Open Journal of Geology, 2022, 12, 663-684
https://www.scirp.org/journal/ojg
ISSN Online: 2161-7589
ISSN Print: 2161-7570

How a New Cenozoic Geology and Glacial History Paradigm Explains Topographic Map Drainage System and Erosional Landform Evidence: Elbert and Lincoln Counties, Colorado, USA

Eric Clausen

Independent Investigator, Jenkintown, USA
Email: eric2clausen@gmail.com

How to cite this paper: Clausen, E. (2022) How a New Cenozoic Geology and Glacial History Paradigm Explains Topographic Map Drainage System and Erosional Landform Evidence: Elbert and Lincoln Counties, Colorado, USA. *Open Journal of Geology*, **12**, 663-684.
https://doi.org/10.4236/ojg.2022.129031

Received: August 13, 2022
Accepted: September 20, 2022
Published: September 23, 2022

Abstract

Detailed topographic map drainage system and erosional landform evidence such as drainage route orientations, drainage divides, divide crossings (low points on drainage divides), erosional escarpments, and similar features in the east central Colorado Elbert and Lincoln County region are considered as pieces of a complex but solvable drainage history puzzle. A satisfactory solution to date has eluded investigators who have worked from the accepted Cenozoic geology and glacial history paradigm (accepted paradigm) perspective in which climatic and tectonic factors operating over long time periods lead to what might be considered to be a randomly determined regional drainage history. A new and fundamentally different Cenozoic geology and glacial history paradigm (new paradigm) in which immense and prolonged south-oriented continental ice sheet meltwater floods flowed across the Elbert and Lincoln County area which at that time was near the rising rim surrounding a thick continental icesheet created and occupied deep "hole". Map evidence documents how northeast-oriented Republican River headwaters valleys eroded headward across must have been large southeast-oriented floods probably moving toward what at that time would have been an actively eroding and deep east-oriented Arkansas River valley head and how those massive southeast-oriented floods subsequently lowered the Colorado Piedmont surface before being beheaded and reversed when the deep northeast- and east-oriented South Platte River valley eroded headward to create in an identifiable sequence (from east to west) what are now long north-oriented South Platte River tributaries. New paradigm predicted massive and prolonged south-oriented meltwater floods flowing across what must have been a rising region explains much, if not all of the Elbert and Lincoln County detailed topographic map drainage system and erosional landform evidence.

Keywords

Arkansas River, Big Sandy Creek, Colorado Piedmont, Geomorphology, Republican River, South Platte River

1. Introduction: Statement of the Research Problem

Shortly after the publication of some of the first United States Geological Survey (USGS) detailed topographic maps several geologists reported an inability to explain at least some of the newly mapped drainage system and erosional landform evidence (e.g. [1] [2]). In subsequent years as detailed topographic map coverage increased and map quality improved most geologists found the topographic maps extremely valuable for geological mapping purposes, however much of the newly mapped drainage system and erosional landform evidence defied satisfactory explanations. By the mid 1900s, many geomorphologists (e.g. [3]) had determined that using detailed topographic maps to interpret drainage system and erosional landform evidence was a nonproductive research activity and turned their attention to other types of research problems. As a result, research studies in which detailed topographic map evidence was used to interpret drainage system and erosional landform histories almost completely disappeared from the geomorphology literature. Using terms from Kuhn's [4] book "The Structure of Scientific Revolutions" what happened was geomorphologists when trying to interpret detailed topographic map drainage system and erosional landform evidence ran into a solid wall of anomalous evidence, which the accepted Cenozoic geology and glacial history paradigm (accepted paradigm) could not satisfactorily explain. As a result, almost all USGS mapped detailed topographic map drainage system and erosional landform evidence still remains unexplained today.

The accepted paradigm's inability to explain detailed topographic map drainage system and erosional landform evidence is apparent in the Elbert and Lincoln County area of east-central Colorado (see **Figure 1**). Pearl [5] explains present-day east central Colorado topography and drainage systems by starting with the close of Ogallala Formation deposition when he sees east- and northeast-oriented streams flowing down a featureless plain that sloped from what at that time were subdued Rocky Mountains across the eastern Colorado Elbert and Lincoln County region and then into western Kansas. In late Pliocene or early Pleistocene time new tributaries of the South Platte and Arkansas Rivers eroded what is now the Colorado Piedmont region with headward erosion of southeast-oriented Big Sandy Creek valley capturing what are today northeast-oriented Big Sandy Creek headwaters, but which Pearl suggests had originally been a northeast-oriented ancestral Arikaree River segment. Scott who had done detailed geological mapping in a region immediately to the north [6] disagreed

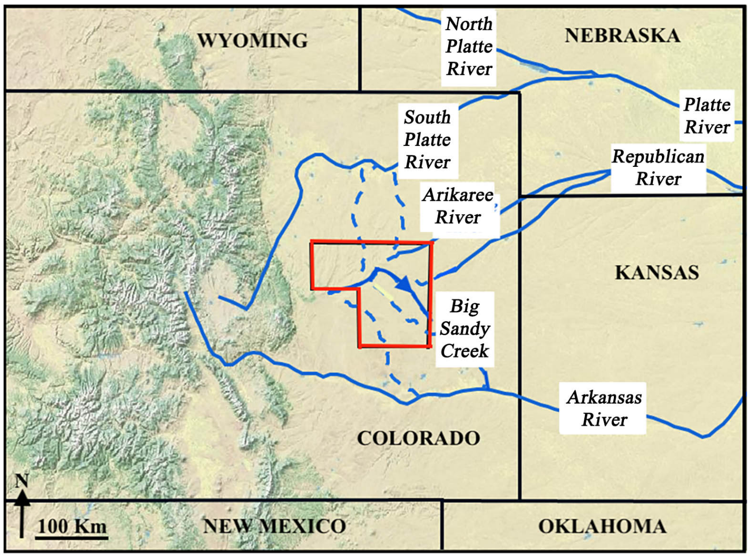

Figure 1. Modified map from United States Geological Survey (USGS) National Map website with red lines enclosing the Elbert and Lincoln County study area.

and stated [7] (p. 9) "The present pattern of streams just east of the mountains suggests that dissection started with streams flowing semi-parallel to the mountain front and emptying into two master streams, the South Platte and Arkansas River. …Very soon after downcutting started all streams flowing across the Ogallala Formation would have been beheaded except the South Platte and Arkansas Rivers. …On the plains, erosion would have been as fast as changing base level would have permitted as the master streams and their new tributaries cut down through nonresistant Tertiary deposits and into even-less-resistant Cretaceous marine shale". Continuing Scott suggests the Ogallala scarp retreated eastward by about 80 km in 2 million years and then he used topographic map evidence to suggest that what are now north-oriented South Platte River tributaries captured water that had once flowed to the southeast-oriented Big Sandy Creek valley, although he did not address most other study region topographic map drainage systems and erosional landform evidence.

Madole [8] (p. 456-7) in a generalized discussion describes interesting Colorado Piedmont map and field evidence by observing "The Miocene and Pliocene rocks and the underlying Paleocene, Eocene, and Oligocene rocks have been eroded from most of the Colorado Piedmont by the South Platte and Arkansas Rivers and their tributaries. …Maximum relief is about 450 m, which is the maximum height of the divide between the South Platte and Arkansas Rivers. …The principal streams heading on the Colorado Piedmont are creeks, most of which flow only intermittently, that trend north or south, or northeast or southeast to the east-flowing South Platte and Arkansas Rivers. The creeks tend to be underfit; commonly, they are only 5 to 10 m wide, yet they occupy flat-floored valleys as much as 1 to 3 km wide". However, Madole fails to explain how the present day intermittently flowing South Platte and Arkansas River tributaries were able to deeply erode the Colorado Piedmont while further to the east comparable deep erosion did not occur. In addition, most investigators have recognized that tectonic uplift played an important Colorado Piedmont erosion history role. For example, Leonard [9] (p. 595) suggested "Late Cenozoic warping of the Colorado piedmont involved interplay of tectonic forcing, river erosion, and isostatic response to erosion", but while illustrating several intriguing transects across the eroded Colorado Piedmont region, like other accepted paradigm researchers his paper leaves most drainage history and regional erosion questions unanswered.

