Lake Roosevelt and the Case of the Channeled Scablands

As you drive toward your summer camping destination at Lake Roos you spot a giant house-sized, **granite** rock sitting in the middle of a wheat field. You wonder, “How did that get there?”

Later you notice the landscape is dotted with patches of barren black rock and in some areas long deep channels, called **coulees**, slice through that **basalt** rock. You find it odd. “What caused that?”

You have just stumbled upon the ***Case of the Channeled Scablands***. The deep coulees, barren **scablands**, the dry falls and the other unusual formations are all a part of the geologic mystery of Lake Roosevelt: a mystery that has puzzled geologists for ages.

Puzzle Piece: Glacial **erratic.**
(Image: National Park Service)

In the early 20th century, geologists pieced together clues from the rocks in Eastern Washington and came up with two possible explanations for the curious geologic formations in the area. One group of geo-sleuths believed that **glaciers** had created the curiosities, while the other group thought a giant river had carved the landscape. Both groups believed that the scabland case had been wrapped up.

Words to Know

Igneous rock - solidified molten material. **Volcanic** rocks solidify above ground and **plutonic** rocks solidify below ground. **Basalt** is a type of igneous rock. **Granite** is a plutonic rock.

Coulee - A long, dry, steep-walled, trench-like gorge representing a canyon carved by water.

Scabland - An irregular land surface of bedrock and thin soil that has been scoured of its soil cover by flood waters.

Like all good detectives, the geo-sleuths based their investigation on some established principles:

Geologic Principle One: **Uniformitarianism**. Geologic change is gradual. It takes millions of years to change the landscape except when volocanos, earthquakes or floods are involved.

Geologic Principle Two: **The Present is the Key to the Past**. By studying geologic events still at work, such as the glaciers that are grinding away rock in alpine valleys of Washington today or the normal occurrence of flooding rivers, you will find clues or *fingerprints* specific to those events. A good geo-sleuth can match event fingerprints from today with those left from events thousands of years ago.

Geologic Principle Three: During the 2 million years of the **Pleistocene** epoch, which ended 10,000 years ago, enormous continental ice sheets advanced from Canada into the northern United States and then retreated. This process was repeated at least four times as suggested by evidence found in the Midwest.

GLACIER THEORY

Each group read the geo-clues they found in the landscape and interpreted them differently. The *glacier-sleuths* were certain that the evidence pointed to ice sheets as the culprit.

Clues important to **glacier-sleuths** who ed glaciers were the culprit:

Clue: The abundance of **metamorphic** and **sedimentary rocks** --gravels and cobbles along the Grand Coulee and elsewhere in the scablands made up of small bits of gneiss, quartzite, chert and chalcedony, limestone and sandstone.

Clue: Giant granite boulders found in the scablands that did not match the rock around them. In some cases they were hundreds of miles or more from their origins in Montana and Idaho; but how did they get here?

Clue: The coulees of Washington state are large and broadly U-shaped in cross section.

The glacial-sleuths knew that these clues were fingerprints of a glacier.

Fingerprint: Glaciers don't simply "stand still." They advance, melt and then advance again over thousands of years. When glacial ice advances, it pushes debris in front of it—a bit like a bulldozer. The material that is moved by a continental ice sheet ranges from house-sized boulders to fist-sized cobbles, to gravel, sand and clay. This is called "till" (Exhibit A). The boulders are glacial **erratics**. Erratics encased in the ice of a glacier can be carried a long way from their point of origin.

Exhibit A: Glacial till east of Republic, glacial fingerprints (Photo: E.G. Soldo)

Fingerprint: Other common fingerprints of glaciers are the U-shaped troughs or valleys glaciers cut into the landscape, usually with a round, scoured bottom. The glacier-sleuths also knew glaciers were active in the Puget Sound and in the Cascade Mountains. Combined with other glacier fingerprints, they were certain glaciers had been active in the eastern half of the state as well.

Words to Know

Sedimentary rocks - Made of particles, like sand or gravel, formed from preexisting rocks. Water, wind or ice deposits these particles into layers, which, if buried deeply or baked, can become compacted and cemented into a solid rock.

Metamorphic rocks - Created when intense heat and pressure change the minerals and the texture of the rock.

