

How a New Cenozoic Geology and Glacial History Paradigm Explains Arkansas-Red River Drainage Divide Area Topographic Map Evidence in and near Pontotoc County, Oklahoma, USA

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Abstract

A new Cenozoic geology and glacial history paradigm (new paradigm), fundamentally different from the accepted Cenozoic geology and glacial history paradigm (accepted paradigm), describes a thick North American continental icesheet (located where continental icesheets are usually reported to have been) which by deep erosion and uplift of surrounding regions created and occupied a deep “hole” (the accepted paradigm does not see this thick ice sheet or the deep “hole”). Unusual erosional landform features in the south-east Oklahoma Pontotoc County region including the asymmetric Canadian-Red River drainage divide, a large escarpment-surrounded basin in which most south-oriented Clear Boggy Creek headwaters begin, and a large escarpment-surrounded upland on which the south-oriented Blue River begins, are used to test the new paradigm’s ability to use large and prolonged south-oriented melt water floods to explain previously unexplained or poorly explained detailed topographic map drainage system and erosional landform evidence. Numerous low points (referred to as divide crossings) indicate large and prolonged south-oriented melt water floods did flow across what is now the Canadian-Red River drainage divide (an interpretation also consistent with Clear Boggy Creek escarpment-surrounded basin and Blue River escarpment-surrounded upland shapes). The new paradigm described massive and prolonged melt water floods also account for previously unrecognized deep regional erosion (which is determinable from detailed topographic map evidence). East-oriented Canadian River valley headward erosion (from the Arkansas River valley) diverted the long-lived south-oriented meltwater

floods to the Arkansas River valley and to what ultimately became the deep “hole’s” only southern exit. Previous southeast Oklahoma drainage history interpretations (made from the accepted paradigm perspective in which Rocky Mountain glacier melt water flowed to east-oriented rivers) do not provide adequate water volumes or flow directions to explain the detailed topographic map drainage system and erosional landform evidence, which the new paradigm’s massive and prolonged south-oriented melt water floods do explain.

Keywords

Asymmetric Drainage Divide, Canadian River, Clear Boggy Creek, Escarpment-Surrounded Basin, Gerty Sand, Muddy Boggy Creek

1. Introduction

1.1. Statement of the Research Question

The Pontotoc County, Oklahoma area Arkansas-Red River drainage divide is located between the east-flowing Canadian River (with water flowing to the Arkansas River) and south-oriented Muddy Boggy Creek and its tributary Clear Boggy Creek (they eventually combine before joining the southeast-oriented Red River) and between north-oriented Canadian Sandy Creek (flowing to the Canadian River) and the south-oriented Blue River and Mill Creek (both flowing directly to the Red River) and south-oriented Rock Creek (flowing to the Washita River which then flows to the Red River). While Canadian River and Red River water eventually ends up reaching the Mississippi River delta, the routes traveled are quite different (see **Figure 1**). The east-oriented Canadian River flows from the Pontotoc County region before turning in a northeast direction to join the east-oriented Arkansas River which then flows between the Ozark Plateau (north) and Ouachita Mountains (south) to reach the south-oriented Mississippi River valley. South-oriented Clear Boggy Creek headwaters originate at Ada, Oklahoma at a point approximately ten kilometers to the south of the east-oriented Canadian River and soon enter a large escarpment-surrounded basin with floor elevations lower than the nearby Canadian River elevation. Just as intriguing is Muddy Boggy Creek which originates just east of Ada (and north of the large escarpment-surrounded basin rim) and flows for ten kilometers in a northeast direction to a point less than five kilometers from the Canadian River before turning in east and then south directions to eventually reach the southeast-oriented Red River. The Blue River originates on a large escarpment-surrounded upland (see **Figure 2** and **Figure 3** and is just west of the Clear Boggy Creek escarpment-surrounded basin and east of the Canadian Sandy Creek-Rock Creek drainage divide). To the west of the Blue River escarpment-surrounded upland is the somewhat more symmetric drainage divide between north-oriented drainage to the Canadian River and south-oriented Mill and

Rock Creeks (both flowing directly to the Washita River which then flows to the Red River). The research question addressed here is how did the asymmetric Canadian-Red River drainage divide, the large escarpment-surrounded basin surrounding most of the Clear Boggy Creek headwaters area, and the large escarpment-surrounded Blue River headwaters area upland originate?

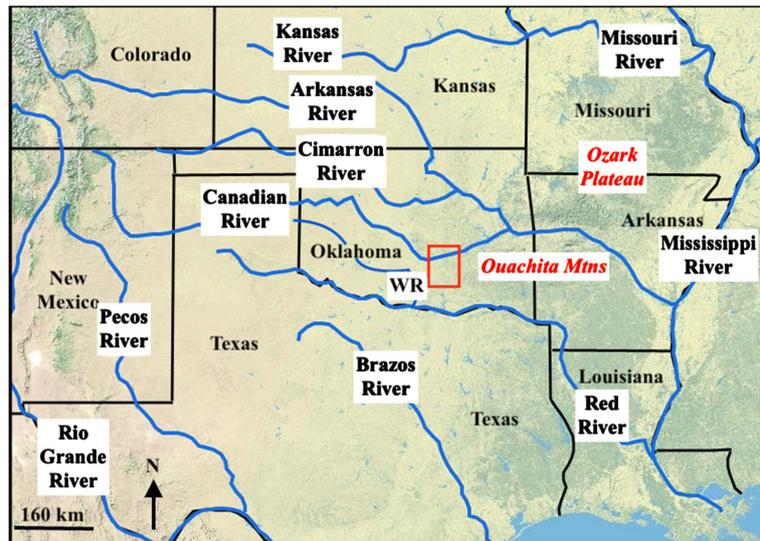


Figure 1. Modified map from the USGS National Map website [1] showing the study area (red rectangle), state lines, and major rivers. Letters WR are located where the Washita River flows in a south direction across the Arbuckle Mountains. Top left corner: Latitude $39^{\circ}8'N$, Longitude $106^{\circ}47'W$.

