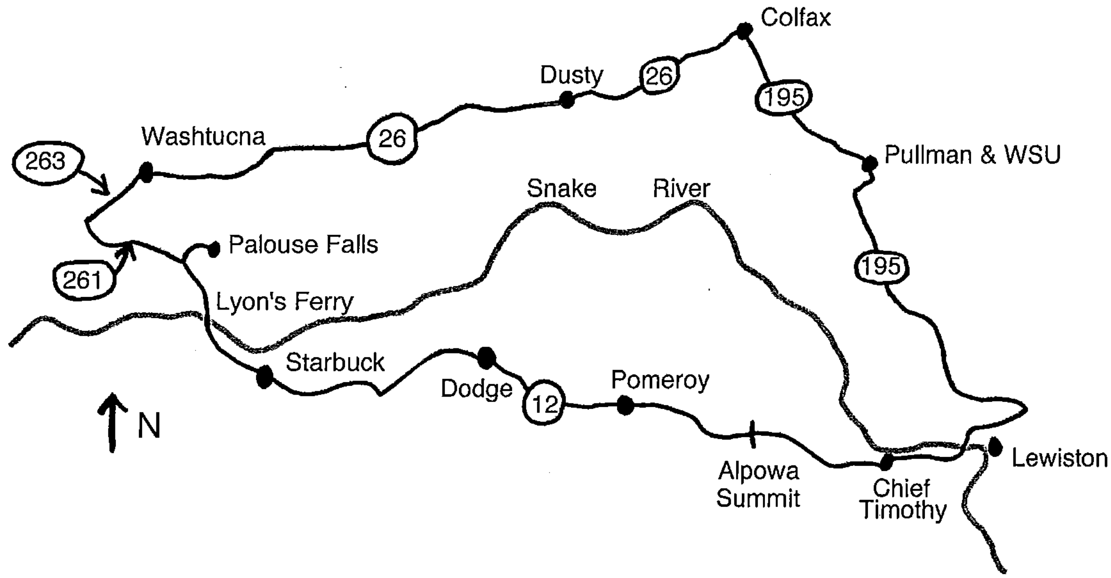
Geological Field Trip 2

Catastrophic Floods of Lava and Ice-Water

Guide written by Dr. E. K. Peter
WSU Geology Department



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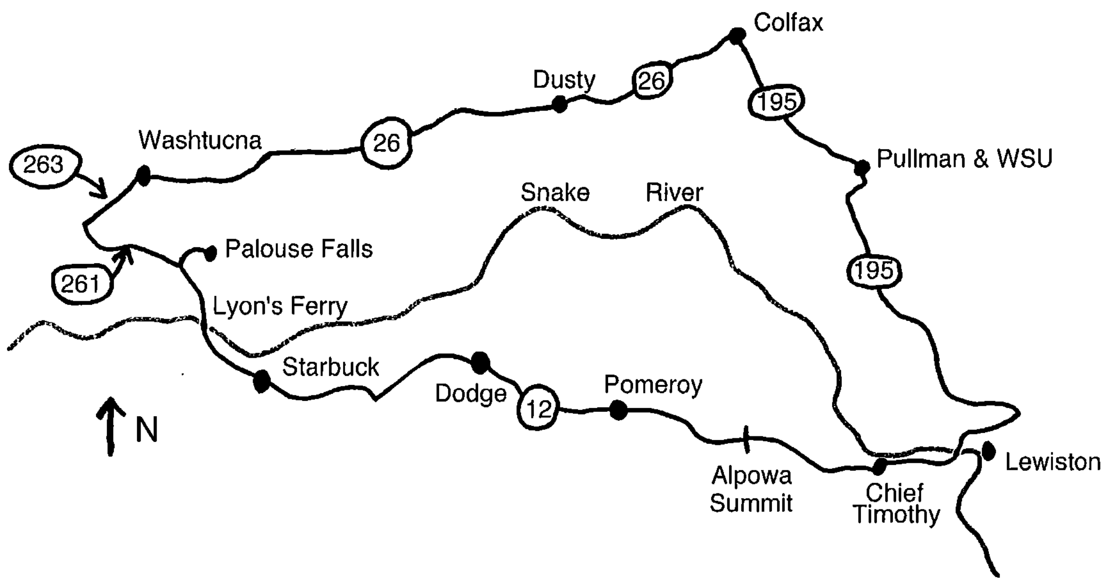
OVERVIEW:

You need a vehicle for this trip and can expect to complete it in one long day. Because Palouse Falls is an impressive sight, you may wish to bring a camera. Water and lunch are also useful because there are not many amenities available on much of the route.

SKETCH MAP OF TRIP:



START:

The trip begins downtown Pullman at the intersection of Grand Avenue and Davis Way (corner with the public library and Washington Mutual Savings Bank). When you are at the intersection, set your trip odometer to zero.

