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Rathdrum Prairie Aquifer Geologic History

The geology of the Spokane Valley-Rathdrum Prairie area is the result of multiple geologic events that have occurred over hundreds of millions of years creating both our landscape and the aquifer of today. Understanding the geologic events of the past helps us better understand our environment and current issues. There are five significant geologic units that compose most of the rock types found in the Rathdrum Prairie area. Below is a brief description of these units.

Belt Supergroup—1.1 to 1.5 billion years ago

What are the Belt Supergroup Rocks?



Belt Supergroup rocks are composed of a thick sequence of sediments that were deposited in an ancient sea basin. The term Supergroup refers to an extremely thick sequence of rocks of the same kind, and Belt refers to the name of the basin that the sediments were deposited within. The basin was formed by geologic forces pulling the rock apart forming a large deep rift. The sediment was deposited deep under water forming thick accumulations. As the rift filled with sediment, it was also slowly sinking, a process geologists call "subsidence." The subsidence allowed even more sediment to accumulate in the rift. Eventually, the rift started to fill and younger sediments were deposited in shallower water. The sediment consisted of mostly clay and silts, along with sands, and calcium carbonate. The basin's great depth allowed sediment that is tens of thousands of feet thick to accumulate. The weight of all the overlying sediment eventually caused the sediment to metamorphose or turn into a type of rock called an argillite.

Window to an Ancient World

The belt rocks were probably deposited much like what we see today with silts and sands from local land masses washing out into the water. Some of the sediments have ripple marks from wave action, indicating they were located near the shoreline. There are fossils

in the metamorphosed sediments of a type of blue-green algae called stromatolites. Stromatolites are the oldest known fossils, and they formed layers or mats often shaped like domes. These fossilized domes are seen in some of the Belt Supergroup rocks. Stromatolites thrived in areas of warm shallow water and, like plants of today, needed sunlight and carbon dioxide to live. Stromatolites lived in large colonies, similar to current day coral reefs. Stromatolites currently exist in a few places in the world. They are found in small, isolated freshwater lakes and shallow marine lagoons.



Ripple marks — Belt Supergroup

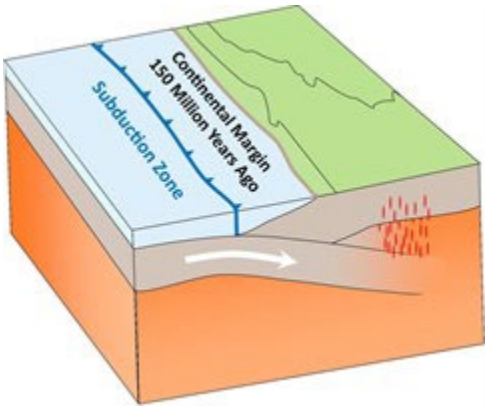




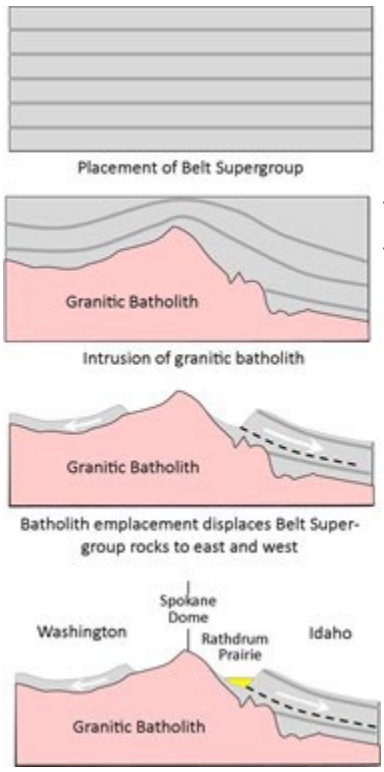
Fossilized and present day stromatolites

Kaniksu Batholith—50 to 100 million years ago

What is a batholith and how do batholiths form?



A batholith is a type of granitic formation. The earth's crust is composed of large moving tectonic plates. About 150 million years ago, the continental margin was located along Idaho's western border, where two tectonic plates collided. This collision resulted in the western plate being drawn down (subducted) and overridden by the eastern plate. As the western plate was subducted, the rock began to heat up as it reached greater depths, melting portions of the upper plate. The melted material was lighter than the surrounding rock and rose up from deep within the earth and solidified near the earth's surface. The solidified body of rock is called a batholith.