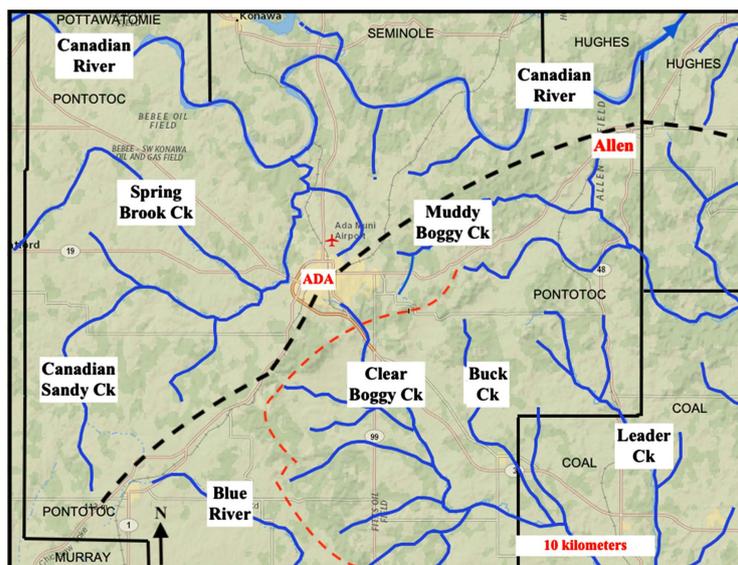


Figure 2. Modified map from the USGS National Map website [1] showing major northern Pontotoc County area drainage routes and approximate rim location (red dashed line) for the southeast-facing escarpment-surrounded basin. Solid black lines and the Canadian River identify county boundaries. Ada is the study region's largest town. The black dashed line shows the Canadian-Red River drainage divide (the Red River drainage basin is to the southeast). Top left corner: $34^{\circ}58'N$, $96^{\circ}57'W$.

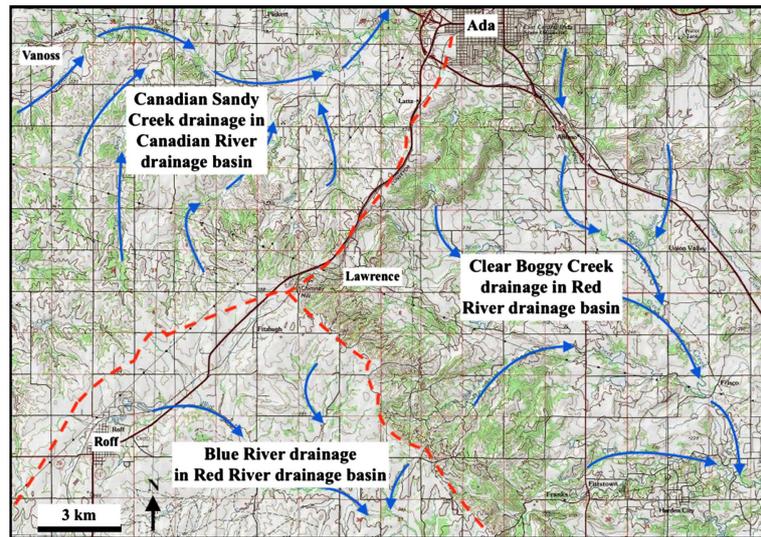


Figure 3. Modified topographic map from USGS National Map website [1] showing the Clear Boggy Creek escarpment-surrounded basin and Blue River escarpment-surrounded upland relationships to drainage divides (dashed red lines) and major drainage basins. The contour interval is 10 meters. Top left corner: 34°46'31"N, 96°04'44"W.

1.2. Geographic Setting

The red rectangle in **Figure 1** identifies the Pontotoc County, Oklahoma study region which straddles the Canadian-Red River drainage divide and which is located at the northeast end of deeply eroded Arbuckle Mountain geologic structures. The Canadian River is the southernmost of long east-oriented Arkansas River tributaries some of which originate in northeast New Mexico. In addition to the Canadian and Cimarron Rivers shown in **Figure 1** these east-oriented tributaries include the Little River (not shown but an eastern Oklahoma Canadian River tributary located north of the study area) and the North Canadian River (not shown but a long Canadian River tributary located north of the Little River and between the Cimarron and Canadian Rivers and which joins the Canadian River to the east of this paper's study area). After being joined by the North Canadian River the Canadian River joins the Arkansas River with their combined flow first moving eastward and then southeastward in the Arkansas River valley which is between the Ozark Plateau (north) and the folded Ouachita Mountains (south) before reaching the Mississippi River. **Figure 2** shows study region drainage routes in more detail with the asymmetric Canadian-Red River drainage divide located just south of the Canadian River and with Clear and Muddy Boggy Creek headwaters in the Red River drainage basin only a few kilometers to the south of the Canadian River. Also seen in **Figure 2** are north-oriented Canadian Sandy Creek and south-oriented Blue River headwaters (south-oriented Rock Creek is not shown but is west of the Blue River). Northeast-oriented Muddy Boggy Creek headwaters are north of the southeast-facing escarpment-surrounded basin in which most Clear Boggy Creek headwaters originate. United States Geological Survey (USGS) detailed topographic maps (at a scale of

1:24,000) cover the entire study region and are available on the USGS National Map website [1].

1.3. The Accepted Paradigm Problems

The accepted paradigm describes a Cenozoic geologic and glacial history during which an extensive north-oriented pre-glacial drainage system [2] developed in regions to the north of **Figure 1**. Late Cenozoic continental ice sheets blocked this pre-glacial north-oriented drainage system with the Missouri River forming when the north-oriented drainage encountered the ice margins and then was forced to flow along or near those continental ice sheet margins. The most important accepted paradigm interpretation pertinent to this paper is that while accepted paradigm investigators have described multiple Pleistocene continental ice sheets that existed to the north of **Figure 1** to date there have been no suggestions that melt water flowed from what is now the Missouri River drainage basin in south directions across Oklahoma and Texas to reach the Gulf of Mexico. Nor have there been any suggestions that a North American continental ice sheet formed and occupied a deep “hole” (the southern rim of which in the new paradigm is here interpreted to have been located along the Canadian-Red River drainage divide).

