THE STRATIGRAPHY OF THE MIOCENE BIG CUT LOCALITY, GILLIAM COUNTY, NORTHERN OREGON

James E. Martin
University of Louisiana Geology Museum
School of Geosciences
Lafayette, LA 70504
Email: JEMartinprofcur@protonmail.com

ABSTRACT

In the 1970s, huge intersecting trenches were excavated as part of the impact studies for a proposed nuclear power plant along the Columbia River south of the town of Arlington, Oregon, in the Pebble Springs area. These trenches produced excellent exposures of the late Miocene Alkali Canyon Formation of the Dalles Group. The author secured permission to collect fossil vertebrates and was able to document the stratigraphic relationships within the trenches. When the nuclear power plant project was abandoned, the trenches were filled. Because these exposures revealed lithostratigraphic successions that were previously poorly known for the formation and because these exposures are no longer extant, the stratigraphic relationships within the Big Cut trenches are presented herein. Most of the deposits within the trenches represent the lower portion of the Alkali Canyon Formation, which has heretofore been virtually unknown. At the Big Cut, the Alkali Canyon Formation is unconformably overlain by late Pleistocene Missoula Flood deposits. The placement of the Big Cut and exposures in the trenches document Miocene erosion by channelization and by widespread erosional episodes demarked by unconformities, as well as illustrating late Miocene lithologies that survived Quaternary erosion and are poorly exposed elsewhere.

Keywords

Oregon, Miocene, Alkali Canyon Fm., North American Land Mammal Age (NALMA)

INTRODUCTION

Nuclear power was being strongly promoted in the Pacific Northwest during the 1970s. Numerous studies were conducted both east and west of the Cascade Mountains by various companies, particularly the Washington Public Power Supply System and the Portland General Electric Company. One of the proposed nuclear power plant sites was along the Columbia River where water for cooling was available and was termed the Boardman Nuclear Project. A site that was seriously considered was south of the town of Arlington (Figure 1) near Pebble Springs in the NW1/4, Section 36, T3N, R21E, Gilliam County, Oregon. Extensive geological studies were undertaken to determine if the site was geologically safe. A series of study trenches were excavated throughout the proposed area, including two long, deep trenches that intersected at right angles. These intersecting trenches with four to five-meter high benches were dug up to 40 meters in depth, were termed the Big Cut, and provided exposures (Figure 2; and Figure 2 of Martin and Johnson 2016) of portions of the lithostratigraphic section that were either poorly exposed or unknown. In addition, vertebrate fossils were encountered, including some complete skeletons (Martin and Johnson 2016), which will be the focus of a subsequent contribution.

The Alkali Canyon Formation was proposed by Farooqui et al. (1981) for exposures in the Arlington Basin, south of the Columbia River, which had previously been informally considered the Arlington lake beds (Hodge 1932) and later

Figure 1. Area of investigation in Gilliam County, south of the Columbia River in north-central Oregon.

***Figure 2.** Views of the Big Cut trenches: a) view to the north; b) view to the south. Note half-ton pickup for scale.*

as the Shutler Formation (Hodge 1942). The depression of the Arlington Basin is part of the Dalles-Umatilla Syncline, bounded on the north by the Columbia Hills Anticline, on the south by the Willow Creek Monocline, on the east by the Service Anticline, and on the west by the Turner Butte Anticline (See Farooqui et al. 1981). Designation of the Alkali Canyon Formation was the result of various geological investigations centered around the nuclear power industry, principally through the Portland General Electric Company during the 1970s. Farooqui et al. (1981) considered the Alkali Canyon Formation as a member of the Dalles Group. Its namesake, the Dalles Formation, was a unit originally noted by Thomas Condon for mammal-bearing outcrops forming cliffs south of the Columbia River at The Dalles. Cope (1881) formalized the Dalles Formation, considering it to be composed of fluvial and lacustrine deposits underlain and overlain by basalt flows. Farooqui et al. (1981), following the work of others, considered the Dalles Formation to be of group status and named the Chenoweth Formation to represent the deposits in the type Dalles area. Interestingly, Newcomb (1966, 1971) had previously pointed out an age discrepency between the rocks of the Dalles Group in the type area (Chenoweth Formation) and those in the Arlington Basin (Alkali Canyon Formation) that is not yet totally resolved.

