GLOSSARY

Anticline: bedrock units folded convex upward so that older rock is in the center of the fold

Dip: the angle at which bedrock is inclined from horizontal

Igneous rock: rock formed by cooling and solidification of molten magma

Intrusion: a mass of molten magma that is pushed or injected into older rock and later cooled to igneous rock

Mass wasting: movement of rock and debris downslope by gravity

Metamorphism: the process by which rock is altered by forces of heat, pressure, and chemical change

Monocline: bedrock units dipping in a single direction

Orogeny: the process by which mountains are formed with emphasis on folding, faulting, and uplifting

Sedimentary rock: rock formed by the layered accumulation of sediments, deposited by water, wind, or ice

Shotcrete: concrete that is pneumatically shot through a hose at high velocity onto a surface

REFERENCES

Do you want to learn more about the geology of McClure Pass and the Muddy Creek and Crystal River areas? The following references were used in the preparation of this road log and will provide insight into the natural resources of the region.

Ellis, Margaret S. et al., 1987, Geologic Map of the Paonia and Gunnison Area, Delta and Gunnison Counties, Colorado, USGS Coal Investigation Map C-109.

Goodwin, Larry H., 1968, Geologic Map of the Chair Mountain Quadrangle, Gunnsion and Pitkin Counties, Colorado, USGS Geologic Quadrangle Map GQ-704.

Rogers, William P., 2005, Critical Landslides in Colorado, A Year 2002 Review and Priority List, Colorado Geological Survey Open-File Report 03-16.

Tweto, Ogden, et al., 1978, Geologic Map of the Leadville 1° by 2° Quadrangle, Northeastern Colorado, USGS Miscellaneous Investigations Series Map I-999.

http://geosurvey.state.co.us is the website for the Colorado Geological Survey. Many excellent references on the geology of Colorado are available on-line.

www.usgs.gov is the website for the U.S. Geological Survey. You can order geologic maps and reports as well as topographic maps on-line or by phone at 1-888-ASK-USGS.

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GEOLOGIC ROAD LOG OF McCLURE PASS AND VICINITY

GUNNISON AND WHITE RIVER NATIONAL FORESTS ALONG STATE HIGHWAY 133

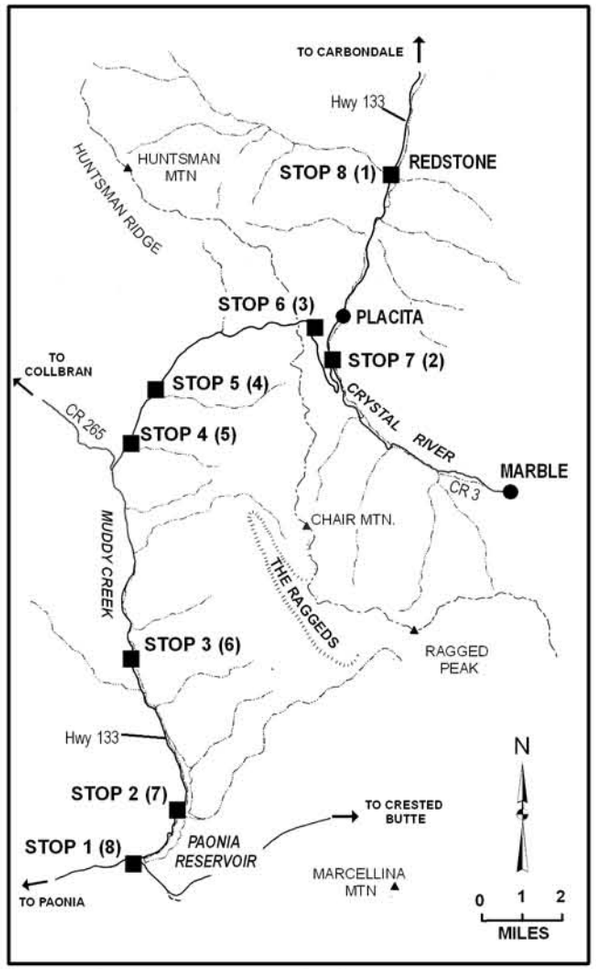
PAONIA RESERVOIR TO THE TOWN OF REDSTONE

THE CRYSTAL RIVER VALLEY LOOKING SOUTHEAST FROM THE SUMMIT OF McCLURE PASS

A LEGACY OF MINING

The Colorado mountains, while bringing to mind a legacy of gold and silver mining, have also been explored for many other minerals . The remote byway of Highway 133 will lead the traveler near mountain coal mining regions as well as the historic marble quarry of the Crystal River Valley. As you travel the McClure Pass road, learn how the settlement of the Muddy Creek and Crystal River Valleys has been shaped by the geology of the land and the mineral wealth held within. The open road beckons; come and learn!

