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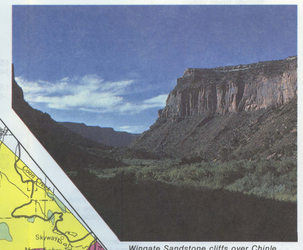
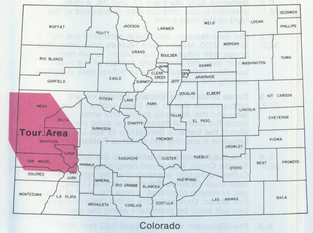


Wingate Sandstone cliffs over Chinle Formation slope.

LOCATION MAP



FURTHER READING

For those of you who have become intrigued with Colorado geology and would like more details we suggest beginning with the following list of books, available at local bookstores.

Canyon Country Geology for the Layman and Rockhound, F. A. Barnes, 1978, Wasatch Publishers, Inc., Salt Lake City, Utah.

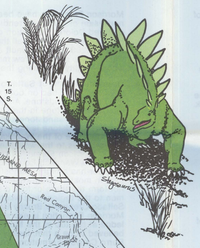
Colorado West, Land of Geology and Wildflowers, R. G. Young and J. W. Young, 1977, Wheelwright Press, Ltd., Grand Junction, Colorado.

The Geologic Story of Colorado National Monument, S. W. Lohnman, 1981, U.S. Geological Survey Bulletin 1508.

Prairie, Peak and Plateau–A Guide to the Geology of Colorado, John and Halka Chronic, 1972, Colorado Geological Survey Bulletin 32.

Red Rock Country, D. L. Baars, 1972, Doubleday/Natural History Press, Garden City, New York.

Roadside Geology of Colorado, Halka Chronic, 1980, Mountain Press Publishing Company, Missoula, Montana (also available from Colorado Geological Survey).



MAP EXPLANATION

- Quaternary sediments—includes river deposits, landslide deposits, rock glaciers.
- Tertiary extrusives (volcanics) and intrusives—includes Grand Mesa, San Juan volcanic field, and others.
- Tertiary and Upper Cretaceous sediments—includes Tertiary Wasatch Formation; Upper Cretaceous Mesaverde Group and Mancos Shale.
- Lower Cretaceous sediments—includes Dakota Sandstone and Burro Canyon Formation.
- Jurassic, Triassic and Permian sediments—includes Jurassic Morrison and Wanakah Formations, Entrada Sandstone; Jurassic/Triassic Navajo Sandstone; Triassic Kayenta Formation, Wingate Sandstone, Chinle, Dolores, Moenkopi Formations; Permian Cutler Formation.
- Precambrian crystalline rocks—granites, gneiss, schist, pegmatite.
- Contact between formations.
- Fault—dashed where approximately located, dotted where concealed; bar and ball on downthrown side.
- Anticline. Syncline. Approximate trace of axis and direction of plunge, dashed where concealed.
- Fault as shown on cross section.
- A——A' Line of cross section

Note: Use color blocks shown here as a guide to the general geology and ages on the cross section and stratigraphic column.

REFERENCES

Cashion, W. B., 1973, Geologic and structure map of the Grand Junction quadrangle, Colorado and Utah: U.S. Geological Survey Map I-736.

Haynes, D. D., and others, 1972, Geology, structure, and uranium deposits of the Cortez quadrangle, Colorado and Utah: U.S. Geological Survey Map I-629.

Steven, T. A., and others, 1974, Geologic map of the Durango quadrangle, southwestern Colorado: U.S. Geological Survey Map I-764.

Tweto, Ogden, 1983, Geologic sections across Colorado: U.S. Geological Survey Map I-1416.

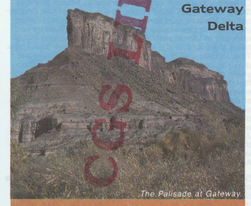
Tweto, Ogden, and others, 1976, Preliminary geologic map of the Montrose 1 x 2 quadrangle, southwestern Colorado: U.S. Geological Survey Map MF-761.

Williams, P. L., 1964, Geology, structure, and uranium deposits of the Moab quadrangle, Colorado and Utah: U.S. Geological Survey Map I-360.

Special Publication 27

Scenic Trips into Colorado Geology: Uncompahgre Plateau

Montrose
Ridgway
Norwood
Naturita
Uravan
Gateway
Delta



The Palisade at Gateway

by Donna Bishop Collins

Colorado Geological Survey
Department of Natural Resources
1985

COLORADO GEOLOGICAL SURVEY

Produced in cooperation with the Department of Local Affairs

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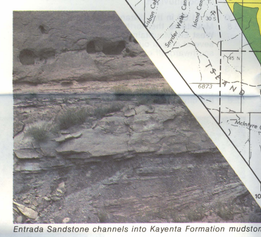
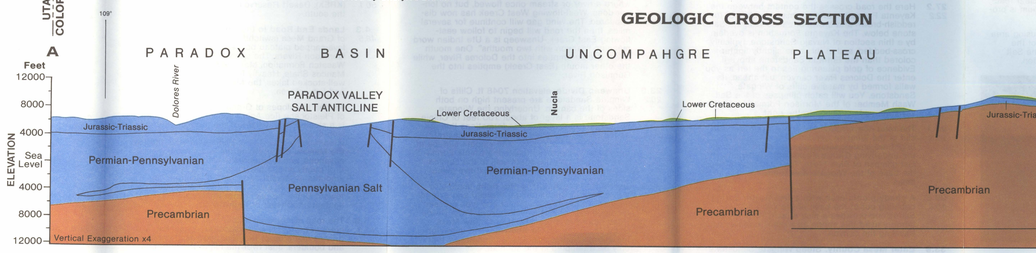


Entrada Sandstone channels into Kayenta Formation mudstones.

Morrison Formation potential ore zone.

GEOLOGIC CROSS SECTION



COMPOSITE STRATIGRAPHIC COLUMN AND EXPLANATION FOR TOUR AREA

Period	Age	Formation	Thickness (ft)	Lithology	Description
QUATERNARY	0-1.6	Alluvium and colluvium	0-50		Unconsolidated sand, gravel, silt, slope debris, landslide deposits, rock glaciers.
TERTIARY	1.6-66	Extrusives and related intrusives	0-200		Flows, dikes, sills and intrusions of igneous rocks. Usually volcanic extrusions or near-surface intrusives.
		Wasatch Formation	0-1500		Variegated clay, shale, sandstone with some limestone and conglomerate, usually forming slope. Only found in northern portion of tour area. Small amounts of shales of Green River Formation included.
UPPER CRETACEOUS	66-98	Mesaverde Formation	0-2600		Tan and brown sandstone, siltstone, mudstone, coaly shale, coal. Often forms alternating cliffs and slopes.
		Mancos Shale	0-4000		**Break indicates formation is too thick to show entirely in this diagram.** Gray and black marine shale, with thin limestone beds near base, forms easily eroded valleys and slopes. Especially thick in Grand and Uncompahgre Valleys; forms slopes and sides of Book Cliffs and Grand Mesa.
		Dakota Sandstone	100-210		Tan, yellow, light-red, and light-brown sandstone with conglomerate lenses, and coarse white conglomerate at base. Contains local beds of coaly shale and coal. Forms rims and caps mesas; sandstones form prominent ledges.
LOWER CRETACEOUS	98-144	Burro Canyon Formation	0-210		White, gray, and red sandstone and conglomerate with thin beds of siltstone, and purple and green shale. Sandstones form steep cliffs.
JURASSIC	144-208	Morrison Formation: Brushy Basin Member	300-500		Interbedded red, purple, blue, green, and gray mudstone and siltstone, with a few thin, fine-grained sandstone and conglomeratic sandstone beds; local thin limestone units. Forms steep slopes.
		Morrison Formation: Salt Wash Member	200-360		Light-brown, gray, and rusty-red, cross-bedded sandstone and reddish-brown, green, and greenish-gray mudstone. Some thin limestone beds near base. Forms alternating sandstone cliffs or ledges ("rims") and shale slopes.
		Wanakah Formation	60-130		Greenish-gray and reddish-brown sandstone forms steep, covered slopes, with light-colored, fine-grained sandstone forming rounded or ledgy cliffs below. Locally, thin, dense, dark-gray Pony Express Limestone marks the base. Formerly called the Summerville Formation in western part of tour area, name is now restricted to an area in Utah.
		Entrada Sandstone	80-250		Massive, white-, tan-, pink-, or salmon-colored, generally cross-bedded sandstone forms distinctive rounded cliff ("slick rock" or "slick rim").
TRIASSIC	208-245	Navajo Sandstone	0-120		Buff and gray, cross-bedded, fine-grained sandstone forms cliff. Only found in far western portion of tour area.
		Kayenta Formation	90-300		Red buff, gray, and purple, irregularly bedded, fine- to coarse-grained sandstone, siltstone, and shale, with lenses of conglomerate and limestone, form benches. Only found in western portion of tour area.
		Dolores Formation 430-600 feet: Wingate Sandstone	275-400		**Cross-hatching indicates that in parts of tour area certain formations were never deposited or were later eroded away.** Reddish-brown, fine-grained, thick-bedded, massive and cross-bedded sandstone forms steep cliffs.
		Dolores Formation 430-600 feet: Chinle Formation	120-450		Dolores Formation: Similar to, and generally considered to be equivalent of lower part of Wingate Sandstone and upper part of Chinle Formation. Found only in southeastern portion of tour area. Red, orange-red, and reddish-brown siltstone, with interbedded lenses of red sandstone, shale and limestone-pebbie and clay-pebble conglomerate, generally forms steep slopes and ledges. Lenses of light-colored, quartz-pebble conglomerate, conglomeratic sandstone, and grit at base often form thick, rounded cliffs and ledges.
		Dolores Formation 430-600 feet: Moenkopi Formation	0-580		Chocolate-brown shale, sandstone, and arkosic conglomerate, with local gypsum beds near base. Upper and lower parts form slope; middle portion forms ledges and slopes. Only found in far western portions of tour area.
PERMIAN	245-286	Cutler Formation	0-7800		**Unconformity line indicates a surface of erosion or lack of original deposition.** Interbedded red, maroon, and purple arkosic siltstone, mudstone, sandstone, and conglomerate, generally form steep slopes with some sheer cliffs and narrow benches. Found on western side of tour area.
PRE-CAMBRIAN	>570	Precambrian Complex	Base not Exposed		Gray and tan, igneous and metamorphic rocks intruded by coarse, pink, granite pegmatite and fine-grained dikes. Generally massive, forming cliffs or steep canyon walls.

