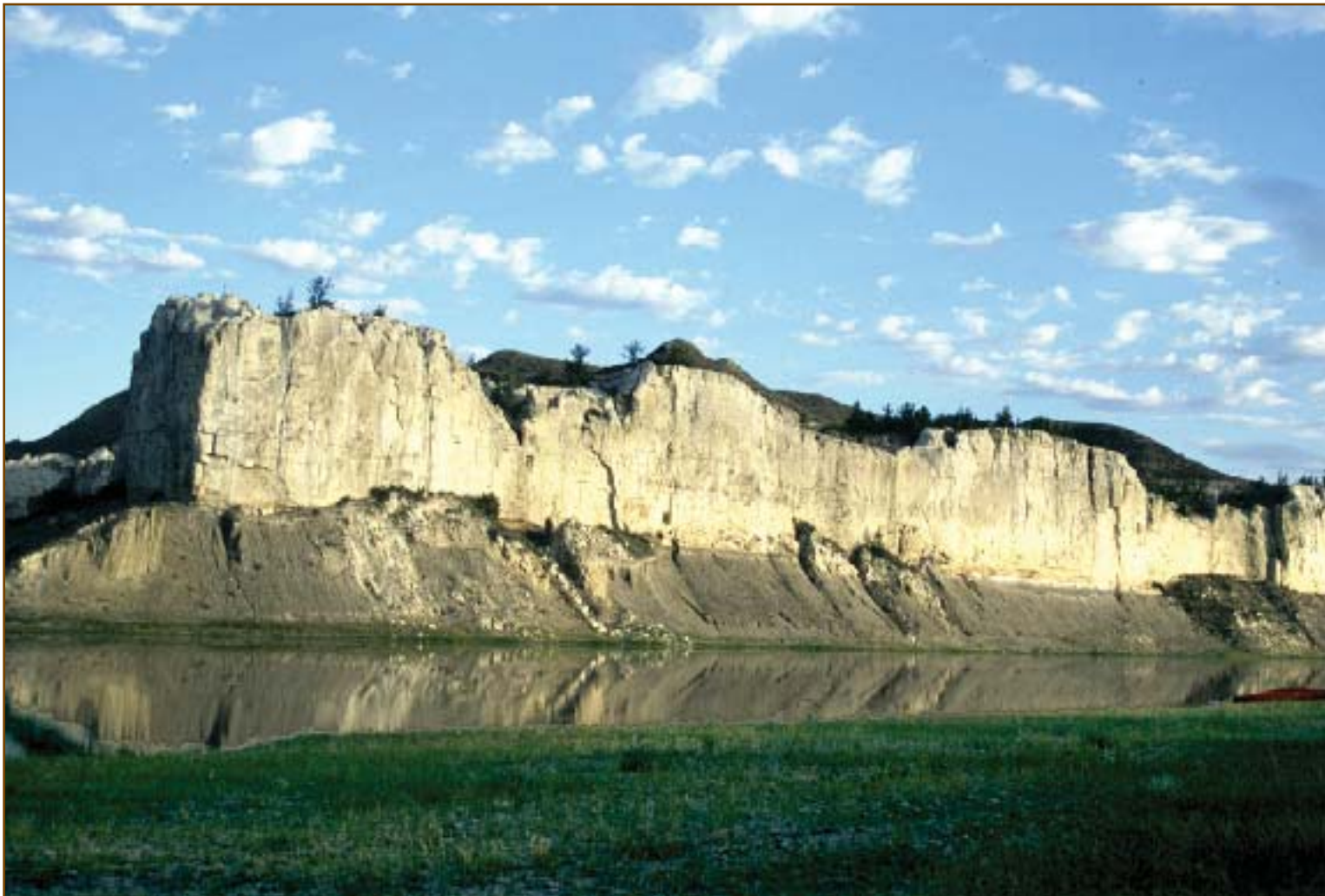




The White Cliffs of the Missouri



Lewis and Clark entered the Missouri Breaks on May 9, 1805 at present-day Fort Peck. Rugged topography and rock outcrops flank the Missouri throughout the Breaks, but the most spectacular scenery and geology are in the White Cliffs of the Missouri.