In 1967, Schminke extended the terminology of the Yakima Basalt and Ellensburg Formation of central Washington (Figure 3) south to the Columbia River. Newcomb (1966, 1971) expanded on Schminke's correlations and extended his terminology into the Arlington Basin south of the Columbia River, and also extended the Dalles Formation into this area. The base of the exposed section in this area is represented by the Pomona Basalt, which crops out along the Columbia River and whose eroded top represents the lowest stratigraphic unit at the Big Cut Locality. The basalt disappears farther south in the Shutler Flat/Alkali Canyon areas (Newcomb 1971). Suprajacent to the Pomona Basalt lies the Rattlesnake Ridge Member of the Ellensburg Formation (Figure 3), a unit interbedded (e.g. Reidel and Tolan 2013) in central Washinton between the Pomona Basalt (12 Ma) and the Elephant Mountain Basalt (10.5 Ma). These dates are consistent with those typically considered equivalent to the late Clarendonian North American Land Mammal Age (Tedford et al. 2004), and the most diagnostic mammalian paleofauna from the Rattlesnake Ridge Member, the Babcock/Foisy local fauna (Martin and Pagnac 2009), confirms the late Clarendonian assignment. In the Arlington Basin area, the Elephant Mountain Basalt occurs locally, but is absent in many surrounding areas (Newcomb 1971). The suprajacent Miocene unit is the Alkali Canyon Formation, which here appears unconformably above the Elephant Mountain down through the Pomona succession. Extensive vertebrate collections were derived from the upper portion of the Alkali Canyon Formation just to the east and were presented in a series of publications (Martin 1984, 1998, 2008); these paleoassemblages indicated a late Hemphillian NALMA, as do those from the McKay Reservoir Locality farther east in the Pendleton area (Martin et al. 2018).

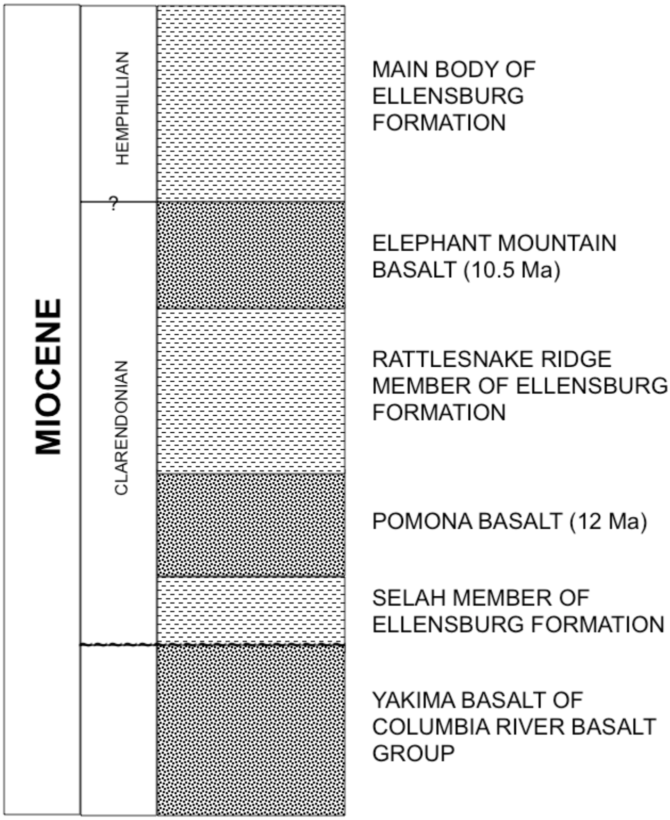

Figure 3. Stratigraphic succession of the Ellensburg Formation and interbedded basalt flows in central Washington.

LITHOSTRATIGRAPHY OF THE BIG CUT LOCALITY

The overall stratigraphic relationships of lithologies exposed at the Big Cut are presented in Figure 4. The base of the stratigraphic section of the Big Cut was floored by the Pomona Basalt according to the geotechnical report for the proposed Pebble Spings nuclear facility (Shannon and Wilson 1975). Only the weathered top was actually exposed at the base of the trenches (Figures 4-5), evinced by a yellowish regolith containing angular vesicular basalt clasts. Seven major lithostratigraphic intervals overlie the basalt and are exposed in the walls of the trenches (Figures 5-8); the lower five are relatively well consolidated and appear to represent Miocene deposits, whereas the sixth and seventh intervals are composed of relatively unconsolidated silts, sands, and gravels representing Pleistocene Missoula Flood deposits derived from flooding events caused by periodic melting at glacial Lake Missoula in Montana. Cut and fill is the dominant sedimentary feature of the entire Big Cut succession with abundant cross-bedding in the coarser units. The Miocene stratigraphic section is typified by five successively stacked major lithological intervals that include a gray mottled siltstone, a