It is important to understand what in the Pontotoc County area the accepted paradigm Cenozoic geology and glacial history paradigm (accepted paradigm) cannot satisfactorily explain. The Canadian-Red River asymmetric drainage divide, southeast-facing escarpment-surrounded basin encircling the south-southeast oriented Clear Boggy Creek headwaters (see **Figure 3**), and northeast-oriented Muddy Boggy Creek headwaters (flowing towards the Canadian River) illustrate intriguing drainage system and erosional landform topographic map evidence, which geomorphologists relying on the accepted paradigm have yet to explain. While not able to explain most drainage system and erosional landforms seen on detailed topographic maps the accepted paradigm has enabled geomorphologists to describe in generalized ways how Oklahoma’s larger rivers developed. The Oklahoma Geological Survey explains Oklahoma’s drainage system history as follows [3] (p. 5). “During the 1.6 million-year-long period of Pleistocene continental glaciation the glaciers extended south only as far as northeastern Kansas. Major rivers fed by meltwater from Rocky Mountain glaciers and the increased precipitation associated with glaciation sculpted Oklahoma’s land. Today’s major drainage systems originated during the Pleistocene. The rivers’ shifting positions are marked by alluvial deposits left as terraces, now tens to hundreds of feet [1 ft = 0.3 m] above present-day flood plains.”

Evidence supporting the above Oklahoma drainage history interpretation are Quaternary terrace deposits shown on geologic maps. The USGS “Digital geologic map database for the State of Oklahoma” [4] shows extensive Quaternary terrace deposits adjacent to many Oklahoma rivers, including along drainage divides now separating what in places are closely spaced but independent river

valleys. Perhaps some of the most intriguing terrace deposits are in the Pontotoc County region where a discontinuous line of such deposits (known as Gerty Sand and also as Girty Sand) extends in a southeast and east direction across what is now the Canadian-Red River drainage divide. On detailed geologic maps [5] [6] [7] Gerty Sand deposits suggest a large river may have diverged from the present-day east- and northeast-oriented Canadian River and flowed across the present-day south-oriented Clear Boggy and Muddy Boggy Creek headwaters (where the water now flows to the Red River). Taff first mapped and described the Gerty Sand more than 100 years ago [8] (p. 4) and said, “At some remote time, yet of recent geologic age, a river flowed across the Coalgate quadrangle in a southeasterly direction from where the Canadian River now enters its the western side. The river at that time flowed about 100 feet [30 meters] above the present level of the Canadian River, and the remnants of the deposit of sand and gravel have an extreme thickness of about 50 feet [15 meters] and a width of nearly 3 miles [5 kilometers]. The sand, like that of the present Canadian, is spread evenly over the edges of older rocks, hard and soft.”

Hendricks in 1937 [9] published what still is one of the most detailed Gerty Sand reports in which he noted (p. 365) “the sand and gravel are almost entirely siliceous, the main constituents being quartz, quartzite, chert, flint, jasper, and silicified wood. H.D. Miser found one pebble of schist.” He described and includes a map of discontinuous Gerty Sand deposits that extend for approximately 150 kilometers from the Pontotoc County area to what is now the Poteau River drainage basin, which drains to the Arkansas River downstream from where the Canadian River now joins it. In terms of age Hendricks comments the silicified wood suggests a Cretaceous age although a single elephant tusk suggests a Pleistocene age. Describing the river history, he said (p. 367) the “Canadian River probably flowed eastward... across a widespread nearly level plain that stood at the level of the present tops of the highest hills of the region... and was at that time not cutting downward but migrating laterally and forming a wide alluvial plain. ...Later, probably in Pleistocene time, the Canadian River started cutting downward through its alluvium and into the folded shales and sandstones of Pennsylvanian age... this downcutting continued... until the river was flowing about 200 feet [60 meters] below the former level,” although he is uncertain as to what caused the downcutting. He sees “considerable evidence that the Canadian River flowed about at the level of the Gerty Sand for a rather long period.” He then describes a series of what might be considered speculative capture events to account for the Canadian River’s present route.

While the Gerty Sand is discussed in more recent publications those reports rarely go beyond what Hendricks said when discussing Canadian River history. For example, during the 1980s Gerty Sand terrace deposits were studied as potential aquifers [10] [11], but Canadian River history was not addressed. In the early 1990s Madole [12] (p. 522) when describing the Gerty Sand commented “The composition of the upland gravel, like that of the valley-floor and terrace

alluvium, indicates a Rocky Mountain rather than a local source. The small size and widely scattered distribution of the upland deposits do not permit confident reconstruction of paleovalley systems. The gravel caps hills as high as 60 m above present stream level but is present also in residual deposits on slopes and hilltops at lower levels.” Most recently, in 2020 Suneson [13] stated (p. 63) “the Girty Sand marks a former course of the Canadian River in southeastern Oklahoma about 20 to 25 miles [32 - 40 km] southeast of its present location”. In summary, the accepted paradigm interpretation is a possibly larger, but probably single channeled Pleistocene Canadian River originated in the Rocky Mountains and flowed for a long period of time along a Gerty Sand deposit indicated route and then through a series of complicated capture events developed a completely new route.

Geomorphologists who take the time to seriously study Ada, Oklahoma, area detailed topographic maps should find numerous problems with the above-described and commonly accepted Gerty Sand interpretation. Perhaps the most notable problem is Gerty Sand deposits in the Ada area are found along the present-day Canadian-Red River drainage divide only a short distance from what is now a south-facing escarpment bounding the south-oriented Clear Boggy Creek drainage basin (seen in **Figure 3**). Something eroded the large escarpment-surrounded basin (which is just to the south and southeast of the Ada area Gerty Sand deposits) either while the Gerty Sand was being deposited or after the Gerty Sand had been deposited. Otherwise, there is no way a large east-oriented ancestral Canadian River could have flowed along what is now the Ada area Canadian-Red River drainage divide without being diverted to flow in a south direction along the Clear Boggy Creek route to reach the southeast-oriented Red River. Further to the east (and just east of Pontotoc County) Gerty Sand deposits are mapped in what is now the Red River drainage basin. Yet, Hendricks and the other cited references say nothing about any Pleistocene or more recent events capable of eroding the escarpment-surrounded basin or about events that would have enlarged the Red River drainage basin to include regions once occupied by an east-oriented ancestral Canadian River channel. Other accepted paradigm problems include the fact that Clear and Muddy Boggy Creek headwaters now actually begin in locations where the hypothesized Canadian River channel must have been located and the Muddy Boggy Creek headwaters even flow for a short distance along what probably was the hypothesized Canadian River channel location. Further, the Hendricks sequence of capture events responsible for shifting the Canadian River route is complicated at best and improbable at worst.