Pleistocene Epoch - The period of geologic time between 10,000 and 2.5 million years before the present.

Glacier - A permanent mass of ice and snow that moves downhill because of gravity.

Erratic - A large rock that is not of local origin and has been moved to its location by glaciers or floods.

RIVER THEORY

The river-sleuths, however, read the clues differently. They were certain the Channeled Scablands had been carved by flowing water during the Pleistocene.

Clues important to *river-sleuths* who believed rivers were the culprit:

Clue: The Columbia River is a large river

Fingerprint: The extensive Canadian glaciers would have produced a great deal of melt-water. It is not impossible to believe that the Columbia River could have swollen in size during the ice ages.

Clue: The coulees of Washington state.

Fingerprint: A river will slowly cut its way through the bedrock.

Note: Rivers will cut a valley that is V-shape, but the coulees are NOT V-shaped. They are U-shaped as mentioned earlier. The river-sleuths had not resolved this issue yet.

Clue: The channels themselves

Fingerprint: When a river floods, its banks it will spread out, creating many different paths or channels (Exhibit B). A much larger Columbia might have spread out and carved the coulees. When the water level dropped, the Columbia River became smaller and retreated to its present channel, leaving the scablands high and dry.

Words to Know

Loess - Silt, clay and dust, originating as glacial sediment, but re-deposited by wind. Wind-blown silt. AKA - Rock-flour.

Exhibit B: The footprints of a Braided River. (Photo:L. Dubiel)

These two solutions, based on what at the time were accepted geologic theories, could have solved the mystery. In the 1920s, however, a geologist named J Harlan Bretz added a little scandal to our mystery. Bretz believed a sudden, massive, but short-lived flood created the scablands. He believed a huge wall of water slashed through the area, eroding the **loess** and basalt. It was a catastrophic hypothesis, the opposite of the number one accepted principle of geology—that things happen slowly.

History Behind the Mystery: What's a Kootenay Arc?

If we take a trip back in time 250 million years ago to the Jurassic Period, eastern Washington looked dramatically different. Salty waves from an ancient ocean lapped against a sandy beach that ended just west of Washington's boarder with Idaho (Exhibit C). Miles beyond the surf a micro-continent about the size of California, called Quesnellia Terrane, stretched across the horizon (Exhibit D). This migrating chunk of the earth's crust, known as a **plate,** inched closer and closer to shore. Though it took millions of years to meet the shore, the geological power of the impact was incredible.

As the heavier oceanic crust slid under the continent at the **subduction zone** it folded and squished the bedrock into a metamorphic rock, known today as the Kootenay Arc (Exhibit D). At great depths within the Kootenay rocks, molten magma slowly cooled to form granite. At this point the basic geology of the rock formations near Lake Roosevelt was complete except for one element: the lava flows that lie largely to the south that are known as the Columbia Plateau basalts.

Words to Know

Plate Tectonics - The Earth's surface is broken into a number of shifting slabs or plates that move relative to one another at speeds ranging from less than one ıtimeter to about ten centimeters per year (about the speed at which fingernails grow).

Subduction Zone -Area where oceanic crust slides under the continental plate into the mantle.

The Crime Scene 250 Million Years Ago

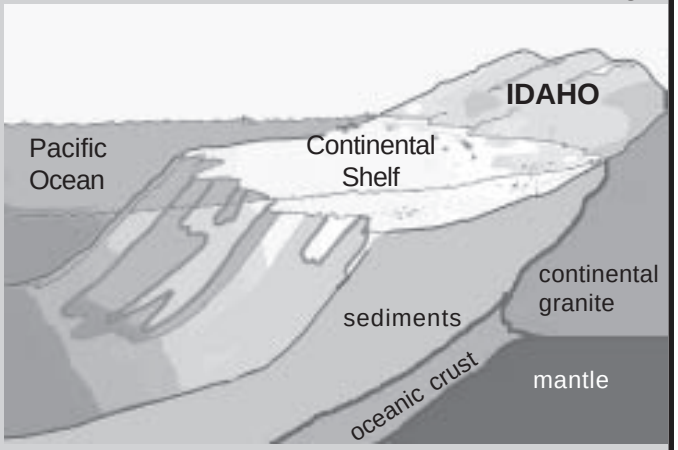


Exhibit C: The edge of the continent near the Pacific Ocean. (Image L. Snook)

