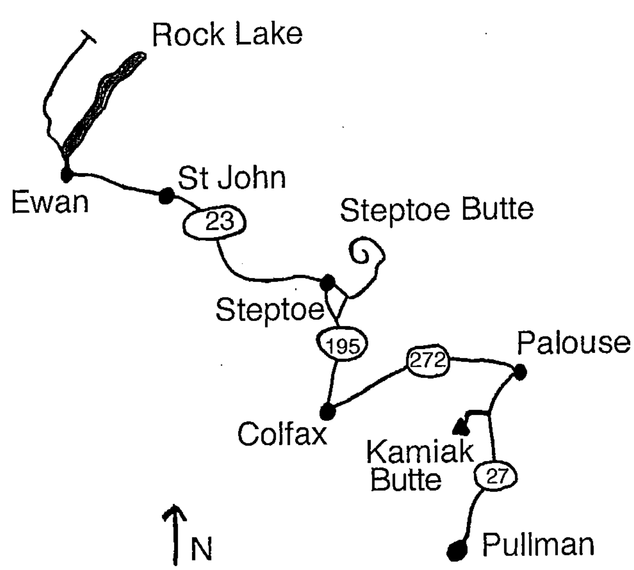
# Geological Field Trip 1

# From Opals and Ancient Mountaintops to Ice Age Lakes

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



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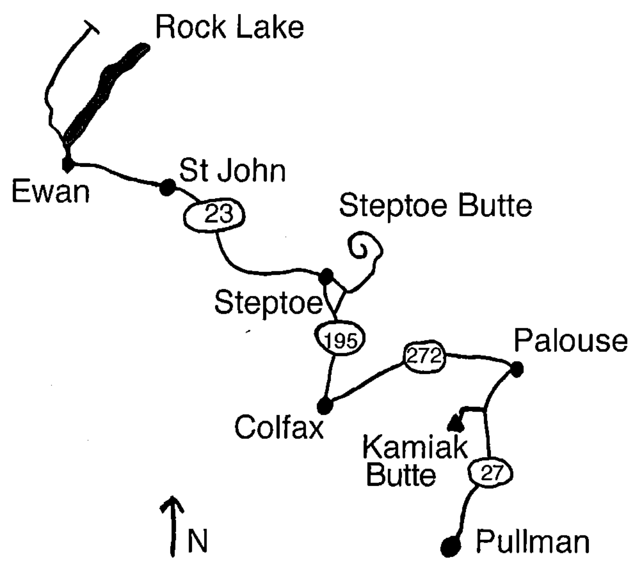
OVERVIEW:

The first portion of the trip is in central Pullman and may be most easily accomplished on foot. It consists of five stops, "A" through "E," and can be done in an hour or two. The rest of the trip requires a vehicle and will take the remainder of a long day.

SKETCH MAP OF THE TRIP




**Start:** Kate Webster Physical Science Building, WSU-Pullman Campus, College Avenue

Proceed west on the service portion of College Avenue, under the skywalk of Owen Science Library and then onto the regular section of College Avenue. Continue west, going downhill. The steepest portion of College Avenue takes you past engineering buildings on your right and then by WSU's power plant at the bottom of the hill.

**Stop A:** Depending on the season, you may see large piles of bituminous coal at the power plant. Coal is the compressed and compacted remains of ancient plants. You can think of it as fossil plant matter, made mostly of carbon. There are three common grades of coal used in the world:

1. Brown coal or lignite: this is low grade coal. It has abundant nitrogen and sulfur impurities. It therefore does not burn cleanly. The nitrogen and sulfur compounds go up in the smoke and then combine with water droplets in the air to make "acid rain" (small amounts of nitric and sulfuric acids). Lignite (brown coal) is used in China today, but not in the U.S. and Canada because of its environmental impact.

2. Bituminous (or "soft") coal: this is medium grade coal, the kind WSU burns. After the original, pre-historic plant matter was covered by sediments, it was buried more deeply than lignite. Warm temperatures in the earth drove off some of the nitrogen and sulfur in the plant remains, making this coal cleaner to burn. Bituminous coal is often mined in the western United States in strip mines. The coal beds are roughly horizontal and lie at shallow depths, so the overlying earth is "stripped" off by heavy machinery. The coal can then be loaded and hauled to places like WSU. Burning the coal here on campus produces heat used to create steam. The steam circulates underground around WSU's campus in large pipes. This steam heats most university buildings. In the future, WSU may also burn coal (as well as natural gas) to generate electricity for the area.

3. Anthracite (or "hard") coal: in the Appalachian Mountains in the eastern United States anthracite coal is mined. The plant matter in this coal predates the age of the dinosaurs. The coal was buried deeply and experienced higher temperatures and pressures than any other coal. Anthracite actually qualifies as a low-grade metamorphic rock! It is close to being pure carbon and has a hard, almost metallic sheen (like the graphite in the middle of a pencil--graphite is pure carbon). Anthracite coal is mined in Appalachia in deep, underground mines. It is the most valuable grade of coal because it burns relatively cleanly and produces the most heat per pound of coal.

Walk over to WSU's coal pile, or find coal pieces scattered on the railroad track, and gather up a handful. Remember, this bituminous ("soft") coal is actually a sedimentary rock. Question to think about: Is the coal more or less dense (hefty) than most rocks you've encountered in your life? Why might that be the case?

