

## THE GEOLOGIC FORMATIONS OF THE JOHN DAY BASIN:

The term "John Day Basin" refers to the fact that for a long time the region was relatively low and gradually sinking, accumulating thick layers of sediment and lava flows. When you cook pancakes and stack them on a plate, the first (oldest) pancake you made ends up on the bottom and the last (youngest) is on top. Likewise, in a normal sequence of sedimentary and volcanic deposits, the oldest layers are at the bottom and the youngest on top. Geologists have compiled a "stratigraphic column" of the geological layers we'll see along the bicycle route.

Alluvium - last few centuries

Mazama Ash - 7,700 years

Rattlesnake Formation - 6-8 million years

(Rattlesnake Ignimbrite - 7.2 million years)

Mascall Formation - 12-16 million years

Columbia River Basalt (Picture Gorge Basalt) - 16 million years

John Day Group - 18-39 million years

Haystack Formation - 18-25 million years

Kimberly Formation - 25-28 million years

Turtle Cove Formation - 28-30 million years

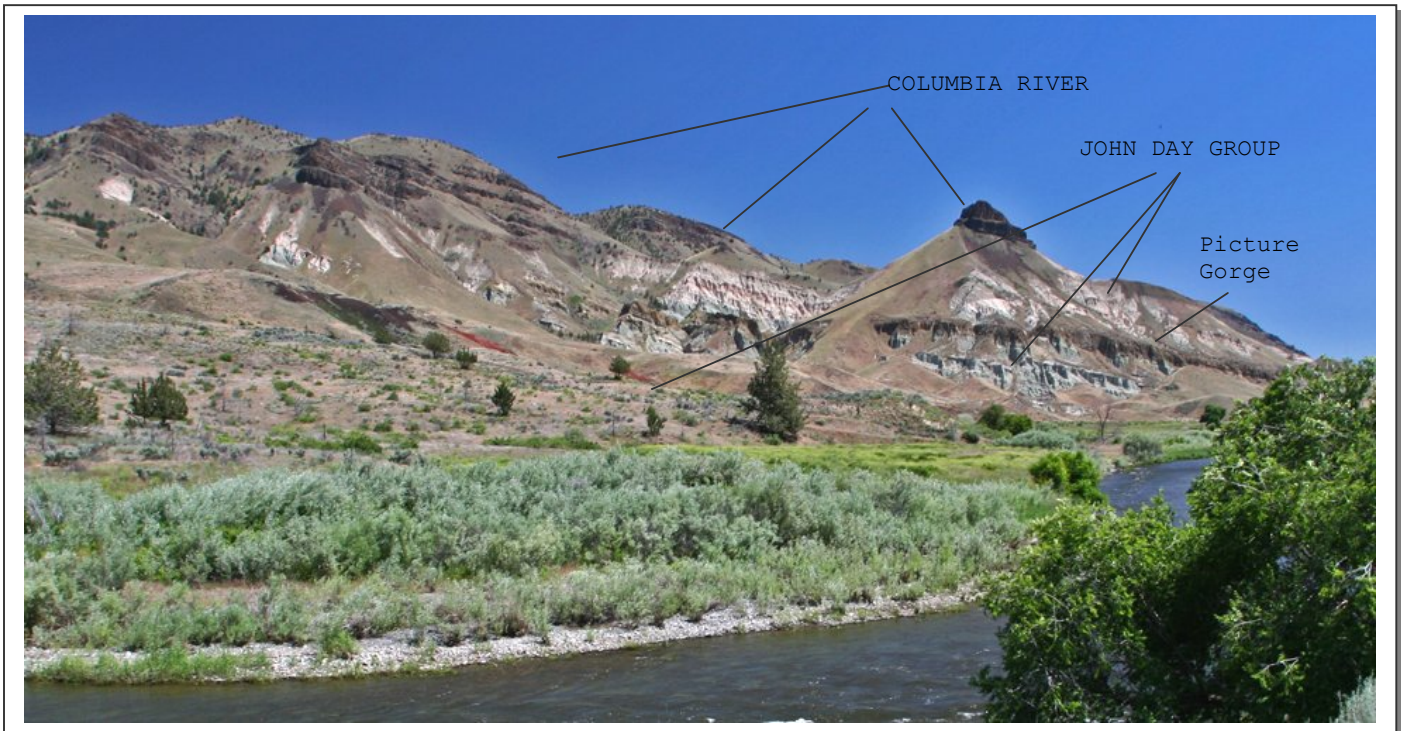
(Picture Gorge Ignimbrite - 28.7 million years)

(Blue Basin Tuff - 28.9 million years)

Big Basin Formation and Bridge Creek Beds (32-35 million years)

