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The Bighorn Basin, Wyoming—Monument to the Flood

Part II: The Retreating Stage

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Abstract

The Bighorn Basin is a spectacular example of the retreating stage of Noah's Flood. Very large, differential vertical tectonics in the early retreating stage initiated drainage of Floodwaters into subsiding ocean basins. Concurrent uplift of mountain ranges warped sedimentary layers, and deformation included the movement of the Heart Mountain Slide in the northwest Bighorn Basin. Erosion removed most of the strata from the Beartooth and Bighorn Mountains, but only Mesozoic and early Cenozoic strata were removed from the Owl Creek Mountains. Eroded sediments provided valley fill for the Bighorn Basin. To the west, the Absaroka Volcanics formed by volcanic debris flows. Large "alluvial fans" formed on the east sides of the Beartooth and Bighorn Mountains but were then deeply eroded by north-flowing, channelized Floodwater currents. These currents also eroded several thousand feet of Bighorn Basin fill. Planation surfaces formed on the edge of the surrounding mountains and in the Bighorn Basin, surviving today as erosional remnants. Currents also transported quartzite from central Idaho, redeposited as gravel lags. Pediment and pediment remnants formed, and at least four water gaps were cut.

Introduction

The Bighorn Basin provides a record of much of Earth's history. Oard (2017) described the onset of the Flood in this area with the carving of the Great Unconformity, visible at the margin of the basin, into granite and gneiss of Creation Week crustal rocks. As energy decreased, around Day 40, the Great Deposition emplaced horizontal layers of the Paleozoic, Mesozoic, and early Cenozoic. These rocks show little evidence of folding or faulting in the western United States, and strata can be traced long distances with little or no sign of erosion between or within layers—powerful evidence for a single depositional event. The Bighorn Basin

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is noted for its numerous dinosaur fossils, and millions of tracks in strata of the northeast Bighorn Basin.

The Two Phases of the Retreating Stage

Walker (1994) identifies the second stage of the Flood as the *recessive or retreating stage*, which he divided into the *abative* or *sheet-flow phase* and the *dispersive* or *channelized-flow phase* (Figure 1). In the *sheet-flow phase*, vast currents, up to 1,000 miles wide or more, flowed unimpeded into subsiding oceans. Current size and velocity depended on global flow patterns. As the Flood level dropped relative to the continents, rising mountains and plateaus increasingly deflected and disrupted these sheets, forming large channels (Figure 2). During the *channelized-flow phase*, these diminished in size and volume, leaving the modern drainage system.

The presence of sheet/channelized flow depended on the elevation of the underlying land surface and Earth's rotation. Both phases could occur simultaneously, channelized flow at higher elevations and sheet flow in lower. For example, channelized flow could have been ongoing in the Rocky Mountains while sheets of water still covered the Gulf Coast.

Huge Differential Vertical Tectonics

Differences in elevation were driven by large-scale differential vertical tectonics, which began either at the peak of the Flood or soon after (Oard, 2008, 2013a). Psalm 104:8 states that the mountains rose and the valleys sank. That this refers to the Flood and not Day 3 of Creation is shown in verse 6, where God *covers* the mountains. On Day 3, He uncovered them. Verse 9 reflects God's promise that there would not be another Flood. Though verse 8 speaks of "mountains" and "valleys," the principle applies at all scales, up to and including the vertical separation of continents and ocean basins. King (1983) described physical evidence for ocean basin subsidence.

These tectonic motions are seen in the Bighorn and Clarks Fork basins and along the edges of the Bighorn and Beartooth mountains, particularly Clarks Fork Canyon (Figure 3). Mackin (1937, p. 819) stated:

> These relations support the view that the Laramide orogenic movements in the Middle Rockies were predominantly differential displacements of basins and ranges, absolute uplift of the ranges being accompanied

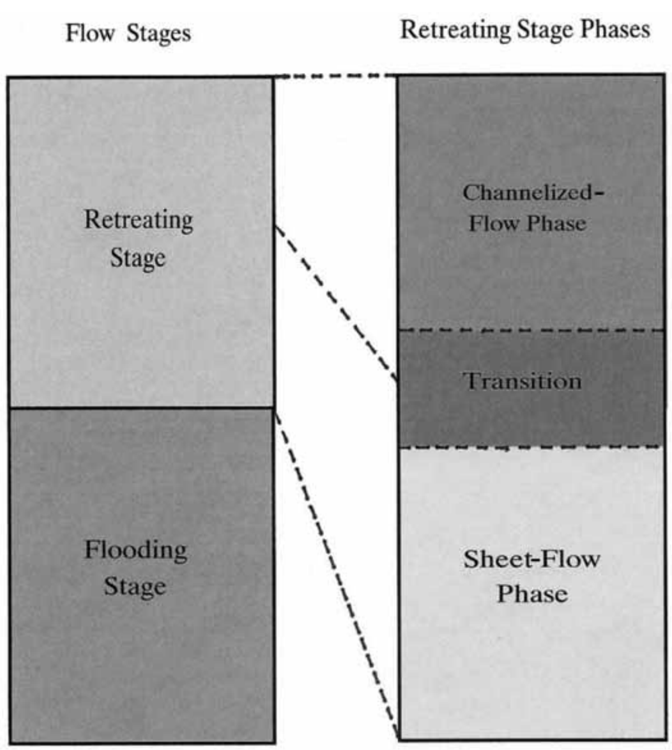

Figure 1. Two stages of the Flood (left) with the two phases of the retreating stage (right) from Walker (1994). Drawn by Mrs. Melanie Richard.

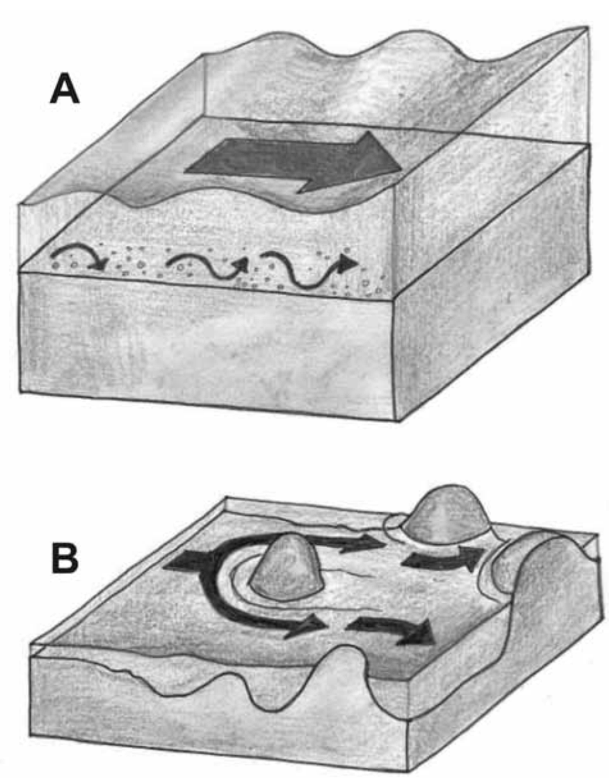

Figure 2. Transition from sheet flow (A) to channelized flow (B) in the retreating stage. Drawn by Mrs. Melanie Richard.

Figure 3. Tilted Paleozoic and Mesozoic strata at Clarks Fork Canyon on the northern end of the Rattlesnake Mountains. Clarks Fork Canyon separates the Rattlesnake Mountains and the Beartooth Mountains.