Mile 0: Downtown Pullman: Intersection of Grand Avenue and Davis Way. Drive uphill (west) on WA Highway 270 towards Colfax (soon you'll be going North on US 195).

As you travel out of Pullman you have fine views of the Palouse Hills. These dune-shaped hills are made of dust-sized particles deposited by winds during the most recent Ice Age, or the Pleistocene (see last page of this guide for a figure showing the geologic time scale). The winds that produced these hills gave them their graceful and unusual shapes. The soil is known as 'loess', from the German word meaning loose. All loess soils owe their origin to wind-borne dust. Topography like that which we see in the Palouse is present only in a few places in the country, so open your eyes and hearts to it!

Photo 1: Loess Hills Near Pullman
(photo by E. Kirsten Peters)

Try to imagine what the scene around you was like when the hills were being formed: remember, dunes MOVE through time and are constantly changing shape under the influence of wind.

Erosion, mostly due to farming which disturbs the soil, is a big problem in the Palouse region. Notice the efforts which farmers are making to plant one crop around the top of a hill and a different one below. The idea is to never have a whole field of 'raw' soil at the same time. Eroding dirt from the top of the hill, it is hoped, will be stopped when it reaches a different crop at a different point of development. In recent years some farmers have begun to use "no till" methods of farming. This entails cutting the stubble short after harvest, and then planting the next year's crop in the stubble without plowing or disking the fields. This approach reduces erosion significantly.

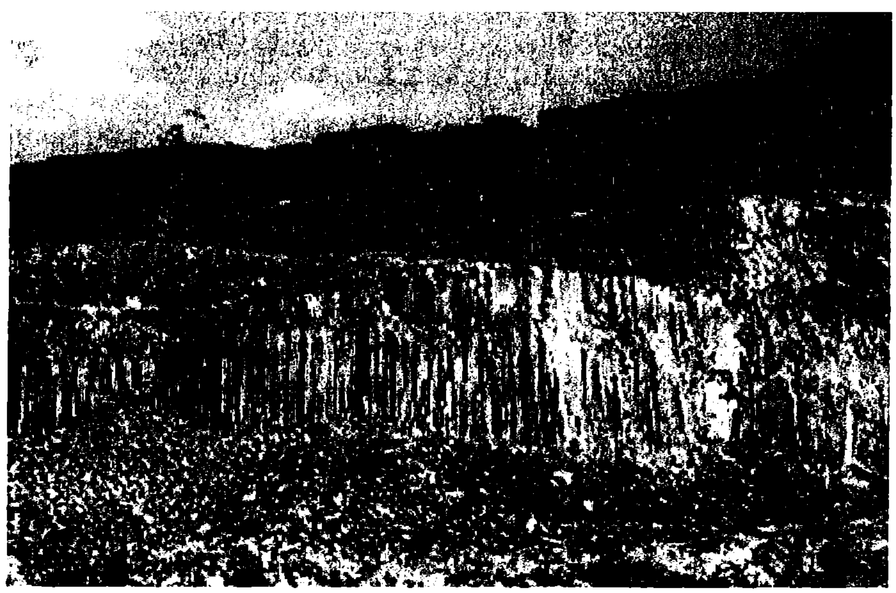
Mile 14.5: Colfax, Washington. Colfax is the county seat for Whitman County.

Note the courthouse on the right side of Main Street as you pass through town. In early 1996, the northern edge of Colfax was partially flooded when all of the branches of the Palouse River rose. The concrete levees that run through Colfax, however, did their job quite well, preventing the severe damage which threatened the town. Score one for the efforts of the Corps of Engineers! (See the field guide for Trip #1 in this series if you are interested in more information on stream flooding and flood control efforts.)

As you leave Colfax, turn west at the junction with WA Highway 26 (towards Washtucna and Seattle).

As you climb out of the Colfax valley, note the outcrops of solid basalt rock near the highway. This dark, volcanic rock reflects massive eruptions of lava, during the time which geologists call the Miocene. (See the geological time scale at the end of the guide.) About 15 million years ago, fissures opened in what is now central Washington and enormous volumes of basalt lava poured out. The eruptions were catastrophic by any standard. Individual basalt flows (layers) can be traced horizontally, sometimes for a hundred miles or more indicating that molten rock was spread simultaneously across the surface of much of our state. And as if that wasn't enough, the eruptions occurred again and again, as indicated by the lava flows you can see, one atop another. All together, the lava flows are thousands of feet thick! (You will get a stronger feeling for how thick they are at the end of this trip when you see the basalts flows stacked up in the Snake River Canyon.)

Some of the basalt flows have column-like shapes in them. The columns are often vertical. They are made by cracks (called "joints" by geologists) that apparently form as the lava cools. We don't understand why the columns are usually vertical, but sometimes horizontal or 'splayed' around a central point. If you can figure this out, please notify the nearest



geologist; we'll name something after you!