Base from U.S. Geological Survey
Drafted by Cheryl A. Brchan

SCENIC TRIPS INTO COLORADO GEOLOGY: UNCOMPAHGRE PLATEAU

MONTROSE
RIDGWAY
NORWOOD
NATURITA
URAVAN
GATEWAY
DELTA

Welcome to Colorful Colorado! The roadside geology tour you are about to take will guide you through an enchanted land where barren shale "deserts" meet beautiful alpine meadows and mountains; where tumbling streams become torrents carving steep-walled canyons into ancient sediments; where major rivers left abandoned valleys, and other valleys never had rivers in them; where the forces of nature raised towering mountains and tore them down, only to raise them again and carve deep canyons through them, showcasing a colorful panorama of the earth's history for you to see and enjoy.

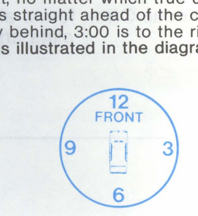
This geologic tour guides you to the mountain ranges, canyon mazes, high country deserts, and river valleys in and around the Uncompahgre Plateau in southwestern Colorado. Your tour begins in relatively barren Mancos Shale desert, but soon climbs to the crest of the Uncompahgre Plateau, surrounded by grassy parks and towering volcanic mountains. The Uncompahgre Plateau is a remnant of the Ancestral Rocky Mountains, once rising taller than, and to the west of the Rockies we now know. This plateau and the overlying sediments were eroded down to sea level, then uplifted again about 66 million years ago. The red rock formations found along the flanks of the Plateau are derived from the material eroded from the highland, then deposited into oceans, streams, and sandy deserts.The canyons on the western side of the Uncompahgre Plateau exhibit thick sections of rock sliced open by the forces of rivers, both present and past. About 35 million years ago the volcanic San Juan Mountains formed to the south, erupting through the already uplifted Colorado Plateau, a vast area covering southwestern Colorado and extending into Utah, Arizona, and New Mexico.

Scenic and geologically exciting, this area is some of the most rugged country easily accessible to motorists. Before you plunge yourself into the geology, consider that facilities for food, water and gas in this area, as in much of the west, can be scarce. It is wise to keep your gas tank filled, to carry water, and to take advantage of opportunities to stop for food and other necessities in the towns along the route.

The road log begins in Montrose, but the tour and its mileages have been broken into segments so you can enter or leave it without recalculating mileages. Towns, especially those providing major entry or departure points to the tour, are shown on the diagram below and marked on the road log with a matching number for easy reference.

Mileages have been provided in both directions, with the **reverse mileage** in italics. If you are going in the opposite direction, remember that features seen will be opposite to the way the road log is written. Abundant, easily *recognized* reference points, usually man-made markers such as county lines, highway mileage markers, road intersections, towns, or bridges where streams intersect the road are printed in bold type, so don't miss the scenery and geology by constantly watching your car odometer.

For orientation, many features are described in terms of a clock, so that, no matter which true direction you are facing, 12:00 is straight ahead of the car as you drive, 6:00 is directly behind, 3:00 is to the right, and 9:00 is to the left. This is illustrated in the diagram.



Rocks are deposited in layers, grouped into units called **formations**. Formation names are taken from **type localities** where the rock units were first described. Examples include the Mancos Shale, named after the rocks near the town of Mancos, and the Morrison Formation, named after the town near Denver. To simplify the map geology similar formations were consolidated. Only the largest faults, or faults directly affecting the geology you will see have been included on the map.

The **stratigraphic column** is a graphic representation of the formations in this area. Not all formations are now present in all localities, either because they were never deposited or because erosion later removed them. On a stratigraphic column the youngest formations are at the top, and the oldest are at the bottom. Thicknesses and **ages** (in million years before present) are approximate. Also included with the map is a simplified geologic **cross section** showing how a slice through the tour area would look if we could separate the rocks for viewing.

This tour is primarily geologic, although a few other interesting features are pointed out. For a full appreciation of the historical, cultural, and natural bounty of the area please refer to **Uncompahgre Canyons**, another circle tour booklet available soon for this area.

The Uncompahgre Plateau tour is readily accessible for those joining from Grand Junction, western Colorado's largest city, and U.S. Interstate 70. When embarking from any point on this tour, allow a full day to complete the 231 mile circle, so you can thoroughly appreciate the geologic and scenic wonders you will encounter.

MONTROSE TO RIDGWAY

0.0 *26.6* **(1) MONTROSE.** Intersection of U.S. Highways 550 and 50 (Main Street) in Montrose, elevation 5794 ft. **Start south on U.S. 550.** Originally developed as a supply point for silver miners in the San Juan Mountains, the city is now the business and agricultural center of the Uncompahgre Valley. Colorado's western slope orchards grow some of the finest fruit in the country, and fresh produce is available at many roadside stands during the summer and early fall.

1.6 *25.0* Leaving Montrose. **Visitor Information Center** on left.

On the skyline ahead lie the volcanic San Juan Mountains. The highest peak is Mount Sneffels, elevation 14,143 ft. The full panorama of the San Juan Mountains unfolds further south.

The highway follows the valley of the Uncompahgre River southward along the **Montrose Syncline**. As you drive up the valley you won't actually see the syncline, but it affects the location and direction of the valley and the river. A **syncline** is like an elongated layer cake of rock that sagged along the middle. In this case, the soft Mancos Shale lies in the center, and is easily eroded by the Uncompahgre River, so the river flows along the axis of the syncline for the next 14 miles, leaving rounded hills and gentle valleys of shale.

The **Mancos Shale** was originally deposited as muds and clays in a large shallow ocean. That ancient sea was teeming with life, and many fossils can now be found in the shale. Because it has a high clay content and a strong tendency to swell when it gets wet, the Mancos Shale weathers deeply and falls apart readily. Hills formed in it are often bleak and bare, looking like lifeless "badlands".

3.2 *23.4* **Cross the Uncompahgre River.** The Ute Museum, open in the summer, and a monument to the Ute Indian Chief Ouray and his wife Chipeta, lie on the west bank of the river.

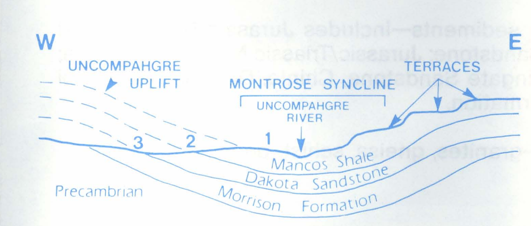
Several levels of **river terraces** are well developed in this area. They indicate previous levels of river flow and contain large deposits of debris washed from Ice-Age glaciers. These terraces consist of nearly horizontal plains above the present river level, with a final steep descent to the river. Try to spot more terraces.

6.2 *20.4* **Cross Montrose-Delta Canal.** This water comes from the Gunnison River through a transbasin diversion to the Uncompahgre River where it then feeds into the canal. In the arid southwest, canals are a vital source of water for farmers and ranchers, often better marked and containing more water than natural streams.

12.0 *14.6* **Ouray County line.** Brownish-tan cliffs of the Dakota Sandstone will soon be seen.

14.0 *12.6* East of the road, the tan Dakota Sandstone appears rather abruptly from beneath the gray Mancos Shale on the north, and forms ridges on both sides of the Uncompahgre River. The **Dakota Sandstone** was originally deposited as beach and near-shore ocean deposits, interfingering with stream and swamp deposits. Coal beds are common in the Dakota Sandstone. An abandoned coal mine lies ahead on the right. Each time you see a **contact** between formations on this tour, or anywhere in the world, you are viewing a place where the surface of the earth once was exposed so new rocks could be deposited on it. Those rocks were themselves then buried by even younger rock materials in a continuing process. Here, they were uplifted and sliced open for you to see. Rock layers are also called **strata**. The terms **stratigraphy** and **stratigraphic column**, refer to how given formations are arranged in relation to others in a geographic region.

As the road crosses formations that have been pushed up, causing younger layers to be eroded off, older rocks will be exposed. The diagram below shows how the rock layers (simplified) would look if you could view a slice through them. You began your drive in Mancos Shale along the Montrose Syncline (point 1), are now crossing into the Dakota Sandstone (point 2), and will move downward stratigraphically into older rocks like the Morrison Formation (point 3). This scenic tour around and across the very old Uncompahgre Plateau will take you through these progressively older layers, then bring you back again to the younger rocks.



14.6 *12.0* Now visible on both sides of the road is the Dakota Sandstone-Morrison Formation contact. The **Morrison Formation** is a series of red, green, and tan shales and sandstones originally deposited in streams and swamps during the age of dinosaurs, and now containing many dinosaur fossils. Colorfully distinctive in the entire region, the Morrison Formation is useful as one of several visual marker formations to orient yourself in the stratigraphic section.

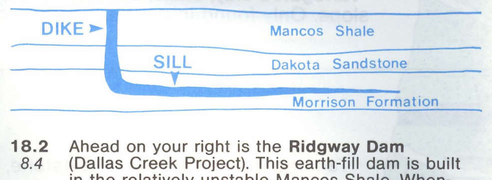
16.3 *10.3* River terrace gravels again indicate a previous level of river flow. Cliffs of Dakota Sandstone rim the skyline on both sides of the valley.

A greenish-gray sill intruded the Morrison Formation on the east side of the Uncompahgre River to your left. A **sill** is a layer of rock formed when hot, liquid rock material (magma) was squeezed **between** layers of existing rocks, then cooled and solidified.

Sill in Morrison Formation at river level.

16.8 *9.8* **Bridge across the Uncompahgre River.**

18.0 *8.6* A small hill, an erosional remnant of the Morrison Formation lies on the west side of the highway at 3:00. At this point the sill in the Morrison Formation thickens and cuts through the bedding (layers) of Dakota Sandstone and Morrison Formation. Turning up abruptly the sill then trends northwest into the Mancos Shale as a dike. A **dike** is similar to a sill except that it cuts across the bedding instead of squeezing between the layers. The heat of the dike at the contact baked the Mancos Shale.



18.2 *8.4* Ahead on your right is the **Ridgway Dam** (Dallas Creek Project). This earth-fill dam is built in the relatively unstable Mancos Shale. Whenever construction takes place in or near such a formation, potential problems of faulting and landsliding should be evaluated.

The sill described above is well exposed in the cliffs on the west side of the valley. There is also an outstanding view of Mount Sneffels on the skyline at 1:00.