Geologic maps at a scale of 1:250,000 exist for some Elbert and Lincoln County areas including Sharps [10] "Geologic map of the Limon 1 degree × 2 degrees quadrangle" and the Scott *et al.* [11] "Geologic map of the Pueblo 1 degree × 2 degrees quadrangle", although other study region areas are only covered by the 1:500,000 scale Tweto [12] "Geologic map of Colorado". Barkmann *et al.* [13] (p. 2) in a detailed report describing Elbert Count geology and groundwater resources state "this is an area where the modern South Platte and Arkansas River systems have incised through a broad, gravel-capped plain that once extended from the Rocky Mountains east to the Great Plains. Only a small portion of the former gravel plain remains in Elbert [County]" yet, like most other reports cited here, explanations for the major drainage divides, most drainage route directions, the erosional escarpments, or any of the other Elbert County drainage system and erosional landform features are not given.

Elbert and Lincoln County detailed topographic maps show numerous intriguing, but yet to be explained drainage system and erosional landform features. Major drainage routes (seen in **Figure 2**) include northeast- and southeast-oriented Big Sandy Creek which not only makes a remarkable direction change but which flows (both before and after its abrupt direction change) near and parallel to major drainage divides. Erosional escarpments surround the higher elevation Republican River drainage basin and a relatively minor intermittent stream begins today in large south-southeast oriented escarpment-surrounded basin. Many drainage basins are asymmetric with much longer tributaries on one side than the other side and numerous low points (referred to as divide crossings) suggest multiple streams of water once crossed all major drainage divides. Explaining detailed topographic map drainage system and erosional landform features is like trying to solve a complicated puzzle. The solution cannot explain just a few selected features but must explain all observed features (a solution unable to explain all of the pieces is not a satisfactory solution). In short, while the accepted paradigm has enabled researchers to describe a generalized Colorado Piedmont geologic history that geologic history does not explain why South Platte River tributaries flow in parallel north-oriented directions, why Arkansas River tributaries flow in southeast-oriented directions, why what are today intermittent South Platte and Arkansas River tributary streams were able to erode the Colorado Piedmont, or why any one of a large number of the Elbert and Lincoln County drainage system or erosional landform features observable on detailed topographic maps developed the way it is.

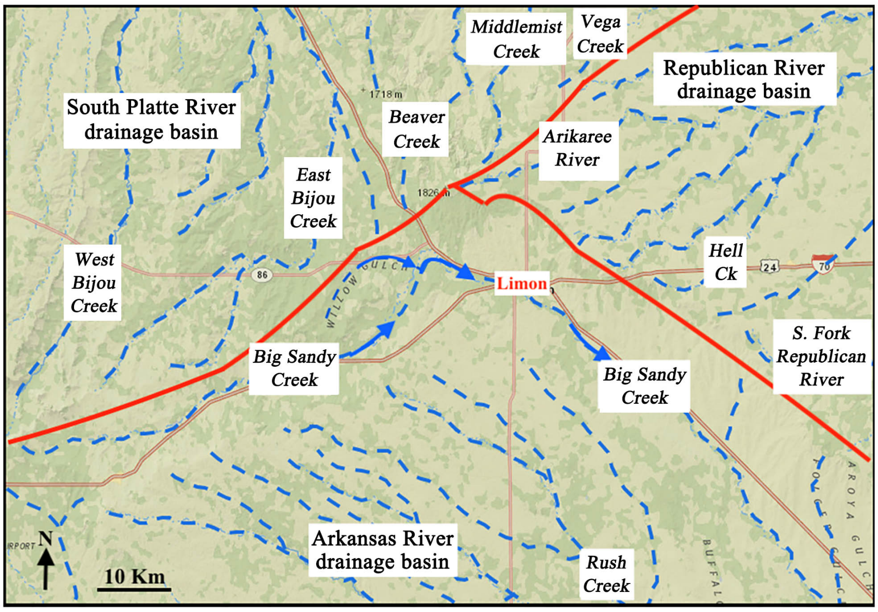

Figure 2. Modified map from USGS National Map website showing drainage routes in the Elbert and Lincoln County, Colorado area. Red lines show major drainage divides.

In an effort to explain detailed topographic map drainage system and erosional landform evidence Clausen [14] used Missouri River drainage basin evidence to develop a new Cenozoic geology and glacial history paradigm (new paradigm) which is able to explain the USGS mapped detailed topographic map drainage system and erosional landform evidence. In brief, the new paradigm sees a thick North American continental icesheet that created and occupied a deep "hole" (by deep erosion and the uplift of surrounding regions). Uplift of regions surrounding the thick icesheet occurred as immense south-oriented melt water floods flowed across what became a rising deep "hole" rim which progressively caused deep valleys to erode headward across the south-oriented floods so as to divert the south-oriented meltwater floods toward what ultimately became the deep "hole's" only southern exit (now the Mississippi River valley). In time the massive south-oriented floods were reversed so as to flow back into deep "hole" space the decaying icesheet had once occupied and to form a second and much thinner icesheet. In contrast, the accepted paradigm, while seeing multiple late Cenozoic continental icesheets (e.g. [15]) does not see an icesheet created deep "hole", a relationship between continental icesheets and surrounding region uplifted areas, or evidence for south-oriented meltwater floods crossing what are now the surrounding uplifted areas (which includes the Colorado Piedmont region where much of the Elbert and Lincoln County study region is located). From a new paradigm perspective Clausen [16] [17] described how the South Platte River valley to the north of the Elbert and Lincoln County study area eroded headward across large and prolonged south-oriented meltwater floods which previously must have continued southward across Elbert and Lincoln Counties. The research described here sought to determine if the new paradigm's immense and prolonged south-oriented meltwater floods could have produced Elbert and Lincoln County drainage system and erosional landform features which are observable on USGS prepared detailed (1:24,000 scale) topographic maps.

2. Research Method

This study began by assuming Elbert and Lincoln County detailed topographic map drainage system and erosional landform evidence to be a solvable puzzle-provided the right solution is found. The new paradigm provides powerful puzzle solving tools not available to accepted paradigm researchers who rely on puzzle-solving tools such as long periods of time, climatic change, tectonic uplift, random erosion events, a glacial history such as that described by Batchelor *et al.* [15], and short-lived catastrophic mega floods of the type described by Connor *et al.* [18]. The first of the powerful new paradigm puzzle solving tools is the ability to use immense and long-lived south-oriented meltwater floods to deeply erode the Colorado Piedmont region (where much of Elbert and Lincoln County study region is located). The new paradigm's massive meltwater floods, while possibly seasonal, almost certainly continued year after year-perhaps for tens or hundreds of thousands of years (or for even longer periods of time). The new paradigm's second powerful puzzle solving tool is recognition that the Mississippi River drainage system developed as on-going deep "hole" rim uplift enabled the systematic erosion of east-oriented valleys headward (west of the Mississippi River) across the large and long-lived south-oriented meltwater floods so as to divert south-oriented melt water floodwaters toward the Mississippi River valley, which in time became the deep "hole's" only southern exit.

The puzzle-solving process began by using major drainage divides to subdivide the Elbert and Lincoln County study region (seen in **Figure 2**) into smaller study regions defined by the three major drainage basins (Republican, Arkansas, and South Platte River drainage basins). The Republican River drainage basin region (partially seen in **Figure 3**) was investigated first to determine what if any topographic map evidence might suggest large south-oriented floods eroded what are today northeast-oriented Republican River tributary valleys. Detailed topographic maps were checked to determine if tributary valley orientations and departures from a northeast orientation suggested the northeast-oriented Republican River tributary valleys had eroded headward across south-oriented floods. Drainage divides between the northeast-oriented Republican River tributaries were checked for low points (or divide crossings) to determine if the northeast-oriented Republican River tributary valleys had eroded headward across multiple streams of south- or southeast-oriented water. Of particular interest were drainage divides with the South Platte and Arkansas River drainage basins (such as seen in **Figures 3-5**) which were checked to determine if South Platte or Arkansas River tributaries now originate on what is primarily a Republican River drained east- and northeast-sloping upland surface.