Figure 4. Heart Mountain north of Cody, Wyoming, slid eastward over the valley fill of the Bighorn Basin that was around 1,500 feet (457 m) higher than now seen at this location.

> by absolute downwarping of the basin floors.

Total motion in Wyoming was easily 45,000 ft (13,716 m) (Oard, 2017). Similar amounts are seen in the Uinta Mountains of northeastern Utah (Hansen, 2005; Oard, 2012). The timing of displacement here appears to correlate to the mid- and late-Cenozoic.

Heart Mountain Slide

The Heart Mountain Slide was a 430 mi^2 (1,114 km^2) mass of limestone that slid eastward over 40 miles (64 km) and broke up into 50 large blocks (Oard, 2006, 2010). The McCullough Buttes and Heart Mountain (Figure 4) slid over valley fill of the western Bighorn Basin, and the South Fork slide occurred about the same time to the south (Clarey, 2013). Most geologists believe that the slide took between 4 and 30 minutes; the mass achieved velocities up to 100 mph or more, despite the slight slope of about 2° east. Today, the glide plane is nearly horizontal. The mechanics of the slide defy uniformitarian explanation, but not the Flood. The blocks could have broken clear and slid underwater when the Yellowstone Park area was uplifted. The area vacated by the slide was filled with up to 6,000 ft (1,829 m) of volcanic lahars, the Absaroka Volcanics, which eventually covered 9,000 mi^2 (23,310 km^2). These events likely occurred during the sheet-flow phase.

Erosion in the Retreating Stage

A tremendous amount of erosion took place during the Retreating Stage of the Flood (Oard, 2008, 2013a; Walker, 1994). This is seen in the Bighorn Basin and surrounding mountains.

Thick Sedimentary Rocks Eroded from the Mountains

The Beartooth and Bighorn Mountains were rising during the sheet-flow phase, resulting in significant, large-scale erosion of overlying strata. Subsiding basins experienced little erosion, and sediments eroded from surrounding mountains filled them. Most of the movement occurred along the Beartooth fault (Figure 5). Valley fill in the northern Bighorn Basin, which overlies thick strata of the ascending phase, reaches 10,000 ft (3,048 m) below sea level. Fill reaches 20,000 ft (6,096 m) below sea level in the southern Bighorn Basin. Basin subsidence and sedimentation began

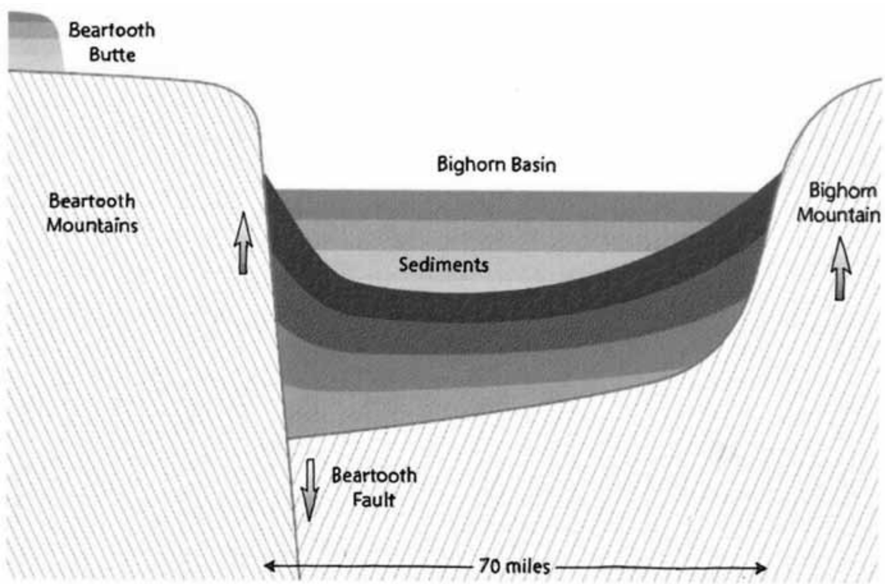

Figure 5. Schematic of Beartooth fault showing about 23,000 feet (7,000 m) of vertical displacement. Slanted patterns represent granite and gneiss of the upper crust. Modified from Coffin and Brown (1983) and redrawn by Mark Wolfe.

in either the ascending and/or zenithic phases, near the Flood's peak at Day 150.

Uplift and erosion was so great that the Great Unconformity was exposed in some mountain ranges, but in the Owl Creek Mountains, Paleozoic cover over the granite core, exposed in the Wind River water gap (Figure 6) shows a different picture. Granite dikes intrude the lower strata, suggesting that hot, plastic granite formed during uplift and was squeezed up into the strata.

The Absaroka Mountains differ from surrounding mountain ranges, exhibiting thick accumulations of volcanic debris flows in lahars. This formation represents a massive amount of volcanics from an unknown area that was eroded and *redeposited* as lahars. These lahars contain numerous petrified trees (Figures 7 and 8). Scientists claim that vertical trees in layers of the Absaroka Volcanics represent tens of thousands of years of forestation and destruction. Some formerly professing Christians say they lost their faith because of this formation (Numbers, 2006, p. 13). A closer examination shows the uniformitarian conclusions are specious. Paleosols are not found with the trees, which include a variety of about 200 species ranging from tropical to cooler temperate zones. Many trees lack roots or branches and show other anomalous features (Coffin, 1997; Coffin et al., 2005). Evidence points to deposition from a floating log mat (Oard, 2014a) (Figure 9), like that seen after the Mount St. Helens 1980 eruption in Spirit Lake. Those trees also lack roots and branches (Morris and Austin, 2003) and demonstrate how logs can be deposited in multiple layers during one cataclysm.

Figure 6. Granite intruding sedimentary rocks in the center of the Owl Creek Mountains.

Figure 7. A vertical, 2.5-meter diameter vertical petrified tree at the top of Specimen Ridge, Yellowstone National Park, Wyoming (Madison Gilmore provides scale).

Figure 8. Large horizontal petrified trees near the top of Specimen Ridge, Yellowstone National Park, Wyoming (Van Wingerten provides the scale).

"Alluvial Fans" from Sheet-flow Erosion

Sheet-flow currents, moving west to east, built up large "alluvial fans" on the east sides of the Beartooth and Bighorn Mountains. At one time, the fan on the east of the Beartooth Mountains was up to 2 miles (3.2 km) thick. It tilts to the east at about a 30° angle, partly due to non-horizontal deposition and partly due to later uplift. Rocks in this fan are mostly angular carbonates up to 25 inches (64 cm) across. Channelized-flow erosion later removed about 99% of the fan, leaving erosional remnants (Figure 10). Figure 11 is a schematic summary of the deposition and erosion of this fan.

The "fan" east of the Bighorn Mountains contains mostly sub-rounded granite rocks (Figure 12), up to 25 ft (7.6 m) in diameter. Carbonate and sandstone rocks must have been pulverized before the fan was deposited. The fan was later eroded by northward currents flowing through the Powder River Basin.

Another deep "alluvial fan" formed over southwest Montana, during the Idaho Batholith uplift. It was then broken up by vertical faulting, and most of its material was removed by channelized erosion. Today it is seen only as erosional remnants in mountains and valleys (Coffin 2009; Thomas, 2016), like Sphinx Mountain (Figure 13)—3,000 ft (914 m) of limestone breccia, like that found east of the Beartooth Mountains.

