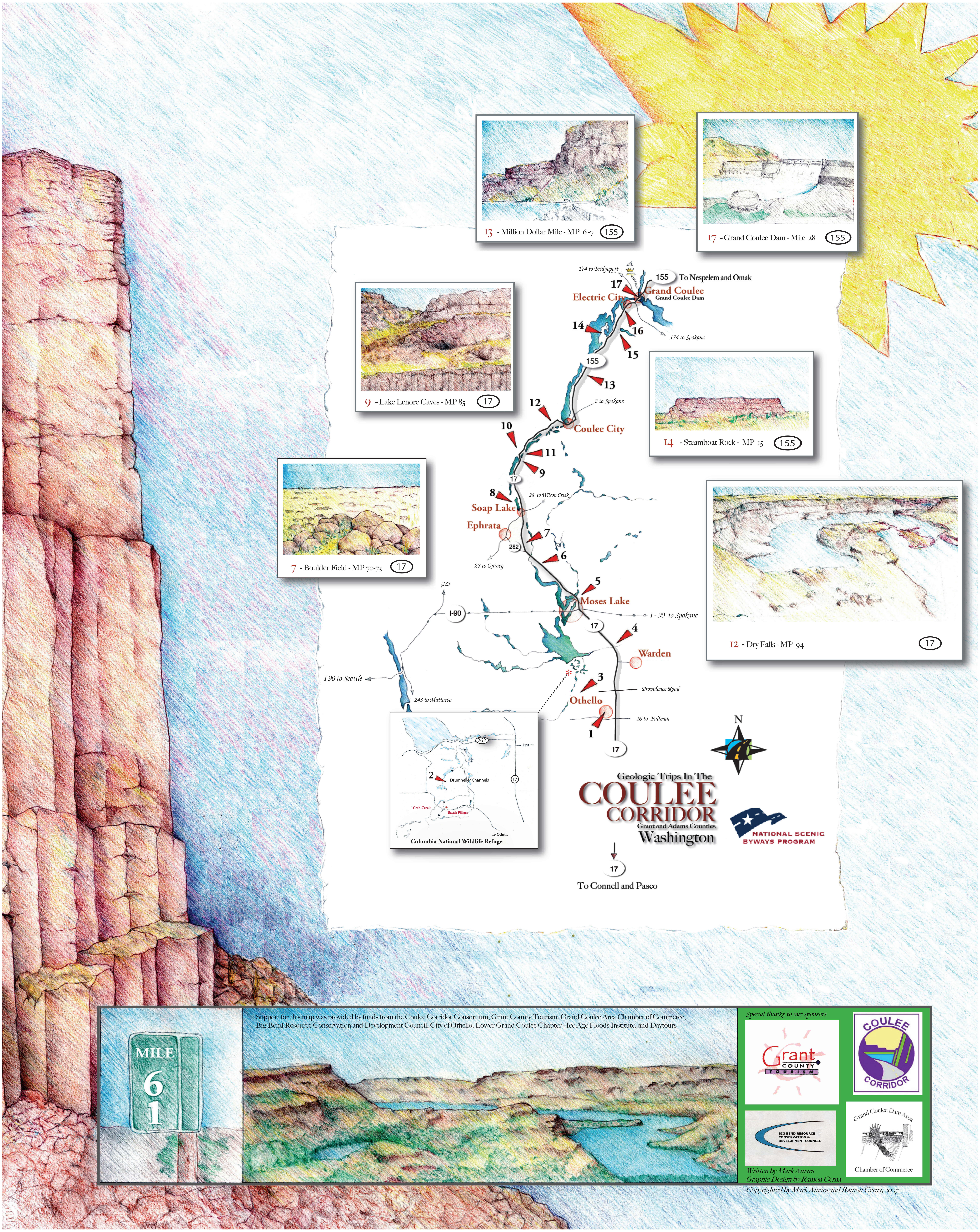
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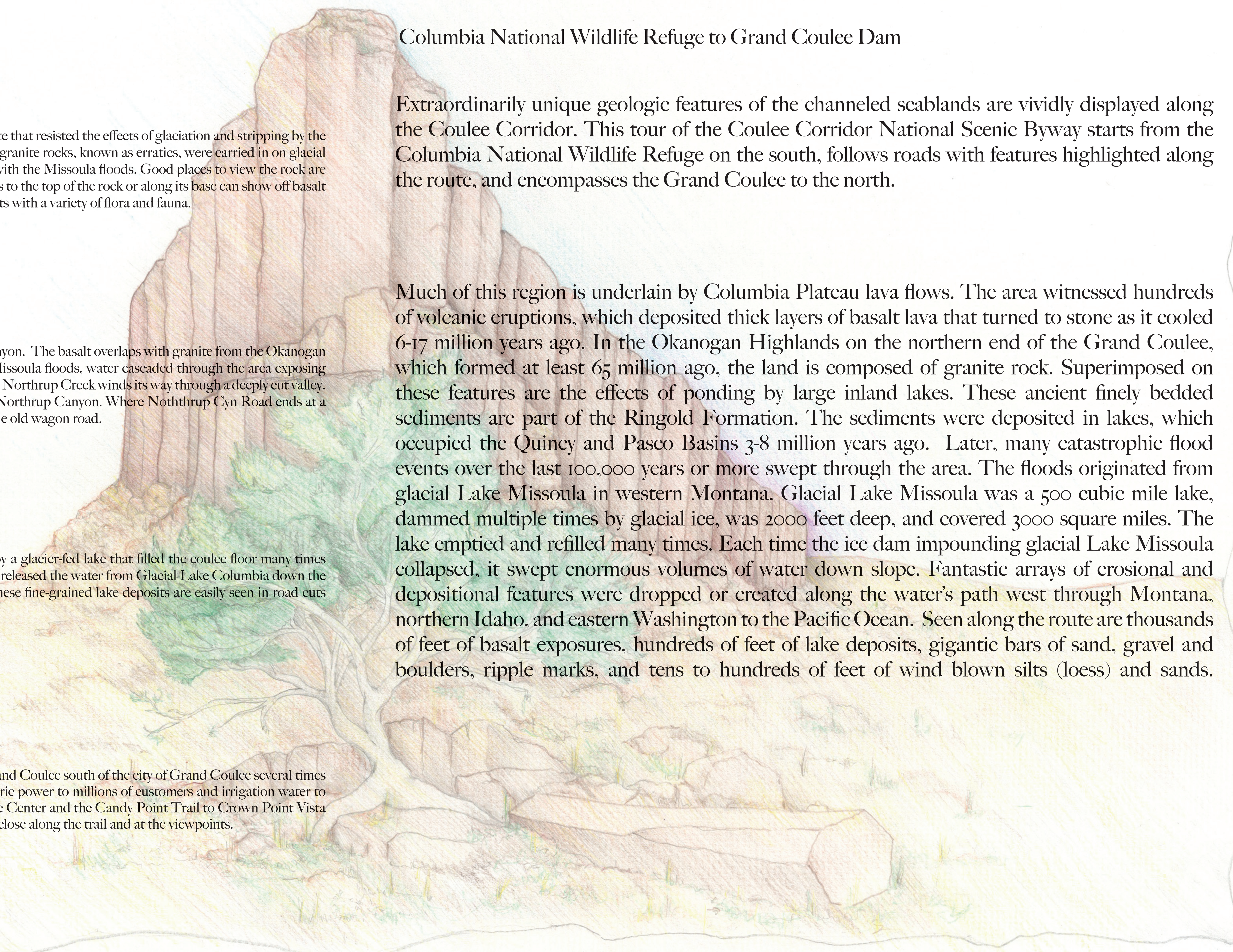
Geologic Trips in the Coulee Corridor National Scenic Byway in Adams and Grant Counties, Washington