19.0 *7.6* For the next half mile note the grassy areas along the right side of the road. These are two- to three-year-old landslides. Disturbed soil in the slide area retains more water than the more compacted surrounding rocks and soils, promoting the lush grass growth.

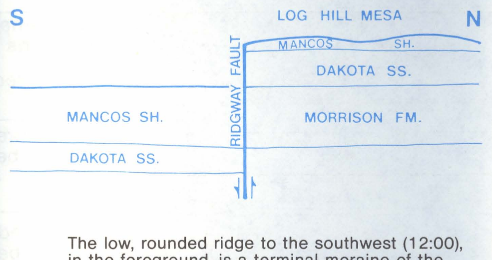
19.7 *6.9* **Ridgway Reservoir** provides domestic and municipal water for the Montrose-Delta area. Roadcuts in the Mancos Shale necessary for realignment of the highway along the eastern side of the reservoir created numerous landslides along the right side of the road for the next half mile. The shale weathers easily, contains large amounts of clays that swell when wet, and is prone to movement by **mass wasting**, a process in which large masses of rock and earth material move by gravity downward from one place to another. The movement can be either slow or very sudden.

20.8 *5.8* This road cut is in Mancos Shale. Rather dramatic landslides are present in the next road cut to the right about a mile ahead. Then, Dakota Sandstone will be exposed.

22.5 *4.1* **Sign and turnout for scenic overlook.** Looking to the south you will see a panoramic view of the majestic San Juan Mountains on the skyline. A series of Tertiary volcanic rocks erupted from the Silverton and Lake City volcanic calderas south of here about 30 to 35 million years ago, and now form most of those skyline mountains. The highest, horn-shaped peak in the center is Mount Sneffels (14,143 ft); it is younger than the other mountains, only 20 to 25 million years old. The rocks forming Mount Sneffels intruded the older volcanic rocks, then cooled and solidified before reaching the surface. Erosion removed the overlying layers of volcanic material, leaving Mount Sneffels exposed. These mountains are examples of the two types of **igneous rocks: extrusive** or volcanic rocks that reached the surface and are usually fine-grained, and **intrusive** rocks that cooled below the surface of the earth and are usually coarser-grained.

Yellow-gray cliffs of Miller Mesa in the middle distance to the southwest (2:00) are in Mancos Shale. A group of shales and mudstones mixed with limestone form the resistant ledge in the middle. Younger volcanic rocks, conglomerates, and mudflows can be seen above the Mancos Shale in the triangular cliff face.

Log Hill Mesa, immediately west of the Uncompahgre River, consists of Dakota and Morrison Formations with local patches of Mancos Shale preserved by a gravel cap. The south end of Log Hill Mesa marks the trace of the east-west trending Ridgway fault. This fault is generally considered to be the southern edge of the Uncompahgre Plateau uplift. The south side of the fault here has dropped about 1500 ft, leaving the Morrison Formation and the Mancos Shale in contact with each other. Recent studies have shown that this fault is still active. Several oil tests, drilled on the south side of the fault, encountered natural gas and flowing hot water.



The low, rounded ridge to the southwest (12:00), in the foreground, is a terminal moraine of the Wisconsinian (a subdivision of the Quaternary period, in this area about 10 to 73 thousand years ago) Uncompahgre glacier. A **terminal moraine** is a large mound of boulders, gravel, sand, and clay deposited at the end of a melting glacier. This moraine was breached by the Uncompahgre River on the east and by Dallas Creek on the west. The original plan for the Dallas Creek dam project called for filling these two natural cuts, effectively recreating the glacial lake that probably existed about 10,000 years ago behind the end moraine (and inundating the town of Ridgway).

23.9 *2.7* Good exposures of Morrison Formation are displayed in the road cut on the left (east). Dakota Sandstone forms the upper part of the ridge across the valley.

24.3 *2.3* **Cross Dry Creek Bridge.** Just beyond the bridge the Ridgway Fault crosses the valley.

24.8 *1.8* **Junction with road to Owl Creek Pass and Silver Jack Reservoir.** Cimarron Ridge, forms the skyline to the east, showing jagged pinnacles of San Juan volcanics resting on older coal-bearing formations.

25.6 *1.0* **Ridgway city limit.** The road cut just inside the Ridgway city limit is in the glacial terminal moraine.

26.6 *0.0* **Junction with Colorado 62** west into Ridgway and over Dallas Divide. The town nestles in the valley just across the Uncompahgre River.

RIDGWAY TO PLACERVILLE

Keep looking in all directions. The scenery is some of the prettiest in the state.

0.0 *23.7* **(2) RIDGWAY. Turn right into town.** This settlement was made into Fort Smith for the filming of the movie "True Grit". The highway winds its way up the the northeast flank of the Uncompahgre Plateau. Dakota Sandstone forms the rim of Log Hill Mesa at 3:00. You now cross the bridge over the Uncompahgre River.

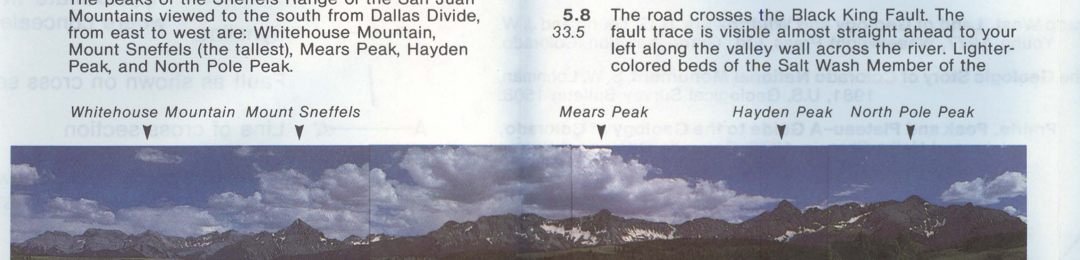
1.9 *21.8* **Log Hill Village turnoff.** From the road you see Mancos Shale to the left and Morrison Formation to the right, at *the same* apparent level. You are driving near the trace of the Ridgway Fault, which cuts through the valley, and brings these two formations together.

3.9 *19.8* Mancos Shale lies ahead in the roadcuts and on the rounded hills, and forms the gentle valleys.

9.7 *14.0* A fine-grained igneous rock lies here in contact with the baked sediments it intruded. This and similar intrusives can be seen in several places along the next few miles. In the roadcut ahead on the right is black, baked Mancos Shale that **looks** like coal.

10.5 *13.2* At the top of the hill, the sweeping panorama of the San Juan Mountains unfolds. Dallas Park and its grassy meadows stretching to the towering, snow-capped San Juan Mountains is one of the most photographed views in the state, often found in books and scenic calendars highlighting our nation's natural beauty. Be sure to stop at the next turnout just beyond the **San Miguel County line** for pictures.

10.9 *12.8* **Dallas Divide. Good turnout for viewing the area.** At an elevation of 8970 ft, this is the crest of the southern end of the Uncompahgre Plateau. The peaks of the Sneffels Range of the San Juan Mountains viewed to the south from Dallas Divide, from east to west are: Whitehouse Mountain, Mount Sneffels (the tallest), Mears Peak, Hayden Peak, and North Pole Peak.



The Sneffels Range from Dallas Divide.

These mountains were formed by a thick series of volcanic rocks erupting from several large volcanic centers over the top of an already uplifted area of the Colorado Plateau. If the volcanics were not there, the view would look much like the mesa and canyon country you are about to enter, because the underlying rocks are the same. As it is, you will see the best of both environments--with world class scenery. From here the highway will descend to the valley of the San Miguel River, via the valley of Leopard Creek.

12.3 *11.4* **Last Dollar Road.** Just beyond the turnoff is a landslide on the right side of the road. Note the step-like terraces where the ground has failed. Watch for other recent slope failures in the next mile.

15.7 *8.0* A small fault in the roadcut at the right slightly offsets the exposed formations.

16.1 *7.6* The **Brushy Basin Member** of the Morrison Formation can be seen in the road cut at the right. A large mudflow lies on the left across the creek. A **mudflow** is a downward flowing mass of fine-grained earth material mixed with water.

17.3 *6.4* In the road cut at the right is the **Entrada Sandstone,** a massive, white, cliff-forming sandstone, originally deposited as sand dunes. The Dolores Formation and its red, thin-bedded shales, siltstones, and sandstones, can be seen in several road cuts ahead, as you move downward through progressively older rocks. Those older rocks were deposited in deltas, floodplains, and deserts surrounding the Ancestral Rockies as the highland was worn away by erosion.

18.7 *5.0* A recent landslide that slid across the road left the rocks, dirt and rubble at the side. Just ahead on the right the Alder Creek Fault brought white sandstones of the Entrada Sandstone on the east into contact with reddish sandstones and siltstones of the Brushy Basin Member of the Morrison Formation on the west, indicating many feet of movement.

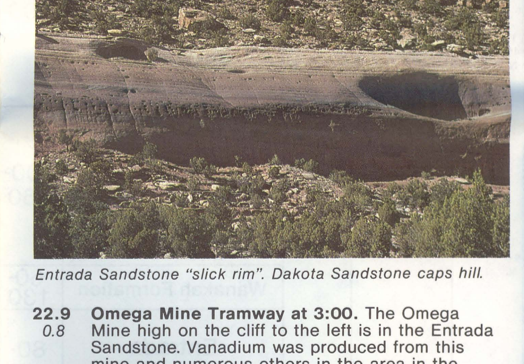
19.8 *3.9* **Bridge to left across river.** Just ahead on the right are remnants of the town of Leonard. Cliffs of white Entrada Sandstone, capped by the thin, dark gray Pony Express Limestone (the bottom member of the **Wanakah Formation**), lie on both sides of the highway. Little Cone, aptly named for its distinctive shape, is visible on the skyline ahead. Although shaped like a volcano, Little Cone is a mass of igneous rock that intruded surrounding rocks, which then eroded off, leaving the cone-shaped mountain.

20.3 *3.4* A **debris flow** (similar to a mudflow but with coarser material) on the right has blocked the road at this location in the recent past.

20.6 *3.1* The remains of a vanadium mine in the Entrada Sandstone can be seen to the right. Near the turn of the century vanadium was used to color glass and ceramics orange, but it is now used by the steel industry to harden steel.

!!! ATTENTION !!! Old mines should never be entered. They are unsafe! Falling rocks and timbers, cave-ins, poisonous gases, lack of oxygen, and the danger of becoming lost or falling down a shaft, provide many hazards.

