White Cliffs of the Missouri

Montana Geology 2011

January

Su	M	T	W	Th	F	S
						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30	31					

February

Su	M	T	W	Th	F	S
		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28					

March

Su	M	T	W	Th	F	S
		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30	31		

April

Su	M	T	W	Th	F	S
					1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30

May

Su	M	T	W	Th	F	S
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				

June

Su	M	T	W	Th	F	S
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30		

July

Su	M	T	W	Th	F	S
					1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30
31						

August

Su	M	T	W	Th	F	S
	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30	31			

September

Su	M	T	W	Th	F	S
				1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	

October

Su	M	T	W	Th	F	S
						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30	31					

November

Su	M	T	W	Th	F	S
		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30			

December

Su	M	T	W	Th	F	S
				1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	31

Butte Office
1300 W. Park Street
Butte, Montana 59701-8997
06-496-4180

Montana Bureau of Mines and Geology

Billings Office
1300 North 27th Street
Billings, Montana 59101
406-657-2938

WHITE CLIFFS AT EAGLE CREEK

Front Photo: Sunset storm clouds darken the White Cliffs, 180-foot river bluffs of Cretaceous (~80 million-year-old) Virgelle sandstone. This area, opposite the mouth of Eagle Creek, was designated the Upper Missouri National Wild and Scenic River in 1976, and the Upper Missouri River Breaks National Monument in 2001.

Geology

Meriwether Lewis and William Clark were among the first to record their geological and geographical observations of the White Cliffs area. By the evening of May 30, 1805, the Expedition had reached a point about 12 miles downstream from Eagle (Stonewall) Creek. The next day, May 31, Lewis wrote:

> *The hills and river Clifts which we passed today…rise to the hight of from 2 to 300 feet and in most places nearly perpendicular; they are formed of remarkable white sandstone...nature presents to the view of the traveler vast ranges of walls of tolerable workmanship….These walls rise to the hight in many places of 100 feet, are perpendicular… and are from one to 12 feet thick. The stone of which these walls are formed is black, dense and durable….These walls pass the river in several places, rising from the water's edge much above the sandstone bluffs, which they seem to penetrate; thence continuing their course on a streight line on either side of the river through the gradually ascending plains, over which they tower to the height of from ten to seventy feet until they reach the hills, which they finally enter and conceal themselves. these walls sometimes run parallel to each other, with several ranges near each other, and at other times intersecting each other at right angles, having the appearance of the walls of ancient houses or gardens.*

Lewis's description includes two very different rocks. The first are the sandstone beds that form the white cliffs, and the second are vertical dikes of dark-colored igneous rocks that intrude the sedimentary beds along the river.

Prince Maximillian of Weid-Neuwide traveled up the Missouri in 1833 nearly to present-day Fort Benton. He too recorded salient aspects of the geography and geology. Karl Bodmer, an artist who accompanied Prince Maximillian, made the first known pictorial representations of the topography and geology of the White Cliffs, likening them to white castles (fig. 1).

Figure 1. Bodmer, Karl (1809-1893); Beyer and Salathe (engravers) View of the Stone Walls on the Upper Missouri, 1840 paper; engraving; hand-colored aquatint .Joslyn Art Museum, Omaha, Nebraska; Gift of the Enron Art Foundation, 1986. With permission.

Geologist F.V. Hayden explored the White Cliffs in 1854 and collected numerous fossils. This initial trip later expanded to become the Hayden Survey, which led to the establishment of Yellowstone National Park. His 1869 map (scale 1:1,200,000) shows the rocks of this area to be of Cretaceous age.

In 1899, Walter H. Weed did the first detailed geologic mapping in this area. He gave the name "Eagle Formation" to rocks exposed near the mouth of Eagle Creek. In 1914, Eugene Stebinger named the Virgelle Sandstone for outcrops near the town of Virgelle, 11 miles northeast of these bluffs. The following year, C.F. Bowen designated the Virgelle Sandstone as the basal member of the Eagle Sandstone. The Virgelle Member has a maximum thickness of about 125 feet. Lindvall (1962) described it as, "massive, white to buff, medium grained, crossbedded sandstone containing sandy limonite concretions. It generally crops out in nearly vertical cliffs. In some places the more resistant concretions cap pillars of sandstone forming pedestals and 'balanced rocks'."

