EAST FORK VALLEY AND THE SAN JUAN GLACIER

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The geology of the East Fork Valley is a study in the processes that formed the Earth and shaped the landscape. This paper is designed as a self-guiding road trip from the Pagosa Springs Chamber of Commerce Visitor Center, along Highway 160 East, and along the East Fork Road in the San Juan National Forest. After a discussion of the geologic history of the area, there is a **ROAD TRIP LOG** which guides your visit. The drive from the Visitor Center to the end of the road trip is measured in mileage between points of interest mentioned in the road log, and also in the total mileage driven from the Center. Important driving instructions are printed in **BOLD LETTERS**. You should read over the road trip log before starting out to be familiar with the route and directions. The attached map shows the roads and features noted in the Log. **NOTE - THE ROAD REQUIRES HIGH CLEARANCE VEHICLES FOR THE COMPLETE TRIP.** Standard passenger vehicles may not be able to cross some of the stream fords and rough stretches of roadway. Always watch for falling rock and be aware of other vehicles using the road.

The accompanying map shows the local features and the major geological formations along the trip route. The map symbols, such as **Kmv**, refer to the geological formations described in the road trip log. A large-scale geological map of this part of Southwest Colorado is available from the United States Geological Survey in Denver or on the internet.

Pagosa Springs sits in the valley of the San Juan River, on a landscape of Cretaceous-age sedimentary rock -- the ocean-bottom mud of the Lewis Shale. During the last years of the Dinosaur Age, some 80 to 100 million years ago, the shallow sea which covered western North America drained away. A series of river deltas, floodplains, and swamps covered this area. The age of the dinosaurs ended 65 million years ago, apparently in a single instant of climate change and cataclysm. No one knows for sure what ended the 200 million year reign of these great beasts, but their disappearance opened the world for the mammals. As the modern Rocky Mountains rose to the north, this flat, wet landscape with its entombed dinosaur bones was buried by debris washed down from those new mountains; at the same time, immense volcanic forces began to rip and shatter the land.

The East Fork of the San Juan River begins high in the volcanic mountains of the Continental Divide. The valley of the East Fork ranges in elevation from 7,600 feet at its mouth (where it enters the main San Juan River valley along Highway 160) to over 9,000 feet, with the surrounding mountain peaks topping 13,000 feet. The road trip log ends at the Silver Falls Guard Station, an historic Forest Service ranger station now rented to visitors, at 8,300 feet elevation. A short hike along the trail just east of the cabin takes you to Silver Falls, a classic example of a hanging valley left behind when the glaciers retreated for the last time. The mountains of the Continental Divide are remnants of a mighty range of volcanos that formed between 40 million and 10 million years ago. After the last eruptions, the volcanic peaks, which may have been as high as 20,000 feet, were swiftly eroded to the level we see today.

Starting about 100,000 years ago, the Earth entered the most recent of a series of glacial periods we call the Ice Age. This period is known to geologists as the Wisconsin Glaciation, and the last retreat of the ice was sometime between 18,000 and 12,000 years ago. The Ice Age itself has not actually ended; interglacial periods are common and we are still in such a period between the advance and retreat of glaciers. How long it may be until the next advance of the ice, no one can predict; but if we can trust our understanding of Earth's past and the processes involved, we know that it will certainly happen.

For the East Fork Valley, the Wisconsin Glaciation was a significant event. Flowing down from the still-lofty volcanic mountains was a river of ice called the San Juan Glacier. At its height, it may have been 2,000 feet thick, and it flowed for an estimated 50,000 years - longer by far than humans have inhabited the Americas. All of recorded human history has only happened since the last remnants of the glacier melted away; the San Juan ice sheet predates all the great civilizations of mankind.