The Crime Scene 175 Million Years Ago

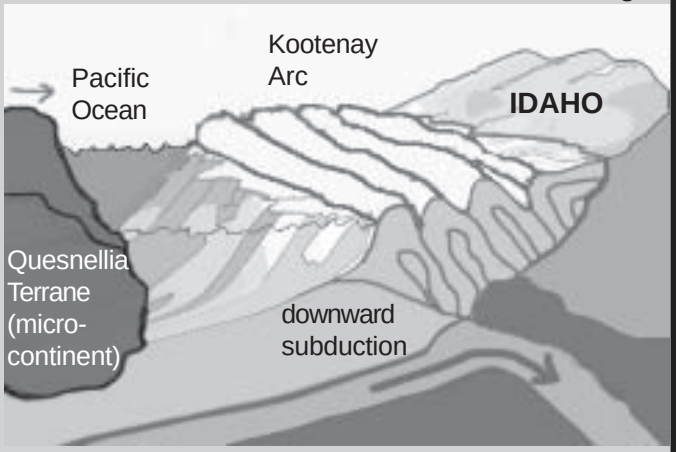


Exhibit D: The micro-continent moving toward the edge of the North American Continent creating the Kootenay Arc. (Image L. Snook)

The Bretz Theory

Bretz was fascinated by the unusual features of the Channeled Scablands, just as many visitors to Lake Roosevelt are today. Summer after summer in the 1920s and 30s, he took walking tours of both the scablands and the land downstream. Up to this point most of the previous glacier and river-sleuths had never even seen the area in person. The field evidence Bretz found held clues that proved that neither glaciers nor a giant swollen river could have created the scablands.

In 1923, Bretz presented his solution to the ***Channeled Scablands Case*** to his fellow geo-sleuths, using the following clues from his field evidence as proof:

Bretz Clue: The complex criss-crossing pattern of the channels

The scabland's channel patterns look like a gigantic **braided stream**—the footprints of a rapid flood of water followed by its rapid retreat (Exhibit B). The bottom of many coulees have no streams running through them and are extraordinarily flat (Exhibit E). There are virtually no normal valleys throughout the scablands that can be associated with a gradual river process. In fact, the unusual shape of these channels are why they are called coulees and not valleys.

Words to Know

Braided Stream - A stream system so overloaded with sediment that there are many dividing and rejoining channels.

Till - Loose, jumbled sediment deposited by glaciers.

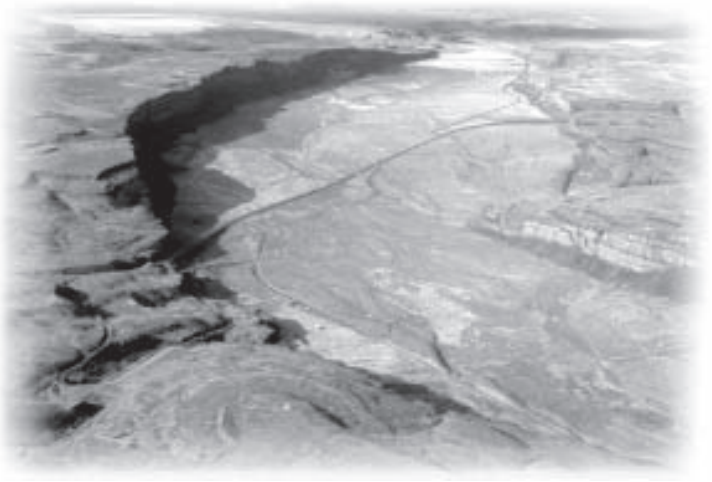


Exhibit E - Footprints : Moses Coulee from the air, view to the southwest. (Photo: E.G. Soldo)

Bretz Clue: Deep gravel bars in the middle of the channels and at the eter of the area

Some of the gravel bars in the coulees are over 100 feet high--a fingerprint of floodwaters that would have been even higher than that. The gravel bars looked like a waterborne deposit, but the Columbia River is over 100 miles away. So, it seems unlikely it was caused by the river flooding. These enormous bars stretch along the edge of the scablands for more than 10 miles and unlike glacial **till,** that would have been a jumbled of unsorted sediments, the huge volume of basalt gravels in this bar are well sorted by size.