Continue west on College Avenue and proceed toward Reaney Park. [If you are in a vehicle, you should now park at Reaney Park.] Turn and walk southeast toward Main Street to the small concrete bridge on Spring Street as it crosses the creek.

**Stop B:** As you stand on the bridge, looking west (downstream) you can see several stream features --- and one modest locality for finding opals.

Opal is an interesting mineral in several respects. Opal was known and valued in the ancient world; the word "opal" itself goes back to the Sanskrit language. Opal is made of silica (silicon and oxygen), just like quartz. Not surprisingly, then, it's a fairly hard mineral (about 6 on the Moh's scale of hardness).

Opal has water molecules dispersed within its silica. Other minerals you may know that are closely related to opal include agate and jasper. There are two kinds of opal: precious and common. Both are usually milk-white in color or may show pale tints. Precious opal, however, shows a strongly colored luster or translucence, with a rainbow "play of colors" on its surface. Precious opal, as the name implies, is worth money! It is used as a gemstone by jewelers worldwide.

The type of opal we have in the Palouse is (alas!) common opal. It lacks the "play of colors" of precious opal but it does have an interesting translucence, not unlike a pearl. Good specimens of common opal are sometimes also used in low-priced jewelry.

Opal has been found in the left (southern) bank of the stream overwhich you are standing. On a warm summer's day, when the creek water is low, you may wish to scramble down the bank and look in the sediments you see there. The creek water can be used to wash any interesting specimens you may find, as well as to keep "rock-hounds" cool.

Why is opal here? The answer lies in the rocks that underlie our Palouse soil and in chemical alterations that have occurred since those rocks formed.

The common dark rock of the Palouse is called basalt. It's a volcanic rock, formed when enormous volumes of lava covered our area and cooled. The basalt rocks of the Palouse have been dated by using radioactive particles within them. They are roughly 13-15 million years old. The rocks formed during the Tertiary, the unit of time that comes just after the Age of the Dinosaurs (the Mesozoic Era). You may wish to look at the geologic time-line at the end of this guide to grasp how "young" our basalts actually are.

When lava reaches the surface of the earth it is often "frothy" due to gasses in the molten material. These gasses (mostly steam and carbon dioxide) form small bubbles in the lava flows. The bubbles rise in the liquid basalt lava if they can, but sometimes the lava cools quickly and "traps" them in the solid rock. In time the gasses escape through tiny cracks in the rocks and mix with the air but the round empty "pockets" remain in the basalt. Pick up several pieces of basalt anywhere in the Palouse and you are likely to see the small round "pockets". These pockets or holes are known as vesicles to geologists and some volcanic rocks (like pumice) have an abundance of them.

What do the vesicles have to do with opal? The answer lies in chemistry. After the basalt formed, circulating waters in the rock dissolved silica --- which is the most common constituent of all rocks. The dissolved silica later precipitated within vesicles (pockets) in the basalt. Opal formed from that silica (plus water molecules). Still later, the basalt rock was weathered and began to break down to soil and sands. The opals, being resistant to weathering, "lasted longer" than the basalt around them. In time they are washed away and redeposited by streams like the one before you here. Thus it is that the opals here show several steps in geologic history. First basalt lava flowed over the area and cooled, forming vesicles in the rock. Later opal precipitated in those vesicles. Still later, the rock was weathered (broken down) so that the opals were free to move down this stream.

Quite another geologic feature, however, is more important to Pullman residents than the opal in the stream bank. You are standing in the floodplain of the creek. Look around you: both Reaney Park and downtown Pullman are part of the stream's floodplain. You can tell this at a glance by the flat expanses on either side of the creek.

Here's the most important practical point of this trip: floodplains are built by floods and, in the future, floods will occupy floodplains once again!

Photo 1: View from Lentil Lane bridge on typical June day (Photo E.K.P.)

Photo 2: View from same place during relatively mild winter flooding.
Stream here is a full as it can be without inundating the floodplain.
(Photo E.K.P.)

How does a stream build a floodplain? During floods a creek like the one you're standing over moves a lot of sediment. Cobbles and small boulders bounce along the stream bed as water rushes along the stream channel. Sand and mud are dispersed throughout the water --- which is why floodwaters often look like chocolate milk. When stream water at flood stage runs out onto a flat floodplain, its speed drops. This allows the fine sediment to settle out of the floodwater, all over the floodplain. In time, with repeated flooding, a floodplain is built of these layers of sediment.

Why are so many of Pullman's businesses built on the floodplain if, in fact, it will be flooded again and again? The answer lies in the economics of the construction trade. Especially in the past, before large earthmoving equipment, it was much easier to construct large buildings on flat ground. Look around you! The <u>only</u> flat places in Pullman are in the floodplains of Pullman's creeks.

So even though rowboats and kayaks go up and down Main Street and Grand Avenue from time to time (very roughly, once each ten years) new businesses are still being built in Pullman's floodplains.

One last point before we leave: looking downstream you'll notice that the stream bends to your left. The railroad tracks that you can see to your right are on the outside of this bend. Water flowing down a stream must run faster on the outside of a bend than on the inside --- like track students rounding a corner while staying in their lanes. The faster moving water <u>erodes</u> the bank it touches while the slower moving water may even <u>deposit</u> sediments on the inside of a bend. Question to think about: if you were going to build a house very near this stream, would you want it on the left or right bank?

Now continue walking over the bridge and toward downtown. When you reach Main Street turn right (west). Walk along Main, noting how much money has been invested into buildings on this piece of the floodplain. When you cross Kamiaken Street, stop at the corner (NW corner of the intersection).

