Greybull Sandstone

Photo by David Lopez, MBMG, 2003

# Montana Geology ’04

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**Butte Office**
1300 W. Park Street, Butte, MT 59701-8997
406/496-4180 Fax: 406/496-4451

*Montana Bureau of Mines and Geology*

**Billings Office**
1300 North 27th Street, Billings, MT 59101
406/657-2629 Fax: 406/657-2633

## Introduction

This year's Montana Geology calendar features hoodoos in the Greybull Sandstone. Hoodoos are pinnacles or pillars of rock formed by differential weathering and erosion in layered formations that have vertical variations in erosional resistance. Relatively resistant rock forms the cap that protects the less resistant underlying layers. These hoodoos are located about 8 miles almost due west of Pryor, Montana. Here, the red color in the upper layers of the hoodoos indicates that relatively high concentrations of iron oxide bind the sand grains together. In contrast, the tan beds below are less well cemented. The erosional process typically begins by chemical weathering along intersecting vertical joints or fractures. The weathered and poorly cemented parts of the rock are more easily eroded, and thus the fractures deepen and widen until the rock remnants left between the fractures are the hoodoos seen here (fig. 1).

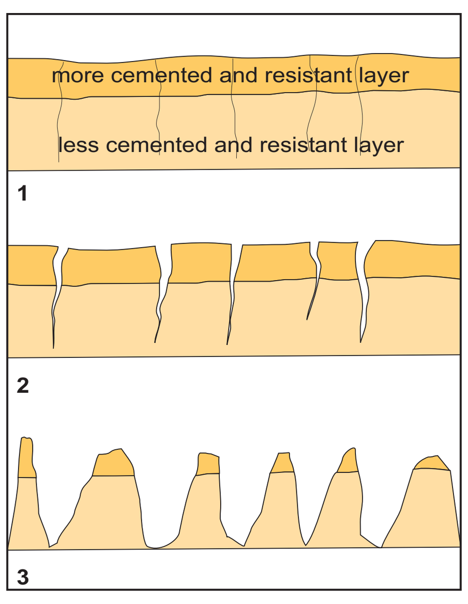



Figure 1. Erosional development of hoodoos from rock layers having differing resistance to erosion.

## Origin of the Name "Hoodoo"

The word "hoodoo" appears to have originated in African cultures and was used to refer to various forms of magic and spiritual and medicinal healing. The connotation of magic carries over into the geological use of the term hoodoo, as their often bizarre shapes commonly resemble the shapes of animals that could embody evil spirits (Bates and Jackson, 1980). The word "voodoo," used to describe spiritual practices well known in the southeastern United States and Caribbean Islands, is an obvious derivative of the African "hoodoo."

## Early History of the Region

The Crow Tribe (Absarokee) arrived in the area in the early 1700's after splitting from the Hidatsa, then residing in the area of present-day Mandan, North Dakota. Before this, the area was occupied by various tribes including the Shoshoni, Arapaho, Kiowa, and perhaps Comanche. Because this part of south-central Montana has always been an excellent hunting ground, several tribes periodically fought with the Crows for occupation of this rich land. Most commonly the Crows battled the Blackfeet, Sioux, Arapaho, and Cheyenne. The trails used by the Native Americans commonly became the trails and roads of later travelers and settlers.

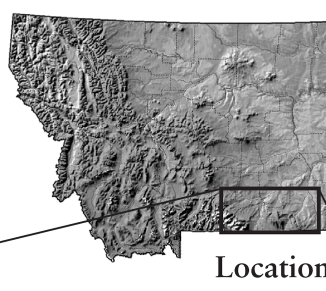
Some historians suggest that the Verendrye brothers, Francois and Louis, reached the foot of the Pryor or Bighorn Mountains in January 1743 while seeking the "western sea." The absence of undisputed landmarks in the journal of their trip, however, leads to multiple interpretations regarding the mountains they described.