Batholiths are commonly composed of granitic-type rocks because of how the magma is formed. The upper crustal material is made up of many different types of minerals (rocks are made from one or more minerals) with different melting temperatures. Minerals with low-melting temperatures melt first and separate from the larger rock mass, eventually mixing and rising to solidify near the earth's surface. The minerals that melt first make up granitic-type rocks. The process of separating the low-melting temperature minerals from the high-melting temperature minerals is called partial melting.

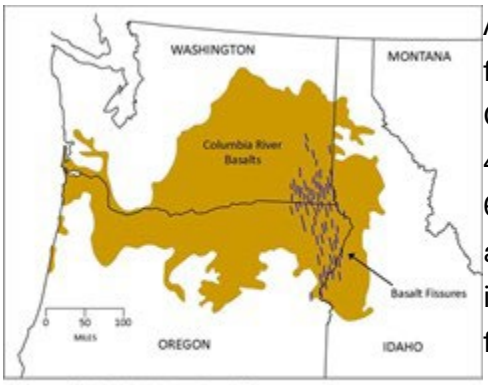
Batholiths are generally created by the combination of many intrusions with similar composition. The size of batholiths can be very large, covering hundreds of square miles. Batholiths can be exposed over time through erosion of the overlying rock or by pushing it off to the side when intruded upward.

Kaniksu Batholith

Located in northern Idaho and northwestern Washington, the Kaniksu Batholith is the northern-most formation of Idaho's many batholiths, which were formed about 70 to 80 million years ago. When the Kaniksu Batholith intruded upward, it forced the overlying Belt Supergroup rock to the east and west. The movement between the Kaniksu Batholith and Belt Supergroup rocks occurred along the Purcell fault. In geology, a fault is where two rock bodies move past each other. The movement of the Belt Supergroup rocks to the east also formed a large trench between the two rock masses that eventually filled with gravels and sand forming the Rathdrum Prairie.

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Columbia River Flood Basalts—10 to 17 million years ago



Extent of Columbia River Basalt flows

About 10 to 17 million years ago, as many as 270 lava flows erupted from fissures located near the Idaho, Oregon, Washington borders. It is estimated that almost 42,000 cubic miles of basalt flowed out over an area of 63,200 square miles. The basalt thickness in the central area of Washington is up to 6,000 feet deep. The individual basalt flows were estimated to be about 150 feet high and moved at approximately 3 miles per hour.

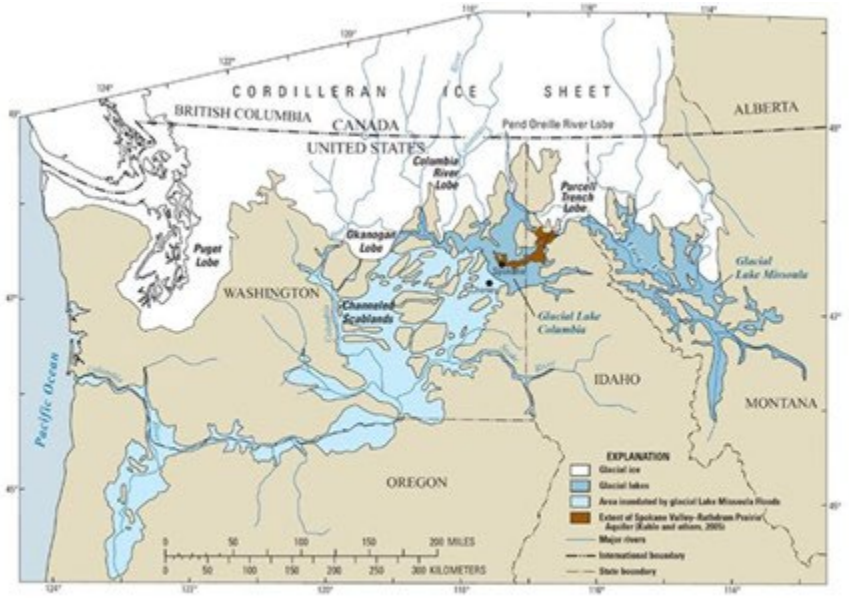
After an eruption and outpouring of basalt, there is generally a long period before the next eruption. The basalt flow that was deposited across the area will cool and develop certain characteristics depending on the rate of cooling. Individual basalt flows can be divided into three parts: a flow top, middle section and flow bottom. The upper part of the basalt flow (flow top) that is in contact with the atmosphere will cool quickly and develop many small air bubbles. Basalt with many small air bubbles is called vesicular. The central part of a basalt flow will take a long time to cool and solidify. As the basalt is cooling, it shrinks and develops cracks. The cracks will start toward the top with the lowest temperatures and then propagate downward developing long columns. Each individual basalt column is referred to as a colonnade. The bottom of the basalt flow is in contact with the top of the previous older basalt flow. Generally, the top of the previous flow has been exposed to the elements and has weathered into soil and smaller bits of basalt. When the new flow flows over the top of the older flow it picks up and incorporates large amounts of the rock debris. Basalt with bits of rock is called breccia. The next basalt flow will cover the previous one and develop similar divisions. You can see all three basalt divisions in exposed formations. In northern Idaho and eastern Washington, the flood basalts filled area drainages, blocking streams and rivers, impounding waters behind them. These ponds and lakes filled with silt and fine-grained sediments that largely formed siltstone and are referred to as the Latah Formation. Many types of fossils including plants, mollusks, and fish can be found in these sediments.