21.2 *2.5* In the canyon on both sides you can see white Entrada Sandstone, with red Dolores Formation below and Morrison Formation and Dakota Sandstone above. The Entrada Sandstone forms a bare, massive, rounded cliff of white or a dramatic salmon pink, often with a white "cap" visible for miles. The shape and bareness of the cliff has given rise to the formation's nickname of the "slick rim" or "slick rock", and will help you to spot the Entrada Sandstone, regardless of color. The Entrada Sandstone is an important marker bed for orienting yourself in the rock section.


Entrada Sandstone "slick rim". Dakota Sandstone caps hill.

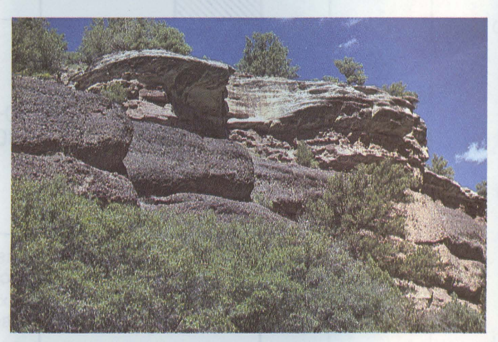
22.9 *0.8* **Omega Mine Tramway at 3:00.** The Omega Mine high on the cliff to the left is in the Entrada Sandstone. Vanadium was produced from this mine and numerous others in the area in the 1940's (a few as early as 1910). As foreign imports depressed the domestic vanadium market, many mines in this region closed until the uranium boom of the 1950's, when vanadium became economically recoverable as a coproduct of uranium.

23.7 *0.0* **Junction of Colorado Highway 62 with Colorado Highway 145.**

PLACERVILLE TO VANCORUM

0.0 *39.3* **(3) PLACERVILLE. The tour continues straight** ahead (northwest) on Highway 145. The town of Placerville, located less than a mile down the road to your left, received its name from nearby placer gold mining along the San Miguel River. In Placerville there is a hot spring (94° F), its sulfur-bearing waters rising along a fault in the Cutler Formation. The spring is known by several names: Lemon Hot Springs, Geyser Warm Springs, and Placerville Hot Springs.

West of here numerous rock terraces can be seen, most of them north of the river. The river valley is notably asymmetrical. The rocks dip gently to the south, and the river flows along the south edge of the valley. The north edge of the wide valley is bounded by the west-trending Black King fault, where the north side moved down as much as 500 feet. Distinctive red sandstones and shales of the **Cutler Formation** are seen along the highway for the next several miles. Impressive in this area are pebble-, cobble-, and boulder-conglomerates, 5 to 25 feet thick, common in the Cutler Formation and exposed along the road. These conglomerates are colorful reds and purples due to oxidation (rusting) of the iron in the formation. These conglomerates are worth slowing down to observe.


Cutler Formation cobble conglomerate.

0.6 *38.7* **Between Mile Markers 77 and 78,** a dark, greenish-brown igneous dike is exposed at the right in the road bend.

1.1 *38.2* Old river terraces and sluice remnants are visible at 3:00. Miners used **sluices**, long troughlike boxes with ridges on the bottom, to run river water over the sands and gravels of the river benches. This washed away lighter rock materials, leaving the heavier gold.

1.5 *37.8* **Cross beds** in the Entrada Sandstone are highly visible due to the large angles of the bedding and the dramatic purple and white coloration along the beds of these former sand dunes. Watch the Entrada Sandstone to see the contact between it and the red **Dolores Formation.**

2.9 *36.4* **The road across the bridge** to the left follows Specie Creek. Purple-red conglomerate of the Cutler Formation is exposed at the right near road level. Observe the small, active (1984), placer mining operation across the river at 10:00 just ahead. Dark red cliffs of the Dolores Formation will soon be prominent along the road.

4.3 *35.0* Pre-Wisconsin valley fill about 100 feet thick forms terraces across the river ahead and to your left. The gravels of this valley fill were the site of **gold placer** operations in the past. Just ahead, the remains of a wooden sluice extend downward from the old river bench where placering took place. Watch for evidence of other placer operations downstream for the next few miles.

5.1 *34.2* Straight ahead is a well-exposed, gravel-filled, abandoned channel of the San Miguel River. The road swings to the left, and the channel will be on your right.

5.8 *33.5* The road crosses the Black King Fault. The fault trace is visible almost straight ahead to your left along the valley wall across the river. Lighter-colored beds of the Salt Wash Member of the Morrison Formation have been dropped on the north side of this west-trending fault against the dark red Dolores Formation on the south side. Here along the valley wall the relative movement is about 200 feet. This fault system continues westward to a point a few miles south of Norwood, roughly paralleling the road.

6.4 *32.9* **Opposite mouth of Saltado Creek.** The conspicuous white bed on both sides of the river is the Entrada Sandstone. An equivalent of the Wingate Sandstone in the Dolores Formation forms the red sandstone cliff below it. Over the Entrada Sandstone is the talus-covered and tree-bearing slope of the Wanakah Formation. For several miles to the west the **Salt Wash Member** of the Morrison Formation makes prominent cliffs above the Wanakah Formation. The Salt Wash Member has a higher sandstone content here than in most of southwestern Colorado, and does not form the three or four discrete ledges common to the region. Just west of the mouth of Saltado Creek the Brushy Basin Member of the Morrison Formation is exposed. A heavy sandstone ledge at the top of the Morrison Formation is believed to be a thin, locally present, stringer of Burro Canyon Formation. The Dakota Sandstone forms the rim of the canyon, at the skyline. A mile ahead dark red Dolores Formation lies at road level.

8.4 *30.9* The contact between the Entrada Sandstone and the Wanakah Formation is about 10 feet above the road at the bend in the road. The Entrada Sandstone is the massive, now salmon-colored rock forming the distinctive rounded cliff. The road travels stratigraphically downward and crosses the upper contact of the Entrada Sandstone just ahead.

9.6 *29.7* **Mile Marker 88.** On your left lies the San Miguel River ranch resort. The Salt Wash Member of the Morrison Formation forms the prominent cliffs on both sides of the valley. The Brushy Basin Member lies above the Salt Wash Member, both capped by Dakota Sandstone. Notice the mines across the river and the mine dumps cascading down the cliffs.

12.0 *27.3* **The road crosses the San Miguel River at the foot of Norwood Hill.** The highway now leaves the San Miguel River valley to ascend Norwood Hill. In the climb you will cross progressively younger formations as the road travels up the stratigraphic section.

12.8 *26.5* **Mile Marker 97** is in the Salt Wash Member of the Morrison Formation. The road cut to the left exposes the contact of the Salt Wash and Brushy Basin Members . The reddish sandstone and shale ledges are part of the Salt Wash Member. The Brushy Basin Member is easily seen as the distinctive, multicolored purple-green-white shales and sandstones.

13.5 *25.8* This is the base of the **Burro Canyon Formation,** a massive, light-gray, conglomeratic sandstone overlain by thin sandstones interbedded with gray and green mudstone. The Burro Canyon Formation lies between the Morrison Formation below and the Dakota Sandstone above.

Mile Marker 98 is posted in the Dakota Sandstone. Note the lens of coal in the Dakota Sandstone to your left. The coal filled a stream channel that at this point nearly destroyed the sandstone ledge that usually forms the base of the Dakota Sandstone. The base of the Dakota Sandstone is just below this coaly lens.

The bank of wind-deposited silt and sand along the right side of the road as you near the top of the hill is characteristic of many mesa tops in southwestern Colorado.

14.2 *25.1* **Top of Norwood Hill.** The nearly flat plain between here and Norwood is developed on the top of the resistant Dakota Sandstone, from which most of the less resistant Mancos Shale has been stripped by erosion.

Several mountains and ranges are now visible to the south and southeast. They were formed of volcanic or other igneous rocks related to the San Juan volcanics, and are all of Tertiary age.

6:30	The Last Dollar Range of the San Juan Mountains.
7:30 to 8:30	Sunshine Mountain, 12,960 ft; Mount Wilson group,highest peak 14,246 ft; Little Cone, 11,981 ft; Dolores peaks, highest peak 12,595 ft.
9:00	Lone Cone, 12,613 ft.

Looking then to the southwest, west, and northwest, you see:

11:30	East-dipping rocks on the east side of the Gypsum Valley anticline.
12:30	West-dipping rocks on the west side of the Paradox Valley anticline.
1:00	East-dipping rocks on the east side of the Paradox Valley anticline in the near distance, the La Sal Mountains in the far distance.
2:00	The low-lying hills are part of the Uncompahgre Plateau.

Gypsum Valley and Paradox Valley are collapsed salt anticlines, formed when thick layers of salts, deposited millions of years ago by evaporation of ancient oceans, started to flow like putty upward along zones of weakness due to pressure from the rocks on the sides and top. As the salts pushed up the overlying sandstones, siltstones, and shales, they created arches called **anticlines**. As the salts neared the surface, fresh waters from the surrounding rocks and from the surface began to dissolve the salt. When enough salt had been removed, the overlying rocks no longer had support, and the anticlines collapsed, forming the present valleys (see cross section with geologic map).

In many cases, no river has ever flowed through these valleys. Paradox Valley, on the other hand, has the Dolores River flowing **across** the valley, rather than along its length as might be expected. This confused early visitors, and led to the valley's name.

17.1 *22.2* **(4) NORWOOD.** Post Office in Norwood, one of the larger towns in the western part of the tour area. For the next fifteen miles the road travels on Quaternary stream and windblown deposits overlying the Dakota Sandstone. The Uncompahgre Plateau lies on the skyline to the right.

18.7 *20.6* The La Sal Mountains of Utah are visible on the skyline at 12:00. "La Sal" is Spanish for "the salt", and it is believed the Indians used to trade salt from the area surrounding the mountains for other goods. These mountains are Tertiary igneous intrusives dated as 23.5 million years old. Three groups of peaks, known as North Mountain, Middle Mountain, and South Mountain are easily recognized. Mount Peale, the highest peak at 12,721 ft, is part of the Middle Mountain group.

19.6 *19.7* **Montrose County line.**

26.2 *13.1* **(5) REDVALE.** Redvale Post Office. From town and the road north of here there is a good view of the southeast end of Paradox Valley. The steep face on the northeast flank of the valley is capped by Burro Canyon Formation.

27.9 *11.4* The San Miguel syncline, a structural depression between the Paradox Valley anticline at 10:00 and the Uncompahgre Plateau at 2:00, trends northwest at 12:00. Dakota Sandstone forms the center of the syncline, and Morrison Formation is exposed on both sides.