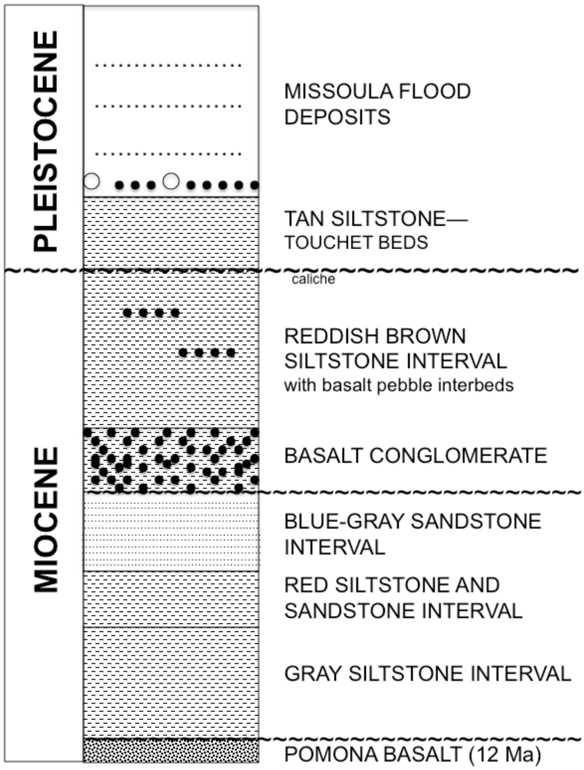

Figure 4. Overall stratigraphic succession at the Big Cut Locality, illustrating intervals within the Alkali Canyon Formation and overlying Missoula Flood deposits.

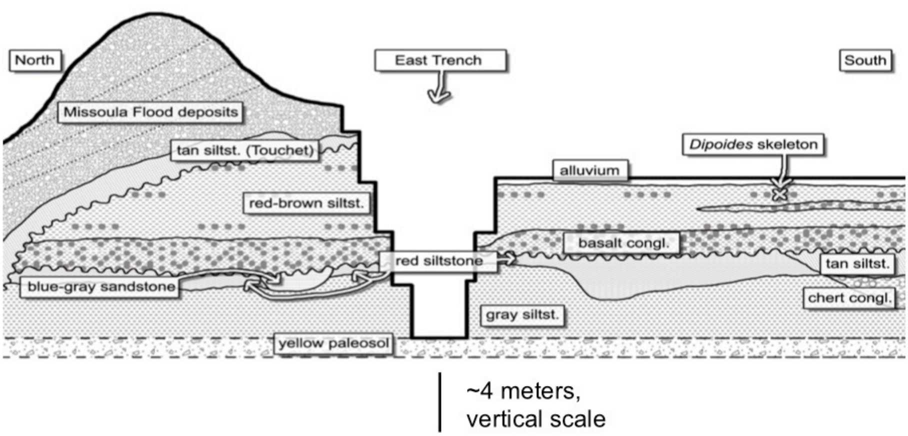

Figure 5. Cross-section of North-South trench view to the east; lateral scale extremely foreshortened. Compare to Figure 2a to illustrate the degree of foreshortening.