MILEAGE **EAST FORK ROAD TRIP LOG**

Between Points	Total Distance	Points of Interest and Driving Instructions
0	0.9	Depart from the Chamber of Commerce Visitor Center and drive north to the traffic light. **TURN RIGHT ON HIGHWAY 160** and drive toward Wolf Creek Pass.
4.6	5.5 Map symbol **Qa**	The bridge crosses the San Juan River, which drains the East Fork Valley. Much of the sediment in the river bottom is **glacial till** (debris) from the glaciers in the upper East Fork, originally deposited as moraines. **Lateral moraines** run alongside the glacier as it flows, and **terminal moraines** form as dams at the lower end of the glacier. These terminal moraine dams can cause lakes of meltwater to form, and when the dams eventually break, huge floods run down the valley below. This must have happened many times over the thousands of years of life of the San Juan Glacier. As the glacier finally melted, its meltwater reworked the glacial debris into a type of sediment called **alluvium**, meaning water-deposited sediment. The accompanying map shows the general geologic formations exposed along the trip route, using standard geologic map symbols (such as **Qa**). These symbols are shown in the mileage column to the left, to help you connect the trip log with the geology on the map and on the ground. The heavy lines on the map outline the area where each rock type is exposed. The symbol **Qa** means **Quaternary** (the geologic age of the sediment) and **alluvium** (the geologic formation or material). This format is followed through the trip log below.
1.0	6.5 **Ti**	**STOP 1 - PARK ON THE RIGHT SIDE OF THE HIGHWAY - WATCH FOR TRAFFIC!** Just north of the San Juan River Village on the west (left) side of the road, is an igneous outcrop in the road cut. This is a **Tertiary intrusive (Ti)**, about 25 to 30 million years old. It is a rock type called **andesite porphyry**; the fresh rock is gray, but it weathers to the dull orange seen above the gray core. This was once molten material, which forced its way between the layers of the sedimentary **Lewis Shale**, and cooled as the Jackson Mountain **laccolith**, a lake-shaped body of igneous rock. Andesite is a classification of fine-grained igneous rock, and porphyry means that it has large individual crystals in a fine-grained matrix. The large crystals are called **phenocrysts**. There are double hexagonal pyramids of **beta-quartz**, a high-temperature variety of common quartz. Phenocrysts of **plagioclase feldspar** show good rectangular crystal shape and internal color zoning, the result of changes in the chemical composition of the magma as it cooled and the crystals grew. **Micropegmatites** (pockets of coarse crystals) of **feldspar, quartz,** and **amphibole** are the result of cooling bubbles of element-enriched fluids, the last part of the magma to crystallize. Thin fissures and cracks are filled with **calcite** and **quartz** crystals, formed after the rock cooled and fractured. Small amounts of **chalcopyrite** and **pyrite** (copper and iron sulfides) occur throughout the rock. It is the iron in these minerals which gives the rock its orange rusty color as it weathers.
	Kl	Look along the edges of the main outcrop, and you will find the **country rock**, the geologic formation which surrounds the igneous intrusive. This is the **Cretaceous** age **Lewis Shale (Kl)** which has been baked into near-ceramic hardness by the heat of the intruding magma. This is an example of **contact metamorphism**, in which rock is chemically changed by heat and pressure. The Lewis Shale is about 80-90 million years old. **CONTINUE ON HIGHWAY 160 TOWARD WOLF CREEK PASS.**

1.1	7.6 Map symbol **Km** **Kmv** **Kl** **TKpa**	For the next mile, the highway passes through several major slumps, where the soil has slid down toward the river. To the left you can see tilted pine trees. The road surface is irregular because of movement of the ground. Road cuts show the contorted layers of rock and thin **coal seams** which formed in the river-floodplain and swamp terrain of this ancient shoreline environment, and were compacted by the weight of later deposits, a process called **soft-sediment deformation**. This rock is late **Cretaceous** in age, about 70 - 90 million years old - the last years of the dinosaur age. From the Chamber of Commerce to this area, you have passed through, from older to younger, the Mancos Shale, Mesa Verde Group, Lewis Shale, Pictured Cliffs Sandstone, and Fruitland Formation as you drove along the highway. This is a series of sedimentary rock layers, representing periods when the area was sea floor (**Km** - Mancos Shale): briefly shoreline and beach (**Kmv** - Mesa Verde Group); sea floor again (**Kl** - Lewis Shale); shoreline beaches and dunes (Pictured Cliffs Sandstone); then peat and coal swamps (Fruitland Formation), and finally the eroded debris from the young Rocky Mountains which buried the swamps (Animas Formation; mapped together as **Tkpa**).
2.8	10.4	**TURN RIGHT ON EAST FORK ROAD IMMEDIATELY AFTER CROSSING THE BRIDGE.** This is a gravel road and is narrow, with blind curves - watch for traffic. To the left you can see the mountains of the Continental Divide, a string of volcanos which erupted up to about 10 million years ago. You are entering the San Juan National Forest, and the lower end of the narrow, V-shaped valley cut by the melting glacial water of the ancient East Fork River.
0.9	11.3 **Qa**	On the left are wire coffers to keep debris from sliding onto the road. The cobbles and gravel in the coffers are river deposits, washed down from glacial debris higher in the valley and smoothed by centuries of tumbling and polishing in the stream. This material formed during the Quaternary age and is called **alluvium (Qa)**.
0.7	12.0 **Ten**	Here, the road passes through the narrowest part of the canyon. The walls were laid down in successive eruptions of Tertiary age eruptive deposits (**Ten**) (**volcanic ash and tuff**) and later reworked by streams (**pyroclastic deposits**). This rock is soft and easily erodes. Notice the **talus slopes** (slides of broken rock) lining the valley along the road and river channel. The San Juan Glacier did not come this far down the valley; the soft volcanic rock could never have withstood the cutting power of the ice. The heavily fractured, dark rock along the road cut is called **dacite**; it is made up of calcium-rich **plagioclase feldspar** crystals in a dark, iron- and magnesium-rich matrix. The plagioclase crystals show layering which indicates that this rock was a lava flow.
0.3	12.3	**STOP 2 - PARK TO THE RIGHT OF THE ROAD.** Walk out onto the meadow and review the geologic history of the valley from the first page.
0.7	13.0 **Qa**	Crossing the East Fork River. The gravel and boulders come from glacial debris higher in the valley.
0.4	13.4 **Ten**	Notice to the left, the thick white ash layers, and the colored layers of tuff and pyroclastic rock below. The colors come from minerals contained in the rock, dissolved and redeposited by ground water.