The Elbert and Lincoln County Arkansas River drainage basin area required a somewhat different investigative process because today other than the northeast-oriented Big Sandy Creek headwaters almost all drainage routes flow in southeast directions. Arkansas River tributaries and secondary streams flowing

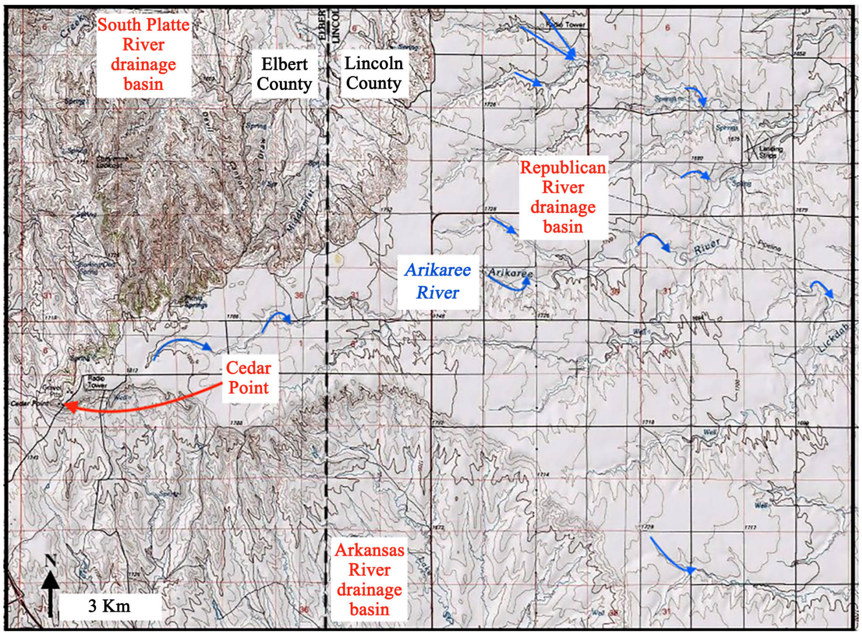

Figure 3. Modified topographic map from USGS National Map website showing the escarpment-surrounded Arikaree River headwaters in the Republican River drainage basin with arrows emphasizing southeast-oriented drainage segments. The contour interval is 10 meters. Top left corner: 39˚28'25"N, 103˚49'40.1"W.

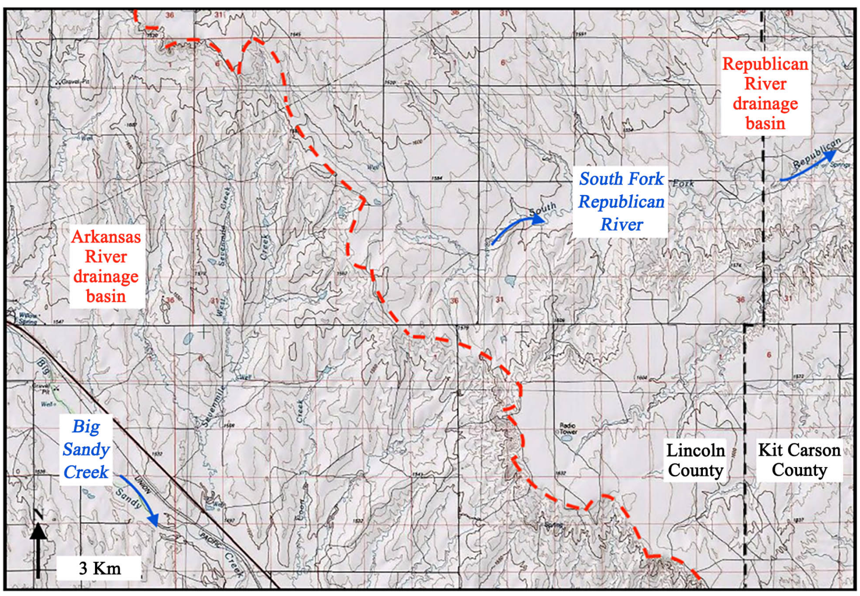

Figure 4. Modified topographic map from USGS National Map website showing how the southeast-oriented Big Sandy Creek valley truncates the asymmetric northeast-oriented South Fork Republican River valley. The red dashed line shows the drainage divide location. The contour interval is 10 meters. Top left corner: 39˚13'19.6"N, 103˚27'02"W.

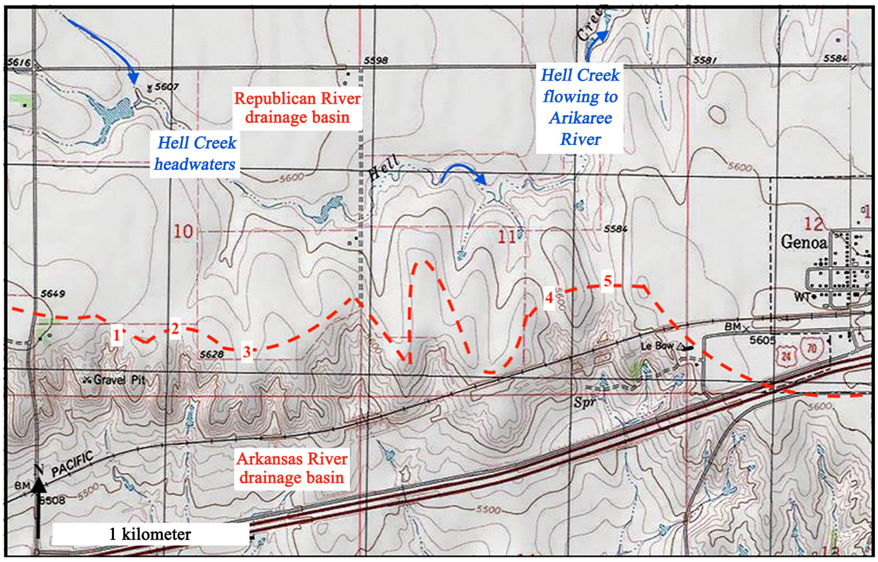

Figure 5. Modified detailed topographic map from the USGS National Map website showing the Hell Creek-Big Sandy Creek drainage divide (dashed red line) and is from an area located about midway between Figure 3 and Figure 4. The contour interval is 10 feet (3 meters). Top left corner: 39˚17'22.4"N, 103˚32'55.8"W.

to them, almost all of which flow primarily in southeast directions, were studied to determine if southeast-oriented floodwaters could have moved across the region in large anastomosing channel complexes as the new paradigm suggests. Drainage divides on either side of the northeast-oriented Big Sandy Creek valley segment were checked for divide crossings to determine whether the northeast-oriented Big Sandy Creek valley eroded headward across multiple streams of southeast-oriented water (consistent with new paradigm predictions). The Arkansas River drainage basin region was also checked for the presence of large southeast-oriented escarpment-surrounded basins (large abandoned headcuts). The presence of such large escarpment-surrounded basins was regarded as evidence that prior to headward erosion of a beheading valley large southeast- or south-oriented floods had eroded deep headcuts in a northwest (headward) direction from what at that time was an actively eroding Arkansas River valley.

The South Platte River drainage basin study area required still different investigative techniques. Almost all study area South Platte River tributaries now flow in north directions-opposite from the new paradigm predicted meltwater flood flow direction. For this reason, detailed topographic map evidence was studied to determine if today's north-oriented South Platte River tributaries originated as channels in a south- or southeast-oriented anastomosing channel complex and had their flow direction reversed when a deep South Platte River valley eroded headward in a southwest and west direction (in the region to the north of the Elbert and Lincoln County study region). The study region's South Platte-Republican River and the South-Platte-Arkansas River drainage divides were studied to identify divide crossings where water might have once flowed from what is now the South Platte River drainage basin into what are now the Republican and Arkansas River drainage basins. Drainage divides between the now north-oriented South Platte River tributaries were investigated to further determine if a large flood-formed south-oriented anastomosing channel complex had previously crossed the region. Since the new paradigm requires the study region's north-oriented South Platte River tributaries to have reversed their flow directions map evidence was sought to determine how the reversed drainage routes obtained enough water to erode what are today significant and roughly parallel north-oriented valleys and were also able to erode what is now a substantial northwest-facing erosional escarpment located near the South Platte-Republican River drainage divide.