**Stop C:** The beautiful building stone used on this structure was brought here from Minnesota. It's a metamorphic rock called gneiss (pronounced "nice"). The swirling textures in the rock, called foliation, show it was heated to very high temperatures while experiencing great pressures within the earth. The minerals in the rock aligned themselves in the swirls you see here when the rock was in a soft, "plastic" state, something like Silly Putty.

Stand back and you can see isolated "eyes" in the foliation. These "eyes" are single large crystals of the mineral called feldspar. These feldspars are called augen (the German word for eyes). The augen grew as metamorphism became extreme.

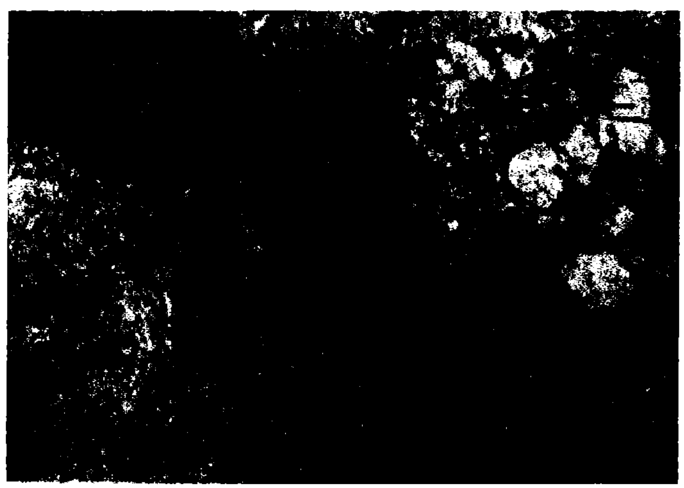


Photo 3: Gneiss with augen toward upper right.
(Photo: E.K.P.)

Originally this rock was granite, an igneous rock. It had all of its minerals randomly oriented, pointing in all directions. Metamorphism has produced the foliation in the "fabric" of the rock. The minerals are the same ones you can find in granite but their orientations and sizes have been greatly changed by the metamorphic process.

The rock was quarried, then cut and polished, to make these building stones. It was brought to Pullman in the 1950's when WSU was building the original section of Holland Library. The library used many of these gneiss blocks and, we can surmise, a downtown businessman purchased some left-overs at the same time.

The gneiss rock may have been quarried around 1950 but when did it form in the Earth? Radioactive particles in the rock allow us to date the gneiss. Remember, the basalt rock all around Pullman is roughly 10 million years old. That's young compared to this gneiss which is about 3.3 billion years old. This is, indeed, an old rock. Put your hands on it and try to appreciate how ancient these minerals and augen are! Rocks can surely make all of human history look short, let alone our individual lifetimes.

Now walk north on Kamiaken one block and cross the street. If the season is right, you'll see a fountain on the corner.

**Stop D:** This is a man-made fountain, with water pumped into its nozzle. The water is recycled in the pool, then pumped and sprayed into the air once again. But read the plaque on the fountain and you'll see it commemorates Pullman's artesian wells. An artesian well is one you don't have to pump --- water just flows up and out of it naturally. In the early history of Pullman there were a number of artesian wells near here. Groundwater was trapped, under pressure, in some of the basalt flows beneath your feet. All it took for release was a well hole dug or drilled down to the right basalt layer. Quite convenient--- especially in an age before electric pumps!

When the over-pressured water had all been released, however, it was the end of Pullman's artesian drinking water. Now we get our water from wells about 2000 feet deep. The water must be pumped up all of that distance and then pumped into the water towers you can see on the tops of Pullman's hills. Today there is legitimate concern that the 2000 foot deep aquifer on which Pullman depends is being depleted faster than natural forces can recharge it. It seems likely that, some day in the future, we may have to do something quite different to obtain drinking water.

Now walk northwest on Olsen Street (the street you just crossed) to reach Cougar Plaza at the corner of Olsen and Grand Avenue.

**Stop E:** In addition to a fine, bronze, cougar --- who has been seen wearing a mortar board at graduation --- you can note the basalt rock on which the cougar stands. **This is it:** the common rock found all around the Palouse. Take a close look and find some vesicles (holes) in the basalt, re-reading the information about Stop B if you need to do so.
Next you may wish to note that the flat "stones" for walking around the plaza are man-made. If you look closely you'll see they are textured concrete.

Behind the cougar, at the back of the plaza, look at the lighter-colored rock which has names carved into it. You can see individual mineral crystals in the rock, some dark, some light colored. Look at the light colored ones. Those that are white and opaque are feldspar --- the most common mineral near the surface of the Earth. There are other minerals that are clear and appear almost as translucent gray crystals. These are quartz, the second-most common mineral in the Earth's crust.

Look at several square inches of the rock. Do you agree that the crystals are randomly oriented, some "pointing" in all directions? Unlike the gneiss you saw earlier, this rock lacks foliation. The minerals are randomly oriented because they formed from a liquid as it cooled. Thus this rock is an igneous rock. Indeed, this is the most common igneous rock on the Earth's continents: granite. Granite is commonly used for building stones. As you can see, it can be polished to a remarkably smooth finish.

