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Topographic Map Interpretation of Bighorn River-Wind River Drainage Divide Located East of Wyoming's Wind River Canyon, USA

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Abstract Detailed topographic map evidence is used to test the ability of two fundamentally different regional geomorphology paradigms to explain Bighorn-Wind River drainage divide evidence in the Copper and Lysite Mountain areas between Wind River Canyon and the Bighorn Mountains. Identified divide crossings were interpreted to be places where water had once flowed across what is now a major drainage divide. More than 20 such divide crossings were identified and ranged in elevation from 1924 to 2485 meters and could all be linked to north-oriented Bighorn River tributaries and also to south-oriented streams flowing to west-oriented Badwater Creek (a Wind River tributary). Lowest elevation divide crossings were located to the north of both Copper Mountain and Lysite Mountain. An attempt was first made to explain each identified divide crossing or group of divide crossings from the accepted paradigm's perspective, which requires drainage routes to have originated on the surface of a hypothesized Oligocene and Miocene sediment cover that buried the drainage divide area with the drainage routes eroding down through the sediment cover as the drainage divide was exhumed. Next the same evidence was interpreted from a recently proposed paradigm's perspective, which requires massive south- and southeast-oriented floods to have flowed across the Missouri River drainage basin as mountain ranges and plateau areas were being uplifted. The accepted paradigm could not easily explain the large number of observed divide crossings, many divide crossing details, and why geologic maps show few or no hypothesized sediment cover remnants. The new paradigm explained the large number of observed divide crossing and most observed divide crossing details and did not require an Oligocene and Miocene sedimentary cover.

Keywords Birdseye Pass, Copper Mountain, Drainage Divide Crossing, Lysite Mountain, Paradigm Comparison, Regional Geomorphology Paradigm, Sioux Pass

1. Introduction

1.1. Statement of the Problem

Kuhn [1] describes paradigms as rules and ideas governing a scientific discipline's research efforts that by themselves are neither correct nor incorrect, but that are judged on their ability to explain evidence and to open up new research opportunities. Kuhn also notes that from time to time an accepted paradigm will fail to explain observed evidence with the anomalous evidence being dealt with in one of three ways: first, the evidence is eventually explained and the accepted paradigm continues without serious interruption; second, the evidence is described and labelled and put on the shelf for future study; and third, a new paradigm emerges (that successfully explains the previously unexplained evidence) and a battle develops over which paradigm should be used. While rarely recognized, detailed topographic maps contain vast quantities of unexplained and shelved geomorphological evidence. Such anomalous evidence identifies previously unexplained drainage divides, low points notched into drainage divides, drainage route orientations, barbed tributaries, and elbows of capture that have been used to construct a new regional geomorphology paradigm [2], which is defined by a requirement that massive south- and southeast-oriented continental ice sheet meltwater floods flowed across what is now the entire Missouri River drainage basin, including what are now high mountain and plateau areas. The study reported here used topographic maps to test whether a paradigm with such a requirement can explain erosional landform features along and near the Bighorn-Wind River drainage divide segment located to the east of Wind River Canyon.

The new regional geomorphology paradigm (new paradigm) and the accepted regional geomorphology paradigm (accepted paradigm) are incompatible with each other and fundamentally different especially in terms of how they interpret Wyoming landscapes. In brief the new paradigm requirement forces recognition of a thick North American continental ice sheet that through deep ice sheet erosion and ice sheet related crustal warping created and occupied a deep "hole" with a segment of the deep "hole" rim following what today is the North American east-west continental divide from northern Colorado across Wyoming and Montana and into Canada. From the accepted paradigm perspective, the new paradigm requirement is impossible because no such deep "hole" exists and also because a pre-glacial northeast-oriented regional slope would have prevented continental ice sheet melt water floods from reaching any Wyoming areas, much less from crossing what are today high Wyoming mountain ranges. The accepted paradigm requires topographic map evidence to be interpreted from the perspective of a pre-glacial north-oriented Bighorn Basin drainage system (north of the Bighorn-Wind River drainage divide) while the new paradigm requires topographic map evidence to be interpreted from the perspective of immense south-oriented floods that flowed through the Bighorn Basin and across the Bighorn-Wind River drainage divide area and southward into Colorado. The paradigm test conducted here looked at the Bighorn-Wind River drainage divide segment to the east of Wind River Canyon to determine which of these two fundamentally different paradigm perspectives best explains the detailed topographic map evidence.

1.2. Bighorn-Wind River Drainage Divide to the East of Wind River Canyon Geographic Setting

Central Wyoming's Bighorn-Wind River drainage divide area to the east of Wind River Canyon consists of the Bridger Range at location number "1" (in figure 1) and Lysite Mountain (not labelled, but between the Bridger Range and the Bighorn Mountains). Number "2" is the Owl Creek Range, which forms the Bighorn-Wind River drainage divide west of Wind River Canyon. The Wind River today flows in a southeast direction between the Wind River Mountains ("4") and the Owl Creek Range into the Wind River Basin where it turns in a north direction to flow through Wind River Canyon (between the Owl Creek and Bridger Ranges) to enter the Bighorn Basin where the river name changes to becomes the Bighorn River. In figure 1 the unnamed west-oriented Wind River tributary to the south of the Bridger Range and Lysite Mountain is Badwater Creek. North of Lysite Mountain is the north- and northwest-oriented Nowood River ("7"). In the figure 1 southeast corner is the north- and east-oriented North Platte River, which begins in northcentral Colorado mountains and flows in a northwest and north direction to reach figure 1 where it cuts across the Laramie Range ("5") northwest end and turns in an east and southeast direction with its water eventually reaching the Missouri River. East of the Bighorn Mountains ("3") is the Powder River Basin and the north-oriented Powder River ("6"). North of figure 1 the Bighorn River and the Powder River flow into Montana where they join the northeast-oriented Yellowstone River, which near the Montana-North Dakota border joins the east-oriented Missouri River, which after turning in southeast, south, and east directions joins the south-oriented Mississippi River with its water flowing to the Gulf of Mexico.

The rectangular shaped study region shown in figure 1 includes drainage basins of streams now originating along the Bighorn-Wind River drainage divide segment east of Wind River Canyon. To the south of that drainage divide segment south-oriented streams drain to west-oriented Badwater Creek and then to the north-oriented Wind River, which after flowing through Wind River Canyon becomes the Bighorn River. Bighorn River tributaries draining the drainage divide's north side from west to east are Buffalo Creek, Kirby Creek, Nowater Creek, and the Nowood River. Buffalo Creek joins the Bighorn River a short distance north of the Bridger Range, but Kirby and Nowater Creek, like the Nowood River, flow for considerable distances in north and northwest directions on the Bighorn Basin floor before joining the Bighorn River. The Nowood River flows near the Bighorn Mountains western flank and is joined by several southwest-oriented streams as barbed tributaries (only hinted at in figure 1), while other south-oriented tributaries from the east make U-turns before flowing in northwest directions to join the north-oriented Nowood River.