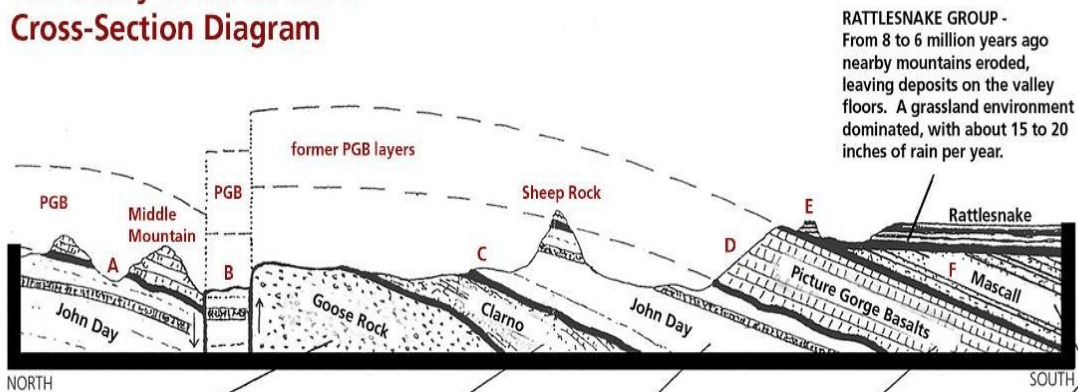
Clarno Group - 37-54 million years

Goose Rock Formation - 80-100 million years



*Sheep Rock, John Day Fossil Beds National Monument displays 23 million years of the John Day Basin's geologic history. The dark cap-rock is Columbia River basalt (16 million years old). The softer, ash-rich, light-colored sediments beneath are part of the John Day Group—from top to bottom, the Haystack Formation, (pinkish) Picture Gorge Ignimbrite (darker) and Turtle Cover Formation (blue-green). The red bands near the bottom are Big Basin Formation—from a wetter warmer time about 35 million years ago. Folding that occurred between 15 and 7 million years ago.*

## The Valley of Turtle Cove Cross-Section Diagram



**RATTLESNAKE GROUP -**  
From 8 to 6 million years ago nearby mountains eroded, leaving deposits on the valley floors. A grassland environment dominated, with about 15 to 20 inches of rain per year.

**GOOSE ROCK -**  
These former ocean bottom deposits were formed a few dozen miles off the continental coastline when most of Oregon was under water. Well-rounded and diverse rocks in the matrix of Goose Rock suggest the source of the deposits as a large river emptying into the ocean about 90 million years ago.

**CLARNO GROUP -**  
These layers were formed 54 to 37 million years ago from ash fall, mudflows, and lava deposits from local volcanic sources. A near-tropical forest, with many vines, covered the land during this warm time period. Rainfall may have been as much 100 inches per year.

**JOHN DAY GROUP -**  
These layers were formed primarily from ashfalls from the Ancestral Cascade Mountains from 39 to 18 million years ago. The temperate climate contained deciduous hardwood forests covering the land. Grasses made their appearance late during this period. Rainfall might have been about 40 inches per year.

**PICTURE GORGE BASALT (PGB) GROUP -** The 17 layers in the gorge are part of the massive Columbia River Flood Basalts formation. The Picture Gorge Basalt Group issued as lava floods from extensive cracks in the earth about 16 million years ago. They cover an area of about 2,500 square miles.

**MASCALL FORMATION -**  
These layers are ashfall from volcanoes to the east, south, and west, active about 15 to 12 million years ago. The climate was dryer than before, with about 25 inches of rain per year. Savannas dominated the area.

**A. Location of Blue Basin (with hiking trails)**

**B. Massive fault lines running east-west for dozens of miles, separating block faults**

**C. Location of the Thomas Condon Paleontology Center and James Cant Ranch**

**D. Picture Gorge, carved by the John Day River and Rock Creek**

**E. Flat mesa topped by the Rattlesnake Ignimbrite layer (with radio antenna)**

**F. Location of Mascall Formation Overlook**

*Geological layering at the Sheep Rock Unit of John Day Fossil Beds National Monument. The left side of the diagram starts at the Blue Basin area. Riding southward (to the right) on Oregon Highway 19, we'll cross fault lines where older layers have been uplifted and exposed by erosion. The layers are tilted southward, so that we'll encounter younger and younger layers as we continue down the highway to the Thomas Condon Visitor Center.*

## GUIDE TO RECOGNIZING THE ROCKS AND FORMATIONS OF THE JOHN DAY BASIN

Rocks can be bewildering. To identify "wild rocks" try looking at them on three scales—first, look at the outcrops from a distance to gauge the overall color, distribution, and other patterns. Then, look at the formation more closely, from about 20 to 100 feet distant—at this scale, you can see more details—is there bedding? Columnar jointing? Then, examine a "hand sample" more closely. For its specific textures—are there holes in the rock that indicate it was once part of a steamy lava flow? Elongate, glassy inclusions (fiamme)? Or other clues to its intimate history? This guide will help you recognize the most abundant rock formations in the John Day Basin. Happy trails!