Photo 2: Basalt lava flows: central flow shows columnar jointing (Photo by E. Kirsten Peters)

Mile 20.0: On your right is the Whitman County Fairgrounds

Mile 32.0: Dusty Jct. There's an outhouse here for emergency stops only. Continue West on WA 26 towards Washtucna.

Mile 38.0: On your left you'll pass two 'eyes' in the hills near the highway. These are, apparently, the slip face of dunes, where material slid down these faces. With that in mind, what direction would you guess the prevailing winds were from when these particular features formed?

Mile 46.0: Pull over at the junction to the town of LaCrosse. Reset your trip odometer to zero (to minimize differences between your odometer readings and the ones in this guide). You are now surrounded by some of the last part of undisturbed Palouse Hills you'll see today. Read the material below, up to Stop 1, or have someone read it aloud as you pull back on the highway and continue west on WA Highway 26, going toward Washtucna.

Soon you will see that you are now at the edge of the Scablands. Note the change in topography all around you. In a few miles, the graceful curves of the Palouse Hills will be entirely gone. The reason for this abrupt change lies at the heart of this field trip: the catastrophic flooding of central Washington at the close of the last ice age. This flooding was not the normal stream overflows you've probably seen in the springtime. Rather, it was a wall of ice water up to two thousand feet high, racing across parts of Washington at 50 mph or more.

Here's the background to this fascinating event and the story of how geologists struggled to understand the Channeled Scablands:

The Scablands of central and eastern Washington State show unusual surface features, including long and deep channels, called coulees. The coulees cut down through the loess and slice into the tough, dark basalt rock. As seen from the air, the coulees form a complex braided pattern. The Channeled Scablands are easily studied by geologists, for as you shall see on this trip, they are almost exclusively barren rock and gravel. Vegetation is sparse because there is little or no soil. The rich loess laid down elsewhere in eastern Washington during the Pleistocene (the Ice Age) has been stripped away from the aptly named Scablands.

In the early part of this century, geologists entertained two ideas about how the coulees of the Scablands could have formed. First, some believed the channels had been cut by glaciers during the Pleistocene. It was well established that during the 2 million years of the Pleistocene, an enormous continental ice sheet had advanced from Canada into the northern United States and then retreated. A total of four cycles of advances and retreats had been documented in the Midwest. The coulees of Washington State are large and broadly U-shaped in cross section, in accord with their formation by glaciers. And glaciers were clearly active elsewhere in Washington, for example, around Puget Sound and in the Cascade Mountains. Giant granite boulders can be found in the Scablands, separated by a hundred miles or more from their origin in Montana or Idaho. Geologists who subscribed to the glacial theory interpreted the boulders as examples of the familiar concept of glacial erratics, or rocks carried in the ice of large glaciers a long way from their origin.

A second and quite different hypothesis was that the Channeled Scablands had been carved out by river processes during the Pleistocene. This school of geologists argued that the Columbia River, which is large even today, would have been much larger during the ice ages when it was draining meltwater from the extensive Canadian glaciers. A much larger Columbia might have spread out during floods and carved the coulees. Then, as the water level dropped and the Columbia River became smaller, the river would have retreated to its present channel, leaving the Scablands high and dry.

Both of these two views – the glacial theory and the Columbia River hypothesis – fall within the framework of what is known as gradualism. That is, both appeal to gradually acting processes that geologists can see and study at work today. There are glaciers grinding away rock in alpine valleys in Washington at this moment. Geologists do not appeal to anything fundamentally new if they say that glaciers cut across Washington during the Pleistocene and carved the coulees. Similarly, the Columbia River is large, and it certainly could have been larger in the past. The normal flooding process of rivers can be studied today and perhaps can account for the Scabland's channels, all of which are indeed near the Columbia.

In essence, both these theories allowed geologists to study the Scablands and link their work to processes still operating. This was the type of geologic research favored in the early part of the 20th century. Let's see now if the first stop of this trip reminds you of the products of gradual geologic processes you are familiar with.

Stop 1: Mile 4.2:

Turn off the highway to the right and pull in the gravel pit. Leave your vehicle and explore a little of this gravel bar: take our word for it, it's ten miles long! Notice that the rocks are fairly well sorted (they are roughly the same size) and rounded (they don't have many sharp edges). These features seem to indicate the rocks in this gravel bar were laid down by running (liquid) water, not glaciers. Glacial ice just pushes debris along like a bulldozer: it does not sort particles and round them the way running water does. Question to think about: It looks like this enormous gravel bar could not have been made directly by glacial ice, all right, but why could it have not been made by rivers draining glaciers or 'normal' flooding during the Ice Ages? (Keep this question in mind throughout the trip.)

Notice also the different rock types in the gravel. Find some granite pieces, some sandstone, and some basalt. Since there is only basalt rock in the outcrops around here, you now can convince yourself that some of the rocks in the gravel bar were carried to this place from far away.