Lewis described this area on May 31:

The hills and river Clifts which we passed today exhibit a most romantic appearance. The bluffs of the river rise to the hight of from 2 to 300 feet and in most places nearly perpendicular; they are formed of remarkable white sandstone which is sufficiently soft to give

Photo courtesy of Otto L. Schumacher

The “remarkable white sandstone” is the Virgelle Member of the Eagle Formation. Rivers deposited it as sand during the Cretaceous Period when a shallow sea covered much of interior North America. The sandstone contains many vertical cracks. Erosion and weathering widen the cracks, weakening the rock. Eventually slabs fall off, leaving near-vertical cliffs. The dark formation below the Virgelle is the Marias River Shale.

*The water in the course of time . . .
has trickled down the soft sand cliffs
and woarn it into a thousand gro-
tesque figures*



Photo courtesy of Brent Phelps



Photo by Ginette Abdo, MBMG

*. . . with the help of less imagination we see the remains or ruins of
ellegant buildings; some collumns standing and almost entire with their
pedestals and capitals . . .*

Hard sandstone in the upper part of the Eagle Formation caps the Virgelle Member, protecting it from erosion. Without the cap rock the softer Virgelle sandstone erodes readily.

*The hills and river Clifts which we passed
today exhibit a most romantic appearance.*

Photo courtesy of Wayne Mumford (www.waynemumford.com)





Photo courtesy of Otto L. Schumacher

Grand Natural Wall is one of many dikes that formed when magma forced its way into joints in the sedimentary rock. The dike rock here is more resistant than the surrounding sedimentary rock.

As we passed on it seemed as if those seems of visionary enchantment would never have an end; for here it is too that nature presents to the view of the traveler vast ranges of walls of tolerable workmanship

Lewis apparently did not realize that the dikes once were molten. He commonly identified most shiny crystals as talc or quartz, possibly considering them related minerals.

. . . these stones are almost invariably regular parallelepipeds, of unequal sizes in the walls, but equal in their horizontal ranges, at least as to depth.

Shown is the parallelepiped shape Lewis noted; it results when cracks form as lava cools.



Photo by Ginette Abdo, MBMG

The Making of a Landscape

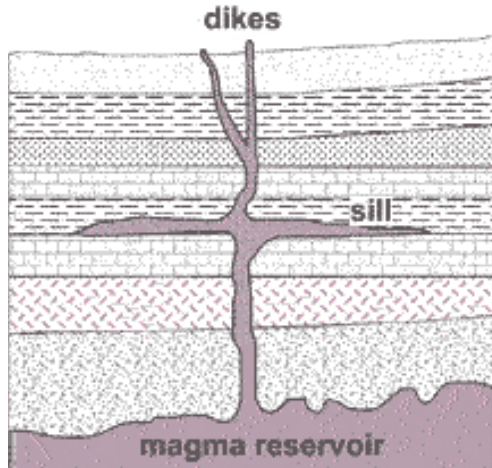


From sediment to rock

A shallow sea occupied the North American interior from 150 to 65 million years ago. When the Rocky Mountains began rising, rivers carried sediments eastward from them to this sea, depositing sand near its shore, silt and clay farther east in deeper water. Continued deposition buried the earlier sediments. Pressure and cementing solutions then changed sand, silt and clay into sandstone, siltstone and shale. Joints and cracks developed in these rocks.

Vulcanism

About 50 million years ago molten rock from deep within the earth rose up through joints in the overlying sedimentary rocks. Erosion has removed most of the volcanic outpouring, but the river cliffs here expose numerous near-vertical dikes.



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Glacial ice forces the Missouri to carve a new course through northern Montana

Contact between a dike (brown) and sandstone (light-gray)



Photo by Ginette Abdo, MBMG

Rivers re-routed

Glacial ice entered northern Montana several times during the ice ages (1.6 million to 10,000 years ago). About 160,000 to 130,000 years ago, ice blocked the Missouri's course northeast of Great Falls. Lakes formed in the rivers south of the ice. Lake levels rose until their waters cut channels into adjacent drainages. Ultimately, the entire flow of the Missouri was rushing eastward in a new valley, carving and deepening it as it went. Smaller streams later occupied much of the Missouri's former valley.



Photo courtesy of Wayne Mumford (www.waynemumford.com)

Erosion of the Missouri

The Missouri River in the upper Breaks area is still carving its new course as evidenced by the valley walls that are steeper than those along its preglacial course.

A drop of rain, a downpour, wind, frost, running water . . . all erode the soft Virgelle sandstone, carving it into the "thousand grotesque figures"



Photo by Ginette Abdo, MBMG