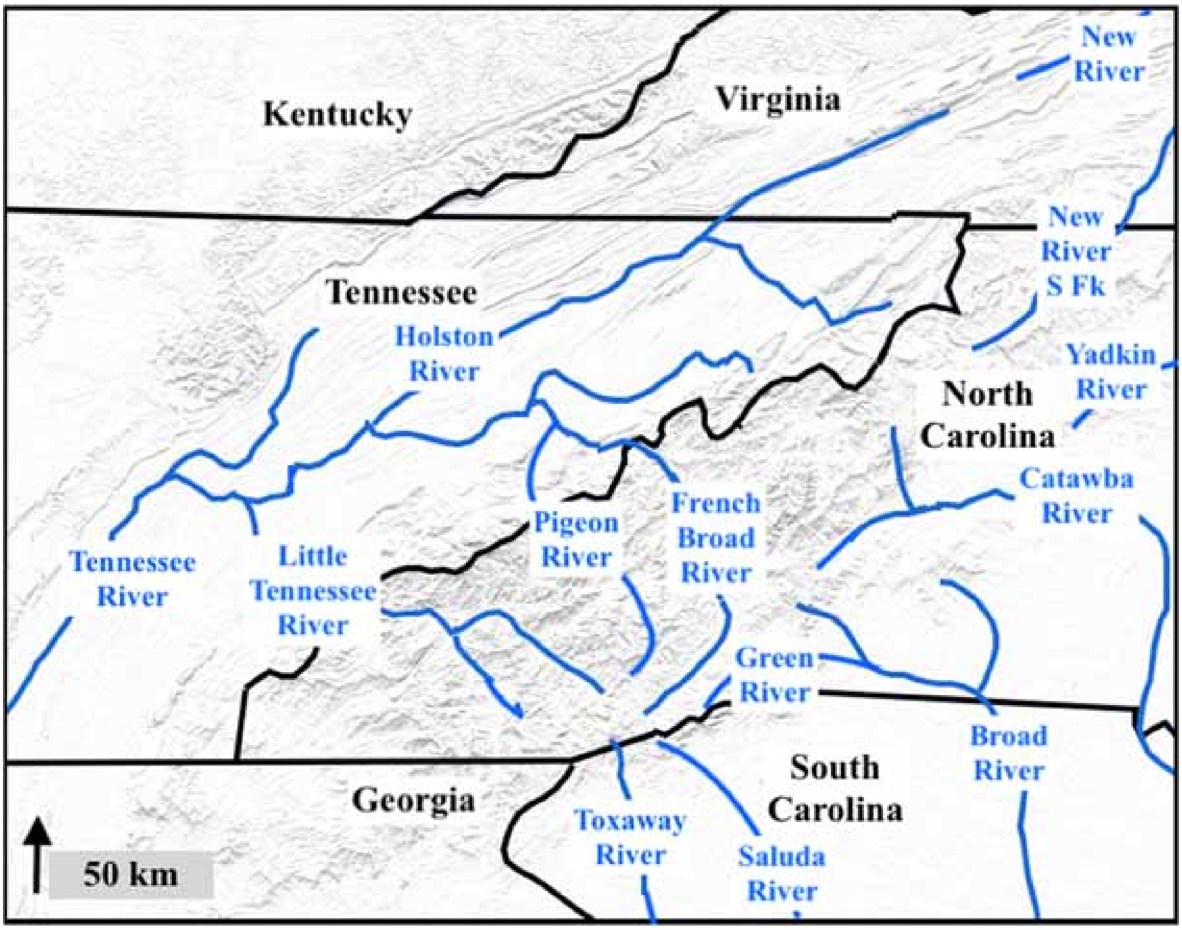

Figure 2. Modified map from the USGS National Map website showing the French Broad River location in relation to surrounding rivers. The Saluda, Broad, and Catawba Rivers all are in the Santee River drainage basin while the Toxaway River flows to the Savannah Rive

The Blue Ridge Escarpment crest which in this region is also the Eastern Continental Divide (the Gulf of Mexico-Atlantic Ocean drainage divide) is located to the south and east of the northeast-oriented French Broad River headwaters. Drainage to the southeast of the northeast-oriented French Broad River headwaters is to the south- and southeast-oriented Saluda River and to the northeast- and southeast-oriented Green River both of which eventually join the south-southeast oriented Broad River which in turn flows to the Santee River. To the northeast of the northeast-oriented French Broad River segment and across the escarpment crest are northeast-oriented Catawba River headwaters which eventually turn in a south and south-southeast direction to join the Broad River and other drainage to form the southeast-oriented Santee River, which flows to the Atlantic Ocean. To the northeast of the northeast-oriented Catawba River headwaters are northeast-oriented New River headwaters which eventually turn in a northwest direction to reach the Ohio River and northeast-oriented Yadkin River headwaters which eventually turn in a southeast and south direction to reach the Atlantic Ocean. The northeast-oriented French Broad River and some New River headwaters flow roughly parallel to and nearly adjacent to the Eastern Continental Divide before turning to flow in northwest directions so as to eventually reach the Gulf of Mexico while some northeast-oriented Saluda, Green, Catawba and Yadkin River headwaters flow roughly parallel and adjacent to the Eastern Continental Divide before turning to flow in south and southeast directions to reach the Atlantic Ocean.

1.3 Accepted Paradigm Literature

Accepted paradigm literature addressing western North Carolina geomorphology generally focuses on still unresolved problems related to the Blue Ridge Escarpment and present-day Appalachian Mountains elevations. Probably the first to tackle the Blue Ridge Escarpment origin question were Hayes and Campbell (1894) who suggested the Blue Ridge Escarpment was a monoclinal flexure. Fenneman (1938, p. 140) reports Campbell later changed his mind, and in a letter attributed the escarpment to faulting. Davis (1903) considered the escarpment to be the stream divide between two peneplains which were drained in different directions with the east-draining peneplain having a shorter route to the ocean than the west-draining peneplain. The Davis interpretation may have been based on the same selective use of evidence as his (1889) interpretation of the Doylestown topographic map on which Clausen (2023b) claims Davis ignored almost all of that map's drainage system and erosional landform evidence.

White (1950, p 1312) objected to the Davis theory, which by 1950 had been at least partially supported by Douglas Johnson (1906), Wright (1928, 1931) and several other investigators, and stated "Actually–far from being a peneplain adjusted to sea level–the Asheville surface is rapidly being dissected by the young west-flowing streams which are pushing gorges eastward from the western scarp of the Blue Ridge Upland where it rises above the Appalachian Valley of the Tennessee. Witness, for instance the gorges of the Hiwasse, the Little Tennessee, the Pigeon, the French Broad, the Nolichucky, the Watauga, and the Toe. On the other hand, the east-flowing streams of the Piedmont show no such rejuvenation except above the line where they enter the Blue Ridge Scarp. This would suggest that the west-flowing streams have undergone an uplift which has not affected the east-flowing streams."

Thornbury (1965, p 107) summarizes the Wright's (1931) interpretation that the Asheville Basin floor was correlative with the Great Valley erosion surface to the west (where the southwest-oriented Tennessee River is located) by saying "The floor of the Asheville Basin is characteristically between 2300 and 2400 feet [700-740 meters] in altitude, and the French Broad River leaves it at an altitude of 2100 feet [640 meters] and flows westward through a gorge to enter the Great Valley at an altitude of 1200 feet [365 meters]. Wright thought that not only did the hard rock barrier account for the difference in altitude of the Harrisburg erosion surface in the two areas, but it also explained why the Harrisburg surface had been so well preserved in the Asheville Basin since uplift." Thornbury notes that about 20 miles [32 kilometers] southeast of Asheville at Hendersonville there is a slightly higher erosion surface with an elevation of about 2400 feet [730 meters].