Looking at the big picture regional drainage picture (seen in figure 1) several puzzling observations stand out. First, there is no observable reason why the southeast-oriented Wind River should abruptly change its flow direction to cross what is today an uplifted mountain belt and enter the Bighorn Basin. By turning in a north direction, in addition to flowing across high mountains the Wind River adds many hundreds of kilometers to the distance its water could travel (without crossing any high mountains) by continuing in an east direction to join the east- and southeast-oriented North Platte River. Just as puzzling is the north-northeast oriented Powder River headwaters originate along the much shorter route the Wind River should logically be taking. Further, the abrupt North Platte River direction change adds to the puzzling observations. Why should the North Platte River, which to the south of figure 1 is a northwest-oriented river, make an abrupt turn in central Wyoming to flow in an east and southeast direction? Looking only at figure 1 the north-oriented North Platte River should more logically continue in a north direction, perhaps by joining the north-oriented Powder River. The two fundamentally different paradigms, as they interpret Bighorn-Wind River drainage divide topographic map evidence, may also be able to provide clues that might help solve these bigger pictures regional drainage history puzzles.

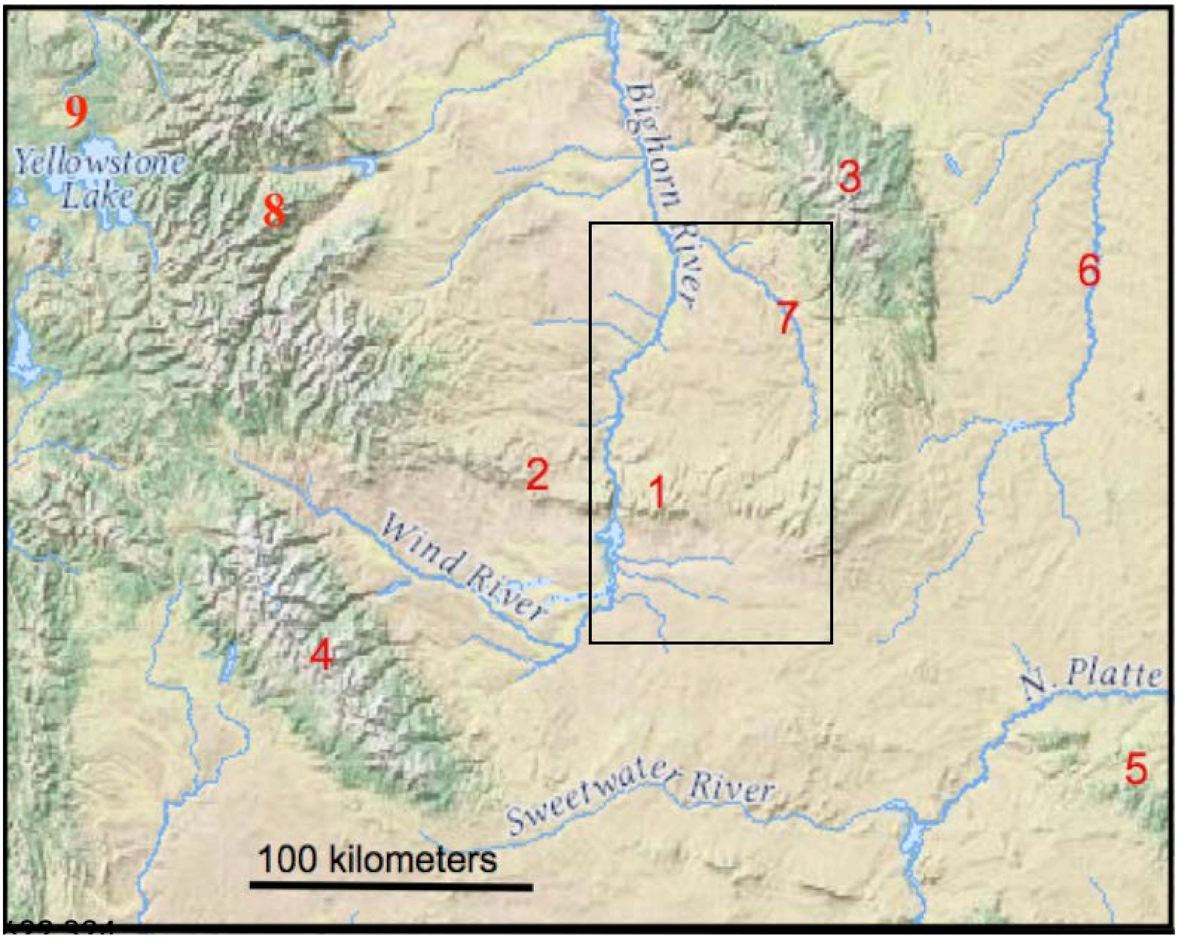

Figure 1. Modified map from United States Geological Survey (USGS) National Map website identifying the study region (black rectangle) location in relation to northcentral and northwest Wyoming Rivers and mountain ranges. Numbered features are: "1"-Bridger Range, "2"-Owl Creek Mountains, "3"-Bighorn Mountains, "4"-Wind River Mountains, "5"-Laramie Range, "6"-Powder River, "7"-Nowood River, "8."-Absaroka Mountains, and "9"-Yellowstone Plateau.

1.3. Previous Work

Previous work related to this paradigm comparison study needs to be subdivided into three categories. The first category consists of paradigm neutral descriptions, which if correctly reported must be explained regardless of which paradigm rules are being used. United States Geological Survey (USGS) topographic maps are an excellent example of paradigm neutral descriptions and are now available for all United States regions at several different scales. Air photos and satellite imagery also represent paradigm neutral information. Geologic maps and reports to the extent they identify and describe observed evidence include many paradigm neutral observations. However, geologic maps and reports also include paradigm biased interpretations. For example, some relative age dating methods are paradigm neutral, however paradigm rules played significant roles in developing other relative age dating methods and many commonly used absolute age dating techniques. The challenge with geologic maps and reports, when comparing fundamentally different paradigms, is to separate paradigm neutral observations from paradigm influenced interpretations.