3. Results

3.1. Republican River Drainage Basin Topographic Map Evidence

The Republican River drainage basin begins in Lincoln County (and a small area of Elbert County) as a series of northeast-oriented tributaries seen in **Figure 2**. To the northeast of **Figure 2** the northeast-oriented tributaries eventually converge to form the Republican River which then flows for a considerable distance in an east direction across southern Nebraska before turning in a southeast direction to enter Kansas and to ultimately join the east-oriented Kansas River (which then joins the east-oriented Missouri River as the water continues on its journey to reach the south-oriented Mississippi River). The westernmost point in today's Republican River drainage basin is the escarpment-surrounded upland in northeast Elbert County where the northeast-oriented Arikaree River begins (seen in **Figure 3**). The first Elbert and Lincoln County drainage system and erosional landform puzzle piece needing to be understood is why the Republican River headwaters flow in a northeast direction when further to the east the Republican River is an east- and southeast-oriented river especially since detailed topographic maps show the Republican River headwaters flowing in a northeast direction on an eastward-sloping surface.

Accepted paradigm researchers usually ignore Republican River direction changes when explaining its drainage history, however the new paradigm requires any puzzle solution to address all significant topographic map drainage system and erosional landform evidence. While not determinable from study region topographic map evidence the new paradigm's large south-oriented floods were probably diverted in a southeast direction in the Elbert and Lincoln County area toward what would have been an actively eroding east-oriented Arkansas River valley head. If so, the new paradigm predicts the northeast-oriented Republican River headwaters valleys eroded headward across the southeast-oriented floodwaters in southwest directions (with the valleys eroding headward in a southeast to northwest sequence). Evidence for valley headward erosion across southeast-oriented flood flow is seen in **Figure 3** where blue arrows emphasize southeast-oriented drainage segments (including southeast-oriented Arikaree River tributaries and short jogs to the southeast). Even better confirming topographic map evidence is seen in **Figure 4** (located south and east of

Figure 3) where headward erosion of the southeast-oriented Big Sandy Creek valley has truncated the asymmetrical northeast-oriented South Fork Republican River valley.

Figure 4, topographic map drainage system and erosional landform evidence just by itself is an intriguing puzzle worthy of a solution. The most significant puzzle pieces are the truncated and asymmetric northeast-oriented South Fork Republican River valley with its barbed or southeast-oriented tributaries, the 150-meter-deep southeast-oriented Big Sandy Creek valley, and the asymmetric Republican-Arkansas River drainage divide. Headward erosion of the 150-meter deep Big Sandy Creek valley truncated the 50-meter-deep northeast-oriented South Fork Republican River valley meaning the asymmetric northeast-oriented South Fork Republican River valley and its multiple closely spaced southeast-oriented tributaries preceded (at least in Figure 4 area) headward erosion of the much deeper southeast-oriented Big Sandy Creek valley. The multiple closely-spaced southeast-oriented tributaries and the asymmetric valley are evidence the northeast-oriented South Fork Republican River valley eroded headward across the same massive southeast-oriented flood flow that subsequently enabled the much deeper southeast-oriented Big Sandy Creek valley to erode headward into Figure 4 area (from the still deeper and probably actively eroding Arkansas River valley head). In other words, headward erosion of the southeast-oriented Big Sandy Creek valley occurred during the same immense southeast-oriented flood events that eroded the northeast-oriented South Fork Republican River valley (which also eroded the northeast-oriented Arikaree River valley).

Further pieces of the Elbert and Lincoln County drainage history puzzle needing consideration are divide crossings (or low points where water once flowed across a drainage divide). Divide crossings are found not only along the major drainage divides but also along drainage divides between the relatively minor secondary streams and are often best observed using the most detailed topographic maps available. Figure 5 illustrates five divide crossings observable on a short segment of the Hell Creek-Big Sandy Creek drainage divide. Divide crossings located at the red numbers 1, 2, and 3 are identified by a single 10-foot (3 meter) contour line while the divide crossings at numbers 4 and 5 are identified by two or more contour lines. All five of the identified divide crossings are evidence water once flowed from the southeast-oriented Hell Creek headwaters drainage basin (with Hell Creek now turning in northeast direction to join the northeast-oriented Arikaree River) into what is now the southeast-oriented Big Sandy Creek valley. Headward erosion of the northeast-oriented Hell Creek valley captured southeast-oriented flow and diverted the water from the Arkansas River drainage basin into the Republican River drainage basin. Similar divide crossings can be found along enough Republican River drainage basin drainage divides to confirm the new paradigm interpretation that northeast-oriented Republican River headwaters valleys eroded headward across large south- and/or southeast-oriented floods, although divide crossing are not observable (even using the most detailed 1:24,000 scale topographic maps) along all drainage divides. The lack of divide crossings along some drainage divides may indicate south- and southeast-oriented floodwaters flowed as sheets of water across a low relief and possibly a low gradient topographic surface.

3.2. Arkansas River Drainage Basin Topographic Map Evidence

The Elbert and Lincoln County Arkansas River drainage basin area includes the large southeast-oriented Adobe Creek escarpment-surrounded basin seen in **Figure 6**. No south-oriented abandoned valleys lead to it, but to the north of the figure both South and North Rush Creeks flow in more of a southeast direction than seen at the figure top. Adobe Creek today is fed by several springs where groundwater seeps out from escarpment walls and one commonly accepted interpretation is spring sapping contributes to the development of such large escarpment-surrounded basins (e.g. [19]). However, west of the Adobe Creek escarpment-surrounded basin (and partially seen in the figure) Horse Creek flows into and through a somewhat similar escarpment-surrounded basin suggesting that both the Horse Creek and the Adobe Creek escarpment-surrounded basins were eroded as giant headcuts as massive southeast-oriented floods eroded the deep Horse and Adobe Creek valleys in a northwest direction. In the case of the Horse Creek escarpment-surrounded basin the Horse Creek valley continued to erode headward from the headcut lip and captured significant upstream flood flow. In the case of the Adobe Creek escarpment-surrounded basin headward erosion of the North and South Rush Creek valleys captured the southeast-oriented sheets of floodwater which had been actively eroding the Adobe Creek valley head in a northwest direction and left the Adobe Creek escarpment-surrounded basin as a large southeast-oriented abandoned headcut, which is what is seen today.

Other than the northeast-oriented Big Sandy Creek headwaters segment seen in **Figure 2** most Elbert and Lincoln County Arkansas River drainage basin streams flow in southeast or south directions and end up in south-oriented Big Sandy, Rush, or Horse Creeks. Rush Creek converges with Big Sandy Creek which joins the east-oriented Arkansas River while Horse Creek being slightly further to the west flows independently to the Arkansas River. Rush and Horse Creek headwaters begin as multiple southeast-oriented intermittent streams only a short distance to the south of the northeast-oriented Big Sandy Creek valley. **Figure 7** provides a detailed topographic map showing a segment of the asymmetric Big Sandy-Rush Creek drainage divide (note the multiple southeast-oriented Rush Creek headwaters streams). Red numbers on or near the drainage divide (red dashed line) identify divide crossings which from the new paradigm perspective are places where streams of south-oriented water (perhaps as channels in a large southeast-oriented anastomosing channel complex) flowed across what is now the divide and into the southeast-oriented Rush Creek drainage basin (again only one contour line defines some divide crossings while multiple contour lines define other divide crossings). Another Elbert and Lincoln County drainage history puzzle piece needing to be understood is how the Big Sandy-Rush Creek drainage divide formed. From the new paradigm perspective, the northeast-oriented Big Sandy Creek valley eroded headward across southeast-oriented floods which were flowing toward what at that time was an actively eroding Arkansas River valley head.