In spite of White's observations, the commonly favored hypothesis appears to be that erosion is moving the Blue Ridge Escarpment inland (and usually ignores how the escarpment formed). Stokes et al (2023) who investigated erosion rates at sites along the escarpment note that "for over a century, researchers have interpreted asymmetric slopes across the Blue Ridge Escarpment as evidence that it is moving inland" and they include Hack (1982), Spotila & Prince (2022) and other investigators who have supported that interpretation. They further report that others, including Prince et al (2010, 2011) and B. Johnson (2020) have found and described evidence in the form of "barbed tributaries, sinuous drainage divides, knickzones, ... and the presence of relict deposits of rounded cobbles near the crest of the escarpment" which has been interpreted to mean stream and river captures have played an important role in the Blue Ridge Escarpment's inland movement. In addition, several researchers including Matmon et al (2003), Gallen et al (2013), Mckeon et al (2014), Liu (2014) and others have tried to explain how the southern Appalachian Mountains, which are interpreted to have developed during Paleozoic time, have maintained their elevations.

1.4 New Paradigm Literature

Clausen (2022a) demonstrated that topographic map drainage system and erosional landform evidence in the Pennsylvania, Maryland, and West Virginia Monongahela River drainage basin area can be explained if the Monongahela River drainage system developed during immense and prolonged southwest-oriented floods of what was probably continental ice sheet meltwater. The floodwaters initially flowed in a southwest direction toward the now northeast-oriented New River headwaters and then probably into the southwest-oriented

Tennessee River headwaters area. Deep "hole" rim uplift that must have occurred as floodwaters flowed across the region enabled north-oriented valleys to erode headward from the continental ice sheet location to capture the large and prolonged southwest-oriented meltwater floods. Clausen (2022b) explained what was previously unexplained northern Alabama topographic map evidence by using large and probably prolonged southwest-oriented floods which had flowed across the present-day Tennessee River-Gulf of Mexico drainage divide prior to the development of what is now the much longer Tennessee River northwest- and north-oriented route that reaches the Ohio and then Mississippi Rivers. Both papers were written from the new paradigm perspective and imply that large southwest-oriented floods flowed through the Great Valley which is located where the French Broad River now joins the southwest-oriented Holston River.

2. Research Method

This study sought to determine if new paradigm predictions could explain previously unexplained topographic map drainage system and erosional landform evidence in the French Broad River drainage basin (upstream from the Asheville, North Carolina area). The investigation used United States Geological Survey (USGS) detailed topographic maps available at the USGS National Map website. One new paradigm prediction (pertinent to the study region) is that uplift of the rim of a deep "hole" in which a thick continental ice sheet was located produced what is now the Eastern Continental Divide while immense and prolonged southwest oriented floods flowed across the region. Another new paradigm prediction is that in the region to the southeast of the rising deep "hole" rim the headward erosion of southeast-oriented valleys systematically captured the southwest-oriented floodwaters (in sequence from the southwest to the northeast) and diverted the flood flow more directly to the Atlantic Ocean. The new paradigm also predicts that in the region located between the rising deep "hole" rim and the thick continental ice sheet margin the headward erosion of northwest-oriented valleys from the developing deep "hole" systematically captured (in sequence from the southwest to the northeast) the southwest-oriented floodwaters and diverted the captured flood flow into deep "hole" space located between the rising deep "hole" rim and the ice sheet margin.

Two French Broad River drainage basin regions were selected for investigation. The first region was the northeast-oriented French Broad River headwaters drainage basin where the river is flowing near and roughly parallel to the nearby northeast-southwest oriented Eastern Continental Divide (Gulf of Mexico-Atlantic Ocean drainage divide) which is located along or near the Blue Ridge Escarpment crest. The investigation began by looking on detailed topographic maps for evidence of a drainage reversal in the form of barbed tributaries which join what is now the northeast-oriented French Broad River headwaters segment. Map evidence was next used to determine if the French Broad River or any of its tributaries were underfit rivers (rivers flowing in valleys too large to have been eroded by the rivers that now flow in them). Map study continued by searching for evidence of flood-formed anastomosing channel complexes (diverging and converging valleys) in what is now the northeast-oriented French Broad River headwaters drainage basin. Finally, the map study looked for evidence in the form of through valleys (valleys crossing drainage divides) and gaps that could have been used by southwest-oriented flood flow as the floodwaters entered what is now a northeast-oriented drainage basin and also as the southwest-oriented flood flow exited the present-day northeast-oriented drainage basin. The gap evidence was then used to construct a valley erosion sequence.

The second geographic region investigated was the French Broad River segment which is oriented in a north direction between the northeast-oriented French Broad River headwaters segment and the city of Asheville. The second region study began by looking for evidence in the form of tributary stream orientations to support the new paradigm prediction that the valley of this north-oriented French Broad River segment had been eroded headward across diverging and converging southwest-oriented flood flow channels. If so, the maps should show tributaries from the east are predominantly barbed and have southwest orientations while tributaries from the west should be explainable as having been formed by reversals of flow in beheaded flood flow channels and should be predominantly oriented in northeast and east directions. The study included a search for evidence in the form of through valleys and gaps eroded across drainage divides separating the French Broad River drainage basin from adjacent drainage basins which could be used to identify where southwest-oriented floodwaters had flowed prior to the headward erosion of what is now a north-oriented French Broad River valley segment. The observed map evidence was next used to interpret a valley erosion sequence.

3. Results

3.1 Northeast-oriented French Broad River Headwaters Segment

The investigation began by looking for barbed tributaries on detailed topographic maps of the French Broad River drainage basin's southernmost areas and then along what is today the northeast-oriented French Broad

River segment. According to Thornbury (1969) barbed "tributaries join the main stream in 'boathook bends' which point upstream. The tributaries are the result of stream piracy" which suggests that at least one of the drainage routes has reversed its flow direction. Figure 3 is a topographic map showing one of the southernmost points in the northeast-oriented French Broad River headwaters drainage basin and illustrates north-northeast-oriented South Flat Creek headwaters being joined by south-oriented Morton Creek (as a barbed tributary) suggesting that a flow reversal has taken place. North-oriented Flat Creek flows to the West Fork French Broad River a short distance upstream from where that southwest-oriented stream joins the south-oriented North Fork French Broad River (both as barbed tributaries) to form the northeast-oriented French Broad River headwaters. Note the absence of any barrier which would have prevented south-oriented floodwaters from flowing across what is now the Eastern Continental Divide from the northeast-oriented French Broad River drainage basin (in the Gulf of Mexico drainage area) into the south-oriented Toxaway River valley which drains along a much shorter route to more directly reach the Atlantic Ocean.

Continuing north from Figure 3 the northeast-oriented French Broad River headwaters segment between Rosman (where the various French Broad River forks converge to form the French Broad River) and Brevard was checked to determine tributary orientations. Figure 4 shows the French Broad River valley segment immediately upstream (southwest) from Brevard where nearly all of the longer tributaries from the west flow in southeast directions to join the French Broad River as barbed tributaries while most tributaries from the east flow in northwest directions, but are much shorter in length. Figure 4 also shows the French Broad River meandering as an underfit river on the floor of a large valley consisting a series of diverging and converging valleys not all of which the river flows through. Red numbers identify some of the more obvious dry valleys in this anastomosing valley complex. The barbed tributaries support the new paradigm prediction that a drainage reversal has occurred and the anastomosing valley complex suggests the valley contains diverging and converging southwest-oriented flood eroded channels which is also consistent with new paradigm predictions.