0.3	13.7	Crossing the river again. The valley is still narrow, steep-walled, and V-shaped - the characteristic shape of a valley cut by running water.
0.5	14.2 **Map symbol Qa**	**STOP 3 - PARK ON THE RIGHT.** This is a **terminal moraine**, the dividing line between the glaciated valley ahead of you and the stream-cut canyon behind. The valley ahead was cut by the most extreme advance of the glacier, but it was not always under ice - when the glacier periodically retreated, floods of meltwater reworked the moraines and other debris left behind on the valley floor. Compare the ground and the stream bed - notice the large amount of clean-washed gravel in the stream, versus the high proportion of sand, silt, and **rock flour** - fine material ground up by the glacier - still remaining in the moraine. This moraine material makes a deep, well-drained and fertile soil. **ONLY VEHICLES WITH GOOD GROUND CLEARANCE SHOULD PROCEED FROM HERE** - there are rough stretches of road and some streams to ford.
0.8	15.0	Entering Mineral County.
0.7	15.7 **Ql**	The road enters private land here (the East Fork Ranch). **PLEASE STAY ON THE ROAD RIGHT-OF-WAY.** This is the true glaciated valley. From here, all the way to the mountains ahead, the valley once lay under 2,000 feet of solid ice. The floor of the valley is broad and flat, and is bounded by steep walls typical of glaciated valleys. Other features are the result of the retreat of the glacier - abundant **landslides** and **slumps (Quaternary age Ql),** when the support of the ice was removed from the steep walls, and **hanging valleys**, which open out into space halfway up the walls - the streams which cut these valleys once flowed onto the top of the glacier. Today, these hanging valleys form numerous small waterfalls. A beautiful example of these hanging valley waterfalls is Silver Falls, at the end of the trip. Along the East Fork Road, notice the Clamshell to the right - the high, gray cliff forming the skyline. It is a layer of lava flows from an ancient eruption, exposed by a landslide and now being stripped away by erosion. The river flows in a pattern called a **braided stream**, the result of highly variable seasonal flow and an abundant supply of sediment - more material than the stream can carry except during extreme floods. The rest of the time, the low-flowing waters thread through channels among gravel banks in multiple streams. Recently, specialists in **hydrology**, the science of river flow, have been working to convert portions of the East Fork and San Juan Rivers from braided to **meandering streams**, to improve fish habitat and reduce the risk of catastrophic floods. A meandering stream is more efficient at containing the flow within its banks, transporting sediment, and produces better spawning and feeding habitat for trout and other fish species.
2.4	18.1	**STOP 4 - TURN LEFT AND PARK AT SILVER FALLS GUARD STATION.** This was once used as a ranger station for the Forest Service, and is now rented out to visitors (check with the Pagosa District Office for information: 970-264-2268). Please respect the privacy of those using the station. A short hike leads to Silver Falls. From here, the East Fork Road continues up and over Elwood Pass, the original settlers' route into the San Juan country before Wolf Creek Pass was "tamed". The road is extremely challenging and is not maintained, but many adventurers enjoy the trip. A few miners still hack at the rock in those high elevations, and rarely, panners find a few "colors" or a small nugget of gold in the cold waters of the East Fork. As you return to Pagosa Springs or continue on over the pass, look at the mountains and remember their long history, and imagine the glaciers still to come some distant day. Geology is about the future, as well as the past!

EAST FORK GLACIER MAP

Geologic Map Symbols:

Kdb	Dakota Sandstone
Kml	Mancos Shale, lower beds
Kmu	Mancos Shale, upper beds
Kmv	Mesa Verde Group
Kl	Lewis Shale
TKpa	Pictured Cliffs Sandstone
Ti	Igneous Stocks and Dikes
Ten	Volcanic Ash Layers
Tev	Volcanic Lava and Ash Flows
Qa	Recent River Sediment
Ql	Recent Landslide Deposits

Glacier-arrows show flow direction

Contact between formations

Fault-bar on downdropped side

MAP SCALE: 1 INCH = 2 MILES