Bretz Clue: Cataract cliffs and **plunge pools** hundreds of feet in diameter

These old waterfalls are now dry cliffs, their former plunge pools now filled with stagnant ponds, which were incapable of having formed such massive features. A fine example is Dry Falls (Exhibit F), near Coulee City.

Exhibit F: Dry Falls as viewed from near the Visitor's Center. (Photo: National Park Service)

Words to Know

Plunge pool - A spot at the base of a waterfall where the descending force of the water strikes the bedrock and carves out a basin. A deserted plunge pool is one whose waterfall has migrated upstream.

Cataract cliffs - A cataract cliff is the remnant of a waterfall that was only temporary, or went dormant due to lack of water, or the stream changed course so that water no longer falls over that particular place. See exhibit O.

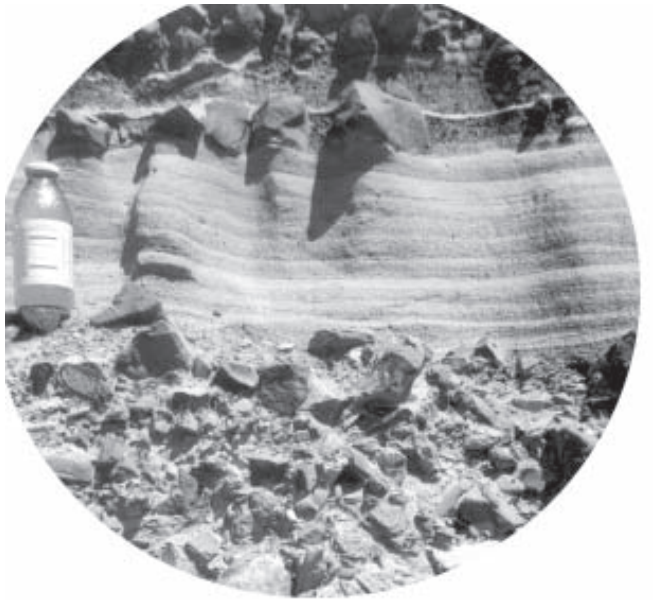


Exhibit G: Back flooding fingerprint—Sediments in a tributary river in the Scablands, with drinking bottle for scale. (Photo: E.K.Peters)

Bretz Clue: Thick layers of fine silts upstream of the Columbia and Snake 's and in their tributaries

This clue led Bretz to believe that the area's two major tributaries must have flowed backward when a wall of water hundreds of feet high reached them. The sediments in the back-flooding areas settled in stages. First the heavier debris fell out of the water and then was topped by the finner sediments when they were near their high-water mark. (Exhibit G).

History Behind the Mystery: Where did all that lava come from?

The Columbia Plateau is known for the huge volume of basaltic lava flows that erupted not from isolated volcanoes, but from giant fissures or cracks in the earth's surface. The eruptions occurred from about 17 to 6 million years ago, during the Miocene Epoch. The lava flows covered about 15,000 square miles between what we now know as the Columbia, Spokane, and Snake Rivers.

The **vesicle-rich** top layer of the Columbia Plateau basalt flow is often underlain by columnades of solid basalt . This **columnar jointing**, formed when the basalt cooled very slowly, is spectacular, both where the columns are still standing and where they have fallen (Exhibit H).

Exhibit H: Columns of basalt showing their tendency to fall down steep slopes. (Photo: National Park Service)

Pillow basalt was formed when a lava flow encountered water, such as a lake or stream, and the water cooled the lava rapidly into bulbous shapes (Exhibit I). You can see it being created today on certain parts of the ocean floor and where lava flows into the ocean in Hawaii. Keep your eyes open as you drive in the Grand Coulee or along the southern boundary of Lake Roosevelt and you may see some of these stone pillows.

Exhibit I: Pillow structures in weathered basalt. (Photo E.G. Soldo)

Words to Know

Vesicular basalt - When basalt lava cools, it becomes solid rock and sometimes contains a lot of gas bubbles, which form small round "holes" called vesicles. Basalt with a lot of vesicles is called vesicular basalt.