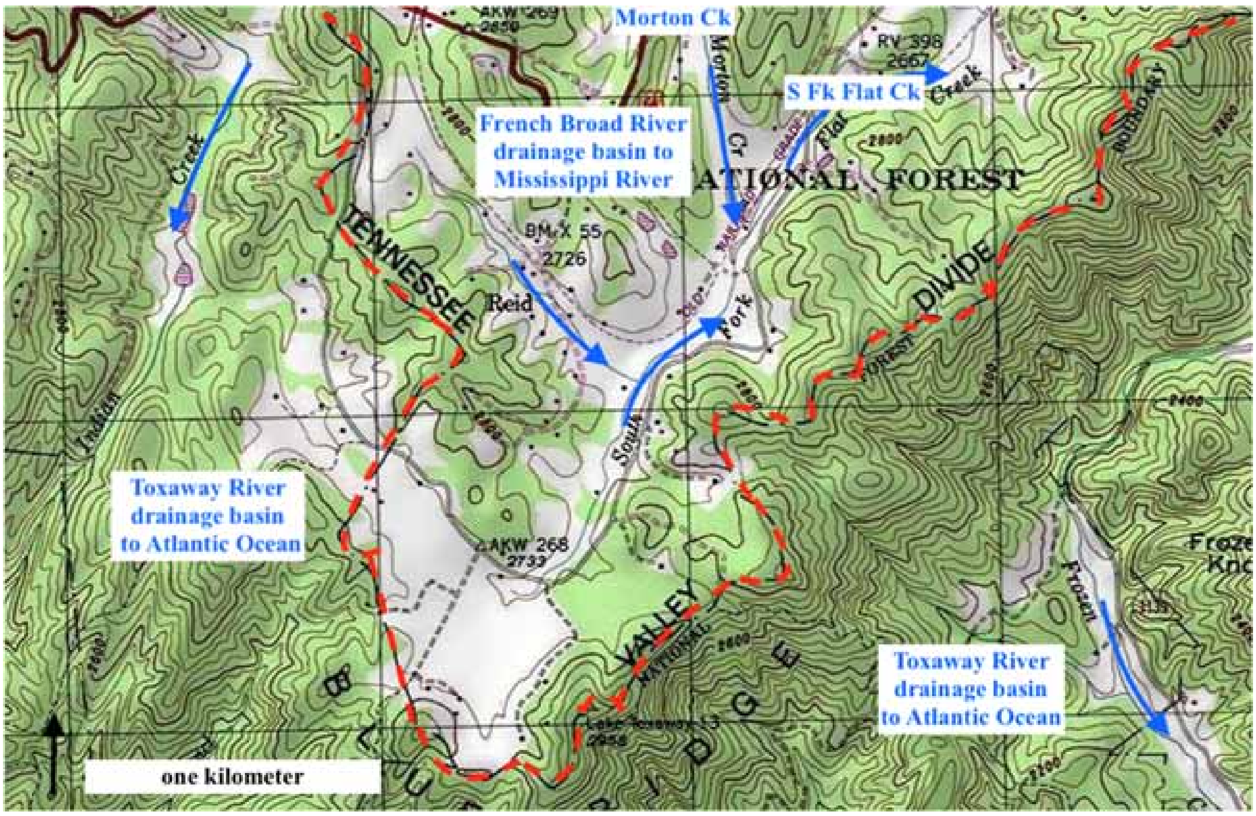

Figure 3. Modified map from USGS National Map website showing a point south of the French Broad River headwaters. Note south-oriented tributaries joining north-oriented South Fork Flat Creek which suggests a drainage reversal has occurred. Red dashed line shows the Eastern Continental Divide location. The contour interval is 40 feet (13 meters)

The northeast-oriented French Broad River headwaters valley extends for about 41 kilometers as the crow flies although the meandering river travels more than twice that distance as it flows from Rosman (where the various forks converge to form the northeast-oriented river) to where north-oriented Mud Creek joins the river and the

French Broad River valley then turns in more of a north direction. The river elevation at Rosman is approximately 665 meters and where Mud Creek joins it the river elevation is about 622 meters suggesting the northeast-oriented valley has a gradient of about one meter per kilometer and that the meandering river itself has a gradient of less than one half meter per kilometer. This low gradient suggests a very minor tectonic uplift of the drainage basin's southwest end could have easily caused the drainage reversal which the numerous barbed tributaries suggest has occurred.

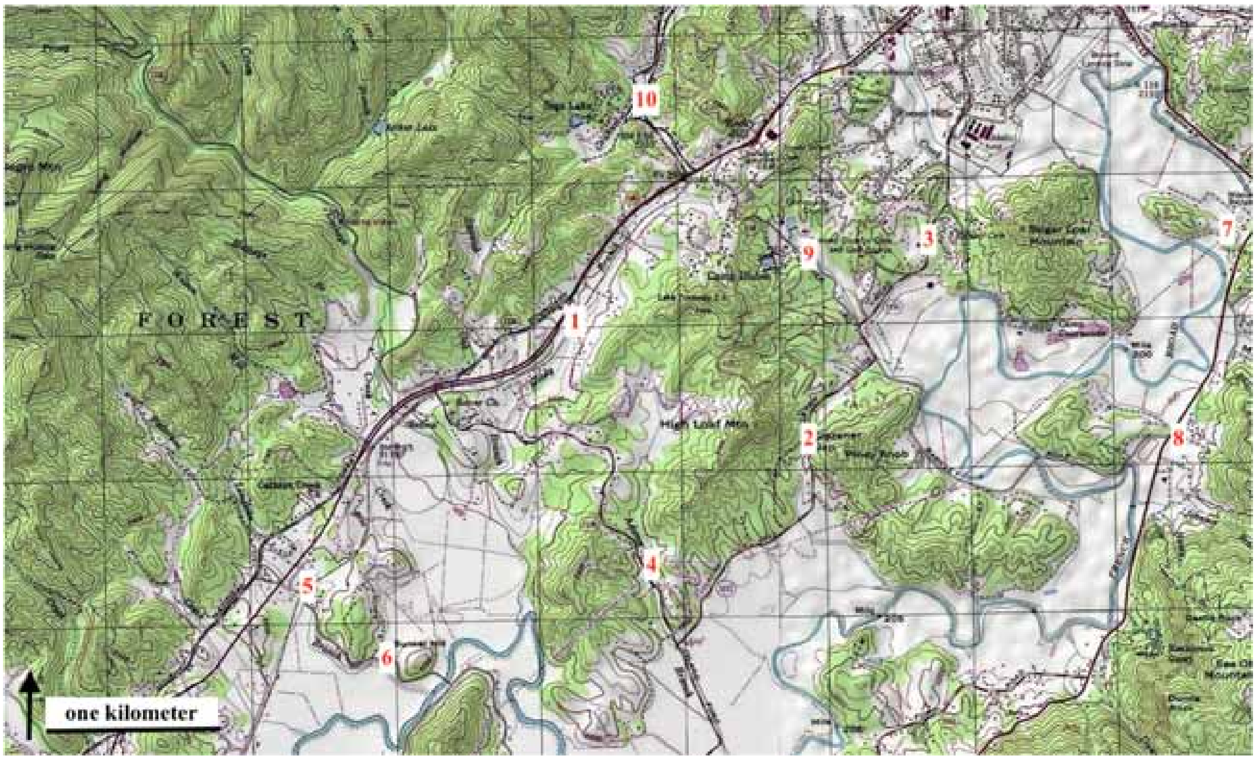

Figure 4. Modified topographic map from the USGS National Map website showing southeast-oriented barbed tributaries flowing to the northeast-oriented French Broad River. Note how the highway and railroad make use of a through (dry) valley. Red numbers identify valleys in the diverging and converging valley complex. The contour interval is 40 feet (13 meters)