The second previous work category consists of accepted paradigm influenced work. Included in this second category are attempts to explain the Missouri River drainage route, which for considerable distances roughly follows the southern and western limit of glacially deposited materials. Early workers, including Todd [3] considered many Montana and North and South Dakota Missouri River segments to have formed when glacial ice blocked north- and northeast-oriented pre-glacial drainage routes and diverted the water along a continental ice sheet margin. North- and northeast-oriented Missouri River tributary drainage basins considered to be pre-glacial in age include the Bighorn and Powder River drainage basins with their water once draining to what is frequently referred to as the pre-glacial Bell River system (see Jackson [4], Duk-Rodkin et al [5], and McMillan [6]). Included in Jackson's description is a summary of a recently proposed Sears [7] suggestion that the Colorado River during the late Oligocene and early Miocene time turned in a north direction as part of what Sears interprets to have been an extensive pre-glacial Bell River drainage network.

In addition to previous drainage system interpretations Scott [8] suggested the Bighorn Basin is often considered a model for the physiographic evolution of Rocky Mountain intermontane basins because it has been studied in much greater detail than most other intermontane basins. Mackin [9] conducted what is often regarded as the classic Bighorn Basin geomorphology study and worked primarily to the north this paper's study region. In terms of regional drainage history, based on previous work (including that of Sinclair and Granger [10]) Mackin suggested that during the early Tertiary the Wind River probably joined the North Platte River and was captured by headward erosion of a north-oriented Bighorn River tributary "when the Owl Creek Mountains were largely submerged in a sea of waste." Based on fossils collected at an elevation of about 2750 meters McKenna and Love [11] stated, "As a result of regional aggradation, the Bighorn Basin was filled with sediments. These buried the rugged peaks and canyons of the Bighorn Mountains up to a level corresponding to the present 9000-foot [2743-meter] altitude during early Miocene time. The lower Miocene and older rocks are beveled by the subsummit surface, a remarkably flat and even surface of Miocene or Pliocene age. Excavation of the Bighorn and Powder River basins and exhumation of the Bighorn Mountains must have been accomplished during the relatively short interval of late Cenozoic time after the subsummit surface was cut."

Mears [12] in a review of Wyoming high level erosion surface literature suggests that following a latest Paleocene and earliest Eocene Laramide orogeny climax when relief of the mountains was greater than today a late Eocene erosion episode lowered the mountains and filled mountain valleys and adjacent intermontane basins. Another erosion episode followed and "the rising level of Oligocene and then Miocene deposits eventually lapped across the lower segments of the crystalline-cored uplands that had been eroded down to broad sub-summit surfaces surmounted by residual hills and peaks. At some time during this aggradational episode, broad regional uplift began to raise the mountains to their present-day elevations. The exhumation of the present broad basin floors and adjacent mountain valleys began in mid-Miocene time, following the end of massive volcanic ash falls and accompanying the acceleration of regional uplift."

More recently Pelletier [13] proposed an increase in the intensity of snowmelt flooding to explain up to 1.5 km of erosion in southern Rocky Mountain intermontane basins since middle Miocene time. He argues, "In the middle Miocene, snowmelt runoff was limited to the highest elevations (>3 km) and hence impacted only a small fraction of the regional landscape. As the global climate system cooled during the late Miocene and Plio-Quaternary periods, the fraction of total river discharge derived from snowmelt increased significantly in areas between 1.5 and 3 km elevation, thereby increasing the magnitude of flooding during periods of snowmelt and the resulting bedload sediment flux and erosion of rivers in that elevation range." In summary, the accepted paradigm requires a north-oriented drainage system to have removed what were up to 1500 meters of Late Eocene, Oligocene, and Miocene sediments that once filled the Bighorn Basin.

The third previous work category represents new paradigm influenced previous work. To date the same author has prepared all new paradigm influenced publications (which first appeared in 2017). Those papers, like this paper, interpret topographic map evidence related to specific geographic areas. To date only about a dozen such papers have been published and only two address Wyoming geographic areas. One published new paradigm influenced Wyoming paper determined that large southeast-oriented floods once flowed across the eastern Powder River Basin [14] and the other published new paradigm influenced Wyoming paper determined that large east-oriented floods flowed across what is today the southeast Wyoming Laramie Range [15]. Other published new paradigm influenced papers have suggested that immense south- and southeast-oriented floods once flowed across rising mountain ranges. Such papers describe how large floods flowed across a rising high South Dakota Black Hills region [16] and in Montana carved what is now North America's east-west continental divide [17]. Still other published new paradigm influenced papers document how north-oriented eastern Montana and western North Dakota Missouri River tributary valleys eroded headward across massive southeast-oriented floods [18, 19] and how in southeast Montana the north-oriented Powder River valley eroded headward across massive southeast-oriented floods [20].

2. Research Method

The study reported here, like studies in the other new paradigm influenced papers published to date, is one component of the author's much larger Missouri River drainage basin landforms origin research project. When first done during the 1999-2001 time period the larger project consisted of systematically studying hard copy mosaics of detailed topographic maps for the entire Missouri River drainage basin. The study looked at drainage divides between all streams shown on the detailed maps. Results indicated almost all Missouri River drainage basin valleys had eroded headward across what must have been large south- and southeast-oriented floods with the Montana north-oriented Missouri River headwaters valley and north- and northeast-oriented Missouri River tributary valleys eroding headward from a continental ice sheet location. Results were fundamentally different from anything in the published literature and at that time could not be demonstrated without large mosaics of detailed topographic maps. The study was repeated during the 2011-2013 time period using National Geographical TOPO software and maps and more than 500 research notes in blog format describing more than 4000 different Missouri River drainage basin drainage divide origins are now posted at geomorphologyresearch.com.

The study reported here used topographic maps found at the USGS National Map website and focused on the Bighorn-Wind River drainage divide area to the east of Wind River Canyon. The study systematically studied maps showing the Bighorn-Wind River drainage divide area beginning at Wind River Canyon and proceeding eastward to the Bighorn Mountains and identified divide crossings or low points that could be interpreted to have been eroded by water that once flowed across what is now a major drainage divide. Floor elevations of each identified divide crossing were noted and ranged from about 1925 meters to approximately 2485 meters (which is almost the same as the Copper Mountain highest elevations). All observed divide crossings could be linked to Bighorn River tributary valleys and also to Wind River tributary valleys and two branches of a Wind River tributary were observed to originate as north-oriented streams, one north of Copper Mountain and the other north of Lysite Mountain. Four groups of divide crossings were identified based on their linkages to one of four north-oriented Bighorn River tributaries. Divide crossings with the lowest floor elevations (many with very similar elevations) linked north-oriented Kirby Creek headwaters and tributary valleys with the south-oriented Bridger Creek valley. An attempt was made to explain each divide crossing or group of divide crossings from the accepted paradigm perspective and also from the new paradigm perspective.