32.2 *7.1* **Mile Marker 116.** Thin coal beds in the Dakota Sandstone are exposed in the road cut on the right. The road now heads toward the San Miguel River valley.

32.7 *6.6* Exposed in the road cut on the right is the contact between a 10-foot conglomerate sandstone of the basal Dakota Sandstone and a light-green mudstone of the underlying Burro Canyon Formation.

33.1 *6.2* **Junction with Colorado Highway 141. Continue straight ahead** as the tour road becomes Colorado Highway 141. Highway 141 to the left provides access to the Gypsum Valley and Slick Rock areas of the Uravan mineral belt of Colorado and Utah (one of the largest uranium mining areas in the United States).

33.3 *6.0* This road cut is in the Burro Canyon Formation, and the next road cut at the right exposes the contact between the Dakota Sandstone and the Burro Canyon Formation.

33.7 *5.6* **Colorado Highway 90** (to right) across the Uncompahgre Plateau to Montrose. **Stay on Highway 141.** Just ahead the road cuts through Dakota Sandstone. As the road enters the valley, you will descend stratigraphically into older formations.

34.9 *4.4* The base of the massive conglomeratic sandstone ledge at the right forms the contact between the Burro Canyon Formation and the underlying Brushy Basin Member of the Morrison Formation.

35.5 *3.8* **Cross Naturita Creek.** Exposed are Dakota Sandstone at the top of the canyon, Burro Canyon Formation below that and the Brushy Basin Member of the Morrison Formation at road level.

36.5 *2.8* **(6) NATURITA.** Naturita city limit. Just ahead to the right is Colorado Highway 97 to Nucla. **Stay on Highway 141.**

37.1 *2.2* **Naturita Post Office.** This settlement is the center of uranium mining in the Uravan mineral belt. Uranium was mined in many nearby canyons, from the Brushy Basin and Salt Wash Members of the Morrison Formation. Uranium ore is contained in stream channel sandstones of these members, often closely associated with fine-grained organic matter and petrified wood. The canyon sides here are formed by the Morrison Formation, and capped by Burro Canyon Formation and Dakota Sandstone.

38.3 *1.0* Southwestern Redimix mines sand and gravel from terraces of the San Miguel River here.

39.3 *0.0* **Junction with Colorado Highway 90** leading to Vancorum. The historic marker on the left commemorates the Dominguez and Escalante Expedition of 1776, which searched for a route to the California missions.

VANCORUM TO GATEWAY

0.0 *49.4* **(7) VANCORUM.** Highway 90 to the left provides access to Vancorum, Paradox Valley, and the La Sal Creek uranium mining area. **Stay on Highway 141**

0.6 *48.8* An old coal mine can be seen near the top of the hill in the Dakota Sandstone to your right. Near road level is the uranium buying station of General Electric's Nuclear Division. This station, closed due to poor uranium market conditions, provided a market for independent miners. It is built on the site of the old Vanadium Corporation of America's Naturita mill which processed vanadium and/or uranium ores from 1939 to 1958. The mill tailings south of the station were removed in 1977-79 to a site in Paradox Valley and reprocessed to recover uranium and vanadium.

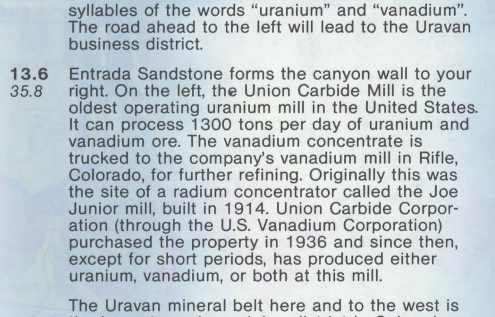
As you view the canyon of the San Miguel River ahead, you see exposures of Dakota Sandstone, Burro Canyon Formation, and both members of the Morrison Formation.

2.8 *46.6* Distinctive large cobbles of river terraces, rest on Morrison Formation. For about the next two miles several levels of terraces form the flat, grassy, and often cultivated surfaces of the valley floor.

3.0 *46.4* Straight ahead, forming a ledge on the canyon rim is the basal conglomeratic sandstone of the Burro Canyon Formation.

4.2 *45.4* The contact between the Brushy Basin Member and the Salt Wash Member of the Morrison Formation lies near road level for about the next three miles. After that, for much of the distance to Uravan the road will pass between steep slopes and cliffs of the Salt Wash Member. The uppermost sandstone unit of the Salt Wash Member forms a ledge about 100 feet above the river at the right. This is the principal uranium-vanadium-bearing unit throughout southwestern Colorado. In this area, however, the sandstone beds are light reddish-brown from oxidized iron (rust) and contain only sparse carbonized plant debris, making the sandstones unfavorable for uranium and vanadium deposits.

6.6 *42.8* The Brushy Basin Member of the Morrison Formation forms the variegated slope to your right, capped by the Burro Canyon Formation. For the next 20 miles or so the Dakota Sandstone is present above the Burro Canyon Formation, but is generally not visible from the road. The upper sandstone unit of the Salt Wash Member lies to your right. As the road drops stratigraphically you will pass through the Wanakah Formation. The next formation to watch for is the Entrada Sandstone (the "slick rock").


Morrison Formation. Uranium mine and dump in Brushy Basin Member.

10.1 *39.3* At road level to your left lies the upper Entrada Sandstone. The covered slope of the Wanakah Formation lies above it. The contact between the Salt Wash Member of the Morrison Formation and the thin, ledgy Wanakah Formation lies at the base of the lower sandstone ledge and above the covered slope at 2:00.

10.6 *38.8* Thin, red shales and mudstones of the Wanakah Formation lie at road level. A **turnout** at the right leads to a brush-covered trail to the river, and a good view of the Salt Wash and Brushy Basin Members of the Morrison Formation on the other side. The next road cut is in shale of the Morrison Formation.

11.7 *37.7* The upper part of the Entrada Sandstone is exposed both in the road cut at the left and near stream level at 2:00. Ahead, high above road level, is the dump of the Rock Raven uranium mine.

11.9 *37.5* The road to the left enters east Uravan, then proceeds up Hieroglyphic Canyon, so named because Indian **petroglyphs** (carvings and drawings on rock) resembling "hieroglyphics" are found on the canyon walls formed in the Salt Wash Member of the Morrison Formation.

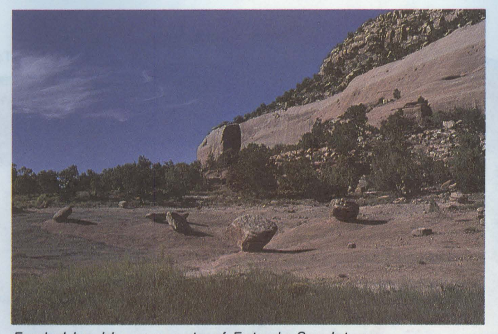
12.0 *37.4* **San Miguel River bridge.** The road is near the top of the Entrada Sandstone. There is a picnic ground to the left. Just ahead, the Club (uranium) Mines can be seen at 11:00.

13.1 *36.3* **(8) URAVAN.** This is a settlement for the employees of Union Carbide Corporation who work in and near the uranium mines and mill here. The name Uravan is derived from the first syllables of the words "uranium" and "vanadium". The road ahead to the left will lead to the Uravan business district.

13.6 *35.8* Entrada Sandstone forms the canyon wall to your right. On the left, the Union Carbide Mill is the oldest operating uranium mill in the United States. It can process 1300 tons per day of uranium and vanadium ore. The vanadium concentrate is trucked to the company's vanadium mill in Rifle, Colorado, for further refining. Originally this was the site of a radium concentrator called the Joe Junior mill, built in 1914. Union Carbide Corporation (through the U.S. Vanadium Corporation) purchased the property in 1936 and since then, except for short periods, has produced either uranium, vanadium, or both at this mill.

The Uravan mineral belt here and to the west is the largest uranium mining district in Colorado, and one of the largest in the country. Ore from here supplied radium to Marie Curie in France, uranium for the atomic bombs in the 1940's, and now provides the raw materials for nuclear reactors to produce electric energy. Vanadium is produced as a coproduct.

14.0 *35.4* Here, northwest of the plant, is the housing area for Union Carbide employees. Dumps of the Dolores Bench mines cascade down the Salt Wash Member of the Morrison Formation.

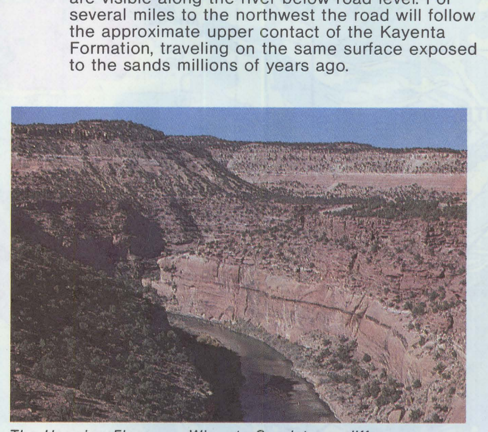

Eroded boulder remnants of Entrada Sandstone.

At the right side of the road a light-colored sandstone with vertical joints lies at the base of the Entrada Sandstone cliff. This is probably a lens of **Navajo Sandstone,** usually not found this far to the southeast. To the west it forms massive cliffs and exposures that look like petrified sand dunes--and that is what they are.

15.0 *34.4* These are the evaporation ponds for liquid mill wastes.

15.4 *34.0* **Bridge over Atkinson Creek.** Massive, salmon-colored cliffs on each side of the San Miguel River valley are recognizable as the "slick rock" of the Entrada Sandstone. Just ahead on the left is the bridge across the San Miguel River and the road following the Dolores River to the Paradox Valley.

15.8 *33.6* **Mile Marker 78.** At 1:00 is the nearly vertical cliff of the Entrada Sandstone, its irregular base channeling into the underlying red mudstone of the **Kayenta Formation.** This channeling indicates the mudstones deposited by rivers and streams were at the surface of the earth when ancient channels and windblown sand began eroding into them, depositing sands that would later become sandstone. The story was preserved in the rock for us to view now, millions of years later. Good exposures of the Kayenta Formation are visible along the river below road level. For several miles to the northwest the road will follow the approximate upper contact of the Kayenta Formation, traveling on the same surface exposed to the sands millions of years ago.


The Hanging Flume on Wingate Sandstone cliff.