The French Broad River's southeast-oriented West Fork and south-oriented North Fork meet to form the meandering northeast-oriented French Broad River as barbed tributaries, but the northwest- and north-oriented Middle Fork and the northwest-oriented East Fork join the French Broad River as normal tributaries. Gaps eroded across the Eastern Continental Divide link north-oriented tributaries flowing to the Middle Fork with south-oriented Toxaway River tributaries. Eastatoe Gap for example is more than 100 meters deep and can be explained if eroded by south-oriented water that flowed from what is now the northeast-oriented French Broad River valley along what is now the north-oriented Middle Fork alignment to reach to the much deeper Toxaway River valley. The northwest-oriented East Fork might also be considered a normal tributary as it joins the northeast-oriented French Broad River, however the East Fork drainage system valley network suggests the East Fork drainage system originated following a reversal of what was once a complex of south-oriented diverging and converging flood flow channels. Gaps present along the Eastern Continental Divide near the heads of north- and northwest-oriented East Fork headwaters and tributaries suggest south-oriented diverging and converging flood flow channels once crossed what is now the Eastern Continental Divide to reach Saluda River headwaters (located in the larger Broad River drainage basin).

Not seen, but east and southeast of Figure 4 is northwest-oriented Carson Creek, which joins the French Broad River just to the south of Figure 4, and which flows in a linear northwest trending through valley which to the southeast of the Carson Creek headwaters is drained by southeast- and east-oriented Little River, which near the Eastern Continental Divide turns in a north direction and joins the northeast-oriented French Broad River (see Figure 5). The through valley continues from the Little River turn in an east-northeast direction and is used by west-southwest oriented Duncan Creek which begins near the 100-meter-deep Green River Gap (along the

Eastern Continental Divide which leads to Green River headwaters). South of the Little River direction change is Walker Creek which at first flows in a south direction but before reaching the 70-meter-deep Jones Gap and Middle Saluda River headwaters makes a U-turn to flow in a north and northwest direction to join the Little River. The Little River and Carson, Duncan, and Walker Creek evidence supports an interpretation that southwest-oriented floods flowing in diverging and converging channels once crossed the region and the Eastern Continental Divide to reach what must have been actively eroding Green and Saluda River headwaters valleys.

Figure 5. Modified topographic map from USGS National Map website showing where the north-oriented Little River joins the northeast-oriented French Broad River and where west-oriented Crab Creek joins the Little River. The contour interval is 40 feet (13 meters)

Downstream (northeast) from Figure 4 topographic maps show the Figure 5 map area where north-oriented Little River joins the northeast-oriented French Broad River and Crab Creek flows in a west-southwest and west oriented valley to join the north-oriented Little River. East of Figure 5 the Crab Creek valley continues as a through valley in a northeast direction and is drained by northeast-oriented Mud Creek, which near Hendersonville is joined by southwest Clear Creek as a barbed tributary while Mud Creek turns to flow in a north-northwest direction to join the French Broad River. The through valley now containing southwest-oriented Clear Creek, northeast-Mud Creek headwaters, and west-southwest and west oriented Crab Creek is a continuous through valley now drained by different streams which must have originally been eroded by water flowing between the French Broad River valley and the Eastern Continental Divide. The through valley provides evidence that diverging and converging flood flow channels once crossed what is now the French Broad River headwaters drainage basin.

Following Clear Creek headward in a northeast direction leads to several unnamed notches (or gaps) in the Eastern Continental Divide which suggest southwest-oriented water flowing across what is now the south-oriented Broad River headwaters area once continued to flow into and then across the present-day French Broad River headwaters drainage basin. Headward erosion of the south-oriented Broad River-Hickory Creek valley appears to have captured the southwest-oriented flow. The southwest-oriented water must have once flowed into the anastomosing complex of channels in the northeast-oriented French Broad River headwaters drainage basin and then flowed to what are today Green and Saluda River headwaters areas and probably also to the Toxaway River drainage basin, which suggests headward erosion of the Toxaway River valley occurred prior to the Broad River headwaters valley headward erosion.

In summary, topographic maps of the northeast-oriented French Broad River headwaters drainage basin show numerous south- and southeast-oriented tributaries flowing to what is now a low gradient and underfit northeast-oriented river which strongly suggests large and prolonged volumes of southwest-oriented water once crossed the region as the new paradigm predicts. As predicted gaps and low areas found along the Eastern Continental Divide were identified and show where southwest-oriented flood flow entered and exited the present-day northeast-oriented French Broad River headwaters drainage basin. Also, as the new paradigm predicts topographic maps show evidence for large floods in the form of diverging and converging valley networks both in the wide northeast-oriented French Broad River valley and in the much larger French Broad River headwaters drainage basin. Finally, the topographic map study found evidence that may support the new paradigm prediction that valleys eroded headward from the Atlantic Ocean in a sequence from the southwest to the northeast.

3.2 North-oriented French Broad River Segment Upstream from Asheville

The study next investigated detailed topographic maps of regions draining to the north-oriented French Broad River segment which is located upstream (south) from Asheville (and downstream or north from the Mud Creek confluence). The new paradigm predicts the north-oriented French Broad River valley eroded headward across massive and prolonged southwest-oriented floods. If so, topographic maps should show southwest-oriented barbed tributaries joining the north-oriented French Broad River from the east. Proceeding northward from the Mud Creek confluence the first major tributary shown is southwest-oriented Cane Creek which joins the French Broad River as a barbed tributary and which flows in what may be a northeast extension of the northeast-oriented French Broad River valley. Following Cane Creek headward in a northeast direction leads to Cane Creek Gap seen in Figure 6. Cane Creek Gap is 170-meters deep and is eroded across the Eastern Continental Divide, which suggests headward erosion of what are now south-oriented Broad River headwaters valleys captured a large southwest oriented stream of water that had been flowing across what is now the northeast-oriented French Broad River headwaters drainage basin. As seen in Figure 6, prior to headward erosion of the valleys of the south-oriented Broad River and its south-oriented Flat Creek tributary, the southwest-oriented water flowed from what is today the east-oriented Catawba River headwaters area.