Grand Mesa-Uncompahgre-Gunnison National Forests



Map of the Geologic Road Log of McClure Pass and Vicinity

HOW TO USE THE ROAD LOG

Follow the general directions below to arrive at the starting point of the road log. Zero your odometer and follow the mileage notations to arrive at the geologic points of interest. If you are traveling north from Paonia Reservoir, use the mileage notation on the left; if you are traveling south from Redstone and Carbondale, use the mileage notation in parentheses. Pull off the road at the designated stops to look around you and read the descriptions. Some of the descriptions refer to stretches of road, so study the landscape as you travel. Don't hesitate to stop along the way, camp, hike, and enjoy the stunning scenery around you. The road log contains mileage references such as intersections and bridges to recalibrate your odometer if you take side trips. A glossary at the end of the log describes the geologic terms used.

From Paonia and the North Fork Valley: Travel up Highway 133 from Delta, past Hotchkiss and Paonia to the dam at Paonia Reservoir State Park. There is a wide pull-out below the dam. This pull-out is STOP 1 for the north-bound route.

From Crested Butte over Kebler Pass: Travel on CR 12 over Kebler Pass to the intersection with Highway 133 just below the dam at Paonia Reservoir. There is a wide pull-out below the dam. This pull-out is STOP 1 for the north-bound route.

From Carbondale to Redstone: Travel south from Carbondale on Highway 133 to the turnoff to Redstone. There is a bridge crossing the Crystal River to the east and a pull-out at the coke ovens to the west. This pull-out is STOP 1 for the south-bound route.

USE CAUTION WHEN PULLING OFF THE ROAD AT THE DESIGNATED STOPS. Highway 133 winds through narrow river canyons and traverses an alpine pass. Several stretches of road pass through areas of rockfall or avalanche hazard. Do not stop in designated rockfall or avalanche areas. Follow the mileage carefully to anticipate the location of pull-outs and be aware of on-coming traffic if you cross the highway to a designated stop and as you pull back into traffic.

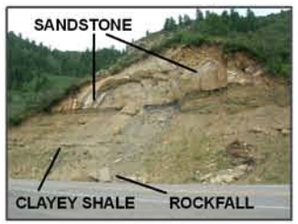
MILEAGE **DESCRIPTION**

0 / (25.1) **STOP 1 (STOP 8):** At the intersection of Highway 133 and CR 12 (the West Elk Loop road over Kebler Pass), drive into the wide pull-out below Paonia Dam. You are located at the confluence of Anthracite Creek and Muddy Creek where they join to form the North Fork of the Gunnison River below Paonia Reservoir. Above you rises the dam for Paonia Reservoir, an earthfill dam containing 1.3 million cubic yards of material. The crest of the dam is 35 feet wide and 770 feet long with an elevation of 6,460 feet above sea level. The spillway is located on the north side of the dam and is designed to allow a flow of 12,600 cubic feet of water every second. Paonia Reservoir was constructed from 1959 to 1961 and was built for water storage. High stream flows resulting from spring snowmelt are stored to be released later in the summer months for purposes of irrigation of the orchard and farm land downstream in the Paonia area (source: www.usbr.gov/dataweb/html/paonia.html).

Bedrock at the dam site is the Mesaverde Formation, a Cretaceous age sequence of interbedded sandstone, siltstone, shale, and coal. The Mesaverde Formation was deposited around 70 million years ago along the shallow shoreline, swamps, and lagoons of a retreating sea. The Mesaverde Formation contains economic coal deposits which have been mined to the west in the towns of Somerset, Bowie, and Paonia and to the east near Redstone. Roadcuts along Highway 133 at Paonia Reservoir provide good exposures of the interbedded sandstone and siltstone deposits.