**Mazama Ash: (7,700 years)** Bright-white, powdery, and unconsolidated (hey, it's ONLY 7,700 years old!) Mazama Ash is exposed as pockets of ashy material, generally less than 20 feet in road cuts. This ash was generally washed off of local slopes and concentrated in local gullies and the sides of stream channels. Today, it reveals where streams and small now-vanished drainages existed 7,700 years ago.



**Rattlesnake Formation: (6-8 million years; 7.2 million years-Ignimbrite)**

Two very different components compose this formation:

- 1) Light-colored, but well-consolidated and cemented tuff. In outcrop, especially near John Day and Mt. Vernon, as well as its exposure atop Picture Gorge, the Rattlesnake Ignimbrite displays broad and crudely developed columns. In hand sample, it displays "fiamme" or wispy, elongate glassy inclusions and some very small quartz and feldspar laths.
- 2) Unconsolidated or poorly consolidated sand and gravel deposits. There are thin deposits of gravel beneath the ignimbrite, and much thicker deposits above the ignimbrite, representing a time of significant river deposition in the John Day valley.



*Fiamme in Rattlesnake*



*Broad columns, Rattlesnake*

The Rattlesnake Ignimbrite forms the nearly horizontal cap or flat-lying rock perched atop the tilted basalts of Picture Gorge. It also forms a distinct horizontal layer in the hills north of Dayville, and can be easily traced along the north side of the John Day Valley from Picture Gorge to John Day.

**Mascall Formation: (12-16 million years)** This formation is well exposed in a small area south and west of Picture Gorge. It is named for the Mascall Ranch, on which it is best exposed.

It can be best observed from a NPS overlook about 2 miles south of Picture Gorge. The rocks are well-consolidated tuffs and lakebeds that preserve a wide variety of animals and plants. The Mascall formation is widely distributed across parts of southeastern Oregon, but is generally absent between Fossil and Dayville, where it has been eroded for the top of the geologic section.

QuickTime™ and a TIFF (Uncompressed) decompressor are needed to see this picture.

*Mascall ash*



The Mascall landscape consisted of several broad basins with lakes and meandering streams that formed atop the last of the basalt flows. These deposits were subsequently covered by successive falls of ash from volcanoes to the west and from the much closer Strawberry volcanics to the east. Alternating between the tuffs - consolidated volcanic ash - are layers of ancient soils and stream deposits that provide evidence of a dynamic floodplain. Many of the vertebrate fossils from the Mascall are found in close association with a prominent layer, the 15 million-year-old "Mascall Tuff." The deposits of the Mascall began when the basalt flows ceased.

QuickTime™ and a  
TIFF (Uncompressed) decompressor  
are needed to see this picture.

Although dramatic fluctuations in the global climate and regional volcanic activity continued, there were enough phases of moderate climate with ample rainfall and fertile soil to allow the growth of lush grasses and mixed hardwood forests. This savanna-like landscape was characterized by broad, level floodplains with scattered lakes.

**Columbia River Basalt:** Basalt is the most common rock in Oregon. They are dark, dense volcanic rocks. Many have small holes of "vesicles" that mark small pockets of gas that escaped as the lava cooled from a dark, iron-rich lava flow. Columnar jointing is a common feature of many basalt flows.

Here are some tips on how to recognize basalt. Like all the other formations, and all of geologic observation, you can make the job of recognition easier by looking at all three scales-landscape, outcrop, and hand-sample!



1) Landscape: The Columbia river basalts generally form the cap rock -the tops of ridges-in much of the John Day basin. Along the John Day River between Spray and Picture Gorge, they form "layers"-or multiple flows-on the ridges above the river.

2) Outcrop: The Columbia River basalts here have two distinctive outcrop forms-they may form columnar jointing or they may display "hackly" jointing which is much less regular, and look like a gigantic tree-bark texture or perhaps as though someone had "hacked" at the outcrop. This texture is more common between Service Creek and Spray than it is upstream from Spray. You might also note red layers at the tops and bottoms of basalt flows. These are especially notable near the east end of Picture Gorge. The red layers usually represent ancient soils that developed on top of the lower basalt flow, and then was baked and oxidized by the subsequent flow. The thickness of these layers-known as "Paleosols" indicate that many thousands of years passed between eruptions of the largest Columbia River basalt flows.