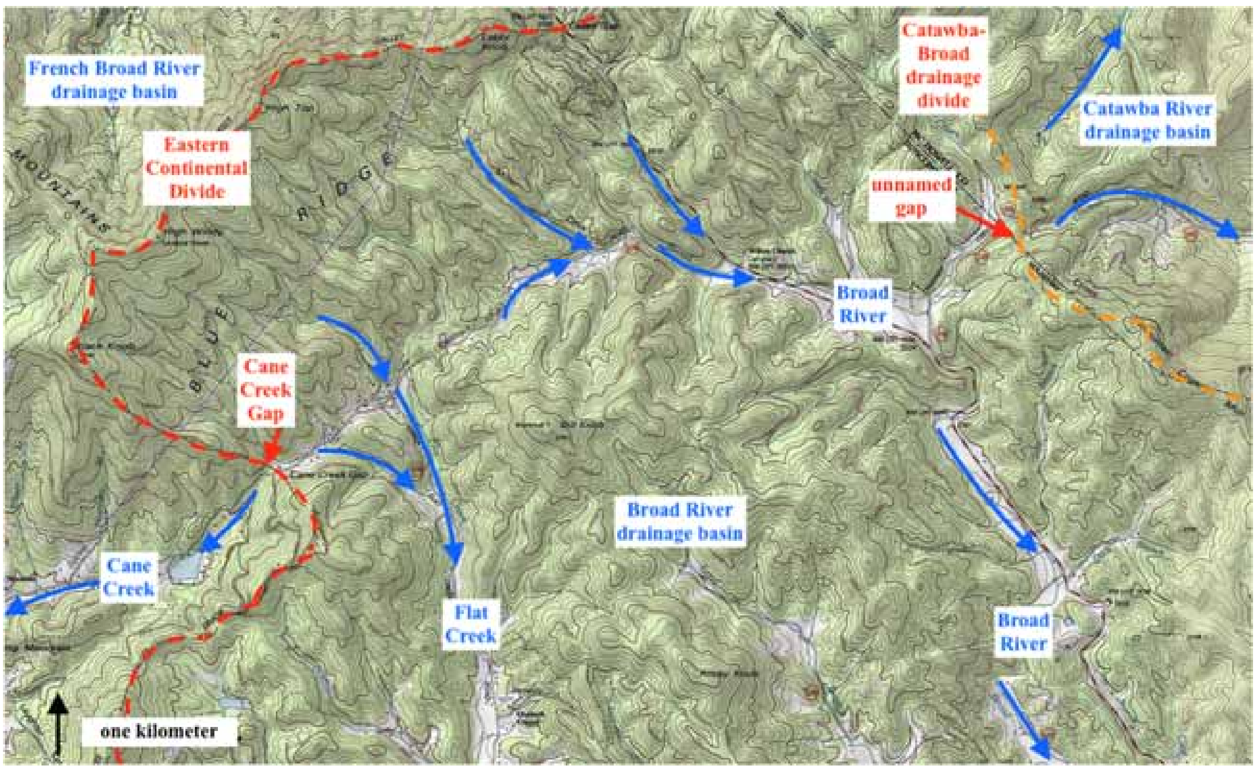

Figure 6. Modified topographic map from USGS National Map website showing Cane Creek Gap area along the Eastern Continental Divide and the gaps and valleys used by water flowing from the Catawaba River drainage basin across today's Broad River headwaters area to enter the French Broad River drainage basin. The contour interval is 40 feet (13 meters)

Following gaps and present-day valleys and drainage routes in an east-northeast direction from Figure 6 suggests the southwest-oriented water that eroded Cane Creek gap once flowed along a route that can be traced headward in a northeast direction across the present-day south-oriented Broad River headwaters and along northeast-oriented Catawba River headwaters valleys and finally along northeast-oriented Yadkin River headwaters valleys. The southwest-oriented stream of water that eroded Cane Creek Gap appears to have been first captured by Toxaway River valley headward erosion (from the Atlantic Ocean) and to have been next beheaded and reversed by French Broad River valley headward erosion (from the deep "hole") before being captured by headward erosion of Broad River headwaters valleys (from the Atlantic Ocean). Catawba River valley headward erosion (from the Atlantic Ocean) next appears to have beheaded and reversed the southwest-oriented stream of water which was subsequentially beheaded and reversed by headward erosion of the Yadkin River valley (also from the Atlantic Ocean). If correctly interpreted this sequence confirms the new paradigm prediction that valleys leading to the Atlantic Ocean eroded headward in sequence from the southwest to the northeast.

The next long west-oriented French Broad River tributary to the north of Cane Creek is the west-southwest oriented Swannanoa River, which joins the north-oriented French Broad River at Asheville. The Swannanoa River does not flow in a straight west-southwest line even through an abandoned valley indicates significant volumes of water must have once flowed in a much straighter west-southwest direction. The present-day Swannanoa River route and the abandoned valley seen in Figure 7 can be explained if large floods of west-southwest oriented water eroded a complex of diverging and converging channels into what is now the west-southwest oriented Swannanoa River drainage basin. Much of that water probably had first moved across what are today the Yadkin and Catawba River headwaters areas and flowed through Swannanoa Gap which is seen in Figure 8 and which is located slightly to the east of the Figure 7 along the Eastern Continental Divide (and to the north of Cane Creek Gap).

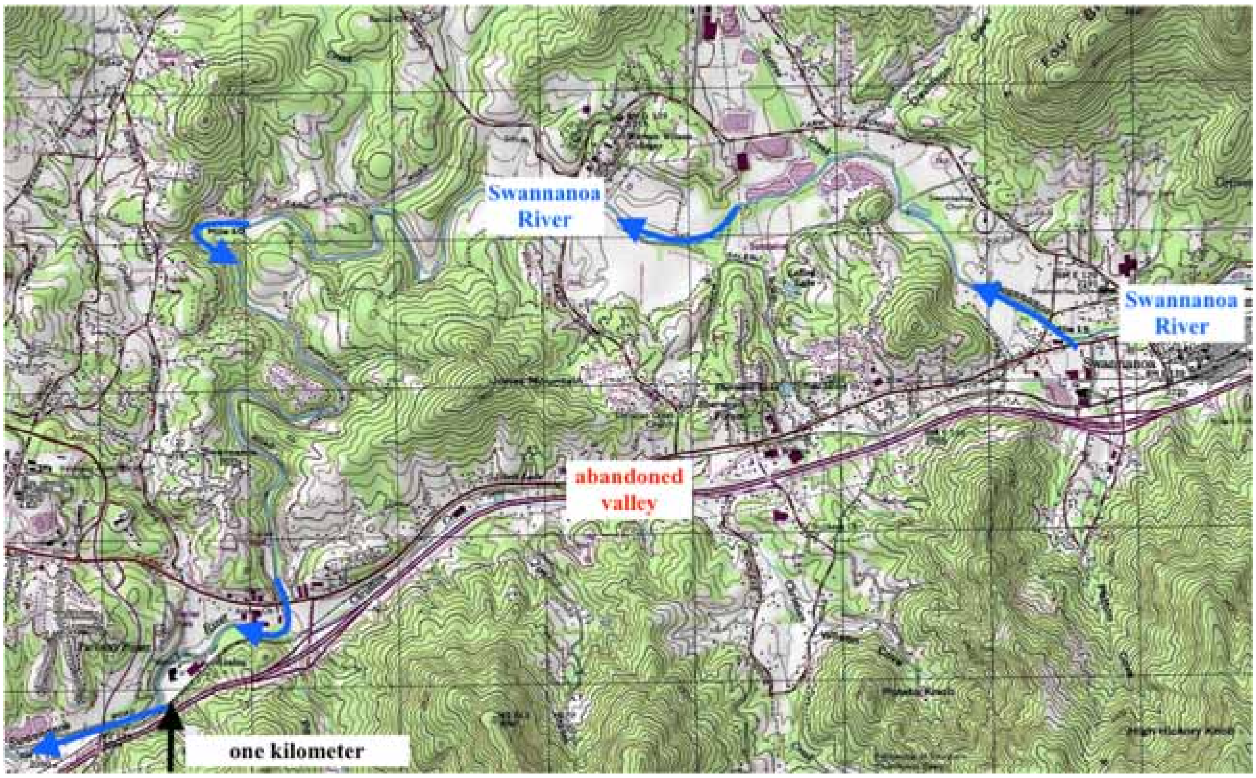

Figure 7. Modified topographic map from the USGS National Map website showing the present-day Swannanoa River route and a much straighter abandoned valley which suggest erosion by diverging and converging flood flow channels. The contour interval is 40 feet (13 meters)

The Swannanoa Gap floor elevation is 810 meters compared to the 892-meter elevation of the Cane Creek Gap floor to the south (some unnamed gaps at the head of Clear Creek which are located still further to the south have floor elevations slightly lower than 800 meters). As previously stated, headward erosion of Broad River headwaters valleys captured the southwest-oriented flow which had eroded the higher elevation Cane Creek Gap (and water that eroded the lower elevation unnamed gaps at the head of Clear Creek), but did not erode far enough north to capture west-oriented flow moving through Swannanoa Gap. Flow through Swannanoa Gap ended when headward erosion of the south-oriented Catawba River valley beheaded and reversed the west-southwest oriented flow to create what are today northeast-oriented Catawba River headwaters and to end the flood flow across what is today the Asheville Basin.