Columbia National Wildlife Refuge to Grand Coulee Dam

Extraordinarily unique geologic features of the channeled scablands are vividly displayed along the Coulee Corridor. This tour of the Coulee Corridor National Scenic Byway starts from the Columbia National Wildlife Refuge on the south, follows roads with features highlighted along the route, and encompasses the Grand Coulee to the north.

Much of this region is underlain by Columbia Plateau lava flows. The area witnessed hundreds of volcanic eruptions, which deposited thick layers of basalt lava that turned to stone as it cooled 6-17 million years ago. In the Okanogan Highlands on the northern end of the Grand Coulee, which formed at least 65 million ago, the land is composed of granite rock. Superimposed on these features are the effects of ponding by large inland lakes. These ancient finely bedded sediments are part of the Ringold Formation. The sediments were deposited in lakes, which occupied the Quincy and Pasco Basins 3-8 million years ago. Later, many catastrophic flood events over the last 100,000 years or more swept through the area. The floods originated from glacial Lake Missoula in western Montana. Glacial Lake Missoula was a 500 cubic mile lake, dammed multiple times by glacial ice, was 2000 feet deep, and covered 3000 square miles. The lake emptied and refilled many times. Each time the ice dam impounding glacial Lake Missoula collapsed, it swept enormous volumes of water down slope. Fantastic arrays of erosional and depositional features were dropped or created along the water's path west through Montana, northern Idaho, and eastern Washington to the Pacific Ocean. Seen along the route are thousands of feet of basalt exposures, hundreds of feet of lake deposits, gigantic bars of sand, gravel and boulders, ripple marks, and tens to hundreds of feet of wind blown silts (loess) and sands.