Basalt flows — Central Washington

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Glacial Lake Missoula Flood Deposits—15 to 100 thousand years ago

The Cordilleran ice sheet flowed southward from Canada about 13 to 100 thousand years ago, extending into northern Montana, Idaho, and Washington. There are many theories as to why the climate became colder causing the generation of these continental glaciers. One theory describes minor variations in the earth's orbit around the sun.



Southern extent of Cordilleran Ice Sheet

These small changes move the earth farther from the sun and are enough to cool temperatures so that large glaciers will form. Other factors may be large amounts of volcanic dust in the air, blocking the sun, along with the decrease of certain atmospheric gases such as carbon dioxide and methane, which normally trap the heat near the earth. The leading edge of the Cordilleran ice sheet had areas that advanced farther than the bulk of the ice sheet and are termed lobes. Two lobes in the area, the Purcell Trench Lobe and Okanagan Lobe, flowed far enough south and eventually blocked the Clark Fork and Columbia Rivers, respectively. The Clark Fork River backed up into Montana and created Glacial Lake Missoula. Glacial Lake Missoula is estimated to have been 2,000 feet deep at the ice dam and contained over 500 cubic miles of water. When the water behind the ice dam became elevated enough, it exerted great force on the ice dam. Eventually, the ice dam failed and released a great volume of water all at once, creating enormous flood events.



Depiction of the glacier's southern extent near present day Farragut State Park. Painting by Stev Ominski

These types of glacial floods are called Jökulhlaups, an Icelandic term meaning glacial run. The water in the Spokane Valley-Rathdrum Prairie area reached depths of about 450 feet and flowed with velocities of 50 to 100 miles per hour. The flow rates may have reached one billion cubic feet per second—more than the flow of all the rivers in the world. Large amounts of ice, cobbles, sand, and gravel were carried along with the water. The larger gravel and cobbles were deposited and the finer-grained silt and sands were carried away. After the flood ended, the end of the ice lobe slowly moved southward again, blocking the Clark Fork River. Eventually, the dam would fail again resulting in another flood event. This repeated flooding deposited large amounts of mainly gravel and cobbles in the Spokane Valley-Rathdrum Prairie area and eventually blocked the tributary valleys, forming Coeur d'Alene, Hayden, Pend Oreille, Spirit, Twin, Hauser, Liberty, and Newman lakes.



Moses Coulee in Central Washington. Photo by USGS

In the same time period, Glacial Lake Columbia flooded the Spokane and Spokane Valley areas and the Rathdrum Prairie almost to the front of the ice dam. Glacial Lake Columbia slowly drained, though a few specific locations formed geologic features called coulees. Coulees are generally long with steep sides caused by the rapid erosion and down cutting from the large amounts of water flowing through them. As the water in Lake Columbia began to rise, water started discharging at the west end through the Moses Coulee. As the Okanagan Lobe moved further south, it blocked the flow of the Moses Coulee diverting the discharge and forming a

new channel called the Grand Coulee. The water from Lake Columbia eventually poured southward to the present-day Columbia River.

The catastrophic floods from Lake Missoula rapidly flowed into Glacial Lake Columbia, displacing enormous amounts of water that spilled out into the coulees to the west and over low points to the south, flowing in enormous sheets across central Washington. The large amounts of water deformed the landscape giving them the name scablands. The flood water then spilled into the present-day Columbia River Gorge and on to the Pacific Ocean.

Evidence of the Glacial Floods



Coarse gravel and cobbles of the Rathdrum Prairie Aquifer

The many glacial floods left behind a large amount of geologic evidence spread across hundreds of miles. Geologists for decades have been piecing this together to fully describe the events. One result from the flood is the gravel and cobbles left behind in the Rathdrum Prairie. The aquifer is composed almost entirely of this coarse material with very little silt and sand. The large flow volume and high velocities carried away the finer material leaving only the gravel and cobbles behind.