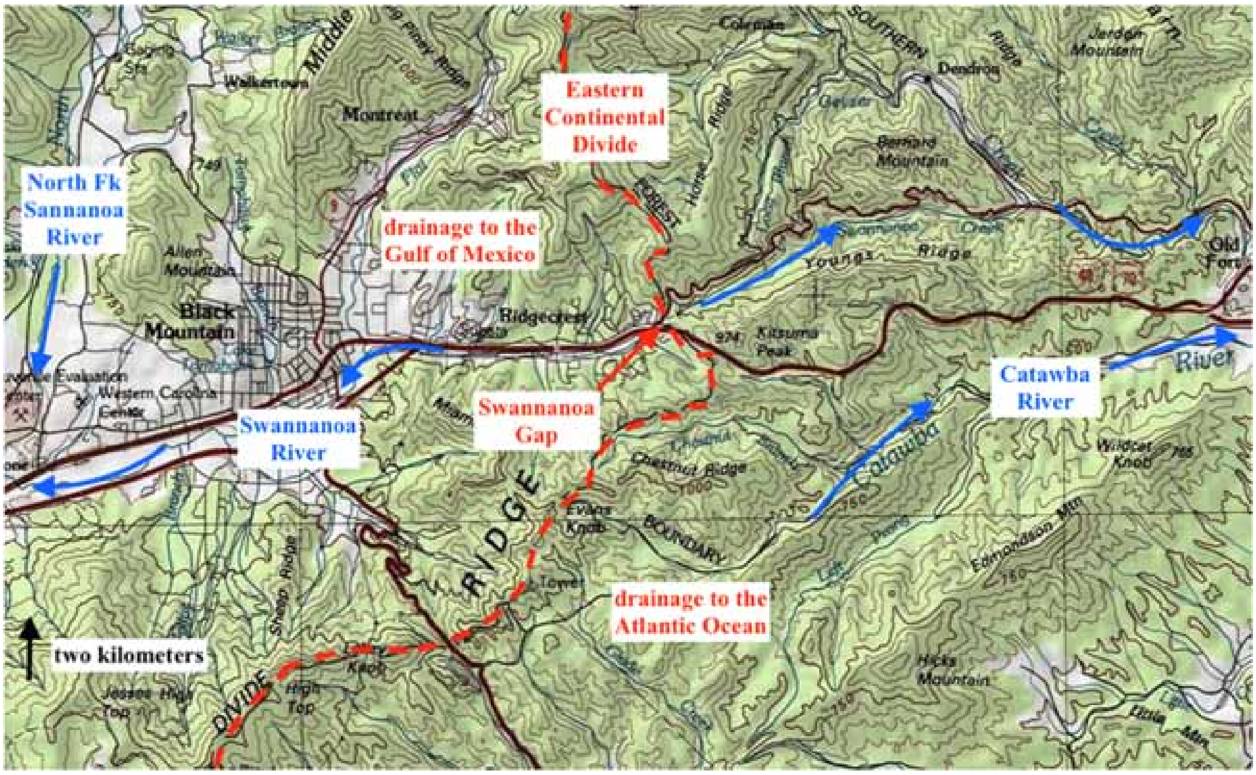

Figure 8. Modified topographic map from the USGS National Map website showing how Swannanoa Gap links west-southwest oriented Swannanoa River drainage with east-northeast oriented Catawba River drainage. The contour interval is 50 meters

Today the west-southwest oriented Swannanoa River joins the north-oriented French Broad River at Asheville as a barbed tributary. Also joining the French Broad River at Asheville (almost directly across from the west-southwest-oriented Swannanoa River) is east-oriented Hominy Creek. Like the Swannanoa River the Hominy Creek valley in the Asheville area is not a straight line. However, further to the west (upstream) Hominy Creek flows in an almost a straight east-oriented valley that has been eroded across a high mountain ridge that in places stands hundreds of meters above the Hominy Creek valley floor (see Figure 9). East-oriented Hominy Creek drainage begins in a through valley less than a kilometer from the north-oriented Pigeon River at Canton, although that east-oriented Hominy Creek drainage is joined about two kilometers to the east of the Pigeon River by southwest-oriented North Hominy Creek as a barbed tributary. Southwest-oriented North Hominy Creek flows in a well-defined almost linear through valley which further to the northeast is drained by northeast-oriented Newfound Creek which joins the north-oriented French Broad River about ten kilometers to the north of Asheville.

The east-oriented Hominy Creek valley can be traced in a westward direction from Canton along two or more different diverging valley routes across the north-oriented Pigeon River drainage basin and into the Little Tennessee River drainage basin. As seen in Figure 2 the Pigeon River is a French Broad River tributary which like French Broad River has eroded a deep north-oriented valley across the Great Smoky Mountains. The northwest-oriented Little Tennessee River which is located to the west and southwest of the Pigeon River has likewise eroded a deep valley across the Great Smoky Mountains. The Hominy and North Hominy Creek valley orientations seen in Figure 9 can be explained if before Pigeon River and French Broad River valley headward erosion a large west-oriented stream of water flowing on what is now the east-oriented Hominy Creek alignment converged near the present-day Canton location with a large southwest stream of water flowing along what is now the northeast-oriented Newfound Creek and southwest-oriented North Hominy Creek alignment. The water then flowed in west and southwest directions along diverging routes into what at the time was an actively eroding northwest-oriented Little Tennessee River drainage basin.