1.4. The New Paradigm Problems

Because the accepted paradigm does not satisfactorily explain most detailed topographic map drainage system and erosional landform evidence the author of this paper spent considerable time using Missouri River drainage basin topo-

graphic map evidence to develop a Cenozoic geologic and glacial history paradigm (new paradigm). The new paradigm was specifically designed to explain as much of the Missouri River drainage basin topographic map evidence as possible and when developed did not consider topographic map evidence from other regions (such as the Oklahoma region discussed in this paper). The new paradigm is fundamentally different and incompatible with many accepted interpretations and leads to a Cenozoic geologic and glacial history that is incommensurable with what the accepted paradigm describes [14]. In brief the new paradigm describes a Cenozoic glacial history beginning with a thick continental ice sheet located where most accepted paradigm investigators see ice sheets to have been, but which deeply eroded the continent and which was heavy enough to raise surrounding regions including mountain ranges so as to create and occupy a deep “hole” (accepted paradigm researchers do not recognize comparable ice sheet deep erosion nor do they see a relationship between ice sheets and the surrounding region and mountain range uplift or the existence of an ice sheet created deep “hole”). Immense south-oriented melt water floods initially flowed from this thick ice sheet across the rising deep “hole” rim (including across rising mountain ranges) but were progressively diverted by deep “hole” rim uplift toward the Mississippi River valley which in time became the deep “hole’s” only southern exit.

The new paradigm’s thick ice sheet eventually decayed with giant ice-walled and ice-floored (and later bedrock-floored) canyons slicing into its surface. Erosional escarpments in North and South Dakota, southwest Minnesota, southwest Manitoba, and southern Saskatchewan are interpreted to be ice-walled and bedrock-floored canyon wall remnants (the accepted paradigm has trouble explaining those escarpments). The giant ice-walled canyons cut into the ice sheet’s surface and opened-up space the thick ice sheet had once occupied permitting north-oriented valleys to erode headward from that newly opened-up space into what is now the northern Missouri River drainage basin. The north-oriented valleys captured what by that time had become immense south-east-oriented ice-marginal melt water floods (the accepted paradigm considers those north-oriented valleys to be components of the pre-glacial Bell River drainage system [2] [15] [16]). At first the large and captured meltwater floods moved through the ice-walled canyons to reach the south-oriented Mississippi River valley (near Saint Paul, MN) and the lower Missouri River valley (near Yankton, SD). As ice sheet melting continued the ice-walled and bedrock-floored canyon network expanded and opened-up new and shorter routes across the deep “hole” floor (between what had become detached thick ice sheet remnants) to the North Atlantic and Arctic Oceans. The reversal of the large melt water floods from flowing to the Gulf of Mexico to flowing to the North Atlantic and Arctic Oceans ended climatic conditions responsible for the ice sheet’s decay and plunged North America into what the accepted paradigm considers to be an ice age, which caused the north-oriented drainage to freeze around what were then detached thick ice sheet remnants so as to form a second and much thinner con-

tinental ice sheet (which was also responsible for glaciation in the then newly uplifted Rocky Mountains).

The Pontotoc County region from the new paradigm perspective contains significant erosional landform features. Perhaps the most important is the Canadian-Red River drainage divide which includes some of the lowest elevations found along the boundary between east-oriented drainage to the Arkansas River (which flows between the Ozark Plateau (north) and Ouachita Mountains (south) to reach the south-oriented Mississippi River) and the southeast-oriented Red River (flowing more directly and southwest of the Ouachita Mountains to reach the Mississippi River delta in southern Louisiana). This boundary has recently been identified as the new paradigm's deep "hole" rim's probable southern margin [17]. The new paradigm predicts immense south-oriented melt water floods first flowed across the deep "hole" rim before rim uplift caused east-oriented Mississippi River tributary valleys to erode headward, which diverted the enormous south-oriented melt water floods toward the south-oriented Mississippi River valley (which in time became the deep "hole's" only southern outlet). These new paradigm predictions mean detailed topographic maps of the Pontotoc County area Canadian-Red River drainage divide region should show evidence that headward erosion of east-oriented Arkansas River tributary valleys captured massive south-oriented floods that had been flowing toward the Red River valley so as to divert the floodwaters to flow toward the Arkansas River (and Mississippi River) valley.

Assuming the new paradigm does satisfactorily explain the Pontotoc County region drainage system and erosional landform detailed topographic map evidence problems remain. From the new paradigm perspective, the two above-described linked continental ice sheets account for almost all topographic map recorded drainage system and erosional landform evidence (in the lower 48 states of the United States). In other words, the new paradigm leads to a Cenozoic geologic and glacial history needing only two linked North American continental icesheets, yet the accepted paradigm has caused geologists to claim multiple North American Cenozoic continental ice sheets formed and melted [18] and their claim is entrenched in the geologic literature. And the inconsistency gets even bigger because from the accepted paradigm perspective valleys eroded by new paradigm melt water floods contain Oligocene and Miocene (and possibly Eocene) sediments [19]. In brief, the new paradigm leads to a significantly different Cenozoic geologic and glacial history than what geologists working from the accepted paradigm perspective have developed. According to Kuhn [20] the important question is not which paradigm is correct, but instead which paradigm best explains the evidence. The study reported here seeks to determine which of the two paradigms best explains Pontotoc County region detailed topographic map drainage system and erosional landform evidence.