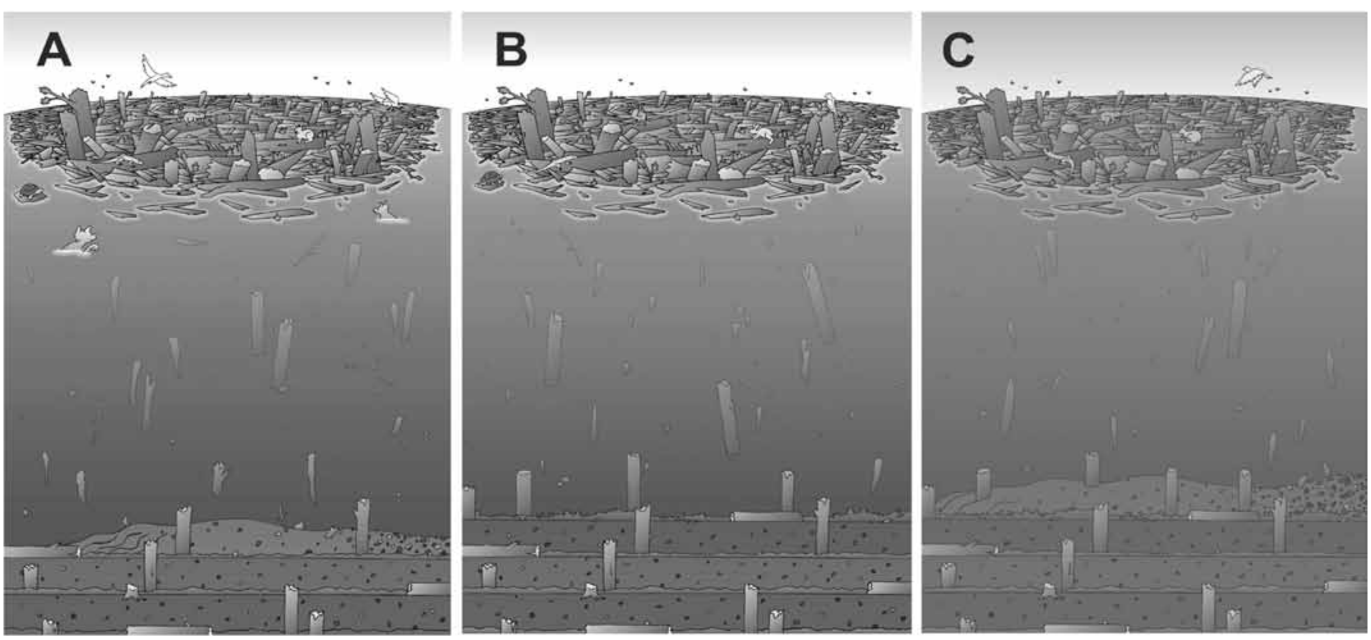

Figure 9. A log mat contributes sinking trees into successive lahars (A-C) forming the Absaroka Volcanics debris flows. Drawn by Keaton Halley.

Figure 10. A 1,300-foot (396-m) high erosional remnant of limestone conglomerate or breccia along the southeast flank of the Beartooth Mountains (view south from the road to Clarks Fork Canyon).

Figure 12. A 9-foot (2.7-m) sub-rounded granitic boulder like many spread east of the Bighorn Mountains (Dr. Harold Coffin for scale).

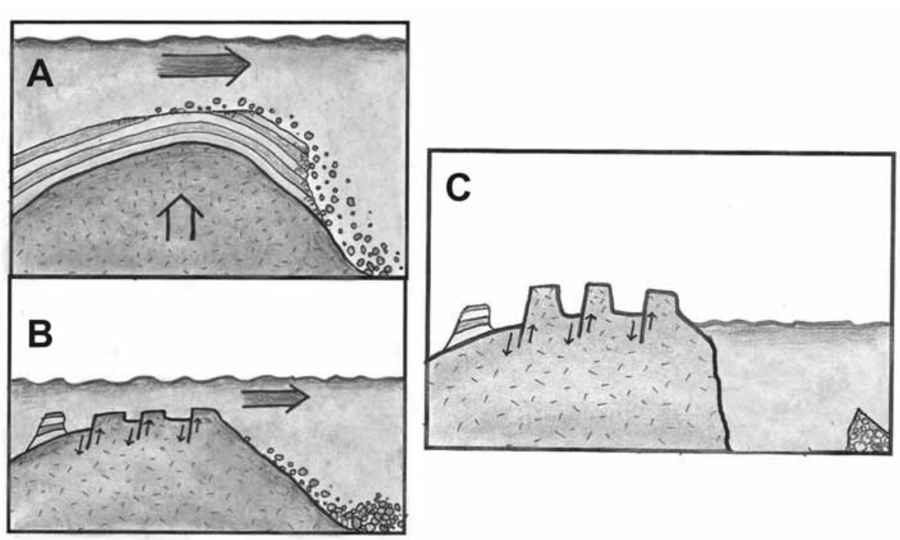

Figure 11. Schematic illustrating deposition and erosion of the conglomerate east of the Beartooth Mountains (drawn by Mrs. Melanie Richard). (A and B) As sedimentary rocks are eroded off the top of the Beartooth Mountains, a thick debris fan piles up on the east side. (C) The Beartooth Mountains emerge from the Flood and channelized currents flow north through the Bighorn Basin (into picture). Most of the debris fan is eroded, leaving behind erosional remnants as much as 2 miles (3.2 km) from the base of the mountains, as in Figure 10.

Thousands of Feet of Valley-fill Erosion

The Bighorn Basin was filled primarily with sediments eroded from surrounding mountains. As flow transitioned to channelized flow, currents moved downslope to the north, where they joined with a west-east current moving across eastern Montana. In the northern Midwest, water converged with currents from the western Appalachians, shifted south, and transported massive volumes of sediment to Texas and the Gulf of Mexico. Debris from the erosion of valley fill from Rocky Mountain basins is not found nearby, as predicted by uniformitarian geology. Instead, it was transported as far as the Gulf of Mexico during Flood runoff.

Several thousand feet of the Bighorn Basin fill sediment was eroded, as shown by the height of erosional remnants and coal rank. Tatman Mountain is a planation surface remnant, about 1,000 ft (305 m) above the lower planation surface in the basin, capped by rounded rocks. Near the top is a layer of low-rank lignite coal, which indicates a previous sediment cover of at least a few thousand feet (Mackin, 1937). This suggests that a patch of valley fill called Darton's Bluff, high in the Bighorn Mountains, is an erosional remnant. Scientists believe that thousands of feet of valley-fill sediments were eroded from the Bighorn Basin (Kochel and Ritter, 1982; McKenna and Love, 1972).

Sheet-flow Planation Surfaces

Several planation surfaces formed in this region during the sheet-flow phase. After the Absaroka Volcanics were de-

Figure 13. Sphinx Mountain, Madison Range, southwest Montana, is composed of 3,000 feet (914 m) of limestone breccia.