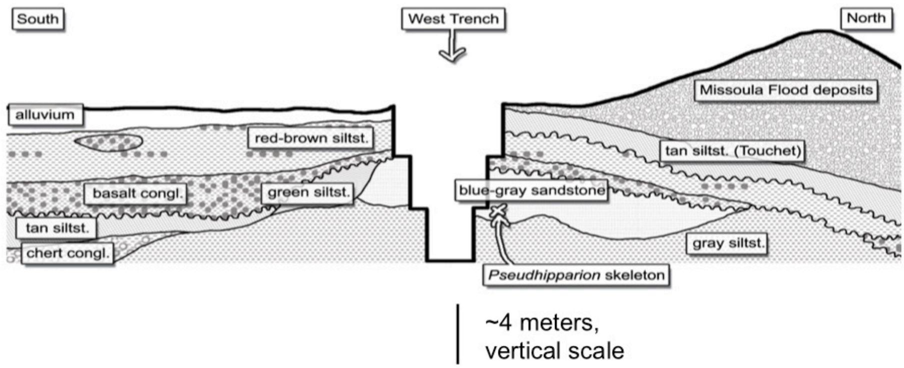

***Figure 6.** Cross-section of North-South trench, view to the west; lateral scale foreshortened.*

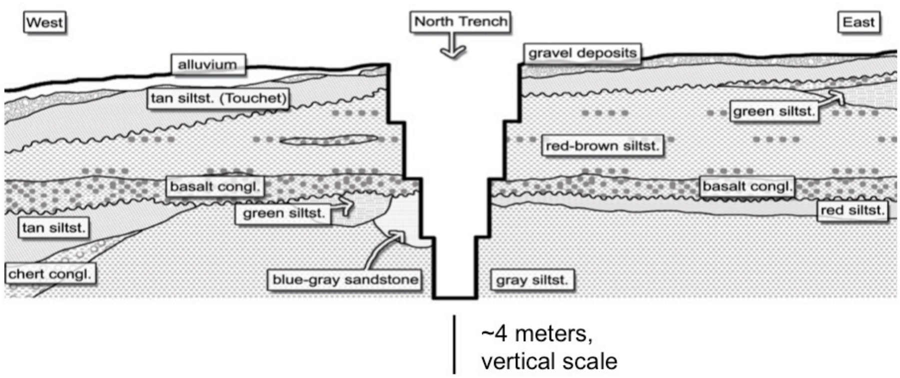

***Figure 7.** Cross-section of East-West trench, view to the north; lateral scale foreshortened.*

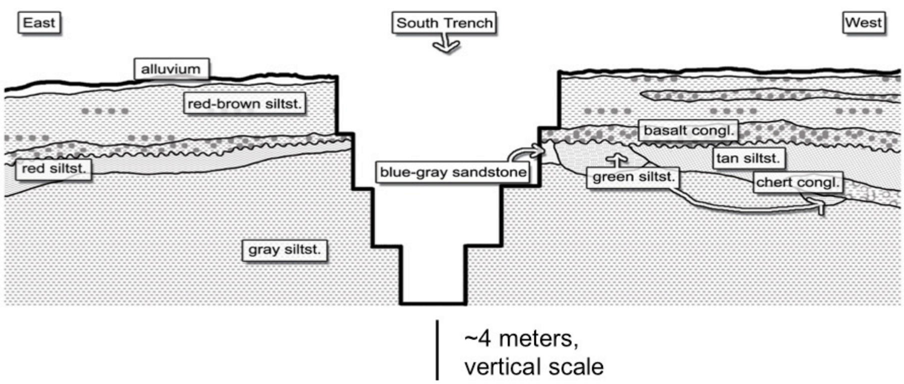

***Figure 8.** Cross-section of East-West trench, view to the south; lateral scale foreshortened.*

massive red siltstone, a blue-gray sandstone with coarser layers, a distinct coarse basalt-clast conglomerate, and a reddish brown siltstone with interbedded lenses of basaltic pebbles (Figure 4).

Near the base of every trench exposure, a gray siltstone crops out, but only on the eastern wall of the North-South trench was the contact with the underlying yellow basaltic regolith exposed (Figure 5). The gray siltstone interval (Figures 7-8) is nearly 10 meters thick, mottled green, and can have interbedded pebble conglomerates composed of pebble-sized rip-up clasts of the gray siltstone. Suprajacent to the gray siltstone interval is usually a massive red siltstone and sandstone, which is approximately 2 meters thick, is characterized by white rootlet molds, and from which a few vertebrate fossils were secured. However, the red siltstone may be completely cut out by various channels within the overlying blue-gray sandstone interval (Figures 7-8).