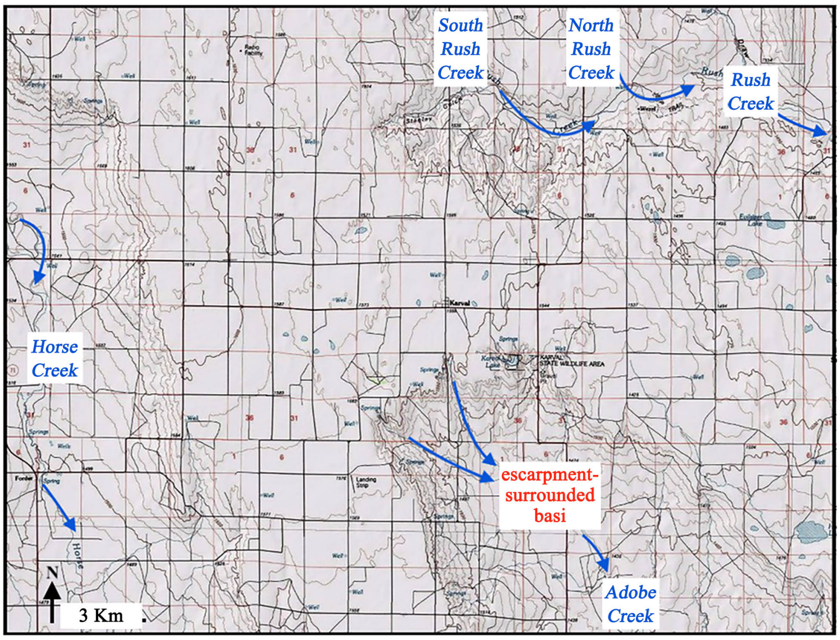

Figure 6. Modified topographic map from the USGS National Map website showing the Adobe Creek escarpment-surrounded basin between Horse and Rush Creeks. The contour interval is 10 meters. Top left corner: 38˚49'28.55"N, 103˚43'06.89"W.

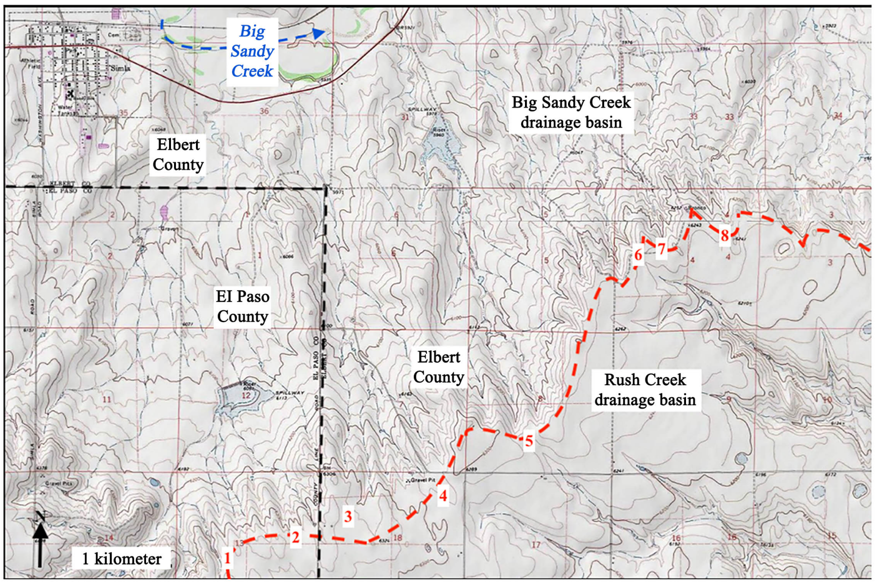

Figure 7. Modified topographic map from the USGS National Map website showing the Big Sandy-Rush Creek drainage divide (red dashed line) in the Arkansas River drainage basin. Red numbers identify divide crossings discussed in the text. The contour interval is 20 feet (6 meters). Left top corner: 39˚08'45.6"N, 104˚05'33"W.

Still another Elbert and Lincoln County drainage history puzzle piece is how immense south-oriented floods eroded north-oriented Big Sandy Creek tributary valleys (such as seen in **Figure 7**). To understand north-oriented Big Sandy Creek tributary valleys some elevation data obtainable from the topographic maps is needed. Elevations on the Big Sandy-Rush Creek drainage divide seen in **Figure 7** are in the 1900-meter range and the Big Sandy Creek valley floor at Simla is about 100 meters lower. To the northwest of **Figure 7** is the unseen Reed Springs-Big Sandy Creek drainage divide which today is also the South Platte-Arkansas River drainage divide (Reed Springs Creek is an east- and north-oriented tributary to East Bijou Creek). Elevations along the Reed Springs-Big Sandy Creek drainage divide (which as seen in **Figure 8** is also crossed by numerous deep divide crossings) are slightly lower than elevations along the comparable Big Sandy-Rush Creek drainage divide to the southeast. These elevations indicate a 100-meter-deep northeast-oriented Big Sandy Creek valley eroded headward across large and prolonged southeast-oriented floods (probably moving in a large complex of shallow anastomosing channels) flowing across what probably was a low relief and low gradient topographic surface now preserved only by higher elevations now found along the drainage divides on either side of the Big Sandy Creek valley. Headward erosion of the 100-meter-deep valley beheaded the southeast-oriented floodwaters and caused reversals of flood flow with the flow direction in newly beheaded flood flow channels being reversed so the water flowed back into the newly eroded and much deeper Big Sandy Creek valley. Because the channels were anastomosing the newly beheaded and reversed flood flow channels could capture flood waters from yet to be beheaded southeast-oriented flood flow channels, which enabled some of the reversed flood flow channels to erode substantial north-oriented valleys.

3.3. South Platte River Drainage Basin Topographic Map Evidence

Puzzle pieces in the Elbert and Lincoln County South Platte River drainage basin area include divide crossings along the South Platte-Arkansas River drainage divide, divide crossings along secondary drainage divides between the northeast- and east-oriented headwaters to north-oriented South Platte River tributaries, divide crossings linking some of the north-oriented South Platte River tributary northeast-oriented headwaters valleys, long north-oriented South Platte River tributaries, South Platte-Arkansas River drainage divide elevations almost 500-meters higher than South Platte River valley elevations to the north, and lower elevations north of the South Platte River valley than the South Platte-Arkansas River drainage divide's elevation. The first step in understanding these puzzle pieces is to recognize that closely-spaced streams of water once flowed across what is now the South Platte-Arkansas River drainage divide. **Figure 8** illustrates a South Platte-Arkansas River drainage divide segment northwest of the Big Sandy-Rush Creek drainage divide seen in **Figure 7** (red numbers identify divide crossings). Elevations along **Figure 7** and **Figure 8** drainage divide segments are similar although elevations along both divides decrease

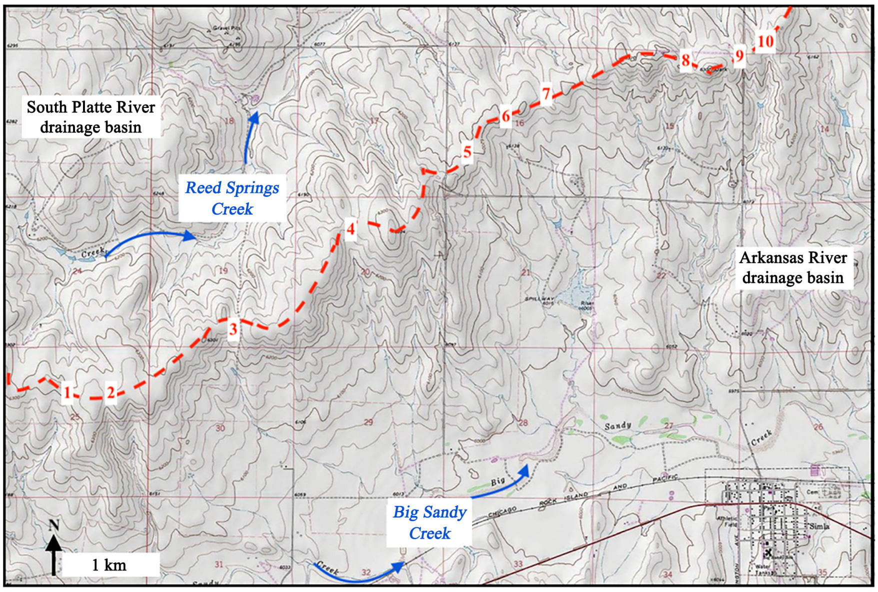

Figure 8. Modified topographic map from USGS National Map website showing the South Platte-Arkansas River drainage divide (red dashed line) located northwest of **Figure 7**. The contour interval is 20 feet (6 meters). Top left corner: 39˚11'09"N, 104˚10'44.4"W.

in a northeast direction and the South Platte-Arkansas River divide is slightly lower than the Big Sandy-Rush Creek divide segment. This evidence suggests a 100-meter-deep northeast-oriented Big Sandy Creek valley probably eroded headward across south- or southeast-oriented floodwaters flowing on what was probably a low gradient and low relief topographic surface equivalent in elevation to present-day drainage divide elevations.