MILEAGE DESCRIPTION

1.7 / (23.4) **STOP 2 (STOP 7):** Pull off the highway onto a large pull-out area on the east side of the highway above Paonia Reservoir. On the west side of the highway is a roadcut exposing interbedded layers of sandstone and clayey shale of the Mesaverde Formation. As the weaker shale erodes, the overlying blocks of sandstone tumble down, sometimes across the highway.



To the east, across the reservoir, Marcellina Mountain is visible rising above the hills surrounding the reservoir. Marcellina Mountain was formed by an intrusion of igneous rock up into the Mesaverde Formation which, in turn, was fractured by the intrusion. The overlying fractured rock eroded away, leaving the harder igneous rock as an isolated mountain peak. Much of the landscape south of Highway 133 was formed by the intrusion of igneous rocks in the Tertiary Period (about 30 million years ago).

3.9 / (21.2) Entrance to Paonia State Park. The park is operated by the Colorado Division of Parks and Outdoor Recreation.

4.1 / (21.0) Bridge across Muddy Creek

5.1 to 5.7 / (19.4 to 20.0) You are driving though an area of active rockfall. Do not stop your vehicle in this section of road. The Mesaverde Formation is exposed as interbedded sandstone, siltstone, and clayey shale in a series of steep roadcuts on the west side of the road while Muddy Creek flows along the east side of the road. Rockfall is an active and on-going process here and you are likely to see rubble from previous rockfalls along the base of the roadcut.

5.7 / (19.4) **STOP 3 (STOP 6):** Exit the highway onto the pull-out area on the east side of the road and study the cliff face to the west. You will begin to notice subtle modifications to the rock face. These are examples of rockfall mitigation methods designed by the Colorado Department of Transportation (CDOT). A rockfence is draped and secured across unstable rock, rock bolts are set to secure fractured rock, and shotcrete is applied in areas of loose rock. Before the rockfall stabilization measures were installed, loose rock was scaled from the cliff face and removed. Mitigation measures are designed to blend with the landscape and are easy to miss when driving past.

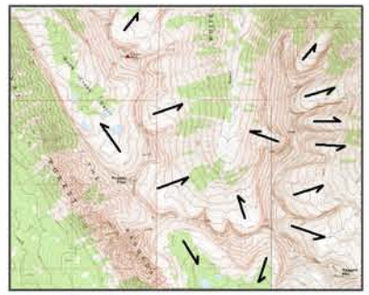
Across Muddy Creek to the east, The Raggeds are visible as a long, linear mountain. On the hillslope below The Raggeds is a massive landslide called the East Muddy Creek Slide, covering many square miles and extending down to Muddy Creek. The rounded hummocky hills cut by scarps are characteristic of landslide topography. In 1986, large scale movement of the slide began as a result of excessive precipitation. The central portion of the landslide advanced 200 feet and approximately one mile of Highway 133 was engulfed. The channel of East Muddy Creek was dammed by the landslide creating the potential of a flood surge into Paonia Reservoir. The Colorado Geological Survey and CDOT initiated emergency measures over a five week period to open the channel of Muddy Creek and to restore access along Highway 133. Eventually movement in the landslide slowed to a creep and the highway was cleared and repaired.

10.7 / (14.4) Intersection with CR 265 to Collbran

11.3 / (13.8) **STOP 4 (STOP 5):** Exit the highway to the east on the wide pull-out. The Raggeds are visible as the linear ridge to the southeast. The steep southwest escarpment of The Raggeds is the face of an igneous intrusion, injected as molten rock into the surrounding sedimentary rock. The overlying bedrock was uplifted and broken, a contributing factor to the formation of the East Muddy Creek Slide on the southwest side of the Raggeds. To the east of The Raggeds is the glaciated alpine valley of Buck Creek Basin.

Map: USGS Chair Mtn. Quad; Air photo: Google Earth

The view from this stop encompasses the past 70 million years of geologic history. Bedrock exposed in the surrounding hills are the Wasatch and Ohio Creek Formations, sediments deposited in lakes and streams during the Laramide Orogeny, a period of mountain building that uplifted the Rocky Mountains in an interval lasting from around 70 to 40 million years ago. The Laramide Orogeny marked the end of marine deposition in Colorado and the shallow sea that deposited the Mesaverde Formation withdrew to the east. As the mountains were uplifted, they began to undergo erosion, and sediments eroded from the mountains were redeposited along streams and in lakes (Wasatch and Ohio Creek Formations). An interval of igneous intrusion followed the Laramide Orogeny around 30 million years ago, injecting molten magma into sedimentary rock resulting in the lofty peaks on the south and east sides of Highway 133. The Pleistocene Ice Age around 1.5 million years ago brought glaciers which carved steep sided U-shaped valleys into the lofty peaks. Finally, the geologic process continues today with on-going erosion and mass wasting (landsliding) of mountain slopes.