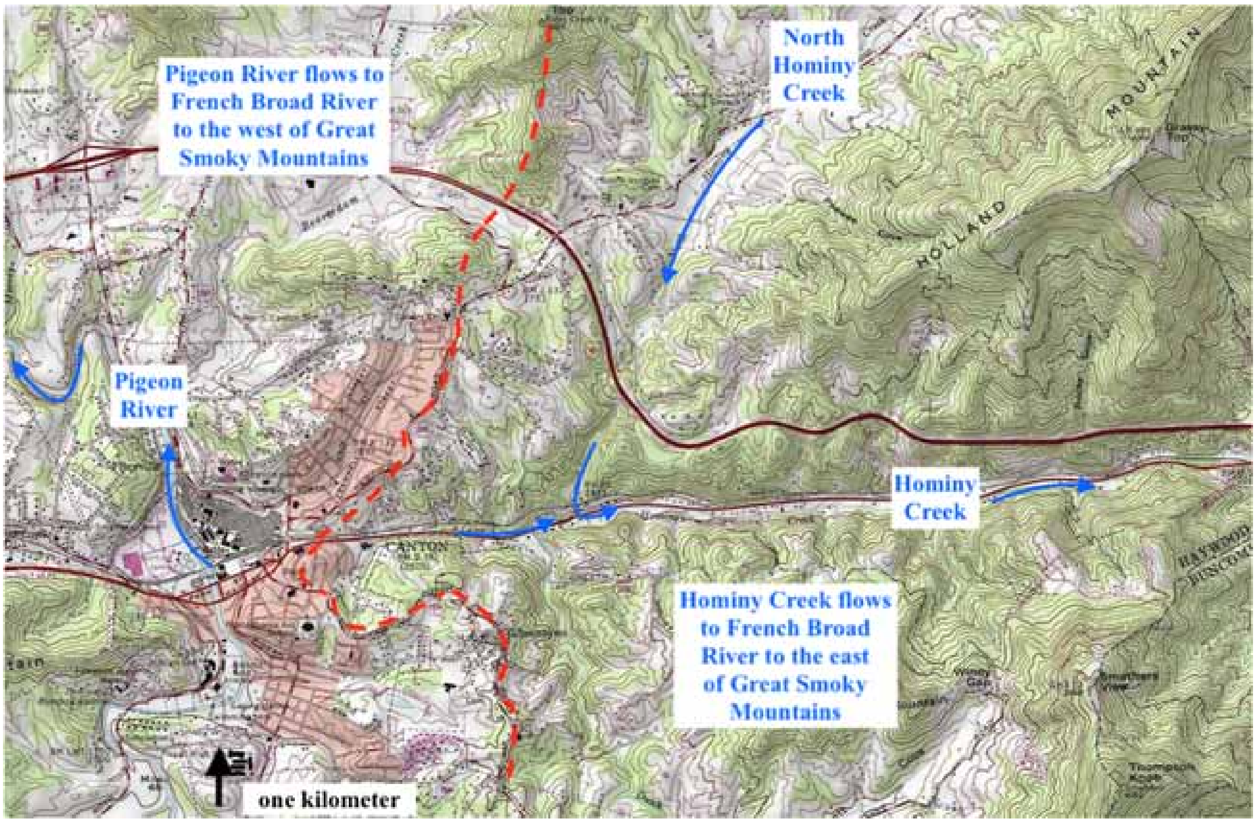

Figure 9. Modified topographic map from the USGS National Map website showing Hominy Creek and the French Broad River-Pigeon River drainage divide (red dashed line) near Canton, North Carolina. The contour interval is 40 feet (13 meters)

Such an explanation requires headward erosion of the northwest-oriented Little Tennessee River valley to have captured the west-and southwest-oriented flow first and headward erosion of the north-oriented Pigeon River valley to have captured the west- and southwest-oriented flow second which would have ended the west- and southwest-oriented flow to the Little Tennessee River drainage basin. Headward erosion of the north- and northwest-oriented French Broad River valley would have next beheaded and reversed southwest-oriented flow on the Newfound-North Hominy Creek alignment to create the Newfound and North Hominy Creek drainage divide and northeast-oriented Newfound Creek. French Broad River valley headward erosion then continued in a southward direction and beheaded and reversed flood flow along the Swannanoa River-Hominy Creek alignment to create east-oriented Hominy Creek. Finally headward erosion of the southeast-oriented Catawba River valley beheaded and reversed the flow to create the Catawba River-French Broad River drainage divide and the northeast-oriented Catawba River headwaters and the southwest-oriented Swannanoa River.

In summary, topographic map study determined the northeast-oriented French Broad River alignment could be explained if headward erosion of the north-oriented French Broad River beheaded and reversed a southwest-oriented flood flow channel so as to create the northeast-oriented French Broad River headwaters and to capture southwest-oriented flood flow on the Cane Creek alignment. Headward erosion of the south-oriented Broad River valley next beheaded the southwest-oriented flow which had been moving through Cane Creek Gap and then along the Cane Creek alignment. Prior to that capture headward erosion of the north-oriented French Broad River valley had beheaded and reversed a west-oriented flood flow channel on the Swannanoa River alignment to create east-oriented Hominy Creek. The North Hominy Creek valley southwest orientation could be explained if headward erosion of the north-oriented French Broad River valley prior to beheading and reversing flow on the Hominy Creek alignment beheaded and reversed a southwest-oriented flood flow channel so as to create northeast-oriented Newfound Creek. Further, topographic map evidence could be explained if Pigeon River valley headward erosion captured west-oriented flood flow to the Little Tennessee River drainage basin before north-oriented French Broad River valley headward erosion captured west-oriented flood flow which had been moving to the Pigeon River valley.

4. Discussion

Drainage system and erosional landform features as depicted on detailed topographic maps are like pieces in a gigantic picture puzzle. When viewed from the proper perspective a meaningful picture emerges and the puzzle has a solution, although when viewed from any other perspective no intelligible picture emerges and researchers grope in the dark looking for a solution that does not exist. The perspective (or paradigm) used determines the questions researchers ask which in turn determines the answers those researchers will discover. For more than century researchers have looked for evidence that the western North Carolina Appalachian Mountains are old and that the Blue Ridge Escarpment is retreating inland and at best have obtained unconvincing results. At the same time those questions have caused researchers to almost completely ignore the well-mapped topographic map drainage system and erosional landform evidence.

The new paradigm as illustrated here asks researchers to look for evidence of immense and prolonged southwest-oriented floods which flowed across a rising mountain region. Such evidence is found on detailed topographic maps in the form of barbed tributaries flowing to what is today the northeast-oriented French Broad River segment which flows in a much larger valley than the river needs. Further the maps show evidence of large floods in the form of diverging and converging valley complexes and of gaps identifying where southwest-oriented floodwaters entered and exited the present-day northeast-oriented French Broad River headwaters drainage basin. In addition, topographic map evidence can be used to determine how headward erosion of southeast-oriented valleys into what must have been a rising mountain region (in sequence from the southwest to the northeast) diverted southwest-oriented floodwaters more directly to the Atlantic Ocean while the headward erosion of north- and northwest-oriented valleys into the rising mountains diverted floodwaters into deep “hole” space and eventually toward deep “hole” southern exits. By causing researchers to ask the right questions the new paradigm points toward easily observed, but previously unexplained topographic map evidence.

Once explained the topographic map drainage system and erosional landform evidence raises additional questions which further map study may be able to help answer. For example, the Hominy Creek valley seen in Figure 9 may be as much as 300 meters deep and suggests floodwaters initially flowed on a surface that was at least 300 meters higher than the Hominy Creek valley floor today (although at a time the entire region may have had a much lower elevation than today). If so, floodwaters must have removed tremendous amounts of material from the rising Great Smoky Mountain region and the removal of such large amounts of material may have contributed to the mountain uplift. Probably lesser amounts of material were removed from the lower elevation regions to the east of the Blue Ridge Escarpment, which suggests meltwater flood erosion of the rising deep “hole” rim may have caused additional deep “hole” rim uplift and may have further shaped Blue Ridge Escarpment and Great Smoky Mountains region development. Further research is needed to better address this possibility.

Based on the results the Blue Ridge Escarpment is not moving inland as is commonly reported, but was instead formed and eroded during immense and prolonged continental ice sheet meltwater floods as ice sheet weight caused crustal uplift of surrounding regions so as to create the rim of a deep “hole” within which the ice sheet was located. If so, Blue Ridge Escarpment features have not changed significantly since meltwater floods and the ice sheet caused regional uplift ended. In other words, the barbed tributaries, the valley orientations and widths, the dry valleys and gaps eroded across the Eastern Continental Divide and other drainage divides, the diverging and converging valley complexes, and even the Blue Ridge Escarpment itself record the landscape as it existed when headward erosion of south and southeast-oriented valleys from the Atlantic Ocean and north- and northwest-oriented valleys from the deep “hole” captured the large and long-lived southwest-oriented meltwater floods which aided by ice sheet caused deep “hole” rim uplift had been shaping the Blue Ridge Escarpment features.