From July 19 to 23, 1806, William Clark camped on the Yellowstone River less than 20 miles northwest of the hoodoos while his men made two small canoes for their exploration downriver. On July 25 Clark passed the mouth of what the Crow had called Arrow Creek and named it after one of the Expedition's sergeants, Nathaniel Pryor. Pryor and three men had been assigned to take the Expedition's remaining horses to Fort Mandan (North Dakota) while Clark's party floated the Yellowstone. Pryor's detail managed to lose the horses and, at Pompey's Pillar, had to make bullboats to descend the Yellowstone. These fragile craft, built of willow sticks and covered with buffalo hides tightly sewn together, generally were used by the natives to cross a river, not to float downriver some 350 river miles. Clark must have thought Pryor's misfortunes rated a river being named for him.

Clark considered the Bighorn and Pryor Mountains to be a single range, and the name Pryor Mountains didn't come into general use until well after the 1870's. The Crow are said to have used the name Arrow or Arrowhead Mountains because of the chert they contain. Chert is a very fine-grained form of quartz that a skilled "flint knapper" easily can turn into projectile points, knife or hatchet blades, hide scrapers, or other cutting instruments.

The discovery of gold at Bannack, Montana, in 1862 and Virginia City in 1863 brought thousands of miners and people to southwest Montana. The principal route to the gold camps was the Oregon Trail from Fort Laramie (along the North Platte River, southeastern Wyoming) to Salt Lake City and then north over what is now called Monida Pass (current route of I-15) to the Montana gold camps. A Georgian, John Bozeman, thought he could establish a shorter route from Fort Laramie to Virginia City. His route generally followed pre-existing trails and ran north of the Bighorn, Pryor, and Beartooth Mountains to the Yellowstone River near Big Timber. As far as is known, only one emigrant train (1863) traveled Bozeman's route, which ran well north of the route that now goes by the name "Bozeman Trail."

Jim Bridger, in 1863, had laid out a trail to the Montana gold fields that ran up the Bighorn Basin west of the Bighorn and Pryor Mountains (fig. 2). In 1866 he was employed by the Army to lay out a trail to Virginia City that would run past Fort C.F. Smith on the Bighorn River. How Bridger's trail became dubbed the "Bozeman Trail" is unclear, but the name has stuck. Bridger's "Bozeman Trail" passed just a few miles north of the Greybull hoodoos, but travelers either didn't stray from the main route or didn't record their observations of geological curiosities. Several wagon trains of gold seekers used Bridger's trail or variations of it, but one of its principal early uses was for hauling produce from the Gallatin Valley to Fort C.F. Smith until the fort's closure in 1868. Bridger's trail also was used for driving cattle from Texas into the valleys of western Montana for fattening. The Bozeman Trail was composed of a number of variant "parallel" routes that left and rejoined the main trail depending upon weather and trail conditions. Portions of the route were used for freighting until sometime after 1910. A paved road east from Pryor occupies the approximate route of the "Bozeman Trail" for about 5 miles, as does a dirt road west from Pryor to the town of Edgar.