Accepted paradigm perspective key elements used when interpreting divide crossing evidence included a sedimentary cover of up 1500 meters of Oligocene and Miocene sediments that buried the present-day Bighorn and Wind River Basins and Owl Creek and Bridger Mountains to an elevation (based on modern-day elevations) of approximately 2750 meters. The surface of this sedimentary cover and what are now high-level Bighorn Mountain and Wind River Mountain erosion surfaces formed what previous investigators have described as a broad and low relief plain on which the present-day Bighorn, Wind, North Platte, and Powder River drainage systems developed. Before being captured, the Wind River flowed in an east direction to join the east- and southeast-oriented North Platte River. Headward erosion of a north-oriented Bighorn River tributary valley captured the east-oriented Wind River and diverted it in a north direction at a time when Oligocene and Miocene sediments still covered the Owl Creek and Bridger Mountains,

New paradigm key elements used when interpreting divide crossing evidence included massive south-oriented continental ice sheet melt water floods flowed across a low relief surface that had been formed by the beveling off of earlier mountain range structures to a level roughly equivalent in present-day elevations to Bighorn Basin erosional remnant tops. For a time, this low relief surface may have sloped in a southward direction as immense floods moved in large complexes of south- and southeast-oriented diverging and converging channels across Wyoming and into Colorado. Present-day drainage systems evolved as ice sheet related crustal warping gradually raised the Colorado and Wyoming region and what are now high mountain ranges, including the Owl Creek, Bridger, and Bighorn Mountains. Regional and mountain range uplift gradually blocked south- and southeast-oriented flood flow routes and forced drainage direction changes and reversals. Other drainage changes occurred when deep valleys eroded headward (from space being opened up on the floor of an ice sheet created deep “hole”) and beheaded what had been low gradient south-oriented flood channels causing water in those channels to flow in north directions toward lower elevation deep “hole” space being opened up as supra-glacial floods sliced ice-walled and bedrock-floored canyons into the decaying ice sheet surface.

3. Results

3.1. Wind River Canyon, Birdseye Pass, and the Copper Mountain Areas

Proceeding eastward from Wind River Canyon the first significant divide crossing is Birdseye Pass (floor elevation about 2135 meters), which is located between Birdseye Mountain (about 2460 meters) to the west and Copper Mountain (about 2500 meters) to the east. Today Birdseye Pass links south- and southeast-oriented Birdseye Creek with north-northeast oriented Grass Creek. Birdseye Creek joins the Wind River at Boysen Reservoir (elevation 1441 meters) near the Wind River Canyon southern end while Grass Creek flows to north-oriented Buffalo Creek and then to the Bighorn River near the Wind River Canyon northern end (at about 1327 meters). Figure 2 illustrates the Birdseye Pass relationship to Wind River Canyon where the Wind River now flows in a north direction. Birdseye Pass is hundreds of meters higher than the Bighorn Basin floor to the north and the Wind River Basin floor to the south. Water flowing in one direction or the other eroded the Birdseye Pass valley, although at that time Birdseye Pass did not stand hundreds of meters above the Bighorn and Wind River Basin floors. In other words, at the time Birdseye Pass was eroded it was possible for a stream or river to flow from the Bighorn Basin across what is now Birdseye Pass to reach the Wind River Basin or vice versus, although in figure 2 the direction of flow may not be obvious.

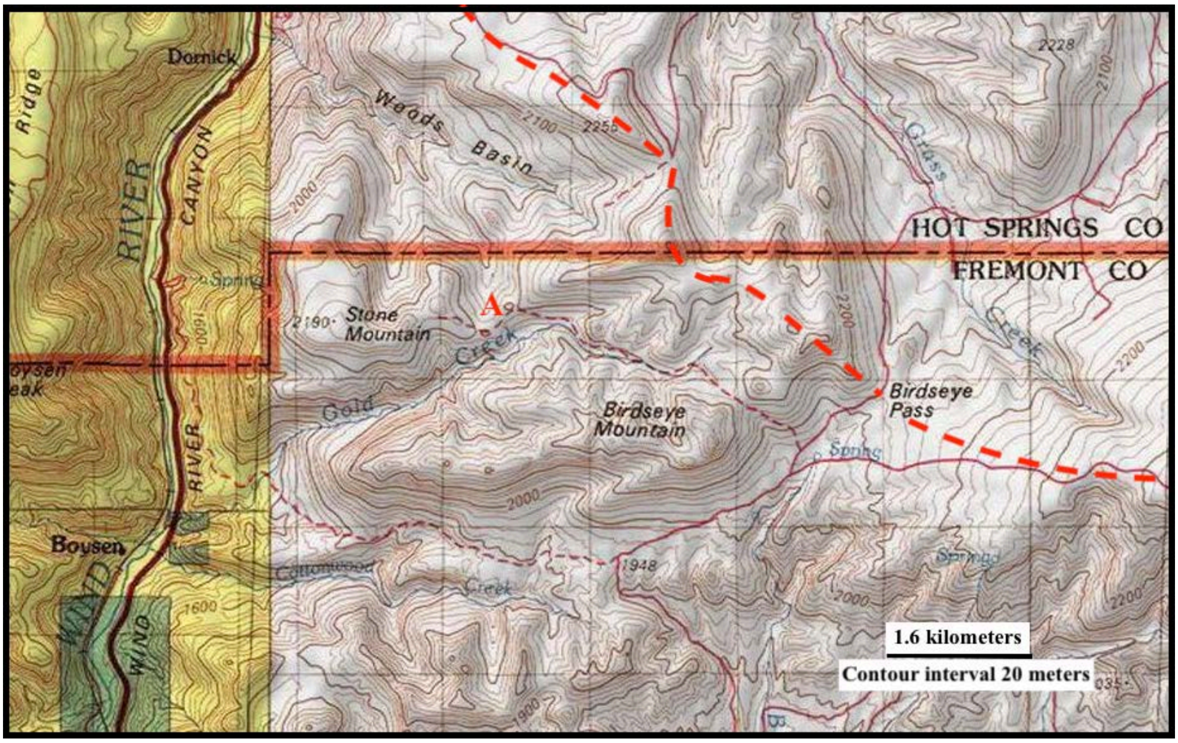

Figure 2. Modified topographic map from USGS National Map website showing Birdseye Pass to the east of the north-oriented Wind River flowing through Wind River Canyon. The dashed red line shows the Bighorn-Wind River drainage divide and the red letter "A" identifies a location discussed in the text.