The next step in understanding South Platte drainage basin area puzzle pieces is to look at drainage divides between east- and northeast-oriented headwaters flowing to the long north-oriented South Platte River tributaries. Reed Springs Creek seen in **Figure 8** is an east and north-northeast oriented tributary flowing to north-oriented East Bijou Creek's northeast- and east-oriented headwaters (see **Figure 9**). Immediately to the north of the east-oriented East Bijou Creek segment is a high drainage divide between the East Bijou Creek valley and the headwaters of north-oriented tributaries flowing to north-oriented Middle Bijou Creek. Elevations along this Middle Bijou-East Bijou Creek drainage divide are slightly lower than elevations along the South Platte-Arkansas and Big Sandy-Rush Creek drainage divides to the south, but all three divides stand almost 500 meters higher than corresponding South Platte River valley elevations to the north. Two deep divide crossings marked in **Figure 9** by the letters A and B along with several shallower and unmarked divide crossings also suggest south-oriented floodwaters once flowed from what is now the north-oriented Middle Bijou Creek drainage basin into the area where the east-oriented East Bijou Creek valley now exists and suggest the east-oriented East Bijou Creek valley eroded headward across south-oriented flood flow that had once been moving

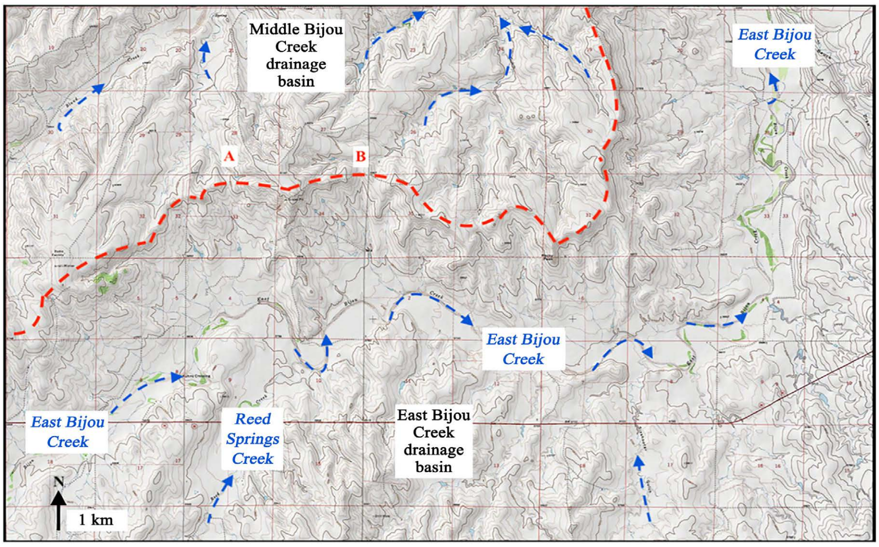

Figure 9. Modified topographic map from USGS National Map website showing Middle Bijou-East-Bijou Creek drainage divide (red dashed line) north of where north-oriented Reed Springs Creek joins East Bijou Creek. Letters A and B identify divide crossings. The contour interval is 20 feet (6 meters). Top left corner: 39˚20'42.3"N, 104˚09'28.3"W.

across the South Platte-Arkansas River divide and which prior to headward erosion of the northeast-oriented Big Sandy Creek valley had been flowing across today's Big Sandy-Rush Creek divide and into what is now the southeast-oriented Rush Creek drainage basin.

Additional puzzle pieces needing to be dealt with are the Big Sandy-Rush Creek, South Platte-Arkansas River, and Middle Bijou-East Bijou Creek drainage divide elevations as seen in Figures 7-9 are directly to the north of what is now a 150-kilometer wide east- and northeast-oriented South Platte River eroded valley and lowland and that no drainage divides further to the north (of the South Platte River lowland) are comparable in elevation to drainage divide elevations seen in Figures 7-9. If massive south- and southeast-oriented floods flowed across the Elbert and Lincoln County region then the regional topography at that time must have been very different than it is now. South-oriented floodwaters could not have flowed across Figures 7-9 drainage divides if the South Platte River lowland and the east- and southeast-oriented North Platte River valley further to the north had been present. Second, at that time Elbert and Lincoln County surface elevations must have been comparable to or lower than the elevations to the north of where the South Platte River lowland now exists. While (or after) the large and prolonged south-oriented floods flowed across the Elbert and Lincoln County region two significant geological events must have occurred. The first was the Elbert and Lincoln County region must have been uplifted relative to regions further to the north (and also relative to regions further to the east). The second event, probably caused by the first event, was the deep east- and northeast-oriented South Platte River valley eroded headward across the massive and prolonged south-oriented flood flow so as to divert the floodwaters eastward toward the south-oriented Mississippi River valley (precisely as the new paradigm predicts).

Perhaps the most difficult puzzle piece to understand is how the massive and prolonged south-oriented floods could erode what are now significant and long north-oriented South Platte River tributary valleys. The simple answer is Elbert and Lincoln County region uplift (relative to regions further to the north and further east) enabled the large east- and northeast-oriented South Platte River valley to erode headward (from east to west) across south-oriented floods which beheaded south-oriented flood flow channels (in what were probably large south- oriented anastomosing channel complexes). The South Platte River valley may have been several hundred meters deep as it eroded headward into northeast Colorado. If the south-oriented floodwaters had been flowing in anastomosing channels on a low gradient and probably low relief surface as the Elbert and Lincoln County drainage divides suggests, South Platte River valley headward erosion would have not only beheaded south-oriented flood flow channels in sequence from east to west, but would have also caused a progressive sequence of massive flood flow reversals in those newly beheaded flood flow channels. Because the flood flow was moving in anastomosing (or interconnected) channels the newly reversed flood flow channels could capture large amounts of south-oriented flood flow still moving in yet to be beheaded flood flow channels further to the west which led to what are now northeast- and east-oriented headwaters valleys leading to many of the long north-oriented South Platte River tributary valleys (such as seen in Figure 9 and Figure 10). These captures of south-oriented flood flow from yet to be beheaded flood flow channels provided large enough water volumes to erode in sequence from east to west a progression of significant and long north-oriented South Platte River tributary valleys.