If you are going to continue on this trip today you'll need a vehicle. Water and a sack lunch may be helpful, too, as the rest of the trip will take a full day to accomplish. Walk back to Reaney Park if you parked there. Drive back to this intersection. When you reach here again, set your trip odometer to zero so it will match this guide. You'll want to come through this intersection and drive north on Grand Avenue (toward Dissmore's IGA). We'll leave Pullman on the road going north toward the town of Palouse.

**Mile 0.0:** Cougar Plaza intersection, Turn north on Grand Avenue.

**Mile 0.7:** Dissmore's and intersection of North Grand and Stadium Way. Continue north, toward the town of Palouse (State Route 27).

**Mile 1.0:** To your left for the next hundred yards you see typical road cuts through the Tertiary basalts of the Palouse. Note that although basalt is black when fresh, it weathers quickly to the yellows and tans you are seeing. The basalt, in short, is turning to clay minerals, the sort of minerals you are used to dealing with in soil.

Above the rocks in the road cuts you can see steep soil slopes. Each spring, when the soil is water saturated and heavy, it "creeps" downhill. Occasionally, more dramatic slumps of earth occur here, spilling over the basalt cliffs. And, of course, some pieces of basalt fall off the face of these man-made cliffs. All of these movements of earth materials under the direct influence of gravity are examples of what geologists call mass movement or mass wasting. And everytime we humans increase the steepness of a slope -- by "pushing back" the side of a hill as the highway department often does --- we guarantee we'll have future problems with slumps, rockfalls, and creep.

As you continue away from Pullman you can see one fork of the Palouse below the road on your right. The flat area around the creek, including the railroad tracks, is all part of the floodplain. Question to think about: in a town like Pullman, why must railroad tracks be laid in floodplains?

**Stop 1: Mile 2.2**

When the road to Albion is on your left, slow down and turn right. Pull over immediately onto the shoulder. There may be no need to get out of your vehicle if you can see the gravel pit to your northeast.

Commercial gravel pits in the Palouse operate just like this one: they crush solid basalt, making angular gravel particles. The gravel is often run up a moveable conveyor belt to form large piles. The slope of the piles can be quite steep. The maximum angle of slope that a pile of any particles can maintain is called its angle of repose. Perfectly rounded, dry sand grains can't be "heaped up" quite as steeply as these angular gravel particles can. In any event, the important point is that if you build your dream home on the side of a hill made of soil, sand, glacial till, or any other loose material you don't want the hillslope to be anywhere near the natural angle of repose. Otherwise you and your house may well experience mass movement of some sort!

Now turn your vehicle around and rejoin highway 27 going north toward the town of Palouse.

As you drive north you see a multitude of undulating, graceful hills. These Palouse features give the area a look and feel literally unique in the world. The hills were formed during the Ice Age, or Pleistocene. The Ice Age glaciers covered what is now Canada and extended into northern Washington. They transported a great deal of loose sediment as they flowed south. The climate near glaciers is harsh, often with strong winds. Winds from the west picked up fine particles --- silt and clay --- from the loose sediment in central Washington. The material was carried here where it dropped out of the air. If you think that the hills around you have the same shape as sand dunes, you're right! They are formed by the same process. Sand dunes and our Palouse hills are both eolian features, that is, formed by the wind. The soil around you is one example of the soil category called loess. It's made up, almost entirely, of silt size particles carried here by the wind toward the end of the Pleistocene.

**Mile 7.0:** From about this point for the next several miles you'll see Kamiak Butte ahead of you and on your left. Note that smaller, but similar buttes are also ahead on your right. All of these buttes are made of truly ancient, and mildly metamorphosed, sandstone. The sands were deposited at what then was the edge of the North American continent. These events occurred a little over one billion (billion with a 'b') years ago! The rocks are therefore of the Proterozoic Eon (see time line at end of guide for reference).

After becoming compacted and cemented to form sandstone, the rocks remained buried. At a later date they underwent relatively mild metamorphism, at low temperatures and pressures, becoming quartzite.

The buttes you see around you are the peaks of ancient mountains. They were here before the loess, and long before the basalts. During the Tertiary, enormous floods of lava entered this area, laying down layer after layer of basalt. As you know from looking around near the Snake and Columbia rivers, the basalt layers are stacked on top of each other --- literally for thousands of feet. Only the very tops of the ancient mountains in this area kept their "heads" above these repeated volcanic floods. Kamiak Butte is one such mountain-top. The highest spot on Kamiak is 3641 feet above sea level. This mountain-top has seen a lot around here! Not only volcanic flows of enormous size, running all the way to the horizon, but, much later, the Ice Age and the formation of the Palouse's eolian soils on top of the basalt.

**Stop 2: Mile 11.7**

The road to Kamiak Butte Park will be on your left. Stop at the junction, pulling over so you can read the sign about Chief Kamiak of the Yakima Tribe. Sometimes people who erect road signs don't get certain details correct, but happily the geologic information on this sign is exactly right!

Proceed west toward Kamiak. At mile 12.9 turn left onto the small access road to the butte.

No doubt you have noticed that this, the north side of the butte, has much thicker timber than what you could see from the south. Question to think about: why is that the case?

**Stop 3: Mile 13.7**

Main Parking Lot. Park your vehicle here. During the warmer parts of the year, toilets and drinking water are likely to be available just downhill from the parking lot. In colder seasons, there may be an outhouse available toward the uphill end of the parking

lot. Question to ponder: could it be problematic to have an outhouse uphill of a drinking water source?