The dashed red line in figure 2 follows the Bighorn-Wind River drainage divide, which to the west of Birdseye Pass is located to the north of Birdseye Mountain. To the north of Birdseye Mountain is southwest-oriented Gold Creek, which flows to the north-oriented Wind River as a barbed tributary. And to the north of the Gold Creek headwaters at the location marked with the red letter "A" is a 90-meter deep divide crossing linking the southwest-oriented Gold Creek valley with a north-oriented valley leading to northwest-oriented Woods Basin, which drains to the Wind River. That 90-meter deep divide crossing is also a water eroded feature. South-oriented water could have easily reached the 90-meter deep divide crossing while north-oriented water would have had to flow over Birdseye Mountain. Other divide crossings seen in figure 2 are immediately to the south and northeast of Birdseye Mountain and suggest that for a time diverging streams of water may have flowed across the region. Thaden [21] shows Birdseye Pass to be located along the contact between Cambrian Flathead Sandstone (west) and Gros Ventre Formation (east). No Oligocene or Miocene rocks are shown on his map; although at lower elevations his map does show "Eocene" age rocks.

Explaining Wind River Canyon, Birdseye Pass, and other figure 2 divide crossings from the accepted paradigm perspective is difficult because it requires Oligocene and Miocene sediments to have buried Birdseye Mountain and the adjacent Wind River and Bighorn Basins. Any explanation requires the Bighorn River to have developed on top of those sediments and a north-oriented valley to have eroded headward across that sediment cover (on the Wind River Canyon alignment) into the Wind River Basin to capture what must have been a much larger Wind River. While valley headward erosion in easily eroded sediments is easy to explain it is almost impossible to explain how such a valley could capture a much larger river (Bishop [22] explains why). A similar north-oriented valley could have eroded headward across the sediment cover on the Birdseye Pass alignment, but such a valley would have been very close to the valley on the Wind River Canyon alignment making it difficult to explain where any stream in such a valley would have obtained enough water to erode down through more than 300 meters of erosion resistant bedrock. Even if under some unlikely circumstance such a stream did erode Birdseye Pass it could not have eroded the other divide crossings now surrounding Birdseye Mountain. As an alternative it might be argued that Birdseye Pass and the divide crossings surrounding Birdseye Mountain had been eroded previous to being buried, but there is still the problem of explaining how and when that erosion occurred in addition to the even more serious problem that geologic maps, including the Love and Christiansen map [23], show almost no traces of the accepted paradigm's hypothesized sedimentary cover.

In contrast the new paradigm requires large south-oriented floods to have flowed from the Bighorn Basin into the Wind River Basin and further to the south across the present-day east-west continental divide into what is now the Colorado River drainage basin. Such a requirement forces recognition that the west-to-east mountain belt now separating the Bighorn and Wind River Basins at least initially was not a barrier to south-oriented flood flow, but gradually rose while south-oriented floods flowed across the region. Floodwaters probably flowed in many constantly changing diverging and converging channels with deeper channels capturing flow from shallower channels, which explains the divide crossings surrounding Birdseye Mountain. Ice sheet related crustal warping logically occurred as massive south-oriented melt water floods flowed across the region and could not only have raised mountain ranges, but also could have created what is today the regional north- and northeast-oriented slope, which would explain why the Bighorn River today flows in a north direction. The Wind River capture occurred when a Bighorn River flow reversal took place, previous to that time the southeast-oriented Wind River joined other south-oriented flood flow to move in a south direction into Colorado. In summary, new paradigm explanations do not require burial by a sedimentary cover, but require a water source large enough to generate immense and prolonged south-oriented floods and a mechanism to explain regional and mountain range uplift that occurred as large south-oriented floods flowed across the region. A thick North American continental ice sheet that created and occupied a deep “hole” not only provides an immense and potentially prolonged water source, but also could reasonably be expected to have triggered regional and mountain range uplift.

3.2. Kirby Creek-Bridger Creek Drainage Divide Area

Copper Mountain forms the Bridger Range’s highest ridge which to the east of figure 2 extends approximately 15 kilometers in a southeast direction. The Bighorn-Wind River divide follows the high Copper Mountain crest ridge for approximately 8 kilometers before descending in a northeast direction to go around the Bridger Creek headwaters area. Further to the east West Bridger Creek headwaters originate on the Copper Mountain north side and flow in a northeast direction before turning in a southeast direction to join south-oriented Bridger Creek, which flows in a south direction between Copper and Lysite Mountains and then to west-oriented Badwater Creek. Two 100-meter deep passes notched into Copper Mountain (floor elevations about 2394 meters) link the northeast-oriented West Bridger Creek headwaters with south-oriented Dry Creek, which also drains to west-oriented Badwater Creek. Still further to the east another 200-meter deep pass (floor elevation about 2140 meters) notched into the Copper Mountain crest ridge links southwest-south oriented East Fork Dry Creek with northeast- and southeast-oriented South Bridger Creek. Including Birdseye Pass at least four significant passes or divide crossings are notched into the high Copper Mountain crest ridge.

However, three of those four high-level Copper Mountain divide crossings do not cross what is today the Bighorn-Wind River drainage divide, which extends in a northeast direction between the northeast-oriented West Bridger Creek headwaters and northeast-oriented West Kirby Creek headwaters. A 250-meter deep divide crossing (floor elevation about 2229 meters) on that Bighorn-Wind River drainage divide segment is located between Copper Mountain and Guffy Peak (2452 meters). Geologic maps [24] show this divide crossing is located on a local fault line and is cut in Cambrian Gros Ventre Formation (siltstone, sandstone, and limestone) and is located to the north of the high Copper Mountain Precambrian bedrock with dipping Mississippian Madison limestone capping Guffy Peak to the northeast. While this divide crossing is structurally controlled significant volumes of water were needed to erode it.

About 3.5 kilometers to the east of Guffey Peak along the Bighorn-Wind River drainage divide there are much lower-elevation divide crossings (seen in figure 3) linking the southeast-oriented West Bridger Creek segment with north-oriented Kirby Creek tributaries and with north-oriented Kirby Creek. Red letters in figure 3 identify four of those divide crossings and their floor elevations are as follows: “A”-about 1932 meters, “B”-about 1935 meters, “C”-about 1933 meters, and “D”-about 1924 meters. To the east of figure 3 Bridger Creek originates on the Lysite Mountain north side as a north- and southwest-oriented stream before turning to flow between Copper and Lysite Mountains and to west-oriented Badwater Creek. Ver Ploeg’s Nowater Creek geologic map [25] shows bedrock in the Lysite Mountain area to mostly be “Eocene” Wagon Bed Formation (“tuffaceous claystone, sandstone, and conglomerate”). To the north of figure 3 the north-oriented Kirby Creek headwaters and other north-oriented Kirby Creek tributaries converge to form north-northwest and west oriented Kirby Creek, which eventually joins the north-oriented Bighorn River. A short distance to the south of the north-oriented Bridger Creek headwaters and across a 2130-meter high ridge, are headwaters of south-oriented Lysite Creek. Lysite Creek has eroded a 100- to 200-meter deep south-oriented valley into the Lysite Mountain upland and then continues in a south direction to also join west-oriented Badwater Creek.