Columnar joints, Picture Gorge

3) Hand Sample: basalts in hand sample are usually covered with a veneer of reddish-brown weathered surface. To see



Vesicles in basalt

their dark, true, black-hearted, iron-rich selves, one has to look at the dark interior. Fortunately, most road cuts include broken rocks. To identify basalt, look for a black or very dark brown fresh surface. Most volcanic rocks -including basalts-will have small holes-or "vesicles" where gas created a tiny bubble as the flow cooled and became solid. Basalts may also contain tiny, rectangular crystals that will sparkle a bit in bright sunlight. Most of the basalts erupted from these local vents, and those at Picture Gorge, include only small vesicles, and have tiny crystals, so look closely.

### **John Day Formations**

The John Day Formation consists mostly of light-colored, crumbly-looking or soft-looking rocks known as tuffs. These rocks are mostly volcanic ash, recycled into ancient soils, and transformed into remarkably hard rock through the slow process of cementation. They are divided into five "formations":

QuickTime™ and a  
TIFF (Uncompressed) decompressor  
are needed to see this picture.

**Haystack: 18-22 million years.** Generally white or very light-colored. Most abundant east of Spray, in Haystack Valley. Tends to be quite crumbly and loosely consolidated. Lies directly beneath the Columbia River basalts.



**Kimberly:** Similar to Haystack Formation, but slightly darker, often buff or pinkish, and better consolidated.

**John Day Formation basalts:** A few odd basalts erupted as part of the John Day Formation. These rocks, about 25 to 20 million years in age, are much older than the Columbia River Basalts that rim the landscape.

**Picture Gorge Ignimbrite:** A hard layer that LOOKS like a lava flow from a distance, complete with columns. Gray or light brown. Look for "fiamme"—stretched-out particles that were molten when the hot, ashy cloud settled onto the ground. Precisely dated at 28.7 million years, it is a great marker bed. It is well exposed on Carroll Rim at the painted Hills unit, JDFB, and also is easy to spot at the top of Picture Gorge.



**Turtle Cove/Blue Basin Formation:** 28-30 million years. A distinctive aquamarine, blue-green color. Found especially at Blue basin, and in the lower part of Cathedral Rock. Represents slightly waterlogged soils that developed in a cool temperate climate. Color is due to two minerals—celadonite, a blue-green clay, and clinoptilolite—a yellowish mineral.

Turtle Cove Formation

**Big Basin Formation:** The oldest of the John Day Formation, and the ash, tuffs, and soils developed in the warmest and most tropical conditions. Hence, the Big basin Formation is generally red or yellow—reflecting its heritage of tropical-type soils and climate. It is exposed in the Painted Hills, and along the John day River between Kimberly and the John Day Fossil beds Thomas Condon Visitors Center, where it appears just north of Blue basin, and again north of the Cant Ranch.



Big Basin Formation

**Clarno Group: Andesite and lahar (mudflows) 50-45 million years old.**



CLARNO Lahar,  
JDFB Clarno Unit

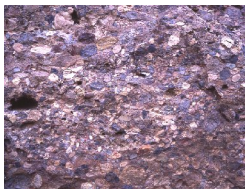
The Clarno Formation represents volcanoes similar in appearance, size, and function to Mount Hood. The rocks include a grey volcanic rock called "Andesite: --the same kind of rock you would find near Timberline Lodge. Clarno andesites are older, and may have a darker or more green-looking visage.

The Clarno Formation also includes lahars, or mudflows. These rocks—like similar deposits at Mt. Hood and other

modern Cascade volcanoes—represent slurries of mud mixed with angular pieces of rock, trees, and other materials that roared down the slopes of ancient volcanoes. Similar mudflows at times flow down modern volcanoes in Indonesia where they are called "lahars."

Clarno rocks are exposed—though rarely--along the John Day River north of Goose Rock. Along the highway, they appear as a single, brown, weathered outcrop north of milepost 189 and 1.5 miles south of the Foree Basin trail turnoff. These rocks are found more easily in other places around Wheeler County, including at Butte Creek Pass between Service Creek and Fossil, and in the vicinity of Ochoco Summit on US 26 15 miles west of Mitchell. They are most abundant as andesites and mudflow (lahar) deposits between Fossil and the John Day River at Clarno.

**Goose Rock Formation: Sedimentary conglomerate, 80-100 million years old (Cretaceous age.)**



This is the oldest formation you will see on your ride. It consists mostly of "conglomerate" --a hard, brown rock composed of rounded pebbles and small rocks cemented in a dark-tan matrix. It looks, in fact, a bit like concrete. You can also find thin beds of sandstone in-between some thick layers of conglomerate. The rock was deposited by a

powerful river that ran from a now-vanished coastal mountain range to the beach at Mitchell, some 100 million years ago.