Photo 3: A variety of rocks, other than basalt, can be found at this stop (Photo by E. Kirsten Peters)

Finally, check out the layer of loess (wind-blown) soil at the very top of the gravel bar! Again and again you'll see in the Scablands that evidence of some sort of flooding and evidence of wind-blown soils are intermixed. That's one reason geologists have come to think that there were multiple episodes of flooding, and they overlapped in time with the period that the wind-blown soils were forming.

Get back on the highway going west. You'll continue to see intermixed Scabland and Palouse topography for a few miles to come.

Mile 6.1: Pampa Pond Road on left

Stop 2: Mile 9.45:

Drive just over the top of a hill, with the old highway roadcut through the hill to your left. Pull off the highway on the right shoulder just before the downhill side guardrail. From this point onward you are surrounded by all-Scabland topography. Notice the vegetation has changed. Tumbleweeds and sage are the common plants, presumably because they can cope with the near absence of good soil and also the low rainfall of this area.

Get out of your vehicle. In one group, carefully cross the highway. Walk down the small gravel access road. Crawl under the barb wire gate, if needed. Follow the old road to your left. You'll walk into what was an earlier highway roadcut on the route from Dusty to Washtucna. Walk along the old road, looking at the sediments on your right and left. Notice the coarser and finer particles, the places you can see beds, and the many places you can see a layer of loess, like frosting, on the top.

Near the end of the road cut, on your left, find the place shown in Photo 4 below. Look carefully at the outcrop. It seems clear that the bigger rocks reached this place in violent floods. Take a close look at the tan material the person in the photo is gesturing toward (at her waist level). What is the size of the particles in this material?

Now here is the mystery: how could a rounded chunk of such fine material have been moved around by floodwaters without breaking up? To put it another way: what could have held the fine material together? (Hint: consider the climatic conditions of the Pleistocene; see the table on geologic time at the end of this guide.)

Photo 4: Mystery "boulder" in outcrop
(Photo by Mary Arndt)

Now you can either read the material below or return to your vehicle and have someone read it aloud as you drive west toward the next stop.

The Scablands are known for their 'coulees', a word coming from the French 'to flow'. A coulee is a channel, cut down into rock, with nearly vertical sides and a flat bottom. Normal valleys are V-shaped (if running water has formed them) or U-shaped (if glacial ice has formed them). But the coulees are unique: they have broad, flat bottoms, and will look 'weird' compared to all other landforms you've seen in your life. They were a big part of early geologists thinking about the Scablands and you need to drink them in and reflect on how they could have formed. In addition to coulees, you can also see closed depressions as you ride along the highway. These are part of what geologists call 'deranged' drainage. What processes could have formed such "confusion" in the landscape?

On the coulee walls you'll see more layers of basalt lava flows. Notice that whatever formed the coulees cut through a lot of rock! The big question is: how much time was involved in all this erosion? Was it fast or relatively slow?

A 20th century geologist named J Harlan Bretz was fascinated by the unusual features of the Channeled Scablands and spent many summers in the 1920s and 1930s walking through the coulees with a mule. His notes do not say whether the mule was a good companion, but the time Bretz spent in the field was intellectually fertile. Summer after summer, he returned and took walking tours of both the Scablands and the land downstream. His observations were not complex; he took no esoteric measurements. But Bretz was an original thinker.

Field evidence made Bretz sure that the coulees had not been carved by glaciers. There was no glacial till in central Washington, and no moraines could be found in the Scablands. He also rejected the fluvial theory of flooding, believing that the morphology of the Scablands was not formed by a river, not even a giant Columbia River at flood stage.

In 1923 Bretz published his first paper on the Scablands, a descriptive piece of work summarizing his field observations. He omitted any explanation of the Scabland's origin, to avoid attacking the prevailing dogma of uniformitarian gradualism. Bretz's article did, however, begin to publicize the area's unusual topographic features. Shortly after publishing this descriptive article, Bretz found the courage to put forward a truly catastrophic hypothesis to explain the origin of the Scablands. He wrote that a wall of water, more than 1000 feet high, had slashed through the area, cutting down through the loess and the basalt. He gave as evidence of this massive outburst flooding the following:

1. The crisscrossing complex of the channels: The Scablands, look like a gigantic braided stream, a channel pattern that indicates rapid inundation by water followed by its rapid retreat. Furthermore, the bottom of many coulees have no streams at all running in them, and some of them are extraordinarily flat, without the hint of a V shape. In fact, this unusual shape lies behind the important words *coulee* or *channel* rather than *valley*. There are no normal valleys throughout the Scablands.

2. Deep gravel bars in the middle of the channels and at the perimeter of the area. Some of the gravel bars in the coulees are 100 feet high and could have been formed only by floodwaters much deeper than that. Stop #1 on this trip was the bar along the eastern boundary of the Scablands. The well-sorted rocks in this bar make it clear the huge volume of material cannot be interpreted as glacial moraine. The bar looks like a waterborne deposit, but it is more than 100 miles from the Columbia. As we have mentioned, this enormous bar stretches along the edge of the Scablands for more than 10 miles.