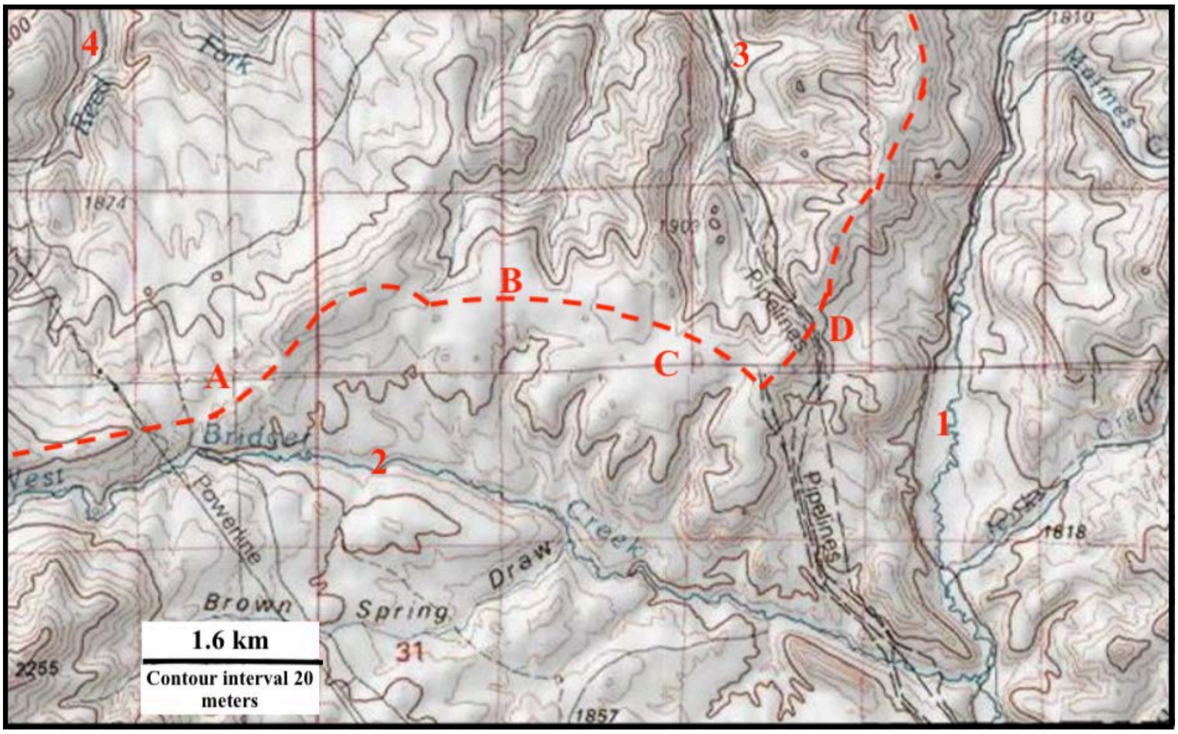

Figure 3. Modified topographic map from the USGS National Map website showing Bighorn-Wind River divide crossings (at the red letters A, B, C, and D) linking north-oriented Kirby Creek headwaters with south-oriented Bridger Creek. Numbers identify streams as follows: "1"-south-oriented Bridger Creek, "2"-northeast- and southeast-oriented West Bridger Creek, "3"-north-oriented Kirby Creek, and "4"-north-oriented Reed Creek flowing to Kirby Creek.

From the accepted paradigm perspective the four high-level Copper Mountain divide crossings, like Birdseye Pass, were probably eroded when north-oriented valleys cut down through the hypothesized sedimentary cover, although it is difficult to understand where enough water was obtained to remove from Copper Mountain all traces of the hypothesized sedimentary cover and also to cut 100 or more meters into the erosion resistant Copper Mountain Precambrian bedrock. The northwest-oriented West Bridger Creek headwaters and some of the divide crossings can be explained if headward erosion of the south-oriented Bridger Creek valley captured north-oriented Kirby Creek and Kirby Creek tributary headwaters, but such an explanation does not explain all of the above described divide crossings nor does it explain how the south-oriented Bridger Creek valley could erode headward between Copper and Lysite Mountains and then capture the north-oriented headwaters of multiple north-oriented streams. Such an explanation would be extremely complicated and Occam's Razor, which Anderson [26] states in science is known as "What can be done with fewer [assumptions] is done in vain with more," suggests the accepted paradigm explanations are probably being done in vain.

From the new paradigm perspective, the high-level Copper Mountain divide crossings, like Birdseye Pass and the deep canyon on the Wind River Canyon alignment, were eroded as a large complex of diverging and converging south-oriented flood flow channels carved valleys into a rising Bridger Mountains uplift area. Bit by bit the Bridger Mountains uplift blocked and reversed flow in the shallower channels creating what are now north-oriented Bighorn River tributary drainage systems, the northeast-oriented West Bridger Creek headwaters, and also concentrating south-oriented floodwaters into fewer and fewer valleys, such as the developing Wind River Canyon valley and what is now the south-oriented Bridger Creek valley. The closely spaced and low elevation Kirby Creek-Bridger Creek divide crossings suggest south-oriented flood flow moving along what is now the north-northwest oriented Kirby Creek alignment formed multiple diverging channels that converged as the flood flow became concentrated in the south-oriented Bridger Creek valley. Uplift of the southern Bighorn Basin relative to the northern Bighorn Basin reversed the direction of flow in the Kirby Creek drainage basin and created the Bighorn-Wind River drainage divide segment seen in figure 3.

3.3. Nowater Creek-Bridger Creek and Nowood River-badwater Creek Drainage Divide Areas

To the north of Lysite Mountain Bridger Creek headwaters flow in a north direction for approximately 3 kilometers before turning in a southwest and south direction to move between Copper Mountain and Lysite Mountain. To the south of the north-oriented Bridger Creek headwaters are several shallow divide crossings (floor elevations in the 2130-meter range) leading from the north-oriented Bridger Creek headwaters valley to the south-oriented Lysite Creek headwaters. Immediately to the north and east of the north-oriented Bridger Creek headwaters valley are north-oriented Nowater Creek headwaters. A broad 100-meter deep divide crossing (floor elevation about 2040 meters) cut into this short Bridger Creek-Nowater Creek drainage divide segment links the Bridger Creek turn (from north to southwest) with a northeast-oriented Nowater Creek tributary valley. Ver Ploeg [24] shows much of the Lysite Mountain area, including the Bridger-Nowater Creek drainage divide, to be underlain by "Eocene" Wagon Bed Formation, with the north-northeast oriented crest of the Lysite Mountain Anticline a short distance to the north of the Bridger Creek direction change. Further to the east a 100-meter deep divide crossing links the north-oriented Nowater Creek headwaters with northeast and south-oriented Bates Creek headwaters, which further to the south turn in an east-northeast direction to join northeast-oriented Nowood River headwaters and which presents still another drainage history puzzle.