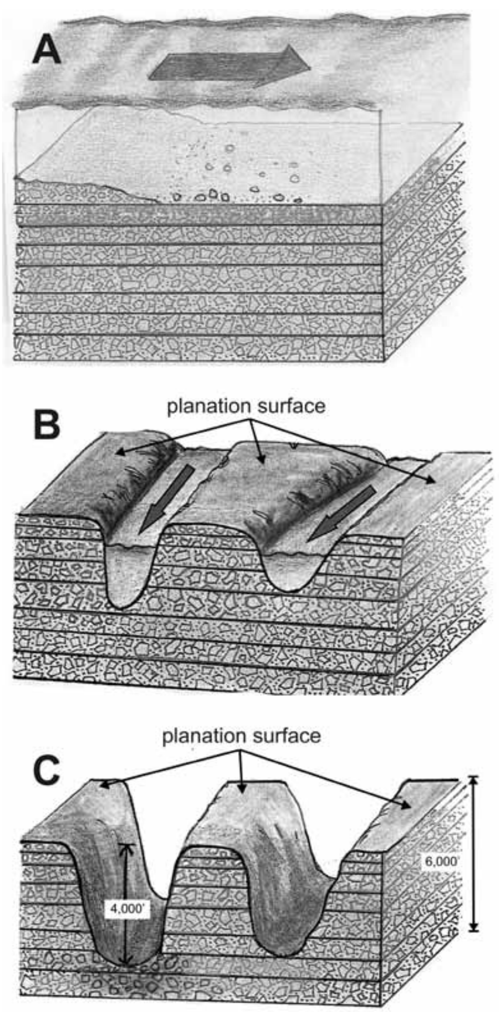

Figure 14 ***(left)*****. Transition from sheet flow to channelized flow erosion in the Absaroka Volcanics of north-central Wyoming and south-central Montana: (A) Deposition of volcanic lahars, (B) sheet erosion formed a planation surface, (C) channelized erosion cut canyons. Drawn by Mrs. Melanie Richard).**

Figure 15 ***(below)*****. Planed top of Gypsum Mountain, northwestern Wind River Mountains, with strata dipping west at about 40°.**

Figure 16. YU Bench, a gravel-capped planation surface about 20 miles (32 km) southeast of Cody, Wyoming, looking north to McCullough Peaks from the Heart Mountain slide. Rounded rocks are primarily from the Absaroka Mountains to the west.

Figure 17. Polecat Bench planation surface. Notice strata dipping slightly to the right.

Figure 18. A planation surface on top of a small plateau in the Bighorn Basin, just west of Greybull, Wyoming. Note that the strata dip to the west at about 30° (view south).

posited, their top was planed, as seen on mountaintops in the southern Absaroka Mountains (Love et al., 2007; Mackin, 1937). Later channelized erosion there created canyons up to 4,000 ft (1,219 m) deep (Figure 14). All of this erosion correlates to the mid-to-late Cenozoic, suggesting that the post-Flood boundary is in the late Cenozoic. Planation surfaces were also cut into thick Paleozoic sedimentary rocks flanking the Wind River Mountains, south of the Bighorn Basin (Figure 15). Planation surfaces likely represent late flow in the area. Waning flow would have deposited the existing thin veneer of mostly rounded rocks atop these surfaces.

Bighorn Basin Planation Surfaces

Tatman Mountain is a remnant of a higher planation surface in the Bighorn Basin that extended from Wyoming to Alberta (Alden, 1932). Erosional remnants of this planation surface are found in the Cypress Hills of southeast Alberta and southwest Saskatchewan and a small quartzite cobble-capped remnant between Circle and Miles City, Montana. At one time, it must have extended at least 600 miles (966 km) north-south and 200 miles (322 m) east-west, sloping down from the Rocky Mountains. Given this extent, it probably formed early during the sheet-flow phase.

This extensive planation surface was eroded, and other lower planation surfaces carved. Alden (1932) claimed that there were four distinct planation surfaces on the High Plains. He underestimated by at least one, missing the Wood Mountain planation surface. In the northern Bighorn Basin, YU Bench (Figure 16) and Polecat Bench (Figure 17) are remnants of another. This surface cut across tilted strata, eroding both hard and soft rock in one continuous surface (Figure 18). It was later dissected by late channelized Flood currents and post-

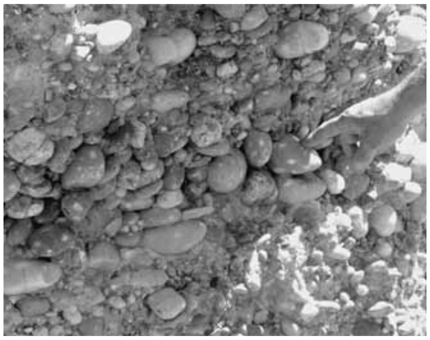

Figure 19. In-situ quartzites with pressure solution marks in the southern Bighorn Basin.

Flood erosion and is capped by rounded rocks, primarily from the Absaroka Volcanics, with minor quartzite.

Quartzite Rocks

Very well-rounded quartzite rocks of gravel to boulder size are found in the Bighorn Basin (Figure 19), the Jackson Hole Valley, and in the western Wind River Basin. The closest source is central Idaho, about 200 miles (322 km) away. These rounded quartzites spread both west and east, suggesting transport during the sheet-flow phase before the Rocky Mountains had been fully uplifted (Oard et al., 2005, 2006). Similar rocks are found on top of at least four mountain ranges in the northern Rocky Mountains and on mountains of eastern Oregon, indicating areas of uplift after the deposition of the quartzites. Some are found concentrated in some valleys, carried by currents of the channelized-flow phase.

The southern third of the Bighorn Basin has similar quartzite rocks, but no planation surfaces. This pattern can be explained by an east-west current that later shifted north. The Owl Creek Mountains were probably just starting to rise, blocking the spread of quartzite rocks and turning the current north. This flow possessed insufficient energy to plane the southern part of the Bighorn Basin but was energetic enough to transport and deposit millions of quartzite rocks. With no mountain ranges blocking the flow to the north, the current accelerated away from the north slope of the Owl Creek Mountains, regaining enough energy to carve planation surfaces in the northern Bighorn Basin. Rocks of Absaroka Volcanics were carried into the northern Bighorn Basin and carpeted most of that planation surface.

Figure 20. Pediment erosional remnant east of the Beartooth Mountains.

Figure 21. A pediment just east of the northeast Beartooth Mountains, Montana.

Pediments

Pediments are planation surfaces found at the foot of mountains. Those along the edges of the Bighorn Basin are mostly isolated but are more developed along the western edge of Clarks Fork Basin (Figure 1 in Oard, 2017). They also suggest formation during the waning fast currents of the Flood; both from erosion and from deposition of lag gravels. Accelerating flow caused erosion of the pediment and then dissected it, leaving only remnants (Figure 20). Another pediment at a lower elevation could have formed, depending upon flow conditions.