1. Othello City Hall (500 E. Main St. in Othello)

From the Othello City Hall, follow McManamon Road north through a portion of the Columbia National Wildlife Refuge. The stark landscape at the Refuge is composed of hard, dark colored basalt lava rock. The basalt erupted from the earth's crust through fissures or cracks several miles long. These features primarily occurred in southeastern Washington to the east though isolated fissure remnants are present near here. Rather than erupting explosively, the basalt magma oozed out of the earth's mantle and spread out over the pre-existing land surface. As the basalt cooled, the fissures hardened to form dikes, which cut through the intervening rock layers. The flows piled up thousands of feet thick from 6 - 17 million years ago. Lava cooled in regular patterns of vesicular, blocky, and columnar basalt. During the last 100,000 years or more to as recently as 13,000 years ago, catastrophic flood events, originating principally from glacial Lake Missoula, swept through the area. The Missoula floods peeled off layer upon layer of lava, leaving vertical exposures of basalt rock, illustrated in the Drumheller Channels northwest of Othello.

2. Drumheller Channels (State Highway 262 MP 15 – 18)

The Drumheller Channels formed as glacial Lake Missoula floodwaters deepened and widened the Crab Creek channel where and when they eroded through the east edge of the Frenchman Hills.

Floodwaters exited glacial Lake Missoula and formed new channels as the existing streams could not handle the enormous flood discharges. Upon reaching the Quincy Basin, many flood channels converged into one flow. Water hundreds of feet deep traveled at least 60 miles per hour when it first entered the Quincy Basin. It accelerated speed again as water headed toward a low point in the Crab Creek watershed, which collected water from a 4000 square mile area. Catastrophic floods cut through wind blown loess, removed Ringold Formation lake sediments, broke through the folded, tilted, and fractured east edge of the Frenchman Hills basalt anticline, and gouged, widened, and deepened Crab Creek. The result is the Drumheller Channels, a nine mile wide by 12-mile long maze of inter-connected channels cut as much as 300 feet deep into the basalt rock. Notice how Columbia Basin Irrigation Project (CBIP) facility structures and irrigation systems are superimposed on the landscape. The CBIP has turned the desert into an oasis supporting hundreds of thousands of acres in diverse crops.

3. Jackass Mountain (West on Providence Road at the Grant –Adams County Line off State Highway 17)

At Jackass Mountain, a higher hill stands above the flatter and/or eroded landscape below. At this location, Missoula flood-deposited boulders overly caliche and lake sediments. The caliche is a relatively dense weakly cemented layer of calcium carbonate limestone. Caliche typically forms in an arid climate and indicates a period of climatic stability. The caliche caps a remnant layer of Missoula flood gravels which overly lake sediments. The flood gravels likely represent an older flood that predates and/or escaped erosion of the Drumheller Channels event to the west. The "mountain" core is composed of Ringold Formation lake sediments. There are superb exposures of (varved) finely bedded lacustrine (lake) sediments hundreds of feet thick. Unsorted weakly cemented calcium carbonate-coated flood sands, gravels, and boulders that escaped flood erosion overlay the lake sediments. Look off to the west for an unobstructed look of the Drumheller Channels. Approach the Mountain from State Highway 17 west off Providence Road at the Grant – Adams County line.

4. Lind Coulee (State Highway 17 and Lind Coulee - E Milepost 42)

At the crossing of State Highway 17 and Lind Coulee (E Milepost 42) stop and look at Ringold Formation sediments exposed in nearly vertical cliff faces. Notice that light brown or white Ringold sediments are sloughing into the coulee. Overlying these sediments are fine-grained slack water and stream-laid deposits, which flowed into and accumulated in Lake Lewis, a short duration lake. During Missoula flooding, Lake Lewis ponded floodwaters backed up in the Quincy and Pasco Basins due to hydraulic damming from Wallula Gap downstream on the Columbia River. As the climate became drier after the last Missoula flood and over the course of several thousand years, the Lind Coulee drainage flowed less and less. Notice wind blown dune sands in cut banks along the west shoreline and in center pivot sprinkler irrigated fields to the north. Now the Lind Coulee drainage again runs year round filled by seepage from irrigation return flow runoff.