Ahead, to your left, is the start of Pine Ridge Trail. It's only half a mile long and, although its uphill, it's the only way to see the quartzite rocks. Take your time walking up the trail. <u>If you and others in your group refrain from talking, you are very likely to hear the wildlife around you.</u>

As you walk up the trail you'll see an increasing number of small stones in the trail bed. Each one is quartzite. This is one of the few places in the Palouse where you can get away from basalt. Enjoy!

At the first real switchback in the trail you can see boulder-sized pieces of quartzite. Many of these rocks have flat sides and a blockish appearance. They have broken along jointing surfaces or cracks in these ancient rocks caused by stresses over their long history. Joints are often rough planes, and come in sets parallel to each other. A second or even third set of joints may cut across the first, promoting angular, blocky, rocks.

At the second switchback (turning to your right as you climb) you will find a fine outcrop of quartzite. Look closely at the rock itself and at the jointing in it. Some faces

Photo 4: Kamiak quartzite outcrop. (Photo: E.K.P.)

of the outcrop are quite fresh and light colored. Others are darker and more orange colored. Red and orange hues are common in weathered rocks exposed to the elements. Small quantities of iron in the rock have oxidized to give the rock this orange color. You can also see moss and lichens growing on the weathered faces. Notice that they have not had time to become established on the fresh, light-colored faces.

Continue climbing to the top of the ridge. On a clear day you can see Pullman to the south and Moscow Mountain to the southeast. In the far distance to the south-southwest are the Blue Mountains. And in the spring and early summer, you'll have wildflowers at your feet.

When you are ready, turn around and walk back to the parking lot.

Once back in your vehicle, drive back to Highway 27. When you rejoin the main highway reset your trip odometer to zero to match this guide. (This will help minimize differences between different odometers.) Turn left onto Highway 27 and head north once again.

**Mile 2.7:** Enter the town of Palouse. Continue straight and across the concrete bridge. At mile 3.2 turn right on Main Street (also east on Washington Route 272).

The downtown area of Palouse is located --- you guessed it --- in a floodplain! The last time we had a serious flooding in the area, the town of Palouse was hit hard. It's interesting to note that the original pioneers of this town built "downtown" on the south hill (to your right). Later, their sons and daughters chose to move all of the downtown businesses to the floodplain --- for the sake of the flat ground. But that decision has caused many financial losses due to flooding over the years.

Leave downtown going east, cross railroad tracks, start up a hill and then immediately pull over to the shoulder on your right.

**Stop 4: Mile 3.6**

Carefully cross the road to the outcrop of rock on your left, looking both ways for traffic!

You can clearly see a dark, basalt flow at the top of this outcrop. Look carefully at the large yellow layer below the topmost basalt. Before reading further in this guide try to imagine what could have created this yellow zone. Look at it closely, walking up and down the outcrop. Take your time and look for clues.

Photo 5: Yellow layer in Palouse's basalt (Photo: E.K.P.)

The basalt flows that covered the Palouse during the Tertiary occurred many times. But in-between each flow, years and years would pass. Imagine a bare, basalt world here during the Tertiary. The climate at that time was much wetter than today because the Cascade Mountains had not yet risen up, blocking moisture from the Pacific. So, here in the Palouse the flat expanses of basalt rock were drenched with rain. In time, streams and lakes were established. The yellow layer in the outcrop before you contains pebbles and cobbles of basalt, doesn't it? The yellow material (largely clays from weathering) and the pieces of basalt in it were sediments in a river that flowed through here. No doubt wildlife drank here and plants grew along the stream's edge. Then, one day long ago, another enormous lava flow swept across the area. You can see how it buried the streambed. You can't see, but you can imagine, how many plants and animals must have been buried by the lava. Geologic history certainly has its grim side. But, on the other hand, it's also amazing what we can deduce about the events that happened right here --- but millions of years ago, during Tertiary time.

Returning to your vehicle, turn it around and drive back through downtown Palouse. Turn right at Mile 4.0 following signs to North State Route 27 to Spokane. Turn left at mile 4.3 to go west on State Route 272 to Colfax.

**Mile 15.3** Junction: turn right toward Colfax

**Mile 16.9** Palouse Grange building on left

**Mile 20.2** Enter Colfax on a STEEP downhill grade. Turn right on Main Street, which is also Highway 195 to Spokane.

**Mile 21.0** Whitman County Courthouse on right

Continue north on Main Street to the Excell Grocery Store. Turn right into the store's parking lot.

**Stop 5: Mile 21.2**

Look over the southern edge of the grocery store's parking lot at the stream channel of the Palouse River. As you can see, the natural channel has been made into a concrete "stream-bed." This project was done by the Corps of Engineers. Both Colfax and Pullman were offered this type of structure. Pullman declined on aesthetic grounds. The practical people of Colfax, however, accepted the proposals of the Corps and these concrete channels can be found throughout Colfax's floodplain.

This structure was full during the last major flooding of the Palouse during the mid-90's. Water was flowing under the bridge to your right --- just barely under the bridge, that is! You'll be glad to know that the concrete channels worked in the sense that downtown Colfax was not flooded.

Consider what must happen, however, just downstream of any structure such as this one. Levees and concrete channels always end someplace, right? Where they end they disgorge a large volume of water which is moving at high speeds and with a great depth (or height). The last point is key: without levees or concrete channels like this, a stream at flood stage spreads out over its floodplain. The water in the floodplain "thins out" and slows down. But with concrete structures like this, the land just downstream will be more severely flooded (by faster, deeper water) than it would have been otherwise.