Two other pieces of evidence showing the history and geographic extent of the floods are giant ripple marks and glacial erratics. The sediment within a stream or riverbed will develop ripple marks as the water pushes the grains of silt and sand downstream. The ripple marks in a stream or river are generally inches in height. The water associated with the glacial floods reworked the soil underneath into ripple marks. Because of the enormous volume and velocity of the flood water, the ripple marks are giant versions of the ripple marks seen at the bottom of streams and rivers reaching heights of 30 to 40 feet. The geology of central Washington is predominantly basalt, but there are isolated large boulders of granite and fine-grained metamorphics (Belt Supergroup) scattered about. How did these boulders get there? These boulders are called glacial



Giant ripple marks in Montana. Photo by Tom Foster


Glacial erratic in Central Washington. Photo by Tom Foster

erratics. Glaciers will often incorporate large boulders as they move over the ground surface and through valleys. When the ice dam broke apart, large pieces of ice with boulders would float many miles downstream. As the piece of ice continued to melt, it eventually would lose the boulder that would drop to the bottom. This process is called ice rafting. The scattering of erratics over central Washington and parts of Oregon indicate the extent of the flood waters. Geologists believe that there were as many as 40 flood events. How do they know? The evidence for this number of floods comes from sediment layers with large rocks on the bottom and clay on top, called rhythmites, found in many places along the flood's path. Each rhythmite indicates a flood event. Some rhythmites are found along Hangman Creek, a drainage located southeast of Spokane, and in Touchet, Washington.


Rhythmites in Touchet, Washington

One of the most important questions that geologists tried to answer for decades was where did all the water come from? In the early 1900s, geologists noticed a series of parallel lines in the surrounding hills near Missoula, Montana. Each line indicated the erosional wave action of an ancient shoreline and presence of a large body of water. These lines extend west from Missoula to the Clark Fork River area where they abruptly end. The ancient shorelines are the evidence of Lake Missoula, and they end at the location of the ice dam. They also tell us that the lake emptied and refilled a number of times always at a lower level than before, otherwise the previous shoreline would have been destroyed. The lower level

of the lake is probably an indication that the ice dam was failing sooner than the previous dam, most likely due to an increasingly warmer climate and the end of the ice age.



Ancient Lake Missoula shorelines, Missoula Montana

The concept of ancient catastrophic floods in the Pacific Northwest was originally introduced by J Harlen Bretz in 1923. Bretz was a geologist from the University of Chicago who spent considerable time in eastern Washington, meticulously analyzing and studying the geologic evidence indicating enormous floods. Bretz's colleagues were highly critical of his findings, since the accepted thinking of the time explained all geological formations through very slow and gradual processes over millions of years. However, based on the geologic evidence, Bretz was convinced he was correct and would not change his position, even though he endured continued criticism and, at times, significant attacks from his critics.



"Ideas without precedent are generally looked upon with disfavor and men are shocked if their conceptions of an orderly world are challenged"

J Harlen Bretz, 1926

One of the most important questions Bretz could not answer was where all the flood water came from. The answer finally came in 1942 when J.T. Pardee, a USGS geologist who had completed field work around Lake Missoula during the 1930s, published a paper presenting evidence of the lake and answering the question of where the water came from. Even with Pardee's evidence, Bretz's catastrophic flood theory still was not widely accepted until the early 1960s.

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Unconsolidated Deposits—Present to 1.6 million years ago


Braided stream channel with unconsolidated silt, sand and gravel. Photo by USGS

Unconsolidated deposits are accumulations of silt, sand, gravel, and cobbles that are loose and not cemented together. These sediments are usually derived from the erosion of rocks and then transported and deposited by wind or water. In the upper elevations of a watershed, the streams have a steep gradient with rapidly moving water. The water in these areas can carry away the fine silts and sands leaving behind coarse gravel and cobbles. In the lower portions of a watershed, the stream gradient is much flatter and the stream velocity is much slower, which allows the finer-grained silts and sands to be deposited.