The Virgelle Sandstone contains numerous vertical cracks. Weathering, erosion, and especially ice-wedging widen these cracks downward. Eventually slabs of rock spall off, leaving near-vertical cliffs with talus piles at their base. Beneath the Virgelle Sandstone, covered by talus, is the Telegraph Creek Formation, which is principally shale. To the west, beyond the river bluffs and mostly hidden by them in the front photo, hills rise another 450 feet higher to the plains and the Missouri River valley. Those distant hills are composed of the upper, darker-colored members of the Eagle Formation and the lower part of the Claggett Shale. Lindvall (1962) noted:

> *The upper and middle members [of the Eagle Formation] together consist of 125 to 150 feet of alternating beds of gray to buff sand, sandstone, shale, carbonaceous shale, and coal. The upper member is locally a thick massive sandstone; the middle member is predominantly shale, but contains two thin beds of coal near the base. The upper and middle members crop out to form badlands and rounded hills, steep and gentle slopes, and small cliffs. The Eagle sandstone is conformably overlain by the Claggett shale.*

Igneous Rocks

Just left of the cliffs in the front photo is a prominence called LaBarge Rock (marked in figure 1). Rising about 200 feet above the river, this rock was named for Joseph LaBarge, who captained several steamboats past this point in the 1860s. LaBarge Rock is a dike of shonkinite that formed about 50 million years ago when molten rock from the Highland Mountains to the south intruded a near-vertical joint, or crack, in the Cretaceous sedimentary rocks. This dike is one of many in the area. Lewis and Clark called the stretch of river where these dikes occurred "The Stone Walls" and named what is now Eagle Creek "Stonewall Creek." Lindvall (1962) described these rocks:

> *Dikes and sills of middle and late Tertiary [Eocene] age crop out in the northern and eastern parts of the [Eagle Buttes] quadrangle. They are shonkinite, a dark igneous rock composed of hornblende, pyroxene, biotite, and orthoclase. Other than a slight baking effect at the contact, the igneous rocks caused little alteration of the intruded rocks. The dikes and sills were intruded after the sedimentary strata were faulted because in places the dikes cut across fault planes without displacement.*

A separate intrusion of molten rock buckled the earth's crust upwards to form the Bears Paw Mountains (fig. 2). As sedimentary beds were tilted by this uplift, layers of rock slid away from the center, producing numerous thrust faults that extended many miles away from the center of the uplift (Reeves, 1946). Locally, these faults are visible in the cliffs along the river south and southwest of the Bears Paw Mountains (Schumacher and Woodward, 2004)

Forming the Present Landscape

Before the Pleistocene began about 2 million years ago, the Missouri River emptied into Hudson Bay, not the Gulf of Mexico. The Judith River flowed northwest to meet the Missouri between Virgelle and Big Sandy; Arrow Creek then may have joined the Judith River near the present-day mouth of Eagle Creek (fig. 2). At that time the floodplains of both valleys were a hundred feet or more above the present level of the Missouri River.

When glacial ice advanced southwest from central Canada, it blocked all the rivers that discharged to Hudson Bay, forming glacial lakes along the ice front. Southwest of the ice-dammed Missouri River, Glacial Lake Great Falls formed. As the waters deepened, the lake expanded. One arm of this lake extended southeast up the valley of the Judith River. When the water level in the lake reached the top of the divide between the pre-glacial Judith River and an east-flowing stream, it spilled over the divide, then began to cut down through it. The tremendous volume of water contained in Glacial Lake Great Falls poured through this new channel, carving much of the present Missouri Breaks and creating a new river that drained southward to the Gulf of Mexico (see Alden, 1932; Fullerton and others, 2004; and Davis and others, 2006). Rain, wind, frost, and streams continue to alter the landscape. Noticeable changes occur to some of the bluffs and other features within just a few years' time.

Human History

Aboriginal

Rugged topography, scarcity of game, and difficulty in obtaining that game contributed to keeping the upper Missouri River Breaks relatively free from human incursions. Exceptions were areas around the mouths of larger streams and some of the steeper bluffs, which were used as buffalo jumps. After the advent of the horse, from at least the 1700s until the 1870s, this area was common ground to the Assiniboine, Atsina, Blackfeet (Piegan and Bloods), and Crow, but others visited here also. One cultural site near the mouth of Eagle Creek has been identified as "Mandan graffiti."

Lewis and Clark

Six canoes and two Mackinaw boats carried the Lewis and Clark Expedition up the Missouri River from its winter camp at Fort Mandan in present-day North Dakota. On May 9, 1805, the Expedition reached the downstream end of the Missouri Breaks near modern Fort Peck, Montana.

Deer, elk, and grizzly bears abounded in the wooded bottoms of the lower Breaks downstream of the present US 191 bridge. Upstream the river bottoms narrowed and the floodplain all but disappeared; game became scarcer. To obtain the large volume of fresh meat needed for the more than 30 expedition members, the hunters often had to seek game in the steep, eroded hills and in the plains. Although bighorn sheep padded the steep cliffs on either side of the river, they were difficult targets for the hunters. The abundance of bighorn sheep in the upper Breaks prompted William Clark to name a large river there "Bighorn River." He later renamed it Judith River for his future wife.