3. Cataract cliffs and plunge pools hundreds of feet in diameter. Such cliffs and pools are now completely dry or occupied by only small amounts of water, which seem unable to have formed such massive features. Two fine examples are Dry Falls, near Grand Coulee and Palouse River Falls which we'll see on this trip.

4. Thick strata of fine silts upstream of the Columbia and Snake Rivers and in their tributaries. Bretz believed that the tributaries of the area's two major streams must have had to flow backward when a wall of water hundreds of feet high reached them. This backflooding produced the fine sediments preserved in tributary valleys as we will see later today.. Beds of fine silt with isolated ice-drop cobbles can be found up the Snake River Canyon as far away as Idaho.

5. Giant ridges, up to 50 feet high, in the gravel bars in the coulees. Interpreting these ridges as normal ripple marks on a gigantic scale, Bretz argued that the coulees must have been filled with water hundreds of feet high and moving in excess of 50 miles per hour.

6. Chaotic or deranged drainage patterns over much of the area. Normal dendritic draining is not found in the Scablands, which are dominated by closed depressions (as you have seen) and coulees. This indicates that the current active small streams did not form the topography.

Bretz's bold papers attracted attention, distressing the leading geologic authorities of the day. Bretz, they feared, was reverting to a catastrophic schemé that belonged in the profession's distant past. Geology had progressed for more than a century on the basis of gradualism, so it was not unreasonable for thoughtful geologists to dread any backsliding into catastrophism. On what, they asked, might Bretz focus next? To gradualists, there seemed no limits to catastrophic thinking.

In 1927 many distinguished geologists gathered in Washington, D.C., for a professional meeting. Although Bretz was invited to defend his views, the invitation appears to have been intended as an opportunity to criticize his arguments. Accordingly, Bretz was attacked in the name of gradualism, and his concepts about massive flooding were denounced. Even though most of Bretz's critics had not seen the Channeled Scablands, they were sure, as a matter of principle, that the forces acting in eastern Washington State could not have been catastrophic.

Bretz's critics' reluctance to accept Bretz's idea was not terribly narrow-minded or stubborn, for gradualism – and interpretations flowing from it – had been extremely helpful in many geologic problems. Now, however, Bretz was asking people to think quite differently, and unless he had compelling evidence, other geologists were understandably reluctant to give up a style of interpretation that had worked well in the past. Nevertheless, from Bretz's point of view, the authorities were confusing methodology with substance.

In retrospect, Bretz's critics did have one valid point. Where did the water for this unprecedented flooding come from? Bretz had apparently not focused on this problem, and it stood as the cornerstone of reasonable challenges to his views. Today, one might look back at the youthful Bretz and say, It is nice to be right, but in science it helps to be right for the right reasons and to explain those reasons to all who ask. A source of the enormous quantities of water that Bretz was relying on was a reasonable "next question" to address.

Another point of interest about the 1927 meeting is a storyteller's delight. Apparently, a young geologist named J. T. Pardee was sitting in the audience, listening to Bretz's talk. When the respected authorities criticized Bretz for failing to offer a source for the enormous quantities of water that his theory demanded, Pardee said to a friend: "I know where Bretz's flood came from; it came from [Pleistocene] Lake Missoula in western Montana." But as the story goes, Pardee knew how to get along in the professional world, and at this point, his idea may only have been a hunch. Since those who made decisions about hiring and promotion all were highly skeptical of Bretz's ideas, Pardee decided not to speak out at the meeting. He did, we think, speak privately to Bretz, but Pardee's public silence is a clear example of the tendency of many scientists not to publish or discuss data, and especially casual hypotheses, that may seem outrageous to their colleagues. All professional disciplines, of course, have this inherent conservatism. For his part, Bretz may not have advanced Pardee's idea either because he felt he could not prove that his floodwaters came from Montana or because, as a matter of professional courtesy, he would not "steal" another geologist's ideas. Revisionist theories were respected by many geologists around the country and were taught to students. But everything changed when Pardee finally spoke up.

In 1942 Pardee published a description of enormous ripple marks on the floor of the Pleistocene Lake Missoula. Pardee had found good data to back up the hunch he had had at the meeting long before. The "ripples" that Pardee described were gravel bars 50 feet high and 500 feet apart. Indeed, they had formed on such a large scale that they had previously been mistaken for normal hills. J Harlan Bretz himself had not understood them when he visited the area in the 1930s. But photography from the air was becoming increasingly common, and Pardee's paper showed that the landforms were just like familiar ripple marks, only expanded to a scale no one had thought to consider. Pardee also described eddy deposits composed of gravel that had formed in the relatively slack floodwater behind promontories. Pardee offered a catastrophic idea—an ice dam had formed the huge lake and when the ice broke, enormous quantities of water moved down the Clark Fork valley toward Spokane, Washington. The "mega" ripple marks were formed at the start of a flood of what one might call biblical proportions. Pardee made a good case for a huge source of water that had drained very rapidly to the west, thereby vindicating J Harlan Bretz.