2. Research Method

The new paradigm was developed by interpreting what accepted paradigm re-

searchers consider to be preglacial [2] north- and northeast-oriented valleys in North and South Dakota to have eroded headward from a continental icesheet location across previously unrecognized immense ice sheet-marginal meltwater floods (which had flowed in large southeast-oriented anastomosing channel complexes). The headward erosion of deep valleys across large anastomosing channel complexes was noted to commonly leave what are today asymmetrical drainage divides such as the Little Missouri-Missouri River drainage divide seen in southwest North Dakota and northwest South Dakota which previous new paradigm publications have described [21]. Large escarpment-surrounded basins were noted to sometimes be located a short distance downstream (in the flood flow direction) from north-oriented valleys which had eroded headward across the southeast-oriented floodwaters such as seen at the Jump-Off escarpment-surrounded basin in Harding County, South Dakota (which is located about 2 kilometers to the east of the north-oriented Little Missouri River—see **Figure 3** in reference [22]). Finally, escarpment-surrounded upland drainage basins such as the north-oriented Beaver Creek headwaters drainage basin located along the Montana-North Dakota border between the north-oriented Yellowstone and Little Missouri River drainage basins (see **Figure 4** in reference [23]) represented a third distinctive meltwater flood eroded landform feature. Research for this paper consisted of studying Pontotoc County, Oklahoma area detailed topographic maps to identify erosional landforms similar to those seen near the ice sheet margin and then applying what had been learned during the new paradigm development process to interpret the Pontotoc County region geomorphic history.

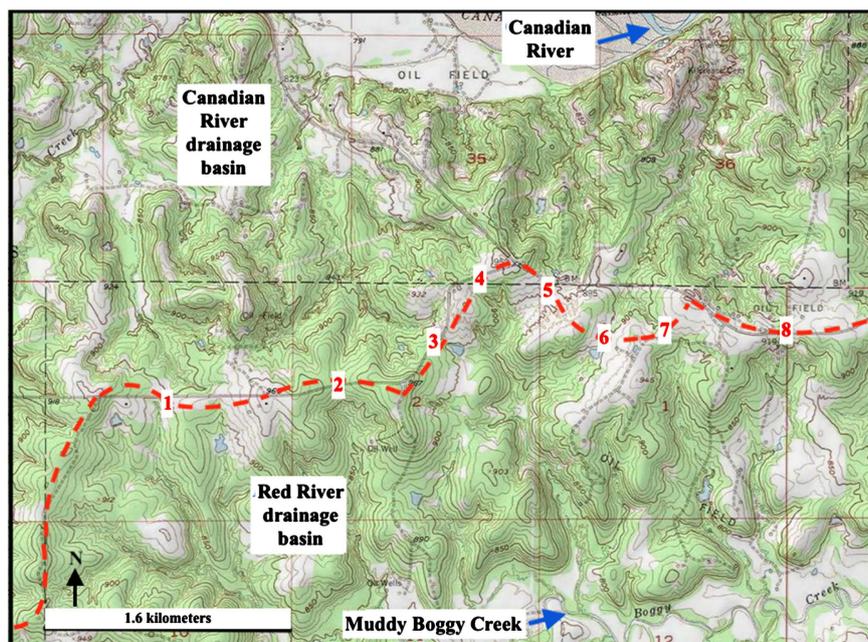


Figure 4. Modified detailed topographic map from the USGS National Map website [1] showing the Canadian-Red River drainage divide (red dashed line) in northeast Pontotoc County. Numbers identify divide crossings (low points on the divide). The contour interval is 10 feet (3 meters). Top left corner: 34° 52'15"N, 96° 34'19"W.

Detailed topographic maps and tools available on the USGS National Map website [1] were used to conduct the study reported here. While now available in digital format 1:24,000 scale USGS produced hard copy maps show all of the required information. The hard copy maps have been available for at least 50 years while digital versions have been available for approximately 20 years yet with rare exceptions represent a vast warehouse of unstudied and unexplained drainage system and erosional landform information. Unlike most accepted paradigm investigators who prefer more sophisticated tools and methods the study reported here is based on simple map reading techniques used to interpret drainage system and erosional landform information found on the USGS produced 1:24,000 scale topographic maps. A major goal was to identify Pontotoc County drainage system and erosional landform features similar to previously studied new paradigm interpreted Missouri River drainage basin drainage system and erosional landforms. Major drainage divides were located and low points along those drainage divides (divide crossings) were identified. Of particular interest were the Pontotoc County area asymmetric Canadian-Red River drainage divide, the Clear Boggy Creek escarpment-surrounded headwaters basin, and the Blue River escarpment-surrounded headwaters upland because those features are similar to asymmetric drainage divides, escarpment-surrounded basins, and escarpment-surrounded uplands found within the Missouri River drainage basin. In addition, abandoned valleys were used to identify former drainage route locations and characteristics (which included consideration of the possibility of massive floods moving across the region in large anastomosing channel complexes).

3. Results

3.1. Canadian-Red River Asymmetric Drainage Divide

The new paradigm predicts large south-oriented melt water floods flowed across the Pontotoc County region before being captured by headward erosion of east-oriented tributary valleys from the south-oriented Mississippi River valley. **Figure 4** shows a detailed topographic map of the northeast Pontotoc County location where the east-oriented Canadian River is now less than 2 kilometers to the north of the Canadian-Red River drainage divide. In the figure Muddy Boggy Creek flows in an east direction (after having flowed in a northeast direction to reach the figure area) and to the east of the figure Muddy Boggy Creek turns in south and south-southeast directions to eventually reach the Red River (which as the crow flies is 130 kilometers to the south-southeast). Red numbers identify obvious divide crossing (or low points along the drainage divide) where water once flowed from what is now the Canadian River drainage basin into what is now the Red River drainage basin. Similar divide crossings are found along most Canadian-Red River drainage divide sections and suggest the east-oriented Canadian River valley eroded headward across a large south-oriented anastomosing channel complex, which in the **Figure 4** area had previously been captured by headward erosion of the northeast- and east-oriented Muggy Boggy Creek

valley. While not seen similar divide crossings are found along the Muddy Boggy-Sincere Creek drainage divide to the south of the figure. Today Sincere Creek flows in a north-northeast and southeast direction to join south-oriented Muddy Boggy Creek, but the north-oriented Sincere Creek headwaters valley is linked by divide crossings to south-oriented Clear Boggy Creek tributaries indicating multiple streams of south-oriented water once flowed across the **Figure 4** area to eventually reach south-southeast oriented Clear Boggy Creek.