River Transport

St. Louis-based fur traders built the first trading post in Montana along the Yellowstone River in 1807; others soon followed. These traders, however, rarely visited the upper Breaks until 1830, leaving this area to the natives—beaver were scarce, and the Blackfeet resisted any encroachment.

In 1831, trader Kenneth McKenzie (sometimes spelled MacKenzie) convinced the Blackfeet to allow him to build a trading post at the mouth of Marias River. The post was named Fort Piegan after the Piegan or Pikuni branch of the Blackfeet Nation. A fire destroyed that post in the spring of 1832, and a new post, Fort McKenzie, was built about 7 miles farther up the Missouri River that summer. From 1832 on, river traffic was commonplace from Fort Union, opposite the mouth of the Yellowstone River near the present-day Montana/North Dakota border. Canoes, Mackinaw boats (shallow-draft boats that could be rigged with a sail), and sometimes keelboats transported men, supplies, and furs between the posts.

In 1837, a smallpox epidemic broke out in a group bringing supplies upriver to Fort McKenzie. The leader of the group stopped at the Judith River (about 40 miles east of the fort by land, but 75 miles by river) to let the epidemic "burn out." The Indians awaiting the trade goods from those boats, however, became impatient at the delay. The factor (manager) at Fort McKenzie claimed that he tried to explain to the waiting Indians that there was "bad medicine" with the supplies, but the Indians thought this was a ruse to charge higher prices. They insisted the supplies be brought up or they would go down to the Judith River for them. When the supplies—and the epidemic—reached Fort McKenzie, the toll among the Blackfeet was fearful.

Steamboat traffic through the Missouri Breaks increased after gold was discovered in southwestern Montana, peaking in 1867 when 39 boats reached Fort Benton. A typical trip from St. Louis to Fort Benton took 35 to 40 days. Passengers paid about $250–$300 apiece; freight (mostly mining equipment) went for about 12¢ per pound. On their return trip to St. Louis some boats carried gold dust. In 1866 Captain Grant Marsh brought the Luella past the White Cliffs loaded with 2½ tons of gold, then valued at $1,250,000, all of which was taken from Confederate Gulch near Helena. Along with the gold, some boats also brought disillusioned prospectors. The last commercial steamboat unloaded at Fort Benton in 1890.

Homestead Days

In the late 1800s and early 1900s ranchers and farmers moved into the area. They built their homes and grew their crops on the wider and more fertile bottom lands along the Missouri, often near the mouth of the larger drainages. At one time there were enough families in the White Cliffs area to warrant a post office (named "Conley") at the mouth of Eagle Creek, but it lasted a little more than a year, from September 1, 1906 to December 31, 1907. Most of the homesteads in this area were abandoned by the 1930s. During the time of the homesteads, several small-scale coal mines operated in this area, mostly for local usage. They derived their coal from the Eagle Formation.

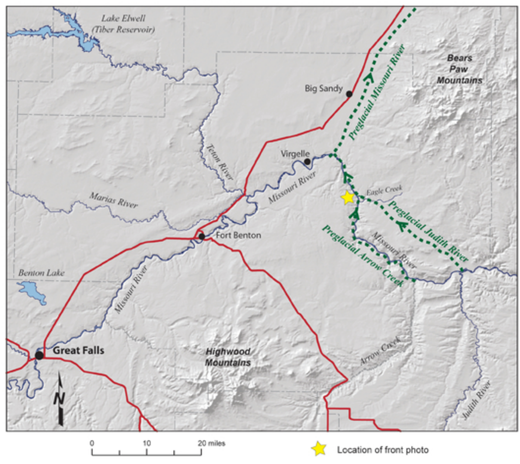

Figure 2. Map of the area showing the past and present courses of the Missouri and Judith Rivers and Arrow Creek, Eagle Creek, and landmarks.

Figure 4. Aerial photo of the Upper Missouri River Breaks. Photo by Airphoto—Jim Wark, with permission. http://www.airphotona.com/

Geologic References

Alden, W.C., 1932, Physiography and glacial geology of eastern Montana and adjacent areas: U.S. Geological Survey Professional Paper 174, 133 p. (especially p. 79–105).

Bowen, C.F., 1915,The stratigraphy of the Montana group, with special reference to the position and age of the Judith River formation in north central Montana: U.S. Geological Survey Professional Paper, 90-I, p. 95–153.

Davis, N.K., Locke, W.W. III, Pierce, K.I., and Finkel, R.C., 2006, Glacial Lake Musselshell: Late Wisconsin slackwater on the Laurentide ice margin in central montana: Geomorphology, v. 75, p. 330–345.