Figure 10 illustrates how newly reversed flood flow channels probably captured yet to be south-oriented flood flow from flood flow channels further to the west. Vega, Middlemist, and Beaver Creeks are today north-oriented streams that converge further to the north (at much lower elevations than in the figure) before reaching the east- and northeast-oriented South Platte River. In a simplified description of what in reality were complex water movements south-oriented flood flow was reversed on the now north-oriented Vega Creek alignment and that reversal captured south-oriented flood flow still moving on the yet to be reversed Middlemist Creek alignment. That capture led to the development of northeast-oriented Vega Creek headwaters and tributaries and erosion of a segment of what is today a significant northwest-facing erosional escarpment. The point B drainage divide crossing (in Figure 10) developed when south-oriented flow on the Middlemist Creek alignment was reversed and ended the captured flood flow movement to the previously reversed flow on the Vega Creek alignment. Reversed flow on the Middlemist Creek alignment then captured south-oriented flow still moving on the Beaver Creek alignment which eroded another segment of the northwest-facing escarpment. The point A

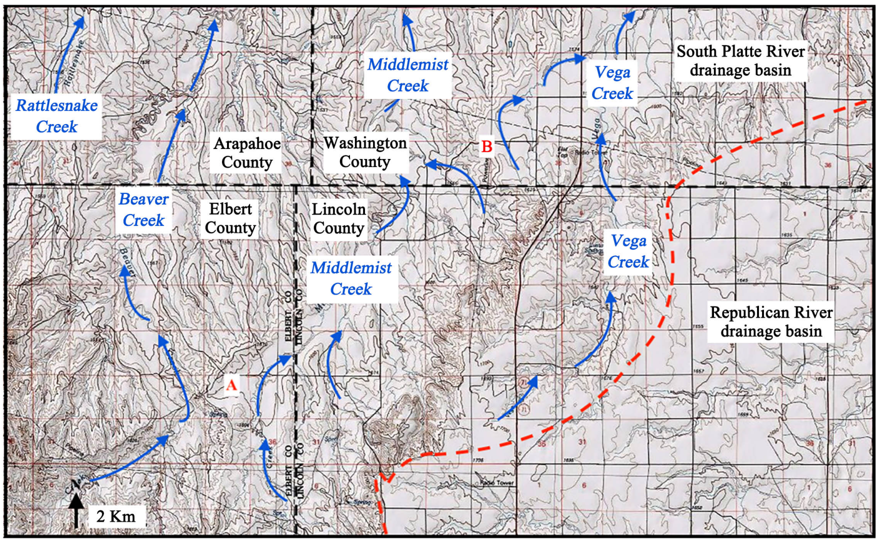

Figure 10. Modified topographic map from the USGS National Map website showing northeast-oriented headwaters to north-oriented South Platte River tributaries and the South Platte-Republican River drainage divide (red dashed line). The contour interval is 10 meters. Top left corner: 39˚37'20.1"N, 103˚49'47.65"W.

(in Figure 10) drainage divide crossing developed when south-oriented flow on the Beaver Creek alignment was reversed and ended captured flood flow movement to the previously reversed Middlemist Creek flow. Reversed flow on the Beaver Creek alignment captured yet to be reversed south-oriented flow still moving on the Rattlesnake Creek alignment. Reversed flow on the Rattlesnake Creek alignment captured south-oriented flow on the yet to be reversed East Bijou Creek alignment. And reversed flow on the East Bijou Creek alignment captured yet to be reversed flow on the West Bijou Creek alignment.

Beaver Creek headwaters are located south and west of Figure 10 southwest corner and slightly south and west of Cedar Point as seen in Figure 11. Point A in Figure 11 marks the lowest point (with an elevation of 1738 meters) in a large and nearly 25-kilometer-wide divide crossing between Cedar Point (elevation 1825 meters) and where the westward rising South Platte-Arkansas River drainage divide again reaches 1825 meters (to the east of Cedar Point South Platte-Republican River drainage divide elevations decrease and in less than 15 kilometers are lower than 1738 meters). Points A and B in Figure 11 identify abandoned north-to-south oriented valleys linking the now north-oriented Beaver Creek drainage system with the southeast-oriented Big Sandy Creek drainage system (the point B elevation is 1741 meters). These are deep divide crossings on the floor of the much larger divide crossing (which is a 25-kilometer-wide erosional gap) that to the southwest of figure includes another pronounced north-to-south oriented abandoned valley (the floor elevation is 1749 meters) linking north-oriented East Godfrey Gulch (which flows to north-oriented East Bijou Creek) with south-oriented drainage to southeast-oriented Big Sandy Creek. Prior to flow reversals in the now north-oriented Beaver Creek and East Bijou Creek drainage systems enormous volumes of south-oriented water must

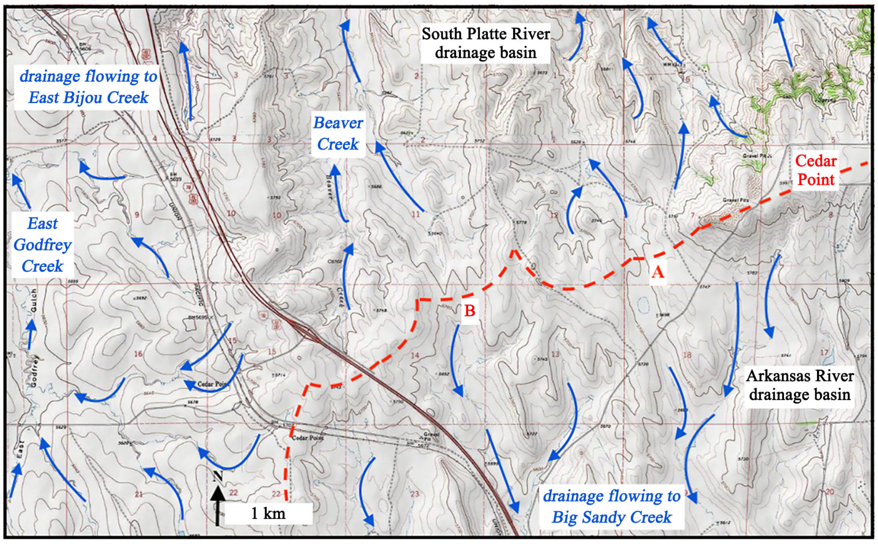

Figure 11. Modified detailed topographic map from the USGS National Map website showing the South Platte-Arkansas River drainage divide (dashed red line) location in the region just to the west of Cedar Point. The contour interval is 20 feet (6 meters). Top left corner: 39˚23'154"N, 103˚54'21.3"W.

have once crossed the present-day South Platte-Arkansas River drainage divide to erode this large erosional gap area and were responsible for headward erosion of the deep southeast-oriented Big Sandy Creek and its tributary Rush Creek drainage basins (which also eroded the southwest-facing escarpment seen in Figure 4) [Note: floodwater movements along drainage divides between what are now north-oriented East Bijou and Beaver Creeks and northeast- and south-east-oriented Big Sandy Creek were complex and the southeast-oriented Big Sandy Creek valley may have captured some of the reversed flood flow moving to the East Bijou Creek valley which would be consistent with a Scott [7] observation].

4. Discussion

The new paradigm's ability to solve the Elbert and Lincoln County detailed topographic map drainage system and erosional landform evidence puzzle points out the dangers of ignoring anomalous detailed topographic map drainage system and erosional landform evidence. USGS detailed topographic maps took many years of painstaking work to prepare, required the expenditure of the equivalent of many billions of today's dollars, and are based on high quality observational data. Subject to the resolution of 1:24,000 scale maps there is every reason to believe drainage systems and erosional landforms as depicted on the USGS detailed topographic maps reflect drainage systems and erosional landforms as they actually exist in nature. Geomorphologists have known since the mid 20th century that much of the USGS-mapped drainage system and erosional landform evidence was inconsistent with accepted Cenozoic geology and glacial history interpretations. This was not a problem involving a small amount of localized anomalous evidence, but was and still is a problem involving vast quantities of anomalous evidence found throughout the continental United States (and probably in many other regions as well). Scientific paradigms are not easily changed, but the accepted Cenozoic geology and glacial history paradigm's inability to explain detailed topographic map drainage system and erosional landform evidence means the accepted paradigm now being actively fleshed out by the geology research community's on-going research efforts will ultimately be replaced and many key assumptions upon which the geology research community's accepted Cenozoic geology and glacial history and current research efforts are now based will become meaningless.

When treated as a solvable puzzle detailed topographic map drainage system and erosional landform evidence when viewed from the new paradigm perspective leads to an internally consistent and unique puzzle solution describing a logical sequence of erosion events. If combined with geologic map evidence the detailed topographic map drainage system and erosional landform evidence also can usually indicate which stratigraphic units have been eroded and which if any stratigraphic units now fill eroded valleys. In the case of the study described here the large south-oriented floods responsible for shaping today's Elbert and Lincoln County landscape occurred after the Ogallala Formation had been deposited, although it is possible that earlier phases of the large and long-lived south-oriented floods may been responsible for transporting and depositing Ogallala Formation alluvium which more recent flood flow movements subsequently eroded. However, Ogallala Formation history cannot be determined from the Elbert and Lincoln County detailed topographic map evidence alone, nor can the source of the immense south-oriented floods. Such determinations require evidence from much larger regions.