We'll come back to aspects of this story as we proceed with our trip.

Mile 11.2: Cross the Palouse River and enter Adams County

Stop 3: Mile 12.9:

Good shoulder on right to pull off just past the basalt roadcut. Staying on our side of the road, walk back and look at the basalt exposure. Notice the drill holes made by the highway construction crew that blasted out the rock. Notice the basalt's vesicles (holes made by trapped gasses in the lava). In some places most vesicles are near the top of individual lava flows. Why would that be?

Finally, notice that weathering (exposure of rock to water and air) makes the dark basalts turn buff or orange or clay colored. The red hues are derived from iron-oxide, the same compound that's in rusty metal. So part of the weathering process here is the "rusting" of the iron in the rock.They are wearing away almost before your eyes.

How many lava flows do you see here?

Can you see crude columns in the upper lava flow?

Referring to earlier in this guide, how old is this basalt? (See also the geologic time scale at the end of this guide.)

Mile 15.0: Pass junction to Hooper. Note columnar jointing in the basalts to your right.

Mile 25.1: Washtucna: This town lies in the bottom of a broad coulee. Turn left and drive through downtown Washtucna and leave town going west on WA 260 towards the town of Kahlotus.

Mile 27.3: Enter Franklin County. Note that the road is following the bottom of Washtucna Coulee. Be sure to appreciate the flat, flat bottom of the Coulee—notice there is no creek in it! That's another clue that the coulees were gouged out over a short time, not carved by normal stream action.

Mile 31.5: Turn left on Lyon's Ferry Road: South on WA Highway 261. Keep your eyes open on this road. You'll see more of the Scablands and, at high elevations, areas of loess that survived the floods because the waters did not reach up that high. The loess "islands" are farmed which, by the way, is part of what accounts for the grain elevators you passed in downtown Washtucna.

Mile 35.9: You have a good view to your right across the Snake River Canyon to the Blue Mountains in the distance.

Mile 38.0: Note the high loess "islands" to your right. If you had been here on the road during the Missoula Floods you would have been swept away but at the top of the loess hills you could have survived.

Mile 40.1: Turn left on Palouse Falls Road (gravel).

Mile 42.2: Gate to the Park. Road narrows. Speed limit is 5 mph.

Stop 4: Palouse Falls State Park

Photo 5: Palouse Falls and basalt flows
(Photo by E. Kirsten Peters)

<u>Stay</u> <u>behind</u> <u>the</u> <u>fence</u>, walking along it to check out the view from several places. When you are ready, try to think like a geologist by asking yourself these questions: Roughly how many times larger is the huge 'bowl' around the falls than the Palouse River as it now flows through here? Could the Palouse River have carved this bowl or did it require larger volumes of water?

J Harlan Bretz was sure that Palouse Falls was formed by a huge cataclysm of water not by the Palouse River we know today. The enormous surge of flood waters carved the amphitheater you see before you. The basic structure of all you see around you would therefore be the same even if the Palouse River were not here at all. Close your eyes and imagine the scene without the river. Does your imaginary scene remind you of any other part of the Channel Scablands?

Dry Falls in the Grand Coulee looks like our falls here (minus the water) but on an even larger scale. If you ever drive Highway 2 across Washington be sure to stop at the Dry Falls Visitor's Center.

Now, when you are ready to think about more recent geologic events, look across the canyon before you at the far wall of rock.

Photo 6: Loose, talus material downstream of the Falls
(Photo by E. Kirsten Peters)

Why are there piles of loose rock there and where are these rocks coming from? To put in another way, is the basalt rock moving downhill, do you think? Geologists call such loose rock falls talus. The talus piles here must have accumulated since the last great flood.

Why is the narrow, vertical chimney [along the path you are meant to stay on towards the highest part of the overlook] where it is? Again, it's gravity that's causing the chimneys to grow. Thinking back to the cooling of basalt lava, what weakness might it be taking advantage of?

Return to the edge of the parking lot near the overlook. One side of the sign board displays an article about the Scablands from Smithsonian magazine. Read the article for another view of this fascinating area.

You may want to eat lunch here and use the outhouses provided. If you are a student on an official WSU field trip, do NOT walk past the outhouse area. Stay in the fenced overlook area.

When you are ready to leave Palouse Falls, reset your odometer to zero before leaving the parking lot. Return up the road on which you entered the Park. When you're back at the Lyon's Ferry Road, turn left (south) and continue down to the Snake River. As you join the Lyon's Ferry Road your mileage should be 2.4 miles.