Map: USGS Chair Mtn. Quadrangle

The topographic map on the left shows The Raggeds, Buck Creek Basin, and the glaciated valleys of Chair and Ragged Mountains. During the Ice Age, glaciers formed in each U-shaped valley, flowed downhill to merge as massive alpine glaciers which carved the jagged shape of the mountains. The arrows show the direction of flow of each valley glacier.

12.7 / (12.4) **STOP 5 (STOP 4):** Exit the highway on the pull-out to the south marked by the sign for the Gunnison National Forest. The ridge to the east is the back slope of the Grand Hogback, a monoclinal fold of Cretaceous aged and younger rock, dipping to the west and forming the western boundary of the Rocky Mountains. Along the Front Range, west of Denver, there is a corresponding hogback that forms the eastern boundary of the Rocky Mountains. To the north is Huntsman Ridge, a small wrinkle in the Grand Hogback, formed by intrusion of igneous rock that pushed the steeply dipping bedrock of the Grand Hogback into a small anticline, creating Coal Basin.

17.4 / (7.7) **STOP 6 (STOP 3):** Using extreme caution for on-coming traffic, pull out onto the overlook on the east side of the road for a view of the Crystal River Valley. You are standing on the summit of the Grand Hogback. Bedrock units to the west are younger than 140 million years and are relatively uniformly bedded; bedrock units to the east include some of the oldest rock in Colorado (1.7 billion years old) and are broken, faulted, and injected with igneous intrusions, a reflection of the mountain building process of the Laramide Orogeny, 70 to 40 million years ago. The parade of lofty mountains to the south include Chair Mountain (to the immediate south), Ragged Mountain, Whitehouse and Treasure Mountains, all formed by intrusion of igneous rock approximately 30 million years ago. Glaciers carved the final landscape of the mountains, leaving characteristic U-shaped valleys and jagged ridges and peaks.

20.2 / (4.9) **STOP 7 (STOP 2):** Intersection of Highway 133 with CR 3 to Marble. Pull off along the shoulder and read the historic markers that tell the story of the Yule Marble Quarry. The beautiful white marble quarried here is a result of metamorphism of the 350 million year old Leadville Limestone by the heat and pressure of igneous intrusions that also underlie the lofty mountains to the south. The redbeds outcropping to the east of Highway 133 are the Permian and Pennsylvanian Maroon Formation, approximately 300 million years old and deposited as material washed down from an ancient mountain range called the Ancestrial Rockies, now long since eroded away.

21.0 / (4.1) Historical marker for the Townsite of Placita and the history of the Yule Marble Quarry.

21.7 / (3.4) There is no pull-out but as you drive this section of highway, look for the abrupt change of color in the steeply dipping bedrock units. On the west side of Highway 133 are the brown and tan Cretaceous age sandstones in sharp contrast with the redbeds of the Maroon Formation to the east. You are passing over a fault associated with the uplift of the Grand Hogback to the west.

25.1 / (0) **STOP 8 (STOP 1):** Pull off the highway at the historic marker for the coke ovens, directly across from the bridge to Redstone. The historic marker describes the function of the coke ovens and, further to the south, another historic marker tells the history of the Coal Basin mines. The unique properties of the coal were a result of metamorphosis of the coal from an igneous intrusion deep below Coal Basin. The result was a high grade "coking" coal used in the processing of steel and of sufficient value to offset the rigors of mining steeply dipping coal seams at elevations exceeding 10,000 feet. The igneous intrusion pushed the uniformly dipping bedrock units of the Grand Hogback up and out to form an anticline which later eroded to create the box canyon of Coal Basin surrounded by the steep alpine slopes of Huntsman Ridge. The igneous intrusion, which metamorphosed the coal beds in the Mesaverde Formation into high grade coking coal, is not exposed at the ground surface but is still deeply buried.