To put it another way, it's unwise to build your dream home immediately downstream of any town that has installed artificial levees or concrete channels.

Could downtown Colfax be flooded next year, despite these concrete channels? The answer is yes. In a really large flood, the capacity of the channels would be exceeded, and water would occupy the floodplain (also known as downtown Colfax). But so far, the channels have been able to hold the floodwaters we've experienced since the Corps of Engineers constructed the concrete structures in front of you.

Perhaps the bottom line about flood "control" projects is this: no man-made structure can keep water out of a floodplain 100% of the time. And all such structures guarantee severe flooding immediately downstream. On the other hand, artificial levees and concrete channels can lessen the frequency of flooding in one particular spot. In sum, different choices can be made by different towns --- for good reasons!

Return to your vehicle and reset your trip odometer to zero to match this guide.

Continue north on Highway 195 out of Colfax (toward Spokane).

**Stop 6: Mile 1.4**

Pull to your right into the overlook area. Below you is the valley that's been formed by erosion --- over many years --- due to stream action. Erosion, as you can see, is a powerful force!

Note that in the northern end of Colfax the stream's floodplain is being used as a golf course. Compared to housing and businesses, a golf course may be a good use of a floodplain. But in the last major flood here, this golf course was covered in water and significantly damaged. Grass was eroded away and stream gravels were deposited on the course. So even a golf course can be greatly affected by floods!

Continue north on Highway 195 toward Spokane.

**Mile 3.7:** Near the top of the hill you'll see Steptoe Butte, our next destination, dead ahead.

**Mile 5.1:** John Deere implement business. As you may know, soil erosion on the steep hills of the Palouse is a major problem for farmers. Machinery has now been developed for "no-till" farming, a technique which allows planting next year's crop in the stubble of last year's. By minimizing the disturbance of the soil by disking (plowing), the no-till method lessens soil erosion. Nevertheless, soil erosion is greater here in the Palouse than in any other region of the country.

**Mile 5.7:** Note the gravel pit on the right, and the typical angle of repose of the gravel piles.

**Mile 6.8:** Turn right onto Hume Road which is marked for Steptoe Butte State Park.

Steptoe Butte is a state park because of the vision of Virgil McCroskey, an early twentieth century Colfax businessman and farmer. He was committed to public land conservation and bought the land on and around Steptoe Butte so that he could donate it to the state of Washington. Since 1946 the Butte has been accessible to all of us, and at no charge.

**Mile 7.9:** Take right-hand branch of the 'Y' in the road.

**Mile 11.9:** Turn left onto the access road to the butte. Look at the spiral highway you can see before you. Question to think about: Are the roadcuts on the highway cut through basalt rock? (Look carefully and you can determine the answer even at this distance.)

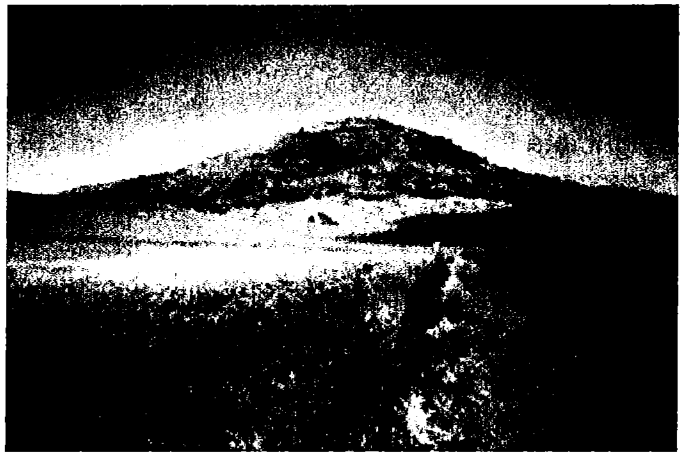


Photo 6: Steptoe Butte from access road (Photo: E.K.P.)

**Mile 12.9:** Picnic area. Outhouse available during most of the year.

Continue up the spiral highway. You can surely see now that the butte is not made of basalt, but of quartzite rock just like Kamiak.

**Mile 16.1:** You're near the top! Take the steep driveway to your left.

**Stop 7: Mile 16.2**

Top of Steptoe Butte, elevation 3,613 feet above sea level. As you may know, Chief Kamiaken defeated Colonel Steptoe in a 19th century battle fought near here. Therefore it's fitting, perhaps, that Steptoe Butte is just a little shorter than Kamiak Butte. Both, however, are made of the same rock and represent the tops of ancient mountains, all but buried by younger basalt flows.

Look all around the horizon and read the signs erected for you. There is one misleading geologic statement in one sign, which states that the quartzites beneath your feet are "over 400 million years old." That's true, but it would be more useful to note the rock is not only "over 400 million" but actually about one billion years old. It's from the Proterozoic Eon (see timeline at end of guide).

As you see on another sign, earlier geologists were sufficiently impressed by Steptoe Butte that the word "steptoe" is occasionally used in the general geologic literature. Any isolated, ancient hill surrounded by much younger lava rock is a steptoe. In this sense, Kamiak Butte is a steptoe. Perhaps Colonel Steptoe would be pleased to have his name immortalized in this manner.

The full, 360° horizon visible from the top of Steptoe Butte is most impressive on a clear day. Using the signs as a guide, you may be able to see Mount Spokane to the north as well as Mica Peak closer and just to the right. Both of those mountains are well worth visiting --- but we can't do so on today's tour.