The **Figure 4** map area is between mapped Gerty Sand deposits at the Ada Airport and at the town of Allen [5] (which is approximately 25 kilometers to the east-northeast of Ada). The Gerty Sand deposit located at Gerty in adjacent Hughes County (see **Figure 5**) is approximately 11 kilometers east of the Ponto-toc County line and 12 kilometers southeast of Allen. As seen in **Figure 5** the Gerty Sand deposit forms a low upland most of which is located to the south of the Canadian-Red River drainage divide. The marked divide crossings suggest south-oriented streams of water flowed from the Canadian River drainage basin around the Gerty Sand deposit to enter the Red River drainage basin and may have been responsible for the Gerty Sand deposition. To the southeast of Gerty and completely within the Red River drainage basin are other mapped Gerty Sand deposits suggesting the Gerty Sand is not just a Canadian River drainage basin deposit, although the Ada Airport Gerty Sand and mapped Gerty Sand deposits to the west of Ada are located within the Canadian River drainage basin. Mapped Gerty Sand locations west of Ada and east and southeast of Allen are such that it is difficult to see how an east-oriented ancestral Canadian River could have deposited them.

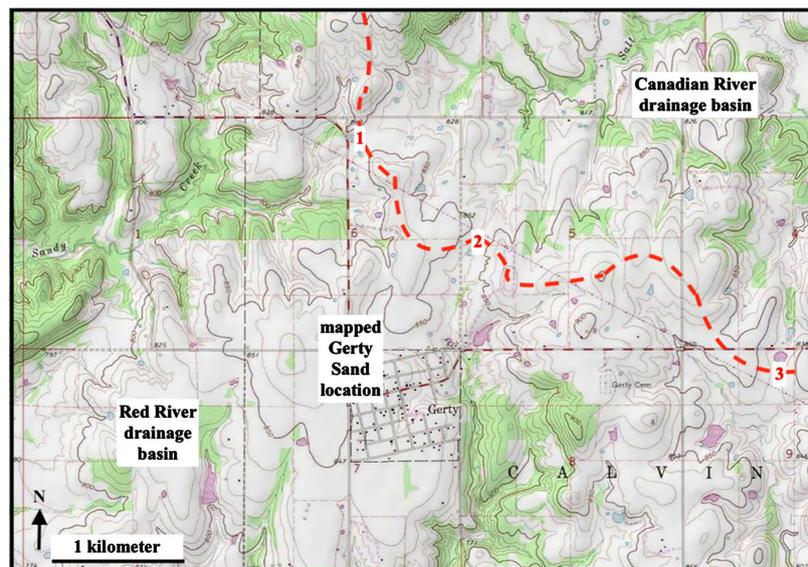


Figure 5. Modified topographic map from the USGS National Map website [1] showing divide crossings (red numbers) along the Canadian-Red River drainage divide (red dashed line). Note how the drainage divide crosses and is also located mostly to the north of the mapped high area on which the Gerty Sand deposit is located. The contour interval is 10 feet (3 meters). Top left corner: 34°51'50"N, 96°19'12"W.

3.2. Clear Boggy Creek Escarpment-Surrounded Basin

Southeast- and northeast-facing erosional escarpments ranging from 50 to 100 meters in height surround much of the Clear Boggy Creek headwaters area as seen in **Figure 3**. These escarpments form what this paper refers to as the Clear Boggy Creek escarpment-surrounded basin. A study of the Ada area geologic map [5] indicates the escarpments sometimes follow geologic features, although in other places the escarpments cross geologic units and structures. The Clear Boggy Creek escarpment-surrounded basin floor is almost everywhere lower in elevation than the Canadian River, which is just 15 kilometers to the north and which has an elevation of 254 meters where Canadian Sandy Creek joins it (to the north of Ada). The City of Ada and a mapped Gerty Sand deposit sit on or near the drainage divide between the Canadian River and the south-oriented Clear Boggy Creek escarpment-surrounded basin and have elevations of 300 to 325 meters while Clear Boggy Creek headwaters where they enter the escarpment-surrounded basin (just to the south of Ada) have an elevation of 247 meters with the Clear Boggy Creek valley elevation then decreasing to less than 230 meters in just five kilometers. Erosion of the basin meant large volumes of water must have stripped 50 to 100 or more meters of bedrock from many hundreds of square kilometers of Pontotoc County.

The Clear Boggy Creek escarpment-surrounded basin is similar in many ways to Missouri River drainage basin escarpment-surrounded basins which became important evidence during the new paradigm's construction. Briefly the new paradigm interprets escarpment-surrounded basins to be flood-formed head-cuts-abandoned when a valley eroded headward across the upstream flood route and diverted the flood flow in a different direction. As previously mentioned, the Harding County, South Dakota Jump-Off escarpment-surrounded basin is interpreted to be a large head-cut that was abandoned when headward erosion of the north-oriented Little Missouri River valley captured massive southeast- and east-oriented ice sheet-marginal melt water floods which had been flowing into what is now the northwest South Dakota Grand River drainage basin [22]. Another new paradigm demonstration paper interprets the Montana Hoskins escarpment-surrounded basin as a giant head-cut abandoned when headward erosion of the northeast- and north-oriented Musselshell River valley captured immense southeast-oriented ice sheet-marginal meltwater floods that had been flowing into the Yellowstone River valley [24]. Also, near the continental ice sheet margin and described in a previously cited paper [21] another large east-oriented escarpment-surrounded basin is located at the North Dakota Russian Springs Escarpment western end and is interpreted to be a flood-formed head-cut abandoned when the north-oriented Little Missouri River valley eroded headward to capture large ice sheet-marginal floods that had been flowing into the developing east-oriented Knife River drainage basin.