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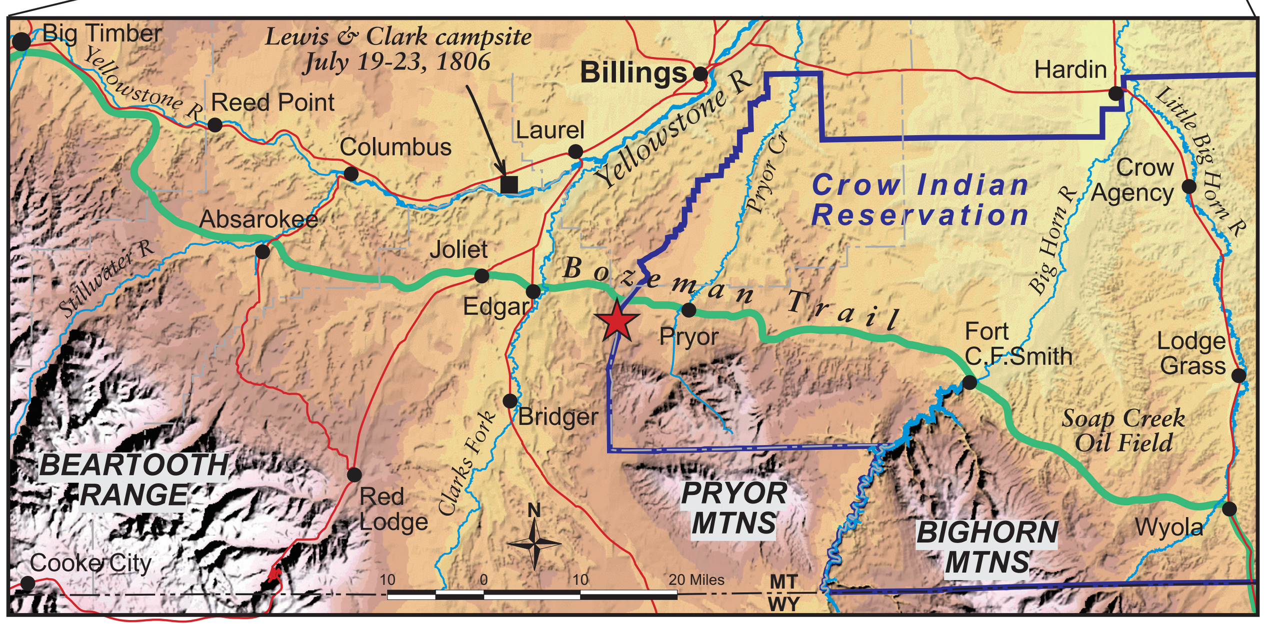


Figure 2. Map of the Bozeman Trail area. The red star indicates the location of the hoodoos.

Figure 3. Chief Grey Bull. Reprinted with permission from Hardin Photo Services, Hardin, Montana.

## Greybull Sandstone

The name Greybull originates from Grey Bull, a chief of the Crow Tribe (fig. 3). In the early days of settlement in the northern Bighorn Basin, Grey Bull's band of Crows spent the winters in the area of present-day Greybull, Wyoming. Because of friendships that developed between the Crows and the early settlers, when the population grew large enough for the organization of a town it was named in honor of Chief Grey Bull.

The stratigraphic name Greybull Sandstone was first a driller's term applied to subsurface oil-bearing sandstones discovered near the town of Greybull, Wyoming, in 1907. The Greybull Sandstone occurs at the top of the Kootenai Formation (fig. 4) and most workers in the past have included it as part of the Kootenai Formation (or Cloverly Formation in Wyoming).

The Greybull Sandstone is an excellent oil and gas reservoir that has produced tremendous volumes of oil and gas in several fields in the Bighorn Basin (including the Greybull Field, which was the original discovery), and continues to be an important oil and gas exploration target. In many areas the Greybull is an excellent aquifer, providing potable ground water to one of Montana's most arid regions. In an area 2 to 10 miles north of the hoodoos, several new wells drilled since 2000 are producing fresh water from Greybull Sandstone.

The rocks forming the hoodoos shown on the calendar front were deposited as sands in an ancient river channel that has been traced on the surface for at least 60 miles, from Soap Creek Oil Field to just northwest of the town of Pryor, Montana (fig. 5). Channel sandstone in this system is generally about 100 feet thick.