Stop 5: Mile 7.4: Overlook of Lyon's Ferry

Pull off the highway on the right immediately after the huge railroad-trestle bridge. Looking across the Snake River, and over the top of the highway bridge across the river, you can see a long, horizontal and flat piece of ground not too far above the water's surface. It almost looks man-made, but it's not. As you'll see when we get closer to it, it's a huge gravel deposit. J Harlan Bretz loved this spot. According to him, as flood waters rushed down the small canyon on your left (now carrying the Palouse River which you just saw at Palouse Falls) the mega-flood crashed into the Snake River. The flood waters were so deep, the water flowed both up and down the Snake. The gravel bar across the river from you was formed as sediment dropped out of the suddenly-slowing waters.

By the way, the Snake River is slack [non-flowing] water here. That's why it is so wide. A couple of federal agencies have dammed the Snake all the way from the Pacific Ocean to Idaho. We enjoy the benefits of electricity and from all the dams, easier shipping but the waterway is no longer what it used to be as far as the fish are concerned.

Returning to your vehicle, continue downhill and across the big bridge over the Snake River.

Mile 8.6: Turn right off the highway and immediately bear left on the asphalt road. Cross the railroad tracks with care and continue.

Stop 6: Mile 11.2:

Drive past the gravel pit on your right, going downhill, and pull over at the small gravel access road for the pit. Walk up into the pit area. Note the various orientations of the gravel beds. The beds dip down in different directions, don't they? (If you are a geology student, measure some strike and dips here.)

The beds make angles and cut across each other, too, which geologists call cross-bedding structure. These various beds resulted from deep, swirling water created when the flood waters crashed down into the Snake River valley and flowed over the promitory behind the gravel pit (toward the river). Again, look for different rock types here, your best clue as to the source and path of the floodwaters.

Notice the usual layer of loess "frosting" on the gravels here.

Return to your vehicle and turn around, going back toward Lyon's Ferry road which you will reach as your odometer reads 13.8. Turn right, away from Lyon's Ferry, and drive south on highway 261. You'll be driving along the edge of the gravel bar which you saw from beside the railroad trestle.

Continue toward the town of Starbuck. You will be going up a valley carved by gradual erosion of a tributary of the Snake River.

Stop 7: Mile 19.2-19.6:

Great road cut on your left, field below to your right. Drive pas the outcrop and pull off to the right; be careful of traffic which cannot see you as you walk back on the curved highway!

Although this spot is not in the path of the Bretz floods themselves, the water running backwards up the Snake River Canyon and its tributaries reached here. Our evidence for this is the many layered beds deposited by the surges of water. This type of bedding is found up the Snake all the way to Lewiston, Idaho. Each bed, most geologists believe represents the backflooding up this valley from a flood from Lake Missoula. The beds are known as rhythmites: the coarse rocks were deposited as the floodwaters surged up this way, the finer particles settled out of the relatively quiet waters at maximum flood level.

Photo 7: One rhythmite layer (drink bottle for scale)
(Photo by E. Kirsten Peters)

The many rhythmites layers are the kind of evidence which led both Bretz and others to recognize different episodes of massive, outburst flooding in the Scablands. The largest flood may have come first, but there were dozens of episodes of catastrophic flooding as the ice dam in Montana reformed when glaciers from the north advanced, and it collapsed when the glaciers retreated or the ice broke of its own accord. It was shown that there were 35 to 40 rhythmites in Lake Missoula sediments, that is, graded beds with very coarse material on the bottom. In between the rhythmites were varves (a pair of layers of alternately finer and coarser silt or clay), each one believed to be the sedimentary record of annual precipitation changes. On average, there were about 50 varves (corresponding to 50 years) between the rhythmites (the evidence of massive floods). Geologists believe that for 2000 years in the late Pleistocene, about 40 outburst floods cut through what is now northern Idaho and eastern Washington. The Snake River ran backward when the wall of water reached the Columbia. The Columbia Gorge, between Oregon and Washington, was scoured deeply by the cataclysmic floodwaters. All this resulted from repeated advances of glacial ice in western Montana, ice that dammed the Clark Ford River and formed a huge, deep lake. Bursting ice dams released water sufficient to cover about 15,000 square miles of land at a depth of several hundred feet.

Mile 19.8: Pass through greater Starbuck. Look around you as you drive and you'll see many roughly horizontal lines on the hill slopes. They look a bit like cow-paths, but there's a zillion of them. They result from tiny slides of soil down the steep slopes. This has nothing to do with the Bretz floods! It's just the response of soil to the pull of gravity. Soil, basically, is always on the move and that's an ongoing geological process found all around the world. It is called creep and it is hellish on any man-made structures: foundations, fences, etc. When you are old and gray, don't build your dream house on any land that looks like this, OK?

Mile 28.1: Junction with Highway 12: Reset the trip odometer to zero and then turn to the left (east to Lewiston).