After coinciding with the short north-to-south oriented Bridger Creek-Nowater Creek drainage divide segment the Bighorn-Wind River drainage divide continues in a south-southeast direction between south-oriented Lysite Creek headwaters and south-oriented Bates Creek headwaters. Several divide crossings with elevations ranging from about 2025 to about 2070 meters link south-oriented Lysite Creek headwaters with south and east-northeast oriented Bates Creek and with northeast-oriented Nowood River headwaters. One of these divide crossings is between a northeast-oriented Nowood River tributary and southwest-oriented East Fork Lysite Creek. Interestingly, while today East Fork Lysite Creek flows for a distance in a west direction a low drainage divide (elevation 1972 meters) separates that west-oriented valley from the 100- to 200-meter deep valley of south-oriented Sagebrush Draw, which like the south-oriented Lysite Creek valley is eroded across the Lysite Mountain upland, and which to the south of Lysite Mountain joins Lysite Creek.

Cottonwood Pass (floor elevation 2050 meters) is identified by the letter "A" in figure 4 and is located approximately one kilometer east of the East Fork Lysite Creek headwaters area. Cottonwood Pass links north-oriented Stove Creek ("7" in figure 4) flowing to northeast-oriented Nowood River headwaters with south-oriented Cottonwood Creek ("1" in figure 4), which like Lysite Creek and Sagebrush Draw flows in a deep valley eroded into the Lysite Mountain upland. Slightly more than one kilometer further to the east the headwaters of north-oriented Stove and Crawford Creeks ("6" in figure 4 identifies Crawford Creek) are linked by several slightly higher elevation dry valleys (at and near the letter "B" in figure 4) that cross the Bighorn-Wind River drainage divide with another south-oriented dry valley cut across the Lysite Mountain upland leading to south-oriented Snyder Creek ("2" in figure 4).

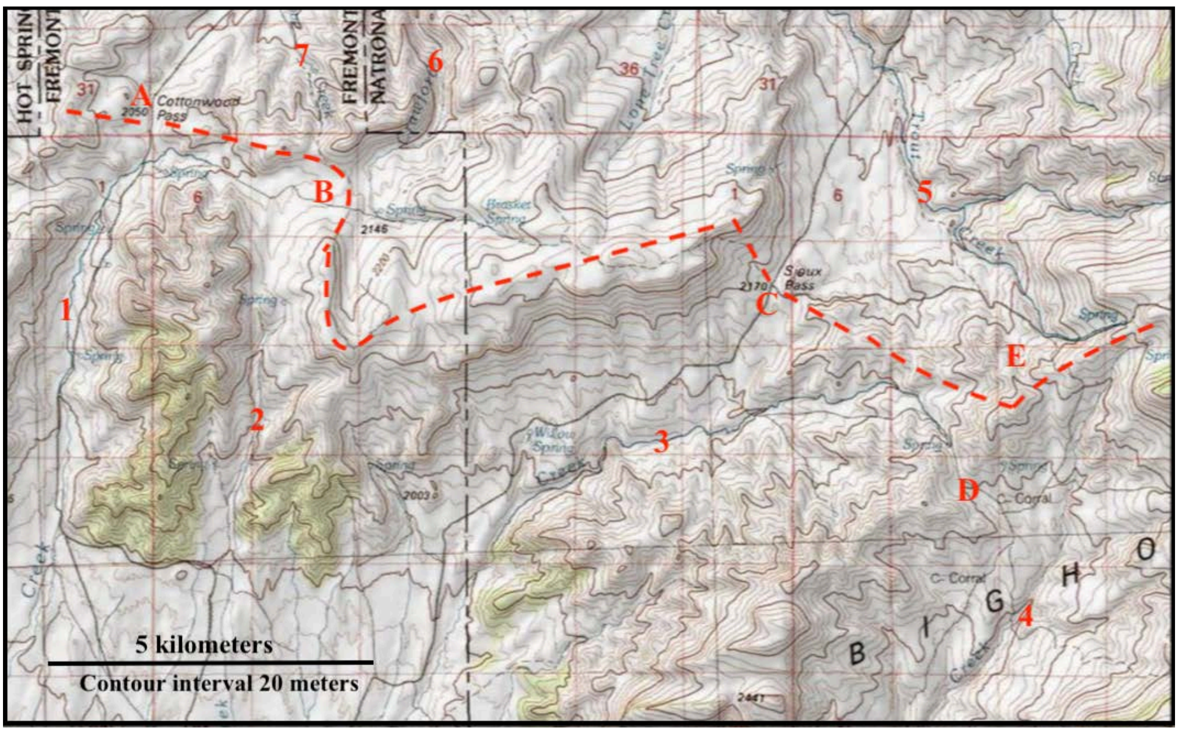

Figure 4. Modified topographic map from USGS National Map website showing where Lysite Mountain (west) and the Bighorn Mountains meet. The dashed red line shows the Bighorn-Wind River drainage divide location, red letters identify major divide crossings as identified in the text, and red numbers identify streams as follows: "1"-Cottonwood Creek, "2"-Snyder Creek, "3"-Sioux Creek, "4"-Clear Creek, "5"-Trout Creek, "6"-Crawford Creek, and "7"-Stove Creek.

Further east (along the Bighorn-Wind River divide) the Lysite Mountain upland ends and the Bighorn Mountains uplift begins and Sioux Pass (identified by "C" in figure 4) has a floor elevation of 2170 meters and links north-oriented Trout Creek ("5" in figure 4) with southeast- and south-oriented Sioux Creek ("3" in figure 4). Trout Creek flows to the northeast- and north-oriented Nowood River while Sioux Creek flows to west-oriented Badwater Creek. Sioux Pass is particularly interesting because unlike the Lysite Mountain area drainage divide crossings it is on the floor of a 200-meter deep water eroded valley cut into much older and much more erosion resistant bedrock units. The letter "E" in figure 4 identifies a 45-meter deep divide crossing between northwest-oriented Trout Creek headwaters to the north and southwest-oriented Clear Creek ("4" in figure 4). Also note in figure 4 how Sioux Creek begins as a northwest-oriented stream near the letter "D" before turning in a southwest direction. The letter "D" identifies a 100-meter deep or deeper divide crossing linking the northwest-oriented Sioux Creek headwaters with a southeast-oriented valley draining to the southwest-oriented Clear Creek valley. While the divide crossing at the letter "D" does not cross the Bighorn-Wind River drainage divide it is significant water eroded divide crossing and needs an explanation.