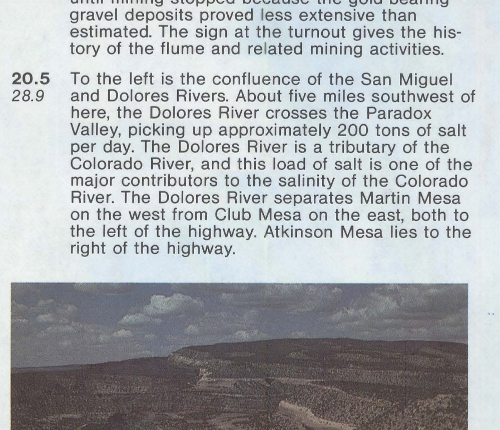
16.8 *32.6* Ledgy sandstones of the Salt Wash Member of the Morrison Formation down through the gentle, covered slope of the Wanakah Formation to the Entrada Sandstone cliff are well exposed ahead. Several mine dumps lie at the base of the upper Salt Wash Member. Along the river canyon at 10:00 are good exposures of the Kayenta Formation. The **Wingate Sandstone,** also deposited as desert sands blown along the sides of the Uncompahgre highland, forms the smooth cliff below.

The Wingate Sandstone and many other cliff-forming sandstones in the west are often covered with **desert varnish**, dark red, brown, and black, often shiny, coatings of manganese and iron that have leached out of the rock over many years. The darker the varnish is, the longer the rock face has been exposed.

18.5 *30.9* This is your first view of Blue Mesa, so named because of the blue shales forming the slopes of the mesa.

19.5 *29.9* **Hanging Flume sign and turnout.** Remnants of a wooden flume built in 1889-90 to carry water to the Lone Tree gold placers cling to the massive cliffs of the Wingate Sandstone. The flume provided water for hydraulic mining during 1891-93, until mining stopped because the gold-bearing gravel deposits proved less extensive than estimated. The sign at the turnout gives the history of the flume and related mining activities.

20.5 *28.9* To the left is the confluence of the San Miguel and Dolores Rivers. About five miles southwest of here, the Dolores River crosses the Paradox Valley, picking up approximately 200 tons of salt per day. The Dolores River is a tributary of the Colorado River, and this load of salt is one of the major contributors to the salinity of the Colorado River. The Dolores River separates Martin Mesa on the west from Club Mesa on the east, both to the left of the highway. Atkinson Mesa lies to the right of the highway.


Aerial view north of Uravan, Atkinson Mesa on the right.

Ahead is Blue Mesa, formed in blue and green shales of the Brushy Basin Member of the Morrison Formation, and capped by the Burro Canyon Formation.

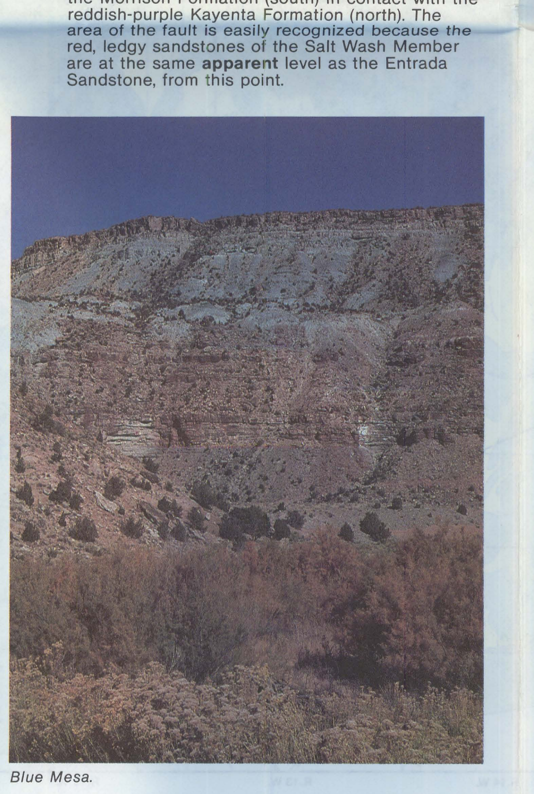
21.3 *28.1* On the left is an old **coke oven** built in the 1880's to heat coal to produce **coke**, a combustible material that burns practically smoke-free.

21.8 *27.6* The gravel deposits on the right show evidence of the mining activities of the old Bancroft gold placer. Across the river, on the left, similar gravels were recently removed by Union Carbide for use in tailings dam construction. Just ahead is the road to Carpenter Flats and Paradox Valley.

23.5 *25.9* **Bridge over Mesa Creek.** The gravel deposits on the right are the Lone Tree Placers, worked for gold in 1891-1893. Similar gravels were also placered to the left of the road. Large cobbles are visible in the river terrace gravels for the next half mile.

26.4 *23.0* **Bridge over Dolores River.** Roc Creek canyon enters to the left. Uranium was first discovered on the Colorado Plateau in the Roc Creek area in 1881. West of the Dolores River between Roc Creek and Salt Creek is Sewemup Mesa. It received its name from the activities of rustlers who would move cattle to this isolated mesa, cut out the existing brands, and sew the wounds back together.

A fault at 12:00 brings the Salt Wash Member of the Morrison Formation (south) in contact with the reddish-purple Kayenta Formation (north). The area of the fault is easily recognized because the red, ledgy sandstones of the Salt Wash Member are at the same **apparent** level as the Entrada Sandstone, from this point.

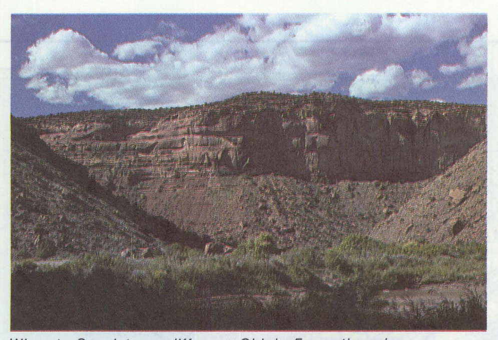

Blue Mesa.

27.2 *22.2* Here the road crosses the contact between the Kayenta Formation and the massive cliffs of the reddish-brown and brown-streaked Wingate Sandstone below. The Kayenta Formation is overlain by a thin section of Navajo Sandstone, typically cross-bedded, and in this area slightly lighter-colored than the Entrada Sandstone above it. Evidence of gold placering lies to the left as you enter the Dolores River canyon just ahead, its walls formed by massive cliffs of Wingate Sandstone. You will catch glimpses of the Salt Wash Member of the Morrison Formation on the skyline in side canyons to the right.

28.1 *21.3* The road now crosses the contact between the cliff of the Wingate Sandstone and the softer, bright-red shales, siltstones, and sandstones of the underlying **Chinle Formation.** Behind is your last glimpse of Blue Mesa. The road travels near the base of the Wingate Sandstone for several miles.

29.6 *19.8* **A shady picnic area with a freshwater spring** bubbling out at the base of the Wingate Sandstone provides a nice stop. Cattlemen and farmers used this spring as a main stopover when traveling the canyon.

33.9 *15.5* **Enter Mesa County.** Steep Wingate Sandstone cliffs cap Chinle Formation slopes straight ahead.


Wingate Sandstone cliffs cap Chinle Formation slope.

35.3 *14.1* Erosion by ice, water, and wind along a joint in the rock ahead is creating a **rock column** that will eventually collapse, adding to the rocky slopes along the edges of the canyon. After it collapses, more rock columns will form; erosion, time and the river below will continue to break down and carry away the rocks nearest the bottom. These canyons maintain a relatively constant slope through continual repetition of this process.

36.0 *13.4* Blue Creek enters the Dolores River from the east (right). The base of the Chinle Formation is about at river level.

37.4 *12.0* The **Moenkopi Formation** forms the slightly darker lower part of the red slope at road level, with white patches of **gypsum** showing near its base. Gypsum (calcium sulfate) is a rock or mineral used to make drywall for building construction. It is also used as a pH conditioner for acidic soils. Dissolved, it adds to the salinity of rivers. Gem quality gypsum is called alabaster and is carved to create ornaments. The upper part of the red slope is Chinle Formation. Wingate Sandstone forms the cliff, with ledges of Kayenta Formation on top.

39.5 *9.9* **Cross cattle guard and Salt Creek.** The road to the left leads to Sinbad Valley, another collapsed, northwest-trending salt anticline. The stratigraphic section from the Salt Wash Member of the Morrison Formation down to the Cutler Formation is exposed ahead and to the right on the west side of Flat Top Mesa.

39.9 *9.5* Large cobbles from river terrace gravels overlie finer-grained, unconsolidated material.

42.6 *6.8* A large river terrace lies to the left.

44.1 *5.3* **Cattleguard.** A small strip mine, currently called the "Alabaster Box Mine" and last mined for gypsum, lies to your left in the Moenkopi Formation. Ahead is the Palisade at Gateway, an impressive, often photographed mesa. Tenderfoot Mesa is on the skyline to the right.

44.4 *5.0* **This is a good turnout point for viewing the Palisade** at Gateway. Formations from the Salt Wash Member of the Morrison, with a small uranium occurrence in it, down through the Wanakah, Entrada, Kayenta, Wingate, Chinle, Moenkopi and Cutler are exposed along the sides of this long, narrow mesa.

44.9 *4.5* Here the road crosses the Moenkopi-Cutler Formation contact. The Cutler Formation is composed of the lighter-red, more resistant beds.

45.5 *3.9* This road cut is in the Cutler Formation, capped in this area by river terrace gravels.

46.1 *3.3* Across the river to the right the Cutler Formation forms the relatively resistant, rounded red beds. An impressive conglomerate lens in the Cutler Formation lies just ahead at 11:00.

48.8 *0.6* **Road to left goes up John Brown Canyon** to Beaver and Polar Mesas. Uranium and vanadium were discovered on Beaver Mesa in 1913, and mining for radium began about 1916 or 1917. Between 1948 and 1970, 1,225,000 tons of uranium and vanadium ore were produced.

49.2 *0.2* **Bridge over the Dolores River.** At this point the tour leaves the Dolores River Valley and enters West Creek Valley, leading to Gateway and Unaweep Canyon.

49.4 *0.0* Enter Gateway, Colorado, elevation 4595 ft, the lowest settlement in western Colorado.

GATEWAY TO WHITEWATER

0.0 *43.7* **(9) GATEWAY.** Gateway nestles at the base of the Palisade, now on your left. In 1875 the town was the site of a supply camp for the Hayden Survey of the U.S. Geological and Geographical Survey (now the U.S. Geological Survey) parties in western Colorado. On the right as you enter town are the ruins of the Gateway Alloys Company's vanadium mill. The mill recovered vanadium from carnotite ores during 1940-1942, and the tailings were reprocessed for uranium in the early 1950's.