Fullerton, D.S., Colton, R.B., Bush, C.A., and Straub, A.W., 2004, Map showing spatial and temporal relations of mountain and continental glaciations on the northern plains, primarily in northern Montana and northwestern North Dakota: U.S. Geological Survey Scientific Investigations Map 2843, scale 1:1,00,000 and Pamphlet to accompany Scientific Investigations Map 2843, 36 p.

Hayden, F.V., 1869, (Bob, I can't find the right reference. Please provide?)

Lindvall, R.M., 1962, Geology of the Eagle Buttes Quadrangle [47°45-48° x 110°-110°15'], Chouteau County, Montana: U.S. Geological Survey Map 1-349, scale 1:62,500.

Reeves, Frank, 1946, Origin and mechanics of thrust faults adjacent to the Bearpaw Mountains, Montana: Geological Society of America Bulletin, v. 57, p. 1033–048.

Schumacher, D.L., and Woodward, L.A., 2004, Magnificent journey: A geologic river trip with Lewis and Clark through the Upper Missouri River Breaks National Monument: Spakane, WA, Woodhaven Press, 150 p.

Stebinger, Eugene, 1915, The Montana group of northwestern Montana: U.S. Geological Survey Professional Paper 90-G, p. 62–68.

Vuke, S.M., Porter, K.W., Lonn, J.D., and Lopez, D.A., 2007, Geologic Map of Montana, Montana Bureau of Mines and Geology: Geologic Map 62, 73 p., 2 sheet(s), 1:500,000.

Weed, W.H., 1899, Description of the Fort Benton quadrangle [Montana]: U.S. Geological Survey Geologic Atlas of the United States, Fort Benton folio, no. 55, 7 p.

Human History Bibliography

Bradley, J.H., 1877, Affairs at Fort Benton from 1831 to 1869: Contributions to the Montana Historical Society, v. 3, 1900, p. 201–287.

Cheney, R.C., 1983, Names on the face of Montana; the story of Montana's place names: Missoula, MT, Mountain Press Publishing Co., 297 p.

Chittenden, H.C., 1902, The American fur trade of the Far West: New York, Francis P. Harper, 3 volumes.

Chittenden, H.C., 1903, History of early steamboat navigation on the Missouri River: Life and adventures of Joseph LaBarge; reprint 1962 by Minneapolis, MN, Ross and Haines, 2 volumes.

Knudson, Ruthann, 1962, Upper Missouri National Wild and Scenic River, Cultural Resource Management Plan, Volume II, Resource Locational Data: Bureau of Land Management Cultural Resources Series 3, 1992; Billings, MT, Montana State Office, 23 pages plus maps, scale 1:62,500.

Malone, M.P., Roeder, R.B, and Lang, W.L., 1991, Montana, a history of two centuries: Seattle, WA, University of Washington Press, 450 p.

Moulton, G.E., ed., 1985, The journals of the Lewis and Clark Expedition: Lincoln, NE, University of Nebraska Press, v. 1, Atlas, maps 41 and 53 (scale about 1 inch = 6 miles) and v. 4: April 7–July 27, 1805, pages 221–227 (May 30 and 31).

Acknowledgments

Front photo by Wayne Mumford, with permission. Other photos by Karl Bodmer and Jim Wark, with permission. Text by Bob Bergantino; editing and layout by Susan Barth. Figures by Susan Smith.

MONTANA BUREAU OF MINES AND GEOLOGY

Montana Tech of The University of Montana

Scope and Organization

The Montana Bureau of Mines and Geology (MBMG) was established in 1919 as a non-regulatory public service and research agency for the State of Montana, to conduct and publish investigations of Montana geology, including mineral and fuel resources, geologic mapping, and groundwater quality and quantity. In accordance with the enabling act, the MBMG conducts research and provides information.

Contact Us:

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

Billings Office
1300 North 27th Street
Billings, MT 59101-0108
406/657-2938 Fax: 406/657-2633

http://www.mbmg.mtech.edu

Abandoned and Inactive Mines	496-4606	Ground-Water Information Center	496-4336
Analytical Services	496-4767	http://mbmggwic.mtech.edu/	
Coal/Coalbed Methane	657-2702	Ground-Water Investigation Program	496-4848
Coalbed Hydrogeology	657-2929	Mine Hydrogeology	496-4157
Director's Office	496-4180	Mineral Museum	496-4414
Earthquake Studies Office	496-4332	Oil & Gas	657-2702
http://mbmgquake.mtech.edu/		Program Development	496-4155
Economic Geology		Public Inquiry/Information	496-4174
Metals	496-4171	Publication and Map Sales	496-4174
Non-metallics	496-4172	http://www.mbmg.mtech.edu/pubsales	
Geographic Information Systems Laboratory	496-4151	Publications Division	496-4687
Geologic Mapping	496-4326	Research Division	496-4159
Ground-Water Characterization Program	496-4153		