Columnar jointing - Long joints, usually vertical, in volcanic rock that splits into columns as the rock cools from the outside in, causing shrinkage and the development of a hexagonal joint structure.

Bretz Clue: Chaotic or “deranged” drainage patterns over much of the area

Normal, connected drainages associated with rivers are not found in the Scablands. It is dominated by depressions with no stream outlets. This makes it unlikely a river caused the pattern.

Bretz Clue: Smooth, bowl-like hollows in the basalt that look like “plucked” or scoured beds

These features were carved by a power of unusual magnitude—a massive flood full of house sized rocks, boulders, and almost immesurable amouts of silt and sand. It was a crushing errosive force that slammed these massive rocks into the basalt, breaking it into hunks which were then plucked away by the floodwaters.

Case Closed?

As you can image, Bretz’s solution distressed the leading geo-sleuths of the day. It directly contradicted the number one rule of geology—things happen gradually—a rule that had been extremely useful in explaining many geologic problems. Geologists feared his theory of catastrophic flooding would set the science of geology back by many years. It was difficult for geologists to abandon the long held rule when Bretz could not explain the source of the colossal flood. He only had proof that a giant flood had slashed the scablands into existence. He had solved one mystery only to create another. Where had all that water come from?

The Plot Thickens:

At the same meeting in 1932 where Bretz explained his wall of water theory, a young geologist named J.T. Pardee was sitting in the audience. 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 Glacial Lake Missoula in western Montana,” yet Pardee did not share his explanation with the entire group or Bretz. He was just beginning his career and wanted to get along in the profession: at this point his idea was probably only a hunch and a good geo-sleuth uses evidence to back up his case.

The case remained in limbo for years. Without a source for the gigantic flood, the geologic community was unwilling to accept Bretz’s catastrophic solution. It wasn’t until 1942, when Pardee had gathered enough evidence to explain the source of Bretz’s, flood that the geo-community decided to open up Bretz’s scabland case file to re-examine his theory.

History Behind the Mystery: Do you feel a chill?

Four million years after the last lava flow erupted, the temperatures across North America dropped and enormous glaciers gradually formed. These were not like the small glaciers of today in the Cascade Mountains. The continental glaciers of the Ice Age were hundreds to thousands of miles across and often more than a mile thick. Slowly, these glaciers flowed south from Canada. A thick glacial tongue flowed into the Puget Sound area and the ice moved into northeastern Washington State (Exhibit J).

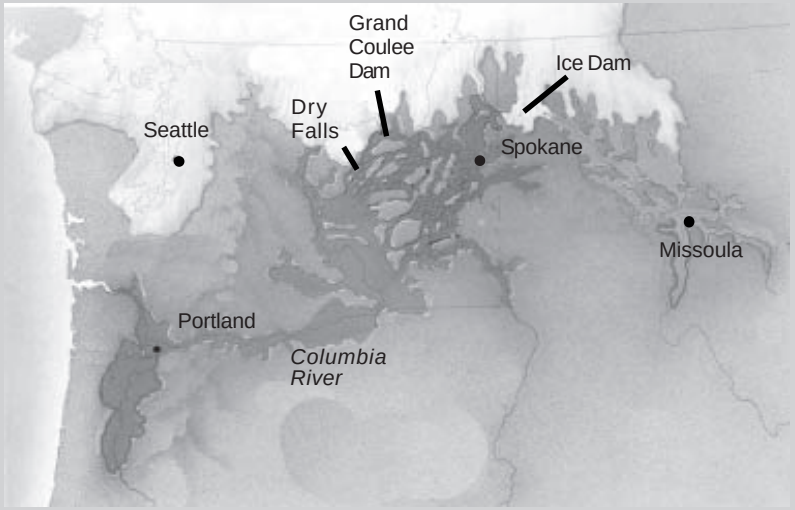


Exhibit J: Map of the Ice sheet in the Northwest (Image: National Park Service)