By itself the new paradigm solution to the Elbert and Lincoln County detailed topographic map drainage system and erosional landform puzzle is internally consistent, but to be meaningful it also needs to be consistent with surrounding region detailed topographic map drainage system and erosional landform evidence. Headward erosion of the east- and northeast-oriented South Platte River valley for example is interpreted in this paper to have beheaded and reversed south-oriented flood flow so as to create in sequence from east to west what are now long north-oriented South Platte River tributaries. If so, consistency requires detailed topographic map evidence to also show a reversal of south-oriented flood flow on what are now north-oriented South Platte River headwaters in the Rocky Mountain region to the west of the Elbert and Lincoln County study region and has been shown by Clausen [20] who interpreted detailed topographic map evidence south of Denver to demonstrate that the now north-oriented South Platte River headwaters valley originated as a south-oriented flood flow channel. Also, it should be possible to interpret detailed topographic map evidence in regions north of the Elbert and Lincoln County area to show south-oriented South Platte River tributaries originated in sequence from east to west and again, such consistency has also been shown by Clausen [17] who used detailed topographic map evidence to demonstrate the Lodgepole, Crow, Lone Tree, and Dale Creek valleys eroded headward from the South Platte River valley in an east to west sequence.

5. Conclusion

Drainage system and erosional landform evidence as depicted on United States Geological Survey detailed topographic maps of the Elbert and Lincoln County, Colorado region can be considered to be pieces of a solvable drainage history puzzle that has a unique solution. The unique solution requires that prior to headward erosion of what is now the deep and broad east- and northeast-oriented South Platte River valley and the uplift that raised the Elbert and Lincoln County region relative to regions further to the north and east, massive and prolonged south-oriented floods (flowing to what was probably an actively eroding east-oriented Arkansas River valley head) eroded the Elbert and Lincoln County landscape to create almost every drainage system and erosional landform feature large enough to be shown on USGS prepared detailed (1:24,000 scale) topographic maps. The long-lived south-oriented floods continued while regional uplift of the Elbert and Lincoln County region enabled a deep South Platte River valley to erode headward (from east to west) and to divert south-oriented floodwaters in east and northeast directions. The ability of a new Cenozoic geology and glacial history paradigm to explain in a logical and internally consistent manner the Elbert and Lincoln County detailed topographic map drainage system and erosional landform evidence (which previous investigators working from the accepted paradigm perspective have yet to explain) points out the geology research community's need (as an earlier paper [14] discusses in detail) to adopt a new and fundamentally different Cenozoic geology and glacial history paradigm which is able to explain detailed topographic map drainage system and erosional landform evidence.

Acknowledgements

Preliminary work leading to the new paradigm was done while employed as a faculty member at Minot State University where other faculty members, students, and library staff members greatly assisted with access to the then needed hard copy topographic maps.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

References

[1] Campbell, M.R. (1902) Masontown and Uniontown Folio, Pennsylvania. Geological Atlas of the United States Folio, United States Geological Survey, Reston, GF-82, 3-4.

[2] Stone, R.W. (1905) Waynesburg Folio, Pennsylvania. Geological Atlas of the United States Folio, United States Geological Survey, Reston, GF-121.

[3] Strahler, A.N. (1952) Dynamic Basis of Geomorphology. *Bulletin of the Geological Society of America*, **63**, 923-938. https://doi.org/10.1130/0016-7606(1952)63[923:DBOG]2.0.CO;2

[4] Kuhn, T.S. (1970) The Structure of Scientific Revolutions. 2nd Edition, Enlarged. The University of Chicago Press, Chicago, 210.

[5] Pearl, R.H. (1971) Pliocene Drainage of East-Central Colorado and Northwestern Kansas. The *Mountain Geologist*, **8**, 25-30.

[6] Scott, G.R. (1982) Paleovalley and Geologic Map of Northeastern Colorado. United States Geological Survey Miscellaneous Investigations Map I-1378 (Scale: 1:250,000), 12.

[7] Scott, G.R. (1982b) Paleovalley and Geologic Map of Northeastern Colorado. Text Accompanying United States Geological Survey Miscellaneous Investigations Map I-1378 (Scale: 1:250,000), 12.

[8] Madole, R.F. (1991) Colorado Piedmont. In: Morrison, R.B., Ed., *Quaternary Non-glacial Geology—Conterminous United States*, Vol. K2, Geological Society of America, Geology of North America, Boulder, 456-461.

[9] Leonard, E. (2002) Geomorphic and Tectonic Forcing of Late Cenozoic Warping of the Colorado Piedmont. *Geology*, **30**, 595-598. https://doi.org/10.1130/0091-7613(2002)030<0595:GATFOL>2.0.CO;2

[10] Sharps, J.A. (1980) Geologic Map of the Limon 1 Degree x 2 Degrees Quadrangle, Colorado and Kansas. United States Geological Survey Miscellaneous Investigations Series Map 1-1250 (Map Scale: 1:250,000).

[11] Scott, G.R., Taylor, R.B., Epis, R.C. and Wobus, R.A. (1978) Geologic Map of the Pueblo 1 Degree x 2 Degrees Quadrangle, South-Central Colorado. United States Geological Survey Miscellaneous Investigations Series Map I-1022 (Scale: 1:250,000).

[12] Tweto, O. (1979) Geologic Map of COLORADO. United States Geological Survey Map (Scale 1:500,000).

[13] Barkman, P.E., Sebol, L.A., Broes, L.D., McGee, K.H. (2021) Geology and Groundwater Resources of Elbert County, Colorado. Open-File Report OF-18-12, Colorado Geological Survey and Colorado School of Mines, 45. (Plus Appendices).

[14] Clausen, E. (2020) Analyzing Anomalous Topographic Map Drainage System and Landform Evidence as a Glacial History Problem: A Literature Review. *Open Journal of Geology*, **10**, 1072-1090. https://doi.org/10.4236/ojg.2020.1011052

[15] Batchelor, C.L., Margold, M., Krapp, M., Murton, D.K., Dalton, A.S., Gibbard, P.L., *et al.* (2019) The Configuration of Northern Hemisphere Ice Sheets through the Quaternary. *Nature Communications*, **10**, Article No. 3713. https://doi.org/10.1038/s41467-019-11601-2

[16] Clausen, E. (2020) North Platte River-South Platte River Confluence Area Drainage System History as Determined by Topographic Map Interpretation: Western Nebraska, USA. *Journal of Geography and Geology*, **12**, 28-39. https://doi.org/10.5539/jgg.v12n2p28

[17] Clausen, E. (2020) Use of Detailed Topographic Map Evidence of the Southern Wyoming Gangplank Area to Compare Two Fundamentally Different Geomorphology Paradigms, USA. *Open Journal of Geology*, **10**, 261-279. https://doi.org/10.4236/ojg.2020.104014

[18] Connor, J.E., Baker, V.R., Waitt, R.B., Smith, L.N., Cannon, C.M., George, D.L., *et*

al. (2020) The Missoula and Bonneville Floods—A Review of Ice-Age Mega Floods in the Columbia River Basin. *Earth Science Reviews*, **208**, Article ID: 103181. https://doi.org/10.1016/j.earscirev.2020.103181

[19] Higgins, C.G. (1990) Seepage-Induced Cliff Recession and Regional Denudation. In: Higgins, C.G. and Coates, D.B., Eds., *Groundwater Geomorphology*: *The Role of Subsurface Water in Earth-Surface Processes and Landforms*, Geological Society of America, Boulder, Special Paper No. 252, 291-318. https://doi.org/10.1130/SPE252-p291

[20] Clausen, E. (2021) How a New Geology and Glacial Paradigm Explains Colorado South Platte-Arkansas River Drainage Divide Topographic Map Evidence, USA. *Open Journal of Geology*, **11**, 573-595. https://doi.org/10.4236/ojg.2021.1111029