5. Moses Lake (State Highway 17 & Interstate 90 cross the lake)

Multiple catastrophic runoff events associated with Missoula floodwaters and glacial ice, which blocked the Columbia River at strategic locations, temporarily diverted the river through the Grand Coulee and Quincy Basin. These floods repeatedly carved and gouged out the Moses Lake proper and left terraces east and west. Moses Lake's actual shape and size was not determined until the last floods swept through the area 13,000 years or so ago. The final disposition of the landscape was determined after rapidly moving high velocity waters removed previously deposited flood sands and gravels from the toe slopes. When the glaciers (Okanogan lobe of the ice sheet) retreated farther north, the Columbia River returned to its ancestral channel and Crab Creek resumed meandering its way through the area.

6. Gravel Bars (State Highway 17 MP56 & MP 57)

Long and narrow gravel bars and ripple marks tens of feet to over a hundred feet high by several miles long are scattered in various locations throughout the Quincy Basin. Gravelly and bouldery sediment was dropped as bars. Some of the bars present are called longitudinal or "shoulder" bars, pendant bars strung out behind natural barriers like basalt outcrops, or as "expansion" bars positioned at stream mouths. Often, developers and county road departments have discovered these gravelly deposits and are quarrying them for various uses.

7. Boulder Field (State Highway 17 MP 70-73)

As Missoula floodwaters swept into the Quincy Basin from the north and east, the gradient dropped abruptly. When the rapidly moving water burst out of the Grand Coulee, it must have caused a ricochet much like when a stone is skipped across water. Hydraulic engineers refer to this process as a hydraulic jump. As a result, the floodwaters did not simply drop their suspended loads. Instead, the floodwaters threw the mass of suspended debris out of the coulee into the wide flat area between Soap Lake, Ephrata, and Moses Lake. After this initial ricochet, the rapid deceleration of the floodwater resulted in an almost chaotic distribution of rock sizes from sand and gravels to boulders tens of feet in diameter. One particularly unusual boulder, locally called the Coyote Sweathouse, is a granite boulder erratic hollowed out by floodwater which came to rest near Ephrata Lake. Access: From State Highway 17, turn onto Troutlodge Road NE (N MP 70) or alternately, cross Rocky Ford Creek (E MP 67) on State Highway 17 for more views of the boulder field.

8. Soap Lake (State Highway 17 MP 76-77)

Soap Lake lies in a small deeply eroded basalt-lined basin without an outlet. The lake gets its name from the waters which froth and bubble on windy days. The water has a soapy, slippery feel because of a high concentration of sodium and calcium carbonate salts. Evaporation concentrates the natural salts of the ground water which flows into the lake. The salt content is so high no fish survive in it. Native Americans called the lake "Smokiam" which means healing waters. Before the turn of the 19th century, Soap Lake was known as Sanitarium Lake. Later it was a treatment site for soldiers returning from World War I who suffered with Buerger's Disease. Their circulatory ailments were reputedly improved using the water. Even today, the water continues to provide relief for sufferers of psoriasis and other maladies. Many of the town's residents have double plumbing with lake water pumped into their homes for drinking and bathing.

9. Lake Lenore Caves (State Highway 17 S MP 85)

The caves are situated above Lake Lenore and Alkali Lake in lower Grand Coulee. The caves are actually rock shelters, which formed as floodwaters ripped apart less resistant contacts between flows by plucking out basalt columns. Plunge pools, basins, and potholes were created and the rock was removed by powerful floodwater whirlpools. After the flooding ended, freezing and thawing occurred causing loose rock, called talus, and rock-fall to nearly close off many of the undercut areas that formed the caves. Early nomadic hunters and gatherers used these natural rock shelters as overnight camps and storage caches for food or tools many thousands of years ago. Access: S MP 85, follow 1/4 mile gravel road to parking lot. Climb cement steps and trail about 1/4 mile to many rock shelters.

10. Basalt flow characteristics

Each basalt flow exhibits a three-tiered sequence. The *vesicular* top is full of small holes through which gases and air escaped. This top is underlain by the *entablature*, which is the center of the flow. This part of the flow consists of seemingly unorganized and fractured blocks and twisted and flared columns. The *colonnade* occurs at the bottom of the flow. Since the base of the lava flow cools the slowest, the joints shrink 5-10% to form characteristic hexagonal polygons of honeycombed columns. "Pillow" basalts formed when molten lava flowed into water or saturated soil, forcing it to cool very quickly. Look for turnouts all along the Grand Coulee (State Highway 17 & State Highway 155) to view the basalt flow characteristics and estimate the number of flows that lie one on top of the other.