Missouri River drainage basin escarpment-surrounded basins (such as the Jump-Off, Hoskins Basin, and Russian Springs Escarpment western end) were

used during new paradigm development process to check previously interpreted (by the use of divide crossings along drainage divides) meltwater flood flow directions by assuming (unless there was reason to believe otherwise) each escarpment-surrounded basin opened in the direction a large melt water flood had once flowed. While the “V”-shaped notch at Lawrence suggests large amounts of east-oriented flood water may have entered the Clear Boggy Creek escarpment-surrounded basin the southeast-orientation of the Clear Boggy Creek drainage system and northeast-facing basin escarpment wall suggest the most intense flood flow was in a southeast direction. If correctly interpreted, the massive southeast-oriented flood flow was eroding the southeast-facing basin wall headward in a northwest direction. Southeast-oriented Canadian River valley segments, southeast-oriented Spring Brook Creek, and southeast-oriented Canadian Sandy Creek segments and tributaries seen in **Figure 2** also support a southeast-oriented flood flow direction and suggest headward erosion of the east-oriented Canadian River valley (in the area to the area north of Ada) and of the north-oriented Canadian Sandy Creek valley (to the west of Ada) captured the southeast-oriented flood waters and left the Clear Boggy Creek escarpment-surrounded basin as a large abandoned head cut similar to previously described Missouri River drainage basin escarpment-surrounded basins.

3.3. Blue River Escarpment-Surrounded Upland

The Blue River (as seen in **Figure 3** and **Figure 6**) originates as a north-northeast oriented stream on an escarpment-surrounded upland referred to here as the Blue River escarpment-surrounded upland. After flowing in a north direction near the upland’s northwest-facing escarpment the Blue River turns in an east

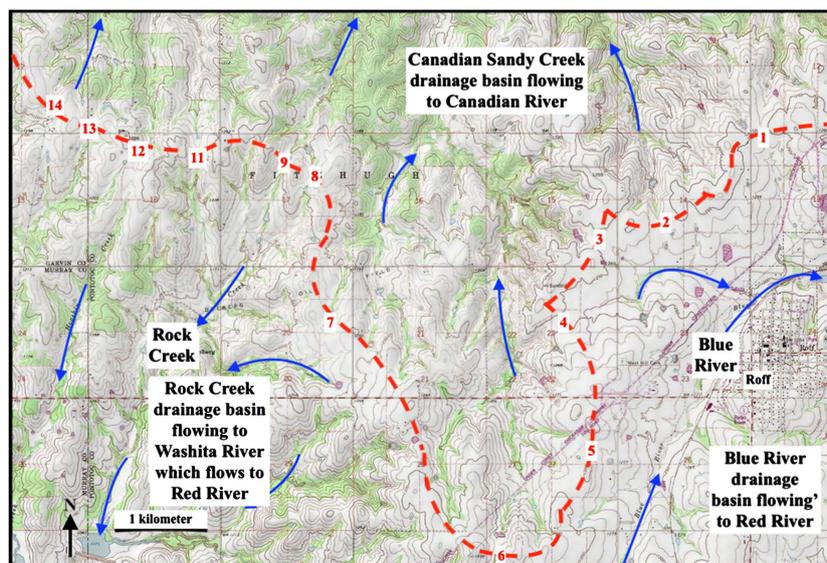


Figure 6. Modified topographic map from USGS National Map website [1] showing the Canadian-Red River drainage divide (red dashed line) on and west of the Blue River escarpment-surrounded upland. Numbers identify the most obvious divide crossings. The contour interval is 10 feet (3 meters). Top left corner: 34° 39' 58" N, 96° 56' 30" W.

direction just to the north of the town of Roff before turning in southeast and then south-southeast directions to flow near and roughly parallel to the upland's northeast-facing escarpment with all of the upland areas to the north of the Blue River U-turn draining to the Blue River. The V-shaped Blue River escarpment-surrounded upland points in a northward direction with its 75-to-100-meter-high northeast-facing wall draining to southeast-oriented Clear Boggy Creek and eventually to the Red River. The 40-to-70-meter-high and somewhat less well-defined northwest-facing wall's northern end drains to north-oriented Canadian Sandy Creek which flows to the east-oriented Canadian River while further to the south the upland's northwest-facing wall drains to south-southwest oriented Rock Creek and the Washita River (which then flows to the Red River). The Canadian-Red River drainage divide extends westward from the Blue River escarpment-surrounded upland and is crossed by many divide crossings as seen in **Figure 6**.

The Blue River escarpment-surrounded upland is a remnant of the regional erosion surface that must have existed before flood erosion scoured out the Clear Boggy Creek escarpment-surrounded basin (to the east) and lowered the Canadian-Washita (Red) River drainage divide area (to the west,) although geologically much of the upland is underlain by Ordovician bedrock while younger Paleozoic age bedrock is found in lower elevation areas to the east and west [5]. Initially, south-oriented floodwaters flowed from the north into what is now the Blue River drainage basin with south-oriented water on what is now the north-oriented Blue River headwaters alignment flowing to either southeast-oriented Little West Creek (which is a Blue River tributary), south-oriented Mill Creek (which like the Blue River flows to the Red River), and/or Rock Creek (which flows to the Washita River). Numbers 1, 2, and 3 in **Figure 6** identify divide crossings where water from the north probably flowed onto the upland surface before the surrounding region erosion and number 4 identifies a divide crossing where south-oriented flow from the upland surface probably moved into what is now the north-oriented Canadian Sandy Creek drainage basin (but which at that time may have flowed to the Rock Creek drainage basin). Eventually as south-oriented floodwaters continued the southeast-oriented Clear Boggy Creek escarpment-surrounded basin was scoured out to the east while the Canadian-Washita (Red) River drainage divide was lowered to the west which ended all south-oriented flood flow into the present-day Blue River headwaters area. Headward erosion of the east-oriented Canadian River valley subsequently captured the south-oriented floodwaters causing reversals of flow on what are today north-oriented drainage routes. Evidence for those reversals of flow can be seen in the form of southeast-oriented Canadian Sandy Creek segments and barbed (southeast-oriented) tributaries joining north-oriented Canadian Sandy Creek (see **Figure 2**).

