Bighorn Canyon

Montana Geology '99

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The Bighorn Canyon

The spectacular scenery of the Bighorn Canyon National Recreation Area is the result of a long history of geologic events, culminating in the incisement of the Bighorn River across the north end of the Bighorn Mountains. The beautiful winter view of the canyon is looking south from the *Ok-a-beh* area (mainly in sections 14 and 23 of Township 6 South, Range 30 East, Big Horn County on the Crow Indian Reservation). *Ok-a-beh* in the Crow language means "bend of the river."

As told by Crow Tribal Historian, Joe Medicine Crow, the origin of the names of the Bighorn Mountains and the Bighorn River is a very interesting story. Long ago, the Crow liked to camp near the mouth of the Bighorn Canyon because of an excellent spring located there. On one occasion while a group of Crows was camped there, a man and his stepson decided to go into the canyon to hunt bighorn sheep. After traveling quite a long distance along the west side of the canyon, the stepfather told the boy that there were some bighorn sheep down below the cliff on which they were standing. When the boy leaned over to look, the stepfather pushed him over the edge. The stepfather returned to camp and told the mother that the boy had disappeared, but he didn't know what had happened: possibly the boy had fallen over the edge of a cliff while they were separated or maybe a grizzly bear got him. Meanwhile in the canyon, the boy had not fallen all the way down but had managed to grab hold of a small tree part of the way down the cliff. Although he had not been killed, he had no way out and cried for help all through the night. The next morning he heard voices below saying that they had heard his cries and had come to help. The voices instructed him not to be afraid, no matter what; to do exactly as he was told; and they would help him get up to the top of the cliff. It so happened that the voices were those of seven bighorn sheep. The bighorn sheep told the boy that one of them would get directly beneath him and the boy was to get on its back and hold onto its horns. The seven sheep took turns carrying the boy up until he was safely to the top of the cliff. When they reached the top, the leader of the bighorn sheep told the boy that each of the seven would then give him gifts or powers, and they did so. Next the leader told the boy to go home and chew a piece of sinew until it was soft and roll it into a ball in his mouth. Then he was to throw the ball into the fire saying, "This is my father," and his evil stepfather would die. The leader of the bighorn sheep then told the boy, "These are our mountains, and this is our river, and you must tell your people that they must be called the Bighorn Sheep Mountains and the Bighorn Sheep River." The leader told the boy: "This canyon is full of horses, so the river will make you wealthy and successful, but if you ever change these names, the river will be taken from you." When he returned home, to the great surprise and relief of his mother, the boy did as he was told with the sinew and the stepfather immediately died. The boy then told the elders what the bighorn sheep had instructed him about the name of the mountains and river. And so the names have been Bighorn River and Bighorn Mountains ever since.

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Bighorn Lake was formed by the filling of the canyon behind Yellowtail Dam, which is located just a few miles downstream of this view (the view looks south, which is upstream). Yellowtail Dam was named in honor of Robert Yellowtail, who was a former Crow Tribal Chairman and Bureau of Indian Affairs Crow Agency Superintendent. Because the dam and reservoir, proposed by the U.S. Bureau of Reclamation, are located on the Crow Indian Reservation, tribal approval for the project was required. The project was a highly contentious issue and caused great division among the Crow Tribe. Many of the younger men, recently back from World War II, were in favor of the project because it would provide jobs for many tribal members and would bring a large lump sum payment to the Crow Tribe. Many of the elders, including Robert Yellowtail, were against the project and fought to prevent its construction for several years. The Bureau of Reclamation proclaimed that it would use "Eminent Domain" as authority to proceed with the project even without the tribe's approval. A settlement was finally reached, and the Crow Tribe gave its approval. Construction of the dam began in 1961 and was completed in October 1965. Yellowtail Dam and the Bighorn Canyon National Recreation Area were dedicated on October 31, 1968. Initially, Robert Yellowtail was against the use of his name for the dam but was convinced by some of his relatives and elders to accept the honor. Robert Yellowtail, therefore, participated in the dedication ceremony with several other tribal elders and was given the honor of "pulling the lever" to symbolically turn on the power.