11. Alkali Lake and the Coulee Monocline (State Highway 17 MP 86)

As basalt lava flows piled up layer upon layer thousands of feet thick in the same area over millions of years, the weight and volume of rock on the surface caused it to buckle and fold. The Coulee Monocline is a 45-degree dip in the basalt. Since the basalt was tilted and folded, it was much more fractured and less resistant to flood erosion and was more easily swept away by Missoula floodwaters. Remnants of the Coulee Monoclines tilted columnar basalt flows may be seen as islands in the middle of Lake Lenore, Alkali Lake, Blue Lake, and Park Lake and between the lakes.

12. Dry Falls Panorama (State Highway 17 N MP 94)

At the Dry Falls Interpretive Center Overlook look out over the 14,000-year-old waterfall that was 350 feet high by 3.5 miles wide. This was five times the width and twice the height of Niagara Falls. During the flood maximums, there was at least 300' of water over the top of the falls. When the enormous waterfall or cataract was a raging river of glacial floodwater, gigantic icebergs, mud, sand, gravel, and huge boulders cascaded over it.

13. Million Dollar Mile (State Highway 155 MP 6-7)

State Highway 155 used to follow the bottom of upper Grand Coulee before Banks Lake was created. As plans for the Columbia Basin Irrigation Project evolved, it became apparent that the road had to be moved to higher ground from the coulee floor to avoid being under the waters of Banks Lake. The re-routing of State Highway 155 required blasting through a mile of basalt rock now called the Million Dollar Mile. It cost more than $1 million to excavate the basalt and build the new road prior to Banks Lake being filled in the early 1950s.

14. Steamboat Rock (State Highway 155 MP 15)

Steamboat Rock, in profile, looks like a giant steamboat. The rock is actually a mid-coulee basalt butte that resisted the effects of glaciation and stripping by the Missoula floodwaters. Granite boulders on top of the Steamboat are not native to the location. The granite rocks, known as erratics, were carried in on glacial ice, rolled along the bed of the flood channel, and were dropped by high velocity waters associated with the Missoula floods. Good places to view the rock are (N MP 15 State Highway 155) at Steamboat Rock State Park or along the edge of Banks Lake. Hikes to the top of the rock or along its base can show off basalt flow characteristics, flood-carved relief, sandy and gravelly textures, and native and non-native habitats with a variety of flora and fauna.

15. Northrup Canyon (State Highway 155 S MP 19)

Basalt bedrock on the north end of the Columbia Plateau covers most of the length of Northrup Canyon. The basalt overlaps with granite from the Okanogan Highlands near the mouth of the canyon as it outlets into Banks Lake. During the course of the Missoula floods, water cascaded through the area exposing bedrock and left rugged escarpments and scablands throughout the length of the canyon. Present day Northrup Creek winds its way through a deeply cut valley. Access is by gravel road (S MP 19) across from the Steamboat Rock Boat Launch at the mouth of Northrup Canyon. Where Noththrup Cyn Road ends at a parking lot, hike through the canyon toward Northrup Lake about three miles to the east or along the old wagon road.

16. Nespelem Formation (State Highway 155 S MP 21-23)

Stratified silt and clay deposits make up the Nespelem Formation. The sediments were dropped by a glacier-fed lake that filled the coulee floor many times between/after which floods passed through it. As glacial ice melted and retreated for the last time, it released the water from Glacial Lake Columbia down the Grand Coulee and Columbia River leaving much of the sediment intact without much erosion. These fine-grained lake deposits are easily seen in road cuts between Electric City and south near Steamboat Rock.

17. Grand Coulee Dam (State Highway 155 Mile 28)

A combination of glacial ice and Missoula floodwaters diverted the Columbia River through the Grand Coulee south of the city of Grand Coulee several times during the last 40,000 years or more. Grand Coulee Dam, completed in 1941, provides hydroelectric power to millions of customers and irrigation water to more than 670,000 acres in the Columbia Basin Irrigation Project. Grand Coulee Dam Interpretive Center and the Candy Point Trail to Crown Point Vista provide opportunities to visualize the grandeur of the areas and experience the relief and geology up close along the trail and at the viewpoints.

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