The geologically influenced Blue River escarpment-surrounded upland surface is what remains of a former erosion surface that probably once extended across much or all of the Pontotoc County region. Now much of the Pontotoc County

region surface elevation is from 50 to 150 meters lower than the Blue River escarpment-surrounded upland surface suggesting that many hundreds of cubic kilometers of bedrock material have been removed with most of that material eroded from what is now the Red River drainage basin. Vast volumes of water were needed to erode and transport such large amounts of Pontotoc County bedrock material to the Mississippi delta and most of that water had to flow in a south direction across the Pontotoc County region to reach the southeast-oriented Red River. The numerous divide crossings seen on detailed topographic maps further show massive amounts of south-oriented water once flowed across the Pontotoc County area Canadian-Red River drainage divide into what are now the Rock, Clear Boggy, and Muddy Boggy Creek drainage basins (all of which are included in the much larger Red River drainage basin). This major Pontotoc County erosion event must have taken place before Canadian River valley development and prior to formation of what is today the Canadian-Red River drainage divide.

4. Discussion

The new paradigm interpretation that east-oriented Canadian River valley headward erosion across massive and prolonged south-oriented melt water floods explains Pontotoc County, Oklahoma, region detailed topographic map drainage system and erosional landform evidence much better than the accepted paradigm's more generalized interpretation that Oklahoma's east-oriented rivers are the result of increased Pleistocene precipitation and melt water from Rocky Mountain glaciers. To fully understand the significance of this observation, the Pontotoc County region should be viewed as just one small geographical region in a much larger geographic picture. In the western United States, the deep "hole" rim extends southward along the Montana, Wyoming, Colorado east-west continental divide and then southward along the Sangre de Cristo Mountains crestline into northern New Mexico before turning in an eastward direction along the divide between drainage flowing to the Arkansas River (via the Canadian River) and drainage flowing more directly to the Gulf of Mexico (via the Rio Grande and Red Rivers). With elevations ranging from about 270 to 400 meters the Pontotoc County region Canadian-Red River drainage divide has some of the lowest elevations (other than in the Mississippi Valley itself) found along the deep "hole" rim's western section. East of the Mississippi River the deep "hole" rim extends eastward and northeastward along the Ohio River-Gulf of Mexico and Ohio River-Atlantic Ocean drainage divides.

The new paradigm's deep "hole" formed when a thick North American continental ice sheet (located where accepted paradigm researchers consider continental ice sheets to have been) deeply eroded the underlying bedrock and due to its weight caused surrounding regions including mountain ranges and plateau areas to rise. The thick continental ice sheet when fully developed contained as much water as a small ocean and stood high enough to attract (at least along its margins) heavy precipitation (snow). Ice flow caused the ice sheet to extend

southward into climatic zones where at least during summer months significant melting occurred, although heavy snowfalls occurring at the ice sheet's higher elevations balanced ice sheet margin melting. Ice sheet marginal melting produced gigantic and prolonged melt water floods only able to flow in south directions. These huge melt water floods (while perhaps seasonal) continued year after year and were not short-lived catastrophic floods of types accepted paradigm researchers have described in the Columbia River drainage basin [25]. Initially the new paradigm's massive and prolonged melt water floods flowed in south directions across the still rising deep "hole" rim (including across rising mountain and plateaus), but in time deep "hole" rim uplift and headward erosion of deep valleys diverted the melt water floods to what were still lower elevation deep "hole" rim locations with the south-oriented Mississippi River valley eventually becoming the deep "hole's" only southern exit. However, before headward erosion of the east-oriented Arkansas River valley (between the rising Ozark Plateau to the north and Ouachita Mountains to the south) and headward erosion of its east-oriented Canadian River tributary valley (to the west of the Ozark Plateau and Ouachita Mountains) immense melt water floods flowed in south directions from the ice sheet margin across eastern Oklahoma into what is now the Red River drainage basin.

The Canadian River and other Oklahoma rivers according to at least some of accepted paradigm literature developed during the Pleistocene as water from Rocky Mountain glaciers flowed eastward across Oklahoma. How the Canadian and other Oklahoma rivers developed their present-day courses is usually left for future geomorphologists to discover, although further to the west geomorphologists who followed accepted paradigm rules and assumptions tried to reconstruct the Canadian River's late Cenozoic history [26] [27]. These accepted paradigm interpretations suggest most melt water from Pleistocene Southern Rocky Mountain glaciers would have probably flowed to what are now the Rio Grande, Pecos, Cimarron, North Canadian, and Arkansas Rivers with only a limited amount of the alpine glacier melt water flowing to an ancestral Canadian River. Further, Pleistocene Southern Rocky Mountain glaciers as described in the published literature simply were not large enough to account for the amount of Pontotoc County region erosion determinable from topographic maps. In contrast Canadian River valley headward erosion is consistent with new paradigm interpretations of northeastern New Mexico detailed topographic map evidence which show headward erosion of the Canadian River valley and Canadian River tributary valley captured what were multiple south-oriented flood flow channels [18] and is also consistent with new paradigm interpretations of detailed topographic map evidence which was interpreted to show how the east-oriented Sweetwater River valley eroded headward along a high elevation central Wyoming east-west continental divide and deep "hole" rim segment [28].

5. Conclusions

Pontotoc County, Oklahoma, region detailed topographic map drainage system

and erosional evidence can be explained if massive and prolonged south-oriented continental ice sheet melt water floods eroded and helped shape the Clear Boggy Creek escarpment-surrounded basin and Blue River escarpment-surrounded upland and if headward erosion of the east-oriented Canadian River valley (from the Arkansas River valley) across the large and prolonged south-oriented floods created the asymmetric Canadian-Red River drainage divide. Such an interpretation is consistent with new paradigm predictions that prior to deep “hole” rim uplift immense south-oriented melt water floods flowed across eastern Oklahoma and that as deep “hole” rim uplift occurred east-oriented valleys eroded headward from the south-oriented Mississippi River valley so as to divert the enormous south-oriented melt water floods to what ultimately became the deep “hole’s” only southern exit. Pontotoc County region drainage system and erosional landform detailed topographic map evidence supports a new paradigm Cenozoic geology and glacial history interpretation and does not support the accepted paradigm’s Cenozoic geology and glacial history interpretation.

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Conflicts of Interest

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

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