The power plant at the base of Yellowtail Dam produces an average of one billion kilowatt-hours of energy annually. The dam and reservoir also provide stability to the flow of the Bighorn River downstream and prevent devastating floods. The Bureau of Reclamation estimated that through 1986 the dam had prevented flood damages of more than $31 million. The control of the flow and temperature in the river below the dam has also helped to develop a world-class trout fishery that draws fly fishermen from all over the world.

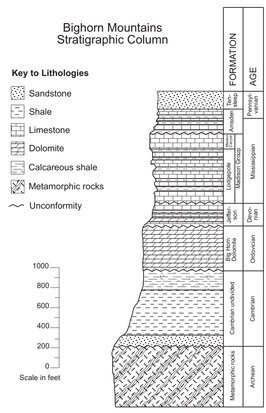
The spectacular bedrock exposures in the canyon are mainly of limestones in the Madison Group of Mississippian age. The upper massive cliff-forming beds are part of the Mission Canyon Limestone. Below the cliffs, are thin to thick beds of limestone interbedded with thin shale layers that are in the Lodgepole Limestone. The Mission Canyon Limestone represents deposition on a very shallow carbonate shelf during the regressive part of a marine cycle; the deeper ocean basin was to the west during this part of the geologic past. The underlying Lodgepole Limestone was deposited on the same carbonate shelf but in deeper water during the transgressive part of the marine cycle.

After deposition of the Madison Group, the area was exposed to the atmosphere, and a karst surface developed. Sinkholes, caverns, and collapse breccias are common products of this period of subaerial exposure. The porosity formed by solution during this time makes the Madison a good ground-water aquifer and reservoir for oil and gas.

The Amsden Formation, which is exposed in the smooth snow-covered slopes above the cliffs, was deposited on the erosional surface at the top of the Madison. It consists of interbedded pale red mudstones, and gray limestone and sandy limestone. These rocks were deposited in intertidal, lagoonal, and very shallow near-shore marine environments. The Amsden is the source of the red staining on the cliffs of the upper part of the Madison Group. The age of the Amsden crosses the boundary between the Mississippian and Pennsylvanian periods, and is therefore lower Pennsylvanian and upper Mississippian.

At the tops of the ridges above the smooth snow-covered slopes in the front photograph, and usually covered by pine trees, is the Pennsylvanian-age Tensleep Sandstone. The Tensleep is typically light-brown, fine-grained sandstone that was deposited in a combination of dune and beach environments.

Farther south, where the canyon crosses the axis of the Bighorn Mountains uplift, older rocks are exposed (see stratigraphic column). The Devonian-age Jefferson Limestone underlies the Madison Group and is characterized by interbedded limestone, dolomite, and shale. Beneath the Jefferson is the Ordovician Bighorn Dolomite, which is mainly light-brownish-gray dolomite and dolomitic limestone, and forms massive cliffs. Cambrian-age rocks underlie the Big Horn Dolmite and are correlative with the Gros Ventre Formation and Gallatin Limestone of Wyoming stratigraphy; and with the Flathead, Woolsey, Meagher, Park, and Pilgrim formations of Montana terminology. The basal Flathead Quartzite is not visible above the lake level but is important in that it represents the first Paleozoic marine transgression across the previously uplifted and nearly flat erosional surface formed on crystalline rocks of the Precambrian basement. Rocks that make up the remainder of the stratigraphic section of Cambrian through Devonian rocks are all marine sediments deposited on a marine shelf.