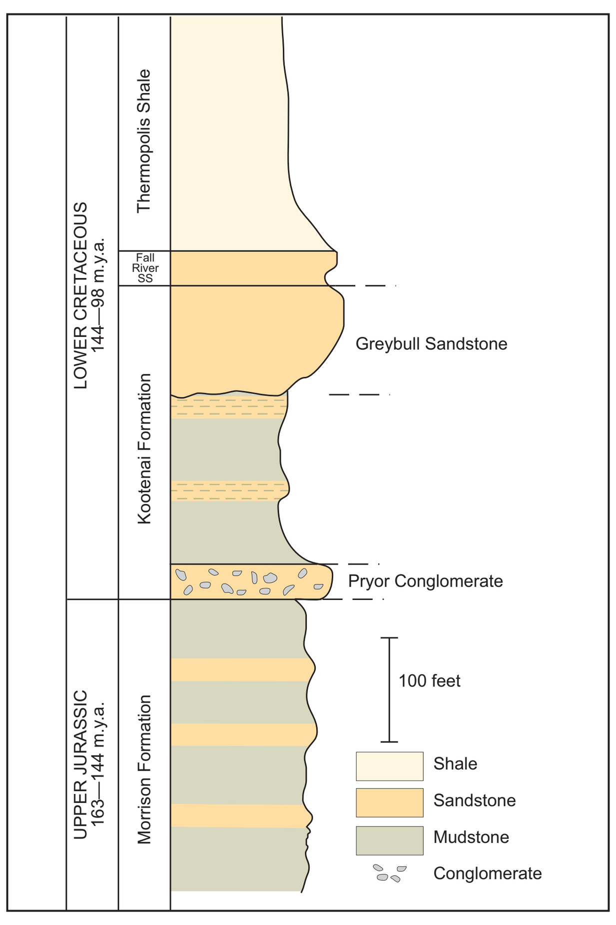


Figure 4. Stratigraphic relationships of the Kootenai Formation and Greybull Sandstone.

Exposures of Greybull Sandstone typically exhibit excellent planar cross bedding (fig. 6a). Cross bedding is a natural phenomenon caused by the downstream transport and deposition of sand. Figure 6b illustrates how cross bedding forms. The direction of stream flow (paleocurrent) in the ancient Greybull channel can be determined by measuring the orientation of the cross beds. These measurements indicate that about 100 million years ago, the ancient river that formed the channel from Soap Creek to Pryor flowed westward and then changed abruptly northward, as also suggested by the trace of the river channel (fig. 5). Surface geologic mapping has identified a system of faults in the area of the channel bend. The abrupt northward change in the trend of the channel coincides with the location of these faults, which suggests the faults were active and controlled the direction and location of the river's channel (fig. 5).

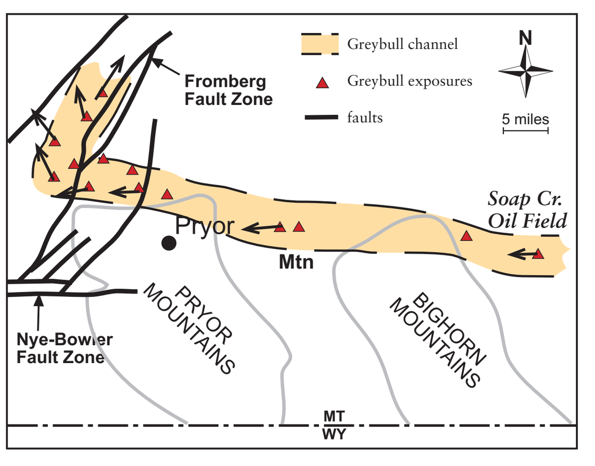


Figure 5. Structural control on Greybull channel trend and Greybull channel exposures in the Soap Creek-Pryor area. Arrows indicate transport directions, measured from planar cross bedding attitudes.

By studying surface outcrops and understanding the factors that controlled the development of the river channel, geologists can better predict where the channel may trend in the subsurface. This information is part of the basic data necessary to explore in the subsurface for oil and gas reservoirs in the Greybull Sandstone. The same information is also used to predict where the Greybull Sandstone may contain fresh water.

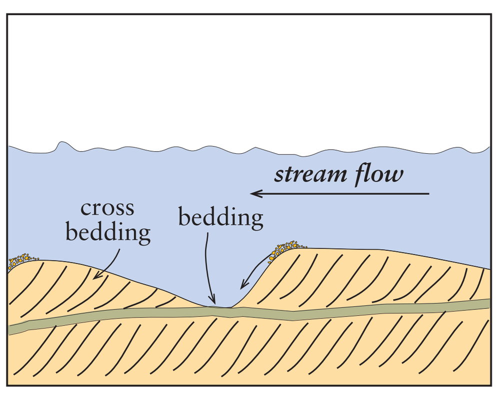


Figure 6b. Cross bedding forms along dunes and ripples that migrate downstream.

Figure 6a. Cross bedding in the channel.


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# *Montana Bureau of Mines and Geology*

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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.

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- **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
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