1.5 *42.2* Northeast of Gateway, gravels from Unaweep Canyon, reworked by West Creek, overlie rocks of the Cutler Formation.

2.5 *41.2* On the left large, dark-colored boulders are in a good exposure of purple-red Cutler Formation. The lighter-colored boulders are from thick Tertiary gravels overlying the Cutler Formation.

4.2 *39.5* **Road junction with Calamity Mesa Road. The** road crosses West Creek and leads to Outlaw and Calamity Mesas.

4.6 *39.1* This is the contact between siltstones and shales of the Cutler Formation (about 245 million years old) and **Precambrian granite** (nearly 2 billion years old) in the gorge of West Creek. This contact marks the western boundary of the Uncompahgre Uplift and its major high-angle fault system (see the geologic cross section). The granite is part of the Precambrian core of the Ancestral Rocky Mountains, uplifted again with the Uncompahgre Plateau, along that large fault. The Ancestral Rocky Mountains rose about 300 million years ago, then eroded, providing rock materials to form large parts of the Pennsylvanian, Permian, and Triassic formations of southwestern Colorado and southeastern Utah. All of these formations thin and lap out onto the Precambrian rocks to the east. Formations like the Navajo Sandstone and Kayenta Formation are often either thin or missing entirely in this area, but become very thick as you travel further west. By the time younger sedimentary formations covered the previously uplifted area, the mountains had worn down substantially. About 66 million years ago, a northwestern portion of this area began to be folded and uplifted to form the present Uncompahgre Plateau. Subsequent uplift occurred between 10 and 28 million years ago.

4.9 *38.8* **Bridge over West Creek.** The road now enters the gorge of West Creek (West Creek Narrows) cut in Precambrian rocks. The oldest rocks seen here were once sediments, recrystallized by processes of heat and pressure (**metamorphism**, producing **metamorphic rocks**) nearly 2 billion years ago. In spite of the great age, in places you can see banding that suggests the layers of the original sedimentary rock. Various igneous rocks (generally light-colored ones like granite) then intruded these metamorphic rocks about 1.5 billion years ago.

9.0 *34.7* **Bridge over West Creek.** River cobbles are visible to the right where the valley is incised into coarse valley fill. Just ahead the road leaves the West Creek Narrows, and the valley widens.

11.5 *32.2* **View of Unaweep Canyon,** cut primarily into Precambrian crystalline rocks, forming nearly vertical cliffs 500 to 1000 feet high. This canyon is almost certainly the abandoned channel of a large river (probably either the Colorado River or the Gunnison River or both). The two streams occupying the canyon now (and flowing in opposite directions) are much too small to have ever carved this large channel. The main river probably abandoned Unaweep Canyon about 2 million years ago, during one of the major glacial periods in Colorado history. The canyon is broad and flat-floored with recent debris accumulated along the valley walls.

12.4 *31.3* **Alluvial fans** are deposits formed when small streams drop the load of sand and gravel they have carried. Here they are heavily covered with scrub oak and other bushes, coalescing on the valley floor, to form the gentle slopes at the right.

16.9 *26.8* The road now lies in Precambrian rocks. Ahead is a good view of older Precambrian rocks cut by younger Precambrian dikes and sills.

18.7 *25.0* Ruins of the Driggs Mansion on right. A wealthy man from New York, in 1916-1917 imported skilled stone masons from the East to build him an elegant summer home. It was never used.

19.5 *24.2* **Unaweep Canyon.** Here is an excellent view of Unaweep Canyon, now a wind gap on the Uncompahgre Plateau. A **wind gap** is a place where a river or stream once flowed, but no longer does. West-flowing West Creek has now disappeared. The wind gap will continue for several miles, then the road will begin to follow east-flowing East Creek. Unaweep is a Ute Indian word meaning "canyon with two mouths". One mouth (West Creek) empties into the Dolores River, while the other mouth (East Creek) empties into the Gunnison River.

23.5 *20.2* **Unaweep Divide,** elevation 7048 ft. Cliffs of Wingate Sandstone are present high on both sides of the canyon. Underlying the Wingate Sandstone is a layer of about 100 feet of Chinle Formation (remember, these formations thinned as they were deposited against the Ancestral Rocky Mountain highland). The smooth surface of the Precambrian rocks under the Chinle Formation is evident on the south wall of the canyon and can be seen for about the next five miles.

29.2 *14.5* **Divide Road turns off to the right,** leading to the top of the Uncompahgre Plateau and extending to the Plateau's southeast end (you crossed the southeast end at Dallas Divide). From Divide Road other roads branch off to Outlaw Mesa, Delta, Montrose, Nucla, and Norwood. Although the drive is impressive, it is recommended that it only be attempted in the summer.

The Taylor Ranch is located just ahead in East Creek Valley. Precambrian granite there is cut by numerous northwest-trending faults and much younger dikes, creating an impressive display of lines criss-crossing the granites.

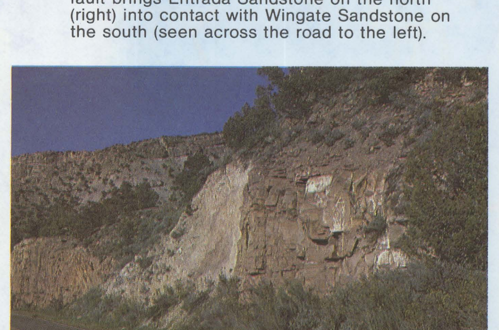
31.6 *12.1* **Bridge over Nancy Hanks Gulch.** Up the gulch is part of the Unaweep mining district. A few carloads of high grade copper ore and minor amounts of gold and silver were mined in the late 1890's from the Chinle Formation. Most mineralization is located along faults and dikes in Precambrian rocks and younger sedimentary formations. Specimen quality malachite (bright green copper ore) is still sometimes found. In recent years fluorite and amethyst, especially in Precambrian rocks, have received attention.

The road is now on Precambrian rocks. Visible on both sides is the contact between Precambrian crystalline rocks and younger sedimentary formations. The formations here are the same ones found on the southwest side of the Uncompahgre Plateau, with only slight differences in the rocks, but they are much thinner or totally missing here. In the next two miles the road passes out of the Precambrian rocks and climbs through the Wingate, Entrada, and Wanakah Formations.

32.5 *11.2* **Bridge over East Creek.** Just ahead on the left is the site of the former settlement of Copper City. In the late 1800's a matte smelter was built here to process the copper ores being mined, but the Unaweep mining district did not produce enough ore to be economic.

33.9 *9.8* **Cattle guard.** Cross-bedded Wingate Sandstone is now present on both sides of the road.

34.2 *9.5* **Bridge over Cactus Park drainage.** The Cactus Park fault crosses the highway just ahead, and **fault gouge** (whitish, ground-up rock where fault movement crushed the rocks against each other), is exposed in the road cut to the right. At the **Cactus Park Road turn-off** you can see how the fault brings Entrada Sandstone on the north (right) into contact with Wingate Sandstone on the south (seen across the road to the left).


Cactus Park fault, white fault gouge.

35.5 *8.2* This is about the top of Nine-Mile Hill. The Brushy Basin Member of the Morrison Formation forms the slope up to the massive sandstone of the Burro Canyon Formation, with Dakota Sandstone cliffs crowning them. Across the **Grand Valley** of the Colorado River ahead are the **Bookcliffs,** etched in Mancos Shale and capped by sandstones of the **Mesaverde** Formation. Below the Bookcliffs stretches the Mancos Shale "desert" in the Grand, Gunnison, and Uncompahgre Valleys. These valleys have long been known for their major fossil beds and many species of dinosaurs.

To the left is the valley of East Creek, choked with rock rubble from the Burro Canyon and Dakota Formations. Softer shales of the Morrison Formation erode and wash away, leaving sandstone above unsupported to break off in blocks, and accumulate in the valley below.

As you descend from the Uncompahgre Plateau into the valley below, the road ascends stratigraphically, until it reaches Mancos Shale in the valley. The formations are all dipping down as does the road, into the synclinal valley.

36.8 *6.9* High on the right side of the cliff ahead is an old mine probably explored for veins of copper, gold, and silver.

37.9 *5.8* East Creek Gorge to the left displays the upper part of the Salt Wash Member of the Morrison Formation near the bottom of the gorge.

40.8 *2.9* **Cattle guard.** The road is now on the Brushy Basin Member of the Morrison Formation. The cliffs to the left are carved in the Burro Canyon Formation and Dakota Sandstone rims the skyline.

41.2 *2.5* The road crosses the contact between the Morrison Formation shales and the massive, blocky sandstone of the Burro Canyon Formation.

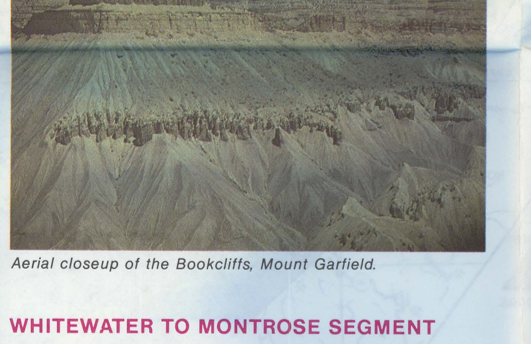
42.3 *1.4* **Bridge over East Creek.** To the right is Cotter Corporation's crushing and sampling plant. In recent years uranium-vanadium ore from the company's mines in the Uravan mineral belt was trucked to this plant where it was sampled, stockpiled, and crushed. Crushed ore was then transported across the Gunnison River on a conveyer belt, and loaded onto railroad cars for shipping to Cotter's mill at Canon City on the eastern slope of the Rocky Mountains. This arrangement was unusual, in that most companies use mills relatively near their mines. Ahead is **Grand Mesa,** a broad, flat-topped erosional remnant of the **Wasatch Formation, Mesaverde Formation,** and Mancos Shale, preserved because it is capped by a resistant Tertiary lava flow.

42.6 *1.1* This is the approximate contact between the Burro Canyon and Dakota Formations.

43.3 *0.4* **Cross the Gunnison River.** The Gunnison River was originally known as the Rio Javier, or by the Indian name Tomichi. After the death of Captain John Gunnison, one of the last explorers for the U.S. Geographical and Topographical Survey (today's U.S. Geological Survey), in the fall of 1853, it was renamed in his honor.

Rounded hills and gentle valleys north of the river are eroded into Mancos Shale. Grand Mesa forms the skyline in the distance.