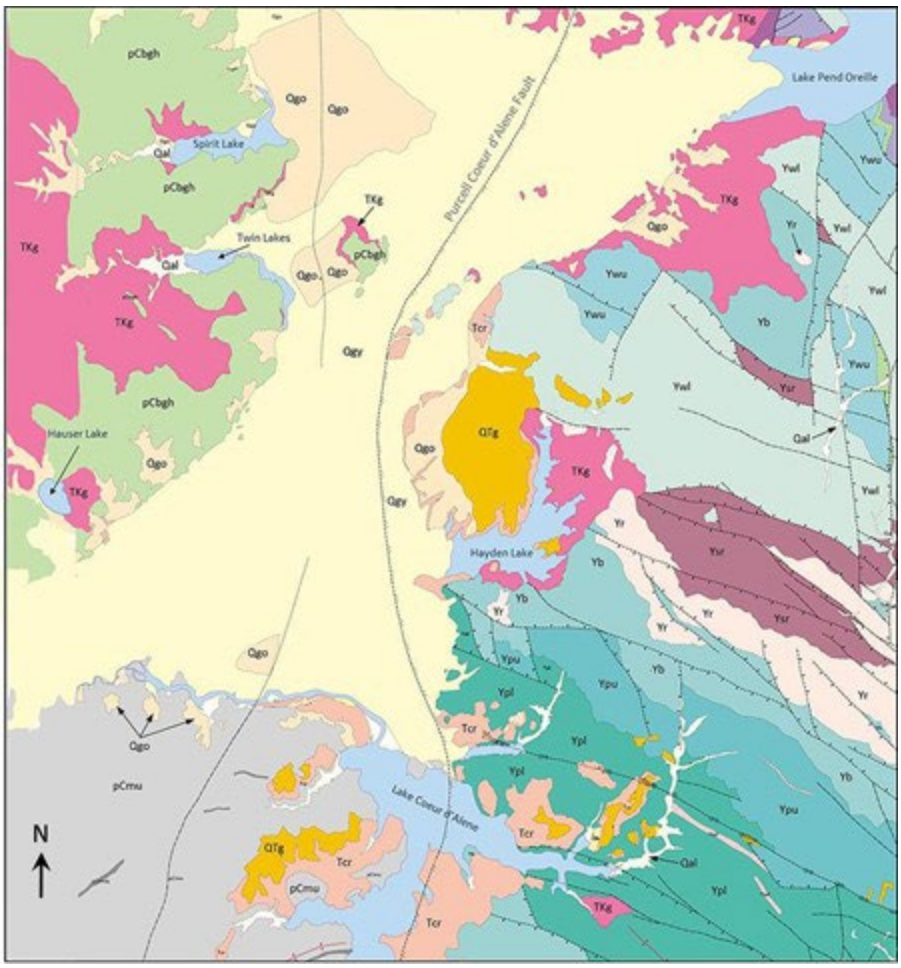

Loess soil in East Central Washington. Photo by USRA

There are some unconsolidated sediments in the Rathdrum Prairie region that were deposited by the wind. These include the Palouse wind-blown sediments that extend from Central Washington to the Pullman-Moscow area, north to some of the upland areas surrounding Spokane. About a million years ago, a warm dry climate existed and significant winds from the southwest carried silt from the central Washington area. The source of the fine silt was the fine material that flowed with the catastrophic floods and settled in the channeled scablands. These wind-blown silts are also called loess deposits, derived from the German word for loose.

Rathdrum Prairie Geology Map

The geologic map of the Rathdrum area shows the major rock units described above. The Belt Supergroup rocks are largely on the east side of the Rathdrum Prairie, and the granitic Kaniksu Batholith rocks are on the west side. The glacial flood deposits fill the area in between and create the land surface of the Rathdrum Prairie and the aquifer below. There are some basalt remnants along the edges, as most of this rock was likely removed with the massive floods. Finally, in the side streams and valleys, there are unconsolidated deposits as the rock from the upland areas erode and wash downstream.

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References

Subducting Plate Image by Gary Stevens

Granitic batholith Image by Gary Stevens

Stromatolite photo source by Paul Harrison (Wikimedia Commons)
http://en.wikipedia.org/wiki/Stromatolite#mediaviewer/File:Stromatolites_in_Shark bay.jpg

Stromatolite Fossil Photo by Greg Williams (Creative Commons)
http://www.panoramio.com/photo/6714972

Ripple Marks Photo source by Glacier NPS (Creative Commons)
https://www.flickr.com/photos/glaciernps/4500337506/

Basalt Formations Photo (Wikimedia Commons)
http://en.wikipedia.org/wiki/Columbia_River_Basalt_Group#mediaviewer/File:3-Devils-grade-MosesCoulee-Cattle-Feed-Lot-PB110016.JPG

Columbia River Basalt Extent Image modified by Gary Stevens from ISU Digital geology

Latah Formation Fossil. Photo by Dr. Bill Rember

Giant Ripple Marks. Photo by Tom Foster.

Glacial Erratics Photo by Tom Foster.

Ancient Lake Missoula shorelines photo
http://wind.caspercollege.edu/~gnelson/1999.htm

Cordilleran Ice Sheet Image by USGS SIR 2005-5227

Rhythmites in Touchet, Washington (Wikimedia Commons)
https://commons.wikimedia.org/wiki/File:Touchet-formation-2.JPG