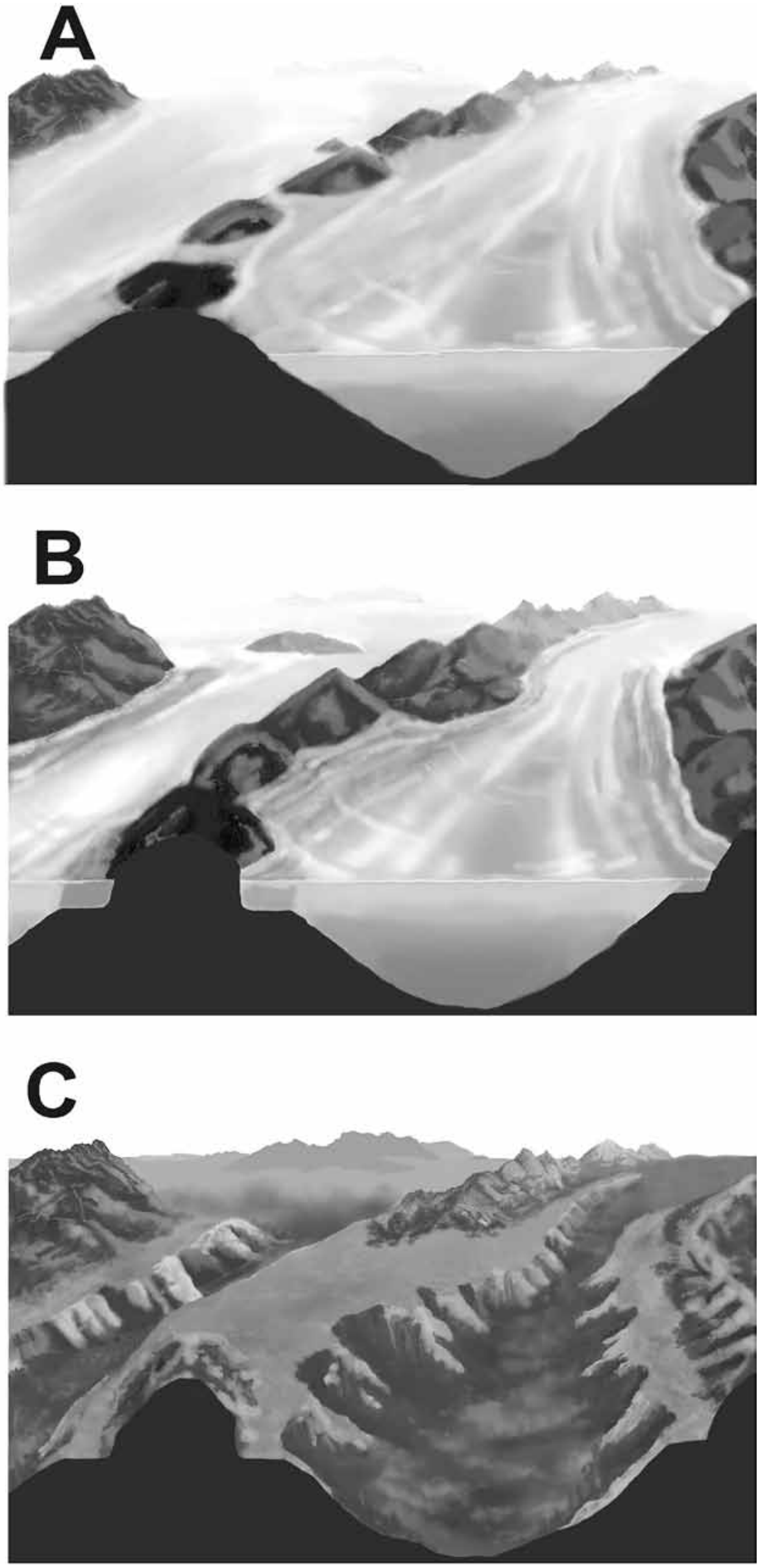

Figure 22. Schematic of the formation of a pediment pass (drawn by Mrs. Melanie Richard). (A and B) Channelized Floodwater carved a pediment on both sides of the mountain range. (C) Pediments merged at the top of the range.

The most spectacular pediment is found along the northeast corner of the Beartooth Mountains in the Clarks Fork Basin (Figure 21). It stands about 1,500 feet (457 m) above Clarks Fork Basin and about 3,000 feet (914 m) above the Yellowstone River to the north. Pediment remnants are found at about the same altitude to the west, along the northern Beartooth Mountains. This high pediment probably formed during sheet-flow erosion (most pediments in mountain valleys would have formed during the channelized-flow phase). It was preserved possibly because the fast flows between the broad currents moving eastward over the Montana and Alberta High Plains and the one flowing north from the Bighorn Basin converged, with the strongest flow being away from the mountains, creating a low flow velocity area over this pediment.

Most secular theories of pediment formation (except Crickmay's superflood idea) include water flowing out of adjacent mountains (Oard, 2013a). However, this pediment extends from a *ridge* in the Beartooth Mountains. The deep valleys carved in the pediment connect with valleys from the Beartooth Mountains, indicating that mountain streams dissected the pediment but did not create it. Flow in uniformitarian conditions is not powerful or widespread enough to cut pediments (Oard, 2013a). Pediments, pediment passes, and pediments found on uplifted rock domes all demonstrate that uniformitarianism cannot explain field features.

A *pediment pass* is parallel pediments on two sides of a mountain range. An example is found in southern Arizona, where pediments converge and then merge atop a mountain range but at different altitudes (Howard, 1942) (Figure 22). If water from the mountains carved the flat pediments, as uniformitarians believe, how could it have formed a pediment that high? Furthermore, uplifted domes in the Mojave Desert, like Cima Dome, are surrounded by pediments.

Figure 23 ***(above)*****. Cima Dome, eastern Mojave Desert, California, with a few monadnocks, rounded erosional remnants left behind from the erosion.**

Figure 24 ***(below)*****. Block diagram showing the developing of pediments (A-E) along the sides of mountains during the downvalley drainage of the Floodwater. Drawn by Peter Klevberg.**