43.7 *0.0* **Whitewater. Junction of Colorado 141 and U.S. Highway 50.** Turn right (south) toward Delta to complete the tour. Grand Junction, 9 miles to the left, is the home of the Museum of Western Colorado, housing Dinosaur Valley, a new, permanent exhibit featuring life-like, moving, breathing, bellowing dinosaur replicas. The city also provides one entrance to Colorado National Monument.


Aerial closeup of the Bookcliffs, Mount Garfield.

WHITEWATER TO MONTROSE SEGMENT

0.0 *52.8* **(10) WHITEWATER. The tour proceeds south on U.S. 50 toward Delta and Montrose.** Grand Junction, western Colorado's largest city, lies to the north on U.S. Interstate 70. Colorado 141 to the right travels through scenic Unaweep Canyon to Gateway on the Dolores River. The agricultural communities of Delta and Montrose nestle in the valley ahead along the tour route. The Gunnison River, visible directly to your right has cut a shallow canyon on the northeastern flank of the Uncompahgre uplift. This canyon parallels Highway 50 for the next 25 miles.

1.2 *51.6* Along the road to the left in the Mancos Shale are large, rounded limonite-stained (yellow and orange iron oxide), carbonate nodules exposed in two horizons most of the way to Delta. These **concretions** formed by chemical precipitation around a central nucleus, in or near the bottom of the ocean where the shales were deposited. The zone containing the concretions will be seen several times in the next few miles.

1.8 *51.0* White patches to the right of the road for the next half mile are salts leaching out of the Mancos Shale. A more resistant ridge of Mancos Shale is present on the left (east) side of the road.

2.7 *50.1* Directly to your right are three **radio towers** (KREX). Desert Reservoir is just beyond them to the south.

4.3 *48.5* **Lands End Road** to the left climbs to the top of Grand Mesa (switchbacks at 9:00), a 10,000 ft, lava-capped plateau between the Colorado and Gunnison Rivers. The sides are etched in Wasatch Formation, Mesaverde Formation and Mancos Shale. Heavily forested, and with many well-stocked lakes, the Mesa is a favorite camping and fishing area.

Around the slopes of Grand Mesa are four levels of Pleistocene (Ice Age) pediments. A **pediment** is a sloping, nearly flat surface produced by erosion of bedrock, usually thinly covered with stream sediments. These pediments were cut into the Mancos Shale during the last several glacial advances, and are generally capped by 15 to 30 ft of poorly sorted gravel containing large amounts of **basalt** (dark-colored lava) pebbles from nearby volcanics. As the tour continues toward Delta the pediments will be quite evident east and northeast of Highway 50.

5.5 *47.3* The road climbs onto a pediment surface. At the crest of the hill in the roadcut are pediment gravels made up of well-rounded basalt cobbles and boulders. Just over the hill to the right is a gravel excavation operation. Beneath the pediment gravels are several horizons of siltstone in the Mancos Shale, commonly containing **fossils** such as small **pelecypods** (clams and oysters are pelecypods). In this valley the Mancos Shale is often weathered to depths of 100 ft or more. Where the Mancos Shale has weathered it is often a yellow color from oxidation (rusting) of iron in the sediments.

The route continues along the pediment surface, here covered by a one-pebble thick veneer of rounded basalt pebbles and cobbles. More pediments can be seen along the east side of the highway.

Pediments in Mancos Shale.

5.8 *47.0* **Cross Indian Creek.** The panorama ahead is of the "Stinking Desert National Monument" stretching for the next 18 miles or so. The monument (not shown on maps) is not sanctioned by any branch of the state or federal governments, but was created in 1979 by the "Friends of the Desert", a small group from Grand Junction. On Labor Day weekend, signs are put up to notify travelers of the monument's existence. A pamphlet detailing all of the points of interest in the monument is available at the Fool's Hill rest area.

East of here in the Indian Creek area archaeologists have recently reported finding ancient Indian camp areas and fire rings, exposed as nature erodes away rock and soil.

7.0 *45.8* The extensive slope from 1:00 to 4:00 of Dakota Sandstone dipping off of the Uncompahgre Uplift is referred to as the Hunting Ground. This slope graphically demonstrates the draping of the younger rocks as the ancient Uncompahgre Plateau was pushed up and the Montrose syncline sagged.

10.2 *42.6* **Cross King Creek.** Ahead to your left is Indian Point (elevation 10,000 ft), one of two prominent basaltic lava arms of Grand Mesa.

10.7 *42.1* Basalt boulders from the Grand Mesa flows cover the surface of another pediment exposed here in the road cut.

12.1 *40.7* **Entering Delta County.** Ahead and to your right is Dominguez Canyon, cut by Big Dominguez Creek into the east side of the Uncompahgre Uplift, exposing red rocks of the Chinle Formation and the Wingate Sandstone.

To your left is Paradox Mesa, one of the older and more prominent pediments in the valley.

Notice the broad gentle valley between the Uncompahgre uplift on the west and Grand Mesa on the east, generally following the line of the Montrose syncline, where the river has cut down into soft Mancos Shale.

A distant panorama of the San Juan Mountains is visible on the skyline.

14.5 *38.3* The uppermost Dakota Sandstone crops out in the roadcut to the right. The road travels on top of the sandstone for the next half mile. On the right shoulder of the highway ahead is a large juniper "Christmas Tree" decorated each holiday season following a tradition started in the 1930's. The tree was spared when Highway 50 was widened 20 years ago and now serves as the official forest preserve of the "Stinking Desert National Monument".

15.1 *37.7* Directly to the left the roadcut exposes upper Dakota Sandstone and about 3 ft of coaly shale interbedded with sandstone and shale below it. Just ahead on the curve is more coal and coaly shale. At the other end of the road cut is a small fault.

15.3 *37.5* Wells Gulch to the right exhibits exposures of Dakota Sandstone, Burro Canyon Formation, and Brushy Basin Member of the Morrison Formation. This is a pretty little canyon, hidden among the barren flats of the Mancos Shale.

16.1 *36.7* **The road to the right** leads down Wells Gulch into Dominguez Canyon and the Gunnison River.

17.7 *35.1* Three rounded hills at 11:00 represent dissected remnants of former pediment surfaces on the Mancos Shale. Eventually all of the pediments in this area will be eroded away, or covered over by other rocks, in an endless cycle.

18.6 *34.2* **Escalante Canyon.** The road to the west leads to the Gunnison River and Escalante Canyon beyond. This is the turn for the **Fool's Hill rest area** and information on the "Stinking Desert National Monument".

20.1 *32.7* Dakota Sandstone is exposed at the heads of several canyons below road level to the right, with multicolored sediments of the Morrison Formation below the sandstone cap.

20.9 *31.9* Look to your left to see several pediments on the southwest flank of Grand Mesa. The West Elk Mountains in the distance at 11:00 were formed by Tertiary intrusives. Precambrian rocks straight ahead were entrenched by the Gunnison River, forming the Black Canyon of the Gunnison. Ahead and slightly to the right in the distance, Cimarron Ridge is capped by resistant Tertiary volcanic rocks erupted from the San Juan Mountains to your right.

22.4 *30.4* **Bridge over Alkali Creek.** This is typical weathered Mancos Shale.

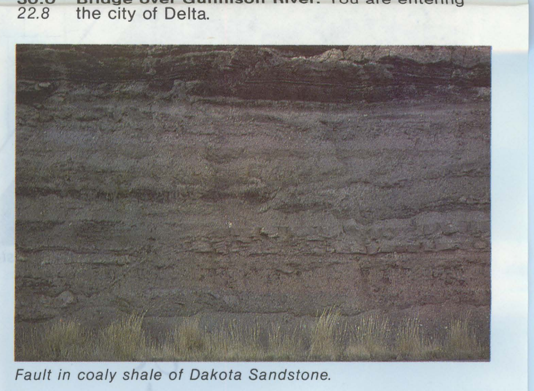
23.9 *28.9* To your right the Gunnison River begins cutting into the eastern flank of the Uncompahgre Plateau. Alluvial river terraces begin to appear along the Gunnison River.

25.3 *27.5* **Delta Speedway** to the left. The road crosses a deep arroyo cut into river-deposited sediments called **alluvium.**

27.0 *25.8* At 11:00 in the distance are the Ragged Mountains, the northernmost part of the volcanic West Elk Mountains. Closer in, on your left, are several glacial outwash surfaces descending southward off of Grand Mesa.

27.3 *25.5* Two deep arroyos cut in alluvium are now bridged by the road.

30.0 *22.8* **Bridge over Gunnison River.** You are entering the city of Delta.


Fault in coaly shale of Dakota Sandstone.

30.4 *22.4* **(11) DELTA. Junction of U.S. Highway 50 and Colorado Highway 92. The tour continues straight ahead on Highway 50** to Montrose. Colorado 92 to the left goes eastward up the valley of the North Fork of the Gunnison River to the coal-mining and fruit-growing towns of Hotchkiss and Paonia.

Delta was founded at the junction of the Gunnison and Uncompahgre Rivers and is supported primarily by agricultural activity. The highway will now travel in the broad Uncompahgre River valley, formed along the Montrose syncline.

33.0 *19.8* **Sweitzer Lake Road to the left leads to Sweitzer State Recreation area.** Just ahead you will again begin to see Mancos Shale and an overlying thin layer of gravel.

37.4 *15.4* **Entering Montrose County.** The road climbs up a low river terrace.

39.9 *12.9* Underground onion storage cellars lie to the right, housing one of the valley's more important crops.

41.1 *11.7* **(12) OLATHE.** Junction with business route of Highway 50 to the town of Olathe on the right. The tour route continues on the main route of Highway 50, bearing to the left.

42.9 *9.9* To your right are two alluvial terraces formed by the Uncompahgre River. The highest terrace is aptly named High Mesa.

47.6 *5.2* The deep road cut to your left is in the Mancos Shale.

48.2 *4.6* Horsefly Peak (elevation 10,348 ft) seen at 2:00, is the highest point on the Uncompahgre Plateau, located near its southeastern end. The peak is capped and flanked by glacial deposits. At 1:00 in the distance is Dallas Divide, crossed by the tour route, and the imposing north-facing Sneffels Range, marking the northwestern edge of the San Juan Mountains.

49.1 *3.7* North Mesa to your left, and Spring Creek Mesa to your right are river terraces left by the Uncompahgre River as it cuts its way into the valley.

52.8 *0.0* **Junction of U.S. 550 and U.S. 50 in Montrose.** We hope you enjoyed your geologic tour and will visit Colorado again!