Now, looking at your feet, examine the rock that makes up this steptoe. Do you see jointing surfaces like you did at Kamiak?
When you are ready, return to your vehicle and drive slowly down the spiral highway. Depending on the season, as you descend you may notice many different zones of wildflowers or see some of Steptoe Butte's resident deer population.

**Mile 19.3:** Picnic area and outhouse facility.

**Mile 20.3:** Turn right onto Hume Road, toward the town of Steptoe.

**Mile 24.1:** Leave Hume Road, bearing right on McCroskey Road.

**Mile 24.2:** Turn right on Scholz Road toward the town of Steptoe.

**Mile 25.9:** Just as you enter town, turn hard right (180°) onto Bethel Cemetery access road. Note the quartzite rock used for the pillars of the entrance signs.

**Stop 8: Mile 26.2**

Drive to the highest (north) part of the cemetery and park. Carefully and respectfully, walk around the cemetery and look at the headstones. You will doubtless see gneiss and granite (like you saw downtown Pullman). The older residents of the cemetery often chose marble for their tombstones: it's the white, "soft" or translucent-looking stone. Note that even the pioneers of the area didn't use basalt for headstones, but went to the trouble and expense of importing different rocks. Question to think about: why not use readily available basalt for tombstones?

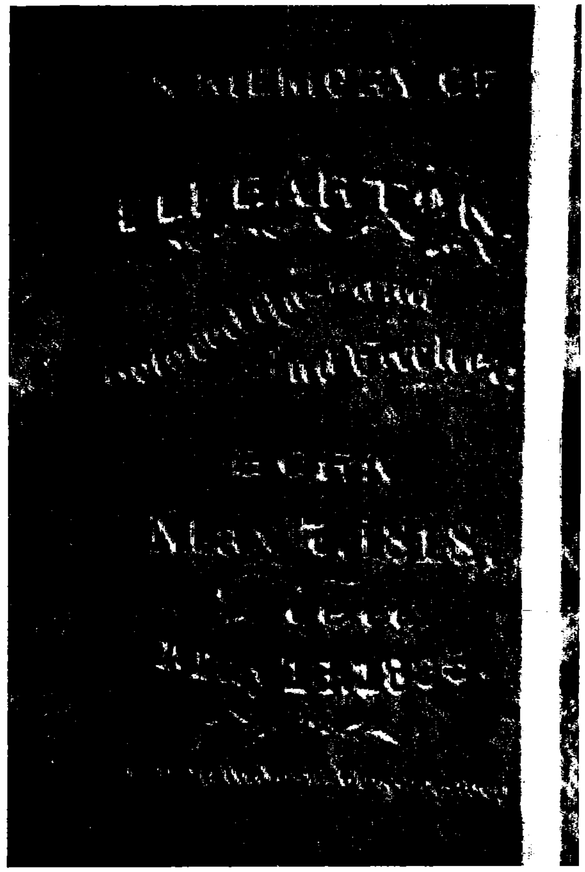


Photo 7: Marble headstone, Steptoe Cemetery (Photo: E.K.P.)

Cemeteries can be viewed as sad places, but they also record our history. At least two veterans of the American Civil War lie here. As his marble headstone attests, Cyrus Wood fought for four years in Company L of the 2nd Iowa Cavalry. And James B. Wilson was a member of Company C of the seventh regiment of the Tennessee Volunteers. The granite headstone of Nels Nelson makes it clear that there were Scandinavian settlers in Steptoe's history. And numerous early headstones show us that babies and young children all too often died in earlier times.

Question to think about: what rock type did the Huffman family favor for their tombstones? (Hint: some makers of gravestones call the rock "rainbow stone" but you know the geologic name because you met this rock downtown Pullman).


Photo 8: Many Huffmans have chosen this rock (Photo: E.K.P.)

And here is a non-geologic question to think about: what group of Palouse residents are not in this cemetery at all?

Return to your vehicle and drive back to Scholz Road. Turn right and enter the town of Steptoe.

The road you are on will make a junction with U.S. Highway 195 which runs basically north (to your right) and south (to your left). As you wait at the stop sign at the junction, reset your trip odometer to zero to match this guide. Drive straight across Highway 195, going west toward the town of St. John on State Route 23.

**Mile 6.5:** Grain elevator.

**Mile 9.0:** Small Christmas tree farm.

**Mile 13.9:** Enter St. John, noting the low, brick building on your right belonging to the St. John Grain Growers' Co-op. You'll likely see the price of wheat and barley posted on the front of the building. St. John is an agricultural town and a closely knit community. Its downtown is one of the few shopping districts in a small town to continue to be economically healthy into the 21st century. The unusual sociology of St. John was the subject of a study by a professor and graduate student in WSU's Department of Rural Sociology.

Continue northwest out of St. John on State Route 23 toward Ewan and Sprague. You may wish to read, or read aloud, the material for the next stop as you travel because it's a rather lengthy portion of this guide.

**Stop 9: Mile 21.6**

Pull over to the shoulder on your right as you approach the tiny town of Ewan. On your left you'll see unusual, craggy outcrops of basalt with broad gullies between them. The landscape you are looking at is the edge of Washington State's "Channeled Scablands." This unusual area is the main subject of Geological Field Trip #2 in this series. We won't go into great detail about the Channeled Scablands here, but the following may serve as an introduction to this fascinating subject.