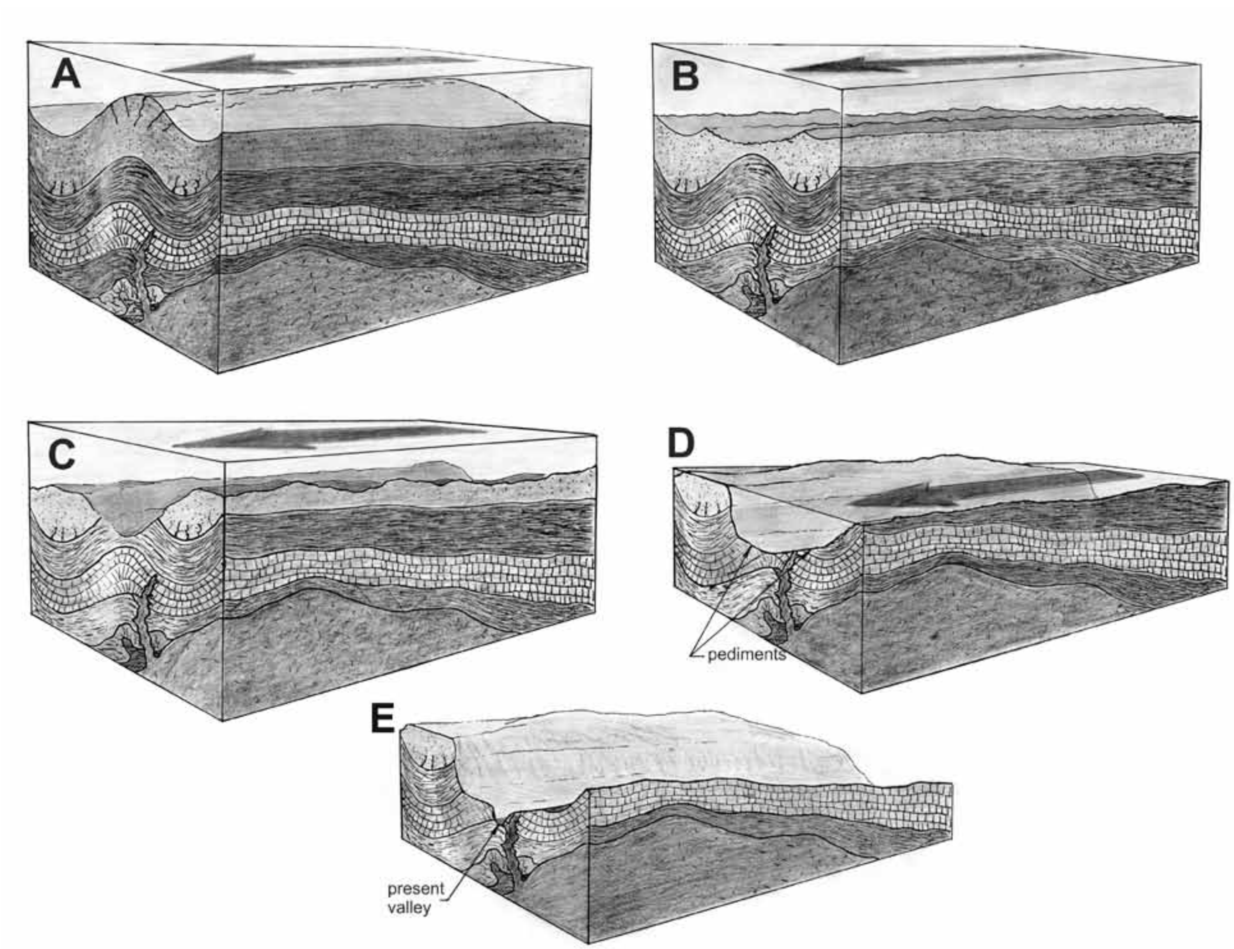

Figure 25. A water gap through the Rattlesnake Mountains west of Cody Wyoming. The Shoshone River flows east toward the viewer.

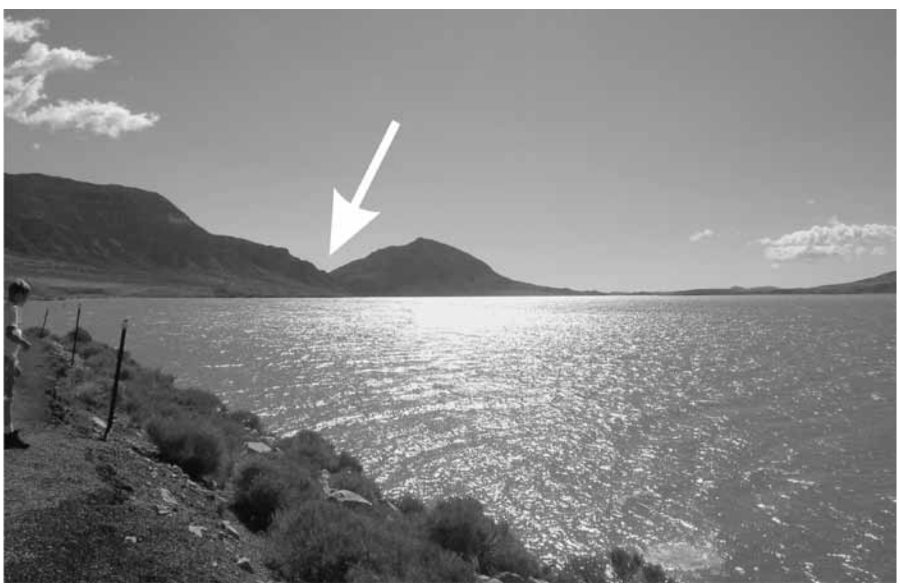

Figure 26. Buffalo Bill Reservoir showing wide low point to the south (view southeast). The arrow shows Shoshone water gap.

Cima Dome and its encircling pediments are the same altitude and topped with rounded rock (Figure 23). A Flood explanation better addresses field reality.

Crickmay's (1974) superflood hypothesis comes closest to explaining pediments. He understood the necessity of flood currents parallel to the mountains. He also noticed the exotic rocks atop some pediments and concluded that they were cut by superfloods flowing parallel to the mountains. I have seen many pediments topped by exotic quartzites transported from central Idaho. These large, rounded rocks clearly indicate flow *parallel* to the mountains, although many of the rocks originated from the surrounding mountains, which is expected since there would be a component of flow from off the mountains during a waning current. Cobble to boulder-sized rocks require large, energetic currents. Crickmay was on the right track, but his recurring "superfloods" were too small, since the valleys were filled by deep, fast currents. The pediment on the northeast tip of the Beartooth Mountains shows that *all of Montana* east of the divide was covered by a deep, fast current, energetic enough to erode the High Plains to the level of the Yellowstone River, 3,000 feet (914 m) below the pediment. In the Flood model, pediments were eroded during the channelized erosion as currents swept down the valleys (Figure 24). These currents represented the last Floodwaters in that area.

Water Gaps

Water gaps are found in the Bighorn Basin and adjacent mountains. Water gaps are gorges that transect a mountain, mountain range, plateau, or any other structural barrier and carry a stream or river. There are thousands of water gaps across the world (Oard, 2013a); the Susquehanna River basin in Pennsylvania alone has 653 (Lee, 2013).

A spectacular water gap is found west of Cody, Wyoming, carrying the Shoshone River (Figure 25). It is 2,500 ft (762 m) deep, carved into hard granite and the sedimentary rocks of the Rattlesnake Mountains. Uniformitarians think the present river eroded it, but had it moved only two miles (3.2 km) south, it could have flowed around the southern end of the Rattlesnake Mountains instead of cutting their southern edge (Figure 26).The area to the south is so low that engineers had to place another dam on the Buffalo Bill Reservoir to keep the water out of the Bighorn Basin.

A 3,000 ft-deep (914 m) water gap cuts through the Owl Creek Mountains south of Thermopolis, Wyoming (Figure 27). The Wind River flows through this gap and becomes the Bighorn River on the north side. Uniformitarians think that sediments in the Wind River Basin were once higher than today. If so, the Wind River should have exited a low to the east, toward Casper. The pass is about 1,000 ft (305 m) higher than the Wind River at Riverton, Wyoming, but the Owl Creek Mountains are 3,000 ft (914 m) high. Mackin (1937) says this water gap was formed by stream capture—a small stream in the Owl Creek Mountains eroded south through the mountains and captured the Wind River, which was flowing east.

Another water gap is found in a low saddle between the northern Bighorn Mountains and the Pryor Mountains to the north. It is unique—its river flows through entrenched meanders 1,300 ft (396 m) deep. The meanders are on top of the water gap (Figure 28). Both sides of the entrenched meanders are vertical, while meandering channels have a steep outside bend and a gentle inside bend (Oard, 2013a).

The Sheep Mountain water gap carries the Bighorn River through a 1,000-ft (305-m) uplift in the northwest Bighorn Basin (Figure 29). A pediment was carved after the uplift on its east slopes. The uplift is partially capped by exotic quartzite rocks and dissected by subsequent erosion.