While the study reported here has explained considerable topographic map drainage system and erosional landform evidence only a small fraction of the western North Carolina and adjacent region unexplained topographic map drainage system and erosional landform evidence has been addressed. In the case of the French Broad River drainage basin only the area upstream from Asheville has been studied. Additional studies are needed to determine if other western North Carolina and adjacent region topographic map drainage system and erosional landform evidence also supports the results obtained here. Detailed topographic maps at the USGS

National Map website still represent an almost blank slate of well-mapped drainage system and erosional landform evidence silently waiting to be analyzed and explained.

5. Conclusions

Detailed topographic map drainage system and erosional landform evidence in the western North Carolina French Broad River drainage basin area (upstream from Asheville) tells a meaningful drainage history. Barbed tributaries flowing to a much larger valley than the present-day northeast-oriented French Broad River headwaters justify and diverging and converging valley complexes strongly suggest southwest-oriented floodwaters once flowed across what is now the northeast-oriented French Broad River headwaters drainage basin. Gaps eroded into what today is the Eastern Continental Divide identify locations where southwest-oriented floodwaters both entered and exited what is today the northeast-oriented French Broad River headwaters drainage basin. Map study also determined that headward erosion of the north- and northwest-oriented French Broad River valley captured southwest-oriented flow to the north-oriented Pigeon River valley which had captured flow to the northwest-oriented Little Tennessee River and that headward erosion of the south-oriented Broad River valley captured southwest-oriented flood flow which had been moving through what is now the northeast-oriented French Broad River headwaters drainage basin to reach the south-oriented Toxaway River.

These map study observations and interpretations are consistent with a new glacial and geology paradigm's predictions which include: 1) the Eastern Continental Divide was uplifted as the rim of a thick continental ice sheet created deep "hole (in which a thick continental ice sheet was located) as immense and prolonged southwest-oriented meltwater floods flowed across it, 2) headward erosion of south and southeast-oriented valleys (in sequence from southwest to northeast) diverted floodwaters more directly to the Atlantic Ocean, and 3) headward erosion of deep north- and northwest-oriented valleys from the developing deep "hole" (in sequence from southwest to northeast) diverted floodwaters through deep "hole" space between the rising deep "hole" rim and the continental ice sheet margin toward deep "hole" southern exits (eventually the Mississippi River valley became the deep "hole's" only southern exit).

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References

Clausen, E. (2022a). How a new Cenozoic geology and glacial history paradigm explains anomalous Monongahela River drainage basin topographic map evidence, PA, WV, Md, USA. *Earth Science Research,* 11(1), 47-63. https://doi.org/10.5539/esr.v11n1p47

Clausen, E. (2022b). How a new glacial history paradigm explains northeast Alabama's Tennessee River-Gulf of Mexico drainage divide area topographic map drainage system evidence. *Journal of Geography and Geology,* 14(2), 38-51. https://doi.org/10.5539/jgg.v14n2p38

Clausen, E. (2023a). *The Topographic Map Mystery: Geology's Unrecognized Paradigm Problem*. Xlibris, 146 p.

Clausen, E. (2023b). William Morris Davis: father of geomorphology or father of geology's unrecognized paradigm problem. *Open Journal of Geology, 13*, 579-597. https://doi.org/10.4236/ojg.2023.136025

Davis, W.M. (1889). A river-pirate. *Science,* 13(314), 108-109. https://doi.org/10.1126/science.ns-13.314.108

Davis, W. M. (1903). The stream contest along the Blue Ridge. *Bulletin of the Geographical Society of Philadelphia, 3*(5), 213-244.

Fenneman, N.M. (1938). *Physiography of Eastern United States*. McGraw-Hill Book Company, New York.714p.

Gallen, S.F., Wegmann, K.W., & Bohnenstiehl, D.R. (2013). Miocene rejuvenation of topographic relief in the southern Appalachians. *GSA Today,* 23(2), 4-10. https://doi.org/10.1130/GSATG163A.1

Hack, J.T. (1989). Geomorphology of the Appalachians; Chapter 11 in The Appalachian-Ouachita Orogen in the United States, Vol. F-2 of *The Geology of North America*, Geological Society of America, p 459-470. https://doi.org/10.1130/DNAG-GNA-F2.459

Johnson, B. (2020). Stream capture and the geomorphic evolution of the Linville Gorge in the southern Appalachians, USA. *Geomorphology, 368*, 107360. https://doi.org/10.1016/j.geomorph.2020.107360

Johnson, D.W. (1906). Drainage modifications in the Tallulah District. *Boston Society Natural History Proceedings, 33*, 211-248.

Kuhn, T. (1970). *The Structure of Scientific Revolutions, second edition, enlarged*. University of Chicago, 210 p.

Liu L. (2014). Rejuvenation of Appalachian topography caused by subsidence-induced differential erosion. *Nature Geoscience, 7*, 518-523. https://doi.org/10.1038/ngeo2187

Matmon, A., Bierman, P.R., Larsen, J., Southworth, S., Pavich, M., & Caffee, M. (2003). Temporally and spatially uniform rates of erosion in the southern Appalachian Mountain Great Smoky Mountains. *Geology, 31*(2), 155-158. https://doi.org/10.1130/0091-7613(2003)031<0155:TASURO>2.0.CO;2

Mckeon, R.E., Zeitler, P.K., Pazzagalia, F.J., Idelman, B.D., & Enkelmann, E. (2014). Decay of an old orogen: inferences about Appalachian landscape evolution from low-temperature thermochronology. *Geological Society of America Bulletin, 126*, 31-46. https://doi.org/10.1130/B30808.1

Prince, P. S., Spotila, J. A., & Henika, W.S. (2010). New physical evidence of the role of stream capture in active retreat of the Blue Ridge Escarpment, southern Appalachians. *Geomorphology, 123*(3-4), 305-319. https://doi.org/10.1016/j.geomorph.2010.07.023

Prince, P.S., Spotila, J. A, & Henika, W.S. (2011). Stream capture as driver of transient landscape evolution in a tectonically quiescent setting. *Geology, 39*(9), 823-826. https://doi.org/10.1130/G32008.1

Spotila, J. A., & Prince, P. S. (2022). Geomorphic complexity and the case for topographic rejuvenation of the Appalachian Mountains. *Geomorphology, 417*, 108449. https://doi.org/10.1016/j.geomorph.2022.108449

Stokes, M.F., Larsen, I.J., Goldberg, S.I., McCoy, S.W., Prince, P.S., & Perron, J.T. (2023). The erosional signature of drainage divide motion along the Blue Ridge Escarpment. *Journal of Geophysical Research*: *Earth Surface, 128*, e2022JF006757. https://doi.org/10.1029/2022JF006757

Thornbury, W.D. (1965). *Regional Geomorphology of the United States*. John Wiley and Sons, Inc. 609p. https://doi.org/10.1097/00010694-196508000-00018

Thornbury, W.D. (1969). *Principles of Geomorphology, second edition*. John Wiley and Sons, Inc. 594 p.

White, W. A. (1950). Blue Ridge Front–A Fault Scarp. *Bulletin of the Geological Society of America, 61*, 1309-1346. https://doi.org/10.1130/0016-7606(1950)61[1309:BRFFS]2.0.CO;2

Wright, F.J. (1928). The erosional history of the Blue Ridge. *Denison University Bulletin, Journal Science Laboratories, 23*, 321-344.

Wright, F.J. (1931). The older Appalachians of the South. *Denison Universities Bulletin, Journal Science Laboratories, 26*, 143-250.