As the ice sheets melted at the end of the Pleistocene about 12,000 years ago life at the edge of continental ice sheet is not easy for animals or plants. In the summer, meltwater carries sediment from the edge of the glacier down across the **floodplain**. Much of what is now south-central Washington was a floodplain for the glacial ice. With little vegetation to hold freshly arriving sediment in place, southernly prevailing winds easily became laden with loess. The winds deposited the silt particles throughout eastern Washington in the Palouse regions. The deposits of loess are farmed today throughout eastern Washington, forming the familiar rich fields of the region (Exhibit K). In some places the loess forms gently rolling, rounded hills, similar in shape to sand dunes. The shape of the hills indicates the wind-derived nature of the soils. Wherever you see wheat, barley and lentils today you can be assured that they are flourishing because of the heavy dust storms of the late Pleistocene.

Exhibit K: A loess hill in the Palouse showing sand-dune-like shape (Photo: E.K.Peters)

Words to Know

Floodplain - The flat area where a stream or river may overflow.

Pardee's Clue

The major clue to proving the existe
Glacial Lake Missoula, Pardee discovered, v
the enormous **ripple marks** on the floor of where th
lake once stood. These ripples were gravel bars 50
feet high and 500 feet apart formed on such a large
scale that they had previously been mistaken for
normal hills. Bretz himself had not understood
them when he visited the area in the 1930s.
However, as with all scientific disciplines,
technology can give us better tools to
solve mysteries. Just as the discovery of
has improved criminal investigation, aeria
photography helped reveal the truth abou
giant gravel bars.

From the air, Pardee's ripple marks were similar to
formed by powerful currents that flowed over a lake b
shaping the sediments into smooth, parallel ridge-rows, only
expanded to a scale no one had thought to
consider (Exhibit N). This was the last piece of
the puzzle. Pardee was now able to explain
Bretz's catastrophic flood from start to finish.

Exhibit N - The last puzzle piece: Markle Pass, Montana: Mega-ripples viewed from the air. (Photo E.G. Soldo)

According to Pardee, an ice dam had formed (Exhibit J),
blocking the Clark Fork River in Montana, creating a huge
lake. When the ice broke, enormous quantities of water
thundered down the Clark Fork Valley toward Spokane,
Washington. This was the source of water for Bretz's
catastrophic flood.

Aerial photography also helped make Bretz's field evidence
easier to believe. By examining the photographs of
the scablands, it is easy to pick out the pitted
surfaces and chaotic drainages that Bretz
studied from the ground (Exhibit L).

Words to Know

Ripple Mark - Deposits left by currents flowing over a river bottom that shape the sediments into smooth, parallel ridge rows, resulting in washboard-like ripples that are regularly patterned.

History Behind the Mystery: Glacial Lakes

At 153 miles long, Lake Roosevelt seems enormous to most visitors. During the most recent Ice Age, however, lakes much larger covered parts of northeast Washington, as well as northern Idaho and western Montana.

The largest, deepest, and the highest of these lakes was glacial Lake Missoula. It formed when the Clark Fork River valley was dammed by glacial ice. Standing high in the mountains of Montana, Lake Missoula contained more water than some of the Great Lakes do today! Its volume has been estimated at 530 cubic miles. That is 176 times more than Lake Roosevelt today when at it's full pool of 3 cubic miles. Equally important, Lake Missoula's waters were thousands of feet above sea level - 700 feet deeper than modern Lake Roosevelt. Off and on during the Pleistocene, when the Spokane and Columbia Rivers were blocked by the edge of the continental ice sheet, water backed up in the lowlands of Spokane County forming glacial Lake Spokane. To complicate matters the Columbia River was occasionally blocked by the Okanagan Lobe of the continental ice sheet near what is now Grand Coulee Dam. This caused the Columbia River in the area of Lake Roosevelt to back up and form glacial Lake Columbia.

In short, during the Ice Age many major rivers near the continental ice margins were blocked by glacial ice. When these ice dams were in place, enormous volumes of water were impounded forming giant lakes.

Wave-cut strandlines cut into the slope at left in photo. These cuts record former high-water lines, or shorelines of Glacial Lake Missoula near Missoula, Montana. Gullies above the highway are the result of modern-day erosion. (National Park Service Photo)

Even more arresting are the isolated islands of loess with their tear-dropped shapes. With a little imagination, you can almost see the floodwaters moving from the lower left to the upper right of exhibit “M”, stripping away all the loess that had earlier been a blanket around what is now the island of good soil.