The distinctive blue-gray sandstone interval is over 3 meters thick, is quite similar to blue-gray units exposed in the Ellensburg Formation in Washington, and is also the most variable interval, characterized by numerous fluvial channels. Normally, the blue-gray sandstone channel cuts into or through the subjacent red siltstone and is composed of fine- to coarse-grained volcaniclastic sandstone characterized by high angle cross-bedding (Figure 9). The base of the channel is characterized by fossil vertebrates (including a horse skeleton) and wood fragments. The blue-gray sandstone channel is cut by a greenish siltstone channel that can be incised down into the the gray siltstone. A chert-clast conglomerate, similar to some commonly found in the Ellensburg Formation, cross-cuts the green

Figure 9. Cross-bedding in the blue-gray sandstone interval. The suprajacent basaltic conglomerate channel is incised into the blue-gray unit indicating a major unconformity in the stratigraphic section.

channel and also locally cuts into the gray siltstone. Lastly, a tan siltstone channel overlies and cuts into the chert conglomerate and through all other channels into the underlying gray siltstone interval. No fossil remains were found in these latter three channel fills. This interval, termed the blue-gray sandstone interval, exhibits complex cut and fill structures with variable lithologies including chert conglomerate channel fills, contains only rare basaltic pebbles, and probably represents a relatively significant amount of time.

A distinct lithological change occurs with the deposition of 1-2.5 meters of basalt-clast conglomerate in a widespread channel. The conglomeratic clasts are subrounded to rounded, cobble to small boulder size, and supported by a basaltic sand matrix. The base of this channel is disconformable with distinct cut and fill and truncates most of the units of the blue-gray sandstone interval down to the red siltstone interval as can be seen in the southern wall of the East-West trench (Figure 8). This basaltic conglomerate persists throughout the Big Cut and contains scattered fossil vertebrate remains.

The interval overlying the widespread basaltic conglomerate consists principally of a massive reddish brown siltstone approximately 11 meters thick that is characterized by manganese-stained rootlet molds and yellow wood fragments. This unit has 10-50 cm thick basalt pebble channel interbeds that are fossiliferous. A skeleton of the beaver, *Dipoides stirtoni*, was collected from the upper portion of the massive siltstone (Martin and Johnson 2016), as well as additional beaver

Figure 10. Missoula Flood deposits with bedded, fine-grained, slack-water deposits overlain by poorly consolidated, subangular, poorly sorted cobble to boulder gravel. The geology hammer leans against a granite boulder, although most boulders are of basalt as to the right of the hammer. The white clasts represent reworked locally derived caliche fragments.

cranial and jaw material. At the top of the reddish brown siltstone is a distinctive caliche layer that follows the Miocene paleotopography and is overlain by silts identical to the slack-water deposits of the late Pleistocene Missoula Flood (Clague et al. 2003), informally known as the Touchet beds in southeastern Washington. These fine-grained deposits are identical and even exhibit the clastic dikes that characterize the Touchet beds farther east along the Columbia River and further north in southeastern Washington. The Touchet silts also contain the typical fossil assemblages found in Washington that are poorly fossilized and commonly contain fossil ground squirrels. Overlying these fine sediments are unconsolidated, poorly sorted, angular to subangular basaltic gravel with some large granite erratics interbedded with thin layers of poorly cross-bedded basaltic sandstone and siltstone (Figure 10). These sediments represent flood deposits from the catastrophic Lake Missoula flooding that created the scablands of eastern Washington. The caliche that occurs below the slack-water deposits dips approximately 15 degrees northerly and represents a major unconformity that lies above all the underlying units exposed at the Big Cut (Figures 4-5).

SUMMARY—GEOLOGICAL HISTORY

Approximately 12 million years ago, the Pomona Basalt flowed across eastern Washington and north-central Oregon. Although not well exposed in the Big Cut, the weathered top of the basalt appears in the southern portion of the trenches (Figure 5). Weathering indicates a disconformable relationship with suprajacent deposits, a lacuna representing the missing time that occurred during the weathering process. Probably little sedimentation occurred over the basalt until the gray siltstone interval was deposited. Otherwise, the weathered yellow regolith would likely have been eroded, leaving only the resistant basalt. Therefore, relatively little time appears to be represented by the disconformity.

The suprajacent gray siltstone interval appears to represent a fluvial overbank deposit. Its thickness and massive nature suggest significant water, probably over considerable time, covering the flood plain during deposition. Thin basaltic pebble conglomerates occur above the gray siltstone interval but do not persist laterally; tortoise shell plates were found reworked in this pebble gravel. This conglomerate is overlain by a massive red siltstone and sandstone, characterized by white molds of rootlets. The conglomerate and red siltstone may represent a graded bedded depositional package, with paleosol development in the red siltstone.