The Channeled Scablands show unusual surface features, including long and deep channels, which local residents call coulees (from the French "to flow"). The coulees cut down through the loess soil and slice into the tough, dark basalt rock. As seen from the air, the coulees form a complex braided pattern. Grand Coulee is a well-known and huge channel in the Scablands.

In the early part of the 20th 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 recent Ice Age, or 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 at least 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, which would be 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.

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 these views --- the glacial theory and the Columbia River hypothesis --- fall within the framework of gradualism. That is, both appeal to slow 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 relatively 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.

A geologist of that time named J Harlan Bretz was fascinated by the unusual features of the Channeled Scablands and spent many summers in the 1920s and 1930s literally walking through the coulees with a mule packing his gear. 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 (the jumble of large and small rocks a glacier moves) in central Washington, and no glacial moraines could be found in the Scablands. He also rejected the river 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 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 up to 2000 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. One bar along the eastern boundary of the Scablands rises impressively at the edge of the large loess hills. The well-sorted basalt gravels in this bar make it clear the huge

volume of material cannot be interpreted as moraine. The bar looks like a waterborne deposit, but it is more than 100 miles from the Columbia. This enormous bar stretches along the edge of the Scablands for more than 10 miles. (You can visit it on trip #2 of this series.)

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 (also part of trip #2).

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.

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.

Bretz's bold papers attracted attention, distressing the leading geologic authorities of the day. Bretz, they feared, was reverting to a catastrophic scheme that belonged in the profession's distant past when dreadful acts-of-God had been called upon to explain everything. 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 <u>had</u> <u>not</u> <u>seen</u> 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 critic's 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 their own mental habits with the truth.

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 wisely 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.

Throughout the 1930s, Bretz continued his publications on the Scablands, amassing a longer and richer descriptive data base for the area. But out of stubbornness, arrogance, or fear, Bretz largely ignored the question of the source of the floodwaters, and this gap in his views meant that his position did not attract many supporters. Eventually, several of the important and "gradualist" geologists of the day visited the Scablands in a series of field trips, but they concentrated on modifying the glacial and river hypotheses. Although they tried to take into account some of what Bretz had described, they did so in a framework of gradualism. These 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.

In fairness to Bretz's early critics, however, the outburst flooding he called for was so great that it is difficult to visualize even now. Geologists believe that for 2000 years in the late Pleistocene, about 40 outburst floods from Lake Missoula 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 Fork 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.

Enough reading! You'll see more of the craggy Scabland features from here to the next stop.

**Mile 22.0:** Cross the concrete bridge in Ewan and immediately turn right on Rock Lake Road.

**Stop 10: Mile 24.1**

Rock Lake lies to your right. You can turn right into the gravel area but note that to truly park here you are meant to have a Washington State "Access Stewardship Permit." If you stay right with your vehicle, however, you may decide to stop and look at the lake before you. (If you are on this trip during warm weather, you should beware of rattlesnakes in this area. Rattlers thrive in the Channeled Scablands!)

Rock Lake is a long and deep body of water. It owes its origin to the Lake Missoula flooding. J Harlan Bretz recognized Rock Lake for what it is: a flooded coulee. You can see the basalt walls of the coulee to your left and right. The rock walls of the lake

go straight down; they are responsible, perhaps, for an old idea among locals that this lake has no bottom.

The rocky cliffs around this lake seem to contribute to strong wind gusts. The author of this guide knows of two separate incidents in which multiple people have drowned owing to storms capsizing boats. Because the lake is so deep, bodies are generally not recovered from this flooded coulee.

When you are ready, return to your vehicle and continue across the bridge and farther down Rock Lake Road.

As you drive farther west and north you will see alternating Scabland features and areas of good loess soil. The farmable soils lie on the high spots --- just above the water level of the catastrophic floods.

**Stop 11: Mile 25.5**

On your right in the grassy field you can see another remnant of the Ice Age. Notice the low regular mounds on the field. These are known as Mima Mounds. They are similar to what exists in many permafrost soils, roughly polygonal mounds or high areas. The frost action of the Ice Age in these soils produced these patterns. Although we don't understand exactly how the mounds are made, we do understand we are looking at earlier permafrost soils. Once again, the Ice Age (or Pleistocene) continues to shape the world around us, although here the features are more subtle than in the case of coulees.

This point marks the end of this field trip. Congratulations: you've seen many different geologic features of the area around WSU. If you reread this field guide, you can consolidate all that you've learned today.

Note to drivers: at this point, to return to Pullman most directly, you can drive back to Ewan, St. John, and then Steptoe. At the Steptoe junction, turn right (south on U.S. Highway 195). This will take you directly to Colfax, and then straight on to Pullman.

# 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<br>Cascades begin to grow<br>Basalt flows of Eastern WA<br>Whales and bats appear<br>Yellowstone Volcanics begin |
| | | | Mammals diversify and flourish |
| | | | 66 million years ago |
| Mesozoic (MIDDLE-LIFE) Era | | | Dinosaurs disappear<br>Beginning of Rocky Mountains |
| | | | Mammals appear, remain small |
| | | | Early Dinosaurs |
| | | | 245 million years ago |
| Paleozoic (OLD-LIFE) Era | | | Abundant and large reptiles<br>Coal beds in Eastern U.S. form<br>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<br>Atmosphere has free oxygen gas<br>Cells with organized nucleus |
| | | | 2.5 billion years ago |
| Archean | | | 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