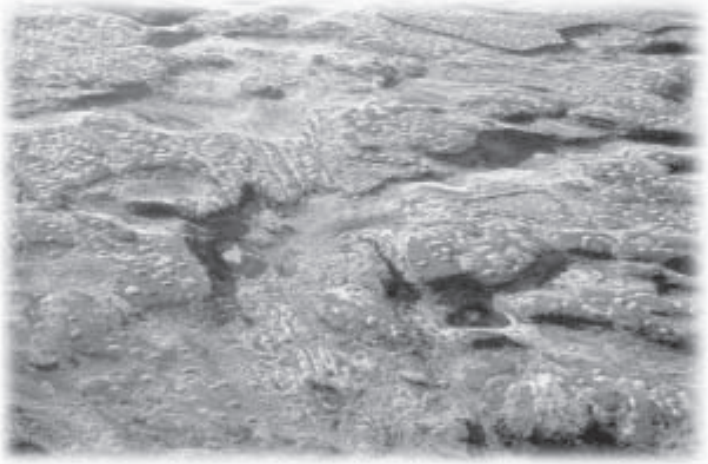


Exhibit L: Scabland near Cheney-Sprague (Photo: National Park Service)

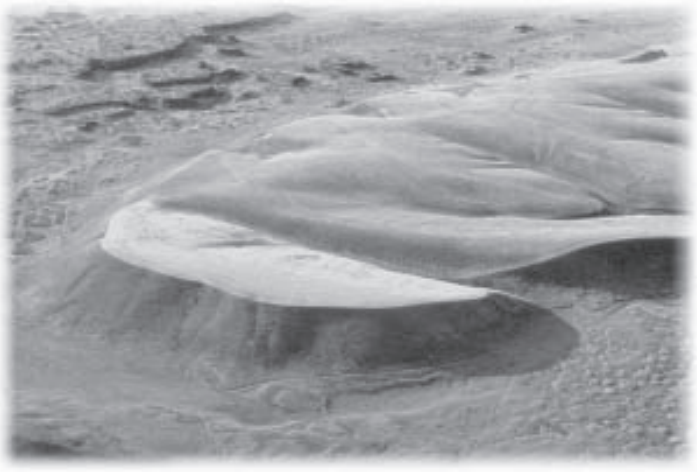


Exhibit M: Loess island from the air. (Photo: National Park Service)

THE THEORY TODAY

With the last piece of the puzzle in place for the case of the Channeled Scablands a more complete picture can be drawn. Geologists believe that for 2,000 years in the late **Pleistocene epoch**, repeated advances of glacial ice in western Montana dammed the Clark Fork River and formed a huge, deep lake. On more than fifty occasions, the dam would break and outburst floods would cut through what is now northern Idaho and eastern Washington releasing enough water to cover about 15,000 square miles of land to a depth of several hundred feet. The violent floods of water, ice and rock that swept across the Columbia Plateau moving at up to 50 miles per hour made the Snake River run backwards when the wall of water reached the Columbia River. The Columbia Gorge, between Oregon and Washington, was scoured deeply by the cataclysmic floodwaters. A blast of compressed air would have preceded the wall of rapidly moving water and the roar it produced may have been heard for half an hour before the water arrived.

The Grand Coulee today is occupied by the man-made Banks Lake. Water is pumped up into Banks Lake from the Columbia River at Grand Coulee Dam. The Grand Coulee is a great channel originally formed when the Columbia River was blocked by a lobe of the continental ice sheet just west of Grand Coulee Dam. Glacial Lake Columbia formed behind this ice dam, eventually filling so deep that it flooded to the southwest, contributing to the carving out of the Grand Coulee (Exhibit N). The greatest amount of carving, however, occurred as the flood waters from Lake Missoula hit Lake Columbia which over flowed to the south.