Bighorn Canyon was formed by the incisement of the Bighorn River across the axis of the Bighorn Mountains. The Bighorn Mountains are a typical Laramide uplift of the Rocky Mountain Foreland. These uplifts are controlled by basement-involved reverse faults and associated folds. Many of these folds have been referred to as drape folds over basement faults or as basement-involved fault-propagation folds (folds that form above and ahead of a fault as it propagates through the basement and overlying younger sedimentary rocks). The Laramide orogeny occurred mainly during Late Cretaceous and was completed in early Tertiary time. During the Laramide, the intervening basins like the Bighorn Basin and the Powder River Basin (west and east of the Bighorn Mountains, respectively) were filled with sediment eroded off of the rising mountains. By early Miocene time, much of the sedimentation had ceased and the Bighorn Mountains, were largely buried by these young sedimentary rocks. Beginning in the late Miocene (about 10 million years ago) and continuing to the present, epeirogenic uplift (broad regional vertical uplift) has raised the Rocky Mountain Front 1.5 to 2 km and the eastern Great Plains 100 to 500 m. This resulted in the development of a gently eastward sloping piedmont and regional eastward-flowing drainages. The ancestral Big Horn River was established across the area during this period of epeirogenic uplift. Bighorn Canyon was formed by the down-cutting of a superimposed stream. This occurs as a stream or river is established in relatively soft sedimentary rocks and its downward erosion continues undeflected across buried older structures. Therefore, the course of the present day Bighorn River, including the tight meanders, was inherited from an earlier stage when the river was eroding softer undeformed rocks that buried the Laramide structure of the Bighorn Mountains.

South end of Bighorn Canyon National Recreation Area near Devil's Canyon Lookout facing north.

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Scope and Organization

The Montana Bureau of Mines and Geology (MBMG) was established in 1919 as a public service agency and research entity for the State of Montana, *to conduct and publish investigations of Montana geology, including mineral and fuel resources, geologic mapping, and ground-water quality and quantity.*

In accordance with the enabling act, MBMG conducts research and provides information but has no regulatory functions. To carry out its duties more effectively, MBMG operates in five divisions: Research, Analytical, Information Services, Computer Services, and Administration, while the director holds the position of State Geologist.

Science and Service for Montana

- **Analytical Services**–analyzing the chemical quality of ground water and surface water; analyzing soils and biological tissue for metal content
- **Coal Hydrology**–investigating ground water in coal areas before, during, and after mining
- **Coal Resources**–evaluating effective reserves and establishing regional data bases
- **Computerized Resource Data Storage and Retrieval Systems**–compiling and storing Montana's coal, water, and mineral resources information
- **Earthquake Studies Research**–monitoring and analyzing seismic activity in Montana
- **Economic Geology**–making detailed studies of Montana's metalliferous deposits, industrial minerals, and coal and reporting on the activities of Montana's mineral industry
- **Environmental Sampling and Monitoring**–providing objective analysis of contaminated water and soils
- **Geographic Information Systems**–generating digital maps of geology, minerals, and hydrology
- **Geologic Maps**–field mapping and compilation of bedrock and surficial geology; digital publication of quadrangle maps and other maps at various scales
- **Geothermal Investigations**–mapping and measuring Montana's natural hot water resources
- **Ground-Water Resources Investigations**–evaluating the quality and the quantity of ground water in Montana
- **Hydrogeological Research**–assessing water-related environmental concerns, including saline seep and mine water drainage
- **Lectures and Public Addresses**–speaking to public groups on MBMG research, and Montana geology and hydrology
- **Mine Hydrology and Mine Waste Disposal**–investigating mine impacts on ground water and surface water
- **Mineral Museum**–displaying over 1,200 high-quality mineral specimens, group tours available
- **Montana Ground-Water Characterization**–monitoring and characterizing the state's ground-water aquifers
- **Montana State Map**–revising and updating the state geologic map and derivative maps in 1°x 2° quadrangles
- **Public Inquiry**–providing information on Montana geology and ground water
- **Publication and Map Sales**–providing documents on bureau research, USGS topographic and geologic maps, derivative maps, and access to federal aerial photos
- **Small Miners Assistance**–providing assistance to operators of small mines and prospectors
- **Statewide Ground-Water Assessment**–systematically evaluating Montana ground water and aquifers
- **Topical Studies in Regional Geology**–conducting investigations of Montana geology
- **Water Supply Evaluation**–evaluating the quality and quantity of water for municipalities and state agencies