The blue-gray sandstone represents the oldest unit of a chaotic interval of cut and fill by numerous channels, probably over significant time. The blue-gray sandstone interval is comprised principally of volcaniclastics, is highly cross-bedded indicating high energy (Figure 9), and consists of extensive paleochannels. Wood remnants and fossil vertebrates characterize this interval, which is the most fossiliferous of the entire Big Cut section and produced the horse skeleton mentioned previously. The blue-gray sandstone channel fill is identical to blue-gray sands found in the Ellensburg Formation in central Washington. A green siltstone channel cross-cuts the blue-gray coarse sand, which in turn is cut by a chert conglomerate that is channeled by a tan siltstone. This indicates significant channel formation over time. The similarity of the sediments to those in Washington and the lack of significant basalt clasts suggests the possibility that this interval from the gray siltstone through the blue-gray sandstone interval could represent a member of the Ellensburg Formation or equivalent. Once the fossil vertebrates are analyzed, some correlations of these sedimentary units may be substantiated.

The suprajacent basaltic conglomerate indicates a significant change in sedimentation. Relatively little evidence of basalt clasts occurs below this layer indicating the conglomerate represents a time when the Columbia River Basalt Group was being actively eroded and redeposited. This conglomerate can occur unconformably over all lithostratigraphic units down to the red siltstone interval. This widespread unconformity appears to represent significant time and may represent the time of erosion of the Elephant Mountain Basalt, which occurs nowhere in the exposed section or in the immediate surrounding area, although it is identifiable along the Columbia River just to the north and to the east along Willow Creek (Newcomb 1971). The overlying reddish brown siltstone interval could represent the upper portion of a graded bedded package whose basal unit is the basalt conglomerate. The siltstone is also interbedded with minor basaltic sand and gravel channels that produced significant fossil remains and may represent smaller graded bedded sequences within the reddish-brown siltstone interval. Specimens of *Dipoides stirtoni*, including a complete skeleton (Martin and Johnson 2016), collected from the reddish brown deposits indicate deposition during the early Hemphillian NALMA (see Tedford et al. 2004) after the time of extrusion of the Elephant Mountain Basalt during the Clarendonian NALMA. The Hemphillian fossils provide additional evidence that the major unconformtiy below the basalt conglomerate represents erosion of some late Clarendonian sediments and the Elephant Mountain Basalt. To the east and higher in the section, specimens of a more derived (advanced) species of *Dipoides* occur in conjuncation with specimens indicative of the late Hemphillian NALMA (Martin 2008). These late Hemphillian rocks appear to have been eroded at the Big Cut during formation of a major unconformity above the reddish-brown siltstone. To the west, this unconformity cuts down across all sedimentary units above the Pomona Basalt (Figures 4-5). A caliche was formed at the surface of the unconformity, suggesting some aerial exposure prior to deposition of late Pleistocene slack-water sediments (Touchet beds) caused by periodic flooding backing water into canyons where the sediment load was discharged. Above the Touchet beds are poorly sorted, chaotic detrital rocks of the Missoula Flood. Therefore, in the Big Cut, rocks representing the late Miocene, Pliocene, and a significant portion of the Pleistocene are missing. Only the fortunate event of the trenches being excavated at this particular site provided direct evidence of the erosion through this upper Cenozoic stratigraphic succession, the exposure of the remnants of late Miocene deposits, and their relationships with the Missoula Flood deposits.

Overall, the timing of events recorded in the Big Cut (Figure 4) from the late Miocene until the present is as follows: 1) extrusion of the Pomona Basalt (12 Ma) and weathering of its top; 2) deposition of gray siltstone through blue-gray sandstone interval, probably representing an Ellensburg member equivalent up through and including the Elephant Mountain Basalt (10.5 Ma); 3) erosion of the late Clarendonian NALMA section including the Elephant Mountain Basalt and portions of the Ellensburg equivalent sediments; 4) deposition of the Hemphillian NALMA basalt conglomerate through reddish-brown siltstone and higher units attributed to the Alkali Canyon Formation of the Dalles Group; 5) erosion of Hemphillian and later sediments down to the reddish-brown siltstone followed by development of widespread caliche across the resulting paleosurface; 6) deposition of slack-water sediments of the tan siltstone (Touchet beds) caused by periodic flooding down the Columbia River during the latest Pleistocene; 7) deposition of chaotic flood deposits during the latest Pleistocene as the result of major catastrophic flood events from Lake Missoula down the Columbia River drainage; and 8) deposition of aeolian loess deposits and Recent alluvium resulting in the present landscape.

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