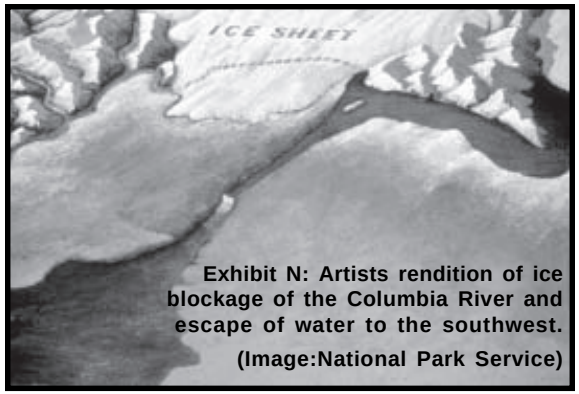
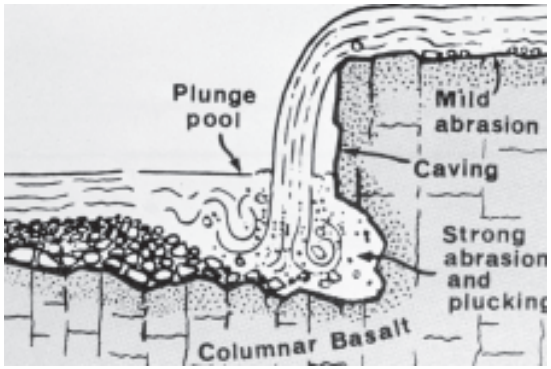


Exhibit N: Artists rendition of ice blockage of the Columbia River and escape of water to the southwest. (Image:National Park Service)

Exhibit O: Undercutting of columnar basalt showing a plunge pool in cross-section (Image: National Park Service)



When it was not dammed, the Columbia River would follow its normal path to the west. The waters of Glacial Lake Missoula became deep enough that they floated the ice dam. Once the ice dam was lifted it began to break apart as water began flowing under it. During the enormous flood events that followed, the Columbia River was again blocked by ice. Thus, when the wall of floodwater from Glacial Lake Missoula hit the Columbia ice dam, the water turned south again rapidly eroding the Grand Coulee into the largest single coulee in the scablands. As the floodwaters swept down the lower Grand Coulee, they ripped away the vertical pillars of the columnar basalt of the area (Exhibit O). This created a wide plunge pool across the coulee that retreated upstream as water abraded and plucked the basalt rock. What we see at Dry Falls today is a record of how far, approximately 21 miles, this process advanced during the great floods. (Exhibit P).

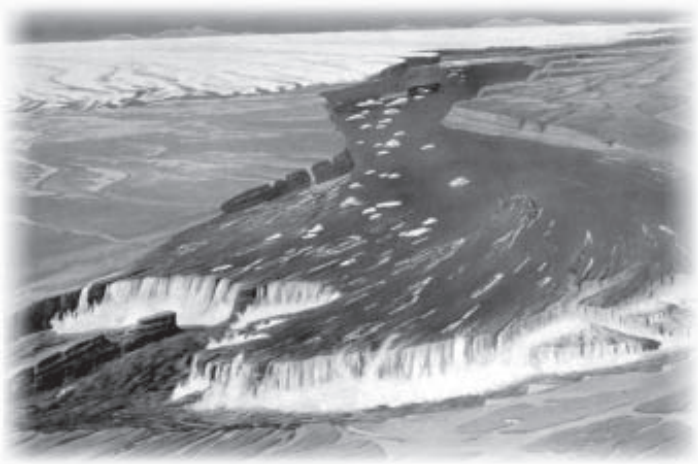


Exhibit P: Artists rendition of the Grand Coulee and Dry Falls area near the end of one of the catastrophic floods. (Image: National Park Service)

There are still many mysteries surrounding the geologic history of Lake Roosevelt. Recently, some geologists have argued that there was at least some catastrophic flooding of the Grand Coulee due to glacial waters coming down from British Columbia, not just from Glacial Lake Missoula. A new generation of geologists working in this new century will doubtless add to our knowledge of how and why rocks, mountains, and coulees around Lake Roosevelt came into being.

This booklet was made possible through the extensive research and knowledge of Dr. E. K. Peters, Washington State University. Lake Roosevelt National Recreation Area would like to thank her for her time and expertise.

Front Cover Photo: Sockem-tickem slide area near Fort Spokane. E. Soldo