Uniformitarian geology has not explained water gaps. Every hypothesis has serious difficulties (Oard, 2013a). The single greatest problem is the courses of the rivers. With slow, gradual erosion, rivers seek low ground. In many cases, rivers could have flowed around structural barriers, rather than through them. John Wesley Powell formulated one of the earliest hypotheses for water gaps in the 1860s to explain the remarkable water gaps on the Green River and the Colorado River (Oard, 2014b). He called it the *antecedent river hypothesis*. He believed that rivers were already in place and that the structural barrier rose at the same erosion rate as the river. This remarkable balance allowed the river to erode the barrier rather than flow around

Figure 27. A 3,000-ft (914 m) deep water gap through the Owl Creek Range, south of Thermopolis, Wyoming.

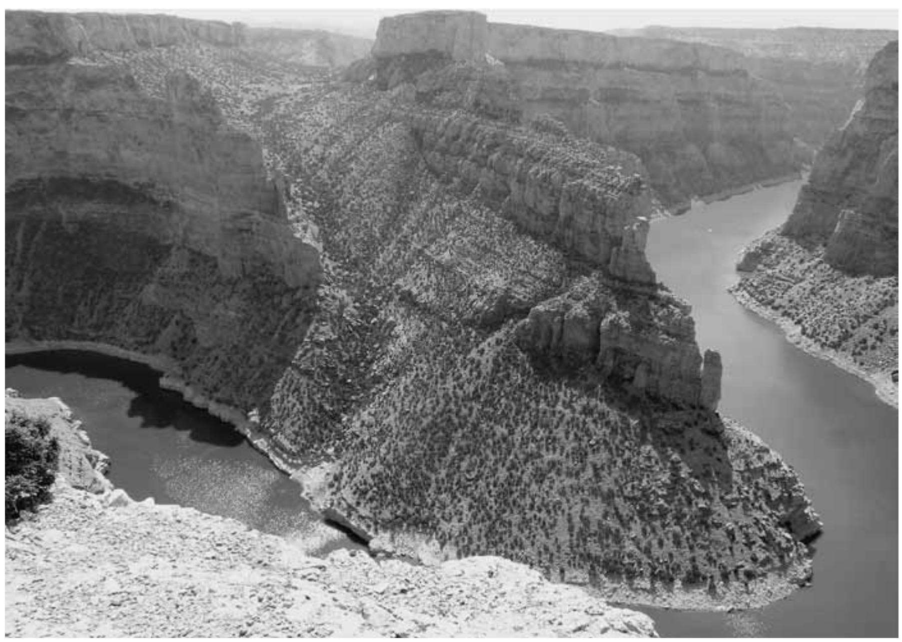

Figure 28. Entrenched meanders on the Bighorn River as it cuts through a water gap in a ridge between the Bighorn and Pryor Mountains.

Figure 29. Water Gap of the Bighorn River through the Sheep Mountain anticline just northeast of Greybull, Wyoming, in the Bighorn Basin. The anticline is about 1,000 feet (305 m) high.

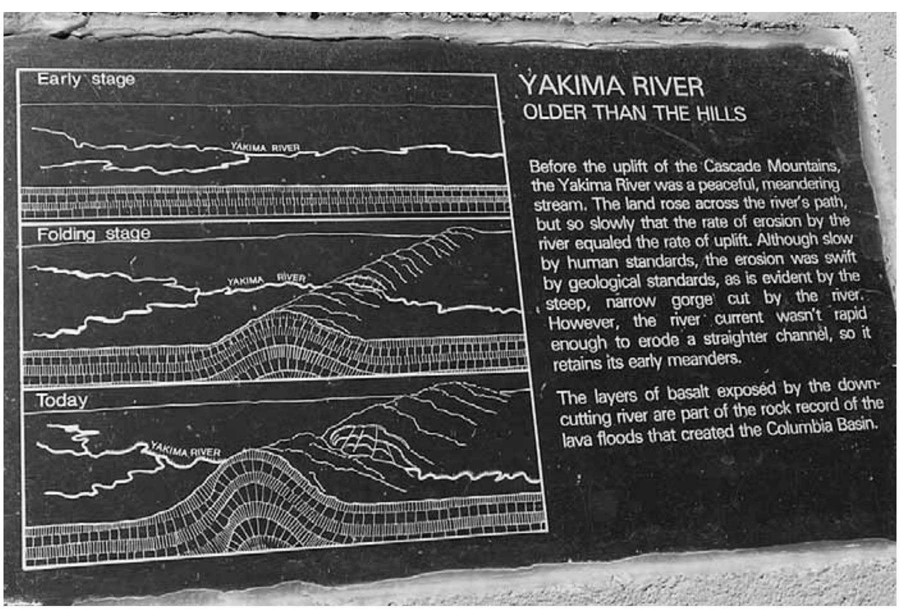

Figure 30. Plaque of the antecedent river hypothesis explaining how the Yakima River cut through a lava ridge. The Yakima River was already present as the ridge slowly uplifted at the same rate the river eroded downward, keeping the course in place.

it or form a lake (Figure 30). How likely was his idea? Not very. Most scientists have rejected it because the majority of mountains and plateaus, including those carved by the Green and Colorado Rivers, indicate the barrier preceded the river.

Water gaps are readily explained by late Flood erosion (Figure 31). Water draining over rising barriers found low spots (Figure 31a), channelized and accelerated through these spots (Figure 31b), and eroded preferentially through the developing gaps (Figure 31c), leaving gaps for developing rivers, or, if high enough, became wind gaps (Figure 31d). Wind gaps are almost as common as water gaps.