Stop 8: Just after turning, stop on the right (there is a wide gravel shoulder). Getting out of your vehicle, you'll see extremely fine grained sediments. These are known as the Touchet Formation. They were laid-down in slackwater "lakes" that briefly existed as the mega-flood waters backed up all the tributaries of the Snake River. What's the size of particles here? How does it compare with the graded beds you saw down by Starbuck? Does the size difference make sense if you think of particles carried along by water coming up this valley? Look carefully at the vertical "veins" of silts and clays in the road cut. There's more than one type: one just exists on the surface (run-off from above) but others are "real" and extend back into the roadcut.

Photo 8: Complex "veins" of silt and clay (coin for scale)
(Photo by E. Kirsten Peters)

Look around and dig your hands into them. Were they formed from the bottom up or the top down? What processes may have been involved? (This is a real question, one that geologists are struggling with today. We don't fully understand these veins!)

Mile 8.2: Junction with road to Central Ferry. Go EAST on 12 toward Lewiston.

Mile 11.8: Note the bright red basalt layer as you drive by. The color comes from oxidized iron in the basalt. We'll see this layer again, far from here. It's quite recognizable by its color.

Mile 19.8: Pomeroy

Stop 9: Mile 27.0:

You'll see the road that goes left to Lower Granite Dam. Stay on the highway to Lewiston but stop just after the junction at the historical marker on your right (Lewis and Clark). Pick up a little American history, free of charge!

Mile 30.8: Top of grade: Alpowa Summit (Elev. 2785 feet). You can note around you – a bit down the hill – a good V shaped valley with a flatish bottom where the floodplain resides.

Mile 39.5: Enter Asotin County. Note the orientation of the lava beds.

Stop 10: Mile 43.3:

Chief Timothy State Park. Drive into the park, then walk north toward the waters of the Snake River. The lava beds here have been disturbed after they formed. They have, in fact, been folded; that's why their orientation are unlike what you've seen elsewhere on this trip. The folding of the beds is called a monocline; it's the same structure you will see if you use both hands to hold a piece of paper out in front of you (looking at it edge-on) and drop one hand lower than the other while moving both hands a little bit toward each other. The steeply inclined lava beds are the equivalent of the "bend" in the paper. Deformation like this happens due to mild compressional stress --- and of course the lava beds were deformed after they had each formed and cooled, one on top the next. Again, we can see that geologic history is LONG, involving many steps that each take a lot of time.

You'll get a better view of the monocline --- briefly --- as you get back in your vehicle and continue towards Lewiston.

Mile 44.8: On right, note the columnar basalt that is splayed in all directions (not merely vertical as usual). How could this have formed? (This is a real question not one geologists fully understand.)

Mile 48.0: Clarkston just coming into view. Note the columnar basalt on the right. This time the columns are dramatic --- and vertical in orientation.

Mile 50.2: Just after you pass the Golf Course there's another Lewis and Clark sign if you are interested.

Proceed toward town but turn left at major intersection (the sign says East to 128 and 193 – Port Districts) and take the big bridge across the Snake River --- the bridge is known to some as the Bridge To Nowhere and to the authorities as Red Wolf Crossing. Reset your trip odometer to zero as you turn onto the bridge.

As you come down off the bridge, turn right toward Idaho.

Mile 2.2: Welcome to Idaho!

Mile 4.2: Port of Lewiston on your right: turn left toward Pullman on Hwy 95 (up what we call "the Lewiston Grade").

Stop 11: Mile 8.8:

Near top of grade on the right, in the road cut, a red basalt layer is nicely offset by a small fault. Again, this feature was clearly created after the lava beds have formed. Most likely, when the beds were folded into the monocline, they were being compressed. Such forces create this kind of fault, called a reverse or thrust fault by geologists.

Note: If it is still fairly light, you may wish to stop at the overlook on the top of the grade which affords a great view of the Clearwater and Snake valleys.

Mile 17.0: Uniontown, WA

Mile 20.1: Colton, WA

Mile 35.5: Kate Webster Physical Sciences Building. Welcome back!

GEOLOGIC TIME SCALE

Today

Cenozoic (RECENT-LIFE) Era — Quaternary — Holocene

10,000 years ago

Pleistocene

Ice Age Glaciations

about 2 million years ago

Tertiary

Early Hominid Species
Cascades begin to grow
Basalt flows of Eastern WA
Whales and bats appear
Yellowstone Volcanics begin

Mammals diversify and fluorish

66 million years ago

Mesozoic (MIDDLE-LIFE) Era

Dinosaurs disappear
Beginning of Rocky Mountains

Mammals appear, remain small

Early Dinosaurs

245 million years ago

Paleozoic (OLD-LIFE) Era

Abundant and large reptiles
Coal beds in Eastern U.S. form
Amphibians and Insects flourish

Land plants appear

Fish and abundant shelled animals in sea

545 million years ago

Proterozoic Eon

Multicellular plants and animals in oceans
Atmosphere has free oxygen gas
Cells with organized nucleus

2.5 billion years ago

Atmosphere has no oxygen

Single-cell fossils
Oldest rocks on Earth

4 billion years ago

Earth entirely molton

4.6 billion years ago Earth forms