But even more interesting is further to the east and well into the Bighorn Mountains uplift area a 225-meter deep divide crossing or through valley (floor elevation 2485 meters) links southwest-oriented Badwater Creek headwaters with north-oriented Deep Creek headwaters (flowing to the north-oriented Nowood River). Interestingly the Deep Creek-Badwater Creek divide crossing floor elevation is today approximately the same as the highest Copper Mountain elevations and is much higher than the Wind River Canyon rim elevations seen in figure 2. Ver Ploeg's map [24] shows the Deep Creek-Badwater Creek through valley to be cut across erosion resistant units including Precambrian granite gneiss, Mississippian Madison Limestone, and Pennsylvanian Tensleep Sandstone.

The largest and deepest divide crossing observed is between Copper Mountain and the Bighorn Mountains southwest margin in the Sioux Pass area where a 25-kilometer wide or wider stretch in the Lysite Mountain area is as much as 500 meters lower in elevation than Copper Mountain and Bighorn Mountains elevations on either side. With the exception of the Sioux Pass and Deep Creek-Badwater Creek divide crossings all Lysite Mountain area divide crossings are all on the floor of this much wider and deeper divide crossing. As already mentioned much of the Lysite Mountain area is now covered by "Eocene" Wagon Bed Formation while exposed bedrock in the Bighorn Mountains are folded Paleozoic and Mesozoic units and at Copper Mountain those same bedrock units surround an uplifted Precambrian bedrock core. While apparently overlying a downfolded region between Copper Mountain and the Bighorn Mountains the large and deep Lysite Mountain area divide crossing is also a water eroded feature needing an explanation.

The large Lysite Mountain area divide crossing and the many divide crossings located on its floor are just as difficult to explain from the accepted paradigm perspective as the previously discussed divide crossings. If Oligocene and Miocene sediments once covered the entire region to an elevation equivalent to a modern-day 2750-meter level (as some previous investigators have suggested) the Lysite Mountain area should have been buried. If it was not buried then the question can validly be asked, why does the Wind River flow between the Owl Creek and Bridger Mountains and not in the lower elevation Lysite Mountain area? And if the Lysite Mountain was buried, then how did what were probably local north- and south-oriented drainage routes erode the large and deep Lysite Mountain area divide crossing and create the present-day lower elevation stretch of the Bighorn-Wind River drainage divide with its numerous divide crossings while also removing all of the hypothesized Oligocene and Miocene sediments? Any accepted paradigm answer to these questions will at best be extremely complicated.

On the other hand, the new paradigm perspective provides a simple explanation of how the large Lysite Mountain divides crossing and the many divide crossings on its floor originated. The Bridger Mountains (Copper Mountain) and Bighorn Mountains were uplifted as massive south-oriented floods flowed across the region. As Copper Mountain and the Bighorn Mountains were uplifted south-oriented floodwaters were diverted to either flow on what must have been the deeply eroding Wind River Canyon route or to flow across what would have been a low elevation Lysite Mountain area. Floodwaters flowed in diverging and converging channels and uneven uplift gradually concentrated the Lysite Mountain area floodwaters in the deepest south-oriented channel (now the south-oriented Bridger Creek valley) and caused flow reversals on north ends of abandoned channels to create what are today the north-oriented Bridger Creek and Bates Creek headwaters. Eventually the uplift blocked and reversed all south-oriented flood flow channels to the Bridger Creek valley so as to create what are today the north-oriented Nowood River and Nowater and Kirby Creek drainage systems.

4. Discussion

When referring to the Wagon Bed Formation (in the above results section) quotation marks were deliberately placed around the word "Eocene" to emphasize that while both of the fundamentally different paradigms must recognize the existence of the Wagon Bed Formation and how those sediments relate to overlying and underlying deposits each paradigm interprets those sediments in different ways and those different interpretations almost certainly lead to quite different regional geologic histories. For example, the two paradigms require differing periods of absolute time between Wagon Bed Formation deposition and the present. The accepted paradigm requires long periods of absolute time for the erosion of previously uplifted mountains while up to 1500 meters of Oligocene and Miocene sediments were deposited in intermontane basins and additional long periods of absolute time while those sediments were removed and rivers carved deep canyons in erosion resistant bedrock. On the other hand, the new paradigm does not require any time to erode previously uplifted mountains or for large quantities of eroded materials to be deposited in intermontane basin nor does it require time for the removal of those intermontane basin sediments. While the new paradigm does require some absolute time to erode deep canyons as regional and mountain range uplift took place, the new paradigm provides a mechanism able to carve deep canyons much more rapidly than any mechanism the accepted paradigm provides.

Further, previous investigators have reported Wagon Bed sediments include conglomerates, some with quite large boulders, which may be indicative of flood transported material and it is possible that massive south-oriented floods did deposit some or all of the Wagon Bed Formation sediments. Such a determination would be consistent with the drainage divide crossing evidence presented here, but would not be consistent with the accepted paradigm's interpretation of Tertiary history and could have significant implications regarding "Eocene", "Oligocene", "Miocene", "Pliocene", and even "Quaternary" absolute time intervals. What is important at this stage of the new paradigm's development is to remember, one paradigm cannot be used to judge another paradigm. Fundamentally different paradigms must be judged on their ability to explain observed evidence. In this and other new paradigm papers published to date no attempt has been made to determine absolute dates from a new paradigm perspective and additional new paradigm research is needed before the new paradigm will be sufficiently fleshed out that any such attempt should be made.

5. Conclusions

Paradigms by themselves are neither correct nor incorrect and should be judged on their ability to explain observed evidence. Detailed topographic map evidence was used to compare the ability of two fundamentally different paradigms to explain more than 20 divide crossings along the Bighorn-Wind River drainage divide in the region to the east of Wind River Canyon. Identified divide crossings ranged in elevation from 1924 meters to 2485 meters with only three having floor elevations higher than Wind River Canyon rim elevations. Included among the divide crossings was a 25-kilometer wide and 500-meter deep divide crossing in the Lysite Mountain area with more than ten lower elevation divide crossings located on its floor. Accepted paradigm interpretations require Oligocene and Miocene sediments to have buried underlying geologic structures with the drainage routes responsible for eroding the divide crossings to have originated on that sedimentary cover surface and fail to satisfactorily explain much of the identified divide crossing evidence. New paradigm interpretations require mountain range and regional uplift to have occurred as massive south-oriented floods flowed across the region and successfully explained most if not all of the identified divide crossing evidence.

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