Post-Flood Rapid Glaciation

The Bighorn Basin also displays remnants of the Ice Age (Oard, 2004, 2013a,

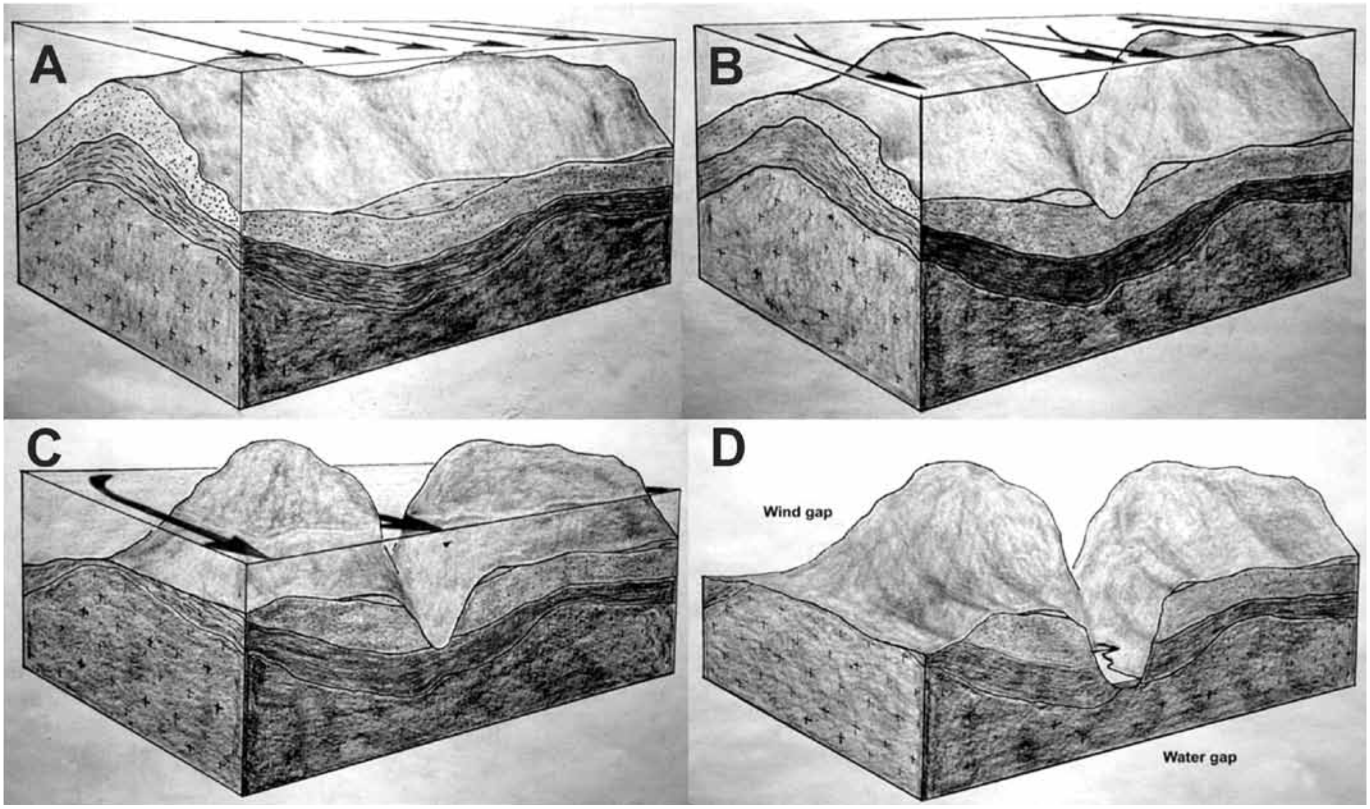

Figure 31. Schematic showing the formation of water and wind gaps (drawn by Peter Klevberg). (A) Water flowing perpendicular to a transverse ridge forms shallow notches on the ridge. (B) Notches erode deeper as the water drops below the ridge. (C) Notches deepen as water level subsides. (D) After Flood, river drainage is established in existing low. Higher notches become wind gaps.

2013b). A terminal moraine at Clarks Fork Canyon is locked between two erosional remnants of an alluvial fan east of the Beartooth Mountains (Figure 32). Thousands of partially rounded granite boulders dot the plains up to 6 miles (10 km) east of this moraine. The boulders are up to 6 ft (2 m) in diameter (Figure 33). It is possible that they were spread when a flood breached the terminal moraine. Or, they may represent catastrophic melting of an ice sheet, if it was large enough to carry them. Outwash terraces around and east of Cody formed by catastrophic melting, as did outwash terraces found near Red Lodge, near the northeast corner of the Beartooth Mountains.

Figure 32. End moraine at the mouth of Clarks Fork Canyon. A breach in the moraine at right may have allowed the deposition of boulders in Figure 33.

Figure 33. Rounded granite boulders near Clarks Fork Canyon.

erosion removed rocks from many mountains. Some of this was trapped in the Bighorn Basin, forming thick valley fill. Huge "alluvial fans" accumulated east of the Beartooth and Bighorn Mountains and were then mostly eroded. Several thousand feet of this valley fill was swept away by energetic currents as the water was restricted during the channelized phase. During both stages, planation surfaces formed and were then eroded. Quartzite rocks, up to boulder size, were transported long distances and spread. Pediments were carved and then re-eroded, and water gaps formed. Figure 34 summarizes these events. The Ice Age, an aftereffect of the Flood, left behind moraines, outwash features, and boulders. The Bighorn Basin is a monument to the Flood.

Conclusions

Evidence from the retreating stage of the Flood and the Ice Age are seen in the Bighorn Basin and surrounding mountains. Huge differential vertical tectonics, during the later stage of the Flood, is seen in the uplift of the mountains and sinking of the basin. The rapidity of movement is seen where sediments sharply bend over the high rising mountains, and by displacement of the Heart Mountain Slide. As the Flood retreated,

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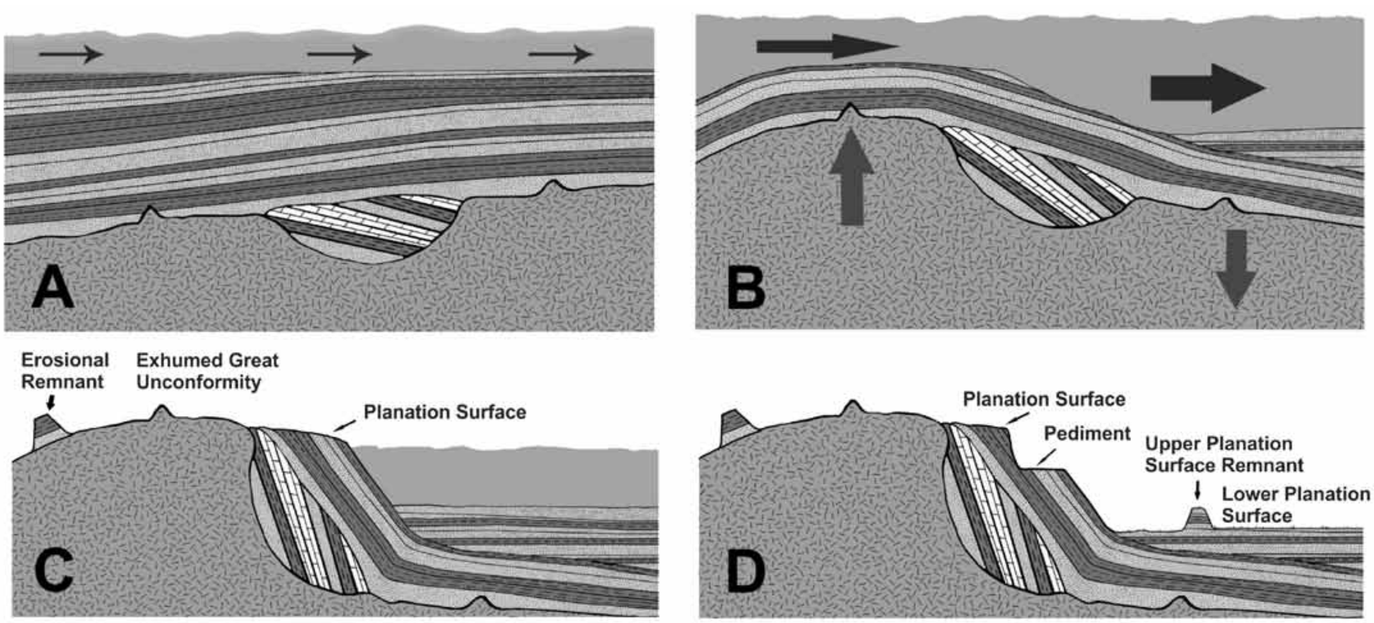

Figure 34. Schematic of the retreating stage of the Flood (drawn by Mrs. Melanie Richard). (A) The end of the flooding stage. (B) The mountains rise and the valleys sink down. (C) The Great Unconformity exhumed, eroded sediments fill valley, and planation surfaces are formed in the strongly tilted sedimentary rocks. (D) The terrain today.

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